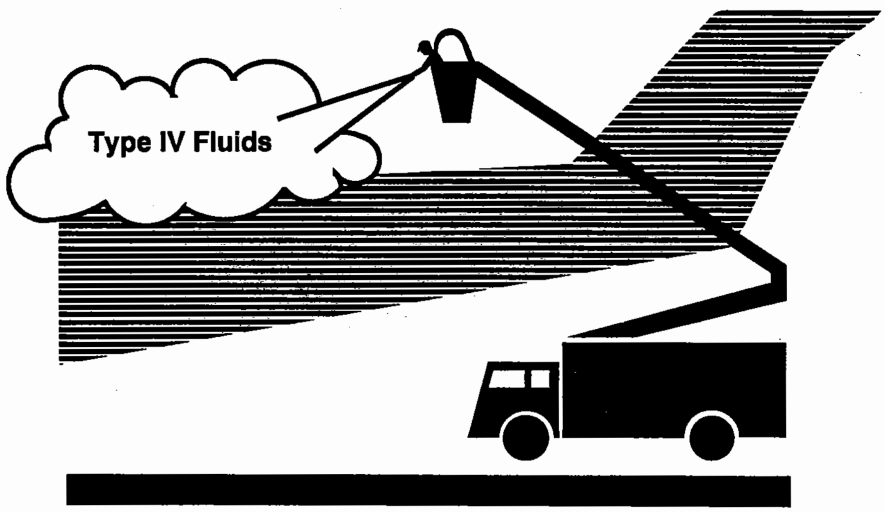
TP 12896E

Aircraft Ground De/Anti-icing Fluid Holdover Time Field Testing Program for the 1995-1996 Winter



by

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APS AVIATION INC.

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Un sommaire français se trouve avant la table des matières.

PREFACE

At the request of the Transportation Development Centre of Transport Canada, APS Aviation Inc. has undertaken a research program to further advance aircraft ground de-icing/anti-icing technology. Specific objectives of the overall program were:

- To complete the substantiation of the existing Type I and Type II fluid SAE/ISO holdover time tables by conducting cold-soak tests and very low temperature tests;
- To determine the holdover time performance of the proposed Type IV fluids over the range of characteristic conditions and develop a generic Type IV holdover time table;
- To establish the precipitation, wind, and temperature values that delimit the holdover times given in the tables;
- To validate that test data on Type IV fluid performance on flat plates used to establish the SAE holdover time tables are representative of Type IV fluid performance on service aircraft under conditions of natural freezing precipitation;
- To document the characteristics of frost deposits occurring naturally during very cold temperatures;
- To validate that fluid performance on cold-soaked boxes used for establishing holdover times is representative of fluid performance on a cold-soaked wing;
- To identify potential means of enhancing the visibility of failed wing surfaces from inside the aircraft; and
- To identify optimum wing locations to be used as representative surfaces by measuring the wet film thickness profiles of fluid application on aircraft wing surfaces.

The research activities of the program conducted on behalf of Transport Canada during the 1995/96 winter season are documented in six separate reports. The titles of these reports are as follows:

- TP 12896E Aircraft Ground De/Anti-icing Fluid Holdover Time Field Testing Program for the 1995/96 Winter;
- TP 12897E Evaluation of Frost Formations at Very Cold Temperatures;
- TP 12898E Feasibility of Enhancing Visibility of Contamination on a Wing;
- TP 12899E Validation of Methodology for Simulating a Cold-Soaked Wing;
- TP 12900E Evaluation of Fluid Thickness to Locate Representative Surfaces; and
- TP 12901E Aircraft Full-Scale Test Program for the 1995/96 Winter;

This report, TP 12896E, addresses the objective of completing the substantiation of the existing Type I and Type II fluid SAE/ISO holdover time tables by conducting cold-soak tests and very low temperature tests; of determining the holdover time performance of the proposed Type IV fluids over the range of characteristic conditions and developing a generic Type IV holdover time table; and of establishing the precipitation, wind, and temperature values that delimit the holdover times given in the tables.

Funding for the research has come from the Civil Aviation Group, Transport Canada, with support from the Federal Aviation Administration. This program of research could not have been accomplished without the assistance of many organizations. APS would therefore like to thank the Transportation Development Centre, the Federal Aviation Administration, the National Research Council, Atmospheric Environment Services, Transport Canada and the fluid manufacturers for their contribution and assistance in the project. Special thanks are extended to Air Canada for provision of personnel and facilities and for their cooperation on the test program. APS would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data leading to the preparation of this document.

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Research reports produced on behalf of Transport Canada for testing during previous winters are available from TDC. Six reports (including this report) were produced as part of this winter's research program. The subject matter of these reports is provided in the preface. Funding for this project was provided by TDC and, in part, by the FAA.

16. Abstract

The objectives of this program were to use data acquisition, processing, and analysis, as well as presentation of the results of holdover time testing to assess the performance of commercially available de/anti-icing fluids according to current SAE/ISO guidelines. Natural precipitation tests were performed at Dorval airport. Artificial precipitation tests were conducted at the NRC Climatic Engineering Facility (Ottawa). The overall program consisted of 468 natural snow, 62 freezing drizzle, 100 light freezing rain, 82 freezing fog, and 115 rain on cold-soaked box tests.

The test procedure consisted of pouring the fluids onto clean aluminum plates and/or cold-soaked boxes and recording the fluid failure progression as a function of time. Several manufacturers provided Type IV fluids, which were tested in both neat and diluted forms.

A preliminary holdover time table was developed for Type III fluids. Several changes were made to the format of the holdover time tables. New values were determined for diluted and neat Type IV fluids:

- Holdover times for neat Type IV fluids range from 50 percent to more than 200 percent longer than those for neat Type II fluids.
- Holdover times for 75/25 Type IV fluids were found to be slightly longer than those for 75/25 Type II fluids.
- Holdover times for 50/50 Type IV fluids were found to be slightly shorter than those for 50/50 Type II fluids.

Two new columns of holdover times are proposed for rain on a cold-soaked wing. The first (corresponding to drizzle and light rain) closely matches the values selected for use in the 1996/97 season. The second (moderate to heavy rain) has values shorter than the corresponding selected values.

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

Les rapports sur les recherches effectuées au cours des hivers précédents pour le compte de Transports Canada sont disponibles au CDT. Six rapports, dont le présent, ont été produits dans le cadre des recherches menées cet hiver. L'objet de ces recherches figure dans l'avant-propos. Les recherches ont été financées principalement par le Groupe Aviation civile, Transports Canada et en partie par la FAA.

16. Résumé

Ce programme comportait la saisie, le traitement et l'analyse de données, ainsi que la production des rapports d'essais portant sur la durée d'efficacité de liquides de dégivrage/antigivrage offerts sur le marché, afin d'évaluer leur performance à la lumière des lignes directrices SAE/ISO actuellement en usage. Des essais en conditions de précipitations naturelles ont été menés à l'aéroport de Dorval, et d'autres essais en conditions de précipitations simulées ont été réalisés dans le laboratoire de recherches climatiques du Conseil national de recherches, à Ottawa. L'ensemble du programme a porté sur 468 essais sous neige naturelle, 62 sous bruine verglaçante, 100 sous pluie légère verglaçante, 82 sous brouillard verglaçant, et 115 mettaient en jeu des précipitations de pluie sur des boîtes sur-refroidies.

Les procédures ont consisté à déposer les liquides sur des plaques d'aluminium propres et/ou sur des boîtes sur-refroidies et à noter la perte d'efficacité de ces derniers en fonction du temps. Aux fins des essais, des fabricants ont fourni des liquides de type IV, qui ont été utilisés dilués et non dilués.

Une table provisoire de durées d'efficacité a été établie pour les liquides de type III. Le format des tables de durée d'efficacité a été refondu. De nouvelles valeurs ont été déterminées pour les liquides de type IV, dilués et non dilués :

- les durées d'efficacité des liquides de type IV non dilués sont de 50 p. 100 à 200 p. 100 supérieures à celles des liquides de type II non dilués;
- les durées d'efficacité des liquides de type IV dilués dans un rapport de 75 à 25 se sont révélées légèrement supérieures à celles des liquides du type II essayés dans un même rapport de dilution;
- les durées d'efficacité des liquides de type IV dans un rapport de dilution de 50/50 étaient légèrement inférieures à celles des liquides de type II 50/50.

Deux nouvelles colonnes de durées d'efficacité sont proposées pour des précipitations de pluie sur une aile sur-refroidie. Les valeurs de la première colonne (correspondant aux précipitations de bruine et de pluie légère) sont très similaires aux valeurs retenues pour la saison 1996-1997. La deuxième colonne (qui correspond aux précipitations de pluie moyennes à abondantes) contient des durées d'efficacité plus courtes que celles retenues pour la saison 1996-1997.

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

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EXECUTIVE SUMMARY

At the request of the Transportation Development Centre of Transport Canada, APS Aviation Inc. undertook a research program to further advance aircraft pre-flight deicing/anti-icing technology. While a number of objectives of the test program are covered by other related reports, the primary objectives specifically addressed in this document were:

- To test the new Type IV fluids over the entire range of conditions covered by the holdover time tables; and

- To conduct laboratory cold-soak tests to complete the substantiation of the Type I and Type II holdover time tables.

The project involved the participation of several de/anti-icing fluid manufacturers, the Transportation Development Centre of Transport Canada, the National Research Council of Canada, the Federal Aviation Administration, and Atmospheric Environment Services.

Most holdover time tests consisted of pouring a variety of freezing point depressant fluids (neat and diluted) onto clean, flat, inclined, aircraft aluminum plates which were exposed to a range of natural and artificially-produced icing conditions. The elapsed time required to reach a pre-defined end condition was recorded. The end condition and the plate inclination were set according to the SAE/ISO G-12 Committee guidelines.

The variables which were measured included total precipitation, failure time, ambient temperature, visibility, wind speed, wind direction, type of fluid, and type of precipitation.

Data Collection

During the 1995/96 test season, data were collected for natural precipitation tests conducted at Dorval airport. Data were also collected for artificial precipitation tests which were performed indoors at the Climatic Engineering Facility of the National Research Council in Ottawa. These included test conditions simulating freezing drizzle, light freezing rain, freezing fog, and rain on cold-soaked surfaces. The listing below indicates that the majority of the more than 800 tests were carried out either with Type IV fluids or under natural snow conditions.

CONDITION	**Natural Snow**	**Freezing Drizzle**	**Light Freezing Rain**	**Freezing Fog**	**Cold-Soak**
FLUID TYPE					
Type I Standard	12	2	1	9	21
Type I Diluted	6	-	-	8	21
Type II Neat	139	8	15	6	15
Type II 75/25	70	4	4	4	14
Type II 50/50	24	9	9	2	-
Type IV Neat	93	17	43	24	25
Type IV 75/25	82	15	17	16	19
Type IV 50/50	42	7	11	13	-
Total	**468**	**62**	**100**	**82**	**115**

Meteorological Considerations

With the cooperation of the Atmospheric Environment Service, APS Aviation was able to obtain detailed meteorological information for the tests at the Dorval site. The data provided by the Atmospheric Environment Service instruments were automated and provided minute-by-minute information such as total precipitation, wind speed and direction, visibility, and temperature. The precipitation collection devices used at the Dorval test site included plate pans and two precipitation gauges. A plot of the average visibility measured by the automated station plotted against average precipitation rates showed less variability than in the past.

Test Procedures

Identification of end conditions for tests performed in freezing fog below -14°C presented some difficulties. This was especially true for Type IV fluids. Further testing under these conditions has been recommended.

The holdover times of two different neat Type IV fluids (when applied by standard flat plate test conditions) were found to be longer than when the fluids were applied by backpack sprayer. In the case of one of these fluids, the holdover times of poured fluid application were twice that of sprayed fluid application.

Holdover times of two-step applications of three different neat Type IV fluids tested were shorter than those for the standard one-step method of applications. For the tests under artificial light freezing rain, the reduction in holdover time was about 10 percent.

Holdover Times

A preliminary holdover time table for Type III fluids was developed.

Several changes have been made to the holdover time table format. The most notable changes are related to temperature restrictions on fluid type and fluid dilution. Type II 50/50 fluids and Type IV 50/50 fluids have both been limited to use at temperatures greater than or equal to -3°C.

In association with the SAE G-12 Holdover Time Sub-Committee, new holdover time values were established for Type IV fluids in both neat and diluted forms.

Under conditions of snow, freezing fog, freezing drizzle, and light freezing rain, Type II and Type IV fluid behaviours were compared:

- Neat Type IV fluids exhibited holdover times ranging from 50 percent to more than 200 percent longer than neat Type II fluids.

- The holdover time range for Type IV 75/25 fluids was only marginally longer than that determined for Type II 75/25 fluids except in the case of freezing fog conditions, in which holdover times for Type IV 75/25 fluids were increased by a factor of two over Type II 75/25 fluids.

- In the case of fluids diluted to 50 percent by volume (50/50), Type IV fluids generally exhibited shorter holdover times than Type II fluids.

At the 1996 SAE G-12 Holdover Time Sub-Committee meetings, changes to the holdover times for rain on a cold-soaked surface were made. The lack of data resulted in reductions to all previously established holdover time ranges. Furthermore, for the Type II 50/50 and Type IV 50/50 fluids the holdover times were removed from the tables altogether.

Cold-soaked testing involved exploration of varying precipitation rates, skin temperature, reservoir size, precipitation type, and fluid type. Over the complete test range, the variable exhibiting the greatest influence on failure times was found to be the rate of precipitation; skin temperature and reservoir size contribute less significantly to failure times.

Based on results of cold-soak tests performed at the NRC Climatic Engineering Facility, two new columns of holdover time ranges were developed. Adoption of this modification should be forwarded for SAE approval. From this study, the recommended holdover times for the first column (drizzle and light freezing rain) closely match existing values in the holdover time tables. The recommended holdover times for moderate and heavy rain are significantly shorter than the current holdover time values.

Future Testing

Recommendations were made concerning the refinement of test procedures and enhancements to equipment. In addition, it was recommended that future testing focus on new Type IV fluids in their neat and diluted forms over the complete range of icing conditions; Type III fluids should be subjected to the same treatment in order to establish a Type III holdover time table.

SOMMAIRE

À la demande du Centre de développement des transports de Transports Canada, APS Aviation Inc. a entrepris un programme de recherche visant à faire progresser la technologie sous-jacente aux opérations de dégivrage des avions au sol. On trouvera dans divers autres rapports publiés dans la foulée de ce programme les résultats obtenus à l'égard d'un certain nombre d'objectifs du programme. Le présent rapport s'attache spécifiquement aux résultats des essais suivants :

- essai des nouveaux liquides de type IV sous toute la gamme des conditions couvertes par les tables de durées d'efficacité;

- essais en laboratoire sur des boîtes sur-refroidies, destinés à achever la validation des tables de durées d'efficacité des liquides de type I et de type II.

Ont participé au programme plusieurs fabricants de liquides de dégivrage/antigivrage, le Centre de développement des transports de Transports Canada, le Conseil national de recherches du Canada, la Federal Aviation Administration des États-Unis et le Service de l'environnement atmosphérique.

La plupart des essais ont consisté à déposer divers liquides abaisseurs du point de congélation (dilués et non dilués) sur des plaques d'aluminium d'avions propres, plates, inclinées, sous une gamme de conditions naturelles et simulées propices à la formation de givre. On notait ensuite le temps nécessaire pour qu'une condition prédéterminée, indicatrice de la perte d'efficacité du liquide, soit remplie. Cette condition et l'angle d'inclinaison des plaques ont été déterminés en fonction des lignes directrices du Comité G-12 SAE/ISO.

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

Saisie des données

Durant la campagne d'essais 1995-1996, des données ont été colligées suite à des essais sous précipitations naturelles menés à l'aéroport de Dorval et à des essais sous précipitations simulées réalisés à l'intérieur, au laboratoire de recherches climatiques du Conseil national de recherches, à Ottawa. Les précipitations simulées comprenaient la bruine verglaçante, la pluie légère verglaçante, le brouillard verglaçant, et la pluie sur des surfaces sur-refroidies. Comme le montre la liste ci-après, la majorité des plus de 800 essais mettaient en jeu des fluides de type IV sous des précipitations de neige naturelle.

CONDITION	Neige naturelle	Bruine vergl.	Pluie légère vergl.	Brouillard vergl.	Pluie sur surf. sur-ref.
TYPE DE LIQUIDE					
Type I standard	12	2	1	9	21
Type I dilué	6	-	-	8	21
Type II non dilué	139	8	15	6	15
Type II 75/25	70	4	4	4	14
Type II 50/50	24	9	9	2	-
Type IV non dilué	93	17	43	24	25
Type IV 75/25	82	15	17	16	19
Type IV 50/50	42	7	11	13	-
Total	**468**	**62**	**100**	**82**	**115**

Considérations météorologiques

Grâce à la collaboration du Service d'environnement atmosphérique, APS Aviation a pu obtenir des données météorologiques détaillées pour ses essais à Dorval. Les données informatisées fournies par les instruments du SEA renseignaient les chercheurs, de minute en minute, sur la quantité de précipitation totale, la vitesse et la direction du vent, la visibilité et la température. Les collecteurs de précipitation utilisés à l'aéroport de Dorval comprenaient des bacs de faible profondeur et deux pluviomètres. Un graphique de la visibilité moyenne mesurée par la station automatisée en fonction des taux moyens de précipitation a montré moins de variabilité que par le passé.

Procédures

La caractérisation du moment où les liquides de dégivrage/antigivrage cessent d'être efficaces a présenté des difficultés, surtout lors des essais réalisés sous brouillard verglaçant à des températures inférieures à -14 °C. Cela était particulièrement vrai des liquides de type IV. Il a été recommandé de procéder à d'autres essais sous ces conditions.

Les durées d'efficacité de deux liquides de type IV non dilués (lorsque déposés sur plaques planes selon les procédures normalisées) se sont révélées plus longues que lorsque les mêmes liquides étaient appliqués au moyen de pulvérisateurs à dos. Pour un des liquides, les durées d'efficacité étaient deux fois plus longues lorsque le liquide avait été versé sur la surface que lorsqu'il avait été pulvérisé.

Les durées d'efficacité de trois liquides de type IV non dilués étaient plus courtes lorsque les liquides étaient appliqués en deux étapes plutôt qu'en une seule. Pour les essais sous pluie légère verglaçante simulée, les durées d'efficacité étaient raccourcies d'environ 10 p. 100.

Durées d'efficacité

Une table provisoire des durées d'efficacité a été établie pour les liquides de type III.

Le format des tables de durées d'efficacité a été refondu. Les changements les plus remarquables ont trait à l'établissement de degrés de température limites pour l'utilisation d'un type de liquide, selon un taux de dilution. À titre d'exemple, l'utilisation des liquides de type II 50/50 et de type IV 50/50 a été restreinte aux températures égales ou supérieures à -3 °C.

De concert avec le Sous-comité G-12 de la SAE sur les durées d'efficacité, de nouvelles valeurs ont été déterminées pour les liquides de type IV, dilués et non dilués.

La performance des liquides de type II et de type IV a été comparée sous des précipitations de neige, de brouillard verglaçant, de bruine verglaçante et de pluie légère verglaçante. Voici les principaux résultats de cette comparaison :`

- Les liquides de type IV non dilués présentent des durées d'efficacité supérieures de 50 p. 100 à plus de 200 p. 100 à celles des liquides de type II non dilués.

- La plage des durées d'efficacité des liquides de type IV 75/25 n'est que légèrement plus étendue que celle des durées d'efficacité des liquides de type II 75/25, sauf sous brouillard verglaçant : les durées d'efficacité des liquides de type IV 75/25 étaient alors deux fois plus longues que celles des liquides de type II 75/25.

- Si on considère les liquides dilués à 50 p. 100 en volume (50/50), les durées d'efficacité des liquides de type IV étaient généralement inférieures à celles des liquides de type II.

À sa réunion de 1996, le Sous-comité G-12 de la SAE sur les durées d'efficacité a modifié les tables de durée d'efficacité pour les précipitations de pluie sur surface sur-refroidie. Faute de données suffisantes, on a revu à la baisse toutes les plages de durées d'efficacité établies antérieurement. De plus, pour les liquides de type II 50/50 et de type IV 50/50, les durées d'efficacité ont été tout simplement retirées des tables.

Les essais sur surface sur-refroidie ont mis en jeu les variables suivantes : le taux de précipitation, la température superficielle, la capacité du réservoir, le type de précipitation et le type de fluide. Dans toute la série des essais, le taux de précipitation est la variable qui exerçait la plus grande influence sur la perte d'efficacité; la température superficielle et la capacité du réservoir influaient également, mais dans une moindre mesure, sur les durées d'efficacité.

Les résultats des essais sur surface sur-refroidie réalisés au laboratoire de recherches climatiques du CNR ont mené à l'ajout de deux colonnes aux tables de durées d'efficacité. Cet ajout demeure sujet à l'approbation de la SAE. Selon les résultats de la présente étude, les durées d'efficacité recommandées pour la première colonne (bruine et pluie légère verglaçante) sont très similaires aux valeurs existantes consignées dans les tables. Quant aux durées recommandées pour la pluie d'intensité moyenne et abondante, elles sont passablement plus courtes que les valeurs qui figurent actuellement dans les tables.

Essais futurs

Il a été recommandé, en prévision des essais futurs, de perfectionner les procédures qui président aux essais et d'améliorer le matériel. Il a également été recommandé que les essais futurs portent sur de nouveaux liquides de type IV, dilués et non dilués, sous toute la gamme des conditions propices au givrage; les liquides de type III devraient être soumis à des essais semblables, afin que puisse être établie une table des durées d'efficacité pour ce type de liquides.

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FIGURE NUMBER		PAGE NUMBER

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LIST OF ACRONYMS

ACAC	Air Carrier Advisor Circular
AES	Atmospheric Environment Services (Canada)
APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
C/FIMS	Contaminant/Fluid Integrity Monitoring System
FPD	Freezing Point Depressant
HHET	High Humidity Endurance Test
HOT	Holdover Time
ISO	Organization for International Standards
MANOBS	Manual of Surface Weather Observations
NCAR	National Centre for Atmospheric Research
NRC	National Research Council
OAT	Outside Air Temperature
POSS	Precipitation Occurrence Sensing System
READAC	Remote Environmental Automatic Data Acquisition Concept
RVSI	Robotic Vision Systems Inc.
SAE	Society of Automotive Engineers
TC	Transport Canada
TDC	Transportation Development Centre
UCAR	Union Carbide
UQAC	Université du Québec à Chicoutimi
WSET	Water Spray Endurance Test

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1. INTRODUCTION

At the request of the Transportation Development Centre (TDC) of Transport Canada (TC), APS Aviation Inc. (APS) undertook a research program to further advance pre-flight aircraft de-icing/anti-icing technology.

Over the years APS Aviation has completed substantial testing on behalf of Transport Canada relating not only to fluid holdover time, but also to technology development for de/anti-icing. A summary of the research activities relating to fluid holdover time testing is provided in Table 1.1.

Aircraft ground icing has been the subject of concentrated industry attention over the past decade as a result of a number of fatal aircraft accidents. Much of this attention has been given to the abilities of anti-icing fluids to provide an extended protection against further snow or ice build-up following initial de-icing. This has led to the development of fluid holdover time tables accepted by regulatory authorities for use by aircraft operators. As well, new and improved fluids have been developed with the specific objective of extending holdover times without affecting the aerodynamic characteristics of the airfoil.

Aircraft are de-iced using heated Type I de-icing fluids. While excellent for removing ice and snow which has already accumulated on the wings of aircraft, Type I fluids provide limited protection against further ice build-up. The Type II fluids, being significantly more viscous and thereby providing a thicker film, provide longer protection. Type III fluid (previously called Type 1.5) is a thickened fluid which has properties that lie between Types I and II. Its shearing and flow-off characteristics are designed for aircraft with lower take-off speeds. Newer, longer lasting Type IV fluids are also in development, and they are examined in this report.

Holdover time tables have been developed to provide airline operators with guidelines for use in departure planning. Examples of these are given in Tables 1.2, 1.3 and 1.4 of this section. Each cell of a table refers to a specific fluid type and dilution factor and contains a time range.

TABLE 1.1

SUMMARY OF APS HOLDOVER TIME TESTING ACTIVITIES

Year	Transport Canada Report #	Conditions Tested	Primary Fluids Tested	Location of Testing
1990/91	TP 11206E	• Natural Precipitation (mostly snow)	Type II (100%)	Mostly Dorval, World-Wide
1991/92	TP 11454E	• Natural Precipitation (mostly snow)	Type III	Mostly Dorval, St. John's
1992/93	TP 11836E	• Natural Precipitation (snow) • Simulated Freezing Drizzle (preliminary) • Simulated Freezing Fog (outdoor)	Type I (Standard)	Dorval and Ottawa (NRC)
1993/94	Summary Report Available	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (outdoor)	Type II (75/25, 50/50)	Dorval and Ottawa (NRC)
1994/95	TP 12654E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface (preliminary)	• Type I (Diluted for 10°C buffer) • Type IV (Preliminary)	Dorval and Ottawa (NRC)
1995/96	TP 12896E	• Natural Precipitation • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	Type IV	Dorval and Ottawa (NRC)

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TABLE 1.2

SAE/ISO HOLDOVER TIME TABLE FOR TYPE I FLUIDS USED IN 1995/96

TABLE 2. Guidelines for Holdover Times Anticipated by SAE Type I and ISO Type I Fluid Mixtures as a Function of Weather Conditions and OAT.

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY AND IT SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

TYPE I

Freezing Point of Type I Fluid Mixture used must be at least 10°C (18°F) below OAT.

OAT		Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
					PROPOSED		
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0	above 32	0:18-0:45 **S**	0:12-0:30 **NS**	0:06-0:15 **S**	0:05-0:08 **S**	0:02-0:05 **S**	0:06-0:15 **NS**
0 to -7	32 to 19	0:18-0:45 **S**	0:06-0:15 **S**	0:06-0:15 **S**	0:05-0:08 **S**	0:02-0:05 **S**	CAUTION! clear ice may require touch for confirmation
below -7	below 19	0:12-0:30 **S**	0:06-0:15 **S**	0:06-0:15 **S**	** **S**	*** **S**	

This table does not apply to other than SAE or ISO Type I FPD fluids.

The responsibility for the application of these data remains with the user.

** Approximate Holdover Time for Freezing Drizzle is between 5 to 8 min below -7°C to -10°C.

*** Approximate Holdover Time for Light Freezing Rain is between 2 to 5 min below -7°C to -10°

S = Substantiated

NS = Not substantiated

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TABLE 1.3

SAE/ISO HOLDOVER TIME TABLE FOR TYPE II FLUIDS USED IN 1995/96

TABLE 1. Guidelines for Holdover Times Anticipated by SAE Type II and ISO Type II Fluid Mixtures as a Function of Weather Conditions and OAT.

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY AND IT SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

TYPE II

OAT	OAT	Type II Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
						PROPOSED	PROPOSED	
°C	°F		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0	above 32	100/0	12:00 S	1:15-3:00 NS	0:25-1:00 S	0:30-1:00 S	0:15-0:30 S	0:24-1:00 NS
above 0	above 32	75/25	06:00 S	0:50-2:00 NS	0:20-0:45 S	0:20-0:45 S	0:10-0:25 S	0:18-0:45 NS
above 0	above 32	50/50	04:00 S	0:35-1:30 NS	0:15-0:30 S	0:15-0:25 S	0:05-0:15 S	0:12-0:30 NS
0 to -7	32 to 19	100/0	08:00 S	0:35-1:30 S	0:20-0:45 S	0:30-1:00 S	0:15-0:30 S	CAUTION! clear ice may require touch for confirmation
0 to -7	32 to 19	75/25	05:00 S	0:25-1:00 S	0:15-0:30 S	0:20-0:45 S	0:10-0:25 S	
0 to -7	32 to 19	50/50	03:00 S	0:15-0:45 S	0:05-0:15 S	0:15-0:25 S	0:05-0:15 S	
below -7 to -14	below 19 to 7	100/0	08:00 S	0:35-1:30 S	0:20-0:45 S	A S	C S	
below -7 to -14	below 19 to 7	75/25	05:00 S	0:25-1:00 S	0:15-0:30 S	B S	D S	
below -14 to -25	below 7 to -13	100/0	08:00 NS	0:35-1:30 S	0:20-0:45 S			
below -25	below -13	100/0 if 7°C (13°F) Buffer is maintained	A buffer of at least 7°C (13°F) must be maintained for Type II used for anti-icing at OAT below -25°C (-13°F). Consider use of Type I fluids where SAE or ISO Type II cannot be used. NS	NS				

This table does not apply to other than SAE or ISO Type II FPD fluids.

The responsibility for the application of these data remains with the user.

A - Approximate Holdover Time for Type II Neat in Freezing Drizzle is between 30 to 60 min below -7°C to -10°C.

B - Approximate Holdover Time for Type II 75/25 in Freezing Drizzle is between 20 to 45 min below -7°C to -10°C

C - Approximate Holdover Time for Type II Neat in Light Freezing Rain is between 15 to 30 min below -7°C to -10

D - Approximate Holdover Time for Type II 75/25 in Light Freezing Rain is between 10 to 25 min below -7°C to -1

S = Substantiated

NS = Not substantiated

TABLE 1.4

HOLDOVER TIME TABLE FOR ULTRA FLUID USED IN 1995/96

TABLE 1. Guidelines for Holdover Times Anticipated by SAE Type II and ISO Type II Fluid Mixtures as a Function of Weather Conditions and OAT.

CAUTION: THIS TABLE IS FOR USE IN DEPARTURE PLANNING ONLY AND IT SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

ULTRA

OAT		Ultra Fluid Concentration Neat-Fluid/Water (% by volume)	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)					
						PROPOSED		
°C	°F		FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0	above 32	100/0	18:00 **S**	1:52-4:30 **NS**	0:37-1:30 **S**	0:45-1:30 **S**	0:22-0:45 **S**	0:24-1:00 **NS**
		75/25	06:00 **NS**	0:50-2:00 **NS**	0:20-0:45 **NS**	0:20-0:45 **NS**	0:10-0:25 **NS**	0:18-0:45 **NS**
		50/50	04:00 **NS**	0:35-1:30 **NS**	0:15-0:30 **NS**	0:15-0:25 **NS**	0:05-0:15 **NS**	0:12-0:30 **NS**
0 to -7	32 to 19	100/0	12:00 **S**	0:52-2:15 **S**	0:30-1:07 **S**	0:45-1:30 **S**	0:22-0:45 **S**	CAUTION! clear ice may require touch for confirmation
		75/25	05:00 **NS**	0:25-1:00 **NS**	0:15-0:30 **NS**	0:20-0:45 **NS**	0:10-0:25 **NS**	
		50/50	03:00 **NS**	0:15-0:45 **NS**	0:05-0:15 **NS**	0:15-0:25 **NS**	0:05-0:15 **NS**	
below -7 to -14	below 19 to 7	100/0	12:00 **S**	0:52-2:15 **S**	0:30-1:07 **S**	A **S**	C **S**	
		75/25	05:00 **NS**	0:25-1:00 **NS**	0:15-0:30 **NS**	B **NS**	D **NS**	
bel** -14 to -30	bel** 7 to -22	100/0	12:00 **S**	0:52-2:15 **S**	0:30-1:07 **S**			

This table does not apply to other than Ultra FPD fluids.

The responsibility for the application of these data remains with the user.

A - Approximate Holdover Time for Ultra Neat in Freezing Drizzle is between 45 to 90 min below -7°C to -10°C.

B - Approximate Holdover Time for Ultra 75/25 in Freezing Drizzle is between 20 to 45 min below -7°C to -10°C.

C - Approximate Holdover Time for Ultra Neat in Light Freezing Rain is between 22 to 45 min below -7°C to -10°C.

D - Approximate Holdover Time for Ultra 75/25 in Light Freezing Rain is between 10 to 25 min below -7°C to -10°C.

**** - Below -30°C, consider use of Type I fluid.**

S = Substantiated

NS = Not substantiated

The upper times given in the current Type I and Type II holdover time tables were originally defined by European airlines based upon limited data and assumptions related to fluid properties. The lower times of the Holdover Time (HOT) ranges (a fraction of the higher times) were established by the Society of Automotive Engineers (SAE) G-12 HOT Sub-Committee based upon data from the 1990/91 winter tests. For Type I and Type II fluids, the extensive testing conducted by APS was designed to determine the performance of fluids on standard flat plates in order to substantiate the holdover times, or if warranted, to recommend changes. For the Type IV fluids, testing was carried out to determine totally new holdover times. Preliminary tests were conducted in winter 1994/95 with one Type IV fluid (Union Carbide Ultra). Tests with this fluid and six other new Type IV fluids were carried out in winter 1995/96.

The holdover time tables in the 1994/95 holdover time report (Transport Canada report TP 12654E) provided the basis for selecting the tests to be performed during the 1995/96 winter season. These are included in this report and serve as a reference point for discussions and analyses of the most recent data collected. The data for the 1994/95 and the 1995/96 test seasons have been included in this report and are contained in Appendices I and J, respectively. Table 1.2 is for Type I fluids. Table 1.3 is for Type II fluids. Table 1.4 is for Ultra Type IV fluids. Each block in each table is labelled with an indicator to provide its status at the time of publication. The designation "S" signifies the holdover times for which specific conditions and fluids have been substantiated; "NS" indicates holdover times that were not substantiated. The primary focus of the testing conducted during the 1995/96 winter was to substantiate the blocks designated by "NS", and to make the Ultra Table 1.4 a generic table for all Type IV fluids. It is worthwhile to note the differences in holdover times between Type II and Type IV fluids (Tables 1.3 and 1.4). The largest differences in performance between them is found in the neat (100%) category. Neat Type IV fluids were observed to increase holdover times by more than 50% when compared to neat Type II fluids. As the Ultra Fluid is diluted, its performance tends toward that of the diluted Type II fluids.

The detailed objectives of the holdover time test program for the 1995/96 winter are provided in the work statement included as Appendix A. The primary objectives are summarized below:

- To test the new Type IV fluids over the entire range of conditions covered by the holdover time tables; and

- To conduct laboratory cold-soak tests to complete the substantiation of the Type I and Type II holdover time tables.

Extensive natural precipitation tests were carried out at the APS Dorval test site. Freezing drizzle, light freezing rain, freezing fog, and rain on cold-soaked surface tests were also conducted at the Climatic Engineering Facility (National Research Council (NRC) Ottawa). The results of flat plate tests were presented to the SAE G-12 Sub-Committee where they were reviewed and discussed; new holdover time tables, based largely on this work, were proposed by the Sub-Committee and accepted by the full SAE G-12 Committee and have been proposed for world-wide use during the 1996/97 winter. The tables are presented in Section 5.7.

- Section 2 of this report describes the test and analysis methodologies used as well as equipment and personnel requirements (necessary to carry out testing);

- Section 3 describes the different conditions under which data were collected;

- Section 4 presents meteorological considerations and the instruments used to measure weather conditions and precipitation rates;

- Section 5 contains discussions of the data and results of holdover time testing related to fluid type and test conditions. It also includes the most recently proposed holdover time tables;

- Section 6 presents conclusions based upon the aforementioned sections; and

- Section 7 lists recommendations for future testing and underscores the need to be able to produce or simulate snow under laboratory conditions.

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2. METHODOLOGY

This chapter contains descriptions of the tests, equipment, and procedures used during the 1995/96 test season. It is divided into sections dealing with weather, test site, test conditions, equipment, procedures, data forms, fluids, personnel, analysis methodology, and additional comments.

2.1 Definition of Weather Conditions

Holdover times (see Tables 1.2 to 1.4) are provided as a function of *weather condition*, fluid mixture, and outside air temperature (OAT). The objective of the winter test program was to substantiate these holdover times or develop new ones based upon test data.

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

Table 2.1 includes definitions for the weather conditions described in the holdover time tables illustrated in Section 1 (frost, freezing fog, snow, freezing drizzle, light freezing rain and rain). Definitions for snow pellets, snow grains, hail and ice pellets are also presented. The test procedure developed for usage by observers during the flat plate tests (see Appendix B) contains a pictorial summary of the International Classification for Solid Precipitation (page B-45).

2.1.1 Snow

Table 2.1 provides the criteria used to estimate the intensity of snow. This is based upon horizontal visibility as follows:

Table 2.1

DEFINITIONS OF WEATHER PHENOMENA

Weather Phenomenon*	Definition*
FROST	Ice crystals that form from ice-saturated air at temperatures below 0°C (32°F) by direct sublimation on the ground or other exposed objects.
FREEZING FOG (F)	A suspension of numerous minute water droplets which freeze upon impact with ground or other exposed objects, generally reducing the horizontal visibility at the earth's surface to less than 1 km (5/8 mile).
SNOW (S)	Precipitation of ice crystals, most of which are branched, star-shaped, or mixed with unbranched crystals. At temperatures higher than about -5°C (23°F), the crystals are generally agglomerated into snowflakes.
FREEZING DRIZZLE (ZL)	Fairly uniform precipitation composed exclusively of fine drops [diameter less than 0.5 mm (0.02 in.)] very close together which freeze upon impact with the ground or other exposed objects.
FREEZING RAIN (ZR)	Precipitation of liquid water particles which freeze upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5 mm (0.02 in.) or smaller drops which, in contrast to drizzle, are widely separated.
RAIN (R)	Precipitation of liquid water particles either in the form of drops of more than 0.5 mm (0.02 in.) diameter or of smaller widely scattered drops.
SNOW PELLETS (SP):	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2-5 mm (0.1-0.2 in.). Grains are brittle, easily crushed; they bounce and break on hard ground.
SNOW GRAINS (SG):	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is less than 1 mm (0.04 in.). When the grains hit hard ground, they do not bounce or shatter.
HAIL (A):	Precipitation of small balls or pieces of ice with a diameter ranging from 5 to > 50 mm (0.2 to 2.0 in.) falling either separately or agglomerated.
ICE PELLETS (IP):	Precipitation of transparent or translucent pellets of ice, which are spherical or irregular, and which have a diameter of 5 mm (0.2 in.) or less. The pellets of ice usually bounce when hitting hard ground.

Intensity Criteria**

Snow (S) and Freezing Drizzle (ZL)

Estimated Intensity	Horizontal Visibility (statute mile)
Light (-)	If visibility is 5/8 mi (1.0 km) or more
Moderate	If visibility is less than 5/8 to 5/16 mi (1.0 to 0.5 km)
Heavy (+)	If visibility is less than 5/16 mi (0.5 km)

Note: Horizontal visibility is only an estimation of snow and freezing drizzle intensity. Measurements and observations have shown that visibility and precipitation intensity are not always directly correlated.

Drizzle Intensity (ZL):

Light(-): From a trace to 0.01 inch/hr (0.254 mm or 2.54 gr/dm^2/hr)
Moderate From 0.01 to 0.02 inch/hr (<0.508 mm or 5.08 gr/dm^2/hr)
Heavy(+): More than 0.02 inch/hr (>0.508 mm or 5.08 gr/dm^2/hr)

Rain (R) and Freezing Rain (ZR)

Light (-)	Measured Intensity	Up to 0.10 in/hr (2.5 mm or 25 gr/dm^2/hr); Maximum 0.01 inch in 6 minutes
	Estimated Intensity	From scattered drops that, regardless of duration, do not completely wet an exposed surface up to a condition where individual drops are easily seen.
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm or 76 gr/dm^2/hr); more than 0.01 to 0.03 inch in 6 minutes
	Estimated Intensity	Individual drops are not clearly identifiable; spray is observable just above pavement and other hard surfaces.
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm or 76 gr/dm^2/hr); more than 0.03 inch in 6 minutes
	Estimated Intensity	Rain seemingly falls in sheets; individual drops are not identifiable; heavy spray to height of several inches is observed over hard surfaces.

Conversions for Water

1 mm = 0.03937 in = 10 gr/dm^2
1 in = 25.4 mm = 254 gr/dm^2

*From World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation (1983)
** From American Meteorological Society, Glossary of Meteorology WSOH #7 MANOBS (3/94)

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP: Feb 01, 1996

- Light Visibility is þ 1.0 km
- Moderate Visibility is 0.5 km to < 1.0 km
- Heavy Visibility is < 0.5 km

A Belfort Forward scatter meter was used to measure visibility (see Section 2.4) during natural precipitation flat plate tests. An evaluation of the instrument measurements and the measurements of precipitation rate is provided in Section 4.

Visibility is, however, only an indicator of the snow intensity (see Table 2.1) and that the two parameters are not always correlated. Further details regarding this topic are presented in Section 4.2. In an effort to get an improved measure of snow intensity, research is continuing at the National Centre for Atmospheric Research (NCAR), and the data collected will be sent to NCAR.

During tests conducted at the Dorval test site during the 1995/96 winter, test personnel were asked to record whether snow was wet or dry. This measure could be helpful in order to establish further relationships between visibility, snow intensity, and the water content of the snow. If clear differences exist between visibility and wet or dry snow, the snow column in the holdover time tables could be subdivided into two columns; one for wet snow, and one for dry snow. Before take-off, pilots receive available information pertaining to the type of precipitation. Access to tables with the snow category so subdivided could alleviate some of the indecision associated with selection of holdover times based on the holdover time tables currently in use. For further details and comments regarding this concern, see Sections 4.4 and 5.1.5.

2.1.2 Freezing Drizzle

Freezing drizzle is composed exclusively of closely packed fine droplets with a diameter less than 0.5 mm (see Table 2.1). The intensity is determined, as for snow, through the measurement of visibility. The holdover time table has one column for freezing drizzle; however, Table 2.1 shows three intensity levels (light, moderate, and heavy). For example, under moderate freezing drizzle, the rate of precipitation should range between 2.5 and 5.1 g/dm²/hr.

2.1.3 Freezing Rain and Rain

This form of precipitation exists either in the form of drops with diameters greater than 0.5 mm, or smaller drops which, in contrast to drizzle, are widely separated. As with snow and drizzle, three intensity levels are available, and for each level, a guideline (subjective) is provided in Table 2.1 for an observer to determine whether the intensity is light, moderate or heavy. The following definitions apply when an instrument is available to measure the intensity of precipitation:

- Light — Precipitation rate is $\leq$ 25 g/dm²/hr
- Moderate — Precipitation rate is > 25 g/dm²/hr but $\leq$ 76 g/dm²/hr
- Heavy — Precipitation rate is > 76 g/dm²/hr

2.1.4 Median Volume Diameter

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

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

where the MVD is in mm and the rate of precipitation is in g/dm²/hr. At 25 g/dm²/hr, this equation gives an MVD of 1.2 mm, at 76 g/dm²/hr the MVD is 1.6 mm, and for 150 g/dm²/hr the MVD is 1.9 mm.

These parameters were engineered into the design and calibration of the test apparatus used to simulate light freezing rain and rain on a cold-soaked surface.

2.2 Test Sites

In situ natural snow testing for the 1995/96 winter was performed at Montreal's Dorval Airport. The location of the site at Dorval is shown on the plan view of the airport in Figure 2.6 (this is included at the end of this section). Photo 2.1 was taken at the site and shows a remote sensor mounted on top of the test stand on the left and the trailer at the back. A larger trailer, compared to previous winters, was leased for the 1995/96 winter in order to accommodate requirements of the growing equipment list and the greater amounts of test fluid. The test site is located adjacent to Environment Canada's Atmospheric Environment Services (AES) automated weather observation station (Photo 2.2) at Dorval Airport. Some in situ testing was also carried out by the National Centre for Atmospheric Research (NCAR) at Denver. Their results from tests relating to holdover times have been incorporated into this report.

Tests during the 1995/96 winter season under conditions of freezing fog, rain on cold-soaked surface, freezing drizzle, and light freezing rain were conducted at NRC's indoor Climatic Engineering Facility (CEF). The precipitation was artificially produced.

Photo 2.3 was taken outside the CEF and provides a general indication of the size of the facility. Photo 2.4 was taken inside the CEF. The facility was designed and built for the testing of locomotives. The size of the chamber is 30 m by 5.4 m and its total height is 8 m. The lowest temperature achievable is -46°C.

2.3 Test Conditions

Outdoor testing was conducted during natural precipitation events. Supplementary tests to simulate freezing precipitation were carried out at the NRC Climate Engineering Facility (see Photo 2.4). Sub-section 2.3.1 provides a description of the spray assembly (see Photo 2.5) and of the methods used to produce and calibrate the fine water droplets in these artificial precipitation tests, followed by a summary of the categories and characteristics of each precipitation type produced for these tests.

2.3.1 Droplet Size and Rate of Precipitation

Over the last year, much more attention was given by industry to the influence of droplet size on holdover time. To clarify this issue, experiments were performed to measure droplet size produced by different nozzles (various gauge hypodermic needle tips) and different pressures in the spray delivery unit. Although the gauge of the needles is an important factor in the production and size of the droplets, the air and water pressure levels in the sprayer system are as important. The actual spray assembly consists of two to four droplet delivery nozzles, attached to the end of a rocker arm. The rocker arm is centre-mounted to a rotatable shaft. A drive mechanism imparts a smooth see-saw motion to the shaft which is synchronously translated back-and-forth along its axis of rotation. The combined actions result in an approximately circle-eight-shaped droplet pattern. Some calibration experiments were conducted in previous years by NRC using an optical gauge manufactured by HSS (see Photo 2.6) to verify that the simulation of freezing fog, freezing drizzle, and light freezing rain were satisfactory.

Calibration of droplet size was also required for tests under conditions of moderate and heavy rain for the simulation of rain on a cold-soaked wing. The APS team carried out calibration experiments using a manual dye-stain technique*, used at the NRC CEF. This technique consists of dusting Whatman No. 1 filter paper discs with a water-activated, very finely divided powder form of methylene blue dye. The prepared discs are manually positioned (Photo 2.7) under artificial precipitation for a fixed time in order to acquire a droplet size pattern. Figure 2.1 illustrates the appearance of such a pattern acquired under conditions of drizzle. A calibration curve (Figure 2.2) developed for use at the CEF was used to convert from the measured diameter of the droplets on the pattern to the experimental median volume diameter (MVD). The theoretical MVDs for rain were determined based upon equations provided in Sub-section 2.1.4.

	Experimental MVD (mm)	**Theoretical Range of MVD (mm)**
Heavy Rain	1.6	> 1.6
Moderate Rain	1.4	1.2 to 1.6
Light Rain	1.0	< 1.2
Drizzle	0.3	< 0.5
Fog	< 0.1	

The following is a point-form summary of the set of test conditions under which data for freezing drizzle, light freezing rain, rain on a cold-soaked surface, and freezing fog were collected at the NRC CEF.

(i) Freezing Drizzle Characteristics During Tests

- Droplet median volume diameter: 300 µm;
- Precipitation rate: less than 13 g/dm²/hr;
- Droplets produced with two #24 hypodermic needles; and
- Air temperature: 0 to -10°C.

* Naughton, I.I., and Wyatt, J.G., "*The Dye-Stain Technique for Measuring the Size of Rain Drops*", Royal Aircraft Establishment, July 1965, Report No. 65136.

Figure 2.1

Droplet Size Pattern Produced at NRC

Freezing Drizzle

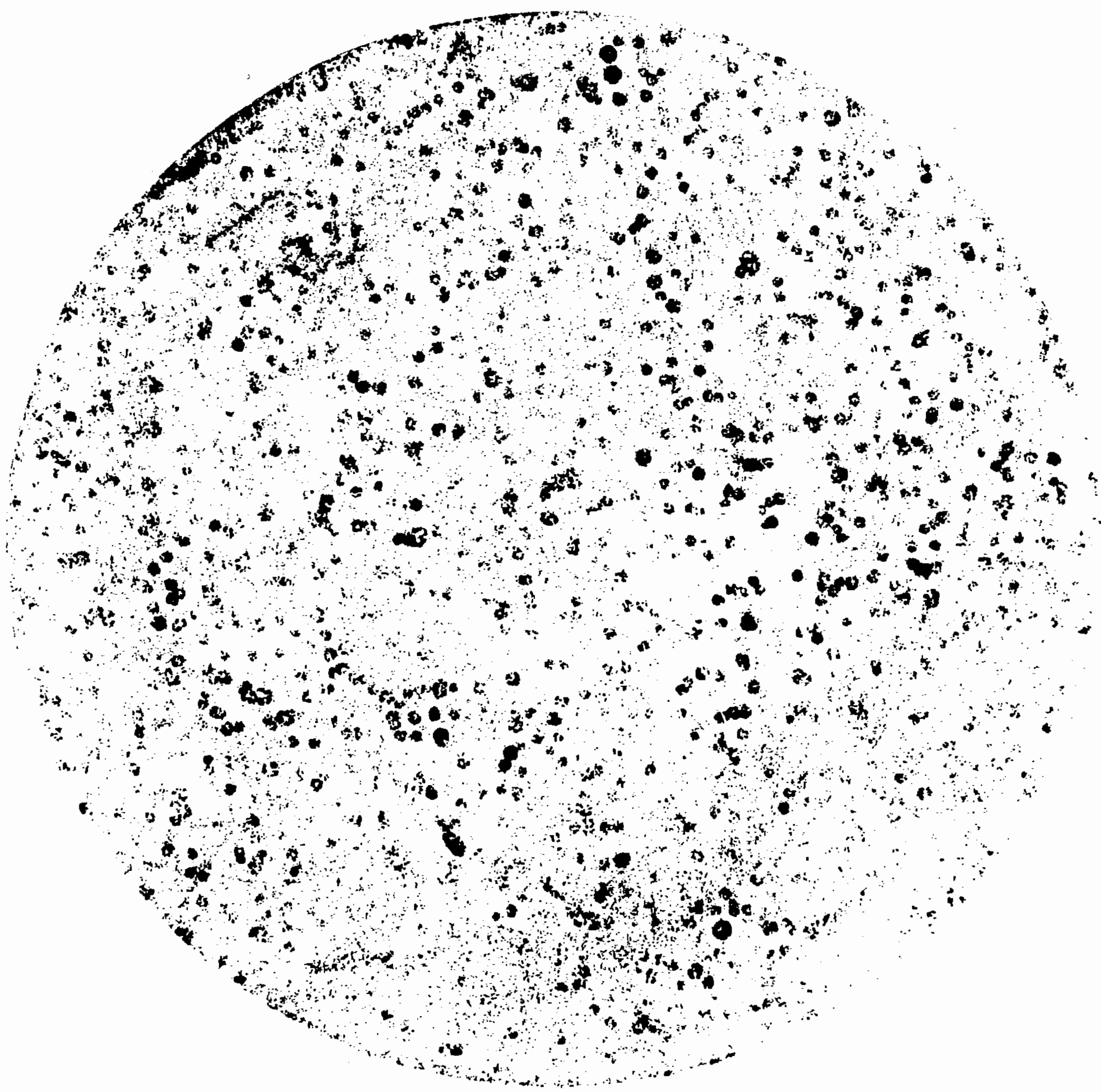
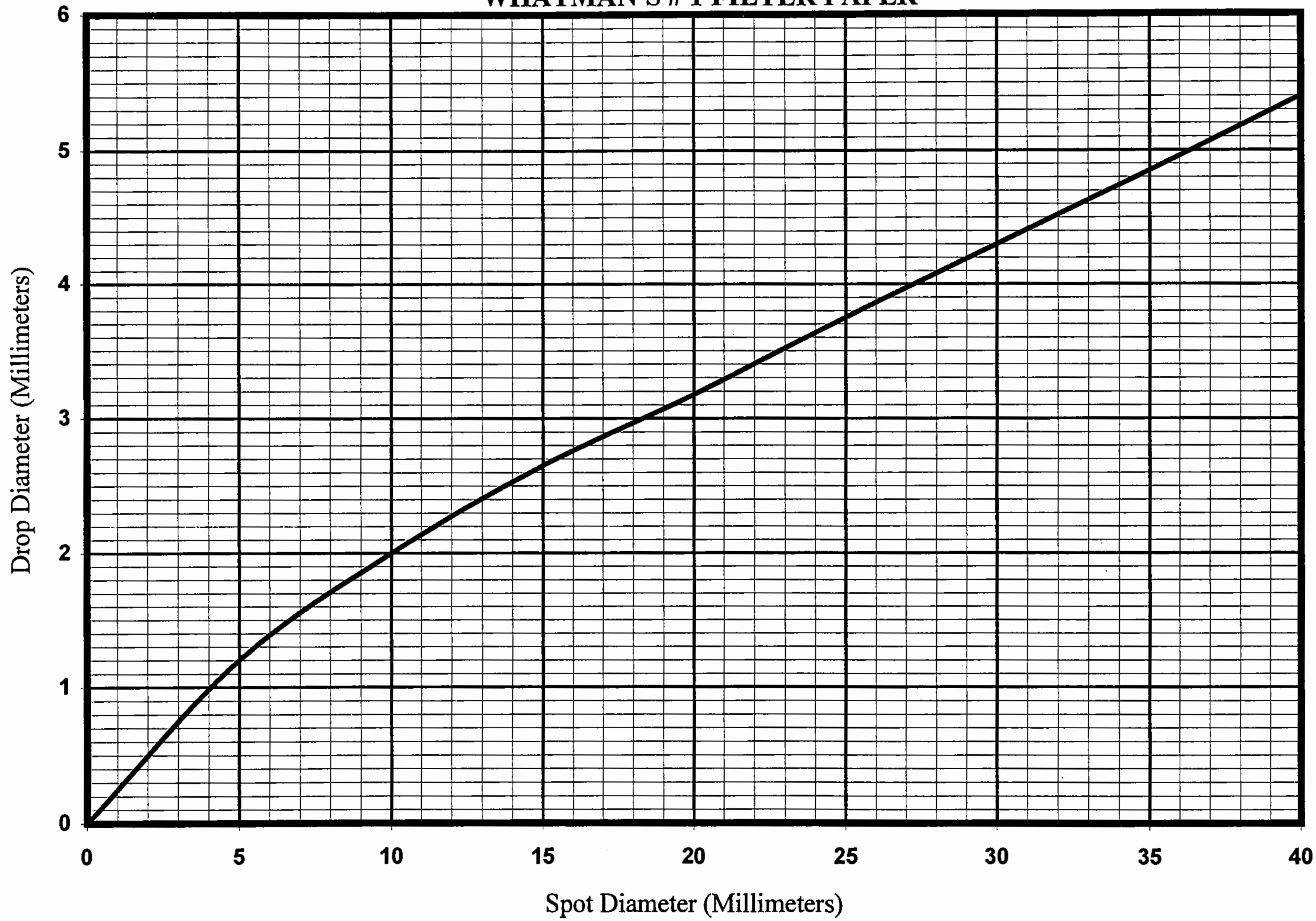


FIGURE 2.2

CONVERSION OF SPOT DIAMETER TO DROP DIAMETER

WHATMAN'S # 1 FILTER PAPER



g:cm1283\report\hot_subs\Droplet.xls
At: Conversion
Printed: 97-12-03

(ii) Light Freezing Rain Characteristics During Tests

- Droplet median volume diameter: 1000 μm;
- Precipitation rate: 13 to 25 g/dm²/hr;
- Droplets produced with two #20 hypodermic needles; and
- Air temperature: 0 to -10°C.

(iii) Drizzle and Light Rain on Cold-Soaked Surface Characteristics During Tests

- Same as items i and ii, except air temperature was +2°C.

(iv) Moderate Rain on Cold-Soaked Surface Characteristics During Tests

- Droplet median volume diameter: 1400 μm;
- Precipitation rate: 25 to 75 g/dm²/hr;
- Droplets produced with two #17 hypodermic needles; and
- Air temperature: +2°C.

(v) Heavy Rain on Cold-Soaked Surface Characteristics During Tests

- Droplet median volume diameter: 1600 μm;
- Precipitation rate: more than 75 g/dm²/hr;
- Droplets produced with two #17 and two #18 hypodermic needles; and
- Air temperature: +2°C.

(vi) Freezing Fog Characteristics During Tests

- Droplet median volume diameter: 30 to 60 μm;
- Liquid water content: 0.2 to 0.6 gm^{-3}; and
- Air temperature: 0 to -27°C.

In past years, the MVD for freezing drizzle had been erroneously quoted as 600 μm (microns). The correct experimentally determined MVD for freezing drizzle is approximately 300 μm, and is within the defined range of 0 to 500 μm.

2.4 Equipment

Figure 2.3 shows a schematic of the stand used for testing. Six test plates are normally mounted on the stand and these are inclined at a 10° slope. Each plate represents a *flat plate test*, and during each run at Dorval with six plates, the intent was to test three different fluids in duplicate.

Figure 2.3 also depicts the size of a typical flat plate and markings on the flat plate. The plates were marked with three parallel lines, 2.5 cm (1"), 15 cm (6") and 30 cm (12") from the top of the plate. The plates were marked with 15 crosshairs. These crosshairs were used in determining whether end conditions (see Section 2.5.2 for definition) were achieved. Photo 2.8 was taken outdoors at Dorval and shows six test plates mounted on a stand. Two plates (u and w) are equipped with AlliedSignal Contaminant/Fluid Integrity Monitoring System (C/FIMS) ice detection sensors mounted at the 15 cm line.

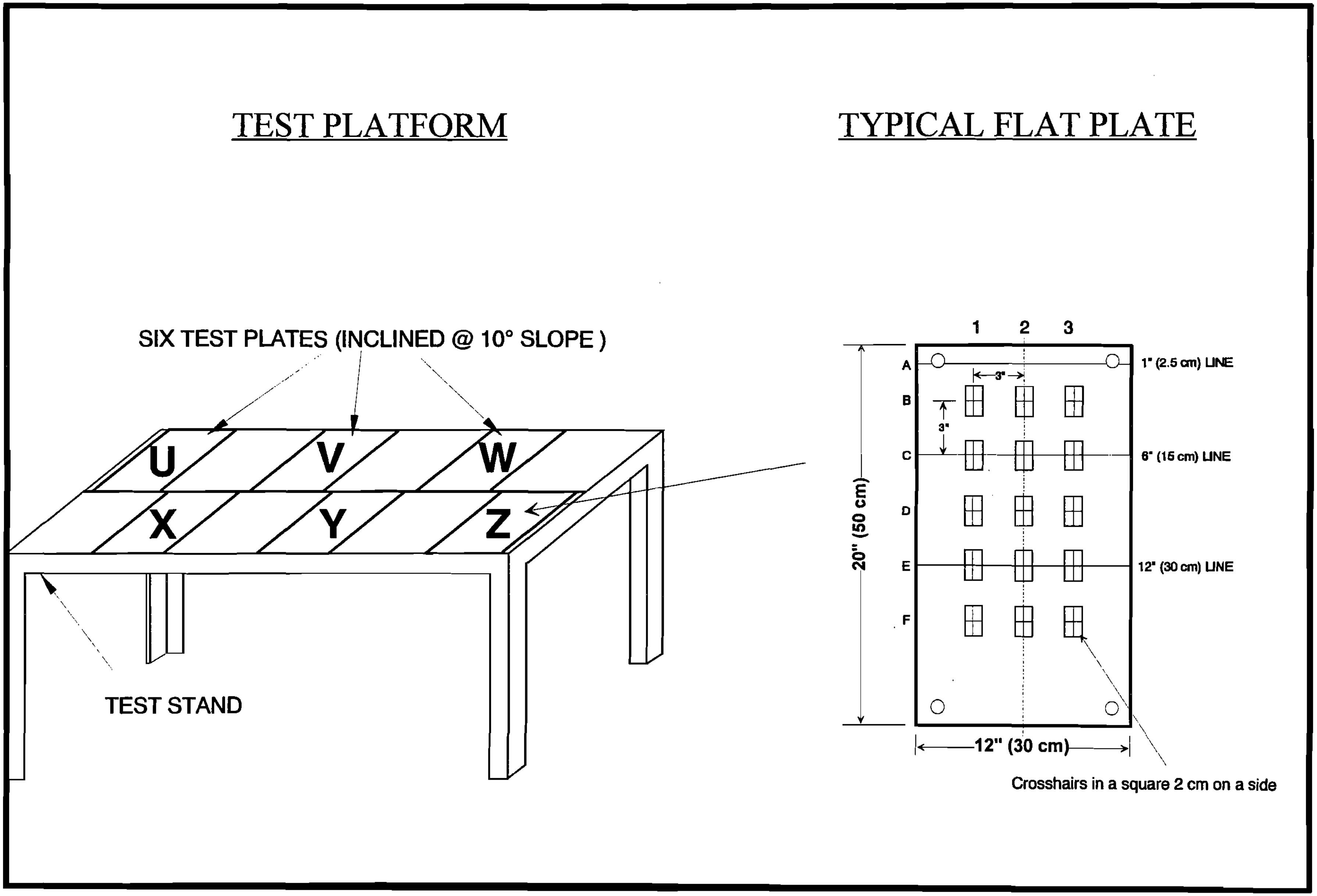
Figure 2.4 shows the collection (plate) pan which is of the same size as a standard plate and used for measuring amounts of precipitation for the outdoor tests. Photo 2.9 shows the collection pans used for measuring precipitation rates indoors at the NRC. A new snow gauge, manufactured by ETI, was acquired and used to measure precipitation in 1995/96 testing (see Photo 2.10).

Sealed boxes (15 cm, 7.5 cm and 2.5 cm deep) were used for simulating a cold-soaked wing (see Figure 2.4).

The ice sensors used in the 1995/96 season included four C/FIMS from AlliedSignal, one external optical area sensor by Robotic Vision Systems Inc. (RVSI) of New York, and an area ice detection sensor by SPAR (see Photo 2.11). The AlliedSignal and RVSI sensors were used primarily during the natural snow outdoor tests, and the SPAR sensor was used for a limited number of tests at NRC's cold chamber. Photo 2.12 shows the computer data acquisition installations inside the trailer at the Dorval test site. A detailed equipment list and specifications are included within the test procedures in Appendices B and C for the outdoor and indoor tests, respectively.

FIGURE 2.3

FLAT PLATE TEST SET-UP

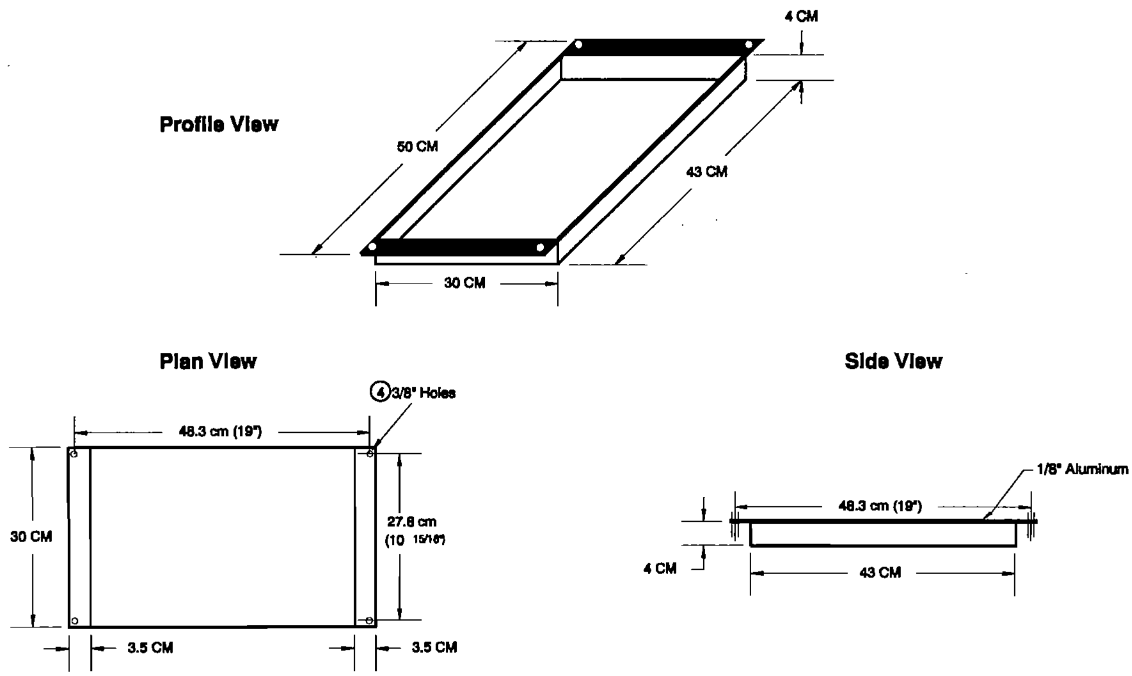


cm1283\report\hot_subs\ns_snw.drw

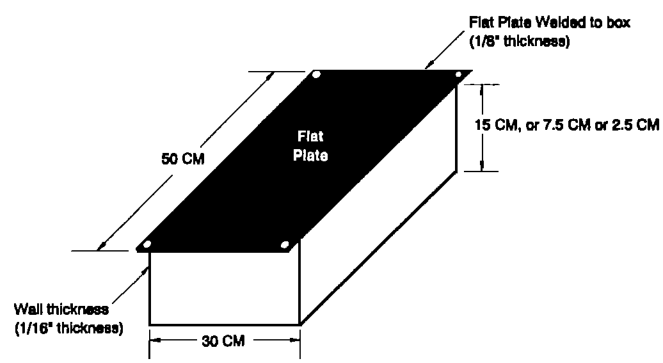
FIGURE 2.4

SCHEMATICS OF PLATE PAN AND SEALED BOXES

PLATE PAN USED OUTDOORS



SEALED BOXES FOR COLD-SOAK SIMULATION



cm1283\vep\hot_subs\pan&box.drw

In addition to the equipment at the APS Dorval site, data from Environment Canada's automated weather observation equipment installed adjacent to APS's site were acquired. Appendix D shows a typical listing of the data provided by the Remote Environmental Automatic Data Acquisition Concept (READAC). This information was acquired from the Atmospheric Environment Service (AES) on diskette on a minute-by-minute basis for the entire winter. The READAC equipment provides an indispensable means of monitoring meteorological conditions for test programs such as this. It consists of the following instruments:

- *Relative Humidity Gauge and Thermometer.*

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

- *Precipitation Occurrence Sensing System (POSS):* The POSS system (Instrument at rear of Photo 2.13) consists mainly of a Doppler radar set with a transmitter and a receiver as separate units (bi-static set-up). The system is aimed at an area a few centimetres above it where it measures the rate of fall of hydrometeors. The Doppler frequency shift of the returned signal provides the precipitation type, and the spectro power of the returned signal provides the intensity (light, moderate or heavy) and amount of precipitation. The output of the system consists of the start time, stop time, type, and intensity of precipitation.

- *Precipitation Gauge:* The READAC precipitation gauge (Instrument at right of Photo 2.13) is a modified Belfort weighing gauge. A bucket is attached to a spring balance and cable pulley arrangement connected to a rotating shaft. The degree of rotation of the shaft corresponds to the amount of accumulated precipitation in the bucket. The total amount of precipitation is the only value returned by the precipitation gauge arrangement. The gauge accuracy is subject to thermal expansion and contraction of the weighing mechanism. It is also affected by freezing precipitation accumulating on the sides of the gauge and melting later on, resulting in a delayed and erroneous output. To minimize the noise and associated error from the system, the gauge output resolution was reduced by Environment Canada from 0.1 to 0.5 mm (liquid water equivalent).

- *Belfort Forward Scattermeter:* The Belfort Forward Scattermeter (Instrument at left of Photo 2.13) provides an estimate of visibility. The system consists of a Zenon bulb transmitter and a receiver both at an angle of 22°C below the horizontal aimed at a 0.02 m^3 sample volume of air 2.5 m above the ground. The transmitter illuminates the sample volume of air. The receiver measures the amount of light scattering off the aerosols present in the sample volume of air. The measurement is inversely proportional to visibility. The instrument output scale is in units of miles. The measurements output by the instrument at any time are the time averaged signal envelopes from the previous ten minutes of monitoring.

2.5 Test Procedures

Testing consisted of pouring de-icing or anti-icing fluids onto clean test panels (which were exposed to various winter precipitation conditions) and recording the elapsed time for each crosshair to fail before the test panels reached the end condition (see Section 2.5.2 below).

2.5.1 Protocol

For the tests at Dorval, a test stand contained six test plates, each plate representing a flat plate test. During each run with six plates, three different fluids were tested in duplicate. When testing the new Type IV fluids at Dorval, two panels with Type II fluid were tested at the same time on the same stand. When the end condition occurred on the Type II fluid, a new test with the same Type II fluid was re-started immediately.

The procedure for the natural snow flat plate tests was developed by the SAE G-12 Holdover Time Sub-Committee. The major steps are listed below. The complete details of the actual test procedures are provided in Appendix B. Appendix C contains the procedure used for testing at the Climatic Engineering Facility during freezing drizzle, light freezing rain, freezing fog, and cold-soaked surface rain tests.

- Synchronize all times.
- Clean panels and start.
- Apply (pour) fluids to test panels. Type I fluids are at room temperature (15°C to 20°C). Type II and Type IV fluid are at ambient temperature. Fluids are poured using a single step fluid application.
- Record crosshair end condition times.
- Continue testing until at least 5 crosshairs have reached the end condition on each test panel.
- Monitor weather conditions.
- Clean panels and restart.

Rain on a cold-soaked wing can not be simulated using standard test flat plates. These plates do not provide the required heat sink effect (caused by cold fuel) necessary to cause ice formation at OATs greater than 0°C. This effect must be simulated to assure test results are representative of cold-soaked wings. The top of the cold-soak box consists of an aluminum flat plate identical to the standard flat plate. A box shaped reservoir is welded to the bottom of the plate. The volume (depth) of the reservoir was decided on based upon the analysis contained in the related Transport Canada report TP 12899E.

The cold-soak tests were performed at NRC's Climatic Engineering Facility. The ambient temperature was set at +2°C. The reservoirs were filled with Freezing Point Depressant (FPD) fluid and cooled using a liquid nitrogen cryostat. All box surfaces except the top were insulated with 2.5 cm thick rigid Styrofoam sheeting. Plate temperatures on top of the box were recorded throughout the test using thermistors and/or hand-held temperature probes.

2.5.2 End Condition Definitions

The procedure and the determination of the end condition evolved from the experiences of various test programs from previous winter seasons. Plate failure time is that time required for the end condition to be achieved. This occurs when the accumulating precipitation fails to be absorbed or ice forms at any five of the crosshair marks on the panels. A crosshair is considered failed if:

- There is a visible accumulation of snow bridging on top of the fluid at the crosshair when viewed from the front. There should be an indication that the fluid can no longer de-ice or absorb the precipitation at this point; OR

- When precipitation or frosting produces a "loss of gloss" (i.e. dulling of the surface reflectivity) or a change in colour (dye) to grey or greyish appearance at any crosshair, or ice (or crusty snow) has formed on the crosshair (look for ice crystals). This condition is *only* applicable during light freezing rain, freezing drizzle, ice pellets, freezing fog, rain on a cold-soaked surface or during a mixture of snow and light freezing rain, freezing drizzle and ice pellets.

To better understand how the end condition is determined, Photo 2.14 was taken during snow conditions on painted wooden planks. The first plank closest to the eye has slush and has not reached the defined end condition, the second and third planks have slush and are starting to reach the defined end condition, and the remaining planks have clearly reached the end condition.

2.6 Data Forms

Two forms were used by the testers to collect data at Dorval during the 1995/96 winter season. The form used to mark the failure times of the fluid over each crosshair on the plates is shown in Table 2.2. A new form (Table 2.3) was developed to allow the collection of data relating to meteorological conditions during a test. One notable addition to the test procedure from previous winter seasons was the increase in frequency for measurement of precipitation rate using plate pans. One half of the Plate Pan Data Form (Table 2.3) is designated for precipitation rate measurements. The rest of the page is reserved for documentation of meteorological conditions and the changes in them which prevail during the test.

Because of care in the use of collection pans for measuring precipitation rates is important, a separate form was developed for use in the cold chamber at CEF (Table 2.4). It has been observed that the placement (positioning) of collection pans on the stand is more critical for laboratory tests than for outdoor tests. In the laboratory, the rate of precipitation over a plate is reproducible from test to test, but is different from plate to plate. For outdoor tests, the opposite is true. The rate of precipitation is the same from plate to plate, but is not reproducible from test to test.

TABLE 2.2

END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME — VERSION 3.0 — Winter 95/96

LOCATION: **DATE:** **PLAN #** (see Attachment I): **RUN # :** **STAND # :**

Real Time After Fluid Applied to Plates U and X: am / pm

RVSI Series # : ____________ **Frame # :** ____________

CIRCLE SENSOR PLATE: u v w x y z

SENSOR NAME: ___ ___ ___ ___ ___ ___

DIRECTION OF STAND: ________ °

OTHER COMMENTS (Fluid Batch, etc):

28

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

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

Time of Fluid Application: → ______ hr:min (V & Y) ______ hr:min (W & Z)

	Plate U			Plate V			Plate W		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
TIME OF SLUSH FORMATION ON SENSOR HEAD	1st	½	Full	1st	½	Full	1st	½	Full

	Plate X			Plate Y			Plate Z		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
TIME OF SLUSH FORMATION ON SENSOR HEAD	1st	½	Full	1st	½	Full	1st	½	Full

TABLE 2.3

METEO/PLATE PAN DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME　　VERSION 3.0　　Winter 95/96

LOCATION:　　**DATE:**　　**PLAN #** (see Attachment I):　　**RUN # :**　　**STAND # :**

RVSI VIDEO CASSETTE #:　　**Real Time After Fluid Applied to Plates U and X:**　　**am / pm**

VIDEO CAMERA (PANNING) CASSETTE #:　　**HAND HELD VIDEO CASSETTE #:**

PLATE PAN WEIGHT MEASUREMENTS *

PAN #	t TIME BEFORE (hr:min)	t TIME AFTER (hr:min)	w WEIGHT BEFORE (grams)	w WEIGHT AFTER (grams)	COMPUTE RATE (Δw*4/ Δt) ($g/dm^2/h$)

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

METEO OBSERVATIONS **

TIME (hr:min)	TYPE (Fig. 4) ZR, ZL,S, SG IP, IC, BS, SP	AMOUNT + +, +, -, --	CLASSIF. (See Fig. 3)	Visibility (day only)	If SNOW, WET or DRY	TEMP °C	WIND SPEED	WIND DIR.

**observations at beginning, end, and every 15 min. intervals. Additional observations when there are significant changes.

COMMENTS : ______________________________

____

____

____

____

____

____

____

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

File:g:\cm1283\reprt\hot_subs\PFORM2-2.XLS　At:Meteo & Pan

TABLE 2.4

PRECIPITATION RATE MEASUREMENT AT CEF IN OTTAWA

Date: ______________________

Start Time: ______________________ am/pm

Run # : ______________________

Precip Type: ______________________ (FZD, FZR, FZF, S)

Pan Location:

U	UU	V	VV	W	WW
XX	X	YY	Y	ZZ	Z

Collection Pan:

Pan/ Cup #	Area of Pan (dm²)	Location		Weight of Pan (g) Before	After	Collection Time (min) Start	End
		U	=				
		UU	=				
		V	=				
		VV	=				
		W	=				
		WW	=				
		XX	=				
		X	=				
		YY	=				
		Y	=				
		ZZ	=				
		Z	=				

Comments: ______________________

Handwritten by: ______________________

Measured by: ______________________

Precipitation Rate = $\Delta g/\text{area } (dm^2)/hr$

File:g:/cm1283/report/hot_subs/Rate_frm.xls
Printed:97-12-03

2.7 Fluids

During the 1995/96 test season, Type I fluids were tested under conditions of rain on a cold-soaked wing only. Type I fluids are usually obtained from manufacturers in standard dilution forms. Each manufacturer sets its own concentration based on performance requirements and cost. For example, one manufacturer's standard Type I fluid contains 57% glycol as delivered. These fluids are tested in their standard dilution forms and also in further diluted forms specific to particular test temperature requirements. These concentrations are adjusted by refractive index. The freezing point of a solution is concentration dependent and is usually lowered by increasing the concentration. If a given test is to be performed at 0°C, the fluid concentration will be adjusted to freeze at -10°C. This diluted solution is now said to either "possess a 10°C buffer" or "is buffered for 10°C".

Type II and Type IV fluids contain a minimum of 50 percent glycol and are considered *thickened* because of added thickening agents. These allow fluids to be deposited in a thicker film and to remain on the aircraft surfaces until the time of takeoff. These fluids are often delivered to air carriers in this form and are designated as neat (100%) fluids. Sometimes (mostly in Europe) neat Type II and Type IV fluids are mixed with water as follows:

- 75% of neat formulation and 25% water. This is designated Type II 75/25 or Type IV 75/25; and
- 50% neat formulation and 50% water. This is designated Type II 50/50 or Type IV 50/50.

Figure 2.5 provides the list of fluids which have been used over past winters. The fluids used during the 1995/96 winter are shown in italics, and the fluids marked with an asterisk are known to be no longer commercially available. Union Carbide (UCAR) Ultra fluid was designated (prior to 1995/96) as a Type II fluid. It now carries a Type IV fluid designation. Type IV fluid samples were ordered for testing from six manufacturers; however, only four manufacturers provided fluid as follows:

FIGURE 2.5
FLUID LIST

TYPE I (STANDARD)

DOW 146AR
*OCTAGON ADF
*FG 1000
*U.C. ADF/2D
BASF AEREX
HOECHST 1732
KILFROST DF1D
*TEXACO WD20
U.C. XL54
Hoechst MPI 1938
ARCO + (95/96)
Kilfrost (95/96)
ARCO +
OCTAGON (94/95)
HOECHST (94/95-MPI 1898)
SPCA DE-825
SPCA DE-910

TYPE II (NEAT)

*U.C. 5.1
KILFROST ABC
SPCA AD104 (new formulation)
*DOW FG 2000
OCTAGON 40 Below
*HOECHST 1704
*TEXACO
*ULTRA - Type IV
ULTRA (94/95 & 95/96) - Type IV
SPCA AD-104
Hoechst MPII 1906

TYPE II (50/50 DILUTED)

OCTAGON 40 Below
*U.C. 5.1
*ULTRA - Type IV
KILFROST ABC
*HOECHST 1704
ULTRA (94/95 & 95/96) - Type IV
SPCA AD-104
Hoechst MPII 1906

TYPE II (75/25 DILUTED)

OCTAGON 40 Below
*U.C. 5.1
*ULTRA - Type IV
KILFROST ABC
*HOECHST 1704
ULTRA (94/95 & 95/96) - Type IV
SPCA AD-104
Hoechst MPII 1906

* Fluid not commercially available
1995/96 Fluids in italics

TYPE I (DILUTED)

ARCO +
OCTAGON (94/95)
HOECHST (94/95)
U.C. XL54
Hoechst MPI 1938
ARCO + (95/96)
Kilfrost (95/96)
SPCA DE-825
SPCA DE-910

TYPE III

*U.C. 250-3
*UCAR

TYPE IV (NEAT)

Ultra +
SPCA AD-404
SPCA AD-460
Kilfrost ABC-4
Hoechst MPIV 1934
Hoechst MPIV 1957

TYPE IV (75/25 DILUTED)

Ultra +
SPCA AD-404
SPCA AD-460
Kilfrost ABC-4
Hoechst MPIV 1934
Hoechst MPIV 1957

TYPE IV (50/50 DILUTED)

Ultra +
SPCA AD-404
SPCA AD-460
Kilfrost ABC-4
Hoechst MPIV 1934
Hoechst MPIV 1957

Manufacturer/Brand	Glycol Base
UCAR Ultra	Ethylene
UCAR Ultra +	Ethylene
SPCA AD-404	Ethylene
SPCA AD-460	Propylene
Kilfrost ABC-4	Propylene
Hoechst MPIV 1934	Propylene
Hoechst MPIV 1957	Propylene

UCAR Ultra+ was shipped three times. The first batch, shipped in January 1996, was recalled because it did not pass one of the Université du Québec à Chicoutimi (UQAC) fluid qualification tests. The new second batch was shipped at the end of the winter and was subjected to limited testing. A third batch was shipped for the cold-soaked tests. Type IV Hoechst MPIV 1934 fluid was tested over the entire winter; however, UQAC subsequently advised Transport Canada that the water spray endurance test time was less than the proposed 80 minutes for Type IV fluids. Therefore, tests conducted with this fluid were removed from the data base. A new Type IV fluid from Hoechst, MPIV 1957, was shipped in July 1996 and used primarily for cold-soaked tests.

Limited quantities of Type I and Type II fluid samples were also ordered from some of the fluid manufacturers. Type I fluids were used to conduct a few Type IV over Type I holdover time tests; and to conduct cold-soak holdover time experiments. During the outdoor tests, Type II fluids were tested simultaneously with the Type IV tests, allowing comparisons to be made.

The fluids were received mostly in 20 L containers in the neat (100%) concentration. The addition of water to obtain either 50/50 or 75/25 mixes was carried out by research assistants in the trailer. This operation, while not a difficult one, raised some concerns as a result of the possibility of mixing errors. The procedure provided to the testers was as follows:

1st step: Add water to the neat concentrate to get the required dilution (50/50 or 75/25).

2nd step: Verify with a refractometer that the freeze point of the mixture was equal to the freeze point provided by the fluid manufacturer.

3rd step: If the freeze points do not match, then add water or concentrate until the freeze points are equal.

In most cases, the freeze points matched. In one case, the freeze points were obtained after some tests from the manufacturer. This resulted in mixing errors due to matching fluid dilutions to erroneous refractive index values. Because the test site is not equipped with plumbing, it would be considered a courtesy if manufacturers could pre-mix fluids to required specifications prior to shipment.

2.8 Personnel

The site at Dorval was staffed mainly by university students supervised by APS staff. Depending on the rate and duration of precipitation, up to two test stands were in use at Dorval. To operate two test stands, five testers with the following responsibilities (see Appendix B, Attachment III for details) were utilized.

Test Site Leader (1):	Supervise and train site personnel, ensure site is functional, and ensure that test procedures are adhered to.
End Condition (2):	Record end condition times for each crosshair.
Video (1):	Video record fluid failure progression on all plates.
Meteo (1):	Record meteorological conditions during every test.

The utilization of personnel for the cold chamber tests was slightly different. To ensure that the cold chamber facility was used at all times, dedicated technicians were often assigned specific tasks. For example, fluids were prepared, mixed and replenished after every test. During cold-soak testing, a technician was dedicated to ensuring the cryostat was maintained in operational status and the cold-soak boxes were properly thermostatted.

2.9 Analysis Methodology

Before all the collected data were analyzed, the raw data underwent verification to correct or remove any obvious errors. The primary data parameters and the units used in the final analysis are listed below.

- Precipitation rate - (g/dm^2/hr) averaged over test
- Air temperature - (°C) averaged over test
- Wind speed - (kph) averaged over test
- Wind direction - (degrees from true north) averaged over test
- Platform angle - (degrees from true north)
- Time to failure of five crosshairs - (minutes)

Data on other parameters were collected by the automated station at Dorval for the natural snow tests. The data for these other parameters (see Appendix D) are available at one-minute intervals for each test.

The analysis was performed in two stages. Analysis for the first stage was driven by the requirement to present results to the SAE G-12 Committee in Denver and Zurich. During the second stage, the data underwent further verification.

Figure 2.6
Test Site at Dorval Airport

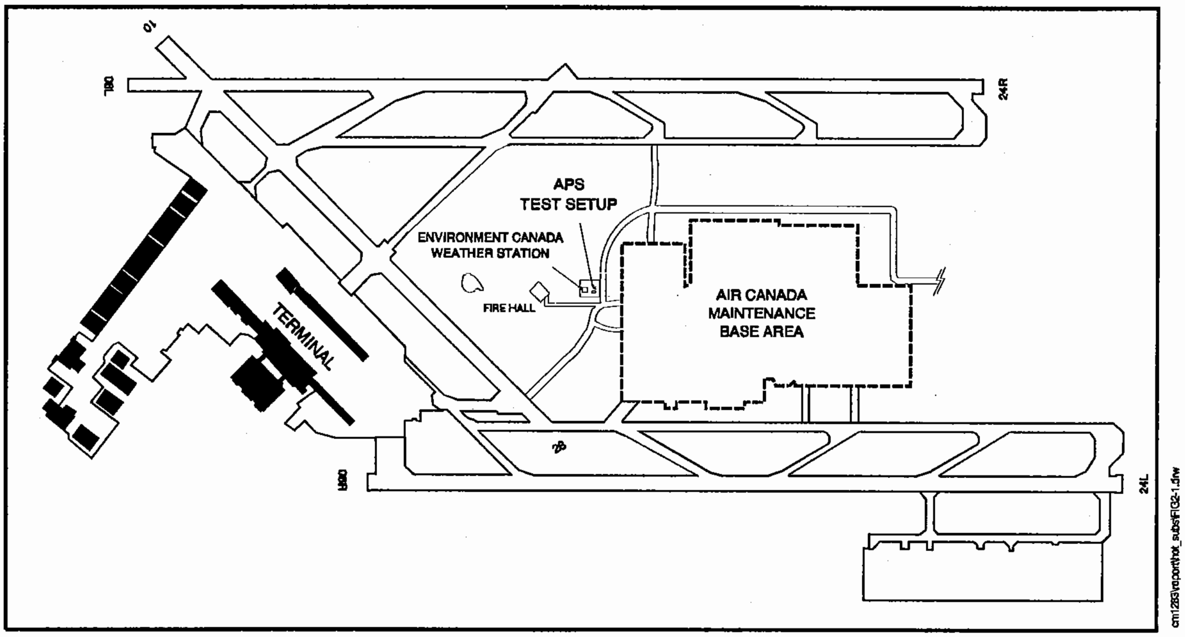


Photo 2.1
View of Dorval Test Site and Associated Equipment

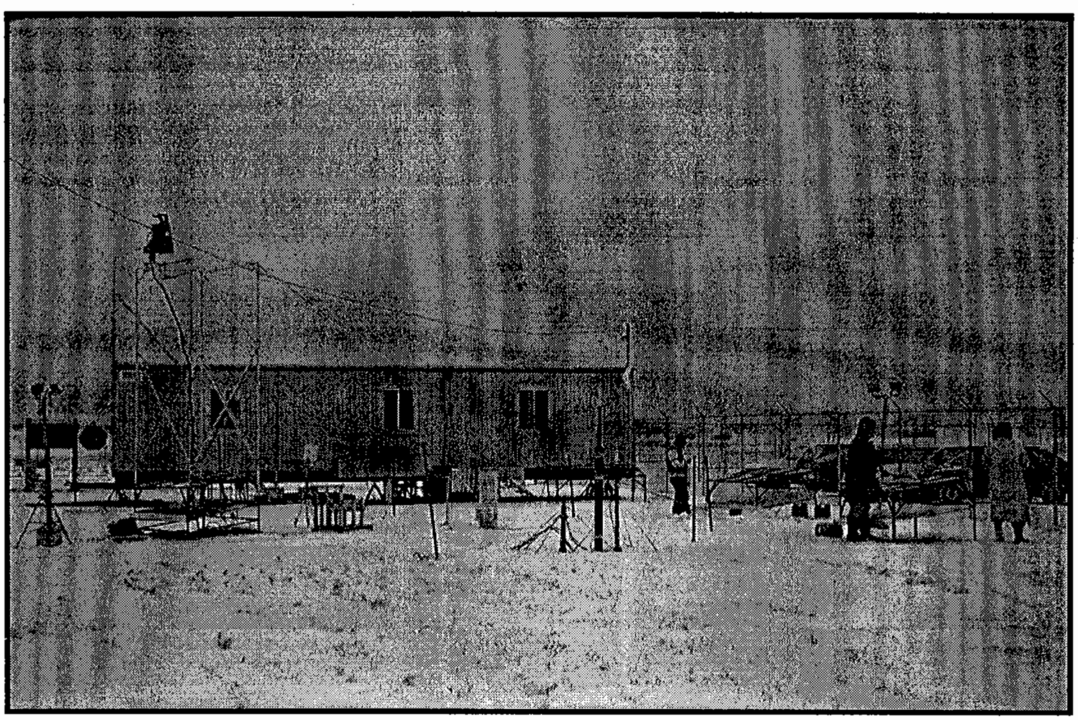


Photo 2.2
Environment Canada's Weather Observation Station at Dorval Airport

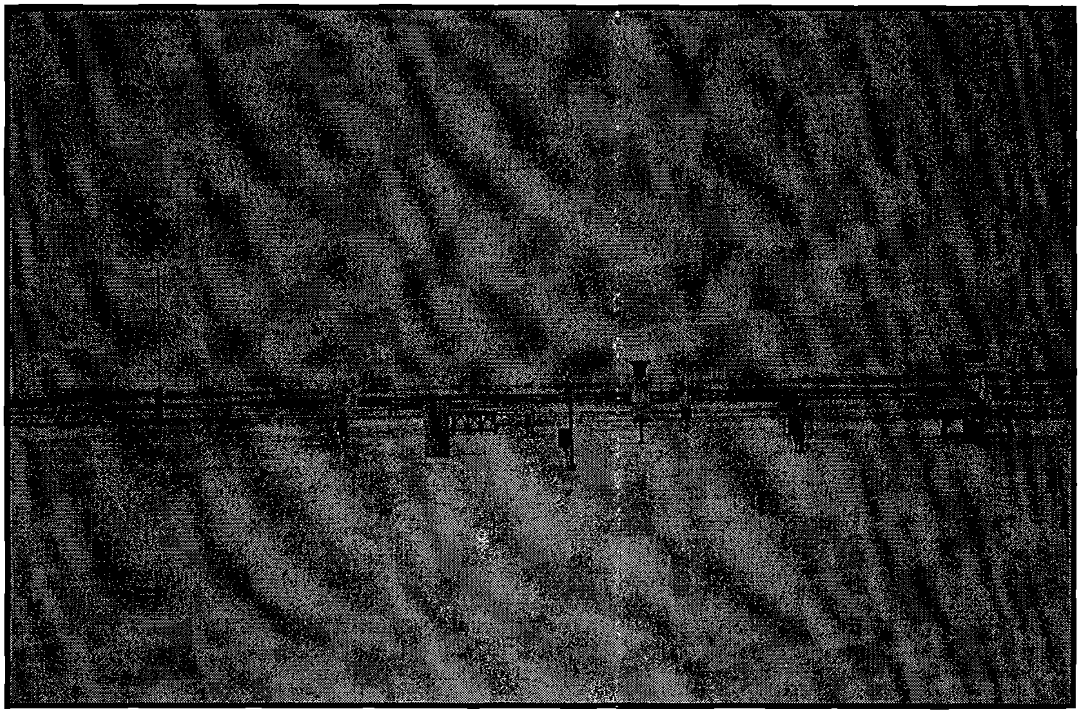


Photo 2.3
Outdoor View of NRC Climatic Engineering Facility

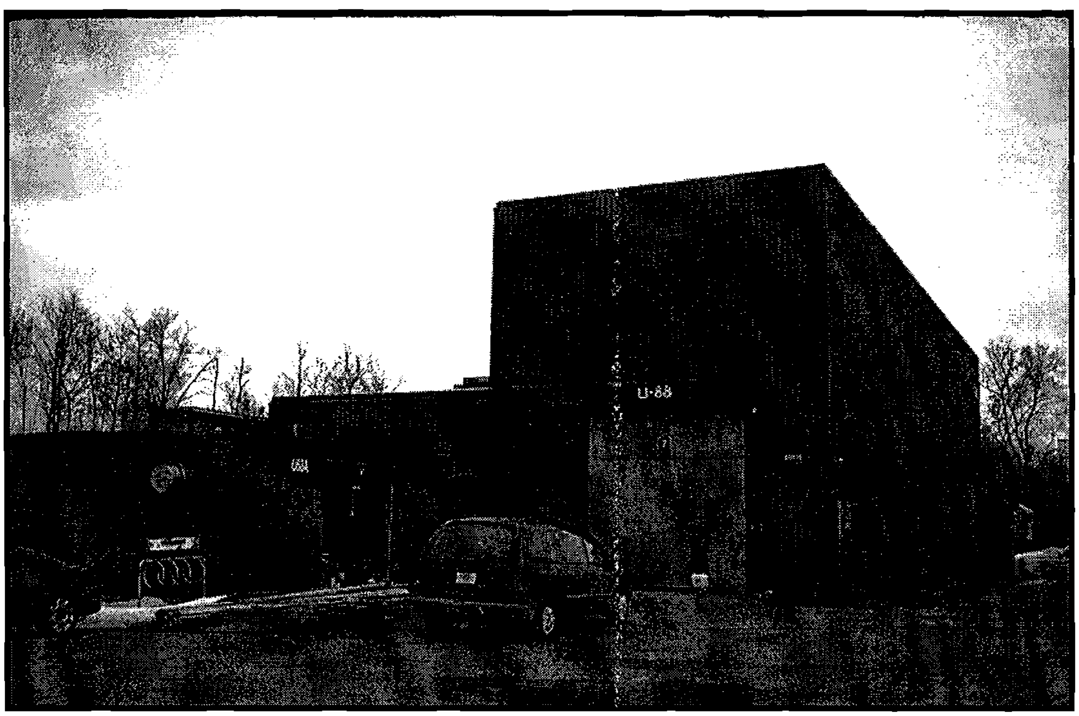


Photo 2.4
Inside View of NRC Climatic Engineering Facility

Photo 2.5
Sprayer Assembly Used to Produce Fine Droplets

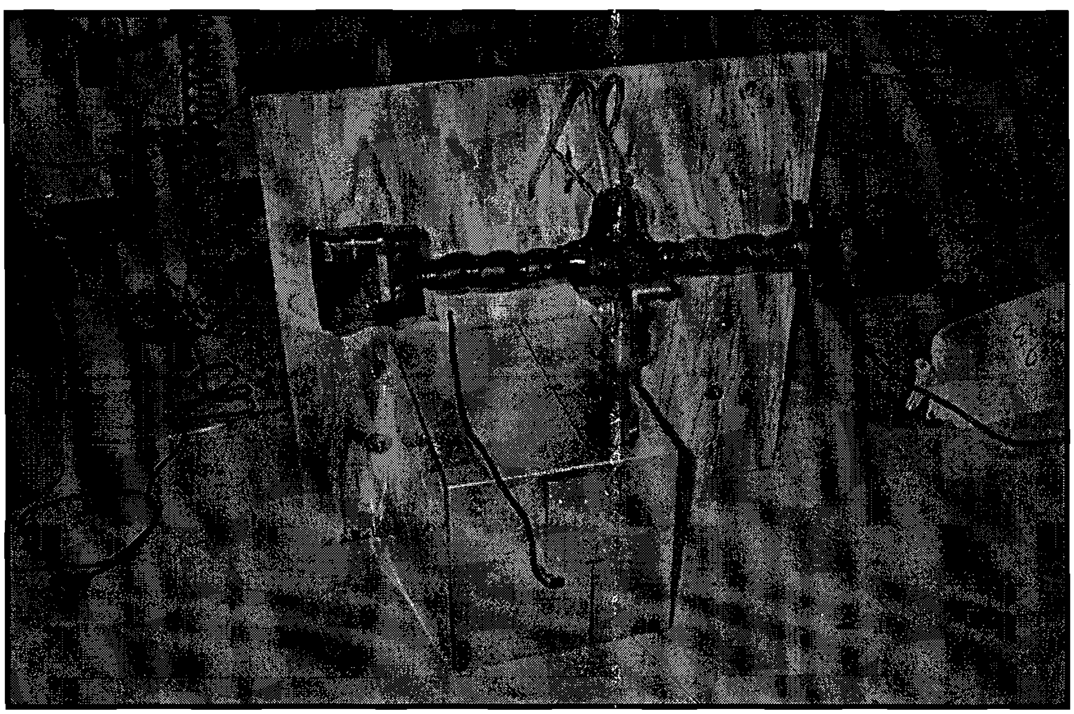


Photo 2.6
Optical Gauge by HSS to Measure Droplet Size

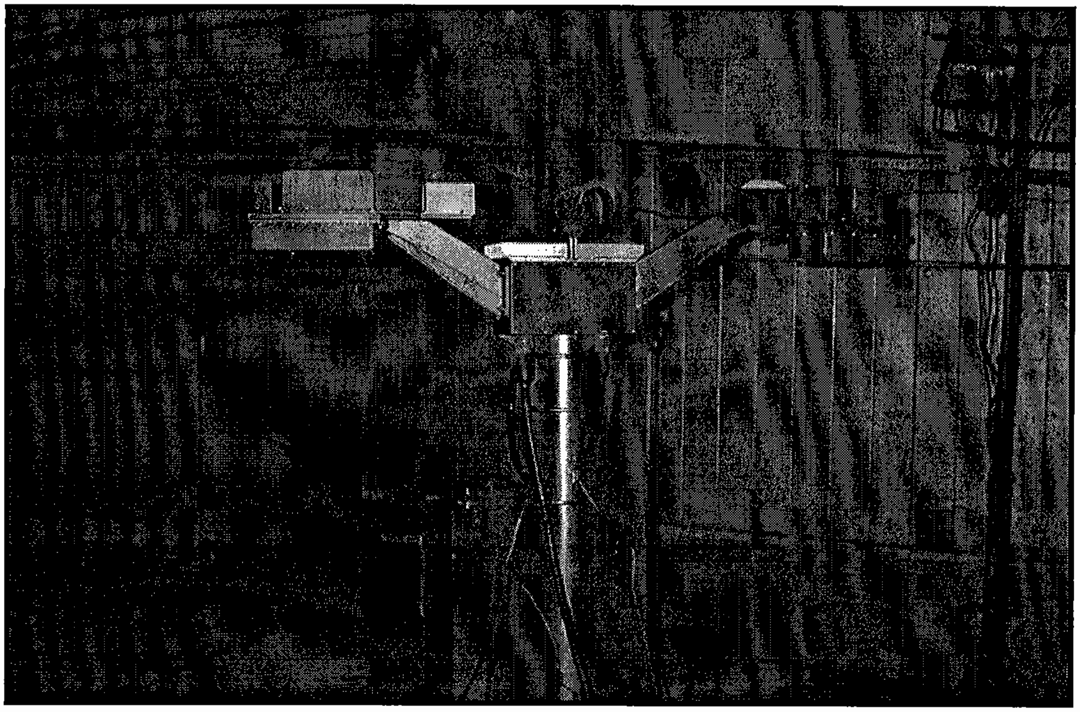


Photo 2.7
Examples of Droplet Sizes Produced by NRC Spray System

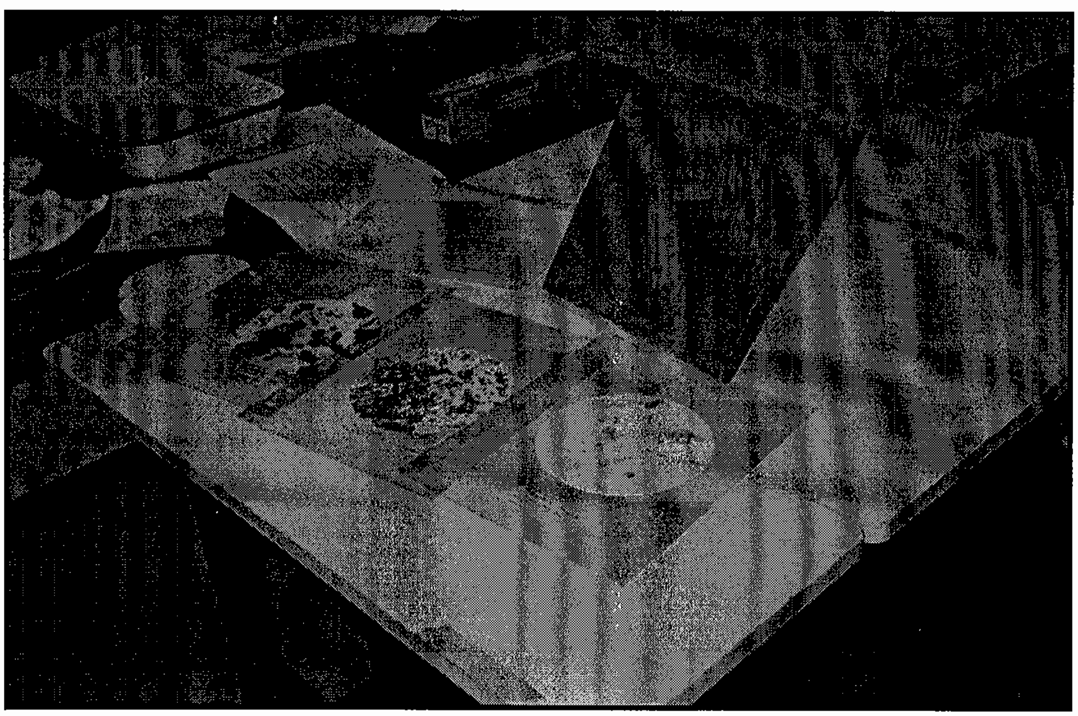


Photo 2.8
Test Plates Mounted on a Stand

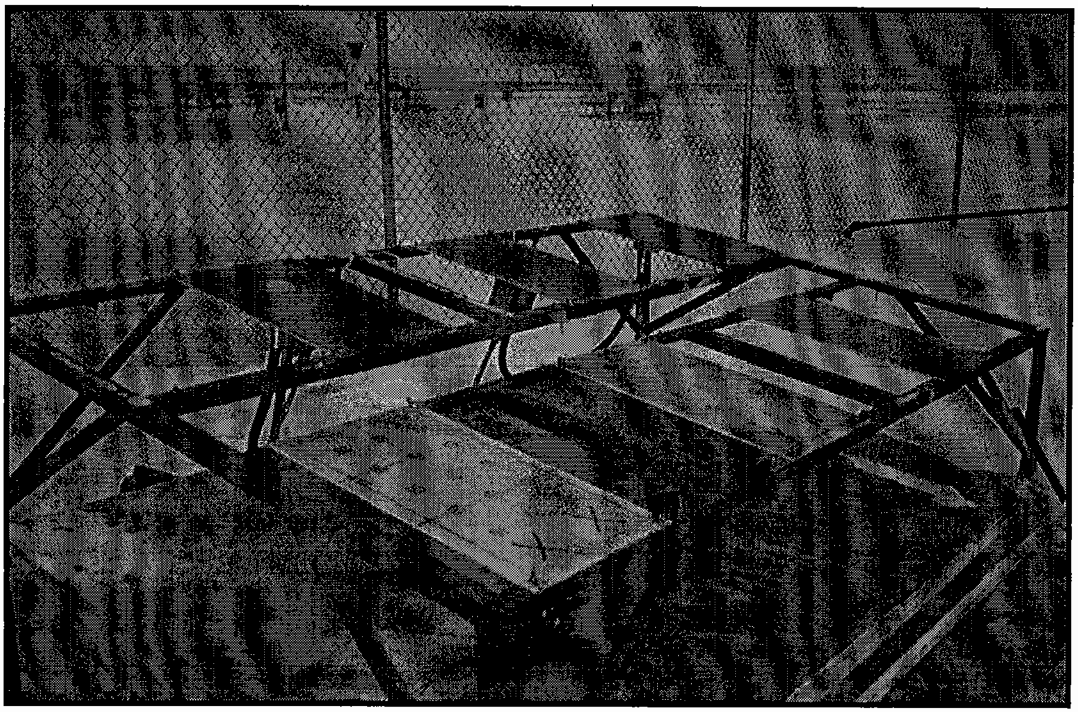


Photo 2.9
Collection Pans Used Indoors at NRC

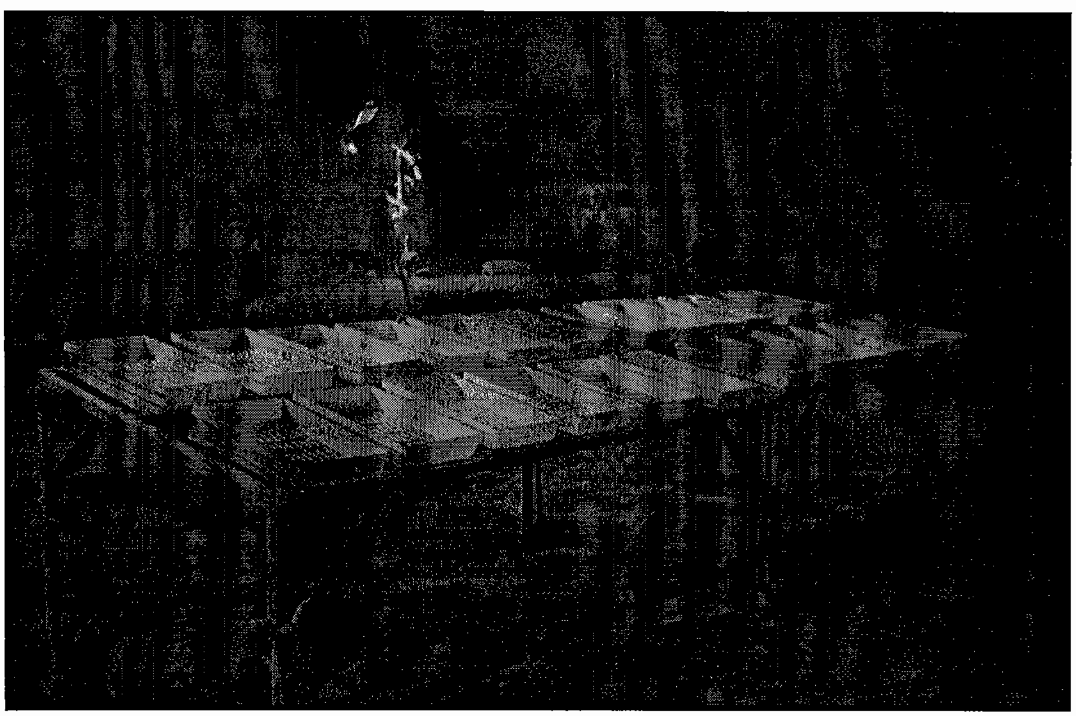


Photo 2.10
Snow Gauge by ETI

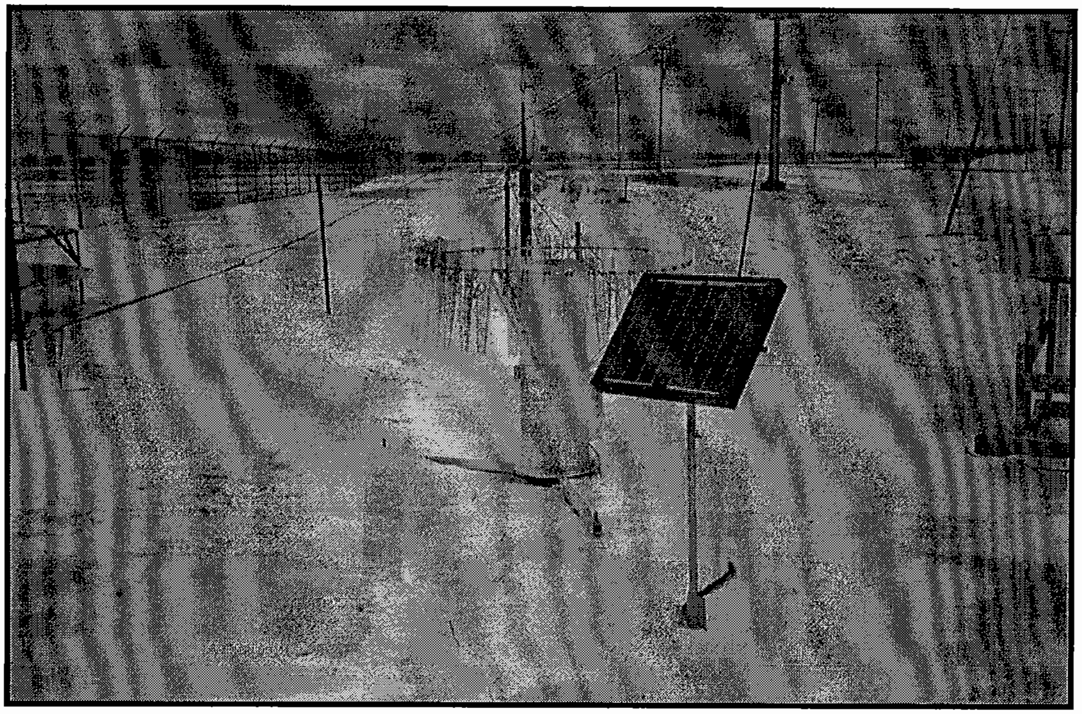


Photo 2.11
Ice Detection Sensor by Spar

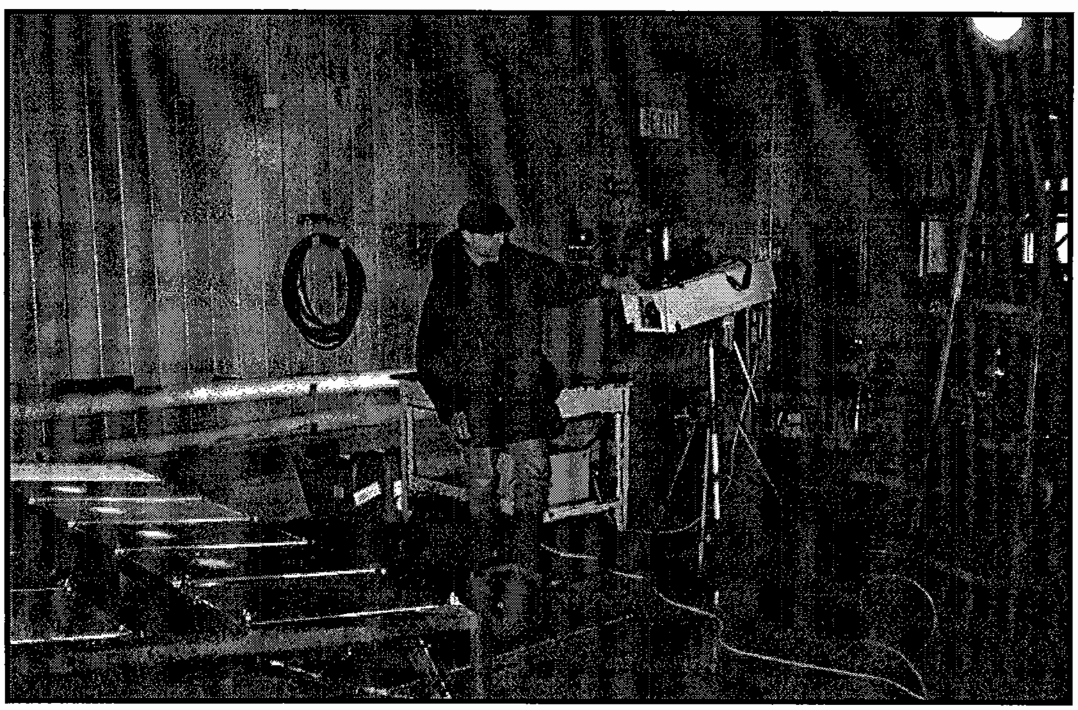


Photo 2.12
Computer Installations Used for Data Acquisition

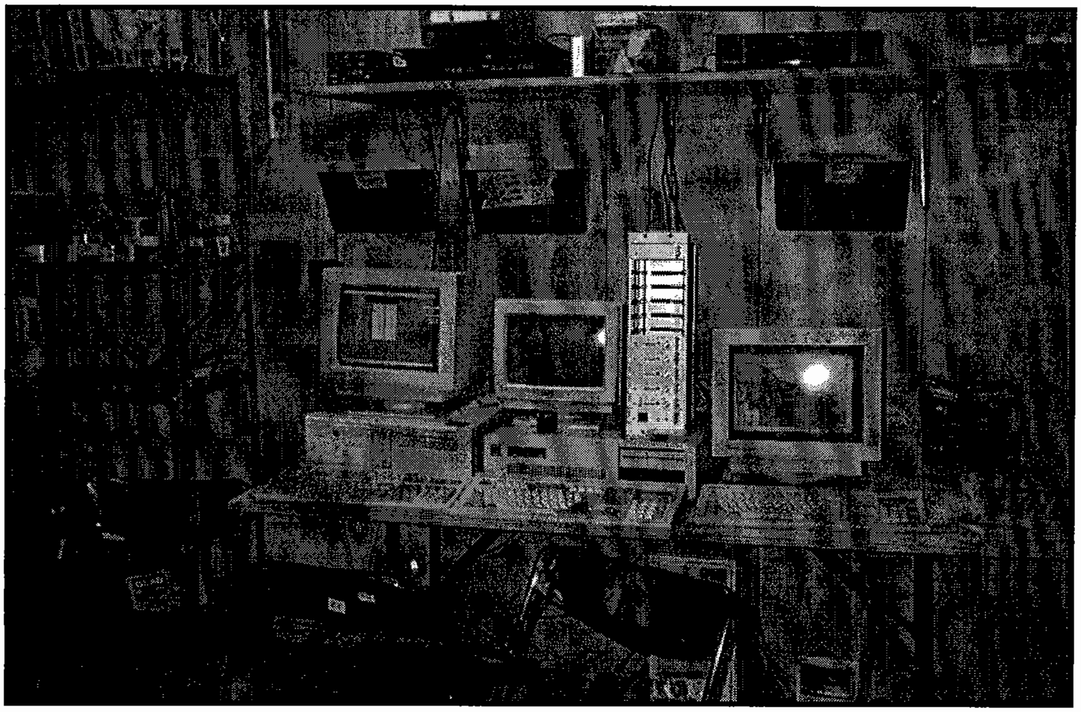
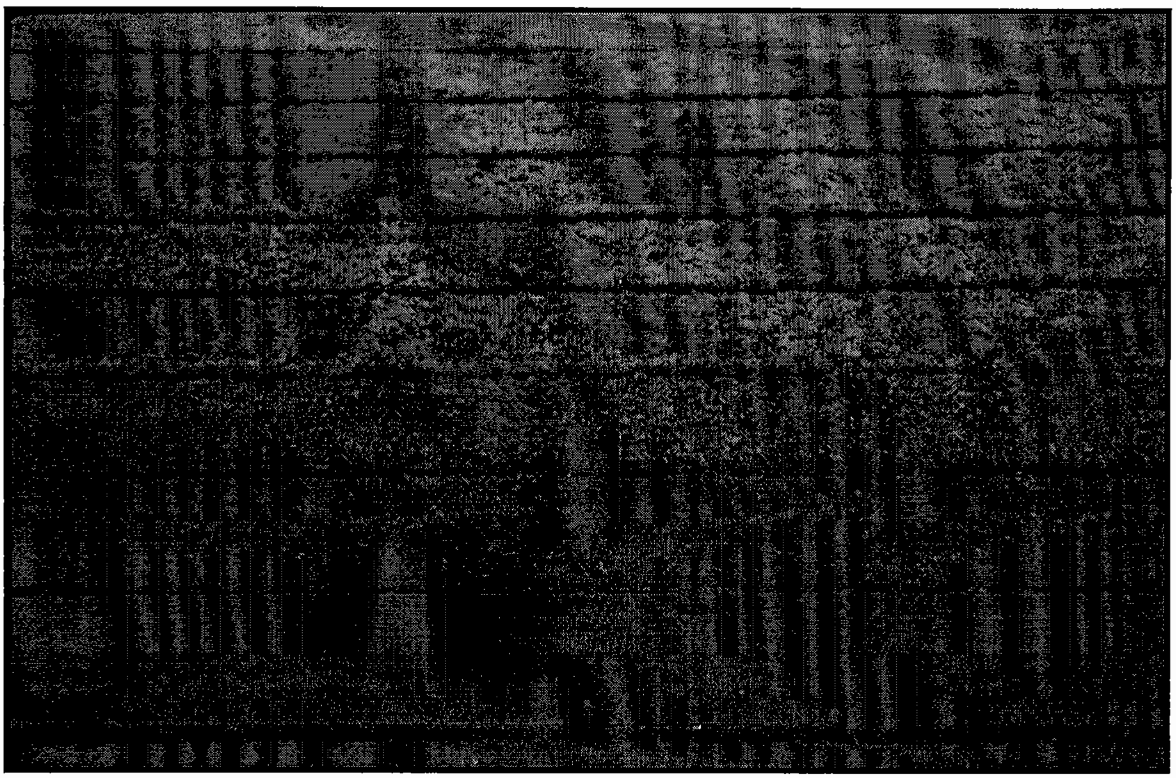


Photo 2.13
AES Automated Weather Station Instruments

Photo 2.14
Demonstration of Failure on Wooden Planks (15 cm wide)



3. DESCRIPTION OF DATA

Appendices B and C contain detailed tables showing the tests which were planned prior to the winter. It was not always possible to conduct all the planned tests because fluids were not always available or often arrived later in the winter. For the outdoor tests, the strategy was to plan as many tests as possible under every weather condition, knowing in advance that it would not be possible to get all conditions.

Table 3.1 provides a summary of the flat plate tests which were conducted both at Dorval and at the NRC. At Dorval, 468 tests were conducted during natural snow precipitation on 19 days over the 1995/96 winter. The number of tests conducted during the 1995/96 winter was high in relation to previous winters, especially considering that Type IV fluids take longer to fail. Table 3.1 shows that most of the snow fell early in the winter, particularly in December. The total precipitation that occurred from November 1995 to March 1996 was slightly below the 30-year average for that period.

At the NRC, tests were conducted on seven different occasions. The selection of the dates (see Table 3.1) was often based upon the availability of the chamber and sprayer system, and Transport Canada requirements. On two occasions (May 10, and September 6 and 9) testing was carried out to address concerns and questions raised at SAE G-12 Holdover Time Sub-Committee meetings.

This section provides a summary of the number of data samples collected. Breakdowns are provided for quantity of data collected, versus fluid type and distributions of basic weather parameters such as temperature, precipitation rate, wind speed and direction over the range of the tests collected. This is presented for the natural snow tests conducted at Dorval, and light freezing rain, freezing drizzle, freezing fog and cold-soaked tests conducted in Ottawa.

TABLE 3.1

SUMMARY OF TESTS PERFORMED IN 1995/1996

Natural Snow Tests at Dorval

Date	# of Tests	Total Precip. (for the day) (cm)	Total Precip. (during tests) (cm)	Month	Total Precip. of month (cm)	Normal Precip. of month (cm)
Nov-27-95	23	17				
Nov-28-95	8	3.6	20.6	Nov-96	48.1	24.1
Dec-01-95	41	9.2				
Dec-03-95	46	11.6				
Dec-06-95	12	0.8				
Dec-09-95	56	20.8				
Dec-14-95	61	19.6				
Dec-20-95	12	8.4				
Dec-21-95	28	2.6	73	Dec-96	86.4	54.8
Jan-09-96	12	5.8				
Jan-10-96	12	0.6				
Jan-19-96	8	2.6				
Jan-27-96	34	4.2				
Jan-29-96	12	3.2	16.4	Jan-96	24.2	47.7
Feb-07-96	10	0.8				
Feb-09-96	38	3.4				
Feb-11-96	32	9.4	13.6	Feb-96	17.4	41.2
Mar-20-96	14	2.4				
Mar-21-96	9	1.2	3.6	Mar-96	13.2	31.3
Total	**468**	**127**	**127**		**189**	**199**

Tests Performed at CEF

Date	Condition Tested
March 11-14, 1996	LFZR, FZD
April 01-03, 1996	FZF
May 10, 1996	Verification of LFZR HOT range for Type IV's
June 25-28, 1996	Cold-Soak Temperature Profile
July 29-Aug 02, 1996	Chamber Calibration, Cold-Soak Temperature Profile, FZD
August 06-09, 1996	LFZR, Cold-Soak Boxes (DRZ, LR, MR, HR)
Sept 6 & 9, 1996	Verification of HOT for Type IV Fluid C-107

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Printed: 1/7/98

3.1 Dorval Natural Snow Tests

3.1.1 Data Acquisition

During the 1995/96 test season, a total of 720 tests were started on the two stands at Dorval. Of this total, 468 points were usable and 252 points were discarded (see listing below). All of the 468 tests occurred during natural snow conditions.

	# of Tests
Usable	468
Fluids did not fail (e.g. snow stopped)	123
Fluid Hoechst MPIV 1934 did not qualify	102
Fluid Ultra + (1st batch did not qualify)	21
Other (wrong fluid mixture, ice crystals)	6
Total Tests Started	720

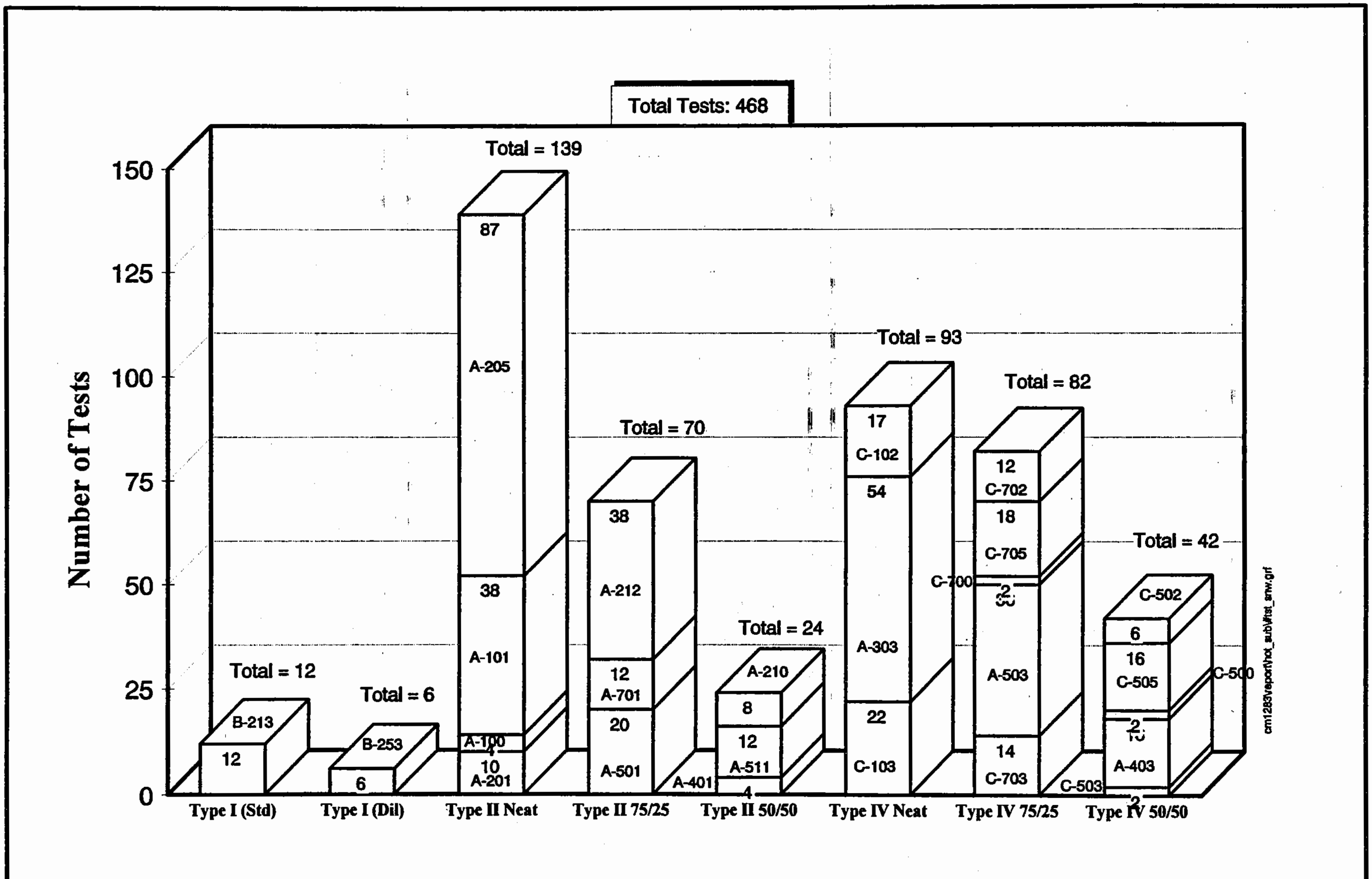
The breakdown by fluid type of the 468 tests is shown in Figure 3.1 and summarized below. The majority of tests were conducted using Type II and Type IV fluid.

	# of Tests
Type I (standard)	12
Type I (diluted)	6
Type II Neat	139
Type II 75/25	70
Type II 50/50	24
Type IV Neat	93
Type IV 75/25	82
Type IV 50/50	42
Total Usable Tests	468

FIGURE 3.1

NUMBER OF NATURAL SNOW TESTS CONDUCTED

1995-1996 TEST SEASON AT DORVAL



3.1.2 Test Location and Fluids Tested

All 468 tests were carried out at Dorval. In addition, 27 tests were conducted at Denver by the National Centre for Atmospheric Research (NCAR) with Type IV neat Fluids A-303 and C-106 during the 1995/96 winter. The NCAR tests are not included in the totals of this section, but the data are described in Section 5.

Tests at Dorval were conducted with fluids manufactured by Octagon, Union Carbide, Hoechst, Kilfrost, and SPCA. (Figure 3.1 shows concisely how many fluids brands were tested for each fluid type.)

3.1.3 Distribution of Average Precipitation Rates

The amount of precipitation at Dorval was measured using plate pans, the ETI precipitation gauge, and the precipitation gauge from Environment Canada's automated weather station. Because most of the data from previous winters were analysed using rate of precipitation computed with plate pans, and because this gives a more accurate depiction of the *catch rate* on the plates, this measure was used to illustrate the data in the sections that follow. In the previous years, plate pans were left out on the stand until all plates reached the end condition. For the 1995/96 winter, the frequency of measurement of total precipitation with the plate pans was increased. The two precipitation gauges were used as back-up and the data from the instruments were used for investigation of outlying test points. The data from the gauges will be provided to NCAR for further research on the correlation of the instruments.

Two plate pans were used during a test with six panels to measure the quantity of precipitation. The pans were weighed every 15 minutes. The average rate of precipitation for each test was computed by dividing the total precipitation recorded (from the start of test to the time of failure) by the failure time.

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

The distributions show that the rate of precipitation for most tests ranged from 4 to 20 $g/dm^2/hr$. This low range may be explained by two observations. Large storms during the 1995/96 winter at Dorval were not experienced, and any precipitation rate *surges* were *smoothed* by the longer failure times of Type IV fluids.

3.1.4 Distribution of Other Meteorological Conditions

The air temperature, wind speed, and wind direction were measured for every test over the duration of the test. These parameters were measured with instruments purchased by APS on behalf of Transport Canada, and also with instruments at Environment Canada's automated weather station. A comparison of the measurements from each instrument is provided in Section 4. A summary of the distribution of the APS measures for each test is illustrated in Figures 3.4 to 3.8 as follows:

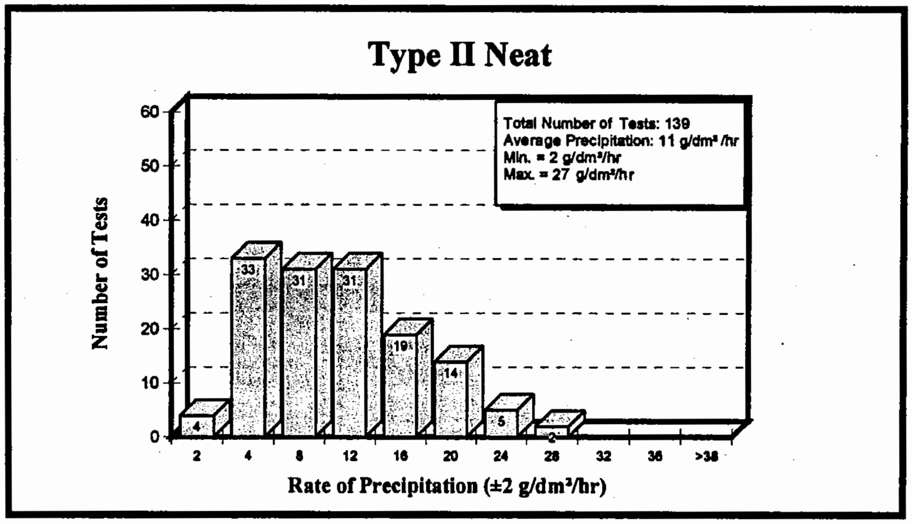
Figure 3.4	Distribution of Air Temperature for Type II Fluids
Figure 3.5	Distribution of Air Temperature for Type IV Fluids
Figure 3.6	Distribution of Wind Speed for Type II Fluids
Figure 3.7	Distribution of Wind Speed for Type IV Fluids
Figure 3.8	Comparison of Wind Direction to Platform Direction

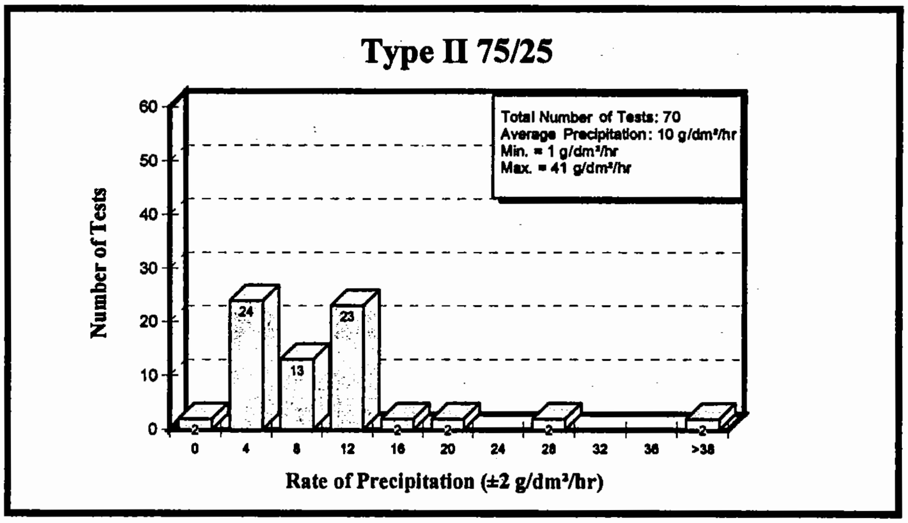
FIGURE 3.2

DISTRIBUTION OF PRECIPITATION RATE - TYPE II FLUIDS

Natural Snow Tests

1995-1996





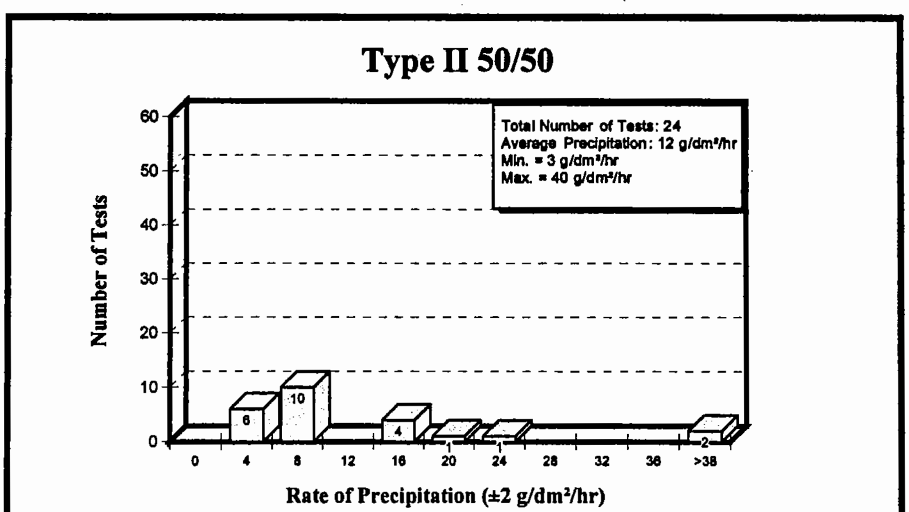


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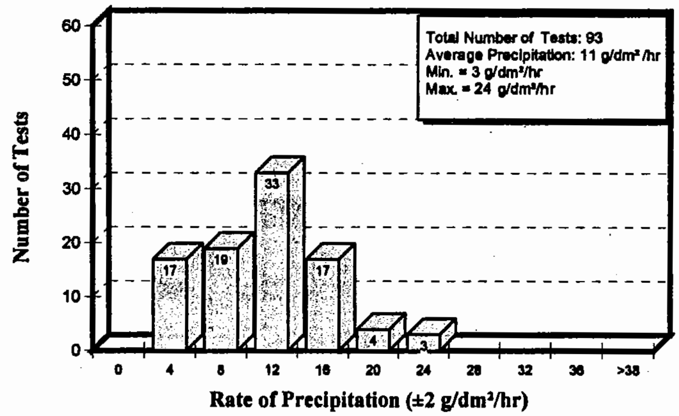
FIGURE 3.3

DISTRIBUTION OF PRECIPITATION RATE - TYPE IV FLUIDS

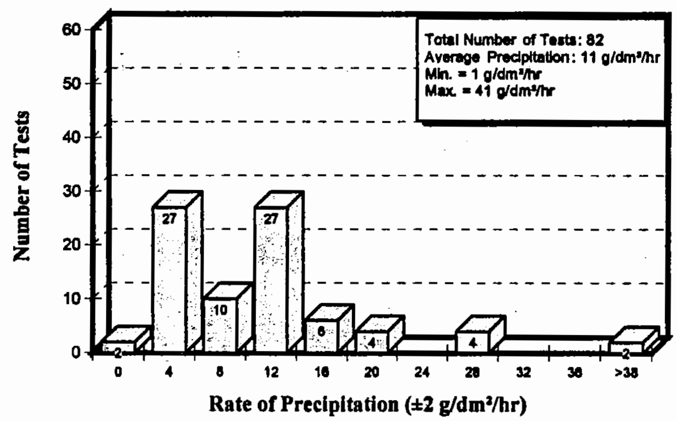
Natural Snow Tests

1995-1996

Type IV Neat



Type IV 75/25



Type IV 50/50

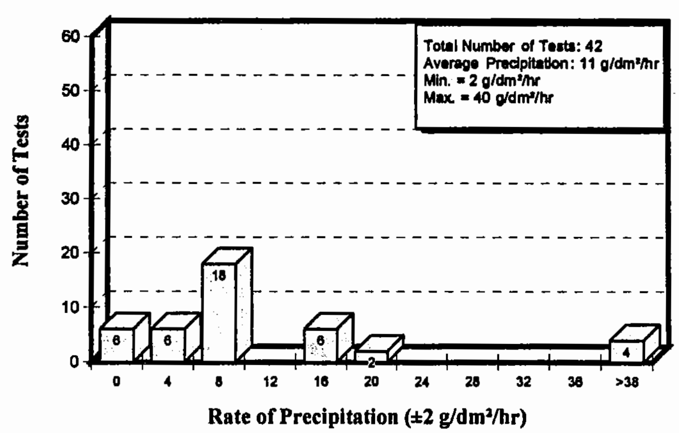


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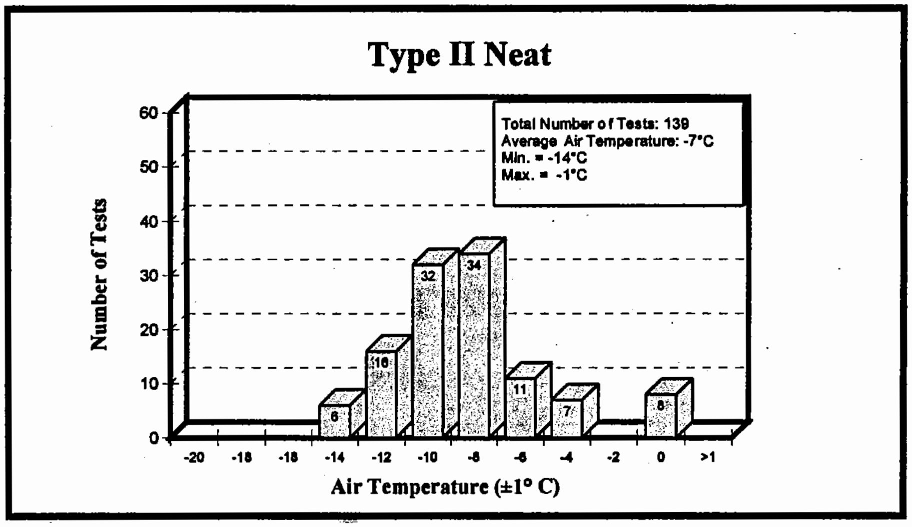
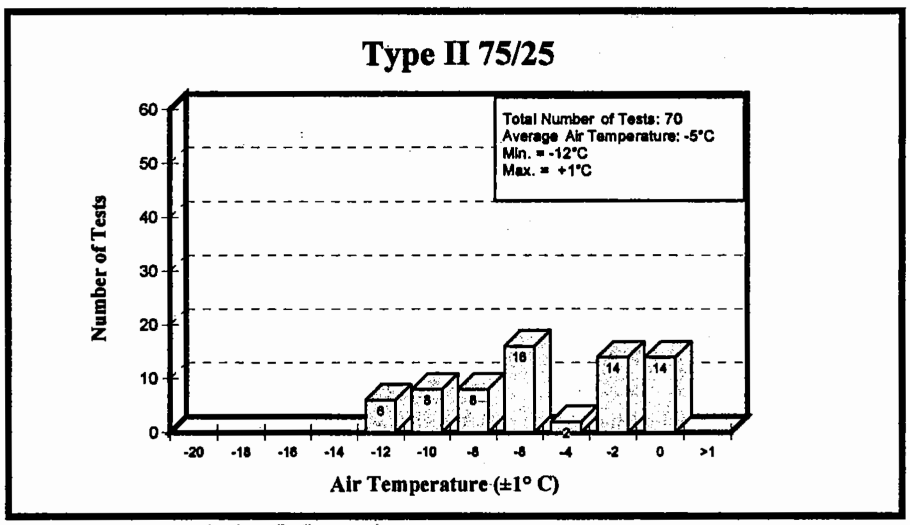
FIGURE 3.4

DISTRIBUTION OF AIR TEMPERATURE - TYPE II FLUIDS

Natural Snow Tests

1995-1996





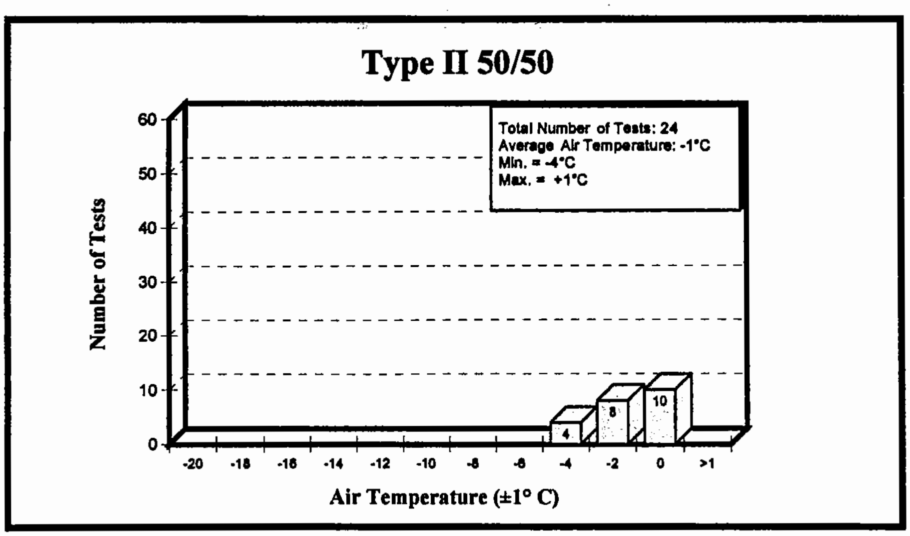


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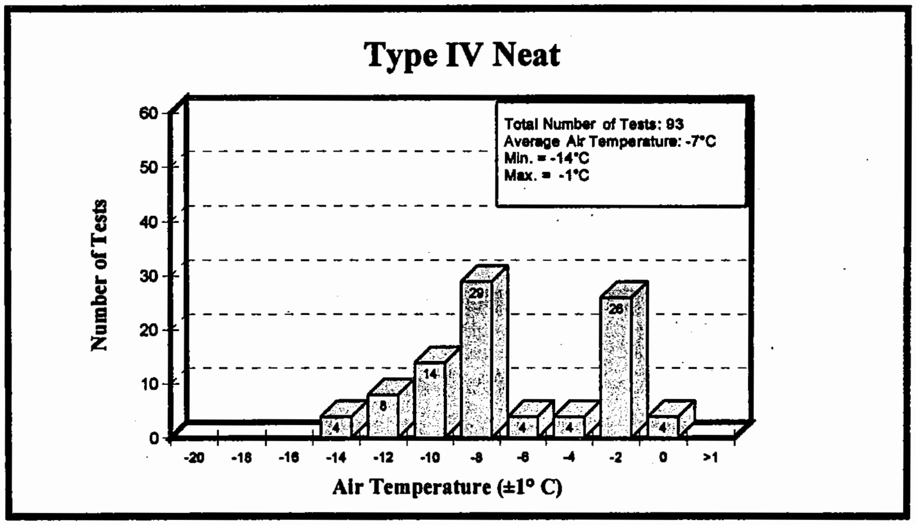
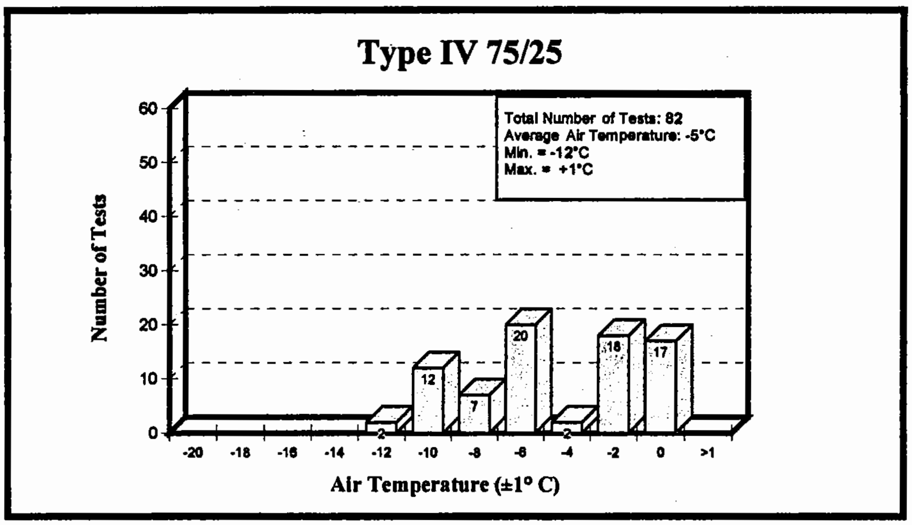
FIGURE 3.5

DISTRIBUTION OF AIR TEMPERATURE - TYPE IV FLUIDS

Natural Snow Tests

1995-1996





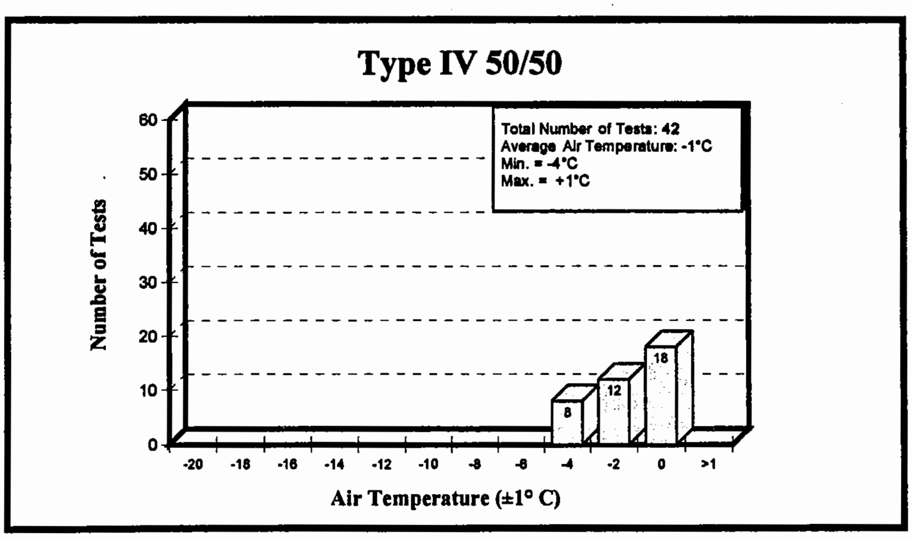


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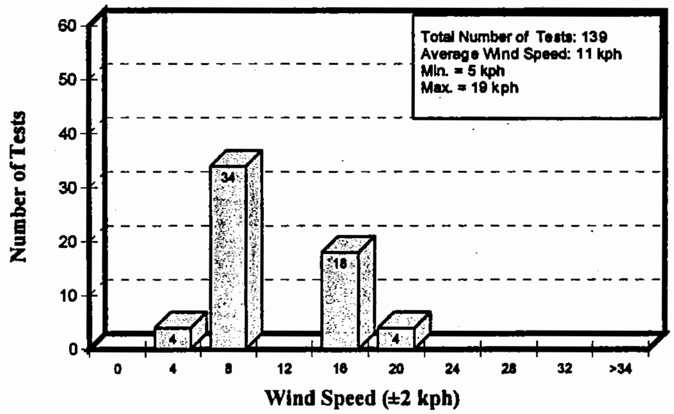
FIGURE 3.6

DISTRIBUTION OF WIND SPEED - TYPE II FLUIDS

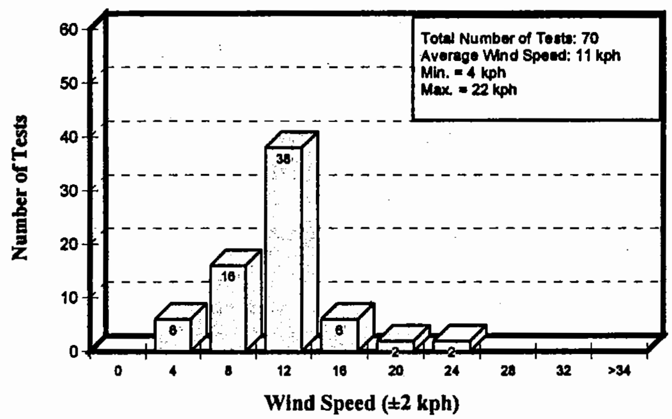
Natural Snow Tests

1995-1996

Type II Neat



Type II 75/25



Type II 50/50

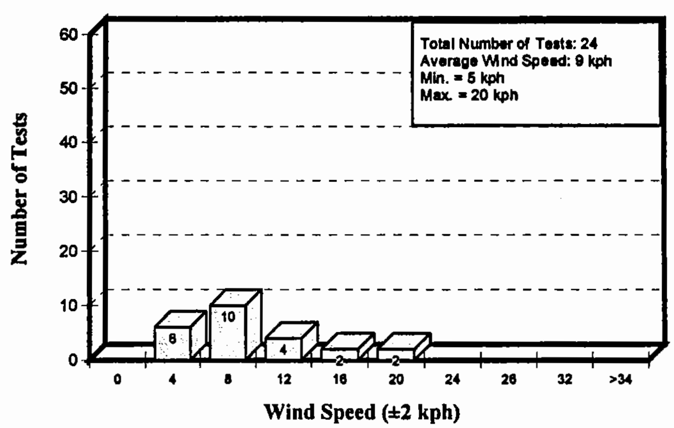


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FIGURE 3.7

DISTRIBUTION OF WIND SPEED - TYPE IV FLUIDS

Natural Snow Tests

1995-1996

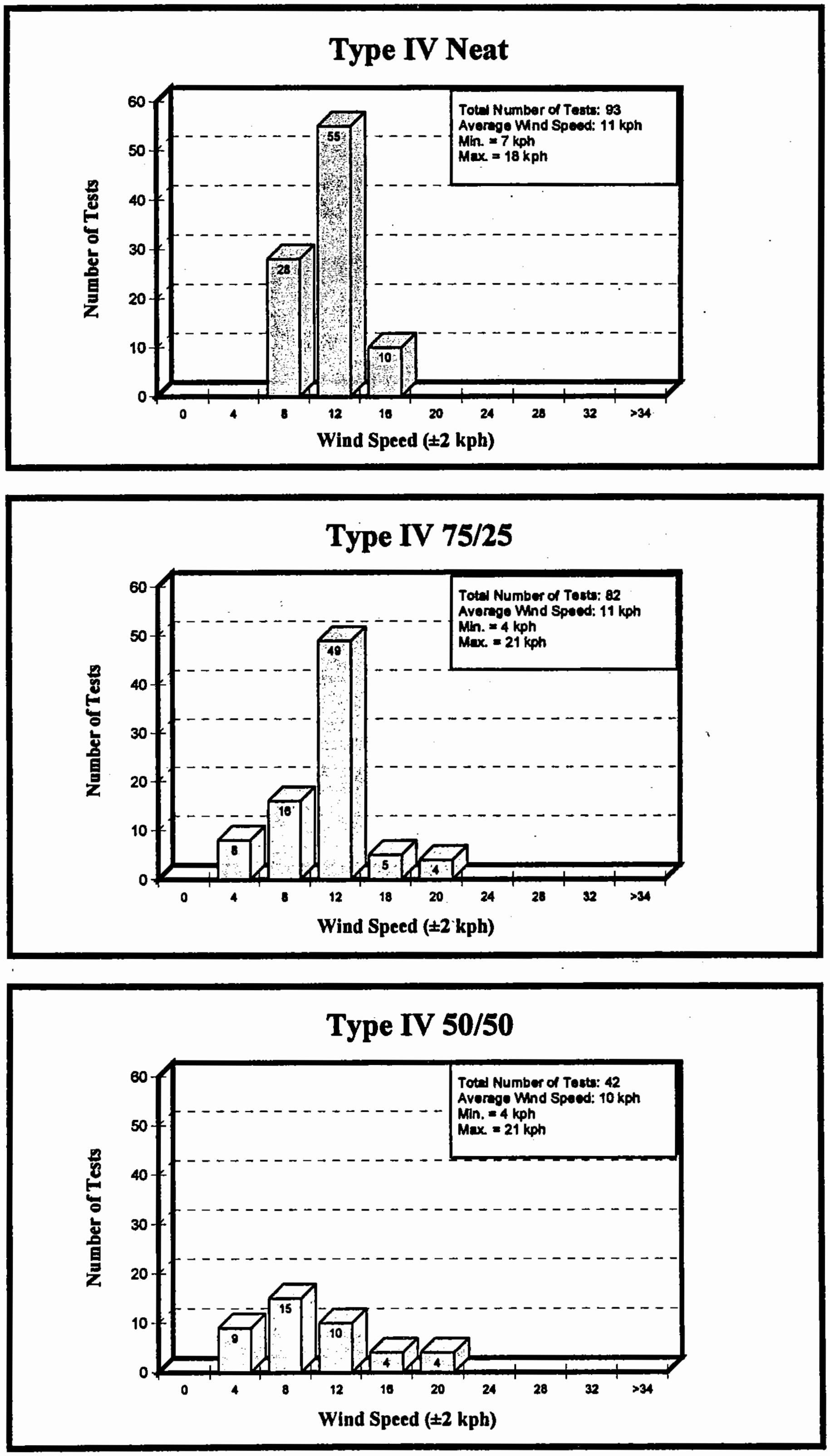

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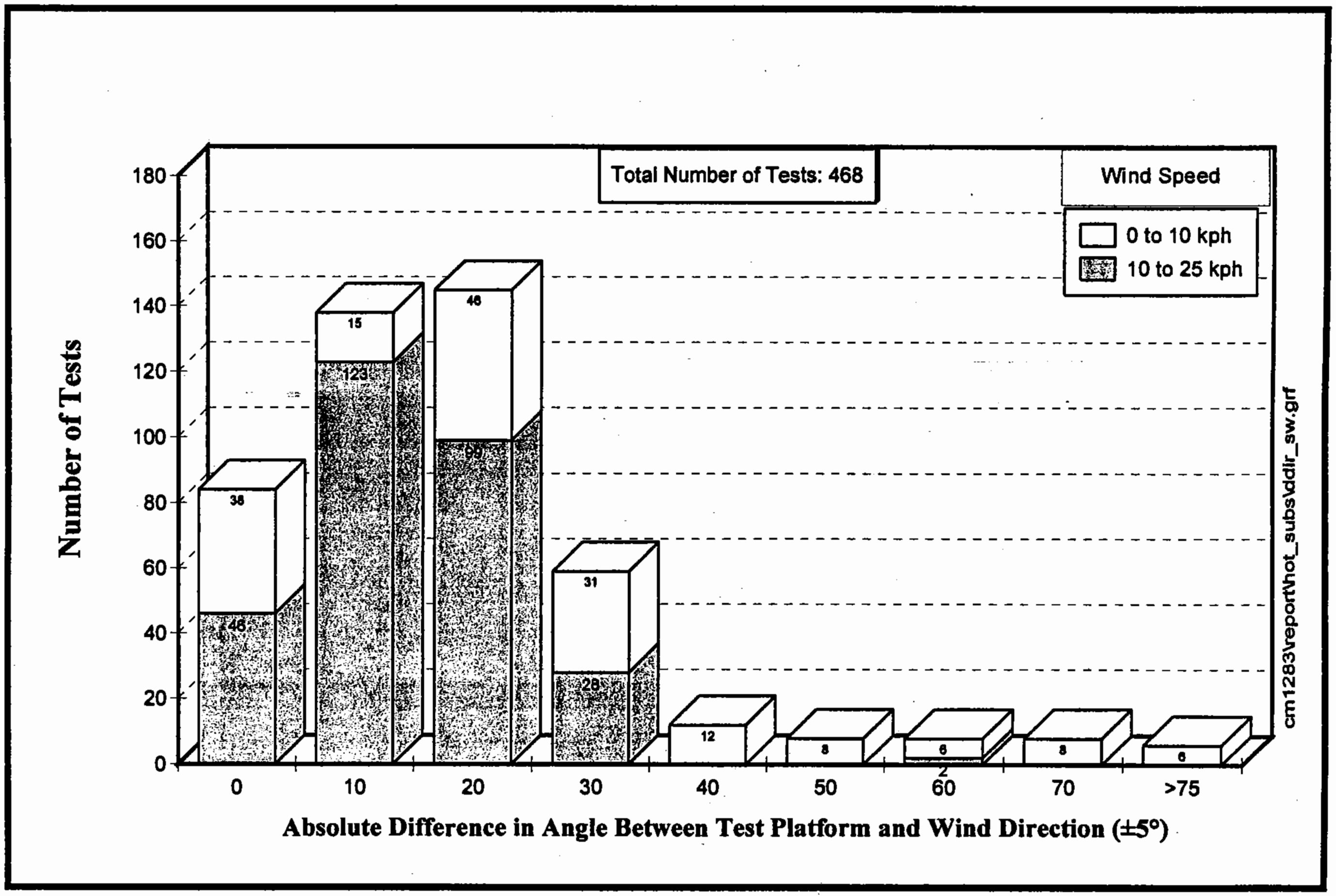
FIGURE 3.8

COMPARISON OF WIND DIRECTION TO PLATFORM DIRECTION

Natural Snow Tests

1995-1996



3.2 Simulated Freezing Drizzle and Light Freezing Rain

3.2.1 Data Acquisition

The test plan developed for experiments to be conducted in freezing drizzle and light freezing rain is described in Appendix C. Figure 3.9 shows that 62 freezing drizzle and 100 light freezing rain flat plate tests were carried out in the 1995/96 winter. Supplementary Type IV neat fluid tests were conducted under light freezing rain conditions to address questions raised by the SAE G-12 Committee. The majority of the tests used Type IV fluid. Type II fluids were tested simultaneously with Type IV fluids for comparison and calibration with previous winter tests.

