COMMISSION OF INQUIRY INTO THE AIR ONTARIO CRASH AT DRYDEN, ONTARIO

Second Interim Report

Aircraft Ground De-icing and Related Flight Safety Issues

The Honourable Virgil P. Moshansky
Commissioner

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Commission of Inquiry into the Air Ontario Crash at Dryden, Ontario

Commission d'enquête sur l'écrasement d'un avion d'Air Ontario à Dryden (Ontario)

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TO HIS EXCELLENCY
THE GOVERNOR IN COUNCIL

MAY IT PLEASE YOUR EXCELLENCY

Having submitted my Interim Report on December 8, 1989, pursuant to Order in Council PC 1989-532, I would not in the normal course of events be communicating with Your Excellency at this time. Any further recommendations would ordinarily be contained in my Final Report at the conclusion of this Inquiry.

Matters of major concern related to aviation safety have, however, surfaced in the recently completed hearings by my Commission into aircraft ground de-icing in Canada. I feel obliged to report to you at this time on these concerns.

I now beg to submit the attached Second Interim Report.

Respectfully submitted.

V. P. Moshansky

Commissioner

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CONTENTS

PREFACE

In the course of the hearings of this Commission I became aware of a number of major aircraft accidents in North America and Europe that were related to ground icing, all of which are considered to have been preventable accidents. Some of these accidents bore certain similarities to the Air Ontario crash at Dryden, Ontario, on March 10, 1989. In at least three of these accidents the aircraft had been de-iced but were held on the ground for 27 to 60 minutes prior to take-off. As a result of this evidence and the research conducted by my officials, it became apparent that, in the interests of aviation safety, a thorough investigation of the state of aircraft ground de-icing in Canada ought to be undertaken on a priority basis. Accordingly, a specific ground de-icing phase was introduced into the Inquiry schedule early in 1990, and technical experts and counsel were assigned for its conduct.

My decision to examine, in depth, the state of aircraft ground de-icing technology employed by air carriers in Canada flowed, first, from my finding that wing contamination was at least a contributing factor in the crash of Air Ontario Flight 1363 at Dryden, Ontario; second, from that portion of my mandate requiring me to make recommendations to the Governor in Council in the interests of aviation safety; and, third, from the evidence given during the course of the Inquiry by airline pilots and others involved in the aviation industry expressing concerns about safety with respect to ground de-icing of aircraft and the long delays before take-off in adverse winter weather in Canada, generally, and, in particular, at Lester B. Pearson International Airport in Toronto.*

* Because of accepted usage, I have referred to Toronto International Airport throughout this report as Lester B. Pearson International Airport, or some short form thereof, despite the fact that the name has never been gazetted.

1 INTRODUCTION

> The principal (underlying) cause of these accidents is a lack of understanding of the significant effect that slight surface roughness can have on aerodynamic characteristics of wings and control surfaces and the subsequent changes of aircraft performance, stability, and control. Recent (since 1977) introduction of large numbers of new airline operators and new, inexperienced personnel (owners, management, flight crews, maintenance crews, etc.) is partially contributory to this trend. This lack of awareness has led to decisions to attempt takeoff when they (pilots and others) were aware that ice formations were present. An ice formation was present because it was either residue from a previous flight or because of ice, snow or frost accumulations, due to precipitation or sublimation, while the aircraft was on the ground or both.
>
> In several of these accidents the pilot believed that snow would blow off prior to the aircraft becoming airborne. In three of these accidents, the aircraft had been deiced using weak solutions (10% to 40%) of conventional ground deicing fluids and takeoff was delayed (27 to 60 minutes transpired between deicing and takeoff). In the eleven (11) other accidents the aircraft were not deiced at all. In many cases it is uncertain why the aircraft was not deiced; however, it appears that the flight crew either believed that the contamination (usually snow) would blow off or that it would not have an effect. In all of these cases it is apparent that the pilot did not have a proper appreciation of the potentially catastrophic effects of ice, frost, or snow formations that were on his aircraft.*

This statement is contained in a study provided to this Commission by Mr Richard Adams, of Newport News, Virginia, an aeronautical engineer and aviation consultant, and, until recently, national resource specialist for aircraft icing with the Federal Aviation Administration in the United States. His words underlie everything that will follow.

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* Richard Adams, "Assessment of Major Aircraft Ground-De-icing-Related Accidents: Remedial Actions Taken to Date and Recommended Future Actions" (study prepared for the Commission of Inquiry into the Air Ontario Crash at Dryden, Ontario, June 12, 1990).

In January 1990 this Commission decided to examine aircraft ground de-icing procedures, equipment, and fluids used by Canadian carriers and to compare them with those used by U.S. and European carriers. It was also decided that an examination of aircraft de-icing facilities was warranted, with particular emphasis on the situation at Toronto's Pearson International Airport.

Pearson Airport is owned and operated by Transport Canada and is Canada's busiest airport in terms of commercial traffic. Both our investigation and the sworn evidence has shown that, in recent years, traffic congestion, particularly in adverse weather conditions, has caused safety-related operational problems. Our investigation of these matters was indeed timely in that a severe winter storm occurred in the Toronto area on February 15, 1990, causing serious operational problems.

During the ground de-icing hearing phase of this Commission, evidence was heard from a variety of witnesses, many of them internationally recognized experts in the field of aircraft wing contamination, de-icing and anti-icing equipment, fluids, methods, and facilities. A substantial number of experienced airline pilots have testified about safety-related problems encountered by airline flight crews because of departure delays at Pearson International Airport in severe winter weather. Evidence heard from a number of pilots called before the Commission subsequent to the de-icing phase of the hearings further confirms these concerns. A number of witnesses mentioned an apparent incompatibility between the length of time during which de-icing or anti-icing fluid offers protection against freezing precipitation (hold-over time) and the departure delays at certain major Canadian airports.

A number of problems relating to aircraft ground de-icing were addressed during this phase of the Inquiry. It is impossible to deal with all such matters in this originally unplanned interim report since the ongoing hearings of the Commission impose constraints on the time available. At this time I propose, first, to identify the major de-icing operational problems at Pearson International Airport by referring to the evidence of certain witnesses before this Commission and, second, to address the ground de-icing shortcomings which, in terms of flight safety, are of the greatest immediate concern and demand the urgent attention of your government. Any remaining de-icing matters will be dealt with in my final report. The main thrust of this phase of the Inquiry has been to conduct an in-depth examination of:

- the operational problems at Pearson International Airport which, in adverse winter weather conditions, have an impact on aviation safety; and

- the aircraft ground de-icing facilities, fluids, and procedures in use in Canada, compared with the United States and Europe, including aircraft ground de-icing and anti-icing fluids and their hold-over times in various winter weather conditions, as well as the type of ground de-icing equipment employed by carriers.

The evidence heard in this phase of the Inquiry is distinctly unflattering to the Canadian airline industry and regulatory authorities. One would have assumed that Canada, as a northern nation, would be a leader in the research, development, and use of ground de-icing and anti-icing fluids, equipment, facilities, methods, and regulations. Unfortunately, I must report that this is not the case. Compared with European experience and standards in this area, Canadian ground de-icing/anti-icing standards, methods, and facilities can best be described as primitive. In the United States, the aviation industry and regulatory authorities have, in recent years, awakened to and are actively addressing the serious aviation safety problems related to ground de-icing and anti-icing of aircraft as well as the safety concerns induced by lengthy departure delays in adverse weather.

2 WINTER OPERATIONS AT PEARSON INTERNATIONAL AIRPORT

Pilot Perspective

In his testimony before the Commission, Bradley Somers, an F-28 captain with Air Ontario, graphically described the difficulties and dilemma facing airline flight crews while waiting in line for take-off in severe winter weather after being de-iced at Pearson International Airport:

> So operationally and in an airport, particularly like Toronto, the biggest concern I have is the time that it is going to take me from where I get sprayed until I'm on the runway and departing.
>
> There is just basically no guarantee on holdover times, and there is no, really, legitimate way of being able to evaluate what the condition of the aircraft can be in.
>
> Even the provision for inspecting the wings is really no guarantee. It – there can be subtle forms of icing that are almost impossible to see or that are impossible to see. You can't really pick them up only if you are up on the wing and feeling around on it at times...
>
> The only real way you can guarantee that an aircraft is going to be ice free is to have the aircraft sprayed at the runway and depart immediately from that time.
>
> (Transcript, vol. 39, p. 155)

Captain Erik Hansen, a 20,000-hour senior captain with Air Ontario until August 1989 and a former chief pilot and Transport Canada civil aviation inspector, also testified: "You are bound to pick up some contaminants when you leave the ramp, particularly if it's snowing heavily, and Toronto is getting worse by the day" (Transcript, vol. 79, p. 79).

On November 1, 1990, Mr Martin Brayman, a former Transport Canada superintendent, Large Airplanes Air Carrier Operations, Ontario Region, addressed the problems associated with winter operations at Toronto's Pearson International Airport. Mr Brayman's career as a pilot spans 40 years of military, airline, and Transport Canada flying and he has inspected a wide variety of aircraft. He provided evidence as follows:

Q. Mr. Brayman, in your capacity as a superintendent of inspection and your prior years as an inspector in the Ontario region, you would have had a great deal of experience with Pearson International Airport; isn't that right?
A. Only insofar as my own flying activities went, not in any capacity at the airport. But as an inspector, I flew in and out of the airport a great deal, that's correct.
Q. You and I discussed briefly the issue of Pearson in the winter, the lineups, the difficulties with deicing, the holdover times, the predicament that pilots find themselves in.
Are you able to give your views on that to the Commissioner?
A. This would simply be personal.
Q. Yes.
A. Well, there's two problems. One is the problem of fuel and the other the problem of contamination on the airframe.
Pearson was not designed in a manner to allow aircraft that are lined up to return very easily to the gate. In fact, if you are number 30 on a lineup, you have to wait till you get to the button, taxi down a live runway to an access and then return. And even the concept of returning to a gate is not practical because as soon as you leave the gate, the gate is filled up by an incoming airplane.
So the two problems for a captain is if he sits there for half an hour, is he going to burn into his reserve fuel, and the other one is if he gets dumped on by snow or freezing drizzle or freezing rain at the button, he's got a problem because if it exceeds the time the airframe will remain clear, then he has got to go back to the gate or go back to the tarmac, and that's difficult.
Q. Tough decision for the captain?
A. No question. Very tough.
Q. And this is something that you had seen in your capacity for a number of years?
A. I have never seen it quite as bad as we have at Pearson. You know, at most airports, the ability to pull out of the line and return is a great deal less restrictive, but Pearson has particular problems.

(Transcript, vol. 132, pp. 56–58)

He further stated:

Q. All right. Based on the experience that you have had, both as a pilot and with Transport in the various capacities that you have held, can you tell me, sir, if the potential exists at Pearson for a disaster in the winter season with the lineups, with the decision that the pilot has to make, and the present type of deicing fluid that is used, which is Type 1?
A. The potential, the potential, most definitely does exist.

(Transcript, vol. 132, p. 62)

Captain Reginald Smith is an internationally recognized expert in aviation safety. After serving as an RCAF jet pilot and squadron flight safety officer in Europe, he joined Air Canada as a pilot. He has a long and distinguished record as chairman of the safety committee of the Canadian Air Line Pilots Association (CALPA) and he served as regional vice-president for the North Atlantic in the International Federation of Air Line Pilots Associations (IFALPA) for two terms, and then as president of IFALPA, which represents 70,000 airline pilots around the world.

