

AEROSPACE INFORMATION REPORT

SAE AIR1335

REV.
A

Issued 1975-01
Revised 2000-03

Ramp De-Icing

FOREWORD

Changes in this revision are format/editorial only.

TABLE OF CONTENTS

INTRODUCTION	2
1. SCOPE	4
2. REFERENCES	4
3. DE-ICING WEATHER.....	4
3.1 Season and Temperature	4
3.2 Heat	4
4. SURFACE DE-ICING FLUID	5
5. RAMP DE-ICING	5
6. THE FUTURE OF DE-ICING.....	6
7. WHY DE-ICING?	8
7.1 De-Icing	8
7.2 Why De-Ice?	8
7.3 Ice-Accretion	8
7.4 Icing Conditions for Jets	10
8. IMPROPER DE-ICING	10
8.1 "Aileron and Rudder Nibble vs Vibration Enroute" - An Actual Occurrence.....	10
8.2 Reaction.....	11
APPENDIX A	12

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright 2000 Society of Automotive Engineers, Inc.

All rights reserved.

TO PLACE A DOCUMENT ORDER: (724) 776-4970
SAE WEB ADDRESS: <http://www.sae.org>

FAX: (724) 776-0790

Printed in U.S.A.

**SAE values your input. To provide feedback
on this Technical Report, please visit
<http://www.sae.org/technical/standards/AIR1335A>**

SAE AIR1335 Revision A

INTRODUCTION

A. REPORT ON DE-ICING

This brief report attempts to summarize many different factors and it should be noted that the figures are not exact and should only be taken as "rule of thumb" figures; there are many, many exceptions to them. De-icing is a long way from an exact science and is actually a very rough science, with very little having been written about it. Much of the following information has been received from Air Canada and we wish to give credit and thanks to Air Canada for their help. De-icing probably affects Air Canada more than any other airline in the western world, consequently, they are probably more concerned with the problem than other airlines. In recent years, however there has been an increasing awareness by all airlines flying in the northern hemisphere and, consequently, the management of all of these airlines are much more concerned with the possibility of delays, particularly with the increased travel and increased size of the aircraft.

B. BRIEF HISTORY OF RAMP DE-ICING

As recently as 1957, the only type of de-icing or snow removal equipment available to many airlines was manual or if a hangar was available, then the aircraft could be moved into the hangar, and the snow or ice washed off with water from the fire hydrant. A manual method of removing snow was either by the use of brooms, which were very dangerous both to personnel and to aircraft, or by tying knots in a rope with rags in the knots. The rope would then be thrown over the wing and one man on either end would pull the rope back-and-forth, in this way loosening up the snow and ice and partially cleaning the wings. It was fairly common in the 1950's to have a plane towed to a hangar and have the snow washed off with a fire hydrant hose and then someone on a stepladder with a bucket of glycol would spray on a protective coating. This procedure was improved by having a small, air-cooled engine driving a pump and a tank of glycol, all supported by a forklift and the operator could be maneuvered around the aircraft. There were many other such methods, even a simple platform, for the operator to stand on, mounted on a truck.

During the 1950's, Canada's role in North American defense was one of having fighter aircraft at various bases across the northern part of North America. These fighters were to become airborne in the event of an attack by a foreign power. The threat was ever present of catching the fighter aircraft with snow on the wings and snow on the runway, preventing the aircraft from interrupting the possible attack. This situation caused activity to obtain equipment to not only wash the snow and ice off of the wings of the aircraft quickly but also to clean the runways quickly. Possibly the fore-runner of sophisticated de-icers was developed for the Canadian Air Force in the mid-1950's in the form of a small, three-wheeled vehicle with a single boom which would not only elevate but also traverse between the wheels and having a tank which was heated electrically and a pump to dispense the heated fluid. At the same time, the U. S. Air Force had a requirement for a decontaminating vehicle which could spray hot, decontaminating fluid on a bomber in the event of its returning from a nuclear bombing raid and having been subjected to nuclear fallout. A large number of these vehicles were built, however, the device turned out to have all of the basic ingredients of a sophisticated de-icer, insofar as it had tanks, pumps, closed flame heaters and the aerial apparatus. These machines were too costly for the commercial airlines and it was only Air Canada that bought any, the cost justified by using them for flight maintenance as well as de-icing. Equipment needs changed and, with the size of aircraft increased, this small, three-wheel machine was too small, too slow and provided insufficient heat for a busy station.