3.2.2 Test Location and Fluids Tested

All of the 162 tests were conducted at NRC's Climatic Engineering Facility in Ottawa. The Type IV fluids tested were:

- Kilfrost ABC-4
- UCAR Ultra +
- UCAR Ultra
- SPCA AD-404
- SPCA AD-460
- Hoechst MPIV 1957

Testing with UCAR Ultra + and Hoechst MPIV 1957 fluid was limited.

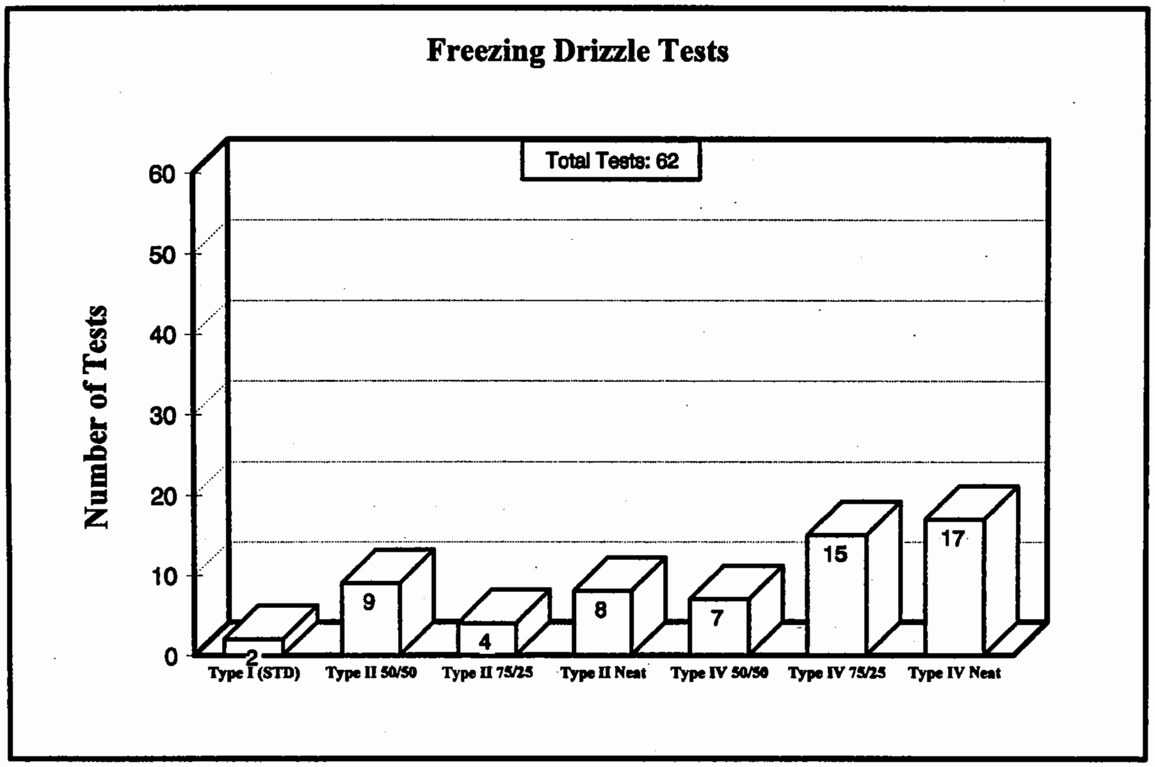
3.2.3 Distribution of Average Precipitation Rates

The average precipitation rates for freezing drizzle and light freezing rain were computed from weight measurements taken with plate pans (see Section 2). Pans were positioned on the stand at every plate position before and after each run for two 15-minute periods. The distribution of average precipitation rate measured for the tests is shown in Figure 3.10 for Type II fluid and Figure 3.11 for Type IV fluid.

FIGURE 3.9

NUMBER OF SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN TESTS

1995-1996 TEST SEASON



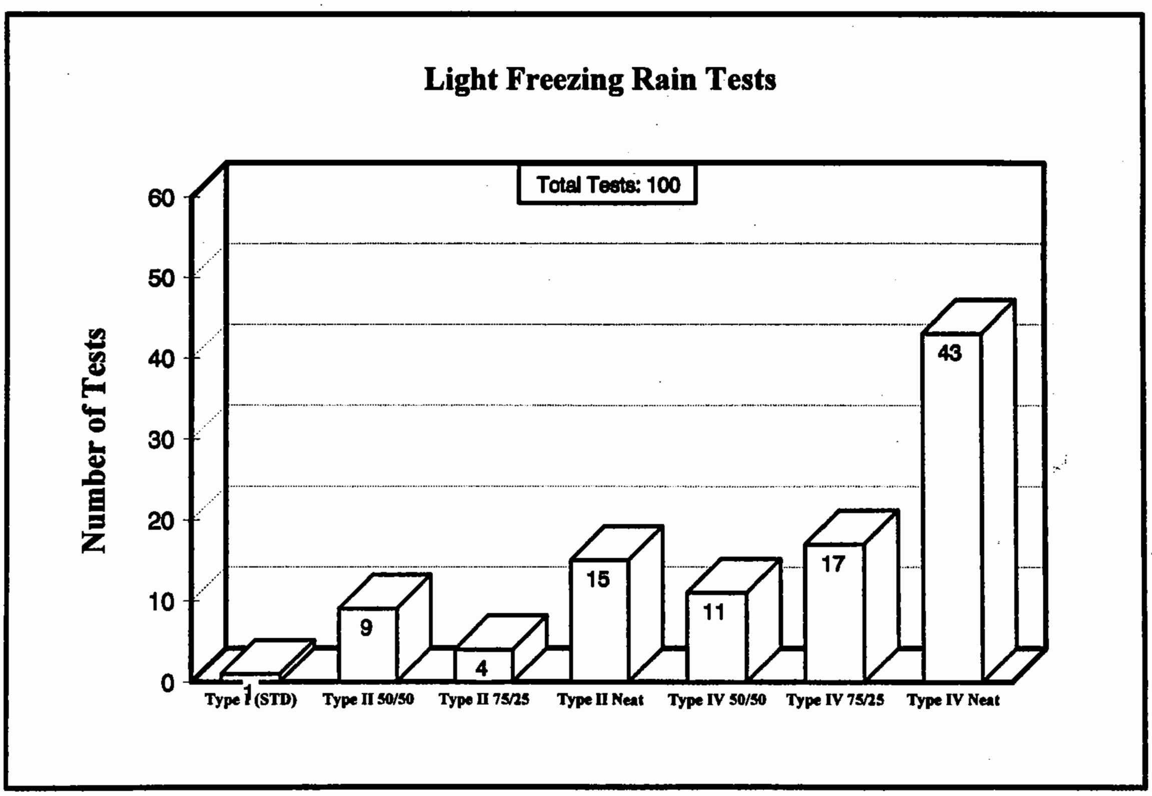


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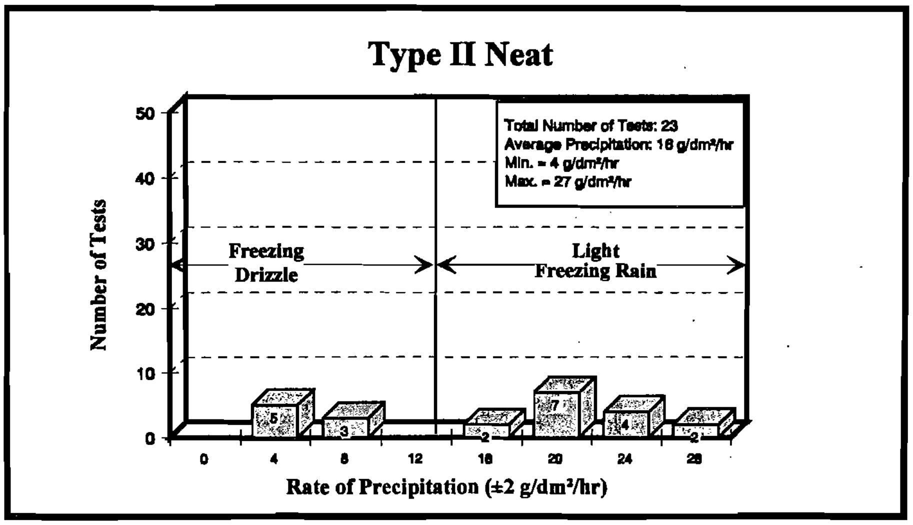
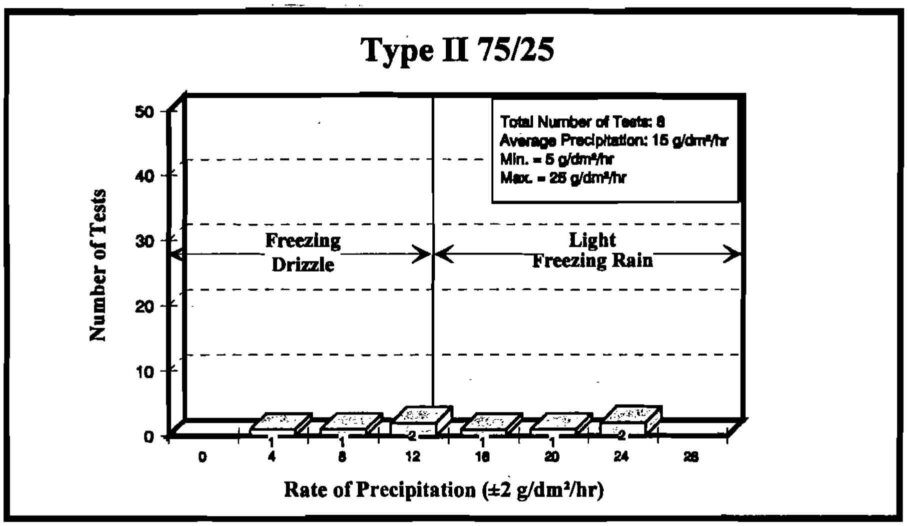
FIGURE 3.10

DISTRIBUTION OF PRECIPITATION RATE - TYPE II FLUIDS

Simulated Freezing Drizzle/Light Freezing Rain Tests
1995-1996





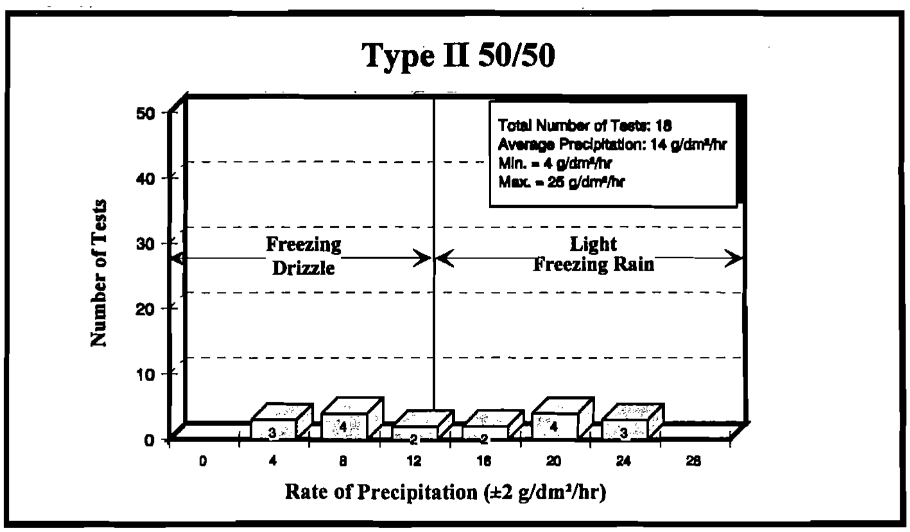


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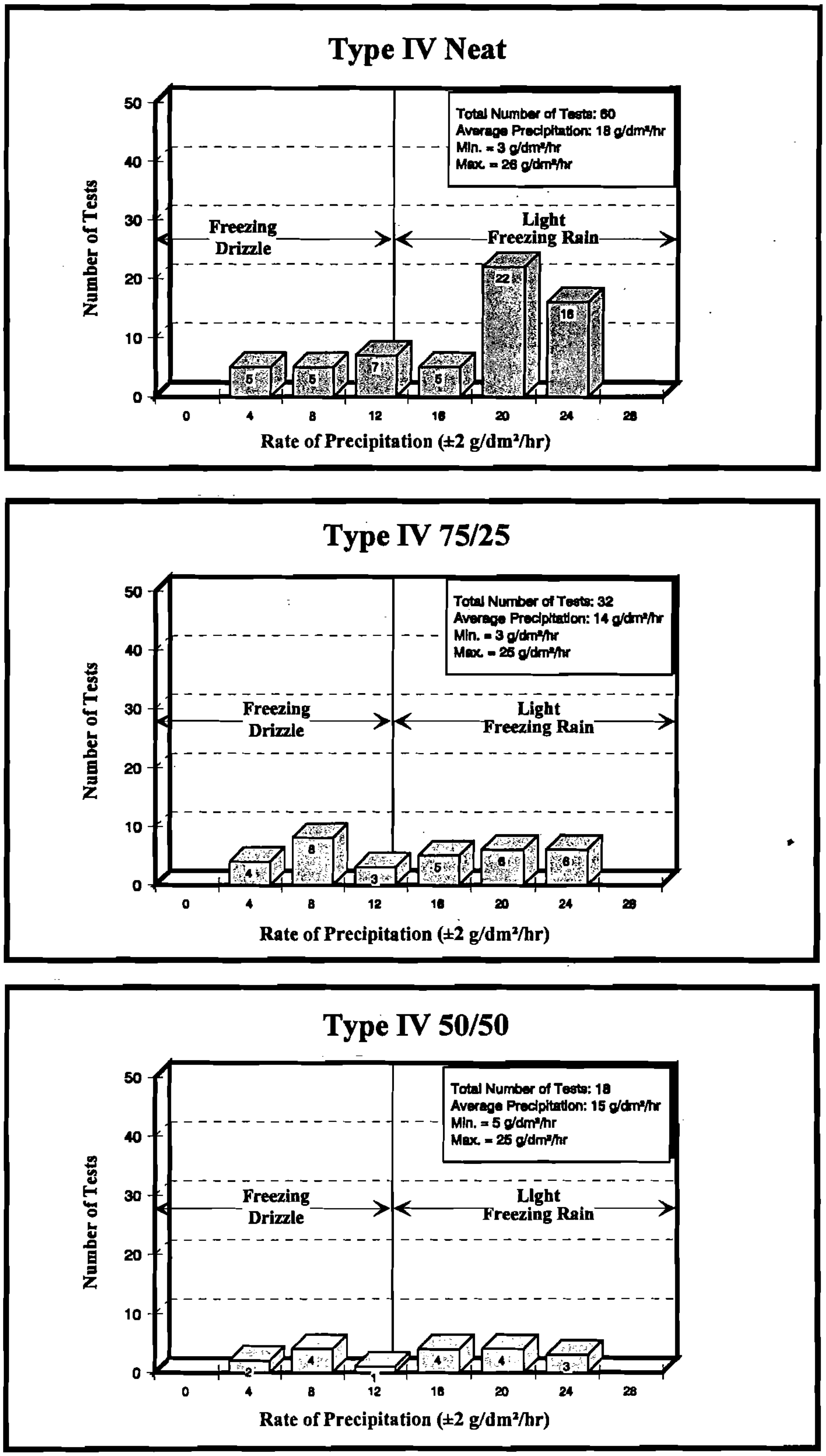
FIGURE 3.11

DISTRIBUTION OF PRECIPITATION RATE - TYPE IV FLUIDS

Simulated Freezing Drizzle/Light Freezing Rain Tests

1995-1996



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Precipitation rates for freezing drizzle were in the 2 to 13 g/dm^2/hr range, and for light freezing rain, in the 13 to 25 g/dm^2/hr range.

3.2.4 Distribution of Other Meteorological Conditions

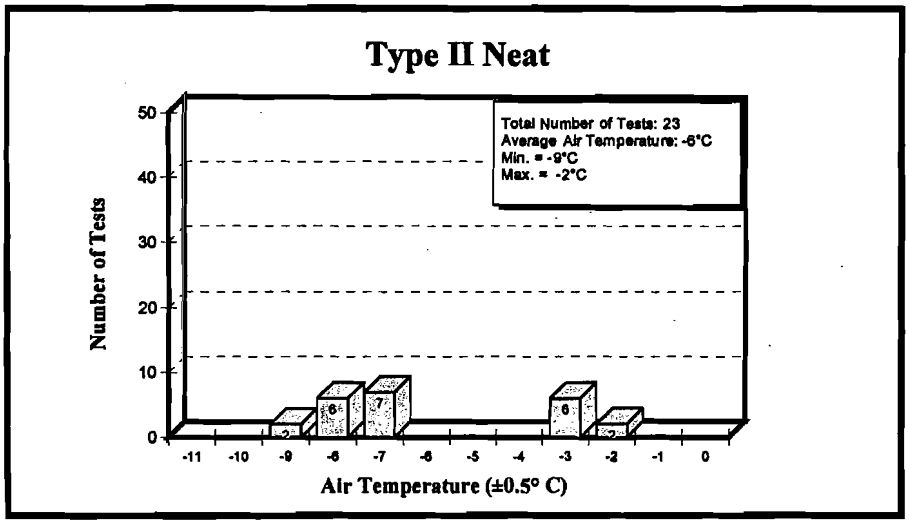
The only other meteorological factor which was varied during the freezing drizzle and light freezing rain tests was air temperature. The distribution of the air temperatures is presented in Figures 3.12 and 3.13, which show that the majority of the tests were conducted with air temperatures of -8°C or -9°C, and -2°C or -3°C. The few tests at -11°C and -7°C were conducted as part of the special tests requested by the SAE G-12 Committee.

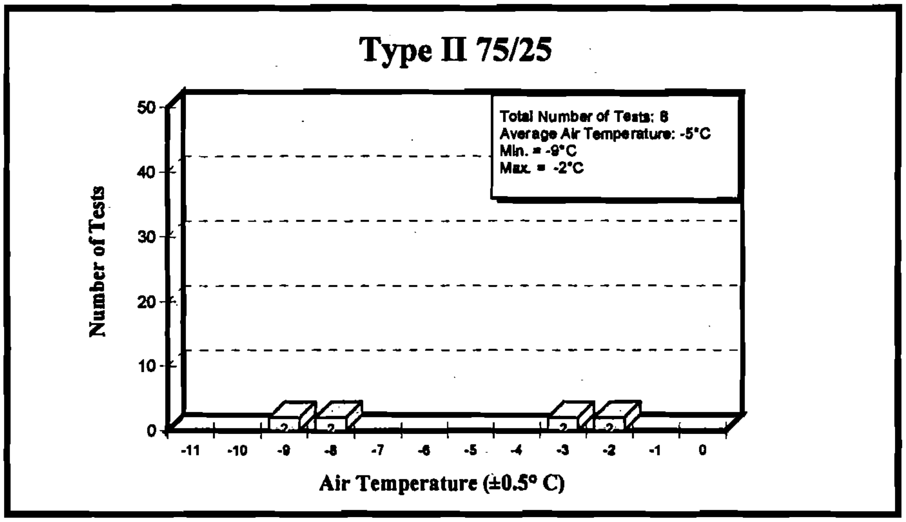
FIGURE 3.12

DISTRIBUTION OF AIR TEMPERATURE - TYPE II FLUIDS

Simulated Freezing Drizzle/Light Freezing Rain Tests

1995-1996





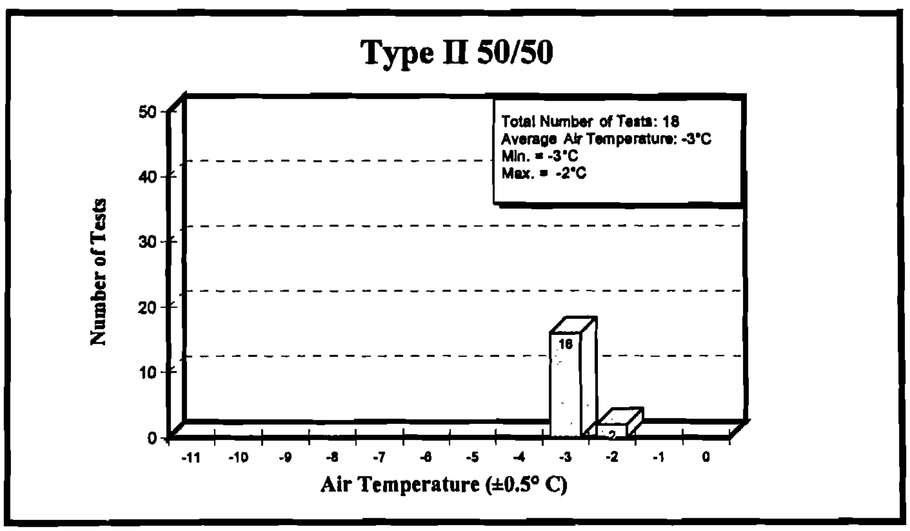


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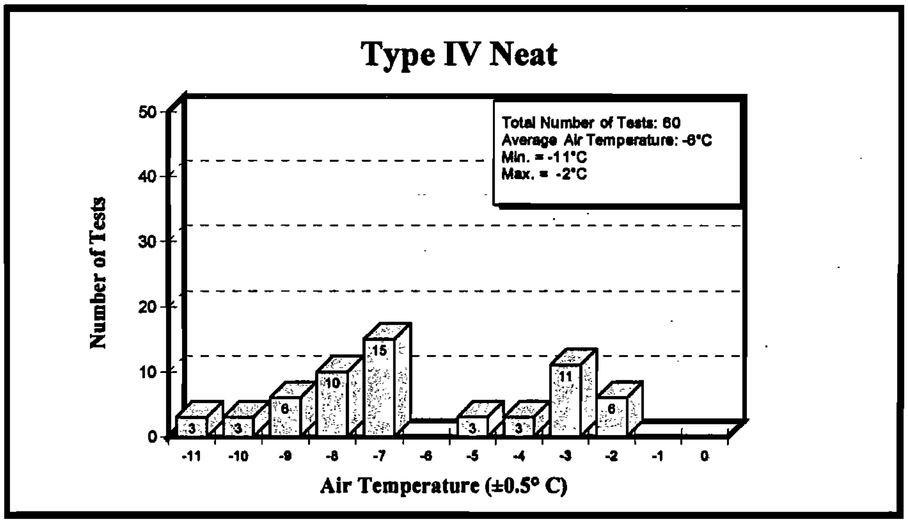
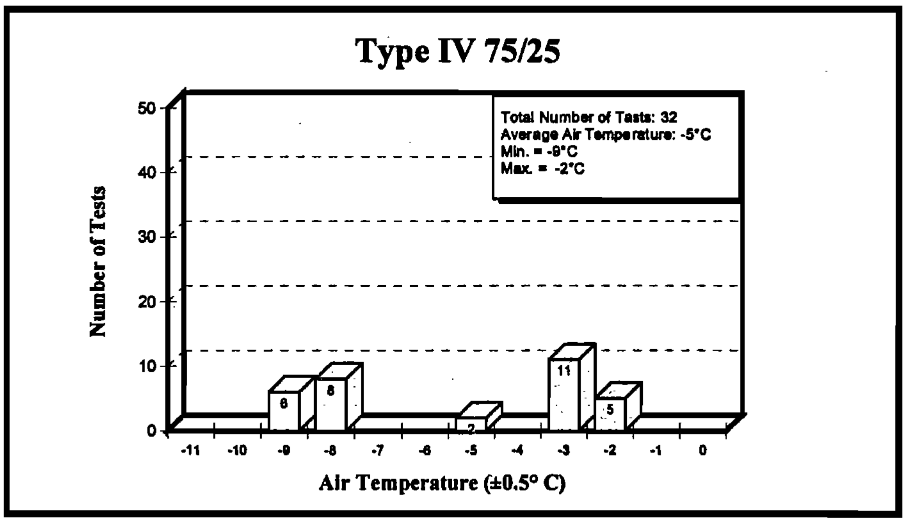
FIGURE 3.13

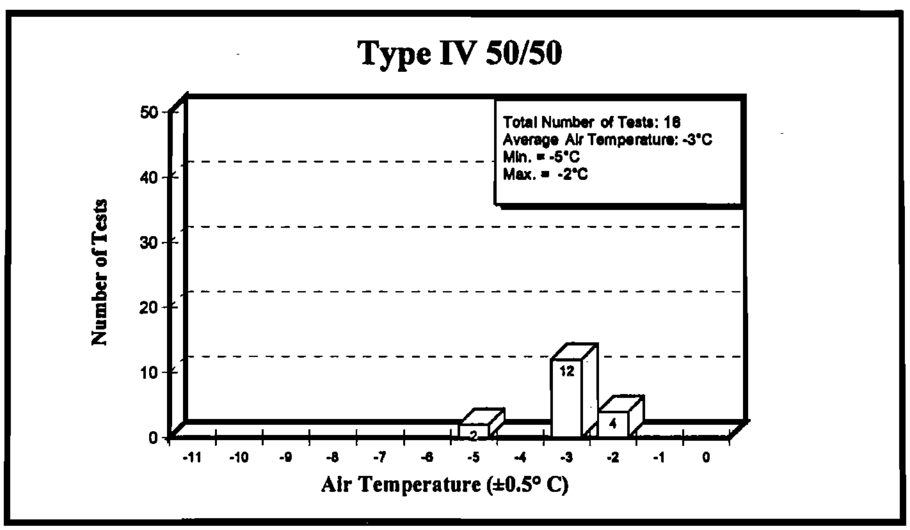
DISTRIBUTION OF AIR TEMPERATURE - TYPE IV FLUIDS

Simulated Freezing Drizzle/Light Freezing Rain Tests

1995-1996







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3.3 Simulated Freezing Fog Tests

3.3.1 Data Acquisition

A total of 82 tests were carried out under simulated freezing fog in the 1995/96 winter. The majority of these tests were performed using Type IV fluid (see Figure 3.14). Type II fluids were tested simultaneously to compare with previous winter tests. A few Type I fluid tests were conducted at low temperatures below -25°C.

3.3.2 Test Location and Fluids Tested

All of the tests were conducted at NRC's cold chamber in Ottawa. The Type IV fluids tested were:

- UCAR Ultra
- UCAR Ultra +
- Kilfrost ABC-4
- SPCA AD-404
- SPCA AD-460

3.3.3 Distribution of Average Precipitation Rates

The average precipitation rates for freezing fog were computed from weight measurements taken with plate pans. Pans were positioned on the stand at every plate position before and after each run for two 15-minute periods. The distribution of average precipitation rate measured for the tests is shown in Figure 3.15 for Type I fluid, Figure 3.16 for Type II fluid, and Figure 3.17 for Type IV fluid. Precipitation rates for freezing fog ranged from 1 to 10 g/dm^2/hr.

3.3.4 Distribution of Tests by Air Temperature

The other condition which was varied during the freezing fog tests was the temperature. The distribution of temperatures is presented in Figures 3.18, 3.19, and

3.20, for Type I, Type II and Type IV fluids. For Type II 50/50 and Type IV 50/50 fluid, tests were conducted at approximately -3°C. For Type II 75/25 and Type IV 75/25, tests were conducted at approximately -3°C and -14°C. For Type II Neat and Type IV Neat fluid, tests were conducted at approximately -3°C, -14°C, and below -22°C.

FIGURE 3.14

NUMBER OF SIMULATED FREEZING FOG TESTS

1995-1996 TEST SEASON

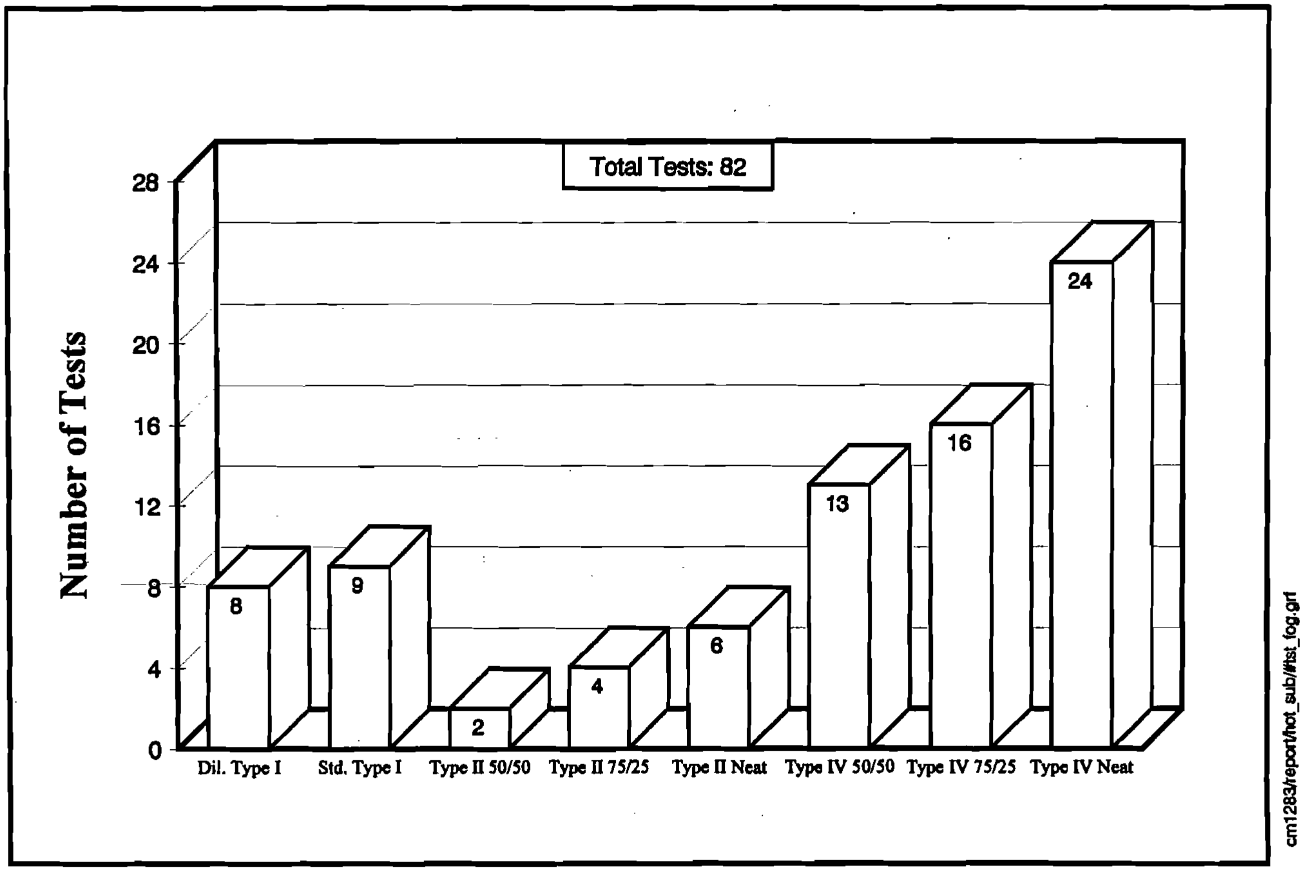
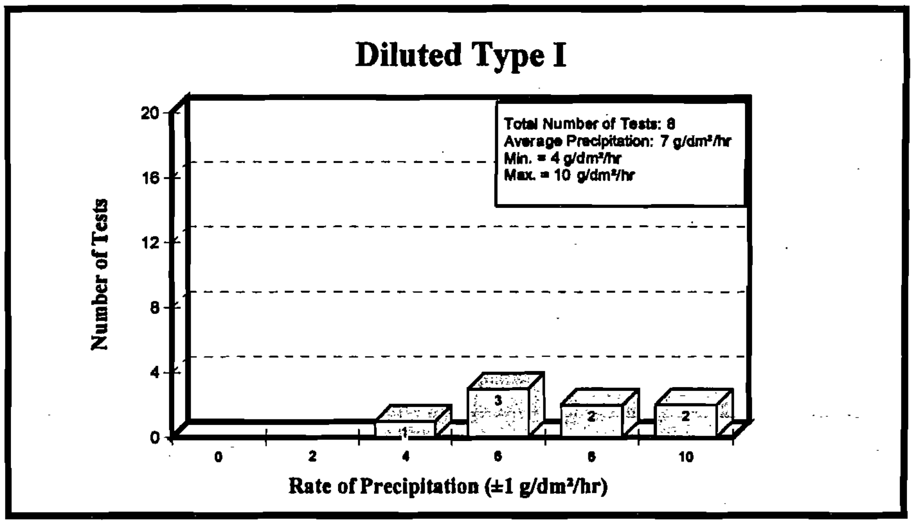


FIGURE 3.15

DISTRIBUTION OF PRECIPITATION RATE - TYPE I FLUIDS

Simulated Freezing Fog Tests
1995-1996



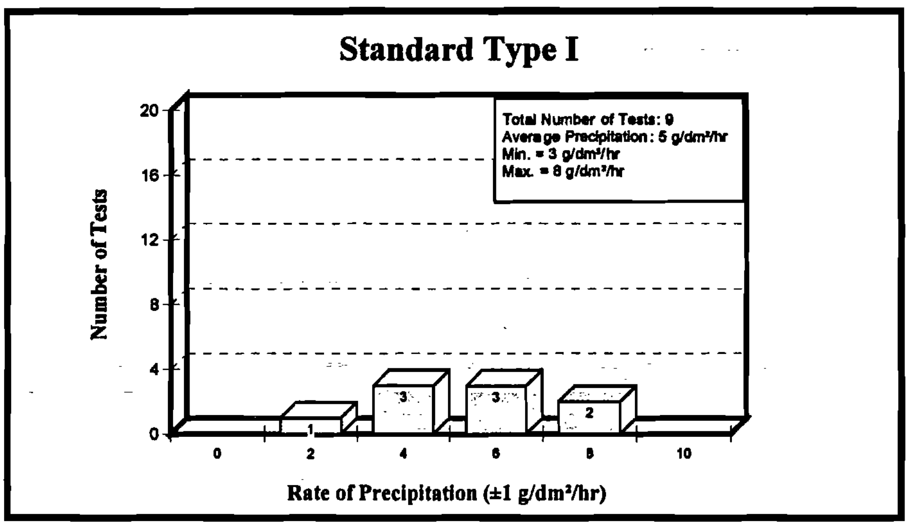


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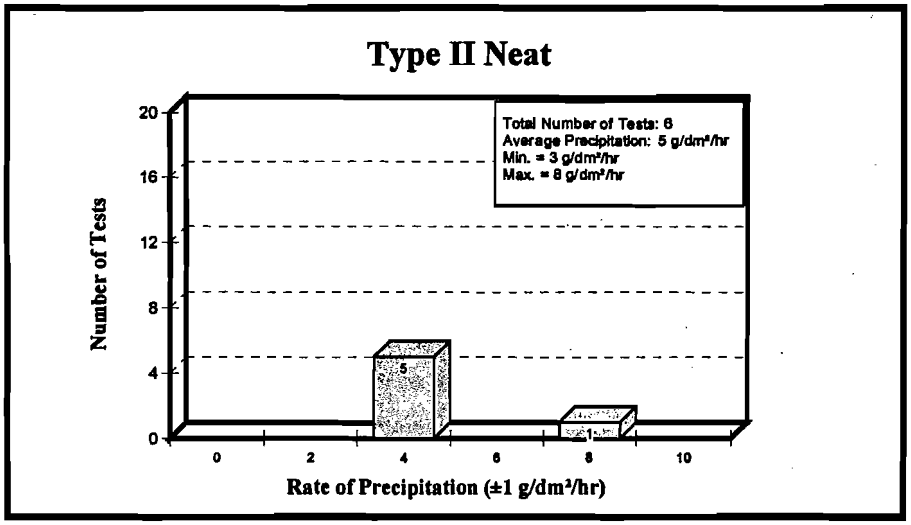
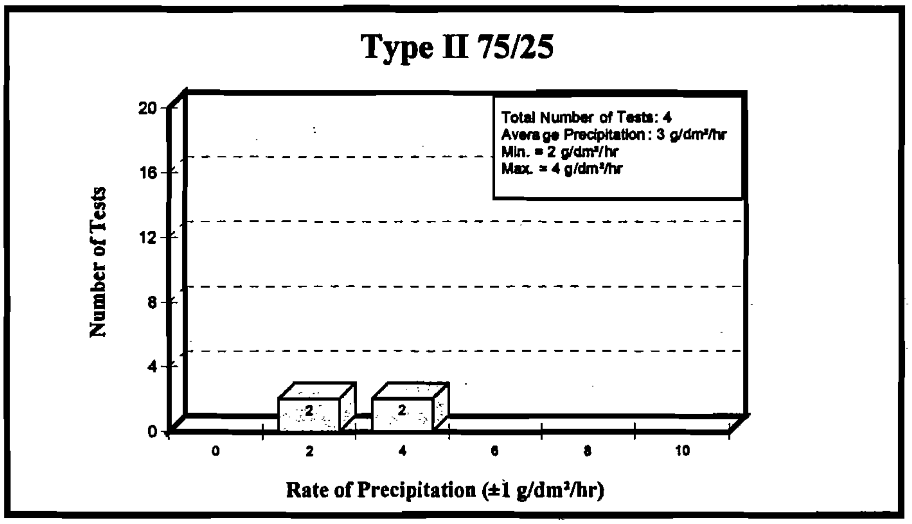
FIGURE 3.16

DISTRIBUTION OF PRECIPITATION RATE - TYPE II FLUIDS

Simulated Freezing Fog Tests

1995-1996





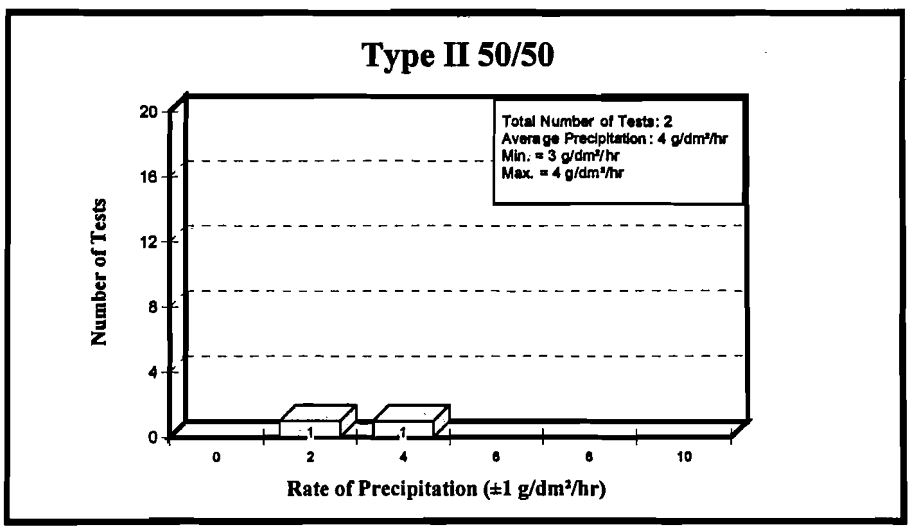


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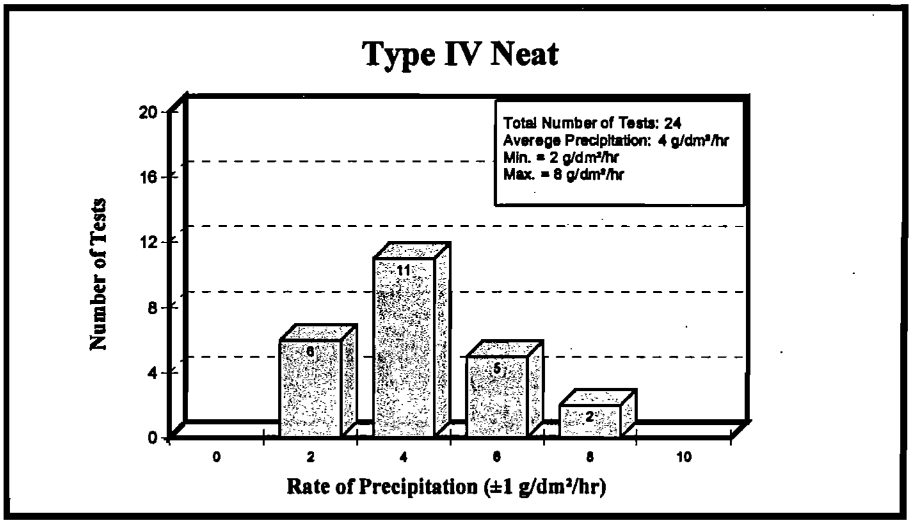
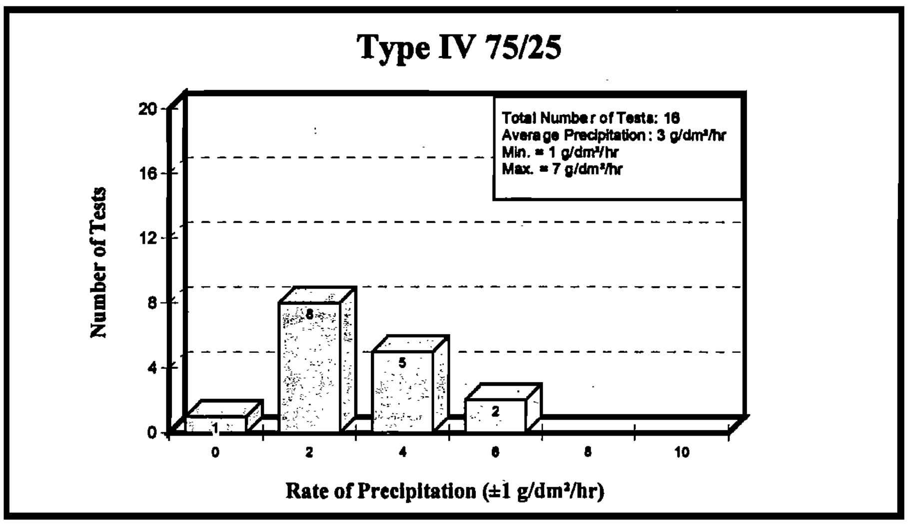
FIGURE 3.17

DISTRIBUTION OF PRECIPITATION RATE - TYPE IV FLUIDS

Simulated Freezing Fog Tests

1995-1996





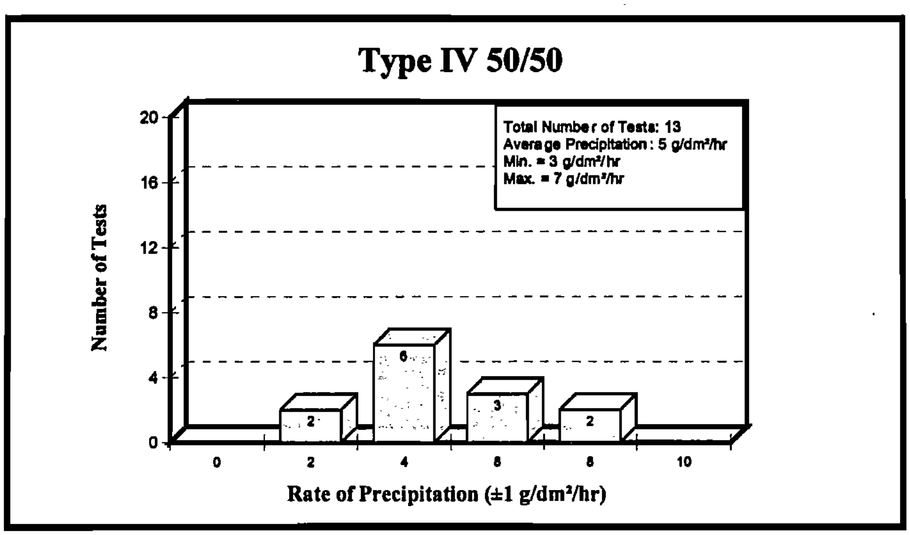


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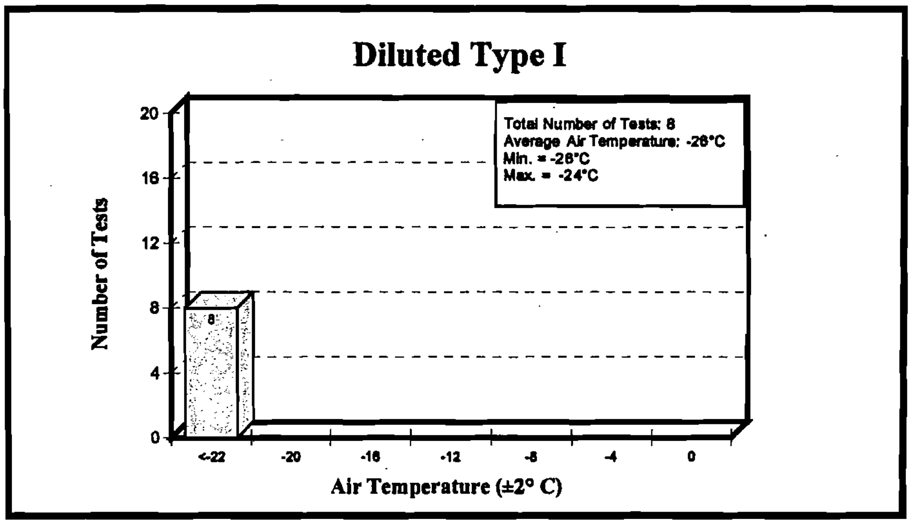
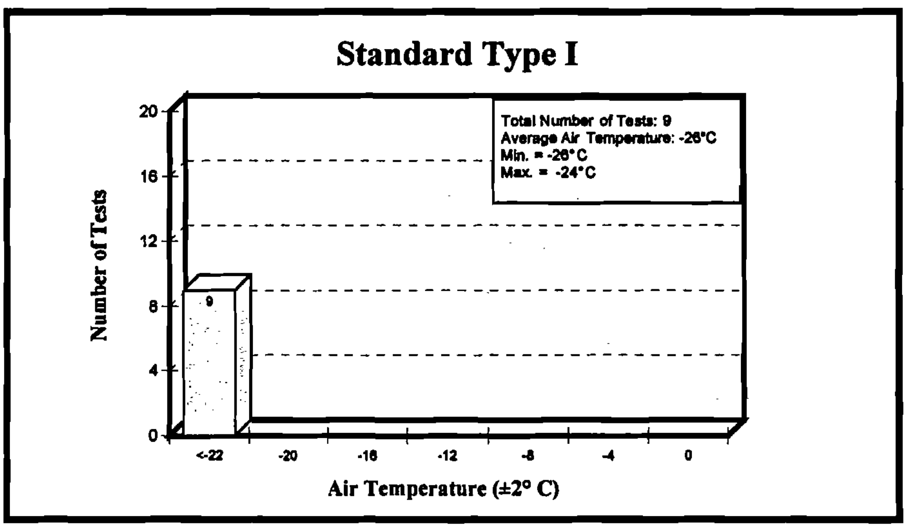
FIGURE 3.18

DISTRIBUTION OF AIR TEMPERATURE - TYPE I FLUIDS

Simulated Freezing Fog Tests
1995-1996





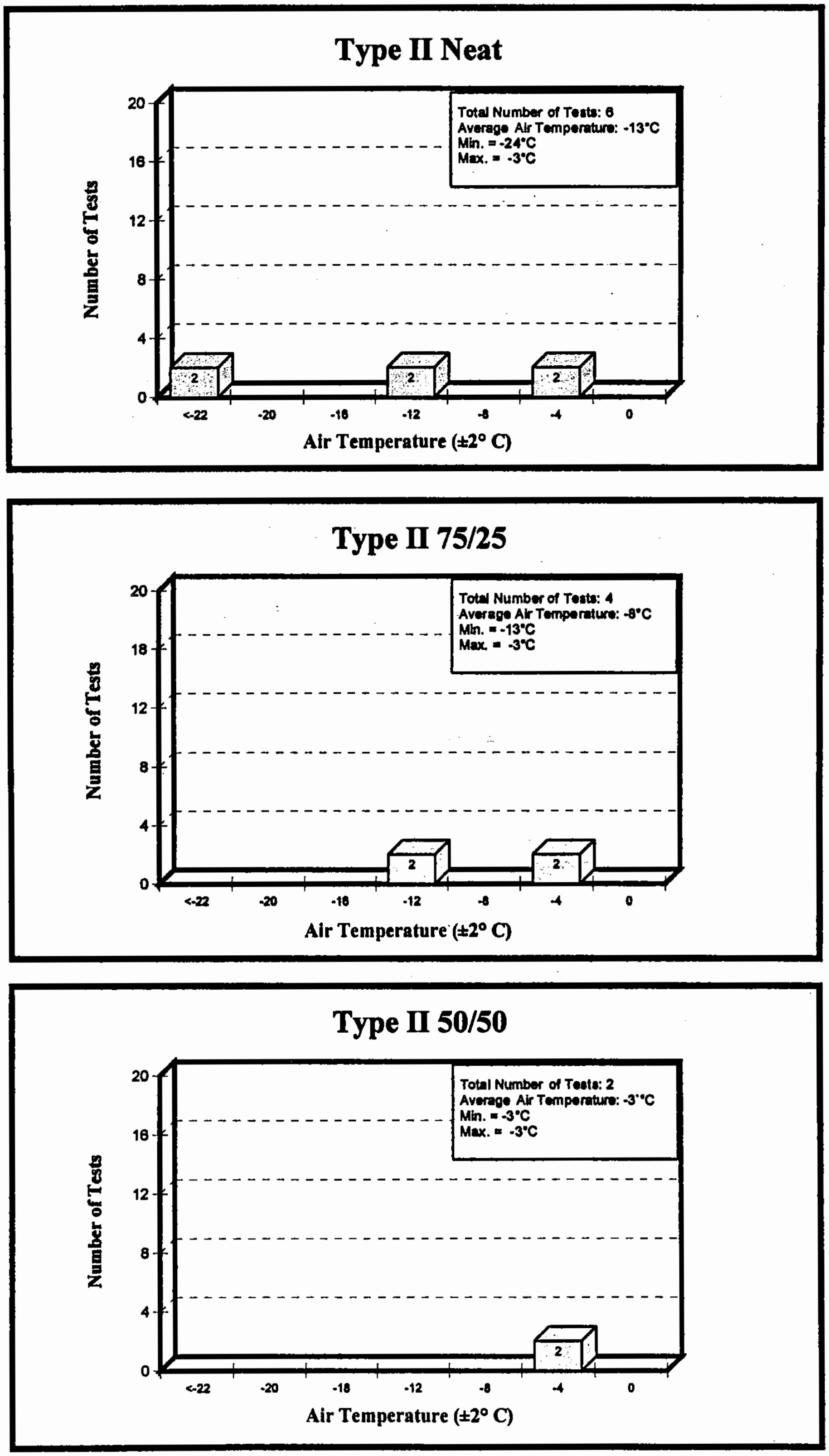
cm1283\report\hot_sub\dtem_fg1.grf

FIGURE 3.19

DISTRIBUTION OF AIR TEMPERATURE - TYPE II FLUIDS

Simulated Freezing Fog Tests

1995-1996



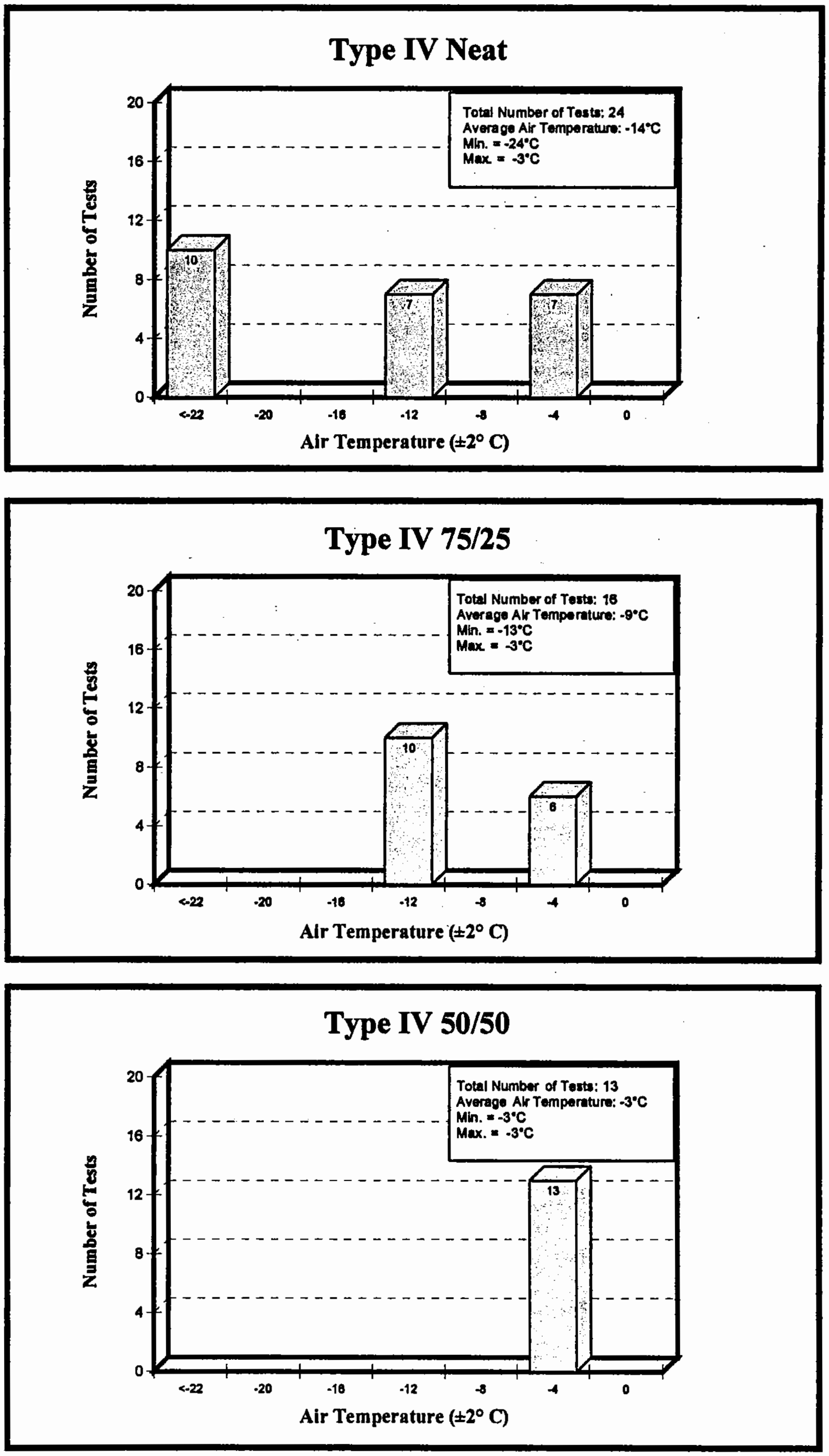
cm1283\report\hot_sub\dtem_fg2.grf

FIGURE 3.20

DISTRIBUTION OF AIR TEMPERATURE - TYPE IV FLUIDS

Simulated Freezing Fog Tests

1995-1996



cm1283\report\hot_sub\dtem_fg4.grf

3.4 Simulated Rain on Cold-Soaked Surface Tests

3.4.1 Data Acquisition

A total of 115 cold-soaked tests using sealed boxes were conducted during the 1995/96 test season. The breakdown of tests, by size of sealed box and by fluid type, is shown in Figure 3.21. Tests with Type II 50/50 and Type IV 50/50 fluid were not carried out because these fluids were removed from the holdover time tables because of their limited holdover time capabilities.

3.4.2 Test Location and Fluids Tested

All 115 tests were completed at NRC's cold chamber in Ottawa. The Type IV fluids tested were UCAR Ultra +, SPCA AD-404, and Hoechst MPIV 1957. Type II fluids tested were Octagon 40 below and Kilfrost ABC-3; Type I fluids were provided by Hoechst, UCAR and Octagon.

3.4.3 Distribution of Average Precipitation Rates

Precipitation for the drizzle and light rain on cold-soaked surface tests was produced using the same apparatus as was used for freezing drizzle and light freezing rain tests. Moderate rain and heavy rain precipitation was also produced using the same apparatus, but with different hypodermic needles and water/air pressures. The distribution of tests conducted as a function of the quantity of precipitation is shown in Figure 3.22 for Type I fluid, in Figure 3.23 for Type II fluid, and Figure 3.24 for Type IV fluid.

Only a limited number of tests were carried out during heavy rain with precipitation rates exceeding 75 g/dm^2/hr. In practice, fluid applied on a wing in this condition would probably be washed away quickly.

FIGURE 3.21
NUMBER OF COLD-SOAKED TESTS
1995-1996 TEST SEASON

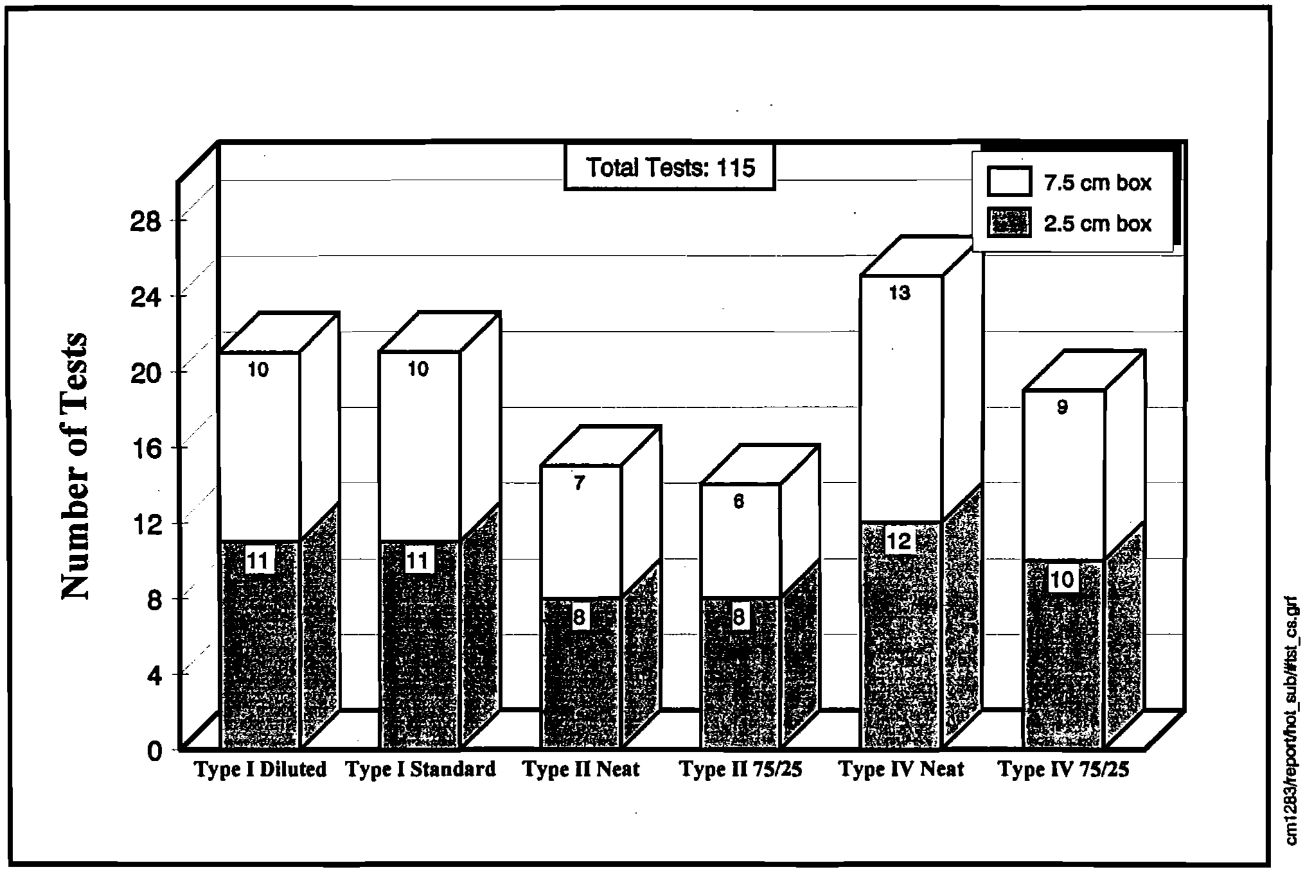
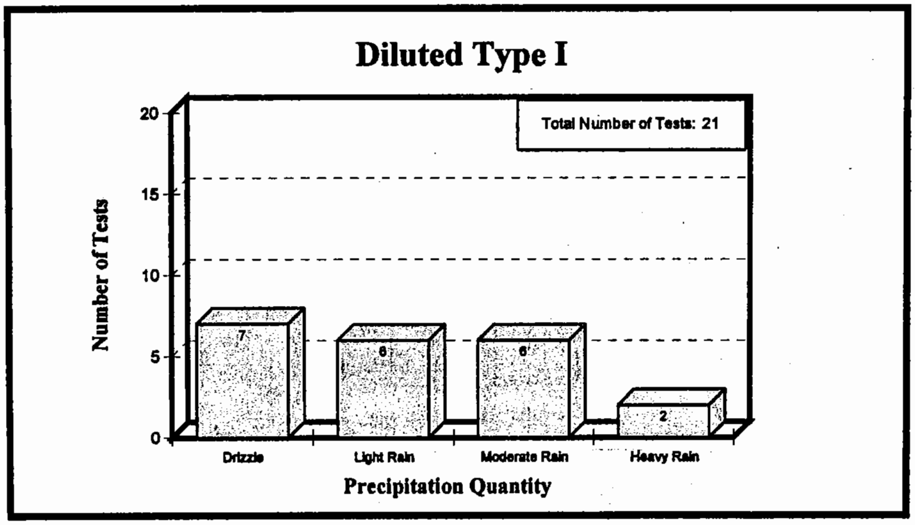


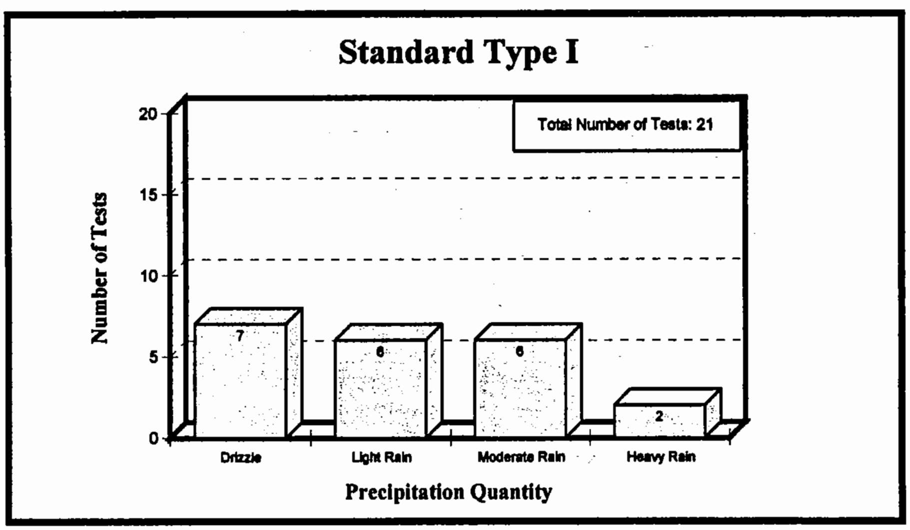
FIGURE 3.22

DISTRIBUTION OF PRECIPITATION RATE - TYPE I FLUIDS

Cold-Soaked Box Tests

1995-1996





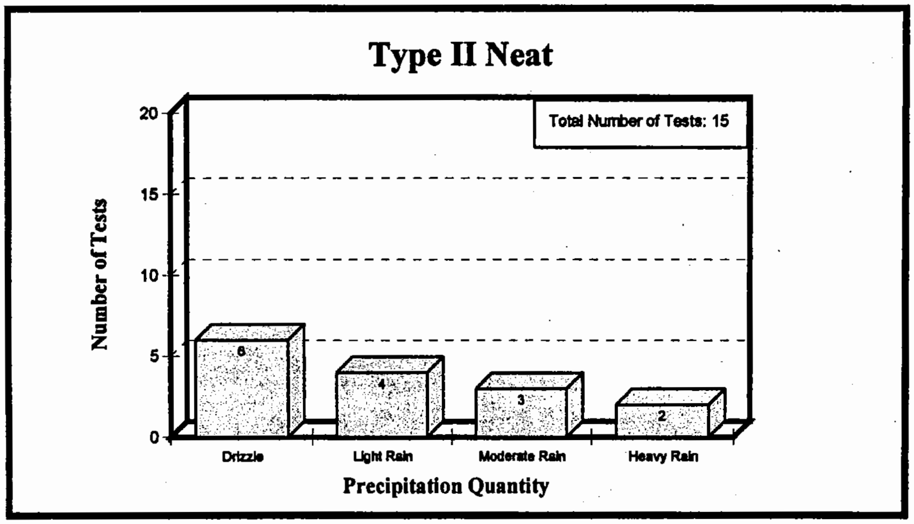
cm1283\report\hot_sub\dpre_bx1.grf

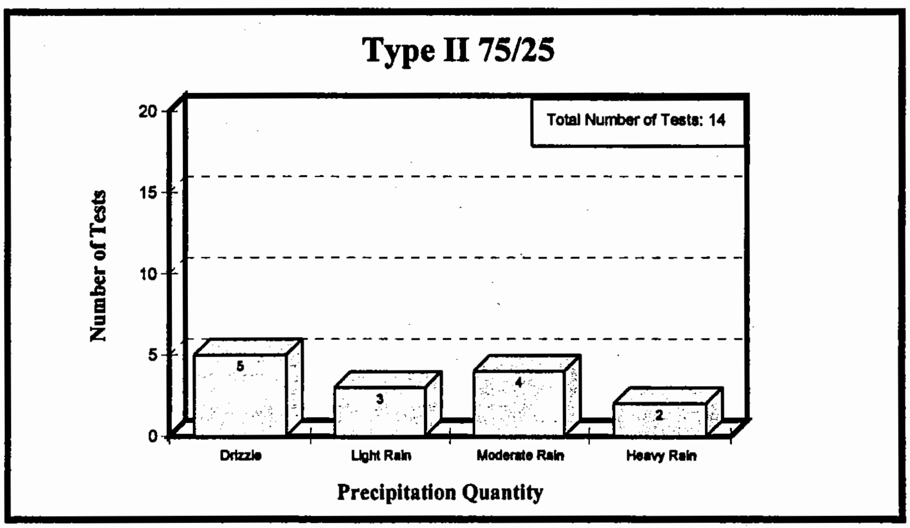
FIGURE 3.23

DISTRIBUTION OF PRECIPITATION RATE - TYPE II FLUIDS

Cold-Soaked Box Tests

1995-1996





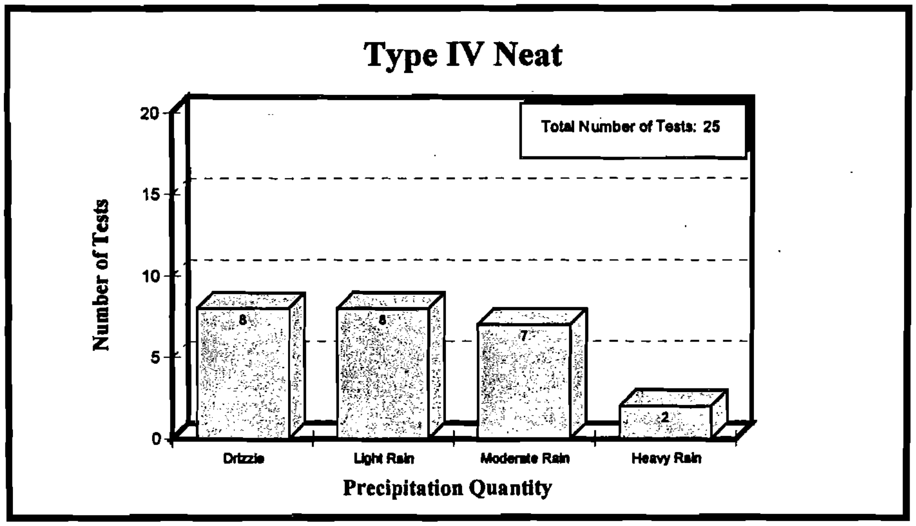
cm1283\report\hot_sub\dpre_bx2.grf

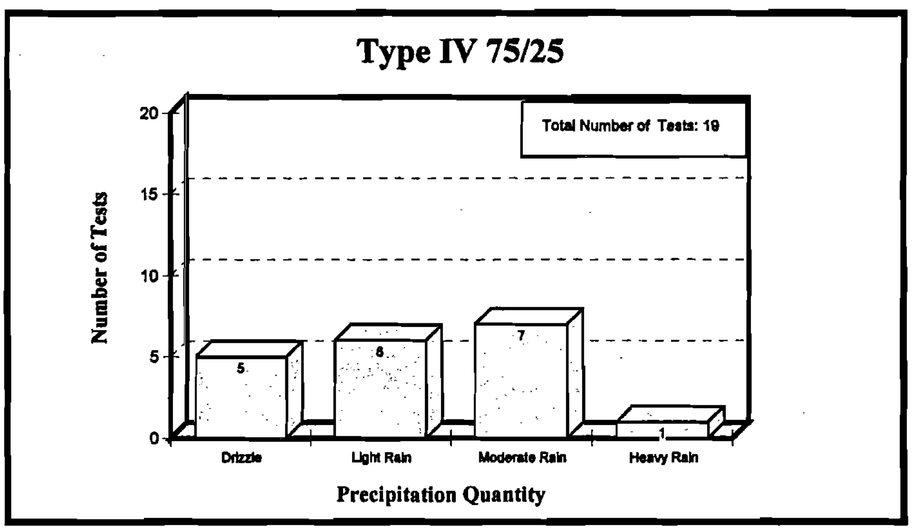
FIGURE 3.24

DISTRIBUTION OF PRECIPITATION RATE - TYPE IV FLUIDS

Cold-Soaked Box Tests

1995-1996





cm1283\report\hot_sub\pre_bx4.grf

3.4.4 Distribution of Tests by Average Surface Skin Temperature

The ambient air temperature was set to +2°C during the rain on cold-soaked surface tests. The temperature on the test surface (sealed box) was measured with either a thermistor sensor or a hand-held surface temperature probe. The instrument was positioned above a crosshair marking located 22.5 cm (9") from the top of the test surface (see Appendix C, Attachment IX). Most tests were started when the test surface temperature was -10°C. Several Type I fluid tests were started when the test surface was -5°C. To get the average temperature over a test, the final surface temperature was also measured at the completion of the test.

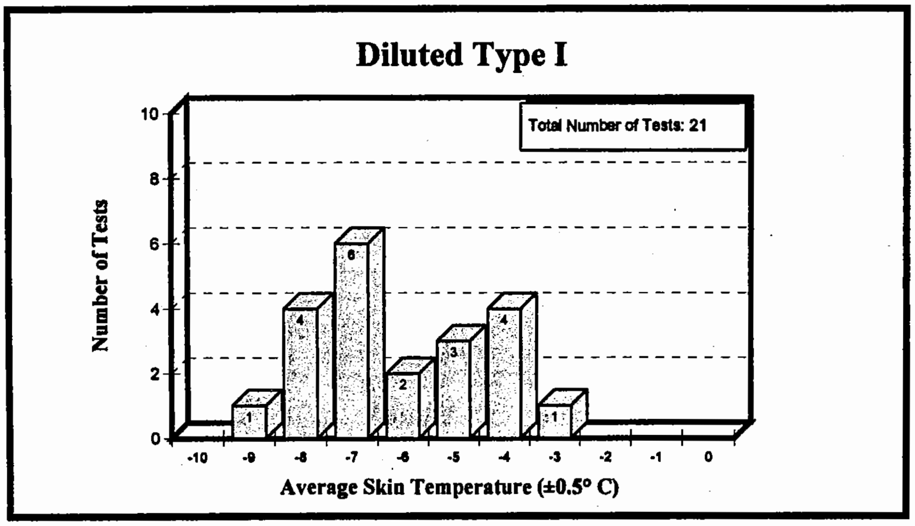
Figure 3.25 gives the number of Type I fluid tests conducted as a function of average test surface skin temperature. The number of Type II and Type IV fluid tests conducted as a function of average surface temperature are provided in Figures 3.26 and 3.27, respectively.

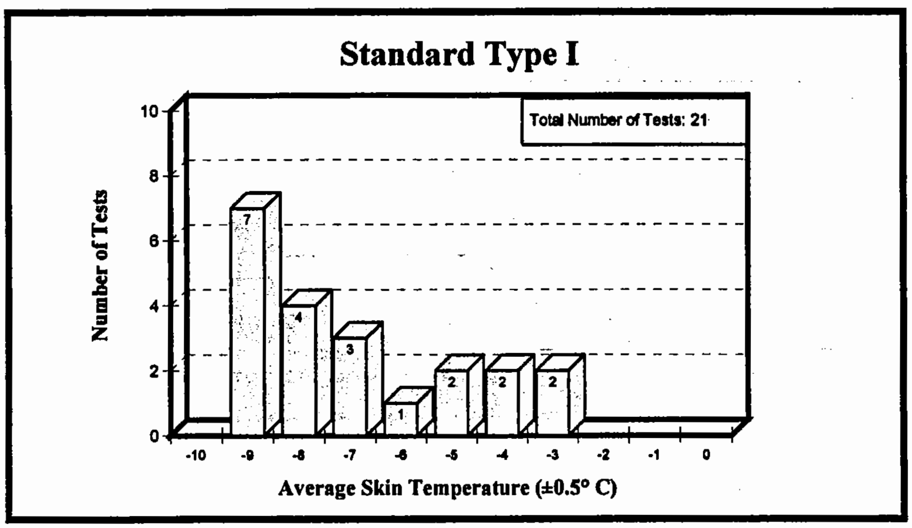
FIGURE 3.25

DISTRIBUTION OF SKIN TEMPERATURE - TYPE I FLUIDS

Cold-Soaked Box Tests

1995-1996





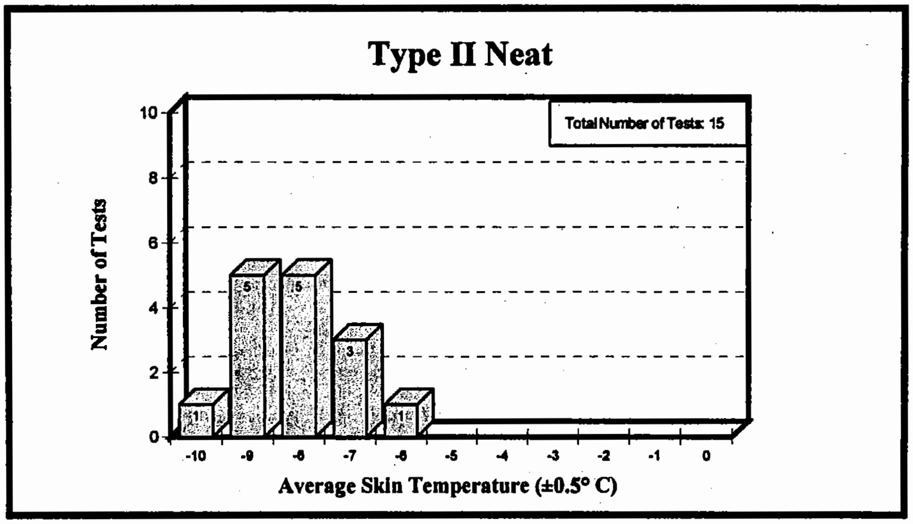
cm1283\report\hot_sub\tem_bx1.grf

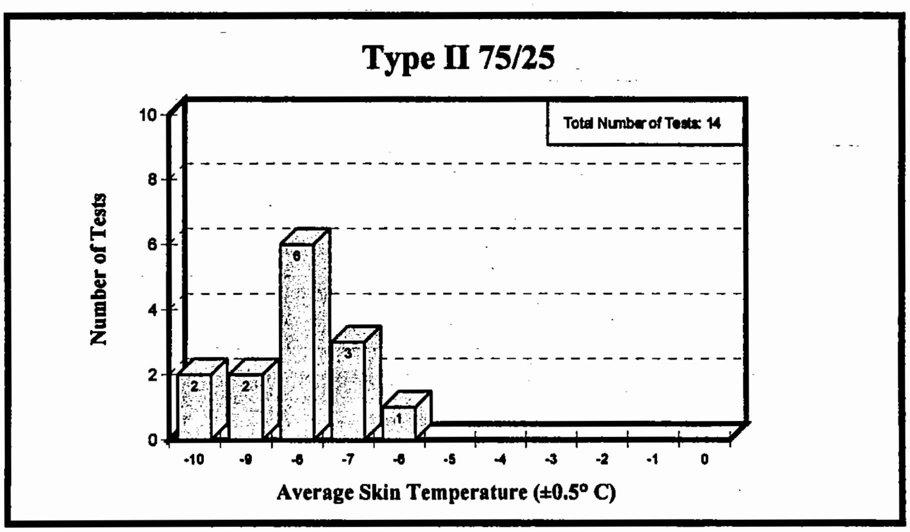
FIGURE 3.26

DISTRIBUTION OF SKIN TEMPERATURE - TYPE II FLUIDS

Cold-Soaked Box Tests

1995-1996





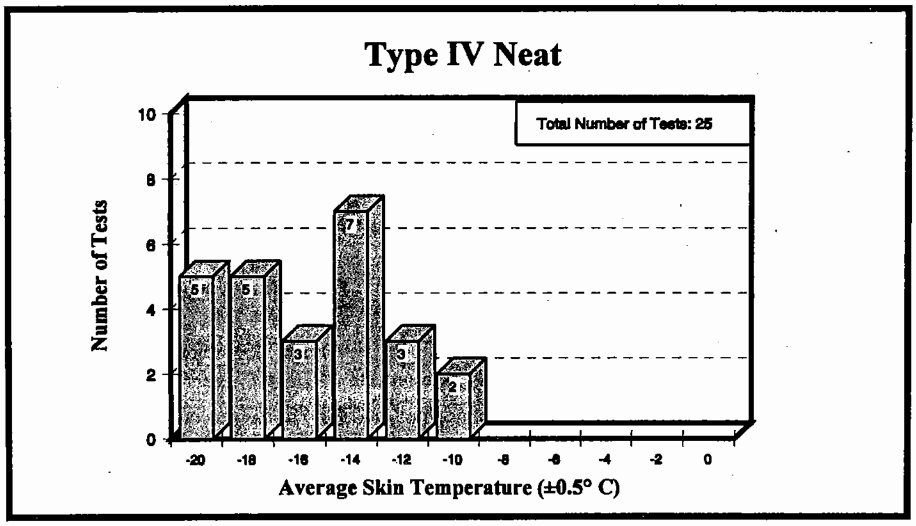
cm1283\report\hot_sub\dtem_bx2.grf

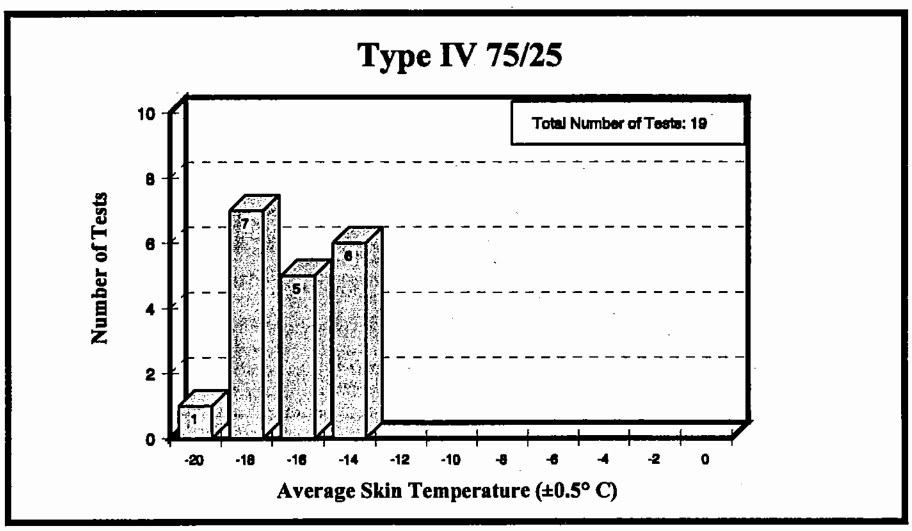
FIGURE 3.27

DISTRIBUTION OF SKIN TEMPERATURE - TYPE IV FLUIDS

Cold-Soaked Box Tests

1995-1996





cm1283\report\hot_sub\dtem_bx4.grf

4. METEOROLOGICAL ANALYSIS

The following sub-sections examine meteorological instruments including precipitation collection devices, and provide a comparison of the Dorval site equipment with that of Environment Canada's AES equipment. Data collection during 1995/96 at the AES site were automated. It is referred to as Remote Environmental Automatic Data Acquisition Concept (READAC).

4.1 Precipitation Collection Devices at Dorval

The measurement of precipitation in previous winters was made using a European ombrometer, plate pans, and collection devices used by the City of Montreal. For the 1994/95 and 1995/96 winter season, Environment Canada had available a shielded collection device (see Photo 2.13) which was part of the READAC station, and was similar to the instruments used by the City of Montreal. Previous analysis has shown that the amount of precipitation collected with the plate pans correlated well with the shielded gauges.

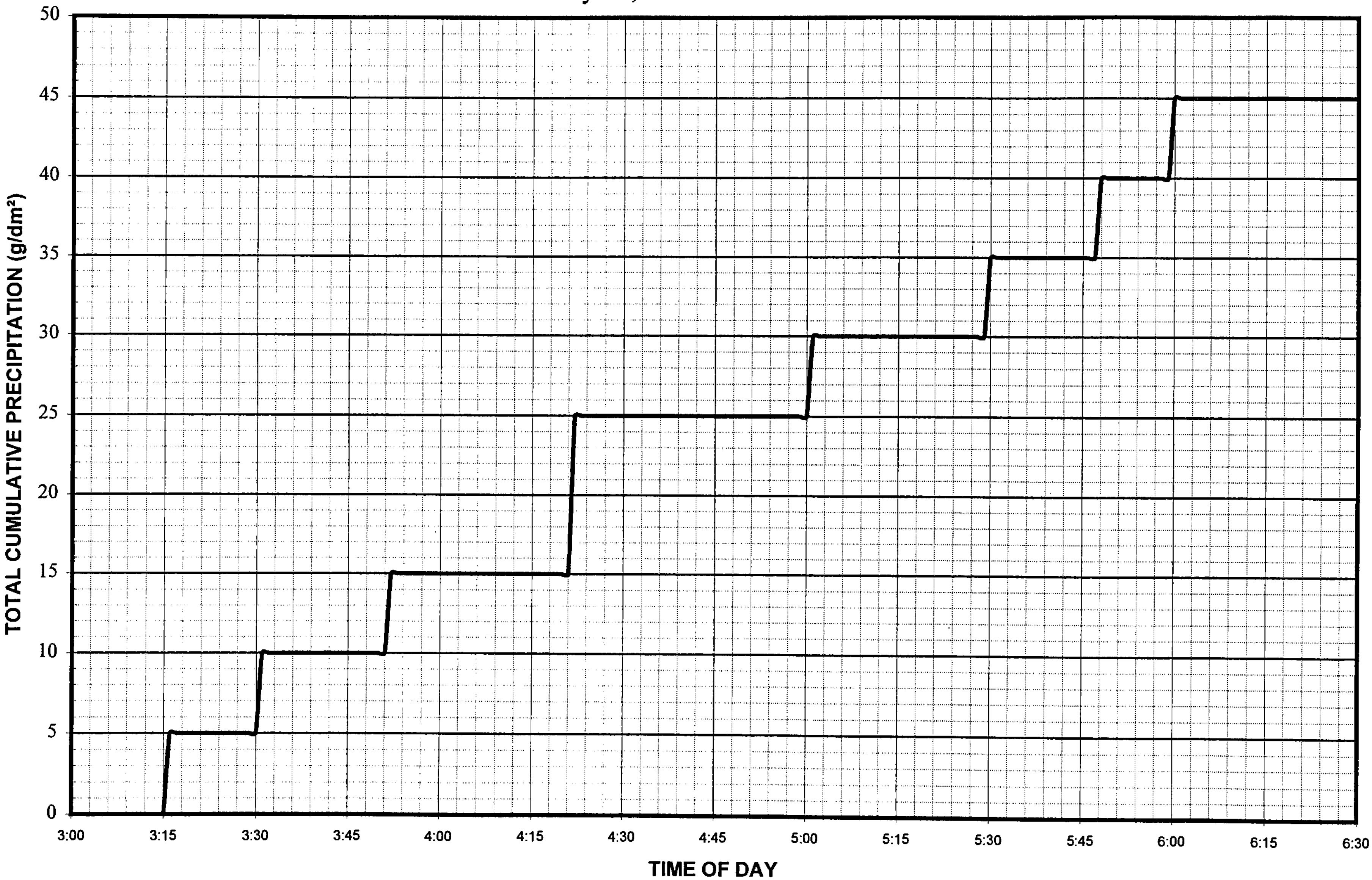
Measurement of amount of precipitation with plate pans which are mounted beside the plates and at the same angle as the plates, provides the most accurate measurements of precipitation on the plates. Therefore, plate pans have been utilized for all tests, including indoor testing at NRC. All the charts included in Section 5 of this report are based on precipitation rates computed from measurements taken with plate pans. Data from the READAC precipitation gauge and the new ETI gauge were used when available to examine outlying test points.

Figure 4.1 shows a typical plot of total cumulative precipitation as function of time from the READAC precipitation gauge installed at Dorval. The measurements shown in Figure 4.1 are from February 11, 1996 while tests on both stands were in progress. The sensitivity of the instrument was changed in 1995/96 by AES to 5 g/dm^2 from 1 g/dm^2 and measurements of cumulative precipitation were recorded every minute.

FIGURE 4.1

READAC PRECIPITATION GAUGE
TOTAL CUMULATIVE PRECIPITATION AT DORVAL

Feburary 11, 1996 - Forms 92 to 97



g:/cm1283/report/hot_subs/Ratfeb11
At: READAC
Printed: 1/8/98

The chart shows that noise from the readings, which was present when the instrument sensitivity was 1 g/dm^2, is non-existent with the 5 g/dm^2 sensitivity. While the noise is reduced, the new sensitivity may not pick up a five-minute snow squall of 50 g/dm^2/hr because this would only provide a total precipitation of 4.2 g/dm^2. For Type I fluids, this system may not be appropriate; however, it may be satisfactory for the longer lasting Type IV fluids.

Figure 4.2 shows a typical plot of the total cumulative precipitation as a function of time from the ETI precipitation gauge installed at Dorval. These measurements are from the same snowfall on February 11, 1996. The sensitivity of the ETI instrument is 2.5 g/dm^2 and measurements are registered every 10 seconds.

Based upon Table 3.1, Figure 4.1 and Figure 4.2, the total precipitation recorded for February 11, 1996 was as follows:

- Official AES measure 9.4 cm
- READAC gauge (for test period) 45 g/dm^2
- READAC gauge (for day) 60 g/dm^2
- ETI gauge (for test period) 40 g/dm^2
- ETI gauge (for day) 55 g/dm^2

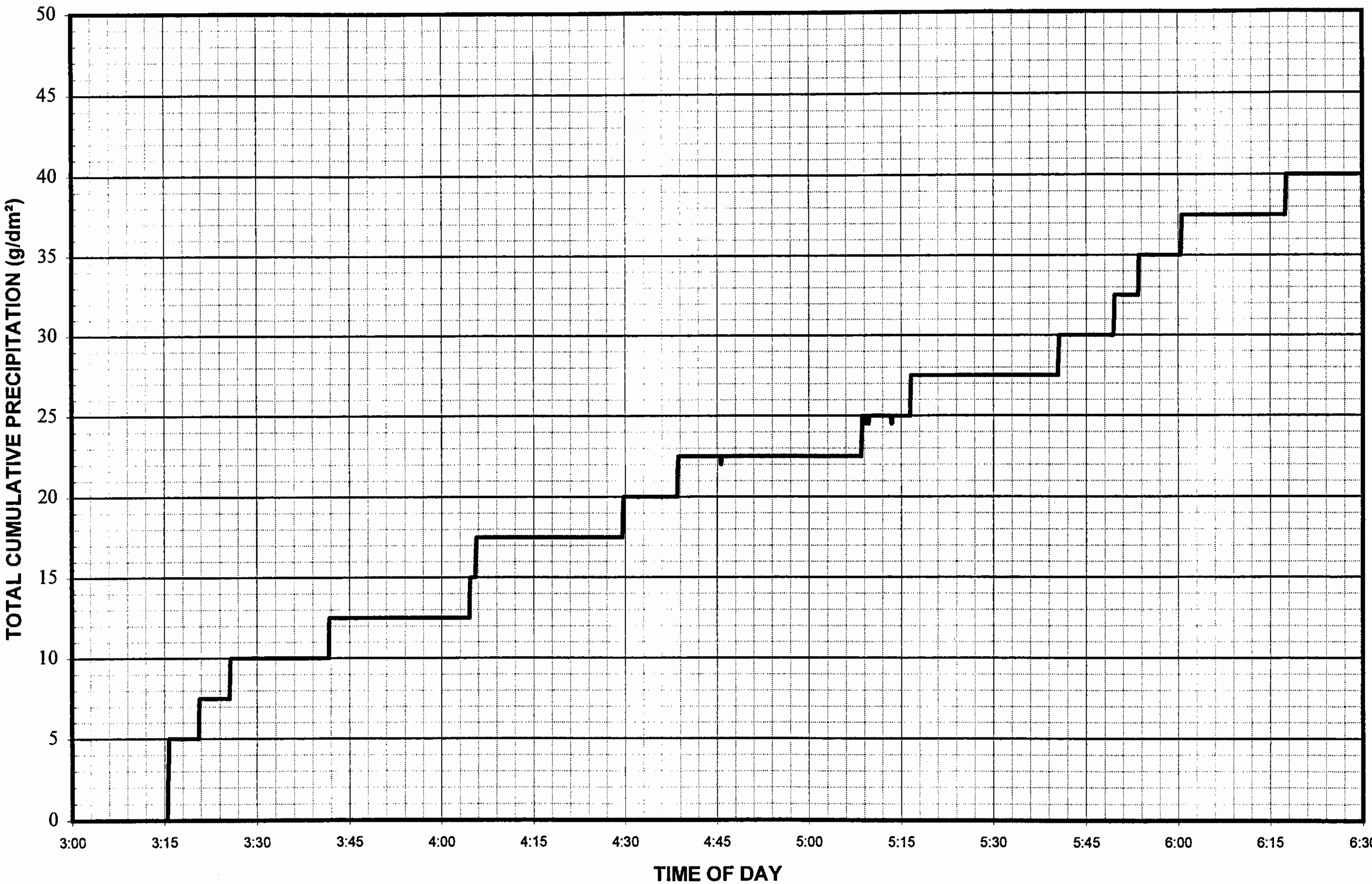
This shows that the two instruments provided similar measurements for the day. Closer examination of Figure 4.1 and Figure 4.2 shows that, for shorter time intervals, the precipitation rates could be significantly different.

The general rule of thumb is that 10 g/dm^2 results in 1 cm of snow. The fact that the total precipitation recorded by AES was 9.4 cm (about 3 to 4 cm more than would be expected) indicated that the snow was probably dry and less dense than the norm.

FIGURE 4.2

ETI PRECIPITATION GAUGE
TOTAL CUMULATIVE PRECIPITATION AT DORVAL

February 11, 1996 - Forms 92 to 97



g:/cm1283/report/hot_subs/Ratfeb11
At: ETI GAUGE
Printed: 1/8/98

4.2 Visibility Versus Rate of Precipitation

The methods used to measure precipitation rate included plate pans, the READAC precipitation gauge, and ETI precipitation gauge.

Plate Pan Method. The rate of precipitation is taken directly from the mass of snow accumulated in each pan (two per test stand) during a fluid test. On each stand, both plate pans are allowed to collect snow for a 15-minute interval. The mass of snow is measured from each pan and the total snow mass from both pans is calculated.

The plate pan data acceptance criterion was set so the difference in snow mass between individual plate pan measurements was less than 10% of the sum of snow collected in both pans on one test stand:

$m_{1\ snow}$	=	(mass plate pan 1 + snow) - mass plate pan 1
$m_{2\ snow}$	=	(mass plate pan 2 + snow) - mass plate pan 2
Difference	=	absolute value ($m_{1\ snow}$ - $m_{2\ snow}$)
Total	=	$m_{1\ snow} + m_{2\ snow}$
Acceptance Criteria	=	(Difference/Total) < 0.10

READAC Precipitation Gauge. The READAC precipitation rate was computed by dividing the precipitation between jumps (5 g/dm^2) by the time elapsed to the next jump (see Figure 4.1).

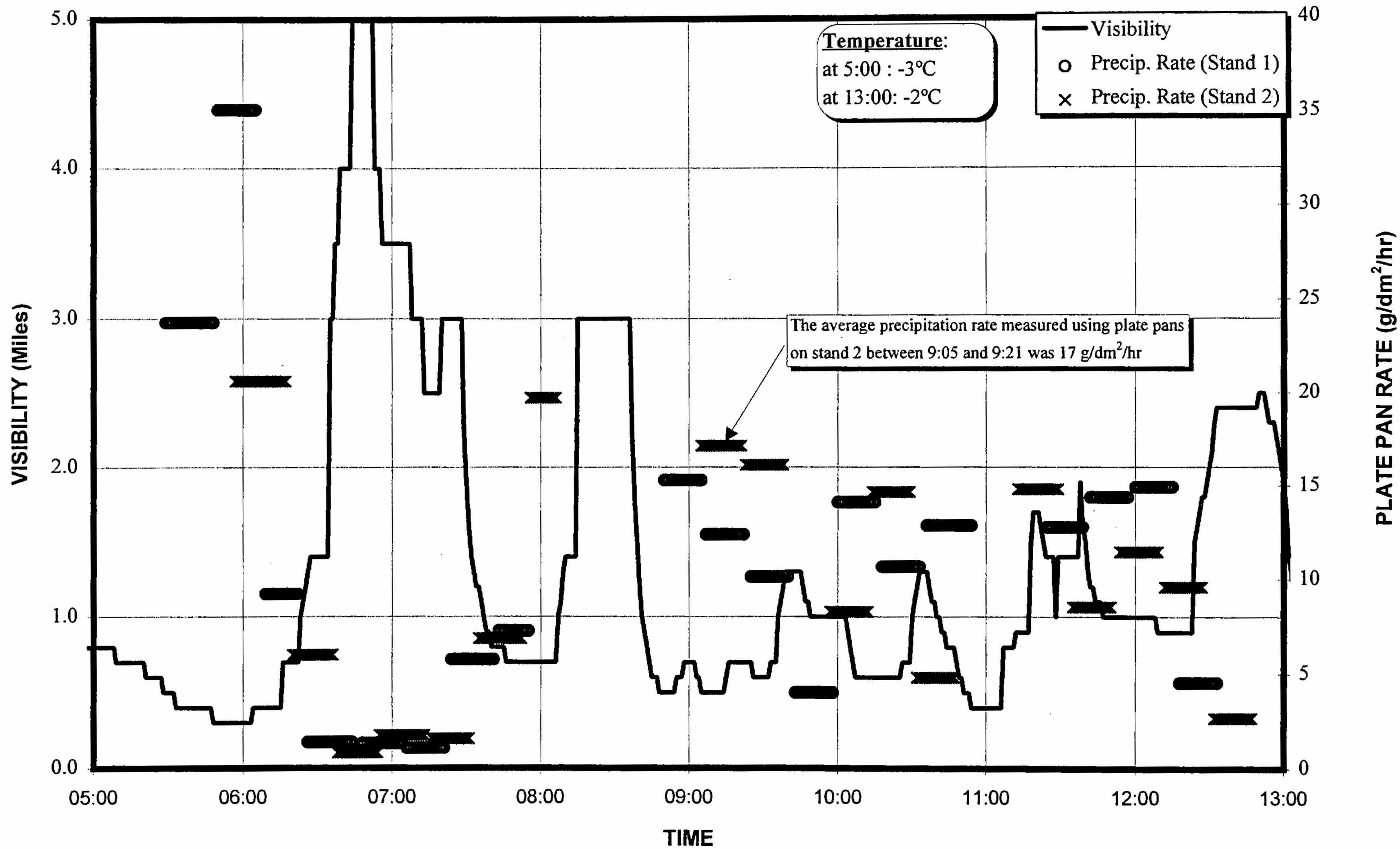
ETI Precipitation Gauge. The ETI precipitation rate was computed by dividing the precipitation collected between jumps (2.5 g/dm^2) by the time elapsed to the next jump (see Figure 4.2).

In Figure 4.3, both **visibility** (in miles) from the READAC instrumentation and **rate of precipitation** (in g/dm^2/hr) from the plate pan measurements are plotted versus time (in hours) from data acquired during one APS test session. The heavy horizontal markings (see

FIGURE 4.3

READAC VISIBILITY AND RATE OF PRECIPITATION VERSUS TIME

DECEMBER 01, 1995



File:g:\cm1283\reoport\hot_subs\VIS_D01.XLS
At: vis_vs_time
Printed: 28/02/97

legend) refer to the precipitation rates measured using the plate pan method for pans mounted on each of two flat plate test stands. The oval-shaped markings represent precipitation rates measured on test stand 1; the other markings refer to precipitation rates measured on test stand 2. The READAC visibility is given by the continuous line extending over the full abscissa range. For most of the test period, the visibility is inversely proportional to the precipitation rate. However, reduced visibility measurements may be caused by conditions other than high rates of precipitation. This is apparent during several time intervals on the plot, and may be attributable to fog or fine drizzle at temperatures close to 0°C.

The selection of the data points appearing in Figure 4.4 and 4.5 required that all three methods of measurement were in simultaneous operation.

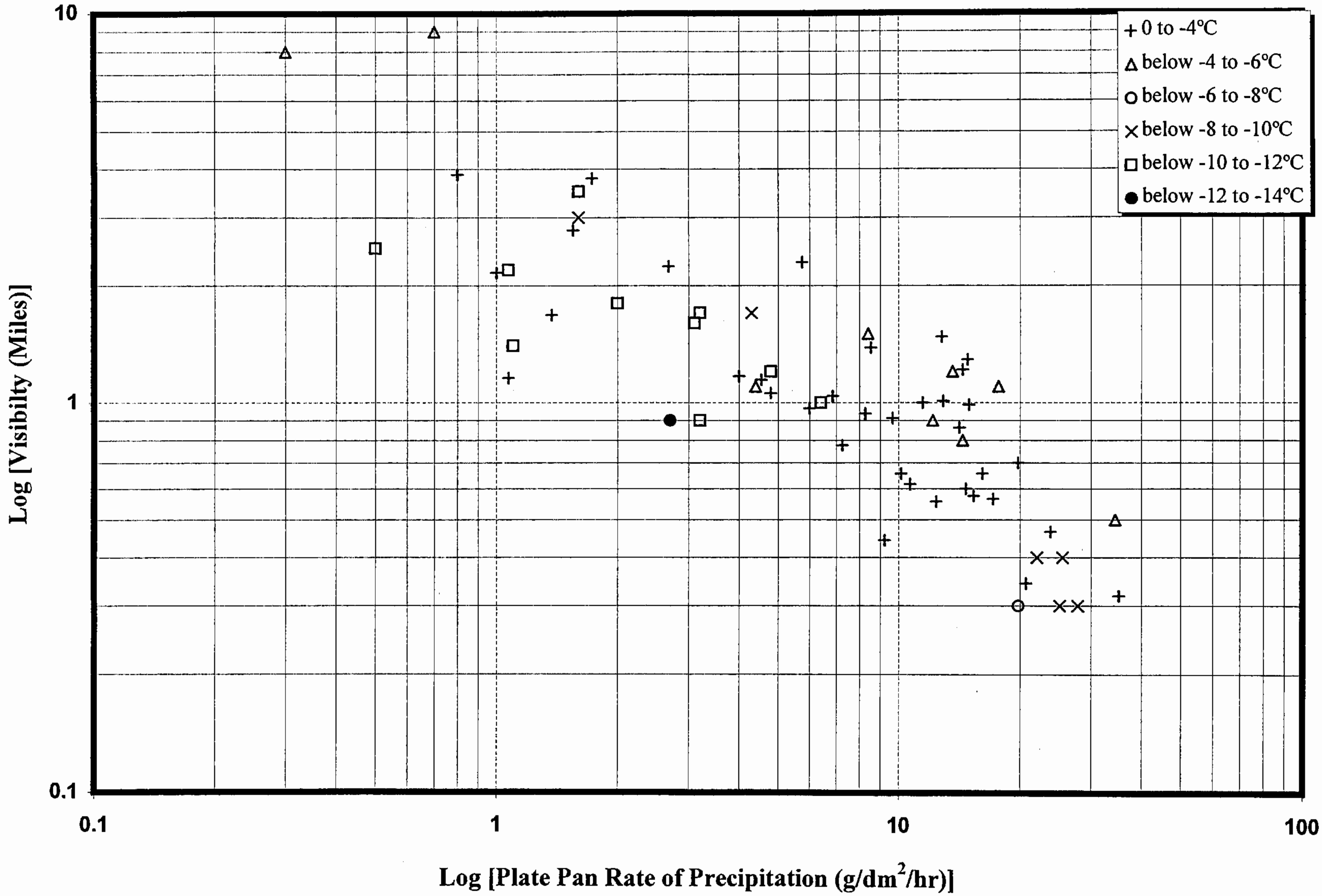
The 1995/96 natural snow accumulation data for which all three methods of precipitation measurement were active were initially separated from the raw data base. From these, data not satisfying the plate pan acceptance criterion were rejected. From the remaining data points, 20 to 40 data points representing snow occurrences on more than three separate occasions were randomly selected to be included in the plots of Figures 4.4 and 4.5.

Figure 4.4 is a plot of READAC visibility versus plate pan precipitation rate data (including the data used to construct the plot in Figure 4.3) in log/log format. The top half of Figure 4.5 is a plot of READAC visibility versus READAC precipitation rate. The bottom of Figure 4.5 is a plot of READAC visibility versus ETI precipitation rate.

The data presented in Figures 4.1 to 4.5 will be forwarded to NCAR for further detailed analyses and instrument evaluation. A draft report describing precipitation rate and visibility relationships was prepared by NCAR and was submitted to TDC. It provides the background for the utilization of these data.

FIGURE 4.4

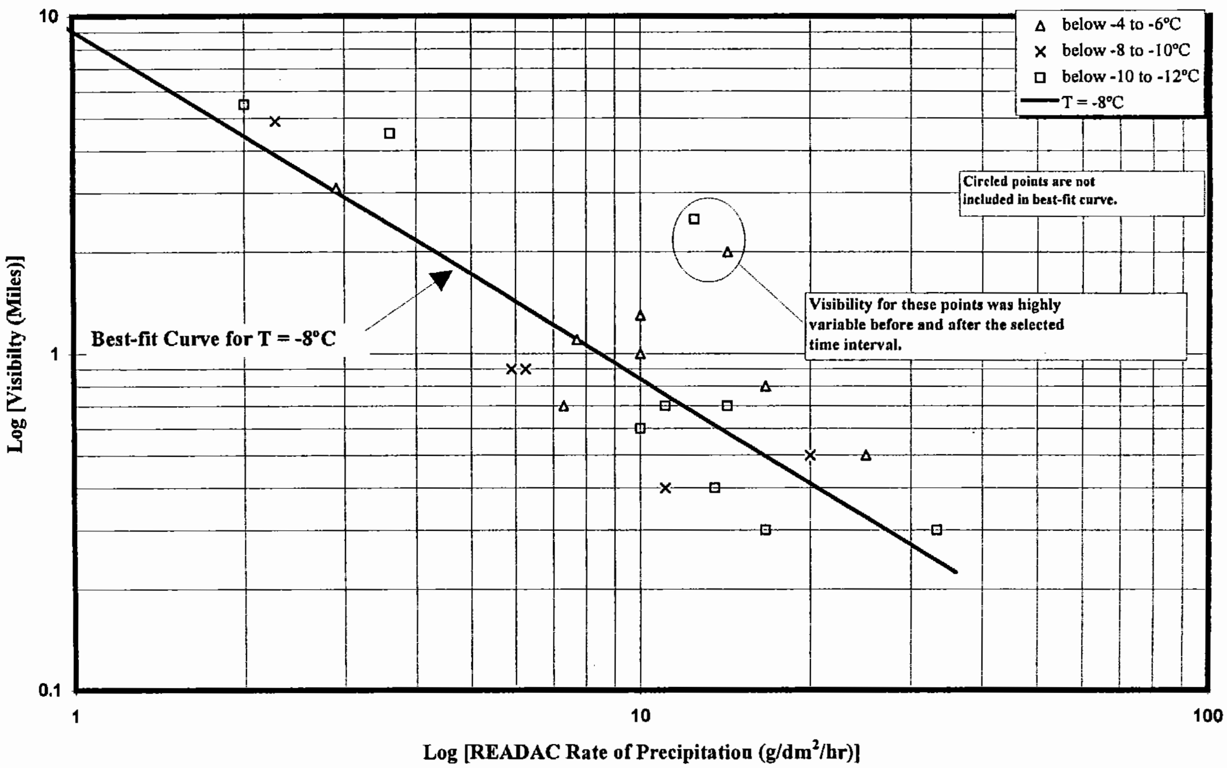
READAC VISIBILITY vs PLATE PAN RATE OF PRECIPITATION



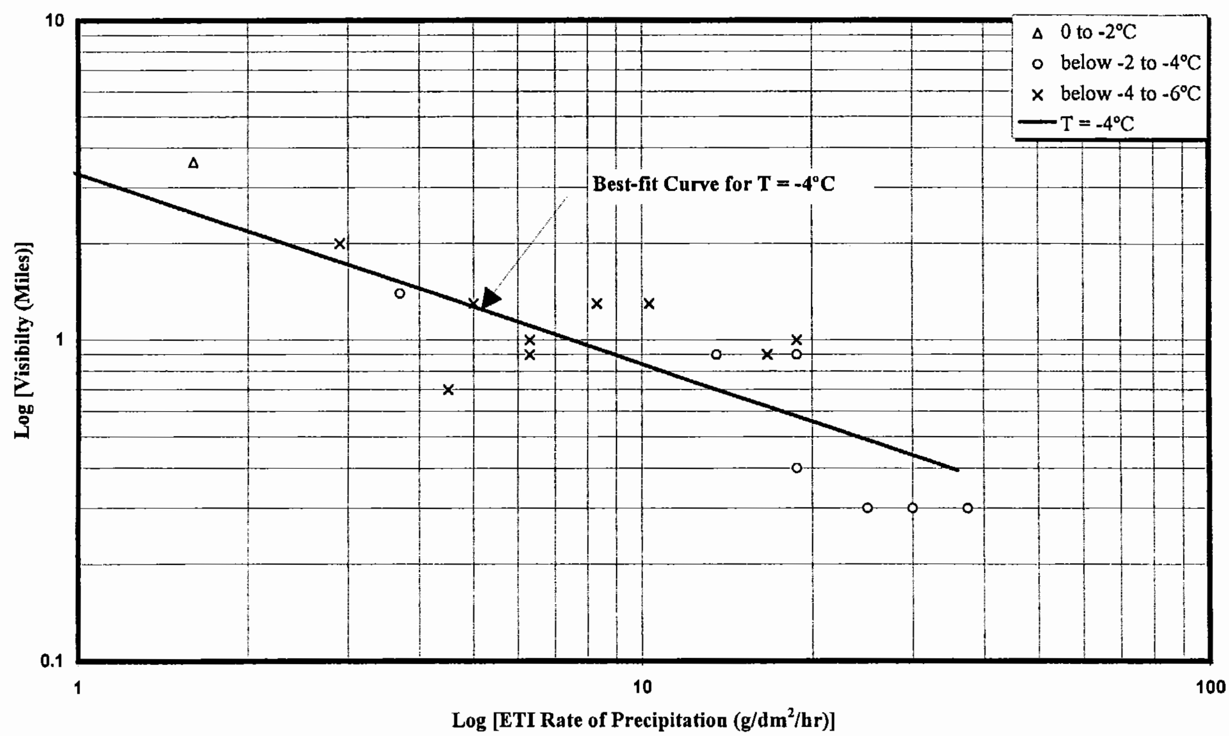
g:cm1283\report\hot_subs\VISRATE2.XLS
At: Read.vs.Plate (inc. dec.01)
Printed: 97-4-4

FIGURE 4.5

READAC VISIBILITY vs READAC RATE OF PRECIPITATION



READAC VISIBILITY vs ETI RATE OF PRECIPITATION



File:g:\cm1283\reprt\hot_subs\RDC_VIS.XLS
At:VIS_vs_ETI & READAC
Printed:97-4-4

4.3 Comparison of Meteorological Measurements

Figure 4.6 represents test site wind speed measurements versus Environment Canada's READAC wind speed measurements. In both cases, wind speed is computed to be the average wind speed over the duration of the test. The test site measurements were on average only 54% as high as the measurements from READAC. The READAC measurements are taken at a height of 10 m, whereas the wind at the test site is measured 3 m above the ground to more accurately monitor wind flow over the test plates.

Figure 4.7 shows the comparison of wind direction from the APS test site wind vane and from the READAC instrument. The chart shows that, if the standard 16° variation between Magnetic and True North was applied, the correlation between the two instruments is very good.

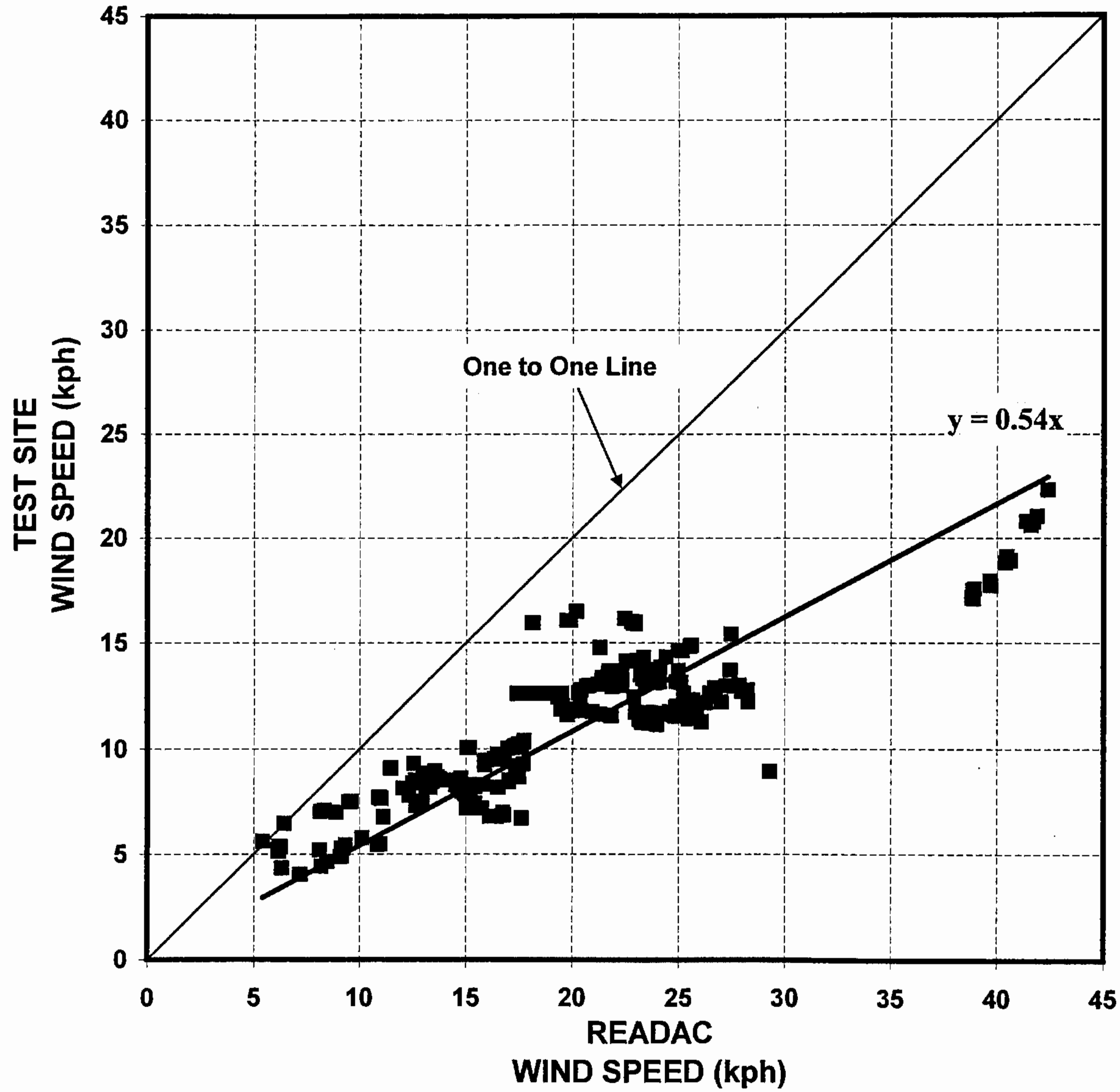
Figure 4.8 shows the comparison of temperature data, which shows excellent correlation between AES's instrument and the test site instrument.

FIGURE 4.6

COMPARISON OF WIND SPEED DATA

APS DATA VS READAC DATA

1995 - 1996



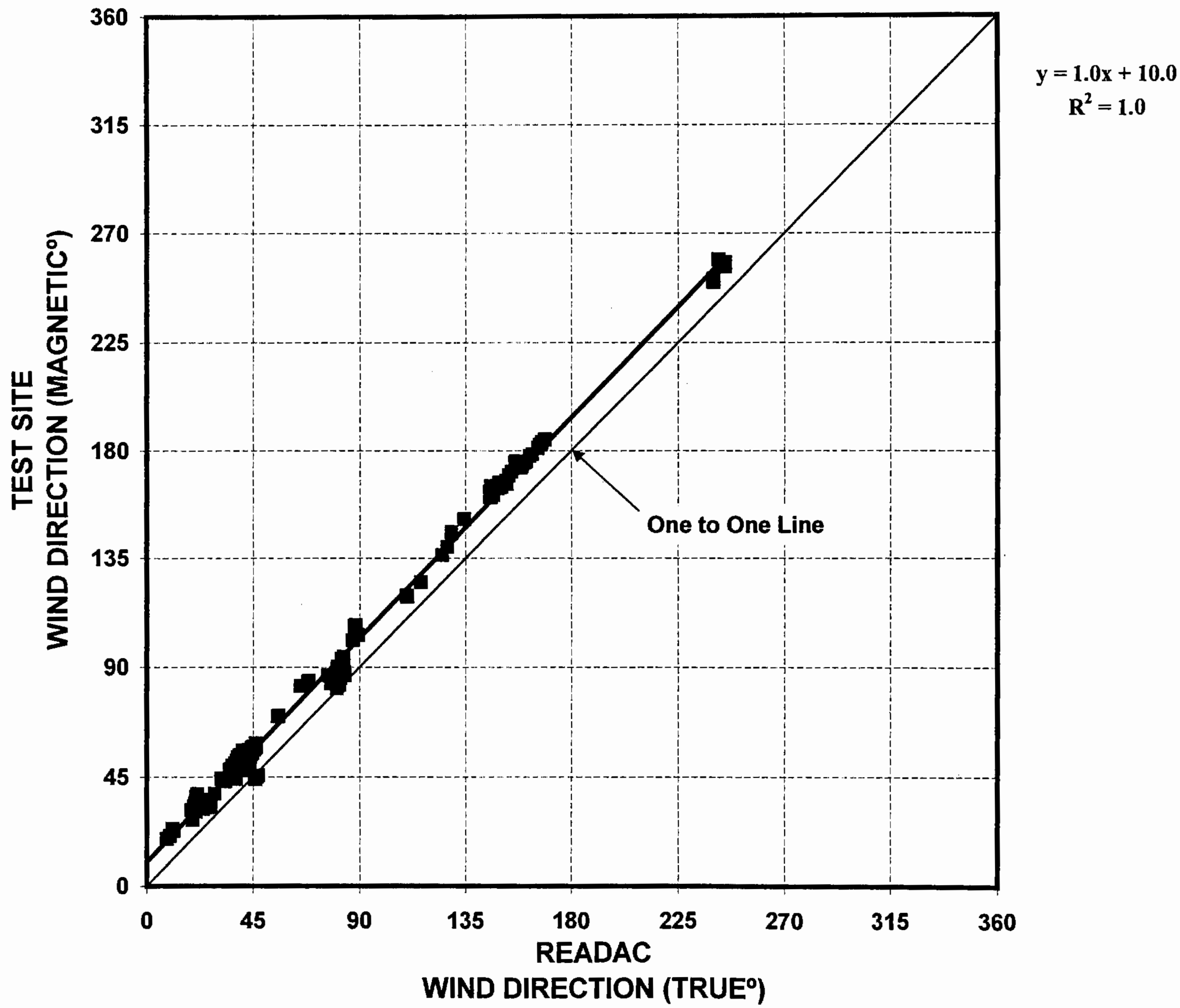
g:\cm1283\report\hot_subs\Redc_aps
At: Wind Speed Printed: 1/8/98

FIGURE 4.7

COMPARISON OF WIND DIRECTION DATA

APS DATA VS READAC DATA

1995 - 1996



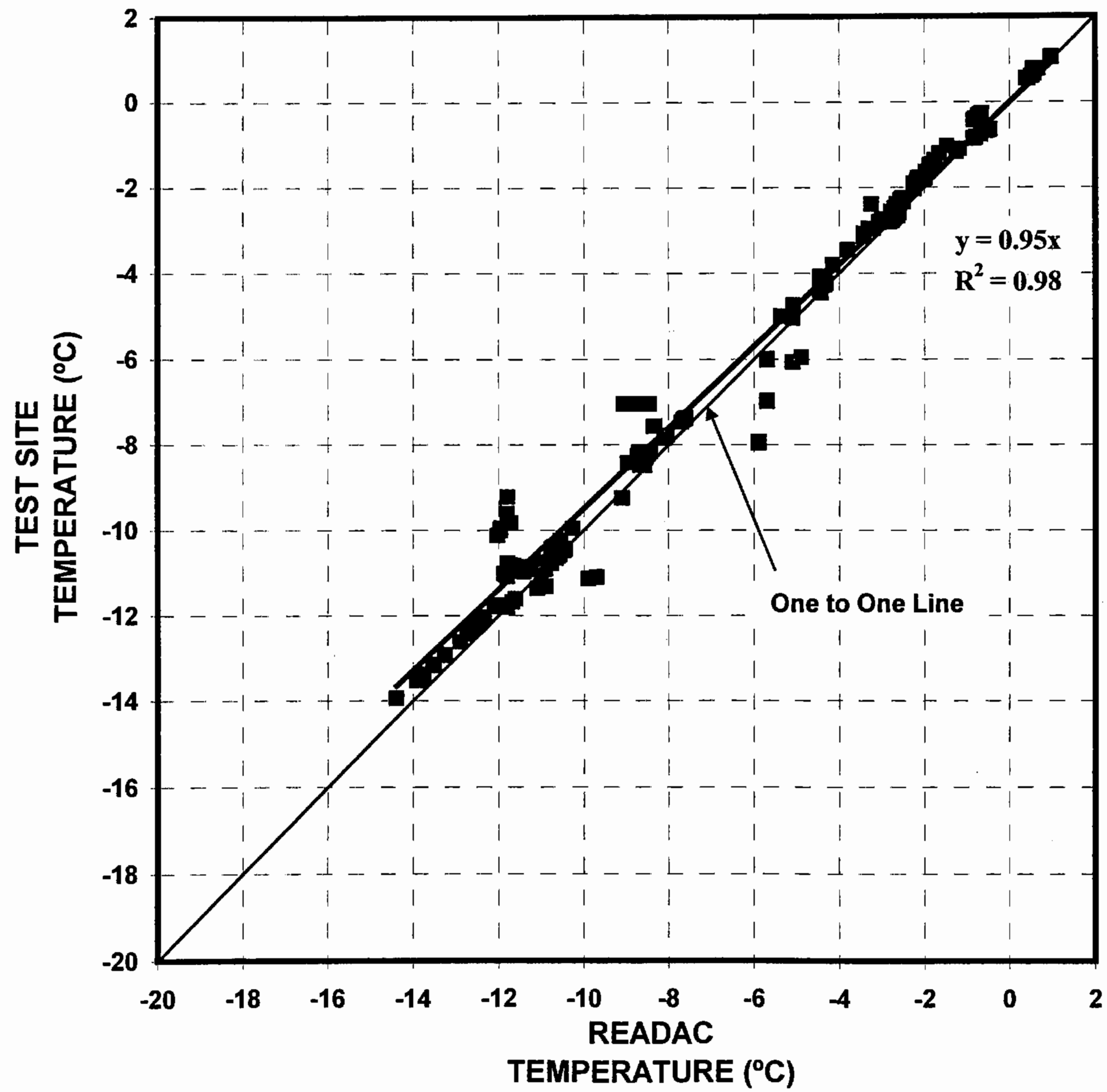
g:\cm1283\report\hot_subs\Redc_aps
ind Di ?rinted

FIGURE 4.8

COMPARISON OF TEMPERATURE DATA

APS DATA VS READAC DATA

1995 - 1996



g:\cm1283\report\hot_subs\Redc_aps
At: Temperature Printed: 1/8/98

4.4 Other Meteorological Measurements

A subjective measure of other meteorological parameters was carried out for some outdoor tests during the 1995/96 winter at Dorval (see Table 2.3). These other meteorological parameters include: type of precipitation; amount of precipitation; classification of precipitation; day visibility; and a subjective determination of whether the snow was wet or dry. Section 5.1.5 lists observations pertaining to differences in failure times between conditions of wet or dry snow.

The data described above were sometimes used to supplement the electronic measurements from both the test site and AES instruments, and to explore some of the variability in the holdover time data.

Visibility during the day was measured by an APS observer during one test occasion on February 9, 1996. The markers used to designate distance are those used by Environment Canada when the observations are being made manually (see Appendix B, Attachment VII). Most of the 15 measures of visibility by the observer were found to be below the READAC instrument measurement of visibility, particularly when the visibility was high. They may have resulted from the difficulty in seeing distant markers (markers were not located in one direction).

4.5 Evaluation of Natural Snow Precipitation Rates

Measurements of snow fall from precipitation gauges installed at Dorval in 1993/94 and 1994/95 were studied to determine the probabilities of obtaining extreme snow conditions exceeding 25 g/dm²/hr. The probability of exceeding 25 g/dm²/hr during a snow storm is very high; however, the probability of exceeding an average of 25 g/dm²/hr over, for example, a 40-minute period is much lower. The lower limit of the holdover time range of Type IV fluid for snow is between 30 and 45 minutes, depending on the temperature. The holdover times for snow were developed and substantiated based upon data collected from outside tests. The lower limit was usually determined by inspection of test data up to 25 g/dm²/hr. Tests with precipitation rates in excess of 25 g/dm²/hr were usually not considered in the determination of the lower limit. This condition is covered by the *caution* statement in the holdover time tables which indicates that holdover time will be reduced during heavy conditions.

The following was determined based upon the study of significant snow falls in 1993/94 and 1994/95. This was not carried out for 1995/96 because the increment in total precipitation was 5 g/dm².

Probability of exceeding		
1.25	g/dm² in 3 minutes is	10 to 25%
2.5	g/dm² in 6 minutes is	10%
8.75	g/dm² in 21 minutes is	7%
18.75	g/dm² in 45 minutes is	5%

The values imply that the average rate of precipitation is greater than 25 g/dm²/hr for the period indicated above. For example, to get more than 8.75 g/dm² (8.75 mm of snow based on a 10 to 1 snow to water equivalency) in 21 minutes, the average precipitation rate must be more than 25 g/dm²/hr. The probability values are based on three-minute moving averages.

These probabilities can vary from storm to storm or season to season but do indicate that the chances of obtaining high average rates of precipitation over a longer period of time diminishes. Therefore, the newer Type IV fluids take longer to fail because:

- Type IV fluids are more viscous and assume a thicker film profile which resists breakdown by precipitation longer than other fluids; and
- The probability of sustained high precipitation rates diminishes with increasing time interval.

The probability of occurrence of high precipitation rates for long periods (e.g. 5% from above data) coupled with the fact that the airport ground crews may not be equipped to handle these large storms, indicates that the holdover times should be reduced under these conditions or operations should be postponed or suspended. Use of Type I fluids under these extreme conditions (which could occur much more frequently) could be risky and should be minimized. Heat imparted to the wing by Type I fluid has likely given extra benefit to the holdover times in past operations.

4.6 Evaluation of Precipitation Rate at NRC

In the past, much attention has been paid to the variability in the natural snow test data. During natural snow tests, precipitation rates may vary from run to run, but for the same run, are consistent from one plate pan to the next. During indoor tests, variation in precipitation rate occur from pan to pan, but are consistent from one run to the next. The large number of indoor tests conducted at the NRC Climatic Engineering Facility during the 1994/95 and 1995/96 winter seasons has led to some scatter between the data collected during indoor testing for freezing drizzle and light freezing rain. Closer inspection of the data showed failures on some plates occurring from the bottom and from the sides of the plate. Care was always taken to ensure consistency in precipitation rate from time to time, over the entire plate area, however the variation in precipitation rate measurement from crosshair to crosshair on each plate, particularly on the edge of the spray pattern, has caused some of the scatter.

Photo 4.1 shows six plate pans each containing nine smaller containers mounted inside the plate pans. Precipitation was collected for one test to see the variability in the rate of precipitation between each small container. The precipitation produced was light freezing rain and the collection time was more than 30 minutes. The precipitation rates were plotted for the nine containers over each of the six positions (see Figure 4.9). The percentage difference from the mean rate of the plate is also displayed (in italics) in each grid. The following observations could be made:

- The variations from the mean in these tests were usually within 20%. The largest variation was observed on plate D.

- A 20% variance in precipitation rate is not considered to be significant to holdover times in light freezing rain but could be for freezing drizzle. This is so because data for freezing drizzle would lie close to the sensitive part of the failure time versus rate curve.

Photo 4.1
Test Set-up to Measure Precipitation Rates

Figure 4.9
Distribution of Precipitation Rate Over Six Test Plates

Plate A

17 *-15%*	19 *-4%*	22 *11%*
18 *-9%*	20 *1%*	20 *1%*
19 *-4%*	21 *6%*	23 *16%*

Plate B

25 *-12%*	27 *-5%*	29 *2%*
27 *-5%*	29 *2%*	29 *2%*
27 *-5%*	31 *9%*	31 *9%*

Plate C

31 *-1%*	32 *2%*	32 *2%*
31 *-1%*	31 *-1%*	32 *2%*
31 *-1%*	31 *-1%*	31 *1%*

Plate D

19 *-3%*	22 *13%*	23 *18%*
18 *-8%*	19 *-3%*	22 *13%*
15 *-23%*	19 *-3%*	19 *-3%*

Plate E

25 *7%*	26 *11%*	N/A
22 *-6%*	24 *3%*	25 *7%*
19 *-19%*	20 *-14%*	26 *-11%*

Plate F

27 *8%*	28 *12%*	27 *8%*
25 *0%*	26 *4%*	25 *0%*
22 *-12%*	22 *-12%*	23 *-8%*

Legend

31	Designates rate of precipitation ($g/dm^2/hr$).
-1%	*Designates variance from the mean precipitation rate of the plate.*

- Greater variations from the mean would be experienced closer to the edge of the test stand (and spray pattern).

- A plate located on the left and slightly above plate A could experience failure progressing from the bottom of the plate. This could erroneously influence the failure time.

Test data collected last year (1994/95) and this year (1995/96) were examined in more detail. Tests having failures from the bottom were discarded. Recommendations were made for future tests and are included in Section 7.

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5. DISCUSSION OF DATA

General

Flat plate tests were conducted under four general categories of conditions:

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

The SAE/ISO holdover time tables used up to and including the 1995/96 winter season were shown in Section 1, Tables 1.2, 1.3, and 1.4. Proposed tables based upon the 1995/96 winter testing are provided in Section 5.7 of this report (see Tables 5.3, 5.4, 5.5 and 5.6). The data to support the proposed changes to the tables are discussed in this section. Data sets for each condition are sub-divided into fluid types. Many of the proposed changes follow discussions and resolutions which resulted from the SAE G-12 Holdover Time Sub-Committee meetings in 1996 at Denver and Zurich. New holdover time ranges were agreed by the Sub-Committee based upon the results obtained by APS. The methodology used by the SAE Sub-Committee to determine the new range of holdover times in each cell of the tables was as follows:

> **Lower Holdover Time Number:** Selecting by inspection either the shortest failure time for the highest precipitation rate in the range or a more conservative time. Consistency with adjacent cells of the holdover time table was maintained.
>
> **Upper Holdover Time Number:** Selecting a time which is greater than the failure time representing most or all of the data points within the precipitation range.

Test data for Type IV fluids from the 1995/96 winter were combined and plotted with the corresponding Type IV fluid flat plate test data obtained during previous winters. The data provided in Transport Canada report TP 12676E ***Consolidated Fluid Holdover Time Field Test Data*** were used as the source for previous winter data.

As a result of discussions at SAE G-12 meetings in 1995, several changes to the temperature breakdowns in the holdover time tables were made. The use of Type II 50/50 and Type IV 50/50 fluid is limited to temperatures above or equal to -3°C, rather than -7°C. This change was based on concerns in Europe with one manufacturer's fluid freeze point not satisfying the 7°C buffer requirements. While this change restricts the use of Type II 50/50 or Type IV 50/50, it may provide some benefit to the holdover times in the 0°C to -3°C category. To determine whether there is any benefit, further investigation is required of both this winter's (1995/96) data and previous winter data contained in Transport Canada report TP 12676E ***Consolidated Fluid Holdover Time Field Test Data.*** For the Type I fluid holdover time table, the temperature range was changed from 0 to -7°C, to 0 to -10°C, because of the cut-off at -10°C for freezing drizzle and light freezing rain.

Changes were made by the SAE holdover time Sub-Committee to the notes and cautions of the holdover time tables. A note was added to each table for the freezing drizzle column to *use light freezing rain holdover times if positive identification of freezing drizzle is not possible*. The caution statement at the bottom of the holdover time tables became:

> **CAUTION:**
>
> The time of protection will be shortened in heavy weather conditions, heavy precipitation rates or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.

The above caution is used as quoted for U.S. operators, however the last sentence in this caution statement is different for Canadian operators. The Canadian version states: *The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.*

The caution note indicates that the holdover times will be reduced during heavy precipitation. On the other hand, a Transport Canada Air Carrier Advisory Circular (ACAC No. 0092 included in Appendix K) provides a technique for creating three holdover time ranges corresponding to light, moderate and heavy snow conditions. The lower limit of the SAE/ISO holdover time range for snow has been determined using data with precipitation rates **up to** 25 g/dm^2/hr, the upper range of the moderate snow condition. At precipitation rates of 25 g/dm^2/hr and above, representing heavy snow, **the lowest holdover time would need to be reduced.** (Although the practice of segmenting the holdover time table may be useful, the method should be reviewed and the above caution statement should be carefully reconsidered.)

The data obtained during Type IV fluid holdover time testing for the 1995/96 test season are grouped together with data from the previous winter and presented graphically in Appendix H. These figures have been prepared to show the effects of: fluid type, temperature, wind speed, and precipitation rate on fluid failure times for Neat, 75/25 and 50/50 Type IV fluids. These encompass all types of precipitation including natural snow, simulated freezing drizzle, light freezing rain, freezing fog, and rain on cold-soaked surfaces. Where applicable, NCAR data have been plotted with APS data. Also included in Appendix H are plots for Type I fluid (neat and diluted) and Type II (neat, 75/25 and 50/50) for rain on cold-soaked surfaces. Plots of Fluid Failure Time vs Temperature are also included and generally indicate recommendations for new holdover time ranges where supported by the data.

The results of fluid performance for natural precipitation under all conditions *excluding snow* for the last five years (1990-1995) have been compiled in Appendix F. These appear as plots of Fluid Failure Time vs Precipitation Rate. These results were arrived at using data obtained during tests conducted by APS, largely at its Dorval Airport test site. They were prepared to maintain data records in a form which can be easily compared to current test results. They make this information readily accessible to parties specifically interested in fluid performance under these conditions.

At the 1996 Denver SAE G-12 Holdover Time Sub-Committee meeting, it was agreed that during ice pellet conditions, operations should not be attempted on the grounds that the pellets may penetrate the fluid layer and adhere directly to metal surfaces. Pellets can bounce and roll into gaps surrounding moving wing surfaces and subsequently interfere with the functioning of control surfaces requiring adjustment during ground and flight operations.

5.1 Natural Snow

Tables 1.2, 1.3, and 1.4 in the introduction present the holdover times that were in place for the 1995/96 winter. All the holdover time ranges in the cells of the snow category for Type I and Type II fluids were substantiated. For the UCAR Ultra table, only the holdover times for the neat (100%) fluid concentration were substantiated. The actual holdover times for the neat Ultra fluid were 50% higher than the holdover times of neat Type II fluid.

For the natural snow tests conducted on flat plates, charts were produced as follows:

	Ordinate	*Abscissa*	*Sub-grouping*
i)	Fluid failure time	Rate of precipitation	Fluid brand
ii)	Fluid failure time	Rate of precipitation	Temperature range
iii)	Fluid failure time	Rate of precipitation	Wind speed
iv)	Fluid failure time	Temperature	Precipitation rate

The fourth chart shows the proposed and/or current holdover time ranges as a function of temperature. These charts were produced for the Type IV fluids (100%, 75/25 and 50/50), and are described in detail in the following sub-sections. Charts are located in Appendix H.

Many tests during the 1995/96 winter were conducted with Hoechst Type IV Fluid MPIV 1934; however, APS was subsequently informed that this fluid did not satisfy the water spray endurance test requirement of 80 minutes. Therefore, all tests with this fluid (in all dilutions) were discarded. The data are, however, included as part of Appendix J. Data from Ultra tests conducted in 1993/94 have not been included because the Ultra fluid used that winter is no longer commercially available.

5.1.1 Type IV Neat (100%) Fluids in Natural Snow

Neat Type IV fluid tests were conducted at Dorval by APS and in Denver by NCAR. Photo 5.1 and Photo 5.2 show the progression of Type IV fluid failure on flat plates during natural snow tests at Dorval. Photo 5.1 shows that the three top crosshairs, 7.5 cm from the top of the plate, have reached the end condition.

In Appendix H, Figure H.1 depicts the APS data points for both the 1994/95 and 1995/96 winter seasons plotted as a function of fluid brand. Figure H.2 shows the same graph, but with NCAR's test points added. Figures H.3 to H.5 show the combined APS and NCAR data points plotted as listed below:

Figure H.1	Time vs rate vs fluid brand	APS data
Figure H.2	Time vs rate vs fluid brand	APS and NCAR data
Figure H.3	Time vs rate vs temperature	APS and NCAR data
Figure H.4	Time vs rate vs wind speed	APS and NCAR data
Figure H.5*	Time vs temperature vs rate	APS and NCAR data

* Also reproduced at the top of Figure 5.1

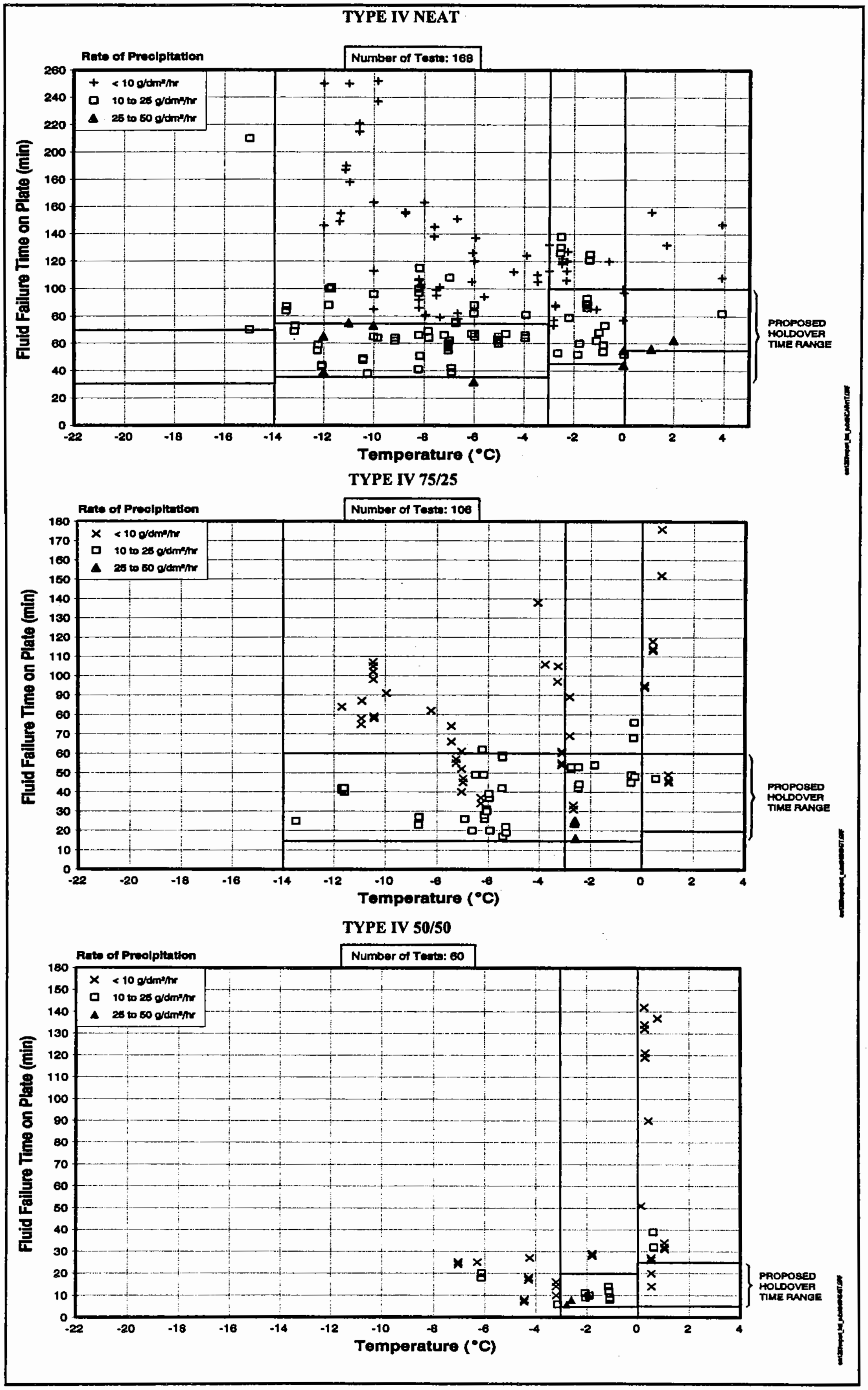
Both data sets are in agreement (see Figure H.2). Based on these data, the holdover time ranges illustrated in Figure H.5 were determined in association with the SAE G-12 Holdover Time Sub-Committee. The previous winter (1995/96) holdover time range for Ultra Type IV neat was 30 to 67 minutes for temperatures below 0°C (see Table 1.4). This was based upon 1994/95 test data, which showed a 50% increase over the Type II fluid holdover times. Figure H.5 (top of Figure 5.1) indicates even greater holdover times for most of the temperature sub-divisions.