Captain Smith expressed grave concern over the congestion and long departure delays experienced at Pearson International Airport. He himself has routinely encountered 25- to 40-minute delays and occasionally delays of one hour or more after de-icing with type I fluid, which has an approximate hold-over time of 15 minutes in non-freezing precipitation and virtually no hold-over time in freezing precipitation. He confirmed the frustration expressed by many other pilots in such circumstances and pointed to the near impossibility of making a reasoned judgment, before take-off, about the state of the aircraft lifting surfaces in moderate or heavy snowfall conditions, particularly at night in conditions of poor visibility. Referring to the effect of such departure delays at Pearson International Airport, Captain Smith testified:

> A. ... I'm very much aware of delays in excess of an hour.
> Q. ... Well, Captain, how could you ever have a plane, if you're just using type 1 fluid, how could you ever have a plane in wet snow sitting on the taxiway for an hour not be contaminated by the time it gets to the threshold?
> A. You couldn't.
>
> (Transcript, vol. 76, p. 154)

Captain Smith unequivocally identified departure delays in bad weather as constituting a safety problem, both in terms of theory and precedent:

> Q. Do you consider this 45-minute lineup in bad weather to be a problem, to be a safety problem?
> A. Yes, no matter whether there's contaminants or not. If there are contaminants, of course, it's a safety problem. There's no doubt at all.
>
> ...
>
> Q. ... The hold in the lineup before takeoff in bad weather, was that, to your knowledge, a factor in the Air Florida Washington crash, the 737 that crashed into the Potomac?
> A. Absolutely.
> Q. So, in addition to theoretically being a safety problem, it has shown historically to be a safety problem?
> A. Certainly.

Q. And, in fact, to have contributed to the death of a great number of passengers?
A. Yes.

(Transcript, vol. 76, pp. 158–59)

With respect to the matter of the different types of de-icing fluids in use and the need for standardization, Captain Smith explained:

Q. ... In relation to the types of fluids ... you have flown in the United States, sir?
A. Yes, sir.
Q. And you've also flown into Europe?
A. Yes.
Q. And you've obviously done a lot of flying in Canada?
A. That's correct.
Q. And there are different types of fluids that are used in these different countries, are there not?
A. I'm aware of that, yes.
Q. Captain, would it be a move in the right direction to possibly look at some type of standardization of the types of fluids that are used from a pilot's point of view?
A. Certainly.
Q. Do you think that this is something which is worthwhile for the Commissioner to look at as a possible recommendation?
A. Absolutely. We're out on a limb right now because of the non-standardization and the constantly changing research in regards to de-icing and anti-icing fluids.
Q. And that would enhance aviation safety, sir?
A. Absolutely, and make the decision-making process much easier.

(Transcript, vol. 76, pp. 109–10)

Captain Smith also gave testimony about runway-end de-icing pads:

Q. ... Would it make sense from your perspective, Captain, to have de-icing bays located closer to the point of departure?
A. Well, from a safety standpoint, of course. Anytime it cuts down that ground delay period is going to make it safer.
Q. As, for example, as the case at Dorval in Montreal?
A. Correct.
Q. As, for example –
A. I might add, at the Dorval case for 6 right. Now, should you unlikely have to travel to 24 right at Montreal, you're into the same type of problem as you are at Toronto.

(Transcript, vol. 76, p. 115)

The problem at Toronto that Captain Smith was referring to in the last sentence is the very long taxi distances, after de-icing at the gate or ramp de-icing areas, to the take-off ends of the two runways generally in use in bad weather. These taxi distances are more than two miles for runway 24 right and more than three miles for runway 06 left. Two other problems at Toronto identified by Captain Smith are:

- the complex taxiing routes to the runways;
- the close proximity of the ramp de-icing area to the button of runway 24 left which causes congestion in the taxi area of Terminal 2.

A. ... But what is equally significant is the complexity of the route through the taxiways and the delays that you may encounter on the taxiways to get to the runway. It's a fairly complex taxiing route.

Q. All right, we'll get into that in a bit more detail in a moment.
From your experience, sir, may we assume that not too many takeoffs would be done on 24 left after being de-iced at the pads that you have noted on Exhibit 588?

A. Unfortunately so. Most of us, as pilots, being aware of schedule obligations and also de-icing obligations, would prefer to taxi immediately for takeoff on 24 left.
The problem, of course, is the proximity of the de-icing area to the button of 24 left, which will back up traffic, and you'll get traffic congestion in the taxi area of terminal 2.

(Transcript, vol. 76, p. 77)

Air Traffic Control

The unit operations specialist of airport traffic control (ATC) services at Pearson International Airport, Mr Clare Vasey, testified before the Commission. By virtue of his position he is responsible for ATC airport operations at Pearson. At my request, he accompanied Mr Frank Black, my chief technical advisor, and Mr John Holm, then superintendent of air operations at Pearson International Airport, on an inspection of de-icing facilities at O'Hare International Airport in Chicago. I found both Mr Vasey and Mr Holm, to whom I shall next refer, to be extremely knowledgeable and impressively credible witnesses. Their evidence and opinions ought to command respect and attention.

The evidence is clear that there are fundamental flaws in the design of Pearson International Airport itself and that these are the root causes of its current congestion. Its design consists of runways laid out in the shape of an 'H', with the terminals all concentrated on the northeast outer perimeter of the airport (see figure 1). This design contrasts with that of the newest and most modern airports in the world, such as the Hartsfield Atlanta International Airport and the Los Angeles International Airport, where terminals are placed in the centre of the airport with dual parallel runways on the perimeter (see appendix B). None of the runways in Atlanta intersects another.

The main operational problems at Pearson International Airport were illustrated in Mr Vasey's evidence of June 13, 1990:

> Q. ... Let's deal with the situation of deteriorating weather. The weather is starting to come down. How do you alternate – or alter your operation?
>
> A. Well, once again, deteriorating weather, without any form of precipitation, will probably require us to shift the arriving traffic from 6 left to runway 6 right, of course, which is the Category 2 approach runway.
>
> And, as precipitation begins to occur and the likelihood of icing, then, of course, we have directed our staff that, in the consideration for a departing runway, one of the prime considerations must be to reduce the exposure to any contamination by selecting a runway that is relatively close to the terminal buildings.
>
> So, in that situation, assuming we have precipitation, then we will shift the departing traffic from runway 6 left to runway 33.
>
> There are several inherent problems with that operation in that, now that we're on runway 33 and because the relatively – there is a relatively short distance between the threshold of that runway and the aprons, we find ourselves with traffic backing up into the aprons and creating congestion in these particular areas.
>
> As well, with diminishing weather, as we stated earlier, runway 33 does not have an RVR system, so one of the requirements that the operators dictate is that they have a runway with RVR, and we can't give them 6 left, although it has an RVR, because of the excessive taxi times.
>
> Runway 33 does not have an RVR, so then we're forced to move the departure operation to runway 6 right because it has two RVRs. And, also, it has the centerline lights, which are required.

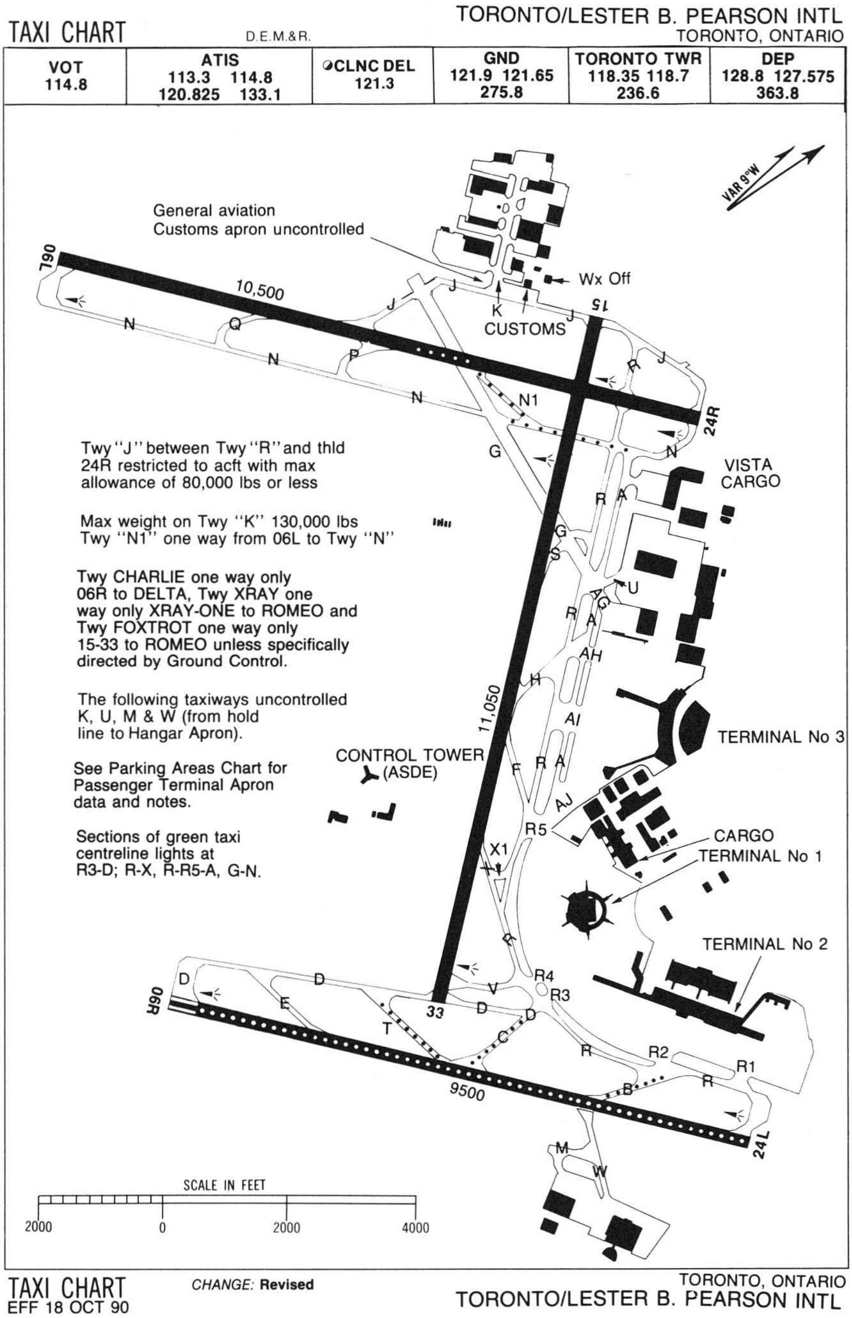

Figure 1 Lester B Pearson International Airport, Toronto: taxi chart. Courtesy Jeppesen Sanderson, Inc.

Q. All right, let's use an example: The weather is deteriorating and it's a Friday afternoon and there's a great deal of traffic in and out of the airport.

Can you give us a scenario where the weather is going down to IFR conditions, 200 and a half mile, for example, and there's precipitation, snow, a winter day.

A. Okay, one of the problems, obviously, in operating on a single runway is that you require increased separation between the arriving aircraft; therefore, you're reducing the arrival capability at the airport and the problem of trying to squeeze departures out on that runway with respect to the arriving aircraft.

The ultimate is – in that operation is to get one down, one up, and then one down. You can't always achieve that, because, with precipitation, of course, you now have a contaminated runway, and therefore, the aircraft after landing are going to remain on that particular runway for a longer period of time, thereby diminishing the possibilities of getting aircraft off between the landing traffic.

And then the queuing begins to occur, and it begins to back up across runway 33, and we could run into situations during those operations where you're looking at probably 20 to 25 aircraft waiting to go with departure delays approaching an hour.

Q. Now, what taxiway are the aircraft queuing on?

A. They're on taxiway Delta.

Q. So, in deteriorating weather on a snowy winter day, can you just tell me where the aircraft are coming from and how you're handling those aircraft and getting them off the ground.

A. With the freezing precipitation, of course, then the de-icing program starts up and, as Captain Smith pointed out, some of the de-icing is carried out on the gates with the larger aircraft; however, a lot of de-icing is conducted on the south perimeter.

And I might add that, from our vantage point, that we cannot see, even in good weather, most of that Terminal 2 complex, so a lot of our time was spent attempting to resolve problems, conflictions, which we, in our mind – because we had to maintain a visual impression of what was going on – that weren't really problems.

And, conversely, there were problems there with congestion that, in our minds, we could not see. We did not perceive them being as problems and which, ultimately, were problems.