SAE AIR1335 Revision A

Because of the inadequacies of the small de-icer, the next generation device was a truck-mounted unit which, of course, had much higher ground speeds, larger tanks, larger pumps and closed flame heaters similar to those used by the U. S. Air Force. In all of the de-icers mentioned to this point, 10 gallons per minute from a nozzle was considered a fairly large flow. In the early 1960's, a three wheel vehicle type de-icer was developed in the United States which had much larger tanks, larger pumps and an open flame gas fired heater. This unit was produced in quantity and was quite satisfactory except for its ground speed. In the mid-1960's, the quantity of glycol sprayed from the nozzle increased dramatically and it was proven that the larger gallonages from the single nozzle transmitted more BTU's to the wings, more efficient in heat transfer and in time to de-ice an aircraft. The increased use of glycol was accepted. In the meantime, Air Canada was experiencing higher costs than any other airline because of many more days of de-icing weather and because of the increase in the size of planes and in the frequency of flights. A third generation of aircraft de-icers was ordered, which, of course, had larger tanks, larger pumps, higher pumping pressures, higher aerial devices and closed flame heaters.

In early 1968 the Air Transport Association's committee on de-icing and aircraft servicing drew up specifications for a fourth generation of de-icers which came into being with the introduction of the 747. The fourth generation was very much larger and truck mounted, with a minimum 1500 gallon tank size and the ability of "instant heat". This would give them the ability to take the fluid from a partly heated tank and discharge it at the maximum temperature directly on to the aircraft. Any type of de-icer with a hot tank and a pump and some sort of aerial device could de-ice the first plane but when additional de-icing was necessary and the vehicle had to be refilled with cold glycol, a large amount of heat was needed in order to heat fluid to get back to work quickly without having to sit back in a corner and heat up. This also brought in the importance of a closed flame heater.

This fourth generation of de-icer is now widely used and is most effective on the large jets as well as the large number of smaller jets.

The four generations of de-icers are roughly as follows:

First - Small three-wheeled self-propelled electrical heaters.

Second - Larger three-wheeled self-propelled open flame gasoline fired heaters, larger pumps.

Third - Truck mounted, medium sized tanks, both open and closed flame gasoline fired heaters, larger pumps.

Fourth - Large truck mounted, large tanks, large closed flame gasoline fired heaters with instant heat, large pump.

SAE AIR1335 Revision A

1. SCOPE:

The specific purpose of this AIR is to provide general background information to better acquaint those who are involved with ramp de-icing of aircraft.

Because the wide variance of atmospheric conditions at different airports, as well as at any individual airport, the figures given are of a general nature only and are to be taken as a very rough guide to the various factors concerned with ramp de-icing.

2. REFERENCES:

AIRCRAFT ICING, FLIGHT OPERATIONS, VOL. LVIII, Dec. 1963

DOT Amendment No. 9 to CIR-3450, OBS-300, 1 July 1961, MANOBS, fifth edition.

P-52, 53, Our American Weather, Geo. H. T. Kimble, McGraw-Hill Book Company, Inc., New York, 1955.

3. DE-ICING WEATHER:

3.1 Season and Temperature:

Generally, the airlines expect the de-icing season to start October 15 and go through to April 15. These dates, of course, have to be modified depending upon the part of the country, as early frosts are quite common as early as September 15 and late snowfalls occur in certain areas as early as September 15 and as late as May 15.

Mainly, de-icing temperatures are between 20° - 40 °F (-6.7° - 4.4 °C). The operators jokingly say that de-icing is usually necessary at night, on a weekend or on a holiday, particularly, when skilled personnel are usually off duty. Storms do often happen on Thanksgiving weekend, Christmas and New Years. The general rule of thumb is that de-icing weather is reasonably light in the Fall but January and February, and in many areas March, are bad months. There are some areas where they can expect to be de-icing as much as one out of every three days during the bad months.