- above 0°C 55 to 100 minutes
- 0°C to -3°C 45 to 100 minutes
- below -3°C to -14°C 35 to 75 minutes
- below -14°C to -25°C 30 to 70 minutes

Recall that the 1994/95 data showed that all test points exceeded 40 minutes (twice the Type II fluid minimum holdover time); however, judgement for the 50% increase was based upon comparison with Type II fluid tests conducted simultaneously with UCAR Ultra fluid tests.

FIGURE 5.1

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME
NATURAL SNOW CONDITIONS



The combined data show that with high rates of precipitation (>25 g/dm^2/hr), the holdover time could be reduced to values below the proposed lower limits. However, average rates of precipitation exceeding 25 g/dm^2/hr over a period of 30 to 40 minutes do not occur frequently. Under these circumstances, operations at most airports would likely be reduced, if not suspended or cancelled.

5.1.2 Type IV 75/25 Fluids in Natural Snow

Type IV 75/25 fluid tests were conducted at Dorval by APS during both the 1994/95 (only one fluid brand) and 1995/96 winter seasons. Figures H.6 to H.9 show the data points from both winters plotted as listed below:

Figure H.6	Time vs rate vs fluid brand
Figure H.7	Time vs rate vs temperature
Figure H.8	Time vs rate vs wind speed
Figure H.9*	Time vs temperature vs rate

* Also reproduced in middle of Figure 5.1

Based on these data, the holdover time ranges illustrated in Figure H.9 (and Figure 5.1) were determined in association with the G-12 SAE Holdover Time Sub-Committee. The 1995/96 holdover time range for Ultra Type IV 75/25 was 15 to 30 minutes for temperatures below 0°C to -14°C (see Table 1.4). This was based upon limited test data from 1994/95, which showed little or no increase over the Type II 75/25 fluid holdover times. The combined data from both winters support this observation, particularly for the lower holdover time limit. The lower holdover time limit for Type IV 75/25 fluids was left the same as the Type II 75/25 lower limit. The upper limit of 30 minutes was increased to 60 minutes - most of the data points with rates less than 5 g/dm^2/hr were above 60 minutes.

5.1.3 Type IV 50/50 Fluids in Natural Snow

Type IV 50/50 fluid tests were conducted at Dorval during both the 1994/95 (only one brand) and 1995/96 winter seasons. Figures H.10 to H.13 show the data points from both winters plotted as listed below:

Figure H.10	Time vs rate vs fluid brand
Figure H.11	Time vs rate vs temperature
Figure H.12	Time vs rate vs wind speed
Figure H.13*	Time vs temperature vs rate

* Also reproduced at bottom of Figure 5.1

Based on these data, the holdover time ranges illustrated in Figure H.13 (and Figure 5.1) were determined in association with the G-12 SAE Holdover Time Sub-Committee. The 1995/96 holdover time for Ultra Type IV 50/50 was 5 to 15 minutes for temperatures below 0°C to -7°C (see Table 4.1). This was based upon 1994/95 test data which showed no increase over the Type II 50/50 fluid holdover times. The combined data from both winters support this observation. For temperatures from 0°C to -3°C, the proposed holdover time range is 5 to 20 minutes, a 5 minute increase on the upper limit of the holdover time range.

5.1.4 Type I and Type II Fluids in Natural Snow

Much discussion has transpired at SAE G-12 holdover time meetings regarding the reduction of the holdover times for Type II fluids (Neat, 75/25 and 50/50) under snow conditions at temperatures above 0°C. The lower limit values were reduced to reflect holdover time values just below 0°C. The justification was that the wing could be cold-soaked and that this may not be realized by the operator.

A significant number of tests with Type II fluids were conducted during the 1995/96 winter. The basis for this was to run tests with Type II fluid simultaneously with the tests with new Type IV fluids. Because the Type II fluids failed before the Type IV fluids, tests with Type II fluids were restarted, adding to the total number of Type II tests. These data for 1995/96 were plotted to maintain records for future reference. The charts are presented in Appendix E.

The following observations can be made from the plots:

- When the Type II neat fluid data from 1995/96 are superimposed over the Type II neat data from previous winters (see Figure 3.17 of report TP 12676E Consolidated Data), the points circled in Figure E.1 of Appendix E fall below most of the points in Figure 3.17 of report TP 12676E. The points are also below the holdover time lower limit of 20 minutes for Type II Fluid. The circled test points occurred during relatively cold temperatures (-12°C to -13°C) and moderate rates of precipitation. The tests were all with one fluid (Type II Neat Fluid A-101) on the same day.

  This could be the characteristic of this particular fluid because other Type II fluids tested on the same day (at slightly warmer temperatures) lasted more than 20 minutes. Type IV fluids tested simultaneously with this fluid lasted 2 to 3 times longer. More tests should be conducted with this fluid and other fluids at these more severe conditions to determine whether the holdover time range lower limit for Type II fluids should be reduced to 15 minutes.

- Type II 75/25, Type II 50/50 and Type I data is in agreement with the current holdover times for these fluids.

5.1.5 Observation of Wet and Dry Snow

A subjective determination (see Appendix B for procedure) of whether snow was wet or dry was made by observers during the tests at the Dorval site. A plot of fluid failure on the plate versus the precipitation rate as a function of the characteristic of the precipitation (wet or dry) is illustrated in Figure H.14 for Type IV neat fluids tested at Dorval in snow conditions during the 1995/96 winter. Similar charts were produced for Type IV 75/25 fluid (see Figure H.15) and Type IV 50/50 fluid (see Figure H.16).

The following observations can be made:

i) Most of the wet snow occurred when the rate of precipitation ranged from 5 to 15 g/dm²/hr. Expectations were that wet snow would typically occur at the higher precipitation rates (>25 g/dm²/hr).

ii) The wet snow cases generally occurred at warmer temperatures than did the dry snow cases (see related charts Figure H.3, Figure H.7 and Figure H.11).

iii) The fluid failure times for the wet snow cases are generally longer than for the dry snow cases.

iv) The observation iii correlates well with the following:

- The higher fluid failure times are possibly a result of the warmer temperatures - fluid failure time increases as temperature increases.

- Wet snow melts faster and is absorbed by the fluid more readily than dry snow. This could effect an increase in the failure time determination as called by the observer. At warmer temperatures, fluids exhibit lower viscosities. This would tend to facilitate wetting and/or mixing of precipitation with fluid at the interface.

These observations are based on limited data from Dorval for one winter. More data are required to evaluate whether the character of the snow could be utilized to provide an improved measure of snow intensity and to evaluate whether wet snow is a more severe condition, perhaps approaching that of freezing rain.

5.2 Simulated Freezing Drizzle and Light Freezing Rain

Simulated freezing drizzle and light freezing rain experiments were carried out at NRC's Climatic Engineering Facility (CEF) at Ottawa. Past experience at APS and NRC helped set the parameters for the precipitation as defined in Section 2.3: rates for freezing drizzle ranged from 2 to 13 g/dm^2/hr with a median volume droplet diameter of 300 þm, whereas for light freezing rain, the rates ranged from 13 to 25 g/dm^2/hr and the median volume droplet diameter was 1000þm. This year's Type IV fluid data is systematically presented with data from previous years and are located in the figures in Appendix H. These data sets were combined because they were produced according to the same set of parameters.

The tables in Section 1, which present the holdover times for the 1995/96 winter, show that all the holdover times in the cells of the freezing drizzle and light freezing rain category for Type I and Type II fluids were substantiated. For the UCAR Ultra table, only the holdover times for the neat (100%) fluid concentration were substantiated. The actual holdover times for the neat Ultra fluid were 50% higher than the holdover times of neat Type II fluid.

The results of fluid tests conducted on flat plates under conditions of freezing drizzle and light freezing rain were plotted on charts as follows:

Ordinate	***Abscissa***	***Sub-grouping***
i) Fluid failure time	Rate of precipitation	Fluid brand
ii) Fluid failure time	Rate of precipitation	Temperature range
iii) Fluid failure time	Temperature	Precipitation type

The third chart format shows the proposed holdover time ranges as a function of temperature. These charts were produced for the Type IV fluids (100%, 75/25 and 50/50), and are described in detail in the sub-sections which follow. The proposed holdover time tables are located in Tables 5.3 to 5.6 in Section 5.7.

Several tests during the 1995/96 winter were conducted with Hoechst Fluid MPIV 1934; however, this fluid did not satisfy the proposed water spray endurance test minimum requirement of 80 minutes. Therefore, all tests with this fluid in all dilutions were discarded. Data from Ultra tests conducted in 1993/94 have not been included because the Ultra fluid used that winter is no longer commercially available. In Appendix G, APS and UQAC data for freezing drizzle and light freezing rain are compared.

5.2.1 Type IV Neat Fluids Under Freezing Drizzle and Light Freezing Rain

Type IV neat (100%) fluid tests were conducted at NRC by APS during the 1994/95 (only one fluid brand) and 1995/96 winter seasons. Figures H.17 to H.19 illustrate the data points from both seasons as listed below:

Figure H.17	Time vs rate vs fluid brand
Figure H.18	Time vs rate vs temperature
Figure H.19*	Time vs temperature vs precipitation type

* Also reproduced in Figure 5.2

The figures show both the freezing drizzle and light freezing rain test points plotted on the same chart, with the sub-division at 13 $g/dm^2/hr$.

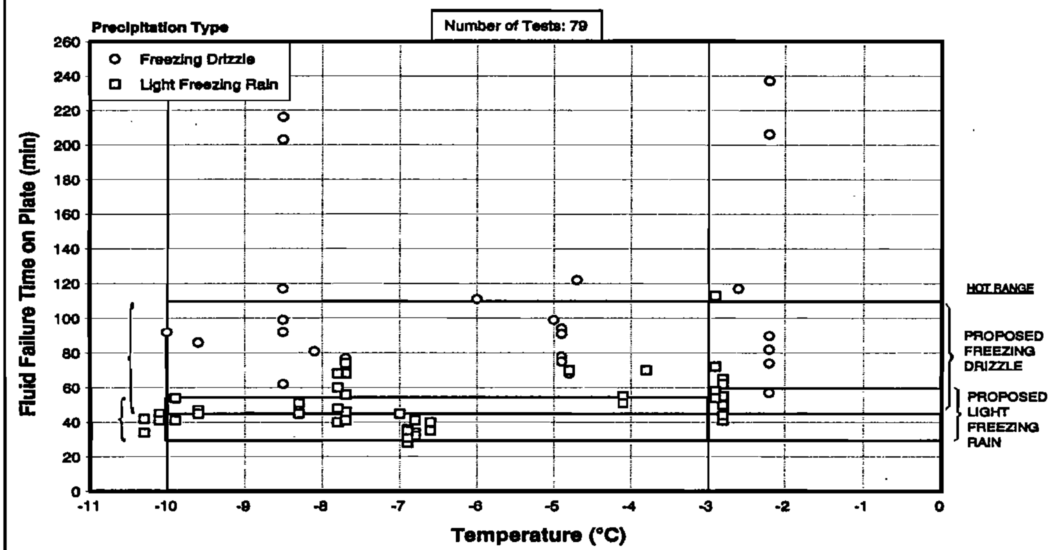
The 1995/96 holdover time range for Ultra Type IV neat fluid (as shown in Table 1.4) was 22 to 45 minutes for light freezing rain and 45 to 90 minutes for freezing drizzle at all temperatures. This was based upon 1994/95 test data which showed that neat Ultra fluid holdover times were at least 50% better than the Type II fluid holdover times, consistent with natural snow. Figure H.19 indicates slightly greater holdover time ranges. For freezing drizzle, the new holdover time range proposed for neat Type IV fluid was 45 to 110 minutes for temperatures down to -10°C. For light freezing rain, the holdover time range proposed was 30 to 60 minutes for temperatures above 0°C to -3°C, and 30 to 55 minutes for temperatures from below -3°C to -10°C. These proposed HOT changes are summarized in Table 5.6.

FIGURE 5.2

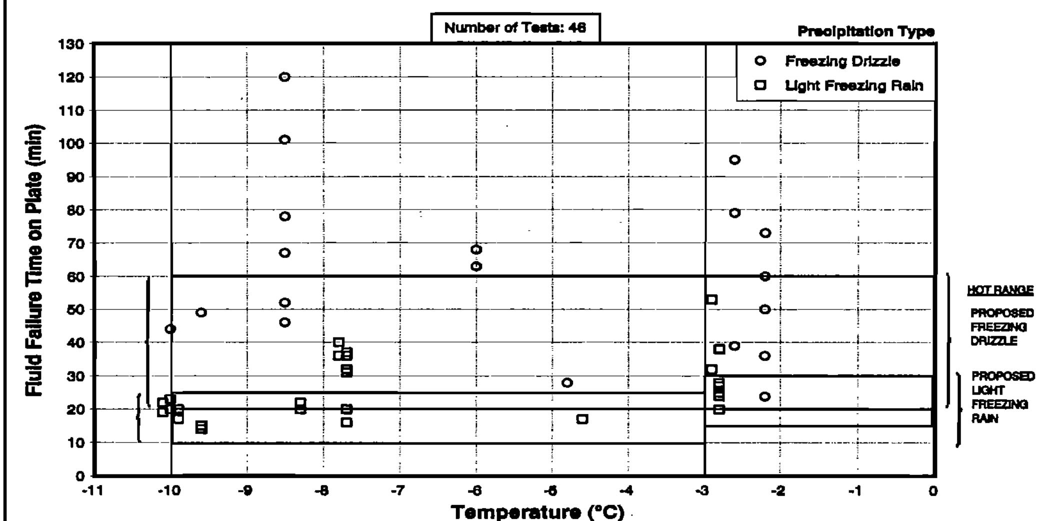
EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

FREEZING DRIZZLE AND LIGHT FREEZING RAIN

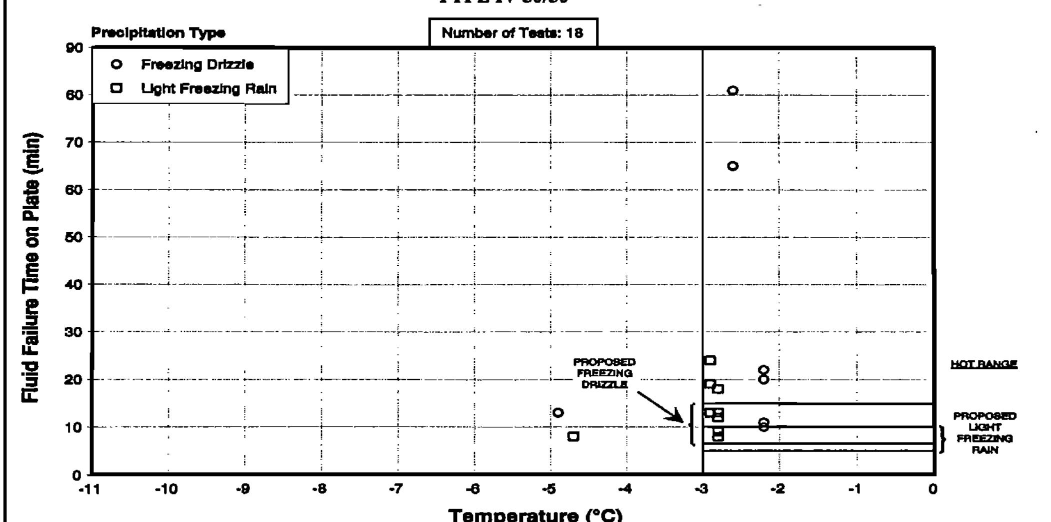
TYPE IV NEAT



TYPE IV 75/25



TYPE IV 50/50



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5.2.1.1 Supplementary Type IV and Type II Fluid Tests

A new Type IV fluid (C-107) was developed and shipped for testing at Chicoutimi during the summer of 1996. UQAC qualifies the fluid according to the normal WSET, High Humidity Endurance Test (HHET) and aerodynamic tests. However UQAC also conducted tests under artificial light freezing rain. The tests raised concerns that the new Type IV neat fluid would not be satisfactory at maximum level of moderate precipitation rates under natural snow conditions. Their tests showed that the holdover times with this new fluid were significantly below the Type IV neat fluid holdover times and equivalent to Type II neat fluid holdover times. APS was advised that the rates of precipitation and temperature for the UQAC tests were approximately 25 g/dm^2/hr and -5°C.

APS subsequently conducted a series of tests under light freezing rain conditions at NRC's cold chamber (see Figure 5.3). The conditions and tests are described below:

- Six runs were carried out over two days resulting in a total of 23 tests;
- Three fluids were tested: Type II neat Fluid A-205; Type IV neat Fluid C-100; and the new Type IV neat Fluid C-107;
- The rate of precipitation is shown on the horizontal axis of Figure 5.3 for each test, and ranged from 19 to 26 g/dm^2/hr (one test was at 30 g/dm^2/hr); and
- The ambient air temperature was -7°C.

The holdover times ranged from:

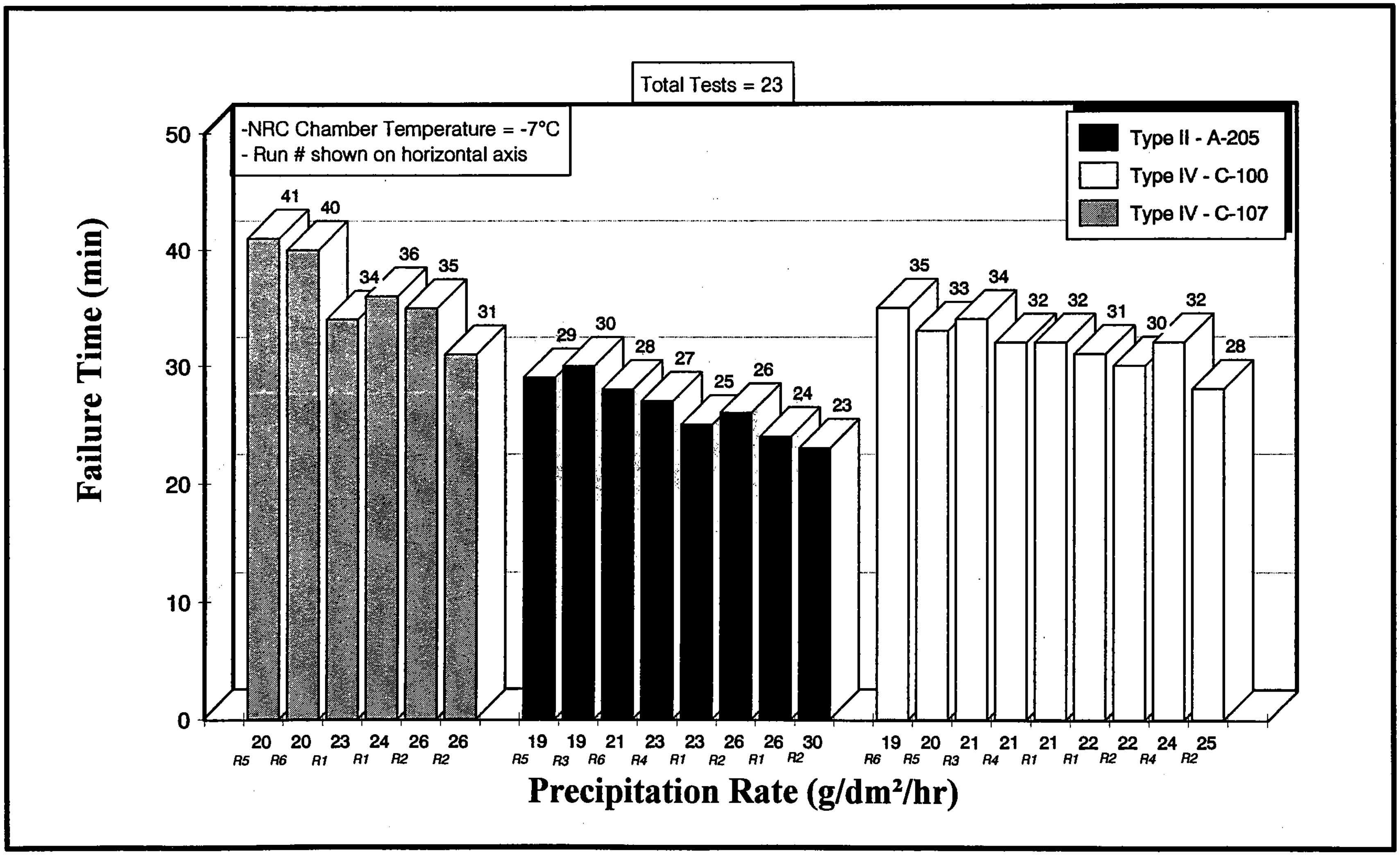
- 23 to 30 minutes for Type II neat Fluid A-205;

FIGURE 5.3

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FLUID FAILURE TIME

Simulated Light Freezing Rain Tests

September 6 & 9 - 1996



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- 28 to 35 minutes for Type IV neat Fluid C-100; and
- 31 to 41 minutes for the new Type IV neat Fluid C-107.

It should be noted that the holdover times determined for the Type II fluid in this series of tests were substantially longer than the 10 minutes lower holdover time table value for Type II fluids under these conditions. It is possible that the result is due to this particular Type II fluid being a higher performance formulation than other Type II fluids.

The holdover time range presented here for neat Type IV C-107 Fluid does not agree with UQAC test results for the same fluid.

5.2.1.2 Comparison of Simulated and Natural Freezing Rain Data

In order to establish the validity of flat plate testing, the behaviour of Type IV fluids on flat plates (as employed in standard test procedures) was compared to Type IV fluid performance on actual aircraft wings. The details of this study are described in the separate TDC report TP 12901E entitled "Aircraft Full-Scale Test Program for the 1995/96 Winter".

Two full-scale tests were carried out on actual aircraft wings under natural light freezing rain precipitation. Simultaneous tests were also conducted on standard flat plates.

Union Carbide Ultra Type IV fluid applications were performed using Air Canada de-icing facilities and spray vehicles at Dorval Airport. For the first run, the Type IV fluid on the standard flat plates reached failure after 72 minutes, while areas totalling less than 10% of the entire wing exhibited fluid failure for the same time interval. During the second run, similar results were observed; flat plate failure occurred after only 53 minutes while the first failure on the wing was observed to occur after 50 minutes.

The data from both full-scale tests were super-imposed onto the flat plate test data. These data were collected during laboratory simulations of freezing drizzle and light freezing rain at NRC using Type IV fluid. The resulting plot is shown in Figure 5.4. Also included in Figure 5.4 are the proposed HOT ranges for these conditions. The figure indicates that the failure times recorded for these tests are within or above the HOT range proposed and validate the consistency in procedures and results respectively employed and determined in this study.

5.2.1.3 Observational Details of Full-Scale Tests

The condition of the fluid over the wing prior to failure is illustrated in Photo 5.3. The green dye of the Ultra fluid provided confirmation at the start of the test that the Type IV fluid was evenly applied to the wing surface. As soon as contamination was observed on the wing, failures were easily identifiable, provided the viewing angle was appropriate. Photo 5.4 clearly shows failure of the wing leading edge during one of the two tests. Initial fluid failures on the leading edge were observed at seams which join two leading edge panels.

The failures propagated from these joints. Fluid failures at these locations were simple to identify because fluid at the joint area was *matte* in contrast to the adjoining *shiny* fluid of the leading edge. Similarly, the contrast between the un-failed fluid on the middle of the wing and the failed fluid on the leading edge provided easy failure identification, and allowed observers to follow the progression of the failure.

Progression of fluid failure on a flat plate during the natural freezing rain tests is shown in Photo 5.5. It can be seen that fluid failure is easily identifiable when ice progresses to the 3" (7.5 cm) line. Photo 5.6 shows failure of a Type IV 50/50 fluid on a flat plate during artificial freezing rain tests at the NRC. The similarity of this failure to the one during natural freezing rain

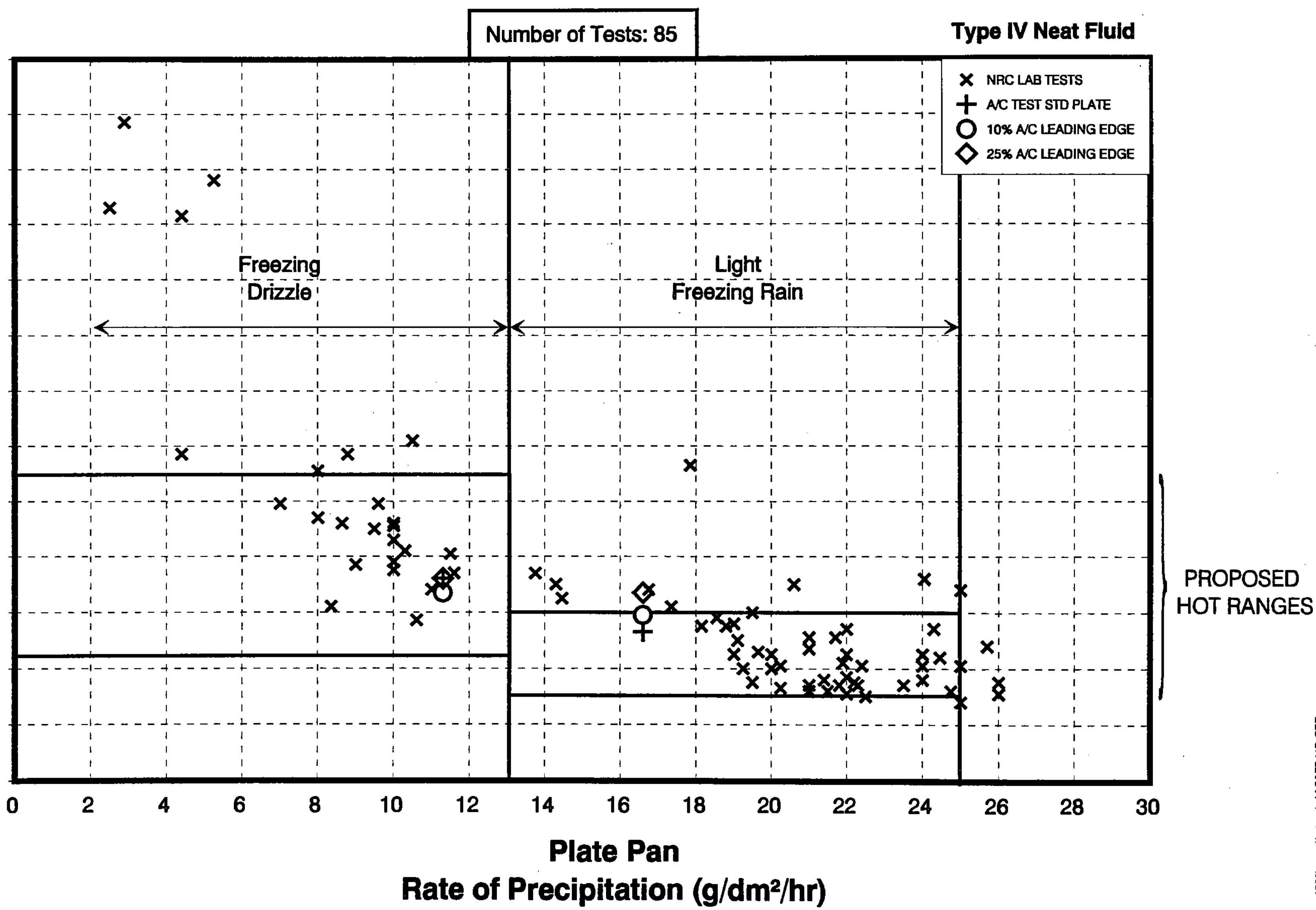
FIGURE 5.4

EFFECT OF RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1994-1996



demonstrates consistency in procedures. Extensive photo coverage of these results can be found in the related report TP 12901E.

5.2.2 Type IV 75/25 Fluids Under Freezing Drizzle and Light Freezing Rain

Type IV 75/25 fluid tests were conducted at NRC during the 1994/95 (only one fluid brand) and the 1995/96 winter seasons. The data collected from both seasons have been assembled into plots to show holdover times for different fluids at various temperatures (for the two precipitation types) both as a function of the rate of precipitation and as a function of temperature. These plots are located in Appendix H and are presented in the following formats:

Figure H.20	Time vs Rate (by fluid brand)
Figure H.21	Time vs Rate (by temperature)
Figure H.22*	Time vs Temperature (by precipitation type)

* Also reproduced in Figure 5.2

The holdover time range during 1995/96 for Ultra Type IV 75/25 fluid was 10 to 25 minutes for light freezing rain, and it was 20 to 45 minutes for freezing drizzle, for temperatures ranging from above 0°C to -10°C (see Table 1.4). These times were based upon limited test data from 1994/95, which showed little or no increase over Type II 75/25 fluid holdover times. Therefore, the Type IV 75/25 fluid holdover times were kept the same as the Type II 75/25 fluid holdover times. The combined data from both test seasons led to the following proposed Type IV 75/25 fluid holdover time ranges (see Table 5.6):

- For light freezing rain — 15 to 30 minutes for above 0°C to -3°C; 10 to 25 minutes for below -3°C to -10°C

- For freezing drizzle — - 20 to 60 minutes for above 0°C to -10°C

These holdover times were agreed to during the SAE G-12 Holdover Time Sub-Committee meetings at Denver and Zurich in 1996. For light freezing rain, the Type IV 75/25 fluid holdover time range was raised by 5 minutes for temperatures above 0°C to -3°C, and remained the same for temperatures below -3°C to -10°C. For freezing drizzle, the upper limit of the holdover time range was increased from 45 minutes to 60 minutes.

5.2.3 Type IV 50/50 Fluids Under Freezing Drizzle and Light Freezing Rain

UCAR Ultra 50/50 fluid was tested during the 1993/94 winter; however, that particular mix is no longer commercially available. The results of those tests (see 1993/94 Holdover Time Report ***Test Results Summary***) showed that the holdover times for this fluid were equivalent to or shorter than the holdover times of the other Type II 50/50 fluids (see Table 1.3). Tests conducted during the 1995/96 season show similar results (see Appendix H, Figure H.23, Figure H.24 and also Table 5.6).

The holdover time range during 1995/96 for UCAR Ultra 50/50 fluid for all temperatures down to -7°C was (see Table 1.4):

- 5 to 15 minutes for light freezing rain
- 15 to 25 minutes for freezing drizzle

These holdover times were the same as the holdover times for Type II 50/50 fluids (see Table 1.3). The use of Type IV 50/50 is now limited to -3°C and above, based upon a request by the European airlines and the fact that the North American airlines do not use a 50/50 dilution. Discussions at the SAE G-12 holdover time meetings and the test data led to the following proposed holdover time ranges (see Table 5.6):

- 5 to 10 minutes for light freezing rain
- 7 to 15 minutes for freezing drizzle

These proposed holdover times are lower than those from the 1995/96 winter, and lower than the substantiated Type II 50/50 holdover time ranges.

5.2.4 Type II and Type I Fluids Under Freezing Drizzle and Light Freezing Rain

Limited tests with Type II fluids were conducted during the 1995/96 test season to ensure consistency in results with the Type IV fluids. These data for 1995/96 were plotted and are included in Appendix E to maintain records for future reference. Charts are not presented for Type I fluid because only three tests were carried out with standard Type I fluid. The following observations can be made from the plots:

- The reproducibility of the test results and procedures is observed when comparing the Type II neat fluid data from Figure E.15 with the Type II neat fluid data from previous seasons (see Consolidated Report TP 12676E).

- Comparable holdover time results from one season to another are also observed with Type II 75/25 and Type II 50/50 fluids (see Figures E.17 and E.19).

- The data from 1995/96 tests are in agreement with the current holdover time ranges for Type II fluids (Neat, 75/25 and 50/50). Due to concerns raised by some members of the SAE G-12 Holdover Time Sub-Committee (see Appendix G), the lower limit of the holdover time range for meat Type II fluid (under the category for light freezing rain and the temperature range below -3°C to -10°C) was reduced from 15 minutes to 10 minutes. The upper limit of the holdover time range remained the same at 30 minutes.

- When comparing the holdover times of side by side tests of Type II and Type IV fluids, it was found that neat Type IV fluids were superior to neat Type II fluids. Type IV 75/25 fluids were slightly superior or equivalent to Type II 75/25 fluids. One Type II 50/50 fluid, however, exhibited performance far superior to that of the same manufacturer's Type IV 50/50 fluid.

5.3 Simulated Freezing Fog

During the 1995/96 season, simulated freezing fog experiments were conducted at NRC's Climatic Engineering Facility in Ottawa. Past experience at APS and NRC helped set the parameters for the precipitation as defined in Section 2.3. This year's Type IV fluid data are shown in Appendix H by fluid type. Also presented are data from previous years, as these data sets were produced according to the same set of parameters as this year's data.

The tables in Section 1 containing the holdover times used for the 1995/96 winter show that most of the holdover time ranges in the cells of the freezing fog category for Type I and Type II fluid were substantiated. For temperatures below -25°C, the holdover times for Type II fluids were not substantiated. For both Type I and Type II fluids, the holdover time range for temperatures above 0°C cannot be substantiated by testing. For these temperatures above 0°C, the holdover times for the temperatures from 0°C to -3°C should be used. For the UCAR Ultra table, only the holdover times for the neat (100%) fluid concentration were substantiated. The actual holdover times for the neat Ultra fluid as tested during the 1994/95 season were more than 50% higher than the holdover times of neat Type II fluid, consistent with natural snow tests.

Tests were conducted in the 1995/96 season at temperatures below -25°C. At temperatures below -25°C, the viscous fluids (on flat plates) are thicker than at warmer temperatures; however, the failure mechanism is different. The fluids tend to become *slushy* as the precipitation accumulates on the plate. Because the freezing fog particles are very fine, slush forms on the top surface of the fluid long before, it forms on the lower surface. Whether this constitutes failure of the fluid on a plate needs to be addressed. The tests below -25°C are not reported here due to the questionable determination of failure. Freezing fog testing at temperatures below -25°C should be conducted with ice detection sensors such as AlliedSignal's C/FIMS.

For the artificial freezing fog tests conducted on flat plates, three types of charts have been produced as follow:

Ordinate	***Abscissa***	***Sub-grouping***
i) Fluid failure time	Rate of precipitation	Fluid brand
ii) Fluid failure time	Rate of precipitation	Temperature range
iii) Fluid failure time	Temperature	Precipitation rate

The proposed holdover time range as a function of temperature is shown on the third chart. These charts were produced for the Type IV fluids both neat and diluted (100%, 75/25 and 50/50), and are described in detail in the following sub-sections (see Appendix H, Figures H.25 to H.32).

Several tests were conducted with Hoechst Fluid MPIV 1934; however, because this fluid did not satisfy the proposed water spray endurance test requirements of 80 minutes, all tests with this fluid in all dilutions were discarded.

Data from UCAR Ultra tests conducted in 1993/94 have not been included because the Ultra fluid used that winter is no longer commercially available.

5.3.1 Type IV Neat (100%) Fluids Under Simulated Freezing Fog

Type IV neat (100%) fluid tests were conducted at NRC by APS during the 1994/95 (only one fluid brand) and 1995/96 winter seasons. Figures H.25 to H.27 illustrate the data points from both seasons as listed below:

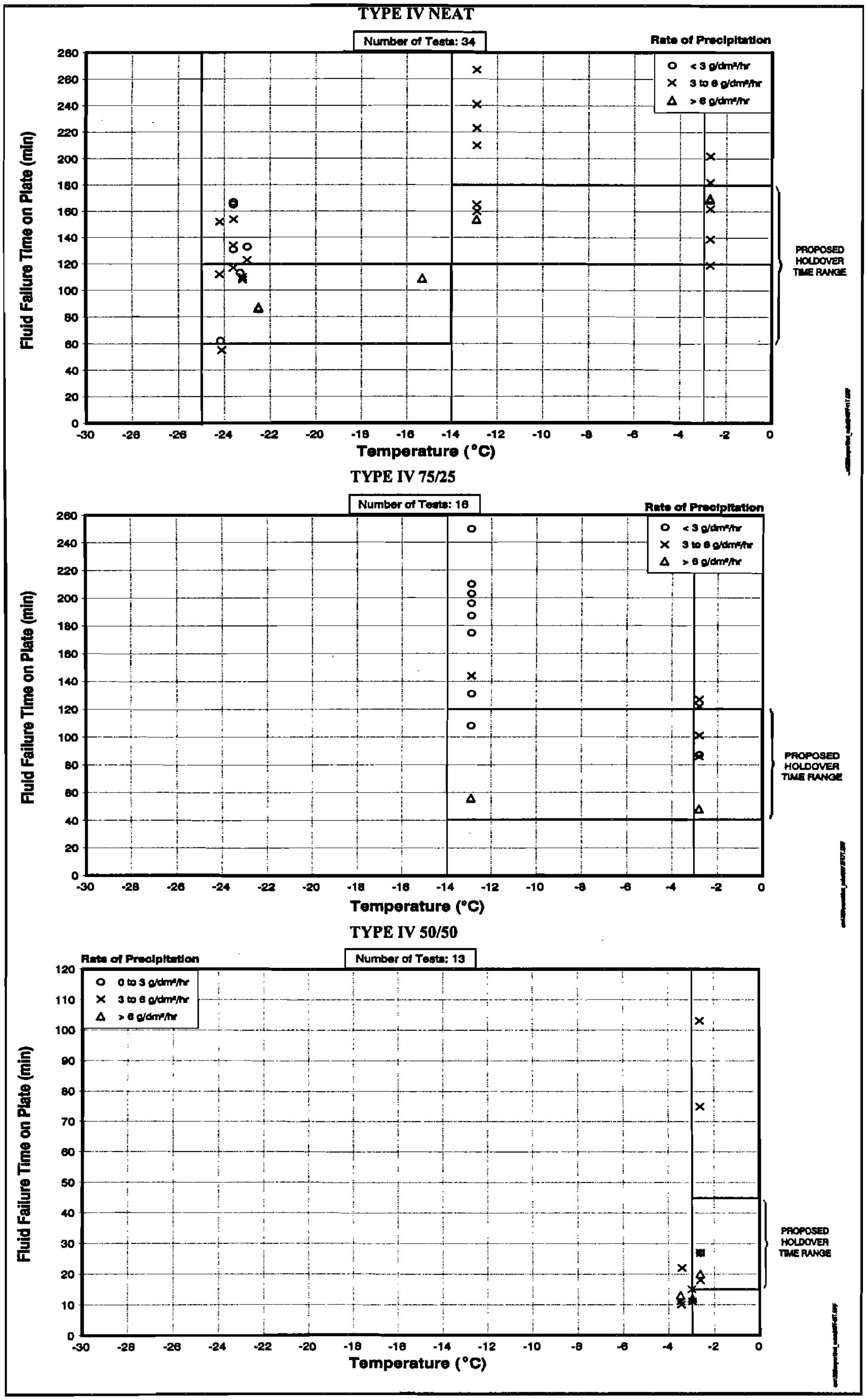
Figure H.25	Time vs rate vs fluid brand
Figure H.26	Time vs rate vs temperature
Figure H.27*	Time vs temperature vs precipitation rate

* Also reproduced in Figure 5.5

The holdover time range used during 1995/96 for UCAR Ultra neat fluid during freezing fog conditions was 50% greater (see Table 1.4) than the holdover time range for Type II neat fluid:

FIGURE 5.5

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME FREEZING FOG



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- For above 0°C 112 to 270 minutes
- For 0°C to -30°C 52 to 135 minutes

These times were consistent with the times determined for snow, freezing drizzle, and light freezing rain and were supported by tests conducted under artificial freezing fog with neat Ultra fluid.

New proposed holdover times were determined from 1994/95 and 1995/96 test data (see Figure H.27 and Figure 5.5) as follows:

- For above 0°C to -14°C 120 to 180 minutes
- For below -14°C to -25°C 60 to 120 minutes

For temperatures between 0°C and -14°C, these figures represent an increase to the lower limit of more than 100%.

The tests conducted at temperatures below -22°C should be reviewed to ensure that the failure call was satisfactory, and new tests utilizing C/FIMS ice sensors should be carried out.

5.3.2 Type IV 75/25 Fluids Under Simulated Freezing Fog

Type IV 75/25 fluid tests were conducted at NRC during the 1995/96 season. Figures H.28 to H.30 contain the data points as listed below:

Figure H.28	Time vs rate vs fluid brand
Figure H.29	Time vs rate vs temperature
Figure H.30*	Time vs temperature vs precipitation rate

* Also reproduced in Figure 5.5

The holdover times during the 1995/96 season for Ultra 75/25 fluid (see Table 1.4) were left the same as the holdover times for Type II 75/25 fluids:

- Above 0°C 50 to 120 minutes
- 0°C to -14°C 25 to 60 minutes

The zero increase was consistent with the other forms of precipitation when utilizing Ultra 75/25 fluid. Three calibration tests had been conducted during 1994/95 with UCAR Ultra 75/25 at low temperatures (-15°C) and high deposition rates (>10 g/dm^2/hr). These tests showed that a factor of 1.5 applied to the Type II 75/25 fluid holdover times would have been suitable for Ultra 75/25 fluid during freezing fog conditions. The 1995/96 test data confirmed this. The new proposed holdover time range (0°C and below) for Type IV 75/25 fluids in freezing fog was increased almost 100% (40 to 120 minutes) from the Type II 75/25 holdover time range.

5.3.3 Type IV 50/50 Fluids Under Simulated Freezing Fog

Type IV 50/50 fluid tests were conducted at NRC by APS during the 1995/96 season. Figure H.31 shows the plate failure time plotted as a function of rate of precipitation and by fluid brand, and Figure H.32 (and Figure 5.5) shows the same data plotted as a function of temperature.

Three tests conducted in 1994/95 with UCAR Ultra 50/50 fluid showed no significant difference in holdover time compared to the Type II 50/50 fluids. Therefore, the Ultra 50/50 holdover time range for 1995/96 (see Table 1.4) was the same as the Type II 50/50 holdover time (15 to 45 minutes for 0°C to -7°C).

The new proposed holdover time range for Type IV 50/50 fluids was also left the same (15 to 45 minutes) for temperatures of 0°C and below. For temperatures above 0°C, the holdover time range was reduced (from 35 to 90 minutes) to 15 to 45 minutes.

5.3.4 Type I and Type II Fluids Under Simulated Freezing Fog

Several tests were conducted during the 1995/96 test season with Type I and Type II neat, 75/25 and 50/50 fluids. These data were plotted and are included in Appendix E to maintain records for future reference. The following observations can be made from the plots:

- Several tests with Type I fluid were conducted at temperatures below -25°C. Test results (see Appendix E) show failure times within the holdover time range of 6 to 15 minutes. The failure calls should be verified with an AlliedSignal C/FIMS ice sensor.

- The few Type II tests conducted show that the present holdover time ranges are satisfactory, except at colder temperatures below -14°C for Type II neat fluid (third paragraph, Section 5.3). The questionable failure calls at these low temperatures must be reviewed. C/FIMS ice sensors should have been used for this evaluation, but were not available.

The Type I and Type II fluid holdover time tables in Section 1 show that the cell values for freezing fog above 0°C are *not substantiated.* It is not possible to conduct tests under freezing fog above 0°C, however meteorological experts have indicated that this condition could occur. Because this condition does not occur frequently and the holdover time ranges below 0°C are lower, it is recommended that the holdover time values in the cells at 0°C and below be utilized for the holdover time range above 0°C.

5.4 Simulated Rain on Cold-Soaked Surface

Simulation of rain on a cold-soaked wing was achieved through the use of test procedures identical to standard flat plate tests but performed on cold-soaked boxes. The method and validity of relating the boxes to a representative aircraft wing surface are discussed in two Transport Canada reports:

- *Methodology for Simulating a Cold-Soaked Wing*, TP 12678E, and
- *Validation of Methodology for Simulating a Cold-Soaked Wing*, TP 12899E.

The first report, prepared as part of the 1994/95 season, focused on a theoretical approach for simulating a cold-soaked wing. The second report, prepared as part of the 1995/96 test program, evaluated the approach for simulating a cold-soaked wing experimentally.

Three boxes with identical surface dimensions but different depths were employed. During the 1994/95 test season, two boxes having depths of 15 cm and 7.5 cm were used. For the 1995/96 tests, the third box, 2.5 cm deep, and the 7.5 cm box were used.

The tables in Section 1, presenting the holdover times for the 1995/96 winter show that all the holdover times in the cells for the rain on cold-soaked wing category for Type I, Type II, and UCAR Ultra fluids were not substantiated.

In the absence of any data, the holdover times for the neat (Ultra) fluid were kept the same as the holdover times for neat Type II fluid. The 50% increase over the neat Type II fluid that characterizes the Ultra table (see Section 1) was not applied for the rain on cold-soaked wing category.

Preliminary test results from the 1994/95 season (see report TP 12654E) showed that the SAE holdover time ranges as originally conceived were probably high for the cases of Type II 50/50 fluid and diluted Type I fluid.

A matrix (see Table 5.2) showing which charts were produced for the cold-soaked surface tests was developed. It shows that four charts were developed for each fluid type (I, II and IV) including the diluted variations of these fluid types. For each fluid type, test results are provided as a function of the most significant variables:

Ordinate	*Abscissa*	*Sub-grouping*
i) Fluid failure time	Rate of precipitation	Fluid brand
ii) Fluid failure time	Rate of precipitation	Skin temperature
iii) Fluid failure time	Rate of precipitation	Box depth
iv) Fluid failure time	Skin temperature	Precipitation rate

The data from the 1994/95 test season (see report TP 12676E) were combined with the data from the 1995/96 test season. Several cold-soaked tests during the 1995/96 season were conducted with the new Hoechst Fluid MPIV 1957.

To ensure that the charts that follow are clear and concise, a description of some parameters (variables) is repeated below in a summarized format.

Failure time on box: The same failure definition as on a standard flat plate was used.

Rain rate of precipitation: Four categories of precipitation rates were produced:

i) < 13 $g/dm^2/hr$ Drizzle

ii) 13 to 25 $g/dm^2/hr$ Light rain

iii) 25 to 75 $g/dm^2/hr$ Moderate rain

iv) > 75 $g/dm^2/hr$ Heavy rain

The rates were measured with plate pans before and after each test. For tests conducted in 1994/95, moderate and heavy rain were not simulated. Limited testing was carried out under conditions of heavy rain.

TABLE 5.1

MATRIX OF COLD-SOAKED SURFACE CHARTS SHOWING VARIABLES PLOTTED

	Figure numbers given below			
FLUID TYPE	**Time vs Rate vs Fluid Brand**	**Time vs Rate vs Skin Temperature**	**Time vs Rate vs Box Depth**	**Time vs Skin Temperature vs Rate**
I Standard	Figure H.33	Figure H.34	Figure H.35	Figure H.36
I Diluted	Figure H.37	Figure H.38	Figure H.39	Figure H.40
II 100/0	Figure H.41	Figure H.42	Figure H.63	Figure H.44
II 75/25	Figure H.45	Figure H.46	Figure H.47	Figure H.48
II 50/50	Figure H.49	Figure H.50	Figure H.51	Figure H.52
IV 100/0	Figure H.53	Figure H.54	Figure H.55	Figure H.56
IV 75/25	Figure H.57	Figure H.58	Figure H.59	Figure H.60
IV 50/50	Figure H.61	Figure H.62	Figure H.63	Figure H.64

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Skin Temperature:

- This parameter was measured on the box surface, 22.5 cm from the plate leading edge.

- Temperatures were measured just before fluid application and immediately after failure using a hand-held temperature probe. For some tests, thermistors were attached to the plate surfaces to measure the skin temperature and these measurements were logged every six seconds.

- Most tests conducted in 1995/96 were started when the skin temperature on the box was -10°C. This value was assumed to be the most limiting case for cold-soaked wings based on an analysis of wing skin temperature data (see report TP 12899E). Some Type I tests were started when the surface temperature was -5°C.

- The average skin temperature over the test period was computed and used in the charts described in this section.

- The ambient air temperature was +2°C.

The following general comments can be made from observation of the 32 charts (Figure H.33 to Figure H.64). More comments relating specifically to each fluid type are provided in the sub-sections which follow.

- Over the test range and for each fluid type, the variable exhibiting the greatest influence on fluid failure time is rate of precipitation.

- Skin temperature and box size are related; their influence on failure time for the tests conducted was not as significant as that of the precipitation rate (see report TP 12899E).

- The size of the box has less influence as the rate of precipitation increases and the holdover time decreases.

- Prior to carrying out these tests, many believed that the rain would wash away the fluid at high precipitation rates and that the heat imparted to the box surface from the rain would not permit the surface to freeze. This was not the case for the rates of precipitation tested, provided that the tests were started when the box surface temperature was about -10°C. This effect was only observed when the surface temperature on the box was close to 0°C.

The 1995/96 holdover times for rain on a cold-soaked wing from Section 1 are summarized in Column 1 of Table 5.2. The holdover times are provided as a function of fluid type. At the 1996 SAE G-12 Holdover Time Sub-Committee meeting in Denver changes to the holdover times for conditions of rain on a cold-soaked wing were proposed and appear in Column 2 of Table 5.2. These changes included reductions to all of the holdover time ranges, except for Type II 50/50 and Type IV 50/50 fluids which were removed from the tables. Use of these diluted fluids is not permitted when a wing is cold-soaked and it is raining.

Two additional columns with holdover times were developed from the tests conducted at NRC and are shown in Table 5.2. Column 3 shows the range of times from the drizzle and light rain tests, and Column 4 shows the range of times from the moderate and heavy rain tests.

The table is segmented into Columns 3 and 4 based upon several factors. First, four (4) intensities of rain were used in data acquisition. Second, data from these four sets were grouped according to the most predominant natural patterns of precipitation. Third, freezing drizzle and light freezing rain categories already exist in the holdover time tables, so the "drizzle" and "light rain" categories are natural extensions to the tables. The recommended holdover times for the drizzle and light rain category values (see Column 3) are not very different from current values in the holdover time tables (see Column 2). However, the recommended holdover times for moderate to heavy rain category (see Column 4) are significantly below the current holdover time table values. Further details regarding the segmenting scheme are presented in the next paragraph. The probability of occurrence of moderate to heavy rain at outside air temperatures between 0°C and 5°C warrants investigation.

For each fluid type, a best fit lower limit curve was superimposed over the test values. The recommended holdover time range for drizzle and light rain (Column 3) was determined by examination of this curve (see Figure 5.6 for an example). The lower value of the range for drizzle and light rain (Column 3) was taken at the intersection of the curve with the rate of 25 g/dm^2/hr (the upper limit of light rain), and the upper value was taken at the intersection of the curve with a rate of precipitation between 5 and 10 g/dm^2/hr (mid-point of drizzle). The recommended holdover time range for moderate and heavy rain (Column 4) was determined by taking the value at about 150 g/dm^2/hr for the lower limit and the value at about 50 g/dm^2/hr for the upper limit. If this method of analysis is accepted by the SAE G-12 Holdover Time Sub-Committee, more tests at the higher rates of precipitation should be conducted to confirm the lower limit values in Column 4.

The failure time values determined with the boxes are probably more conservative than those that would be determined on a wing, because the fluid film thickness on a wing over the cold-soaked area is thicker than on the 15 cm line of the cold boxes (angled at 10°) used to simulate a wing.

5.4.1 Type I Fluids on a Cold-Soaked Surface

The holdover time range for Type I fluids was decreased from 6-15 minutes, to 2-5 minutes at the SAE meeting in Denver. This is in agreement with last winter's

FIGURE 5.8

EFFECT OF RATE OF PRECIPITATION AND SKIN TEMPERATURE ON FAILURE TIME
RAIN ON COLD-SOAKED SURFACE

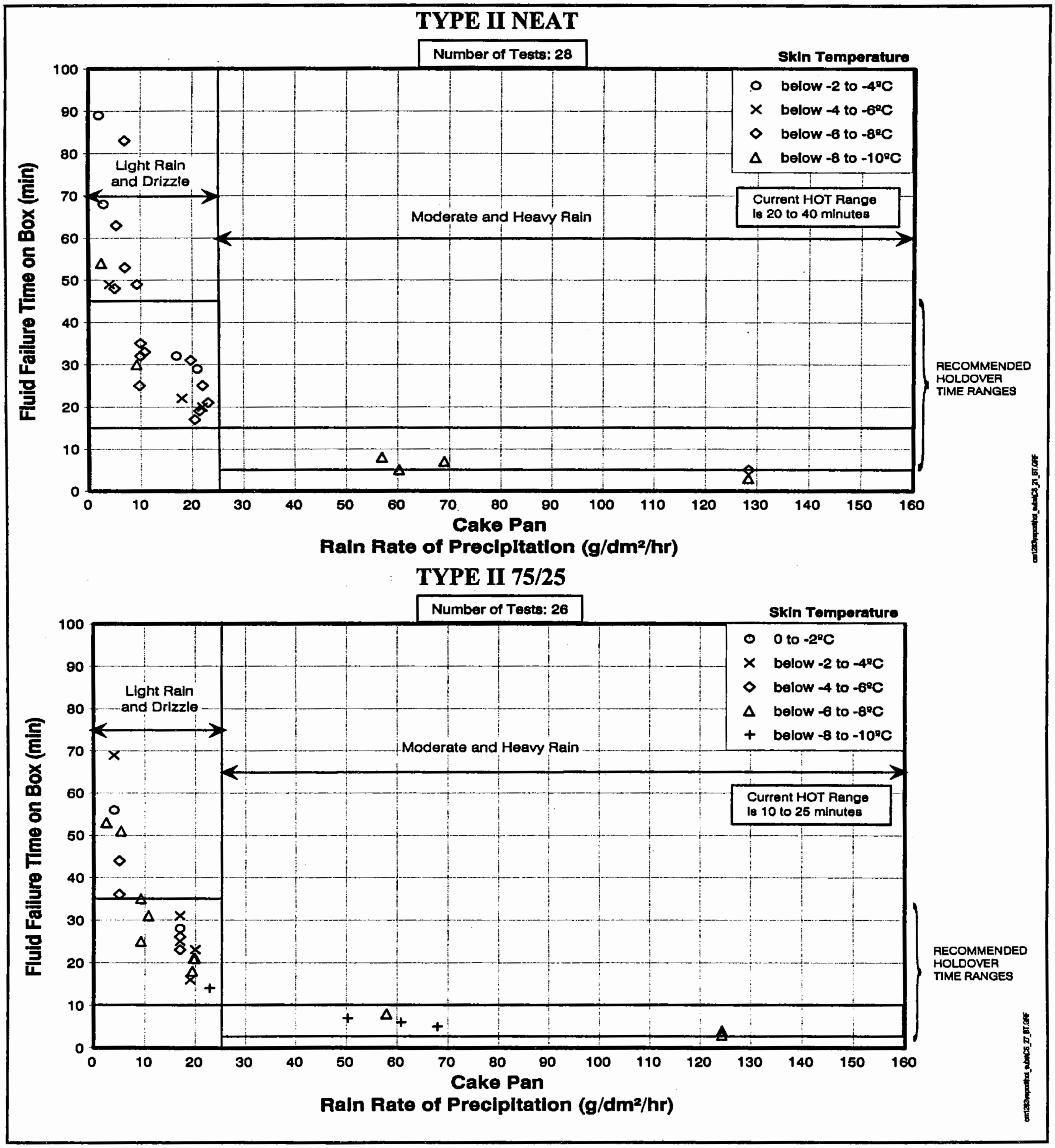

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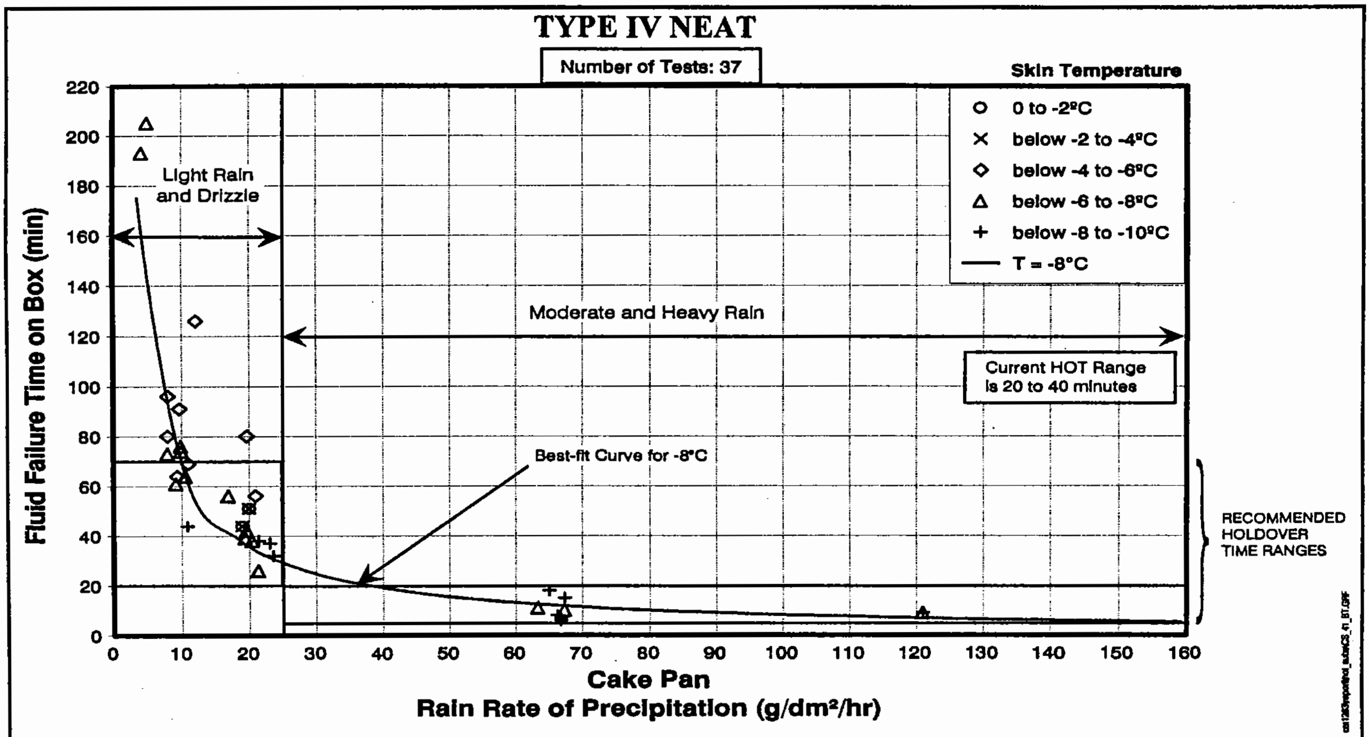
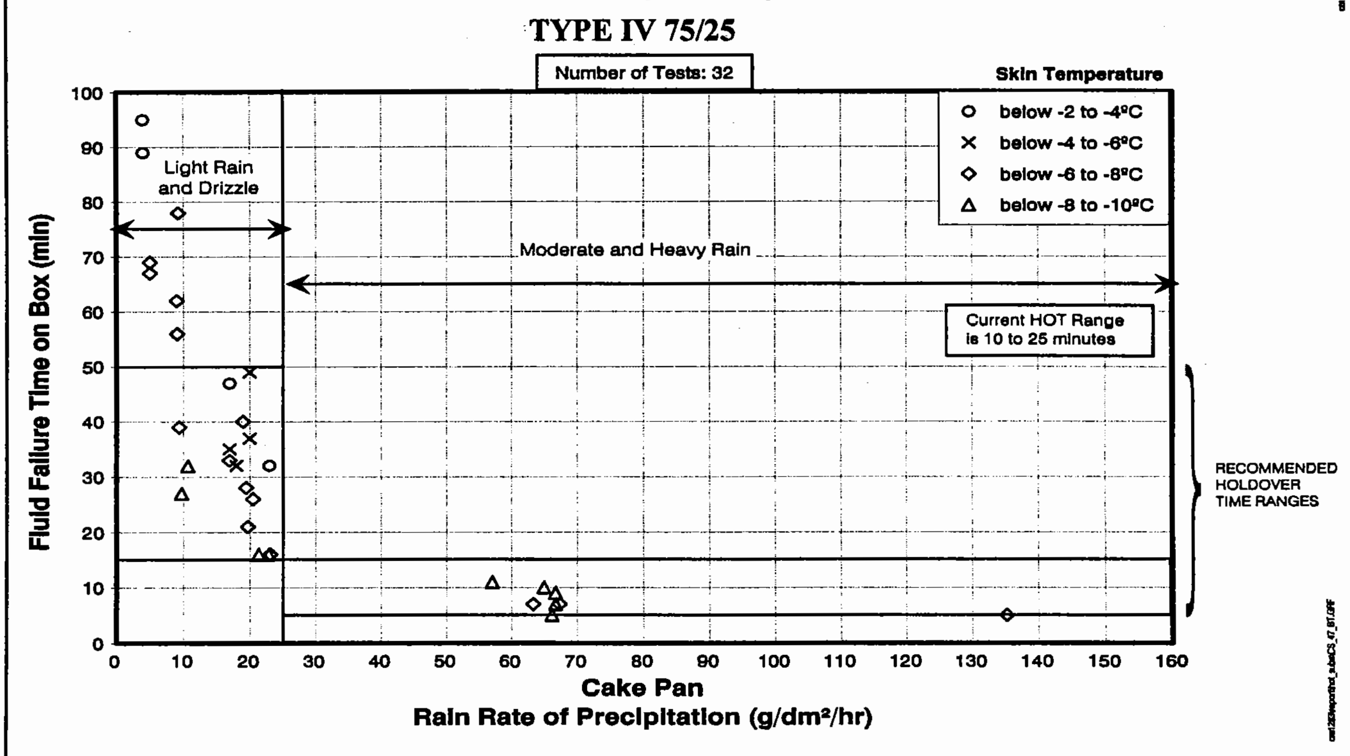
FIGURE 5.9

EFFECT OF RATE OF PRECIPITATION AND SKIN TEMPERATURE ON FAILURE TIME

RAIN ON COLD-SOAKED SURFACE





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5.5 Holdover Time for Type III Fluids

As discussed in Section 1, Type III fluid is a thickened fluid that exhibits physical properties lying between Type I and Type IV fluids. Its shear and flow characteristics are designed for aircraft with lower take-off speeds.

The SAE document Aerospace Recommended Practice (ARP) 4737 refers to Type III fluids and it is recommended that smaller commercial aircraft with lower rotation speeds use the less viscous Type III fluids as opposed to new Type IV fluids to ensure minimal lift degradation. However, no Type III holdover time table is presently in existence. For this reason, a "proto-type III" fluid holdover time table has been developed and is presented in Table 5.5.

The original holdover time testing of Type III fluids was carried out in the 1991/92 test season using primarily Union Carbide 250-3 fluid (see report TP 11454E). The most recent data for Type III fluid testing are available from the Appendix G of Transport Canada report TP 11836E. These data are somewhat obsolete as it is based on the Union Carbide fluid 250-3 which is no longer commercially available. These data were combined with data from tests on Type IV 75/25 fluid.

The combined data were assembled to provide a basis for the proposed Type III holdover time table. Union Carbide has indicated that it plans to commercialize a diluted version of their Type IV Ultra+ fluid, probably a modified Type IV Ultra + 67/33 mix, as a Type III fluid.

It is understood that acceptance of this table would be premature and recognizes the necessity to substantiate these values through testing with new Type III fluids.

5.6 Effect of Fluid Application Procedure on Holdover Time

During 1995 SAE G-12 meetings on aircraft ground de-icing, some concerns were raised regarding one-step vs two-step fluid application. In the standard test on flat plates used to substantiate or develop new holdover times, fluid is poured onto the plates in a one-step application. During actual aircraft operations, a two-step application method is used and fluid is sprayed onto the wing. When Type II or Type IV anti-icing fluid is used on aircraft wings, the first step normally uses a Type I fluid for de-icing.

5.6.1 Set-up for Special Tests

To study the effect on holdover time of one-step vs two-step fluid application, a series of supplementary tests were planned and conducted at NRC's cold chamber under artificial light freezing rain conditions. In addition, a backpack garden sprayer (see Photo 5.7) was used to apply fluid onto some plates to see the effect on holdover time testing of spraying the fluid versus pouring.

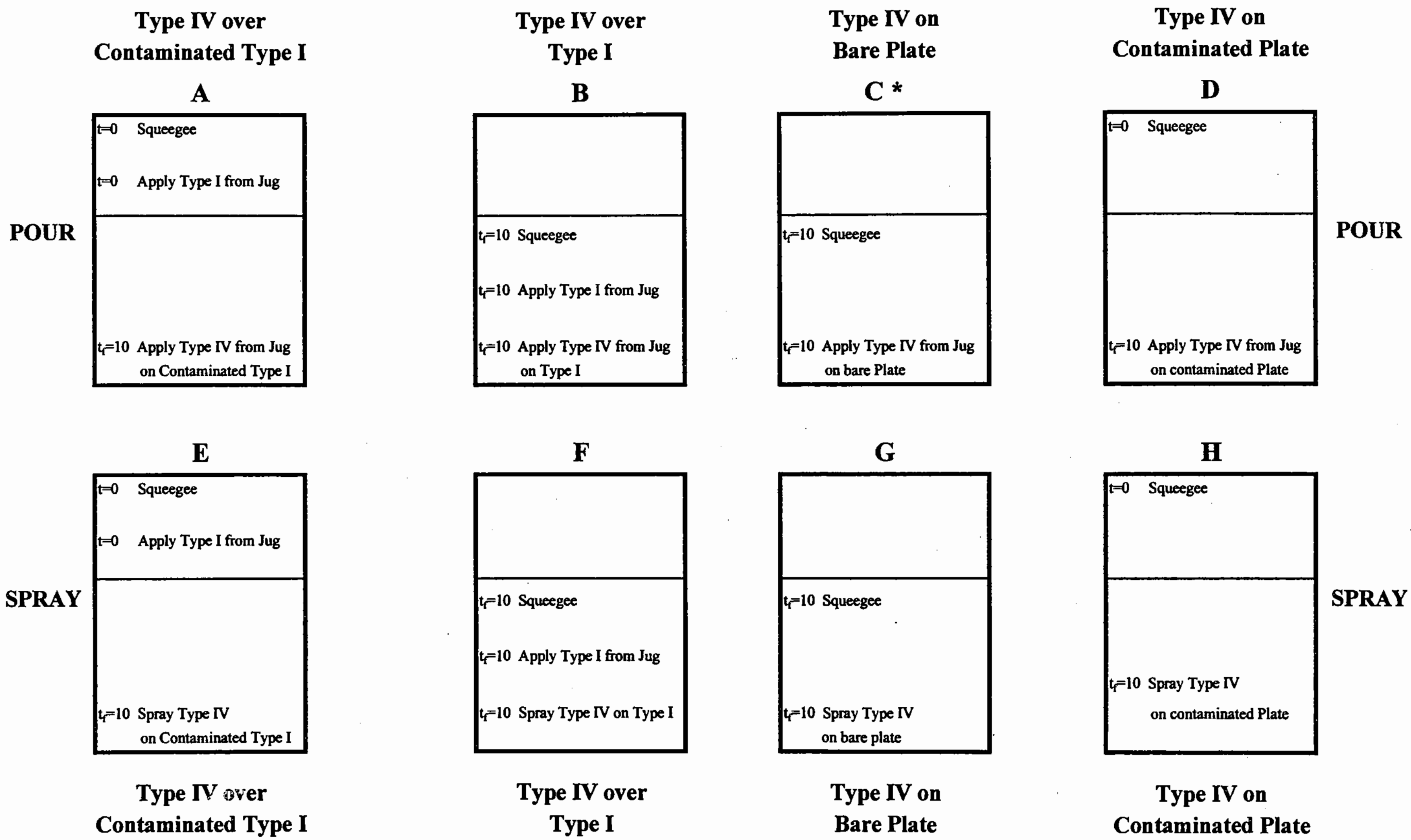
Eight different fluid application methods (see Figure 5.10) were used for these tests. For the four top plates (A to D) in Figure 5.10, Type IV fluid was poured, and for the four bottom plates (E to H), Type IV fluid was sprayed. The fluid application was as follows:

Type IV over contaminated Type I (Plates A and E): Plates A and E were cleaned, and Type I fluid was poured from a hand-held container. The Type I was allowed for fail, then Type IV was poured on plate A and sprayed on plate E.

Type IV over Type I (Plates B and F): Plates B and F were cleaned after the failure of Type I fluid on plates A and E. Type I fluid was poured on both plates, followed immediately by the application of Type IV fluid, also poured on plate B and sprayed on plate F.

FIGURE 5.10

FLUID APPLICATION PROCEDURE FOR TESTING OF TYPE IV OVER TYPE I



NOTES:

* This test procedure is exactly the same as the standard flat plate test procedure.

i) It is assumed above that the failure time of the Type I which fails last is 10 minutes. At this time apply Type IV.

ii) When applying Type IV from the jug, use 1.5 L in all cases.

iii) When using garden sprayer, spray for 1 minute.

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Type IV on a Bare Surface (Plates C and G): Plates C and G were cleaned after the failure of Type I fluid on plates A and E. Type IV fluid was poured immediately onto plate C and sprayed on plate G. *The plate C procedure represents the standard holdover time test.*

Type IV on Contaminated Plate (Plates D and H): Plates D and H were cleaned at the same time as plates A and E. After failure of Type I fluid on plates A and E, Type IV fluid was poured onto plate D and sprayed onto plate H.

When applying Type IV fluid from a container, 1.5 L of fluid was used. When using the backpack sprayer to apply Type IV, fluid was sprayed for 1 minute (the volume expended is about 1.5 L).

5.6.2 Results of Special Tests at NRC

A total of 29 tests were conducted at the NRC under light freezing rain conditions: 16 tests used Type IV neat Fluid C-100 and 13 tests used Type IV neat Fluid C-105. For the Type IV Fluid C-100 tests, the rate of precipitation was between 16 and 21 g/dm^2/hr depending on the plate, and for Type IV Fluid C-105 tests, the precipitation rate was between 19 and 25 g/dm^2/hr. The variations in precipitation rates measured for these tests are a consequence of the fluid delivery apparatus in the spray chamber. The precipitation rate is constant at a fixed location in the chamber, but varies slightly from one location to the next. The ambient air temperature was -3°C and the 29 tests were conducted over three runs in one day.

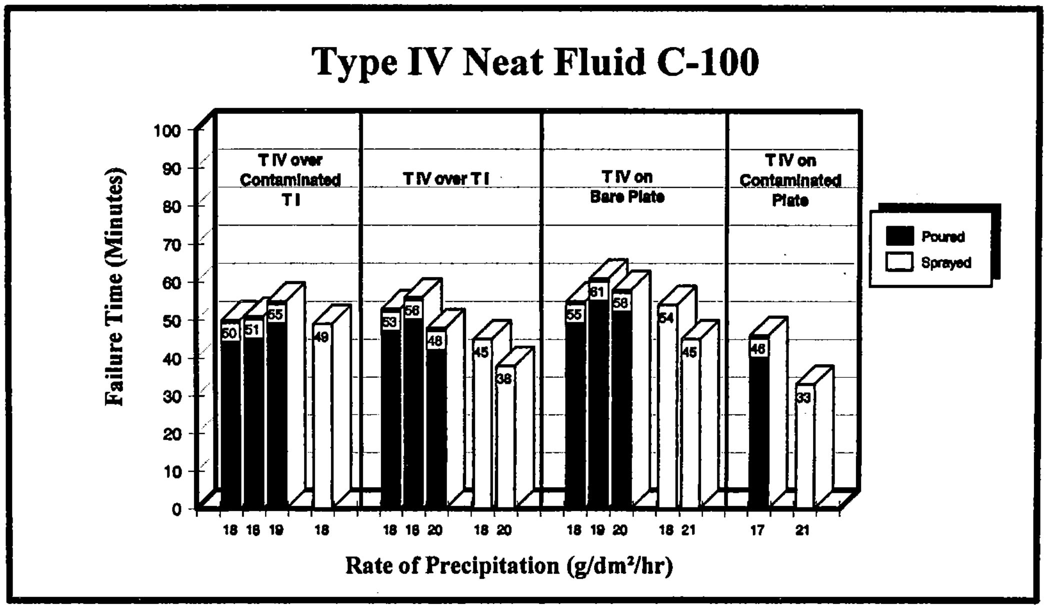
The results from the 29 tests are depicted graphically in Figure 5.11 for both fluids. The holdover time is shown on the vertical axis, and the rate of precipitation for each test is indicated on the horizontal axis. The following observations can be made:

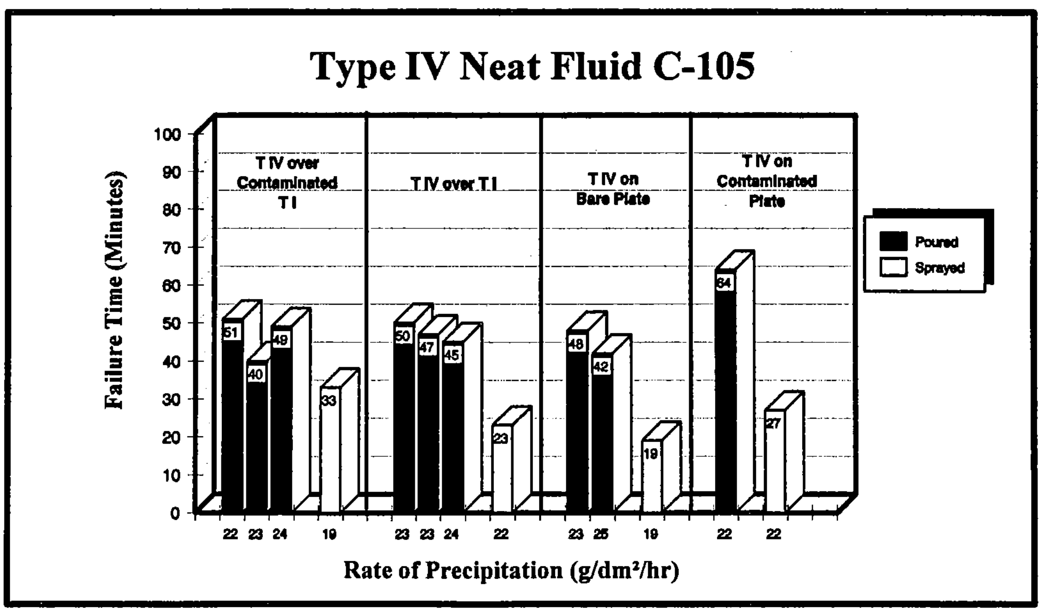
- The holdover time for the comparable plates with the sprayed fluid is less than for the plates with the poured fluid, in all cases for both fluids. Fluid

FIGURE 5.11

COMPARISON OF FLUID APPLICATION METHOD

LIGHT FREEZING RAIN AT NRC





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thickness measurements also showed reduced thickness for the sprayed fluids (see related report TP 12900E). In general, the poured film fluid thickness is not achieved with the backpack sprayer. The shear forces needed to reduce the liquid to this droplet size delay the thixotropic restructuring of the fluid that allows it to resist flow and remain in a thick layer on the test surface. High shear forces are encountered when fluids are applied by commercial spray equipment with appropriate nozzles as used on de-icing trucks, but the droplet size is not nearly as fine as those emitted from a backpack sprayer. Therefore, thixotropy is restored much more rapidly when the fluid is sprayed from the trucks.

- For the poured tests with Type IV neat Fluid C-100, the standard plate tests (Type IV on a bare surface) have the longest holdover times. The average holdover time of the three standard plate tests is about 10% higher than the average time of the Type IV over Type I tests, and also 10% higher than the average of the Type IV over contaminated Type I tests.

- For the tests carried out with sprayed Type IV neat Fluid C-100, the holdover times are highest for the fluid applied on the bare plate. In fact, the holdover time was 20% higher than that for the plates on which Type IV was sprayed over Type I.

- For Type IV neat Fluid C-105 (both poured and sprayed), the average holdover times were higher for the two-step applications than on the standard test plate. Furthermore, the holdover time for fluid application on a contaminated plate was substantially higher than for most of the corresponding applications. This was not the case for Type IV Fluid C-100.

5.6.3 Results of Special Tests at Dorval

A few preliminary tests using several of these different fluid application methods were also conducted outdoors at the Dorval test site during natural snow conditions. Figure 5.12 shows the results from four runs. During each run, all tests were conducted simultaneously. Because outdoor conditions are not controllable and failure times differ, the average rate of precipitation over the entire test was often different from plate to plate. Neat Type IV Fluid A-303 was used for these outdoor tests, and this manufacturer's Type I fluid was used for two-step fluid applications. The following observations are made.

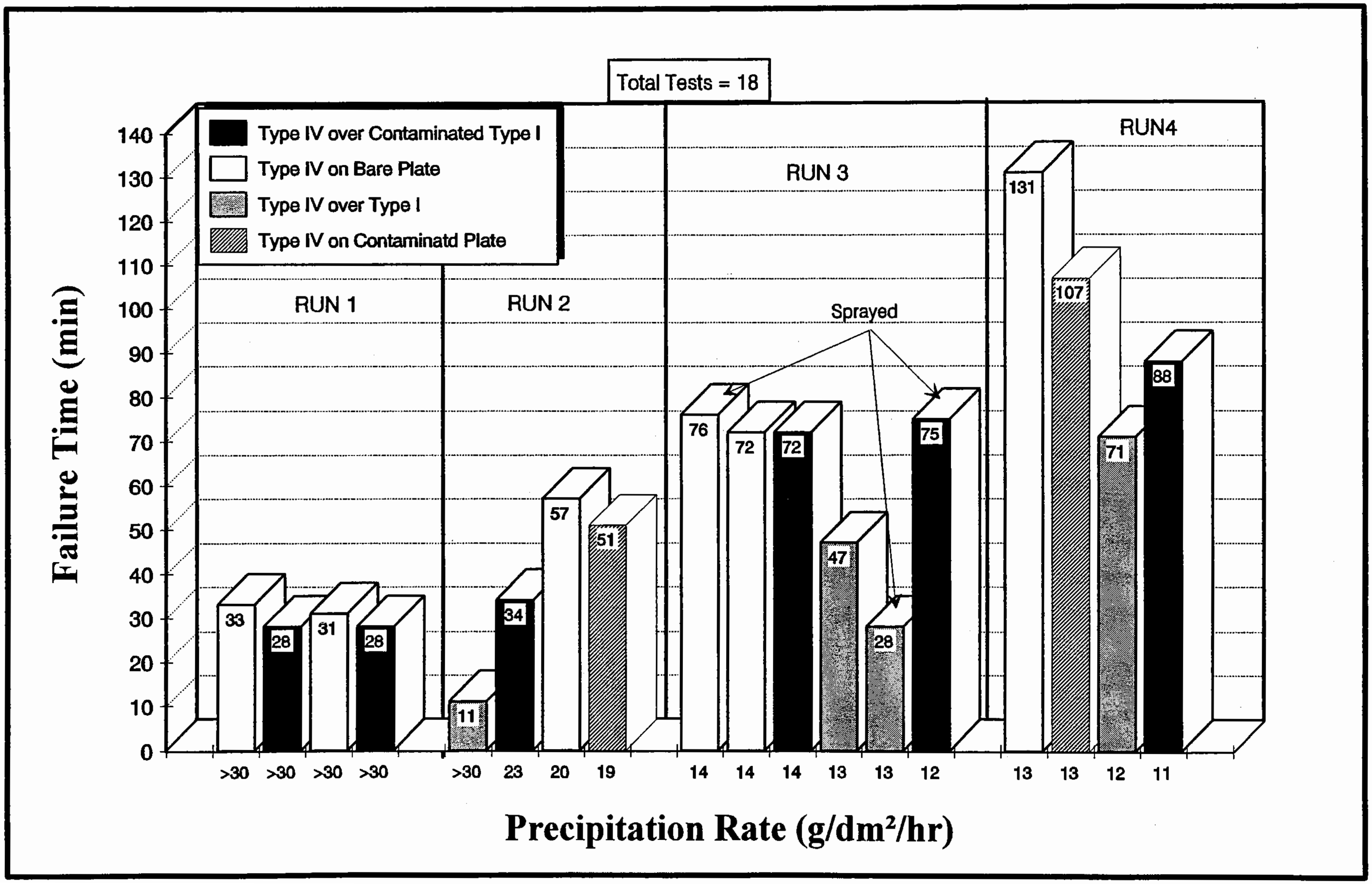
- The holdover time corresponding to the Type IV on a bare plate application was always the longest, except for one run when it lasted for 72 minutes (3 minutes less than the longest).

- The holdover time for the two-step Type IV over Type I was always the shortest. It should be cautioned that during these tests, the quantity of Type IV applied was not controlled.

- The holdover time for Type IV over contaminated Type I was always higher than the holdover time for Type IV over uncontaminated Type I.

FIGURE 5.12

SUMMARY OF NATURAL SNOW SPECIAL TESTS
1995 - 1996



5.7 Summary of Holdover Time Tests

Flat plate tests were conducted under a variety of precipitation conditions. Tables 5.3 to 5.6 provide the current status of the SAE/ISO holdover times as they have been proposed by the SAE G-12 Holdover Time Sub-Committee. These are the tables which are proposed for world-wide use during the 1996/97 winter. Table 5.3 is for Type I, Table 5.4 is for Type II, Table 5.5 is the proposed Type III table, and Table 5.6 is for the new Type IV fluids. The most notable change from the 1995/96 winter was the substitution of the Type IV holdover time table to replace the Ultra fluid holdover time table. A preliminary table for Type III fluids was developed.

For each table, in each block, an indicator on the current status is provided. "S" designates that the times for the specific condition and fluid are substantiated, and "NS" indicates that they are not substantiated.

TABLE 5.3

PROPOSED SAE/ISO HOLDOVER TIME TABLE FOR TYPE I FLUIDS TO BE USED IN 1996/97

Guideline for Holdover Times Anticipated for SAE Type I and ISO Type I Fluid Mixtures as a Function of Weather Conditions and OAT.

The responsibility for the application of these data remains with the user.

SAE TYPE I

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
°C	°F	*FROST	FREEZING FOG	SNOW	**FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	0:45 S	0:12-0:30 NS	0:06-0:15 S	0:05-0:08 S	0:02-0:05 S	0:02-0:05 NS
0 to -10	32 to 14	0:45 S	0:06-0:15 S	0:06-0:15 S	0:05-0:08 S	0:02-0:05 S	
below -10	below 14	0:45 S	0:06-0:15 S	0:06-0:15 S			

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
FP = Freezing Point

* During conditions that apply to aircraft protection for ACTIVE FROST
** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

SAE Type I Fluid / Water Mixture is selected so that the FP of the mixture is at least 10°C (18°F) below OAT.

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT. THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIMETABLE CELL.

S = Substantiated
NS = Not substantiated

Tranport Canada (Aug. '96)

TABLE 5.4

PROPOSED SAE/ISO HOLDOVER TIME TABLE FOR TYPE II FLUIDS TO BE USED IN 1996/97

Guideline for Holdover Times Anticipated for SAE Type II and ISO Type II Fluid Mixtures as a Function of Weather Conditions and OAT.

The responsibility for the application of these data remains with the user.

SAE TYPE II

OAT °C	OAT °F	SAE Type II Fluid Concentration Neat-Fluid/Water (Vol%/Vol%)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes) *FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	100/0	12:00 S	1:15-3:00 NS	0:20-1:00 S	0:30-1:00 S	0:15-0:30 S	0:20-0:40 NS
		75/25	6:00 S	0:50-2:00 NS	0:15-0:45 S	0:20-0:45 S	0:10-0:25 S	0:10-0:25 NS
		50/50	4:00 S	0:35-1:30 NS	0:05-0:15 S	0:15-0:25 S	0:05-0:15 S	
0 to -3	32 to 27	100/0	8:00 S	0:35-1:30 S	0:20-0:45 S	0:30-1:00 S	0:15-0:30 S	
		75/25	5:00 S	0:25-1:00 S	0:15-0:30 S	0:20-0:45 S	0:10-0:25 S	
		50/50	3:00 S	0:15-0:45 S	0:05-0:15 S	0:15-0:25 S	0:05-0:15 S	
below -3 to -14	below 27 to 7	100/0	8:00 S	0:35-1:30 S	0:20-0:45 S	**0:30-1:00 S	**0:10-0:30 S	
		75/25	5:00 S	0:25-1:00 S	0:15-0:30 S	**0:20-0:45 S	**0:10-0:25 S	
below -14 to -25	below 7 to -13	100/0	8:00 NS	0:35-1:30 S	0:20-0:45 S			
below -25	below -13	100/0	NS	NS	SAE TYPE II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type II fluid cannot be used.			

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
FP = Freezing Point

* During conditions that apply to aircraft protection for ACTIVE FROST
** The lowest use temperature is limited to -10°C (14°F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT. THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE TIMETABLE CELL.

S = Substantiated
NS = Not substantiated

Transport Canada (Aug. '96)

CM1222\PRESENT\AOTT_OC95\HO1_TBLS.XLS
TYPE II 97-4-18

TABLE 5.5

PROPOSED SAE/ISO HOLDOVER TIME TABLE FOR TYPE III FLUIDS TO BE USED IN 1996/97

Guideline for Holdover Times Anticipated for SAE Type III and ISO Type III Fluid Mixtures as a Function of Weather Conditions and OAT. The responsibility for the application of these data remains with the user.

SAE TYPE III FLUID

OAT		Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
above 0°	above 32°	5:00 NS	0:40 to 2:00 NS	0:15 to 1:00 NS	0:20 to 1:00 NS	0:15 to 0:30 NS	0:10 to 0:25 NS
0 to -3	32 to 27	5:00 NS	0:40 to 2:00 NS	0:15 to 1:00 NS	0:20 to 1:00 NS	0:15 to 0:30 NS	
below -3 to ??	below 27 to ??	5:00 NS	0:40 to 2:00 NS	0:15 to 1:00 NS	0:20 to 1:00 NS	0:10 to 0:25 NS	

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
FP = Freezing Point

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT. THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIMETABLE CELL.

NS = Not Substantiated

Transport Canada (Aug. '96)

TABLE 5.6

PROPOSED SAE/ISO HOLDOVER TIME TABLE FOR TYPE IV FLUIDS TO BE USED IN 1996/97

Guideline for Holdover Times Anticipated for SAE Type IV and ISO Type IV Fluid Mixtures as a Function of Weather Conditions and OAT.

The responsibility for the application of these data remains with the user.

SAE TYPE IV

OAT °C	OAT °F	SAE Type IV Fluid Concentration Neat-Fluid/Water (Vol%/Vol%)	*FROST	FREEZING FOG	SNOW	***FREEZING DRIZZLE	LIGHT FRZ RAIN	RAIN ON COLD SOAKED WING
			Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
above 0°	above 32°	100/0	18:00 S	2:00-3:00 S	0:55-1:40 S	0:45-1:50 S	0:30-1:00 S	0:20-0:40 NS
		75/25	6:00 S	0:40-2:00 S	0:20-1:00 S	0:20-1:00 S	0:15-0:30 S	0:10-0:25 NS
		50/50	4:00 S	0:15-0:45 S	0:05-0:25 S	0:07-0:15 S	0:05-0:10 S	
0 to -3	32 to 27	100/0	12:00 S	2:00-3:00 S	0:45-1:40 S	0:45-1:50 S	0:30-1:00 S	
		75/25	5:00 S	0:40-2:00 S	0:15-1:00 S	0:20-1:00 S	0:15-0:30 S	
		50/50	3:00 S	0:15-0:45 S	0:05-0:20 S	0:07-0:15 S	0:05-0:10 S	
below -3 to -14	below 27 to 7	100/0	12:00 S	2:00-3:00 S	0:35-1:15 S	**0:45-1:50 S	**0:30-0:55 S	
		75/25	5:00 S	0:40-2:00 S	0:15-1:00 S	**0:20-1:00 S	**0:10-0:25 S	
below -14 to -25	below 7 to -13	100/0	12:00 S	1:00-2:00 S	0:30-1:10 S			
below -25	below -13	100/0	SAE TYPE IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of SAE Type I when SAE Type IV fluid cannot be used.					

°C = Degrees Celsius
°F = Degrees Fahrenheit
OAT = Outside Air Temperature
FP = Freezing Point

* During conditions that apply to aircraft protection for ACTIVE FROST
** The lowest use temperature is limited to -10°C(14°F)
*** Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

CAUTION: THE TIME OF PROTECTION WILL BE SHORTENED IN HEAVY WEATHER CONDITIONS, HEAVY PRECIPITATION RATES OR HIGH MOISTURE CONTENT. HIGH WIND VELOCITY OR JET BLAST MAY REDUCE HOLDOVER TIME BELOW THE LOWEST TIME STATED IN THE RANGE. HOLDOVER TIME MAY ALSO BE REDUCED WHEN AIRCRAFT SKIN TEMPERATURE IS LOWER THAN OAT. THE ONLY ACCEPTABLE DECISION CRITERIA TIME IS THE SHORTEST TIME WITHIN THE APPLICABLE HOLDOVER TIMETABLE CELL.

S = Substantiated
NS = Not substantiated

Transport Canada (Aug. '96)

cm1283\report\hot_sub\HO1_TSLS.XLS
At:TYPE IV 97-4-18

Photo 5.1
Failure of Type IV Neat Fluid at Three Crosshairs - Plate W - Dorval

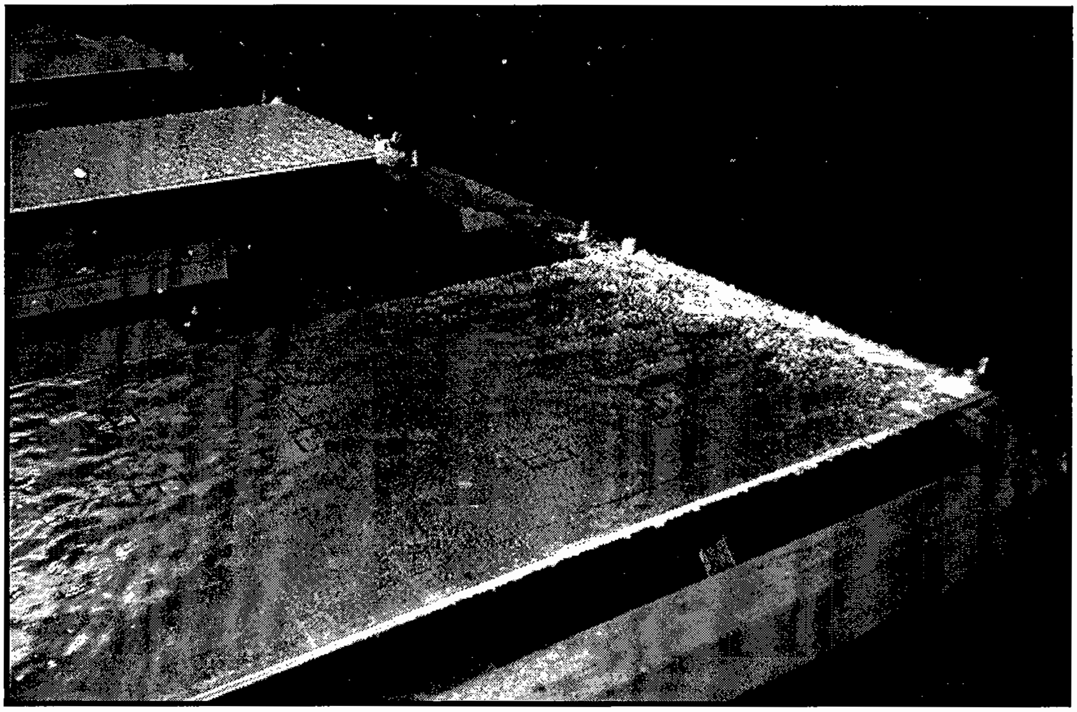


Photo 5.2
Failure of Type IV Neat Fluid at Three Crosshairs - Dorval
Plate Z (bottom row, right hand position to the left of the plate pan)

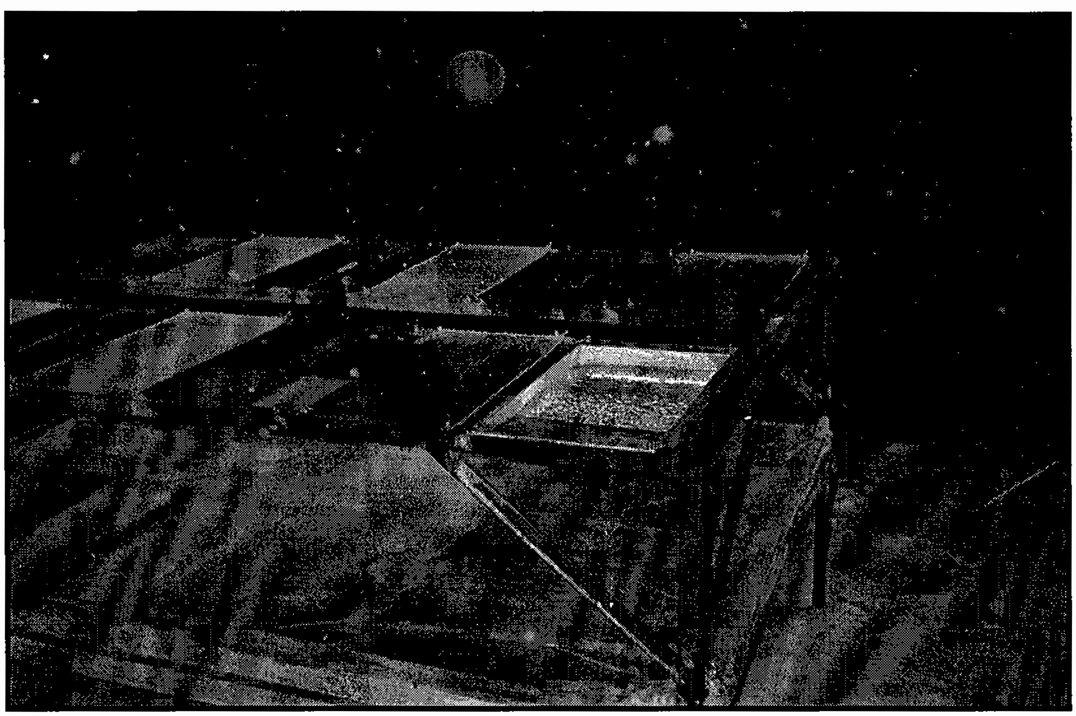


Photo 5.3
DC-9 Wing Surface During Freezing Rain Tests at Dorval
Prior to Failure

Photo 5.4
DC-9 Wing Surface During Freezing Rain Tests at Dorval
During Failure

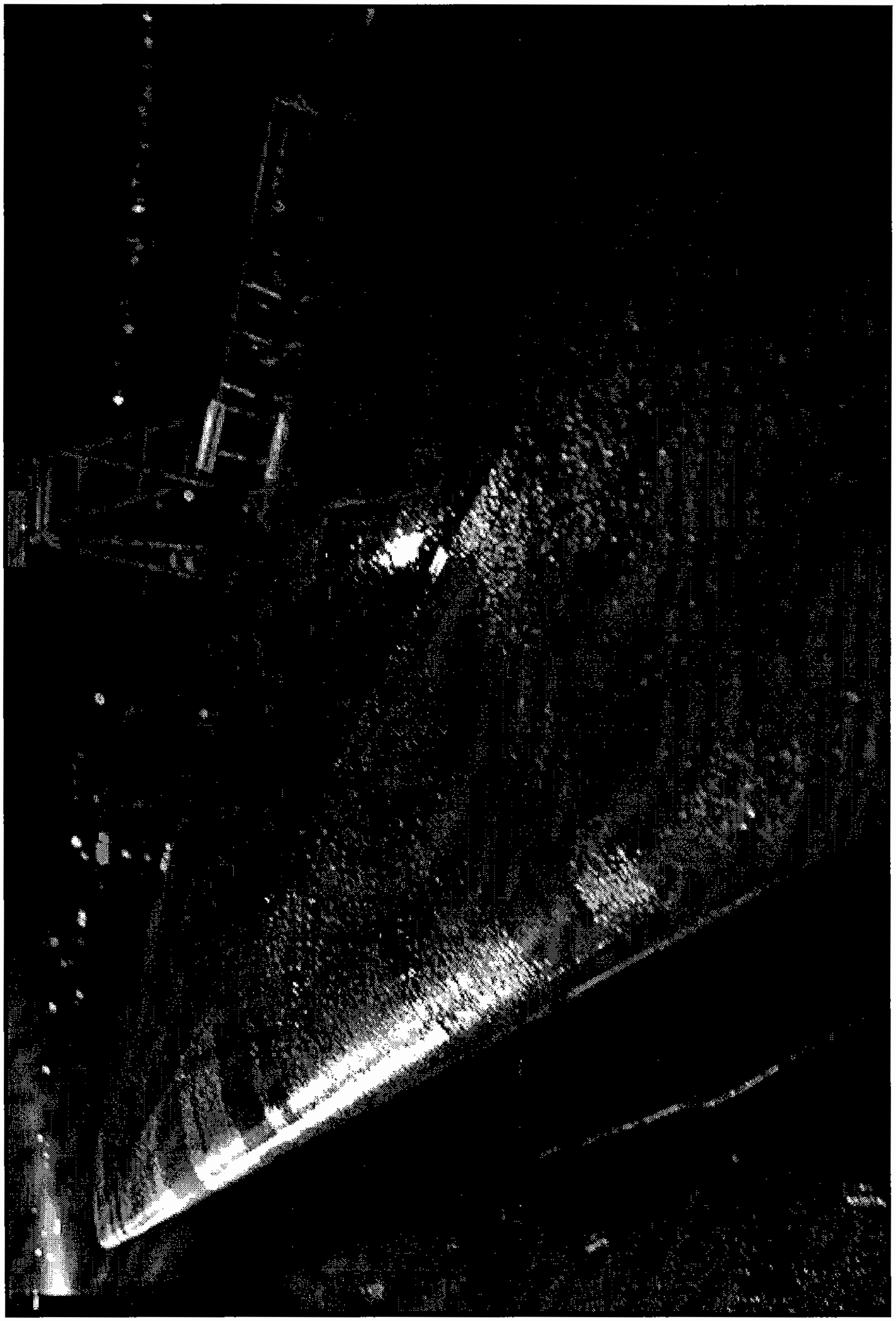


Photo 5.5
Flat Plate During Freezing Rain Tests at Dorval
Failure Progression to 3" Line

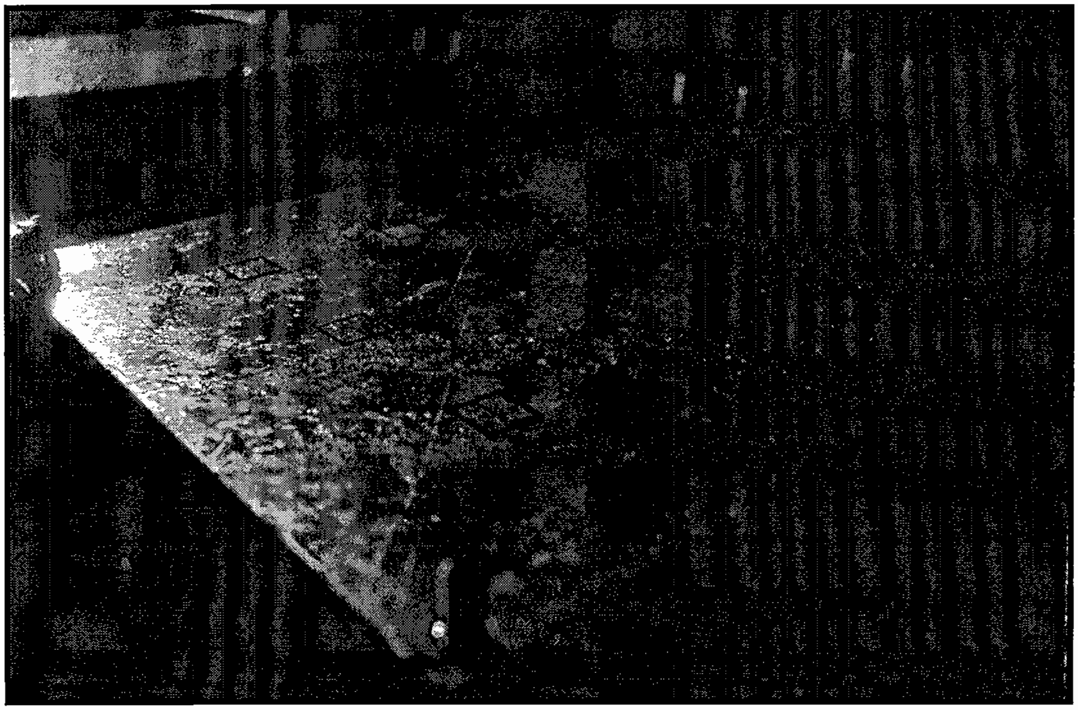
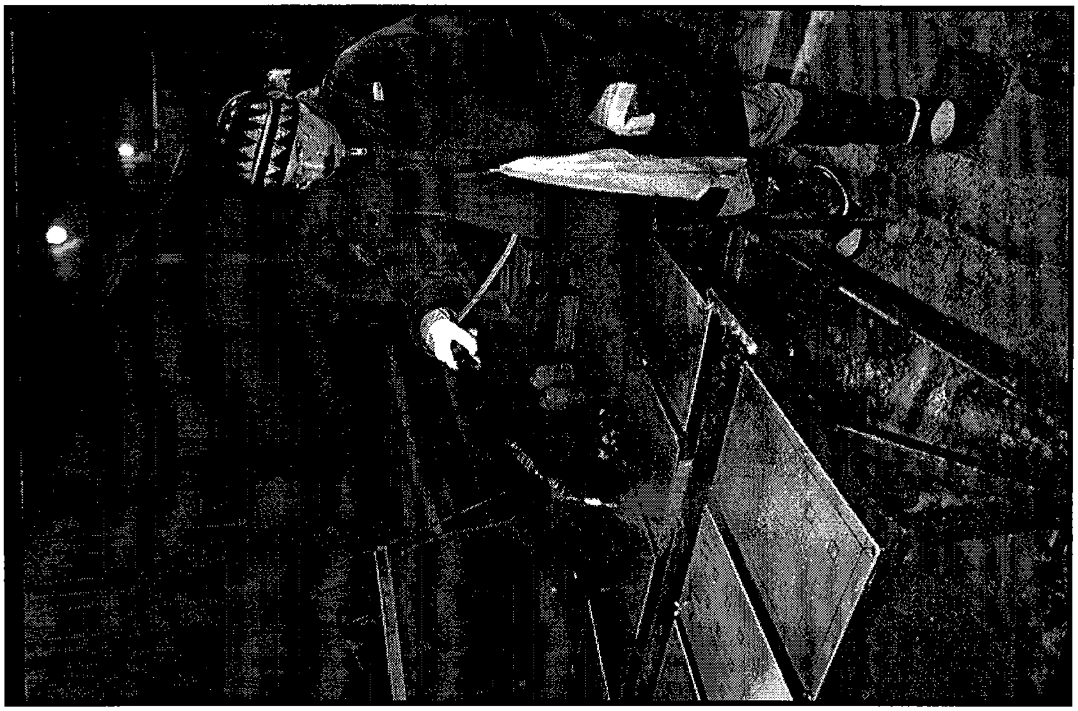
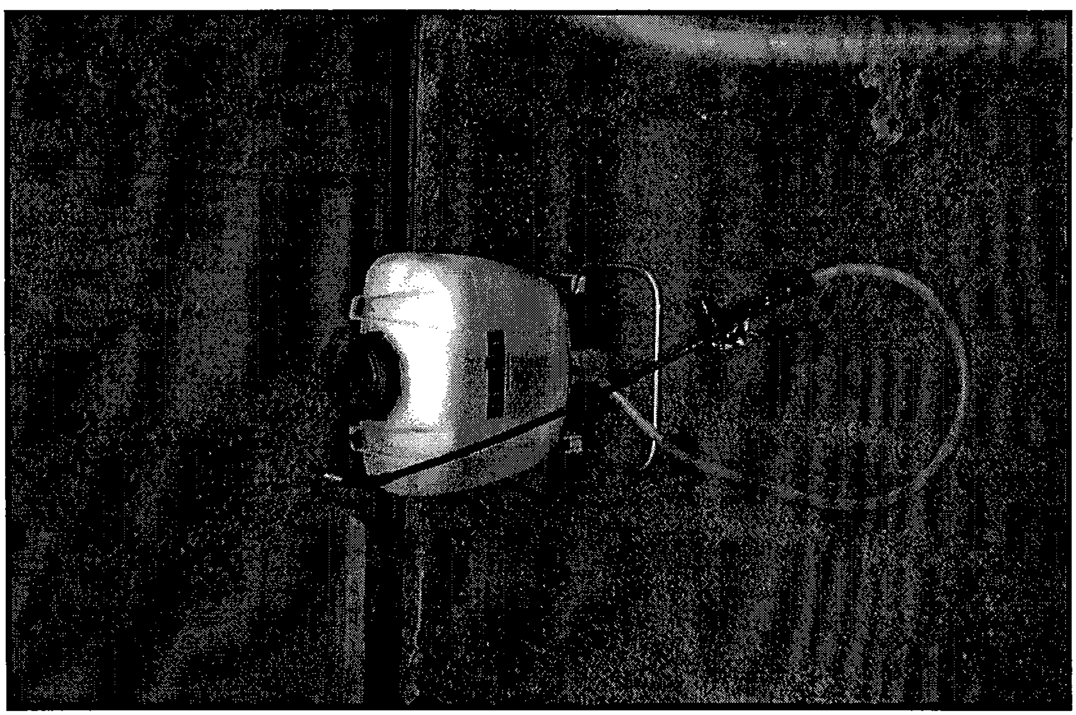


Photo 5.6
Flat Plate During Artificial Freezing Rain Tests at NRC

Photo 5.7
Sprayer Used For Application of Fluids on Flat Plates





6. CONCLUSIONS

The winter 1995/96 program mainly consisted of testing new Type IV fluids and developing a new Type IV fluid holdover time table. Flat plate tests were conducted under natural snow at the AES Dorval test site. Simulated freezing fog, freezing drizzle, light freezing rain and cold-soaked tests were carried out at the NRC cold chamber in Ottawa.

The conclusions are presented as they pertain to fluid holdover time tests, test procedures, equipment, and meteorology.

6.1 Holdover Time Tests

Flat plate tests were conducted over a wide range of icing precipitation conditions. The results of these tests were presented to the SAE G-12 Holdover Time Sub-Committee where they were reviewed and the proposed holdover times discussed. The Sub-Committee recommended new or revised Type I, Type II, and Type IV holdover time tables which were subsequently approved by the SAE G-12 Committee.

The most notable change from the 1995/96 winter was the substitution of the Type IV holdover time table to replace the Ultra fluid holdover time table. A preliminary table for Type III fluids was developed and presented in Section 5.

Several changes were made to the format of the holdover time tables. The most notable relates to the temperature changes. The caution note in the tables was also changed slightly and reads as follows: *The time of protection will be shortened in heavy weather conditions, heavy precipitation rates or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check.*

6.1.1 Natural Snow

- New Type IV holdover time values for snow conditions were developed for both diluted and neat concentrations.

- The holdover time range for neat Type IV fluid was more than double the neat Type II holdover time range for temperatures from 0°C to -3°C, and about 70% higher than for neat Type II fluid at temperatures below -3°C to -14°C.

- For Type IV 75/25 fluid, the lower limit of the holdover time range remained the same as the Type II 75/25 lower limit. The upper limit of 30 minutes was increased to 60 minutes for temperatures of 0°C and below.

- For Type IV 50/50 fluid, the proposed holdover time range was 5 to 20 minutes, providing a five-minute increase (over Type II 50/50 fluid) to the upper limit for temperatures from 0°C to -3°C.

- The lower limits of the holdover time range for Type II fluids (neat and diluted) at temperatures above 0°C were reduced to reflect values from 0°C to -3°C.

6.1.2 Freezing Drizzle and Light Freezing Rain

- New holdover time values were developed for neat and diluted Type IV fluids for the categories of freezing drizzle and light freezing rain.

- The holdover time ranges for neat Type IV fluids were increased by more than 50% over those for neat Type II fluids. The increase resulted in holdover times of between 45 and 110 minutes for freezing drizzle. In the case of light freezing rain an increase by a factor of two in holdover times for Type IV over Type II fluids was adopted.

- For light freezing rain, the Type IV 75/25 fluid holdover time range was raised by 5 minutes over Type II 75/25 for temperatures above 0°C to -3°C, and remained the same for temperatures below -3°C to -10°C. For freezing drizzle, the upper limit of the holdover time range was increased from 45 minutes (for Type II 75/25) to 60 minutes.

- The proposed holdover times for Type IV 50/50 fluids were lower than those for Type II 50/50 and have been limited for use at temperatures of -3°C and above. The new holdover time ranges were set at 5 to 10 minutes for light freezing rain and 7 to 15 minutes for freezing drizzle.

- Tests conducted employing an actual aircraft in natural freezing rain conditions showed results consistent with those for Type IV neat fluids on standard flat plates.

- The lower limit of the holdover time range in the Type II fluid table under the category for light freezing rain and temperatures below -3 to -10°C was reduced from 15 to 10 minutes.

6.1.3 Freezing Fog

- New holdover time values were developed for Type IV fluids (100%, 75/25 and 50/50) for the condition of freezing fog.

- The neat Type IV fluid holdover time range for temperatures from 0°C to -14°C was more than doubled relative to the range for neat Type II fluid, 120 to 180 minutes. The range of holdover times for temperatures between -14 to-25°C was 60 to 120 minutes, almost double those for Type II fluids.

- The holdover time range for Type IV 75/25 fluids compared to the Type II was almost double, 40 to 120 minutes.

- For Type IV 50/50 fluids, the holdover time range remained the same as Type II 50/50 for temperatures of 0°C to -3°C, 15 to 45 minutes. For temperatures above 0°C, the same holdover time range, 15 to 45 minutes, was selected representing a decrease compared to Type II 50/50 fluid under the same conditions.

- A conservative change to the holdover time values for freezing fog at temperatures above 0°C was recommended and should merit consideration by the SAE Holdover Time Sub-Committee (see Section 7.6).

6.1.4 Rain on a Cold-Soaked Surface

- Changes to the holdover times were proposed at the 1996 SAE G-12 Holdover Time Sub-Committee meetings by several committee members. These changes included reductions to all of the holdover time ranges. For Type II 50/50 and Type IV 50/50 fluids, the holdover time ranges were removed from the tables.

- Subsequent to the 1996 SAE meetings, tests were conducted on cold-soaked boxes. Over the test range and for each fluid type, the variable exhibiting the greatest influence on failure time was rate of precipitation. Skin temperature and box size were related and their influence on failure time for the tests conducted was not as significant as the precipitation rate.

- Two new columns of holdover time ranges were developed from the tests conducted at NRC. The holdover times for drizzle and light rain are generally close to the values in the holdover time tables. The holdover times for the moderate and heavy rain column are significantly below the current holdover time values. It is recommended that these and other changes be proposed to the SAE G-12 Committee for review and adoption (see Section 7.6).

6.2 Meteorological Analysis

- The relationship between average visibility and precipitation rate showed a better correlation than in previous winters, however the variations are still excessive and do not allow visibility to be used as a measure of precipitation.

- Closer inspection of freezing drizzle and light freezing rain test data for some tests at NRC showed that the rate of precipitation over the area on a plate at the edge of the test stand varied from the mean by an unacceptable amount, thereby reducing the number of test panels that can be used.

6.3 Test Procedures and Equipment

- Special experiments were conducted to measure droplet size produced by the NRC sprayer used to make artificial precipitation. Measured droplet sizes, using a technique developed by the NRC, were within the acceptable range of the theoretical values. For freezing drizzle, the experimental median volume diameter was about 300 þm, which is within the defined range of 0 to 500 þm.

- Preparation and mixing of diluted Type II and IV fluids (75/25 and 50/50) proved to be difficult at times. During the testing season, it became evident that, if fluids were not premixed by the manufacturer before shipment, improper fluid mixtures could result.

- Determination of the end condition is subjective. A detailed examination of APS failure calls using two ice-detection sensors during tests conducted under artificial light freezing rain showed consistency with failure calls from previous tests. The UQAC group provided APS with test results which were reported to be obtained under equivalent conditions. The UQAC failure calls were superimposed onto C/FIMS traces for experiments carried out by APS.

  This revealed that the UQAC failure calls were made at a time for which the C/FIMS trace in the APS experiments indicated no change in fluid state relative to the start of the test. It is therefore concluded that the UQAC failure calls were premature.

- Determination of the end condition for tests conducted under freezing fog conditions at temperatures below -14°C was not conclusive, particularly for the more viscous Type IV and Type II fluids. This situation is described in Section 5.3 of this report. Further tests under these low temperatures conditions are necessary to define what constitutes a failure with these fluids.

- The holdover times of Type IV neat fluids when applied in two steps could be different than the times resulting from the ***standard*** one-step flat plate fluid application. Application of the anti-icing fluid in a two-step fluid application should be such that most or all of the initial fluid is "flushed off" the surface.

  Preliminary tests using a backpack sprayer to apply fluids onto flat plates showed that neat Type IV fluids could exhibit as low as 50% of the holdover times of poured fluid (standard test). Similar tests should be conducted with all Type IV fluids using actual spray vehicles to ensure that holdover time reductions do not occur in standard day-to-day deicing operations.

7. RECOMMENDATIONS ON FUTURE TESTING

Future testing should be undertaken to refine the data even further and to continue the substantiation and development of the holdover time tables.

7.1 Test Procedures and Equipment

- In light of:

  a) The results of the (portable) sprayer application of fluid, and
  b) The potential of heated Type I fluids to subsequently reduce the viscosity of the over sprayed Type IV fluids,

  It is recommended that new test procedures for the determination of holdover times for two-step fluid application be developed. This recommendation is repeated in report TP 12900E.

- Using Allied Signal's C/FIMS and a remote ice detection sensor, conduct tests under freezing fog conditions at the NRC cold chamber to evaluate and define the criteria to be used for determination of fluid failure at very cold temperatures.

- Evaluate the need to conduct tests for rain on a cold-soaked wing at high rates of precipitation and conduct the tests identified.

- Measure precipitation rates for freezing drizzle and light freezing rain in more detail in future laboratory tests, as follows:

  - Ensure that failures occur from the top to the bottom of the plate;

  - Consider a redesign of the test stand to minimize the gap between the top and bottom plates;

- Use fewer plates for each test to minimize edge effects; and

- Ensure that the distribution of precipitation rate over the plate area is uniform (variance of no more than 20% from the mean).

7.2 Evaluation of Outdoor Versus Indoor Tests

Qualifying new fluids involves a considerable expenditure of resources. This is particularly so for outdoor testing. This has prompted the SAE Committee to request airlines and fluid manufacturers to provide financial support for the testing of new fluids. To minimize the expense of fluid testing, it would be convenient to simulate all relevant natural conditions. Progress in fluid testing is highly dependent upon the prevailing weather. The simulation of true snow conditions in a laboratory environment is a particularly daunting task, but one that is required in order to rapidly and economically standardize the qualification of new de-icing and anti-icing fluids. The qualification of these fluids includes the high humidity, water spray endurance, and aerodynamic fluid performance tests.

To ensure that the results of natural snow testing are adequately reproduced in the laboratory, a series of tests should be devised that compare fluid failure times under conditions of simulated freezing drizzle to those under conditions of natural snow. The failure time dependence on water droplet size should be determined for a range of fluids. These results should allow a reliable correlation between the failure times for simulated drizzle and natural snow. They would also provide the necessary guidelines and limits to apply to tests using the artificial snow which can presently be produced indoors.

7.3 Type IV Fluid Holdover Time Tests

Tests with Type IV fluids were conducted during 1995/96 and a new holdover time table was developed. However, the holdover time table was developed from tests with Type IV fluids, which either have recently been removed (e.g. Kilfrost ABC-4) or for which formulations were subsequently changed (e.g. Ultra to Ultra +, Hoechst MP IV 1934 to MP IV 1957).

- Test new Type IV fluids (NASA, Octagon, Ultra +, Hoechst, SPCA, etc.) over the entire range of conditions covered by the Type IV holdover time tables. These programs should include outside testing under conditions of natural precipitation, and laboratory testing at NRC's Climatic Engineering Facility for tests involving freezing fog, freezing drizzle, light freezing rain and rain on a cold-soaked surface.

7.4 Type III Fluid Holdover Time Tests

For some commuter operations, the less viscous Type III fluids must be used to ensure that the fluid does not adversely affect the performance of the aircraft.

- Conduct tests with Type III fluids over the entire range of conditions to establish a Type III table. These programs should include outside testing under conditions of natural precipitation, and laboratory testing in the NRC Climatic Engineering Facility for tests involving freezing fog, freezing drizzle, light freezing rain and rain on a cold-soaked surface.

7.5 Type II Fluid Holdover Time Tests

- Conduct more tests with Type II fluids (particularly Type II Fluid A-101 if it is not replaced by the manufacturer's new Type IV fluid) during natural snow conditions at temperatures around or below -14°C.

- Further testing of Type II (and Type IV) fluids during freezing fog at very low ambient temperatures (below -14°C, and particularly below -25°C) is recommended to fully characterize the failure process and mechanisms of these thickened fluids (see Section 5.3).

7.6 Recommendations Proposed for Consideration by the SAE

Freezing Fog

- In addition to the conclusions drawn form this study regarding fluid behaviour in freezing fog conditions, the following conservative changes to holdover time values for freezing fog conditions at temperatures above 0°C are recommended for the following fluids:

  - Neat Type I fluids (6 to 15 minutes);
  - Neat Type II fluids (35 to 90 minutes);
  - Type II 75/25 fluids (25 to 60 minutes);
  - Type II 50/50 fluids (15 to 45 minutes).

Rain on a Cold Wing

- This recommendation refers to findings tabulated in Table 5.2 of this report. Although the proposed holdover time values for drizzle and light rain are generally close to the current holdover time table values for rain on a cold-soaked wing, the proposed holdover time values for moderate to heavy rain are significantly shorter than the current values. Hence, it is worthwhile to consider another column in the holdover time tables to address these circumstances.

In addition to this, the following items also merit careful consideration by the SAE Holdover Time Sub-Committee.

- A diluted Type I fluid should not be used for anti-icing when a wing is cold-soaked and rain intensity is moderate to heavy.

- The lower limit of the holdover time range for neat Type II fluids should be reduced from 20 to 15 minutes under conditions of drizzle and/or light rain.

- The test data for drizzle and light rain suggest that the holdover time upper values for neat Type IV fluid could be raised from 40 to 70 minutes. Furthermore, the range for Type IV 75/25 fluid under these conditions could be raised form 10-25 minutes to 15-50 minutes.

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APPENDIX A

TERMS OF REFERENCE - WORK STATEMENT

TRANSPORTATION DEVELOPMENT CENTRE

WORK STATEMENT
(revised* November 96)

AIRCRAFT AND FLUID HOLDOVER TIME TESTS FOR WINTER 95/96
(Short Title: Winter Tests 95/96)

1 INTRODUCTION

In the last decade, a number of fatal aircraft accidents have occurred in the winter at take-off during periods of precipitation that could contaminate aerodynamic surfaces; in several of these accidents the effectiveness of aircraft ground anti-icing has been suspect. Of particular importance to Canada was the crash of an Air Ontario F-28 at Dryden, Ontario on 10th March 1989, which led to a Commission of Inquiry led by Justice Moshansky.

The deicing fluids used on aircraft were originally expected to provide protection for the surfaces during only brief taxi and take-off periods. As traffic demand has grown, operations under more extreme weather conditions have increased, and traffic congestion on the airports has introduced lengthy line-ups for take off with the accompanying longer anti-icing protection requirement. This led to the development of the Type II anti-icing fluids for the jet aircraft and the Type III fluids for turboprops, both of which provide longer protection time (known as Holdover Time) following application. The times given in the official Holdover Time Tables were originally established by the Association of European Airlines (AEA) based on assumptions of fluid properties, and anecdotal data all related to operations in the European environment. These tables are published by the AEA, the Society of Automotive Engineers (SAE) and the International Standards Organization (ISO).

In a series of meetings on holdover time sponsored by the SAE Committee on Aircraft Ground Anti-icing involving the major airlines, aircraft manufacturers and anti-icing fluid producers, a program for field testing Type II fluids to establish holdover times in representative weather conditions was proposed. TDC took the lead in accepting to coordinate these activities for the 90/91 winter season with the participation of a number of carriers, deicing fluid manufacturers, the University of Quebec at Chicoutimi (UQAC), the National Research Council (NRC), and the Federal Aviation Administration (FAA). TDC undertook to prepare the test procedures and analyze and distribute all test results.

During the 90/91 season the methods of testing were developed and Type II and Type III fluids were tested. The Type II fluid results indicated that the times in the holdover tables were excessively long under normal winter snow conditions in North America. This led to the introduction of a range of time values for each condition (except frost) in the AEA/SAE/ISO tables, the original AEA value being retained for the high time and a new lower time from the TDC tests for the "worst" conditions.

For the 91/92 winter season TDC tests were made on Type III fluids exclusively because of the importance of this fluid to commuter operators.

With the release of the recommendations of the Dryden Inquiry in March, 1992 and the setting up of the Dryden Commission Implementation Project Office (DCIP), even greater support for these holdover tests was generated in Canada. Almost simultaneously the La Guardia crash of a F-28, also in March 1992 spurred the FAA to introduce Holdover Time regulations and to request that the SAE Committee on Aircraft Ground Deicing spearhead work on establishing holdover guidelines. This led to the formation of the holdover time working group, co-chaired by DCIP and FAA/ARC. Building on the earlier work initiated by TDC for the 90/91 and 91/92 winter seasons, a major test program was initiated to substantiate the existing holdover time tables. DCIP undertook to coordinate the expanded test program as part of its fulfilment of the recommendations of the Dryden Commission.

The 92/93 series of outdoor winter tests were in Montreal and involved revision of the test protocol, tests in both natural and artificial snow on flat plates, on simulated wings and on wing leading edges, and used a sensor to confirm fluid failure criteria. Type I, Type II and Type III fluids were tested. Simulated frosting, freezing fog and freezing rain conditions were tested at the NRC facilities in Ottawa. As a result of these tests large parts of the Type I and Type II tables were substantiated

For the 93/94 testing season, efforts were aimed at continuing the substantiation of the holdover tables and mostly involved testing diluted Type II fluids. All natural snow tests were made at Dorval, freezing fog at the NRC Helicopter Icing Facility and Freezing drizzle and freezing rain at the NRC Cold Environment Facility (CEF). In addition to the Instrumar sensor the RVSI remote sensor was also used to assist in collecting data. UCAR provided a new long lasting Type II fluid for preliminary testing.

An important effort was made in the 94/95 season to verify that the flat plate data were representative of aircraft wings. Air Canada cooperated with DCIP by making aircraft and limited ground support staff available at night to facilitate the correlation testing of flat plates with performance of fluids on aircraft. The new UCAR ULTRA fluid was extensive tested and resulted in a new TC/FAA holdover table providing 50% longer holdover times for use during the 95/96 winter season. Additional testing was undertaken to evaluate the suitability of hot air for de-icing as an alternative to heated de-icing fluids at low (e.g. -30^{0}C and below) ambient temperatures. wet snow. Tests were also performed to assess the potential for extending the use of hot water for de-icing from the current -3^{0}C limitation down to -7^{0}C or lower, where past experience has shown it feasible.

The winter 94/95 season testing was very restricted by the paucity of snow conditions and therefore much of the planned testing was not completed. Substantiation of the Type I and Type II tables needs certain special conditions hard to find in the field such as low temperatures with precipitation, and rain or other precipitation on cold soaked surfaces. The development of ULTRA by Union Carbide has stimulated all the manufacturers to produce new long lasting anti-icing fluids that will be defined as Type IV; all these fluids will contribute to the definition of the performance requirements for a generic Type IV. Although the Holdover tables are widely used in the industry as guides to operating aircraft in winter precipitation the significance of the range of time values given in each cell of the table is obscure; there is a clear need to improve the understanding of the limiting weather conditions to which these values relate. The few aircraft tests made to validate the flat plate tests were inconclusive and more such tests are needed. The testing with hot water and with hot air for special deicing conditions have not been completed. All these areas are the subjects for the further research that is planned for the 95/96 winter.

2 PROGRAM OBJECTIVE (MCR 16)

Take an active and participatory role to advance aircraft ground de-icing/anti-icing technology. Develop international standards, guidance material for remote and runway-end de-icing facilities, and more reliable methods of predicting de-icing/anti-icing hold-over times.

3 PROGRAM SUB-OBJECTIVES

3.1 Substantiate the guideline values in the existing holdover time (HOT) tables for type IV fluids that have been qualified as acceptable on the basis of their impact on aircraft take-off performance.

3.2 Perform tests to establish relationships between laboratory testing and real world experience in protecting aircraft surfaces.

3.3 Develop reliable holdover time (HOT) guideline material based on test information for a wide range of winter weather operating conditions.

3.4 Support development of improved approaches to protecting aircraft surfaces from winter precipitation.

4 PROJECT OBJECTIVES

4.1 To complete the substantiation of the existing Type I and Type II SAE holdover time Tables by conducting cold soak tests and very low temperature tests.

4.2 To determine the holdover time performance of the proposed Type IV fluids over the range of characteristic conditions and create a generic Type IV holdover time table.

4.3 To establish the precipitation, wind and temperature values that delimit the holdover times given in the tables.

4.4 To validate that flat plate test data used to establish the SAE Type IV holdover time tables is representative of Type IV performance on service aircraft. under conditions of natural freezing precipitation.

4.5 To evaluate hot air de-icing as an alternative to heated de-icing fluids for frost removal at low ambient temperatures.

4.6 To undertake special tests of Type IV fluids in comparison with a Type II fluid at high rates of precipitation.

5. DETAILED STATEMENT OF WORK

The work shall be broken down into the several distinct areas of activity consistent with the project objectives, together with activities for presentations and reporting at the completion of work. A detailed workplan, activity schedule, cash flow projection, project management control and documentation procedure shall be developed and delivered to the TDC project officer for approval within one week of effective start date.

5.1 Substantiation of Type I and Type II Tables

5.1A Laboratory "Cold soak" Test Program

Tests will be conducted at the Climatic Engineering Facility (CEF), of the National Research Council, Ottawa. APS will supply all necessary equipment and fluids for the conduct of the tests. Laboratory test should be performed after the field tests so that some temperatures can be chosen to match the field tests.

5.1.1 Develop an experimental plan to conduct tests, analyze results and prepare a report to provide values given for the SAE/ISO Holdover Time Tables for Type I. Type II and Type IV fluids using cold soaked boxes to simulate cold soaked wing conditions for a range of precipitation rates above and below freezing.

5.1.2 Include tests at +2°C and -7°C and at temperatures corresponding to selected field tests and cover a range of box temperatures from 0°C to -15°C and a range of precipitation rates, simulating rain, freezing drizzle and snow. These rates should be determined in consultation with personnel from AES and NRC. APS will use their own cold box designs.

5.1.3 Present the test plan to TDC Project Office for review Comment and approval.

5.1.4 Schedule tests with NRC and give advance notice of all intended tests to the TDC project officer.

5.1.5 Conduct tests in the NRC cold chamber using flat plates as benchmark

5.1.6 Analyze results from cold boxes and compare with the flat plate results

5.1B ***Field "Cold soak" Test Program***

Conduct full scale aircraft cold soak experiments with the cooperation of local airlines. Use thermistors to measure temperatures on cold soak box and aircraft wing.

5.1C **Low Temperature Test**

Test Type I and Type II fluids on flat plates to establish holdover times at the lowest temperatures encountered in the winter. These test will be similar to those in the program of Type IV testing and will run concurrently with the Type IV tests

5.2 Program of Type IV

This program will test new "long-life" Type IV fluids over the entire range of conditions covered by the HOT Tables and will include outside testing under conditions of natural precipitation, and laboratory testing in the NRC CEF for tests involving freezing fog, freezing drizzle and light freezing rain.

5.2.1 Develop a program to test samples of the new Type IV fluids to establish holdover times over the full range of HOT table conditions.

5.2.2 Obtain samples from producers of qualified Type IV fluids

5.2.3 Establish a test site for the conduct of outside tests at Montreal, Dorval Airport

5.2.4 Arrange for support services and appropriate facilities.

5.2.5 Recruit and train local personnel .

5.2.6 Repair and replace TDC supplied equipment used for testing in previous years as necessary.

5.2.7 In consultation with TDC, devise a method to evaluate the precipitation type in order to assess the effects of wet and dry snow on visibility in precipitation.

5.2.8 Install an ETI precipitation gauge at Dorval to study its correlation with the READAC gauge and the plate pans.

5.2.9 Acquire data from the READAC station at Dorval on a minute-by-minute basis.

5.2.10 Give advance notice of all intended tests to the TDC project officer.

5.2.11 Conduct tests during periods of freezing precipitation concurrent with HOT Table substantiation tests of conventional fluids. For Type I,II and IV fluids, frequent testing should be conducted under natural precipitation conditions when temperatures are below -14°C.

5.2.12 Coordinate scheduling of the indoor tests with the NRC.

5.2.13 Install Instrumar's C/FIMS on at least one plate, if available RVSI's and SPAR remote sensor will be set up to view the stand holding six standard test plates. All sensors will be used for both the chamber tests and all the field tests where feasible. Determine fluid failure by visual observation

5.2.14 Conduct tests with simulated freezing fog, freezing drizzle and light freezing rain in the NRC CEF facility, Ottawa, supplying the necessary materials and equipment for tests.

5.2.15 Conduct ancillary tests at Dorval and the NRC Chamber to study the effect of HOT's of successive application of new and conventional Type II fluids on clear and contaminated Type I's.

5.2.16 Collect visibility data during periods of freezing precipitation at Dorval and correlated with concurrent meteorological data, including precipitation rate, precipitation type, temperature, wind velocity and direction as appropriate.

5.2.17 Present program results and plans for completion for a "mid-term" review to be called by TDC.

5.2.18 Video tape the tests for archival purposes

5.2.19 Test results will be collected, analyzed and a report produced.

5.3 Weather

The significance of weather conditions in the holdover time tables needs to be defined the high time value represents "light"" conditions and the shortest time is the boundary for a "heavy" condition. Some evaluation of these terms shall be developed on the basis of existing and current data.

5.3.1 Review weather conditions for test data from all years and all sites for the cases where failure time lay outside the range in the tables for Type I and Type II fluids

5.3.2 Study extreme weather conditions during the 1995/96 winter tests at Dorval using a Type 1 fluid to evaluate "Light" conditions and a Type II to evaluate "heavy" conditions

5.3.3 Analyze the data with respect to the parameters of experimental site, weather conditions, fluid type and fluid manufacturer to establish relationships between weather parameters and holdover time values

5.3.4 Recommend caution statements to go into the holdover time tables

5.3.5 Recommend revisions to the fluid performance tests.

5.4 Performance of Ultra Fluids on Flat Plates Versus Aircraft Surfaces

This test program will be conducted at Dorval International Airport, using aircraft made available by an airline, and, subject to weather conditions, will include three (3) all night test sessions. In general, aircraft will be made available for testing outside regular service hours, i.e. available between 23:00 hrs. and 06:00 hrs. Tests will be conducted to verify that fluid failures on the flat plates used to develop HOT guidelines for the new fluid occurred before failure on the aircraft wings. Depending on the site selected for these tests, it is expected that Air Canada will be providing ancillary equipment and services as stipulated in their agreement with Transport Canada for the 1994/95 winter; this equipment will include lighting fixtures as necessary, observation platforms, vehicles, storage facilities, office facilities and personnel rest accommodation. Additional tests, if required, may be requested subject to agreement by all parties involved.

5.4.1 Develop an experimental program for concurrent comparison testing of fluids under conditions of natural freezing precipitation on flat plates and on aircraft.

5.4.2 ***Prepare the following test plan features, plans and procedures:***

a) A detailed statement of work for each of the participants;

b) A specific test plan, for review by all parties, which will include as a minimum:

- Schedule and sequence of activities;
- Detailed list of responsibilities;
- Complete equipment list;
- List of data, measurements and observations to be recorded; and
- Test procedures.

c) Activities including:

- Visual and Instrumented Data Logging;
- Monitoring and recording environmental conditions, including:
  - Air temperature,
  - Wing surface temperature at selected locations,
  - Wind velocity and direction, and
  - Precipitation type and rate;
- Record of aircraft and plate orientation to the wind; and
- Use of instrumentation to determine the condition of the fluid.

d) Acquisition of data from the tests will address:

- Identification of fluid failure criteria;
- Location of first point of fluid failure on the wing, and subsequent failure progression;
- Correlation of fluid failure time to environmental conditions;
- Correlation of fluid failure times on flat plates and aircraft; and
- Behaviour of fluid on the "representative" surface.

5.4.3 Present the experimental programs for review and approval by the TDC project officer.

5.4.4 Arrange (with the cooperation of TDC) for deicing equipment and aircraft representative of those in common use by airlines in Canada to be made available for the tests .

5.4.5 Present the approved program to the airline involved prior to the start of field tests.

5.4.6 Recruit and train local personnel who will conduct test work.

5.4.7 Provide all equipment and all other instrumentation necessary for conduct of tests and recording of data.

5.4.8 Arrange for the provision of fluids by UCAR for spraying an aircraft.

5.4.9 Secure necessary approvals and passes for personnel and vehicle access for operation on airport airside property

5.4.10 Schedule tests on the basis of forecast significant-duration night-time periods of freezing precipitation;

5.4.11 Provide advance notice to Air Canada of the desired test set-up, including aircraft orientation with respect to the forecast wind direction, sequence of fluid applications, and any additional services requested.

5.4.12 Confirm that the de-icing equipment used for the tests is equipped with a nozzle suitable for the application of Ultra fluids. Application of fluids will be by airline personnel.

5.4.13 Arrange for spray application during the initial tests to be observed by the fluid manufacturer's representative for endorsement.

5.4.14 Orient the aircraft with leading edge into the wind on two occasions and trailing edge into the wind on the third occasion.

5.4.15 Conduct tests of Type II Ultra plus fluid on standard flat plates and aircraft, using Ultra on the plates as a benchmark fluid along with a standard Type II when available.

5.4.16 Record the progression of fluid failure on the wing over the series of tests conducted.

5.4.17 Videotape records of all tests will be made.

5.4.18 Return any equipment obtained from airlines for use during the tests to its original condition at the end of the test program.

5.4.19 Assemble and analyze all results

5.5 Frost Removal

Frost alleviation and removal by "sweep and shine" and hot air shall be explored.

5.5.1 Sweep and Shine

Tests shall be conducted at very low temperatures to evaluate the efficacy of sweep and shine. Micromeasurements of frost shall be made prior to tests and following various amounts of sweeping. Numbers of crystals per area will be noted along with their height and shape to indicate roughness level

5.5.2 Hot Air

Successful application of hot air for frost removal is dependent on provision of a well designed air application tool; one that is user friendly and will provide speedy and effective results. provision will be made to evaluate prototype equipment in conjunction with an airline and a manufacturer.

5.6 Wing Surface Visibility Study

Examine various options to enhance visibility of failed wing surfaces from inside the cabin and flight deck and make recommendations.

5.7 Representative Surfaces Guidelines Study

5.7.1 Study the optimum locations for representative surfaces on specific test aircraft wings.

5.7.2 Develop generic guidelines for defining the optimum locations for representative surfaces on any aircraft and for installation of wing contamination sensors.

5.8 *Heavy Precipitation Type IV Tests*

Using the NRC CEF, test all qualified Type IV fluids at 100% concentration along with a standard Type II fluid as a benchmark at simulated high precipitation rates of 25gm/dm2/hr and at low temperatures close to -7C.

5.9 Presentations of test program results

5.9.1 Prepare and present preliminary findings of test programs involving field tests with aircraft to representatives of Transport Canada and the Airlines involved at end of the test season, but no later than April 30 1995.

5.9.2 Prepare and present, in conjunction with Transport Canada personnel, winter test program results at SAE G-12 Committee meetings in Chicago, and London, England.

5.10 Reporting

Reporting shall be in accordance with section 10 "Reporting", below.

5.10.1 Substantiation of HoldOver Time Tables
A final report shall be prepared covering all winter testing sponsored by TDC and DCIP, including that from previous winters, conducted to substantiate the SAE HOT Tables.

5.10.2 Reporting of Other Testing
Separate final reports shall be issued for each area of activity consistent with the project objectives.

APPENDIX B

APS TEST PROCEDURES
FOR DORVAL NATURAL PRECIPITATION -
FLAT PLATE TESTING

BM2980.00

EXPERIMENTAL PROGRAM
FOR DORVAL NATURAL PRECIPITATION FLAT PLATE TESTING
1995 - 1996

APS Aviation Inc.

January 10, 1996
Version 2.3

EXPERIMENTAL PROGRAM
FOR DORVAL NATURAL PRECIPITATION FLAT PLATE TESTING
1995 - 1996

This document provides the detailed procedures and equipment required for the conduct of natural precipitation flat plate tests at Dorval for the 1995/96 winter season.

1. OBJECTIVE

To complete the substantiation of the existing SAE/ISO Holdover Time Tables and proposed table extensions by conduct of tests on standard flat plates as follows:

- Type I and Type II fluids under conditions of natural snow at the lowest temperature ranges.
- All samples of Type IV fluids will be tested to establish the holdover times over the full range of HOT table conditions for this potential new fluids category.

2. TEST REQUIREMENTS (PLAN)

Attachment I provides the list (not in any order) of tests to be conducted at the Dorval test site located adjacent to AES. These tests shall be conducted during natural precipitation conditions.

3. EQUIPMENT

Test equipment required for the flat plate tests was determined from previous winters in association with the SAE working group. This equipment is listed in Attachment II.

4. PERSONNEL (See Attachment II)

The following personnel are required for the conduct of tests. The responsibility for each tester is provided in Attachment III.

For one stand

1 x Test site Leader/video
1 x End condition tester
1 x Meteo tester

For two stands

1 x Test site leader
2 x End condition tester
1 x Video
1 x Meteo

5. PROCEDURE

The modified test procedure is included in Attachment II. This procedure was developed more than five years ago and was modified over the years to incorporate discussions at the SAE working group meetings. Attachment V contains a brief summary of the steps required to conduct a test.

6. DATA FORM

The data forms are included with Attachment II. One data form was developed for the end-condition tester (Table 1) and one data form for the Meteo/video tester (Table 1a).

TABLE 1

END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME

VERSION 3.0 Winter 95/96

LOCATION: DATE: PLAN # (see Attachment I): RUN # : STAND # :

Real Time After Fluid Applied to Plates U and X: am / pm

RVSI Series # : ____________ Frame # : ____________

CIRCLE SENSOR PLATE: u v w x y z

SENSOR NAME: ___ ___ ___ ___ ___ ___

DIRECTION OF STAND: ______ °

OTHER COMMENTS (Fluid Batch, etc):

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

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

Time of Fluid Application: → ______ hr:min (V & Y) ______ hr:min (W & Z)

	Plate U			Plate V			Plate W		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
TIME OF SLUSH FORMATION ON SENSOR HEAD	1st	½	Full	1st	½	Full	1st	½	Full

	Plate X			Plate Y			Plate Z		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
TIME OF SLUSH FORMATION ON SENSOR HEAD	1st	½	Full	1st	½	Full	1st	½	Full

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TABLE 1.a

METEO/PLATE PAN DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH AES - USE REAL TIME | VERSION 3.0 | Winter 95/96

LOCATION: **DATE:** **PLAN #** (see Attachment I): **RUN # :** **STAND # :**

RVSI VIDEO CASSETTE #: **Real Time After Fluid Applied to Plates U and X:** am / pm

VIDEO CAMERA (PANNING) CASSETTE #: **HAND HELD VIDEO CASSETTE #:**

PLATE PAN WEIGHT MEASUREMENTS *

PAN #	t TIME BEFORE (hr:min)	t TIME AFTER (hr:min)	w WEIGHT BEFORE (grams)	w WEIGHT AFTER (grams)	COMPUTE RATE (Δw*4/ Δt) (g/dm²/h)

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

METEO OBSERVATIONS **

TIME (hr:min)	TYPE (Fig. 4) ZR, ZL,S, SG IP, IC, BS, SP	AMOUNT + +, +, - , --	CLASSIF. (See Fig. 3)	Visibility (day only)	If SNOW, WET or DRY	TEMP °C	WIND SPEED	WIND DIR.

**observations at beginning, end, and every 15 min. intervals. Additional observations when there are significant changes.

COMMENTS : ______________________________

____

____

____

____

____

____

____

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

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Meteo & Pan

TABLE 2

PERCENTAGE OF GLYCOL MIXTURE WITH WATER (%) AS A FUNCTION OF OAT USED FOR DILUTED TYPE I TESTS TO ACHIEVE A 10°C BUFFER

Outside Air Test Temperature (°C)	Fluid Freeze Point (°C)	B-255* Propylene	B-251* Propylene	B-254* Propylene	B-253* Ethylene	B-256* Propylene	B-331* Propylene	B-330[1] Propylene + Ethylene
0 °C	-10 °C	28%	27%	31%	23%	30%	29%	30%
-2 °C	-12 °C	31%	29%	36%	26%	35%	33%	33%
-4 °C	-14 °C	35%	31%	39%	29%	39%	37%	38%
-6 °C	-16 °C	37%	34%	43%	31%	42%	40%	41%
-8 °C	-18 °C	40%	37%	45%	34%	45%	44%	43%
-10 °C	-20 °C	42%	40%	48%	36%	48%	47%	46%
-15 °C	-25 °C	47%	45%	54%	41%	54%	54%	52%
-20 °C	-30 °C	52%	50%	58%	46%	59%	61%	57%
-25 °C	-35 °C	56%	55%	63%	50%	63%	67%	62%
-30 °C	-40 °C	60%	59%	68%	54%	66%	72%	64%
-33 °C	-43 °C		61%**	71%**	57%**	68%**	75%**	66%**
-35 °C	-45 °C	63%**	63%			69%	77%	67%

* Based on a 10°C buffer. If verifying the glycol concentration/freeze point with a refractometer, note that the freeze point will be 10°C lower.

** Standard Type I mixtures

1 This fluid cannot be checked with the Refractometer

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At: CODED
Printed: 02/10/96

Coded

ATTACHMENT I

NATURAL SNOW PRECIPITATION TEST PLAN

			TYPE I* (De-Icing)														TYPE II (Anti-Icing)												TYPE IV (Anti-Icing)																							
GLYCOL BASE			ETHEL		PROPL		ETHEL/PROP		PROPL		PROPL		PROPL		PROPL		PROPL			PROPL			PROPL			PROPL			ETHEL			ETHEL			PROPL			ETHEL			PROPL			PROPL			PROPL			PROPL		
FREEZING POINT (°C)			-43	*	-45	*	-43	*	-43	*	-45	*	-43	*	-43	*	-45	-24	-12	-48	-30	-15	-36	-22	-10.5	-34	-20	-10	-49	-30	-15	-59	-36	-18	?	?	?	-47	-30	-17	-43	-25.5	-12	?	?	?	-36	-22	-10.5	-34	-20	-10
RU	TEMP	TESTS	STD	DIL	STD	DIL	STD	DIL	STD	DIL	STD	DIL	STD	DIL	STD	DIL	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50	100/0	75/25	50/50
#	DEG °C		B-213	B-253	B-215	B-255	B-230	B-330	B-231	B-331	B-221	B-251	B-216	B-256	B-214	B-254	A-202	A-510	A-700	A-205	A-210	A-212	A-201	A-401	A-501	A-101	A-511	A-701	A-303	A-403	A-503	C-100	C-700	C-500	C-101	C-701	C-501	C-102	C-702	C502	C-103	C-703	C-503	C-104	C-704	C-504	C-105	C-705	C-505	C-106	C-706	C-506
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60	-7 TO -1	6		2																														2																		2
61	-7 TO -1	6				2																												2						2												
62	-7 TO -1	6	2																															2																		2
63	-7 TO -1	6	2	2																														2																		
64	-14 TO -2	6	2	2																													2																			
65	-14 TO -2	6	2			2																											2																			
66	-14 TO -2	6										2																					2																		2	
67	-14 TO -2	6																	2									2																					2		
68	-14 TO -2	6																							2			2			2																				
69	-14 TO -2	6																	2												2						2														
70	-14 TO -2	6																				2															2												2		
71	-14 TO -2	6																	2			2			2																										
72	<-25	6	2	2																													2																			
73	<-25	6	2			2																											2																			
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78	<-25	6																				2															2												2		
79	<-25	6																	2			2			2																										
TOTAL		474	24	20	0	12	0	0	0	0	0	10	0	0	0	0	0	0	0	28	16	12	16	8	6	16	8	6	24	16	12	24	28	44	0	0	0	24	16	12	0	0	0	0	0	0	0	0	0	24	20	34

ATTACHMENT II
FLAT PLATE FIELD TEST EQUIPMENT AND PROCEDURE
1995 - 1996 (Version 6.2)

This field test procedure has been developed by the Holdover Time Working Group of the SAE G-12 Committee on Aircraft Ground De/Anti-icing as part of an overall testing program that includes laboratory tests, field tests and full-scale aircraft tests, which is aimed at substantiating the holdover time table entries for freezing point depressant (FPD) fluids known as de/anti-icing fluids. This procedure will also be utilized for the development of new tables for the "next generation" fluids.

1. SCOPE

This procedure describes the equipment and generalized steps to follow in order to standardize the method to be used to establish the time period for which freezing point depressant (FPD) fluids provide protection to test panels during inclement weather such as freezing rain or snow.

2. EQUIPMENT

Environment Canada's READAC (Automated Weather Station) is located within 50 metres of the Dorval test stands. Data from this station will be required on a one minute basis. Temperature, total precipitation, visibility, wind speed and direction are among a few of the parameters measured.

2.1 Rain/Snow Gauge

The following equipment or equivalent are recommended:

2.1.1 Cake Pan or Plate Pan (see Figure 0)

A large low cakepan (6"x 6"x 2" minimum) may be used to collect and weigh snow. A plate pan (the same area as a flat plate and 4 cm deep) may be preferable since it lies like the flat plates at a 10° incline. A schematic of the plate pan is provided as Figure 0.