So, in that de-icing operation, you have traffic moving off the gates going to the de-icing area, you have the flow of traffic requiring de-icing coming out of this area, and of course, you have traffic pushing off the gates here that want to get to the departure runway, and compounding that, you have aircraft

> landing on this particular runway that want to get into the gates, so it ends up as a quasi-unmanageable situation.
>
> (Transcript, vol. 77, pp. 38–43)

Mr Vasey, who had recently made a personal inspection of the Atlanta airport, said that air traffic controllers there handled between 180 and 200 movements per hour (compared with 70 at Toronto), with maximum queues of five to six aircraft and not more than 10-minute ground delays. Most significant was his evidence that, by reason of the airport's design, no aircraft was more than three to four minutes from the gate to the threshold of any particular runway, notwithstanding any queuing that might occur.

Mr Vasey described the types of pressure experienced by both pilots and air traffic controllers in severe weather at Pearson International Airport. Speaking of reluctance on the part of pilots to leave a departure line-up for a second de-icing in freezing precipitation, he said:

> Q. So I take it there tends to be a reluctance on the part of all parties to return because of the loss of a slot time, because of the delay of de-icing and a number of factors?
>
> A. Mm-hmm.
>
> Q. And you, as a tower controller, are aware of the pressure on these pilots?
>
> A. Mm-hmmm, yes, very definitely.
>
> (Transcript, vol. 77, pp. 44–45)

When Mr Vasey was asked in cross-examination about the line-ups of aircraft in bad weather for runway 06 left or 24 right, he stated:

> A. It's not unusual to see 15 to 20 aircraft, and I have seen, I believe, numbers approaching 30, and I have seen delay factors, delay times in the extreme situations reaching in excess of an hour, but that is an extreme situation.
>
> Q. All right. Now, you mentioned that at times you feel the size of the knot in your gut increasing, you feel your heart rate quickening, and you notice the voice of the controller goes up an octave or so. Is this the kind of scenario that triggers that response?
>
> A. That can be one of the situations, yes ...
>
> Q. Do you sense the same kind of response on the part of pilots through the radio?
>
> A. Yes, yes, very definitely ...
>
> ...
>
> Q. All right. What kind of feedback do you get from the pilots when you're lining them up 25 deep? Do they say, look, if you can't

get me off, I'm going to have to go back and get fuel or I'm going to have to go back and de-ice?

What kind of communication flows through to you in ATC in that scenario?

A. Actually, you're sensing high degree of aggravation on their part, and sometimes if you don't control the frequency, then you can get one or more pilots who are, essentially, controlling the frequency by making requests that are unreasonable because of their high level of frustration, such as, if he's number 20 in the line, what's my delay? Well, the airport controller doesn't have time at that particular moment to calculate what the delay factor will be. This further aggravates the pilot.

(Transcript, vol. 77, pp. 89–91)

A possible alternative to departure delays suggested by Dr Lloyd McCoomb, director general of safety and technical services of Transport Canada, Captain Charles Simpson, senior vice-president of flight operations for Air Canada, and others was to hold aircraft at the gate in bad weather. Mr Vasey, however, was emphatic that, owing to the airport's design, gate holds at Pearson International Airport only compound the problem because arriving aircraft must enter the terminal areas, which are already congested with ongoing de-icing operations, and have no other place to go. As he put it succinctly: "There's just no more concrete to accommodate them" (Transcript, vol. 77, p. 46). Mr Holm was of a similar view.

I find Mr Vasey's and Mr Holm's statements to be extremely significant. The evidence before this Commission shows that in the most efficient international airports there are a far greater number of strategically placed concrete ramps, taxiways, and runways than at Pearson International. I cite by way of example the following facts, in rounded numbers, before this Commission:

- O'Hare International Airport in Chicago has a total land area of 7000 acres, of which 5500 acres (78.5 per cent) consist of concrete, not including buildings.

- Hartsfield Atlanta International Airport has a total land area of 3900 acres, of which 2262 acres (58 per cent) consist of concrete.

- Los Angeles International Airport has a total land area of 3563 acres, of which 2316 acres (65 per cent) consist of concrete.

- Pearson International Airport has a total land area of 4400 acres, of which only 1400 acres (31.8 per cent) consist of concrete, including all buildings.

In cross-examination, Mr Vasey expanded on the inadequacy of the movement area at Pearson International Airport:

Q. ... What do you mean when you say the movement area is inadequate, and explain in some more detail how that inadequacy manifests itself?
A. Specifically, the aprons are one of the primary causes in my making the statement that the manoeuvring area is inadequate to accommodate aircraft. The design of those two areas does not make for efficient movement of traffic. And frequently – and I mean this can happen twice a day, three times a day in peak traffic periods – the situation within those aprons and the taxiways around the terminals becomes unmanageable.
   Also, there – there should be additional taxiways, as I said. If you look at progressive airports south of the border, adjacent to the terminal complexes, there's frequently an inner and outer taxiway, allowing you to establish a two-way flow around those terminal buildings and therefore eliminating the need for an aircraft pushing back at the northeast end of Terminal 2 to proceed through that apron area to get to a runway. He should be able to get out of that area immediately and onto one of those perimeter taxiways.
Q. What do you mean, the situation becomes "unmanageable"? What does an unmanageable situation look like? Because I don't know.
A. If I could use a term "grid lock" ... essentially, you end up with aircraft nose to nose, unable to move in any direction because of lack of space.
Q. And then blocking everybody else?
A. Yes.

(Transcript, vol. 77, pp. 93–94)

It is glaringly obvious that the concrete areas at Pearson International Airport are totally inadequate by any standards. More concrete translates into more runways, more taxiways, more ramp parking, more perimeter access roads, and runway-end de-icing pads.

The imminent opening of the new Terminal 3 on the north perimeter of Pearson is likely to exacerbate the problem further. As Mr Vasey explained:

Q. Well, let me ask you this: Generally, Terminal 3 will be coming into operation in the near future. Are you going to be able to move more aircraft as a result of Terminal 3 operation?
A. Not really. My perception of Terminal 3 from an air traffic control standpoint would be it will become an area that people can wait longer in greater comfort until we get more runways and more taxiways.

...

Q. So, whatever the building of Terminal 3 may achieve, it will in no way impact upon this safety problem of aircraft queuing up in bad weather waiting up to an hour after de-icing before being cleared for takeoff?
A. That's correct.
Q. All right. Why will more passengers be waiting than are presently waiting once Terminal 3 is built?
A. We now have 25 more gates that will accommodate additional carriers. It's my understanding that the major carrier in Terminal 1 will move into Terminal 3, and therefore, the space that they vacate will be taken up by additional carriers.
Q. All right. So I take it, then, it is your impression that there will be an increased workload imposed upon this airport environment which will result in longer delays?
A. Theoretically, assuming the cap were lifted or increased, that could occur, yes.
Q. And, if anything, then the safety problem concerning queues of aircraft may get worse?
A. Yes, I would expect it would, yes.

(Transcript, vol. 77, pp. 85, 88)

Mr Vasey also pointed out that in an effort to alleviate departure delays in bad weather, controllers attempt to get more aircraft out of the line-ups and airborne by "shaving" to one and three-quarter miles the minimum separation requirement of two miles between departing and incoming traffic on the same runway. This undesirable procedure can cause a missed approach by the landing aircraft, resulting in that aircraft being handed back to the arrival controllers, who are already over-burdened with incoming traffic. A further factor in this equation is the growing mix of medium-sized, lighter, feeder aircraft with the larger jet transport aircraft that has resulted since deregulation. These lighter aircraft require greater separation behind jet aircraft because of the dangers posed by jet wake turbulence. Separation shaving was cited by the U.S. National Transportation Safety Board (NTSB) as a finding in the icing-related takeoff crash of an Air Florida jet into the Potomac River at Washington, DC, in 1982.

Mr Vasey left no doubt that the congestion at Pearson International Airport has continued steadily to worsen and that, if left as it is, the trend will continue unabated:

Q. All right. I'm sorry, to return to Terminal 3, the trend in the past few years has appeared to be such that the problem of queuing aircraft, delays and so on, is getting worse and worse; is that right?
A. That's true.
Q. It appears that that trend will continue unabated?

A. That's true, without significant improvements in the manoeuvring area, yes.

(Transcript, vol. 77, p. 89)

Air Operations

Mr Vasey was supported in his views by Mr John Holm who, until recently, was employed by the Airports Authority Group of Transport Canada as superintendent of air operations at Pearson International Airport. An ex-RCAF and Danish air force pilot, Mr Holm has been involved extensively in aviation safety matters. He served for a number of years in Europe in the tactical evaluation of flight operations during ice and snow conditions, including the solution of winter operating problems through de-icing. He has vast flight operational experience in northern Norway and elsewhere in Europe. Mr Holm joined Transport Canada in 1979, served as a civil aviation inspector and check pilot for air carrier flight crews and later worked in civil aviation planning. In 1987 he was appointed to the senior operational position at Pearson International Airport.

Mr Holm was an extremely knowledgeable witness. He had been specifically sought out for his position at Pearson by the airport general manager, Mr David McAree, who wanted a superintendent with operational experience. He was head of airside operations at Pearson International as well as chairman of the Civil Aeronautics Committee and the Aviation Safety Committee at the airport. Mr Holm testified that after taking up his position, he found that many of the incidents occurring at the airport related to ground de-icing of aircraft. He proceeded to gather statistical information on hold-over times of flights by Air Canada, Canadian Airlines International, and Wardair, after de-icing, and found "that there was a significant number of flights that had holdover periods of several hundred percent in excess of the time the fluid theoretically should be good for" (Transcript, vol. 78, p. 48). Addressing the operational problems at Pearson, Mr Holm concluded:

A. They were operational realities, and they were getting substantially worse with the increase of traffic. And I was very concerned about the overall layout of the airport, which got worse and worse. It seemed like there was very little operational input. With "operational input," I mean input from somebody with significant airport planning knowledge and insight into aircraft operation.

And it seemed like the only thing that was looked at was more or less construction costs. The actual cost of operation or effect on flight safety was not part of the consideration.

Q. That's the way you saw it when you came in?

A. That's the way I saw it, and I think that I based that perception on some of the issues that I had seen passing through the air

> navigation planning section, such as I briefly saw the Terminal 3 approval process.
>
> (Transcript, vol. 78, p. 28)

Both Mr Vasey and Mr Holm agreed in their evidence that there was little operational input into the actual planning of the airport and that construction costs were the only consideration. Mr Holm was in complete agreement with Mr Vasey that Terminal 3 was in the wrong location. He testified that, before construction began on Terminal 3, he had suggested that it ought to be located infield. Mr Holm's evidence relating to the management structure at Pearson International is pertinent:

> Q. And you felt that there was insufficient representation on the operations side within the Airports structure at Pearson?
>
> A. That's true, and I felt that the section dealing and running the overall airport operation or the airside operation should be, minimum, run by a director with significant aviation knowledge and background.
>
> I also felt that it should not – the operational function should not be spread over so many managers as it currently is. It caused a lot of confusion and a lot of things being – falling through the cracks and also matters being done twice and difference in opinion and so forth.
>
> (Transcript, vol. 78, pp. 58–59)

Planning an airport without input from officials involved in flight operations is similar to planning a hospital without consultation with the medical doctors over the design of the facility in which they are to work.

Mr Holm supported Mr Vasey's contention that there was a lack of concrete at Pearson:

> Q. ... Now, you also – you've also made recommendations for more taxiways, which would always be nice; is that correct?
>
> A. Well, one of the main problems at the airport for the air traffic controllers, as was explained by Clare Vasey yesterday, was simply the availability of concrete.
>
> (Transcript, vol. 78, p. 43)

He explained that he had made proposals to alleviate the congestion on the apron area:

> A. Also, I proposed to expand the apron area to include, possibly, taxiways on the apron area itself.
>
> Q. Around which terminals?
>
> A. Around Terminal 1 and Terminal 2 to ease the operation and congestion right now – right in that area, right –

At the current time, basically it's a one-way street, and it's a narrow one-way street. It is, on several places, below the standards, and with the start-up of the 747-400 operation, of course, it's even tighter.

Q. All right. Now, I think you propose another parallel taxiway north and west of 06 left?

A. That's correct, propose to extend this one (indicating) initially down to join in with the Quebec, but towards the end, down to hook in at the button of 6 left to create more flexibility or a two-way taxiway system, basically.