3.2 Heat:

The next most important factor is heat. Many operators will tell you that this is the main ingredient and the de-icing fluid is merely the means of transferring the heat onto the wing and melting the ice. Because of the heat there is only a thin film of glycol left on the wings and there is a possibility of larger amounts of fluid being left on the wings which will cause problems in flight. Therefore, it is important that if you are transferring heat on to the wings, then you should do it by heating the fluid so that it contains the most number of BTU's per gallon but also to put on a stream which will transfer it with a minimum loss of heat to the air. A fine fog coming out of the nozzle will cool the fluid off very rapidly and practically no heat will get transferred to the wings or aircraft surfaces. A solid stream is the most efficient means of transferring this heat. The further you are away from the aircraft, of course, the more heat loss to the environment; the closer you are, the more danger there is of a solid

SAE AIR1335 Revision A

3.2 (Continued):

stream of high gallonage fluid damaging the aircraft. A rough guideline is that the nozzle should never be closer than about 10 ft (3 m) from any aircraft surface and then the stream should be directed in such a manner that it is hitting the aircraft surfaces at a very low angle. A very rough figure is that the heat transfer is only about 25% efficient so that you can see the need for putting as many BTU's as possible into the smallest number of gallons. A safe heat is around 180° - 190 °F (82° - 88 °C). This presents a problem since pumping hot glycol from a tank shortens the life of the pump. When the pump sucks the fluid from the tank, it lowers the pressure and lowers the boiling point of the fluid and, consequently, the pump then will be pumping partial vapor and cavitating. A reasonably safe figure is to have the tank around 140 °F (60 °C) and then using a coil type of heater to add the heat to it after the fluid has left the pump and before coming out the nozzle. This will insure a much longer life for the pump. It does, of course, require considerably larger heaters but the heat capacities specified by the A.T.A. committee is suitable for the capability of taking semi-heated fluid and heating it up during the last pass before going out of the nozzle. The cost of heating the fluid is very low in comparison with the cost of the de-icing fluid and a rough rule of thumb is that you get about 100,000 BTU's at the nozzle for every gallon of gas burned. 2,000,000 BTU's per hour heating capability would burn approximately 20 gallons of gas per hour at a cost of less than \$5.00 per hour. This is, of course, if it were heating continuously at its highest output.

4. SURFACE DE-ICING FLUID:

A de-icing fluid is generally referred to as "glycol" because most de-icing fluids are made up of a mixture of ethylene glycol, propylene glycol, and then certain additives, such as a corrosion inhibitor, and then a wetting agent that would contain material similar to glucose, which makes the fluid adhere to the appropriate surfaces to give it the anti-icing quality while it taxis out to the end of the runway. There are, of course, many different de-icing fluids on the market and several manufacturers attempt to keep their formulations secret. The main ability of the de-icing fluid is not to freeze and to run off of the aircraft surfaces but still to leave a thin film to provide anti-icing qualities.

Surface de-icing fluid comes basically from an ethylene stock. This, of course, is a by-product of natural gas as well as crude oil and certainly that produced from natural gas was almost considered a waste product up until a relatively few years ago. It is now widely used in synthetic fibers which are presently taking 1/2 of the ethylene supply. It is anticipated that this market will grow much faster than the market for surface de-icing fluid with the result that the cost of the fluid will increase very noticeably as supplies diminish and demand increases.

5. RAMP DE-ICING:

After analyzing conditions under which de-icing generally is required, it is a coincidence that many of the figures come out to be a 75 to 25 ratio. Some examples are listed below and, again, all of these figures are approximate.

First of all, 75% of all de-icing comes between the 24° - 38 °F (-4.4° - 3.3 °C) range. The balance, or 25% of de-icing, is done outside this range.

SAE AIR1335 Revision A

5. (Continued):

The next item is that 75% of de-icing work is done when the wind velocity is between 0 and 20 miles per hour and, of course, the other 25% is when the wind is in excess of 20 miles per hour.

Another interesting figure is that 75% of de-icing fluid is used in wind velocities under 20 miles per hour.

Still another interesting figure on fluids is that 75% is used on originating flights and 25% on through flights.

75% of de-icing weather is sticking snow, frost, or freezing rain and 25% of the weather is light, medium and heavy snow.

In 75% of de-icing conditions, heat is needed and in 25% it is not needed.

Another very important ratio is that more than 90% of the cost of de-icing operations is for the fluid and the balance is for wages and equipment, etc.

The term de-icing is not a very accurate term since the fluid is applied to an aircraft for more than one reason. Usually, it is first used when heavy frosts occur, at which time only a very light coating of fluid is used. Heat is not a factor in removal of frost. The next is freezing rain or freezing sleet when hot fluid then is a necessity. Next the removal of heavy snow. Next is the removal of large quantities of ice from prolonged freezing rain and, lastly, is anti-icing. Anti-icing can be used in two ways: (1) Immediately before the flight departs to protect the plane against falling snow or freezing rain while it taxis out to the end of the runway; (2) Going around to the aircraft during the night where the aircraft is parked and spraying it every hour to prevent a buildup of snow. Basically, the de-icing operation could be described as (1) snow removal, (2) de-icing and (3) anti-icing.