Note: When this method is used the bottom and sides of the pan MUST BE WETTED (before each pre-test weighing) with Type IV anti-icing fluid to prevent blowing snow from escaping the pan. The plate pans should be carefully rotated every 10 minutes to prevent accumulating snow from blowing away. The time of rotation should be reduced to 5 minutes during heavy precipitation or high wind conditions.

2.1.2 Tipping Bucket

2.1.2.1 ETI Snow Gauge

Electronic simulation of a Tipping bucket with a (0.01 inch) 0.25 mm accuracy. The instrument is not heated (anti freeze used to melt precipitation).

2.2 Temperature Gauge for Panels (optional)

T or K type thermocouple thermometer capable of measuring outside air and panel temperatures to an accuracy of 0.5 degrees C (1 degree F) over the range +10 to -30 C (+50 to -20 F). This gauge is optional and should be used to verify that the panel temperatures are cold-soaked to the OAT.

2.3 Test Stand

A typical test stand is illustrated in Figure 1; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to Figures 1 and 2. There shall be no flanges or obstructions close to the edges of the panels that could interfere with the airflow over the panels.

2.4 Test Panels

2.4.1 Material and Dimensions

Alclad Aluminum 2024-T6 or 5052-H32 polished standard roll mill finish 30 x 50 x 0.32 cm, for a working area of 25 x 40 cm. Thicker aluminum stock may be needed when an instrument is mounted on the plate.

2.4.2 Markings

Each panel shall be marked as shown in Figure 2 with lines at 2.5 and 15 cm from the panel top edge, with fifteen cross-hair points and with vertical lines 2.5 cm from each side; this marks off a working area of 25 x 45 cm on each panel. All marks shall be made using a 1/8" thick black marker or silk screen process, which does not come off with application of the test fluids or any of the cleaning agents. Remarking of the plates will be required as the markings fade because of the cleaning actions.

2.4.3 Attachment

For attachment to the test stand, at least four holes shall be made, spaced along the two sides of each panel; the holes shall be within 2 cm from the panel edge.

2.5 Fluid Application

The fluid should be poured onto the plates from a manageable container, until the entire test section surface is saturated. Up to two litres of fluid should be applied to each panel. This amount is dependant upon the amount of ice/snow on the panels prior to the start of the test. Strong wind conditions will require greater amounts of fluid. For indoor tests at the NRC, about 1 litre of fluid per panel is sufficient.

2.6 Film Thickness Gauge

Film thickness at the six inch line can be evaluated (this is optional). Painter's wet paint film thickness gauge. 1-08 mil gauge or equivalent is available from Paul N. Gardner Company Inc. Pompano Beach Florida.

2.7 Video recording

A panning video camera should be mounted to record salient events during testing. Care must be taken that the camera and any lighting do not interfere with the airflow or ambient temperatures.

Tests must also be recorded with a hand-held video camera, in particular at the start of the test and when failures are being called.

2.8 Anemometer

Wind Minder Anemometer Model 2615 or equivalent. Available from Qualimetrics Inc. Princeton New Jersey. To be mounted at 3 metres.

2.9 Wind Vane

Model 2020 Qualimetrics or equivalent. To be mounted at 3 metres.

2.10 Relative Humidity Meter

Cole Parmer RH/Temperature Indicator P/N N-032321-00 with remote probe P/N N-03321030 temperature average or equivalent. Temperature limits -30 to 60°C RH range 20 to 100% accuracy ± 7% (20-30%); = -5% (30-100%); or equivalent. Available from Cole Parmer Instrument Company Chicago Illinois. The temperature gauge should be mounted at a height of 2 metres.

2.11 Ice Detection Sensors

Where feasible surface or remotely mounted ice detection sensors should be used during the tests.

2.12 Additional Equipment

- Squeegee
- Extension power cords
- Stopwatch
- Flood lights (2 x 500 watts)
- Pressurized space pens, pencils or "China Markers"
- Water repellent paper
- PC to record meteorological data

2.13 Integration of Equipment

Attachment IV provides a description of the equipment and how it is integrated.

3. DE/ANTI-ICING FLUIDS

3.1 Test Fluids

Only fluids that have been certified will be included in tests. Fluid suppliers shall submit to the test coordinating organization proof of certification for the fluids they provide.

3.2 Certification

Type II fluids shall be sheared by each manufacturer to that viscosity which would have been obtained by subjecting their fluids to the shear Stability Test found in the AEA Material specification revision C (October 1, 1988) paragraph 4.2.8.2.2.

Each manufacturer shall provide samples and a certificate of compliance showing the viscosity of their test sample of fluid before and after the Shear Stabile Test. Test verifications of each fluid may be made at the University of Quebec at Chicoutimi (UQAC).

3.3 Dye

Fluids will be supplied for certification and for testing in the form to be used on aircraft.

3.4 Dilution of Type I Fluids

Diluted Type I fluids must be mixed by the testers as a function of outside air temperature according to Table 2. These concentrations were determined based upon information provided by the fluid manufacturers for which a buffer of 10°C from the fluid freeze point is maintained. When preparing the mixtures, verify with a refractometer that the percentage concentrations are accurate. Union Carbide products are based on Ethylene Glycol, while the Octagon, Hoechst and Arco products are Propylene Glycol based.

Some tests are also planned with Standard Type I fluids and the concentrations of these are shown in Table 2. The dilution of these fluids is based upon the standard mixes used by many North American operators.

4. PROCEDURE

Attachment V contains a summary of the major steps required for the conduct of flat plate tests. This should be mounted on the wall in the trailer at the site.

4.1 Start-up and Close-up

Attachment IV provides a reference to enable tester to open the equipment at the start of a test session. This attachment also provides reference on what should be closed at the end of a session.

4.2 Set-up

4.2.1 Panel Test Stand

If there is any wind, orient the test fixture so that the test panels are facing into the wind direction at the beginning of the test and the wind is blowing up the panels,

```
i.e.   ---->    /
       wind   panel
```

If the wind shifts during the test do not move the fixture; simply note it on the data sheet.

4.2.2 Precipitation Gauge

Place the Precipitation Gauge as close as possible to the test fixture. Ensure that the interior level is used to indicate that the gauge is level. Ensure that the gauge is not shadowed by an object which would interfere with the collection of precipitation. If there is drifting snow it may be necessary to raise the snow gauge above the drift level but no higher than the test panel. The snow gauge measurements should be started as early as feasible and continue throughout the duration of all tests to provide a continuous record of precipitation.

4.2.3 Manual Cake Pan or Plate Pan Method

Add ¼ inch anti-icing fluid (Type IV) to the bottom of the pan as well as wetting the inner sides of the pan. Weigh the wetted pan prior to testing to the nearest gram. Weigh the pan at 15 minute intervals over the course of the test (see Table 1.a). Replace the pans on the test stand as long as the duration of the last test panel. Do not remove the contents of the pan until the test is complete. Weigh again after test completion of each panel to determine the true water content reading of the precipitation.

Use of more than one cake or plate pan is recommended to provide multiple readings through the course of the test period; mounting the pans on the test stand at the same orientation of the plates is recommended.

When using plate pans to measure precipitation rate, two plate pans shall be used. Care must be taken to ensure that snow or ice does not fall into the pans when transporting them into the trailer.

4.3 Test Panel Preparation

4.3.1 Before the start of each day's testing, ensure the panels are clean.

4.3.2 Place the panels on the fixture and attach to the frame screws with flat bolts (wing nuts will make attaching and removal easier in poor weather)

4.3.3 Allow the panels to cool to outside air temperature.

4.4 Fluid Preparation and Application

4.4.1 Fluid Temperature

Except for Type I fluids, all fluids should be placed outside (cold-soaked to ambient temperature conditions) at the start of the evening session.

4.4.2 Cleaning Panels

Before applying test fluid to a panel, squeegee the surface to remove any precipitation or moisture. Fluid being used for the test could be used to help remove snow or ice from the test panel.

4.4.3 Order of Application

Apply the fluid to the panels, commencing at the upper edge of the test panel and working downwards to the lower edge. Ensure complete coverage by applying the fluid in a flooding manner. Start with the top left panel U, then cover panel X in the second row with the same fluid, then flood the second test fluid on panel V followed by panel Y, etc. (see Figure 0).

4.4.4 Testing New Fluids

When testing the new Type IV fluids, two panels with standard Type II fluids should be tested at the same time on the same stand. When the end condition occurs on the standard Type II fluids, a new test with the same Type II fluids should be started immediately. A new form should be used for this and the test # and Run # should be the same, but with an "a" (eg. Test # 7a, Run # 23a). At the start of this new test, the plate pans should be weighed again. The test should be continued until these new panels have reached the end condition.

Similarly, when testing Type IV 50/50 fluids with Type I fluids, new tests should be started with Type I fluids if these fail much before the Type IV 50/50.

4.5 Holdover Time Testing

4.5.1 Set the **timer on** (for video) as the first fluid application (plate U and X) is completed. This designates the start of the test (time = zero). Note the time when fluid application is completed on the remaining panels.

4.5.2 Commence recording the test with a video recorder until the test reaches the END CONDITION. See Section 5 for definition of end condition.

4.5.3 Record the elapsed time (holdover time) required for the precipitation to achieve the test END CONDITION.

4.5.4 In heavy precipitation, continue the test until the precipitation reaches the bottom of the panel. Record the time for this event.

4.6 Video Recording

The panning camera should be positioned and functional for every test. It must capture the 1", 3" and 6" line of the top plates (u, v, w). A suggested position is to center the camera motor laterally and position it 8' from the back of the stand at the same height as the top plates.

Video record each test with a hand-held camera in the following sequences:

1) General outdoor condition prior to test (get good view of snow falling).

2) Video record the data forms.

3) Video record pouring. Ensure that name of fluids are captured, testers faces, your voice, name and stand # (ensure date and time are available and synchronized).

4) Record pans being weighed and brought out.

5) Record timer/clock (at beginning of run and during the run).

6) Record establishing shot of test stand (all the plates).

7) Record establishing shot of each plate, followed by a close-up of the plate (scan the plate slowly), then returning to wide shot of the plate. Repeat this with each plate in sequence, beginning from left to right, top to bottom. Always follow the same sequence. Ensure that each plate has a tag marked with the type of fluid used on the plate and that the plate itself is marked with its corresponding letter (X, Y, Z...). Record the clock/timer often.

8) For each failure, record an overview of the plates, followed by a wide shot of the plate, zooming in into a close-up of the failure. Return to the establishing shot at the end of the procedure. Repeat this procedure for each failure.

9) Ensure that the lighting is appropriate for video purposes.

10) Ensure that the video camera is in fact recording. At the end of a test, rewind a few seconds and check that the test was recorded.

4.7 Plate Pan Measurements

Measure the quantity (rate) of precipitation using at least two plate pans mounted on the test stand. Record these measurements on the Form (Table 1.a) at the following times:

- at the start of the test;
- every 15 minutes;
- when there is a significant change in the rate (intensity) for more than one minute;
- after failure of each panel (measure only once if two panels fail at almost the same time); and
- at the end of the test.

4.8 Meteorological Observations

Meteorological observations must be recorded at the same times as in 4.7, and when there are changes in the type and category of precipitation. Significant changes in wind speed and direction should also be noted.

4.8.1 Type of Precipitation

Note the type of precipitation (refer to Figure 4 for the codes). This is a subjective determination. If two or three forms of precipitation co-exist, then note all of these.

4.8.2 Amount of Precipitation

This is a subjective determination by the tester. Normally, this is determined by a trained meteo observer using visibility as a guideline. The symbols are as follows: ++ is heavy; + is moderate; - is light; -- is very light.

4.8.3 Classification of Precipitation

While many different classifications are available, a simple classification of ten forms of solid precipitation is shown in Figure 3. Use of black velvet to collect the snow and inspect it, will facilitate the identification.

4.8.4 Determination of Wet or Dry Snow

While this is usually temperature and humidity level dependant, determination of wet or dry snow could be determined by collecting snow in a dry plate pan on a stand not being used. If in the course of a test, the snow in the pan can be combined and formed into a "snow-ball", then this will be identified as wet snow. If the snow does not form into a "snow-ball" or if the snow does not even accumulate, then this is considered dry snow. Note that the time to form a "snow-ball", when collecting with gloves, should be less then 5 seconds. One other method to determine whether the snow is wet or dry would be to measure the depth of the snow in the pan and compare it to the liquid equivalent depth. If the ratio is > 10, then it would be wet snow.

4.8.5 Temperature and Wind Measurements

These can be read and recorded from the computer monitor at the site.

4.8.6 Visibility

Manual visibility measurements should be taken during daylight conditions. The markers to designate distance are those used by Environment Canada when these observations were being made manually.

4.9 Video Organization

The video equipment cassettes should be marked sequentially for the panning camera and the Hi 8 cameras. These #'s should be recorded on the data form at the time of testing. When these are full, then they should be marked as full.

5. END CONDITION

The plate failure time is that time required for the end conditions to be achieved. This occurs when the accumulating precipitation fails to be absorbed at any five of the crosshair marks on the panels.

A crosshair is considered failed if:

- There is a visible accumulation of snow (not slush, but white snow) on the fluid at the crosshair when viewed from the front (i.e. perpendicular to the plate). You are looking for an indication that the fluid can no longer accommodate or absorb the precipitation at this point.

OR

- When precipitation or frosting produces a "loss of gloss" (i.e. a dulling of the surface reflectivity) or a change in colour (dye) to grey or greyish appearance at any five crosshairs, or ice (or crusty snow) has formed on the crosshair (look for ice crystals). This condition is only applicable during freezing rain/drizzle, ice pellets, freezing fog or during a mixture of snow and freezing rain/drizzle and ice pellets.

As these determinations are subjective in nature, the following is **very important**:

- Whenever possible, have the same individual make the determination that a crosshair has failed.
- When making such a determination, ensure consistency in the criteria used to call the end of a test.
- Under light snow conditions or when the precipitation rate decreases, snow may sometimes build up on the fluid and then be absorbed later as the fluid accommodates (absorbs) it. If this occurs, record the first time snow builds up and note (in the comments sections) that there was an "un-failure" at a specific crosshair.

Under conditions of moderate to heavy snow or hail, coverage may be very uneven; over about one-third of the panel should be recorded.

6. END OF TEST

Run test at least 10% longer than the time to reach the end condition on the last panel. This will allow the sensor traces to be longer for analysis. Once the test has ended, restart the testing procedure and continue as long as the weather conditions warrant.

7. REPORTING & OBSERVATIONS

Calculate and record test data, observations and comments in the format of Tables 1 and 1a. Each test must be conducted in duplicate. Detailed definitions and descriptions of meteorological phenomena are available in the Manual of Surface Weather Observation (MANOBS) - a copy is available at APS offices.

ATTACHMENT III
PERSONNEL RESPONSIBILITY

Test Site Leader

- Call personnel to conduct tests.
- Ensure test site is safe, functional and operational at all times.
- Supervise site personnel during the conduct of tests.
- Ensure site is opened and closed properly.
- Monitor weather forecasts on a daily basis.
- Report to project manager on site activities on daily basis.
- Review data forms upon completion of test for completeness and correctness (sign).
- Decide what fluids should be tested.
- Ensure results are reasonable.
- Ensure all clocks are synchronized at all times.
- Monitor weather forecasts during test period.
- Ensure fluids are available and verify fluids being used for test are correct.
- Get samples of all fluids.
- Ensure computers are all operational.
- Ensure electronic data is being collected for all tests.
- Ensure proper documentation of tapes, diskettes, cassettes.
- Verify test procedure is correct (eg. stand into wind).
- Ensure all materials are available (pens, paper, batteries, etc.)
- Ensure all equipment is on (tilt and pan video etc.).
- Fill in end of testing checklist for every session (see Attachment VI).

End Condition Tester

- Monitor the progression of failures on the plates.
- Record end condition times for each crosshair.
- Communicate to video operator the end condition times.
- Apply fluids onto test panels.
- Complete and sign Data Form (Table 1).
- Prepare fluids for each test.
- Prepare name tags for each test.

ATTACHMENT IV

SYSTEM MANAGEMENT AND PROCEDURES

Meteo Tester

- Record meteo for both stands
- Rotate and measure plate pan weights.
- Squeegee plates prior the fluid application.
- Complete and sign Data Form (Table 1a).
- Assist end condition tester when failure times occur quickly.
- Place stop-watch and start stop-watch on test stand.

Video Tester

- Sign and fill in cassette #'s, etc. in data form (Table 1a)
- Video all tests (see procedure)
- Verify all equipment is on (tilt and pan video etc.).
- Document and mark all cassettes used for all electronic equipment.
- Ensure camera batteries are recharged and available.
- Ensure lighting is appropriate.

Table of Contents:

System management and procedures

OBJECTIVE:

The object of this report is to provide written procedures to follow for each test session at the APS trailer site. These procedures are intended for normal operations during testing but will offer guidelines in the case of abnormalities such as computer breakdown.

An introductory section will describe the general aspects of the computer systems as well as the peripheral components involved in their functioning and test operations.

Procedures will be placed in a black binder that will determine procedures for anti icing and computer operations.

Introduction

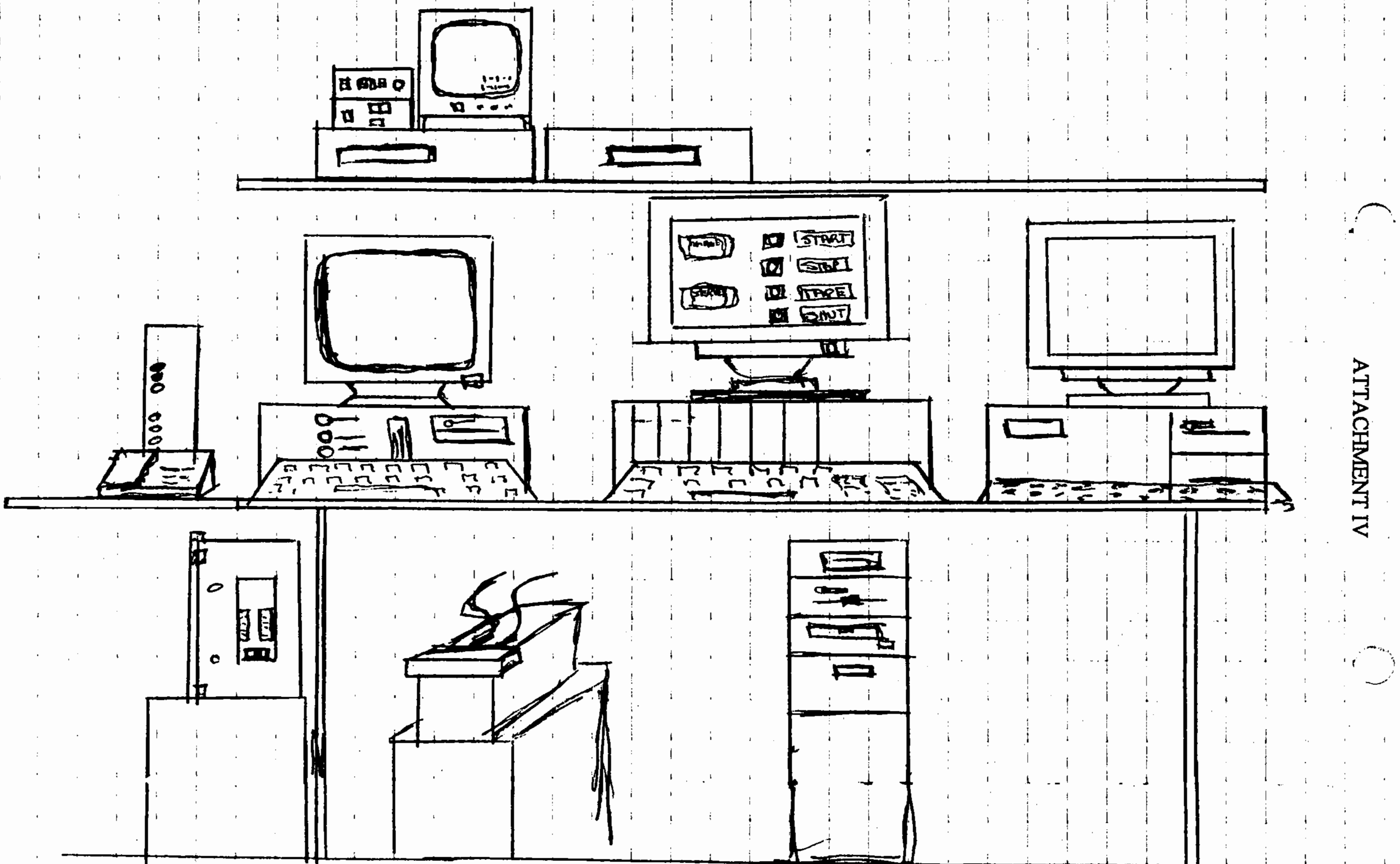
There are three computer systems running at the same time to ensure proper data collection at the APS site. The primary functions of these computers are to provide meteorological data as well as sensor data. The three computer systems are called:

1. MET computer;
2. RVSI;
3. CFIMS (or CWDS).

Along with these systems are the video recording equipment, as well as various power unit boxes that assure a proper power supply .

(Feb 4 '95)

APS TRAILER SITE SYSTEM SETUP FOR SYSTEMS MANAGEMENT REPORT:



- DC Power Source.

ATTACHMENT IV

MET COMPUTER

MET is the chosen abbreviation for meteorological computer. The computer may also be referred to as the WX station, for weather station. This computer is hooked up to a series of reading instruments located on the outside that provide necessary information such as ambient temperature, wind speed, etc.. The information is obtained through a program called GET-DATA. It is vital to set proper time and date on this computer before the start of any experiment.

The computer is equipped with a 5¼ floppy drive and is running in the DOS 5.0 environment. Usually the computer is running on a 24 hr. basis.

Table of commands for the **MET** Computer:

COMMANDS	DESCRIPTION
Alt-X or Ctrl-Esc	to exit the program GET-DATA and go into DOS. You may go back to the program by typing GET-DATA. When turning on the computer, a window will pop up asking if the user wishes to append the unsaved data or overwrite onto the file.
F5	to start a new test file. A test file is started at the beginning of the session when testing starts.
F6	to close a test file. A test file is closed when all testing is completed for the night.
Alt-F10	to escape to DOS temporarily (10 to 15 min.) also called shelling to DOS.
Alt-H	for HELP
DIAGNOSTIC / MAINTENANCE FUNCTIONS ** Warning. Data collection will be interrupted with these.	
Ctrl-F2	Debug / Diagnostic Mode ON/OFF
F4	DOS / Module Time Toggle
Alt-F4	Read in new DEFAULTS/ PARAMETERS
F8	Sync. time
Ctrl-F8	Sync. time now

The accumulated data is going to be stored in files (located in directory **c:\1100\DATA**) that are labeled under three categories:

i) **S** for scan 24 hr. data (backup), extension .CVS (Direct read excel)
ii) **L** for log, running log that keeps track of events on computer, extension .LOG
iii) **T** for test file, actual experiment.

These files are saved according to their category followed by the date sequence **YYMMDD**. Note that all files are denoted by date in this form as presented in the following example:

ex: S941201.CVS
L940302.LOG

Once the files are saved, they are compressed through a ZIP program.

MET COMPUTER PROCEDURES

1) Turn on the screen (bottom right hand side, on the side), the terminal itself is usually running 24 hrs.
2) Call **FSS**: 633-3345, to get a time check to set the computer:
note:
UTC time = Zulu time, i.e. you must subtract 5 hrs. to get E.S.T.
for example: 18:15 Zulu time → 13:15 E.S.T.
or request EST time (i.e. Local time check)

3) Enter the new time in the computer:
- **Alt-F10** to DOS
- set the time
- type in **exit** then press **enter**
- press **F7** and confirm **yes** to reset the data module

4) Open the test file: press **F5**
-you'll see that in the running log the test file is open
(remember to close the test file at the end of the night : press **F6**).

RVSI

This system is named after the developers, *Robotics Vision Systems Inc.*. This system is hooked up to the testing stand, and includes a photo-scanner that relays information back to the computer to display on screen the state of the aluminum plates. The software runs in the OS/2 environment. The computer runs in conjunction with a gray power supply box located under the desk.

This gray power unit also supplies power to heat the RVSI on the scaffolding at the test stand.

While the RVSI is running, a main menu is displayed on screen featuring options to proceed with the tests. The menu options are presented in the following table.

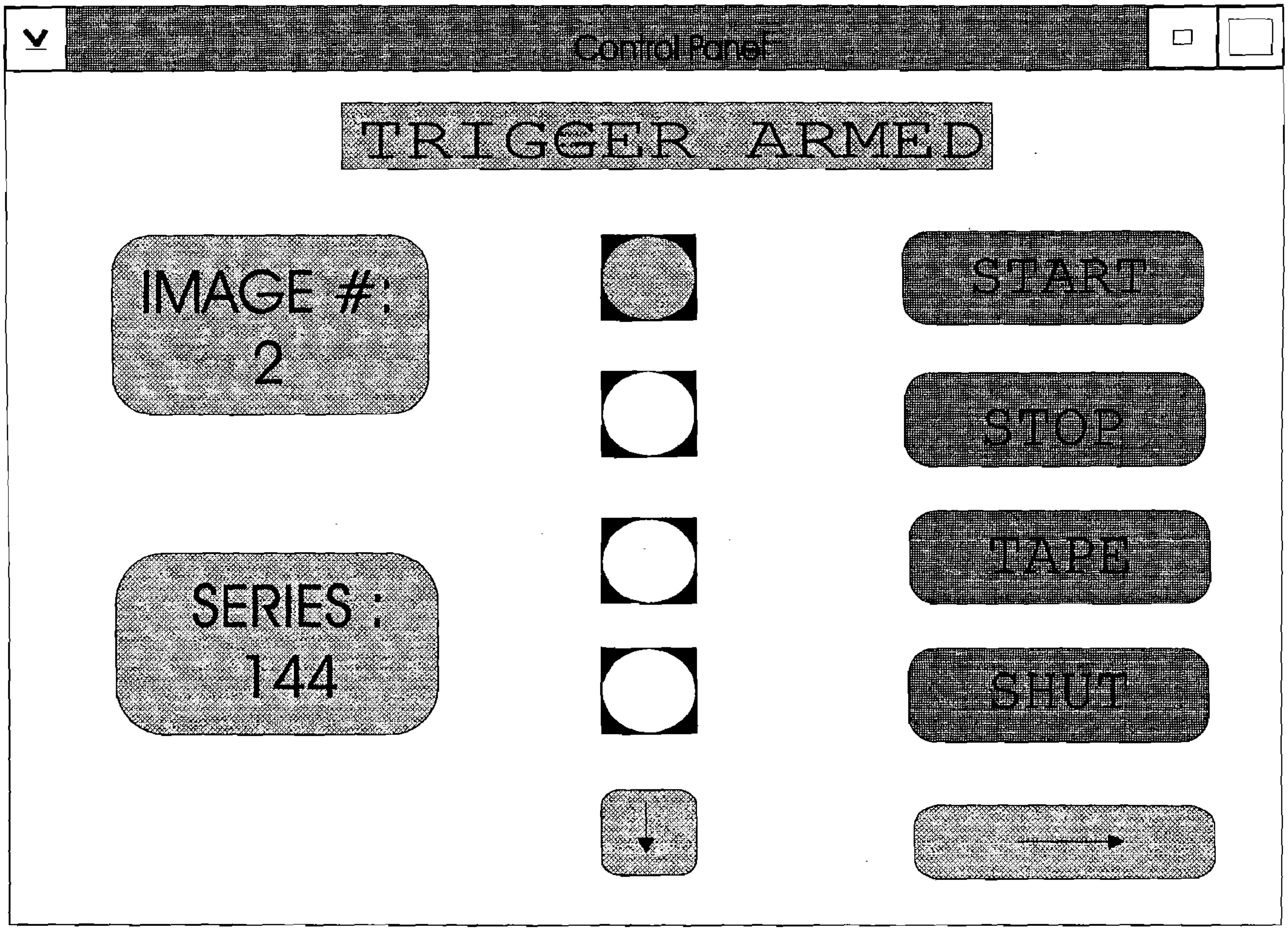
Table of menu options for the RVSI:

MENU	DESCRIPTION
RUN	commence scanning and reads data
STOP	displays " Compressing the image sequence. Please wait..." - after a scanning sequence was run, you have to go to STOP to compress the data. Once that has occurred, the program takes you back to the main menu and stores the data on the hard drive.
TAPE	to transfer the data to a tape backup, this option temporarily takes you into a yellow screen.
SHUT	goes through the proper shut down sequence to exit the program. When you shut down the application, the computer displays some difficulty in terminating the shut down sequence where after a certain delay, when not registering any hard drive activity, it is safe to turn off the computer.

Operating keys to select an item on the MENU are as follows:

- ↓ down arrow to scroll through the menu;
- → right arrow to select an option;
- ← the left arrow will give you an instantaneous scanning and also exits back to the menu (in control panel) if you are in scan mode already.

RVSI SCREEN


Control Panel
TRIGGER ARMED
IMAGE #:
2
SERIES :
144
START
STOP
TAPE
SHUT

RVSI PROCEDURES

1) Turn on the RVSI monitor (bottom right on the face) & CPU (slim gray button on tower).
2) Turn on the gray power supply box in order to have the "result" screen (do not touch the heater power switch, the heater remains on at all times).
3) Set the time on the RVSI
   - click the upper left hand corner with the mouse and go into "window list"
   - select DATETIME.CMD icon to change the date and time, once the date and time have been entered the screen disappears and takes you back to the main menu.
   - If it doesn't exist then select the STARTUP menu, then select DATETIME.CMD icon.
   - Exit the DATETIME.CMD application by selecting the corner of the STATRTUP menu and then selecting close.
4) When the "control panel" menu appears (and the test is ready to start), select RUN this will take you into a "result" screen.
5) At the end of the experiment, press left arrow to exit the "result" screen
6) Then select STOP, in order to save the data (after each test run go to STOP to compress the images).
7) At the end of the night select SHUT
   - if a screen prompts you that there is another application, select YES to shut it down.
8) Shut the gray power supply box as well to save on energy.

Accessing the FILE MANAGER in the RVSI computer:

To view the directories and files in a global manner and perhaps copy them to diskette, it is easier to work through the File Manager in OS/2 Windows. To access the File Manager through complex maze of windows, you might use the following procedure:

1) Starting from the RVSI menu screen, go to the upper right hand corner and click on the small box (the box on the left).
(there may be a delayed response, avoid the temptation of repeatedly clicking)
2) The DATETIME.CMD screen appears, click on the small box of that screen.
3) The Monitor Window appears (with a list of commands), press on the small box of that screen.
4) Then you'll find yourself in a light blue screen: double click on the OS/2 System icon which is on the bottom left hand corner.
5) That will take you to a black screen called OS/2 System-Icon View: double click on the folder located on the bottom left (first in the second row).
6) That takes you to a white screen called Windows Programs-Icon View, double click on the Program Manager icon
7) When the Program Manager screen pops up, select the File Manager (double click or press enter).
8) View the files, copy etc.
9) When finished, go to the top left box of the Program Manager Screen & select close
10) press OK to end WIN-OS/2 session
11) go to top left corner of Windows Programs-Icon View screen and click on the gray file on the top left corner, and select close
12) Go to top left corner of OS/2 System-Icon View screen and click on gray circle, and select close.
13) Go to the top left corner and double click on the start up file
14) Start up screen appears with DATETIME.CMD and Ice Detection icons
15) Double click on the Ice Detection icon and you'll be back to the RVSI screen.

CFIMS

The CFIMS is hooked up to a data logger called the LRU which in turn is connected to the ice sensors. This computer runs on a software called FLUIDSTY that analyses the temperature on the ice sensors.

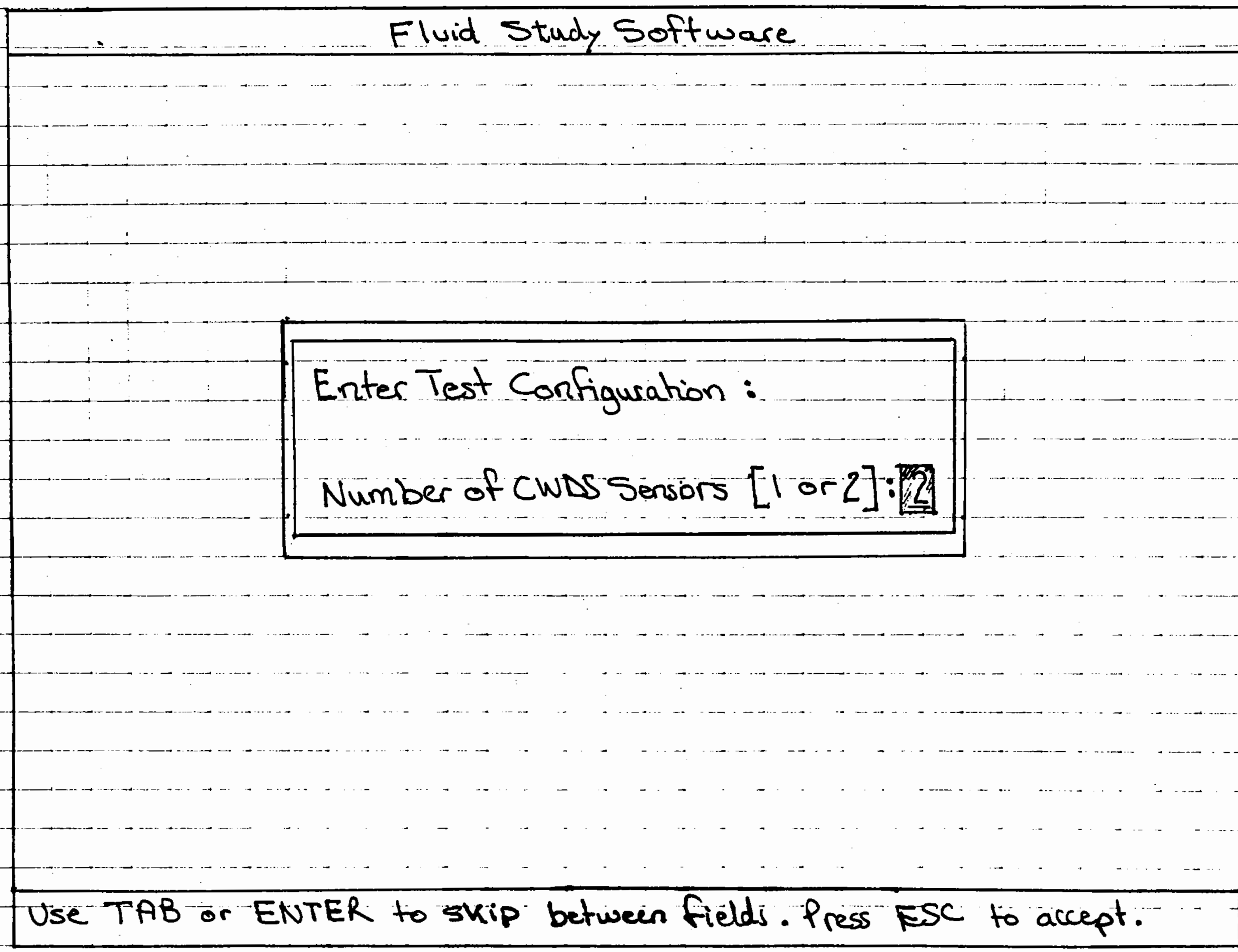
The FLUIDSTY program is located in the **c:\fluidsty** directory. Usually when the computer is powered on, the program is run automatically. Should the user have exited the program, he needs to type in **fluisty** and press **enter** in order to have it run again.

When running the FLUISTY program, the user will encounter five typical screens, not including error messages. These screens guide the user to select or enter the data pertinent to the test such as: the number of sensors used, the snow type, the fluid name, the mounting as well as comments.

Before each test conducted on the test stand #1, it is important to repower the LRU (turn it off then back on). Otherwise an error message will be pop up. (the LRU is the gray box with the switch on the right hand side next to the power cord). On the LRU test panel (the gray box), the Fault light that is not lit, or off, indicates that the sensor is connected correctly. A fault light that is lit, or on, indicates that a sensor is either not connected or not connected correctly.

CFIM PROCEDURE

1) Power on the screen, the computer and the LRU
2) "doskey installed" will pop up, press any key to continue.
3) It will automatically prompt you to set the time and date, use the FSS time.
4) Press **Esc** to accept and continue.
5) On the bottom of the screen it indicates to "Repower LRU", it means to reset the LRU test panel (turn it off then on)
6) When the LRU is reset, you are ready to start sampling.
7) Select "S" to start sampling.
8) Enter the necessary information in each field.
9) Press Esc to accept the configured data.
10) A data collecting screen will appear during the length of the test.
11) At the end of the test, press Ctrl-Q to stop sampling.
12) Enter the test comments to conclude the experiment.
13) Press Esc to accept, and we go back to the first screen.
14) At the end of the night select Q to quit, then it will save all the data.



* First screen that pops up after the time & date were entered.

• Press ESC to accept.

Fluid Study Software

Select a Command

S - Start Sampling
C - Change Setup
Q - Quit

Repower LRU test panel before sampling data

* Repower LRU
* ~~[illegible]~~ press enter to Start Sampling.

. Be sure to start video tape recording also.

Fluid Study Software

Enter Test Description

Initial Precipitation Type: [①]

Sensor 1

Fluid Name: [②]

Mounting: [③]

Sensor 2

Fluid Name: [④]

Mounting: [⑤]

Comment: [⑥]

Use TAB or Enter to skip between fields. Press ESC to accept.

① type of snow or precipitation ex: F1-F2.
The reference to the categories of snow are listed on the appendix C char
pasted on the wall next to the door.

②,④ manufacturer / commercial name (fluid name) / type of fluid
ex: UCAR / ULTRA / type 2
or UCAR / XL54 / 23% / Type 1

③,⑤ select 10° incline

⑥ comments like FSS weather data, other.

Fluid Study Software 02/08/95 23:02:18

CWDS Sensor 1	CWDS Sensor 2
206	193
29	12
191	167
-12	-19
107	89
-5	-10
-12.524C	-12.622C

Sampling data. Press Ctrl+Q to stop sampling.

Fluid Study Software
Enter End-of-Test Comment
Comment:
Enter comment. Press ESC to accept.

. Esc to accept - remember to repower LRU
* turn off VCR - stop recording.

Fluid Study Software

The last instance of this application was terminated for the following reason: RS422/4-- waiting for data ready, timeout period exceeded. The lasttest data set contains sensor data. Do you wish to have the last test data set deleted?

NO

YES

Repower LRU test panel before sampling data

* select no to save data & proceed to screen one

Fluid Study Software

The following error was encountered: RS422/4 -- waiting for data ready, timeout period exceeded. Repower LRU test panel & try again. Terminating the application. Press any key to exit.

Repower LRU test panel before sampling data

* when going ahead without repowering.

VIDEO CAMERA

The video monitor is observing the test stand #1. It is hooked up with a time lapse VCR. The VCR must be turned on in order to receive a picture. There are also two black scan control boxes next to the monitor that permit panning and zooming with the camera. During a test, the scan control will be on the automatic mode in order to pan continuously on the three panels. Behind the RVSI power source is a small DC power source that must be on to power the VCR. The scan control must be set up to focus on the top three plates, on the top third of the plates, i.e. from the top to the 6" line. Then, in order to record the test, it is important to press **play-record** (ensure there is a tape inside) at the beginning of each test and **stop** at the end of each test.

GETTING STARTED:

1A) Call FSS, get TIME & WEATHER check
- synchronize all computers and watches
- type in the FSS weather data in the CFIM comment box

1) Met Computer ON
- F5 to start new test
- Alt-F10, set time, exit
- F7 to reset data module

2) RVSI computer ON
- set the time
- make sure the screen is right
- note down the image # and the series #

3) CFIM computer ON
- set the time

4) Press left arrow to start sampling RVSI
Press "S" to start sampling CFIM , enter data and Esc to accept
VCR ON, press Play-Record

5) START TEST

END OF TEST:

1) Down Arrow to STOP, Right Arrow to select STOP on RVSI
2) STOP VCR
3) Ctrl-Q to end CFIM data collection, Repower LRU

END OF NIGHT:

1) F6 on MET
2) SHUT on RVSI
3) Quit on CFIM
4) Turn off all monitors, CFIM and RVSI computers, VCR and gray power supply box

ATTACHMENT V
SUMMARY OF STEPS TO CONDUCT TESTS

The following are the major steps required to conduct flat plate tests at Dorval.

Upon Entering Trailer

1) Turn on lights (outside and inside) and sign-in
2) Determine tests to be conducted and fluids (Type II, IV to be placed outdoors).
3) Remove snow and clear access to stands.
4) Turn on RVSI computer, C/FIMS computers, and video camera equipment.
5) Synchronize all clocks on all equipment in 4) and stop watches.

For Each Test

1) Fill in general material on Table 1 and 1.a, and prepare plate pans for start of test.
2) Place fluids and tags by stand.
3) Ensure stand is into wind.
4) Start logging of following computers: C/FIMS and RVSI, and apply fluids on panels.
5) Start timer on stand (t = 0) after application on plates U and X.
6) Record end condition times of all panels **(care to be taken for the 5th crosshair of each panel).**
7) Measure plate pan weights over the course of the test.
8) Video record start of test, progression of failures, and when the end condition (5 of 15 crosshairs) is being called on each panel.
9) Ensure forms are properly completed and signed.
10) Save C/FIMS and RVSI data.
11) Start a new test.

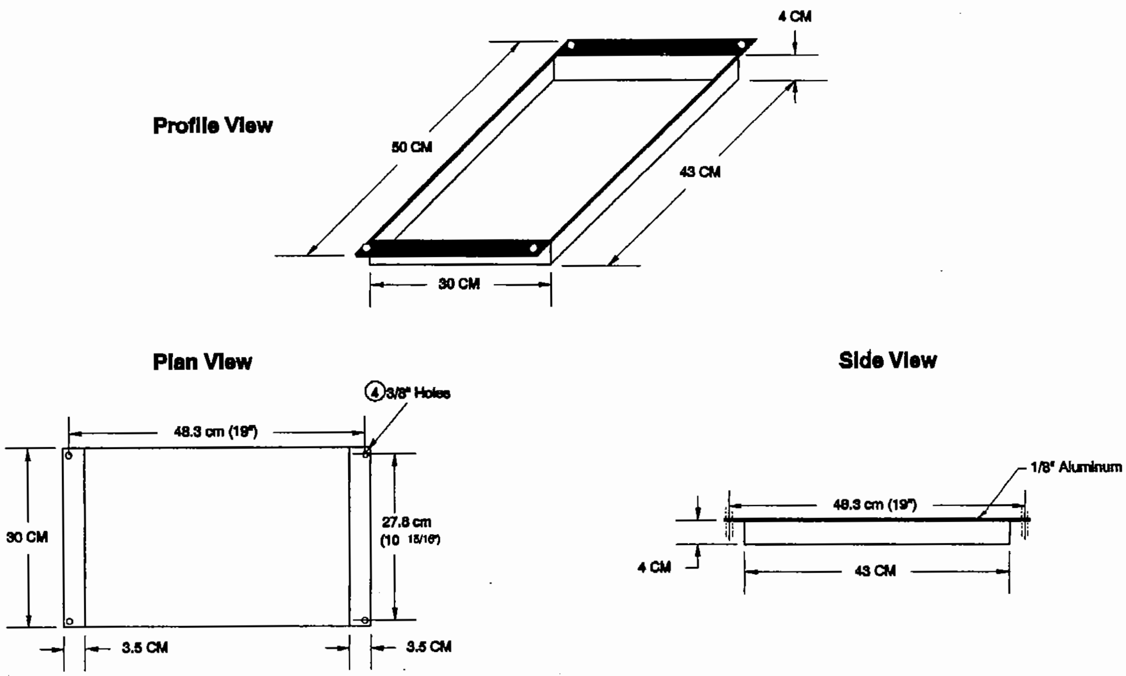
To Close Trailer

1) Replenish fluids.
2) Log and document date, times, test #'s, etc. on all media
3) After major events (more than 10 tests), start new tapes for next occasion.
4) Place all media and test forms in large envelope for delivery to office.
5) Shut off the following equipment RVSI; video camera; and C/FIMS; bring in timers.
6) Clean trailer and all garbage.
7) Ensure outdoor is left clean and presentable.
8) Close lights and sign-out.

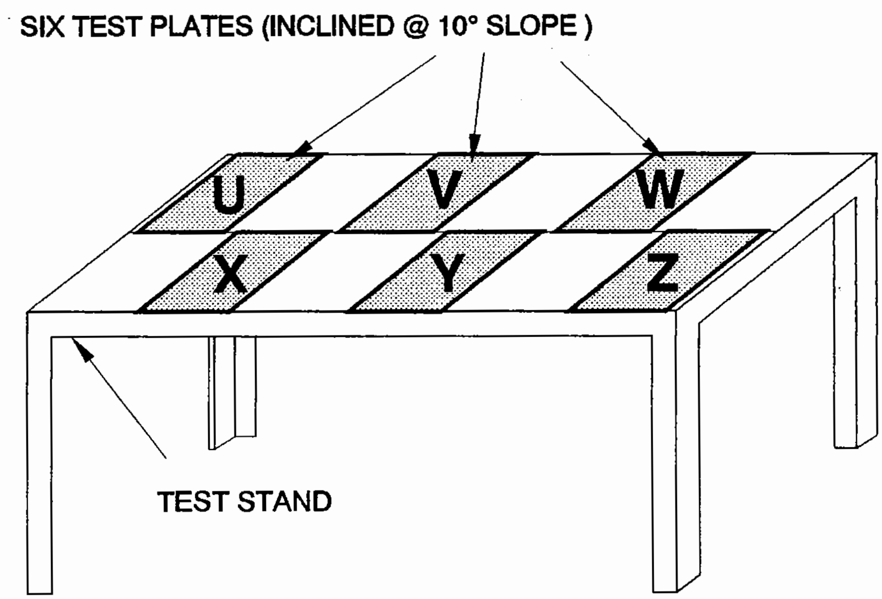
FIGURE 0

SCHEMATICS OF PLATE PAN AND TEST STAND

PLATE PAN

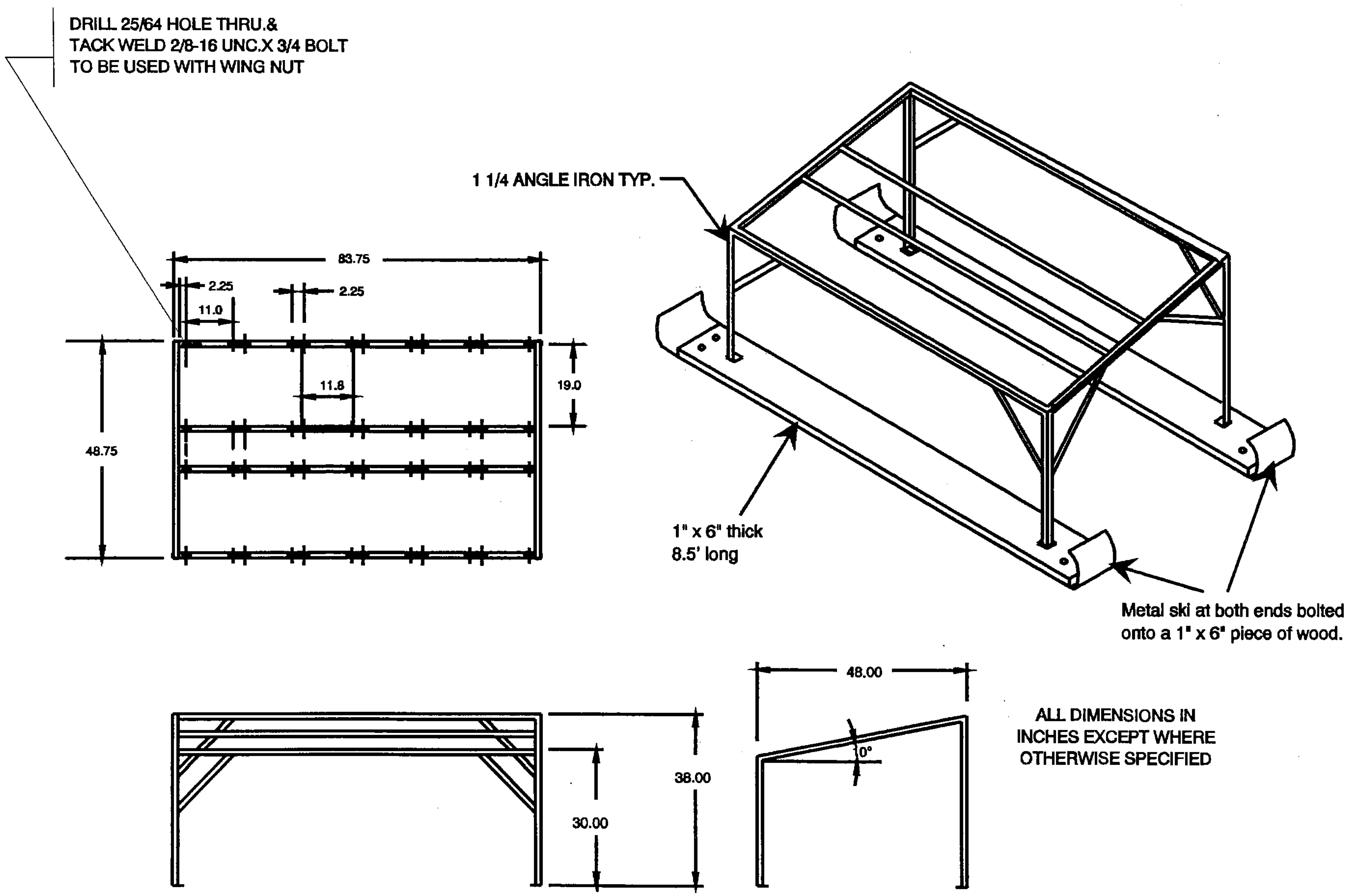


TEST STAND



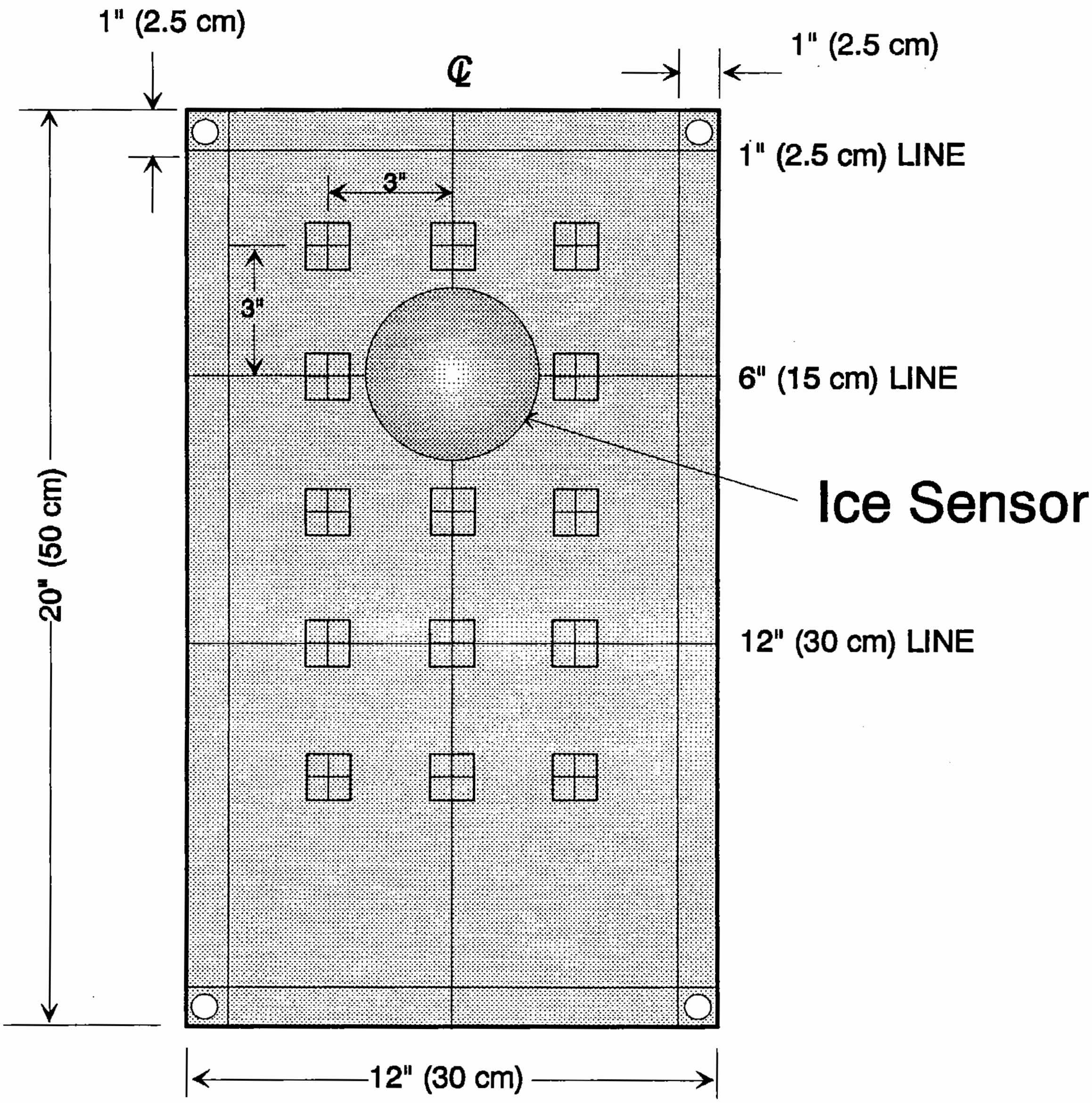
bm2980\procedur\nat_snow\pan&stnd.drw

FIGURE 1
TEST STAND



bm2980\procedur\nat_snow\ack_r2.drw

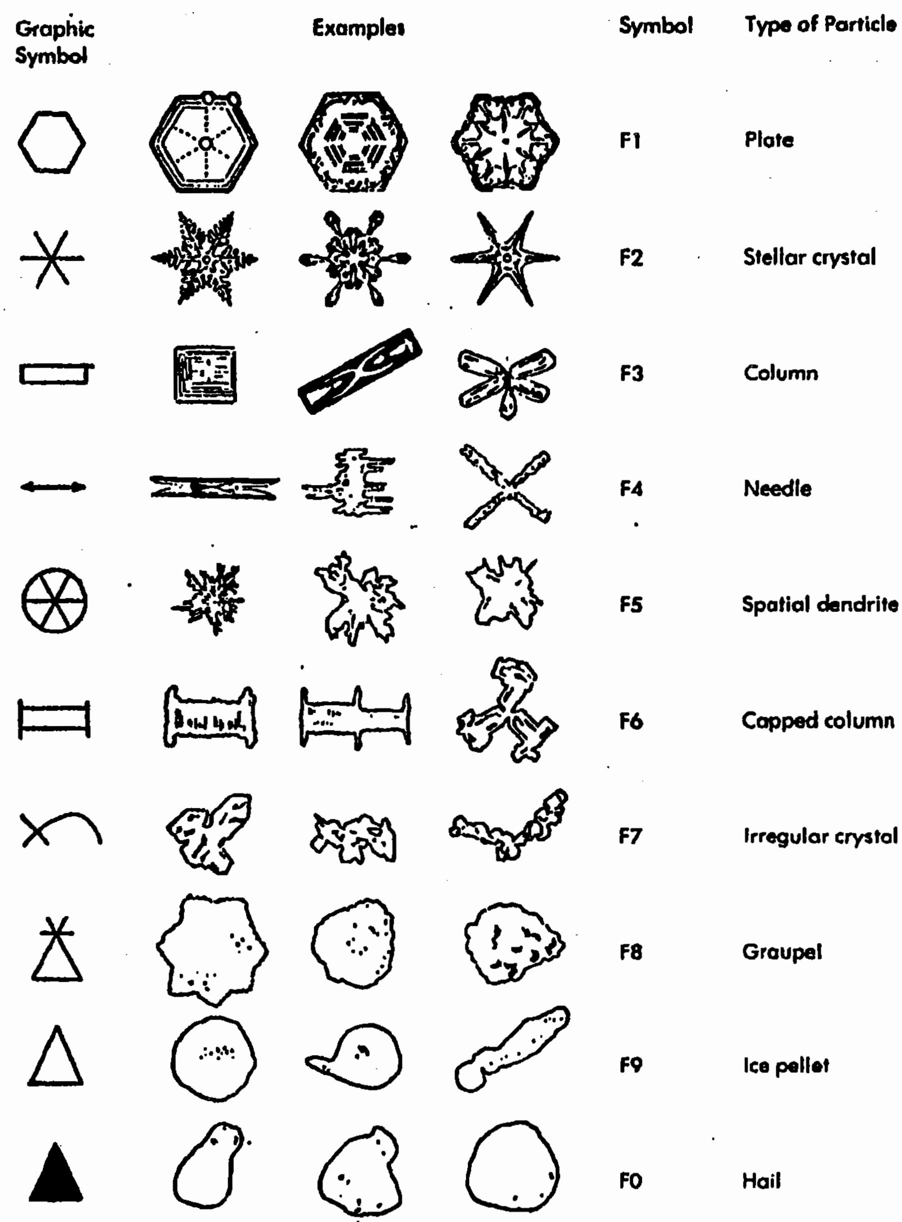
FIGURE 2
TYPICAL ICE SENSOR FLAT PLATE MARKINGS



bm2980\procedur\nat_snow\plate.drw

FIGURE 3

INTERNATIONAL CLASSIFICATION FOR SOLID PRECIPITATION



4. A pictorial summary of the International Snow Classification for solid precipitation. This classification applies to falling snow.

Source: *International Commission on Snow and Ice, 1951*

FIGURE 4

WEATHER PHENOMENA AND SYMBOLS

General Category	Specific Phenomena	Symbol
Tornadoes and Thunderstorms	Tornado	Tornado
	Waterspout	Waterspout
	Funnel Cloud	Funnel Cloud
	Thunderstorm	T, T+
Precipitation	Rain	R--, R-, R, R+
	Rain Showers	RW--, RW-, RW, RW+
	Drizzle	L--, L-, L, L+
	Freezing Rain	ZR--, ZR-, ZR, ZR+
	Freezing Drizzle	ZL--, ZL-, ZL, ZL+
	Snow	S--, S-, S, S+
	Snow Grains	SG--, SG-, SG, SG+
	Ice Crystals	IC
	Ice Pellets	IP--, IP-, IP, IP+
	Ice Pellet Showers	IPW--, IPW-, IPW, IPW+
	Snow Showers	SW--, SW-, SW, SW+
	Snow Pellets	SP--, SP-, SP, SP+
	Hail	A--, A-, A, A+
Obstructions to Vision (visibility 6 miles or less)	Fog	F
	Ice Fog	IF
	Haze	H
	Smoke	K
	Blowing Snow	BS
	Blowing Sand	BN
	Blowing Dust	BD
	Dust Haze	D

ATTACHMENT VI

CHECKLIST FOR END OF TESTING

ITEM	CHECKED	NOTES
ALL FLUIDS BROUGHT IN		
ALL FLUIDS REPLENISHED		
STAND TIMERS BROUGHT IN		
FLUID TAGS BROUGHT IN		
WASTE FLUIDS BROUGHT IN		
HANDHELD CAMERAS BROUGHT IN		
OUTDOOR AND STAND LIGHTS TURNED OFF		
PANNING VIDEO CAMERA TURNED OFF		
C/FIMS COMPUTER TURNED OFF		
MET FILE CLOSED AND NEW FILE OPENED (MET COMPUTER KEPT ON)		
RVSI FILES COMPRESSED AND SAVED TO TAPE		
RVSI COMPUTER AND HEATER TURNED OFF		
WRIST WATCHES HANDED IN		
ALL TEST MEDIA PROPERLY LABELED (VCR, SUPER 8, RVSI, C/FIMS)		
DATA FORMS CHECKED AND SIGNED		
ALL PERSONNEL SIGNED OUT		
TRAILER CLEANED UP		
TRAILER HEATER KEPT AT +17C		
C/FIMS		
TRIPOD		

BM2980\SETUP\CHEKLIST.XLS
10/01/96 10:21 AM

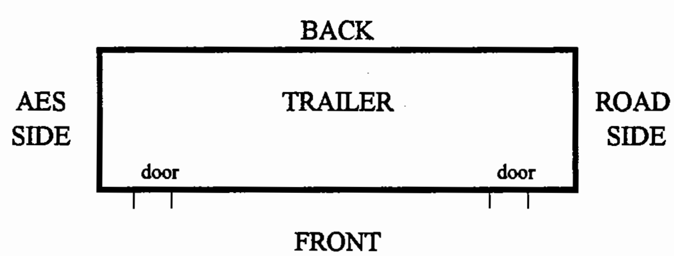
MARKERS FOR DETERMINATION OF VISIBILTY

(Refer to Visibilty Map of the AES Site, Dorval)

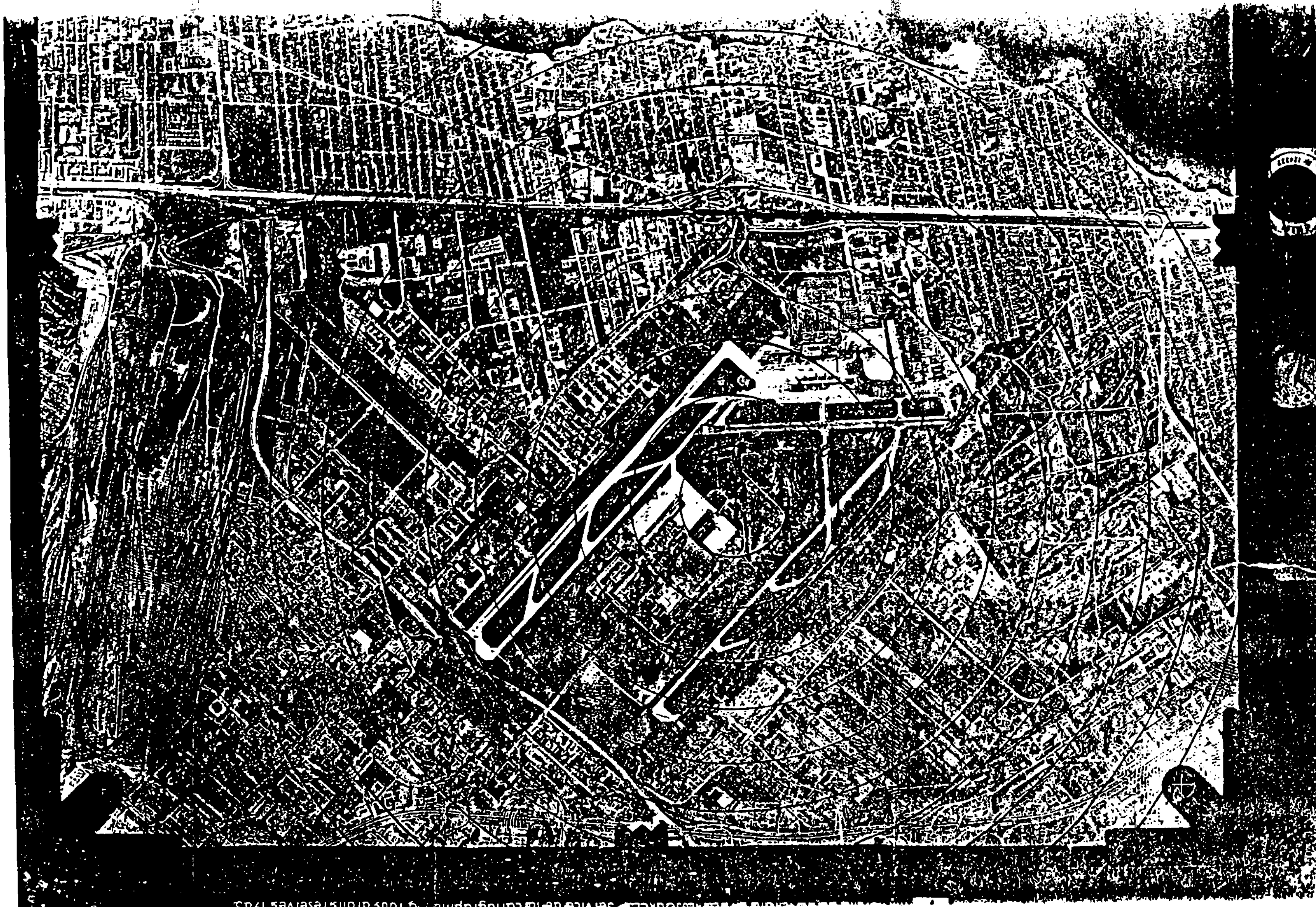
1) Visibility should by measured only during the daylight.
2) To determine visibilty, search for the furthest visible marker and enter the distance of this marker on the data form.

DISTANCE (miles)	LANDMARK	LOCATION FROM TRAILER
1/8	Top of Air Canada garage, Road Side of trailer	N/E
1/4	Air Canada lights (top of Garage), Road Side of trailer	E
3/8	(Judgment call)	??
1/2	Building in Road Side of trailer	N/E
5/8	Air Canada De-Icing trailer (next to runway), front side of trailer	S/W
3/4	Blue Building, between Back & Road Side of trailer	N
7/8	Small Blue Building, Front of trailer	S/E
1.0	Building, Front of trailer	S/E
1.5	Brown Buildings, AES Side of trailer	S/W
2.0	Group of three (3) Buildings, between Back and AES Side	W

ORIENTATION



Attachment VII
Map to determine visibility at AES Site, Dorval
(concentric circle ¼ mile apart)



APPENDIX C

DETAILED PLAN OF
NRC COLD CHAMBER TESTING

DETAILED PLAN OF NRC COLD CHAMBER TESTING
1995 - 1996

- Freezing Fog
- Freezing Drizzle and Light Freezing Rain
- Rain on a Cold-Soaked Surface

APS Aviation Inc.

March 1996
Version 3.3

This document provides the detailed procedures and equipment required for the conduct of simulated freezing fog, freezing drizzle/rain and rain on a cold-soaked surface tests. These tests will be conducted at NRC's Climatic Engineering Facility (CEF) in Ottawa.

1. OBJECTIVES

1.1 Freezing Fog and Light Freezing Rain/Drizzle (March 11 to March 15, and March 22 to March 29, 1996)

This test program was developed to test samples of the new Type IV fluids to establish holdover times over the full range of HOT table conditions. Scheduling of the indoor tests will be coordinated with the NRC. Duration of tests will be ten working days, including set-up time. Fluid failure will be determined by visual observation and supported by any instruments as these are made available. Ancillary tests will be conducted at the NRC Chamber to study the effect of HOT's of successive application of new and conventional Type II fluids on clear and contaminated Type I's.

1.2 Cold-Soaked Conditions (July 29 to August 9, 1996)

An approach for the evaluation and substantiation of cold-soaked wings was developed as part of the 1994/95 test program. Some preliminary experiments were also conducted. The 1995/96 cold-soaked tests will be conducted to substantiate the values given in the SAE/ISO Holdover Time Tables for Type I, Type II and Type IV fluids.

The cooling system used in 1994/95 to cool the test boxes will be used. The tests will be conducted at +2°C, covering a range of box temperatures from 0°C to -15°C, and a range of precipitation rates to be determined in consultation with personnel from AES and NRC. Tests will be conducted with the 7.5 cm boxes used during the 1994/95 test program and the new 2.5 cm sealed boxes (see Attachment VIII).

2. PERSONNEL

Three (3) testers will be required for the CEF testing at all times. Duties will be shared as follows:

Pan/Fluid/Video/Boxes
Tester 1:
- Coordinate all equipment
- Record pan rates

- Assist end condition tester when failure times occur quickly
- Assist Team Leader
- Ensure power cables and lighting is in place
- Pour fluids
- Operate Cooling unit
- General setup
- Prepare plates, boxes and pans for each experiment
- Perform experiments
- Prepare fluids
- Take video (hand-held) as required
- Ensure video equipment (tilt and pan) is operational

End Condition Tester 2:

- Located by test stand
- Make observations and call conditions on test stand A
- Knowledge of procedures for test stands
- Setup lights and stand and cables
- Setting up, C/FIMS and video equipment
- Calling end conditions
- General setup
- Assist Tester 1 as required

Leader Tester 3:

- Knowledge of test procedures and conditions
- Responsible for area and people
- Coordinate actions of APS team and NRC personnel
- Ensure test site is safe, functional and operational at all times.
- Supervise site personnel during the conduct of tests.
- Report to project manager on site activities on daily basis.
- Review data forms upon completion of test for completeness and correctness (sign).
- Ensure all clocks are synchronized at all times.
- Ensure fluids are available and verify fluids being used for test are correct.
- Ensure electronic data is being collected for all tests.
- Ensure proper documentation of tapes, diskettes, cassettes.
- Ensure all materials are available (pens, paper, batteries, etc.)
- Ensure all equipment is on

3. PROCEDURES

The procedures for most tests are the same as per the FPTP document. The data forms used for the tests as well as the rate forms are attached to this document. The following notes apply to the CEF testing:

a) Run numbers followed by a, b or c (sub-run) refer to tests conducted within a primary run.

b) Freezing fog tests will use two stands. Each stand should be started 30 minutes after the other or after the first sub-run is complete, and rates are being measured.

c) Rates will be measured before and after each run and sub-run at all tested locations. For the sub-runs, only the concerned plates should be looked at.

d) The sealed boxes for cold-soaked testing should be prepared in advance by T1 who will also run the cooling unit. T3 will participate in this effort.

e) A video record of most tests will be continuously collected using the time lapse video camera. Any special event should be recorded by T1 using a hand held camera.

f) Refer to Attachment IX for the thermistor mounting procedure.

4. TEST PLAN AND EQUIPMENT LIST

Attachment VII provides an equipment list. Attachment VI provides a day by day test schedule, while Attachment V provides the more general test plan. It is anticipated that the freezing fog, drizzle and rain tests will be conducted during the 10 day period in March 1996, while the cold-soaked tests will be conducted at the end of July 1996 for a 10 day period.

5. Data Form

The data forms are as follows:

- De/anti-icing data form for freezing precipitation, Attachment I
- De/anti-icing data form for cold-soak box, Attachment II
- Precipitation rate measurement, Attachment III
- Cold-soak precipitation rate measurement, Attachment IV

Additional tests (Attachment VIa) to see the effect of Type IV and Type II fluids over Type I are planned based on Attachment Va.

ATTACHMENT I

DE/ANTI-ICING DATA FORM FOR FREEZING PRECIPITATION

REMEMBER TO SYNCHRONIZE TIME — VERSION 3.0 — 1995/96

LOCATION: CEF (Ottawa) DATE: RUN NUMBER: STAND # :

am / pm RVSI SENSOR Series #:

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

	Plate U	Plate UU	Plate V	Plate VV	Plate W	Plate WW
Time of Fluid Application: (real time)						
FLUID NAME						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
TIME OF SLUSH FORMATION ON SENSOR HEAD	1st ½ Full	1st ½ Full	1st ½ Full	1st ½ Full	1st ½ Full	1st ½ Full

	Plate XX	Plate X	Plate YY	Plate Y	Plate ZZ	Plate Z
Time of Fluid Application: (real time)						
FLUID NAME						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
TIME OF SLUSH FORMATION ON SENSOR HEAD	1st ½ Full	1st ½ Full	1st ½ Full	1st ½ Full	1st ½ Full	1st ½ Full

PRECIP: ZF , ZD , ZR AMBIENT TEMPERATURE: ________ °C

COMMENTS: ______________________________ FAILURES CALLED BY : ______________

____

______________________________ HAND WRITTTEN BY : ______________ LEADER: ______________

ATTACHMENT II

DE/ANTI-ICING DATA FORM FOR COLD SOAK BOX

REMEMBER TO SYNCHRONIZE TIME

VERSION 3.0 1995/96

LOCATION: CEF (Ottawa)	DATE:	RUN NUMBER:	STAND # : am / pm	RVSI SENSOR Series #:

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application (real time): ______ ______ ______ ______ ______

Box Depth :	7.5/2.5			7.5/2.5			7.5/2.5			7.5/2.5			7.5/2.5		
	Box A			Box B			Box C			Box D			Box E		
FLUID NAME															
B1 B2 B3															
C1 C2 C3															
D1 D2 D3															
E1 E2 E3															
F1 F2 F3															
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA															

Time of Fluid Application (real time): ______ ______ ______ ______ ______

Box Depth :	7.5/2.5			7.5/2.5			7.5/2.5			7.5/2.5			7.5/2.5		
	Box F			Box G			Box H			Box I			Box J		
FLUID NAME															
B1 B2 B3															
C1 C2 C3															
D1 D2 D3															
E1 E2 E3															
F1 F2 F3															
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA															

PRECIP: Drizzle , Light Rain, Moderate Rain, Heavy Rain

AMBIENT TEMPERATURE: ______________ °C

COMMENTS: ______________________________

FAILURES CALLED BY : ______________

HAND WRITTTEN BY : ______________ LEADER: ______________

File:g\cm1283\procedur\cs\BFORM2-3.XLS Printed: 07/03/96

ATTACHMENT III

PRECIPITATION RATE MEASUREMENT @ CEF IN OTTAWA

Date: ______________________

Start Time: ______________________ am/pm

Run # : ______________________

Precip Type: ______________________ (FZD, FZR, FZF, S)

Pan Location:

U	UU	V	VV	W	WW
XX	X	YY	Y	ZZ	Z

Collection Pan:

Pan/ Cup #	Area of Pan (dm²)	Location		Weight of Pan (g) Before	Weight of Pan (g) After	Collection Time (min) Start	Collection Time (min) End
		U	=				
		UU	=				
		V	=				
		VV	=				
		W	=				
		WW	=				
		XX	=				
		X	=				
		YY	=				
		Y	=				
		ZZ	=				
		Z	=				

Comments: ______________________

Handwritten by: ______________________

Measured by: ______________________

Precipitation Rate = Δg/area (dm^2)/hr

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Printed:07/03/96

ATTACHMENT IV

COLD SOAK PRECIPITATION RATE MEASUREMENT @ CEF IN OTTAWA

Date: ______________________

Start Time: ______________________ am/pm

Run # : ______________________

Precip Type: ______________________ (Drizzle, Light Rain, Moderate Rain, Heavy Rain)

Pan Location:

A	B	C	D	E
F	G	H	I	J

Collection Pan:

Pan/ Cup #	Area of Pan (dm²)	Location		Weight of Pan (g) Before	After	Collection Time (min) Start	End
		A	=				
		B	=				
		C	=				
		D	=				
		E	=				
		F	=				
		G	=				
		H	=				
		I	=				
		J	=				

Comments: ______________________

Handwritten by: ______________________

Measured by: ______________________

Precipitation Rate = $\Delta g/\text{area } (dm^2)/hr$

File:g:\cm1283\procedur\cef\RATE_BOX.XLS
Printed:07/03/96

ATTACHMENT V

TESTS PLANNED AT CEF 1996 (1)

FREEZING DRIZZLE

Variables:

- *** Temperature:** Above -3 °C, above -10 °C
- *** Fluid Type:** STD T1, DIL T1, II 100, II 75, II 50, IV 100, IV 75, IV 50
- *** Fluid mfg:** 3 different ones (eg. UCAR, OCT, KILF, HOECHST)
- *** Rate of Precipitation:** 4, 7, 11 g/dm²/hr

	NUMBER OF TESTS							
TEMP. (°C)	**Type I DILUTED**	**Type I STD**	**Type II NEAT**	**Type II 75/25**	**Type II 50/50**	**Type IV NEAT**	**Type IV 75/25**	**Type IV 50/50**
Above -3	S	S	S	S	9	9	9	9
Above -10	S	S	S	S	NA	9	9	NA

LIGHT FREEZING RAIN

Variables:

- *** Temperature:** Above -3 °C, above -10 °C
- *** Fluid Type:** STD T1, DIL T1, II 100, II 75, II 50, IV 100, IV 75, IV 50
- *** Fluid mfg:** 3 different ones (eg. UCAR, OCT, KILF, HOECHST)
- *** Rate of Precipitation:** 14, 18, 22 g/dm²/hr

	NUMBER OF TESTS							
TEMP. (°C)	**Type I DILUTED**	**Type I STD**	**Type II NEAT**	**Type II 75/25**	**Type II 50/50**	**Type IV NEAT**	**Type IV 75/25**	**Type IV 50/50**
Above -3	S	S	S	S	9	9	9	9
Above -10	S	S	S	S	NA	9	9	NA

S = Substantiated, no test required

NA = Not Applicable

Shaded cells = Absolutely required

(1) Include some Type II fluids simultaneously with Type IV for comparison and calibration with previous winters.

File:g/cm1283/procedur/cef/TESTS.XLS
Date:07/03/96

ATTACHMENT V (cont'd)

TESTS PLANNED AT CEF 1996 (1)

FREEZING FOG

Variables:

- **Temperature:** Above -3 °C, above -14 °C, above -25 °C, above -30 °C
- **Fluid Type:** STD T1, DIL T1, II 100, II 75, II 50, IV 100, IV 75, IV 50
- **Fluid mfg:** 3 different ones (eg. UCAR, OCT, KILF, HOECHST)
- **Rate of Precipitation:** 2, 5, 8 g/dm^2/hr

	NUMBER OF TESTS							
TEMP. (°C)	**Type I DILUTED**	**Type I STD**	**Type II NEAT**	**Type II 75/25**	**Type II 50/50**	**Type IV NEAT**	**Type IV 75/25**	**Type IV 50/50**
Above -3	S	S	S	S	S	9	9	9
Above -14	S	S	S	S	NA	9	9	NA
Above -25	S	S	S	NA	NA	9	NA	NA
Above -30	9	9	9	NA	NA	9	NA	NA

S = Substantiated, no test required

NA = Not Applicable

Shaded cells = Absolutely required

(1) Include some Type II fluids simultaneously with Type IV for comparison and calibration with previous winters.

File:g/cm1283/procedur/cef/TESTS.XLS
Date:07/03/96

ATTACHMENT V (cont'd)

TESTS PLANNED AT CEF 1996 (1)

COLD SOAKED BOXES

DRIZZLE

Variables:

*** OAT:**	+2 °C
*** Skin Temperature:**	Range from -14 to 0 °C (get 2)
*** Fluid Type:**	STD T1, DIL T1, II 100, II 75, II 50, IV 100, IV 75, IV 50
*** Fluid mfg:**	3 different ones for Type IV, 2 for Type I & II (eg. UCAR, OCT, KILF, HOECHST)
*** Rate of Precipitation:**	Range from 2 to 13 g/dm^2/hr (get 2)
*** Box Size (Height):**	2.5, 7.5 cm.

	NUMBER OF TESTS							
BOX SIZE	**Type I DILUTED**	**Type I STD**	**Type II NEAT**	**Type II 75/25**	**Type II 50/50**	**Type IV NEAT**	**Type IV 75/25**	**Type IV 50/50**
2.5 cm	8	8	8	8	8	12	12	12
7.5 cm	8	8	8	8	8	12	12	12

LIGHT RAIN

Variables:

*** OAT:**	+2 °C
*** Skin Temperature:**	From -14 to 0 °C (get 2)
*** Fluid Type:**	STD T1, DIL T1, II 100, II 75, II 50, IV 100, IV 75, IV 50
*** Fluid mfg:**	3 different ones for Type IV, 2 for Type I & II (eg. UCAR, OCT, KILF, HOECHST)
*** Rate of Precipitation:**	Range from 13 TO 25 g/dm^2/hr (get 2)
*** Box Size (Height):**	2.5, 7.5 cm.

	NUMBER OF TESTS							
BOX SIZE	**Type I DILUTED**	**Type I STD**	**Type II NEAT**	**Type II 75/25**	**Type II 50/50**	**Type IV NEAT**	**Type IV 75/25**	**Type IV 50/50**
2.5 cm	8	8	8	8	8	12	12	12
7.5 cm	8	8	8	8	8	12	12	12

(1) Include some Type II fluids simultaneously with Type IV for comparison and calibration with previous winters.

File:g/cm1283/procedur/cef/TESTS.XLS
Date:07/03/96

ATTACHMENT V (cont'd)

TESTS PLANNED AT CEF 1996 [1]
COLD SOAKED BOXES

MODERATE RAIN

Variables:

* **OAT:**	+2 °C
* **Skin Temperature:**	From -14 to 0 °C (get 2)
* **Fluid Type:**	STD T1, DIL T1, II 100, II 75, II 50, IV 100, IV 75, IV 50
* **Fluid mfg:**	3 different ones for Type IV, 2 for Type I & II (eg. UCAR, OCT, KILF, HOECHST)
* **Rate of Precipitation:**	Range from 26 to 75 g/dm^2/hr (get 2)
* **Box Size (Height):**	2.5, 7.5 cm.

	NUMBER OF TESTS							
BOX SIZE	**Type I DILUTED**	**Type I STD**	**Type II NEAT**	**Type II 75/25**	**Type II 50/50**	**Type IV NEAT**	**Type IV 75/25**	**Type IV 50/50**
2.5 cm	8	8	8	8	8	12	12	12
7.5 cm	8	8	8	8	8	12	12	12

HEAVY RAIN *

Variables:

* **OAT:**	+2 °C
* **Skin Temperature:**	From -14 to 0 °C (get 1)
* **Fluid Type:**	STD T1, DIL T1, II 100, II 75, II 50, IV 100, IV 75, IV 50
* **Fluid mfg:**	1 different one (eg. UCAR, OCT, KILF, HOECHST)
* **Rate of Precipitation:**	>75 g/dm^2/hr
* **Box Size (Height):**	2.5, 7.5 cm.

	NUMBER OF TESTS							
BOX SIZE	**Type I DILUTED**	**Type I STD**	**Type II NEAT**	**Type II 75/25**	**Type II 50/50**	**Type IV NEAT**	**Type IV 75/25**	**Type IV 50/50**
2.5 cm	1	1	1	1	1	1	1	1
7.5 cm	1	1	1	1	1	1	1	1

* It is anticipated that the fluids will not freeze under this condition.

(1) Include some Type II fluids simultaneously with Type IV for comparison and calibration with previous winters.

File:g/cm1283/procedur/cef/TESTS.XLS
Date:07/03/96

ATTACHMENT Va

FLUID APPLICATION PROCEDURE FOR TESTING OF TYPE IV OVER TYPE I

PRELIMINARY

CODE A	CODE B	CODE C *	CODE D
t=0 Squeegee t=0 Apply XL54 from Jug			t=0 Squeegee
t_f=10 Apply Ultra from Jug on Contaminated Type I	t_f=10 Squeege t_f=10 Apply XL54 from Jug t_f=10 Apply Ultra from Jug on Type I	t_f=10 Squeege t_f=10 Apply Ultra from Jug on bare Plate	t_f=10 Apply Ultra from Jug on contaminated Plate

CODE E	CODE F	CODE G	CODE H
t=0 Squeegee t=0 Apply XL54 from Jug			t=0 Squeegee
t_f=10 Spray Ultra on Contaminated Type I	t_f=10 Squeege t_f=10 Apply XL54 from Jug t_f=10 Spray Ultra on Type I	t_f=10 Squeege t_f=10 Spray Ultra on bare plate	t_f=10 Spray Ultra on contaminated Plate

NOTES:

* This test procedure is exactly the same as the standard flat plate test procedure.

** It is assumed above that the failure time of XL54 will be at 10 minutes.

*** When applying Type IV from the jug, use 1.5 Litre in all cases.

**** When using garden sprayer, spray for 1 minute.

File:g\cm1283\procedur\cef\FLDAP4_1.XLS
Date:07/03/96

ATTACHMENT VI

CEF DETAILED TEST PLAN (SAMPLE)

FREEZING DRIZZLE AND LIGHT FREEZING RAIN

RUN # : 1 DAY : 1

TEMP. : -3 °C TTC : 300 min

PRECIP. : ZD

O / IV /100	O / II / 100 O / IV / 75 O / IV / 50 **U / I / STD**	K / IV / 100	K / IV / 75 K / II / 75 K / IV / 50	U / IV / 100	U / IV / 75 U / IV / 50 K / II / 50
O / IV /100	O / II / 100 O / IV / 75 O / IV / 50 **U / I / DIL**	K / IV / 100	K / IV / 75 K / II / 75 K / IV / 50	U / IV / 100	U / IV / 75 U / IV / 50 K / II / 50

RUN # : 2 DAY : 2

TEMP. : -3 °C TTC : 150 min

PRECIP. : ZD

H / IV /100 H / II / 50	H / II / 100 H / IV / 75 H / IV / 50 **H / I / STD**	U+ / IV / 100	U+ / IV / 75 O / II / 50 U+ / IV / 50	S / IV / 100 (460	S / IV / 75 (460) S / IV / 50 (460) S / II / 50
H / IV /100 H / II / 50	H / II / 100 H / IV / 75 H / IV / 50 **H / I / DIL**	U+ / IV / 100	U+ / IV / 75 O / II / 50 U+ / IV / 50	S / IV / 100 (404 S / II / 50	S / IV / 75 (404) S / IV / 50 (404) S / II / 50

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ATTACHEMENT VIa

TYPE IV NEAT OVER TYPE I TESTS

TEST PLAN

RUN #	TEST #	PLATE	FLUID	PRECIP**	TEMP °C	TEST CODE	APPLICATION
1	1	U	ULT+ ON CONTAM PLT	LFZR	-3	D	CONTAINER 1.5 LITRES
1	2	UU	***ULT+ ON BARE***	LFZR	-3	G	SPRAYER 1 MIN
1	3	V	ULT+ ON CONTAM TI	LFZR	-3	A	CONTAINER 1.5 LITRES
1	4	VV	ULT+ ON BARE (STD)	LFZR	-3	C	CONTAINER 1.5 LITRES
1	5	W	ULT+ ON TI	LFZR	-3	B	CONTAINER 1.5 LITRES
1	6	WW	RATE	LFZR	-3	RATE *	
1	7	XX	KILF. ON CONTAM PLT	LFZR	-3	D	CONTAINER 1.5 LITRES
1	8	X	***ULT+ ON TI***	LFZR	-3	F	SPRAYER 1 MIN
1	9	YY	KILF. ON CONTAM TI	LFZR	-3	A	CONTAINER 1.5 LITRES
1	10	Y	KILF. ON BARE (STD)	LFZR	-3	C	CONTAINER 1.5 LITRES
1	11	ZZ	KILF. ON TI	LFZR	-3	B	CONTAINER 1.5 LITRES
1	12	Z	RATE	LFZR	-3	RATE *	
2	13	U	***ULT+ ON CONTAM TI***	LFZR	-3	E	SPRAYER 1 MIN
2	14	UU	***ULT+ ON BARE***	LFZR	-3	G	SPRAYER 1 MIN
2	15	V	ULT+ ON CONTAM TI	LFZR	-3	A	CONTAINER 1.5 LITRES
2	16	VV	ULT+ ON BARE (STD)	LFZR	-3	C	CONTAINER 1.5 LITRES
2	17	W	ULT+ ON TI	LFZR	-3	B	CONTAINER 1.5 LITRES
2	18	WW	RATE	LFZR	-3	RATE	
2	19	XX	***ULT+ ON CONTAM PLT***	LFZR	-3	H	SPRAYER 1 MIN
2	20	X	***ULT+ ON TI***	LFZR	-3	F	SPRAYER 1 MIN
2	21	YY	KILF. ON CONTAM TI	LFZR	-3	A	CONTAINER 1.5 LITRES
2	22	Y	KILF. ON BARE (STD)	LFZR	-3	C	CONTAINER 1.5 LITRES
2	23	ZZ	KILF. ON TI	LFZR	-3	B	CONTAINER 1.5 LITRES
2	24	Z	RATE	LFZR	-3	RATE	
3	25	U	***KILF. ON CONTAM TI***	LFZR	-3	E	SPRAYER 1 MIN
3	26	UU	***KILF. ON BARE***	LFZR	-3	G	SPRAYER 1 MIN
3	27	V	ULT+ ON TI	LFZR	-3	B	CONTAINER 1.5 LITRES
3	28	VV	ULT+ ON BARE (STD)	LFZR	-3	C	CONTAINER 1.5 LITRES
3	29	W	ULT+ ON CONTAM TI	LFZR	-3	A	CONTAINER 1.5 LITRES
3	30	WW	RATE	LFZR	-3	RATE	
3	31	XX	***KILF. ON CONTAM PLT***	LFZR	-3	H	SPRAYER 1 MIN
3	32	X	***KILF. ON TI***	LFZR	-3	F	SPRAYER 1 MIN
3	33	YY	KILF. ON TI	LFZR	-3	B	CONTAINER 1.5 LITRES
3	34	Y	KILF. ON BARE (STD)	LFZR	-3	C	CONTAINER 1.5 LITRES
3	35	ZZ	KILF. ON CONTAM TI	LFZR	-3	A	CONTAINER 1.5 LITRES
3	36	Z	RATE	LFZR	-3	RATE	

* Rates measured every 15 minutes in addition to before and after entire run

** FZD test plan to follow

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Printed:31/10/96

ATTACHMENT VIa

FLUID APPLICATION PROCEDURE FOR TESTING OF TYPE IV OVER TYPE I

TEST 1 to 12

PLATE U	PLATE UU	PLATE V	PLATEVV*	PLATE W	PLATE WW
t=0 Squeegee		t=0 Squeegee t=0 Apply XL54 from Jug			
t_f=10 Apply Ultra from Jug on contaminated Plate	t_f=10 Squeege t_f=10 Spray Ultra on bare plate	t_f=10 Apply Ultra from Jug on Contaminated Type I	t_f=10 Squeege t_f=10 Apply Ultra from Jug on bare Plate	t_f=10 Squeege t_f=10 Apply XL54 from Jug t_f=10 Apply Ultra from Jug on Type I	

PLATE XX	PLATE X	PLATE YY	PLATE Y*	PLATE ZZ	PLATE Z
t=0 Squeegee		t=0 Squeegee t=0 Apply Kilfrost Type I from Jug			
t_f=10 Apply Kilfrost from Jug on contaminated Plate	t_f=10 Squeege t_f=10 Apply XL54 from Jug t_f=10 Spray Ultra on Type I	t_f=10 Apply Kilfrost Type IV from Jug on contaminated Type I	t_f=10 Squeege t_f=10 Apply Kilfrost from Jug on bare Plate	t_f=10 Squeege t_f=10 Apply Kilfrost Type I from Jug t_f=10 Apply Kilfrost Type IV from Jug on Type 1	

NOTES:

* This test procedure is exactly the same as the standard flat plate test procedure.

i) It is assumed above that the failure time of the Type I which fails last is 10 minutes. At this time apply Type IV.

ii) When applying Type IV from the jug, use 1.5 Litre in all cases.

iii) When using garden sprayer, spray for 1 minute.

File:g\cm1283\procedur\cef\ATTACH6A.XLS
RUN 1
Date:31/10/96

ATTACHMENT VIa

FLUID APPLICATION PROCEDURE FOR TESTING OF TYPE IV OVER TYPE I

TEST 13 to 24

PLATE U	t=0 Squeegee t=0 Apply XL54 from Jug	t_f=10 Spray Ultra on Contaminated Type I
PLATE UU		t_f=10 Squeege t_f=10 Spray Ultra on bare plate
PLATE V	t=0 Squeegee t=0 Apply XL54 from Jug	t_f=10 Apply Ultra from Jug on Contaminated Type I
PLATEVV*		t_f=10 Squeege t_f=10 Apply Ultra from Jug on bare Plate
PLATE W		t_f=10 Squeege t_f=10 Apply XL54 from Jug t_f=10 Apply Ultra from Jug on Type I
PLATE WW		
PLATE XX	t=0 Squeegee	t_f=10 Spray Ultra on contaminated Plate
PLATE X		t_f=10 Squeege t_f=10 Apply XL54 from Jug t_f=10 Spray Ultra on Type I
PLATE YY	t=0 Squeegee t=0 Apply Kilfrost Type I from Jug	t_f=10 Apply Kilfrost Type IV from Jug on contaminated Type I
PLATE Y*		t_f=10 Squeege t_f=10 Apply Kilfrost from Jug on bare Plate
PLATE ZZ		t_f=10 Squeege t_f=10 Apply Kilfrost Type I from Jug t_f=10 Apply Kilfrost Type IV from Jug on Type I
PLATE Z		

NOTES:

* This test procedure is exactly the same as the standard flat plate test procedure.

i) It is assumed above that the failure time of the Type I which fails last is 10 minutes. At this time apply Type IV.

ii) When applying Type IV from the jug, use 1.5 Litre in all cases.

iii) When using garden sprayer, spray for 1 minute.

File:g\cm1283\procedur\cef\ATTACH6A.XLS
RUN 2
Date:31/10/96

ATTACHMENT VII

NRC COLD CHAMBER TESTS

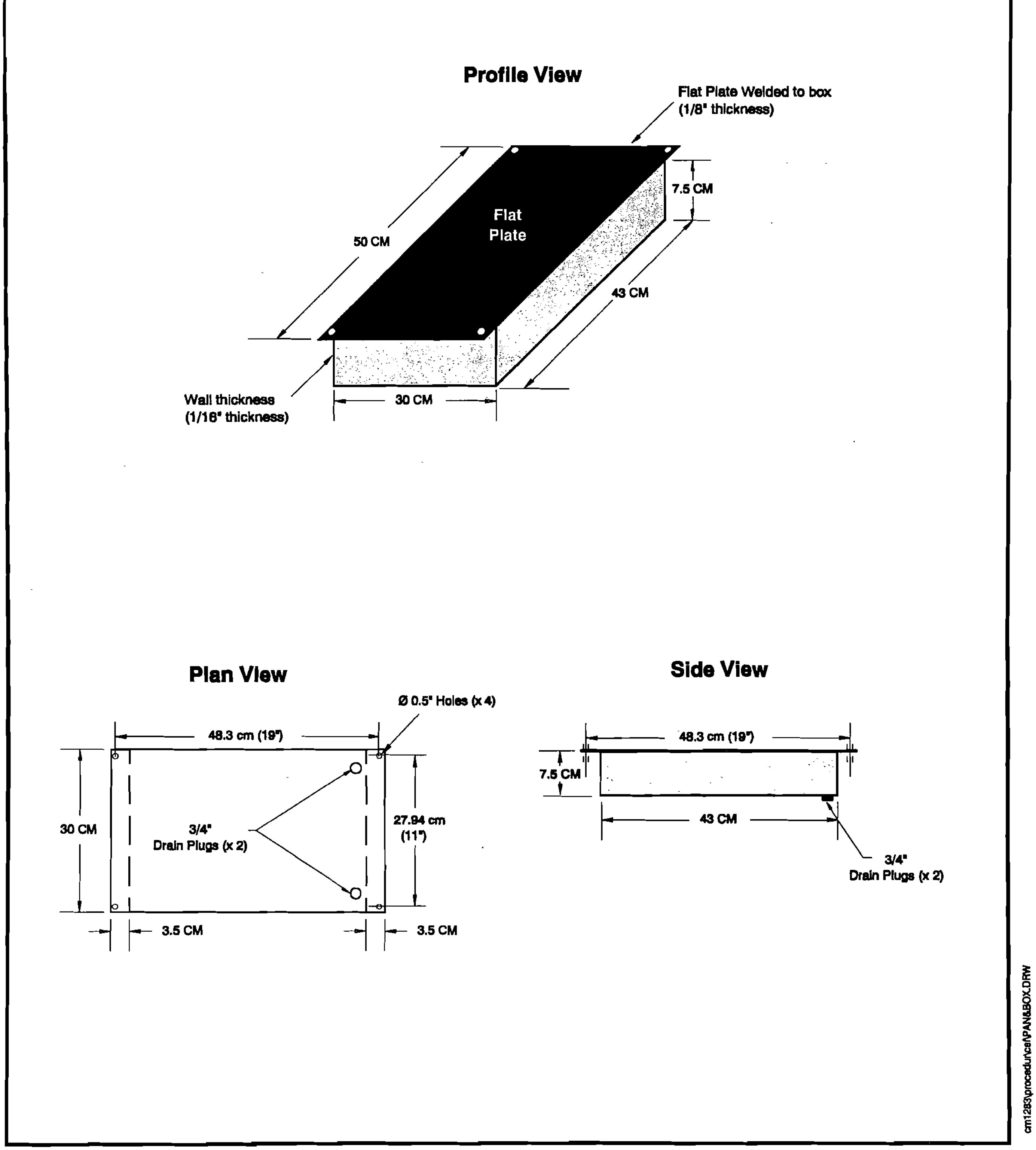
TEST EQUIPMENT CHECKLIST

TASK	*NRC Cold Chamber*	
	Resp.	**Status**
Logistics for Every Test		
Make Hotel reservations		
Rent Van/Car		
Call Site Personnel		
Call RVSI Personnel		
Test Equipment		
Stand x 1		
C/FIMS Equipment x 2		
Still Photo Camera		
Tape Recorder with Mic.(voice)		
Weigh Scale		
Stand Video Camera		
VCR for Video Camera		
T.V. for Video Camera		
Pole for Video Camera		
Video Camera X 1 (Surf & Snow) + Access		
Reg. Plates (wing nuts) X 12+12		
Data Forms for plates and cold-soaked boxes		
Precipitation rate Data Forms		
Reports + Tables		
Cake Pans x 12		
Video Tapes		
Type I Fluids		
Type II Fluids, Type IV Fluids		
Clipboards x 3		
Pencils + Space pens x 4		
Paper Towels		
Rubber squeegees		
Plastic Refills for Fluids and funnels		
Electrical Extension Cords		
Lighting x 2		
Tools		
Box Plate Model x 12		
Cooling Unit for Box Coolant		
Coolant Fluid		
Insulation Jacket for Cold-Soaked Box x 12		
Stop watches x 3		
Storage bins for small equipment		
Thermistor Probes x 10 (P.Dawson's unit)		
Putty for Thernistors		
Protective clothing		
Refractometer		
Tie wraps		
Tags (Labels) for Fluid designation on stand		
Sprayer		
2.0 Litre Containers		
Sampling Data Forms for refractometer		

File:g:\cm1283\procedur\cef\CHKLS_CC.XLS
Printed:31/10/96

SCHEMATICS OF SEALED BOX
DEPTH OF 7.5 CM

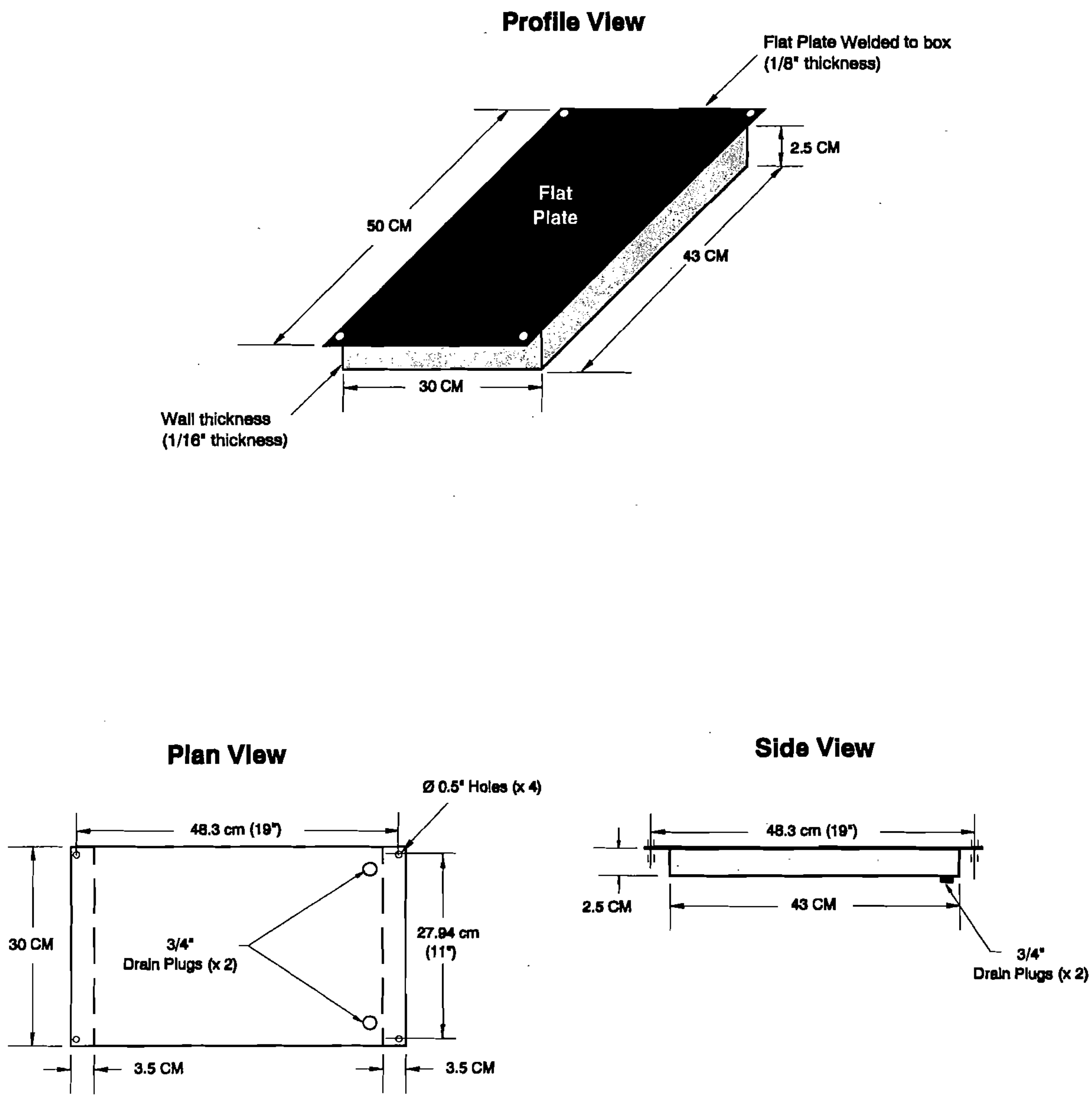
SEALED BOX



ATTACHMENT VIII (cont'd)

SCHEMATICS OF SEALED BOX
DEPTH OF 2.5 CM

SEALED BOX



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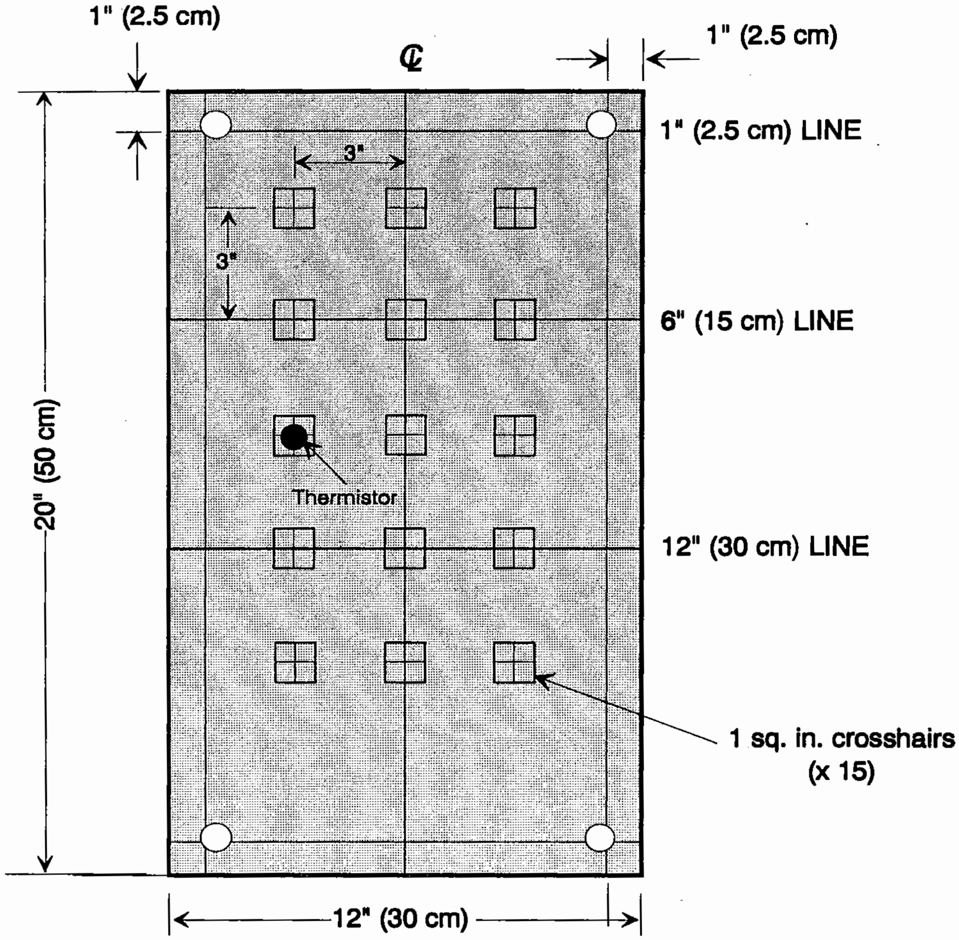
ATTACHMENT IX

THERMISTOR MOUNTING PROCEDURE
TYPICAL BOX



- Ensure that there are ten operational thermistors (one for each box). Each thermistor must have a clear marking relating it to the boxes (A to J) and the data logger software.
- Mount thermistors on crosshair C1 of the 9" line immediately before pouring fluid and after failure of the box is declared failed.
- Prior to mounting the thermistor, warm it up with you finger. This will provide an indication (marker) on the data logger that this sensor is being activated.
- Keep the thermistor on the plate for about 15 seconds before pouring at least three minutes after failure.

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APPENDIX D

SAMPLE OF READAC INFORMATION

APPENDIX D

LEGEND OF READAC INFORMATION

YUL 020200 11SCT22OVC58OVC/9.+/C/M/-12.0/-20.9/26110G20/037//21010/42 9+/10255/-132-120/27011G020264241//3596-1/

-1	PCPN totale dans la dernière heure (0.1 mm)
3596	Quantité PCPN dans la collecteur (359.6 mm)
//	Données de verglas (intmt Z/./Z intmt/,/Z/ ou rien)
1	Unités de la moyenne de vent de deux minutes
26424	Direction et vitesse du plus haut vent de la dernière heure
G020	Rafale durant les 10 dernières minutes
27011	Direction et vitesse des vents (Moyenne 10 minutes)
-132 -120	Température Min et Max de la dernière heure
10255	Pression de la station (1025.5 mb)
42 9+	Visibilté Min et Max des 10 dernières minutes
21010	Opacité cumulative pour chaque couche de nuages (20% pour la première couche) (100% pour les deux premières couches) (100% pour les trois premières couches)
037	Calage Altimétrique (30.37)
26110G20	Direction et vitesse des vents (Moyenne de 2 minutes)
-20.9	Point de Rosée
-12.0	Température
M	Pression MSL (Toujours manquant)
C	PCPN détectée par la POSS (Type (Valeurs possibles: C,L,R,S,A et P) + intensité)
9.+	Visibilité
11SCT22OVC58OVC	Couches de Nuages
020200	Date et heure d'observation
YUL	Identification

File:g:\cm1222\data\readac\WEATHER.XLS

APPENDIX D

SAMPLE OF READAC INFORMATION

RA/ZUL/SA/062137/AUTO/19OVC/9.+/S-/M/-3.8/-9.2/18403/979//10/509+/10047/-43-37/19004G00000000//3864-0/

RA/ZUL/SA/062138/AUTO/19OVC/9.+/S-/M/-3.7/-9.1/18503/979//10/809+/10047/-43-37/19004G00000000//3864-0/

RA/ZUL/SA/062139/AUTO/19OVC/9.+/S-/M/-3.8/-9.1/18503/979//10/709+/10047/-43-37/19004G00000000//3864-0/

RA/ZUL/SA/062141/AUTO/19OVC/9.+/S-/M/-3.8/-9.2/19303/979//10/709+/10047/-43-37/19004G00000000//3864-0/

RA/ZUL/SA/062142/AUTO/19OVC36OVC/9.+/S-/M/-3.8/-9.1/20002/979//1010/609+/10047/-43-37/19004G00000000//
O

RA/ZUL/SP/062143/AUTO/19OVC37OVC/9.+/S--/M/-3.7/-9.1/20502/980//1010/609+/10048/-43-37/19003G00000000/
g

RA/ZUL/SA/062144/AUTO/19OVC/9.+/S--/M/-3.8/-9.0/00000/980//10/609+/10048/-42-37/19003G00000000//3863-0/
5

RA/ZUL/SA/062145/AUTO/19OVC/9.+/S--/M/-3.7/-9.0/00000/980//10/609+/10048/-42-37/19002G00000000//3865-0/

RA/ZUL/SA/062146/AUTO/19OVC/9.0/S--/M/-3.7/-8.8/00000/980//10/609+/10048/-42-37/19002G00000000//3863-0/

RA/ZUL/SP/062147/AUTO/19OVC/9.0/S-/M/-3.7/-8.8/22002/980//10/509+/10049/-42-37/20002G00000000//3865-0/

RA/ZUL/SA/062149/AUTO/20OVC/9.0/S-/M/-3.6/-8.9/22003/980//10/509+/10050/-42-36/21002G00000000//3865-0/

RA/ZUL/SA/062150/AUTO/20OVC/9.0/S-/M/-3.6/-8.8/22503/980//10/509+/10050/-41-36/22002G00000000//3863-0/

RA/ZUL/SA/062152/AUTO/20OVC/8.0/S-/M/-3.6/-8.9/22104/980//10/409+/10051/-41-36/22002G00000000//3863-0/

RA/ZUL/SA/062153/AUTO/21OVC/8.0/S-/M/-3.5/-8.9/22003/980//10/409+/10051/-41-35/22002G00000000//3865-0/

RA/ZUL/SA/062154/AUTO/20OVC/8.0/S-/M/-3.5/-8.8/22904/981//10/409+/10051/-40-35/22003G00000000//3863-0/

RA/ZUL/SA/062156/AUTO/20OVC/8.0/S-/M/-3.6/-8.8/24304/981//10/409+/10051/-40-35/23003G00000000//3863-0/

RA/ZUL/SA/062159/AUTO/17OVC/5.0/S-/M/-3.6/-8.8/23904/980//10/159+/10051/-39-35/23004G00000000//3864-0/

RA/ZUL/SA/062200/AUTO/17OVC/5.0/S-/M/-3.6/-8.8/24804/981//10/159+/10051/-39-35/24004G00000000//3864-0/

RA/ZUL/SA/062201/AUTO/11SCT17OVC/4.0/S-/M/-3.6/-8.9/24804/981//010/159+/10052/-39-35/24004G00000000//3
p

RA/ZUL/SA/062202/AUTO/11SCT17OVC/3.5/S-/M/-3.7/-8.9/25004/981//110/159+/10052/-39-35/24004G00000000//3

RA/ZUL/SP/062203/AUTO/11OVC/2.9V/S-/M/-3.7/-8.8/24704/981//10/15V9+/10052/-39-35/24004G00000000//3864-0

RA/ZUL/SA/062204/AUTO/11OVC/2.7V/S-/M/-3.7/-8.7/24705/981//10/15V9+/10053/-39-35/25004G00000000//3864-

RA/ZUL/SA/062205/AUTO/11OVC/2.5V/S-/M/-3.7/-8.7/25006/981//10/15V80/10053/-39-35/25005G00000000//3864-0

APPENDIX E

TYPE II AND TYPE I FLAT PLATE TEST DATA

TYPE II AND TYPE I FLAT PLATE TEST DATA

The following figures are provided in Appendix E. These data were collected as part of the 1995/96 winter testing season, and is not described in detail in Section 5 of this report. The data are illustrated here in the event that it is required in the future.

FIGURE E.1

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II NEAT

NATURAL SNOW CONDITIONS

1995 - 1996

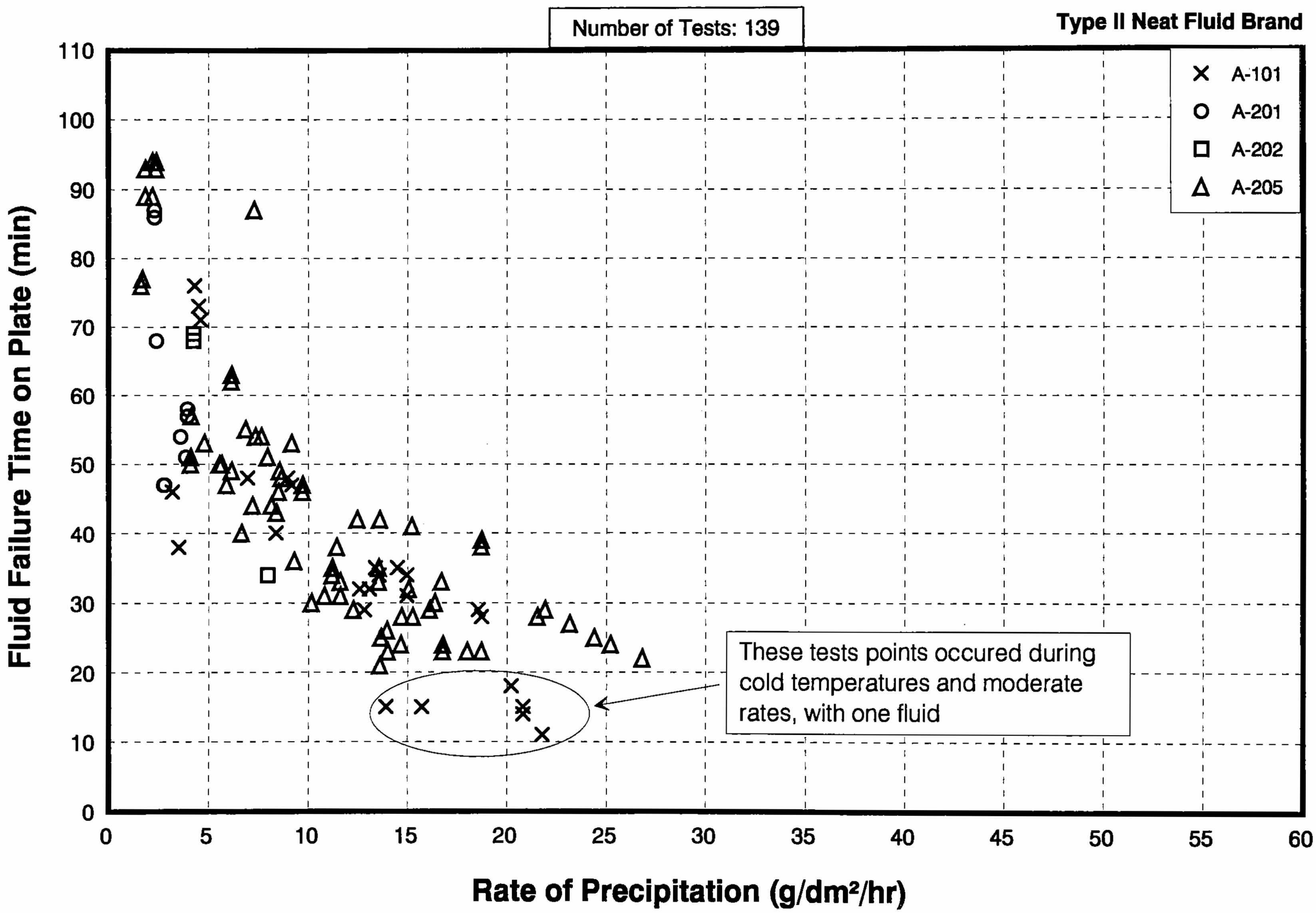

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FIGURE E.2

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II NEAT

NATURAL SNOW CONDITIONS

1995 - 1996

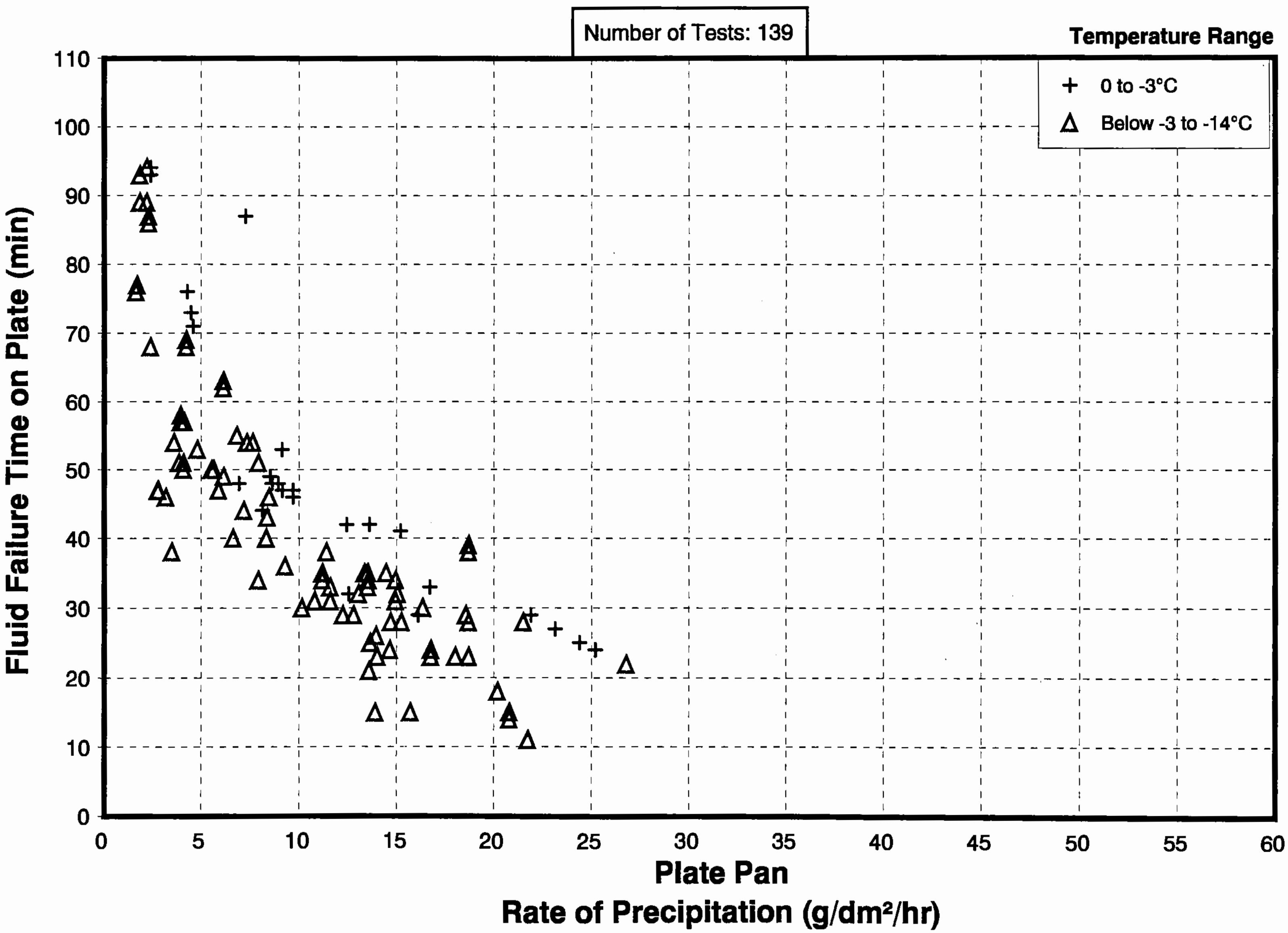

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FIGURE E.3

EFFECT OF WIND SPEED AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II NEAT

NATURAL SNOW CONDITIONS

1995 - 1996

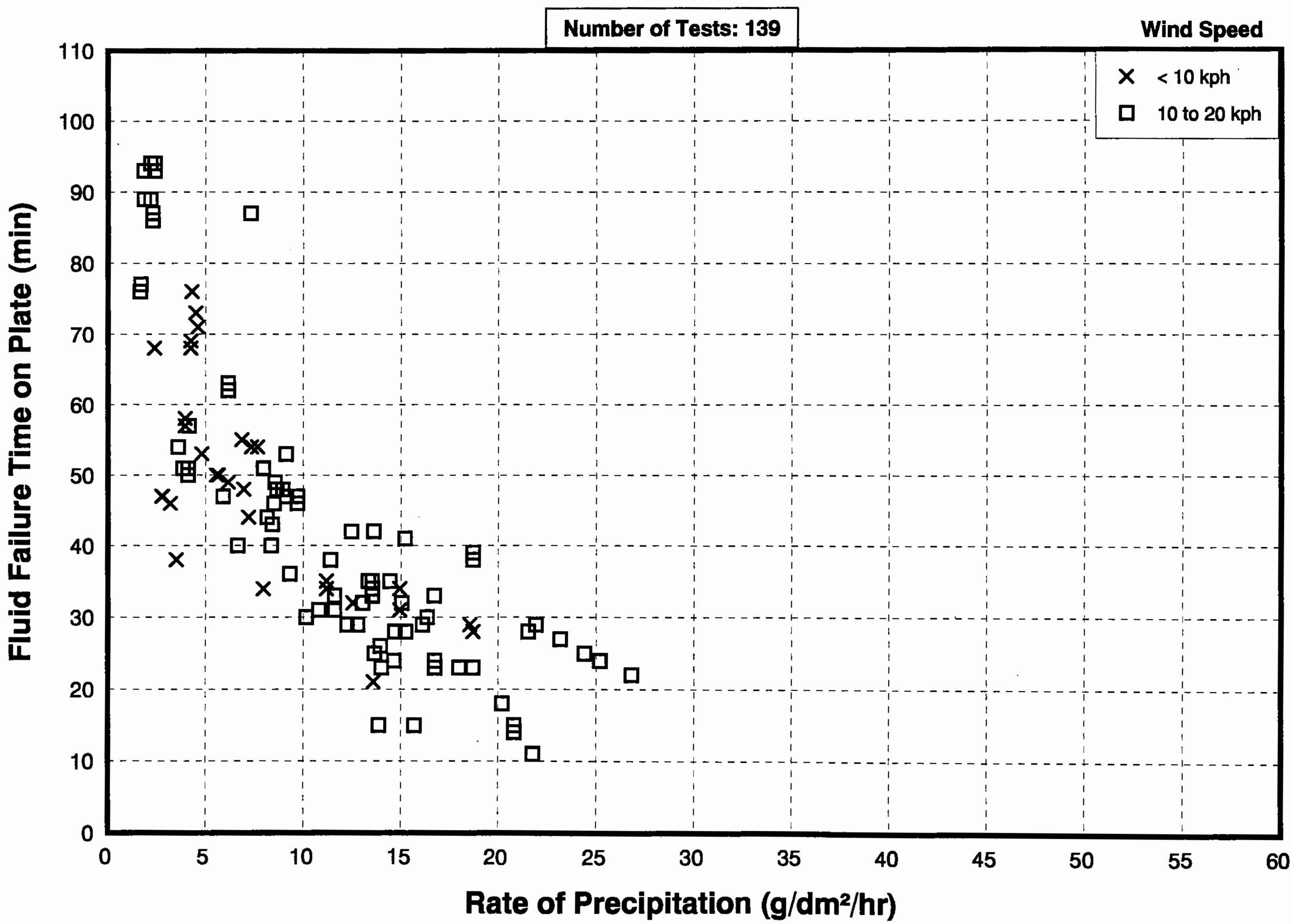

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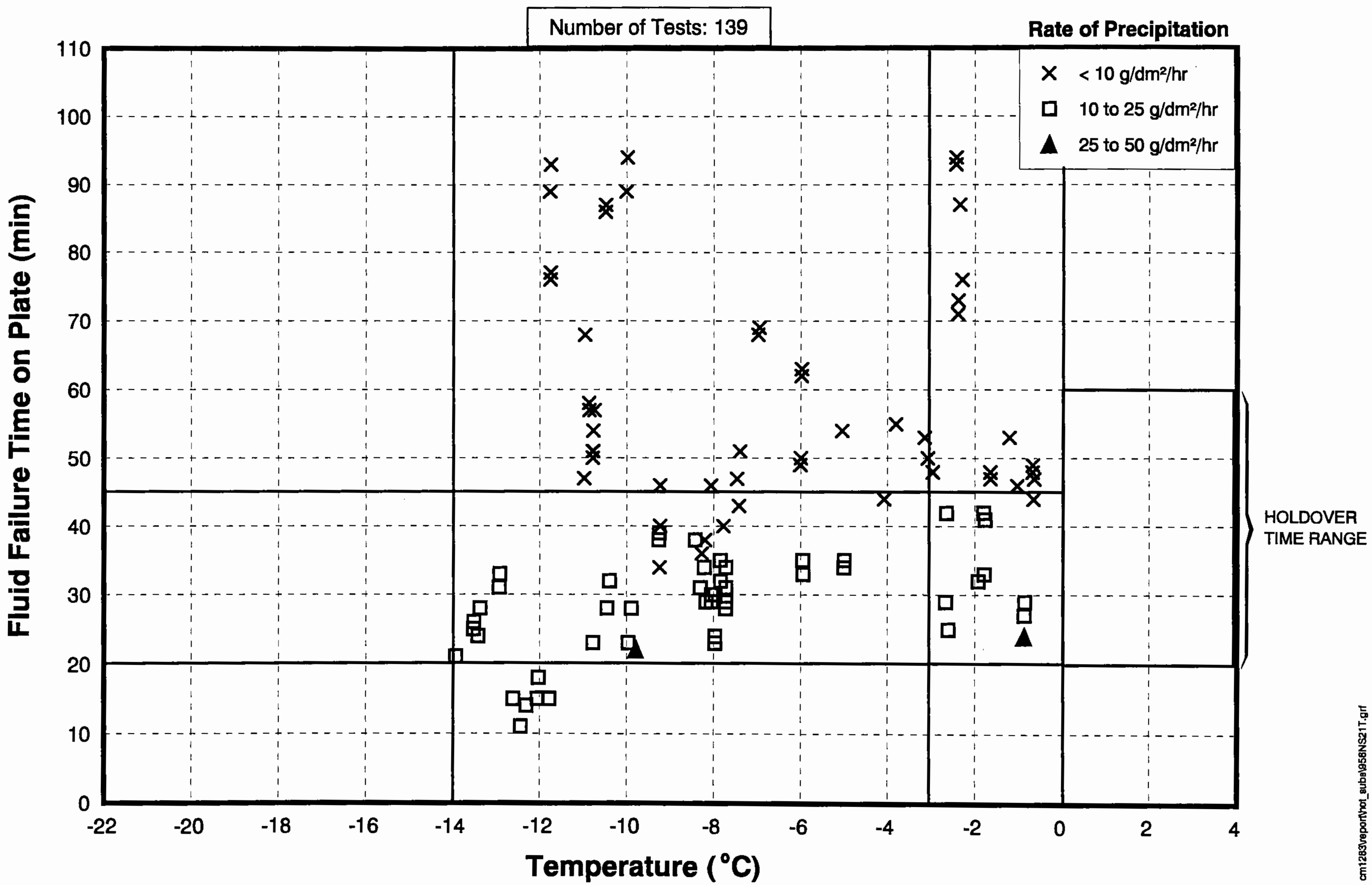
FIGURE E.4

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

TYPE II NEAT

NATURAL SNOW CONDITIONS

1995 - 1996



cm1283\report\hot_sube\958NS21T.grf

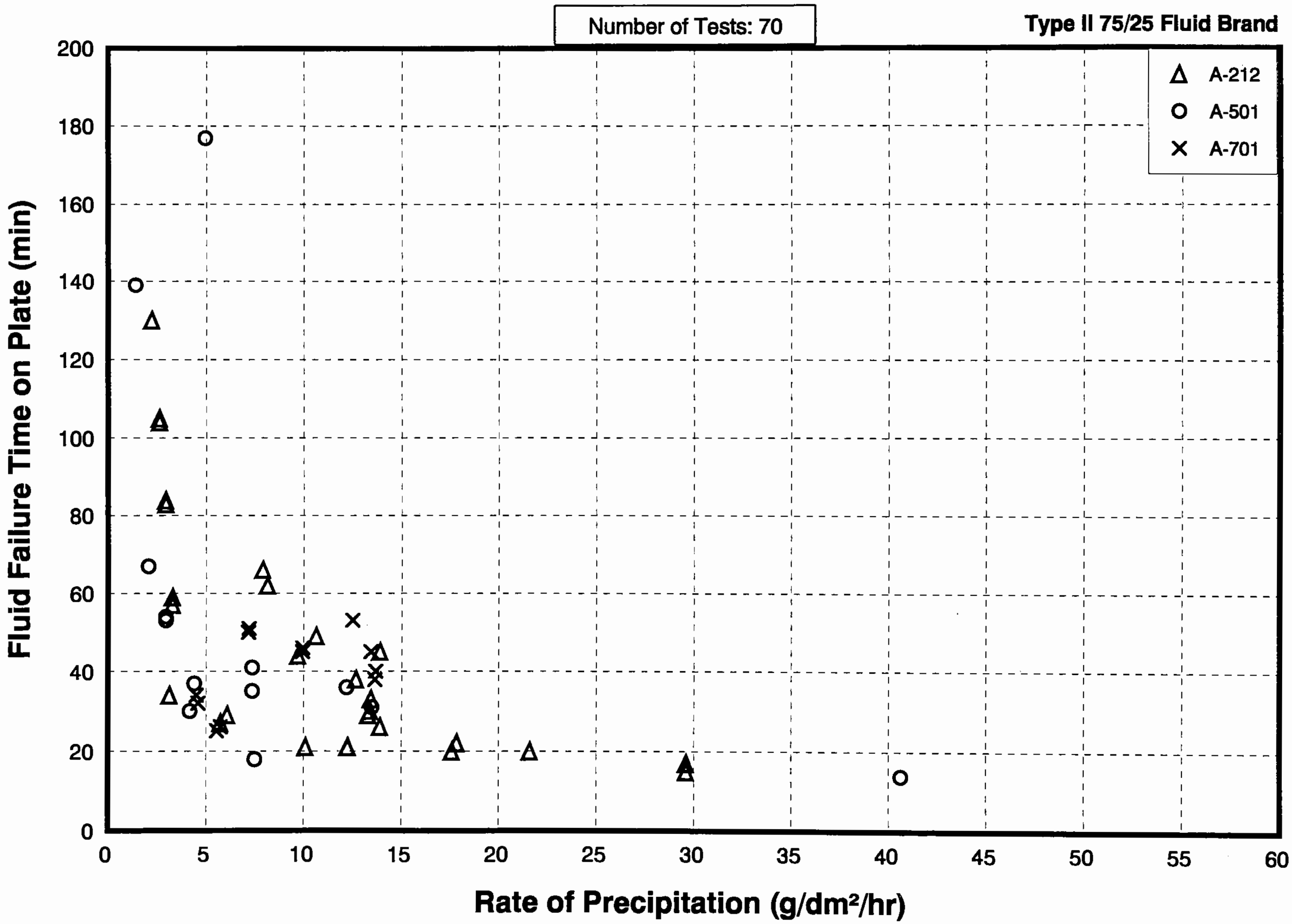
FIGURE E.5

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 75/25

NATURAL SNOW CONDITIONS

1995 - 1996



cm1283\report\pt_sub\958NS27R.GRF

FIGURE E.6

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 75/25

NATURAL SNOW CONDITIONS

1995 - 1996

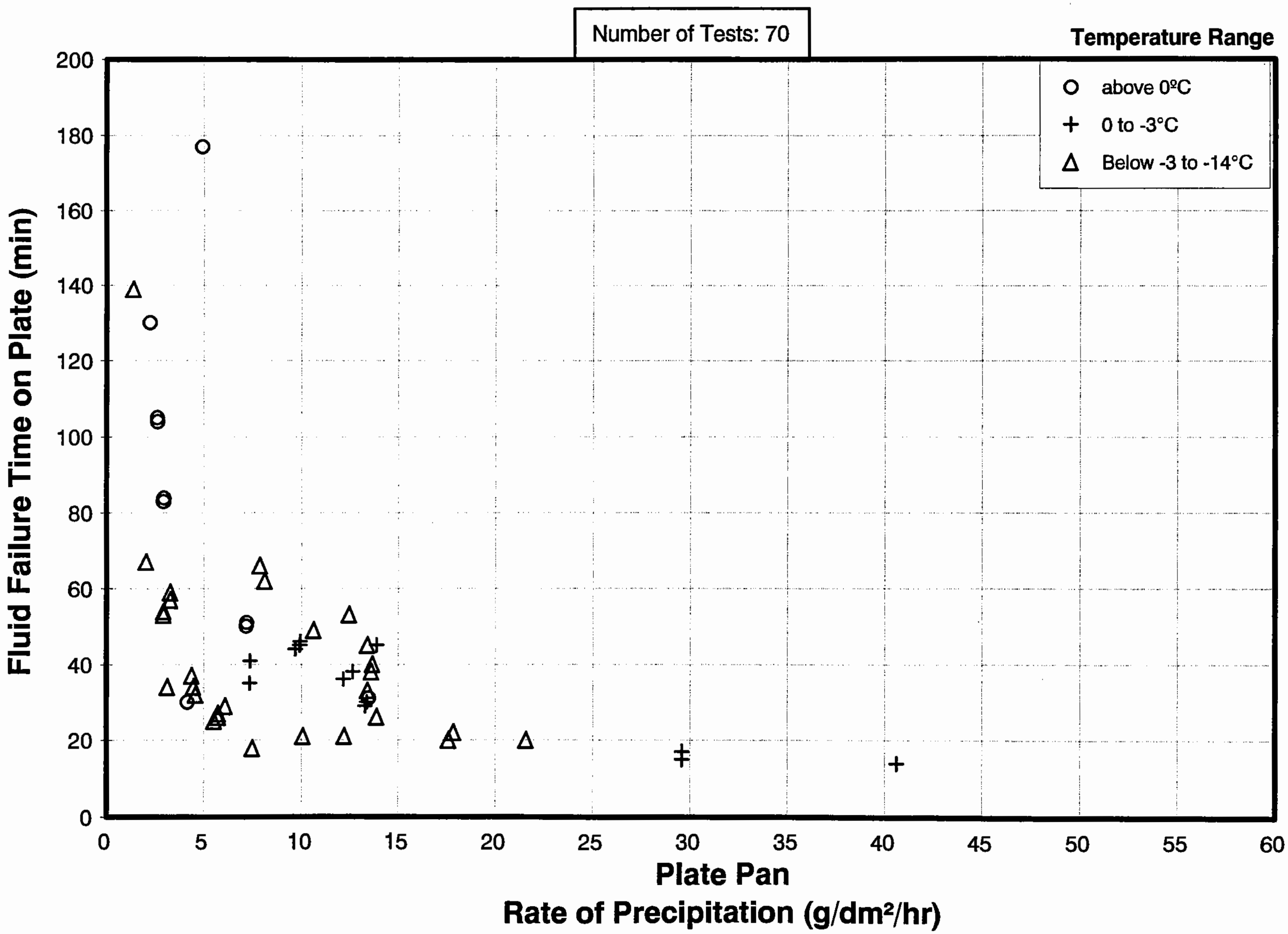


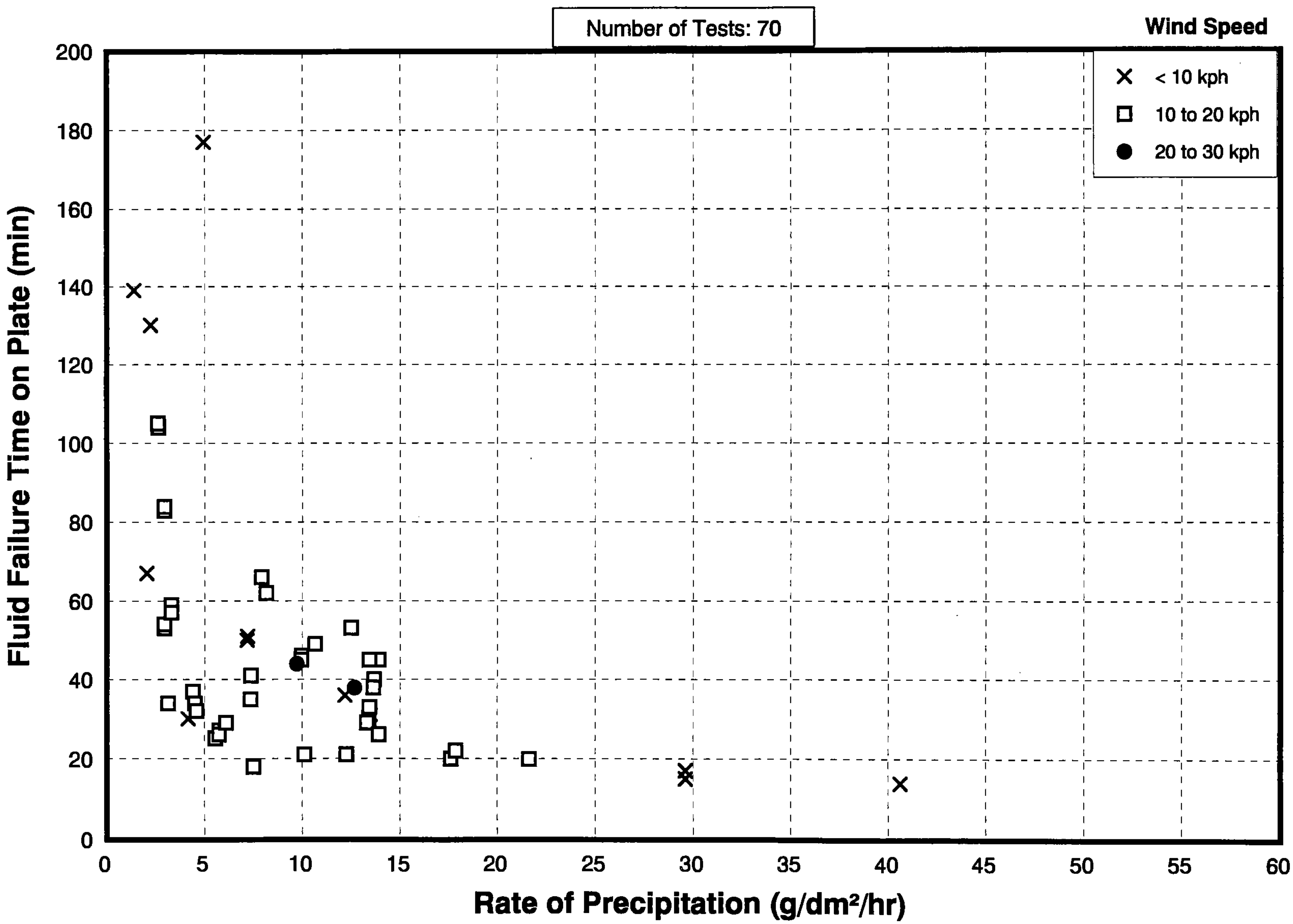
FIGURE E.7

EFFECT OF WIND SPEED AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 75/25

NATURAL SNOW CONDITIONS

1995 - 1996



cm1283\report\rot_subs\958NS27W.GRF

FIGURE E.8

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

TYPE II 75/25

NATURAL SNOW CONDITIONS

1995 - 1996

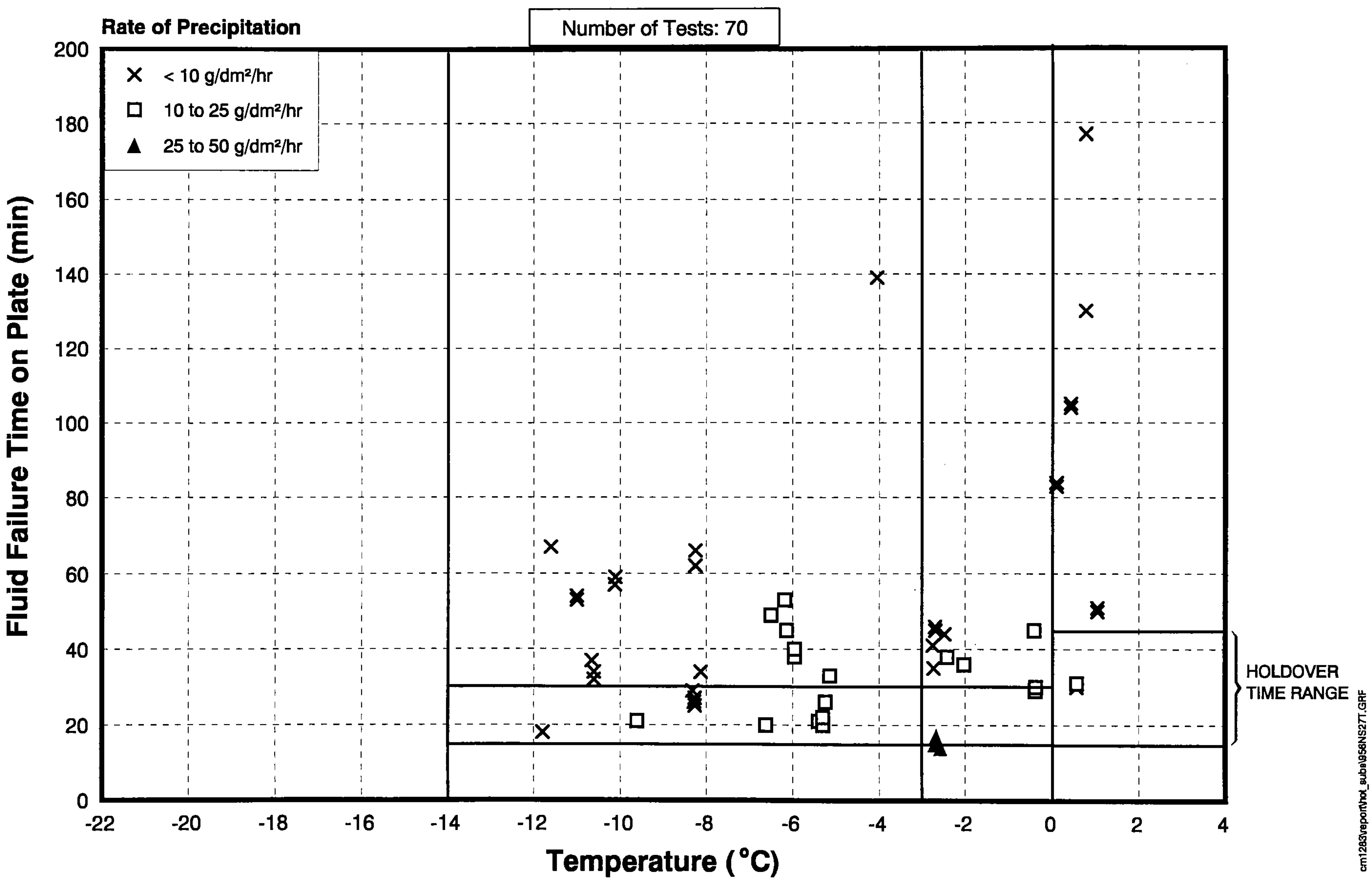


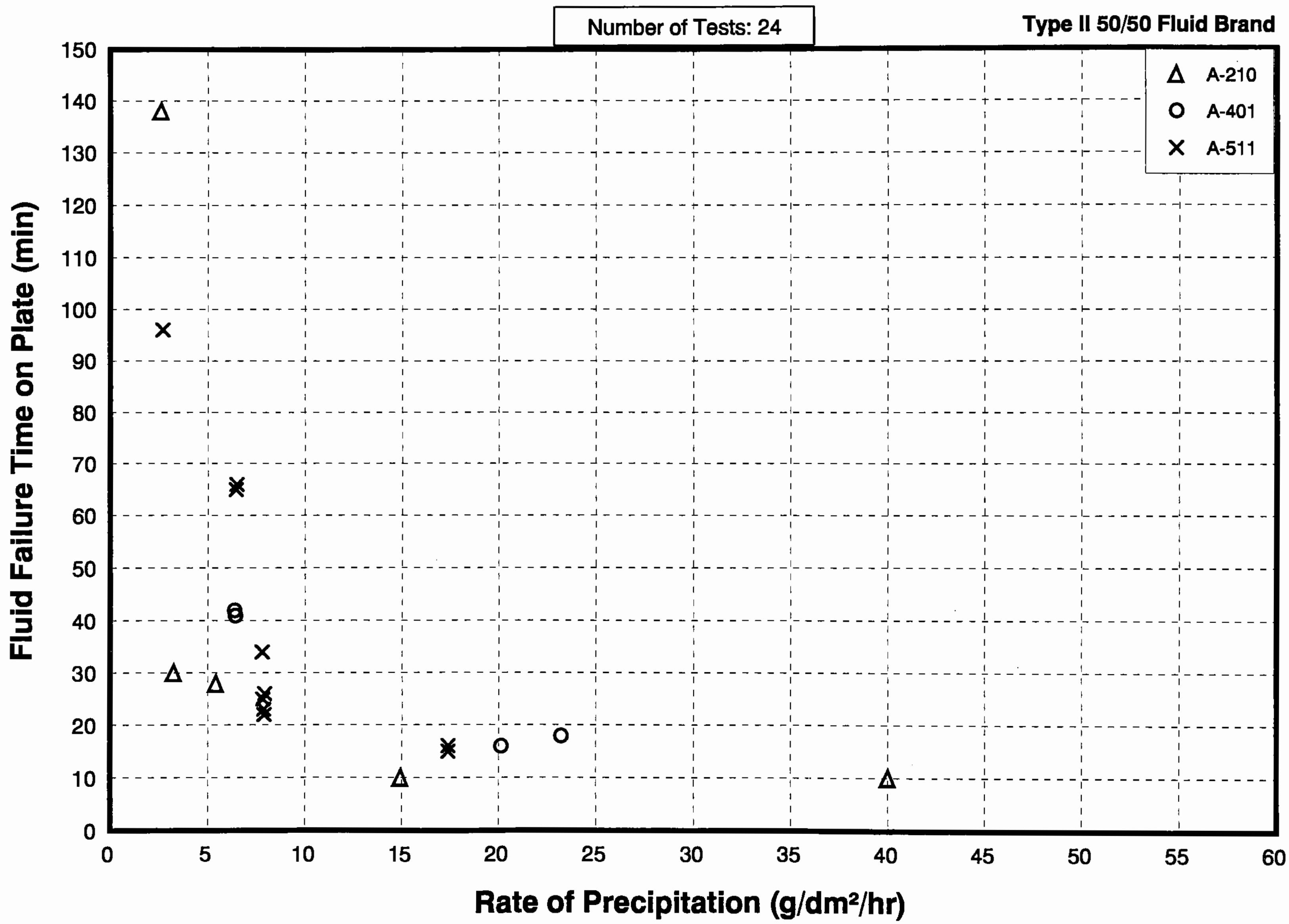
FIGURE E.9

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 50/50

NATURAL SNOW CONDITIONS

1995 - 1996



cm1283\report\rpt_subs\958NS25R.GRF

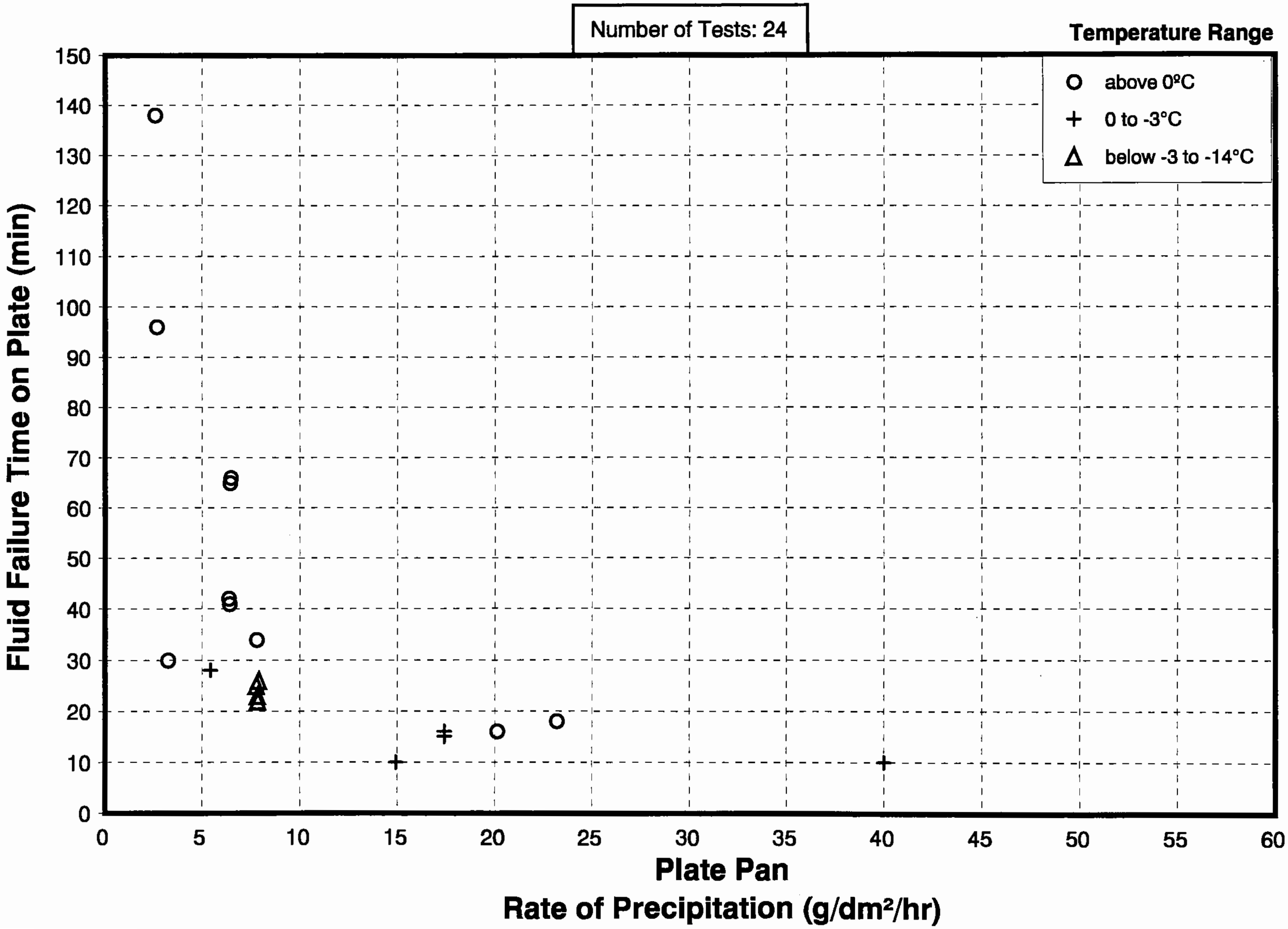
FIGURE E.10

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 50/50

NATURAL SNOW CONDITIONS

1995 - 1996



cm1283\report\hot_subs\956NS25C.GRF

FIGURE E.11

EFFECT OF WIND SPEED AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 50/50