(Transcript, vol. 77, pp. 45–46)

Mr Holm left no doubt in his evidence about the possibility of an air disaster at Pearson International Airport in the absence of remedial action. While referring to the long departure line-ups on bad days and the need for runway-end de-icing pads, he gave the following chilling assessment:

Q. You recognize a serious safety concern at an airport when you see one?

A. Yes.

Q. All right. Now, the situation that exists at Pearson today where, in bad days, we've got line-ups of aircraft an hour long, 30 aircraft deep after they've been de-iced waiting to take off, a situation that Mr. Vasey described as a potential disaster waiting to happen, is it your opinion as an experienced pilot that that is a dangerous problem, a safety concern?

A. It's a very serious safety concern, and my personal feelings are that we are just very lucky we haven't had an accident so far.

...

Q. And, hopefully, this Inquiry will stop another Dryden from happening at Lester B. Pearson International Airport this winter; is that right?

A. That's right.

Q. And the only way that will happen is if we get these de-icing pads put in place; is that right?

A. ... It's hard to do everything in a short time frame, but at least take some of the immediate steps and maybe take some interim steps, such as, perhaps, find a current area where you can do last-minute backup de-icing or something to that effect, but at least attempt to make it safer this winter, and then go forward and do what I proposed.

Q. So, sir, you've had the intestinal fortitude to get up on this witness stand and to tell Canada that another Dryden can happen at Lester B. Pearson International if things aren't done immediately; is that right?

A. That's correct, yes.

(Transcript, vol. 78, pp. 132, 156)

De-icing Personnel

First-hand evidence on de-icing procedures at Pearson International Airport was given by an Air Canada senior station attendant, Mr Paul Lefebvre. Mr Lefebvre is the co-chairman of the Airport Operations Safety & Health Committee, Air Canada, at the airport. He testified about the confusion and disagreement between Air Canada de-icing attendants and their co-ordinators during the severe winter storm on February 15, 1990. He described the snowstorm as follows:

> Q. Sir, I would like to deal with you a little bit more about the February the 15th, '90 incident.
> Do I take it that this was a very bad winter storm?
> A. Yes, it started out as a snowstorm in the morning, medium snowstorm, and it developed into a heavy snow storm, and then it developed into a heavy freezing rain, ice pellet storm.
> Q. What time did you get on work that day?
> A. I started at 5:00 a.m.
> Q. And were you de-icing planes right at the beginning of the day?
> A. Yes, we started right away.
>
> (Transcript, vol. 79, pp. 189–90)

The co-ordinators, he indicated, had instructed the de-icing attendants to de-ice aircraft with hot water and, immediately thereafter, to apply the Air Canada type II anti-icing fluid that had recently been introduced. When the attendants found that the aircraft wings were freezing right after this procedure, they advised their co-ordinators by approximately 10:30 a.m. and requested permission to use a hot 30 per cent glycol/70 per cent water solution instead of the hot water. The co-ordinators nevertheless insisted that the hot-water procedure continue. Mr Lefebvre described the problem as follows:

> Q. ... You've told us that problems developed with the type of fluid that you were using, which was the type 2 fluid.
> A. The problems that we were experiencing were with using the water and not the 30-70 mix to do the washing, as far as I was concerned and many of my co-workers.
> Q. I don't think you've given this evidence, but you can help me if you have: What time did the problem start?
> A. The first time, I believe, I indicated it to my coordinator was around 10:00 or 10:30 a.m. that day that the storm was at the stage where the water wasn't keeping up with what we tried to accomplish.
>
> ...
>
> Q. ... Do you know if any of the other personnel in the de-icing trucks would have passed similar information to the coordinator?

A. Throughout the day, I heard, when I was driving and I wasn't up in the bucket, I heard similar transmissions asking what temperature it was and can we go to a glycol mix, the water's not working. That sort of went on throughout the day.
(Transcript, vol. 79, pp. 190–91)

Mr Lefebvre testified that there were repeated warnings by de-icing attendants to supervisory and management personnel of Air Canada that the de-icing procedures were not working and that ice was re-forming on the wings of aircraft. These warnings were ignored for several hours and aircraft continued to be dispatched. These procedures were not halted by Air Canada management until late in the day.

Mr Lefebvre testified that in the afternoon of February 15, 1990, the worst line-ups for take-off he had ever seen occurred at Pearson International Airport. He said it entered his mind that planes could be going out with contaminated wings. Mr Lefebvre stated that after 6:30 p.m. that day he got out of his truck and asked a de-icing checker if he was familiar with the type II fluid. The checker put his hand underneath the type II fluid on the wing and found ice beneath:

A. ... I climbed out of the truck at about 6:30 to 7 o'clock before I did that last Lockheed 1011, and I asked one of the checkers, had he – was he conversant with type 2 fluid. He said he'd never seen it or had any training on the type 2 fluid, and he was quite angry, visibly upset at the time.
Q. Why was he angry?
A. He was angry that he had to check something that he wasn't trained about, and he was angry that there was ice forming underneath and he couldn't visibly see it without sticking his hand through this gooey substance, which was the type 2 jelly.
(Transcript, vol. 79, p. 192)

Mr Lefebvre commented that "[g]enerally, we have a fairly good operation [but] ... I don't know what was going on ..." (vol. 79, p. 54). He stated that around 7:00 p.m. "we had to close the airport because of what was happening with the fluids" (Transcript, vol. 79, p. 51). (In fact, what Mr Lefebvre meant was that Air Canada had to terminate its operations because of what was happening.) He agreed with Mr Holm's view that the ingredients are present for a potential disaster at Pearson International Airport and he stated he was personally surprised it has not happened already:

Q. Okay. Would you agree with the conclusion reached by Mr. Holm – and I can tell you that Mr. Vasey reached this conclusion also – that the ingredients at Pearson are present for a potential disaster?
A. Yes.

Q. And we're talking about a winter day with pilots under stress in the line-up, air traffic control under stress in the line-up; you agree with that conclusion?
A. Yes, I'm surprised it hasn't occurred already.
Q. And it's probably pure luck that it didn't happen on February the 15th, '90; would you agree with me?
A. That day or any of the days similar.

(Transcript, vol. 79, p. 201)

He testified that Air Canada de-ices some other carriers, including Air Ontario, on request, but that this service does not include control checks by de-icing checkers after the de-icing. He said he has routinely observed such aircraft taxi away after de-icing without being checked. In fact he stated he has never seen an Air Ontario aircraft have a control check after being de-iced by Air Canada. Furthermore, he said in 12 years as a de-icing attendant at Pearson International Airport he has never seen a flight crew with a carrier under contract, including Air Ontario, get out of the aircraft and check the wings after a de-icing.

Mr Lefebvre complained of extremely poor lighting at the gate for de-icing purposes, which he felt was a safety concern. He said that the airport authority, in a cost-cutting endeavour, has removed half of the lighting bulbs at the terminal gates, resulting in extremely poor lighting conditions. He indicated that dim lighting has caused a number of ramp accidents at night, where ramp attendants have been struck by vehicles. He described one occasion when he was convinced he had properly de-iced a Boeing 767 wing but a de-icing co-ordinator, on checking the wing, discovered a ¼–½-inch layer of clear ice on the wing. He stated that repeated complaints by the Airport Operations Safety & Health Committee to Air Canada and Transport Canada regarding the poor lighting resulted in a regulatory amendment to the lighting code that lowered lighting requirements at the gate. As a result, inadequate lights now meet the lowered standards. He indicated that the changed lighting code now requires airport gate lighting of only one-tenth that required for dock workers. His assessment of the situation as "disgusting" is not difficult to understand.

Mr Lefebvre also pointed to a potentially dangerous practice when an aircraft is sprayed at the gate at Pearson International Airport. In contrast to the prescribed practice, which is to de-ice an aircraft wing from the leading edge towards the trailing edge, at Pearson, because there is no space in front of the wing in which to drive a de-icing truck, the wing is sprayed from the trailing edge forward. The reason for applying the de-icing from the leading edge is to prevent damage to the trailing edge control surfaces and to prevent freezing slush and snow from being driven into the control surfaces at the rear of the wing, where they could freeze and jam the controls. Mr Lefebvre stated that, because the gates are narrow, with little manoeuvring room for the necessary equipment, de-icing at the gate is a hazardous situation for both the bucket man, who handles the spray nozzle, and the truck driver.

Moving aircraft away from the gate for de-icing would, however, impact on the ramp taxi areas, which are already inadequate. This again points to the urgent need for more concrete at Pearson International Airport.

Mr Lefebvre gave evidence on the difficult conditions in which de-icing attendants work. They are required to put in long hours in extreme winter weather in an open bucket, exposed not only to the elements but also to the glycol spray, which drifts as far away as three adjacent gates and covers everything. He stated that he has to wipe his goggles continuously but that some bucket operators removed their goggles in frustration and worked without them. An enclosed operator's bucket, such as that provided by the Elephant-Beta system in use at Chicago and elsewhere, would provide a safer and healthier work environment. It is axiomatic that better and safer working conditions produce a better and safer work product.

One further concern raised by Mr Lefebvre is the extremely slippery ramp conditions created by the use of glycol spray in freezing precipitation. He described the result as a "soup" of glycol, jet fuel, and hydraulic fluids, causing attendants to fall and vehicles and aircraft to collide. There is an obvious need for an effective system to clean the gate and ramp areas, such as the Zamboni-type vacuum machine used in Europe.

Mr Lefebvre testified that the Airport Operations Safety & Health Committee at Pearson International Airport had unanimously recommended to Air Canada that de-icing procedures should be moved away from the gate, but without result. He stated that the committee had also written to the minister of transport and the minister of environment in this regard, but had received only an acknowledgment in reply.

Mr Lefebvre said that most spraying is conducted at a distance of 8 to 15 feet from the aircraft surface. He noted that, in some cases, fluid is shot from a greater distance because of a lack of manoeuvring room at the gates. He said that, in his experience, the furthest spraying distance between the spray nozzle and the surface has been as much as 60 to 90 feet. He has had no training from his employer about the rate at which de-icing liquids cool. Expert evidence before the Inquiry indicates that, depending on outside temperatures, the type I de-icing fluid, which is heated to 180°F, can cool as much as 4°F for every foot of distance sprayed. It is obvious that at 60 feet the spray would lose virtually all its heat. Heat is, of course, critical to the de-icing process. The expert evidence is that, for maximum effectiveness, hot de-icing fluid should be applied at a distance of approximately 30 inches from the surface being sprayed. An important bonus from close spraying is that less de-icing fluid is required.

Air Carrier Management

Air Canada

Mr Bjarne Jensen, manager of airport operations and ground equipment services for Air Canada, agreed in his evidence that there was cause for concern about the safety of de-icing practices at Pearson International Airport. He stated he was part of a team in 1989 that tried to set up centralized de-icing close to the runways at Pearson, but that the objective was not pursued because of cost. He agreed, nevertheless, that de-icing bays at the end of runways were very important to the solution of this safety problem:

> Q. ... Would you agree that the hold-over guidelines, at best, provide limited protection?
> A. Yes, sir.
> Q. And would you also agree that, for example, in Toronto, with the various ATC problems we're having, that the queues lining up for takeoff are getting longer and not shorter?
> A. That has been my observation, yes, sir.
> Q. Okay. And would you agree that, in adverse conditions, wing surfaces and other parts of the aircraft may be very difficult for pilots to see, especially at night?
> A. Yes, sir.
> Q. Okay. And, by your own evidence, sir, you would also agree that very few aircraft return to the ramp for secondary de-icing?
> A. That's right.
> ...
> Q. ... Now, in view of these premises which I've just discussed with you, you would not disagree with me that at Pearson, there appears to be a safety concern from a de-icing perspective; would you agree with me on that?
> ...
> A. That's a fair assessment, yes, sir.
> ...
> Q. But, Mr. Jensen, you, then, are in agreement that de-icing bays, with whatever they involve, close to the proximity of the end of runways is something which is very important?
> A. I believe so, yes.
>
> (Transcript, vol. 84, pp. 107, 109, 114)

Mr Jensen agreed that the safety concerns in question were not insurmountable and that there was a high degree of urgency to do something at Pearson before the next de-icing season:

> Q. ... Let me ask you a very fundamental problem, then, sir.