6. THE FUTURE OF DE-ICING:

There is no question but that de-icing will be with us for a long time to come. The increase in the size of planes has taken place for the 1970's but the increase in number of flights and ground congestion at the airports is still to be faced. The longer the lineups for takeoff, the more de-icing becomes a problem. The plane can be satisfactory when it leaves the gate, but it may not be when it is cleared for takeoff.

One airline actually de-iced aircraft with the engines running at a de-icing location away from the terminal in the late 1960's. However, this was dropped with a change of personnel but it did prove it could be done.

There are two factors which could make a completely new generation of de-icers necessary at some of the main stations because of the above mentioned factors and ECONOMY and ECOLOGY. ECONOMY is because of the very large quantity of de-icing fluid that is required on the large planes, which in numerous cases has reached as high as 3,000 gallons for a single aircraft. De-icing fluid costs anywhere from \$.50 to \$1.50 per gallon depending on whether it is bulk purchases or purchased in small quantities in drums. An average figure of \$1.00 per gallon can be assumed and it then becomes obvious that when the cost of de-icing consists of over 90% of it being de-icing fluid, then this is the prime target for cost cutting.

SAE AIR1335 Revision A

6. (Continued):

The other important factor is ECOLOGY. New airports which are being planned or under construction are being restricted from dumping this de-icing fluid down the drains. This restriction can spread and it could happen that any given airport can be given orders not to dump their de-icing fluid down the storm sewers.

Air Canada is doing a very comprehensive, on-site study under actual de-icing conditions to de-ice their planes at a fixed pad and attempt to recover the fluid; firstly, to reconstitute it to its original strength and, secondly, to recycle the de-icing fluid. It is quite possible that the cost of reconstituting and recycling will eat up a substantial part of the savings but this is minimal compared to collecting the de-icing fluid and pumping it into special sewage lagoons and allowing it to "break down" or processing it to speed up the breaking down of the fluid. The average de-icing fluid used today can be considered non-biodegradable but it actually, in time, is bio-degradable. This, of course, could mean very expensive installations of lagoons to break down the de-icing fluid and, therefore, it seems the obvious approach to take is that being taken by Air Canada - collecting the de-icing fluid into holding tanks and then handling it in the most economical way, which could be either recycling or hauling it away in tankers and disposing of it in some manner.

The second major change that is coming is that at any time the ecologists can rule against the emissions from burning the large quantities of gasoline necessary to heat the fluid. This, of course, will mean that the heaters of the future more than likely will be burning liquid propane or some suitable fuel producing an acceptable emission level.

Because of the new Federal Motor Vehicle Safety Standards and the OSHA requirement to meet American National Standards Institute Standard A92.9, 1969, the largest tank capacity that is practical to mount on a reasonably priced single rear axle vehicle is 1800 gallons. To exceed this capacity requires special axles and, consequently, heavier frames, engines, and transmissions, which jump the cost of the vehicle by as much as 50%.

The present mobile de-icer will be with us for a long time to come, even though many very busy stations may adopt the de-icing pad concept. However, a de-icing pad concept can be very costly and require the cooperation of several airlines as well as the airport authority. The biggest problems that the airlines will be facing in the 1970's in de-icing will be: (1) How to keep an aircraft ready to fly until it is No. 1 for takeoff; and (2) What to do with the used de-icing fluid.

The cost of glycol is estimated to rise as much as 2-3 times over the next few years. This is basically because glycol is made from ethylene stock and because of the natural gas shortage. Since the ethylene stock is also used in the production of synthetic fibers, the demand is increasing much faster than the supply. It will, therefore, be more necessary than ever to explore means of de-icing an aircraft with a minimum amount of glycol; not only because of the impending shortage of glycol and the increased cost but because this product is a definite part of the Energy Crisis.

SAE AIR1335 Revision A

7. WHY DE-ICING:

7.1 De-Icing:

De-icing is the process of removing ice and/or snow accumulations from aircraft surfaces. The need arises because ice and snow deposits on an aircraft's surfaces seriously affect the aircraft's performance and/or its controllability.