NATURAL SNOW CONDITIONS

1995 - 1996

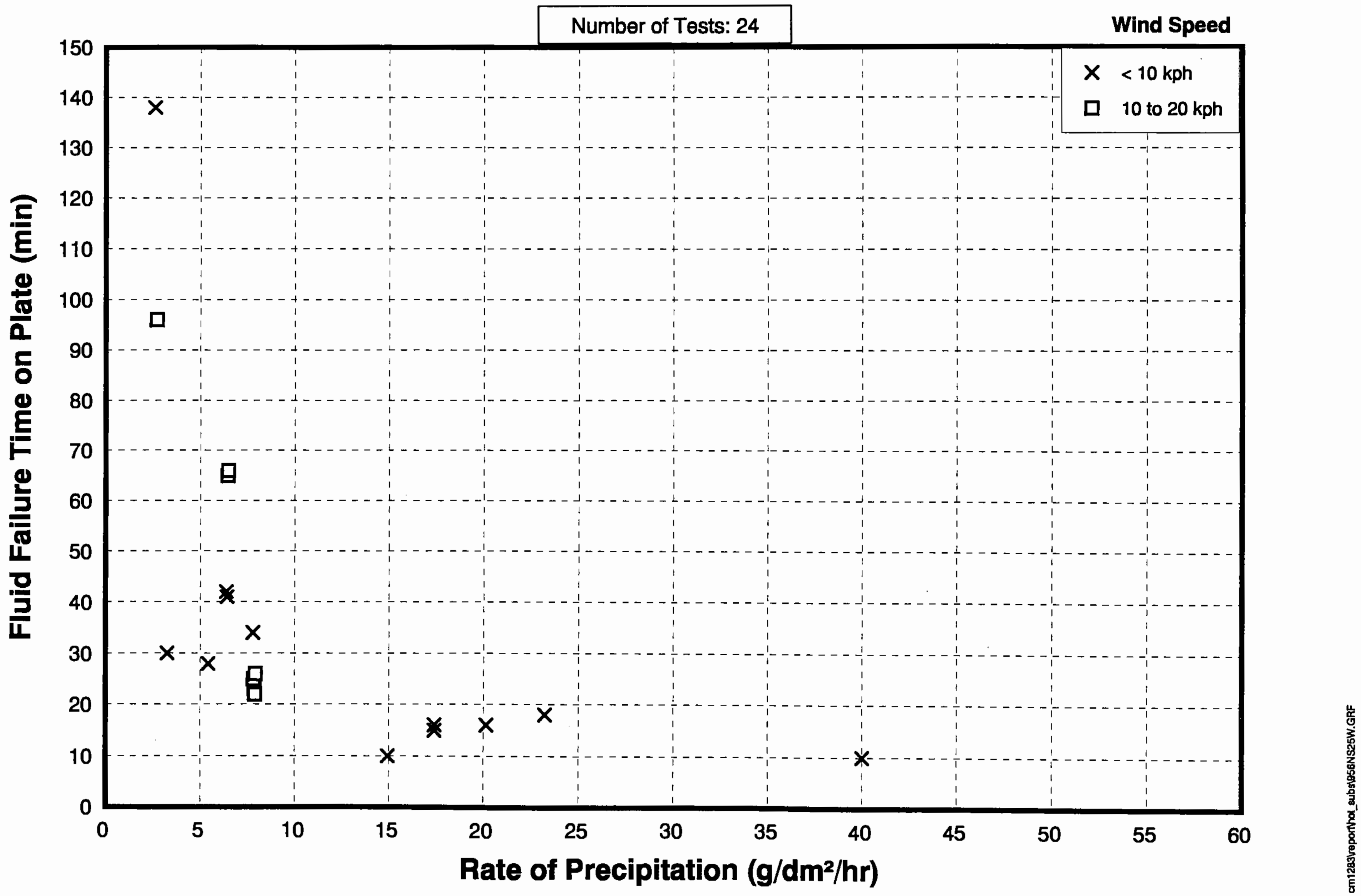


FIGURE E.12

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

TYPE II 50/50

NATURAL SNOW CONDITIONS

1995 - 1996

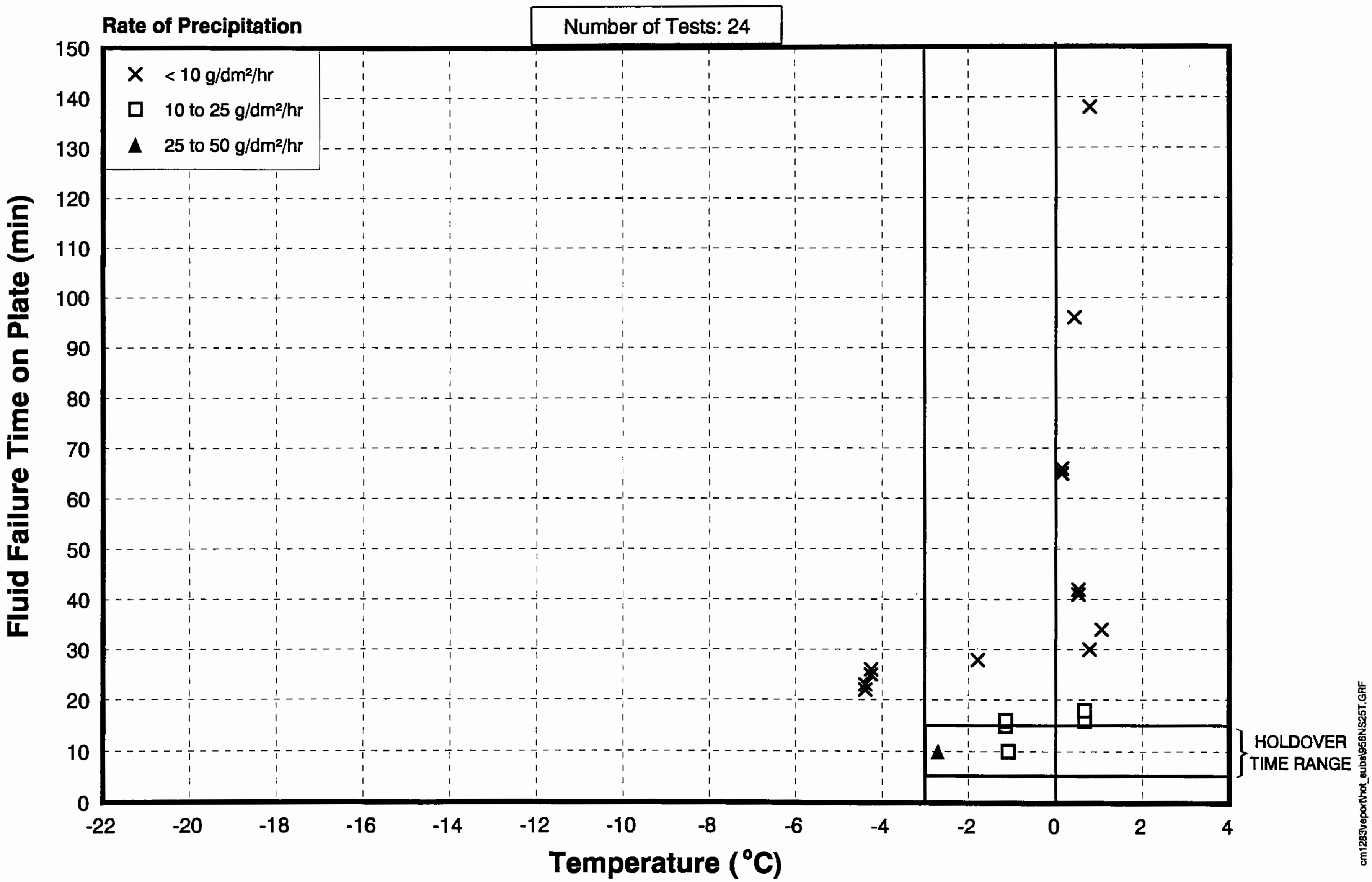


FIGURE E.13

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

STANDARD TYPE I

NATURAL SNOW CONDITIONS

1995 - 1996

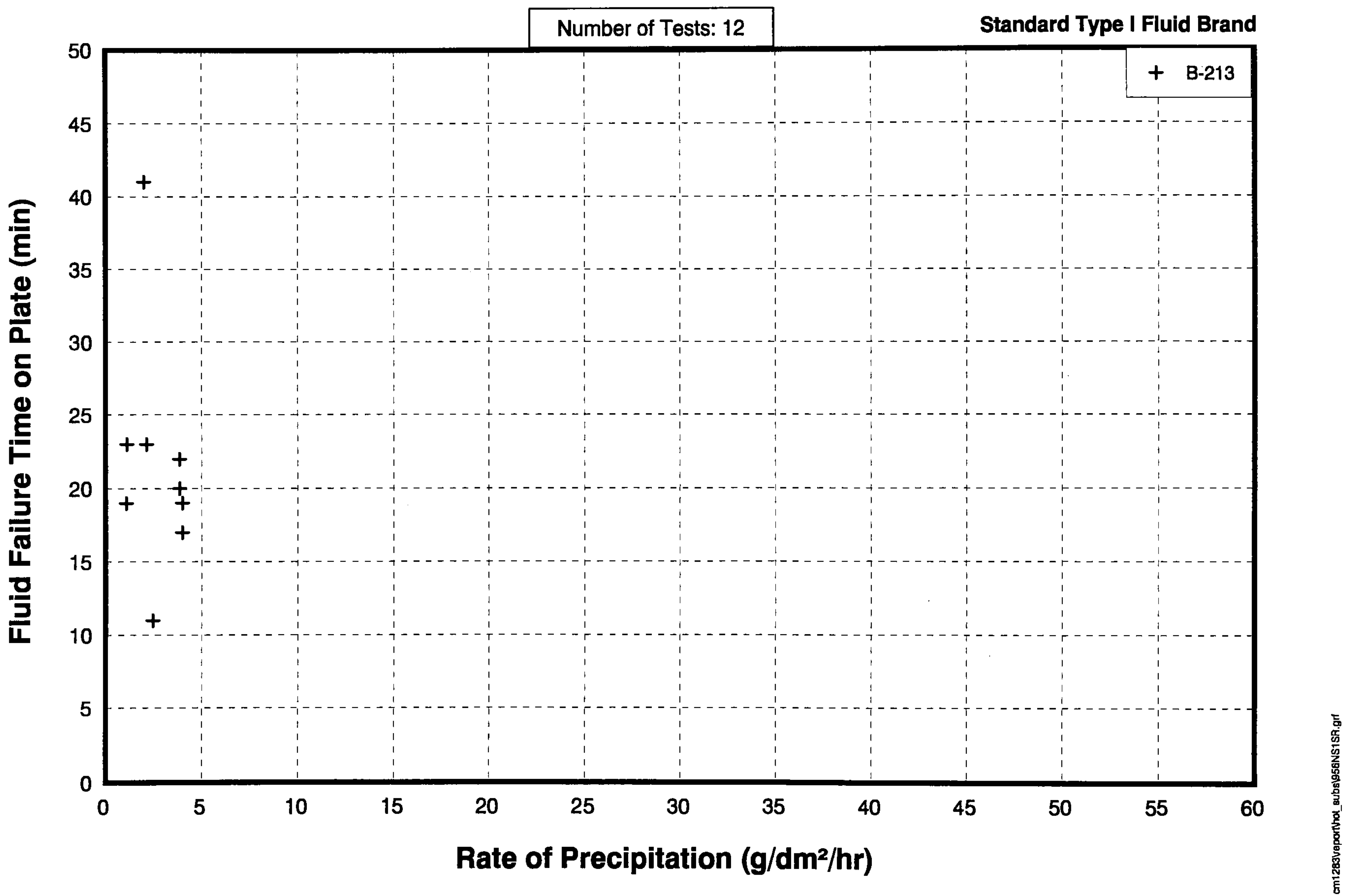


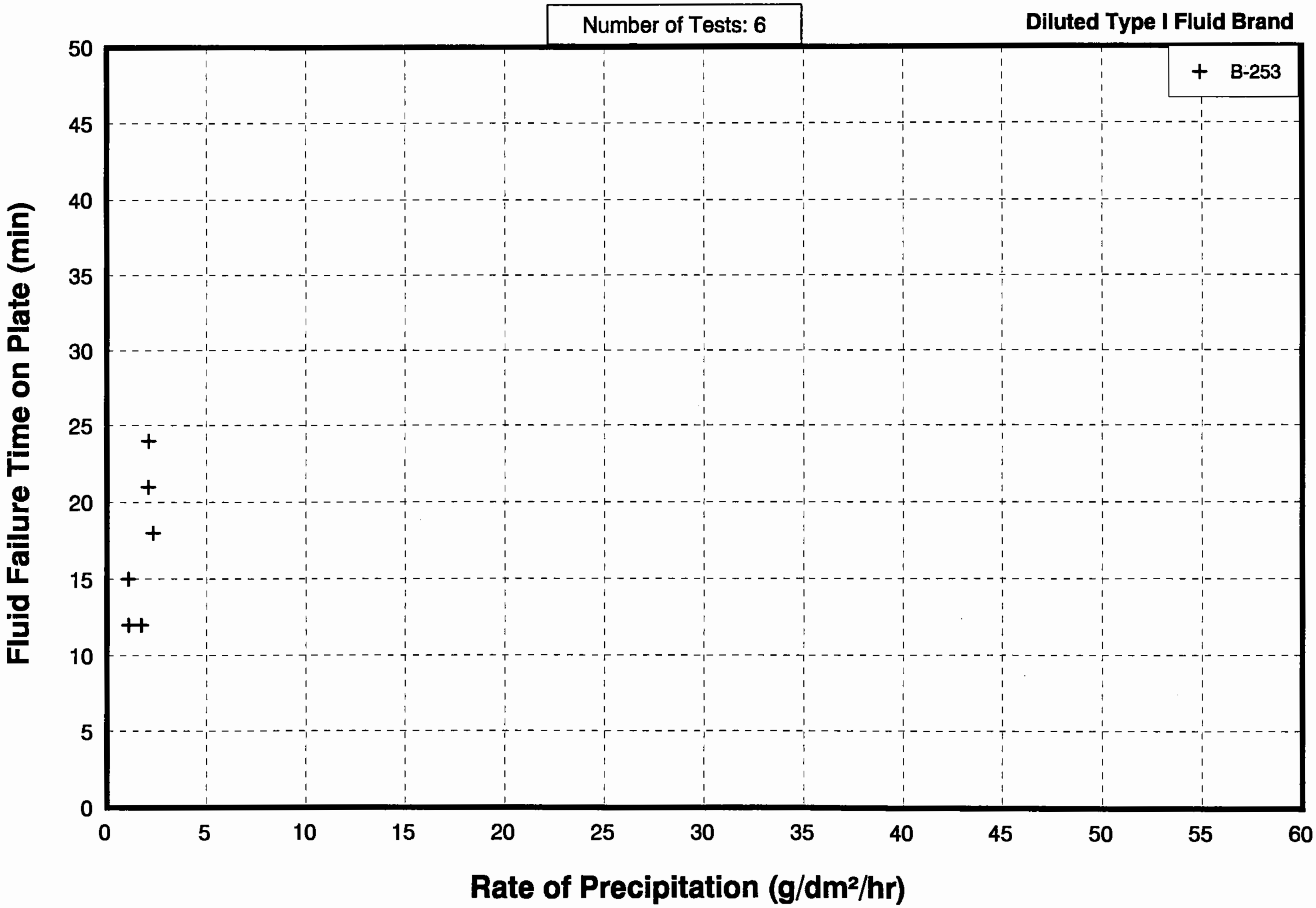
FIGURE E.14

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

DILUTED TYPE I

NATURAL SNOW CONDITIONS

1995 - 1996



cm1283\report\hot_subs\956NS1DR.grf

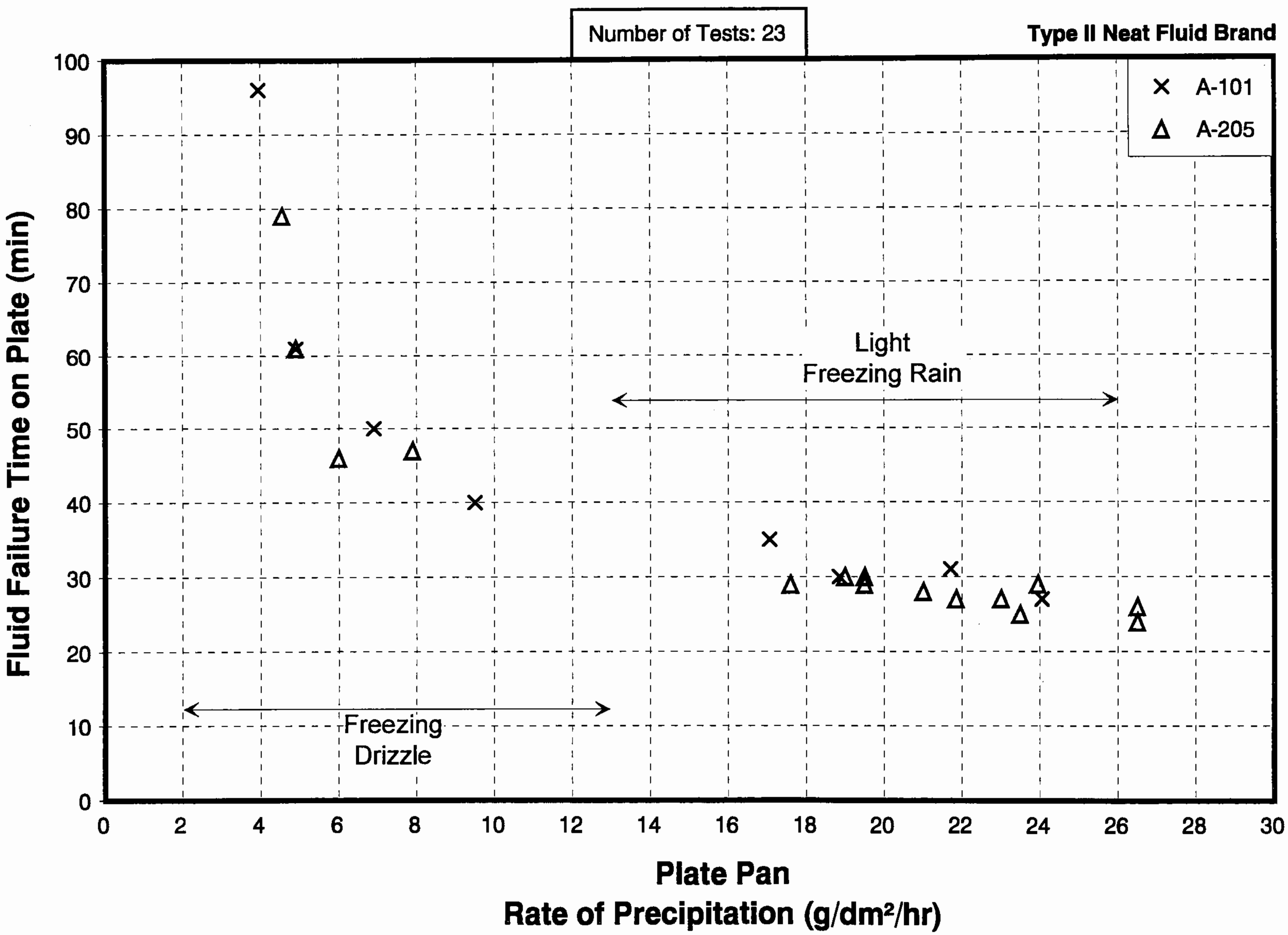
FIGURE E.15

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II NEAT

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1995 - 1996



cm1283/report/hot_subs\96FZR21R.GRF

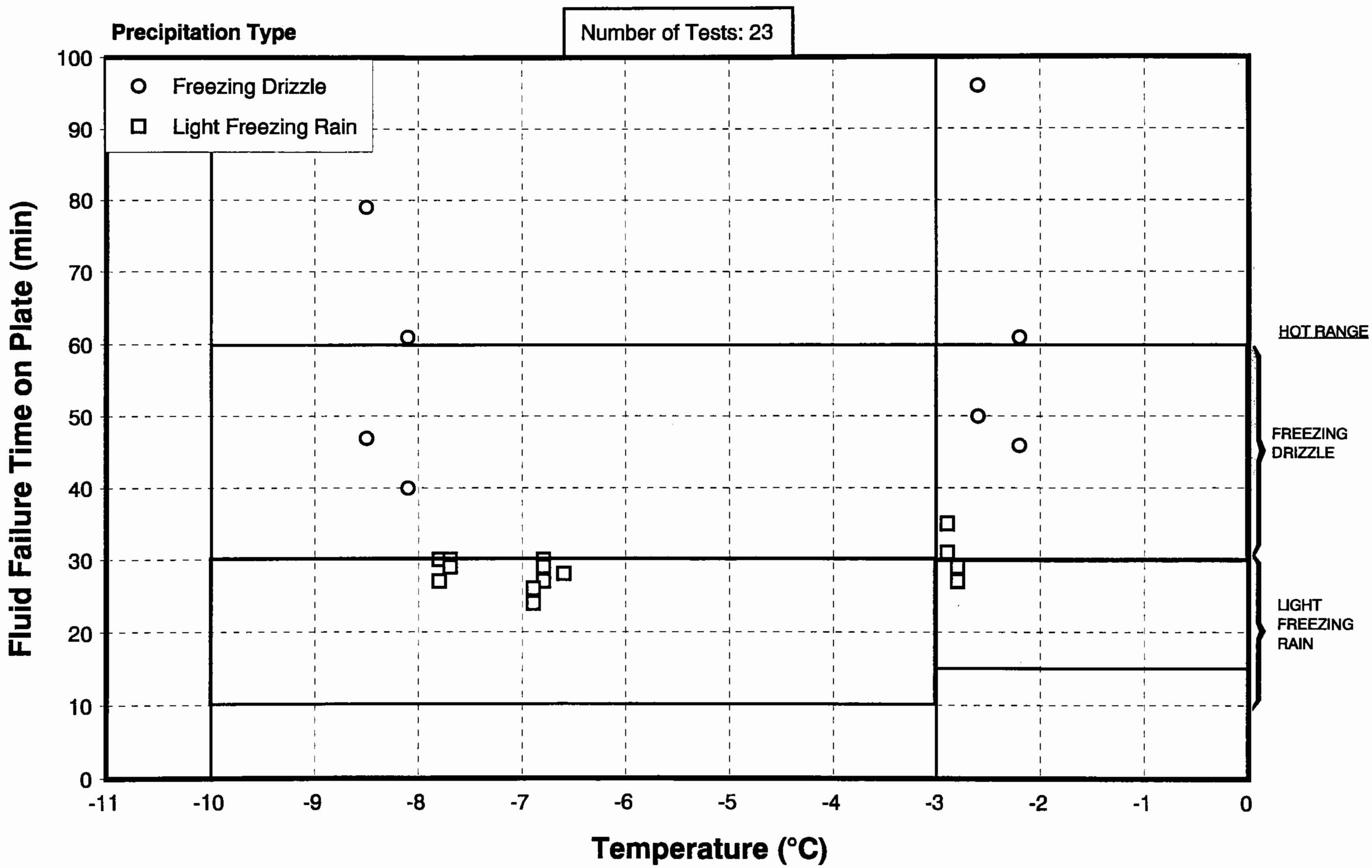
FIGURE E.16

EFFECT OF PRECIPITATION TYPE AND TEMPERATURE ON FAILURE TIME

TYPE II NEAT

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1995 -1996



cm1283\report\hot_subs\96FZR21T.GRF

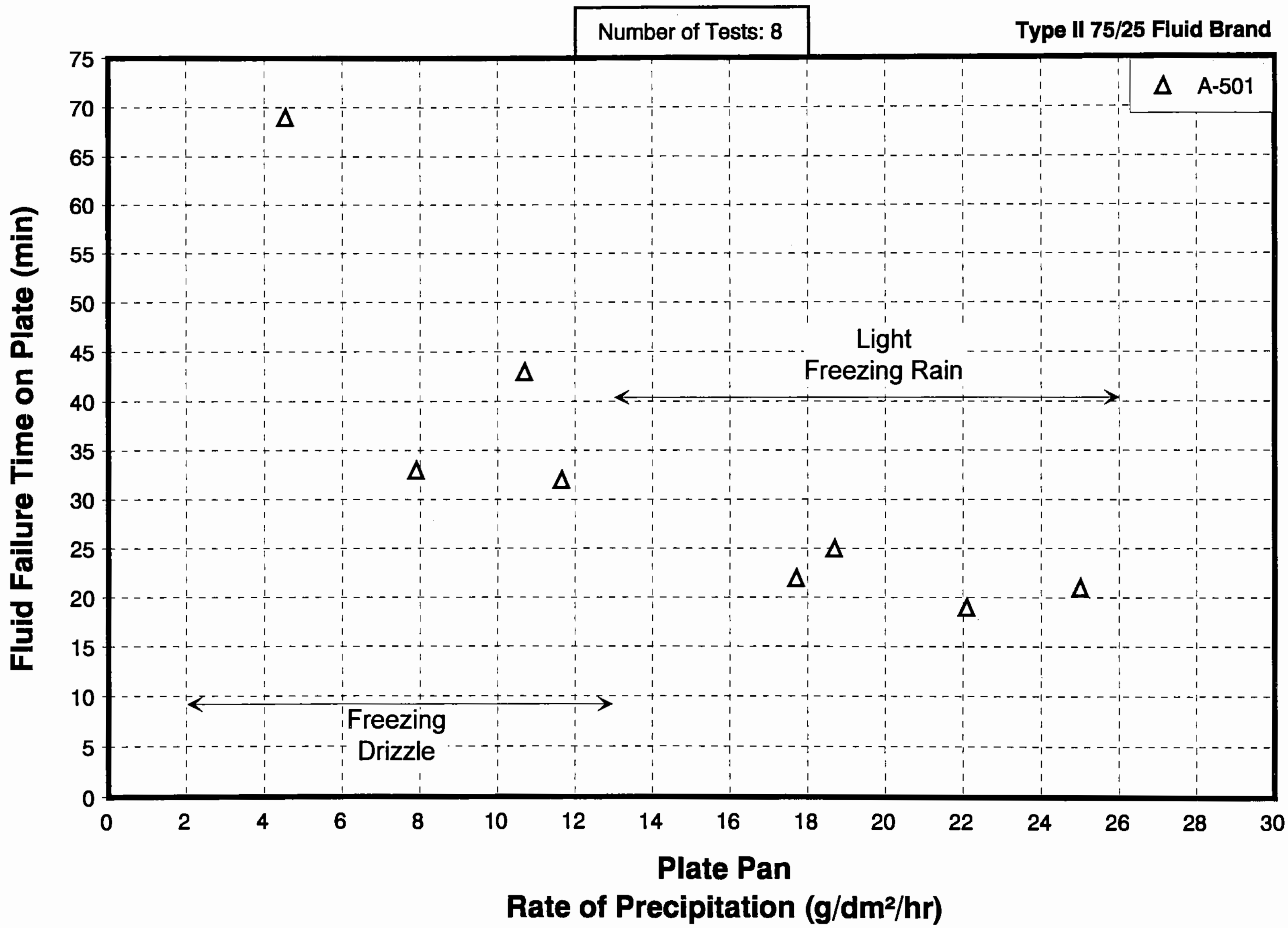
FIGURE E.17

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 75/25

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1995 - 1996



cm1283\report\xl_subs\96FZR27R.GRF

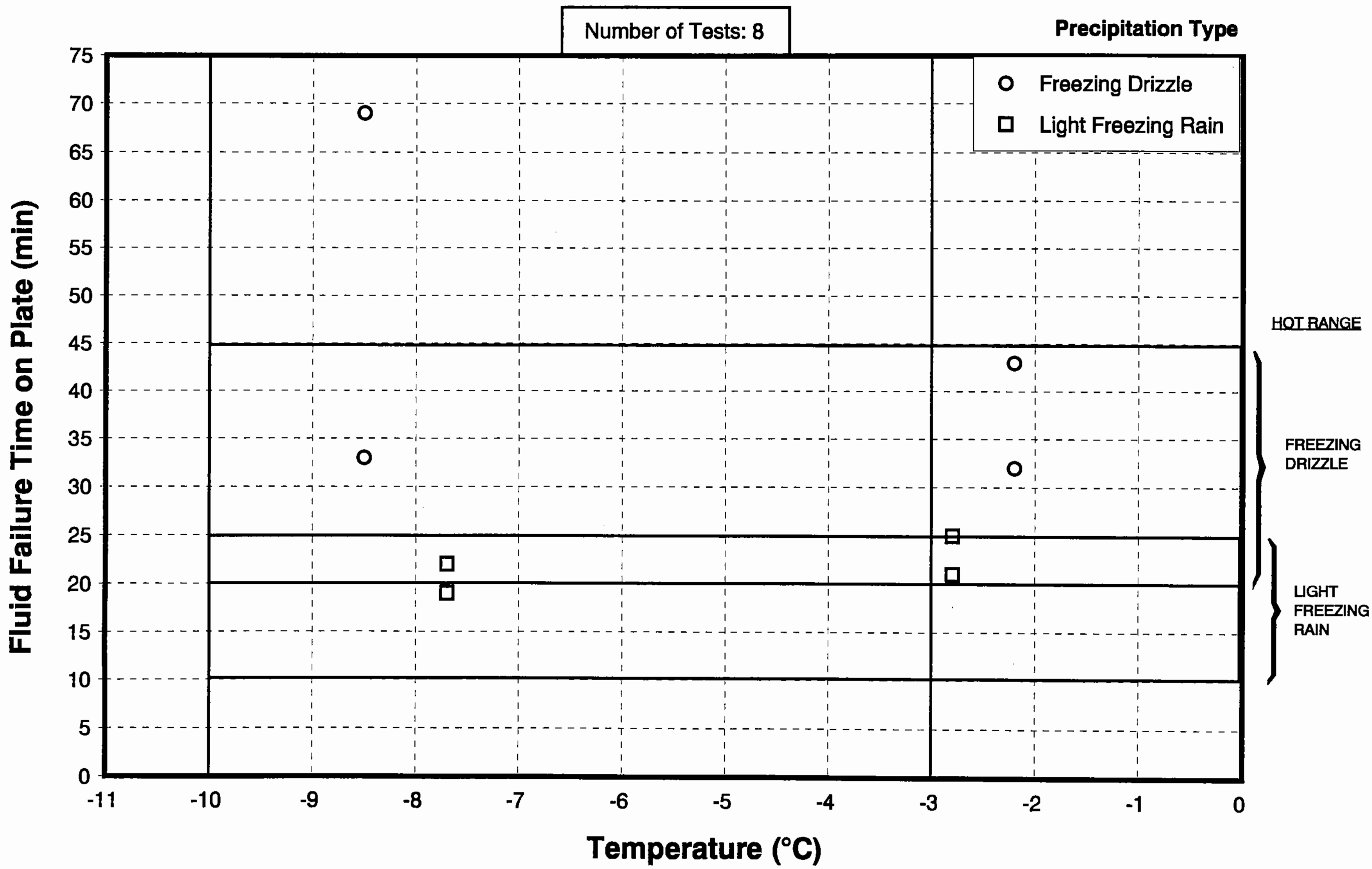
FIGURE E.18

EFFECT OF PRECIPITATION TYPE AND TEMPERATURE ON FAILURE TIME

TYPE II 75/25

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1995 -1996



cm1283\report\hot_subs\96FZR27T.GRF

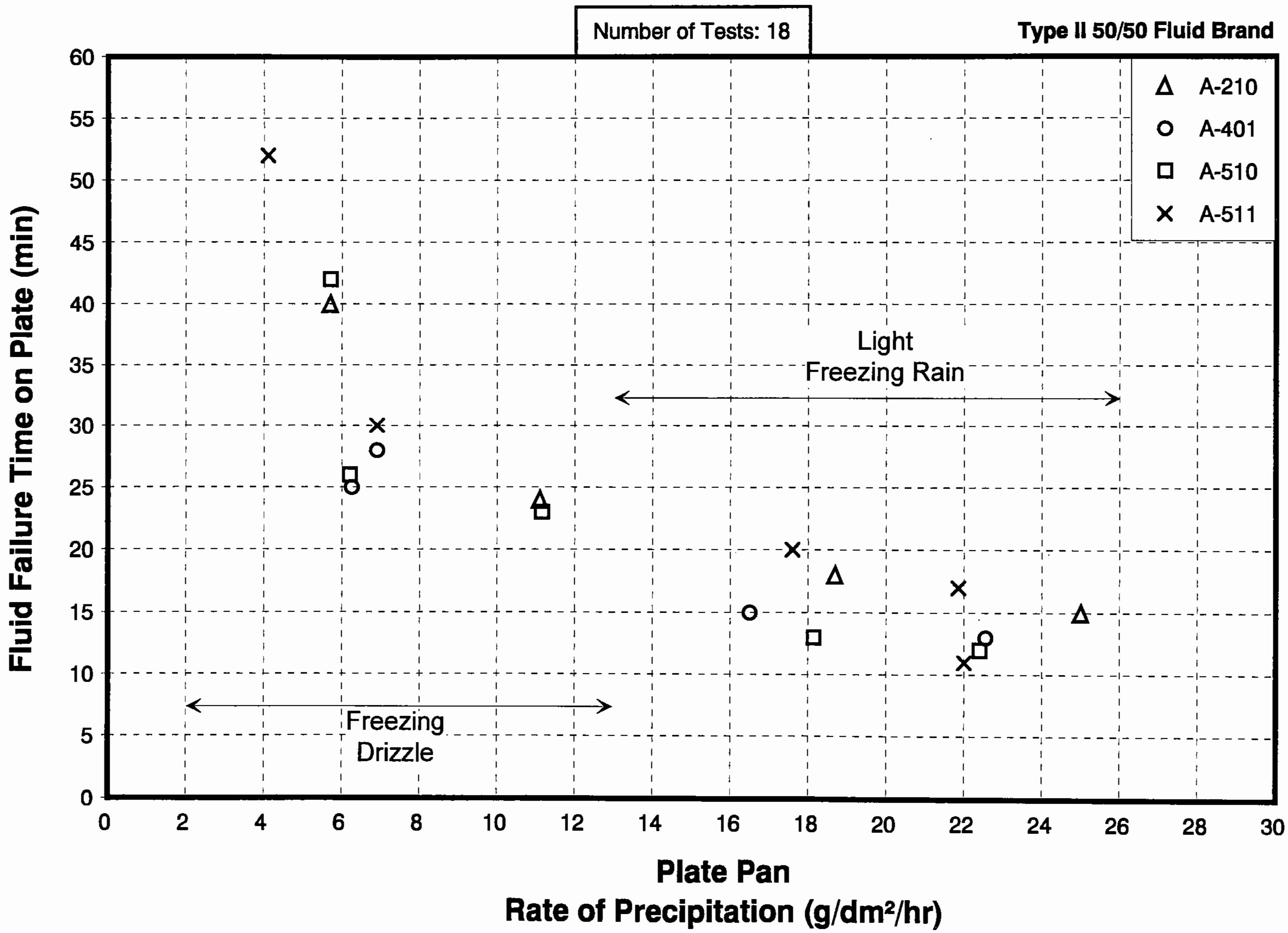
FIGURE E.19

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 50/50

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1995 - 1996



cm1283/report/hot_subs\96FZR25R.GRF

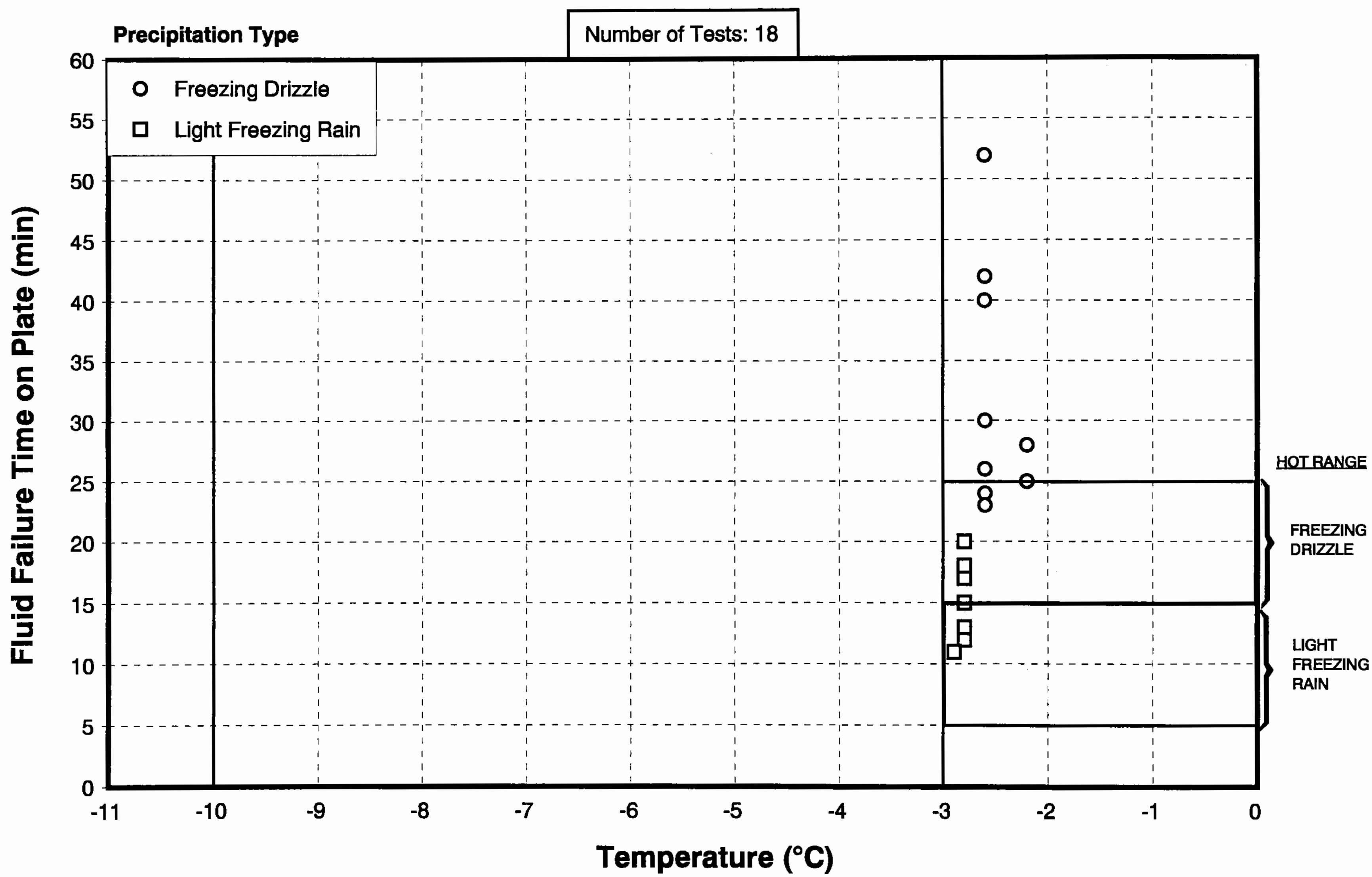
FIGURE E.20

EFFECT OF PRECIPITATION TYPE AND TEMPERATURE ON FAILURE TIME

TYPE II 50/50

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1995 -1996



cm1283\report\hot_subs\96FZR25T.GRF

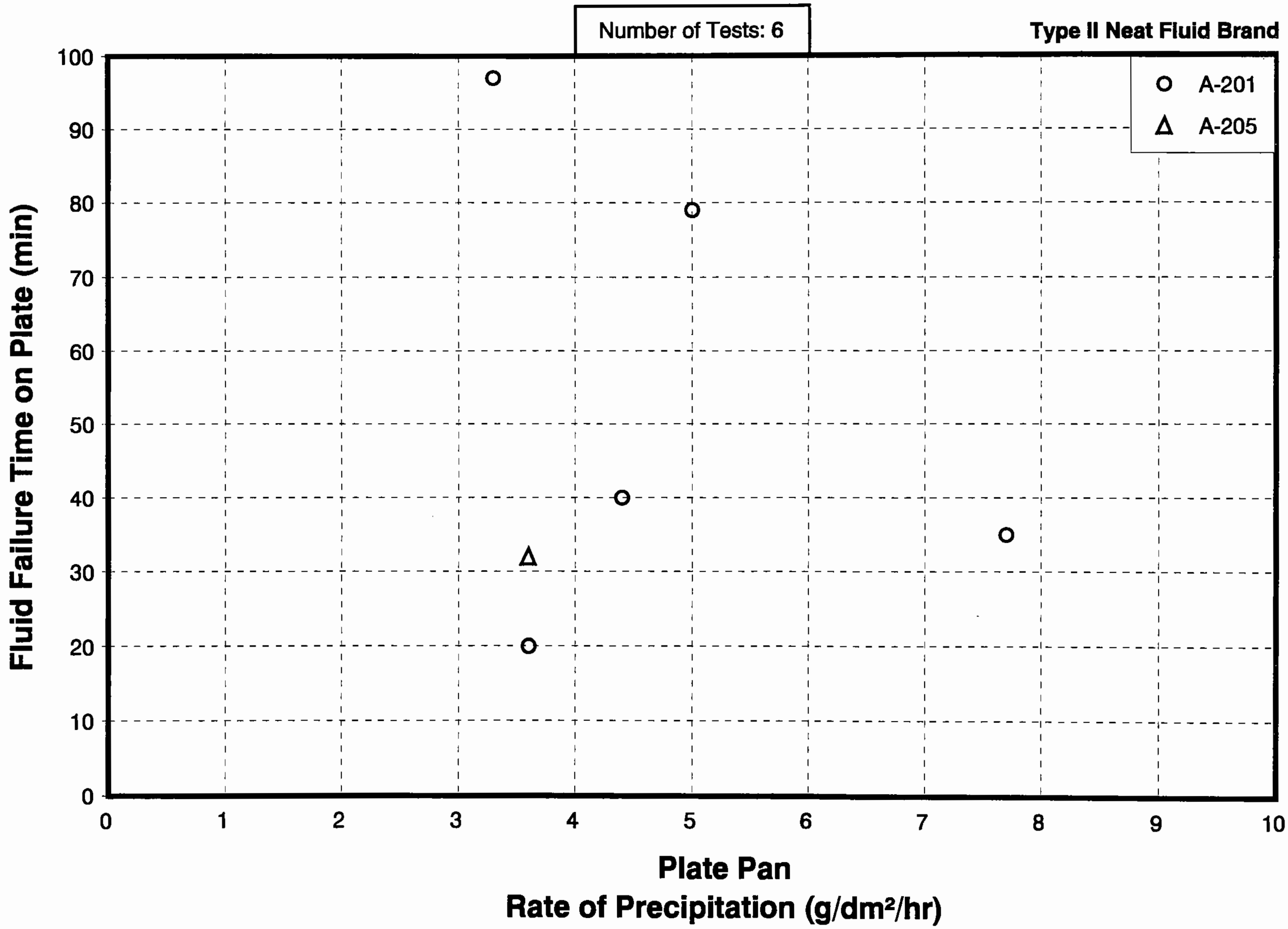
FIGURE E.21

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II NEAT

SIMULATED FREEZING FOG

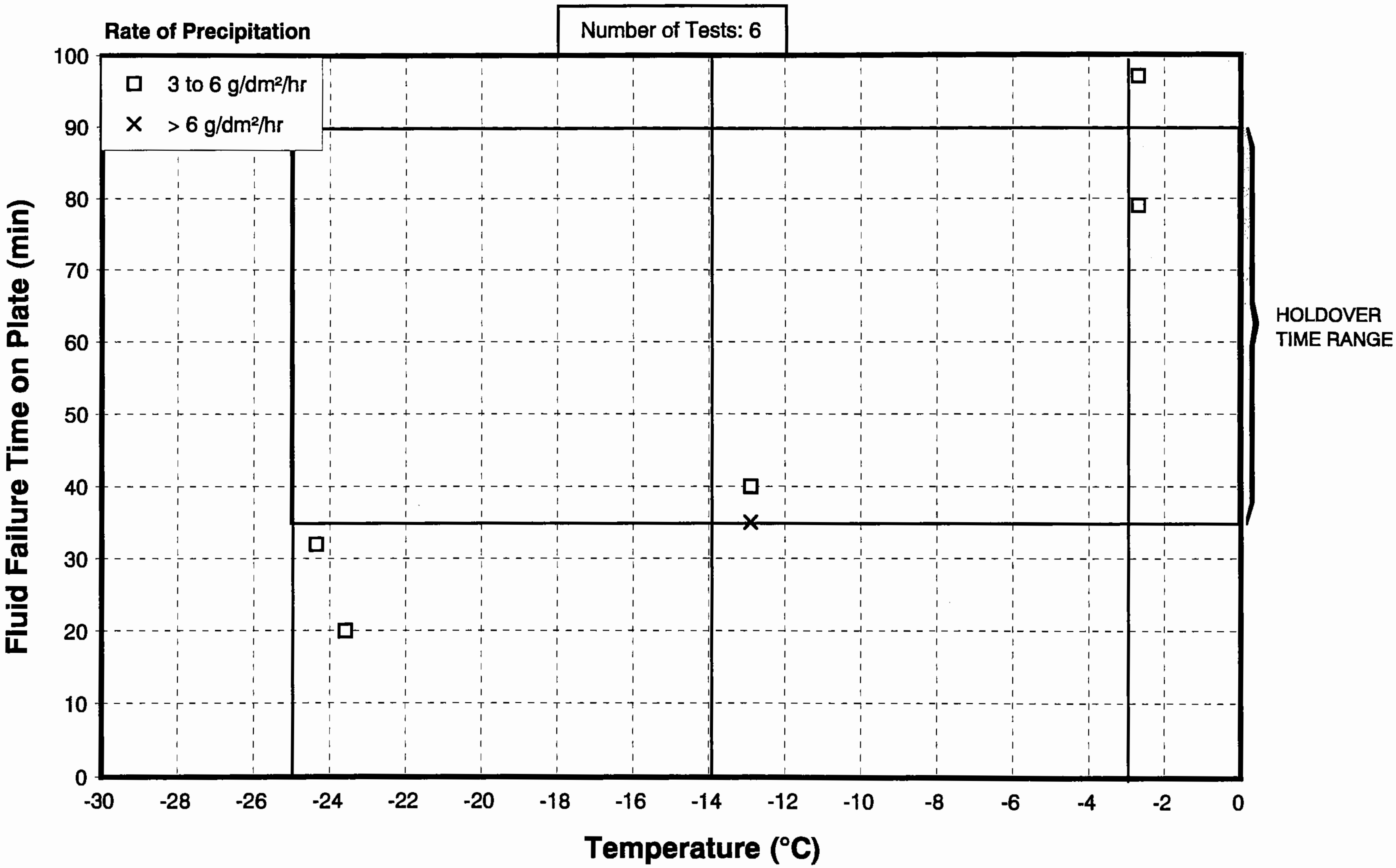
1995 - 1996



cm1283/vaportvol_subs\96FZF21R.GRF

FIGURE E.22

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME
TYPE II NEAT
SIMULATED FREEZING FOG
1995 -1996



cm1283\report\hot_subs\96FZF21T.GRF

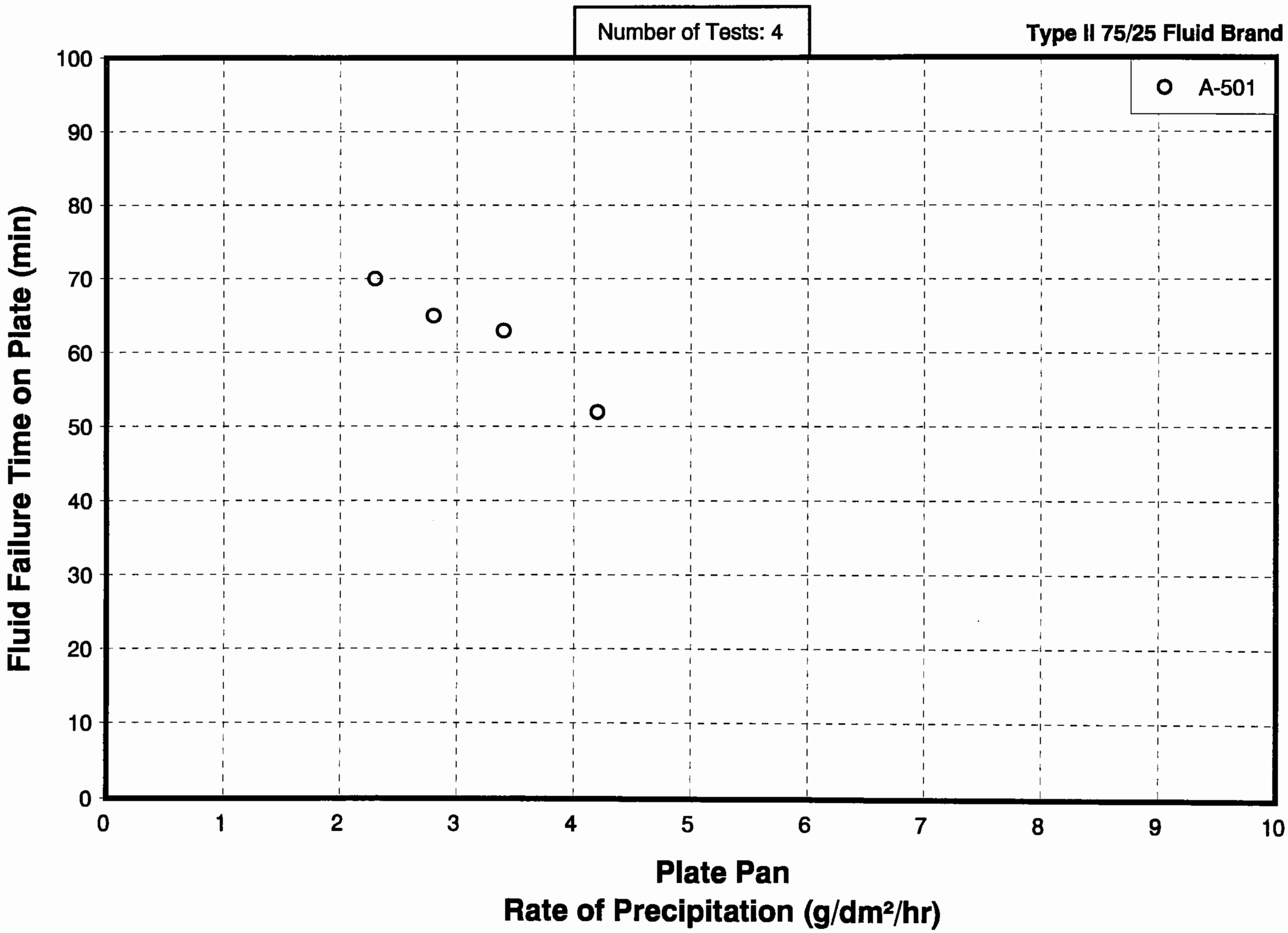
FIGURE E.23

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 75/25

SIMULATED FREEZING FOG

1995 - 1996



cm1283\report\hol_subs\96FZF27R.GRF

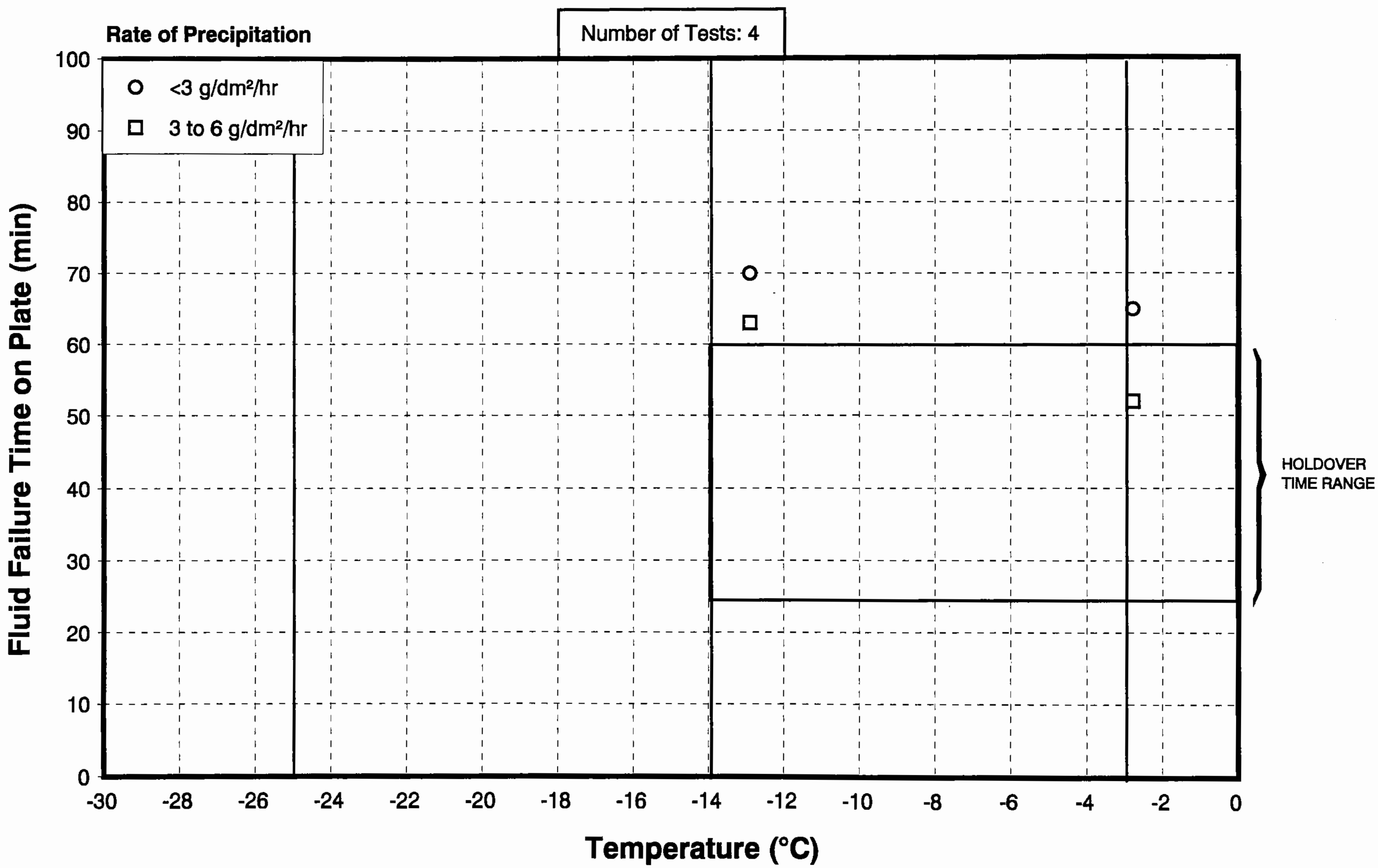
FIGURE E.24

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

TYPE II 75/25

SIMULATED FREEZING FOG

1995 -1996



cm1283\report\hot_subs\96FZF21T.GRF

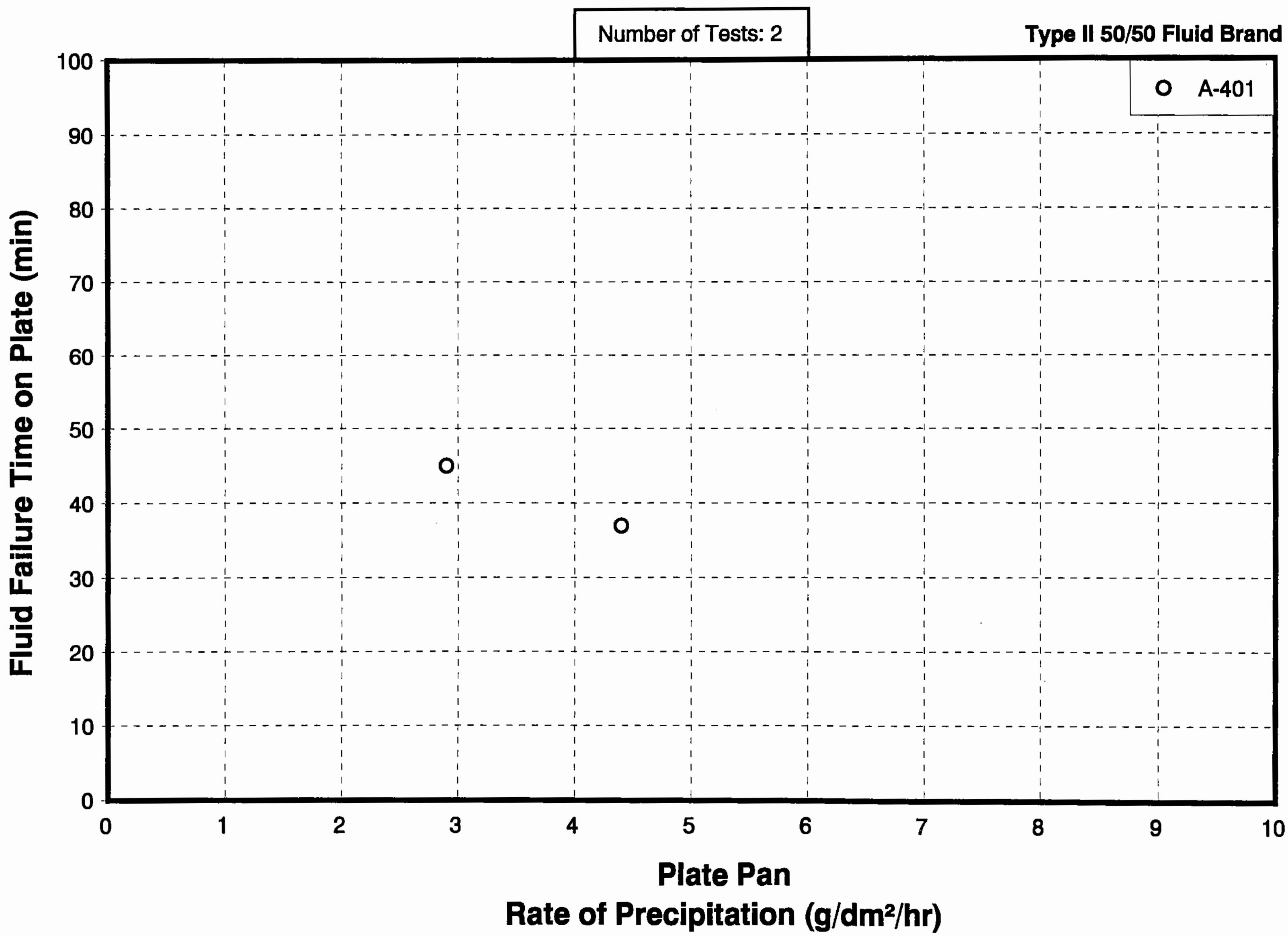
FIGURE E.25

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 50/50

SIMULATED FREEZING FOG

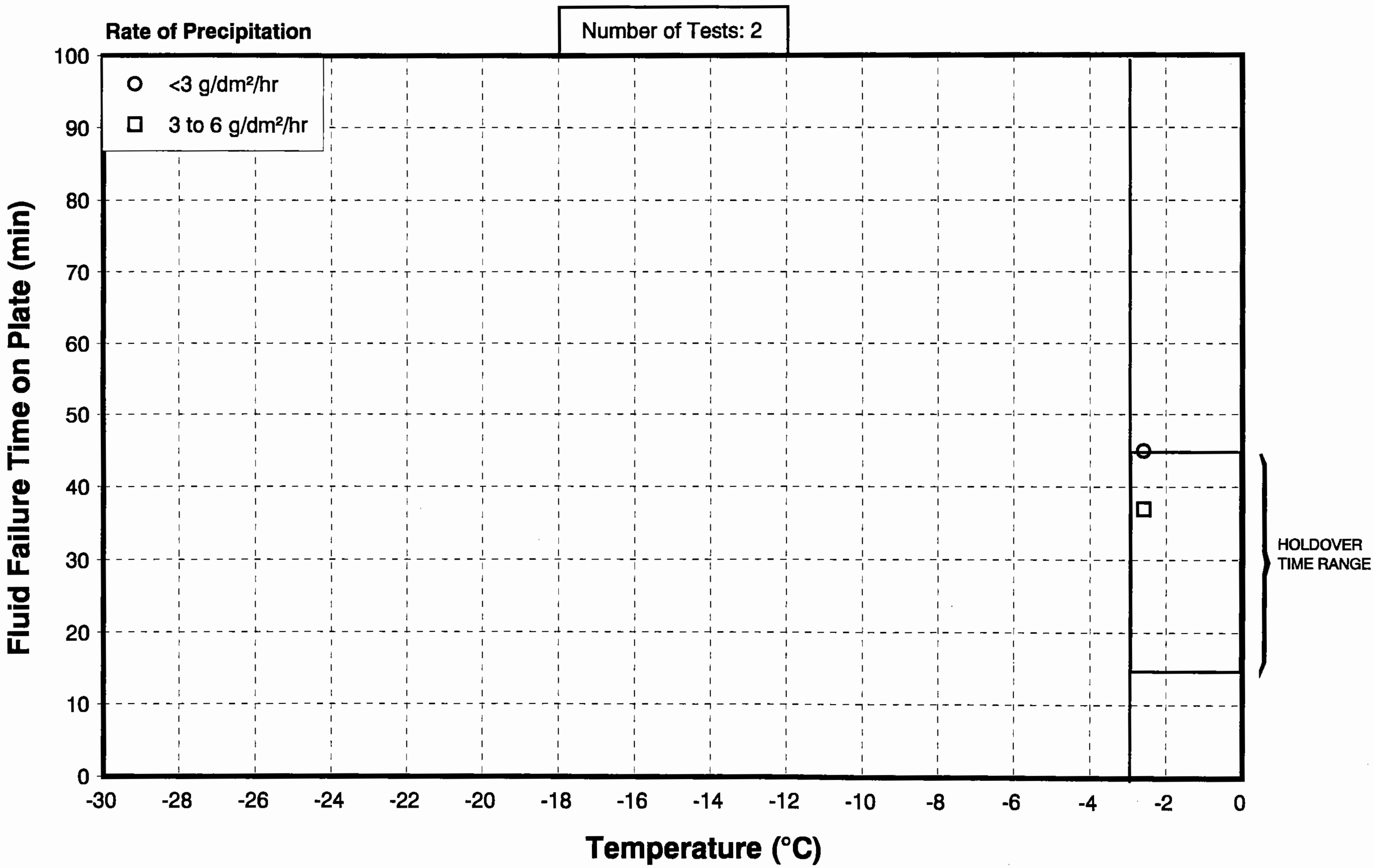
1995 - 1996



cm1283\report\rot_subs\96FZF25R.GRF

FIGURE E.26

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME
TYPE II 50/50
SIMULATED FREEZING FOG
1995 -1996



cm1283\report\hot_subs\96FZF25T.GRF

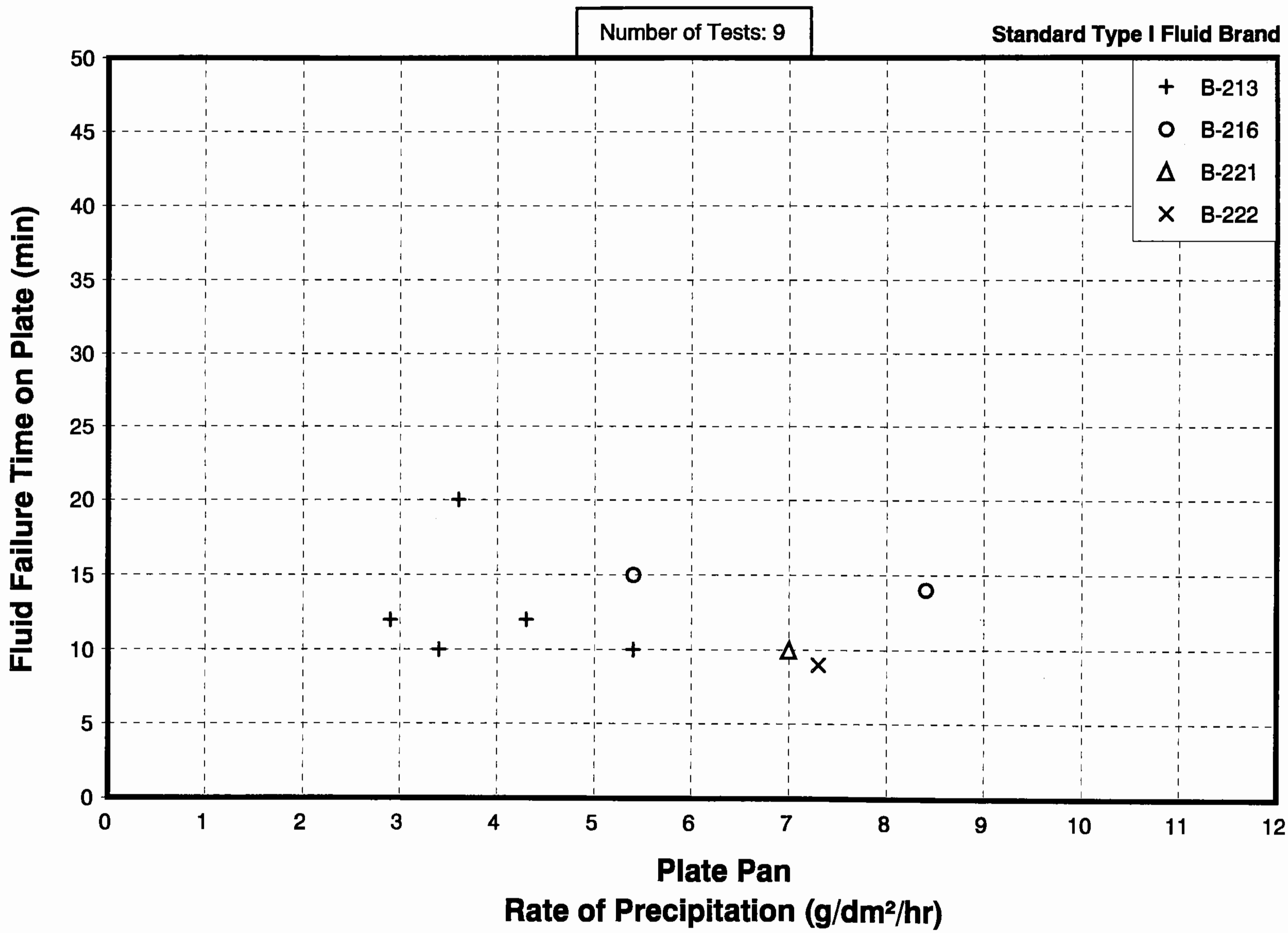
FIGURE E.27

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

STANDARD TYPE I

SIMULATED FREEZING FOG

1995 - 1996



cm1283\report\hol_subs\96FZF1sR.GRF

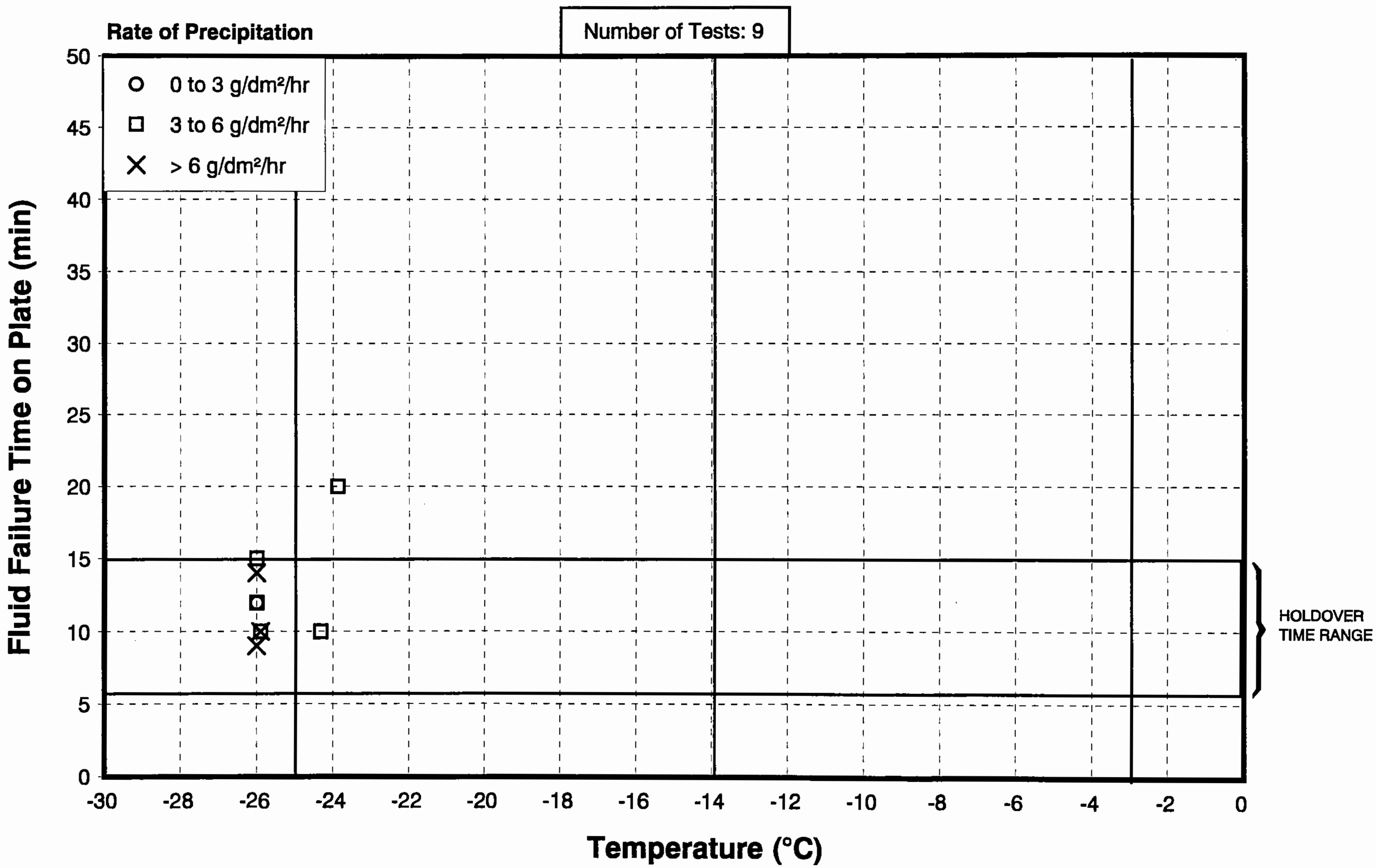
FIGURE E.28

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

STANDARD TYPE I

SIMULATED FREEZING FOG

1995 -1996



cm1283\report\hot_subs\98FZF1ST.GRF

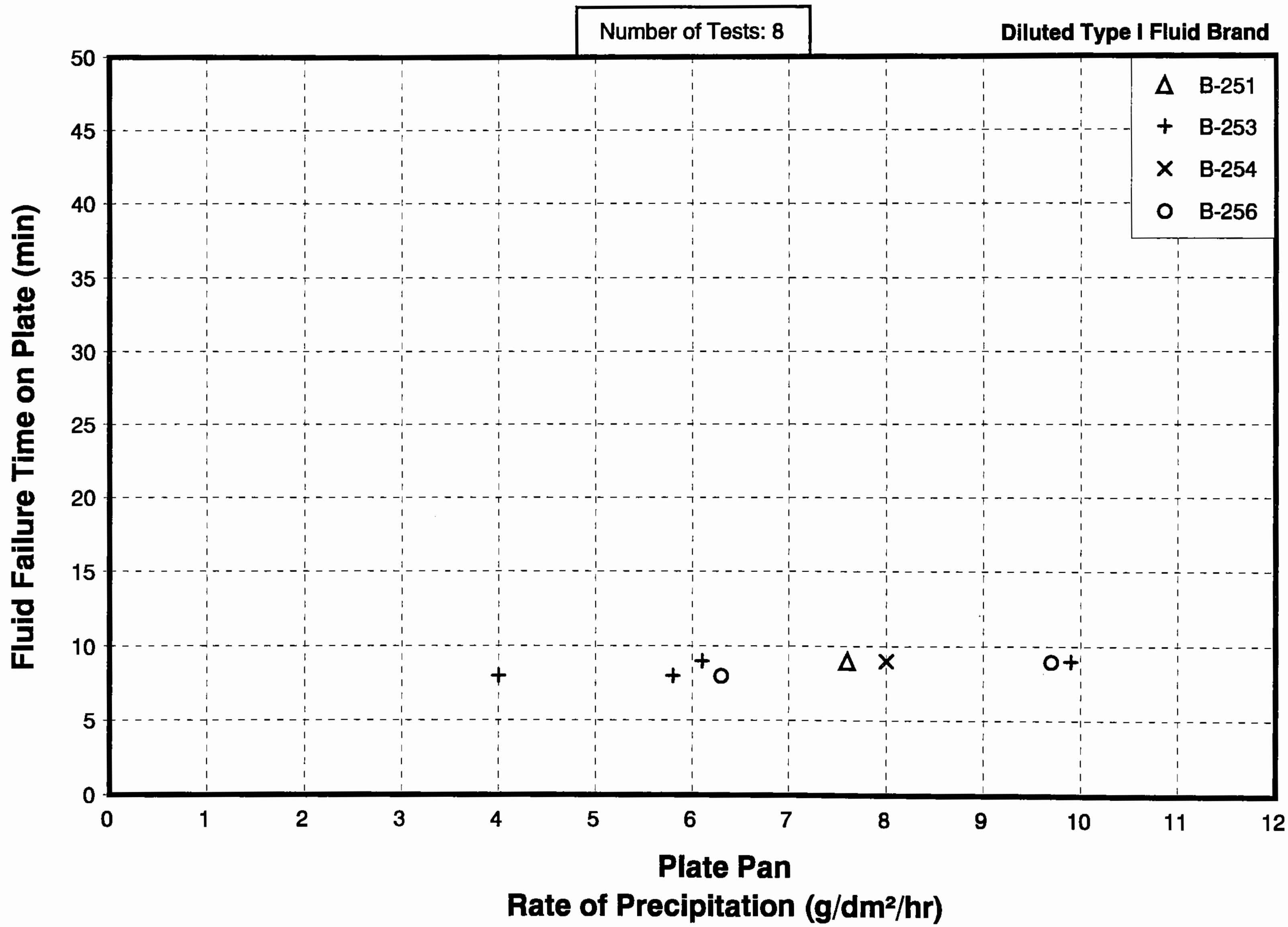
FIGURE E.29

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

DILUTED TYPE I

SIMULATED FREEZING FOG

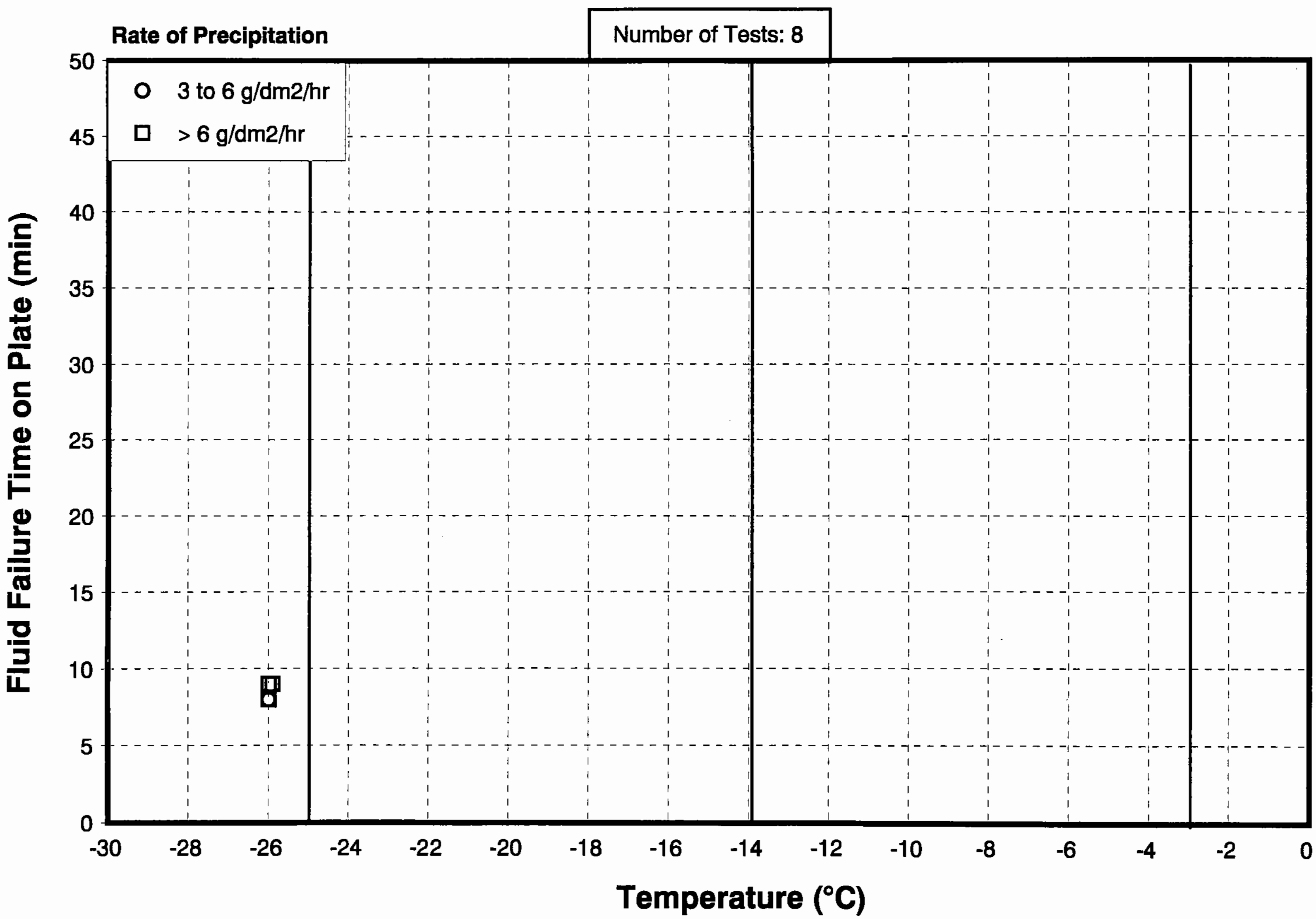
1995 - 1996



cm1283\report\rot_subs\96FZF1DR.GRF

FIGURE E.30

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME
DILUTED TYPE I
SIMULATED FREEZING FOG
1995 -1996



cm1283/report/hot_subs/96FZF1DT.GRF

APPENDIX F

NATURAL FREEZING PRECIPITATION DATA

EXCLUDING SNOW

NATURAL FREEZING PRECIPITATION DATA EXCLUDING SNOW

Appendix F is a compilation of figures prepared from fluid failure data under natural freezing precipitation conditions, excluding snow. The figures are plots of fluid failure time(s) as a function of rate of precipitation for the different categories of precipitation. The data were collected outdoors between 1990 and 1995, largely at the APS Dorval Airport test site. The following symbols were used for precipitation type:

IC	=	Ice crystals
IP	=	Ice pellets
S	=	Snow (included here because it may have been mixed with another form of precipitation).
FZR	=	Freezing rain
FZD	=	Freezing drizzle

Five charts are presented:

Type I Diluted
Type I Standard
Type II Neat
Type II 75/25
Type II 50/50

These charts are included for data record purposes for future reference. The failure calls may have significant variability due to the difficulty and uncertainty expressed by observers during these conditions. Standardization in the method for determining failure time is difficult due to the rarity of these conditions.

It was concluded at an SAE G-12 Holdover Time Sub-Committee meeting that operations should be postponed, suspended or cancelled if ice-pellets are reported by the meteorological station.

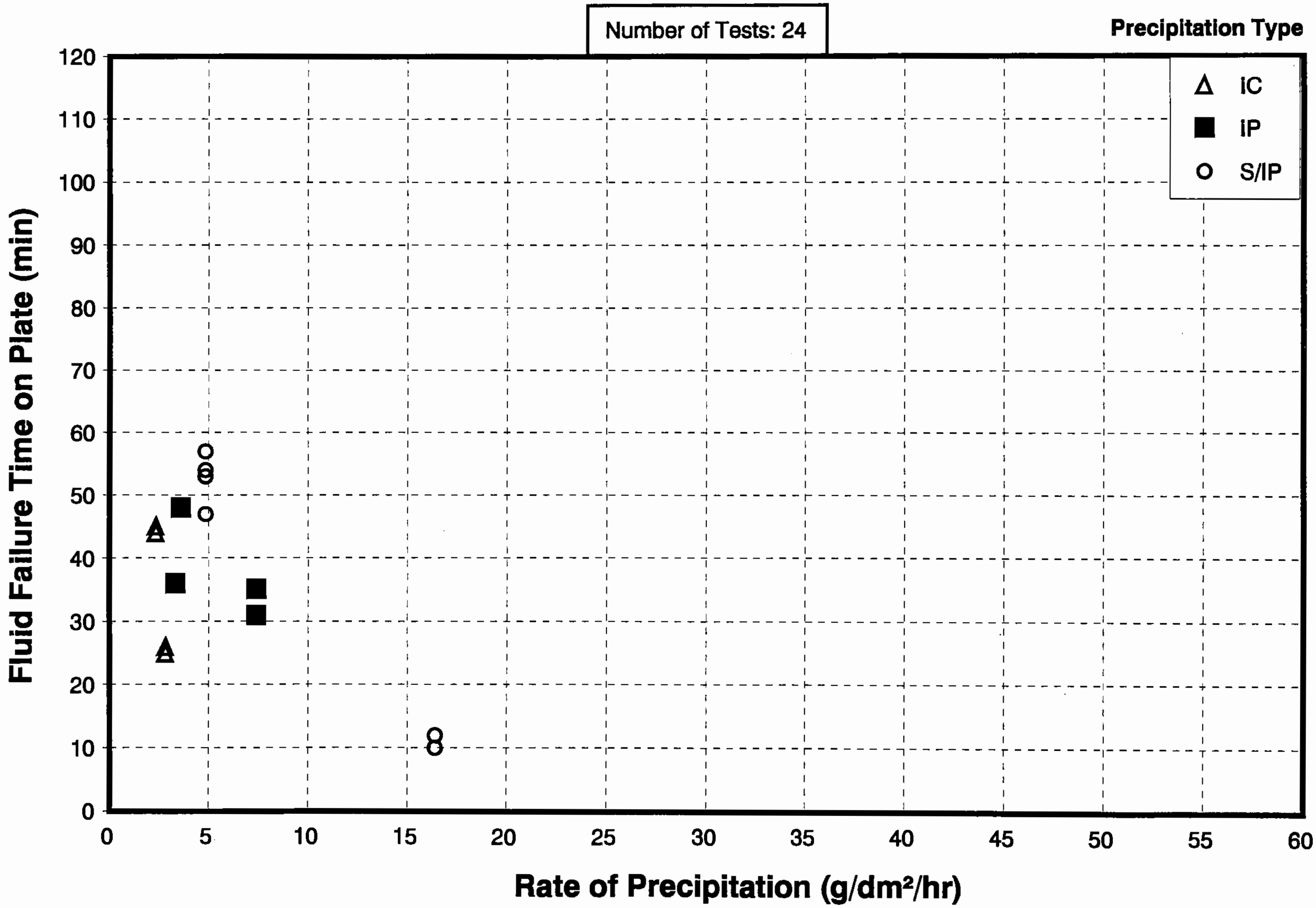
FIGURE F.1

EFFECT OF TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE I DILUTED

FREEZING PRECIPITATION

1990 - 1995



cm1283\report\hot_subs\FP905_1D.GRF

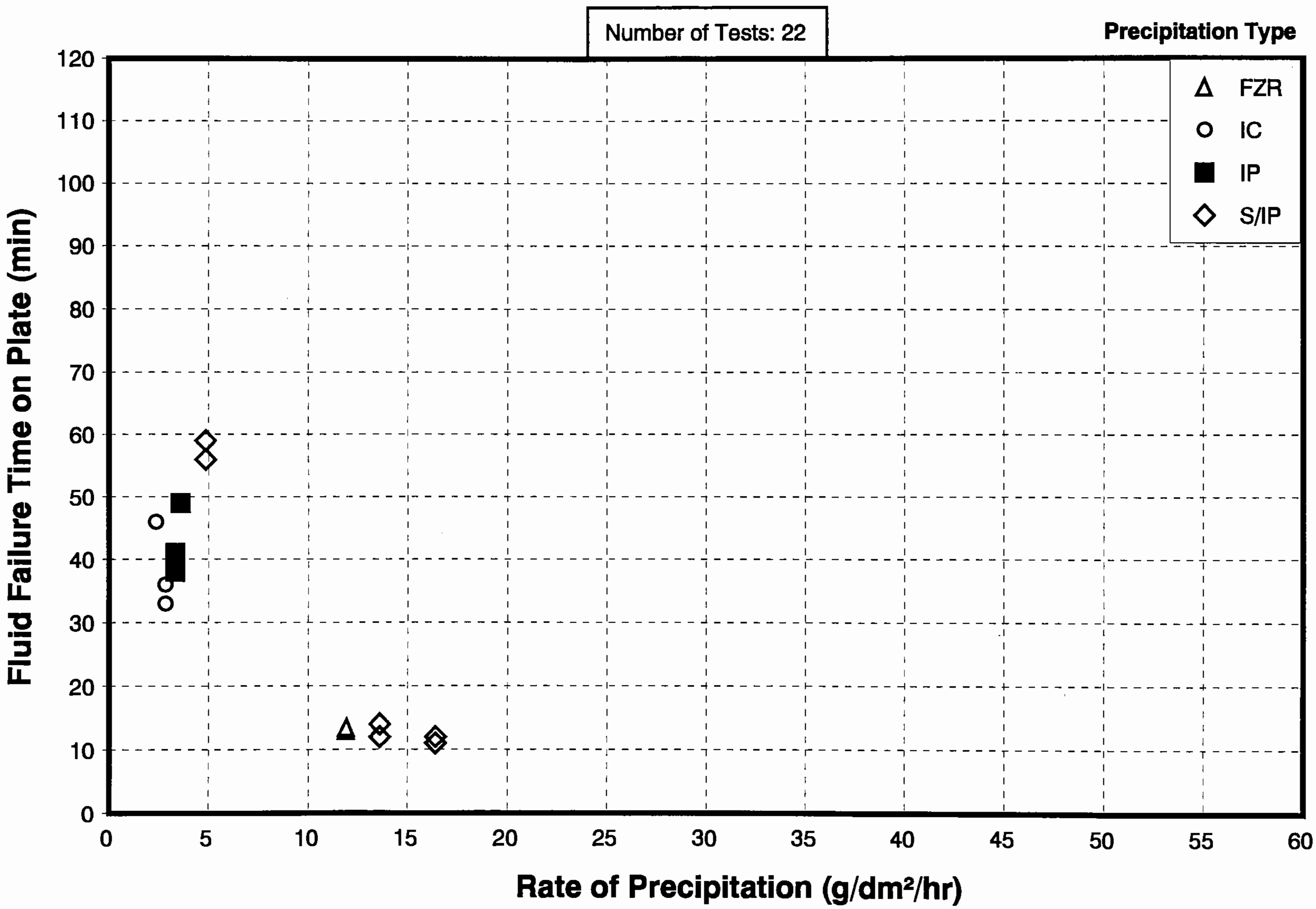
FIGURE F.2

EFFECT OF TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE I STANDARD

FREEZING PRECIPITATION

1990 - 1995



cm1283\report\hot_subs\FP905_1S.GRF

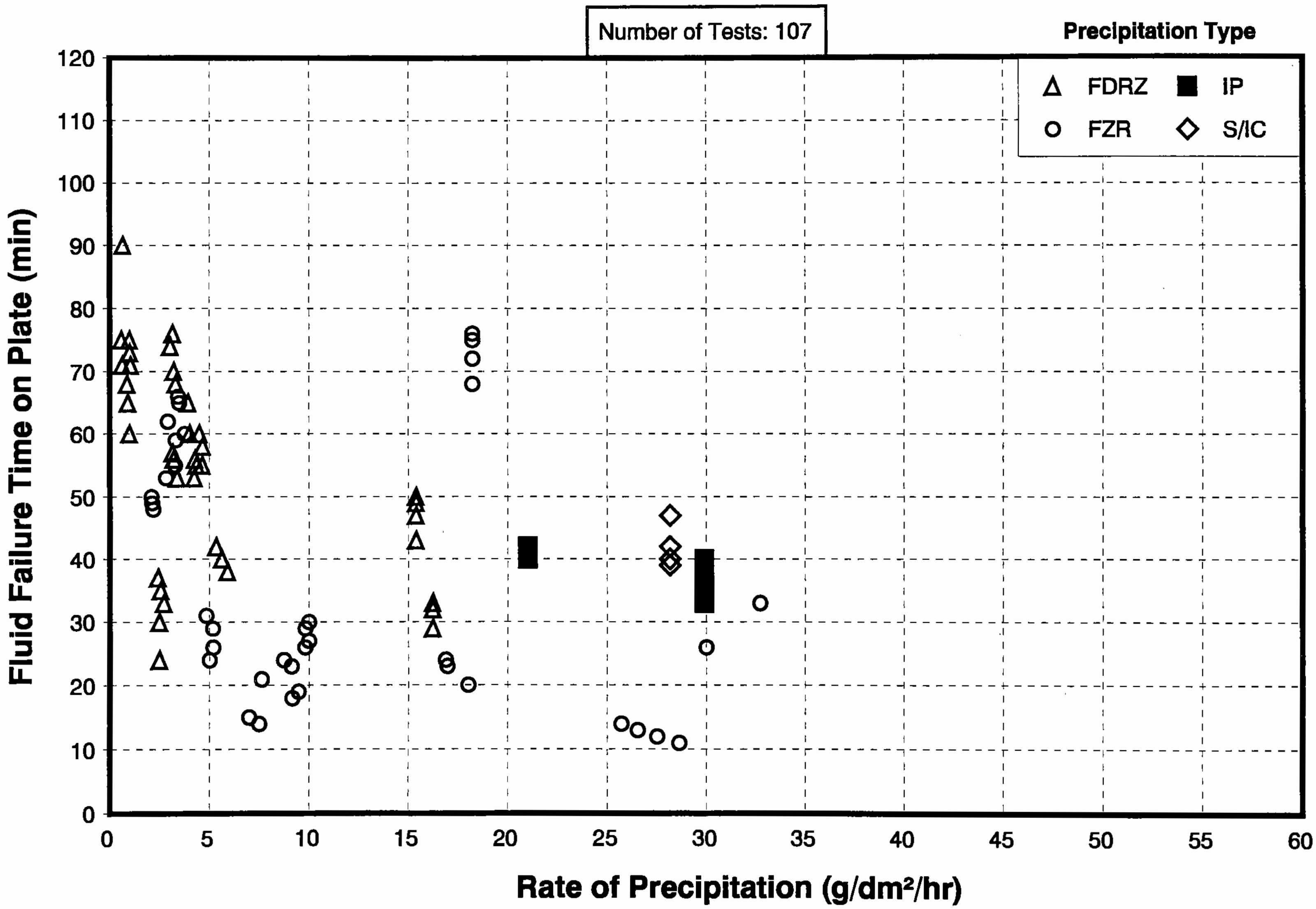
FIGURE F.3

EFFECT OF TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II NEAT

FREEZING PRECIPITATION

1990/1995



cm1283\report\hot_subs\FP905_21.GRF

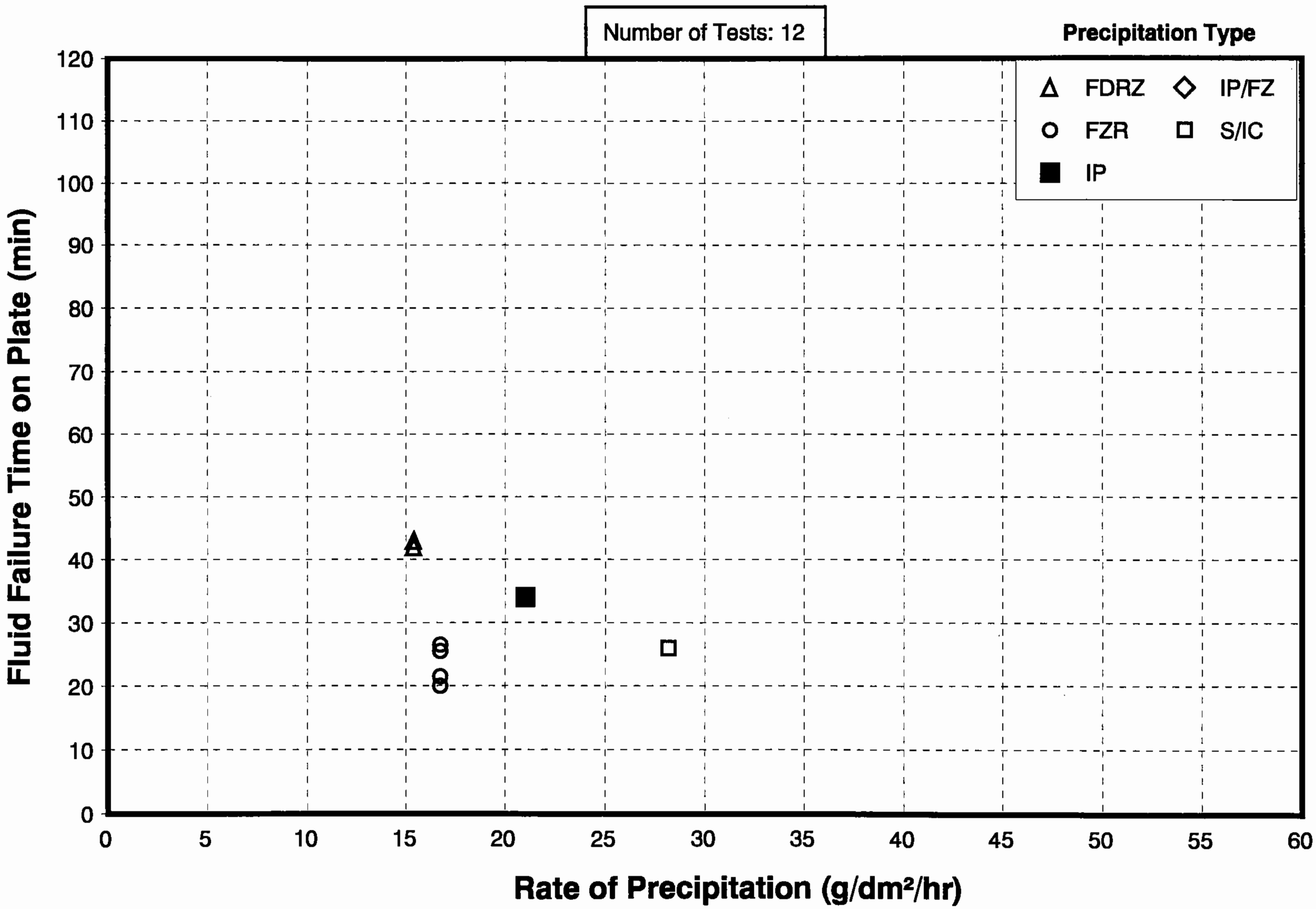
FIGURE F.4

EFFECT OF TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 75/25

FREEZING PRECIPITATION

1990 - 1995



cm1283\report\rot_subs\FP805_27.GRF

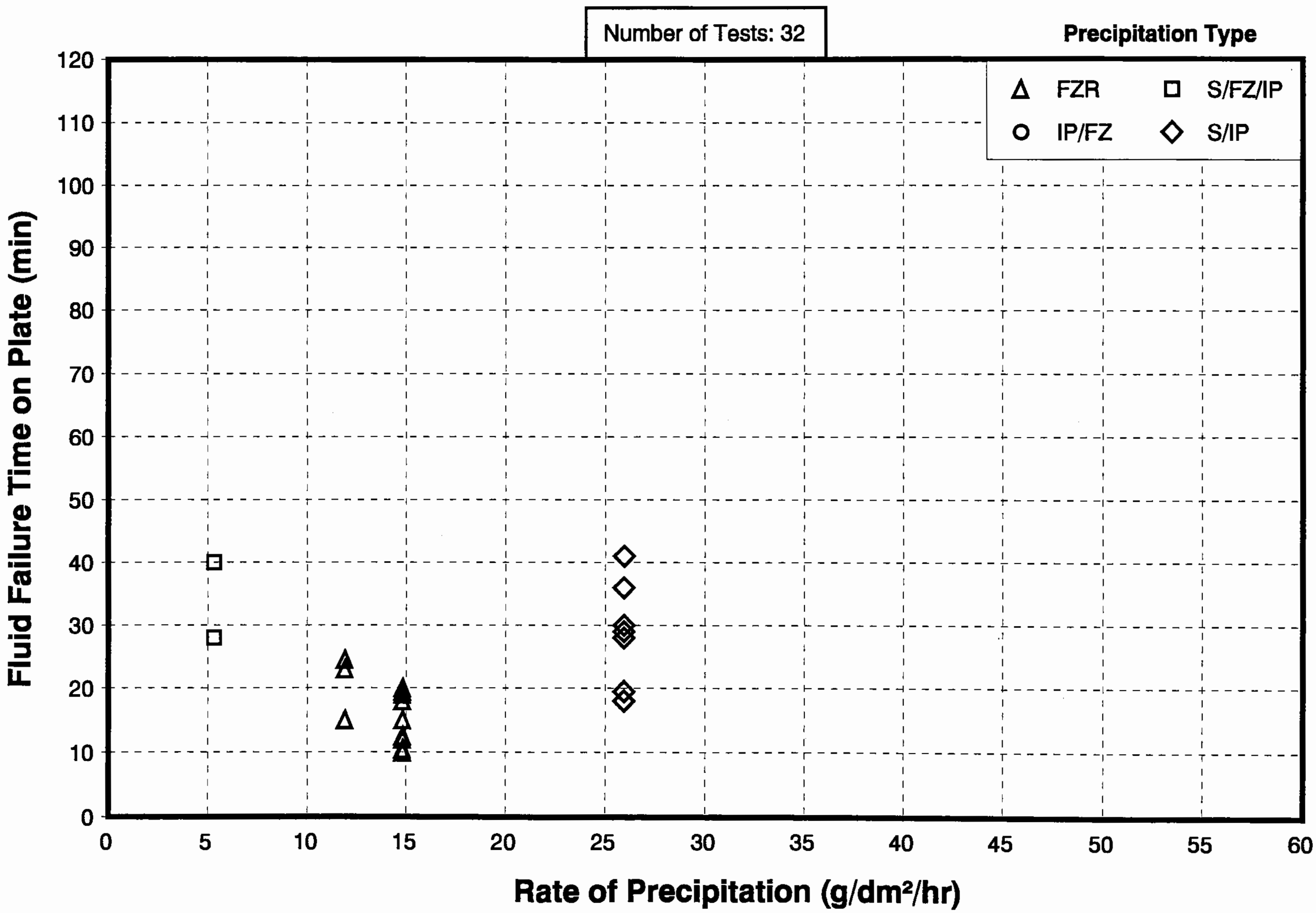
FIGURE F.5

EFFECT OF TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 50/50

FREEZING PRECIPITATION

1990 - 1995



cm1283\report\hot_subs\FP905_25.GRF

APPENDIX G

EVALUATION OF FAILURE CALLS USING ICE DETECTION SENSORS

EVALUATION OF FAILURE CALLS USING ICE DETECTION SENSORS

The following material is presented to confirm the integrity of the APS simulation of freezing drizzle and light freezing rain.

The qualification of freezing point depressant fluids for use in aircraft de-icing and anti-icing is based on tests developed and conducted by the group at Université du Québec à Chicoutimi (UQAC). For a fluid to qualify, it must pass three tests: water spray endurance test (WSET); high humidity endurance test (HHET); and fluid run-off performance aerodynamic test.

UQAC has conducted additional tests at their facility in Chicoutimi to simulate freezing drizzle at a precipitation rate of 10 g/dm²/hr and light freezing rain at 25 g/dm²/hr. The holdover time results were provided to APS and are summarized in Table G.1.

Table G.1
Summary of UQAC HOT Test Results
(minutes)

	Light Freezing Rain		**Freezing Drizzle**	
	Type II	**Type IV**	**Type II**	**Type IV**
-14°C	6	6	-	-
-10°C	11	17	27	52
-7°C	23	34	37	100
-5°C	26	35	-	-
-3°C	-	-	72	100

Note: Average times were computed when multiple tests were conducted under the same conditions.

In the past, questions were raised concerning the validity of APS tests. These concerns were addressed in last year's (1994/95) report TP 12654E wherein one conclusion reached reads as follows: Comparison of the UQAC WSET data at low rates of precipitation to APS' freezing drizzle data, and comparison of the WSET data at higher rates of precipitation to APS' light freezing rain data, showed that the data from UQAC and APS were in agreement. Charts to support this conclusion were presented at an SAE/ISO G-12 meeting and are included in report TP 12654E.

These questions refer specifically to holdover times determined from tests of Type II and Type IV fluids under conditions of freezing drizzle and light freezing rain in the temperature range of -3°C to -10°C. APS was advised of these concerns very shortly prior to the 1996 Denver Holdover Time Sub-Committee Meeting and were not able to verify these claims in time to present updated material at the meeting. However, additional light freezing rain tests were conducted in the interim prior to the Zurich meeting and further tests were conducted after the Zurich meeting.

Ice detection sensors were also employed as part of the data acquisition process in these tests. This permitted instrument response analysis and comparison to observers' fluid failure calls.

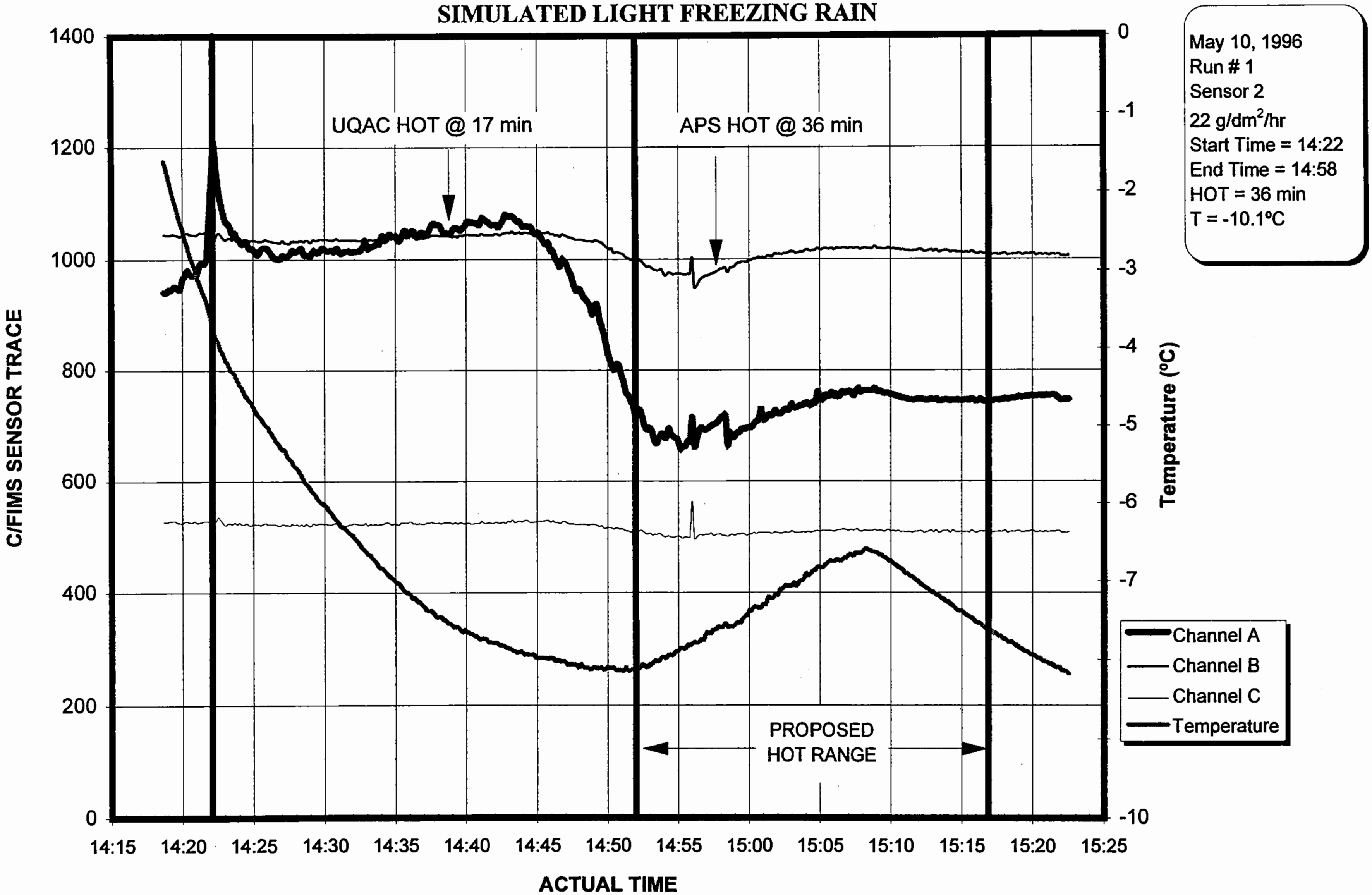
Figure G.1 shows the sensor response for three channels of Allied Signal's C/FIMS detector plotted against time for a neat Type IV fluid tests conducted under artificial light freezing rain at -10.1°C. The precipitation rate was measured to be 22 $g/dm^2/hr$. Also indicated in the figure are the UQAC fluid failure times from Table G.1 (17 minutes), the APS observer's visual failure call (36 minutes), and a trace of the plate temperature. The APS failure call compares favourably with the proposed holdover time range of 30 to 60 minutes and closely coincides with the discontinuity in the C/FIMS sensor traces. At 17 minutes into the test, the C/FIMS trace shows the fluid film to be as thick, if not thicker, than at the start of the test. It appears that from 14:46 to 14:53 (elapsed time range: 24 to 31 minutes), the film was being diluted and thinned by the precipitation. Between 14:53 and 15:00 (elapsed time range: 31 to 38 minutes), the sensor traces suggest that ice was forming on the sensor head. Failure of the plate crosshair above the sensor was noted by the APS observer at 14:59 (elapsed time: 36 minutes).

Figure G.2 shows the C/FIMS trace from a neat Type II fluid test conducted in 1995 under artificial light freezing rain at -8.3°C. Again, the precipitation rate was measured to be 22 $g/dm^2/hr$. It appears from the detector trace that under the conditions of the APS test, the

FIGURE G.1

C/FIMS SENSOR TRACE vs TIME FOR TYPE IV NEAT - RUN 1

SIMULATED LIGHT FREEZING RAIN

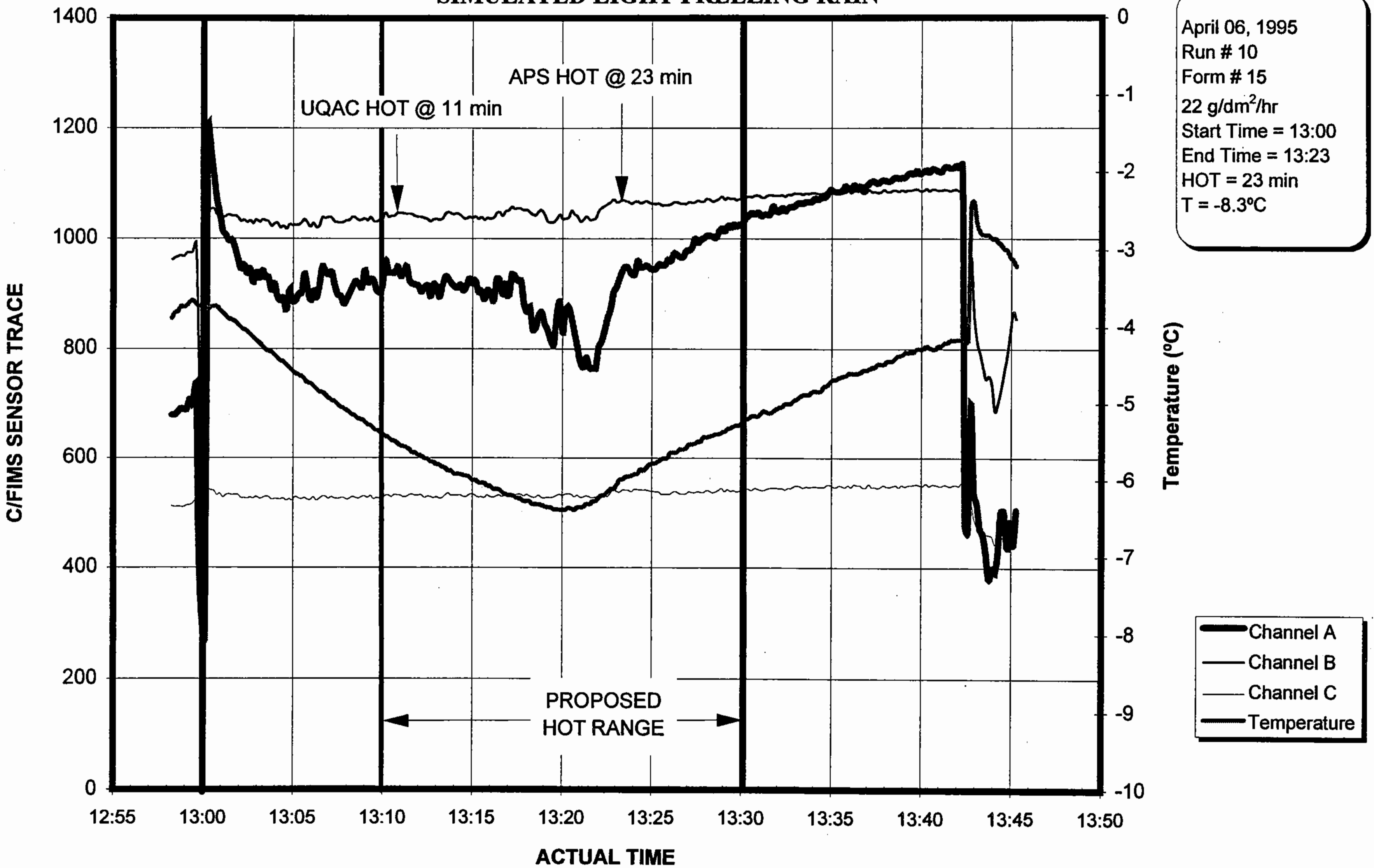


File:c\cm1283\report\hot_subs\UQAC_APG.XLS
At: May 10, Run 1, 12/03/97

FIGURE G.2

C/FIMS SENSOR TRACE vs TIME FOR TYPE II NEAT

SIMULATED LIGHT FREEZING RAIN



File:c\cm1283\report\hot_subs\UQAC_APG.XLS
At: April 6, Run 10-F15, 12/03/97

UQAC failure call (11 minutes) was prior to fluid thinning by precipitation. Although the deflection is less pronounced than the detector response exhibited in Figure G.1, the dip begins at 13:18. The APS failure call was made at 13:23, just after the discontinuity in the C/FIMS trace. It is evident that the APS call is close to the upper time limit of the proposed HOT range.

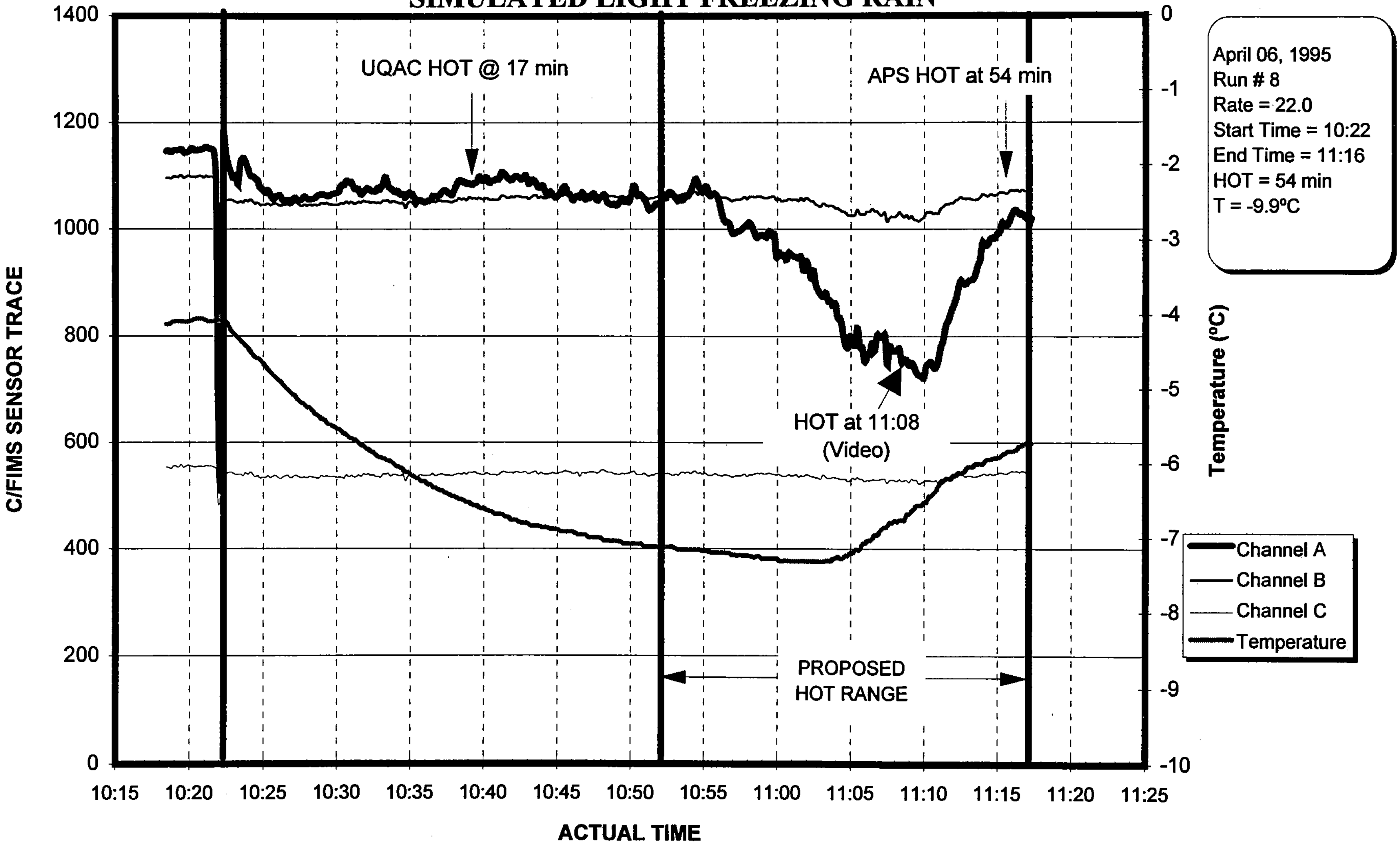
Note that UQAC calls were made on tests which were supposed to be equivalent to test conditions employed by APS. The UQAC team was not actually present during the tests from which Figures G.1 and G.2 were prepared. The ambiguity between the failure call times may have arisen from differences in the simulation conditions and is not intended to call the UQAC team's judgement into question. Note also that in Figure G.2, the APS failure call corresponds to a region in the C/FIMS trace which is consistent with that of Figure G.1. Nonetheless, based upon the UQAC test results, the holdover time lower limit for neat Type II fluids was reduced from 15 minutes to 10 minutes.

The C/FIMS sensor traces for six other APS experiments (Figure G.3 to G.8) are also presented. All indicate UQAC failure calls significantly before the C/FIMS traces signal the onset of ice formation in the APS tests. All APS failure calls were consistently made just after abrupt discontinuities appear in the C/FIMS traces.

For some tests, RVSI's ID-1 remote ice detection sensor was available. This allowed another method of measurement to be employed along with the visual observations and the C/FIMS ice sensors. The bar charts shown in Figure G.9 to G.18 show the observed failure times during the tests along with the proposed holdover time ranges for neat Type IV fluids. The precipitation rates were 19 to 25 g/dm^2/hr under conditions of light freezing rain. The failure times called by the UQAC group are also included for the purposes of comparison. The test corresponding to Figure G.11, for which conditions of light freezing rain at a temperature of -10°C and a precipitation rate of 25 g/dm^2/hr shows the UQAC failure call for an equivalent test (first bar) as being 17 minutes. The three other bars represent the sensitivities of three of the eight channels of the RVSI instrument. These channels represent the three channels which correlated most frequently with APS failure calls.

FIGURE G.3

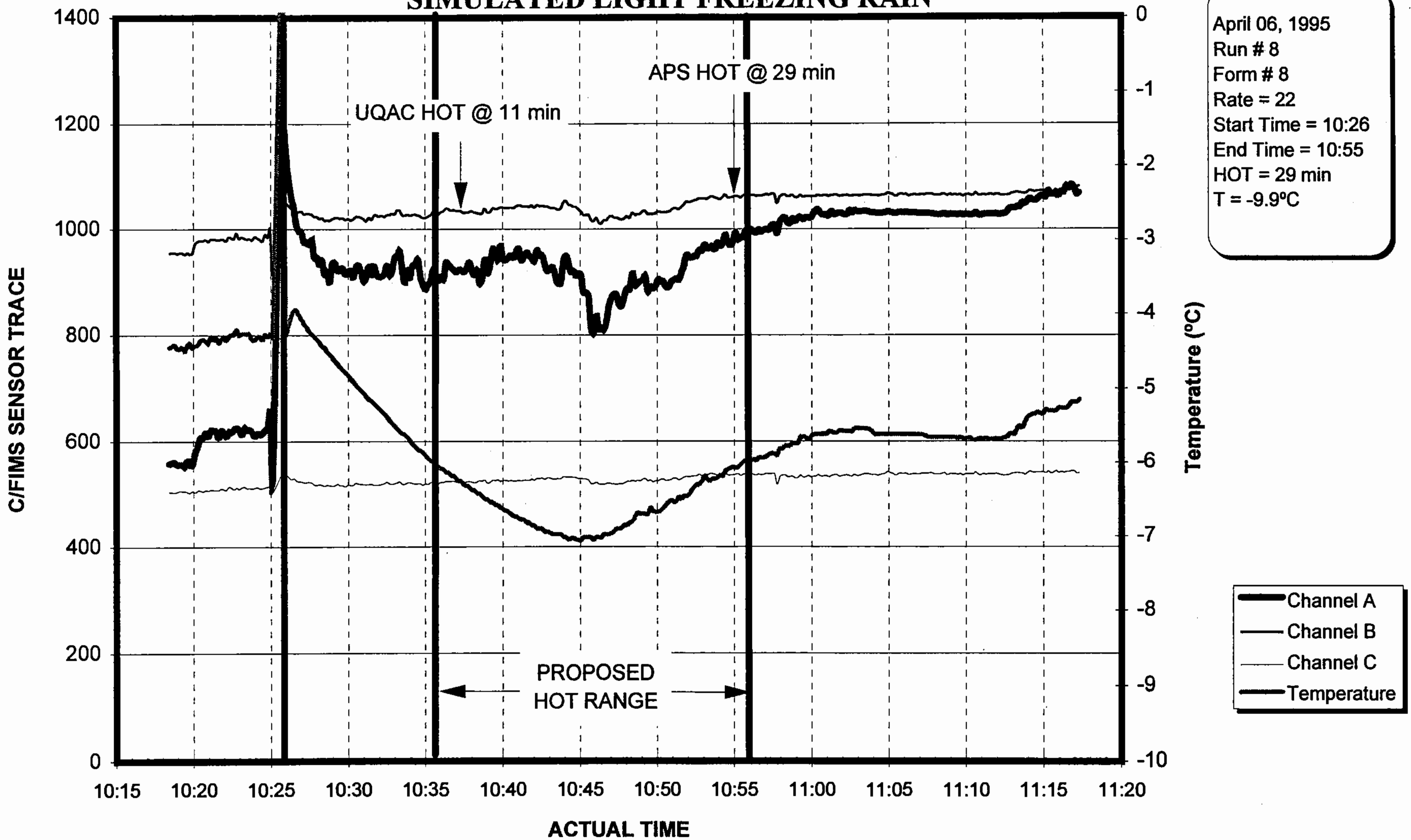
C/FIMS SENSOR TRACE vs TIME FOR TYPE IV NEAT - RUN 8
SIMULATED LIGHT FREEZING RAIN



File:c\cm1283\analysis\frz_prec\UQAC_APG.XLS
At: April 6, Run 8, 12/03/97

FIGURE G.4

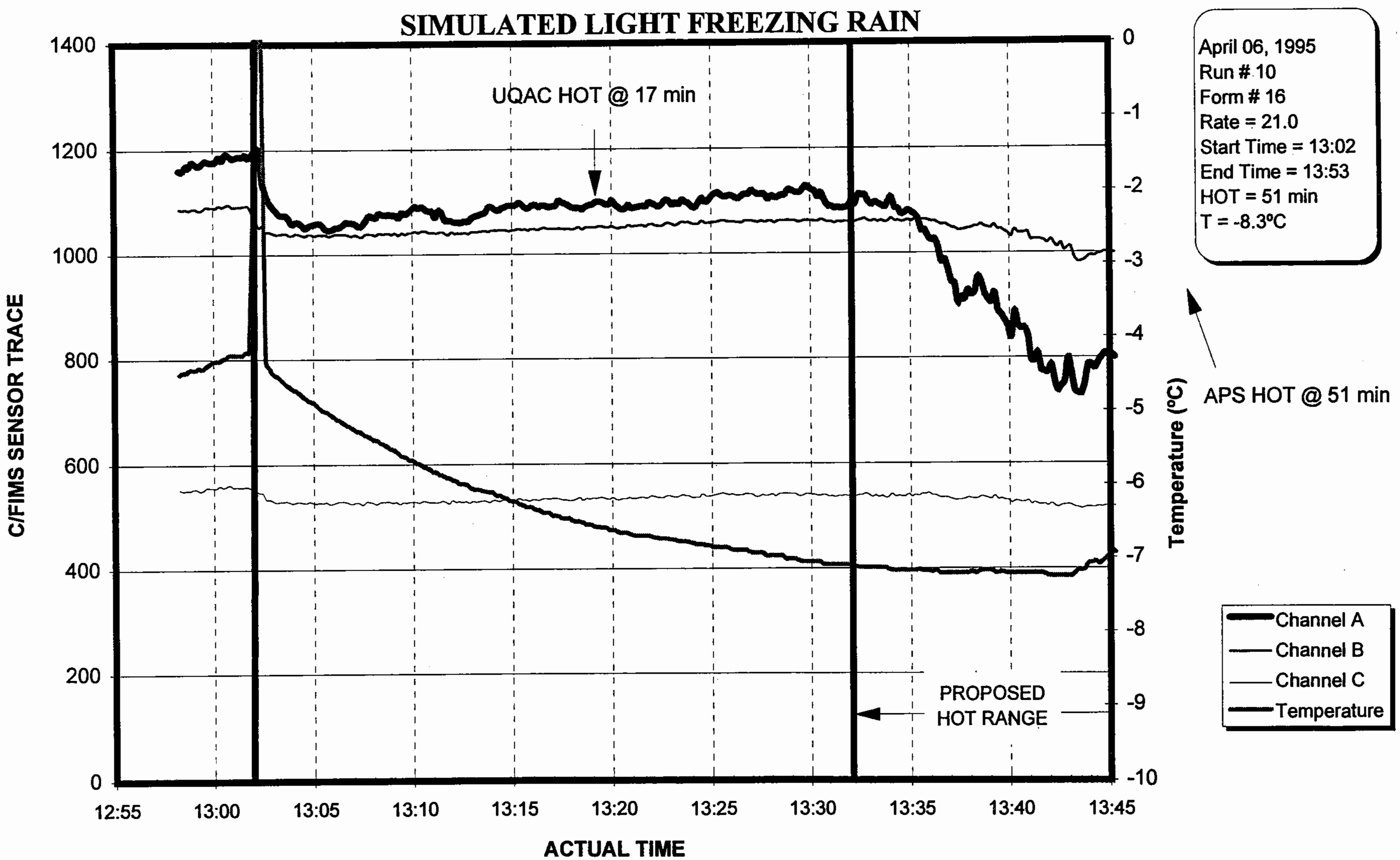
C/FIMS SENSOR TRACE vs TIME FOR TYPE II NEAT - RUN 8
SIMULATED LIGHT FREEZING RAIN



File:c\cm1283\analysis\frz_prec\UQAC_APG.XLS
At: April 6, Run 8-F8, 12/03/97

FIGURE G.5

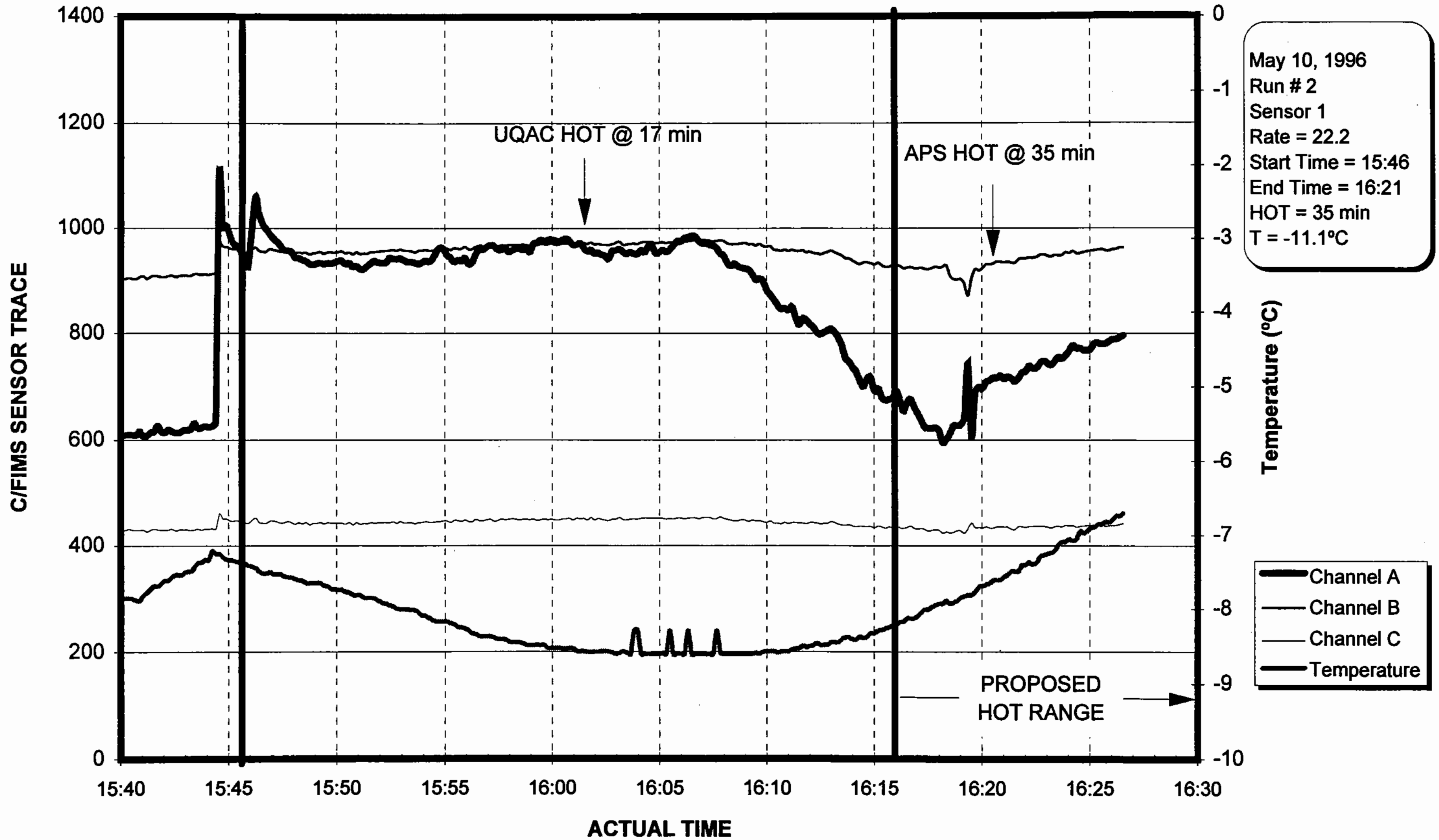
C/FIMS SENSOR TRACE vs TIME FOR TYPE IV NEAT - RUN 10
SIMULATED LIGHT FREEZING RAIN



File:c\cm1283\analysis\frz_prec\UQAC_APG.XLS
At: April 6, Run 10, 12/03/97

FIGURE G.6

C/FIMS SENSOR TRACE vs TIME FOR TYPE IV NEAT - RUN 2
SIMULATED LIGHT FREEZING RAIN

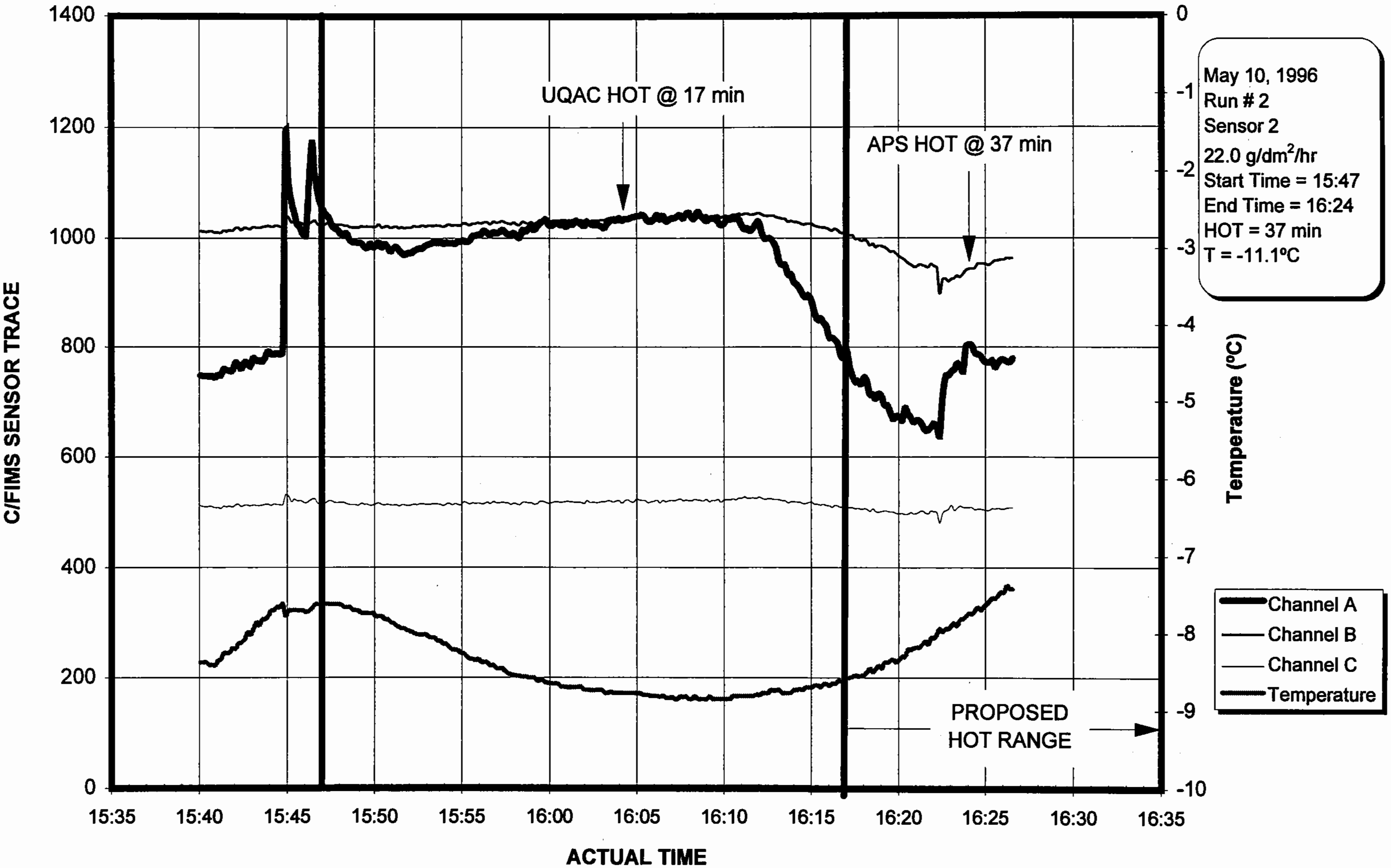


File:c\cm1283\analysis\frz_prec\UQAC_APG.XLS
At: May 10, Run 2, 10/11/96

FIGURE G.7

CFIMS SENSOR TRACE vs TIME FOR TYPE IV NEAT - RUN 2

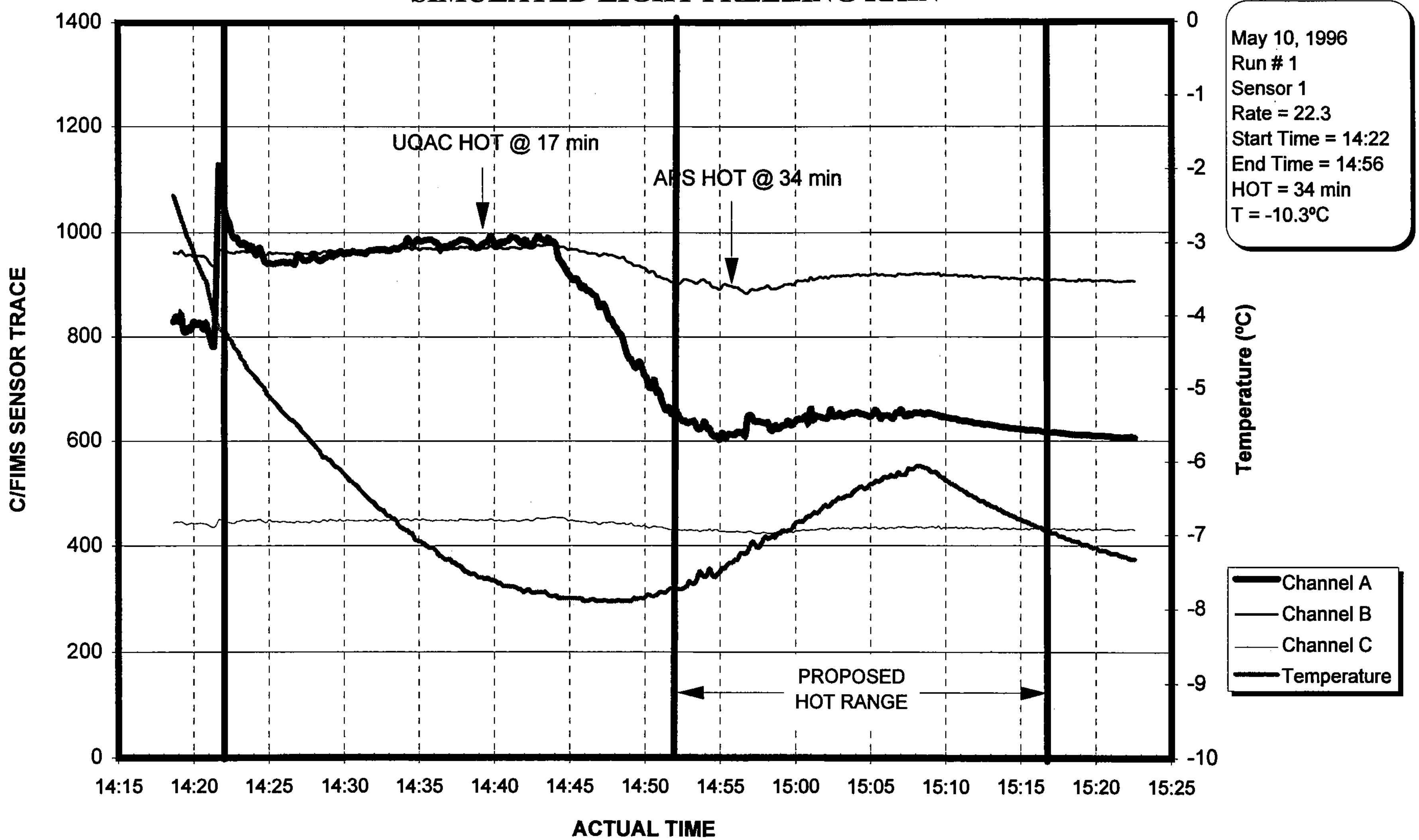
SIMULATED LIGHT FREEZING RAIN



File:c\cm1283\report\hot_subs\UQAC_APG.XLS
At: May 10, Run 2-S2, 10/11/96

FIGURE G.8

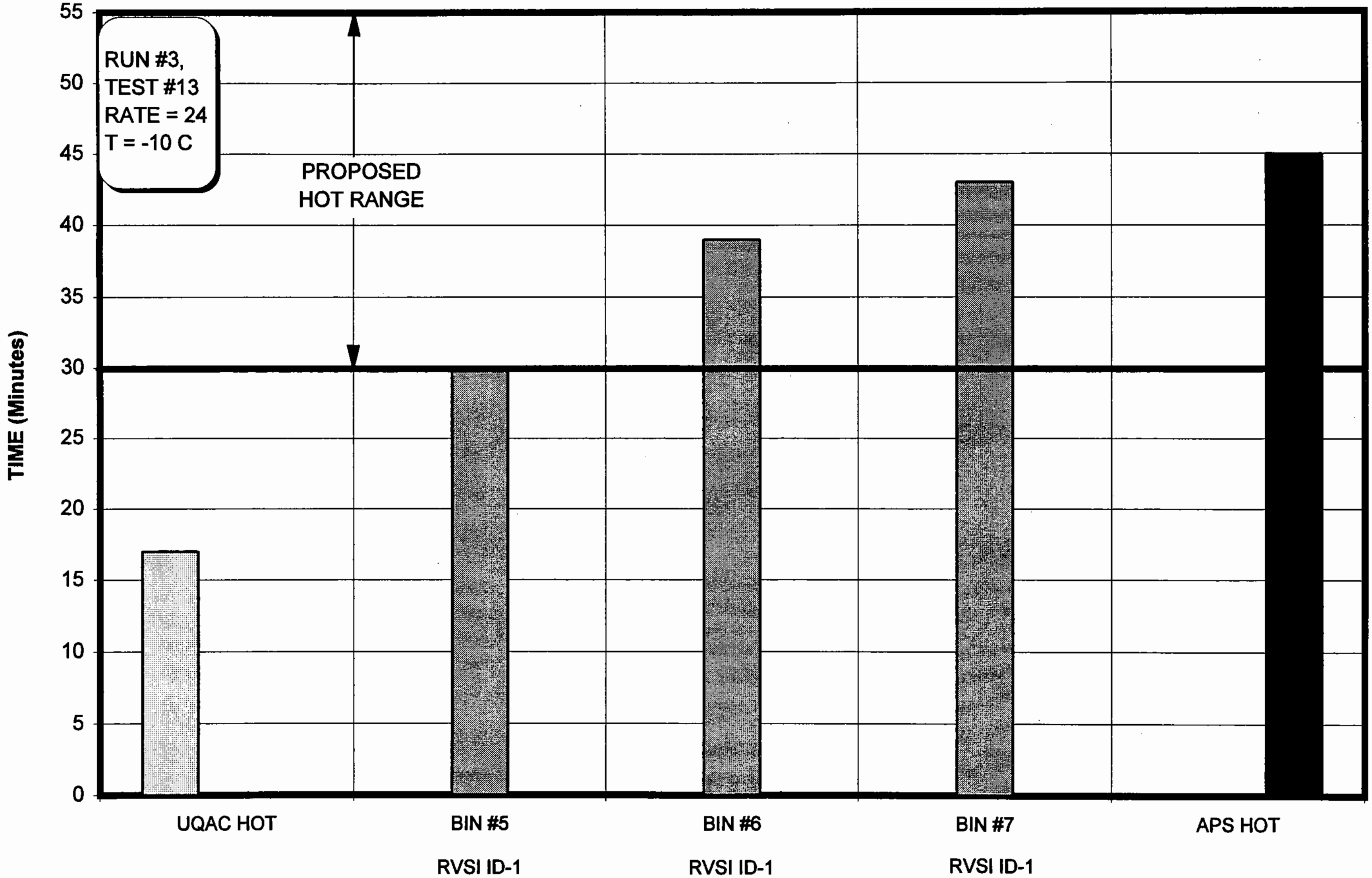
C/FIMS SENSOR TRACE vs TIME FOR TYPE IV NEAT - RUN 1
SIMULATED LIGHT FREEZING RAIN



File:c\cm1283\analysis\frz_prec\UQAC_APG.XLS
At: May 19, Run 1, 10/11/96

FIGURE G.9

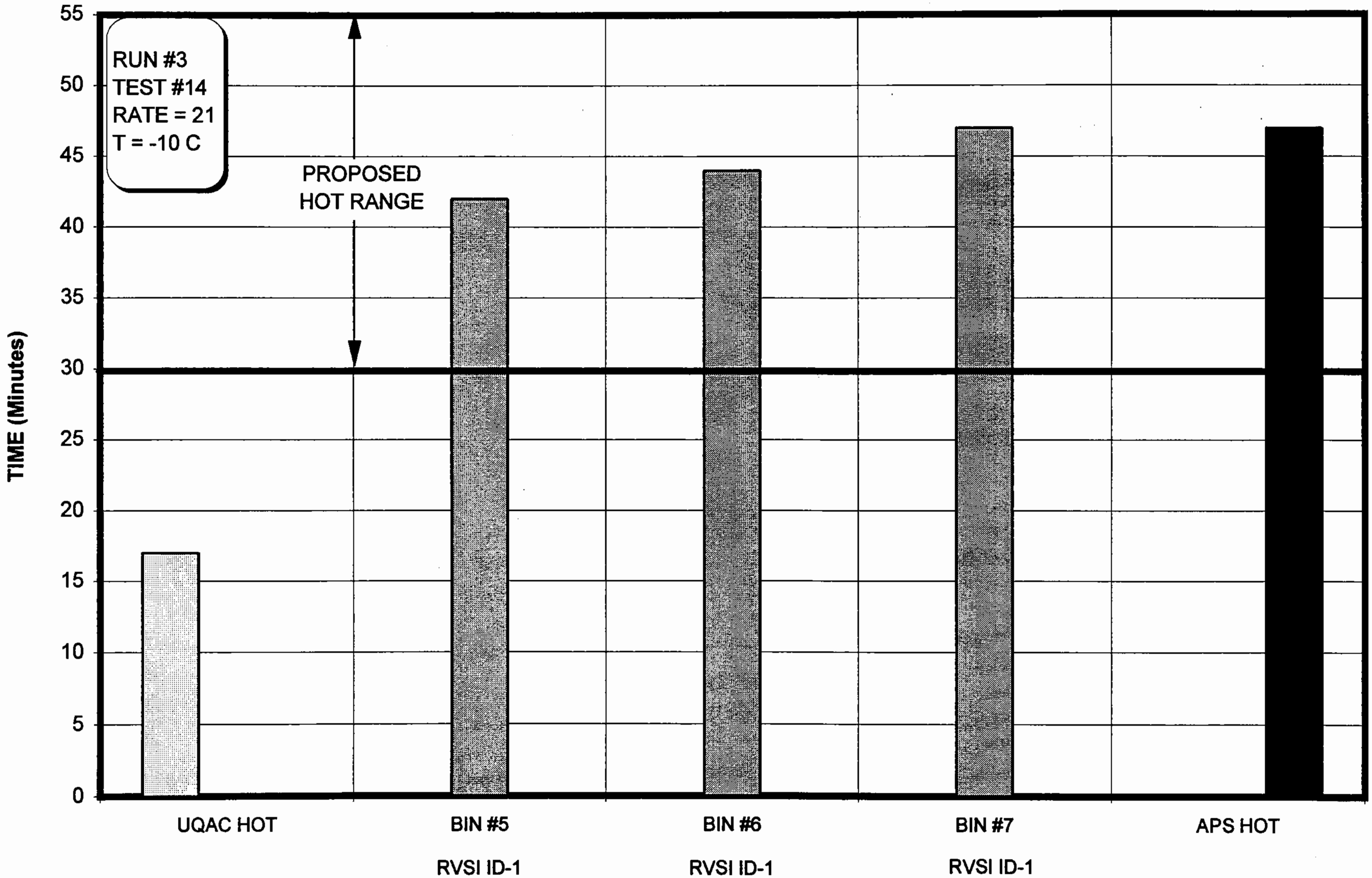
COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 3, TEST 13
TYPE IV NEAT FLUIDS