You've outlined some concerns, issues that you feel have to be addressed. You're not raising these as obstacles; they're not insurmountable, are they?

A. No, sir.

Q. Those are all things that intelligent people can address and find proper solutions to; would you agree with that?

A. I think so.

Q. Okay. Now, let's now get right back to Pearson, where we appear to have a problem. You wouldn't disagree with me that there is a – what I would call a high degree of urgency to look at Pearson and have something done at Pearson, if possible, before maybe even the next de-icing season, hopefully before the next de-icing season? Would you agree with me on that?

A. I think I would agree. I think it's –

Q. Has it been studied enough, sir? Have people looked at it?

A. Yes.

Q. People know what the problem is?

A. I believe so.

Q. And it's time to move on and find a solution; would you agree with that?

A. I think so.

Q. Now, one of the problems that everyone is going to raise, no doubt, is something called cost, right?

A. Least of all us, I'm sure, sir.

Q. Yes. Now, would you agree that Air Canada has a certain responsibility to ensure that its aircraft depart in a safe and uncontaminated manner?

A. It goes without saying.

(Transcript, vol. 84, pp. 125–26)

Mr Jensen was of the view that Transport Canada had a high degree of responsibility to ensure that the necessary airport infrastructure was in place for safe operation:

Q. And would you agree with me that there is a high degree of responsibility on our regulator, Transport Canada, to ensure that the airport infrastructure is adequate and correct and safe in order to facilitate a safe operation?

A. I think so, yes, sir.

(Transcript, vol. 84, p. 126)

Captain Charles Simpson, senior vice-president of flight operations for Air Canada, listed congestion as the root cause of the problems at Pearson International Airport:

Q. ... What part of the fundamental system needs to be fixed, in your opinion?

A. The congestion at Pearson International.
Q. I take it from that, sir, what you are telling us is that the root problem, the root source of concern to you as a pilot, has to be congestion at Pearson?
A. Congestion at Pearson is a major problem, yes.

(Transcript, vol. 123, p. 18)

Canadian Airlines International

Mr Andrew Triolaire, director of safety and the environment for Canadian Airlines International, also supported the view that congestion, departure delays in bad weather, and aircraft ground de-icing were safety concerns at Pearson International Airport:

Q. ... there's no hard-and-fast rule on how long that de-icing would be good for? Would you agree with that, sir?
A. Yes, I would.
Q. And would you agree with me that, in particular in Toronto at Pearson, that, of late, because of ATC problems, congestion and possibly other reasons, that queues at times are getting longer, longer than they were in the past, sir?
A. Yes, I'll agree. That's quite true.
Q. Okay. And that the condition of wing surfaces and other parts of the aircraft that may have – and I use the word "may" – that may have contamination adhering to them are difficult for a pilot to see, particularly at night?
A. That is correct, yes.
Q. Okay. And it's also not in dispute, sir, I believe, that not very many aircraft return back for secondary de-icing?
A. That is correct.

(Transcript, vol. 85, pp. 59–60)

Mr Triolaire agreed with Mr Jensen that the installation of runway-end de-icing bays would be in the interest of aviation safety. He also agreed that Transport Canada, as the airport authority, bore a responsibility to ensure that a proper airport infrastructure was in existence at an airport like Pearson in Toronto:

Q. ... The second option that I explored with Mr. Jensen that he seemed to be leaning to as being viable, sir, was to create de-icing locations in close proximity to the end of runways.
How do you feel about that, sir?
A. I believe it's a distinct possibility that we could have a better operation that way.
Q. Do you think that that type of an operation, sir, would be in the interests of aviation safety, particularly at Toronto Pearson?
A. Yes, it would be.

Q. Okay. And from the evidence that you've heard on Friday from Mr. Jensen, it would appear, sir, that there is a possible problem which may exist at Pearson during wintertime conditions when de-icing is required. You wouldn't disagree with that, would you?
A. No, I wouldn't disagree with that.
Q. Now, if we then take that as a starting premise, Mr. Triolaire, you would also not disagree that Canadian has a responsibility to ensure that its aircraft depart in a safe and uncontaminated fashion?
A. That's correct, yes.
Q. And that there is also a high degree of responsibility on Transport Canada or the airport authority to ensure that there be a proper infrastructure at a given airport like Toronto to further that end?
A. Yes.
Q. Now, if we then have these two areas of responsibility demarcated, would you also agree that it is necessary that this matter be pursued and that some type of proper resolution be found in the interest of aviation safety and to assist the travelling public?
A. Yes, I do.
Q. And Canadian Airlines, as indicated by your counsel, would be prepared and would undertake to, as soon as reasonably possible, to sit down with major carriers, like Air Canada, and the regulators to further that end, hopefully to find a resolution before the next de-icing season?
A. Yes, we will.

(Transcript, vol. 85, pp. 59–60)

Ripple Effects

Mr Holm and Mr Vasey agreed in their evidence that departure delays at Pearson International Airport not only affect Toronto air traffic but also have a ripple effect across Canada and in the United States and Europe as well. Mr Holm testified:

Q. ... I would like to deal with you about the rest of Canada and how problems at Pearson can have a ripple effect.
You heard Mr. Vasey's evidence yesterday?
A. Yes.
Q. All right. Would you agree with him that problems at Pearson where there's delays of an hour, two hours sometimes, affect Timmins, they affect Thunder Bay, they affect Dryden, and they can ripple across Canada; would you agree with that?
A. Yes, in fact, it probably ripples all the way down – a fair distance down in the U.S. as well.

Q. So, the poor planning, the lack of proper de-icing facilities at Pearson, affect virtually all of Canadian air space?
A. And U.S. air space, yes.
Q. And U.S. air space. And do these problems ripple their way through such that you can have a pilot sitting on the ground in Thunder Bay with a delay knowing that there's another problem at Pearson, a place that he flies to all the time; does that give him added stress?
A. It would, because it prevents him from doing his job and, in the long term, it would be an annoyance factor, a definite annoyance factor.

(Transcript, vol. 78, pp. 156–57)

In other words, traffic congestion at Pearson International Airport can cause departure delays that are sufficiently extensive for ATC flow-control procedures to be put into effect. These procedures in turn cause delays at other airports in Canada and the United States.

3 USE OF DE-ICING AND ANTI-ICING FLUIDS

I shall now refer to other evidence before this Commission which is highly relevant to an evaluation of the aircraft ground de-icing experience in Canada compared with that in the United States and the 21 member nations of the Association of European Airlines (AEA). I shall focus on the evidence pertinent to the areas of concern that I have noted.

Europe

Association of European Airlines

For approximately 20 years the major airlines of 21 European countries have been using a standardized de-icing and type II anti-icing fluid. These airlines have entered into an association known as the Association of European Airlines (AEA).

AEA Type II Fluid

As a result of research by aircraft manufacturers, the AEA, and European fluid manufacturers, an improved type II fluid has been developed, which is now in its third generation. AEA type II fluid is a glycol based anti-icing fluid containing corrosion inhibitors, wetting agents, and polymeric thickeners. This pseudo-plastic fluid, applied at ambient temperatures, provides increased hold-over times. As stated earlier, hold-over time refers to the length of time during which de-icing or anti-icing fluid offers protection against freezing precipitation. In Europe, type II fluid is used after de-icing with type I fluid, in order to anti-ice an aircraft on the ground. According to AEA charts, type II fluid can provide a hold-over time in freezing precipitation of approximately 45 minutes after application. A number of variables can increase or decrease the hold-over time period. European pilots are provided with hold-over charts that are to be used as guidelines in determining hold-over times prior to take-off in various weather conditions.

Early AEA type II fluids were found to affect the aerodynamics of flight to a certain extent by reason of their resistance to shearing from the aircraft wings on take-off. The new third-generation AEA type II fluid, however, has shear properties similar to those of type I de-icing fluid, which has virtually no effect on the aerodynamics of flight. Rudy Hornig of Lufthansa German Airlines in his presentation at the Society of

Automotive Engineers (SAE) International Aircraft Ground Deicing Conference in Denver, Colorado, on September 20–22, 1988, stated:

> The rheological properties of the AEA Type II products have, over the years of testing and retesting and making this lab test and that flight test, improved in such a way that based on and confirmed by the wind tunnel testing, the aerodynamic effects between advanced Type II products and Type I products are similar or identical. Therefore, the principle objections against Type II fluids (they are affecting the aerodynamics more than the Type I products) should in our understanding no longer be viable.
>
> (Exhibit 613, p. 151)

Captain Gert Andersson, a veteran captain with Linjeflyg, a Swedish regional airline owned by SAS, who has some 17,000 hours of flying time including 5000 hours on F-28 aircraft, testified in even stronger terms that third-generation AEA type II fluids, in actual flight tests, have exhibited better aerodynamic qualities than type I fluids. Captain Andersson is a world authority on winter operating conditions and on de-icing and anti-icing fluids.

The use of the type II anti-icing fluid by the European carriers of AEA countries is mandatory. Foreign airlines flying into an AEA country must use this fluid in adverse weather. All Canadian carriers flying into Europe in fact do so.

Mr Bjarne Jensen, manager of airport operations and ground equipment services for Air Canada, acknowledged that Air Canada aircraft use the AEA type II fluid in Europe:

> Q. ... I would like to just deal briefly with the AEA type 2 fluid. I take it that Air Canada's present type 2 fluid does not meet the AEA specs?
> A. That's correct.
> Q. And yet we know today that Boeing has approved of the AEA type 2?
> A. That's correct.
> Q. We know that United uses it at Chicago?
> A. Yes, sir.
>
> ...
>
> Q. It's a Mil. spec. But if Air Canada aircraft are in Europe –
> A. Yes, sir.
> Q. – then I'm assuming that you would use the type 2 fluid, the AEA?
> A. That's right.
>
> (Transcript, vol. 84, pp. 174–75)

Mr Andrew Triolaire, director of safety and the environment for Canadian Airlines International, verified that his company also uses the AEA type II fluid in its European operation.

It is a matter of great significance that during the past 20 years in which the AEA countries have used their type II anti-icing fluid exclusively, there has not been one airline crash in Europe related to ground icing.

Canada

De-icing Fluids and Hold-over Times

In Canada, except in the winter of 1989–90 when Air Canada introduced its own type II fluid, a type I de-icing fluid heated to 180°F has been used exclusively to de-ice aircraft. The type I fluid, which in concentrated form consists of a mixture of glycol and water, is primarily a de-icing fluid that removes surface contamination. In non-freezing precipitation it has limited anti-icing properties, providing in the most favourable conditions a maximum hold-over time of 15 minutes before freezing begins. In freezing precipitation the effective hold-over time of type I fluid is reduced to as low as one minute, depending on some 37 variables cited by expert witnesses.

The evidence of a number of pilots who testified before this Commission demonstrated shocking confusion, and lack of understanding on their part, about the effective hold-over time of such fluid in varying weather conditions. Some pilots who testified did not know the difference between type I and type II fluids. This is a clear reflection of the low priority that the airlines and Transport Canada have given to educating pilots about aircraft surface contamination.

The evidence indicates that imprecise de-icing fluid hold-over charts and, in some cases, dangerously inaccurate information about de-icing fluid hold-over times has been provided to Canadian pilots. For example, Captain Robert Nyman, director of flight operations for Air Ontario and a highly experienced pilot, stated in his testimony that he produced a memorandum dated January 20, 1988 (appendix C), for circulation among Air Ontario pilots, which advised that de-icing with type I fluid provided a hold-over time of 15 minutes in freezing precipitation. This memorandum was issued to countermand an earlier Air Ontario memorandum to pilots which postulated a 30-minute hold-over time for type I fluid in freezing precipitation. He testified that he produced his January 1988 memorandum for type I fluid following consultations with Mr Galliker of Air Canada, from whom he verbally obtained this information. However, Air Canada's de-icing hold-over chart, which is an exhibit before this Inquiry (appendix D), indicates a maximum hold-over time of only three minutes for type I fluid in freezing drizzle or in heavy snow at 0°C.