7.1.1 The thrust, lift, drag and control characteristics of aircraft may be altered resulting in an increase in stalling speed and take-off distance and a decrease in its rate of climb.

7.1.2 Deposits on control surfaces may affect aerodynamic and mass balance. This may lead to "flutter" and even to serious structural damage. (Just like the presence of fluid "H" on the control surfaces of A/C 922 produced a "flutter" condition).

7.2 Why De-Ice?:

Since safety is paramount, the creation of situations which may lead to incidents or accidents cannot be permitted. It is necessary, therefore, to thoroughly clean the:

Fuselage
Wings
Tail Surfaces
Control Surfaces
Hinges
Nose Section
Windshield

before departure. This is being done today by all airlines which operate in areas where they may encounter icing and/or snow conditions.

Before we proceed to the discussions of the techniques of de-icing a clear picture is needed of the conditions which may lead to de-icing situations i.e., when does ice-accretion take place?

7.3 Ice-Accretion:

7.3.1 On the ground ice-accretion may occur under the following conditions:

- a. In falling snow with temperatures at or below 26 °F (-3.3 °C). If a warm aircraft (e.g., brought from the hangar) is exposed to this condition the falling snow will melt and subsequently refreeze, forming a very rough deposit which can seriously affect the aircraft's control and stability characteristics. In the case of a cool aircraft, the snow would adhere on contact and again produce an undesirable surface disfiguration.
- b. In freezing rain or drizzle with ground temperatures at or around 32 °F (0 °C). A smooth ice-coating may form on the exposed horizontal surfaces.

SAE AIR1335 Revision A

7.3.1 (Continued):

- c. In fog or misty weather (i.e. high total moisture content) with temperatures at or below 32 °F (0 °C). Ice may form on exposed aircraft surfaces; very thick layers may develop on the windward side.

7.3.2 After Landing, ice accretion may occur:

- a. If the skin temperature of the aircraft itself is below freezing, and frozen or freezing precipitation is falling (these terms are defined in Appendix A).
- b. If frozen precipitation (definition in Appendix A) is falling on the warm (due to cabin heating) fuselage. On contact with the fuselage the precipitation melts and while dripping down refreezes, producing a rough deposit.

7.3.3 Ice Accretion During Flight: Aircraft are affected in varying degrees by ice which forms when the aircraft passes through clouds. Four meteorological factors affect the form and extend of aircraft icing:

1. Water Content of a Cloud - An increasing total quantity of water in a cloud increases the amount of ice that forms on the aircraft.
2. Size of Water Droplets - This factor affects icing because large droplets are less likely to be deflected along with the airflow around the airfoil than are smaller droplets.
3. Temperature of the Droplets - Lower temperatures are usually accompanied by low water content. The worst icing conditions occur at water temperatures just below freezing when ice rapidly forms into high drag ice shapes.

4. Horizontal Extent of the Cloud - The horizontal extent of a cloud is closely related to its total water content.

Icing clouds can be divided into two classes:

- (a) Cumulus
- (b) Stratus

Stratus clouds tend to spread over large areas and, as a result, are more likely to cause heavy icing because the airplane spends more time in them. Stratus generally occur from sea level to 22,000 ft (6710 m).

Cumulus clouds usually have limited horizontal coverage but are thicker than stratus clouds. Cumulus clouds range from 4,000 to a height of 30,400 ft (1220 to 9272 m).

Icing occurs over the same temperature range in the two classes of clouds below 22,000 ft (6710 m), from -22 °F to 32 °F (-30 °C to 0 °C).

SAE AIR1335 Revision A

7.4 Icing Conditions for Jets¹:

Jets are less susceptible to icing problems than piston aircraft because:

- 7.4.1 The greater climb capability of jetliners reduces length of time they are likely to encounter icing conditions. These high rates of climb enable a jet transport to fly through thin stratus type clouds fast enough to prevent heavy ice build-ups. A 2,000 f.p.m. rate of climb carries an airplane through the average layer cloud in about a minute and a half, and through the thickest in about three and a quarter minutes. Thicker cumulus clouds are often avoided due to turbulence, flying around them is the standard procedure.
- 7.4.2 The speed of the jets reduces icing severity and the extent of conditions under which icing will occur. An airfoil passing through air converts the impact energy into an air temperature rise which increases the skin surface temperature. This temperature increase is commonly referred to as the "ram rise". Thus, the jetliner's speed enables it to develop a significant ram rise and this reduces the extent of icing effects. As an example, at sea level an airspeed of 260 knots increases the wet skin temperature to 32 °F (0 °C) when OAT is 24 °F (-4.4 °C). Ram rise thus effectively reduces the thickness of the icing layer. In many cases ram rise is sufficient to prevent icing all the way through many icing layers that would affect piston planes.
- 7.4.3 Jet liner's cruise-altitudes are far above most icing conditions. At these altitudes temperatures are so far below freezing that moisture almost always exists as ice and the air is so dry that icing is seldom possible except in tropical thunderheads.
- 7.4.4 The power of high-performance jet engines reduces the significance of icing drag. That is, a given amount of drag from ice-accretion affects a jet transport less than its piston counterpart because of the jet's greater thrust margin. Since piston aircraft operate near their productive limit, they are more affected by icing drag or drag due to some other cause.
- 7.4.5 The airfoils of jets have longer chord lengths and are swept back - both of these factors reduce the drag increment from a given accumulation of ice at the leading edge.

8. IMPROPER DE-ICING:

8.1 "Aileron and Rudder Nibble or Vibration Enroute" - An Actual Occurrence:

"A short time after departure from Montreal, I felt an aileron "nibble" or "flutter" through the control wheel. I mentioned this to the co-pilot who stated that he did not have too much evidence of it in his control wheel. After being airborne 30 to 45 minutes, the aileron nibble became more evident and a tail vibration or nibble was felt through the rudder pedals. This time the co-pilot acknowledged the condition to be present both in feel and by observing the control wheel oscillating rapidly, as well as the rudder pedals oscillating back and forth in short vibratory movements. Reducing the airspeed 30 to 50 knots, by engine power reduction, corrected the vibration which did not reappear during subsequent descent and landing at scheduled Toronto enroute stop.

1. AIRCRAFT ICING, FLIGHT OPERATIONS, VOL. LVIII, Dec. 1963

SAE AIR1335 Revision A

8.1 (Continued):

"Flight conditions were smooth: 18,000 ft, on top with T.O. A.T. of -40 °C, IAS 295 knots.

"There was broken cloud over Montreal at our departure time, with intermittent very light snow. Surface Temperature was 16 °F to 18 °F.

"The Auto-Pilot was "off". The aircraft was being hand flown.

"The above condition was not noticeable on take-off, but became evident sometime afterwards. Certainly most evident during cruise at or near V.M.O."

8.2 Reaction:

Subsequent investigation revealed that the above condition was caused by the presence of excess de-icing fluid on the control surfaces; the fluid used was one known as Type-H which had been introduced on a trial basis at Dorval and Toronto. The incident described in 8.1 caused the following immediate corrective action:

"As a precautionary measure based on the possibility that fluid "H" as constituted was accumulating excessively on flight surfaces and not being displaced by the air stream, it was decided to reduce its viscosity by addition of water to give a 70 fluid/30 water composition. Standby supplies in large mobile defrosting sprayers were so diluted at both Dorval and Toronto under supervision of Station Services with emphasis on securing proper mixing of this water and fluid".

Considerable discussion took place on what happened to Aircraft 922 including the events leading up to the reported incident, approximately 40 - 45 minutes after its departure from Montreal. Many of the points were difficult to establish since no actual record is maintained at stations on the spraying of aircraft.

It was explained that a flutter such as the one developed on Aircraft 922 is of considerable concern to test pilots. It is the fore-runner of a condition that could become very violent and result in severe damage to the control surfaces. In one opinion - the cause of the flutter was a buildup of the type "H" SDF on the ailerons and rudder, causing them to become aerodynamically unbalanced.

PREPARED UNDER THE JURISDICTION OF
COMMITTEE AGE-2, AIR CARGO AND AIRCRAFT GROUND EQUIPMENT AND SYSTEMS

SAE AIR1335 Revision A

APPENDIX A

DE-ICING WEATHER Definitions and Terms

INTRODUCTION

The following definitions and notes were obtained from the Department of Transport's MANOBS (Manual of Standard Procedures and Practices for Weather Observing and Reporting), fifth edition.

These definitions can be used as a general reference. Their availability will also improve the communicative ability of the terms used in this report.

A.1 PRECIPITATION:

Any product of the condensation of atmospheric water vapor which is deposited on the earth's surface is a type of precipitation.