File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 3_13
Printed: 10/11/96

FIGURE G.10

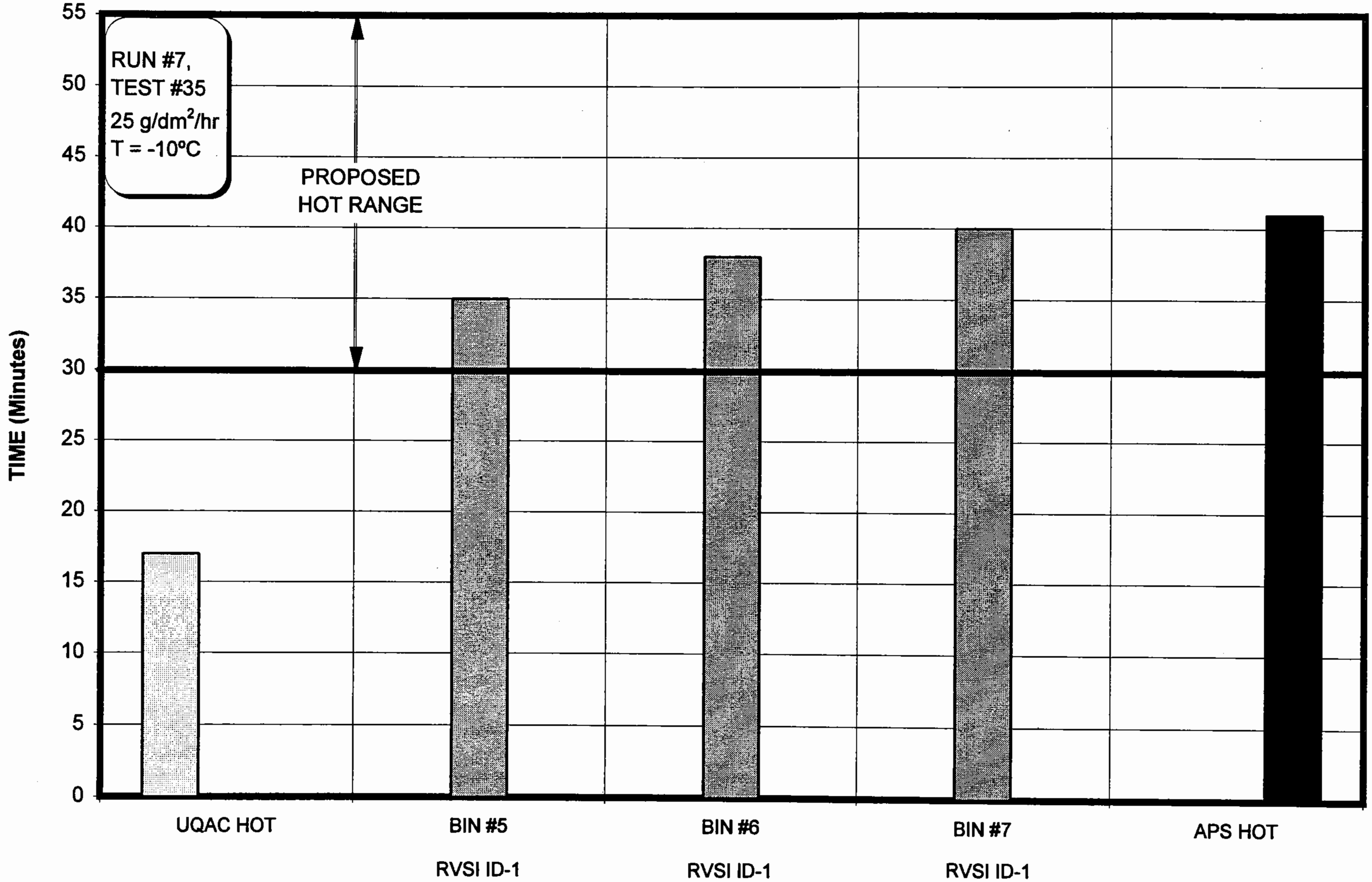
COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 3, TEST 14
TYPE IV NEAT FLUIDS



File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 3_14
Printed: 10/11/96

FIGURE G.11

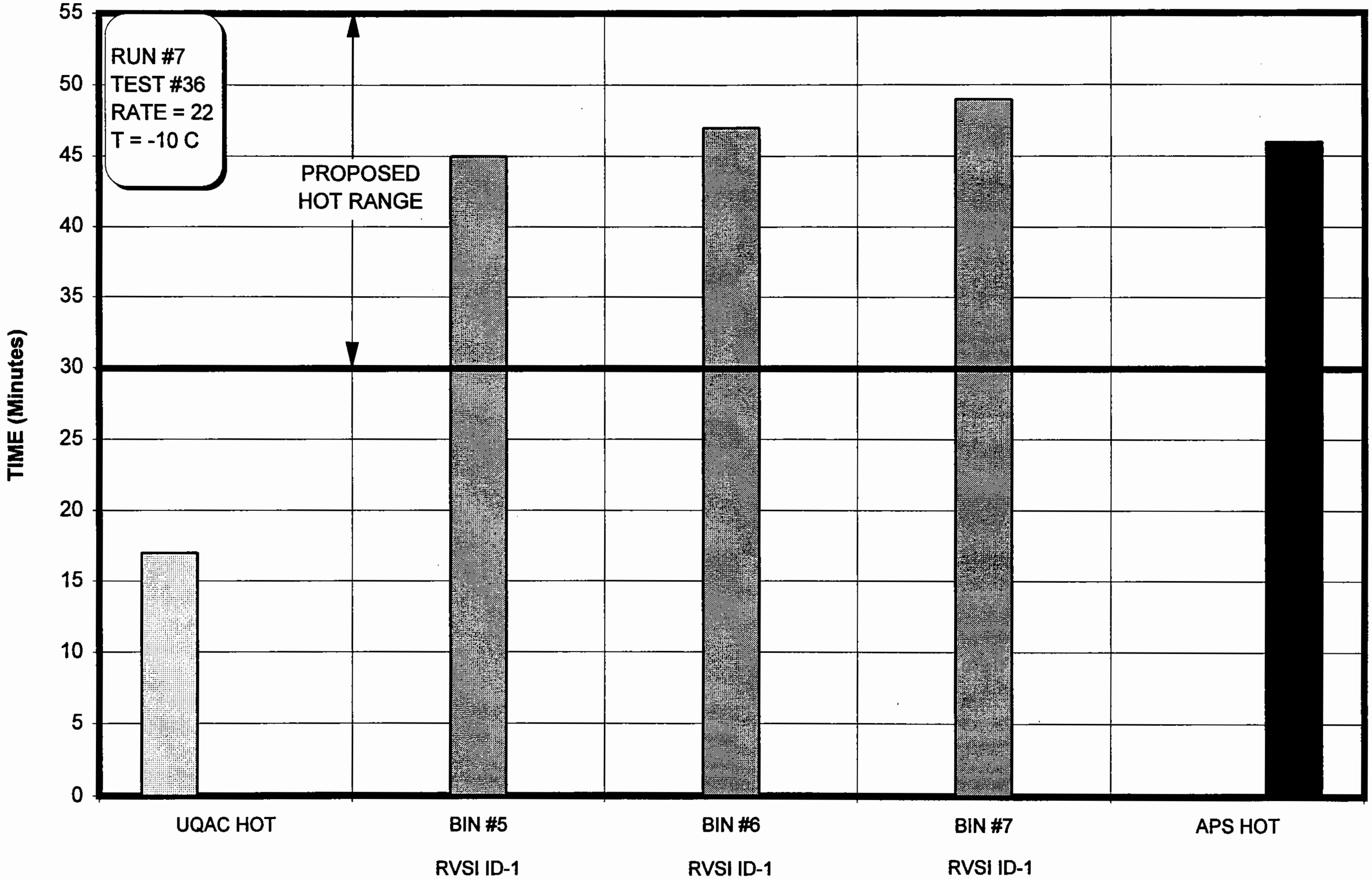
COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 7, TEST 35
TYPE IV NEAT FLUIDS



File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 7_35
Printed: 10/11/96

FIGURE G.12

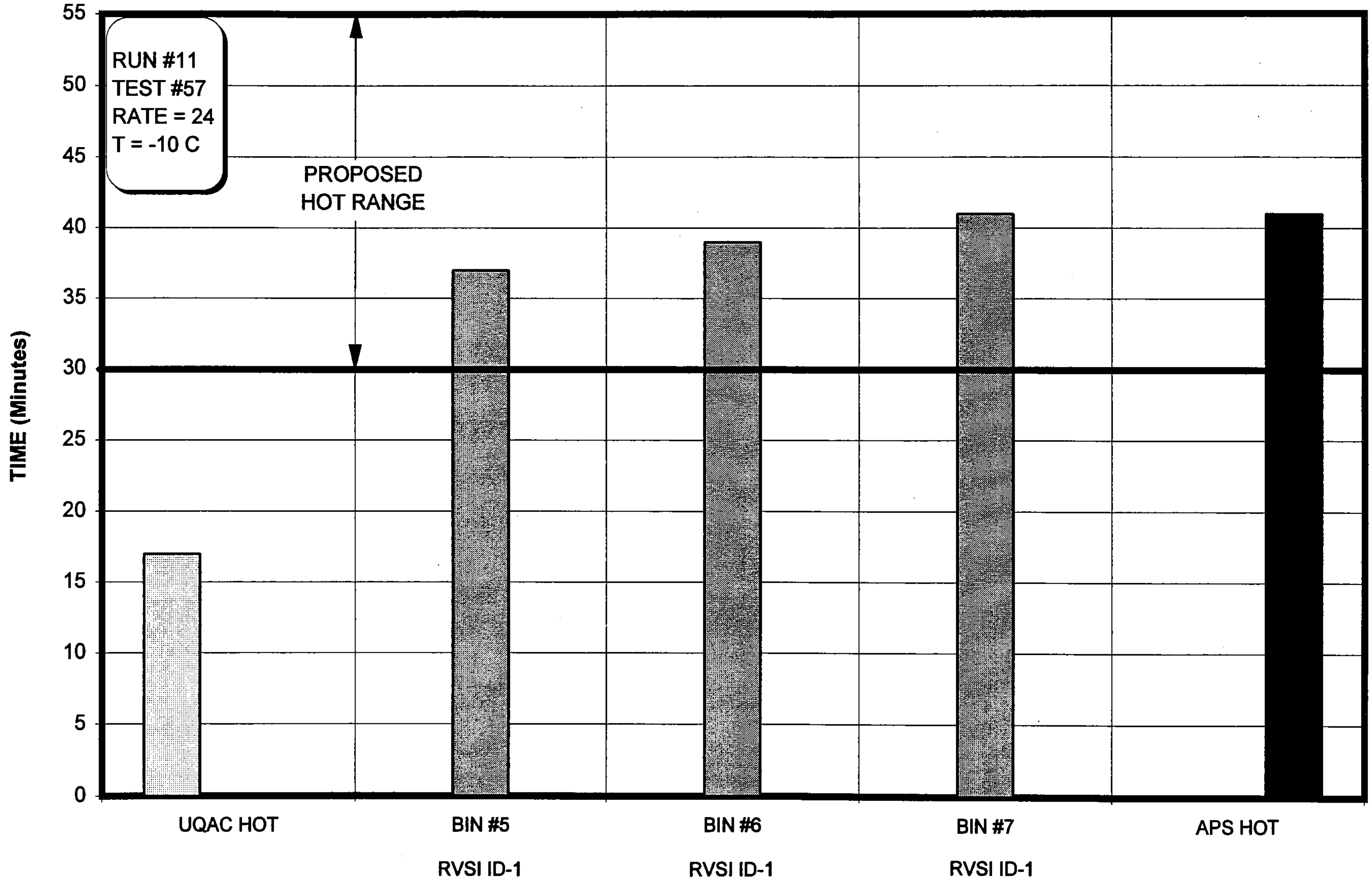
COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 7, TEST 36
TYPE IV NEAT FLUIDS



File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 7_36
Printed: 10/11/96

FIGURE G.13

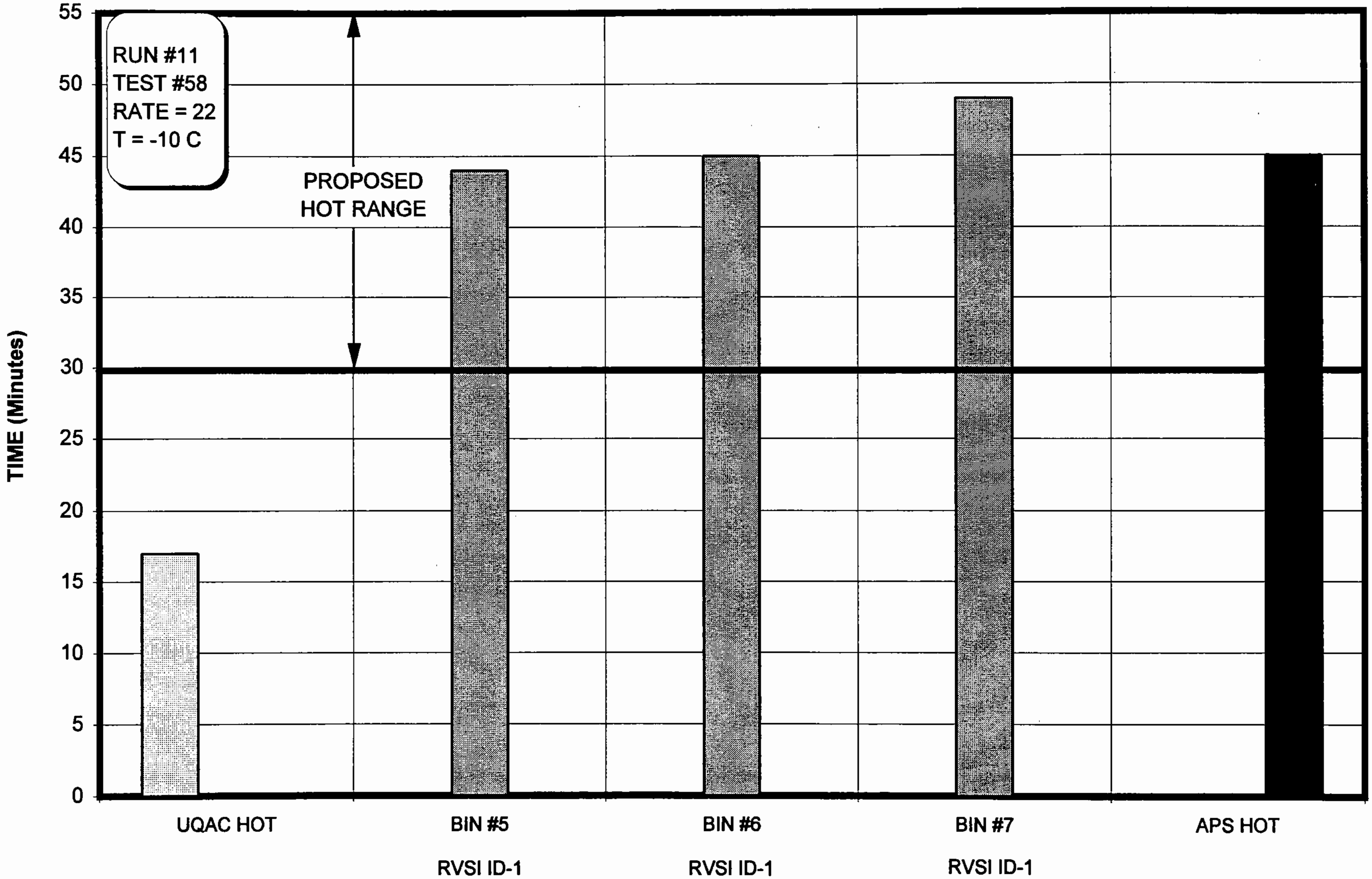
COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 11, TEST 57
TYPE IV NEAT FLUIDS



File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 11_57
Printed: 10/11/96

FIGURE G.14

COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 11, TEST 58
TYPE IV NEAT FLUIDS

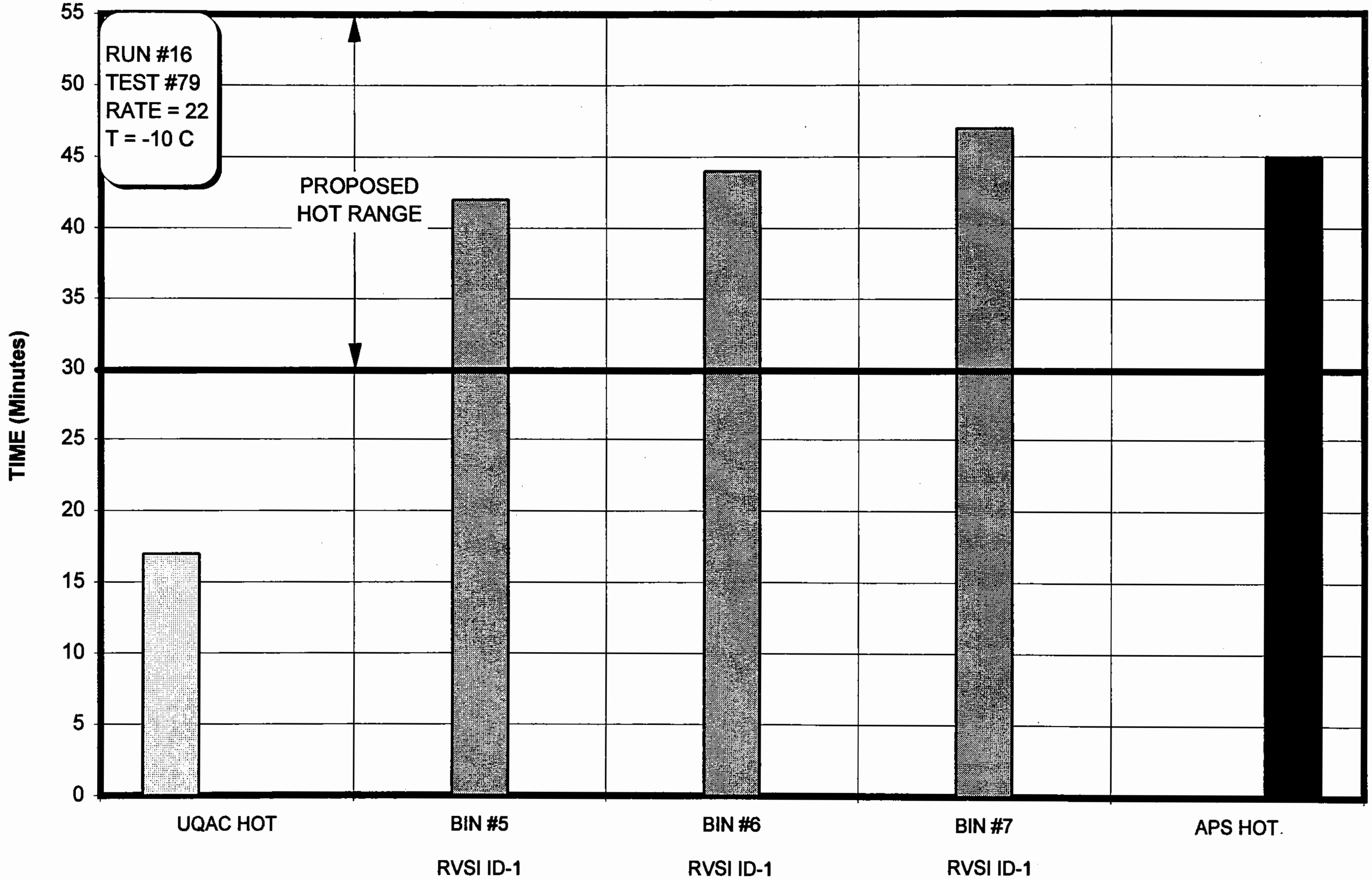


File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 11_58
Printed: 10/11/96

FIGURE G.15

COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 16, TEST 79

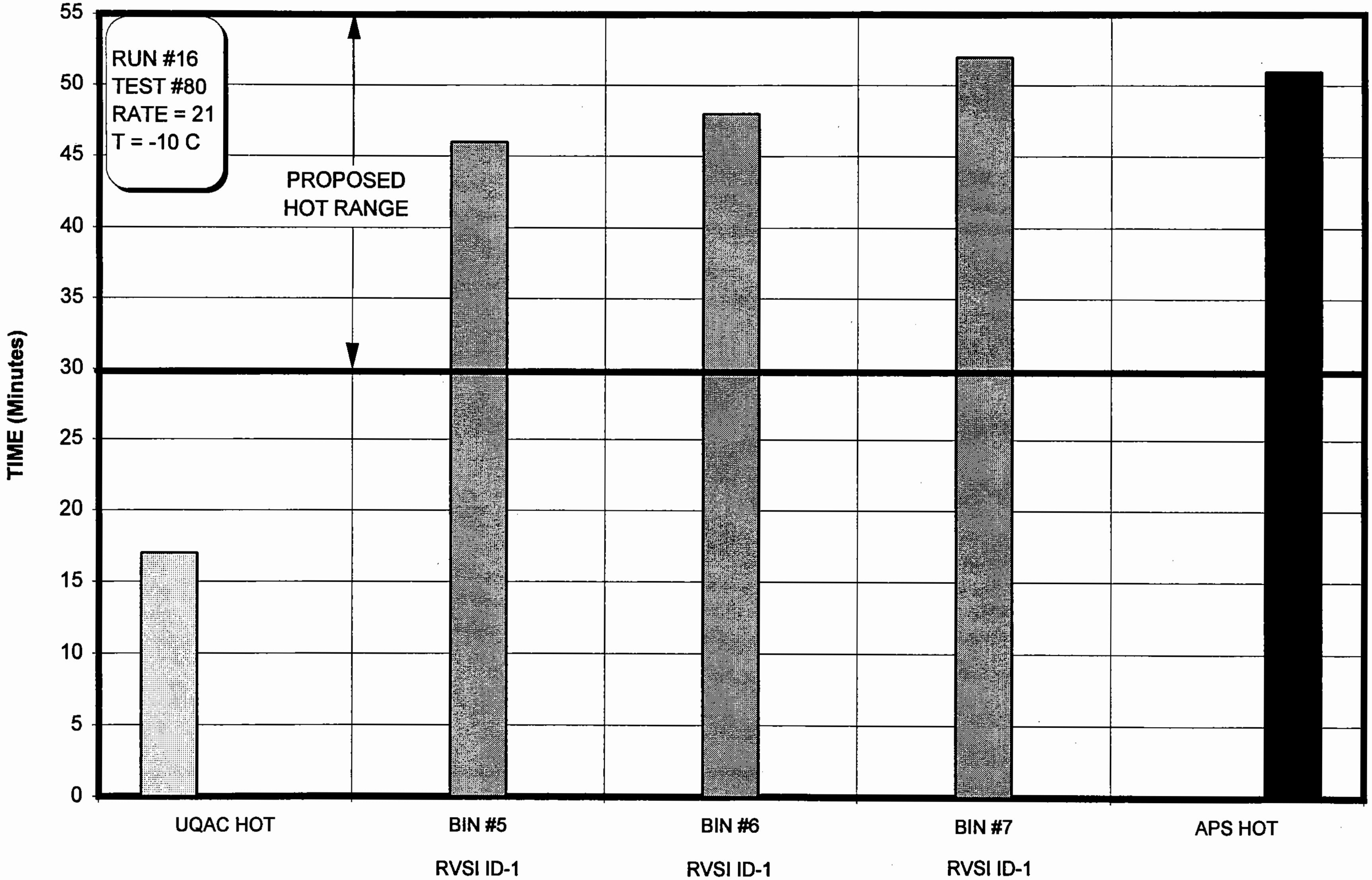
TYPE IV NEAT FLUIDS



File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 16_79
Printed: 10/11/96

FIGURE G.16

COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 16, TEST 80
TYPE IV NEAT FLUIDS

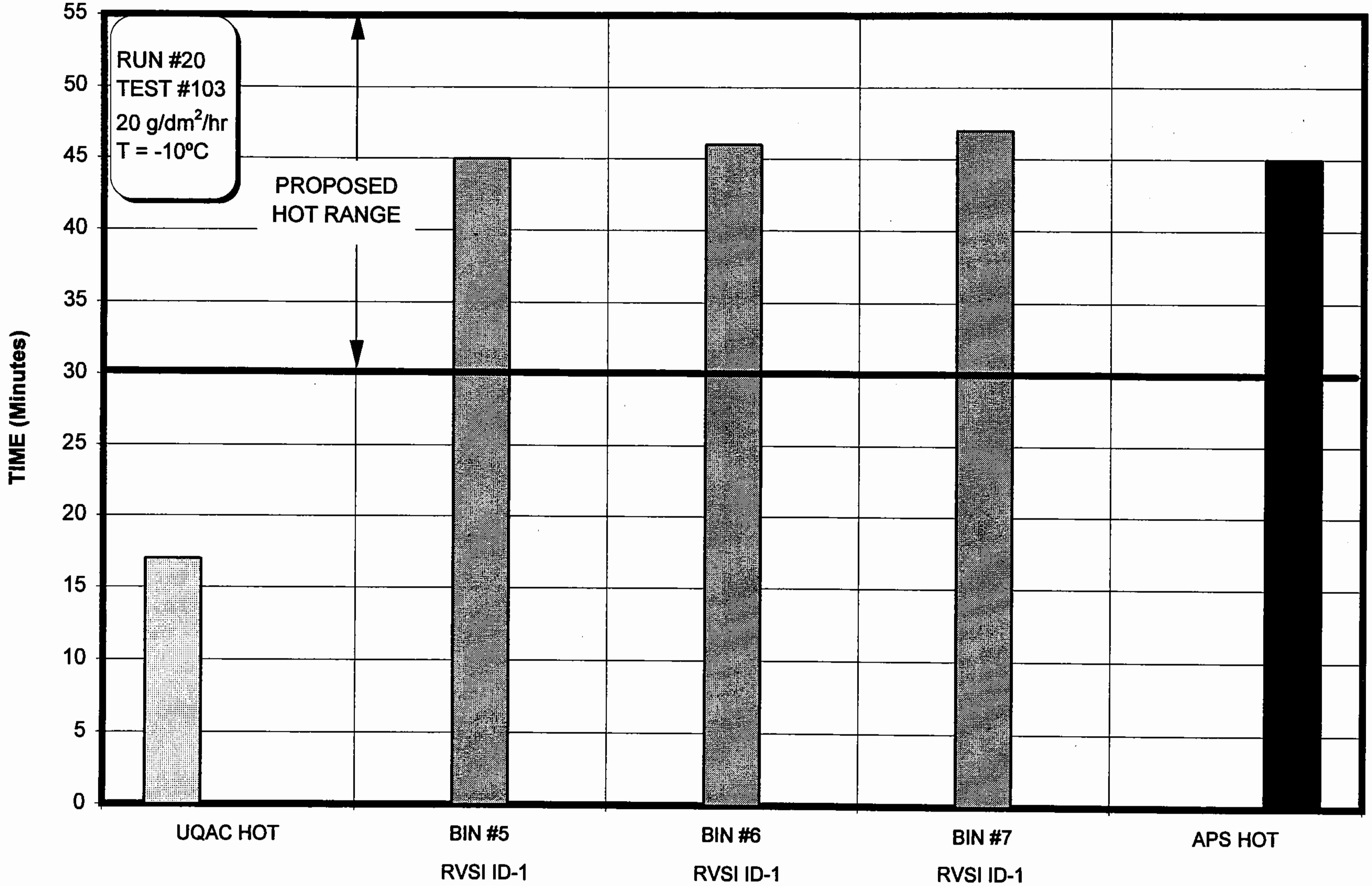


File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 16_80
Printed: 10/11/96

FIGURE G.17

COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 20, TEST 103

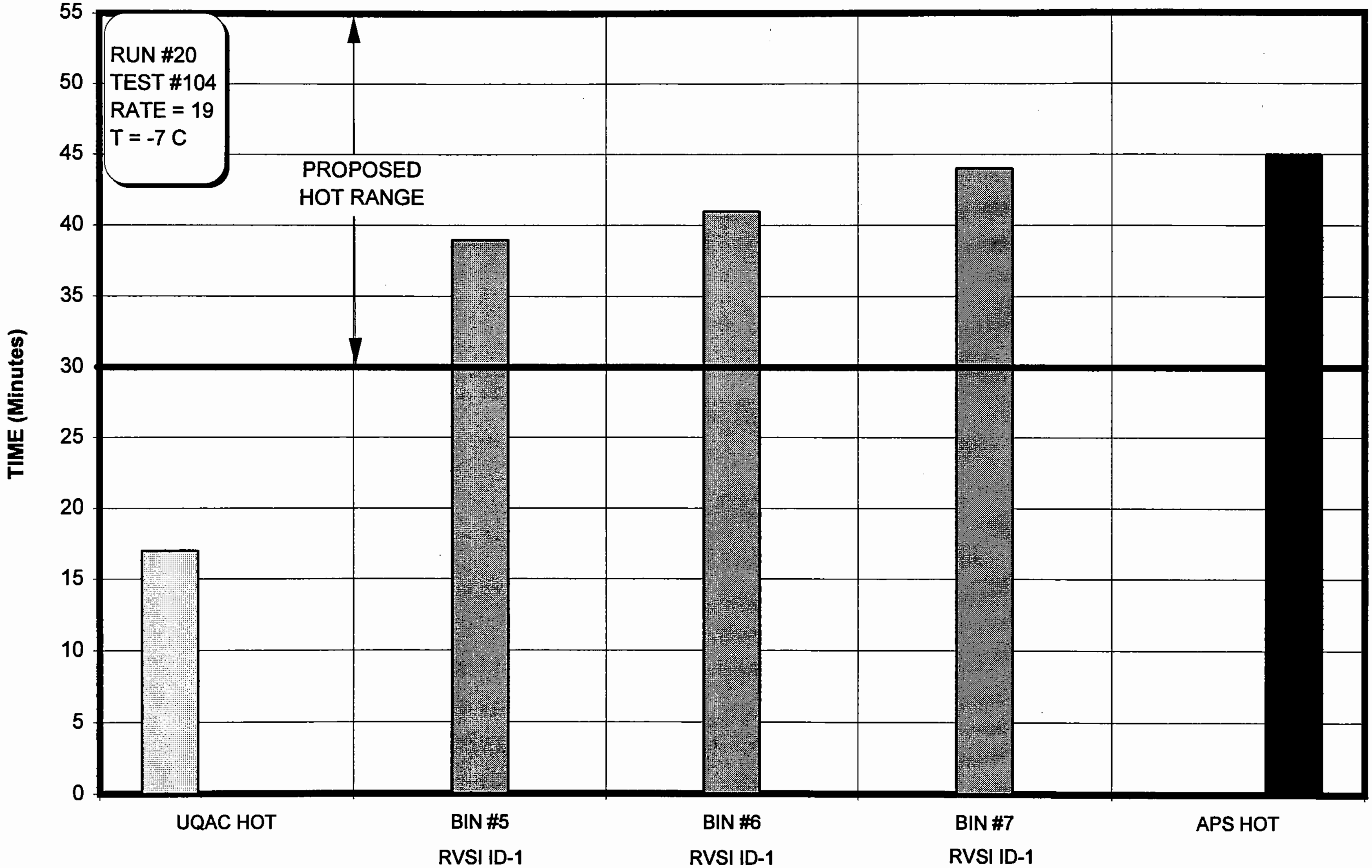
TYPE IV NEAT FLUIDS



File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 20_103
Printed: 10/11/96

FIGURE G.18

COMPARISON OF SENSOR, APS AND UQAC HOT - RUN 20, TEST 104
TYPE IV NEAT FLUIDS



File:g:\cm1283\reoport\hot_subs\RVSI_SPG.XLS
At: 20_104
Printed: 10/11/96

APPENDIX H

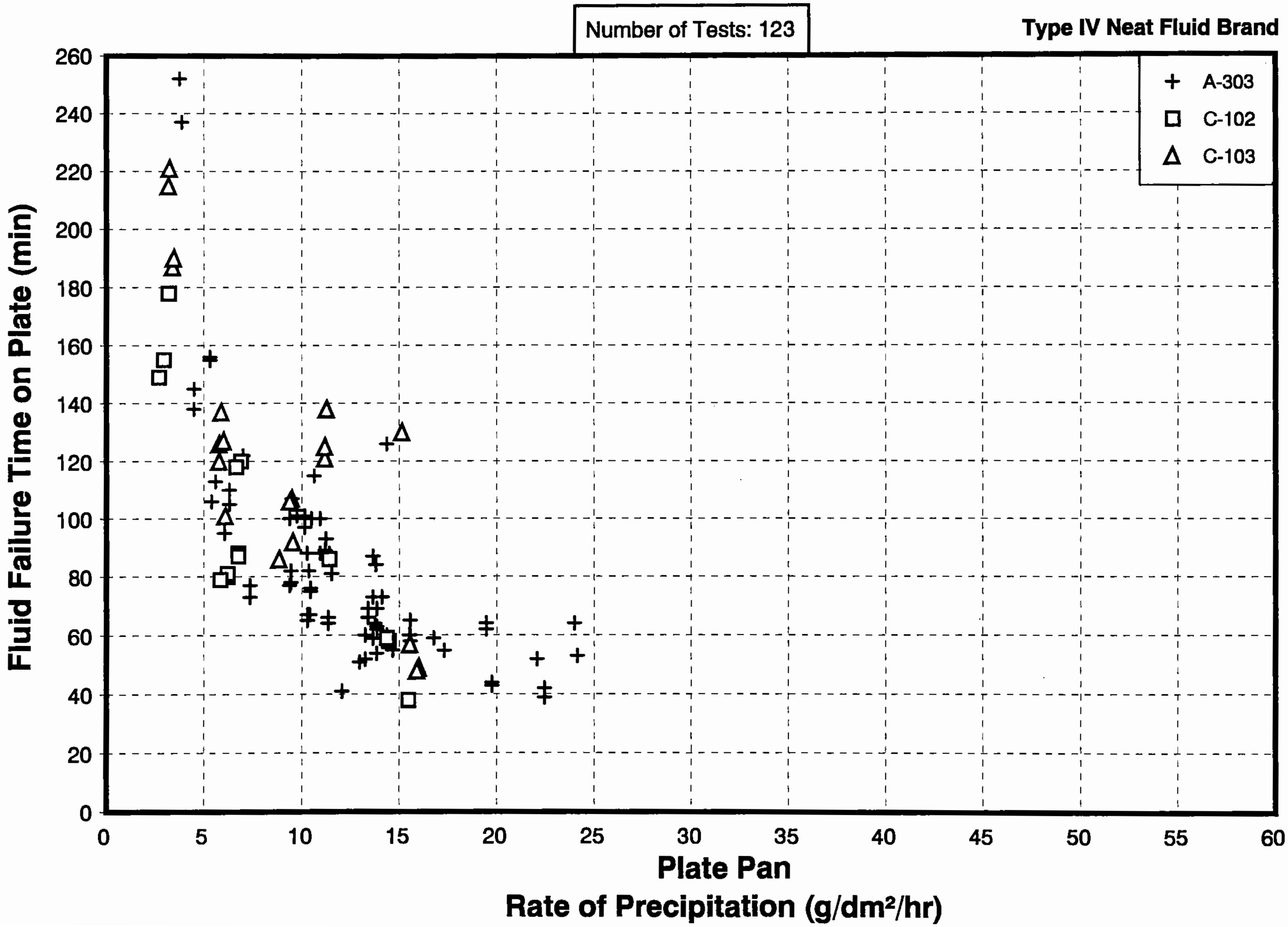
HOT TEST DATA

Type IV Fluid for all Conditions

Type I, Type II Fluid for Rain on Cold-Soaked Surface

FIGURE H.1

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT
NATURAL SNOW CONDITIONS
APS Data - 94/95 to 95/96

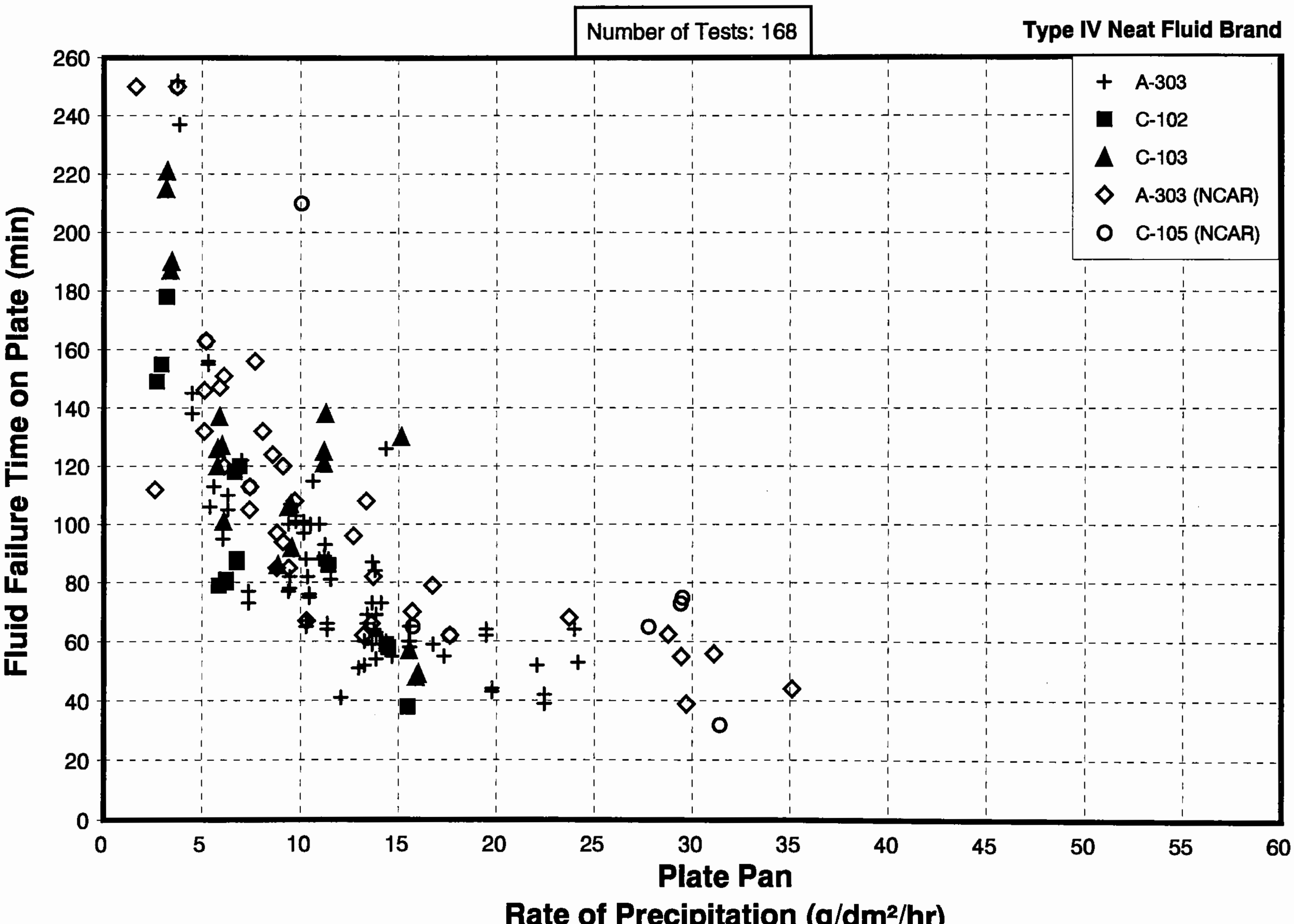


cm1283/report/hot_subs946NS41R.GRF

FIGURE H.2

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT
NATURAL SNOW CONDITIONS

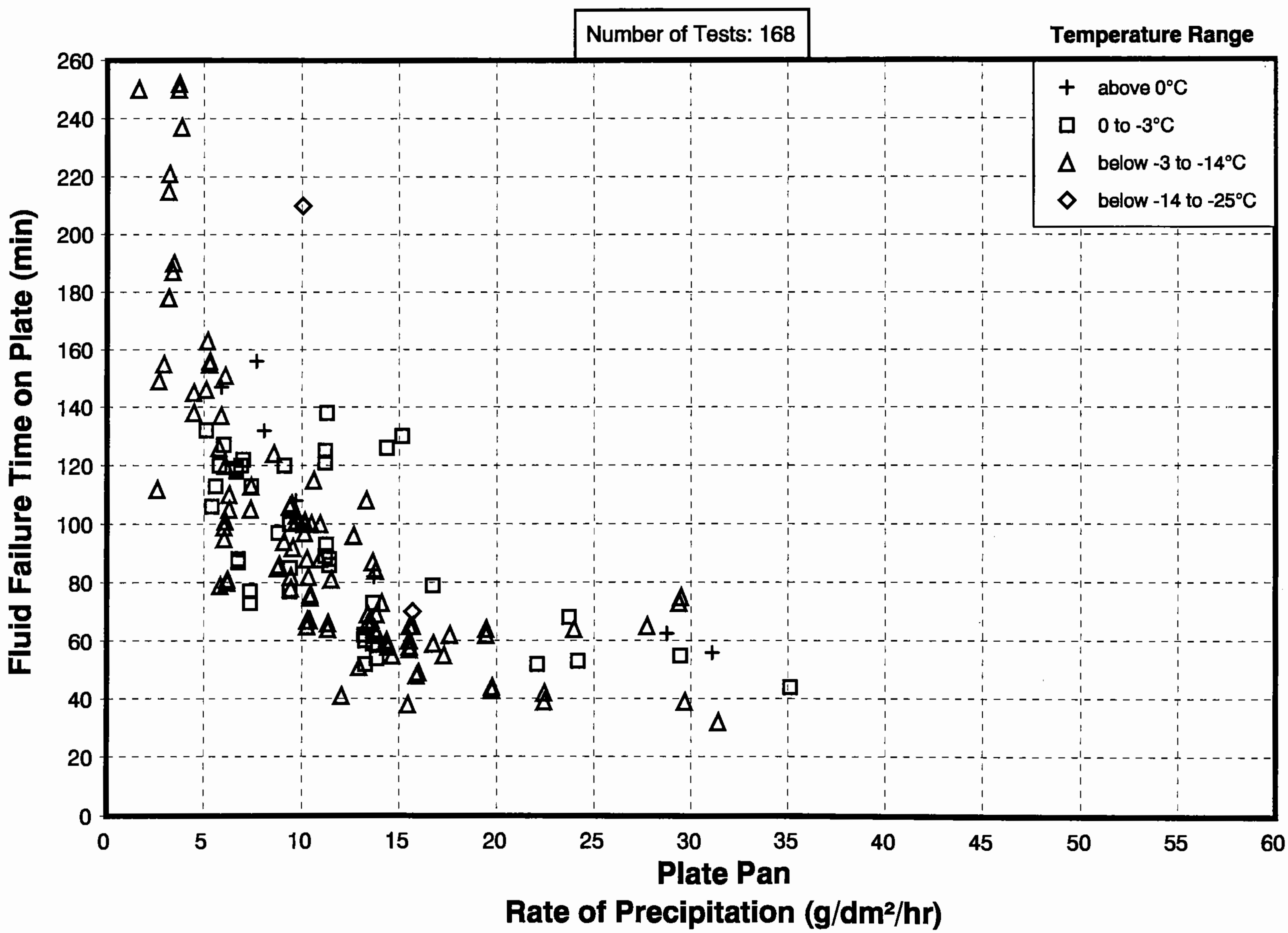
APS Data - 94/95 to 95/96 & NCAR - 94/95 to 95/96



cm1283\report\hot_subs\NCAR41R.GRF

FIGURE H.3

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT
NATURAL SNOW CONDITIONS
APS Data - 94/95 to 95/96 & NCAR - 94/95 to 95/96



cm1283\report\hot_subs\NCAR41C.GRF

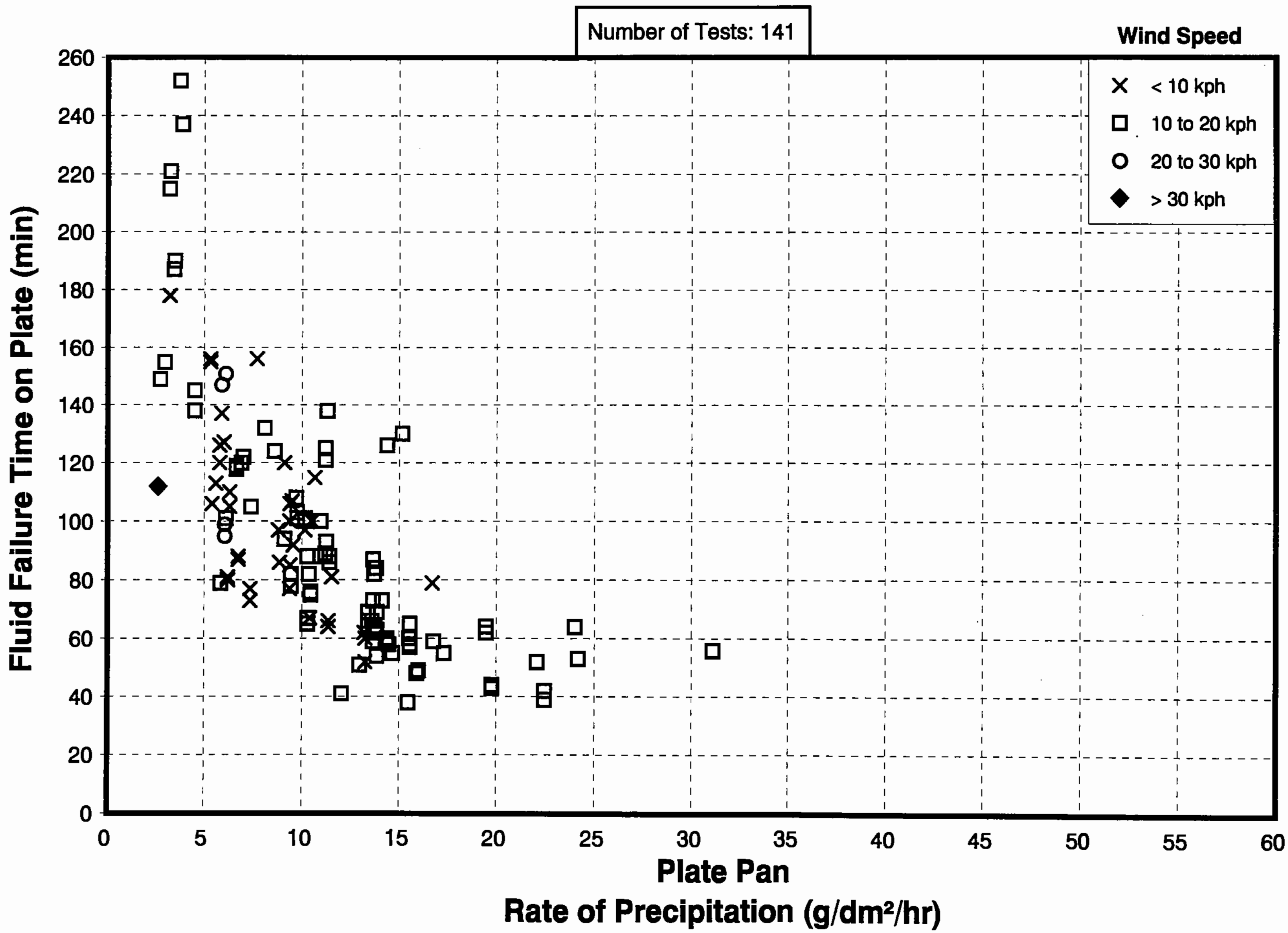
FIGURE H.4

EFFECT OF WIND SPEED AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96 & NCAR - 94/95



cm1283\report\hot_subs\NCAR41W.GRF

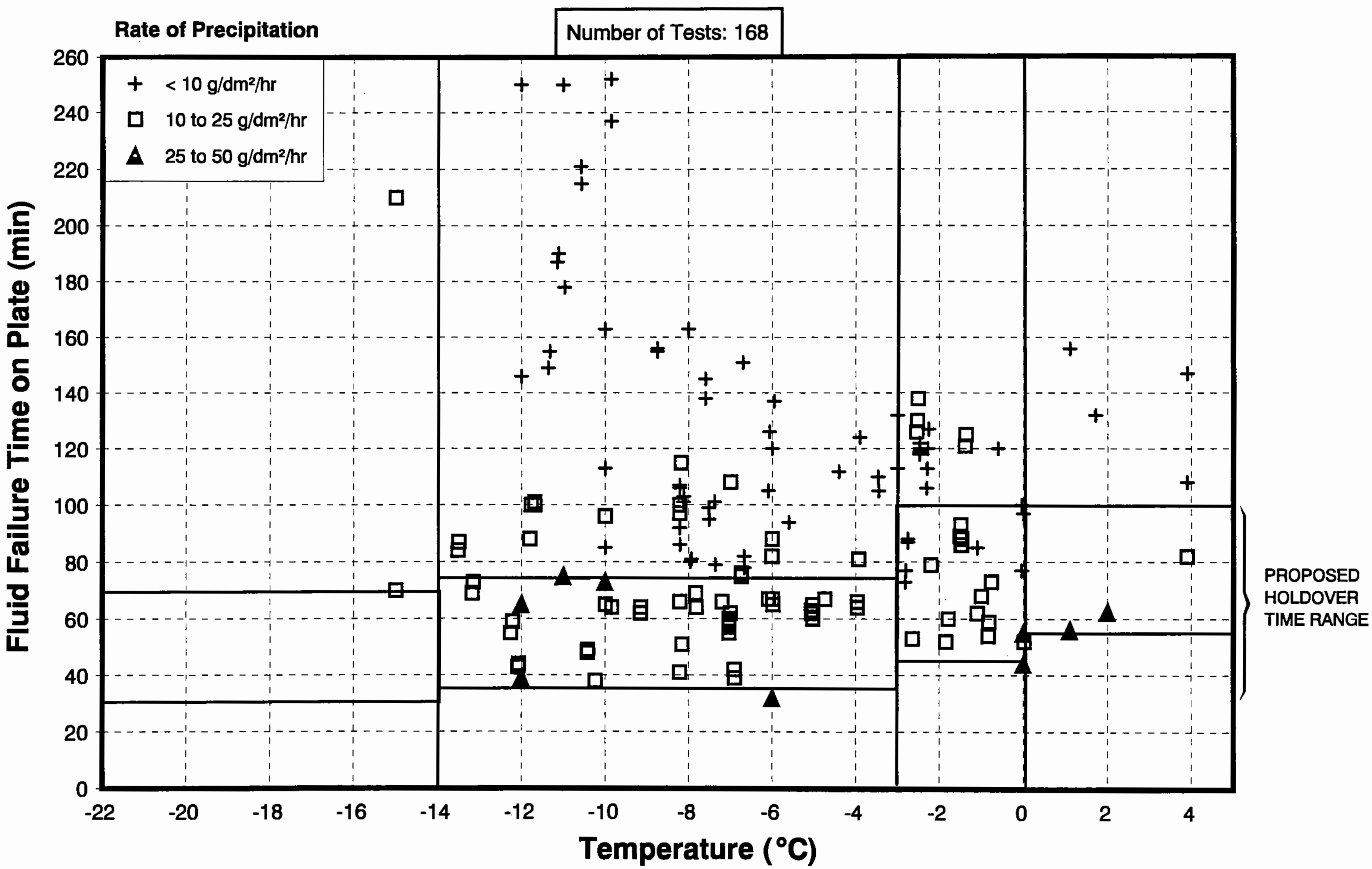
FIGURE H.5

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

TYPE IV NEAT

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96 & NCAR - 94/95 to 95/96



cm1283vepor_hot_subs\NCAR41T.GRF

FIGURE H.6

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96

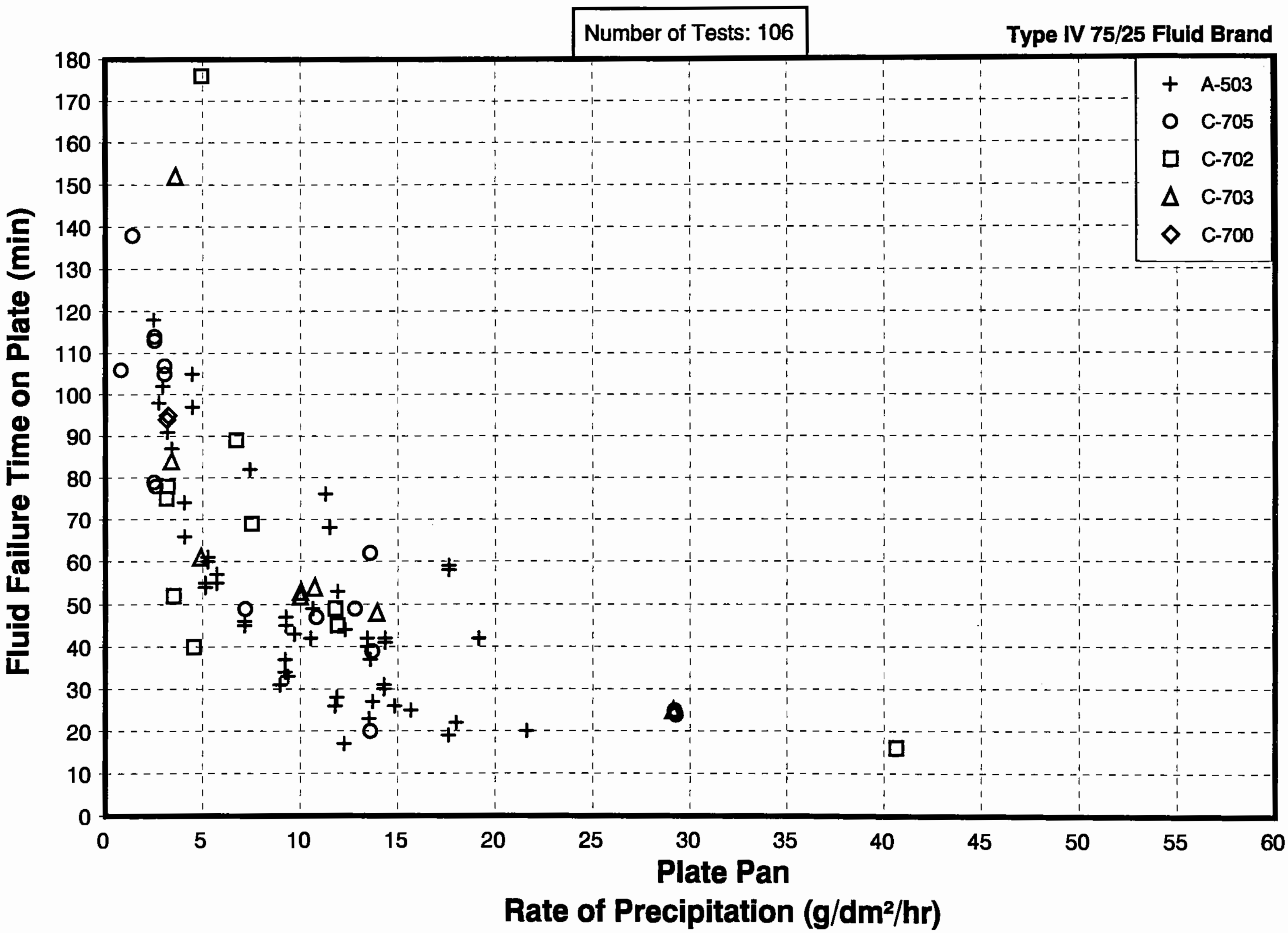


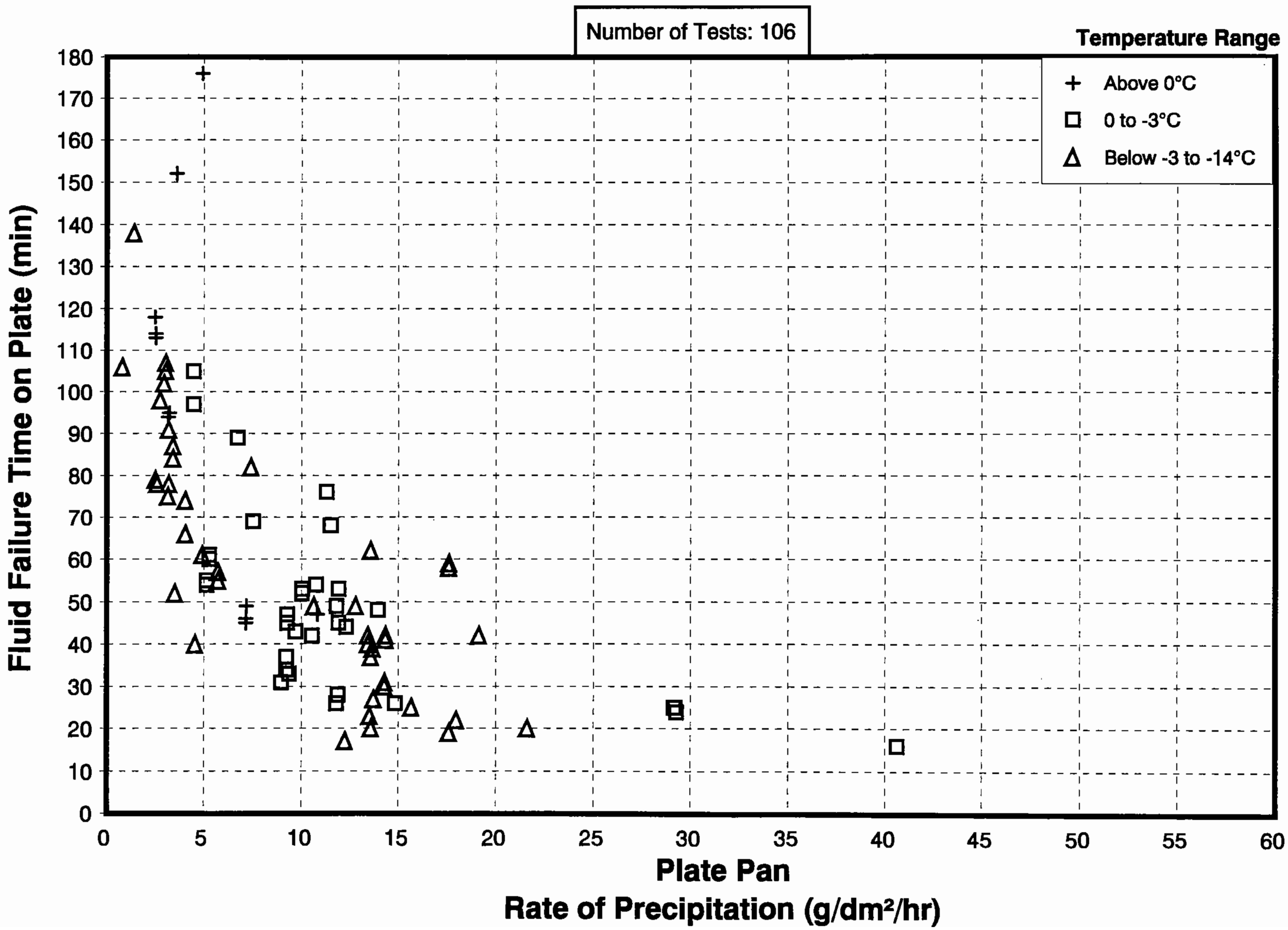
FIGURE H.7

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96



cm1283\report\vol_subs\946NS47C.GRF

FIGURE H.8

EFFECT OF WIND SPEED AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96

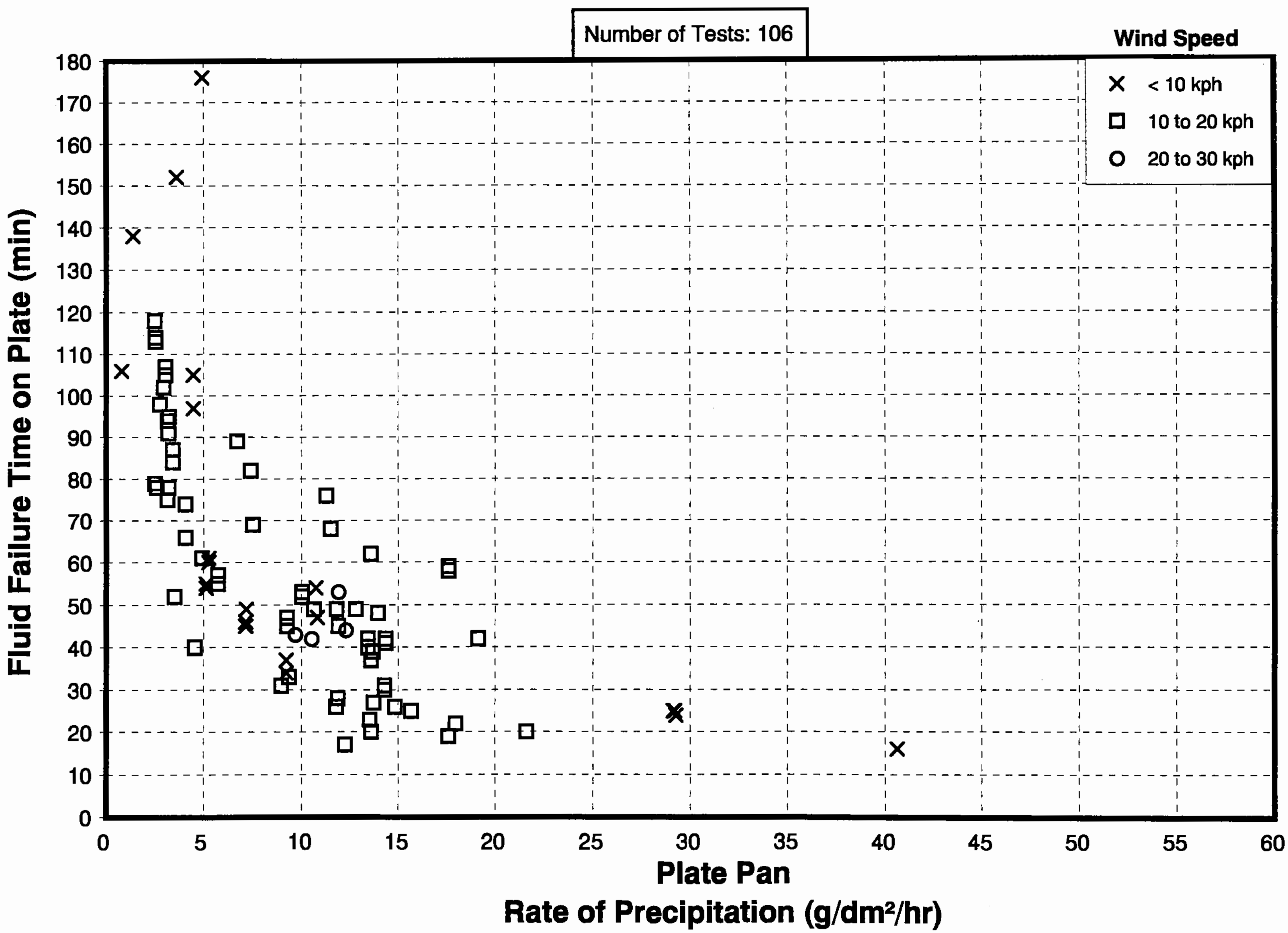


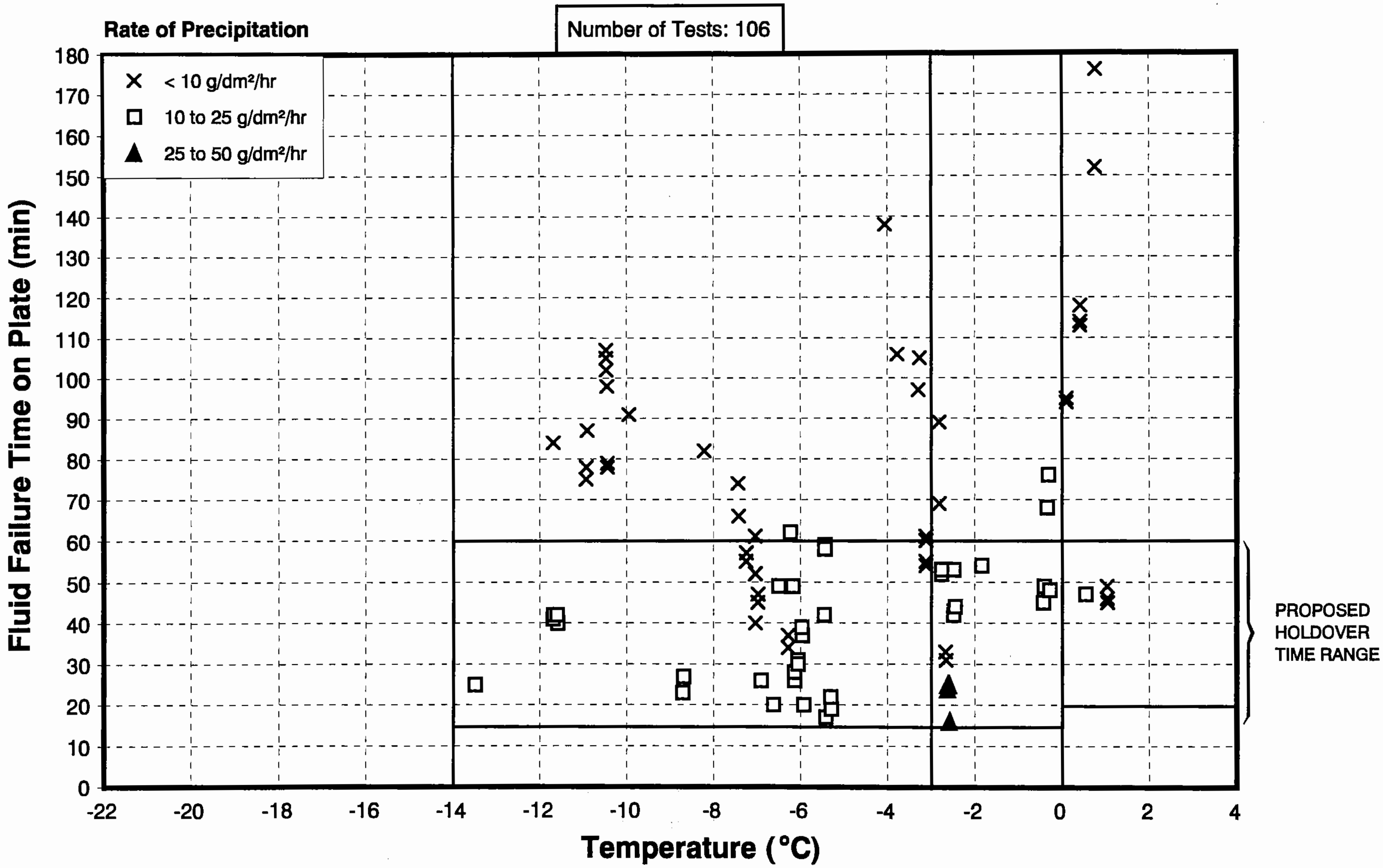
FIGURE H.9

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

TYPE IV 75/25

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96



cm1283vepon\hot_subs\946NS477.GRF

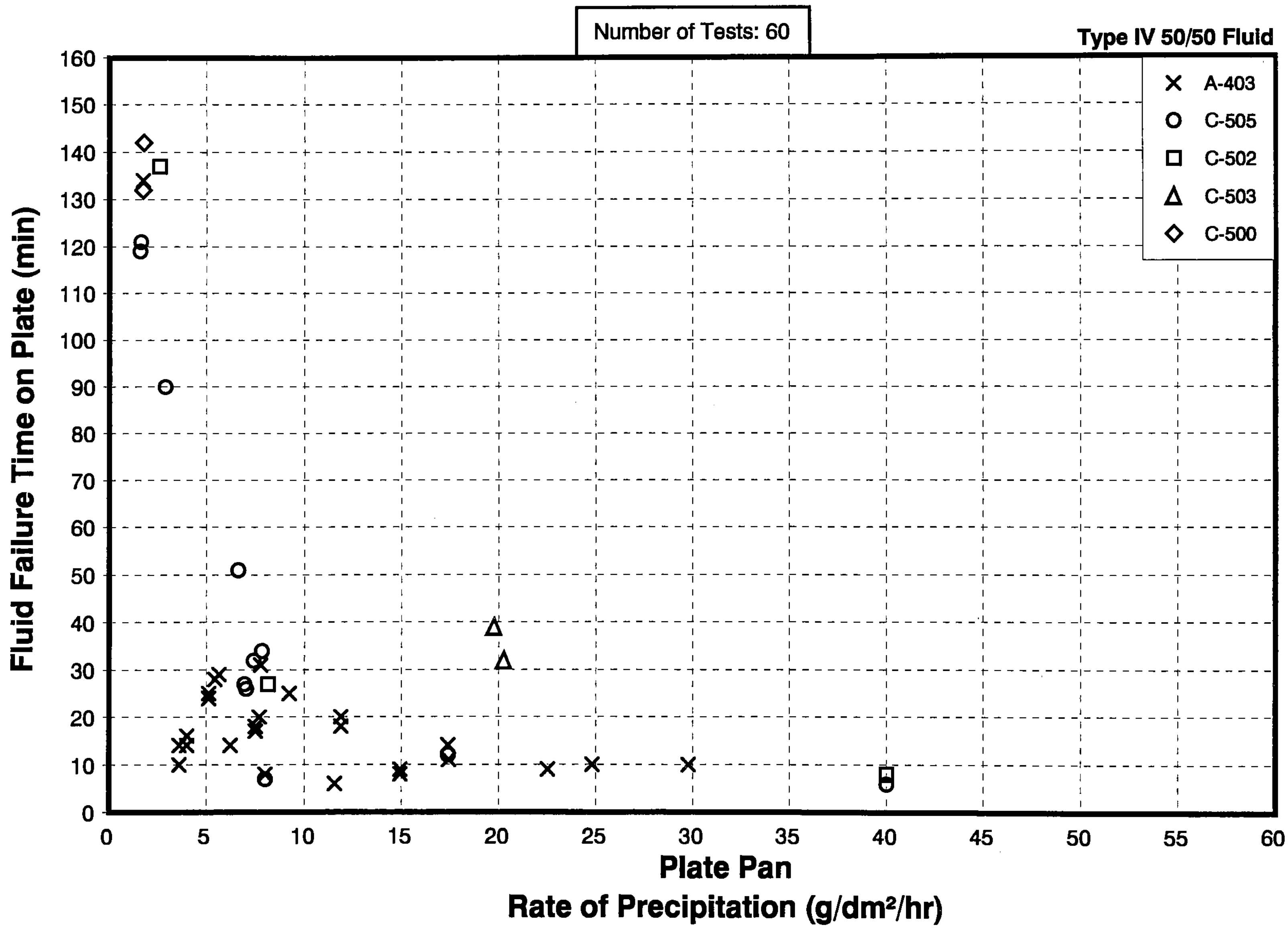
FIGURE H.10

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96



cm1283\report\hot_subs\946NS45R.GRF

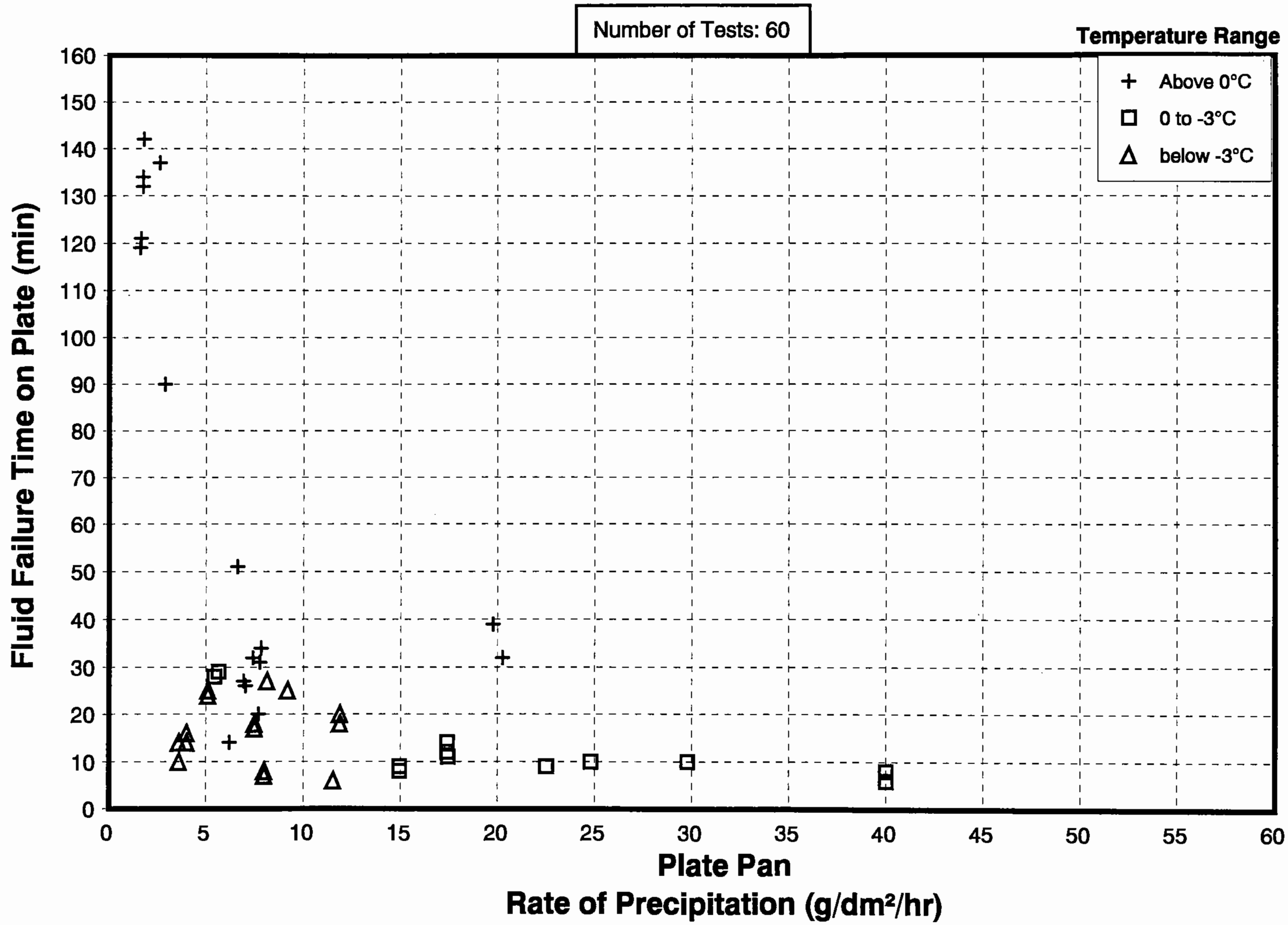
FIGURE H.11

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96



cm1283\report\vol_subs\948NS45C.GRF

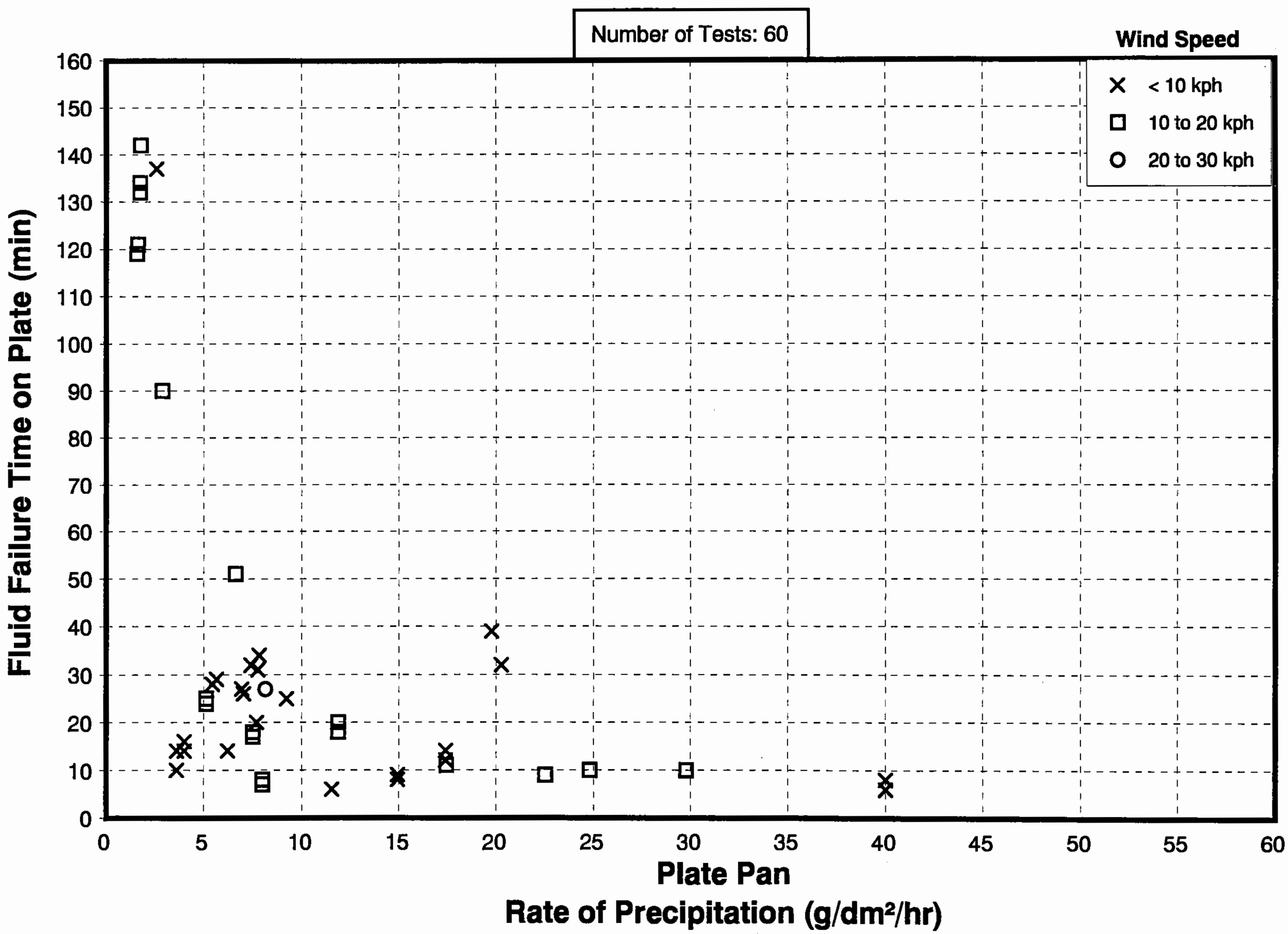
FIGURE H.12

EFFECT OF WIND SPEED AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96



cm1283\report\hot_subs\946NS45W.GRF

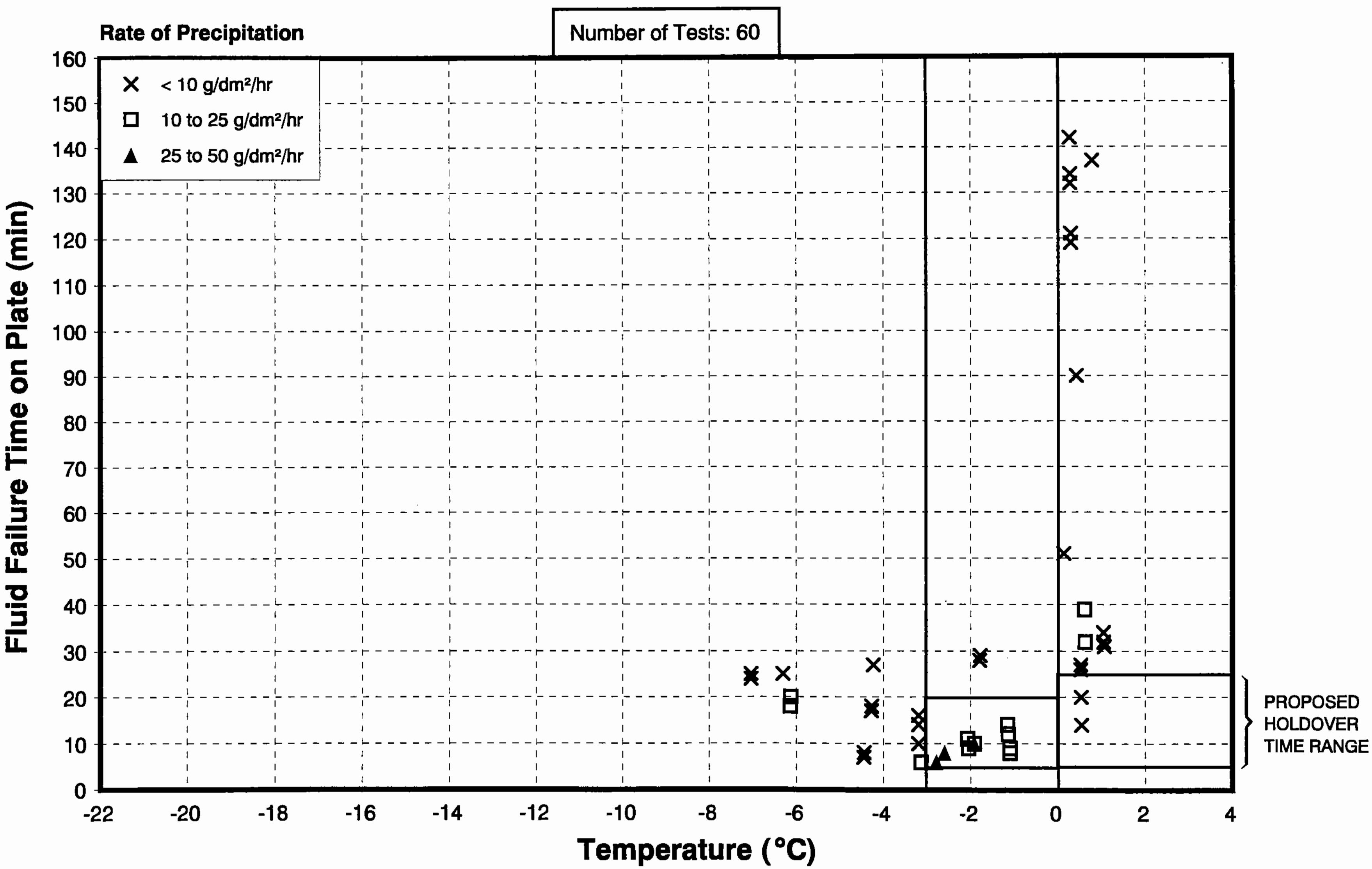
FIGURE H.13

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

TYPE IV 50/50

NATURAL SNOW CONDITIONS

APS Data - 94/95 to 95/96



cm1283veport_hot_subs\946NS45T.GRF

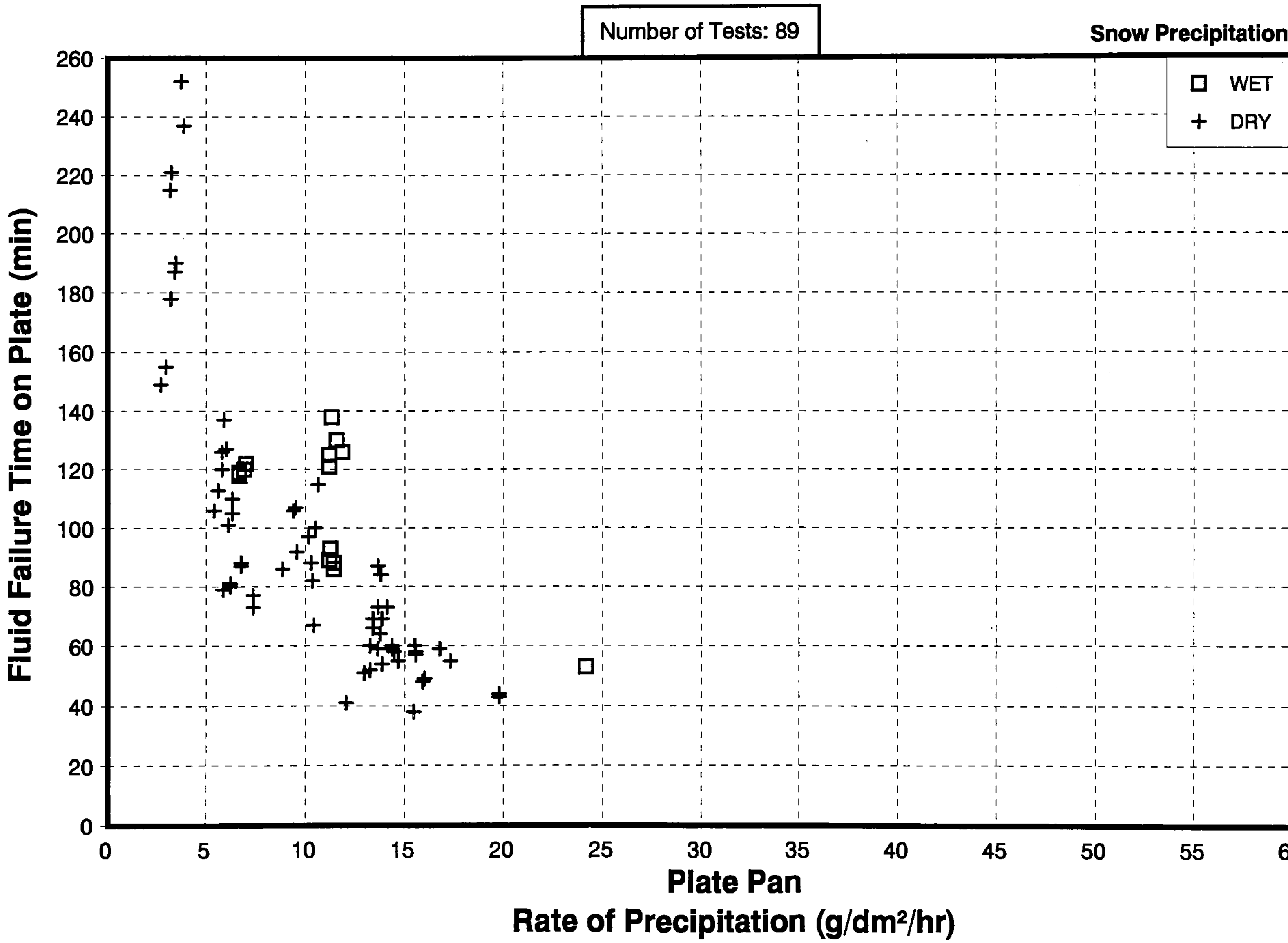
FIGURE H.14

EFFECT OF PRECIPITATION CHARACTERISTIC AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

NATURAL SNOW CONDITIONS

APS Data - 1995/96



cm1283\report\hol_subs\NS_WD41R.GRF

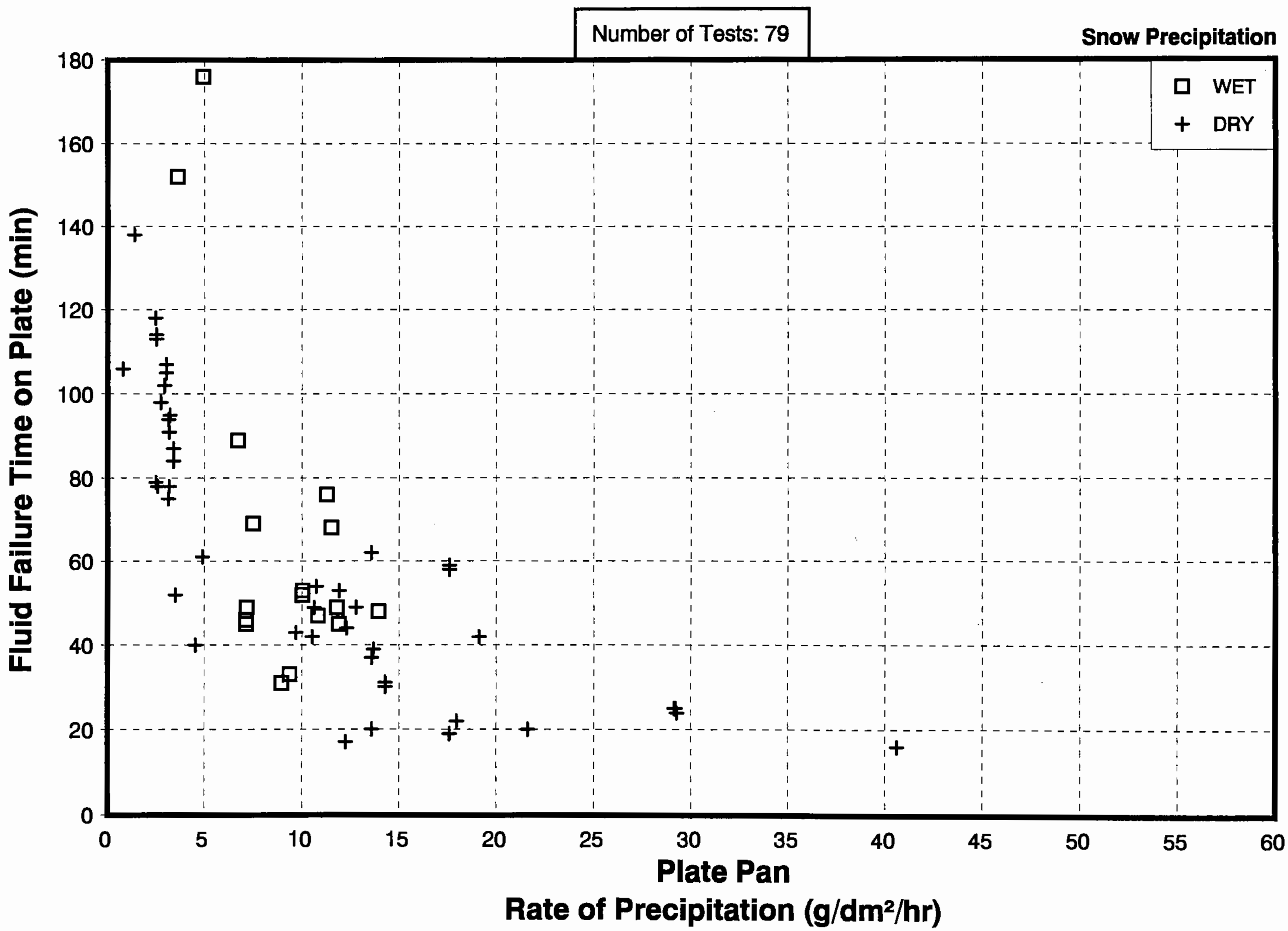
FIGURE H.15

EFFECT OF PRECIPITATION CHARACTERISTIC AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

NATURAL SNOW CONDITIONS

APS Data - 1995/96



cm1283\report\hot_subs\WS_WD47R.GRF

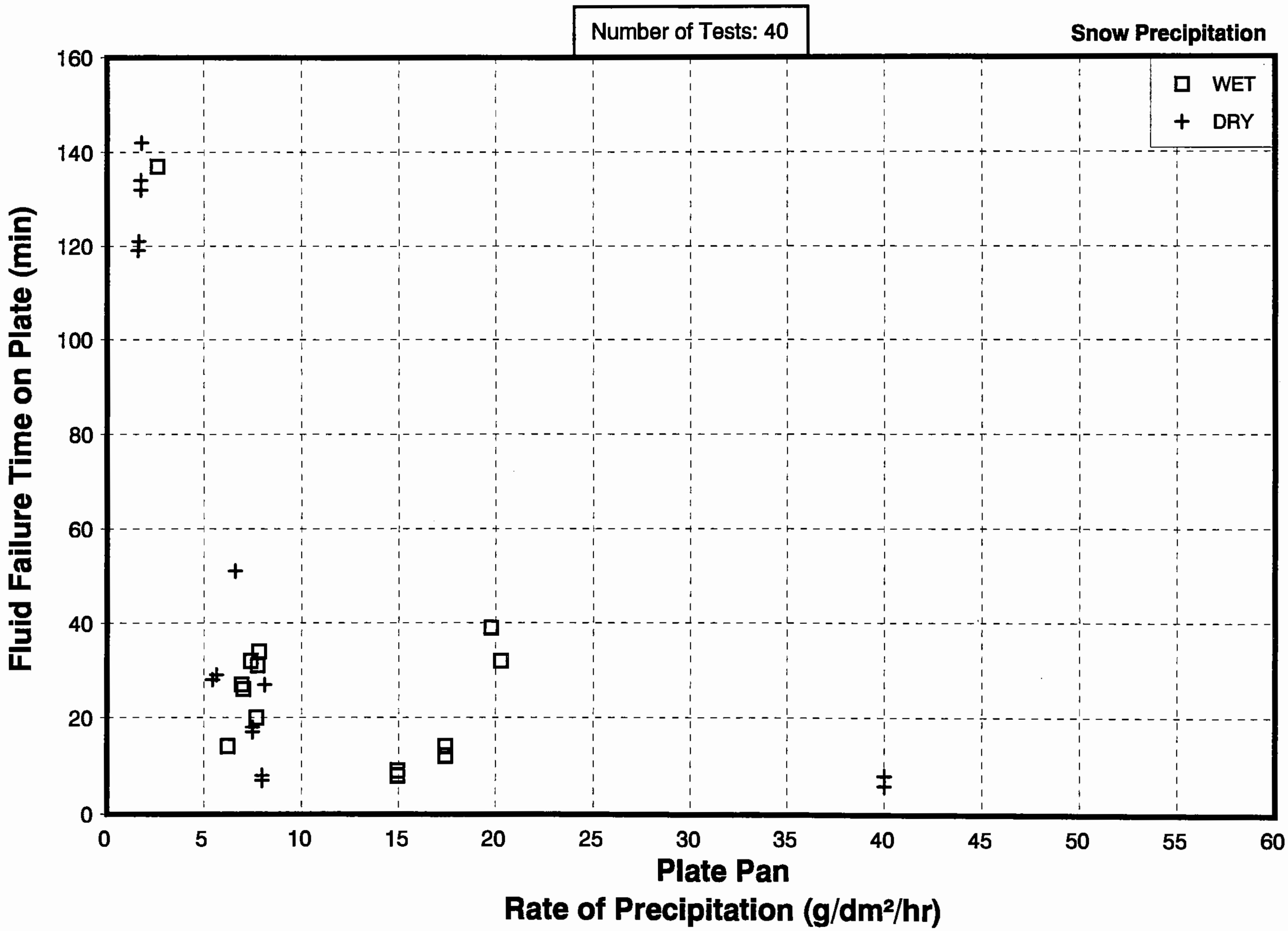
FIGURE H.16

EFFECT OF PRECIPITATION CHARACTERISTIC AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

NATURAL SNOW CONDITIONS

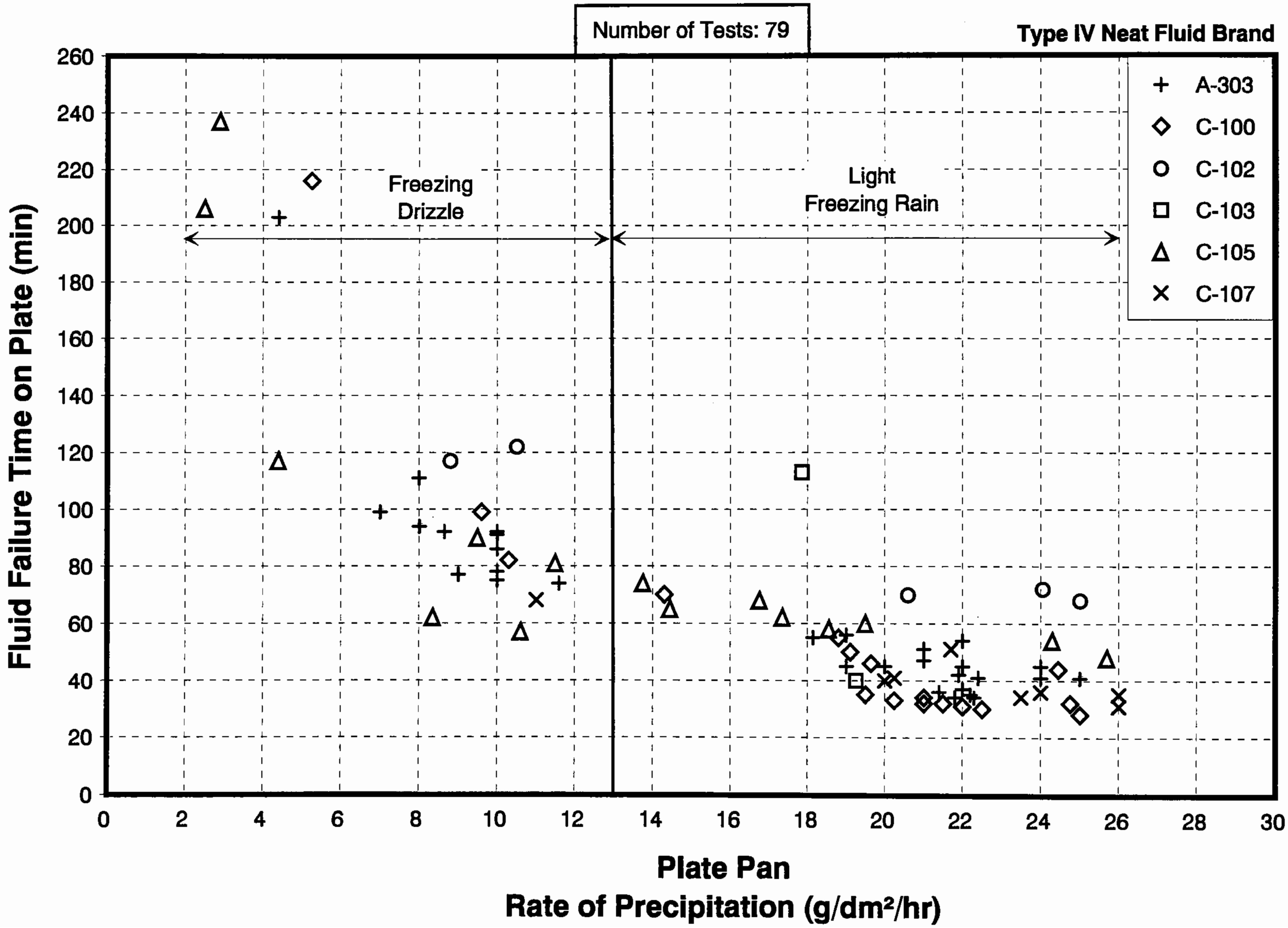
APS Data - 1995/96



H-17

cm1283\report\hol_subsNS_WD45R.GRF

FIGURE H.17
EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT
SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN
1994 - 1996



cm1283\report\rot_subs\948FR41R.GRF

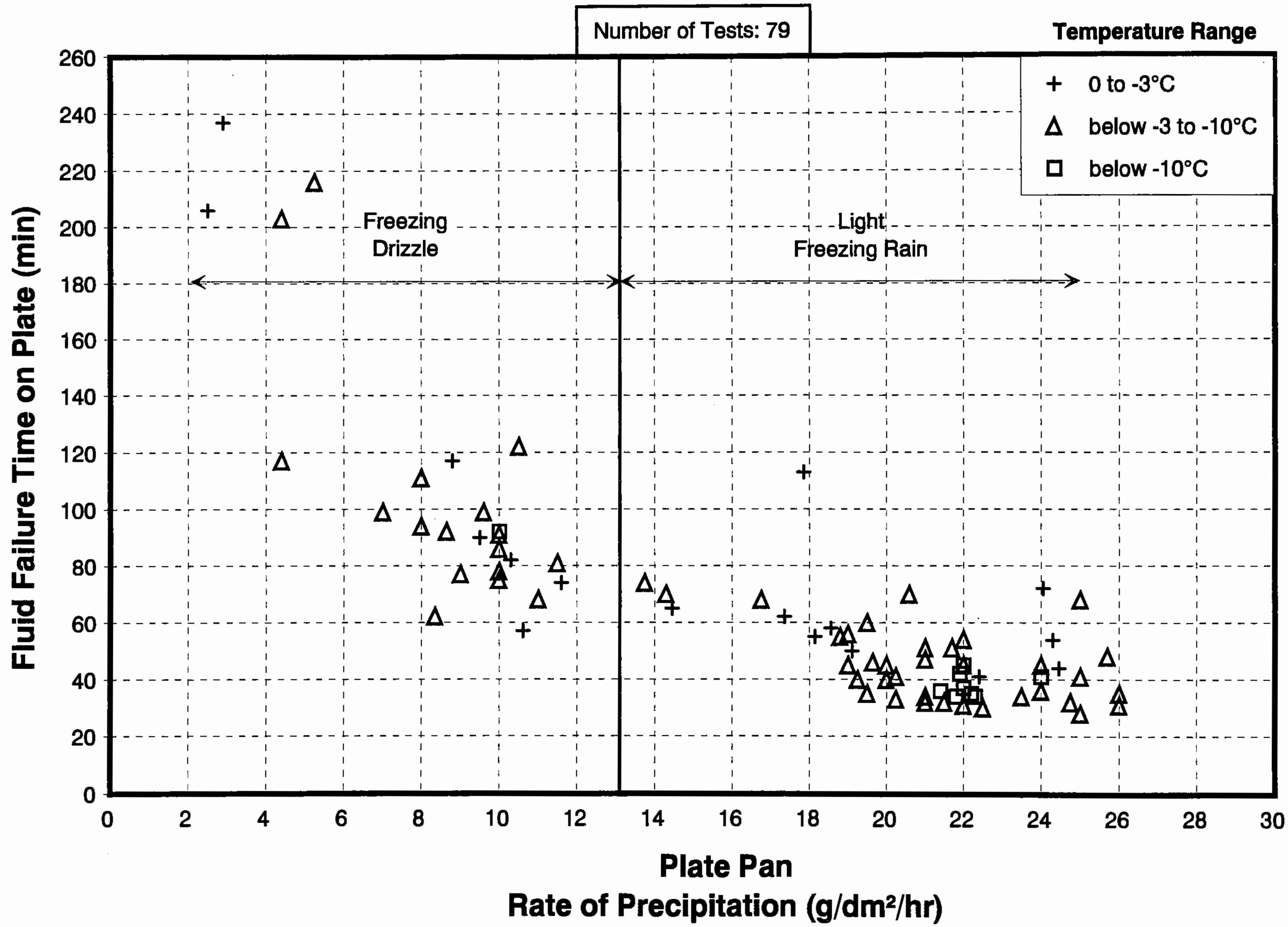
FIGURE H.18

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1994 -1996



cm1283\report\rot_subs\946FR41C.GRF

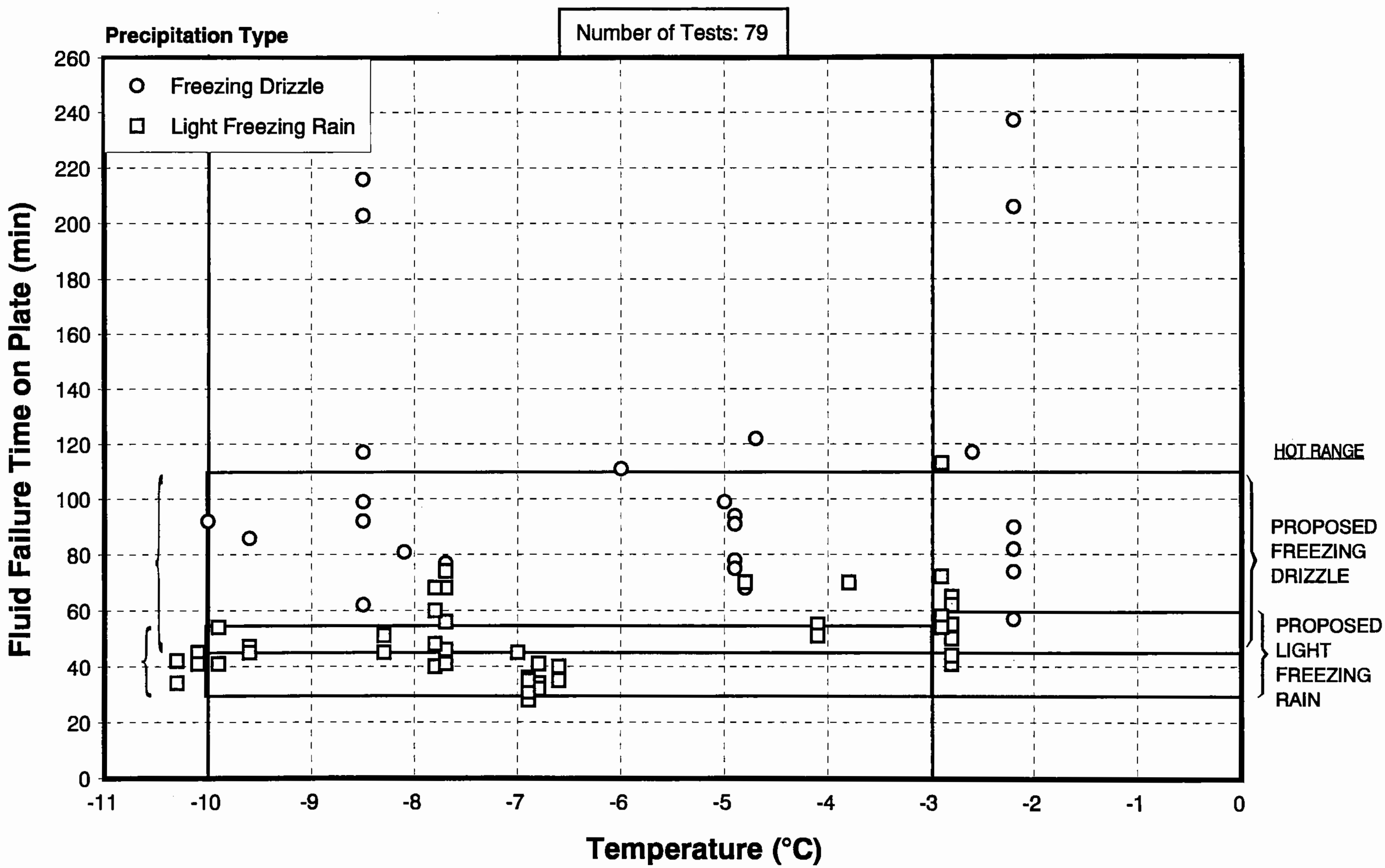
FIGURE H.19

EFFECT OF PRECIPITATION TYPE AND TEMPERATURE ON FAILURE TIME

TYPE IV NEAT

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1994 - 1996



cm1283\report\hot_subs\94BFR41T.GRF

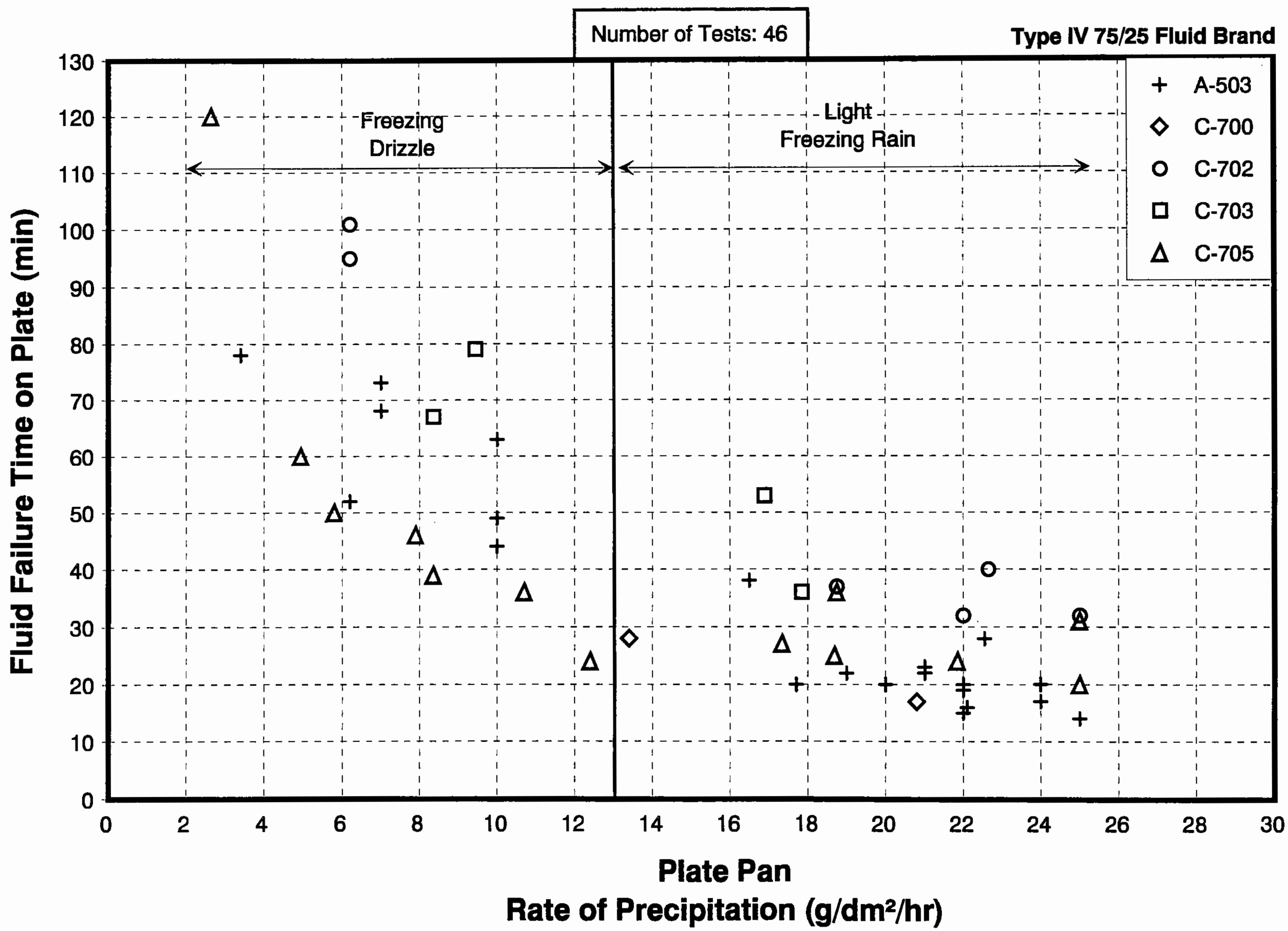
FIGURE H.20

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

FREEZING DRIZZL AND LIGHT FREEZING RAIN

1994 - 1996



cm1283\report\hot_subs\946FR47R.grf

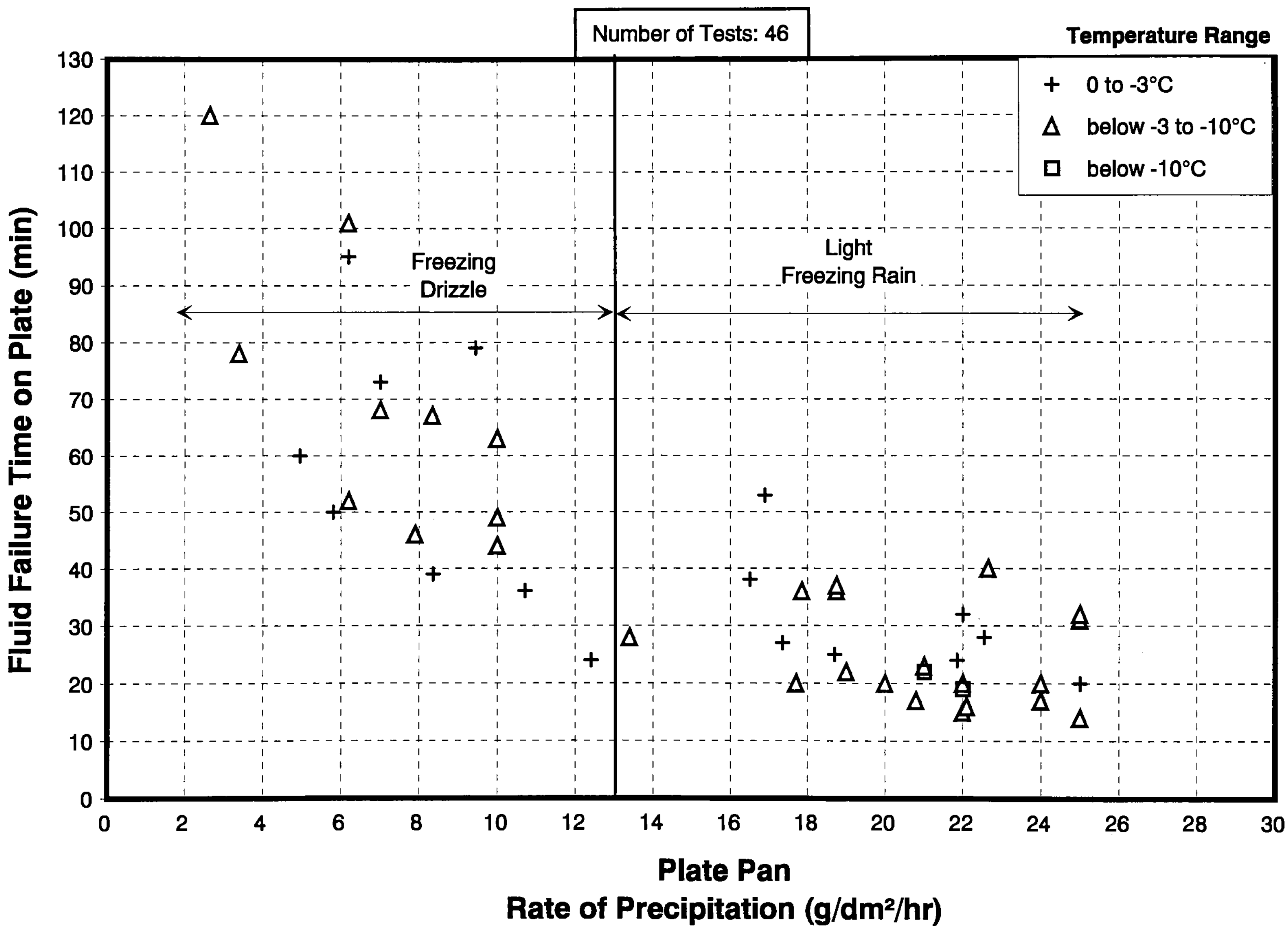
FIGURE H.21

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

FREEZING DRIZZLE AND LIGHT FREEZING RAIN

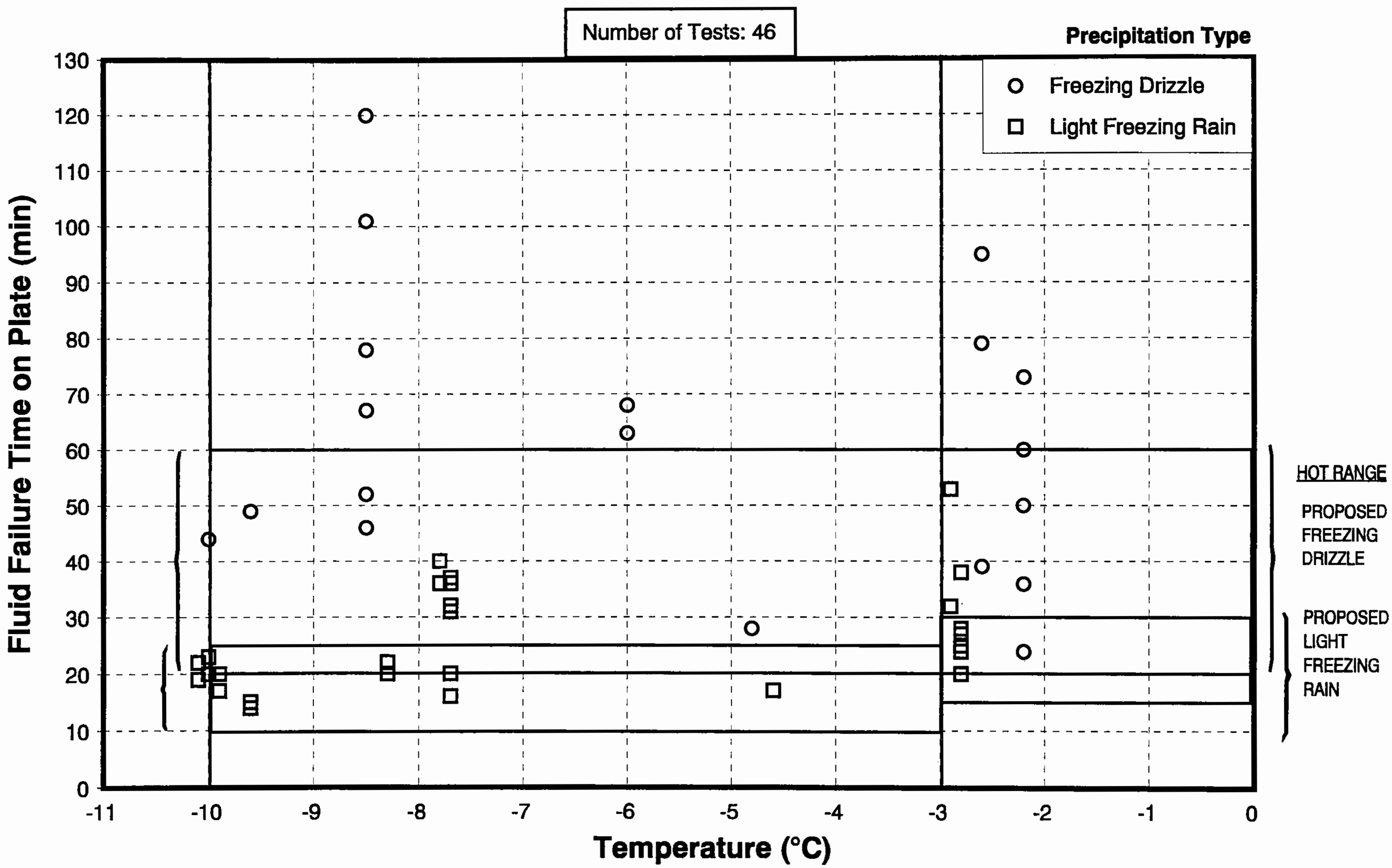
1994 - 1996



cm1283\report\hot_subs\946FR47C.grf

FIGURE H.22

EFFECT OF PRECIPITATION TYPE AND TEMPERATURE ON FAILURE TIME
TYPE IV 75/25
SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN
1994 - 1996



cm1283\report\hot_sube\946FR47T.GRF

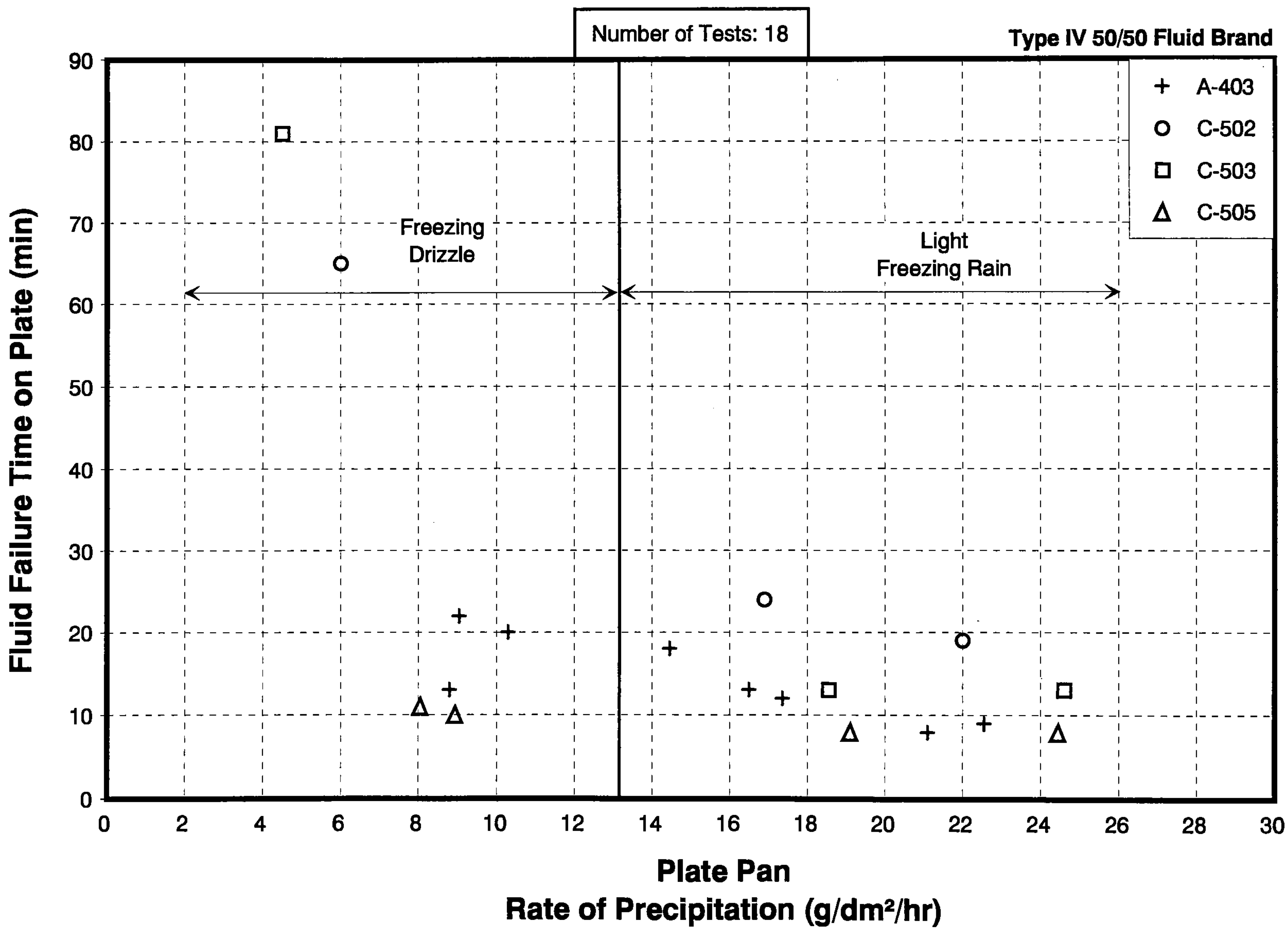
FIGURE H.23

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1995 - 1996



cm1283\report\hot_subs\95\5FR45R.GRF

FIGURE H.24

EFFECT OF PRECIPITATION TYPE AND TEMPERATURE ON FAILURE TIME

TYPE IV 50/50

SIMULATED FREEZING DRIZZLE AND LIGHT FREEZING RAIN

1995 - 1996

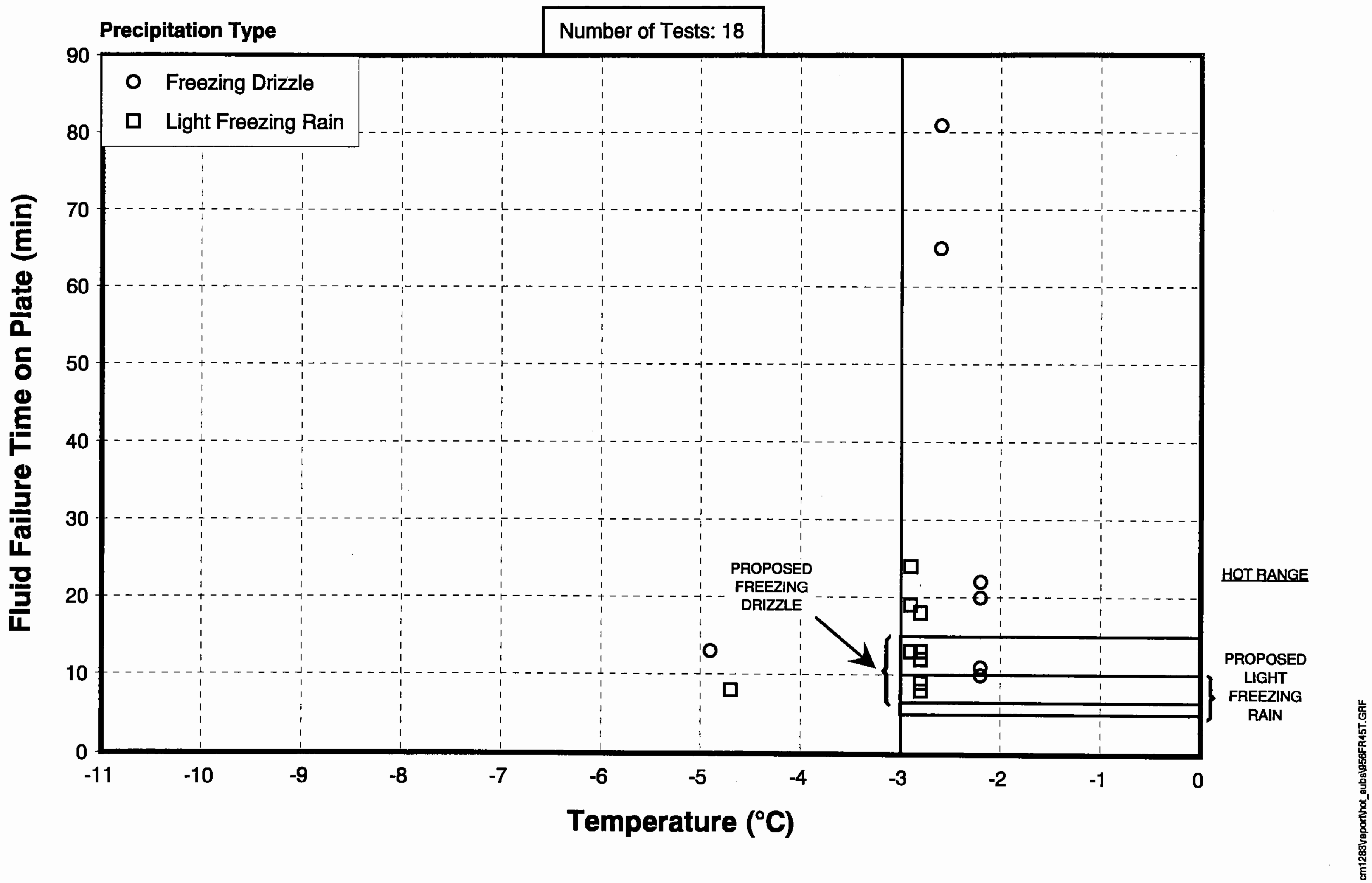


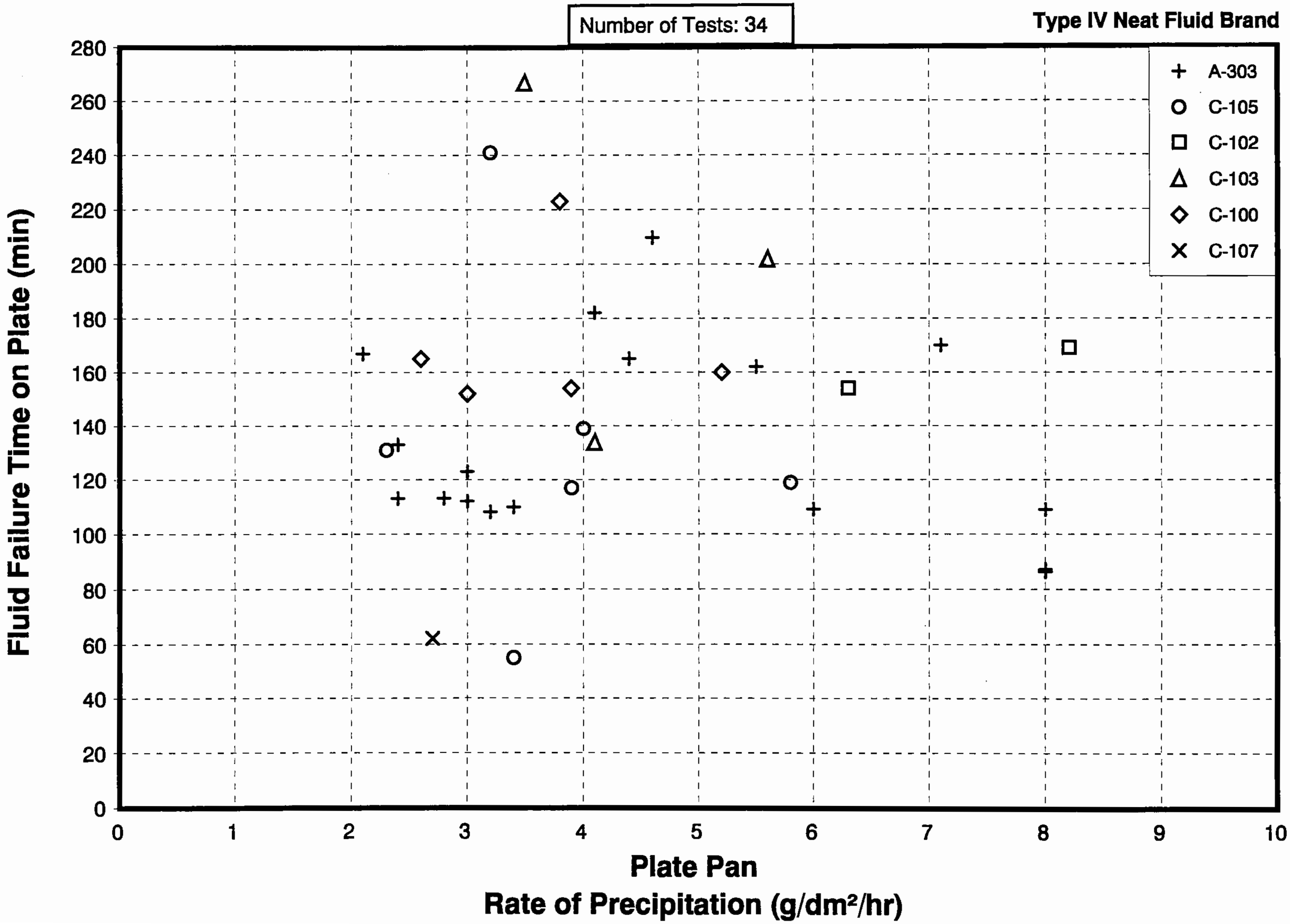
FIGURE H.25

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

SIMULATED FREEZING FOG

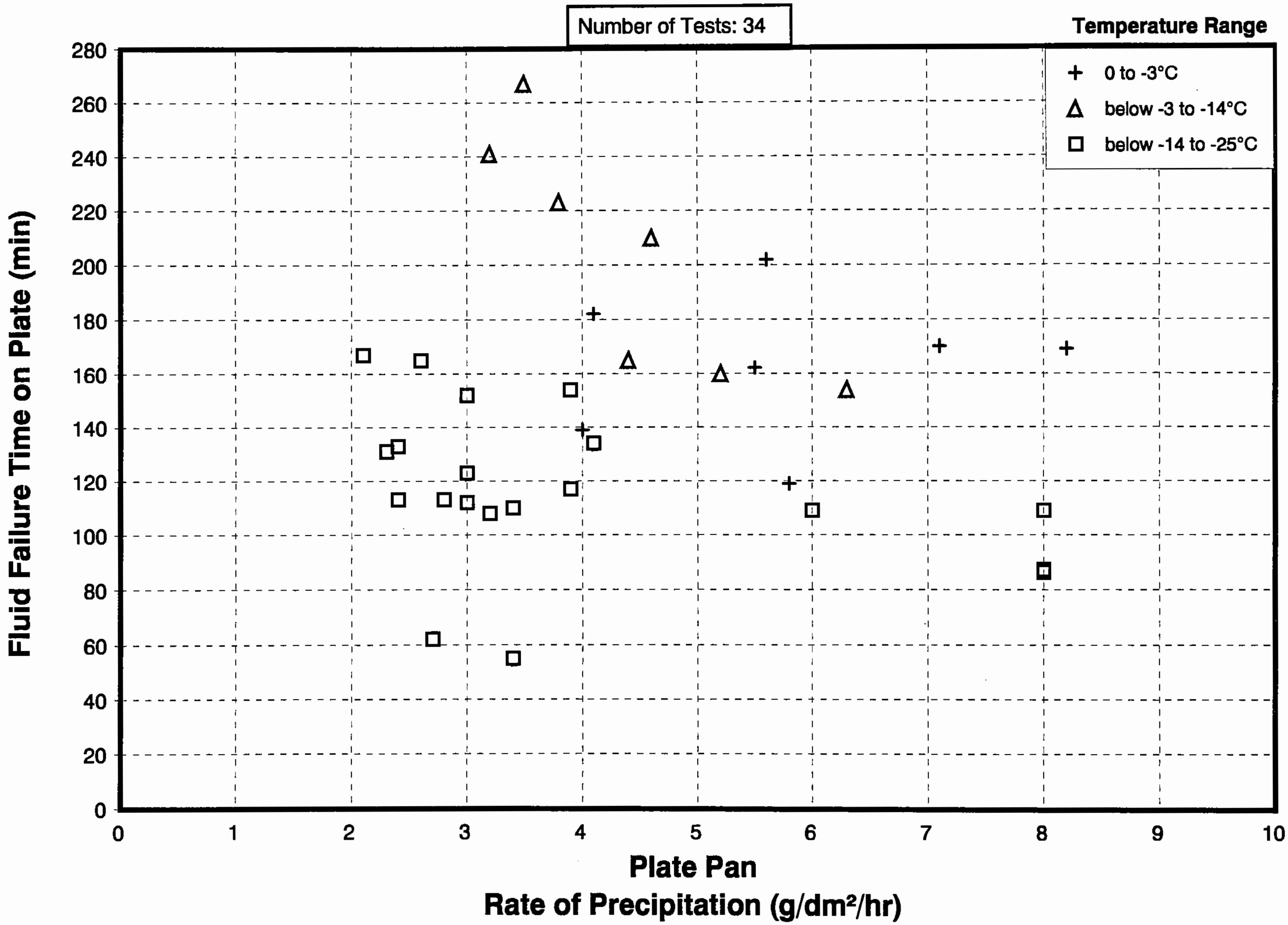
APS DATA - 1995 & 1996



cm1283\report\hot_subs\946FF41R.GRF

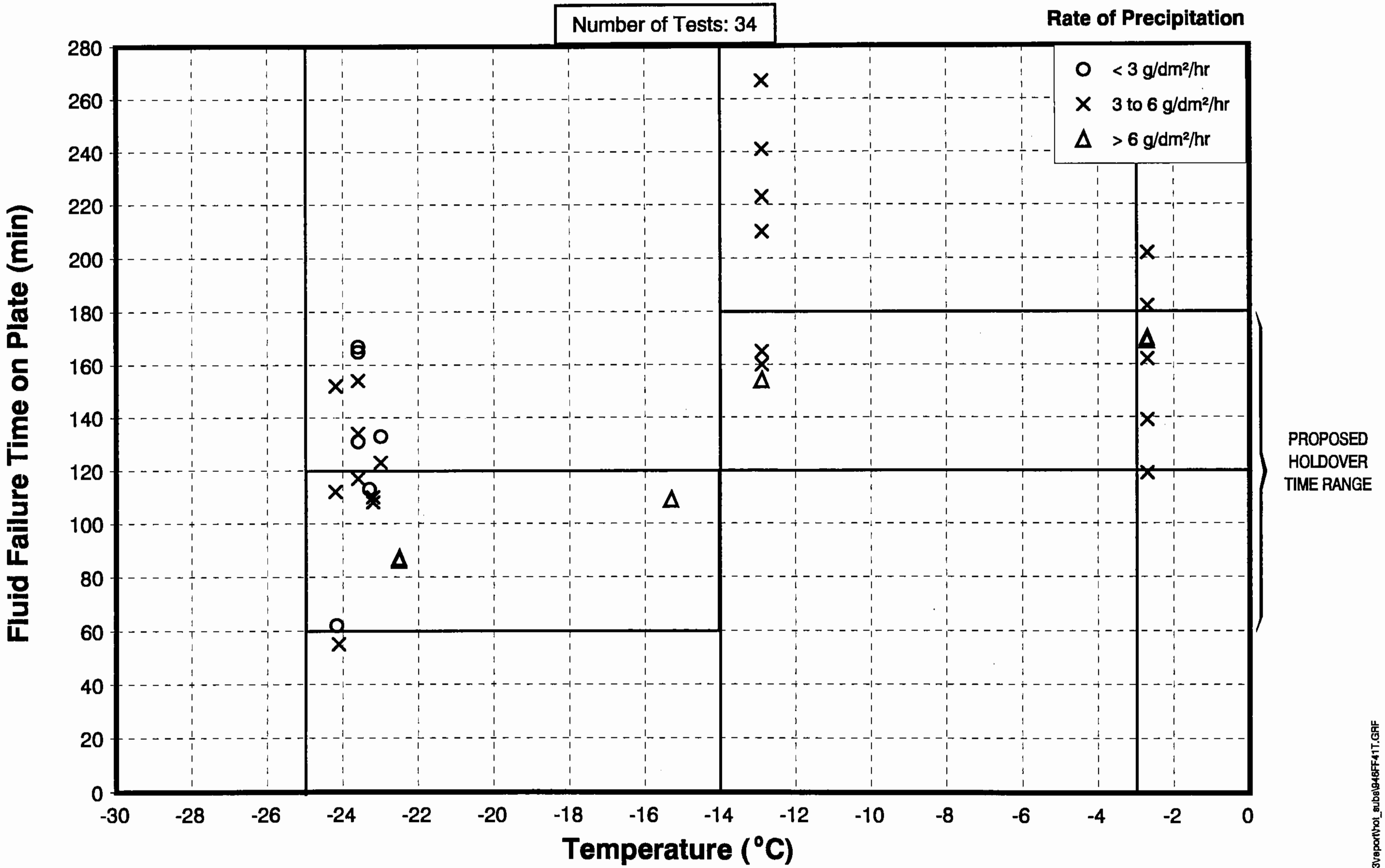
FIGURE H.26

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV NEAT
SIMULATED FREEZING FOG
APS DATA - 1995 & 1996