The confusion among pilots over the actual hold-over time provided by type I de-icing fluid is typified by the evidence of Captain Joe Deluce, Air Ontario chief pilot for the F-28 and CV-580 aircraft. He was extensively questioned, in testimony during the week of September 24–28, 1990, regarding two incidents in which he was involved as pilot-in-command and in which take-offs were made with contamination on the aircraft surfaces. The evidence disclosed that severe vibration of the aircraft occurred immediately following lift-off in both cases, necessitating an emergency return for landing. Both incidents occurred prior to the Dryden crash, the last incident on December 15, 1987, at Pearson International Airport. His aircraft had been in a line-up for up to 40 minutes after de-icing with type I fluid, awaiting take-off in heavy snowfall conditions on a slush-covered runway.

Captain Deluce was questioned about his knowledge of the hold-over protection provided by the de-icing fluid that was, and is, in use by Air Ontario – the type I fluid. The evidence indicates he did not have any hold-over chart to consult. His testimony strikingly illustrated the serious lack of awareness among pilots concerning the severe limitations to protection afforded by the type I de-icing fluids:

> Q. At that time, sir, in 1987, were you aware of the length of time that protection would be obtained if fluid de-icing was effected?
>
> A. I don't – we didn't have anything specific that I recall, but it was a judgment call that pilots had to make, and it would vary. It would vary on the particular circumstances as to what kind of protection that you had.
>
> I was – I was – I was under the belief that with de-icing fluids, that it could be up to 45 minutes.
>
> (Transcript, vol. 121, p. 125)

After pointing out that he had no specific hold-over chart to refer to for guidance, Captain Deluce gave testimony as follows:

> Q. ... If it was left to the judgment of the flight crew and you were the flight crew on that day, what was your judgment on the duration of the hold-over time for the de-icing that was done?
>
> A. Well, I would make that judgment – well, first of all, it was my judgment that it could hold over for a considerable period of time.
>
> Q. What is that?
>
> A. It depended on the conditions and –
>
> Q. Well, you knew the conditions, sir. I wasn't there. You were in the aircraft, you knew the conditions.
>
> What is your estimate of what the hold-over time was of the fluid that was used, de-icing?
>
> A. Well, I estimated that it could have been up to 45 minutes or an hour, depending on the conditions ... but I didn't specifically – you know, I was making my judgment calls based on what I was seeing.
>
> (Transcript, vol. 112, pp. 132–33)

The evidence is, of course, that under the most ideal conditions only 15 minutes' protection is provided by type I fluid. In heavy snow or freezing precipitation, the protection can be reduced to virtually nil.

Captain Deluce's evidence echoes that of many others and indicates the need for more intensive pilot education in this area. I point out the difficulty facing pilots in making reasoned judgments about the condition of their aircraft surfaces in adverse winter weather in the absence of more precise and scientifically validated hold-over chart information. There are some who question the provision of hold-over charts to pilots on the basis that such charts may lull pilots into a false sense of security. This is certainly not the view of most of the experts who testified nor is it that of the pilots, who testified they need all the help they can get in making crucial safety decisions.

Although the information given at present on hold-over charts cannot be taken as gospel because of the many variables, these charts can and certainly should be used by pilots as guidelines, as has in fact been done in Europe successfully for many years. The alternative is to force pilots to rely only on their judgment, which is to say, in this scenario, that they must rely on their best guess as to whether it is safe to take off or not. The wrong guess could produce catastrophic results. Surely this is unacceptable. Expert witness after expert witness has testified before the Commission as to the need for giving pilots every assistance possible to make reasoned judgments when faced with a "go" or "no go" situation.

Captain Nyman testified that his January 20, 1988, memorandum advising a hold-over time of 15 minutes for type I fluid in freezing precipitation would have been provided to Captain George Morwood and First Officer Keith Mills, the cockpit crew of Air Ontario Flight 1363 on March 10, 1989. One can only speculate on the number of Air Ontario pilots, and indeed Air Canada pilots, who have taken off in freezing precipitation after exceeding the three-minute actual hold-over time in the mistaken belief they had 15 minutes of hold-over time. I have no doubt, from the evidence I have heard, that there were many. There is no reason to believe the situation is any different with other carriers in Canada.

De-icing a Large Aircraft

The evidence indicates that, depending on conditions, it can take from 5 to 10 minutes to de-ice an aircraft such as a Boeing 767. In freezing precipitation, given a one-minute or even a 10-minute hold-over time, it is obvious that a large aircraft cannot be completely de-iced before the first areas treated with the type I fluid begin icing up again.

The evidence is that aircraft are routinely dispatched at Pearson International Airport and elsewhere in Canada in various weather conditions, including freezing precipitation, after having been de-iced with type I fluid.

De-icing and Line-ups

The evidence further shows that after being de-iced with type I fluid in adverse winter weather conditions, aircraft at Pearson International Airport routinely enter and remain in line-ups for take-off for varying periods of time that can frequently be as long as 45 minutes and occasionally in excess of one hour. Bearing in mind that as many as 25 to 30 aircraft can be lined up at any one time awaiting take-off, the implications from the perspective of flight safety are obvious. In view of the prohibition against take-off with contamination adhering to aircraft surfaces, one would expect that a considerable number of aircraft would be returning for a second de-icing in freezing precipitation.

The most startling of the evidence adduced in this phase of the Inquiry was the statistic on the number of aircraft that left the departure line-ups at Pearson International and returned for a second de-icing during the winter of 1989–90, a winter that featured some of the worst weather conditions experienced in a number of years. At Pearson International there are approximately 1100 aircraft movements per day. Mr Jensen testified that throughout the entire 1989–90 winter season only two Air Canada aircraft left a departure line-up and returned for a second de-icing at Pearson International Airport, and that none returned on February 15, 1990, the day on which the worst weather of the entire winter occurred. Mr Jensen also testified that only 11 Air Canada aircraft returned for a second de-icing in all of Canada during the winter of 1989–90.

The evidence given by Mr Triolaire disclosed that Canadian Airlines kept no records whatsoever on the number of aircraft that return from a line-up for a second de-icing. He conceded, however, that the return trip is not often made:

Q. ... you sit in those queues from anywhere up to 35, 40, 45 minutes; is that the evidence?
My friend tells me up to one hour; that's what the evidence has been.
A. I think anybody that's sitting in a queue for 45 minutes would find - under those circumstances would find that, with a type 2 fluid, that it would be approaching the limits of a type 2 fluid.
Q. No, we're talking about Canadian and type 1 right now.
A. I know we are. And type 1, we would find ourselves having to taxi back and have the aircraft de-iced again.
Q. And you've indicated earlier, sir, that that return trip is not made very often by Canadian aircraft; is that right?
A. Yes, that's correct.
Q. And you don't have any specific statistics to show, indeed, how many actual times that it did happen?
A. No, I'm afraid I don't.

Q. And Canadian does not keep those statistics?
A. No, we don't.

(Transcript, vol. 85, p. 35)

The absence of statistics is not limited to Canadian Airlines. Transport Canada was also not able to provide any statistics, nor was it able to demonstrate that physical checks of departing aircraft were ever done by Transport Canada inspectors during times of inclement weather. This is corroborated by the evidence of Captain Smith:

Q. ... Now, in your 33 years with Air Canada, have you ever seen Transport Canada regulators check departing aircraft to ensure that they are being operated within the requirements of ANO [Air Navigation Order] series VII, numbers 2 and 3?
A. Not that I'm aware of, no.

(Transcript, vol. 76, p. 125)

Air Canada's Use of Fluids

Air Canada is the parent company of Air Ontario and, at all material times, owned, and presently owns, a 75 per cent interest in the voting stock of Air Ontario as well as a 90 per cent interest in the preferred non-voting stock. Air Canada's working relationship with its regional carrier, Air Ontario, up to March 10, 1989, and thereafter, is being closely examined in the next phase of this Inquiry.

The evidence shows that Air Canada, a major Canadian carrier, has been developing its own version of a type II anti-icing fluid. Evidence before the Commission indicates that the Air Canada type II fluid has shearing properties equal to the AEA type II fluids but that it provides half the hold-over time of the AEA type II fluid. As already stated, Air Canada used its type II fluid for a brief time in its operations at Pearson International Airport during the winter of 1989–90, although supervisors discontinued its use during the severe storm on February 15, 1990, when they found that ice was forming beneath the type II fluid on wing surfaces that had first been de-iced with hot water in freezing precipitation. Several de-icing experts, including Captain Gert Andersson of Sweden, an internationally recognized European de-icing expert, testified before this Commission that de-icing in freezing precipitation should not be accomplished with hot water prior to application of the type II anti-icing fluid. Captain Andersson said that although its use is authorized, hot water is in fact never used to de-ice aircraft in the AEA countries. Rather, de-icing is always accomplished using hot type I de-icing fluid, after which the cold type II anti-icing fluid is applied. The reasoning is self-evident. Water freezes in freezing temperatures much sooner than type I fluid.

Mr Richard Adams, who directed de-icing research for the Federal Aviation Administration in the United States, testified that he knew of no other airline that de-iced with hot water before the application of type II fluid. Mr Jack Lampe of Chicago, the person in charge of all de-icing of United Airlines aircraft in the entire United States, testified that his airline does not de-ice with hot water: "I'm not a proponent of water de-icing. We use a minimum of 20 percent glycol in Chicago, so we would de-ice with 180-degree fluid" (Transcript, vol. 82, p. 64). When heated, type II fluid can be used as both a de-icing and an anti-icing fluid. However, it does not make good business sense to use type II fluid for de-icing, because of its higher cost. Air Canada has in fact used its heated type II fluid to de-ice and anti-ice the under-carriage area of its aircraft.

Two reasons were given for Air Canada's use of hot water rather than glycol for de-icing – cost and environmental concerns. Glycol is far more expensive than water. Mr Jensen testified that cost was a factor in Air Canada's decision to de-ice with hot water instead of glycol: "I'm not hiding the fact that cost is a factor. Definitely, it is. If I can dispense hot water at a cost of simply heating it as opposed to dispensing a hot fluid that would cost me a dollar and twenty-four a litre to buy, yes, sir, I will definitely look at hot water. But I think we have a responsibility beyond the pure economics" (Transcript, vol. 84, p. 172).

There can be little doubt that at least some, and probably a large number, of Air Canada aircraft took off at Pearson International on February 15, 1990, with contaminated wings. The pilots of these aircraft would likely have assumed their aircraft were properly de-iced and anti-iced, relying, according to the evidence, on the assurance of the ramp de-icing co-ordinators that the aircraft surfaces were clean.

An internal technical presentation was made to senior Air Canada management on February 22, 1989, regarding ground de-icing and the use of type I and type II fluids. The submission to the senior management with regard to the hold-over protection provided by Air Canada's type I fluid included the following significant statement:

> This fluid will provide a hold-over time of *maximum* 15 minutes ... There is practically no hold-over time during freezing rain conditions ... Taxi-out times after de-icing in the 1970's and 1980's were relatively short compared to the situation today, and in particular Toronto.

The fact that Air Canada senior management was being alerted to this area of serious concern as late as February 22, 1989, is a further indication that the entire subject of aircraft wing contamination hold-over times and ground de-icing has, until very recently, enjoyed a low priority in the Canadian airline industry.

Colour Coding

During cross-examination of Mr Jensen, it was disclosed that a ground de-icing information bulletin issued by Air Canada to its ground de-icing crews incorrectly described the colours of type I and type II fluids used in Canada at present. The type I fluid was described as being blue in colour, whereas it is actually orange, while type II fluid was said to be orange although it is in fact blue. The purpose of the colours is to make it possible to differentiate visually between the two fluid types. At the very least, it can be said that this misstatement of the facts would be confusing, not only for the de-icing crews but also for the flight crews. It was indicated that steps are being taken by Air Canada to rectify the situation.