A.1.1 Liquid Precipitation:

A.1.1.1 Drizzle: Fairly uniform precipitation, composed exclusively of fine drops of water (diameter less than 1/50 of an inch) very close to one another. Drizzle drops are too small to cause appreciable ripples on the surface of still water.

A.1.1.2 Rain: Precipitation of liquid water particles either in the form of drops of larger diameter than 1/50 of an inch, or of smaller widely scattered drops.

A.1.2 Freezing Precipitation:

A.1.2.1 Freezing Drizzle: Drizzle, the drops of which freeze on impact with the ground or with other objects at or near the earth's surface.

A.1.2.2 Freezing Rain: Rain, the drops of which freeze on impact with the ground or with other objects at or near the earth's surface.

A.1.3 Frozen Precipitation:

A.1.3.1 Snow: Precipitation of mainly hexagonal ice crystals, most of which are branched (star shaped).

The branched crystals are sometimes mixed with unbranched crystals. At temperatures higher than about 23 °F (-5 °C) the crystals are generally clustered to form snow flakes.

A.1.3.2 Snow Pellets: Precipitation of white and opaque particles of ice. These ice particles are spherical or sometimes conical; their diameter is about 1/2 to 1/5 of an inch.

Precipitation of snow pellets generally occurs in showers together with precipitation of snow flakes or rain drops, when surface temperatures are around 32 °F (0 °C).

SAE AIR1335 Revision A

A.1.3.3 Snow Grains: Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is generally less than 1/25 of an inch.

A.1.3.4 Ice Pellets: Precipitation of transparent or translucent pellets of ice which are spherical or irregular, rarely conical, having a diameter of 1/5 of an inch or less. Ice pellets are subdivided into two main types:

A.1.3.4.1 Frozen raindrops; or snowflakes which have largely melted and then refrozen; the freezing process usually taking place near the ground.

A.1.3.4.2 Pellets of snow encased in a thin layer of ice, which has formed from the freezing either of droplets intercepted by the pellets or of water resulting from the partial melting of the pellets.

A.1.3.5 Hail: Precipitation of small balls or pieces of ice (hailstones) with a diameter ranging from 1/5 to 2 in or sometimes more, and which fall either separately or fused into irregular lumps.

A.1.3.6 Ice Prisms: A fall from the air of unbranched ice crystals, in the form of needles, columns or plates, often so tiny that they seem to be suspended in the air.

A.1.4 Fog:

A suspension of very small water droplets in the air.

When sufficiently illuminated, individual fog droplets are frequently visible to the naked eye; they are often seen to be moving in a somewhat turbulent manner.

A.1.5 Haze:

A suspension of extremely small, dry particles invisible to the naked eye and sufficiently numerous to give the air an opalescent (milky or pearly) appearance.

A.2 MEASUREMENT OF PRECIPITATION:

A.2.1 General:

The measurement of precipitation is expressed in terms of vertical depth of water (or water equivalent in the case of solid forms) which reaches the ground during a stated period.

A.2.2 Units:

- the inch is the unit of measurement, and precipitation is reported to the nearest 0.01 inch.
- less than 0.005 in. is referred to as a TRACE.
- snow depth is measured in tenths of inches.

A.2.3 Snowfall:

The amount of snow which has fallen in a given period shall be determined by measuring and averaging the depth of new snow in several places using a ruler.

SAE AIR1335 Revision A

A.3 INTENSITY OF PRECIPITATION:

A.3.1 Intensity of precipitation is determined by effect on visibility and by rate of fall.

A.3.2 Visibility Criteria:

- | | |
|--------------|----------------------------------|
| a. Light: | Visibility 5/8 mile or more |
| b. Moderate: | Visibility 3/8 or 1/2 mile |
| c. Heavy: | Visibility Zero, 1/8 or 1/4 mile |

A.3.3 Rate of Fall Criteria:

- | | |
|--------------|--------------------------------|
| a. Light: | 0.10 inches per hour or less |
| b. Moderate: | 0.11 to 0.30 inches per hour |
| c. Heavy: | More than 0.30 inches per hour |

A.4 CHARACTER OF PRECIPITATION:

A.4.1 Continuous Precipitation continues without a break during the hour (60 minutes) preceding the actual time of observation.

A.4.2 Intermittent Precipitation must have stopped and recommenced at least once during the hour (60 minutes) preceding the actual time of observation.