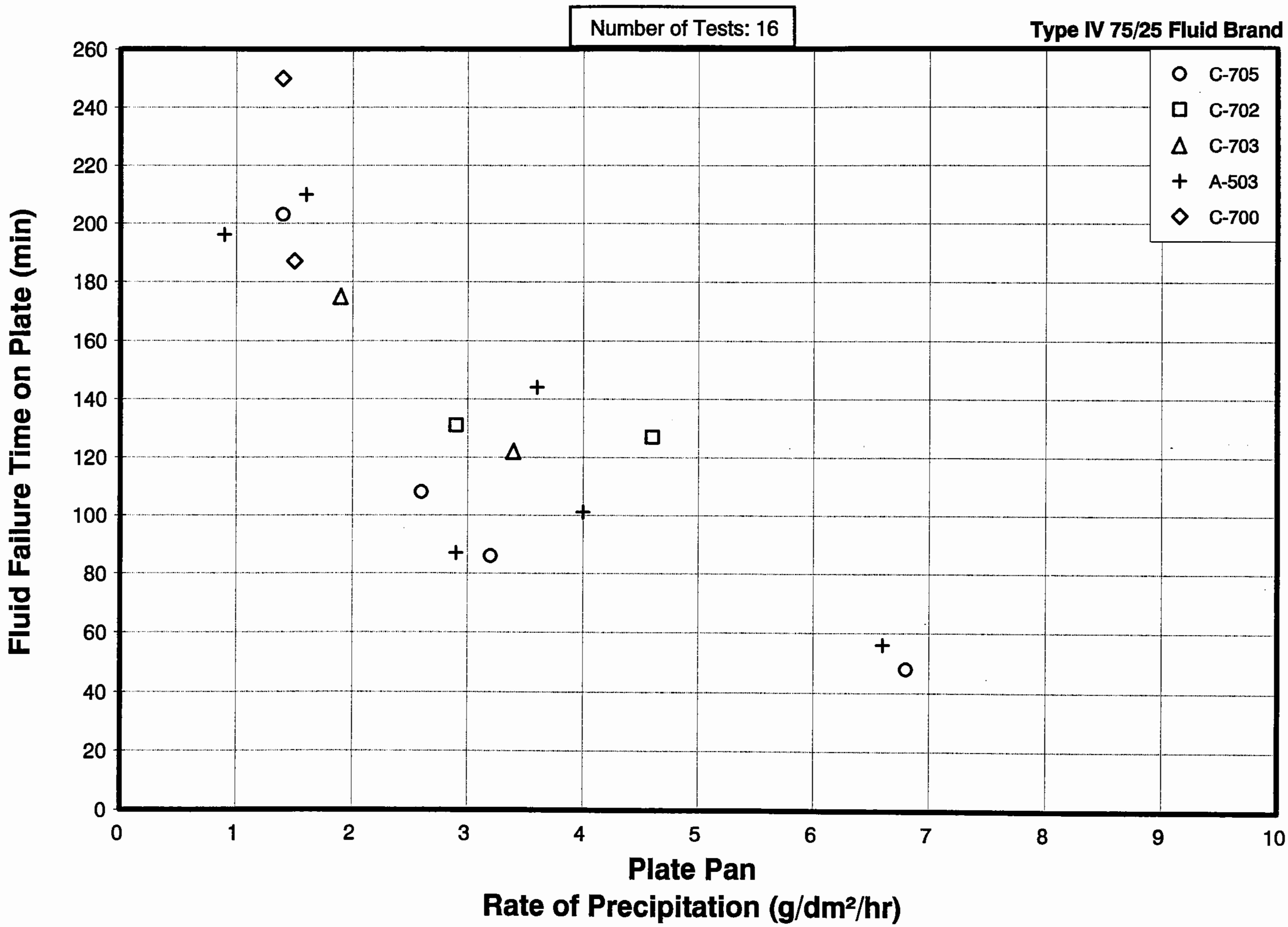
cm1283\report\hot_subs\946FF41C.GRF

FIGURE H.27
EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME
TYPE IV NEAT
SIMULATED FREEZING FOG
APS DATA - 1995 & 1996



cm1283\report\hot_sub\a946FF41T.GRF

FIGURE H.28
EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE IV 75/25
SIMULATED FREEZING FOG
APS DATA - 1996



cm1283\report\hot_subs\96FZ47R.GRF

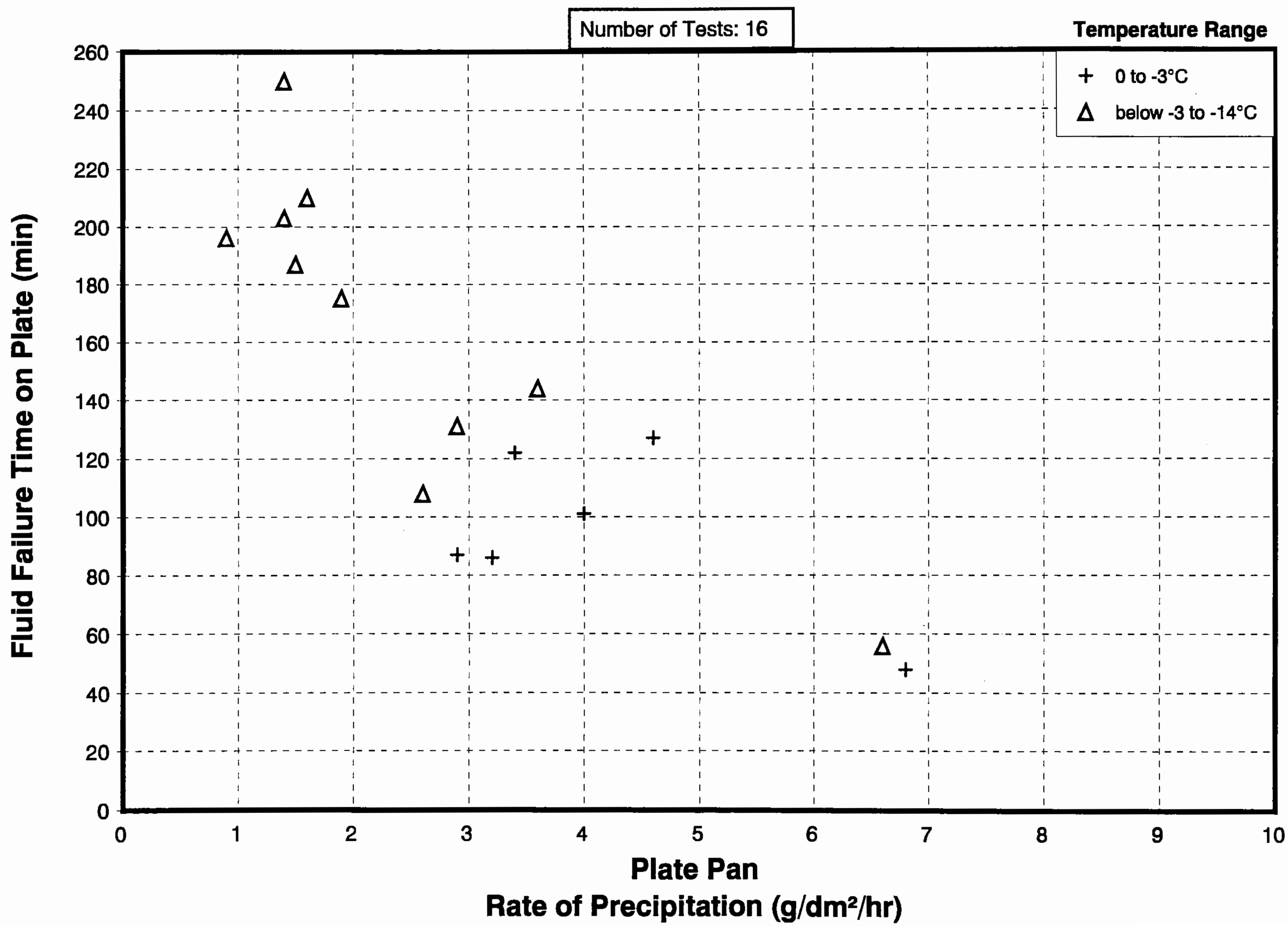
FIGURE H.29

EFFECT OF TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

SIMULATED FREEZING FOG

APS DATA - 1996



cm1283\report\hot_subs\98FZF47C.GRF

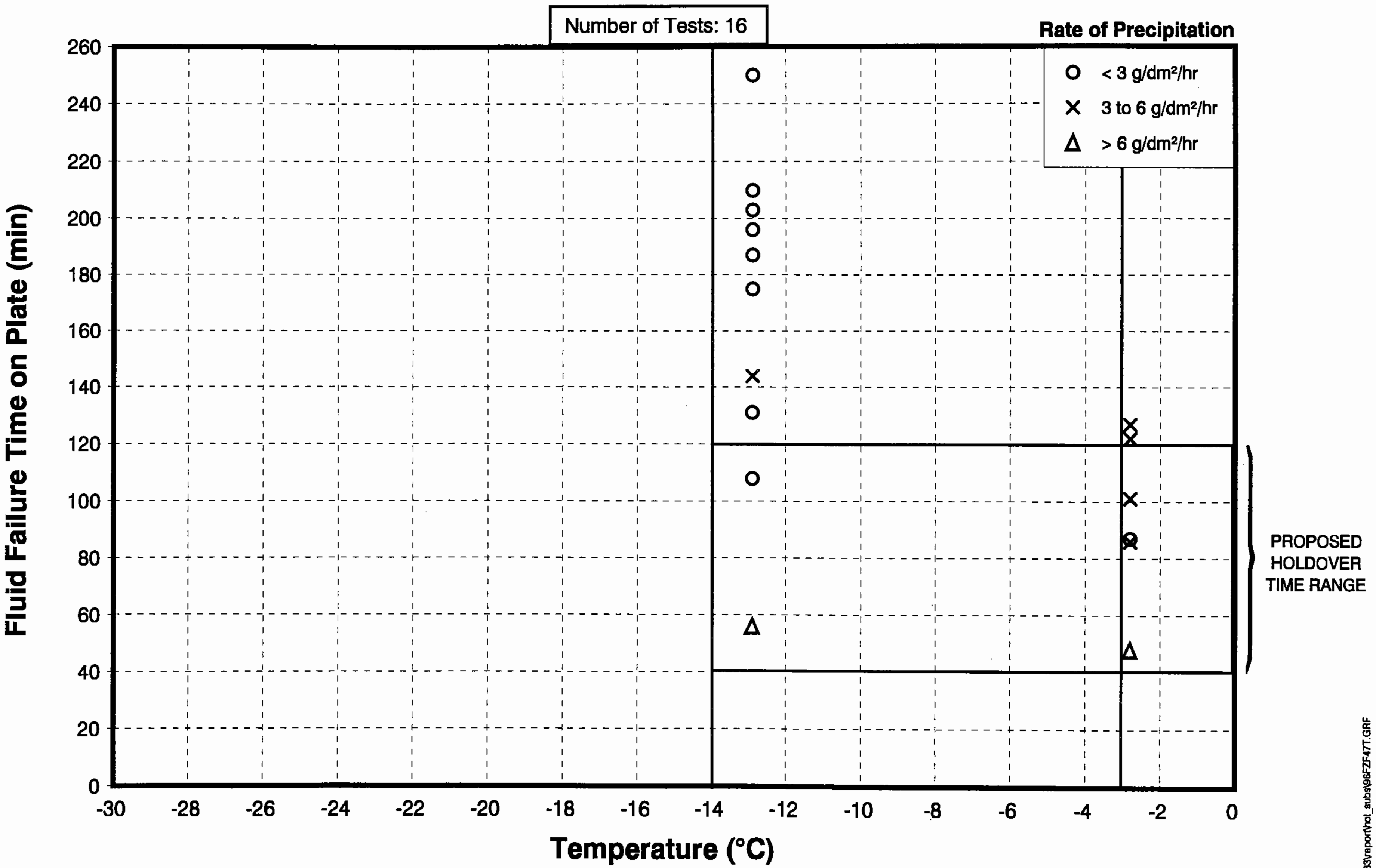
FIGURE H.30

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

TYPE IV 75/25

SIMULATED FREEZING FOG

APS DATA - 1996



cm1283\report\hot_subs\96FZF47T.GRF

FIGURE H.31

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

SIMULATED FREEZING FOG

APS DATA - 1996

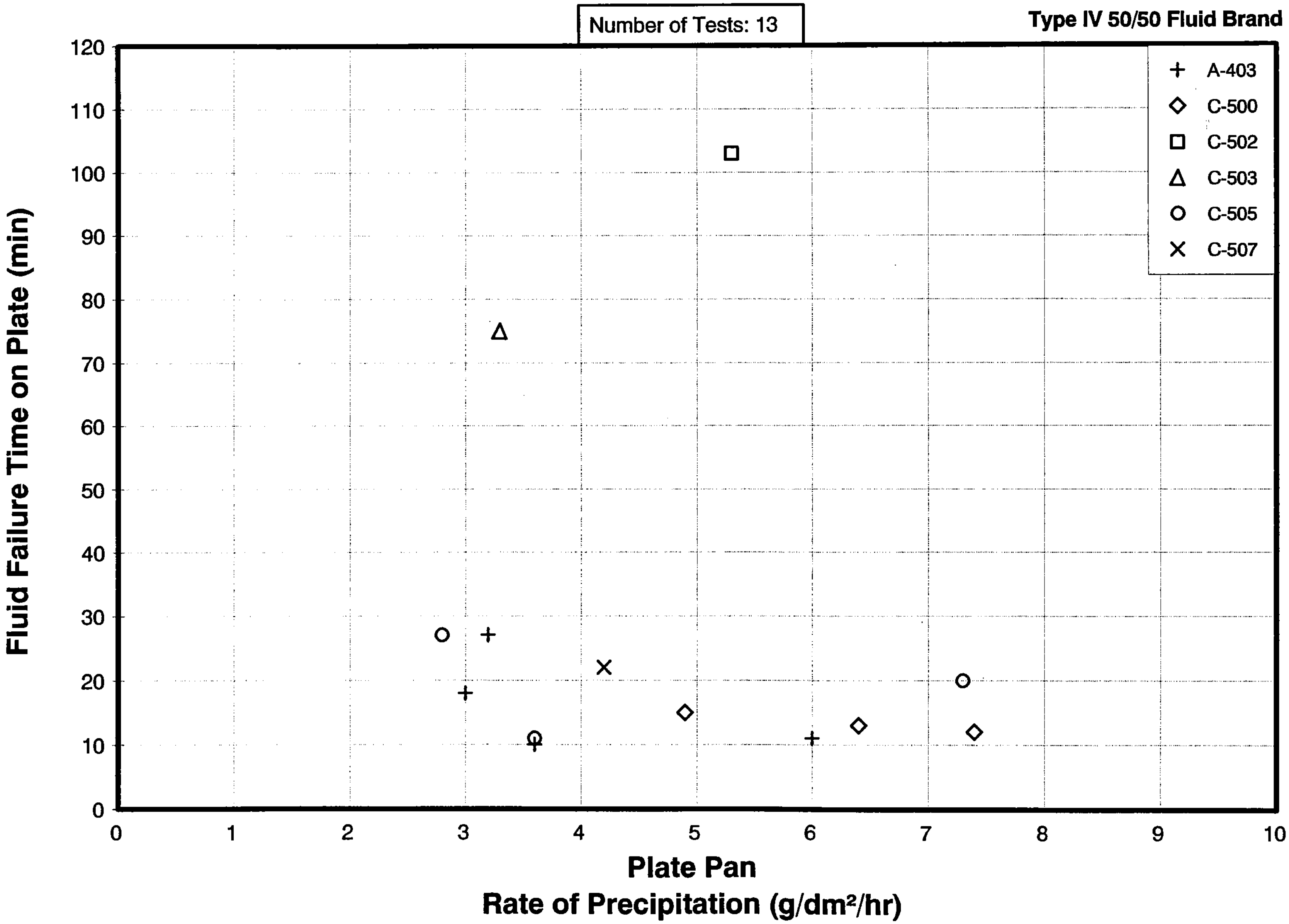


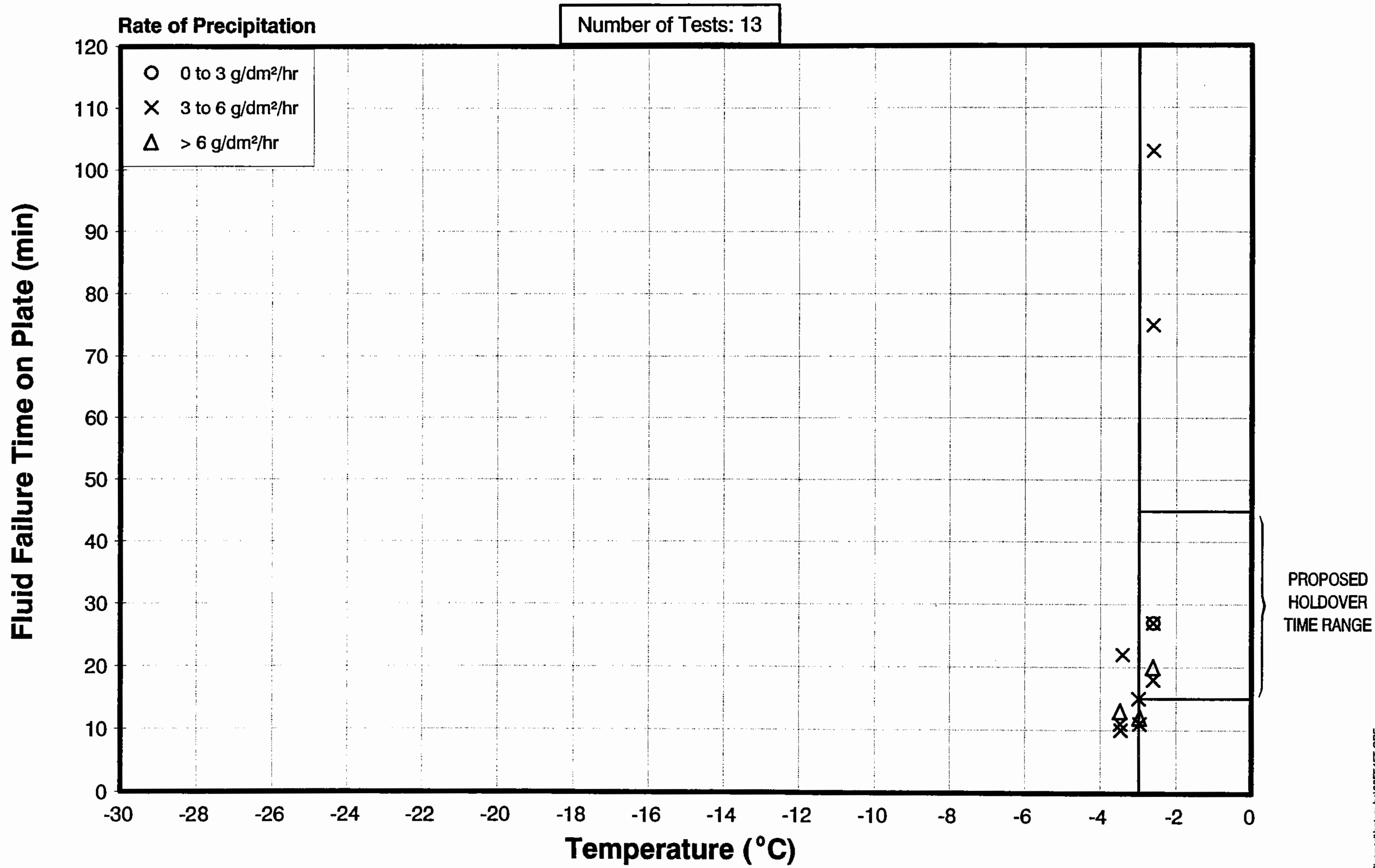
FIGURE H.32

EFFECT OF RATE OF PRECIPITATION AND TEMPERATURE ON FAILURE TIME

TYPE IV 50/50

SIMULATED FREEZING FOG

APS DATA - 1996



cm1283\report\hot_subs\96FF45T.GRF

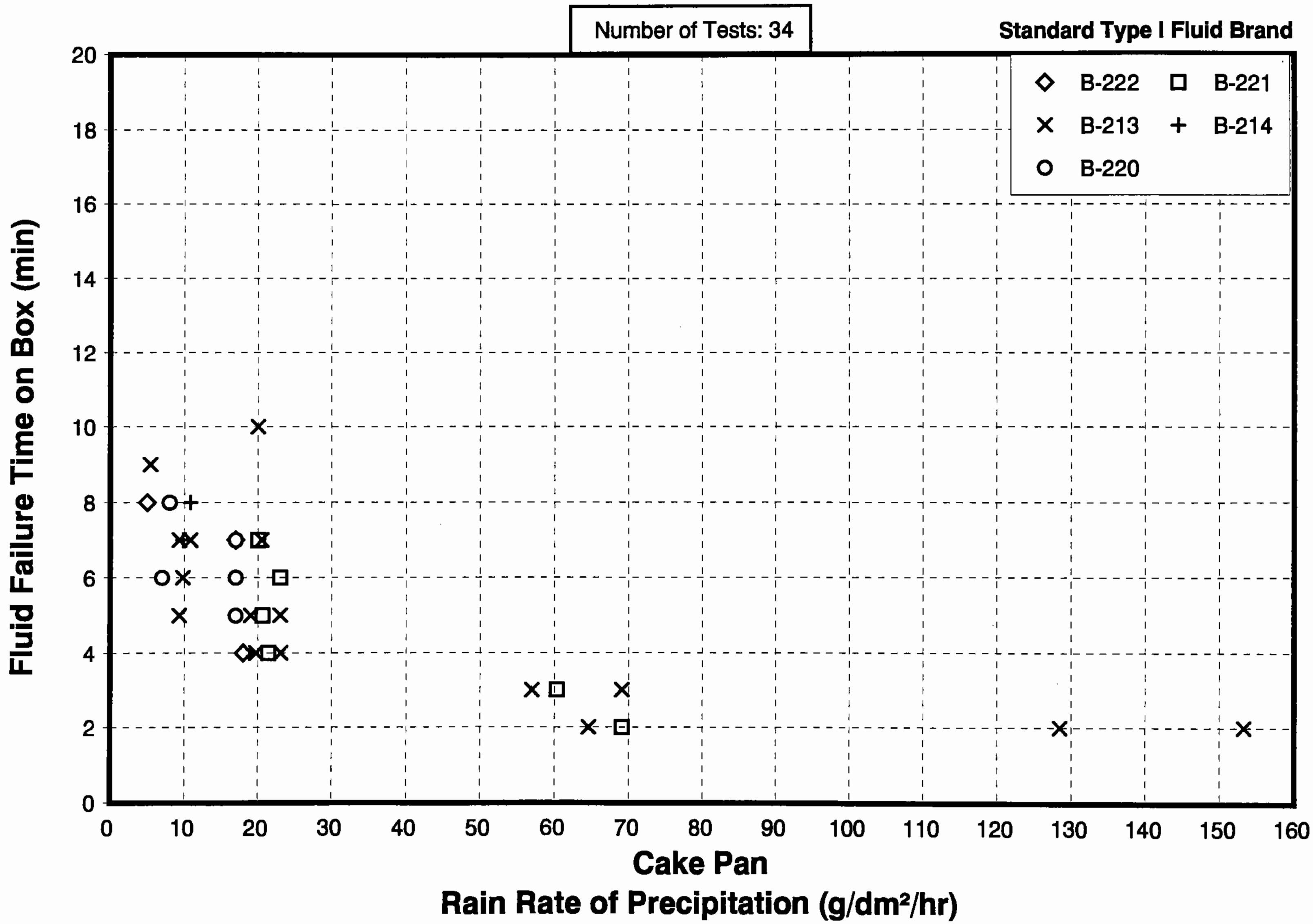
FIGURE H.33

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

STANDARD TYPE I

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_1S_R.GRF

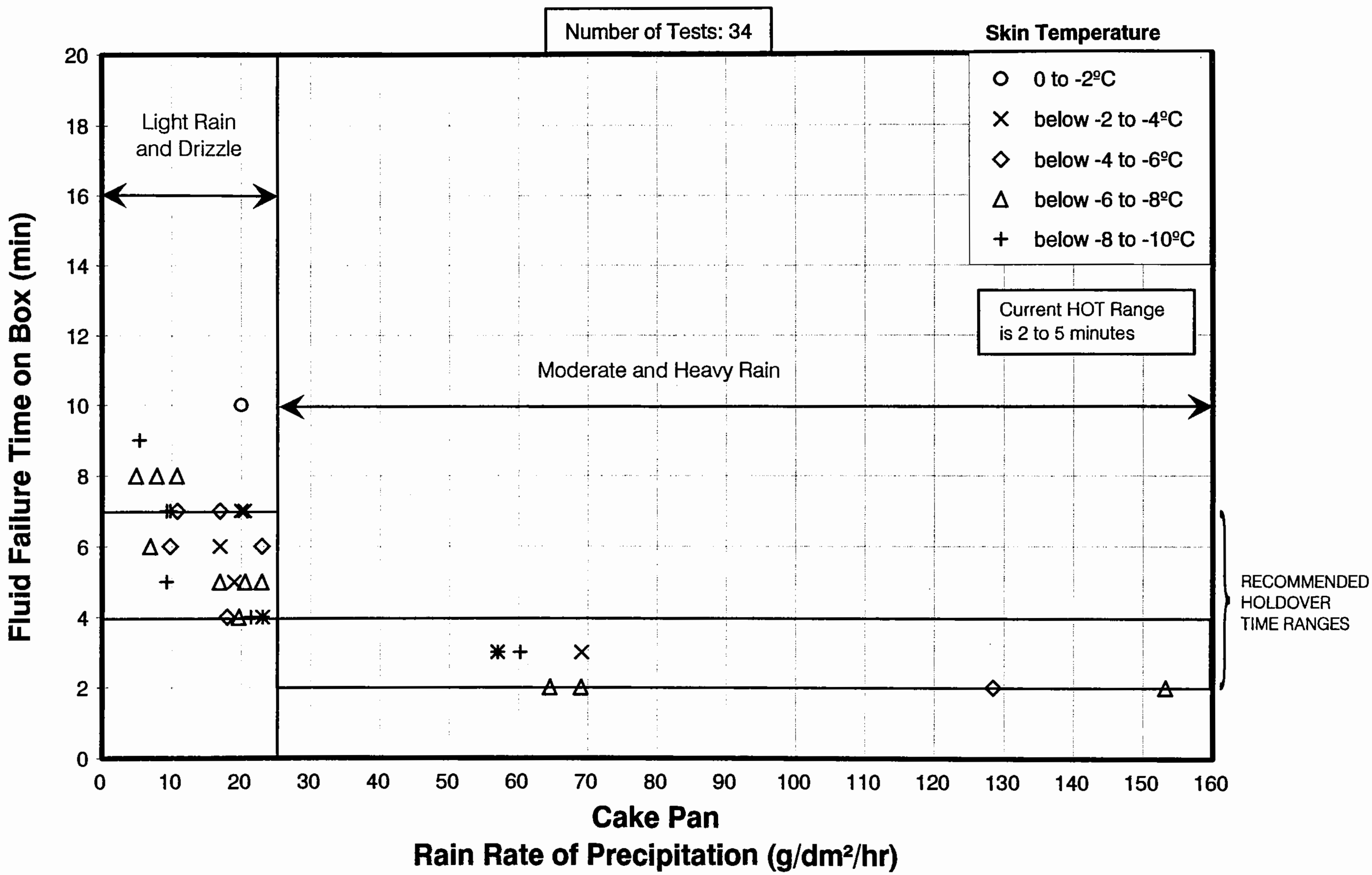
FIGURE H.34

EFFECT OF SKIN TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

STANDARD TYPE I

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_1S_BT.GRF

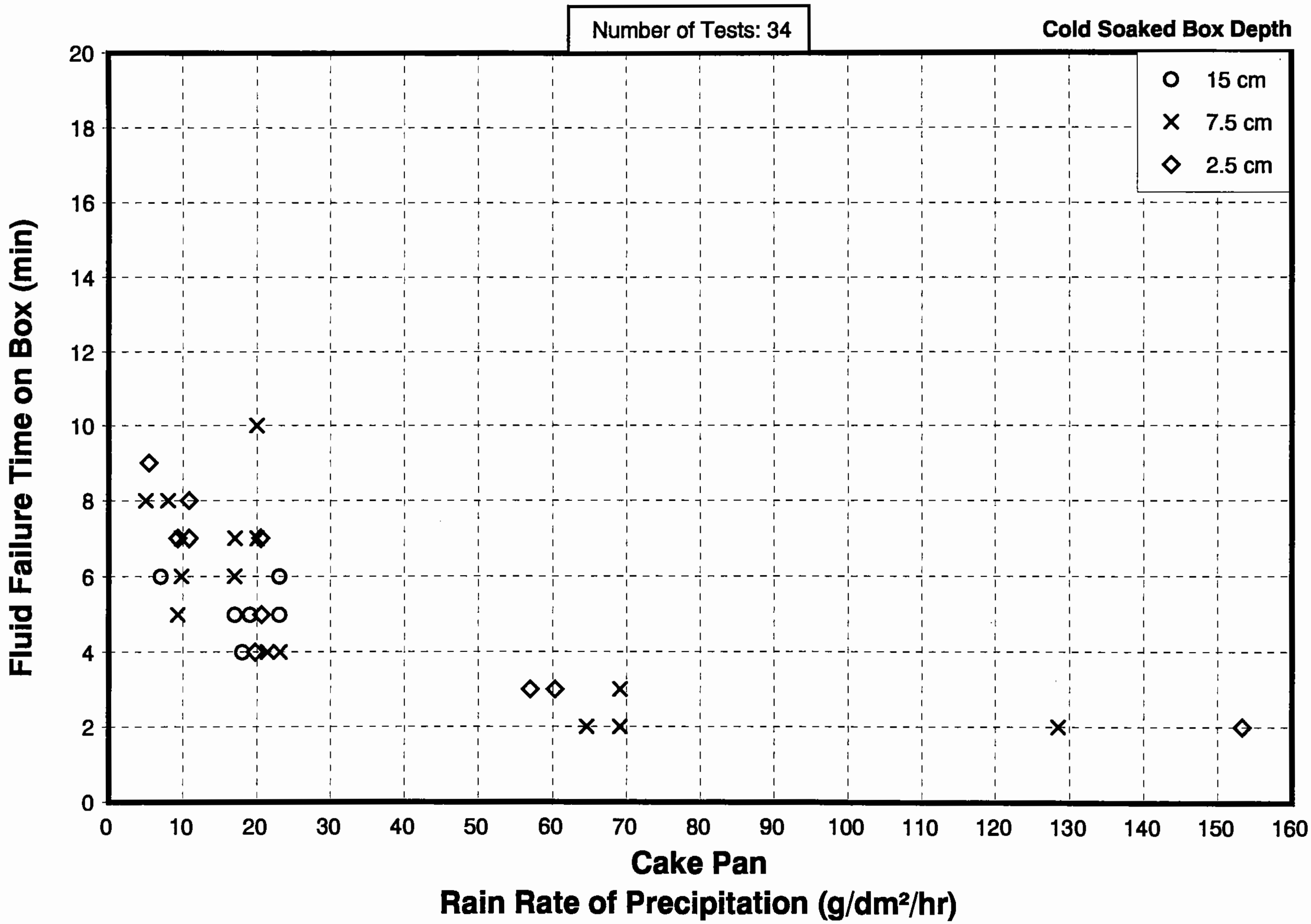
FIGURE H.35

EFFECT OF BOX SIZE AND RATE OF PRECIPITATION ON FAILURE TIME

STANDARD TYPE I

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283vaport\hot_subs\CS_1S_B.GRF

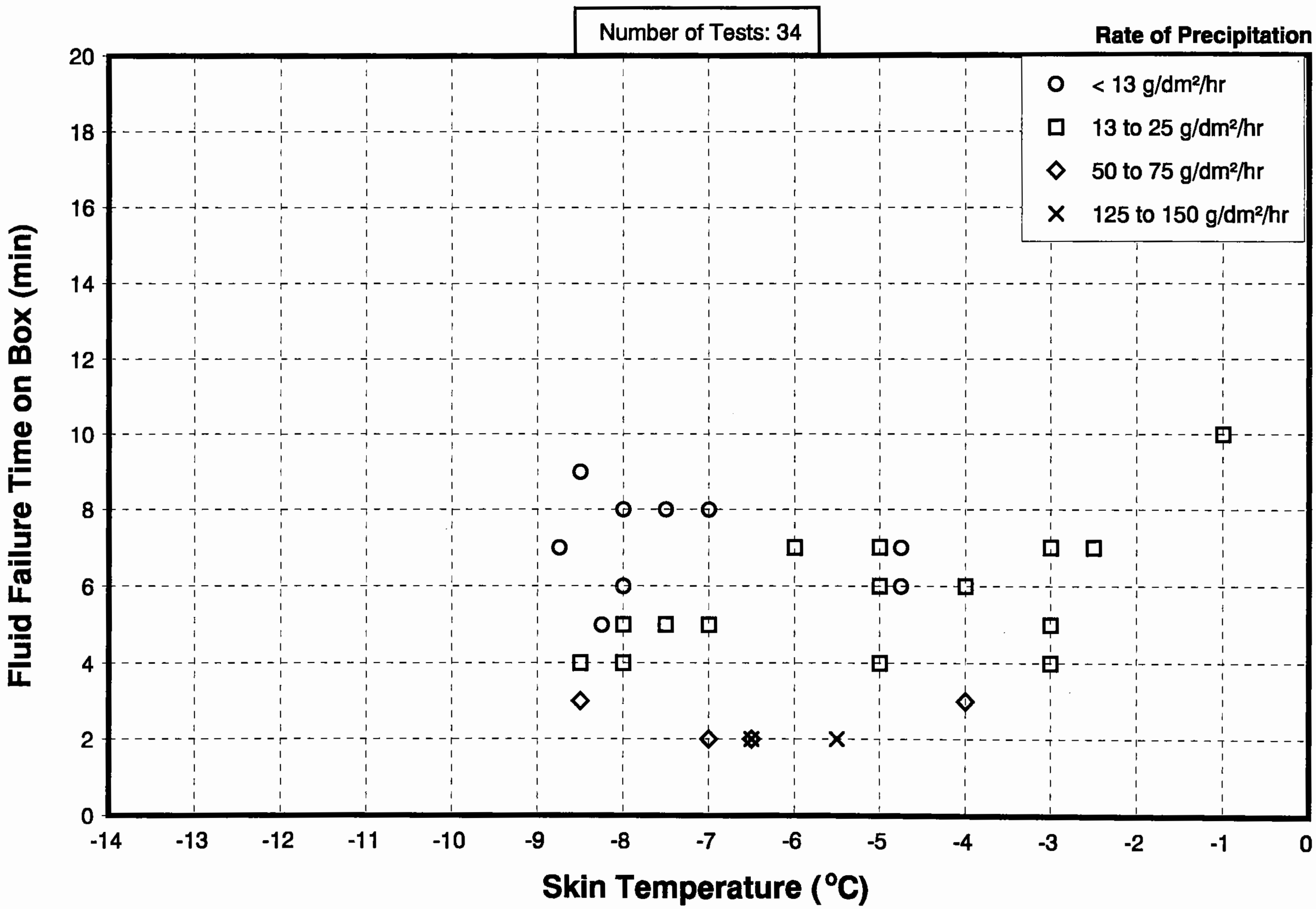
FIGURE H.36

EFFECT OF RATE OF PRECIPITATION AND SKIN TEMPERATURE ON FAILURE TIME

STANDARD TYPE I

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_1S_T.GRF

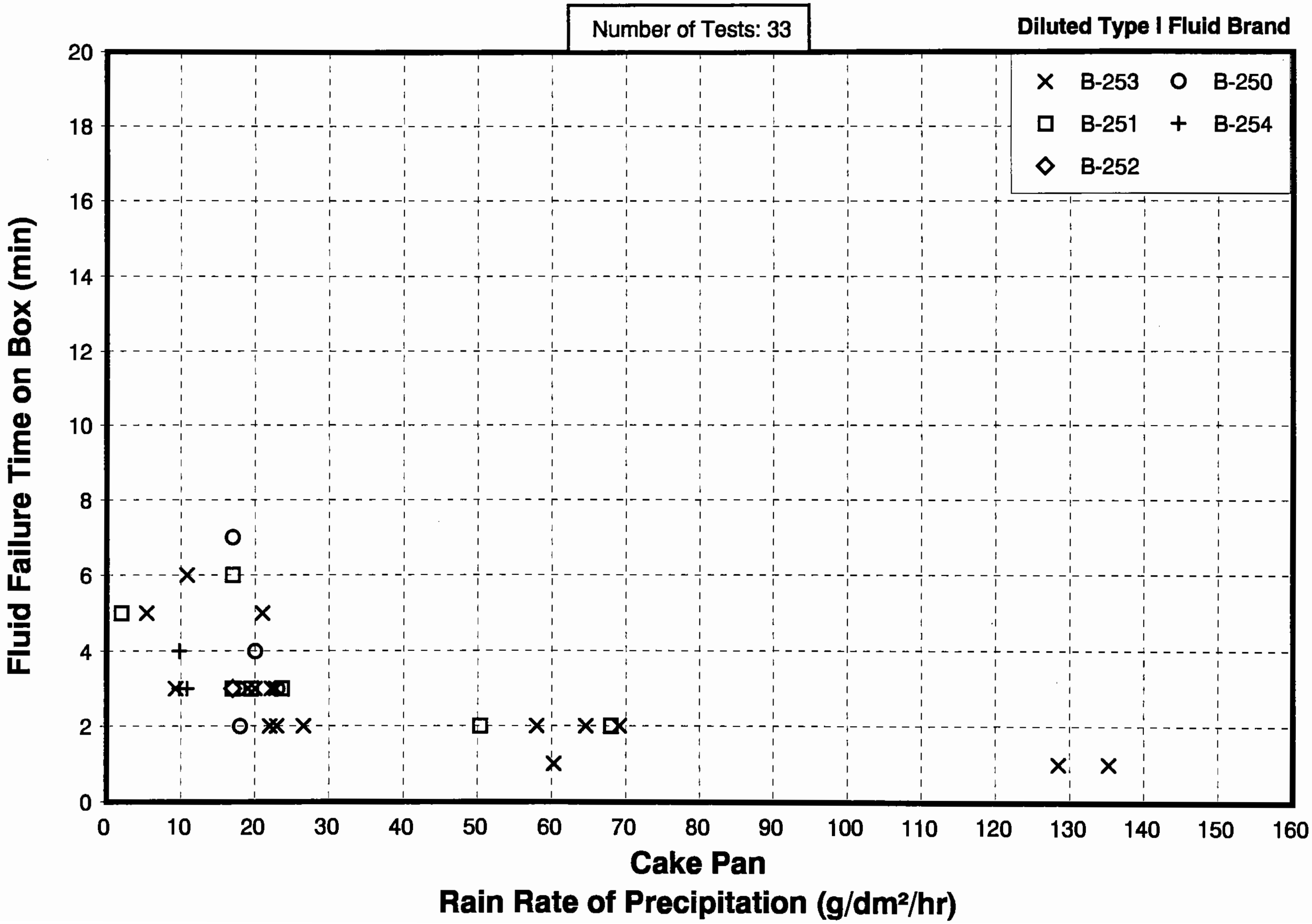
FIGURE H.37

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

DILUTED TYPE I

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_1D_R.GRF

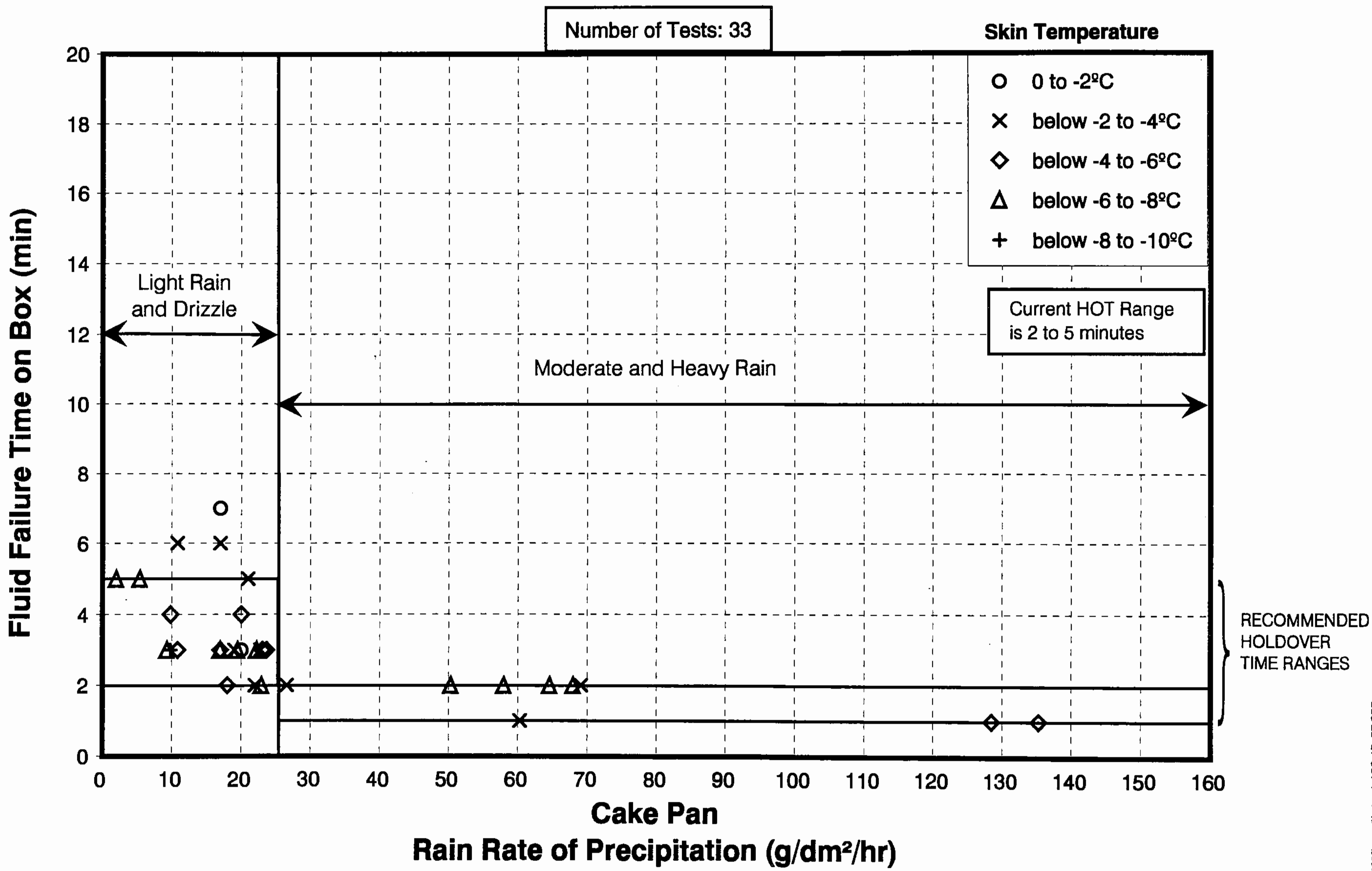
FIGURE H.38

EFFECT OF SKIN TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

DILUTED TYPE I

RAIN ON COLD-SOAKED SURFACE

1994 - 1996



cm1283\report\hot_subs\CS_1D_BT.GRF

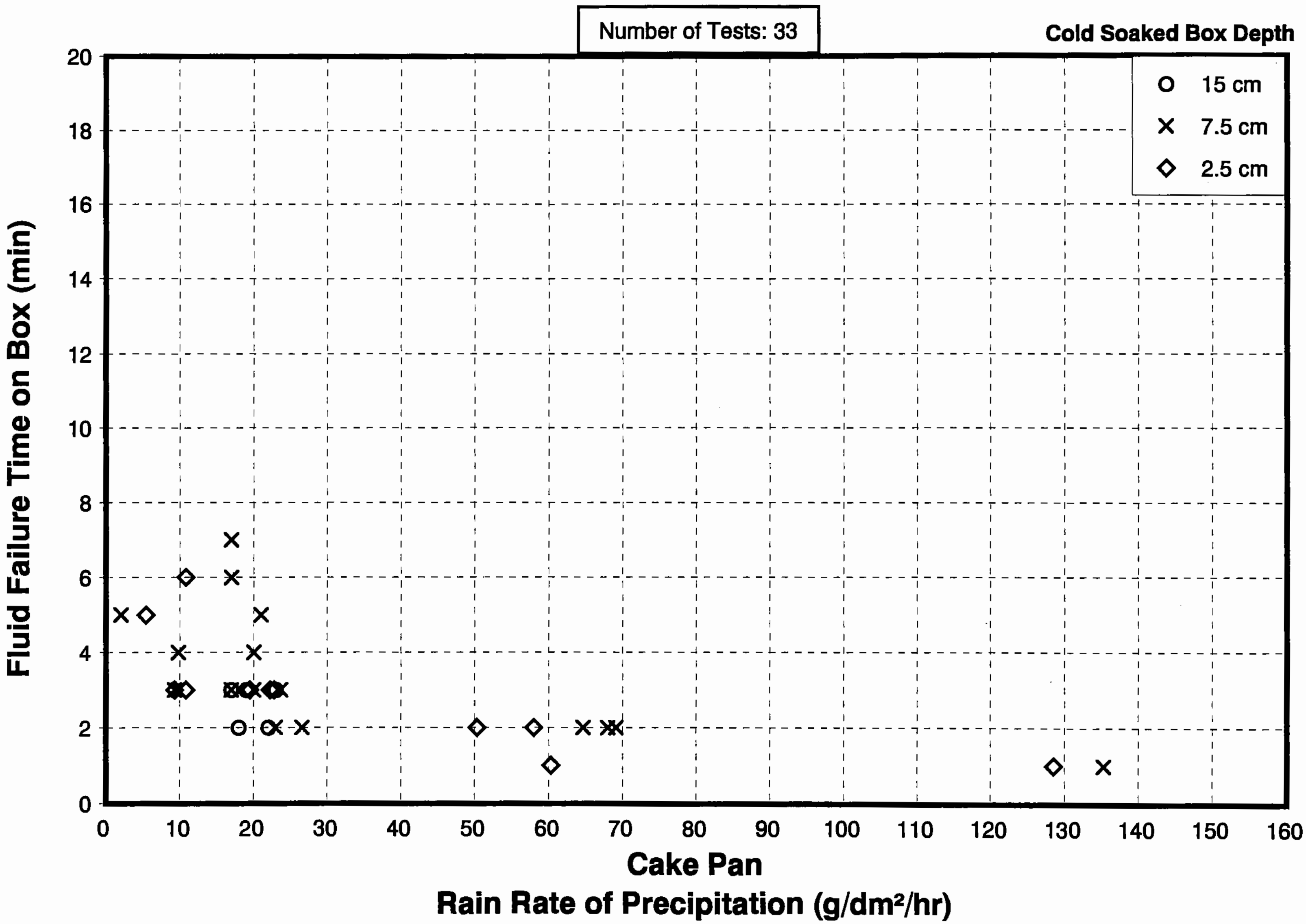
FIGURE H.39

EFFECT OF BOX SIZE AND RATE OF PRECIPITATION ON FAILURE TIME

DILUTED TYPE I

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\rcl_subs\CS_1D_B.GRF

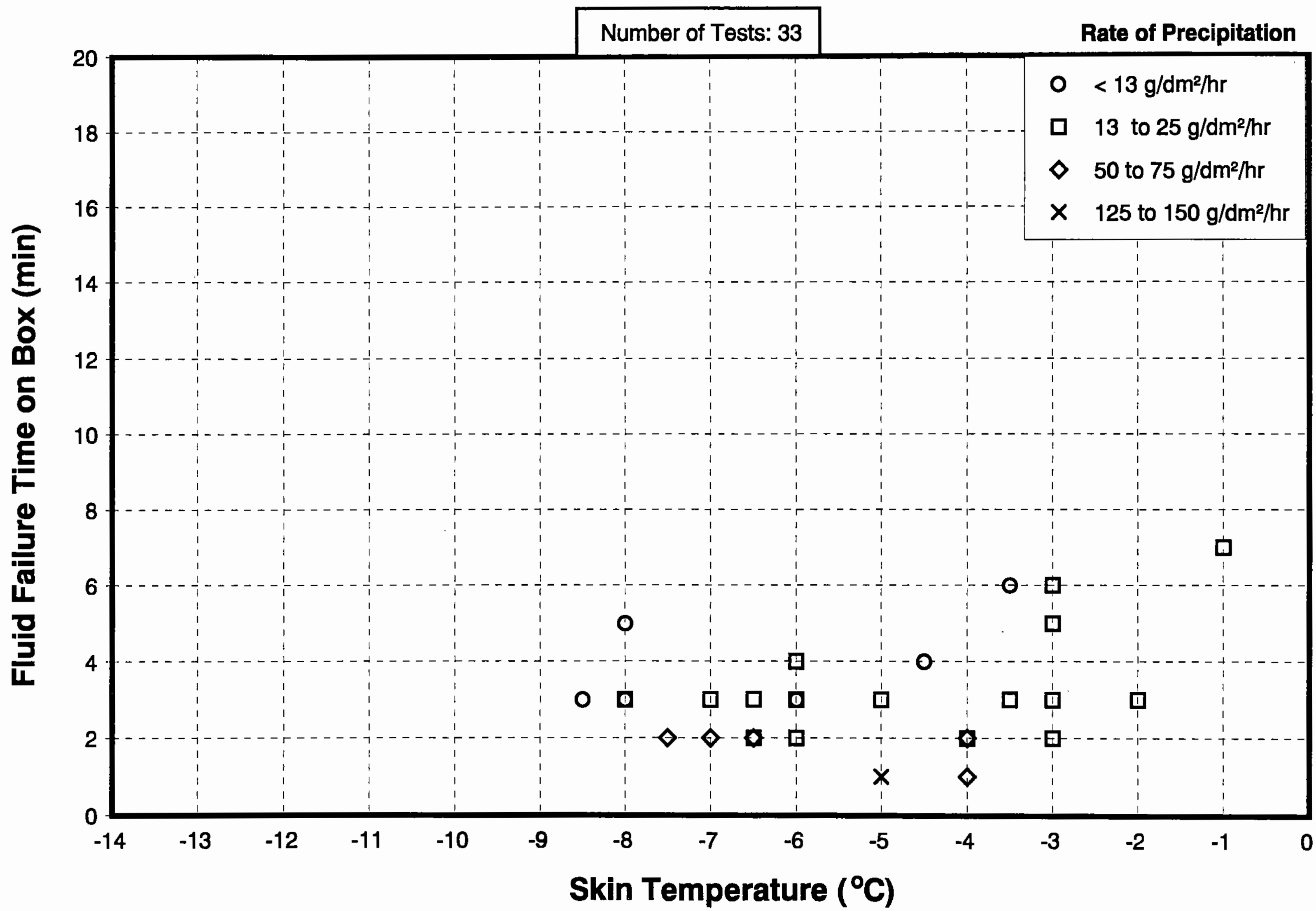
FIGURE H.40

EFFECT OF RATE OF PRECIPITATION AND SKIN TEMPERATURE ON FAILURE TIME

DILUTED TYPE I

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_1D_T.GRF

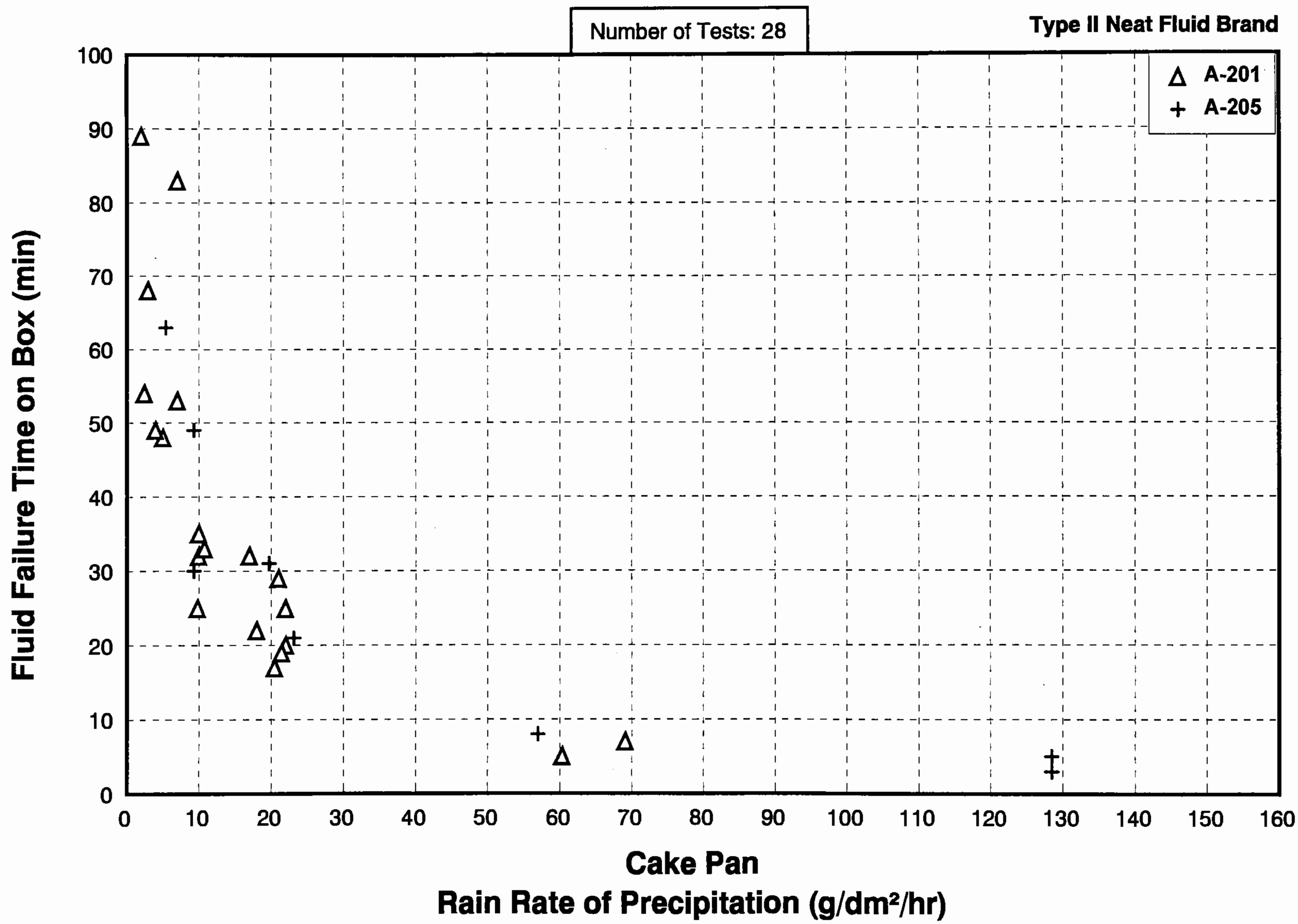
FIGURE H.41

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II NEAT

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hol_subs\CS_21_R.GRF

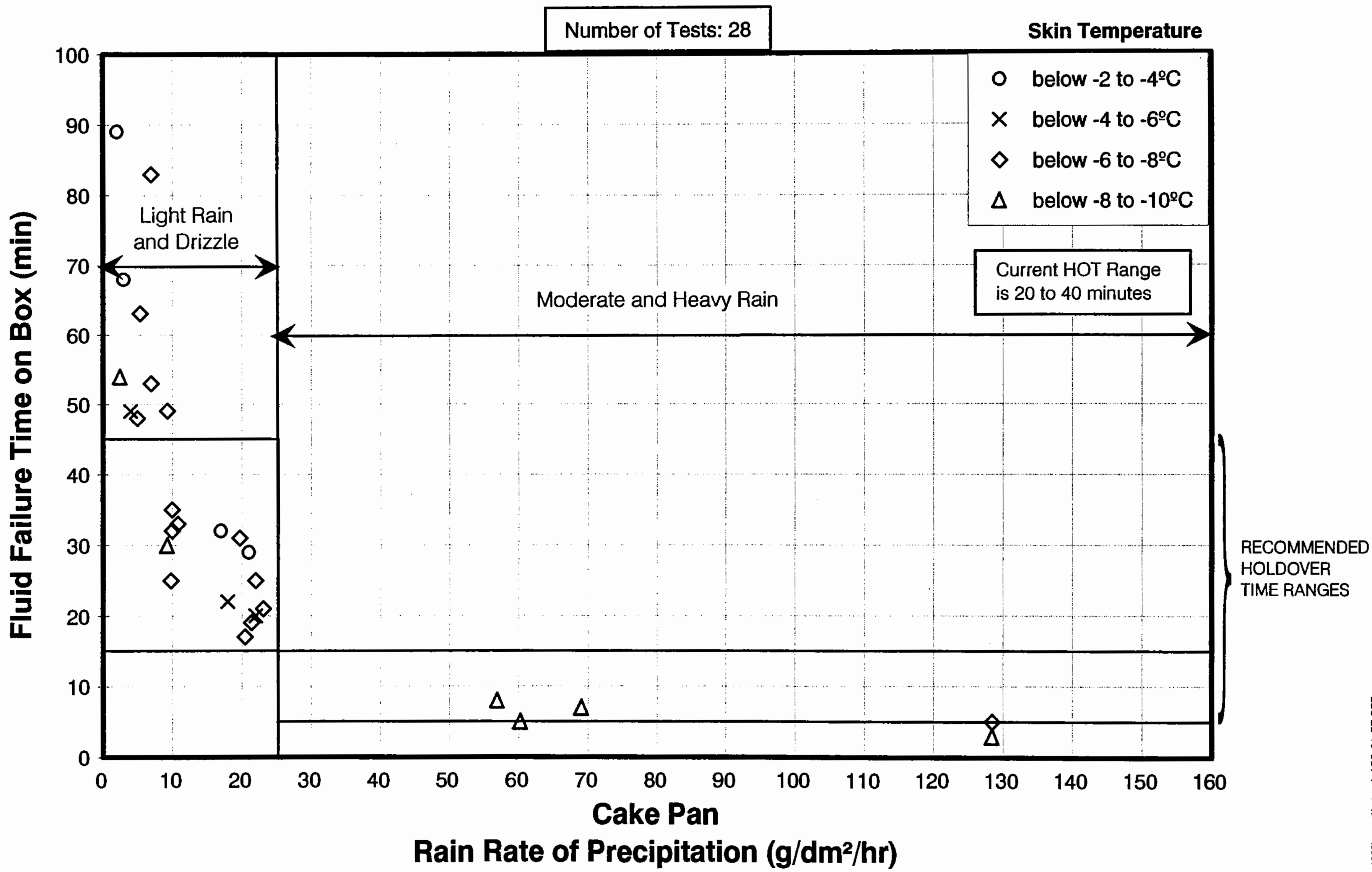
FIGURE H.42

EFFECT OF SKIN TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II NEAT

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_21_BT.GRF

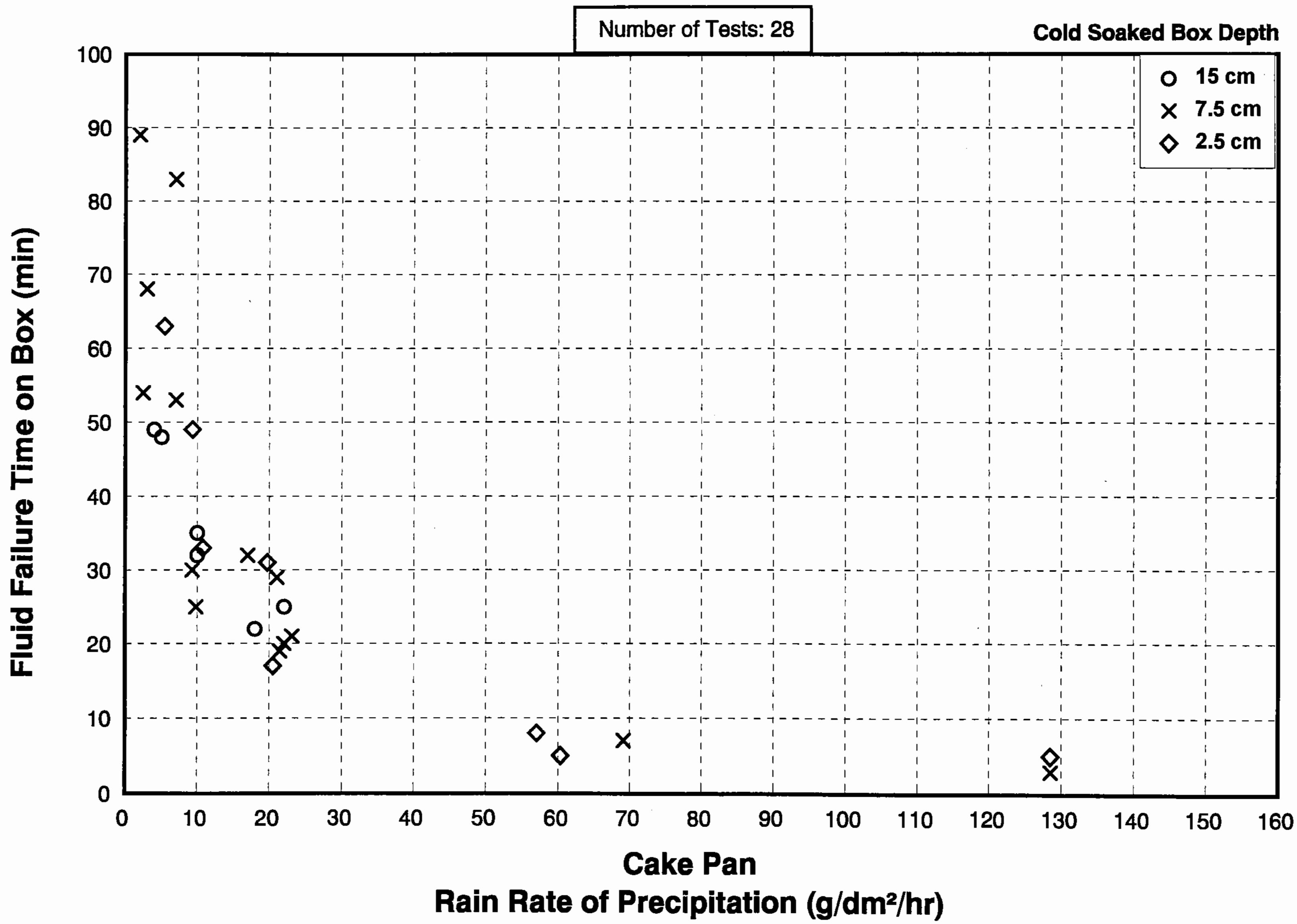
FIGURE H.43

EFFECT OF BOX SIZE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II NEAT

RAIN ON COLD-SOAKED SURFACE

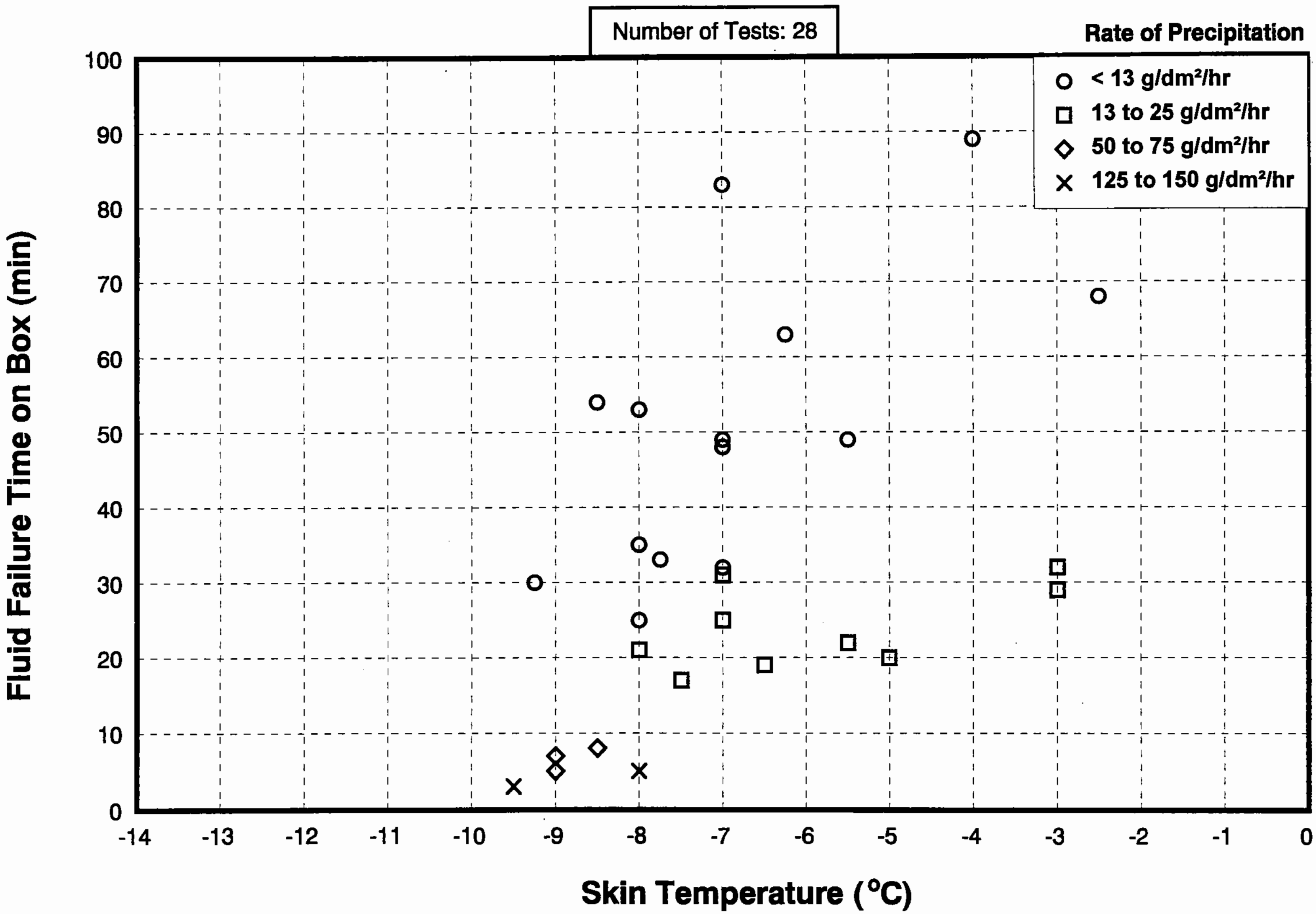
1995 - 1996



cm1283\report\rol_subs\CS_21_B.GRF

FIGURE H.44

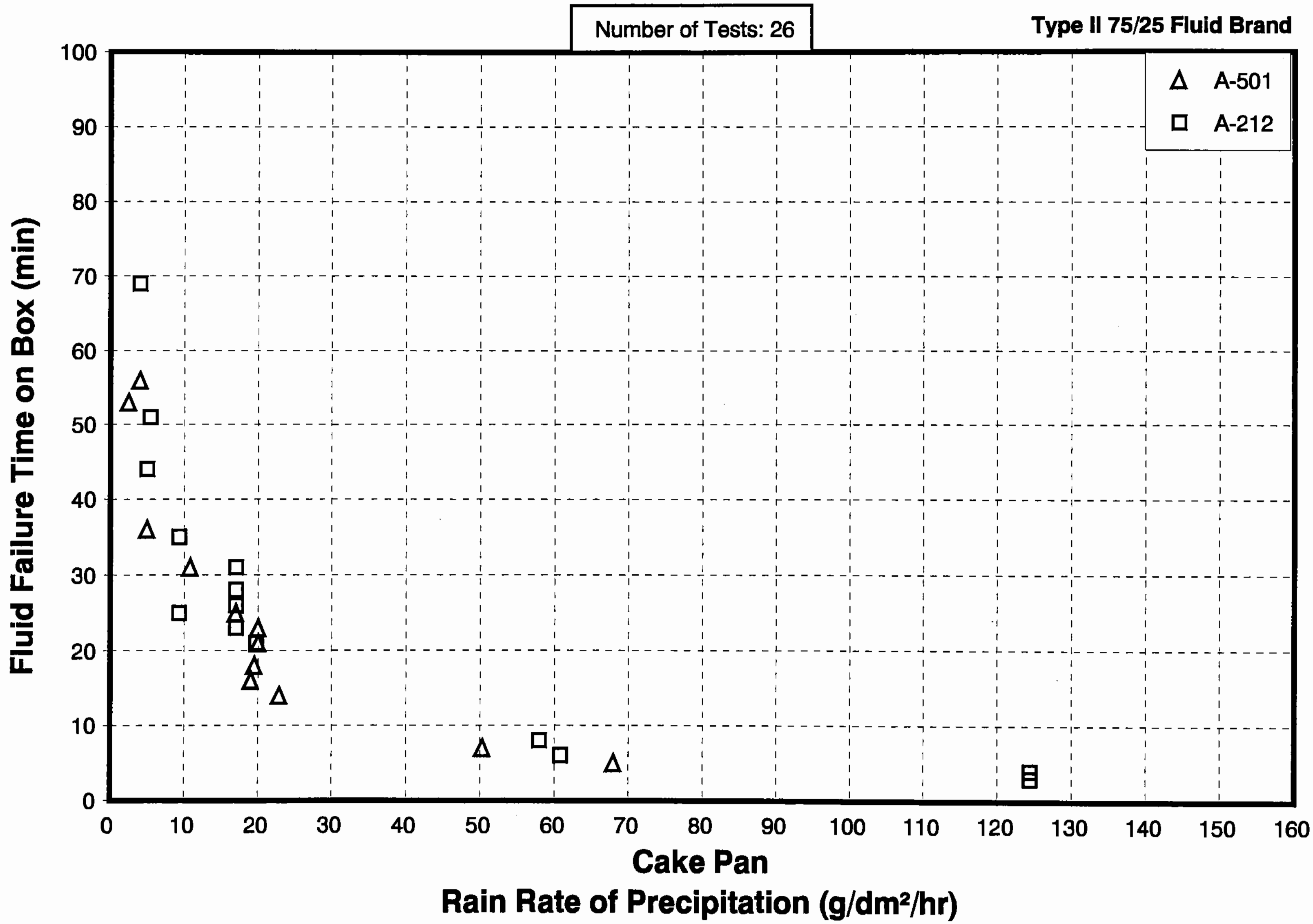
EFFECT OF RATE OF PRECIPITATION AND SKIN TEMPERATURE ON FAILURE TIME
TYPE II NEAT
RAIN ON COLD-SOAKED SURFACE
1995 - 1996



cm1283\report\rai_subs\CS_21_T.GRF

FIGURE H.45

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE II 75/25
RAIN ON COLD-SOAKED SURFACE
1995 - 1996



cm1283\report\hot_subs\CS_27_R.GRF

FIGURE H.46
EFFECT OF SKIN TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME
TYPE II 75/25
RAIN ON COLD-SOAKED SURFACE
1995 - 1996

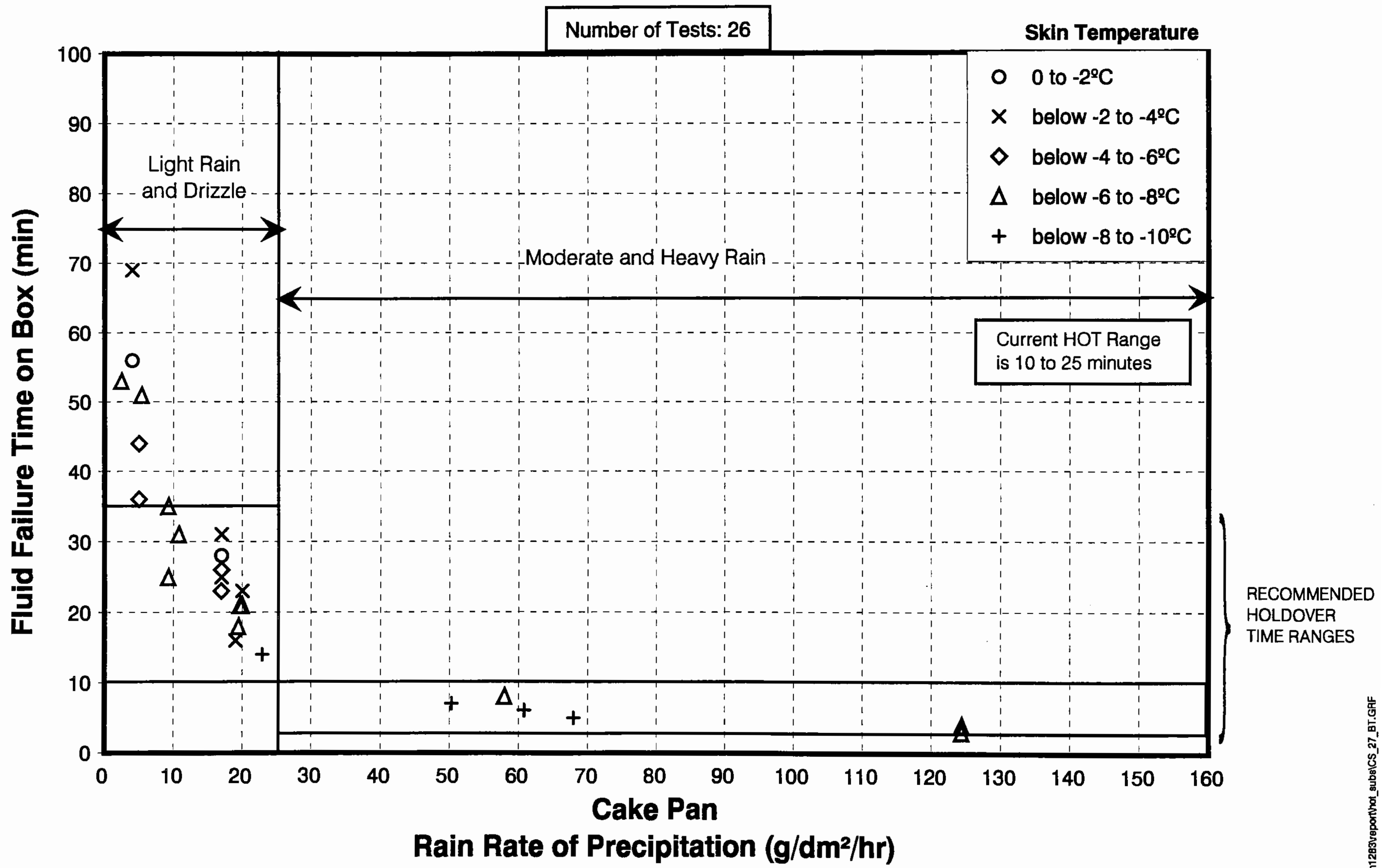


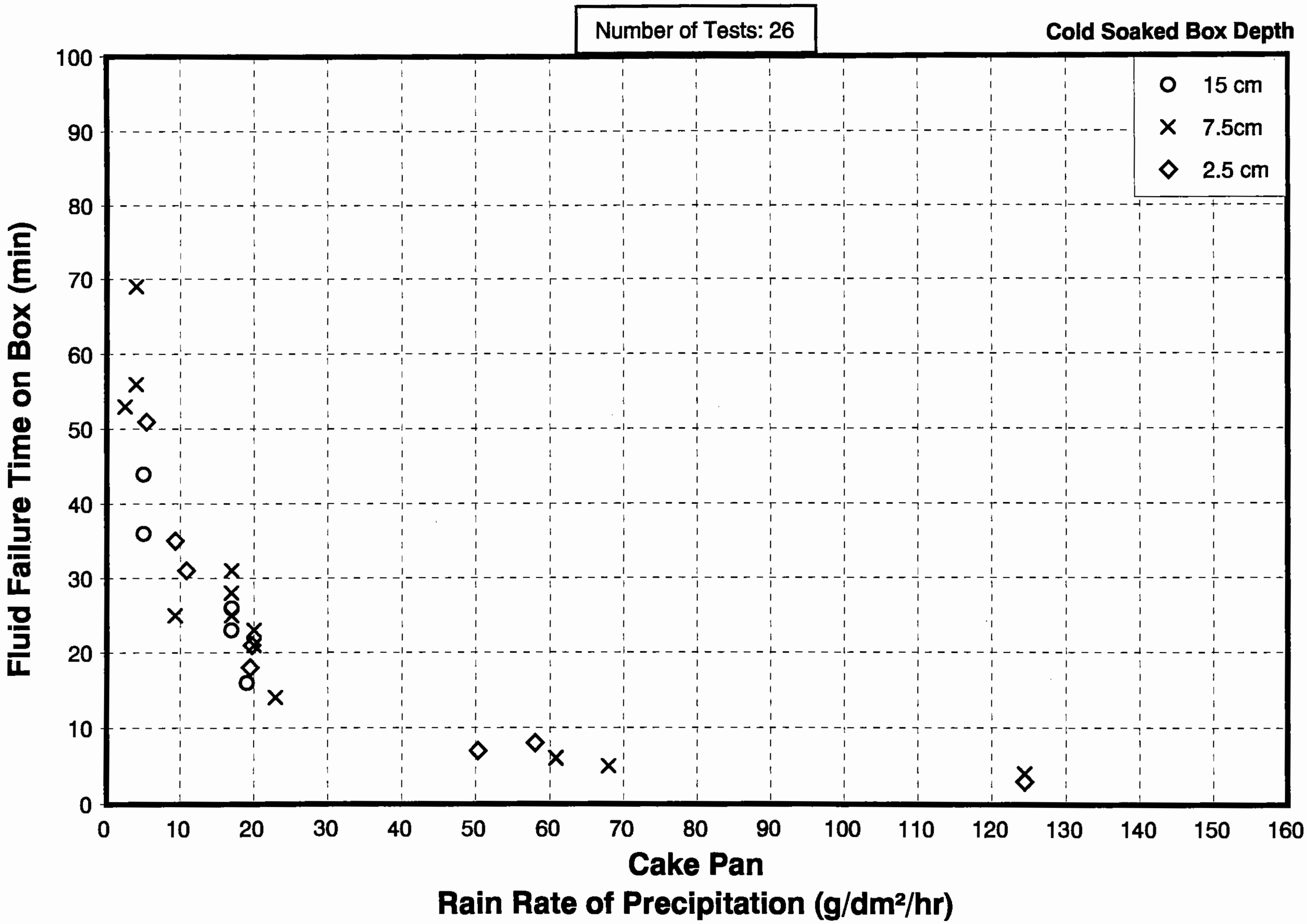
FIGURE H.47

EFFECT OF BOX SIZE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 75/25

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\rot_subs\CS_27_B.GRF

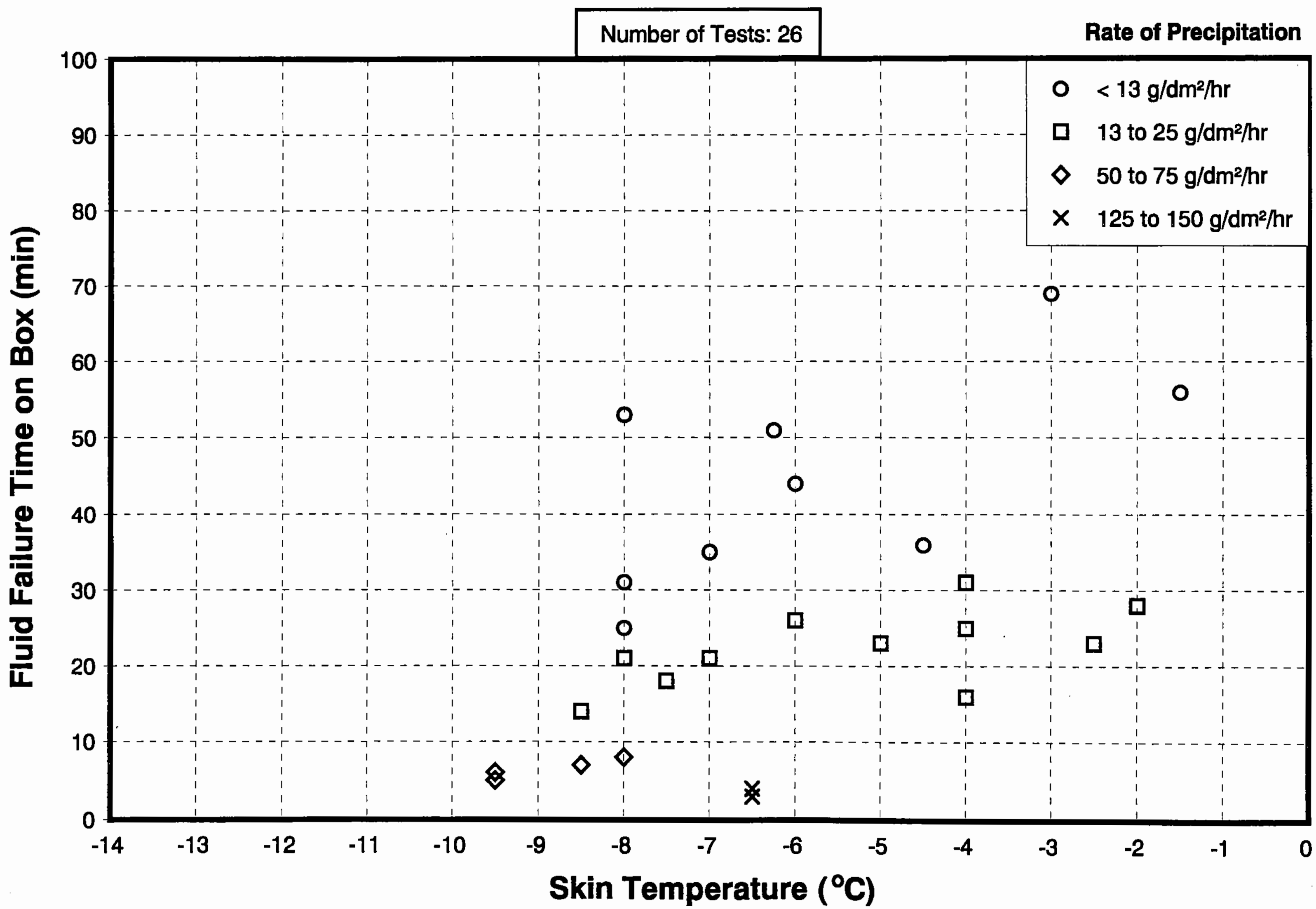
FIGURE H.48

EFFECT OF RATE OF PRECIPITATION SKIN TEMPERATURE ON FAILURE TIME

TYPE II 75/25

RAIN ON COLD-SOAKED SURFACE

1995 -1996



cm1283\report\vol_subs\CS_27_T.GRF

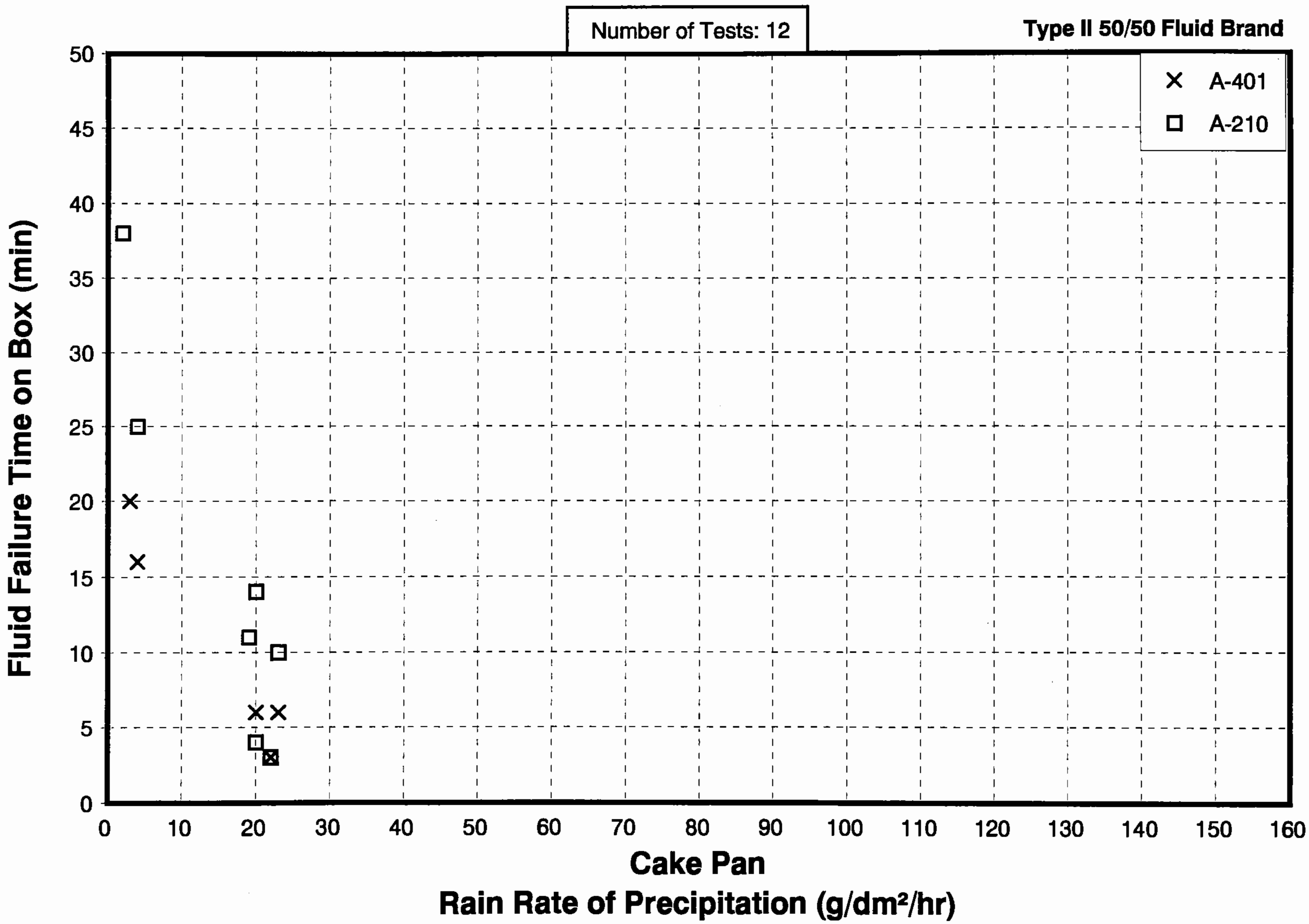
FIGURE H.49

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 50/50

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_25_R.GRF

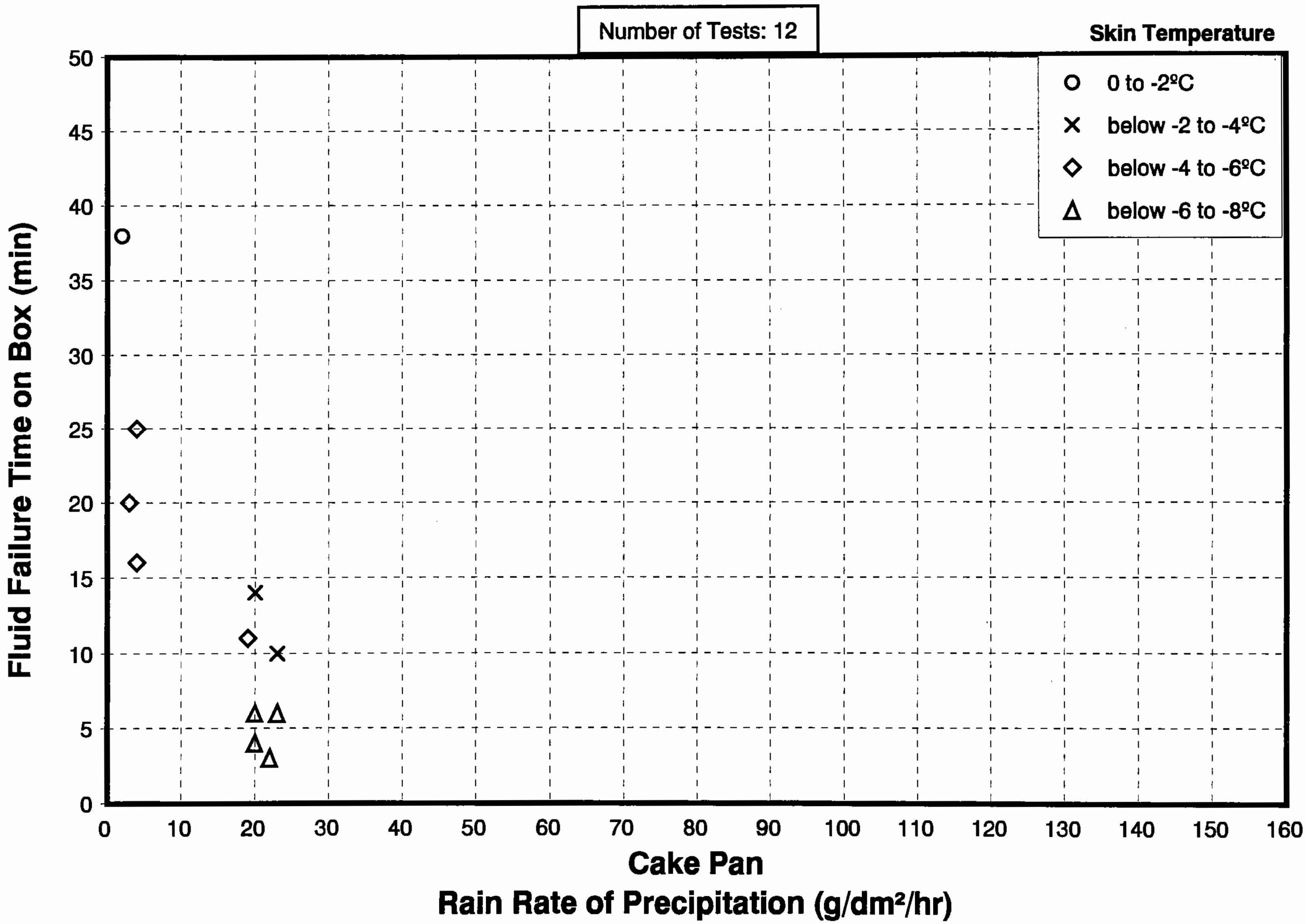
FIGURE H.50

EFFECT OF SKIN TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 50/50

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_25_BT.GRF

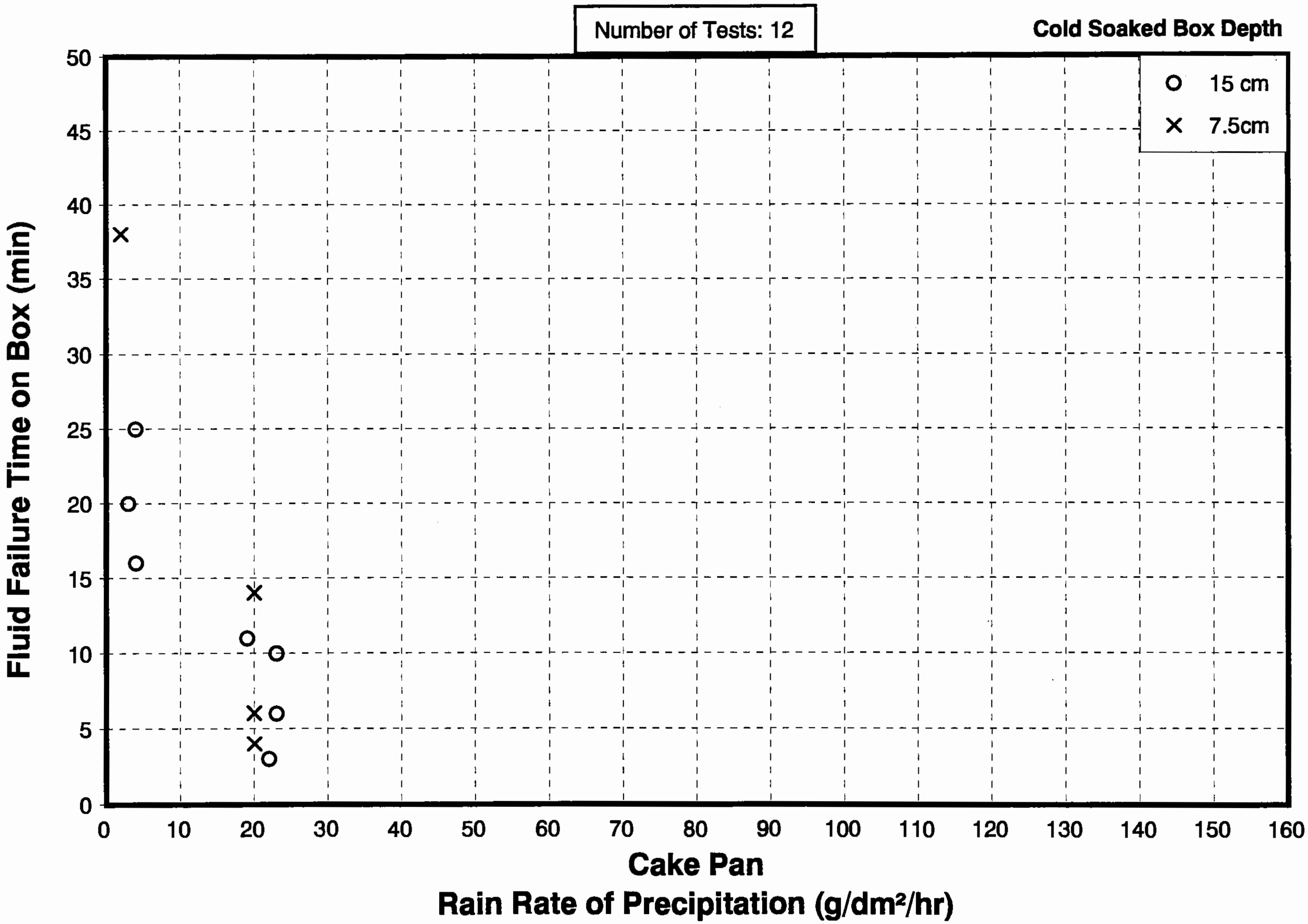
FIGURE H.51

EFFECT OF BOX SIZE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE II 50/50

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\rot_subs\CS_25_B.GRF

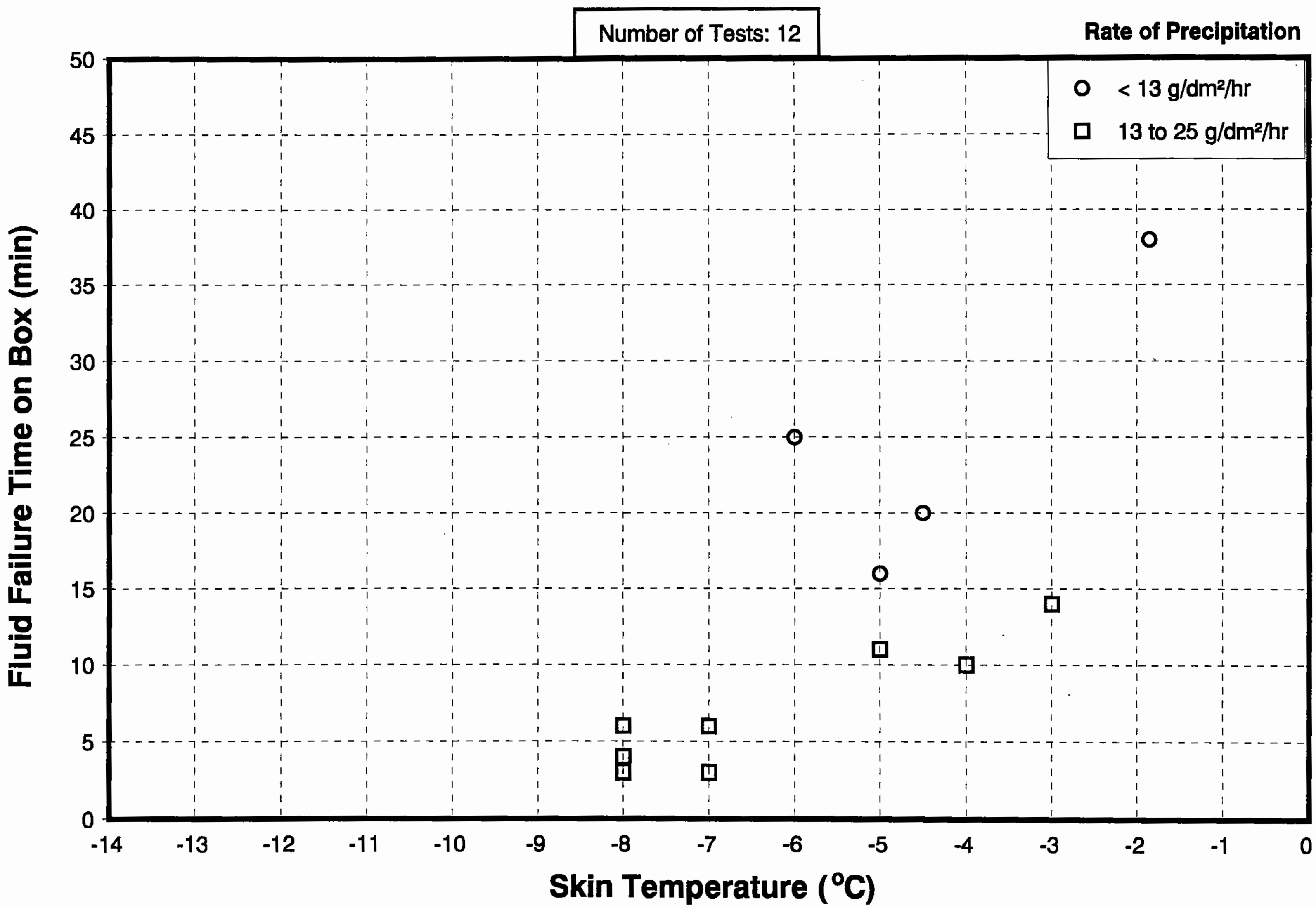
FIGURE H.52

EFFECT OF RATE OF PRECIPITATION SKIN TEMPERATURE ON FAILURE TIME

TYPE II 50/50

RAIN ON COLD-SOAKED SURFACE

1995 -1996



cm1283\report\hol_subs\CS_25_T.GRF

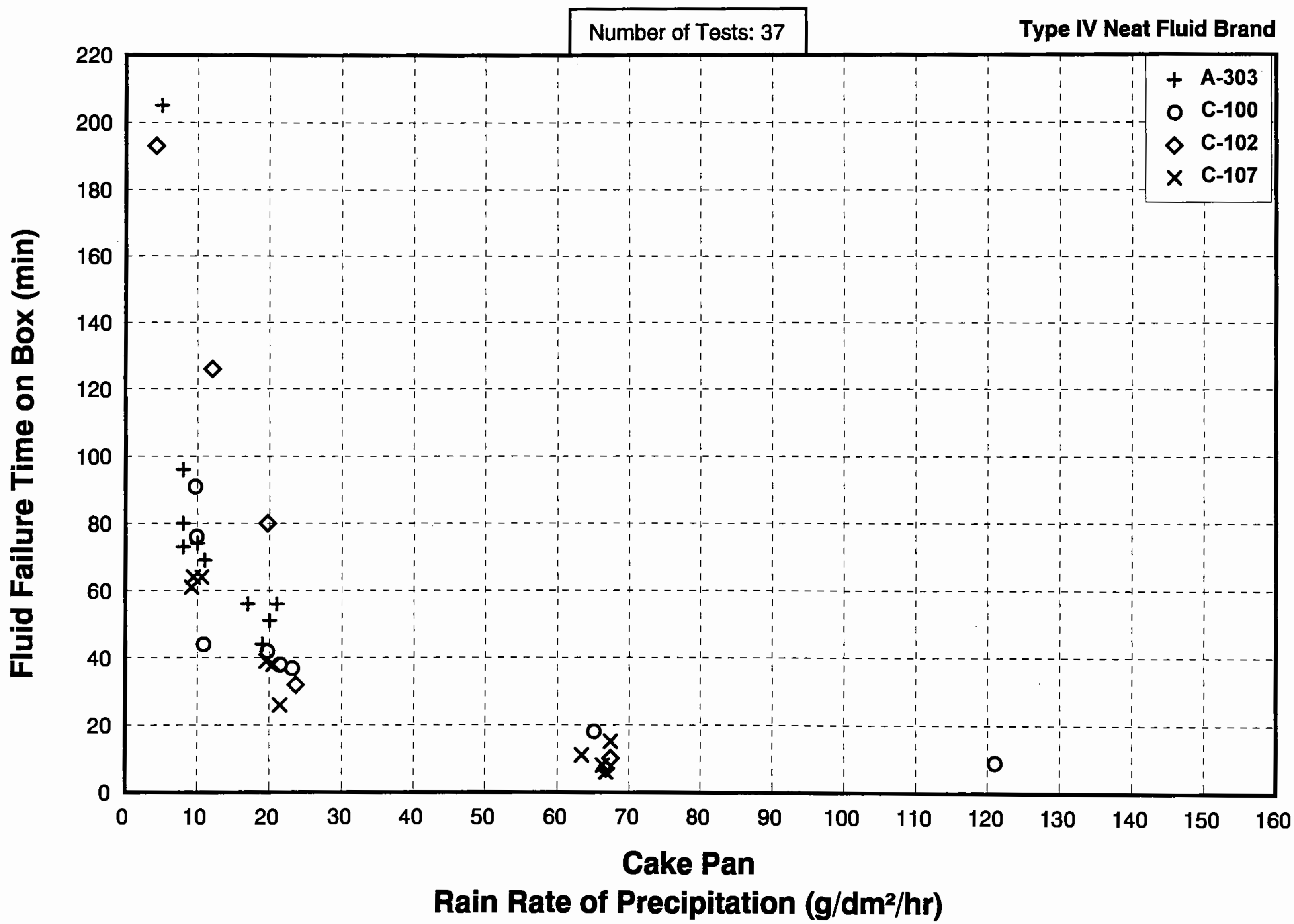
FIGURE H.53

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

RAIN ON COLD-SOAKED SURFACE

1995 -1996



cm1283\report\vol_subs\CS_41_R.GRF

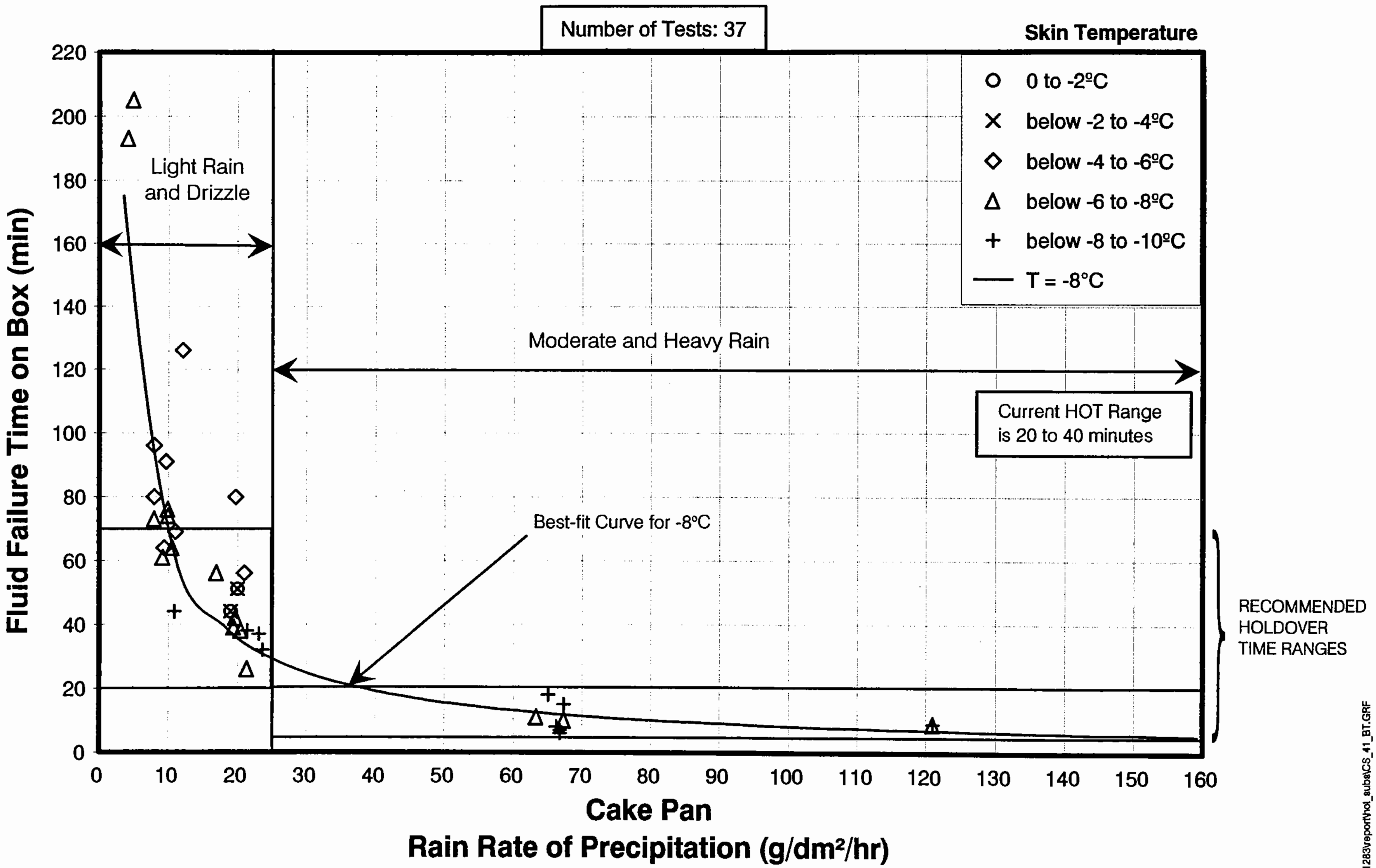
FIGURE H.54

EFFECT OF SKIN TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hol_subs\CS_41_BT.GRF

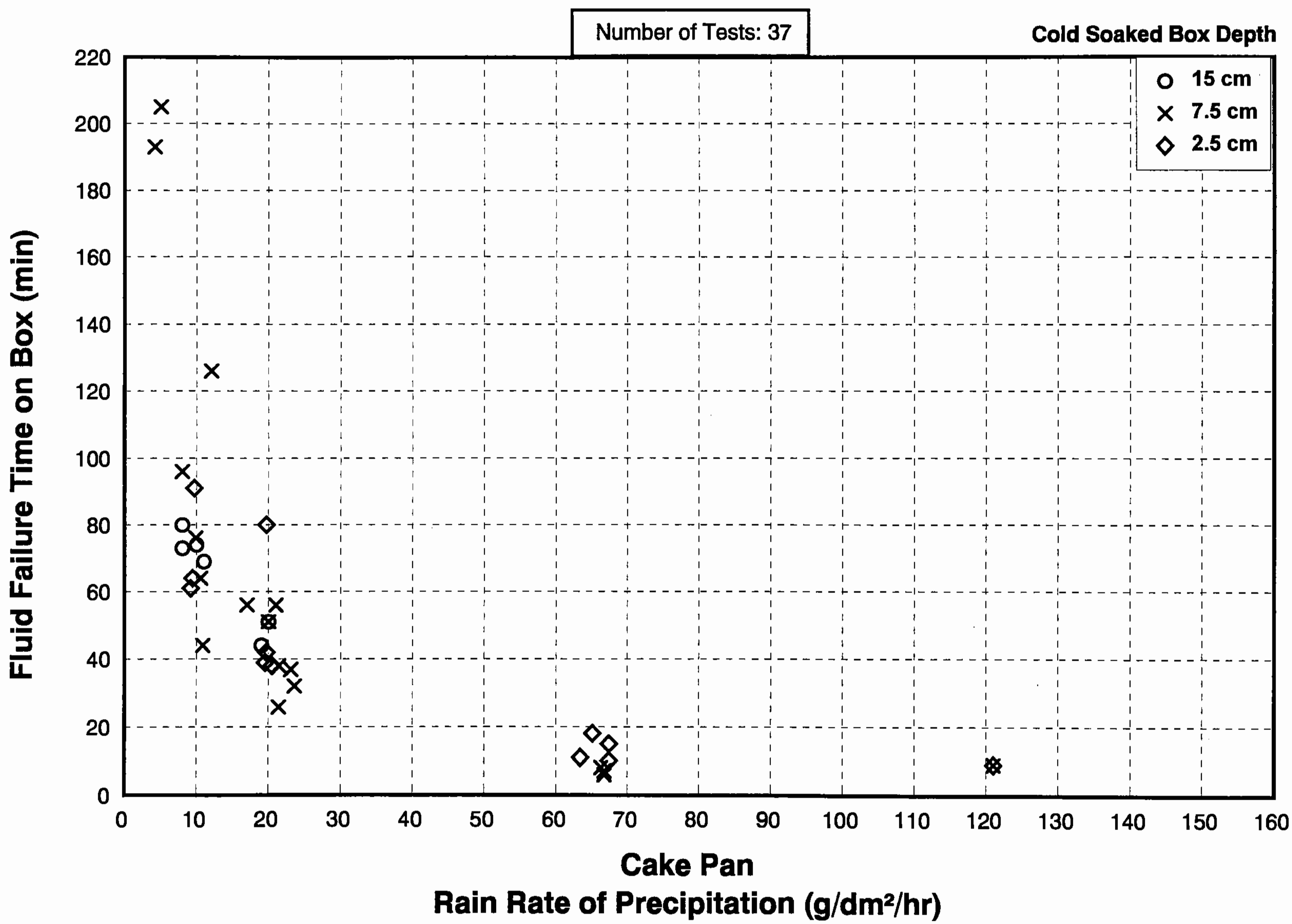
FIGURE H.55

EFFECT OF BOX SIZE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV NEAT

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_41_B.GRF

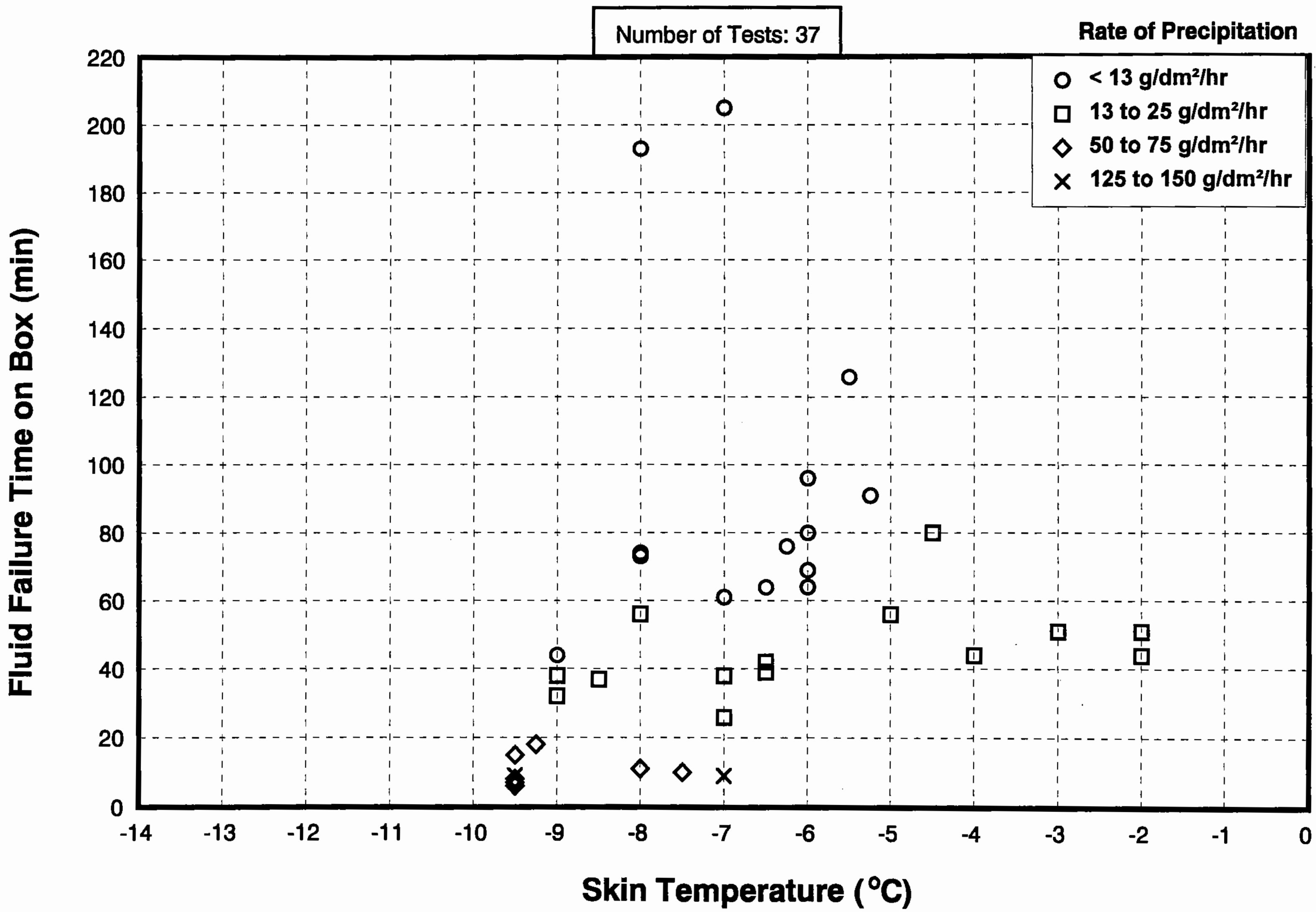
FIGURE H.56

EFFECT OF RATE OF PRECIPITATION AND SKIN TEMPERATURE ON FAILURE TIME

TYPE IV NEAT

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_41_T.GRF

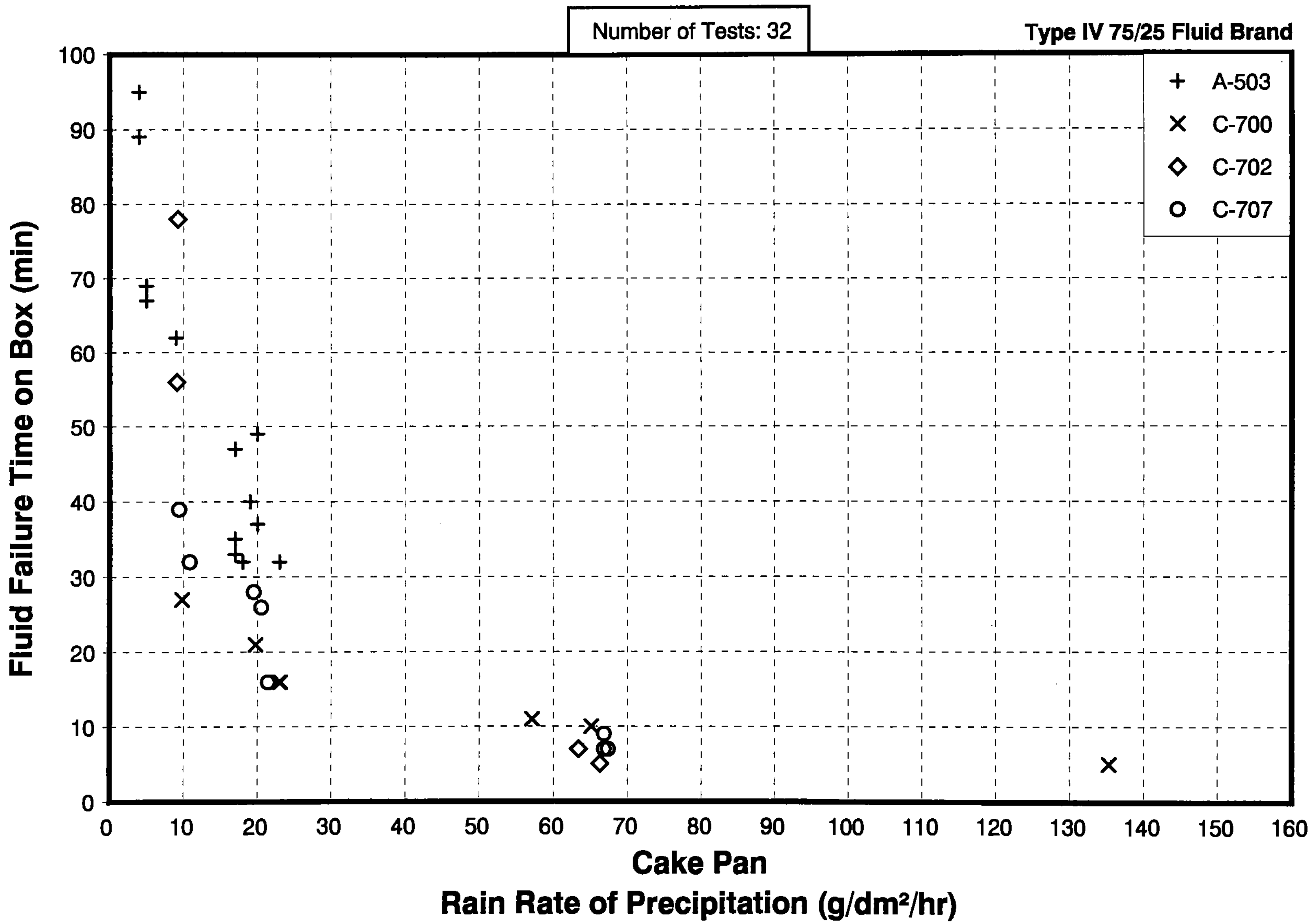
FIGURE H.57

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_47_R.GRF

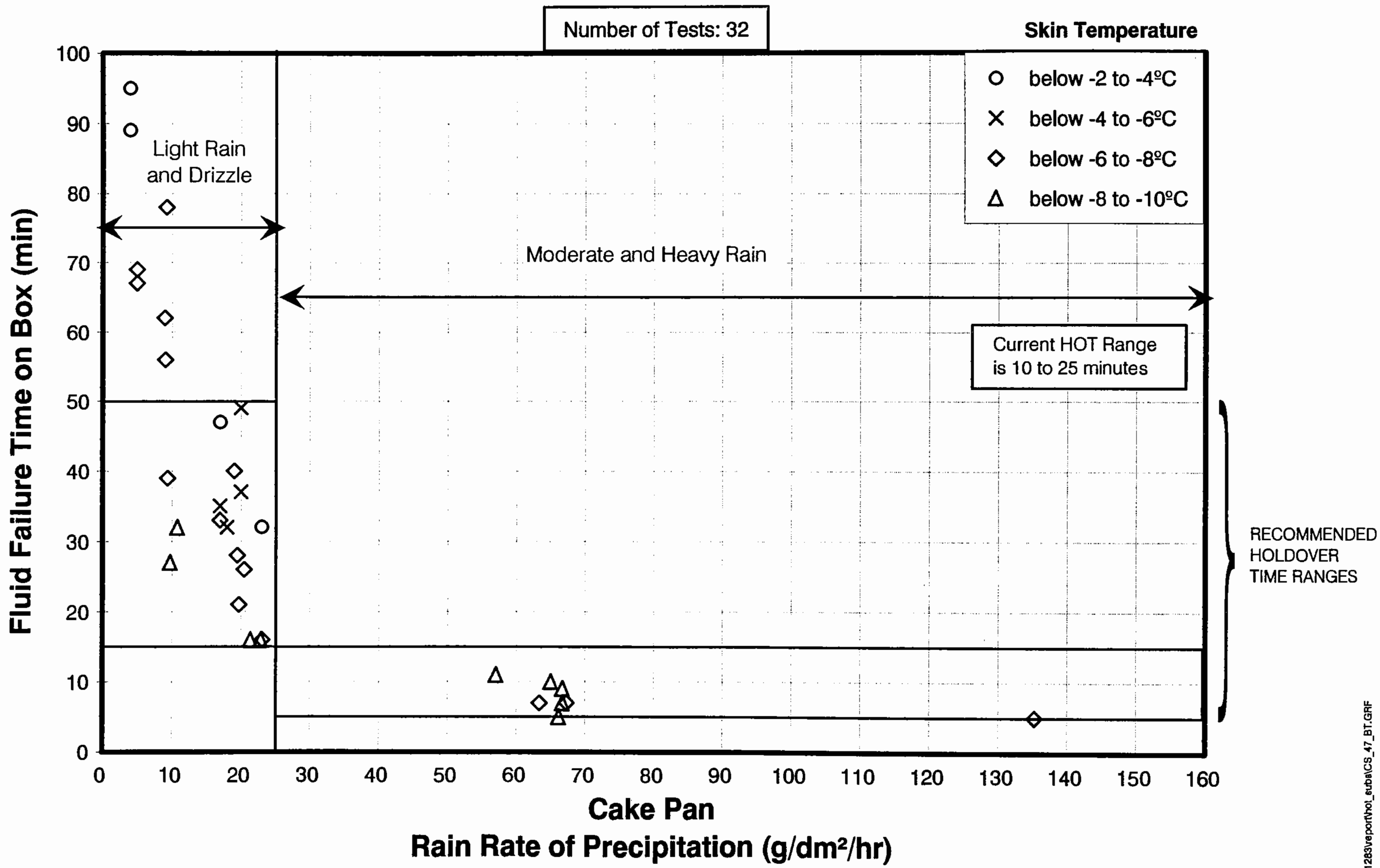
FIGURE H.58

EFFECT OF SKIN TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_47_BT.GRF

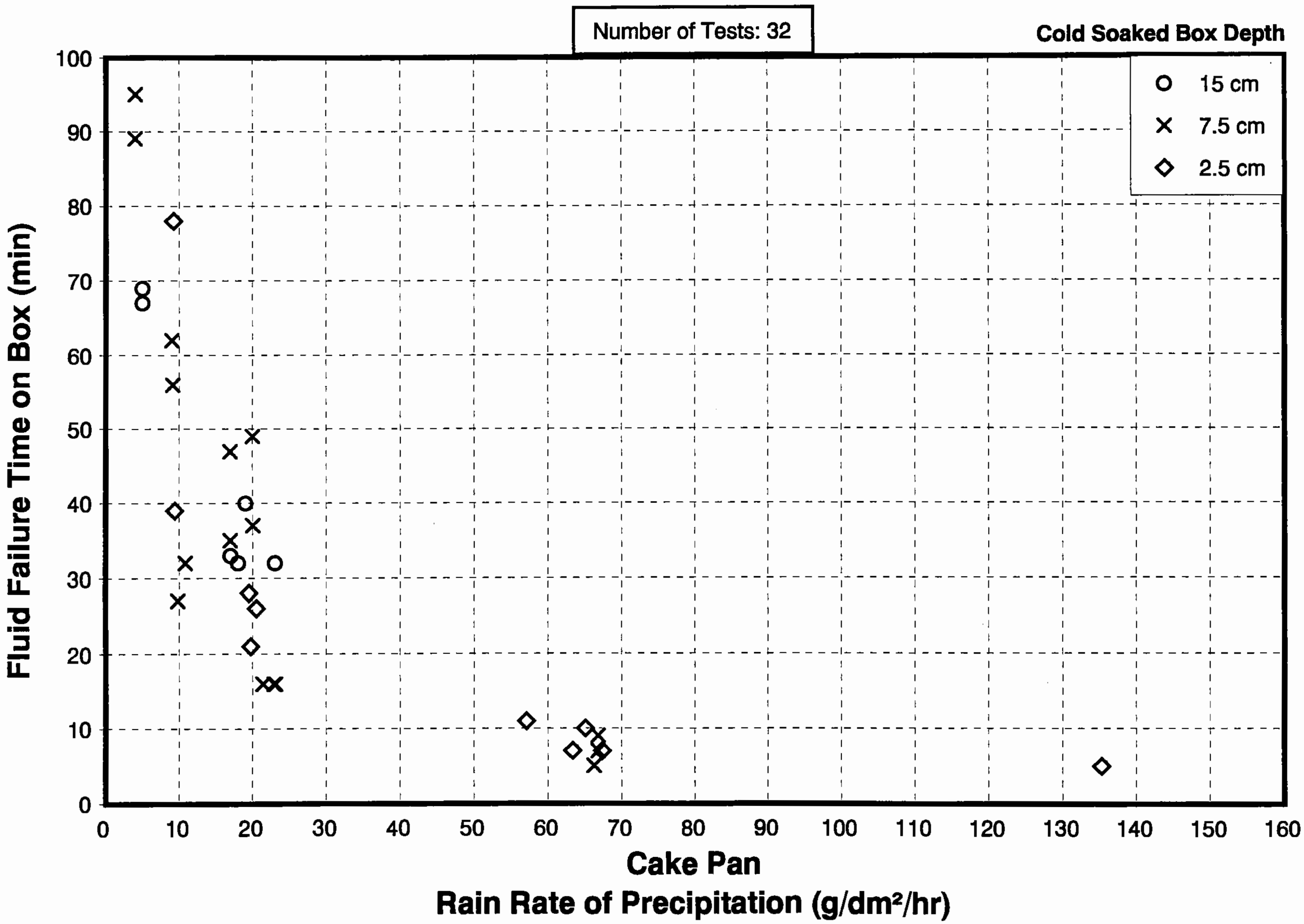
FIGURE H.59

EFFECT OF BOX SIZE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 75/25

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\rot_subs\CS_47_B.GRF

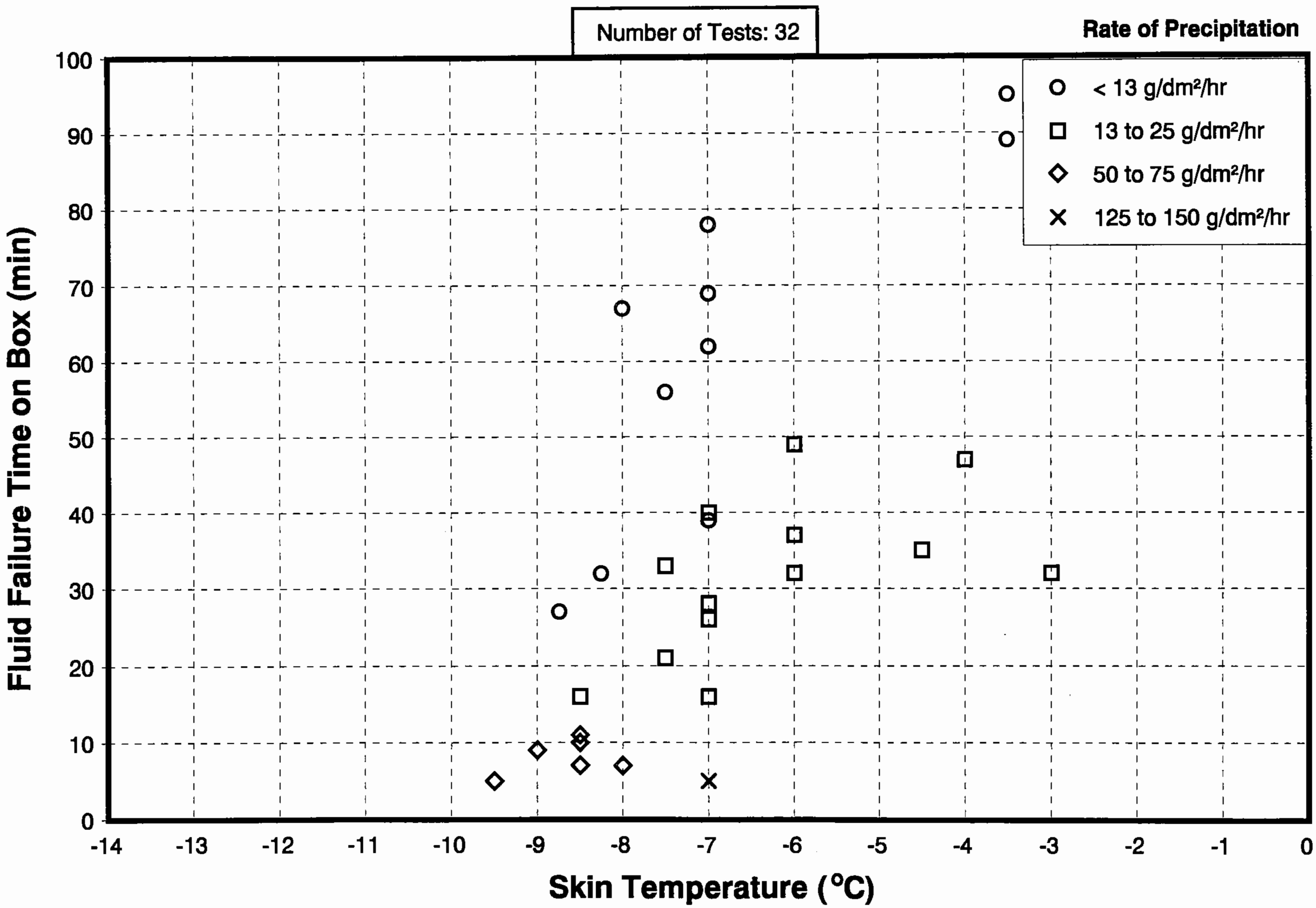
FIGURE H.60

EFFECT OF RATE OF PRECIPITATION AND SKIN TEMPERATURE ON FAILURE TIME

TYPE IV 75/25

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_47_LGRF

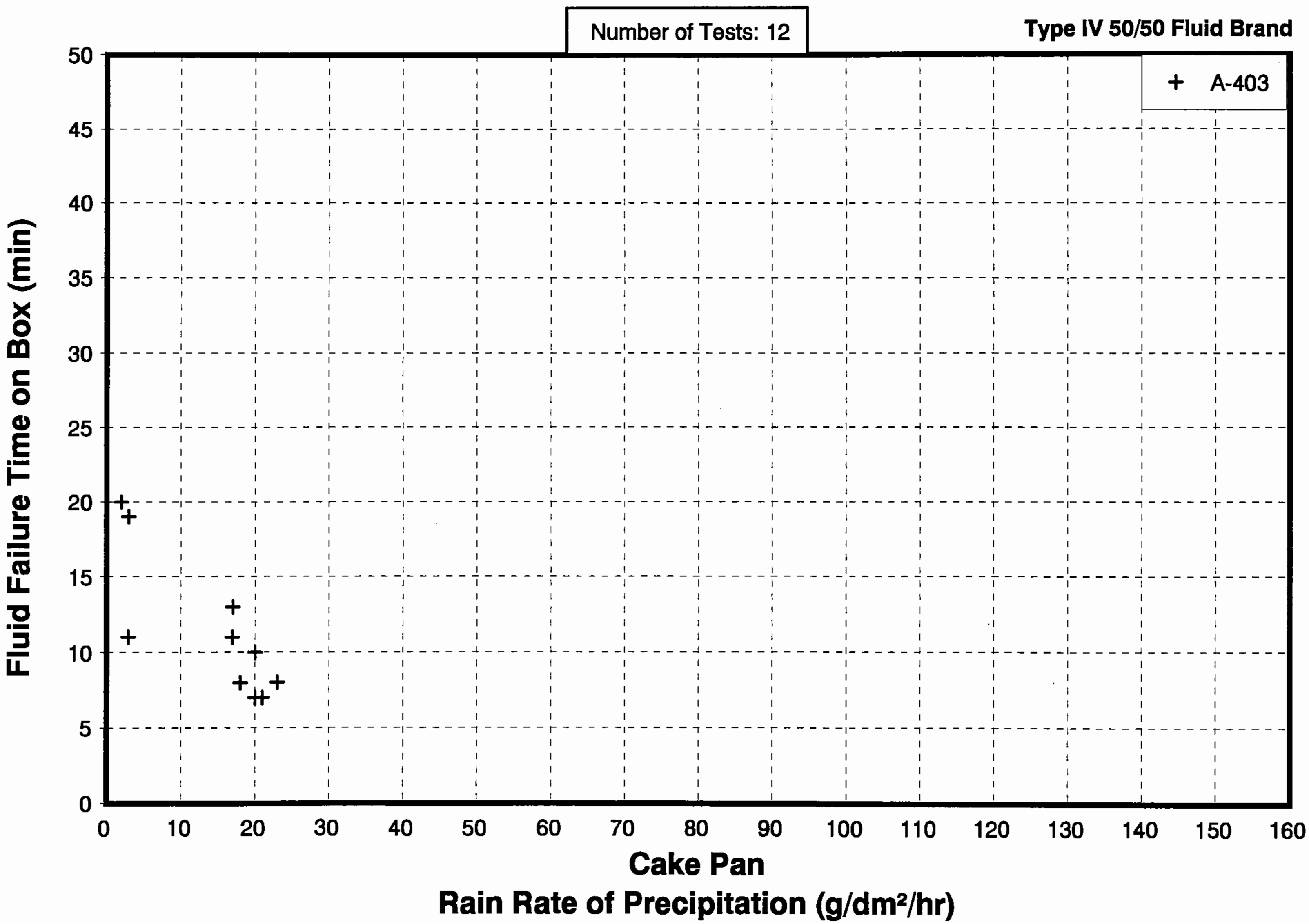
FIGURE H.61

EFFECT OF FLUID TYPE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hol_subs\CS_45_R.GRF

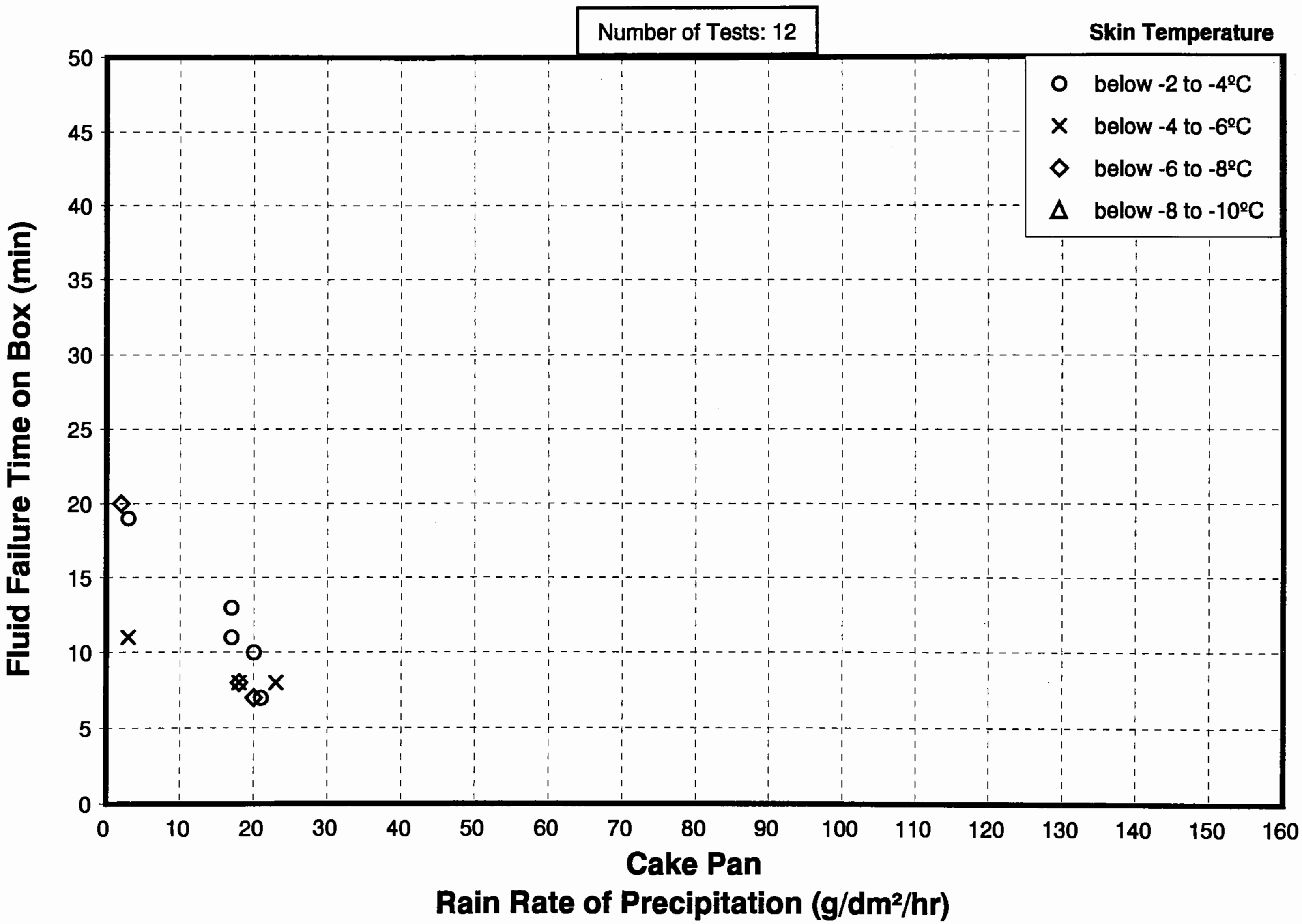
FIGURE H.62

EFFECT OF SKIN TEMPERATURE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_45_BT.GRF

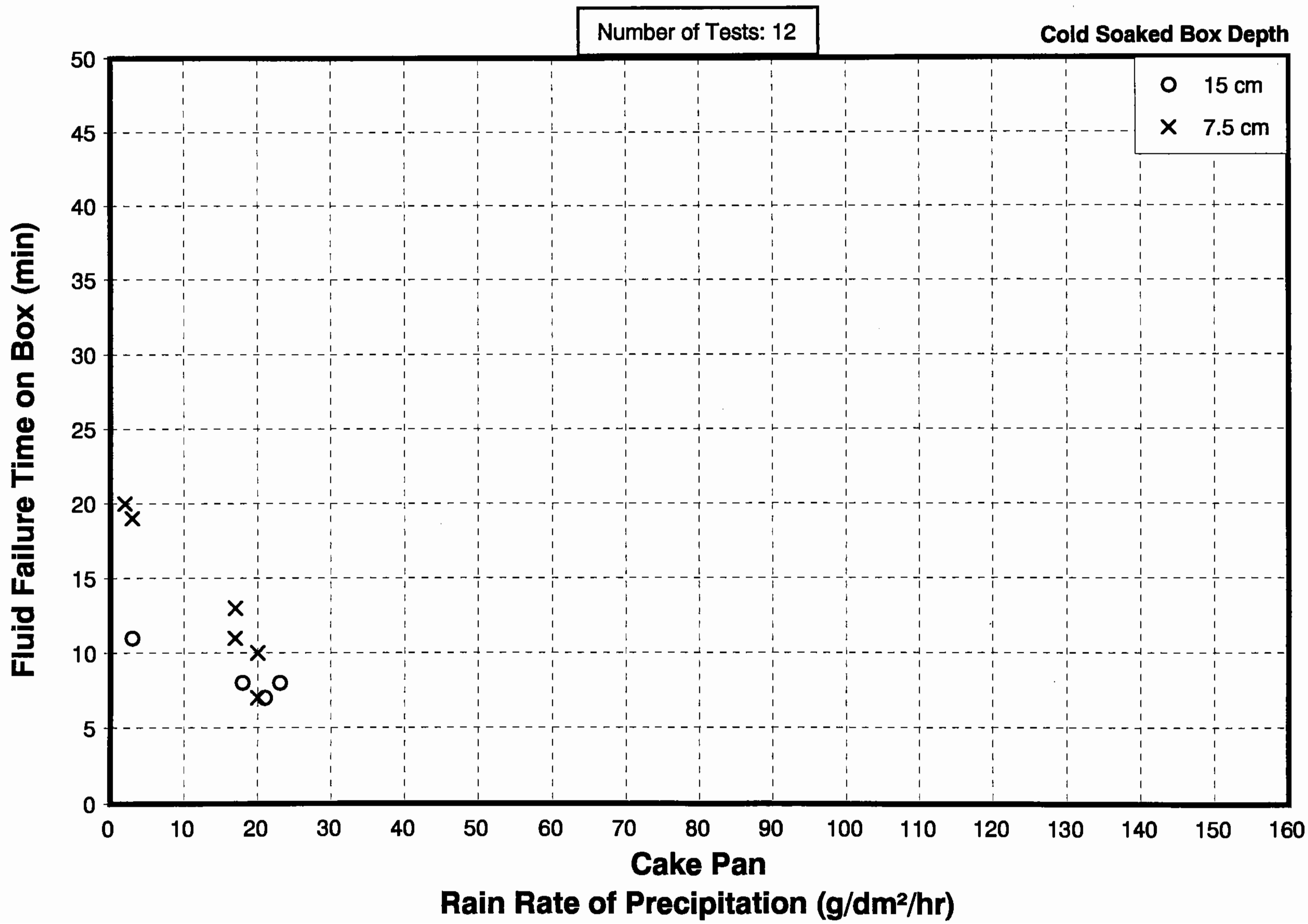
FIGURE H.63

EFFECT OF BOX SIZE AND RATE OF PRECIPITATION ON FAILURE TIME

TYPE IV 50/50

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\hot_subs\CS_45_B.GRF

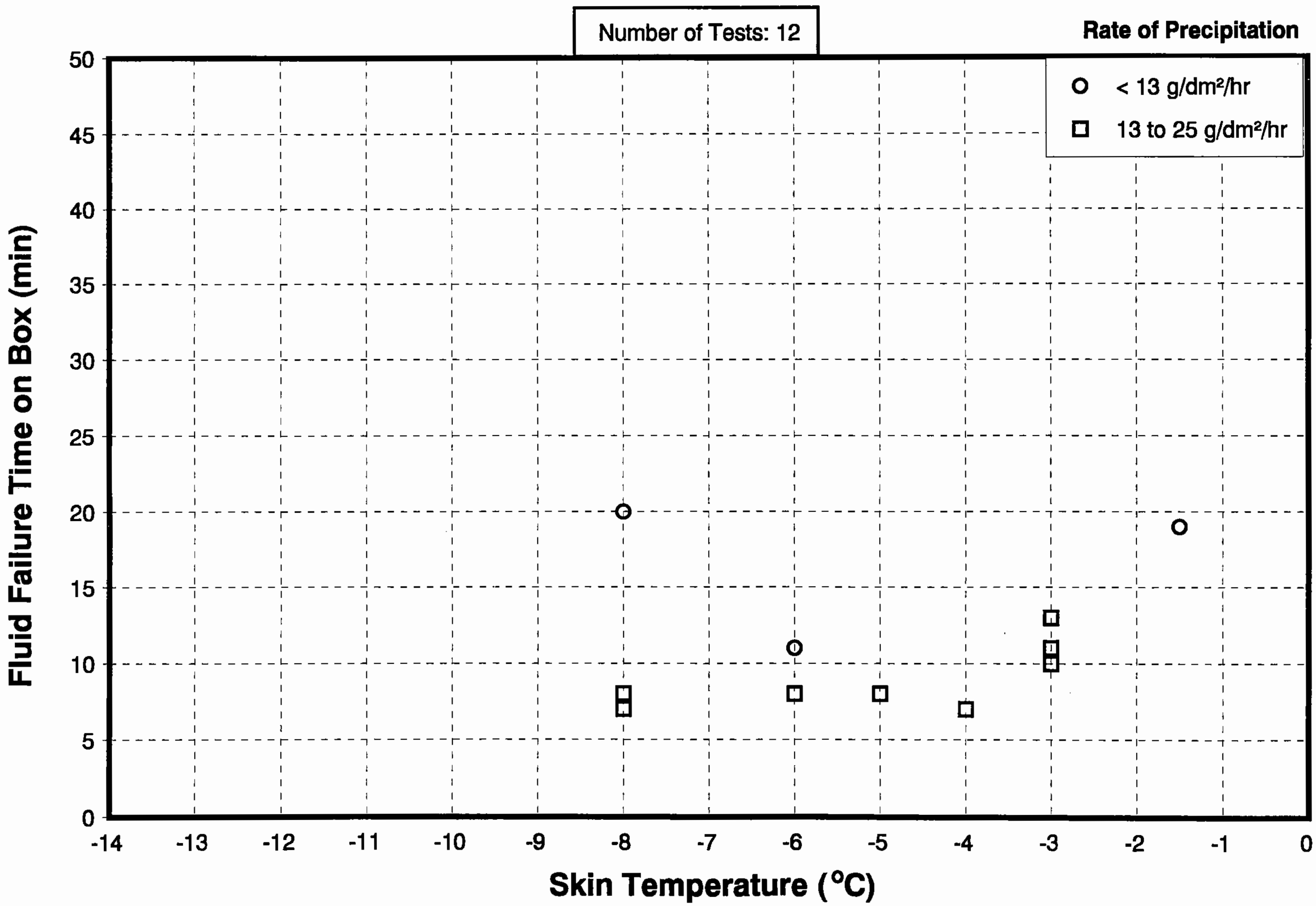
FIGURE H.64

EFFECT OF RATE OF PRECIPITATION AND SKIN TEMPERATURE ON FAILURE TIME

TYPE IV 50/50

RAIN ON COLD-SOAKED SURFACE

1995 - 1996



cm1283\report\vol_subs\CS_45_LGRF

APPENDIX I

LISTING OF FLAT PLATE TESTS CONDUCTED DURING 1994/95

NATURAL SNOW TESTS @ DORVAL 1994/95

test no.	date	fluid dilution	fluid code	fluid type	fail time [min.]	Avg Pan [g/dm²/hr]	APS Data temp [C]	APS Data wind [kph]
1	Nov-28-94	neat	A-205	2	32	28.6	-3	17
2	Nov-28-94	neat	A-205	2	30	28.6	-3	17
3	Nov-28-94	neat	A-205	2	34	28.6	-3	17
4	Nov-28-94	neat	A-205	2	31	28.6	-3	17
5	Dec-09-94	57%	B-213	1	14	2.0	-3	4
6	Dec-09-94	26%	B-253	1a	11	2.0	-3	4
7	Dec-09-94	57%	B-213	1	14	2.0	-3	4
8	Dec-09-94	26%	B-253	1a	13	2.0	-3	4
9	Dec-11-94	57%	B-213	1	7	27.5	-3	24
10	Dec-11-94	29%	B-253	1a	5	27.5	-3	24
11	Dec-11-94	neat	A-205	2	27	27.5	-3	24
12	Dec-11-94	57%	B-213	1	7	27.5	-3	24
13	Dec-11-94	29%	B-253	1a	5	27.5	-3	24
14	Dec-11-94	neat	A-205	2	27	27.5	-3	24
15	Dec-11-94	57%	B-213	1	8	27.3	-2	13
16	Dec-11-94	29%	B-253	1a	7	27.3	-2	13
17	Dec-11-94	75%	A-501	2b	27	27.3	-2	13
18	Dec-11-94	57%	B-213	1	8	27.3	-2	13
19	Dec-11-94	29%	B-253	1a	7	27.3	-2	13
20	Dec-11-94	75%	A-501	2b	29	27.3	-2	13
21	Dec-11-94	57%	B-213	1	8	22.5	-2	15
22	Dec-11-94	29%	B-253	1a	8	22.5	-2	15
23	Dec-11-94	50%	A-403	2a	9	22.5	-2	15
24	Dec-11-94	57%	B-213	1	8	22.5	-2	15
25	Dec-11-94	29%	B-253	1a	8	22.5	-2	15
26	Dec-11-94	50%	A-403	2a	9	22.5	-2	15
27	Dec-11-94	57%	B-213	1	7	29.8	-2	16
28	Dec-11-94	29%	B-253	1a	5	29.8	-2	16
29	Dec-11-94	50%	A-403	2a	10	29.8	-2	16
30	Dec-11-94	57%	B-213	1	8	24.8	-2	16
31	Dec-11-94	29%	B-253	1a	7	24.8	-2	16
32	Dec-11-94	50%	A-403	2a	10	24.8	-2	16
33	Dec-11-94	57%	B-213	1	9	17.5	-2	19
34	Dec-11-94	26%	B-253	1a	8	17.5	-2	19
35	Dec-11-94	50%	A-403	2a	11	17.5	-2	19
36	Dec-11-94	57%	B-213	1	9	17.5	-2	19
37	Dec-11-94	26%	B-253	1a	8	17.5	-2	19
38	Dec-11-94	50%	A-403	2a	11	17.5	-2	19
39	Dec-11-94	57%	B-213	1	10	6.4	-2	13
40	Dec-11-94	26%	B-253	1a	8	6.4	-2	13
41	Dec-11-94	57%	B-213	1	10	6.4	-2	13
42	Dec-11-94	26%	B-253	1a	10	6.4	-2	13
43	Jan-06-95	26%	B-253	1a	13	1.5	-4	11
44	Jan-06-95	26%	B-253	1a	13	1.5	-4	11
45	Jan-06-95	75%	A-503	2b	97	4.5	-4	11
46	Jan-06-95	neat	A-201	2	102	4.5	-4	11
47	Jan-06-95	29%	B-253	1a	20	4.5	-4	11
48	Jan-06-95	75%	A-503	2b	105	4.5	-4	11
49	Jan-06-95	neat	A-201	2	100	4.5	-4	11
50	Jan-06-95	29%	B-253	1a	21	4.5	-4	11
51	Jan-07-95	50%	A-403	2a	6	11.6	-3	11
52	Jan-07-95	57%	B-213	1	9	11.6	-3	11
53	Jan-07-95	26%	B-253	1a	6	11.6	-3	11
54	Jan-07-95	50%	A-403	2a	6	11.6	-3	11
55	Jan-07-95	57%	B-213	1	9	11.6	-3	11

NATURAL SNOW TESTS @ DORVAL 1994/95

test no.	date	fluid dilution	fluid code	fluid type	fail time [min.]	Avg Pan [g/dm²/hr]	APS Data	
							temp [C]	wind [kph]
56	Jan-07-95	26%	B-253	1a	7	11.6	-3	11
57	Jan-07-95	neat	A-205	2	32	14.0	-3	9
58	Jan-07-95	57%	B-213	1	5	12.0	-3	9
59	Jan-07-95	neat	A-205	2	34	14.0	-3	9
60	Jan-07-95	57%	B-213	1	6	12.0	-3	9
61	Jan-07-95	75%	A-503	2b	55	5.1	-3	2
62	Jan-07-95	neat	A-201	2	66	5.1	-3	2
63	Jan-07-95	neat	A-205	2	64	5.1	-3	2
64	Jan-07-95	75%	A-503	2b	54	5.1	-3	2
65	Jan-07-95	neat	A-201	2	64	5.1	-3	2
66	Jan-07-95	neat	A-205	2	62	5.1	-3	2
67	Jan-07-95	75%	A-503	2b	60	5.3	-3	2
68	Jan-07-95	neat	A-201	2	71	5.3	-3	2
69	Jan-07-95	neat	A-205	2	69	5.3	-3	2
70	Jan-07-95	75%	A-503	2b	61	5.3	-3	2
71	Jan-07-95	neat	A-201	2	76	5.3	-3	2
72	Jan-07-95	neat	A-205	2	68	5.3	-3	2
73	Jan-07-95	57%	B-213	1	20	4.0	-3	4
74	Jan-07-95	29%	B-253	1a	14	4.0	-3	4
75	Jan-07-95	50%	A-403	2a	16	4.0	-3	4
76	Jan-07-95	57%	B-213	1	21	4.0	-3	4
77	Jan-07-95	29%	B-253	1a	14	4.0	-3	4
78	Jan-07-95	50%	A-403	2a	14	4.0	-3	4
79	Jan-07-95	26%	B-253	1a	10	3.6	-3	4
80	Jan-07-95	57%	B-213	1	19	3.6	-3	4
81	Jan-07-95	50%	A-403	2a	14	3.6	-3	4
82	Jan-07-95	26%	B-253	1a	10	3.6	-3	4
83	Jan-07-95	57%	B-213	1	11	3.6	-3	4
84	Jan-07-95	50%	A-403	2a	10	3.6	-3	4
85	Jan-07-95	57%	B-213	1	41	0.9	-4	7
86	Jan-07-95	26%	B-253	1a	39	0.9	-4	7
87	Jan-07-95	57%	B-213	1	37	0.9	-4	7
88	Jan-07-95	26%	B-253	1a	32	0.9	-4	7
89	Jan-12-95	35%	B-253	1a	8	9.8	-15	18
90	Jan-12-95	45%	B-250	1a	10	9.8	-15	18
91	Jan-12-95	35%	B-253	1a	8	9.8	-15	18
92	Jan-12-95	53%	B-253	1a	14	9.8	-15	18
93	Jan-12-95	45%	B-250	1a	8	9.8	-15	18
94	Jan-12-95	57%	B-213	1	12	8.8	-15	20
95	Jan-12-95	47%	B-250	1a	9	8.8	-15	20
96	Jan-12-95	57%	B-213	1	15	8.8	-15	20
97	Jan-12-95	47%	B-250	1a	10	8.8	-15	20
98	Jan-12-95	neat	A-205	2	57	5.8	-15	20
99	Jan-12-95	neat	A-205	2	57	5.8	-15	20
100	Jan-12-95	44%	B-253	1a	14	4.7	-15	22
101	Jan-12-95	57%	B-213	1	14	4.7	-15	22
102	Jan-12-95	47%	B-250	1a	13	4.7	-15	22
103	Jan-12-95	44%	B-253	1a	15	4.7	-15	22
104	Jan-12-95	57%	B-213	1	16	4.7	-15	22
105	Jan-12-95	47%	B-250	1a	13	4.7	-15	22
106	Jan-12-95	44%	B-253	1a	6	9.7	-14	25
107	Jan-12-95	57%	B-213	1	12	9.7	-14	25
108	Jan-12-95	47%	B-250	1a	7	9.7	-14	25
109	Jan-12-95	44%	B-253	1a	10	9.7	-14	25
110	Jan-12-95	57%	B-213	1	14	9.7	-14	25