Canadian Airlines International's Use of Fluids

Mr Andrew Triolaire testified that Canadian Airlines International has not used type II fluid at all in Canada, that it lacks the necessary equipment to do so, and that it relies on type I fluid for all of its ground de-icing operations. Apparently unaware of the favourable aerodynamic characteristics of the third-generation AEA type II fluids, Mr Triolaire still spoke of the need for caution in using type II fluids. He did concede, however, that Canadian Airlines de-ices its aircraft with AEA type II fluid in its European operations:

> Q. ... What is the fundamental reason, sir, why the type 2 has not been adopted in Canada?
>
> A. Within our airline, we, as I mentioned earlier, haven't had the equipment necessary to use a type 1 and 2 fluid or a combined hot water — type 1, type 2 ...
>
> But, coming back to the central European operation with type 2, it's a matter of - as I recall, it's a matter of capability to handle a type 2 fluid. We are - we have been for years using type 1. To change would be a rather significant change for us ... we have found that, through the combining of all the airlines to form Canadian, that we - we have stayed with type 1 fluid. And that's why I'm saying we will examine the use of type 2.
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> ...
>
> A. I have asked - and I believe the other department heads have asked - that the - we move cautiously, which is the normal practice in merging airlines, and - to ensure that we keep our procedures as straightforward as possible, and the use of more than one type of fluid, for example, is a concern.
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> (Transcript, vol. 85, pp. 131–32)

Cost of De-icing Fluids

Mr Triolaire indicated that the matter of cost was also a factor in the decision by Canadian Airlines International not to use type II fluid:

Q. And do you intend to examine the use of that fluid at the major hubs of your system, or do you intend to examine it throughout your system at all of your station stops?
A. I can't answer that question by saying that, yes, we will use it at all areas. One, we haven't - we haven't met to make that decision. But we - the committee that - internally within the airline that will examine it will certainly give consideration to its use. To what degree, I can't say at this time. And, as you know, in order to apply, it will require specialized equipment.
Q. And a significant cost to the company?
A. There will be significant costs and issues, that's quite correct.
Q. Nevertheless, it's your personal opinion that you'd like to see its application throughout your system?
A. It's my personal opinion that the use of type 2 fluid would be advantageous.

(Transcript, vol. 85, p. 121)

Both U.S. and European experts have testified that there is only a marginal difference in cost between the two types of fluid. There is, however, a very great difference between the two types of fluid in terms of maximizing hold-over times and, therefore, aviation safety.

The matter of the cost of type II fluids, compared with that of type I fluids, was canvassed during the hearings in order to test the validity of any argument for their non-use in Canada based on cost. Any such reasoning would be difficult to follow in the light of the AEA statistics on the cost differential between the two types of fluid. Captain Andersson, of Lynjeflyg Airlines in Sweden, testified that negotiations with AEA fluid manufacturers in Europe have resulted in the following prices for the 1990–91 season:

Type I (90 per cent glycol content)	Cdn$1.43 per litre
AEA type II	Cdn$1.60 per litre

(Note that the type I fluid used by Canadian carriers has a maximum of 50 per cent glycol content.)

The price differential between type I and AEA type II fluid is only about 10 per cent. However, the difference in hold-over protection provided by type II fluid, compared with the type I fluid, is enormous. The price differential between the two fluids is a small price to pay for the vastly increased margin of safety provided by the AEA type II fluids.

Thus, the evidence before the Commission clearly suggests that the reason for the non-use of the proven European AEA type II anti-icing fluid in Canada is primarily related to the issue of cost. Given the evidence of numerous world-level ground de-icing experts on the proven effectiveness of the AEA type II fluids, it is difficult to comprehend the logic of Air Canada's efforts to reinvent the wheel by experimenting with the production of its own version of type II fluid instead of acquiring licence to manufacture the already proven European type II fluids, as is being done in the United States. While there may be a commercial advantage in developing a domestic type II fluid, this goal should not be achieved at the price of aviation safety during the developmental stage of such a fluid. It seems reasonable to suggest that until a satisfactory Canadian type II fluid, which meets AEA specifications, is developed and available, Canadian carriers should be strongly encouraged, in the interest of aviation safety, to acquire and use the proven AEA type II anti-icing fluid, which, in fact, is already being manufactured in the United States under licence.

De-icing Equipment

Representatives of the two major Canadian carriers raised an additional reason for resistance to the introduction of type II fluid. The evidence is that new equipment capable of dispensing the type II fluid would have to be acquired, or older equipment modified, with attendant costs. These costs, however, in my view are not a valid reason to resist change when the safety of the air-travelling public is at stake. The European airlines embarked on this process more than 20 years ago.

In the case of both major Canadian carriers, the evidence clearly suggests that new ground de-icing equipment is overdue in any event. Mr Lefebvre, a senior Air Canada station attendant, testified that Air Canada is at present using a fleet of de-icing trucks and equipment which, for the most part, dates as far back as the 1960s:

Q. Sir, my notes don't tell me what age the R trucks are. Are they the oldest of the trucks which you called –
A. They're the newest. They came, I believe, in the mid-'80's.
Q. The mid-'80's?
A. Yes, I can't be certain of the year.
Q. And how old are the L trucks, roughly?
A. Roughly, late '60's, early '70's.
Q. And how old are the H trucks?
A. I'd say early '60's.
Q. So Air Canada uses these trucks for a long time, don't they?
A. Yes, they get their money's worth.
Q. Can we then say that if Air Canada were to purchase the new Elephant Beta system that, in all likelihood, they'd get their money's worth.
A. Yes.

(Transcript, vol. 79, pp. 188–89)

Most of this equipment is obsolete, antiquated, and, according to Mr Lefebvre, in such poor condition that the de-icing crews actively compete to get on the few later model units that are considered safer to operate. Mr Jensen of Air Canada indicated that his airline's de-icing equipment likewise consists primarily of a conglomeration of various types of older equipment from several merged companies. He too raised the matter of cost.

However, new or modified de-icing equipment costs would be relatively minuscule compared with the cost of acquiring one large jet transport aircraft. The cost of a Boeing 747, including spares, for example, is approximately $200 million. A fraction of the cost of one such aircraft would far more than pay for the provision of appropriate de-icing equipment and for runway-end de-icing pads at Pearson International Airport. This is not to say that the carriers alone should bear the financial burden of runway-end de-icing facilities. Transport Canada clearly has a responsibility in this area, a subject referred to later in this report.

New, highly efficient, mobile de-icing equipment such as the Elephant-Beta system is available and in use at European airports and at O'Hare International Airport at Chicago.

Given the long line-ups at Pearson International Airport in adverse winter weather and the opinion of expert witnesses that this airport has the potential to be the site of a major air disaster, I am emphatically of the view that Transport Canada and the Canadian air carriers must take immediate steps on the most urgent basis possible to remedy the situation.

Of major significance is the evidence before this Inquiry which established that in the past 20 years a total of 14 major airline crashes have occurred in North America, at a human cost of hundreds of lives. All of these crashes, including the Air Ontario crash at Dryden, Ontario, on March 10, 1989, have been directly related to the ground contamination of aircraft surfaces by ice or snow (appendix E).

United States

Mr Eugene Hill, an internationally recognized aeronautical engineer with extensive experience in aerofoil lifting characteristics associated with anti-icing fluids, indicated that the aviation industry in the United States is moving rapidly towards the use of type II anti-icing fluid. Several U.S. manufacturers have been licensed to produce the third-generation AEA type II fluids used in Europe:

> Q. Are newly-developed type 2 fluids being manufactured and used in North America as well as in Europe? In other words, are they manufacturing type 2 fluids now in North America?
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> A. Yes, they are manufacturing European type 2 fluids here in the United States. The examples I can give you is that companies like ARCO is producing – it's under licence with Kilfrost to produce the Kilfrost ABC-3 here in the United States, or they may be actually importing it for a while until it's being manufactured here.

> Another company that has licence to produce the fluid is Dow, is currently producing the Hoechst 1704 LTV 88. And also Texaco recently contracted with the French firm SPCA to provide the SPCA AD 104 in the United States ...
>
> Q. Now, these – are these the new type 2 fluids that you're speaking about?
>
> A. When I'm speaking of the fluids produced by Kilfrost, SPCA and Hoechst, they are indeed the fluids that are the so-called third generation or that develop out of the experimental fluids that were evaluated during the 1988 wind tunnel testing.
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> (Transcript, vol. 81, pp. 47–48)

Mr Hill, who has been with Boeing Aircraft Company of Seattle since 1959, specializes in various phases of aerodynamics. He is responsible for the airworthiness certification of all the Boeing family of aircraft and is the co-inventor of leading- and trailing-edge flap systems. He is a member of the International Standards Committee working on international ground de-icing standards and is participating in SAE subcommittee work on development of recommended standards for aircraft ground de-icing. As a guest lecturer at the prestigious Karman Institute for fluid dynamics in Brussels, he spoke on the effects of fluids as well as frost or solid contamination on aircraft wings.

In his testimony, Mr Hill extensively reviewed the results of sophisticated windtunnel and flight testing of the European type I and type II fluids conducted by Boeing Aircraft in conjunction with NASA Lewis, the AEA, and the FAA. He traced the history of the development of those fluids and stated that the results of these tests were used by AEA fluid manufacturers to develop the current production of AEA type II fluids. He appraised these new fluids as follows:

> ... compared with the AEA type 1 used historically ... the experimental fluids actually were superior relative to lift loss at the colder temperature [minus 20].
>
> And when compared with the then current type 2 fluids, the experimental fluids were superior in terms of flow-off behavior at both minus 10 and minus 20.
>
> As it turns out, the fluid manufacturers have used the results of this test to develop the current production type 2 fluids, which have characteristics more similar to the experimental fluids than the then current 1987 type 2 fluids. And we were very pleased that we saw that improvement in the fluids and the willingness of the fluid manufacturers to modify their recipes to provide fluids that were less intrusive aerodynamically.
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> (Transcript, vol. 81, p. 33)

Mr Hill went on to refer to the European safety experience with type II fluids:

> In our evaluation of the aerodynamic effects of the fluids, we, of course, hold safety as paramount. We also, as the video commented, realize that the fluid effects are transitory, reducing to about 10 percent of their effects about a minute after liftoff.
>
> They have been successfully used in Europe with a very exemplary safety record in terms of accidents resulting from ground deicing - or ground icing, and there has been some experience even here in Canada on an experimental basis by Air Canada. And also in the United States, Federal Express had also introduced these thickened fluids at their base in Memphis and had an excellent record of being able to safely move their aircraft.
>
> And we also - as I showed on the previous chart, that the new formulation or experimental fluids are essentially equivalent to the historically-used type 1 fluids at the colder temperatures, which is to say that we have had excellent history in use of the type 1 fluids.
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> (Transcript, vol. 81, p. 34)

Despite Boeing's large investment of funds and resources to obtain the data on AEA type II fluid performance, the company, Mr Hill testified, disseminated that information widely. This unselfish corporate act by the Boeing Aircraft Company, in the interests of aviation safety generally, deserves to be publicly applauded.

Besides participating in the 1988 SAE Conference on Deicing in Denver, Boeing wrote a service letter to all airlines describing the test results, in Mr Hill's words, "to make sure that the airlines were aware of our position on use of the fluids and what impact it might have" (appendix F). In response to this letter, Transport Canada issued a Notice to Aircraft Maintenance Engineers and Aircraft Owners on November 20, 1989, dealing with the use of AEA type II fluids (appendix G).