A.4.3 Showers:

Showery precipitation begins and ends abruptly in periods of short duration usually of the order of 15 minutes, although sometimes lasting half an hour or more.

A.5 HUMIDITY:

A.5.1 General:

Humidity is a measure of the water vapor content of the air.

A.5.2 Dew Point:

The dew point is the temperature at which the air would become saturated (with respect to water) if cooled at constant pressure and without the addition or removal of water vapor. It is expressed in degrees Fahrenheit.

A.5.3 Relative Humidity:

Relative humidity is the ratio, expressed as a percentage, of the amount of water vapor (grams of water vapor per kilogram of dry air) actually present in the air to the amount of water vapor which would be present if the air were saturated with respect to water at the same temperature and pressure.

SAE AIR1335 Revision A

A.6 BACKGROUND INFORMATION:

The following useful information about wind velocities was obtained from two sources².

Table 1 illustrates the BEAUFORT SCALE of winds, devised by Rear Admiral Beaufort as the first objective wind scale. Later, Dr. George C. Simpson brought out a simplified version of the scale which was adopted by the International Meteorological Committee at its meeting in Vienna in 1926. This scale, along with the Beaufort numbers, is reproduced on the next page.

A.7 "SNOWFALL" MODIFICATION:

The Department of Transport has modified the reporting procedure for SNOWFALL. The modification³ was instituted to provide greater detail and it reads as follows:

"The snowfall, since the last main synoptic report, shall be reported on the Remarks Section of the Aviation Weather Report by means of a /SS/ group.

"/SS/ is the accumulative depth of newly fallen snow for the six-hour synoptic period and is expressed in whole inches. It will normally be obtained by ruler measurement and standard "round off" procedures.

"/SS/ shall only be reported at the hours when the accumulated (round-off) value equals or exceeds one inch, two inches, three inches, etc."

Example:

Time (GMT)	Accumulated Depth Newly Fallen Snow Since Last Synoptic Report	SS
0100	0.7	01
0200	1.2	No /SS/ reported
0300	1.5	02
0400	2.2	No /SS/ reported
0500	3.7	04
0600	4.5	05
0700	0.4	No /SS/ reported
0800	0.9	01
0900	1.4	No /SS/ reported
1000	2.3	02

This new procedure would result in more detailed snowfall records, and would be helpful to us in many ways.

- a) DOT Amendment No. 9 to CIR-3450, OBS-300, 1 July 1961, MANOBS, fifth edition.
- b) P-52, 53, Our American Weather, Geo. H. T. Kimble, McGraw-Hill Book Company, Inc., New York, 1955.
3. Section 2.2.16.11 of Department of Transport Circular No. 4276 dated July 23, 1965.

SAE AIR1335 Revision A

TABLE 1 - BEAUFORT SCALE OF WINDS

<u>Beaufort Number</u>	<u>Descriptive Term</u>	<u>Speed mph</u>	<u>Range Knots</u>	<u>Specification for Estimating Speed</u>	<u>Average mph</u>	<u>Speed Knots</u>
0	Calm	Less Than 1	Less Than 1	Smoke rises vertically	0	0
1	Light Air	1 - 3	1 - 3	Direction of wind shown by smoke drift but not wind vanes.	2	2
2	Light Breeze	4 - 7	4 - 6	Wind felt on face; leaves rustle; ordinary vane moved by wind	5	5
3	Gentle Breeze	8 - 12	7 - 10	Leaves and small twigs in constant motion; wind extends light flag.	10	9
4	Moderate Breeze	13 - 18	11 - 16	Raises dust and loose paper; small branches are moved.	15	13
5	Fresh Breeze	19 - 24	17 - 21	Small trees in leaf begin to sway; crested wavelets form on inland waters.	22	19
6	Strong Breeze	25 - 31	22 - 27	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	28	24
7	Near Gale	32 - 38	28 - 33	Whole trees in motion; inconvenience felt in walking against wind.	35	30
8	Gale	39 - 46	34 - 40	Breaks twigs off trees; generally impedes progress.	42	37
9	Strong Gale	47 - 54	41 - 47	Slight structural damage occurs (chimneys and slates removed).	50	44
10	Storm	55 - 63	48 - 55	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	60	52
11	Violent Storm	64 - 72	56 - 63	Very rarely experienced accompanied by widespread damage.	68	60
12	Hurricane	Above 72	Above 63			