NATURAL SNOW TESTS @ DORVAL 1994/95

test no.	date	fluid dilution	fluid code	fluid type	fail time [min.]	Avg Pan [g/dm²/hr]	APS Data temp [C]	wind [kph]
111	Jan-12-95	47%	B-250	1a	11	9.7	-14	25
112	Jan-12-95	neat	A-205	2	28	11.4	-14	24
113	Jan-12-95	neat	A-205	2	28	11.4	-14	24
114	Jan-12-95	44%	B-253	1a	6	19.0	-14	28
115	Jan-12-95	57%	B-213	1	8	19.0	-14	28
116	Jan-12-95	47%	B-250	1a	7	19.0	-14	28
117	Jan-12-95	44%	B-253	1a	8	19.0	-14	28
118	Jan-12-95	57%	B-213	1	10	19.0	-14	28
119	Jan-12-95	47%	B-250	1a	8	19.0	-14	28
120	Jan-12-95	44%	B-253	1a	8	22.2	-14	27
121	Jan-12-95	57%	B-213	1	9	22.2	-14	27
122	Jan-12-95	47%	B-250	1a	8	22.2	-14	27
123	Jan-12-95	44%	B-253	1a	10	22.2	-14	27
124	Jan-12-95	57%	B-213	1	11	22.2	-14	27
125	Jan-12-95	47%	B-250	1a	10	22.2	-14	27
126	Jan-12-95	neat	A-205	2	26	15.7	-14	26
127	Jan-12-95	75%	A-503	2b	25	15.7	-14	26
128	Jan-12-95	neat	A-205	2	26	15.7	-14	26
129	Jan-12-95	75%	A-503	2b	25	15.7	-14	26
130	Jan-12-95	44%	B-253	1a	8	24.0	-14	26
131	Jan-12-95	47%	B-250	1a	9	24.0	-14	26
132	Jan-12-95	63%	B-215	1	12	24.0	-14	26
133	Jan-12-95	44%	B-253	1a	9	24.0	-14	26
134	Jan-12-95	47%	B-250	1a	11	24.0	-14	26
135	Jan-12-95	63%	B-215	1	11	24.0	-14	26
136	Feb-04-95	neat	A-303	2	145	4.5	-9	22
137	Feb-04-95	neat	A-201	2	67	4.5	-9	22
138	Feb-04-95	neat	A-205	2	65	4.5	-9	22
139	Feb-04-95	neat	A-303	2	138	4.5	-9	22
140	Feb-04-95	neat	A-201	2	64	4.5	-9	22
141	Feb-04-95	neat	A-205	2	61	4.5	-9	22
142	Feb-04-95	75%	A-503	2b	66	4.1	-8	24
143	Feb-04-95	75%	A-212	2b	59	4.1	-8	24
144	Feb-04-95	75%	A-501	2b	61	4.1	-8	24
145	Feb-04-95	75%	A-503	2b	74	4.1	-8	24
146	Feb-04-95	75%	A-212	2b	63	4.1	-8	24
147	Feb-04-95	75%	A-501	2b	63	4.1	-8	24
148	Feb-04-95	50%	B-222	1	9	4.7	-8	24
149	Feb-04-95	45%	B-252	1a	11	4.7	-8	24
150	Feb-04-95	63%	B-215	1	14	4.7	-8	24
151	Feb-04-95	50%	B-222	1	8	4.7	-8	24
152	Feb-04-95	45%	B-252	1a	10	4.7	-8	24
153	Feb-04-95	63%	B-215	1	13	4.7	-8	24
154	Feb-04-95	75%	A-503	2b	55	5.7	-8	27
155	Feb-04-95	75%	A-212	2b	47	5.7	-8	27
156	Feb-04-95	75%	A-501	2b	52	5.7	-8	27
157	Feb-04-95	75%	A-503	2b	57	5.7	-8	27
158	Feb-04-95	75%	A-212	2b	48	5.7	-8	27
159	Feb-04-95	75%	A-501	2b	53	5.7	-8	27
160	Feb-04-95	63%	B-215	1	27	1.8	-8	27
161	Feb-04-95	63%	B-215	1	23	1.8	-8	27
162	Feb-04-95	75%	A-503	2b	45	9.3	-7	22
163	Feb-04-95	75%	A-212	2b	38	9.3	-7	22
164	Feb-04-95	75%	A-501	2b	42	9.3	-7	22
165	Feb-04-95	75%	A-503	2b	47	9.3	-7	22

NATURAL SNOW TESTS @ DORVAL 1994/95

test no.	date	fluid dilution	fluid code	fluid type	fail time [min.]	Avg Pan [g/dm²/hr]	APS Data temp [C]	wind [kph]
166	Feb-04-95	75%	A-212	2b	41	9.3	-7	22
167	Feb-04-95	75%	A-501	2b	43	9.3	-7	22
168	Feb-04-95	neat	A-303	2	76	10.4	-7	26
169	Feb-04-95	neat	A-201	2	49	10.4	-7	26
170	Feb-04-95	neat	A-205	2	50	10.4	-7	26
171	Feb-04-95	neat	A-303	2	75	10.4	-7	26
172	Feb-04-95	neat	A-201	2	50	10.4	-7	26
173	Feb-04-95	neat	A-205	2	50	10.4	-7	26
174	Feb-04-95	75%	A-503	2b	26	14.8	-7	30
175	Feb-04-95	75%	A-212	2b	23	14.8	-7	30
176	Feb-04-95	75%	A-501	2b	24	14.8	-7	30
177	Feb-04-95	75%	A-503	2b	26	14.8	-7	30
178	Feb-04-95	75%	A-212	2b	23	14.8	-7	30
179	Feb-04-95	75%	A-501	2b	25	14.8	-7	30
180	Feb-04-95	neat	A-303	2	95	6.1	-8	30
181	Feb-04-95	neat	A-201	2	54	6.1	-8	30
182	Feb-04-95	neat	A-205	2	53	6.1	-8	30
183	Feb-04-95	neat	A-303	2	99	6.1	-8	30
184	Feb-04-95	neat	A-201	2	55	6.1	-8	30
185	Feb-04-95	neat	A-205	2	55	6.1	-8	30
186	Feb-04-95	31%	B-250	1a	7	5.0	-8	30
187	Feb-04-95	63%	B-215	1	12	5.0	-8	30
188	Feb-04-95	31%	B-250	1a	7	5.0	-8	30
189	Feb-04-95	63%	B-215	1	14	5.0	-8	30
190	Feb-04-95	31%	B-250	1a	7	6.2	-8	34
191	Feb-04-95	63%	B-215	1	10	6.2	-8	34
192	Feb-04-95	45%	B-252	1a	10	6.2	-8	34
193	Feb-04-95	31%	B-250	1a	8	6.2	-8	34
194	Feb-04-95	63%	B-215	1	9	6.2	-8	34
195	Feb-04-95	45%	B-252	1a	10	6.2	-8	34
196	Feb-05-95	63%	B-215	1	12	10.0	-8	40
197	Feb-05-95	45%	B-252	1a	6	10.0	-8	40
198	Feb-05-95	63%	B-215	1	12	10.0	-8	40
199	Feb-05-95	45%	B-252	1a	7	10.0	-8	40
200	Feb-05-95	neat	A-303	2	103	9.7	-8	35
201	Feb-05-95	neat	A-201	2	49	9.7	-8	38
202	Feb-05-95	neat	A-205	2	47	9.7	-8	35
203	Feb-05-95	neat	A-303	2	101	9.7	-8	35
204	Feb-05-95	neat	A-201	2	49	9.7	-8	35
205	Feb-05-95	neat	A-205	2	48	9.7	-8	35
206	Feb-05-95	63%	B-215	1	18	2.7	-8	10
207	Feb-05-95	45%	B-252	1a	13	2.7	-8	10
208	Feb-05-95	63%	B-215	1	18	2.7	-8	10
209	Feb-05-95	45%	B-252	1a	14	2.7	-8	10
210	Feb-05-95	63%	B-215	1	11	8.0	-8	30
211	Feb-05-95	45%	B-252	1a	7	8.0	-8	30
212	Feb-05-95	63%	B-215	1	11	8.0	-8	30
213	Feb-05-95	45%	B-252	1a	8	8.0	-8	30
214	Feb-05-95	neat	A-201	2	59	2.8	-8	15
215	Feb-05-95	neat	A-205	2	63	2.8	-8	15
216	Feb-05-95	neat	A-201	2	61	2.8	-8	15
217	Feb-05-95	neat	A-205	2	63	2.8	-8	15
218	Feb-10-95	neat	A-205	2	45	7.8	-9	14
219	Feb-10-95	neat	A-201	2	43	7.8	-9	14
220	Feb-10-95	neat	A-303	2	156	5.3	-9	11

NATURAL SNOW TESTS @ DORVAL 1994/95

test no.	date	fluid dilution	fluid code	fluid type	fail time [min.]	Avg Pan [g/dm²/hr]	APS Data temp [C]	wind [kph]
221	Feb-10-95	neat	A-205	2	44	7.8	-9	14
222	Feb-10-95	neat	A-201	2	43	7.8	-9	14
223	Feb-10-95	neat	A-303	2	155	5.3	-9	11
224	Feb-10-95	57%	B-213	1	10	4.6	-9	15
225	Feb-10-95	50%	B-222	1	9	4.6	-9	15
226	Feb-10-95	63%	B-215	1	17	4.6	-9	15
227	Feb-10-95	57%	B-213	1	10	4.6	-9	15
228	Feb-10-95	50%	B-222	1	9	4.6	-9	15
229	Feb-10-95	63%	B-215	1	17	4.6	-9	15
230	Feb-10-95	57%	B-213	1	9	4.7	-9	12
231	Feb-10-95	50%	B-222	1	9	4.7	-9	12
232	Feb-10-95	63%	B-215	1	15	4.7	-9	12
233	Feb-10-95	57%	B-213	1	9	4.7	-9	12
234	Feb-10-95	50%	B-222	1	9	4.7	-9	12
235	Feb-10-95	63%	B-215	1	15	4.7	-9	12
236	Feb-11-95	75%	A-501	2b	45	4.2	-10	15
237	Feb-11-95	neat	A-201	2	83	4.2	-10	13
238	Feb-11-95	75%	A-501	2b	45	4.2	-10	15
239	Feb-11-95	neat	A-201	2	79	4.2	-10	13
240	Feb-11-95	42%	B-250	1a	3	46.7	-10	5
241	Feb-11-95	63%	B-215	1	3	46.7	-10	5
242	Feb-11-95	50%	B-222	1	3	46.7	-10	5
243	Feb-11-95	42%	B-250	1a	3	46.7	-10	5
244	Feb-11-95	63%	B-215	1	3	46.7	-10	5
245	Feb-11-95	50%	B-222	1	3	46.7	-10	5
246	Feb-11-95	75%	A-501	2b	31	9.0	-10	4
247	Feb-11-95	neat	A-201	2	36	9.0	-10	4
248	Feb-11-95	75%	A-501	2b	31	9.0	-10	4
249	Feb-11-95	neat	A-201	2	36	9.0	-10	4
250	Feb-11-95	35%	B-253	1a	3	40.0	-10	4
251	Feb-11-95	48%	B-252	1a	3	40.0	-10	4
252	Feb-11-95	57%	B-213	1	7	14.0	-10	4
253	Feb-11-95	35%	B-253	1a	3	40.0	-10	4
254	Feb-11-95	48%	B-252	1a	3	40.0	-10	4
255	Feb-11-95	57%	B-213	1	7	14.0	-10	4
256	Feb-15-95	57%	B-213	1	8	26.0	-2	24
257	Feb-15-95	26%	B-253	1a	7	26.0	-2	24
258	Feb-15-95	50%	B-222	1	9	26.0	-2	24
259	Feb-15-95	57%	B-213	1	7	26.0	-2	24
260	Feb-15-95	26%	B-253	1a	7	26.0	-2	24
261	Feb-15-95	50%	B-222	1	10	26.0	-2	24
262	Feb-15-95	57%	B-213	1	21	24.0	-1	29
263	Feb-15-95	26%	B-253	1a	14	24.0	-1	29
264	Feb-15-95	50%	B-222	1	20	24.0	-1	29
265	Feb-15-95	57%	B-213	1	21	24.0	-1	29
266	Feb-15-95	26%	B-253	1a	14	24.0	-1	29
267	Feb-15-95	50%	B-222	1	20	24.0	-1	29
268	Feb-15-95	neat	A-201	2	33	22.1	0	24
269	Feb-15-95	neat	A-205	2	33	22.1	0	24
270	Feb-15-95	neat	A-303	2	52	22.1	0	24
271	Feb-15-95	neat	A-201	2	35	22.1	0	24
272	Feb-15-95	neat	A-205	2	33	22.1	0	24
273	Feb-15-95	57%	B-213	1	15	25.1	0	25
274	Feb-15-95	26%	B-253	1a	16	25.1	0	25
275	Feb-15-95	50%	B-222	1	18	25.1	0	25

NATURAL SNOW TESTS @ DORVAL 1994/95

test no.	date	fluid dilution	fluid code	fluid type	fail time [min.]	Avg Pan [g/dm^2/hr]	APS Data temp [C]	APS Data wind [kph]
276	Feb-15-95	57%	B-213	1	16	25.1	0	25
277	Feb-15-95	26%	B-253	1a	14	25.1	0	25
278	Feb-15-95	50%	B-222	1	17	25.1	0	25
279	Feb-23-95	neat	A-205	2	45	10.5	0	9
280	Feb-23-95	75%	A-212	2b	40	10.5	0	9
281	Feb-23-95	50%	A-210	2a	33	10.5	0	9
282	Feb-23-95	neat	A-205	2	47	10.5	0	9
283	Feb-23-95	75%	A-212	2b	41	10.5	0	9
284	Feb-23-95	50%	A-210	2a	31	10.5	0	9
285	Feb-23-95	neat	A-303	2	100	9.4	0	5
286	Feb-23-95	75%	A-212	2b	50	9.4	0	5
287	Feb-23-95	50%	A-210	2a	44	9.4	0	5
288	Feb-23-95	neat	A-303	2	77	9.4	0	5
289	Feb-23-95	75%	A-212	2b	52	9.4	0	5
290	Feb-23-95	50%	A-210	2a	42	9.4	0	5
291	Feb-27-95	neat	A-303	2	88	10.9	-12	16
292	Feb-27-95	neat	A-205	2	40	11.5	-12	19
293	Feb-27-95	neat	A-201	2	45	11.5	-12	19
294	Feb-27-95	neat	A-303	2	100	10.9	-12	16
295	Feb-27-95	neat	A-205	2	43	11.5	-12	19
296	Feb-27-95	neat	A-201	2	45	11.5	-12	19
297	Feb-27-95	75%	A-212	2b	33	14.3	-12	18
298	Feb-27-95	75%	A-501	2b	34	14.3	-12	18
299	Feb-27-95	75%	A-503	2b	42	14.3	-12	18
300	Feb-27-95	75%	A-212	2b	34	14.3	-12	18
301	Feb-27-95	75%	A-501	2b	34	14.3	-12	18
302	Feb-27-95	75%	A-503	2b	41	14.3	-12	18
303	Feb-27-95	neat	A-303	2	100	10.2	-12	20
304	Feb-27-95	neat	A-205	2	38	12.3	-12	20
305	Feb-27-95	neat	A-201	2	45	12.3	-12	20
306	Feb-27-95	neat	A-303	2	101	10.2	-12	20
307	Feb-27-95	neat	A-205	2	38	12.3	-12	20
308	Feb-27-95	neat	A-201	2	43	12.3	-12	20
309	Feb-27-95	75%	A-212	2b	32	13.4	-12	20
310	Feb-27-95	75%	A-501	2b	37	13.4	-12	20
311	Feb-27-95	75%	A-503	2b	42	13.4	-12	20
312	Feb-27-95	75%	A-212	2b	33	13.4	-12	20
313	Feb-27-95	75%	A-501	2b	35	13.4	-12	20
314	Feb-27-95	75%	A-503	2b	40	13.4	-12	20
315	Feb-27-95	neat	A-201	2	65	6.5	-12	19
316	Feb-27-95	neat	A-201	2	67	6.5	-12	19
317	Mar-06-95	57%	B-213	1	10	20.5	-7	23
318	Mar-06-95	30%	B-253	1a	8	20.5	-7	23
319	Mar-06-95	42%	B-252	1a	9	20.5	-7	23
320	Mar-06-95	57%	B-213	1	9	20.5	-7	23
321	Mar-06-95	30%	B-253	1a	9	20.5	-7	23
322	Mar-06-95	42%	B-252	1a	9	20.5	-7	23
323	Mar-06-95	57%	B-213	1	10	23.0	-7	21
324	Mar-06-95	42%	B-252	1a	8	23.0	-7	21
325	Mar-06-95	30%	B-253	1a	8	23.0	-7	21
326	Mar-06-95	57%	B-213	1	10	23.0	-7	21
327	Mar-06-95	42%	B-252	1a	8	23.0	-7	21
328	Mar-06-95	30%	B-253	1a	9	23.0	-7	21
329	Mar-06-95	neat	A-303	2	39	22.4	-7	28
330	Mar-06-95	neat	A-201	2	28	22.9	-7	28

NATURAL SNOW TESTS @ DORVAL 1994/95

test no.	date	fluid dilution	fluid code	fluid type	fail time [min.]	Avg Pan [g/dm²/hr]	APS Data	
							temp [C]	wind [kph]
331	Mar-06-95	50%	A-210	2a	14	22.9	-7	28
332	Mar-06-95	neat	A-303	2	42	22.4	-7	28
333	Mar-06-95	neat	A-201	2	30	22.9	-7	28
334	Mar-06-95	50%	A-210	2a	14	22.9	-7	28
335	Mar-06-95	50%	A-210	2a	42	5.7	-7	26
336	Mar-06-95	50%	A-210	2a	42	5.7	-7	26
337	Mar-08-95	26%	B-253	1a	14	6.6	-4	18
338	Mar-08-95	50%	B-222	1	16	6.6	-4	18
339	Mar-08-95	57%	B-213	1	21	6.6	-4	18
340	Mar-08-95	26%	B-253	1a	15	6.6	-4	18
341	Mar-08-95	50%	B-222	1	17	6.6	-4	18
342	Mar-08-95	57%	B-213	1	21	6.6	-4	18
343	Mar-08-95	26%	B-253	1a	13	5.9	-4	18
344	Mar-08-95	50%	B-222	1	18	5.9	-4	18
345	Mar-08-95	57%	B-213	1	18	5.9	-4	18
346	Mar-08-95	26%	B-253	1a	13	5.9	-4	18
347	Mar-08-95	50%	B-222	1	18	5.9	-4	18
348	Mar-08-95	57%	B-213	1	18	5.9	-4	18
349	Mar-08-95	26%	B-253	1a	5	20.7	-4	17
350	Mar-08-95	50%	B-222	1	6	20.7	-4	17
351	Mar-08-95	57%	B-213	1	7	20.7	-4	17
352	Mar-08-95	26%	B-253	1a	5	20.7	-4	17
353	Mar-08-95	50%	B-222	1	7	20.7	-4	17
354	Mar-08-95	57%	B-213	1	7	20.7	-4	17
355	Mar-08-95	26%	B-253	1a	6	17.6	-4	17
356	Mar-08-95	50%	B-222	1	6	17.6	-4	17
357	Mar-08-95	57%	B-213	1	7	17.6	-4	17
358	Mar-08-95	26%	B-253	1a	6	17.6	-4	17
359	Mar-08-95	50%	B-222	1	6	17.6	-4	17
360	Mar-08-95	57%	B-213	1	7	17.6	-4	17
361	Mar-08-95	neat	A-201	2	53	11.5	-4	16
362	Mar-08-95	neat	A-205	2	53	11.5	-4	16
363	Mar-08-95	neat	A-303	2	81	11.5	-4	16
364	Mar-08-95	neat	A-201	2	53	11.5	-4	16
365	Mar-08-95	neat	A-205	2	51	11.5	-4	16
366	Mar-08-95	neat	A-303	2	64	11.4	-4	14
367	Mar-08-95	neat	A-201	2	45	12.5	-4	14
368	Mar-08-95	neat	A-205	2	42	12.5	-4	14
369	Mar-08-95	neat	A-303	2	66	11.4	-4	14
370	Mar-08-95	neat	A-201	2	48	12.5	-4	14
371	Mar-08-95	neat	A-205	2	43	12.5	-4	14
372	Mar-08-95	neat	A-303	2	60	15.6	-5	12
373	Mar-08-95	neat	A-201	2	38	12.0	-5	12
374	Mar-08-95	neat	A-205	2	38	12.0	-5	12
375	Mar-08-95	neat	A-303	2	65	15.6	-5	12
376	Mar-08-95	neat	A-201	2	38	12.0	-5	12
377	Mar-08-95	neat	A-205	2	40	12.0	-5	12
378	Mar-08-95	neat	A-303	2	62	13.9	-5	12
379	Mar-08-95	neat	A-201	2	38	13.9	-5	12
380	Mar-08-95	neat	A-205	2	40	13.9	-5	12
381	Mar-08-95	neat	A-303	2	63	13.9	-5	12
382	Mar-08-95	neat	A-201	2	42	13.9	-5	12
383	Mar-08-95	neat	A-205	2	40	13.9	-5	12
384	Mar-08-95	neat	A-303	2	65	10.3	-6	13
385	Mar-08-95	neat	A-201	2	42	11.3	-6	13

NATURAL SNOW TESTS @ DORVAL 1994/95

test no.	date	fluid dilution	fluid code	fluid type	fail time [min.]	Avg Pan [g/dm²/hr]	APS Data	
							temp [C]	wind [kph]
386	Mar-08-95	neat	A-205	2	42	11.3	-6	13
387	Mar-08-95	neat	A-303	2	67	10.3	-6	13
388	Mar-08-95	neat	A-201	2	43	11.3	-6	13
389	Mar-08-95	neat	A-205	2	43	11.3	-6	13
390	Mar-09-95	75%	A-503	2b	26	11.8	-6	14
391	Mar-09-95	neat	A-205	2	34	11.9	-6	14
392	Mar-09-95	50%	A-403	2a	18	11.9	-6	14
393	Mar-09-95	75%	A-503	2b	28	11.9	-6	14
394	Mar-09-95	neat	A-205	2	39	11.9	-6	14
395	Mar-09-95	50%	A-403	2a	20	11.9	-6	14
396	Mar-09-95	75%	A-503	2b	37	9.2	-7	17
397	Mar-09-95	neat	A-205	2	44	9.2	-7	17
398	Mar-09-95	50%	A-403	2a	25	9.2	-7	17
399	Mar-09-95	75%	A-503	2b	34	9.2	-7	17
400	Mar-09-95	neat	A-205	2	48	9.2	-7	17
401	Mar-09-95	50%	A-403	2a	25	9.2	-7	17
402	Mar-09-95	neat	A-303	2	78	9.5	-7	17
403	Mar-09-95	neat	A-201	2	60	9.5	-7	17
404	Mar-09-95	neat	A-205	2	60	9.5	-7	17
405	Mar-09-95	neat	A-303	2	82	9.5	-7	17
406	Mar-09-95	neat	A-201	2	62	9.5	-7	17
407	Mar-09-95	neat	A-205	2	60	9.5	-7	17
408	Mar-09-95	50%	A-403	2a	24	5.1	-7	16
409	Mar-09-95	50%	A-210	2a	25	5.1	-7	16
410	Mar-09-95	50%	B-222	1	13	5.1	-7	16
411	Mar-09-95	50%	A-403	2a	25	5.1	-7	16
412	Mar-09-95	50%	A-210	2a	26	5.1	-7	16
413	Mar-09-95	50%	B-222	1	14	5.1	-7	16
414	Mar-09-95	57%	B-213	1	23	3.5	-7	16
415	Mar-09-95	63%	B-215	1	21	3.5	-7	16
416	Mar-09-95	42%	B-252	1a	13	3.5	-7	16
417	Mar-09-95	57%	B-213	1	24	3.5	-7	16
418	Mar-09-95	63%	B-215	1	22	3.5	-7	16
419	Mar-09-95	42%	B-252	1a	14	3.5	-7	16
420	Mar-09-95	57%	B-213	1	34	1.3	-8	17
421	Mar-09-95	63%	B-215	1	36	1.3	-8	17
422	Mar-09-95	42%	B-252	1a	19	1.3	-8	17
423	Mar-09-95	57%	B-213	1	34	1.3	-8	17
424	Mar-09-95	63%	B-215	1	35	1.3	-8	17
425	Mar-09-95	42%	B-252	1a	20	1.3	-8	17

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN @ CEF FOR 1994/95

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	Avg Rate Plate pans [g/dm*2/hr]	Ambient temp [C]	Precip Type
1995	1	Apr-05-95	B-213	57%	1	4	23	-5.9	frz_rain
1995	2	Apr-05-95	B-213	57%	1	5	23	-5.9	frz_rain
1995	3	Apr-05-95	B-220	63%	1	4.5	22	-5.9	frz_rain
1995	4	Apr-05-95	B-220	63%	1	4.5	23	-5.9	frz_rain
1995	5	Apr-05-95	B-221	63%	1	4.5	19	-5.9	frz_rain
1995	6	Apr-05-95	B-221	63%	1	5.5	20	-5.9	frz_rain
1995	7	Apr-05-95	B-253	34%	1a	3	23	-8.6	frz_rain
1995	8	Apr-05-95	B-253	34%	1a	3	23	-8.6	frz_rain
1995	9	Apr-05-95	B-250	40%	1a	3.5	22	-8.6	frz_rain
1995	10	Apr-05-95	B-250	40%	1a	3.5	23	-8.6	frz_rain
1995	11	Apr-05-95	B-251	40%	1a	4	19	-8.6	frz_rain
1995	12	Apr-05-95	B-251	40%	1a	4	20	-8.6	frz_rain
1995	13	Apr-06-95	A-303	100%	2	45	24	-9.6	frz_rain
1995	14	Apr-06-95	A-303	100%	2	47	21	-9.6	frz_rain
1995	15	Apr-06-95	A-503	75%	2b	14	25	-9.6	frz_rain
1995	16	Apr-06-95	A-503	75%	2b	15	22	-9.6	frz_rain
1995	17	Apr-06-95	A-201	100%	2	26	22	-9.6	frz_rain
1995	18	Apr-06-95	A-201	100%	2	27	24	-9.6	frz_rain
1995	19	Apr-06-95	A-501	75%	2b	19	21	-9.5	frz_rain
1995	20	Apr-06-95	A-501	75%	2b	20	24	-9.5	frz_rain
1995	21	Apr-06-95	A-401	50%	2a	7	19	-9.5	frz_rain
1995	22	Apr-06-95	A-401	50%	2a	8	25	-9.5	frz_rain
1995	23	Apr-06-95	A-212	75%	2b	25	20	-9.5	frz_rain
1995	24	Apr-06-95	A-212	75%	2b	26	24	-9.5	frz_rain
1995	25	Apr-06-95	B-252	45%	1a	4.5	22	-9.9	frz_rain
1995	26	Apr-06-95	B-252	45%	1a	5.5	24	-9.9	frz_rain
1995	27	Apr-06-95	B-253	34%	1a	4	21	-9.9	frz_rain
1995	28	Apr-06-95	B-253	34%	1a	4	22	-9.9	frz_rain
1995	29	Apr-06-95	B-210	50%	1	6	19	-9.9	frz_rain
1995	30	Apr-06-95	B-210	50%	1	7	20	-9.9	frz_rain
1995	31	Apr-06-95	B-251	40%	1a	5	20	-9.9	frz_rain
1995	32	Apr-06-95	B-251	40%	1a	6	19	-9.9	frz_rain
1995	33	Apr-06-95	A-212	75%	2b	19	24	-9.9	frz_rain
1995	34	Apr-06-95	A-212	75%	2b	23	21	-9.9	frz_rain
1995	35	Apr-06-95	A-303	100%	2	41	25	-9.9	frz_rain
1995	36	Apr-06-95	A-303	100%	2	54	22	-9.9	frz_rain
1995	37	Apr-06-95	A-503	75%	2b	17	24	-9.9	frz_rain
1995	38	Apr-06-95	A-503	75%	2b	20	22	-9.9	frz_rain
1995	39	Apr-06-95	A-201	100%	2	29	22	-9.9	frz_rain
1995	40	Apr-06-95	A-201	100%	2	32	21	-9.9	frz_rain
1995	41	Apr-06-95	A-501	75%	2b	25	19	-9.9	frz_rain
1995	42	Apr-06-95	A-501	75%	2b	27	20	-9.9	frz_rain
1995	43	Apr-06-95	A-201	100%	2	28	19	-9.9	frz_rain
1995	44	Apr-06-95	A-201	100%	2	31	20	-9.9	frz_rain
1995	45	Apr-06-95	B-251	40%	1a	4	21	-9.9	frz_rain
1995	46	Apr-06-95	B-251	40%	1a	3	21	-9.9	frz_rain
1995	47	Apr-06-95	B-253	34%	1a	5	21	-9.9	frz_rain
1995	48	Apr-06-95	B-253	34%	1a	5	22	-9.9	frz_rain
1995	49	Apr-06-95	B-220	63%	1	7	19	-9.9	frz_rain
1995	50	Apr-06-95	B-220	63%	1	7	20	-9.9	frz_rain
1995	51	Apr-06-95	B-221	63%	1	6	20	-9.9	frz_rain
1995	52	Apr-06-95	B-221	63%	1	7	19	-9.9	frz_rain
1995	53	Apr-06-95	A-201	100%	2	24	24	-10.1	frz_rain
1995	54	Apr-06-95	A-201	100%	2	26	21	-10.1	frz_rain
1995	55	Apr-06-95	A-212	75%	2b	24	22	-10.1	frz_rain

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN @ CEF FOR 1994/95

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	Avg Rate Plate pans [g/dm*2/hr]	Ambient temp [C]	Precip Type
1995	56	Apr-06-95	A-212	75%	2b	24	25	-10.1	frz_rain
1995	57	Apr-06-95	A-303	100%	2	41	24	-10.1	frz_rain
1995	58	Apr-06-95	A-303	100%	2	45	22	-10.1	frz_rain
1995	59	Apr-06-95	A-503	75%	2b	19	22	-10.1	frz_rain
1995	60	Apr-06-95	A-503	75%	2b	22	21	-10.1	frz_rain
1995	61	Apr-06-95	A-201	100%	2	32	20	-10.1	frz_rain
1995	62	Apr-06-95	A-201	100%	2	33	19	-10.1	frz_rain
1995	63	Apr-06-95	A-501	75%	2b	20	19	-10.1	frz_rain
1995	64	Apr-06-95	A-501	75%	2b	21	20	-10.1	frz_rain
1995	65	Apr-06-95	B-250	40%	1a	4	21	-10.1	frz_rain
1995	66	Apr-06-95	B-250	40%	1a	4	24	-10.1	frz_rain
1995	67	Apr-06-95	B-221	63%	1	4	22	-10.1	frz_rain
1995	68	Apr-06-95	B-221	63%	1	4	25	-10.1	frz_rain
1995	69	Apr-06-95	B-213	57%	1	6	19	-10.1	frz_rain
1995	70	Apr-06-95	B-213	57%	1	7	20	-10.1	frz_rain
1995	71	Apr-06-95	B-220	63%	1	8	20	-10.1	frz_rain
1995	72	Apr-06-95	B-220	63%	1	8	19	-10.1	frz_rain
1995	73	Apr-06-95	A-501	75%	2b	18	24	-8.3	frz_rain
1995	74	Apr-06-95	A-501	75%	2b	20	21	-8.3	frz_rain
1995	75	Apr-06-95	A-201	100%	2	23	22	-8.3	frz_rain
1995	76	Apr-06-95	A-201	100%	2	27	25	-8.3	frz_rain
1995	77	Apr-06-95	A-212	75%	2b	24	24	-8.3	frz_rain
1995	78	Apr-06-95	A-212	75%	2b	27	22	-8.3	frz_rain
1995	79	Apr-06-95	A-303	100%	2	45	22	-8.3	frz_rain
1995	80	Apr-06-95	A-303	100%	2	51	21	-8.3	frz_rain
1995	81	Apr-06-95	A-503	75%	2b	20	20	-8.3	frz_rain
1995	82	Apr-06-95	A-503	75%	2b	22	19	-8.3	frz_rain
1995	83	Apr-06-95	A-201	100%	2	27	19	-8.3	frz_rain
1995	84	Apr-06-95	A-201	100%	2	28	20	-8.3	frz_rain
1995	85	Apr-06-95	B-253	34%	1a	4	21	-8.3	frz_rain
1995	86	Apr-06-95	B-253	34%	1a	4	24	-8.3	frz_rain
1995	87	Apr-06-95	B-250	40%	1a	5	22	-8.3	frz_rain
1995	88	Apr-06-95	B-250	40%	1a	5	25	-8.3	frz_rain
1995	89	Apr-06-95	B-252	45%	1a	4	22	-8.3	frz_rain
1995	90	Apr-06-95	B-252	45%	1a	5	24	-8.3	frz_rain
1995	91	Apr-06-95	B-213	57%	1	8	20	-8.3	frz_rain
1995	92	Apr-06-95	B-213	57%	1	7	20	-8.3	frz_rain
1995	93	Apr-06-95	A-503	75%	2b	20	24	-10.0	frz_rain
1995	94	Apr-06-95	A-503	75%	2b	23	21	-10.0	frz_rain
1995	95	Apr-06-95	A-403	50%	2a	4	25	-10.0	frz_rain
1995	96	Apr-06-95	A-403	50%	2a	6	22	-10.0	frz_rain
1995	97	Apr-06-95	A-201	100%	2	25	24	-10.0	frz_rain
1995	98	Apr-06-95	A-201	100%	2	31	22	-10.0	frz_rain
1995	99	Apr-06-95	A-401	50%	2a	9	21	-7.0	frz_rain
1995	100	Apr-06-95	A-401	50%	2a	11	22	-7.0	frz_rain
1995	101	Apr-06-95	A-212	75%	2b	21	20	-7.0	frz_rain
1995	102	Apr-06-95	A-212	75%	2b	23	19	-7.0	frz_rain
1995	103	Apr-06-95	A-303	100%	2	45	20	-7.0	frz_rain
1995	104	Apr-06-95	A-303	100%	2	45	19	-7.0	frz_rain
1995	105	Apr-06-95	B-213	57%	1	6	22	-7.0	frz_rain
1995	106	Apr-06-95	B-213	57%	1	6	25	-7.0	frz_rain
1995	107	Apr-06-95	B-253	29%	1a	6	22	-7.0	frz_rain
1995	108	Apr-06-95	B-253	29%	1a	6	24	-7.0	frz_rain
1995	109	Apr-06-95	B-220	63%	1	7	21	-7.0	frz_rain
1995	110	Apr-06-95	B-220	63%	1	8	22	-7.0	frz_rain

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN @ CEF FOR 1994/95

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	Avg Rate Plate pans [g/dm*2/hr]	Ambient temp [C]	Precip Type
1995	111	Apr-06-95	B-252	39%	1a	6	19	-7.0	frz_rain
1995	112	Apr-06-95	B-252	39%	1a	7	19	-7.0	frz_rain
1995	113	Apr-07-95	A-303	100%	2	111	8	-6.0	frz_driz
1995	114	Apr-07-95	A-503	75%	2b	63	10	-6.0	frz_driz
1995	115	Apr-07-95	A-503	75%	2b	68	7	-6.0	frz_driz
1995	116	Apr-07-95	A-201	100%	2	57	10	-6.0	frz_driz
1995	117	Apr-07-95	A-201	100%	2	80	6	-6.0	frz_driz
1995	118	Apr-07-95	A-501	75%	2b	39	10	-6.0	frz_driz
1995	119	Apr-07-95	A-501	75%	2b	43	5	-6.0	frz_driz
1995	120	Apr-07-95	A-201	100%	2	59	7	-6.0	frz_driz
1995	121	Apr-07-95	A-201	100%	2	67	5	-6.0	frz_driz
1995	122	Apr-07-95	A-212	75%	2b	58	4	-6.0	frz_driz
1995	123	Apr-07-95	A-212	75%	2b	69	3	-6.0	frz_driz
1995	124	Apr-07-95	B-213	57%	1	8	10	-10.0	frz_driz
1995	125	Apr-07-95	B-213	57%	1	9	6	-10.0	frz_driz
1995	126	Apr-07-95	B-253	34%	1a	7	5	-10.0	frz_driz
1995	127	Apr-07-95	B-253	34%	1a	7	10	-10.0	frz_driz
1995	128	Apr-07-95	B-220	63%	1	10	7	-10.0	frz_driz
1995	129	Apr-07-95	B-220	63%	1	12	5	-10.0	frz_driz
1995	130	Apr-07-95	B-210	50%	1	12.5	3	-10.0	frz_driz
1995	131	Apr-07-95	B-210	50%	1	12.5	4	-10.0	frz_driz
1995	132	Apr-07-95	A-212	75%	2b	45	9	-10.0	frz_driz
1995	133	Apr-07-95	A-212	75%	2b	56	7	-10.0	frz_driz
1995	134	Apr-07-95	A-303	100%	2	92	10	-10.0	frz_driz
1995	135	Apr-07-95	A-503	75%	2b	44	10	-10.0	frz_driz
1995	136	Apr-07-95	A-201	100%	2	44	10	-10.0	frz_driz
1995	137	Apr-07-95	A-201	100%	2	60	8	-10.0	frz_driz
1995	138	Apr-07-95	A-501	75%	2b	37	7	-10.0	frz_driz
1995	139	Apr-07-95	A-501	75%	2b	51	5	-10.0	frz_driz
1995	140	Apr-07-95	A-201	100%	2	59	4	-10.0	frz_driz
1995	141	Apr-07-95	A-201	100%	2	68	3	-10.0	frz_driz
1995	142	Apr-07-95	B-251	40%	1a	6	7	-10.0	frz_driz
1995	143	Apr-07-95	B-251	40%	1a	5	9	-10.0	frz_driz
1995	144	Apr-07-95	B-253	34%	1a	6	10	-10.0	frz_driz
1995	145	Apr-07-95	B-250	40%	1a	7	7	-10.0	frz_driz
1995	146	Apr-07-95	B-250	40%	1a	7.5	5	-10.0	frz_driz
1995	147	Apr-07-95	B-253	34%	1a	7	5	-10.0	frz_driz
1995	148	Apr-07-95	B-252	45%	1a	9	3	-10.0	frz_driz
1995	149	Apr-07-95	B-252	45%	1a	8	4	-10.0	frz_driz
1995	150	Apr-07-95	A-201	100%	2	51	9	-9.6	frz_driz
1995	151	Apr-07-95	A-212	75%	2b	39	10	-9.6	frz_driz
1995	152	Apr-07-95	A-303	100%	2	86	10	-9.6	frz_driz
1995	153	Apr-07-95	A-503	75%	2b	49	10	-9.6	frz_driz
1995	154	Apr-07-95	A-201	100%	2	41	7	-9.6	frz_driz
1995	155	Apr-07-95	A-501	75%	2b	47	4	-9.6	frz_driz
1995	156	Apr-07-95	A-201	100%	2	61	5	-9.6	frz_driz
1995	157	Apr-07-95	A-501	75%	2b	61	3	-9.6	frz_driz
1995	158	Apr-07-95	B-250	40%	1a	7	9	-9.6	frz_driz
1995	159	Apr-07-95	B-250	40%	1a	8	7	-9.6	frz_driz
1995	160	Apr-07-95	B-210	50%	1	8	10	-9.6	frz_driz
1995	161	Apr-07-95	B-210	50%	1	10	7	-9.6	frz_driz
1995	162	Apr-07-95	B-213	57%	1	8	7	-9.6	frz_driz
1995	163	Apr-07-95	B-213	57%	1	11	5	-9.6	frz_driz
1995	164	Apr-07-95	B-220	63%	1	11	4	-9.6	frz_driz
1995	165	Apr-07-95	B-220	63%	1	13	3	-9.6	frz_driz

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN @ CEF FOR 1994/95

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	Avg Rate Plate pans [g/dm*2/hr]	Ambient temp [C]	Precip Type
1995	166	Apr-07-95	A-501	75%	2b	34	7	-8.0	frz_driz
1995	167	Apr-07-95	A-501	75%	2b	36	9	-8.0	frz_driz
1995	168	Apr-07-95	A-201	100%	2	40	7	-8.0	frz_driz
1995	169	Apr-07-95	A-201	100%	2	45	10	-8.0	frz_driz
1995	170	Apr-07-95	A-212	75%	2b	40	10	-8.0	frz_driz
1995	171	Apr-07-95	A-212	75%	2b	44	6	-8.0	frz_driz
1995	172	Apr-07-95	B-213	57%	1	6	7	-10.0	frz_driz
1995	173	Apr-07-95	B-213	57%	1	7	9	-10.0	frz_driz
1995	174	Apr-07-95	B-220	63%	1	8	7	-10.0	frz_driz
1995	175	Apr-07-95	B-220	63%	1	9	10	-10.0	frz_driz
1995	176	Apr-07-95	B-210	50%	1	6	8	-10.0	frz_driz
1995	177	Apr-07-95	B-210	50%	1	9	10	-10.0	frz_driz
1995	178	Apr-07-95	B-253	34%	1a	6	3	-10.0	frz_driz
1995	179	Apr-07-95	B-253	34%	1a	7	4	-10.0	frz_driz
1995	180	Apr-12-95	A-303	100%	2	99	7	-5.0	frz_driz
1995	181	Apr-12-95	A-201	100%	2	37	10	-4.9	frz_driz
1995	182	Apr-12-95	A-201	100%	2	42	10	-4.9	frz_driz
1995	183	Apr-12-95	A-303	100%	2	78	10	-4.9	frz_driz
1995	184	Apr-12-95	A-303	100%	2	94	8	-4.9	frz_driz
1995	185	Apr-12-95	A-201	100%	2	39	9	-4.9	frz_driz
1995	186	Apr-12-95	A-201	100%	2	40	10	-4.9	frz_driz
1995	187	Apr-12-95	A-303	100%	2	75	10	-4.9	frz_driz
1995	188	Apr-12-95	A-303	100%	2	91	10	-4.9	frz_driz
1995	189	Apr-12-95	A-201	100%	2	40	9	-5.2	frz_driz
1995	190	Apr-12-95	A-201	100%	2	40	10	-5.2	frz_driz
1995	191	Apr-12-95	A-303	100%	2	77	9	-7.7	frz_driz
1995	192	Apr-12-95	A-201	100%	2	38	10	-7.5	frz_driz
1995	193	Apr-12-95	A-201	100%	2	48	10	-7.5	frz_driz

SIMULATED FREEZING FOG @ CEF FOR 1994/95

Test Season [year]	test no.	date	fluid code	fluid dilution	fld type	fail time (min)	Avg of pan rate [g/dm²/hr]	avg. temp (°C)
1995	1	Apr-3-95	A-303	100%	2	57	13	-23.0
1995	2	Apr-3-95	A-205	100%	2	20	12	-23.0
1995	3	Apr-3-95	A-201	100%	2	10	12	-23.0
1995	4	Apr-3-95	A-201	100%	2	10	15	-23.0
1995	5	Apr-3-95	B-214	50%	1	7	12	-22.6
1995	6	Apr-3-95	B-252	56%	1a	6	16	-22.6
1995	7	Apr-3-95	B-220	63%	1	7	15	-22.6
1995	8	Apr-3-95	B-213	57%	1	7	12	-22.6
1995	9	Apr-3-95	B-253	50%	1a	6	12	-22.6
1995	10	Apr-3-95	B-251	59%	1a	7	15	-22.6
1995	11	Apr-3-95	A-205	100%	2	19	16	-22.0
1995	12	Apr-3-95	A-201	100%	2	7	15	-22.0
1995	13	Apr-3-95	A-205	100%	2	19	12	-22.0
1995	14	Apr-3-95	A-201	100%	2	8	15	-22.0
1995	15	Apr-3-95	B-253	50%	1a	8	13	-22.0
1995	16	Apr-3-95	B-252	56%	1a	9	12	-22.0
1995	17	Apr-3-95	B-214	50%	1	7	12	-22.0
1995	18	Apr-3-95	B-251	59%	1a	7	13	-22.0
1995	19	Apr-3-95	B-213	57%	1	7	15	-22.0
1995	20	Apr-3-95	A-303	100%	2	87	8	-22.5
1995	21	Apr-3-95	A-205	100%	2	25	9	-22.5
1995	22	Apr-3-95	A-201	100%	2	12	10	-22.5
1995	23	Apr-3-95	A-303	100%	2	86	8	-22.5
1995	24	Apr-3-95	A-205	100%	2	22	9	-22.5
1995	25	Apr-3-95	A-201	100%	2	10	11	-22.5
1995	26	Apr-3-95	B-214	50%	1	7	11	-22.4
1995	27	Apr-3-95	B-252	56%	1a	6	11	-22.4
1995	28	Apr-3-95	B-253	50%	1a	6	12	-22.4
1995	29	Apr-3-95	B-220	63%	1	7	12	-22.4
1995	30	Apr-3-95	B-250	49%	1a	6	15	-22.4
1995	31	Apr-3-95	B-221	63%	1	6	14	-22.4
1995	32	Apr-3-95	A-205	100%	2	22	9	-21.6
1995	33	Apr-3-95	A-201	100%	2	18	10	-21.6
1995	34	Apr-3-95	A-205	100%	2	21	9	-21.6
1995	35	Apr-3-95	A-201	100%	2	17	11	-21.6
1995	36	Apr-3-95	B-214	50%	1	8	11	-21.6
1995	37	Apr-3-95	B-251	59%	1a	8	11	-21.6
1995	38	Apr-3-95	B-220	63%	1	8	12	-21.6
1995	39	Apr-3-95	B-250	49%	1a	6	12	-21.6
1995	40	Apr-3-95	B-213	57%	1	7	15	-21.6
1995	41	Apr-3-95	B-253	50%	1a	6	14	-21.6
1995	42	Apr-4-95	A-303	100%	2	87	12	-15.1
1995	43	Apr-4-95	A-205	100%	2	40	12	-15.1
1995	44	Apr-4-95	A-201	100%	2	41	12	-15.1
1995	45	Apr-4-95	A-303	100%	2	87	13	-15.1
1995	46	Apr-4-95	A-201	100%	2	38	15	-15.1
1995	47	Apr-4-95	B-214	50%	1	9	13	-15.1
1995	48	Apr-4-95	B-252	48%	1a	6	15	-15.1
1995	49	Apr-4-95	B-220	63%	1	6	14	-15.1
1995	50	Apr-4-95	B-250	0.42	1a	7	15	-15.1
1995	51	Apr-4-95	B-221	63%	1	7	14	-15.1
1995	52	Apr-4-95	B-253	36%	1a	5	16	-15.1
1995	53	Apr-4-95	A-403	75%	2b	48	13	-15.4
1995	54	Apr-4-95	A-212	75%	2b	30	15	-15.4

SIMULATED FREEZING FOG @ CEF FOR 1994/95

Test Season [year]	test no.	date	fluid code	fluid dilution	fld type	fail time (min)	Avg of pan rate [g/dm²/hr]	avg. temp (°C)
1995	55	Apr-4-95	A-303	100%	2	109	8	-15.3
1995	56	Apr-4-95	A-205	100%	2	48	6	-15.3
1995	57	Apr-4-95	A-201	100%	2	40	12	-15.3
1995	58	Apr-4-95	A-303	100%	2	109	6	-15.3
1995	59	Apr-4-95	A-205	100%	2	43	14	-15.3
1995	60	Apr-4-95	A-201	100%	2	36	11	-15.3
1995	61	Apr-4-95	B-214	50%	1	8	11	-15.3
1995	62	Apr-4-95	B-251	42%	1a	6	12	-15.3
1995	63	Apr-4-95	B-220	63%	1	7	12	-15.3
1995	64	Apr-4-95	B-250	42%	1a	6	15	-15.3
1995	65	Apr-4-95	B-213	57%	1	7	16	-15.3
1995	66	Apr-4-95	B-253	36%	1a	6	15	-15.3
1995	67	Apr-4-95	A-403	75%	2b	45	11	-15.6
1995	68	Apr-4-95	A-212	75%	2b	31	12	-15.6
1995	69	Apr-4-95	A-501	75%	2b	26	12	-15.6
1995	70	Apr-4-95	A-403	75%	2b	45	15	-15.6
1995	71	Apr-4-95	A-212	75%	2b	28	16	-15.6
1995	72	Apr-4-95	A-501	75%	2b	25	15	-15.6
1995	73	Apr-4-95	A-201	100%	2	64	5	-12.1
1995	74	Apr-4-95	A-201	100%	2	64	4	-12.1
1995	75	Apr-4-95	A-201	100%	2	64	5	-12.1
1995	76	Apr-4-95	B-214	50%	1	12	5	-12.3
1995	77	Apr-4-95	B-250	36%	1a	8	4	-12.3
1995	78	Apr-4-95	B-213	57%	1	11	5	-12.3
1995	79	Apr-4-95	B-214	50%	1	11	4	-12.3
1995	80	Apr-4-95	B-250	36%	1a	9	5	-12.3
1995	81	Apr-4-95	B-213	57%	1	11	5	-12.3
1995	82	Apr-4-95	A-403	50%	2a	23	5	-10.6
1995	83	Apr-4-95	A-210	50%	2a	21	4	-10.6
1995	84	Apr-4-95	A-401	50%	2a	16	5	-10.6
1995	85	Apr-4-95	A-403	50%	2a	23	4	-10.6
1995	86	Apr-4-95	A-210	50%	2a	22	5	-10.6
1995	87	Apr-4-95	A-401	50%	2a	15	5	-10.6
1995	88	Apr-4-95	A-212	75%	2b	107	2	-10.7
1995	89	Apr-4-95	A-501	75%	2b	87	2	-10.7
1995	90	Apr-4-95	A-501	75%	2b	101	3	-10.7
1995	91	Apr-4-95	B-252	33%	1a	9	3	-10.4
1995	92	Apr-4-95	B-220	63%	1	14	3	-10.4
1995	93	Apr-4-95	B-253	29%	1a	7	4	-10.4
1995	94	Apr-4-95	B-252	33%	1a	9	3	-10.4
1995	95	Apr-4-95	B-220	63%	1	13	3	-10.4
1995	96	Apr-4-95	B-253	29%	1a	7	3	-10.4
1995	97	Apr-4-95	A-403	50%	2a	40	3	-11.0
1995	98	Apr-4-95	A-210	50%	2a	34	3	-11.0
1995	99	Apr-4-95	A-401	50%	2a	25	4	-11.0
1995	100	Apr-4-95	A-403	50%	2a	35	3	-11.0
1995	101	Apr-4-95	A-210	50%	2a	37	3	-11.0
1995	102	Apr-4-95	A-401	50%	2a	26	3	-11.0
1995	103	Jul-18-95	A-303	100%	2	102	2.9	-26.8
1995	104	Jul-18-95	A-205	100%	2	58	2.6	-27.0
1995	105	Jul-18-95	A-303	100%	2	101	3.1	-26.8
1995	106	Jul-18-95	A-205	100%	2	58	2.9	-27.0
1995	107	Jul-18-95	A-303	100%	2	100	3.4	-26.8
1995	108	Jul-18-95	A-205	100%	2	64	2.9	-27.0

SIMULATED FREEZING FOG @ CEF FOR 1994/95

Test Season [year]	test no.	date	fluid code	fluid dilution	fld type	fail time (min)	Avg of pan rate [g/dm^2/hr]	avg. temp (°C)
1995	109	Jul-18-95	A-303	100%	2	98	3.5	-26.8
1995	110	Jul-18-95	A-205	100%	2	65	3.1	-27.0
1995	111	Jul-18-95	A-303	100%	2	97	3.5	-26.8
1995	112	Jul-18-95	A-205	100%	2	61	3	-27.0
1995	113	Jul-18-95	A-303	100%	2	96	3.4	-26.8
1995	114	Jul-18-95	A-205	100%	2	63	3	-27.0
1995	115	Jul-18-95	A-205	100%	2	85	1.6	-26.8
1995	116	Jul-18-95	A-303	100%	2	171	2.5	-25.5
1995	117	Jul-18-95	A-205	100%	2	83	2.1	-26.8
1995	118	Jul-18-95	A-303	100%	2	105	3.2	-25.5
1995	119	Jul-18-95	A-205	100%	2	75	2.5	-26.8
1995	120	Jul-18-95	A-303	100%	2	125	2.5	-25.5
1995	121	Jul-18-95	A-205	100%	2	74	2.5	-26.8
1995	122	Jul-18-95	A-303	100%	2	98	3.2	-25.5
1995	123	Jul-18-95	B-220	63%	1	14	1.8	-27.0
1995	124	Jul-18-95	B-253	50%	1a	7	1.8	-27.0
1995	125	Jul-18-95	B-253	50%	1a	7	3.7	-27.0
1995	126	Jul-18-95	B-250	56%	1a	9	2.7	-27.0
1995	127	Jul-18-95	B-253	50%	1a	10	1.8	-26.5
1995	128	Jul-18-95	B-253	50%	1a	10	2.7	-26.5
1995	129	Jul-18-95	B-220	63%	1	16	1.8	-26.5
1995	130	Jul-18-95	B-220	63%	1	15	3.7	-26.5
1995	131	Jul-18-95	A-205	100%	2	35	3.1	-24.0
1995	132	Jul-18-95	A-303	100%	2	113	2.8	-23.3
1995	133	Jul-18-95	A-205	100%	2	39	2.4	-24.0
1995	134	Jul-18-95	A-303	100%	2	113	2.4	-23.3
1995	135	Jul-18-95	A-205	100%	2	38	2.4	-24.0
1995	136	Jul-18-95	A-303	100%	2	133	2.4	-23.0
1995	137	Jul-18-95	A-205	100%	2	40	3.1	-24.0
1995	138	Jul-18-95	A-303	100%	2	110	3.4	-23.2
1995	139	Jul-18-95	A-205	100%	2	38	3.1	-24.0
1995	140	Jul-18-95	A-303	100%	2	123	3	-23.0
1995	141	Jul-18-95	A-205	100%	2	39	3.1	-24.0
1995	142	Jul-18-95	A-303	100%	2	108	3.2	-23.2
1995	143	Jul-18-95	A-303	100%	2	NU	NU	-22.0
1995	144	Jul-18-95	A-205	100%	2	106	1.8	-22.8
1995	145	Jul-18-95	A-303	100%	2	NU	NU	-22.0
1995	146	Jul-18-95	A-205	100%	2	104	2.1	-22.8
1995	147	Jul-18-95	A-303	100%	2	NU	NU	-22.0
1995	148	Jul-18-95	A-205	100%	2	103	2.4	-22.8
1995	149	Jul-18-95	A-303	100%	2	NU	NU	-22.0
1995	150	Jul-18-95	A-205	100%	2	71	2.9	-23.0
1995	151	Jul-18-95	B-213	57%	1	16	0.9	-22.7
1995	152	Jul-18-95	B-253	50%	1a	7	2.7	-22.7
1995	153	Jul-18-95	B-213	57%	1	15	1.4	-22.7
1995	154	Jul-18-95	B-253	50%	1a	9	2.7	-22.7

APPENDIX J

LISTING OF FLAT PLATE TESTS CONDUCTED DURING 1995/96

NATURAL SNOW TESTS @ DORVAL 1995/96

test no.	date	fld dilution	fluid code	fld type	fail time [min.]	AVG PAN (g/dm²/hr)	APS Data temp [C]	wind [kph]
1	Nov-27-95	neat	A-303	4	64	24.0	-9.8	13
2	Nov-27-95	neat	A-303	4	64	24.0	-9.8	13
3	Nov-27-95	neat	A-205	2	28	21.5	-9.9	14
4	Nov-27-95	neat	A-205	2	28	21.5	-9.9	14
5	Nov-27-95	neat	A-205	2	22	26.8	-9.8	12
6	Nov-27-95	neat	A-205	2	22	26.8	-9.8	12
7	Nov-27-95	neat	A-303	4	62	19.5	-9.2	12
8	Nov-27-95	neat	A-303	4	64	19.5	-9.2	12
9	Nov-27-95	neat	A-205	2	38	18.7	-9.3	13
10	Nov-27-95	neat	A-205	2	39	18.7	-9.3	12
11	Nov-27-95	75%	A-503	4b	27	13.7	-8.7	13
12	Nov-27-95	75%	A-503	4b	23	13.5	-8.7	13
13	Nov-27-95	75%	A-503	4b	82	7.4	-8.2	13
14	Nov-27-95	75%	A-212	2b	66	7.9	-8.2	12
15	Nov-27-95	75%	A-212	2b	62	8.2	-8.3	12
16	Nov-27-95	57%	B-213	1	23	2.1	-7.5	13
17	Nov-27-95	57%	B-213	1	23	2.1	-7.5	13
18	Nov-27-95	neat	A-205	2	35	13.5	-6.0	11
19	Nov-27-95	neat	A-205	2	33	13.5	-5.9	11
20	Nov-27-95	neat	A-303	4	88	10.3	-6.0	11
21	Nov-27-95	neat	A-303	4	82	10.4	-6.0	11
22	Nov-27-95	neat	A-205	2	63	6.2	-6.0	11
23	Nov-27-95	neat	A-205	2	62	6.2	-6.0	11
24	Nov-28-95	75%	A-212	2b	21	12.3	-5.4	10
25	Nov-28-95	75%	A-212	2b	21	12.3	-5.4	10
26	Nov-28-95	75%	A-503	4b	17	12.3	-5.4	10
27	Nov-28-95	75%	A-503	4b	17	12.3	-5.4	10
28	Nov-28-95	75%	A-212	2b	20	17.6	-5.3	10
29	Nov-28-95	75%	A-212	2b	22	17.9	-5.3	10
30	Nov-28-95	75%	A-503	4b	19	17.6	-5.3	10
31	Nov-28-95	75%	A-503	4b	22	18.0	-5.3	10
32	Dec-01-95	neat	A-205	2	25	24.4	-2.6	13.0
33	Dec-01-95	neat	A-205	2	25	24.4	-2.6	13.0
34	Dec-01-95	neat	A-303	4	126	14.4	-2.5	12.0
35	Dec-01-95	neat	A-303	4	53	24.2	-2.6	13.0
36	Dec-01-95	neat	C-103	4	130	15.2	-2.5	12.0
37	Dec-01-95	neat	C-103	4	138	11.3	-2.5	11.9
38	Dec-01-95	neat	A-205	2	93	2.4	-2.4	11.2
39	Dec-01-95	neat	A-205	2	94	2.4	-2.4	11.2
40	Dec-01-95	neat	A-205	2	29	16.1	-2.7	12.9
41	Dec-01-95	neat	A-205	2	42	12.5	-2.7	12.6
42	Dec-01-95	neat	A-303	4	122	7.0	-2.5	11.7
43	Dec-01-95	neat	A-303	4	119	6.7	-2.5	11.7
44	Dec-01-95	neat	C-102	4	120	6.9	-2.5	11.6
45	Dec-01-95	neat	C-102	4	118	6.7	-2.5	11.6
46	Dec-01-95	neat	A-205	2	87	7.3	-2.3	11.1
47	Dec-01-95	neat	A-205	2	42	13.6	-1.8	11.3
48	Dec-01-95	neat	A-205	2	42	13.6	-1.8	11.3
49	Dec-01-95	neat	A-303	4	89	11.2	-1.5	11.8
50	Dec-01-95	neat	A-303	4	93	11.3	-1.5	11.8
51	Dec-01-95	neat	C-103	4	121	11.2	-1.4	11.6
52	Dec-01-95	neat	C-103	4	125	11.2	-1.4	11.6
53	Dec-01-95	neat	A-205	2	53	9.2	-1.2	11.9
54	Dec-01-95	neat	A-205	2	53	9.2	-1.2	11.9
55	Dec-01-95	neat	A-205	2	33	16.7	-1.8	11.7

NATURAL SNOW TESTS @ DORVAL 1995/96

test no.	date	fld dilution	fluid code	fld type	fail time [min.]	AVG PAN (g/dm²/hr)	APS Data temp [C]	APS Data wind [kph]
56	Dec-01-95	neat	A-205	2	41	15.2	-1.8	11.7
57	Dec-01-95	neat	A-303	4	88	11.4	-1.5	11.9
58	Dec-01-95	neat	A-303	4	86	11.4	-1.5	11.9
59	Dec-01-95	neat	C-102	4	86	11.4	-1.5	11.9
60	Dec-01-95	neat	C-102	4	86	11.4	-1.5	11.9
61	Dec-01-95	neat	A-205	2	46	9.7	-1.0	11.7
62	Dec-01-95	neat	A-205	2	46	9.7	-1.0	11.7
63	Dec-01-95	75%	A-212	2b	30	13.4	-0.4	11.4
64	Dec-01-95	75%	A-212	2b	29	13.3	-0.4	11.4
65	Dec-01-95	75%	C-703	4b	48	14.0	-0.3	11.7
66	Dec-01-95	75%	C-703	4b	48	14.0	-0.3	11.7
67	Dec-01-95	75%	A-212	2b	45	13.9	-0.4	11.3
68	Dec-01-95	75%	A-212	2b	45	13.9	-0.4	11.3
69	Dec-01-95	75%	A-503	4b	68	11.5	-0.3	11.6
70	Dec-01-95	75%	A-503	4b	76	11.3	-0.3	11.7
71	Dec-01-95	75%	C-702	4b	49	11.8	-0.4	11.2
72	Dec-01-95	75%	C-702	4b	45	11.9	-0.4	11.3
73	Dec-03-95	neat	A-101	2	46	3.2	-8.1	9.1
74	Dec-03-95	neat	A-101	2	46	3.2	-8.1	9.1
75	Dec-03-95	neat	A-303	4	107	9.5	-8.1	9.6
76	Dec-03-95	neat	A-303	4	115	10.7	-8.1	9.5
77	Dec-03-95	neat	C-103	4	107	9.5	-8.1	9.6
78	Dec-03-95	neat	C-103	4	106	9.4	-8.1	9.5
79	Dec-03-95	neat	A-101	2	34	13.6	-8.2	10.1
80	Dec-03-95	neat	A-101	2	34	13.6	-8.2	10.1
81	Dec-03-95	neat	A-101	2	34	15.0	-7.7	9.0
82	Dec-03-95	neat	A-101	2	31	15.0	-7.7	9.0
83	Dec-03-95	neat	A-101	2	38	3.5	-8.2	8.9
84	Dec-03-95	neat	A-101	2	38	3.5	-8.2	8.9
85	Dec-03-95	neat	A-303	4	100	10.5	-8.1	9.5
86	Dec-03-95	neat	A-303	4	97	10.2	-8.2	9.5
87	Dec-03-95	neat	C-103	4	92	9.6	-8.2	9.5
88	Dec-03-95	neat	C-103	4	86	8.9	-8.2	9.5
89	Dec-03-95	neat	A-101	2	29	12.8	-8.2	10.2
90	Dec-03-95	neat	A-101	2	29	12.8	-8.2	10.2
91	Dec-03-95	neat	A-101	2	28	18.7	-7.7	9.1
92	Dec-03-95	neat	A-101	2	29	18.6	-7.7	9.1
93	Dec-03-95	neat	A-205	2	30	16.4	-8.0	10.1
94	Dec-03-95	neat	A-205	2	30	16.4	-8.0	10.1
95	Dec-03-95	neat	A-303	4	58	15.6	-8.0	10.6
96	Dec-03-95	neat	A-303	4	60	15.5	-8.0	10.6
97	Dec-03-95	neat	C-103	4	57	15.6	-8.0	10.6
98	Dec-03-95	neat	C-103	4	57	15.6	-8.0	10.6
99	Dec-03-95	neat	A-205	2	29	12.3	-8.1	11.2
100	Dec-03-95	neat	A-205	2	29	12.3	-8.1	11.2
101	Dec-03-95	neat	A-205	2	23	16.8	-8.0	10.6
102	Dec-03-95	neat	A-205	2	24	16.8	-8.0	10.7
103	Dec-03-95	neat	A-303	4	60	14.4	-8.0	11.0
104	Dec-03-95	neat	A-303	4	55	14.7	-8.0	11.1
105	Dec-03-95	neat	C-102	4	58	14.5	-8.0	11.0
106	Dec-03-95	neat	C-102	4	59	14.4	-8.0	11.0
107	Dec-03-95	neat	A-205	2	30	10.2	-8.0	11.4
108	Dec-03-95	neat	A-205	2	30	10.2	-8.0	11.4
109	Dec-03-95	75%	A-212	2b	34	3.2	-8.1	12.5
110	Dec-03-95	75%	A-212	2b	34	3.2	-8.1	12.5

NATURAL SNOW TESTS @ DORVAL 1995/96

test no.	date	fld dilution	fluid code	fld type	fail time [min.]	AVG PAN (g/dm²/hr)	APS Data temp [C]	APS Data wind [kph]
111	Dec-03-95	75%	C-702	4b	40	4.6	-8.3	13.1
112	Dec-03-95	75%	C-702	4b	52	3.5	-8.5	13.7
113	Dec-03-95	75%	C-703	4b	61	4.9	-8.7	14.1
114	Dec-03-95	75%	C-703	4b	61	4.9	-8.7	14.1
115	Dec-03-95	75%	A-212	2b	27	5.8	-8.3	13.2
116	Dec-03-95	75%	A-212	2b	29	6.1	-8.3	13.5
117	Dec-03-95	75%	A-701	2b	25	5.6	-8.3	13.3
118	Dec-03-95	75%	A-701	2b	26	5.8	-8.3	13.4
119	Dec-06-95	neat	A-205	2	24	25.2	-0.9	18.8
120	Dec-06-95	neat	A-205	2	24	25.2	-0.9	18.8
121	Dec-06-95	neat	A-303	4	59	13.7	-0.8	18.0
122	Dec-06-95	neat	A-303	4	54	13.9	-0.8	17.8
123	Dec-06-95	neat	A-205	2	49	8.6	-0.7	17.2
124	Dec-06-95	neat	A-205	2	48	8.7	-0.7	17.1
125	Dec-06-95	neat	A-205	2	27	23.2	-0.9	19.1
126	Dec-06-95	neat	A-205	2	29	21.9	-0.9	18.9
127	Dec-06-95	neat	A-303	4	73	13.7	-0.8	17.7
128	Dec-06-95	neat	A-303	4	73	13.7	-0.8	17.7
129	Dec-06-95	neat	A-205	2	44	8.2	-0.7	17.6
130	Dec-06-95	neat	A-205	2	47	9.7	-0.6	17.5
131	Dec-09-95	neat	A-205	2	93	1.9	-11.7	10.1
132	Dec-09-95	neat	A-205	2	89	1.9	-11.8	10.1
133	Dec-09-95	neat	C-103	4	187	3.4	-11.1	10.1
134	Dec-09-95	neat	C-103	4	190	3.5	-11.1	10.1
135	Dec-09-95	neat	A-205	2	57	4.2	-10.7	10.0
136	Dec-09-95	neat	A-205	2	57	4.2	-10.7	10.0
137	Dec-09-95	neat	A-205	2	76	1.7	-11.8	10.0
138	Dec-09-95	neat	A-205	2	77	1.7	-11.8	10.0
139	Dec-09-95	neat	C-102	4	155	3.0	-11.3	10.3
140	Dec-09-95	neat	C-102	4	149	2.7	-11.4	10.4
141	Dec-09-95	neat	A-205	2	51	4.1	-10.8	10.1
142	Dec-09-95	neat	A-205	2	50	4.1	-10.8	10.1
143	Dec-09-95	neat	A-202	2	68	4.3	-7.0	5.8
144	Dec-09-95	neat	A-202	2	69	4.3	-7.0	5.8
145	Dec-09-95	neat	C-103	4	126	5.8	-6.1	7.3
146	Dec-09-95	neat	C-103	4	137	5.9	-6.0	7.5
147	Dec-09-95	neat	A-205	2	54	7.7	-5.0	9.2
148	Dec-09-95	neat	A-205	2	54	7.4	-5.0	9.2
149	Dec-09-95	neat	A-202	2	34	8.0	-9.2	8.6
150	Dec-09-95	neat	A-202	2	34	8.0	-9.2	8.6
151	Dec-09-95	neat	C-102	4	80	6.2	-8.0	6.8
152	Dec-09-95	neat	C-102	4	81	6.2	-7.9	6.8
153	Dec-09-95	neat	A-205	2	49	6.2	-6.0	5.4
154	Dec-09-95	neat	A-205	2	50	5.6	-6.0	5.5
155	Dec-09-95	neat	A-205	2	55	6.9	-3.8	8.7
156	Dec-09-95	neat	A-205	2	55	6.9	-3.8	8.7
157	Dec-09-95	neat	A-303	4	105	6.3	-3.5	8.4
158	Dec-09-95	neat	A-303	4	110	6.3	-3.5	8.5
159	Dec-09-95	neat	A-205	2	50	5.7	-3.1	8.2
160	Dec-09-95	neat	A-205	2	53	4.8	-3.1	8.3
161	Dec-09-95	neat	A-205	2	34	11.2	-5.0	9.4
162	Dec-09-95	neat	A-205	2	35	11.2	-5.0	9.5
163	Dec-09-95	neat	A-303	4	67	10.4	-4.7	9.7
164	Dec-09-95	neat	A-303	4	67	10.4	-4.7	9.7
165	Dec-09-95	neat	A-205	2	44	7.2	-4.1	9.2

NATURAL SNOW TESTS @ DORVAL 1995/96

test no.	date	fld dilution	fluid code	fld type	fall time [min.]	AVG PAN (g/dm²/hr)	APS Data temp [C]	APS Data wind [kph]
166	Dec-09-95	neat	A-205	2	44	7.2	-4.1	9.2
167	Dec-09-95	neat	A-101	2	71	4.6	-2.4	8.5
168	Dec-09-95	neat	A-101	2	73	4.5	-2.4	8.5
169	Dec-09-95	neat	A-303	4	106	5.4	-2.3	8.6
170	Dec-09-95	neat	A-303	4	113	5.6	-2.3	8.6
171	Dec-09-95	neat	C-103	4	120	5.8	-2.3	8.5
172	Dec-09-95	neat	C-103	4	127	6.0	-2.3	8.5
173	Dec-09-95	neat	A-101	2	48	7.0	-3.0	8.9
174	Dec-09-95	neat	A-101	2	48	7.0	-3.0	8.9
175	Dec-09-95	neat	A-303	4	73	7.4	-2.8	8.8
176	Dec-09-95	neat	A-303	4	77	7.4	-2.8	8.7
177	Dec-09-95	neat	C-102	4	88	6.8	-2.7	8.7
178	Dec-09-95	neat	C-102	4	87	6.8	-2.7	8.7
179	Dec-09-95	neat	A-101	2	76	4.3	-2.3	8.6
180	Dec-09-95	neat	A-101	2	76	4.3	-2.3	8.6
181	Dec-09-95	neat	A-101	2	47	9.2	-1.6	10.2
182	Dec-09-95	neat	A-101	2	48	9.0	-1.6	10.4
183	Dec-09-95	neat	A-101	2	32	12.6	-1.9	7.2
184	Dec-09-95	neat	A-101	2	32	12.6	-1.9	7.2
185	Dec-09-95	neat	A-303	4	52	13.3	-1.8	7.4
186	Dec-09-95	neat	A-303	4	60	13.3	-1.8	7.9
187	Dec-14-95	neat	A-205	2	21	13.6	-13.9	8.9
188	Dec-14-95	neat	A-205	2	21	13.6	-13.9	8.9
189	Dec-14-95	neat	A-303	4	87	13.7	-13.5	12.6
190	Dec-14-95	neat	A-303	4	84	13.8	-13.5	12.5
191	Dec-14-95	neat	A-205	2	24	14.7	-13.4	12.2
192	Dec-14-95	neat	A-205	2	28	15.3	-13.4	12.2
193	Dec-14-95	neat	A-205	2	25	13.7	-13.5	12.8
194	Dec-14-95	neat	A-205	2	26	14.0	-13.5	12.7
195	Dec-14-95	neat	A-303	4	69	13.9	-13.2	13.1
196	Dec-14-95	neat	A-303	4	73	14.1	-13.2	13.2
197	Dec-14-95	neat	A-205	2	31	11.6	-12.9	13.1
198	Dec-14-95	neat	A-205	2	33	11.6	-12.9	13.3
199	Dec-14-95	neat	A-101	2	15	13.9	-12.6	14.8
200	Dec-14-95	neat	A-101	2	15	13.9	-12.6	14.8
201	Dec-14-95	neat	A-303	4	55	17.3	-12.3	13.5
202	Dec-14-95	neat	A-303	4	59	16.8	-12.2	13.6
203	Dec-14-95	neat	A-101	2	14	20.8	-12.3	13.7
204	Dec-14-95	neat	A-101	2	14	20.8	-12.3	13.7
205	Dec-14-95	neat	A-101	2	15	15.7	-11.8	13.7
206	Dec-14-95	neat	A-101	2	15	15.7	-11.8	13.7
207	Dec-14-95	neat	A-101	2	11	21.8	-12.4	14.1
208	Dec-14-95	neat	A-101	2	11	21.8	-12.4	14.1
209	Dec-14-95	neat	A-303	4	44	19.8	-12.1	13.1
210	Dec-14-95	neat	A-303	4	43	19.8	-12.1	13.1
211	Dec-14-95	neat	A-101	2	15	20.8	-12.1	13.0
212	Dec-14-95	neat	A-101	2	18	20.2	-12.0	12.4
213	Dec-14-95	neat	A-205	2	23	14.0	-10.8	15.4
214	Dec-14-95	neat	A-205	2	23	18.7	-10.8	15.4
215	Dec-14-95	neat	C-103	4	49	16.0	-10.4	14.8
216	Dec-14-95	neat	C-103	4	48	15.9	-10.4	14.9
217	Dec-14-95	neat	A-205	2	23	18.0	-10.0	13.7
218	Dec-14-95	neat	A-205	2	23	18.0	-10.0	13.7
219	Dec-14-95	neat	A-205	2	28	14.7	-10.5	14.6
220	Dec-14-95	neat	A-205	2	32	15.1	-10.4	14.6

NATURAL SNOW TESTS @ DORVAL 1995/96

test no.	date	fld dilution	fluid code	fld type	fail time [min.]	AVG PAN (g/dm²/hr)	APS Data temp [C]	APS Data wind [kph]
221	Dec-14-95	neat	C-102	4	38	15.5	-10.2	14.3
222	Dec-14-95	neat	C-102	4	38	15.5	-10.2	14.3
223	Dec-14-95	neat	A-205	2	38	11.4	-8.4	11.6
224	Dec-14-95	neat	A-205	2	38	11.4	-8.4	11.6
225	Dec-14-95	neat	A-303	4	66	13.4	-8.2	11.8
226	Dec-14-95	neat	A-303	4	66	13.4	-8.2	11.8
227	Dec-14-95	neat	A-205	2	31	10.8	-8.3	11.6
228	Dec-14-95	neat	A-205	2	36	9.3	-8.3	11.5
229	Dec-14-95	neat	A-303	4	41	12.1	-8.2	11.6
230	Dec-14-95	neat	A-303	4	51	13.0	-8.2	11.7
231	Dec-14-95	neat	A-101	2	35	14.5	-7.8	12.9
232	Dec-14-95	neat	A-101	2	35	14.5	-7.8	12.9
233	Dec-14-95	neat	A-303	4	69	13.4	-7.8	13.7
234	Dec-14-95	neat	A-303	4	69	13.4	-7.8	13.7
235	Dec-14-95	neat	A-101	2	40	8.4	-7.8	13.6
236	Dec-14-95	neat	A-101	2	40	8.4	-7.8	13.6
237	Dec-14-95	neat	A-101	2	32	13.1	-7.8	14.1
238	Dec-14-95	neat	A-101	2	35	13.4	-7.8	14.3
239	Dec-14-95	neat	A-303	4	64	13.8	-7.8	13.8
240	Dec-14-95	neat	A-303	4	64	13.8	-7.8	13.8
241	Dec-14-95	neat	A-205	2	47	5.9	-7.5	12.2
242	Dec-14-95	neat	A-205	2	47	5.9	-7.5	12.2
243	Dec-14-95	neat	C-103	4	101	6.1	-7.4	11.7
244	Dec-14-95	neat	C-103	4	101	6.1	-7.4	11.7
245	Dec-14-95	neat	A-205	2	43	8.4	-7.4	11.5
246	Dec-14-95	neat	A-205	2	51	8.0	-7.4	11.6
247	Dec-14-95	neat	C-102	4	79	5.9	-7.4	11.7
248	Dec-20-95	neat	A-205	2	94	2.2	-10.0	16.0
249	Dec-20-95	neat	A-205	2	89	2.2	-10.0	15.9
250	Dec-20-95	neat	A-303	4	252	3.8	-9.8	16.0
251	Dec-20-95	neat	A-303	4	237	3.9	-9.8	16.0
252	Dec-20-95	neat	A-205	2	46	8.5	-9.2	15.9
253	Dec-20-95	neat	A-205	2	40	6.7	-9.2	15.9
254	Dec-20-95	75%	A-212	2b	59	3.3	-10.1	15.9
255	Dec-20-95	75%	A-212	2b	57	3.3	-10.1	16.0
256	Dec-20-95	75%	A-503	4b	91	3.2	-10.0	16.2
257	Dec-20-95	75%	A-503	4b	91	3.2	-10.0	16.2
258	Dec-20-95	75%	A-212	2b	21	10.1	-9.6	16.5
259	Dec-20-95	75%	A-212	2b	21	10.1	-9.6	16.5
260	Dec-21-95	neat	A-201	2	54	3.6	-10.8	10.8
261	Dec-21-95	neat	A-201	2	51	3.9	-10.8	10.8
262	Dec-21-95	neat	C-103	4	215	3.2	-10.6	11.0
263	Dec-21-95	neat	C-103	4	221	3.3	-10.6	11.0
264	Dec-21-95	neat	A-201	2	87	2.3	-10.5	11.1
265	Dec-21-95	neat	A-201	2	86	2.3	-10.5	11.1
266	Dec-21-95	75%	A-501	2b	18	7.5	-11.8	10.1
267	Dec-21-95	75%	A-501	2b	18	7.5	-11.8	10.1
268	Dec-21-95	75%	C-703	4b	84	3.4	-11.7	10.1
269	Dec-21-95	75%	C-703	4b	84	3.4	-11.7	10.1
270	Dec-21-95	75%	A-501	2b	67	2.1	-11.6	9.9
271	Dec-21-95	75%	A-501	2b	67	2.1	-11.6	9.9
272	Dec-21-95	75%	A-501	2b	54	3.0	-11.0	10.3
273	Dec-21-95	75%	A-501	2b	53	3.0	-11.0	10.3
274	Dec-21-95	75%	A-503	4b	87	3.4	-10.9	10.5
275	Dec-21-95	75%	A-503	4b	87	3.4	-10.9	10.5

NATURAL SNOW TESTS @ DORVAL 1995/96

test no.	date	fld dilution	fluid code	fld type	fail time [min.]	AVG PAN (g/dm²/hr)	APS Data temp [C]	APS Data wind [kph]
276	Dec-21-95	75%	C-702	4b	75	3.2	-10.9	10.5
277	Dec-21-95	75%	C-702	4b	78	3.2	-10.9	10.5
278	Dec-21-95	75%	A-501	2b	37	4.4	-10.7	10.6
279	Dec-21-95	75%	A-501	2b	37	4.4	-10.7	10.6
280	Dec-21-95	75%	C-705	4b	79	2.5	-10.4	10.7
281	Dec-21-95	75%	C-705	4b	78	2.6	-10.4	10.7
282	Dec-21-95	75%	A-503	4b	102	3.0	-10.5	10.8
283	Dec-21-95	75%	A-503	4b	98	2.8	-10.5	10.7
284	Dec-21-95	75%	C-705	4b	107	3.1	-10.5	10.8
285	Dec-21-95	75%	C-705	4b	105	3.1	-10.5	10.8
286	Dec-21-95	75%	A-701	2b	34	4.5	-10.6	11.3
287	Dec-21-95	75%	A-701	2b	32	4.6	-10.6	11.3
288	Jan-09-96	57%	B-213	1	11	2.5	-10.9	9.3
289	Jan-09-96	57%	B-213	1	11	2.5	-10.9	9.3
290	Jan-09-96	neat	A-201	2	47	2.8	-11.0	7.8
291	Jan-09-96	neat	A-201	2	47	2.8	-11.0	7.8
292	Jan-09-96	neat	C-102	4	178	3.2	-11.0	8.5
293	Jan-09-96	neat	C-102	4	178	3.2	-11.0	8.5
294	Jan-09-96	neat	A-201	2	58	4.0	-10.9	8.4
295	Jan-09-96	neat	A-201	2	57	4.0	-10.9	8.4
296	Jan-09-96	57%	B-213	1	17	4.0	-10.9	7.7
297	Jan-09-96	57%	B-213	1	19	4.0	-10.9	7.6
298	Jan-10-96	neat	A-201	2	68	2.4	-11.0	8.6
299	Jan-10-96	neat	A-201	2	68	2.4	-11.0	8.6
300	Jan-09-96	57%	B-213	1	22	3.8	-10.9	8.2
301	Jan-09-96	57%	B-213	1	20	3.9	-10.9	8.2
302	Jan-10-96	57%	B-213	1	41	2.0	-10.8	8.3
303	Jan-10-96	57%	B-213	1	41	2.0	-10.8	8.3
304	Jan-10-96	37%	B-253	1a	24	2.1	-10.9	8.2
305	Jan-10-96	37%	B-253	1a	21	2.1	-10.9	8.1
306	Jan-10-96	37%	B-253	1a	18	2.3	-10.8	8.2
307	Jan-10-96	37%	B-253	1a	12	1.7	-10.8	8.2
308	Jan-10-96	37%	B-253	1a	15	1.1	-11.1	8.7
309	Jan-10-96	37%	B-253	1a	12	1.1	-11.1	8.9
310	Jan-10-96	57%	B-213	1	23	1.1	-11.0	8.4
311	Jan-10-96	57%	B-213	1	19	1.1	-11.0	8.4
312	Jan-19-96	75%	A-212	2b	38	12.7	-2.4	22.3
313	Jan-19-96	75%	A-212	2b	38	12.7	-2.4	22.3
314	Jan-19-96	75%	A-503	4b	44	12.3	-2.4	21.0
315	Jan-19-96	75%	A-503	4b	53	11.9	-2.5	20.6
316	Jan-19-96	75%	A-212	2b	44	9.7	-2.5	20.8
317	Jan-19-96	75%	A-212	2b	44	9.7	-2.5	20.8
318	Jan-19-96	75%	A-503	4b	42	10.5	-2.5	20.8
319	Jan-19-96	75%	A-503	4b	43	9.7	-2.5	20.8
320	Jan-27-96	75%	A-212	2b	17	29.6	-2.7	8.5
321	Jan-27-96	75%	A-212	2b	15	29.6	-2.7	8.6
322	Jan-27-96	75%	C-705	4b	25	29.2	-2.6	8.1
323	Jan-27-96	75%	C-705	4b	24	29.3	-2.6	8.3
324	Jan-27-96	75%	C-703	4b	25	29.1	-2.6	8.0
325	Jan-27-96	75%	C-703	4b	25	29.1	-2.6	8.0
326	Jan-27-96	50%	A-210	2a	10	40.0	-2.7	8.8
327	Jan-27-96	50%	A-210	2a	10	40.0	-2.7	8.8
328	Jan-27-96	50%	C-505	4a	6	40.0	-2.8	8.1
329	Jan-27-96	50%	C-505	4a	6	40.0	-2.8	8.1
330	Jan-27-96	50%	C-502	4a	8	40.0	-2.6	8.8

NATURAL SNOW TESTS @ DORVAL 1995/96

test no.	date	fld dilution	fluid code	fld type	fail time [min.]	AVG PAN (g/dm²/hr)	APS Data temp [C]	wind [kph]
331	Jan-27-96	50%	C-502	4a	8	40.0	-2.6	8.8
332	Jan-27-96	75%	A-501	2b	36	12.2	-2.0	6.7
333	Jan-27-96	75%	A-501	2b	36	12.2	-2.0	6.7
334	Jan-27-96	75%	C-703	4b	54	10.8	-1.8	7.2
335	Jan-27-96	75%	C-703	4b	54	10.8	-1.8	7.2
336	Jan-27-96	75%	A-501	2b	14	40.6	-2.6	7.4
337	Jan-27-96	75%	A-501	2b	14	40.6	-2.6	7.4
338	Jan-27-96	75%	C-702	4b	16	40.6	-2.6	7.2
339	Jan-27-96	75%	C-702	4b	16	40.6	-2.6	7.2
340	Jan-27-96	50%	A-210	2a	10	14.9	-1.1	8.0
341	Jan-27-96	50%	A-210	2a	10	14.9	-1.1	8.0
342	Jan-27-96	50%	A-403	4a	9	14.9	-1.1	7.5
343	Jan-27-96	50%	A-403	4a	8	14.9	-1.1	7.4
344	Jan-27-96	50%	A-210	2a	28	5.4	-1.8	6.9
345	Jan-27-96	50%	A-210	2a	28	5.4	-1.8	6.9
346	Jan-27-96	50%	A-403	4a	28	5.4	-1.8	6.9
347	Jan-27-96	50%	A-403	4a	29	5.7	-1.8	7.0
348	Jan-27-96	50%	A-511	2a	15	17.4	-1.2	7.9
349	Jan-27-96	50%	A-511	2a	16	17.4	-1.2	8.0
350	Jan-27-96	50%	A-403	4a	14	17.4	-1.2	8.1
351	Jan-27-96	50%	A-403	4a	14	17.4	-1.2	8.1
352	Jan-27-96	50%	C-505	4a	12	17.4	-1.1	7.9
353	Jan-27-96	50%	C-505	4a	12	17.4	-1.1	7.9
354	Jan-29-96	50%	A-511	2a	23	7.9	-4	15.7
355	Jan-29-96	50%	A-511	2a	22	7.9	-4	15.8
356	Jan-29-96	50%	A-403	4a	8	8.0	-4	15.7
357	Jan-29-96	50%	A-403	4a	8	8.0	-4	15.7
358	Jan-29-96	50%	C-505	4a	7	8.0	-4	15.7
359	Jan-29-96	50%	C-505	4a	7	8.0	-4	15.7
360	Jan-29-96	50%	A-511	2a	25	7.8	-4	19.5
361	Jan-29-96	50%	A-511	2a	26	7.9	-4	19.9
362	Jan-29-96	50%	A-403	4a	17	7.5	-4	18.4
363	Jan-29-96	50%	A-403	4a	18	7.5	-4	18.4
364	Jan-29-96	50%	C-502	4a	27	8.1	-4	20.6
365	Jan-29-96	50%	C-502	4a	27	8.1	-4	20.6
366	Feb-07-96	75%	A-701	2b	46	9.9	-2.7	14.2
367	Feb-07-96	75%	A-701	2b	45	9.9	-2.7	14.2
368	Feb-07-96	75%	A-503	4b	33	9.4	-2.7	14.3
369	Feb-07-96	75%	A-503	4b	31	9.0	-2.7	14.3
370	Feb-07-96	75%	C-703	4b	52	10.0	-2.8	13.9
371	Feb-07-96	75%	C-703	4b	53	10.0	-2.8	13.9
372	Feb-07-96	75%	A-501	2b	35	7.4	-2.7	13.9
373	Feb-07-96	75%	A-501	2b	41	7.4	-2.8	13.8
374	Feb-07-96	75%	C-702	4b	69	7.5	-2.8	13.7
375	Feb-07-96	75%	C-702	4b	89	6.7	-2.8	14.1
376	Feb-09-96	75%	A-701	2b	51	7.2	1.0	5.3
377	Feb-09-96	75%	A-701	2b	50	7.2	1.0	5.4
378	Feb-09-96	75%	A-503	4b	45	7.1	1.0	5.4
379	Feb-09-96	75%	A-503	4b	46	7.2	1.0	5.4
380	Feb-09-96	75%	C-705	4b	49	7.2	1.0	5.3
381	Feb-09-96	75%	C-705	4b	49	7.2	1.0	5.3
382	Feb-09-96	50%	A-511	2a	34	7.8	1.0	5.2
383	Feb-09-96	50%	A-511	2a	34	7.8	1.0	5.2
384	Feb-09-96	50%	A-403	4a	31	7.8	1.1	5.1
385	Feb-09-96	50%	A-403	4a	31	7.8	1.1	5.1

NATURAL SNOW TESTS @ DORVAL 1995/96

test no.	date	fld dilution	fluid code	fld type	fail time [min.]	AVG PAN (g/dm²/hr)	APS Data temp [C]	APS Data wind [kph]
386	Feb-09-96	50%	C-505	4a	34	7.8	1.0	5.1
387	Feb-09-96	50%	C-505	4a	32	7.4	1.0	5.2
388	Feb-09-96	75%	A-210	2b	130	2.2	0.8	5.3
389	Feb-09-96	75%	A-210	2b	130	2.2	0.8	5.3
390	Feb-09-96	75%	C-703	4b	152	3.6	0.8	5.4
391	Feb-09-96	75%	C-703	4b	152	3.6	0.8	5.4
392	Feb-09-96	50%	A-210	2a	138	2.6	0.8	5.3
393	Feb-09-96	50%	A-210	2a	30	3.3	0.8	5.2
394	Feb-09-96	50%	C-502	4a	137	2.6	0.8	5.3
395	Feb-09-96	50%	C-502	4a	137	2.6	0.8	5.3
396	Feb-09-96	75%	A-501	2b	30	4.2	0.6	4.0
397	Feb-09-96	75%	A-501	2b	31	13.5	0.6	4.1
398	Feb-09-96	75%	C-705	4b	47	10.8	0.5	4.3
399	Feb-09-96	75%	C-705	4b	47	10.8	0.5	4.3
400	Feb-09-96	50%	A-401	2a	16	20.1	0.7	4.9
401	Feb-09-96	50%	A-401	2a	18	23.2	0.7	4.9
402	Feb-09-96	50%	C-503	4a	32	20.3	0.6	4.6
403	Feb-09-96	50%	C-503	4a	39	19.8	0.6	4.4
404	Feb-09-96	75%	A-501	2b	177	4.9	0.8	7.7
405	Feb-09-96	75%	A-501	2b	177	4.9	0.8	7.7
406	Feb-09-96	75%	C-702	4b	176	4.9	0.8	7.7
407	Feb-09-96	75%	C-702	4b	176	4.9	0.8	7.7
408	Feb-09-96	50%	A-401	2a	42	6.4	0.5	7.5
409	Feb-09-96	50%	A-401	2a	41	6.4	0.5	7.5
410	Feb-09-96	50%	A-403	4a	14	6.2	0.5	5.6
411	Feb-09-96	50%	A-403	4a	20	7.7	0.5	6.5
412	Feb-09-96	50%	C-505	4a	27	6.9	0.5	7.1
413	Feb-09-96	50%	C-505	4a	26	7.0	0.5	7.0
414	Feb-11-96	75%	A-212	2b	26	13.9	-5.2	12.0
415	Feb-11-96	75%	A-212	2b	26	13.9	-5.2	12.0
416	Feb-11-96	75%	A-503	4b	42	19.1	-5.5	11.9
417	Feb-11-96	75%	A-503	4b	42	19.1	-5.5	11.9
418	Feb-11-96	75%	A-212	2b	33	13.4	-5.2	12.0
419	Feb-11-96	75%	A-212	2b	33	13.4	-5.2	12.0
420	Feb-11-96	75%	A-503	4b	59	17.6	-5.4	11.9
421	Feb-11-96	75%	A-503	4b	58	17.6	-5.4	11.9
422	Feb-11-96	75%	A-701	2b	38	13.6	-6.0	12.7
423	Feb-11-96	75%	A-701	2b	40	13.7	-6.0	12.6
424	Feb-11-96	75%	A-503	4b	37	13.6	-6.0	12.8
425	Feb-11-96	75%	A-503	4b	37	13.6	-6.0	12.8
426	Feb-11-96	75%	C-705	4b	20	13.6	-5.9	13.0
427	Feb-11-96	75%	C-705	4b	39	13.7	-6.0	12.6
428	Feb-11-96	75%	A-701	2b	45	13.4	-6.1	13.5
429	Feb-11-96	75%	A-701	2b	53	12.5	-6.2	13.5
430	Feb-11-96	75%	A-503	4b	31	14.3	-6.1	13.0
431	Feb-11-96	75%	A-503	4b	30	14.3	-6.1	12.9
432	Feb-11-96	75%	C-705	4b	49	12.8	-6.2	13.6
433	Feb-11-96	75%	C-705	4b	62	13.6	-6.2	13.3
434	Feb-11-96	75%	A-212	2b	49	10.6	-6.5	13.2
435	Feb-11-96	75%	A-212	2b	49	10.6	-6.5	13.2
436	Feb-11-96	75%	A-503	4b	49	10.6	-6.5	13.2
437	Feb-11-96	75%	A-503	4b	49	10.6	-6.5	13.2
438	Feb-11-96	75%	A-212	2b	20	21.6	-6.6	12.2
439	Feb-11-96	75%	A-212	2b	20	21.6	-6.6	12.2
440	Feb-11-96	75%	A-503	4b	20	21.6	-6.6	12.3

NATURAL SNOW TESTS @ DORVAL 1995/96

test no.	date	fld dilution	fluid code	fld type	fail time [min.]	AVG PAN (g/dm^2/hr)	APS Data temp [C]	APS Data wind [kph]
441	Feb-11-96	75%	A-503	4b	20	21.6	-6.6	12.3
442	Feb-11-96	75%	A-501	2b	139	1.4	-4.1	9.1
443	Feb-11-96	75%	A-501	2b	139	1.4	-4.1	9.1
444	Feb-11-96	75%	C-705	4b	106	0.8	-3.8	7.0
445	Feb-11-96	75%	C-705	4b	138	1.4	-4.1	9.1
446	Mar-20-96	50%	A-403	4a	134	1.8	0.3	12.8
447	Mar-20-96	50%	A-403	4a	134	1.8	0.3	12.8
448	Mar-20-96	50%	C-500	4a	142	1.8	0.3	12.6
449	Mar-20-96	50%	C-500	4a	132	1.7	0.3	12.8
450	Mar-20-96	50%	C-505	4a	121	1.6	0.3	12.9
451	Mar-20-96	50%	C-505	4a	119	1.6	0.3	13.0
452	Mar-20-96	75%	A-212	2b	83	2.9	0.1	10.5
453	Mar-20-96	75%	A-212	2b	84	3.0	0.1	10.5
454	Mar-20-96	75%	C-700	4b	95	3.2	0.1	10.6
455	Mar-20-96	75%	C-700	4b	94	3.2	0.1	10.6
456	Mar-20-96	50%	A-511	2a	65	6.4	0.1	10.9
457	Mar-20-96	50%	A-511	2a	66	6.5	0.1	10.9
458	Mar-20-96	50%	C-505	4a	51	6.6	0.1	10.9
459	Mar-20-96	50%	C-505	4a	51	6.6	0.1	10.9
460	Mar-21-96	75%	A-212	2b	104	2.6	0.4	12.6
461	Mar-21-96	75%	A-212	2b	105	2.6	0.4	12.6
462	Mar-21-96	75%	C-705	4b	114	2.5	0.4	12.5
463	Mar-21-96	75%	C-705	4b	113	2.5	0.4	12.5
464	Mar-21-96	75%	A-503	4b	118	2.5	0.4	12.4
465	Mar-21-96	50%	A-511	2a	96	2.7	0.4	12.6
466	Mar-21-96	50%	A-511	2a	96	2.7	0.4	12.6
467	Mar-21-96	50%	C-505	4a	90	2.9	0.4	12.4
468	Mar-21-96	50%	C-505	4a	90	2.9	0.4	12.4

NATURAL SNOW TESTS @ DORVAL 1995/96 (NOT USABLE)

test no.	date	fld dilution	fluid code	fld type	fall time [min.]	AVG PAN	APS data temp [C]	APS data Wind Sp [kph]
3	Nov-27-95	neat	C-106	4	27	21.2	-10	13
4	Nov-27-95	neat	C-106	4	28	21.4	-10	13
7	Nov-27-95	neat	C-106	4	21	27.4	-10	13
8	Nov-27-95	neat	C-106	4	22	27.2	-10	13
13	Nov-27-95	neat	C-106	4	41	19.1	-10	13
14	Nov-27-95	neat	C-106	4	43	19.1	-10	13
17	Nov-27-95	75%	C-706	4b	27	13.7	-9	13
18	Nov-27-95	75%	C-706	4b	25	13.6	-9	13
21	Nov-27-95	75%	C-706	4b	64	8.2	-9	13
22	Nov-27-95	75%	C-706	4b	70	7.9	-9	13
32	Nov-27-95	neat	C-106	4	39	13.5	-8	13
33	Nov-27-95	neat	C-106	4	39	13.6	-8	13
40	Nov-28-95	75%	C-706	4b	29	11.9	-6	10
41	Nov-28-95	75%	C-706	4b	30	11.9	-6	10
46	Nov-28-95	75%	C-706	4b	22	17.6	-6	10
47	Nov-28-95	75%	C-706	4b	20	17.8	-6	10
135	Dec-03-95	75%	C-706	4b	41	4.8	-8	15
136	Dec-03-95	75%	C-706	4b	44	4.8	-8	15
141	Dec-06-95	neat	C-106	4	41	21.7	-1	15
142	Dec-06-95	neat	C-106	4	41	21.7	-1	15
149	Dec-06-95	neat	C-106	4	53	16.2	-1	13
150	Dec-06-95	neat	C-106	4	51	16.5	-1	13
155	Dec-09-95	neat	C-106	4	118	2.3	-11	9
156	Dec-09-95	neat	C-106	4	119	2.3	-11	9
163	Dec-09-95	neat	C-106	4	97	2.0	-12	9
164	Dec-09-95	neat	C-106	4	99	2.1	-12	9
173	Dec-09-95	neat	C-106	4	81	4.1	-7	45
174	Dec-09-95	neat	C-106	4	81	4.1	-7	45
181	Dec-09-95	neat	C-106	4	58	6.7	-8	8
182	Dec-09-95	neat	C-106	4	54	5.0	-8	8
189	Dec-09-95	neat	C-106	4	84	6.0	-4	8
190	Dec-09-95	neat	C-106	4	84	6.0	-4	8
197	Dec-09-95	neat	C-106	4	43	11.0	-5	11
198	Dec-09-95	neat	C-106	4	43	11.0	-5	11
201	Dec-09-95	neat	C-106	4	70	6.8	-5	11
202	Dec-09-95	neat	C-106	4	68	6.9	-5	11
223	Dec-09-95	neat	C-106	4	37	13.5	-3	6
224	Dec-09-95	neat	C-106	4	37	13.5	-3	6
229	Dec-14-95	neat	C-106	4	29	13.3	-15	12
230	Dec-14-95	neat	C-106	4	29	13.3	-15	12
233	Dec-14-95	neat	C-106	4	27	15.3	-15	12
234	Dec-14-95	neat	C-106	4	26	15.2	-15	12
239	Dec-14-95	neat	C-106	4	25	14.1	-14	12
240	Dec-14-95	neat	C-106	4	25	14.1	-14	12
243	Dec-14-95	neat	C-106	4	33	11.6	-14	12
244	Dec-14-95	neat	C-106	4	33	11.6	-14	12
281	Dec-14-95	neat	C-106	4	43	12.1	-9	10
282	Dec-14-95	neat	C-106	4	43	12.1	-9	10
287	Dec-14-95	neat	C-106	4	36	11.6	-9	15
288	Dec-14-95	neat	C-106	4	35	11.6	-9	15
315	Dec-20-95	neat	C-106	4	102	1.6	-12	13
316	Dec-20-95	neat	C-106	4	101	1.4	-12	13
319	Dec-20-95	neat	C-106	4	43	8.6	-12	13
320	Dec-20-95	neat	C-106	4	44	8.6	-12	13
325	Dec-20-95	75%	C-706	4b	83	2.8	-13	13
326	Dec-20-95	75%	C-706	4b	71	3.0	-13	13
333	Dec-21-95	neat	C-106	4	139	3.0	-11	13
334	Dec-21-95	neat	C-106	4	135	2.6	-11	13
341	Dec-21-95	75%	C-706	4b	58	3.9	-12	13

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NATURAL SNOW TESTS @ DORVAL 1995/96 (NOT USABLE)

test no.	date	fld dilution	fluid code	fld type	fall time [min.]	AVG PAN	APS data temp [C]	APS data Wind Sp [kph]
342	Dec-21-95	75%	C-706	4b	57	4.0	-12	13
367	Jan-09-96	50%	C-506	4a	8	2.5	-11	7
368	Jan-09-96	50%	C-506	4a	11	2.5	-11	7
369	Jan-09-96	neat	C-106	4	104	3.3	-12	8
370	Jan-09-96	neat	C-106	4	104	3.3	-12	8
381	Jan-09-96	50%	C-506	4a	17	2.5	-11	7
382	Jan-09-96	50%	C-506	4a	20	2.5	-11	7
389	Jan-09-96	50%	C-506	4a	34	3.8	-11	9
390	Jan-09-96	50%	C-506	4a	35	3.8	-11	9
399	Jan-19-96	75%	C-706	4b	69	9.7	-3	25
400	Jan-19-96	75%	C-706	4b	70	9.6	-3	25
419	Jan-27-96	75%	C-706	4b	54	10.8	-3	6
420	Jan-27-96	75%	C-706	4b	50	13.3	-3	6
425	Jan-27-96	75%	C-706	4b	11	40.6	-2	11
426	Jan-27-96	75%	C-706	4b	19	40.6	-2	11
433	Jan-27-96	50%	C-506	4a	32	9.4	-1	5
438	Jan-27-96	50%	C-506	4a	31	6.2	-3	7
439	Jan-27-96	50%	C-506	4a	32	6.4	-3	7
466	Feb-07-96	75%	C-706	4b	52	7.5	-3	15
467	Feb-07-96	75%	C-706	4b	66	7.5	-3	15
486	Feb-09-96	75%	C-706	4b	150	3.5	1	5
487	Feb-09-96	75%	C-706	4b	150	3.5	1	5
492	Feb-09-96	50%	C-506	4a	136	2.6	1	6
493	Feb-09-96	50%	C-506	4a	136	2.6	1	6
498	Feb-09-96	75%	C-706	4b	81	9.0	1	4
503	Feb-09-96	50%	C-506	4a	19	23.2	1	4
504	Feb-09-96	50%	C-506	4a	19	23.2	1	4
509	Feb-09-96	75%	C-706	4b	168	4.9	1	11
510	Feb-09-96	75%	C-706	4b	168	4.9	1	11
521	Feb-11-96	75%	C-706	4b	36	19.3	-5	12
522	Feb-11-96	75%	C-706	4b	33	19.3	-5	12
527	Feb-11-96	75%	C-706	4b	35	14.7	-5	13
528	Feb-11-96	75%	C-706	4b	36	14.7	-5	13
545	Feb-11-96	75%	C-706	4b	48	10.6	-6	15
546	Feb-11-96	75%	C-706	4b	48	10.6	-6	15
551	Feb-11-96	75%	C-706	4b	21	22.8	-6	15
552	Feb-11-96	75%	C-706	4b	21	22.8	-6	15
565	Mar-20-96	75%	C-706	4b	105	3.7	0	14
566	Mar-20-96	75%	C-706	4b	105	3.7	0	14
573	Mar-20-96	50%	C-506	4a	72	5.0	0	14
574	Mar-20-96	50%	C-506	4a	72	5.0	0	14
584	Mar-21-96	50%	C-506	4a	106	3.2	0	14
585	Mar-21-96	50%	C-506	4a	106	3.2	0	14

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN @ CEF FOR 1995/96

Test Season	test no.	date	fluid code	fld dilution	fld type	fall time [min.]	rate of precep. [g/dm*2/hr]	ambient temp [C]	Precip Type
1996	1	Mar-11-96	C-105	neat	4	237	2.9	-2.2	frz_driz
1996	2	Mar-11-96	C-105	neat	4	206	2.5	-2.2	frz_driz
1996	3	Mar-11-96	A-205	neat	2	61	4.9	-2.2	frz_driz
1996	4	Mar-11-96	A-205	neat	2	46	6.0	-2.2	frz_driz
1996	6	Mar-11-96	C-100	neat	4	82	10.3	-2.2	frz_driz
1996	7	Mar-11-96	C-705	75%	4b	36	10.7	-2.2	frz_driz
1996	8	Mar-11-96	C-705	75%	4b	24	12.4	-2.2	frz_driz
1996	10	Mar-11-96	A-303	neat	4	74	11.6	-2.2	frz_driz
1996	12	Mar-11-96	A-503	75%	4b	73	7.0	-2.2	frz_driz
1996	13	Mar-11-96	C-705	75%	4b	60	5.0	-2.2	frz_driz
1996	14	Mar-11-96	C-705	75%	4b	50	5.8	-2.2	frz_driz
1996	15	Mar-11-96	A-501	75%	2b	43	10.7	-2.2	frz_driz
1996	16	Mar-11-96	A-501	75%	2b	32	11.7	-2.2	frz_driz
1996	17	Mar-11-96	C-505	50%	4a	11	8.1	-2.2	frz_driz
1996	18	Mar-11-96	C-505	50%	4a	10	9.0	-2.2	frz_driz
1996	19	Mar-11-96	C-105	neat	4	90	9.5	-2.2	frz_driz
1996	20	Mar-11-96	C-105	neat	4	57	10.6	-2.2	frz_driz
1996	21	Mar-11-96	A-403	50%	4a	22	9.1	-2.2	frz_driz
1996	22	Mar-11-96	A-403	50%	4a	20	10.3	-2.2	frz_driz
1996	23	Mar-11-96	A-401	50%	2a	28	6.9	-2.2	frz_driz
1996	24	Mar-11-96	A-401	50%	2a	25	6.3	-2.2	frz_driz
1996	25	Mar-12-96	A-101	neat	2	96	4.0	-2.6	frz_driz
1996	26	Mar-12-96	A-101	neat	2	50	6.9	-2.6	frz_driz
1996	28	Mar-12-96	C-705	75%	4b	39	8.4	-2.6	frz_driz
1996	29	Mar-12-96	C-102	neat	4	117	8.8	-2.6	frz_driz
1996	30	Mar-12-96	C-702	75%	4b	95	6.2	-2.6	frz_driz
1996	31	Mar-12-96	A-511	50%	2a	52	4.1	-2.6	frz_driz
1996	32	Mar-12-96	A-511	50%	2a	30	6.9	-2.6	frz_driz
1996	33	Mar-12-96	A-210	50%	2a	40	5.7	-2.6	frz_driz
1996	34	Mar-12-96	A-210	50%	2a	24	11.1	-2.6	frz_driz
1996	35	Mar-12-96	A-510	50%	2a	26	6.2	-2.6	frz_driz
1996	36	Mar-12-96	C-502	50%	4a	65	6.0	-2.6	frz_driz
1996	37	Mar-12-96	A-510	50%	2a	42	5.7	-2.6	frz_driz
1996	38	Mar-12-96	A-510	50%	2a	23	11.2	-2.6	frz_driz
1996	39	Mar-12-96	C-503	50%	4a	81	4.5	-2.6	frz_driz
1996	40	Mar-12-96	C-703	75%	4b	79	9.5	-2.6	frz_driz
1996	41	Mar-12-96	A-101	neat	2	61	4.9	-8.1	frz_driz
1996	42	Mar-12-96	A-101	neat	2	40	9.5	-8.1	frz_driz
1996	43	Mar-12-96	C-105	neat	4	81	11.5	-8.1	frz_driz
1996	44	Mar-13-96	C-105	neat	4	65	14.5	-2.8	frz_rain
1996	45	Mar-13-96	C-105	neat	4	62	17.4	-2.8	frz_rain
1996	46	Mar-13-96	A-205	neat	2	29	17.6	-2.8	frz_rain
1996	47	Mar-13-96	A-205	neat	2	27	21.9	-2.8	frz_rain
1996	48	Mar-13-96	C-100	neat	4	50	19.1	-2.8	frz_rain
1996	49	Mar-13-96	C-100	neat	4	44	24.5	-2.8	frz_rain
1996	50	Mar-13-96	C-705	75%	4b	25	18.7	-2.8	frz_rain
1996	51	Mar-13-96	C-705	75%	4b	20	25.0	-2.8	frz_rain
1996	52	Mar-13-96	A-303	neat	4	55	18.2	-2.8	frz_rain
1996	53	Mar-13-96	A-303	neat	4	41	22.4	-2.8	frz_rain
1996	54	Mar-13-96	A-503	75%	4b	38	16.5	-2.8	frz_rain
1996	55	Mar-13-96	A-503	75%	4b	28	22.6	-2.8	frz_rain
1996	56	Mar-13-96	C-705	75%	4b	27	17.4	-2.8	frz_rain
1996	57	Mar-13-96	C-705	75%	4b	24	21.9	-2.8	frz_rain
1996	58	Mar-13-96	A-501	75%	2b	25	18.7	-2.8	frz_rain
1996	59	Mar-13-96	A-501	75%	2b	21	25.0	-2.8	frz_rain
1996	60	Mar-13-96	A-403	50%	4a	13	16.5	-2.8	frz_rain
1996	61	Mar-13-96	A-403	50%	4a	9	22.6	-2.8	frz_rain
1996	62	Mar-13-96	A-403	50%	4a	18	14.5	-2.8	frz_rain
1996	63	Mar-13-96	A-403	50%	4a	12	17.4	-2.8	frz_rain
1996	64	Mar-13-96	A-511	50%	2a	20	17.6	-2.8	frz_rain
1996	65	Mar-13-96	A-511	50%	2a	17	21.9	-2.8	frz_rain
1996	66	Mar-13-96	C-505	50%	4a	8	19.1	-2.8	frz_rain
1996	67	Mar-13-96	C-505	50%	4a	8	24.5	-2.8	frz_rain
1996	68	Mar-13-96	A-210	50%	2a	18	18.7	-2.8	frz_rain
1996	69	Mar-13-96	A-210	50%	2a	15	25.0	-2.8	frz_rain

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN @ CEF FOR 1995/96

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	rate of precep. [g/dm*2/hr]	ambient temp [C]	Precip Type
1996	70	Mar-13-96	A-510	50%	2a	13	18.2	-2.8	frz_rain
1996	71	Mar-13-96	A-510	50%	2a	12	22.4	-2.8	frz_rain
1996	72	Mar-13-96	A-401	50%	2a	15	16.5	-2.8	frz_rain
1996	73	Mar-13-96	A-401	50%	2a	13	22.6	-2.8	frz_rain
1996	74	Mar-13-96	A-101	neat	2	35	17.1	-2.9	frz_rain
1996	75	Mar-13-96	A-101	neat	2	31	21.7	-2.9	frz_rain
1996	76	Mar-13-96	C-105	neat	4	58	18.6	-2.9	frz_rain
1996	77	Mar-13-96	C-105	neat	4	54	24.3	-2.9	frz_rain
1996	78	Mar-13-96	C-103	neat	4	113	17.9	-2.9	frz_rain
1996	79	Mar-13-96	C-703	75%	4b	53	16.9	-2.9	frz_rain
1996	80	Mar-13-96	C-702	75%	4b	32	22.0	-2.9	frz_rain
1996	81	Mar-13-96	A-511	50%	2a	11	22.0	-2.9	frz_rain
1996	82	Mar-13-96	C-102	neat	4	72	24.1	-2.9	frz_rain
1996	83	Mar-13-96	C-503	50%	4a	13	18.6	-2.9	frz_rain
1996	84	Mar-13-96	C-503	50%	4a	13	24.6	-2.9	frz_rain
1996	85	Mar-13-96	C-502	50%	4a	24	16.9	-2.9	frz_rain
1996	86	Mar-13-96	C-502	50%	4a	19	22.0	-2.9	frz_rain
1996	87	Mar-13-96	C-105	neat	4	74	13.8	-7.7	frz_rain
1996	88	Mar-13-96	C-105	neat	4	68	16.8	-7.7	frz_rain
1996	89	Mar-13-96	A-205	neat	2	30	19.0	-7.7	frz_rain
1996	90	Mar-13-96	A-205	neat	2	29	24.0	-7.7	frz_rain
1996	91	Mar-13-96	C-100	neat	4	46	19.7	-7.7	frz_rain
1996	92	Mar-13-96	C-705	75%	4b	36	18.8	-7.7	frz_rain
1996	93	Mar-13-96	C-705	75%	4b	31	25.0	-7.7	frz_rain
1996	94	Mar-13-96	A-303	neat	4	56	19.0	-7.7	frz_rain
1996	95	Mar-13-96	A-303	neat	4	41	25.0	-7.7	frz_rain
1996	96	Mar-13-96	A-503	75%	4b	20	17.7	-7.7	frz_rain
1996	97	Mar-13-96	A-503	75%	4b	16	22.1	-7.7	frz_rain
1996	98	Mar-13-96	A-501	75%	2b	22	17.7	-7.7	frz_rain
1996	99	Mar-13-96	A-501	75%	2b	19	22.1	-7.7	frz_rain
1996	100	Mar-13-96	C-702	75%	4b	37	18.8	-7.7	frz_rain
1996	101	Mar-13-96	C-702	75%	4b	32	25.0	-7.7	frz_rain
1996	102	Mar-13-96	A-101	neat	2	30	18.9	-7.8	frz_rain
1996	103	Mar-13-96	A-101	neat	2	27	24.1	-7.8	frz_rain
1996	104	Mar-13-96	C-105	neat	4	60	19.5	-7.8	frz_rain
1996	105	Mar-13-96	C-105	neat	4	48	25.7	-7.8	frz_rain
1996	106	Mar-13-96	C-103	neat	4	40	19.3	-7.8	frz_rain
1996	107	Mar-13-96	C-102	neat	4	68	25.0	-7.8	frz_rain
1996	108	Mar-13-96	C-703	75%	4b	36	17.9	-7.8	frz_rain
1996	109	Mar-13-96	C-702	75%	4b	40	22.7	-7.8	frz_rain
1996	110	Mar-14-96	C-705	75%	4b	120	2.7	-8.5	frz_driz
1996	111	Mar-14-96	A-205	neat	2	79	4.6	-8.5	frz_driz
1996	112	Mar-14-96	A-205	neat	2	47	7.9	-8.5	frz_driz
1996	113	Mar-14-96	C-100	neat	4	216	5.3	-8.5	frz_driz
1996	114	Mar-14-96	C-100	neat	4	99	9.6	-8.5	frz_driz
1996	115	Mar-14-96	C-105	neat	4	117	4.4	-8.5	frz_driz
1996	116	Mar-14-96	C-105	neat	4	62	8.4	-8.5	frz_driz
1996	117	Mar-14-96	A-303	neat	4	203	4.4	-8.5	frz_driz
1996	118	Mar-14-96	A-303	neat	4	92	8.7	-8.5	frz_driz
1996	119	Mar-14-96	A-503	75%	4b	78	3.4	-8.5	frz_driz
1996	120	Mar-14-96	A-503	75%	4b	52	6.2	-8.5	frz_driz
1996	121	Mar-14-96	C-703	75%	4b	67	8.4	-8.5	frz_driz
1996	122	Mar-14-96	C-702	75%	4b	101	6.2	-8.5	frz_driz
1996	123	Mar-14-96	A-501	75%	2b	69	4.6	-8.5	frz_driz
1996	124	Mar-14-96	A-501	75%	2b	33	7.9	-8.5	frz_driz
1996	125	Mar-14-96	C-705	75%	4b	46	7.9	-8.5	frz_driz
1996	126	May-10-96	A-303	neat	4	34	22.3	-10.3	frz_rain
1996	127	May-10-96	A-303	neat	4	34	21.8	-10.3	frz_rain
1996	128	May-10-96	A-303	neat	4	42	21.9	-10.3	frz_rain
1996	129	May-10-96	A-303	neat	4	35	22.2	-11.1	frz_rain
1996	130	May-10-96	A-303	neat	4	37	22.0	-11.1	frz_rain
1996	131	May-10-96	A-303	neat	4	36	21.4	-11.1	frz_rain
1996	132	Aug-02-96	C-107	neat	4	68	11.0	-4.8	frz_driz
1996	133	Aug-02-96	C-102	neat	4	122	10.5	-4.7	frz_driz
1996	134	Aug-02-96	B-213	57%	1	11	12.2	-4.9	frz_driz

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN @ CEF FOR 1995/96

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	rate of precep. [g/dm*2/hr]	ambient temp [C]	Precip Type
1996	135	Aug-02-96	C-100	neat	4	70	14.3	-4.8	frz_driz
1996	136	Aug-02-96	C-700	75%	4b	28	13.4	-4.8	frz_driz
1996	137	Aug-02-96	C-500	50%	4a	13	8.8	-4.9	frz_driz
1996	138	Aug-02-96	B-213	57%	1	19	12.2	-4.6	frz_driz
1996	139	Aug-02-96	C-107	neat	4	51	21.7	-4.1	frz_rain
1996	140	Aug-02-96	C-102	neat	4	70	20.6	-3.8	frz_rain
1996	141	Aug-02-96	C-100	neat	4	55	18.8	-4.1	frz_rain
1996	142	Aug-02-96	C-700	75%	4b	17	20.8	-4.6	frz_rain
1996	143	Aug-02-96	C-500	50%	4a	8	21.1	-4.7	frz_rain
1996	144	Aug-02-96	B-213	57%	1	20	21.2	-4.3	frz_rain
1996	145	Sep-06-96	C-100	neat	4	31	22.0	-6.9	frz_rain
1996	146	Sep-06-96	C-107	neat	4	34	23.5	-6.9	frz_rain
1996	147	Sep-06-96	A-205	neat	2	25	23.5	-6.9	frz_rain
1996	148	Sep-06-96	C-100	neat	4	32	21.5	-6.9	frz_rain
1996	149	Sep-06-96	C-107	neat	4	36	24.0	-6.9	frz_rain
1996	150	Sep-06-96	A-205	neat	2	24	26.5	-6.9	frz_rain
1996	151	Sep-06-96	C-100	neat	4	28	25.0	-6.9	frz_rain
1996	152	Sep-06-96	C-107	neat	4	31	26.0	-6.9	frz_rain
1996	153	Sep-06-96	A-205	neat	2	26	26.5	-6.9	frz_rain
1996	154	Sep-06-96	C-100	neat	4	30	22.5	-6.9	frz_rain
1996	155	Sep-06-96	C-107	neat	4	35	26.0	-6.9	frz_rain
1996	157	Sep-06-96	C-100	neat	4	34	21.0	-6.8	frz_rain
1996	158	Sep-06-96	A-205	neat	2	30	19.5	-6.8	frz_rain
1996	159	Sep-06-96	C-100	neat	4	32	21.0	-6.8	frz_rain
1996	160	Sep-06-96	C-100	neat	4	32	24.8	-6.8	frz_rain
1996	161	Sep-06-96	A-205	neat	2	27	23.0	-6.8	frz_rain
1996	162	Sep-09-96	A-205	neat	2	29	19.5	-6.8	frz_rain
1996	163	Sep-09-96	C-100	neat	4	33	20.3	-6.8	frz_rain
1996	164	Sep-09-96	C-107	neat	4	41	20.3	-6.8	frz_rain
1996	165	Sep-09-96	C-100	neat	4	35	19.5	-6.6	frz_rain
1996	166	Sep-09-96	C-107	neat	4	40	20.0	-6.6	frz_rain
1996	167	Sep-09-96	A-205	neat	2	28	21.0	-6.6	frz_rain

SIMULATED FREEZING DRIZZLE AND LIGHT FRZ RAIN @ CEF FOR 1995/96 (NOT USABLE)

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	rate of prec. [g/dm*2/hr]	temp [C]	Precip Type
1996	25	Mar-12-96	C-106	neat	4	147	1.9	-2.6	frz_driz
1996	44	Mar-12-96	C-106	neat	4	86	3.3	-8.1	frz_driz
1996	78	Mar-13-96	C-106	neat	4	59	13.9	-2.9	frz_rain
1996	79	Mar-13-96	C-106	neat	4	57	17.1	-2.9	frz_rain
1996	115	Mar-13-96	C-106	neat	4	52	14.2	-7.8	frz_rain
1996	116	Mar-13-96	C-106	neat	4	44	17.2	-7.8	frz_rain
1996	140	Mar-14-96	C-106	neat	4	74	9.6	-8.5	frz_driz
1996	32	Mar-12-96	C-506	50%	4a	45	5.5	-2.6	frz_driz
1996	33	Mar-12-96	C-506	50%	4a	26	9.3	-2.6	frz_driz
1996	89	Mar-13-96	C-506	50%	4a	18	18.6	-2.9	frz_rain
1996	90	Mar-13-96	C-506	50%	4a	15	24.6	-2.9	frz_rain
1996	87	Mar-13-96	C-706	75%	4b	38	17.1	-2.9	frz_rain
1996	88	Mar-13-96	C-706	75%	4b	35	21.7	-2.9	frz_rain
1996	109	Mar-13-96	C-706	75%	4b	31	19.0	-7.7	frz_rain

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At: Discarded

SIMULATED FREEZING FOG @ CEF FOR 1995/96

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	rate of precep. [g/dm²/hr]	ambient temp [C]	Precip Type
1996	1	Apr-01-96	A-303	neat	4	167	2.1	-23.6	frz_fog
1996	2	Apr-01-96	C-105	neat	4	131	2.3	-23.6	frz_fog
1996	3	Apr-01-96	C-105	neat	4	117	3.9	-23.6	frz_fog
1996	4	Apr-01-96	C-100	neat	4	165	2.6	-23.6	frz_fog
1996	5	Apr-01-96	C-100	neat	4	154	3.9	-23.6	frz_fog
1996	6	Apr-01-96	C-103	neat	4	134	4.1	-23.6	frz_fog
1996	7	Apr-01-96	A-201	neat	2	20	3.6	-23.6	frz_fog
1996	8	Apr-01-96	B-213	57%	1	12	2.9	-26.0	frz_fog
1996	9	Apr-01-96	B-213	57%	1	12	4.3	-26.0	frz_fog
1996	10	Apr-01-96	B-253	54%	1a	8	4.0	-26.0	frz_fog
1996	11	Apr-01-96	B-253	54%	1a	8	5.8	-26.0	frz_fog
1996	12	Apr-01-96	B-216	68%	1	15	5.4	-26.0	frz_fog
1996	13	Apr-01-96	B-216	68%	1	14	8.4	-26.0	frz_fog
1996	14	Apr-01-96	B-256	66%	1a	8	6.3	-26.0	frz_fog
1996	15	Apr-01-96	B-256	66%	1a	9	9.7	-26.0	frz_fog
1996	16	Apr-01-96	B-222	71%	1	9	7.3	-26.0	frz_fog
1996	17	Apr-01-96	B-254	68%	1a	9	8.0	-26.0	frz_fog
1996	18	Apr-01-96	B-213	57%	1	10	5.4	-25.9	frz_fog
1996	19	Apr-01-96	B-253	54%	1a	9	6.1	-25.9	frz_fog
1996	20	Apr-01-96	B-253	54%	1a	9	9.9	-25.9	frz_fog
1996	21	Apr-01-96	B-221	61%	1	10	7.0	-25.9	frz_fog
1996	22	Apr-01-96	B-251	59%	1a	9	7.6	-25.9	frz_fog
1996	23	Apr-02-96	A-503	75%	4b	196	0.9	-12.9	frz_fog
1996	24	Apr-02-96	A-503	75%	4b	210	1.6	-12.9	frz_fog
1996	25	Apr-02-96	C-705	75%	4b	203	1.4	-12.9	frz_fog
1996	26	Apr-02-96	C-700	75%	4b	187	1.5	-12.9	frz_fog
1996	27	Apr-02-96	C-700	75%	4b	250	1.4	-12.9	frz_fog
1996	28	Apr-02-96	C-703	75%	4b	175	1.9	-12.9	frz_fog
1996	29	Apr-02-96	C-702	75%	4b	131	2.9	-12.9	frz_fog
1996	30	Apr-02-96	A-501	75%	2b	70	2.3	-12.9	frz_fog
1996	31	Apr-02-96	A-501	75%	2b	63	3.4	-12.9	frz_fog
1996	32	Apr-02-96	A-303	neat	4	210	4.6	-12.9	frz_fog
1996	33	Apr-02-96	A-303	neat	4	165	4.4	-12.9	frz_fog
1996	34	Apr-02-96	C-105	neat	4	241	3.2	-12.9	frz_fog
1996	35	Apr-02-96	C-100	neat	4	223	3.8	-12.9	frz_fog
1996	36	Apr-02-96	C-100	neat	4	160	5.2	-12.9	frz_fog
1996	37	Apr-02-96	C-103	neat	4	267	3.5	-12.9	frz_fog
1996	38	Apr-02-96	C-102	neat	4	154	6.3	-12.9	frz_fog
1996	39	Apr-02-96	A-201	neat	2	40	4.4	-12.9	frz_fog
1996	40	Apr-02-96	A-201	neat	2	35	7.7	-12.9	frz_fog
1996	41	Apr-02-96	A-503	75%	4b	144	3.6	-12.9	frz_fog
1996	42	Apr-02-96	A-503	75%	4b	56	6.6	-12.9	frz_fog
1996	43	Apr-02-96	C-705	75%	4b	108	2.6	-12.9	frz_fog
1996	44	Apr-03-96	A-303	neat	4	170	7.1	-2.7	frz_fog
1996	45	Apr-03-96	A-303	neat	4	182	4.1	-2.7	frz_fog
1996	46	Apr-03-96	A-303	neat	4	162	5.5	-2.7	frz_fog
1996	47	Apr-03-96	C-105	neat	4	139	4.0	-2.7	frz_fog
1996	48	Apr-03-96	C-105	neat	4	119	5.8	-2.7	frz_fog
1996	49	Apr-03-96	C-103	neat	4	202	5.6	-2.7	frz_fog
1996	50	Apr-03-96	C-102	neat	4	169	8.2	-2.7	frz_fog
1996	51	Apr-03-96	A-201	neat	2	97	3.3	-2.7	frz_fog
1996	52	Apr-03-96	A-201	neat	2	79	5.0	-2.7	frz_fog
1996	53	Apr-03-96	A-503	75%	4b	101	4.0	-2.8	frz_fog
1996	54	Apr-03-96	C-705	75%	4b	86	3.2	-2.8	frz_fog
1996	55	Apr-03-96	C-705	75%	4b	48	6.8	-2.8	frz_fog
1996	56	Apr-03-96	C-703	75%	4b	122	3.4	-2.8	frz_fog
1996	57	Apr-03-96	C-702	75%	4b	127	4.6	-2.8	frz_fog

SIMULATED FREEZING FOG @ CEF FOR 1995/96

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	rate of precep. [g/dm²/hr]	ambient temp [C]	Precip Type
1996	58	Apr-03-96	A-501	75%	2b	65	2.8	-2.8	frz_fog
1996	59	Apr-03-96	A-501	75%	2b	52	4.2	-2.8	frz_fog
1996	60	Apr-03-96	A-503	75%	4b	87	2.9	-2.8	frz_fog
1996	61	Apr-03-96	A-403	50%	4a	27	3.2	-2.6	frz_fog
1996	62	Apr-03-96	C-505	50%	4a	27	2.8	-2.6	frz_fog
1996	63	Apr-03-96	C-505	50%	4a	20	7.3	-2.6	frz_fog
1996	64	Apr-03-96	C-503	50%	4a	75	3.3	-2.6	frz_fog
1996	65	Apr-03-96	C-502	50%	4a	103	5.3	-2.6	frz_fog
1996	66	Apr-03-96	A-401	50%	2a	45	2.9	-2.6	frz_fog
1996	67	Apr-03-96	A-401	50%	2a	37	4.4	-2.6	frz_fog
1996	68	Apr-03-96	A-403	50%	4a	18	3.0	-2.6	frz_fog
1996	69	Jul-31-96	C-507	50%	4a	22	4.2	-3.4	frz_fog
1996	70	Jul-31-96	A-403	50%	4a	10	3.6	-3.5	frz_fog
1996	71	Jul-31-96	C-505	50%	4a	11	3.6	-3.5	frz_fog
1996	72	Jul-31-96	C-500	50%	4a	13	6.4	-3.5	frz_fog
1996	73	Jul-31-96	C-500	50%	4a	15	4.9	-3.0	frz_fog
1996	74	Jul-31-96	A-403	50%	4a	11	6.0	-3.0	frz_fog
1996	75	Jul-31-96	C-500	50%	4a	12	7.4	-3.0	frz_fog
1996	76	Aug-01-96	C-107	neat	4	62	2.7	-24.2	frz_fog
1996	77	Aug-01-96	C-100	neat	4	152	3.0	-24.2	frz_fog
1996	78	Aug-01-96	A-303	neat	4	112	3.0	-24.2	frz_fog
1996	79	Aug-01-96	C-105	neat	4	55	3.4	-24.1	frz_fog
1996	80	Aug-01-96	B-213	57%	1	20	3.6	-23.9	frz_fog
1996	81	Aug-01-96	B-213	57%	1	10	3.4	-24.3	frz_fog
1996	82	Aug-01-96	A-205	neat	2	32	3.6	-24.4	frz_fog

SIMULATED FREEZING FOG @ CEF FOR 1995/96 (NOT USABLE)

Test Season	test no.	date	fluid code	fld dilution	fld type	fail time [min.]	Rate rate of prec. [g/dm^2/hr]	temp [C]
1996	6	Apr-01-96	C-106	neat	4	129	frz_fog	-26
1996	7	Apr-01-96	C-106	neat	4	114	frz_fog	-26
1996	41	Apr-01-96	C-106	neat	4	20	frz_fog	-26
1996	42	Apr-01-96	C-106	neat	4	21	frz_fog	-26
1996	62	Apr-02-96	C-106	neat	4	133	frz_fog	-13
1996	63	Apr-02-96	C-106	neat	4	79	frz_fog	-13
1996	76	Apr-03-96	C-106	neat	4	146	frz_fog	-3
1996	77	Apr-03-96	C-106	neat	4	129	frz_fog	-3
1996	95	Apr-03-96	C-506	50%	4a	69	frz_fog	-3
1996	96	Apr-03-96	C-506	50%	4a	63	frz_fog	-3
1996	50	Apr-02-96	C-706	75%	4b	175	frz_fog	-3
1996	51	Apr-02-96	C-706	75%	4b	188	frz_fog	-3
1996	85	Apr-03-96	C-706	75%	4b	104	frz_fog	-3
1996	86	Apr-03-96	C-706	75%	4b	87	frz_fog	-3

COLD SOAK DATA @ CEF FOR 1995/96 TEST SEASON

report published (year)	test no.	date	fluid code	fld dil	fld type	Box Size (cm)	BOX fail time [min.]	Avg Rate of pans (Shield) [g/dm^2/hr]	Precip. Type	average skin temp [C]	ambient temp [C]
1996	1	Aug-06-96	C-100	100%	4	2.5	91	9.7	drizzle	-5.3	2.7
1996	2	Aug-06-96	C-100	100%	4	7.5	76	9.9	drizzle	-6.3	2.3
1996	3	Aug-06-96	C-102	100%	4	7.5	126	12.1	drizzle	-5.5	2.7
1996	4	Aug-06-96	C-107	100%	4	7.5	64	10.6	drizzle	-6.5	2.3
1996	5	Aug-06-96	C-700	75%	4b	7.5	27	9.8	drizzle	-8.8	4.4
1996	6	Aug-06-96	C-707	75%	4b	7.5	32	10.8	drizzle	-8.3	4.4
1996	7	Aug-06-96	C-702	75%	4b	7.5	56	9.1	drizzle	-7.5	4.9
1996	8	Aug-07-96	C-107	100%	4	2.5	61	9.2	drizzle	-7.0	1.0
1996	9	Aug-07-96	C-107	100%	4	2.5	64	9.4	drizzle	-6.0	1.0
1996	10	Aug-07-96	C-102	100%	4	7.5	193	4.2	drizzle	-8.0	1.0
1996	13	Aug-07-96	A-205	100%	2	2.5	63	5.4	drizzle	-6.3	1.3
1996	14	Aug-07-96	A-201	100%	2	2.5	33	10.8	drizzle	-7.8	1.3
1996	15	Aug-07-96	A-205	100%	2	2.5	49	9.3	drizzle	-7.0	1.3
1996	16	Aug-07-96	A-201	100%	2	7.5	54	2.5	drizzle	-8.5	1.3
1996	18	Aug-07-96	A-201	100%	2	7.5	25	9.8	drizzle	-8.0	1.3
1996	19	Aug-07-96	C-702	75%	4b	2.5	78	9.2	drizzle	-7.0	1.1
1996	20	Aug-07-96	C-707	75%	4b	2.5	39	9.4	drizzle	-7.0	1.0
1996	23	Aug-07-96	C-100	100%	4	7.5	44	10.9	drizzle	-9.0	1.0
1996	24	Aug-07-96	A-205	100%	2	7.5	30	9.3	drizzle	-9.3	1.3
1996	25	Aug-07-96	A-212	75%	2b	2.5	51	5.4	drizzle	-6.3	1.3
1996	26	Aug-07-96	A-501	75%	2b	2.5	31	10.8	drizzle	-8.0	1.4
1996	27	Aug-07-96	A-212	75%	2b	2.5	35	9.3	drizzle	-7.0	1.4
1996	28	Aug-07-96	A-501	75%	2b	7.5	53	2.5	drizzle	-8.0	1.3
1996	29	Aug-07-96	A-212	75%	2b	7.5	25	9.3	drizzle	-8.0	1.3
1996	31	Aug-07-96	B-213	57%	1	2.5	9	5.4	drizzle	-8.5	1.7
1996	32	Aug-07-96	B-214	71%	1	2.5	8	10.8	drizzle	-7.5	1.7
1996	33	Aug-07-96	B-213	57%	1	2.5	7	9.3	drizzle	-8.8	1.1
1996	34	Aug-07-96	B-213	57%	1	7.5	5	9.3	drizzle	-8.3	1.1
1996	35	Aug-07-96	B-214	71%	1	7.5	7	9.8	drizzle	-8.8	1.2
1996	36	Aug-07-96	B-213	57%	1	2.5	7	10.8	drizzle	-4.8	1.2
1996	37	Aug-07-96	B-213	57%	1	7.5	6	9.8	drizzle	-4.8	1.8
1996	38	Aug-07-96	B-253	21%	1a	2.5	5	5.4	drizzle	-8.0	1.6
1996	39	Aug-07-96	B-254	27%	1a	2.5	3	10.8	drizzle	-6.0	1.6
1996	40	Aug-07-96	B-253	21%	1a	2.5	3	9.3	drizzle	-8.0	1.7
1996	42	Aug-07-96	B-253	21%	1a	7.5	3	9.3	drizzle	-8.0	1.7
1996	43	Aug-07-96	B-254	27%	1a	7.5	3	9.8	drizzle	-8.5	1.6
1996	44	Aug-07-96	B-253	21%	1a	2.5	6	10.8	drizzle	-3.5	1.7
1996	45	Aug-07-96	B-254	27%	1a	7.5	4	9.8	drizzle	-4.5	1.6
1996	46	Aug-08-96	C-100	100%	4	2.5	42	19.7	light rain	-6.5	1.4
1996	47	Aug-08-96	C-107	100%	4	2.5	38	20.5	light rain	-7.0	1.5
1996	48	Aug-08-96	C-102	100%	4	2.5	80	19.7	light rain	-4.5	1.4
1996	49	Aug-08-96	C-107	100%	4	2.5	39	19.5	light rain	-6.5	1.5
1996	50	Aug-08-96	C-100	100%	4	7.5	38	21.4	light rain	-9.0	1.5
1996	52	Aug-08-96	C-102	100%	4	7.5	32	23.6	light rain	-9.0	1.4
1996	54	Aug-08-96	C-107	100%	4	7.5	26	21.4	light rain	-7.0	1.5
1996	55	Aug-08-96	C-100	100%	4	7.5	37	23.1	light rain	-8.5	1.4
1996	57	Aug-08-96	C-700	75%	4b	2.5	21	19.7	light rain	-7.5	1.4
1996	58	Aug-08-96	C-707	75%	4b	2.5	26	20.5	light rain	-7.0	1.5
1996	60	Aug-08-96	C-707	75%	4b	2.5	28	19.5	light rain	-7.0	1.5
1996	61	Aug-08-96	C-707	75%	4b	7.5	16	21.4	light rain	-8.5	1.5
1996	62	Aug-08-96	C-700	75%	4b	7.5	16	23.1	light rain	-7.0	1.5
1996	64	Aug-08-96	C-700	75%	4b	7.5	16	22.9	light rain	-8.5	1.4
1996	65	Aug-08-96	A-205	100%	2	2.5	31	19.7	light rain	-7.0	1.5
1996	66	Aug-08-96	A-201	100%	2	2.5	17	20.5	light rain	-7.5	1.5
1996	67	Aug-08-96	A-212	75%	2b	2.5	21	19.7	light rain	-8.0	1.5
1996	68	Aug-08-96	A-501	75%	2b	2.5	18	19.5	light rain	-7.5	1.5
1996	69	Aug-08-96	A-201	100%	2	7.5	19	21.4	light rain	-6.5	1.5
1996	70	Aug-08-96	A-205	100%	2	7.5	21	23.1	light rain	-8.0	1.5
1996	72	Aug-08-96	A-501	75%	2b	7.5	14	22.9	light rain	-8.5	1.5
1996	73	Aug-08-96	B-213	57%	1	2.5	4	19.7	light rain	-8.0	1.6
1996	74	Aug-08-96	B-221	63%	1	2.5	5	20.6	light rain	-7.5	1.6
1996	75	Aug-08-96	B-253	21%	1a	2.5	3	22.2	light rain	-6.5	1.6
1996	76	Aug-08-96	B-251	25%	1a	2.5	3	19.5	light rain	-7.0	1.6
1996	77	Aug-08-96	B-221	63%	1	7.5	4	21.4	light rain	-8.5	1.8
1996	78	Aug-08-96	B-213	57%	1	7.5	4	23.1	light rain	-8.5	1.8
1996	79	Aug-08-96	B-251	25%	1a	7.5	3	23.6	light rain	-6.0	1.8

COLD SOAK DATA @ CEF FOR 1995/96 TEST SEASON

report published (year)	test no.	date	fluid code	fld dil	fld type	Box Size (cm)	BOX fail time [min.]	Avg Rate of pans (Shield) [g/dm²/hr]	Precip. Type	average skin temp [C]	ambient temp [C]
1996	80	Aug-08-96	B-253	21%	1a	7.5	2	22.9	light rain	-6.5	1.7
1996	81	Aug-08-96	B-213	57%	1	2.5	7	20.5	light rain	-2.5	1.6
1996	82	Aug-08-96	B-213	57%	1	7.5	4	23.1	light rain	-3.0	1.6
1996	83	Aug-08-96	B-253	21%	1a	2.5	3	22.8	light rain	-3.5	1.7
1996	84	Aug-08-96	B-253	21%	1a	7.5	2	26.5	light rain	-3.0	1.7
1996	85	Aug-08-96	C-100	100%	4	2.5	18	65.1	mod. rain	-9.3	1.7
1996	86	Aug-08-96	C-107	100%	4	2.5	15	67.4	mod. rain	-9.5	2.2
1996	87	Aug-08-96	C-102	100%	4	2.5	10	67.4	mod. rain	-7.5	2.4
1996	88	Aug-08-96	C-107	100%	4	2.5	11	63.4	mod. rain	-8.0	2.4
1996	90	Aug-08-96	C-107	100%	4	7.5	6	66.8	mod. rain	-9.5	2.2
1996	91	Aug-08-96	C-102	100%	4	7.5	7	66.8	mod. rain	-9.5	2.3
1996	92	Aug-08-96	C-107	100%	4	7.5	8	66.3	mod. rain	-9.5	2.3
1996	93	Aug-08-96	C-700	75%	4b	2.5	10	65.1	mod. rain	-8.5	2.5
1996	94	Aug-08-96	C-707	75%	4b	2.5	7	67.4	mod. rain	-8.0	2.5
1996	95	Aug-08-96	C-702	75%	4b	2.5	7	63.4	mod. rain	-8.0	2.5
1996	96	Aug-08-96	C-700	75%	4b	2.5	11	57.1	mod. rain	-8.5	2.6
1996	98	Aug-08-96	C-707	75%	4b	7.5	9	66.8	mod. rain	-9.0	2.4
1996	99	Aug-08-96	C-702	75%	4b	7.5	5	66.3	mod. rain	-9.5	2.4
1996	100	Aug-08-96	C-707	75%	4b	7.5	7	66.8	mod. rain	-8.5	2.4
1996	101	Aug-09-96	A-205	100%	2	2.5	8	57.0	mod. rain	-8.5	1.4
1996	102	Aug-09-96	A-201	100%	2	2.5	5	60.3	mod. rain	-9.0	1.5
1996	103	Aug-09-96	A-212	75%	2b	2.5	8	58.0	mod. rain	-8.0	1.4
1996	104	Aug-09-96	A-501	75%	2b	2.5	7	50.3	mod. rain	-8.5	1.4
1996	106	Aug-09-96	A-201	100%	2	7.5	7	69.1	mod. rain	-9.0	1.5
1996	107	Aug-09-96	A-212	75%	2b	7.5	6	60.8	mod. rain	-9.5	1.5
1996	108	Aug-09-96	A-501	75%	2b	7.5	5	68.0	mod. rain	-9.5	1.5
1996	109	Aug-09-96	B-213	57%	1	2.5	3	57.0	mod. rain	-8.5	1.4
1996	110	Aug-09-96	B-221	63%	1	2.5	3	60.3	mod. rain	-8.5	1.6
1996	111	Aug-09-96	B-253	21%	1a	2.5	2	58.0	mod. rain	-7.5	1.5
1996	112	Aug-09-96	B-251	25%	1a	2.5	2	50.3	mod. rain	-7.0	1.5
1996	113	Aug-09-96	B-221	63%	1	7.5	2	69.1	mod. rain	-7.0	1.5
1996	114	Aug-09-96	B-213	57%	1	7.5	2	64.6	mod. rain	-6.5	1.5
1996	115	Aug-09-96	B-251	25%	1a	7.5	2	68.0	mod. rain	-6.5	1.5
1996	116	Aug-09-96	B-253	21%	1a	7.5	2	64.6	mod. rain	-6.5	1.3
1996	117	Aug-09-96	B-213	57%	1	2.5	3	57.0	mod. rain	-4.0	1.5
1996	118	Aug-09-96	B-253	21%	1a	2.5	1	60.3	mod. rain	-4.0	1.5
1996	119	Aug-09-96	B-213	57%	1	7.5	3	69.1	mod. rain	-4.0	1.5
1996	120	Aug-09-96	B-253	21%	1a	7.5	2	69.1	mod. rain	-4.0	1.4
1996	121	Aug-09-96	C-100	100%	4	2.5	9	121.0	heavy rain	-7.0	2.2
1996	122	Aug-09-96	C-700	75%	4b	2.5	5	135.3	heavy rain	-7.0	2.2
1996	123	Aug-09-96	A-205	100%	2	2.5	5	128.5	heavy rain	-8.0	2.2
1996	124	Aug-09-96	A-212	75%	2b	2.5	3	124.4	heavy rain	-6.5	2.2
1996	125	Aug-09-96	C-100	100%	4	7.5	9	121.0	heavy rain	-9.5	2.5
1996	127	Aug-09-96	A-205	100%	2	7.5	3	128.5	heavy rain	-9.5	2.4
1996	128	Aug-09-96	A-212	75%	2b	7.5	4	124.4	heavy rain	-6.5	2.7
1996	129	Aug-09-96	B-213	57%	1	2.5	2	153.3	heavy rain	-6.5	2.2
1996	130	Aug-09-96	B-253	21%	1a	2.5	1	128.5	heavy rain	-5.0	2.3
1996	131	Aug-09-96	B-213	57%	1	7.5	2	128.5	heavy rain	-5.5	2.5
1996	132	Aug-09-96	B-253	21%	1a	7.5	1	135.3	heavy rain	-5.0	2.5

APPENDIX K

SEGMENTING OF HOLDOVER TIME RANGES

ACAC NO. 0092

ACAC No. / Nº de CITA	0092
Date	1995 12 08

Air Carrier Branch | Direction des transporteurs aériens

AIR CARRIER ADVISORY CIRCULAR
CIRCULAIRE D'INFORMATION AUX TRANSPORTEURS AERIENS

SEGMENTING OF HOLDOVER TIME RANGES

PURPOSE

This Air Carrier Advisory Circular (ACAC) is intended to provide guidance to air carriers regarding the technique of dividing published holdover time ranges into *segments* depending on the intensity of prevailing weather conditions.

REFERENCE

Refer to ACAC 0088 dated July 10, 1995 for the latest holdover timetables issued by Transport Canada Aviation (TCA).

BACKGROUND

Existing holdover timetables contain guidelines on the holdover times anticipated for various freezing point depressant (FPD) fluids as a function of weather conditions. Holdover times are expressed as a range. However, if air carriers are employing these charts in the take-off decision-making process, only the shortest (shaded) times may be used. In-ground icing conditions, take-off after the shortest holdover time has expired must be preceded by a pre take-off contamination inspection in order to ensure that the de-icing/anti-icing fluid has remained effective in preventing contamination from adhering to critical surfaces.

SEGMENTING PROCEDURE

It has been determined that holdover time ranges for snowfall may be further divided into segments depending on weather conditions, thus effectively increasing the time available before a pre take-off contamination inspection is required. An example of the procedure used in segmenting the snow column for Type II anti-icing fluid is shown below.

- For a temperature range of 0 to -7°C, 100% Type II anti-icing fluid holdover time in snowfall is :20 to :45 minutes (a 25 minute range).

- Divide the range approximately into thirds, rounding down to the nearest whole number. In this example, 25 ÷ 3 = 8.33, rounded down to 8.

- Start with the low end of the holdover time range (:20) and add 8 minutes. Thus the holdover time in **heavy** snow becomes **:20 - :28**.

- Add 8 to the previously calculated 28 minutes, giving a holdover time in **moderate** snow of **:28 - :36**.

- Because the original range was not evenly divisible by 3, the final range will be 9 minutes. Therefore the holdover time in **light** snow (or very light snow) becomes **:36 - :45**. The segmented holdover times for this example are shown in tabular format below.

100% Type II Fluid, OAT 0 to -7°C

Heavy Snow	Moderate Snow	Light Snow
:20 - :28	:28 - :36	:36 - :45

Note that only the lowest (shaded) time in each range may be used as take-off decision criteria, in accordance with a Ground Icing Operations Program accepted by TCA. Alternatively, air carriers may choose to publish only the decision times (ie. :20,:28,:36) in their holdover timetables, rather than the ranges shown above. Examples of segmented holdover times from the Type I and Ultra tables are shown below.

Type I Fluid, OAT 0 to -7°C

Heavy Snow	Moderate Snow	Light Snow
:06 - :09	:09 - :12	:12 - :15

100% Ultra Fluid, OAT 0 to -7°C

Heavy Snow	Moderate Snow	Light Snow
:30 - :42	:42 - :54	:54 - 1:07

OTHER CONSIDERATIONS

Holdover timetables form part of a Ground Icing Operations Program and must be submitted to TCA for review. Air carriers are free to develop holdover timetables customized to their operation provided that the presentation is clear, caution notes are retained and holdover times are not less conservative than TCA-approved tables. If segmenting is used, holdover times must be pre-calculated before publishing.

At the present time, segmenting will not apply to the operation of turbo-jet aircraft without leading edge devices, such as the F-28 and CL65.

Segmenting applies only to the holdover timetable snow column. Snow pellets or snow grains, alone or mixed with another type of precipitation, must be considered as heavy precipitation due to their high moisture content.

Hourly and special weather reports should be used as a guide in determining snow intensity and holdover time. However, the pilot-in-command has the authority to determine the actual intensity based on conditions as viewed from the flight deck. As a general rule, visibility during a heavy snowfall would be less than 1/2 mile, moderate snowfall visibility would be between 1/2 and 1 mile, and light snowfall visibility would be greater than 1 mile. Note that decision criteria holdover times once established for a specific condition may be reduced but never increased, except if the snowfall ceases.

Training on segmenting techniques and limitations shall be included in an air carrier's Surface Contamination Training Program approved by TCA.

CONCLUSION

This ACAC contains an explanation of procedures and limitations concerning the holdover time snow column segmenting technique. The use of the segmenting technique is optional, therefore individual air carriers may decide whether or not the potential benefits warrant the effort required to put the system and procedures into place.

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