Mr Hill indicated that, except for some performance adjustments for 737-100 and 737-200 aircraft, no adjustments were required by any other of the Boeing family of aircraft when using type II fluid:

> I might comment, because of our considerations for the performance aspect, we did provide adjustments for the 737-100 and 737-200 aircraft where we either require off-load, if the airplane is field length or climb-limited, or increased takeoff speeds to offset the effect of the fluids on the aircraft.
>
> We have found that for the other family of aircraft within Boeing, no adjustments are required. And, as it turns out, as I'll discuss in a few moments, the other aircraft manufacturers, including Airbus, McDonnell Douglas, Fokker, Aero Spatiale, British Aerospace, also feel that there are no performance adjustments required when they use the thickened fluids.
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> (Transcript. vol. 81, pp. 38–39)

Mr Hill testified that studies are now being co-ordinated by Boeing and by the European regional airlines with respect to introducing the use of AEA type II fluid to turbo-prop commuter-type aircraft:

> A. ... The use of the thickened fluids has not been fully understood by the commuter-type aircraft, and it tends to be more segmented than the large aircraft industry, both in terms of the air carriers, as well as the fluid - of the aircraft manufacturers, and there are a number of commuter-type aircraft manufacturers in Europe.
>
> And, as it is turning out, the European regional airlines are providing the focal point on the use of thickened fluids, and they are essentially somewhat following some of the activities or advances or progress we've made with large aircraft, and they are essentially now organizing to look at how do we get these thickened fluids introduced for the turbo-prop aircraft in a safe manner.
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> We have gone back to the Northwest Mountain Region very recently to talk about recent wind tunnel testing.
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> (Transcript, vol. 81, p. 42)

International Standards

Mr Hill supported the goal of establishing international standards for the uniform de-icing of aircraft:

> And, also, toward the goal of reaching international standards and standards such that we have a uniform way of de-icing aircraft around the world and within North America or the United States, we have had several meetings as part of the SAE Ad Hoc Committee, which I believe Dick [Richard Adams] again commented on yesterday. We have supported those meetings, as well as to support the International Standardization Working Group working on international standards.
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> (Transcript, vol. 81, pp. 42–43)

He explained the discrepancy between the European and North American experience in ground icing accidents and other matters as a cultural difference:

> Q. Given all of your experience and everything that you've read on the topic, are you able to offer any insight as to why the European experience is so much different from the North American experience with respect to the accidents?
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> ...
>
> A. I may sound a bit philosophical here, but I think there is a tendency culturally in [North America] for independence, and we can do whatever we want.

Like, we may pass a law that someone riding a motorbike or a motorcycle wear a helmet to protect that person's life, and the motorcyclist will say he doesn't want to wear a helmet.

However, in Europe, I think there is a cultural difference, and once a law is made ... they realize that there is a goal as best for everyone involved that they will strive toward that safety goal. And that's just a cultural difference, let's say, between Europeans and North Americans. And our country was founded on this boot-strap, individual approach.

And that's a difference I had detected in terms of how people look at how they run their businesses and so forth.

(Transcript, vol. 81, pp. 77-78)

Engine Failure on Take-off

Clearly, what Mr Hill was referring to was the tendency on the part of some North American pilots to downplay the admonition against take-off in an aircraft with contamination of any kind on the lifting surfaces. I suspect this view was held by some of the pilots who testified before the Commission. It is rooted in a reliance on the sheer brute power of jet engines to overcome, by their thrust, degradation in take-off performance due to wing contamination. This reliance, however, becomes a deadly trap in the case of loss of engine power on take-off.

Another witness before this Commission was Mr John M. Morgan, a former RAF test pilot who is now employed by the National Aeronautical Establishment in Ottawa as manager of the airborne simulation facilities, a national dynamics research facility. He had this to say about the thrust of jet engines and the catastrophic results of an engine failure on take-off:

Q. We briefly touched on it. Can you expand why you dealt with engine failure on takeoff?

A. Yes, why we dealt with it, I think, is as I thought I had said previously, I think with any accident, there – where a loss of takeoff performance is indicated, one has to look at the power available situation.

The ultimate performance of an aircraft under any flight condition is dependent on the difference between thrust and drag. Thrust is available, drag is present, and [it] is the difference between those two that ultimately determine the performance of the aircraft.

A brick will fly if you give it enough thrust. A barn door will fly if you give it enough thrust. So it is thrust and drag differences, so you would look at the possible loss of thrust.

We found that in the presence of almost any contamination, or any runway contamination, that the effect of an engine failure was so drastic, so catastrophic, that we cease to regard it as being a true factor. (*i.e. in the Dryden crash).

(Transcript, vol. 72, p. 29)

The problem to which Mr Morgan refers has extremely serious implications. Transport-category aircraft are designed to provide an engine-out safety margin for the take-off phase of flight. But there is no provision in normal operating rules or practices that would allow using this safety margin in an attempt to overcome the effects of wing contamination. An air carrier pilot on a routine revenue flight has no way of knowing, prior to take-off, whether a certain amount of contamination on his or her aircraft can be overcome by the engine-out performance margin of the aircraft. In the F-28 wing contamination accident at Hanover, Germany, referred to in the testimony of Mr Jack van Hengst, head of the aerodynamic department at Fokker Aircraft, it was obvious that the thrust available from two properly functioning engines was insufficient to enable the aircraft to fly. To knowingly take-off with any degree of wing contamination is to forfeit the engine-out performance margin of the aircraft and is tantamount to venturing into the realm of test flying with fare-paying passengers on board.

These points were specifically made in the re-examination of Captain Charles Simpson, senior vice-president of flight operations, Air Canada, during which he stated:

> Q. All right, sir. Now, the manufacturer is also required to demonstrate to the certifying or regulatory agencies that an aircraft is capable of accelerating up to or beyond V-1, losing an engine, under certain conditions, for example, weight, temperature, altitude, what have you, and continuing the takeoff safely; no disagreement on that, is there?
>
> A. No.
>
> Q. All right. Now, what flows from this, sir, is then the proposition that an aircraft has inherent in its basic design a performance margin?
>
> A. Yes.
>
> Q. Correct?
>
> A. Correct.
>
> Q. All right. Now, if this aircraft that we now speak of has accumulated some degree of wing contamination, that performance margin is used – and we have evidence to that effect, which I will refer to you in a moment – that performance margin is used to overcome the resultant loss in lift?
>
> A. Correct.
>
> Q. Okay? Now, the problem which then arises, Captain Simpson, is that the use of the performance margin to overcome this loss of lift due to contamination, by doing that, you then forfeit – the pilot then forfeits the engine-out performance margin which he would otherwise have, and that's where the problem starts?
>
> A. Yes, that's correct.
>
> (Transcript, vol. 123, pp. 149–50)

4 RUNWAY-END DE-ICING PADS

Canada

Dorval Airport

The only airport in Canada with a runway-end de-icing facility is Dorval Airport in Montreal, where a de-icing pad is located at the departure end of runways 06 right and 28. Captain Reginald Smith, a senior captain with Air Canada to whom I have already referred, testified on conditions at Dorval:

> Q. So that icing pad at Dorval can service both of those runways; is that right?
> A. That's correct.
> Q. And, sir, how long would it take you approximately to get from where you are de-iced at that pad to either of numbers 1 and 2 which you have marked?
> A. With no traffic in front of you, less than a minute to either departure.
>
> (Transcript, vol. 76, p. 75)

Elsewhere in Canada de-icing is accomplished on the ramp or gate areas.

Pearson International Airport

Current De-icing Procedures

De-icing at Pearson is performed at the gate and on a dedicated area on the east side of the ramp, near the button of runway 24 left. This dedicated area is referred to as a "remote" de-icing area. There are no runway-end de-icing pads at Pearson International Airport. Aircraft are de-iced with the engines shut down.

The words of Gary Wagner, an Air Canada captain and an aeronautical engineer specializing in aircraft performance, are illuminating. He gave the following evidence as to the difficulties facing flight crews in bad weather and the need to improve the system:

> Q. ... Now, it's also a fact that in North America, at least, over the last two decades, we have had a series of apparently ice-related accidents such as Dryden, Gander, Denver, Washington. Isn't that right?

A. Correct.

Q. So to support the status quo for the last 20 years and say, well, you know, it's difficult to detect ice if the plane has been in a lineup for 45 minutes, if you don't do something to change the way things have been for the last 20 years, we can expect to have further accidents such as Denver, Washington, Dryden and Gander, don't you think?

A. That's correct, sir. If I may say, though, I didn't do anything or say anything to suggest that we shouldn't do something to improve things.

What I was actually trying to do to improve things was to point out the difficulty a crew is faced with in the real life situation where you taxi out when it's dark and it's snowing and you can't see through the cabin windows which, of course, is typically what we would do on a large aircraft to see the wings when you have already left the gate. You go back in the cabin, you look out the window, turn on the floodlights at night and see the little bit of what you can see.

The point I'm making to you is it is a difficult problem which brings you back to saying, well, am I suggesting that we should support the status quo. In no way.

Number one, I'm trying to provide education and number two, I'm trying to point out the difficulty with the situation which needs to be resolved. Absolutely.

Q. Excellent. I'm so glad that that testimony is on the record.

Now, Captain, can you offer some suggestions about how the status quo which is not supportable, how this status quo might be changed, then?

A. I think one has to examine the issue itself to understand what the problem really is.

In general terms, it's fair to say, I think, that a lot of the accidents, if you look back through the list you just gave me, were related to extensive delays, post-departure – I mean from the gate, post-spray, prior liftoff.

And the question then becomes the de-icing fluid characteristics itself and how long it's good for and the fact that if we had a system which did not get airplanes sprayed so far in advance and then have extensive ATC delays as you know we have at particularly Pearson in Canada, and other airports, if we could get airplanes sprayed closer to the time they are going to lift off, that eliminates the big problem.

If you know your fluid in the current conditions is good for roughly 25 minutes, and you get sprayed and you know you only have 10 or 12 minutes to go before liftoff, there isn't really much doubt as to whether or not that airplane is safe even if it is still snowing because you have enough work – there is enough margin in there.

> But the reality of the problem you are faced with today is you have to make judgments, like it or not, where you are sprayed and then it's snowing a little bit. There is no real definition, is it light, moderate snow. When you look out the window, well, looks sort of moderate, maybe it's light.
>
> And if you have gone past this spray guideline window which it is and you have been number 27 in the lineup, now you are number 6, you know you got five minutes to go, and you are a little longer than you want to be but – you know, and then you go take your third look at the wings from the cabin and what you are trying to do is make a judgment, is it adhering, you know, you may see a few flakes there. You know the wing is still wet with the fluid and you are saying to yourself at what point do I decide that's it, I'm going back to the gate, knowing I'm going to now be another two hours before I get back in the lineup. That's the reality of the situation.
>
> (Transcript, vol. 73, pp. 109–12)

Captain Wagner identified either primary or secondary de-icing bays, near the runway departure ends, as being the ideal solution to the safety problem created by long line-ups in bad winter weather:

> Q. And do you think it's a good idea, where it can be done, especially if you have got an airport where you are going to be left holding on a taxiway for 45 minutes, to have a second spray bay available to the aircraft right at the threshold of the runway?
>
> A. I think it would be a good idea, but you don't even need it to be the second one.
>
> I don't care if I get sprayed at the gate as long as I get sprayed before I go, and ideally, I would rather get sprayed just before I go.
>
> ...
>
> Q. So there might be a scenario where, you know, if you have got an overnight heavy accumulation of ice-encrusted snow, you might want to get your first spray at the gate, get a top-up spray just before you taxi out on to the runway. That way you are not holding up the whole lineup while you get sprayed intensively.
>
> A. Again, you know, the optimal way to do that I'm not sure. You may need to spray it to clean out – even to get something around the engine cells before you even start up the motors, but there is – obviously that's the kind of thing you figure out what the optimal system is from the standpoint of safety, efficiency, cost, practicality and everything else.
>
> But obviously the closer you spray an airplace to its actual takeoff time, the safer the operation is and the less problems you have with that kind of an operation.
>
> (Transcript, vol. 73, pp. 117-19)

Addressing the question of runway-end inspection of aircraft wings prior to take-off in adverse weather conditions, Captain Wagner said in testimony:

> Q. ... Even if you don't have a spraying bay at the end of the runway, and recognizing, Captain, that it is extremely difficult for you in a swept wing aircraft to look out of the airplane at night and check the exact level of contamination on the wing, especially if you are dealing with glaze ice, how difficult would it be to put some person on a truck on a cherrypicker that's got VHF communication with the air crew to do an inspection right at the threshold of the runway after the plane has been in the lineup for 45 minutes?
>
> Am I missing something, or would that be relatively technologically easy to put in place, an inspection system like that?
>
> A. Obviously that's easy to put in place. It depends. You got to deal more with the airlines and their people.
>
> Q. So what we may be talking about is corporate decisions concerning the allocation of their resources not to do that?
>
> A. Certainly, I guess that's a consideration.
>
> (Transcript, vol. 73, pp. 118–19)

Transport Canada's Responsibilities

The director general of safety and technical services for the Airports Authority Group, Transport Canada, Dr Lloyd McCoomb, who has a PhD in civil engineering with a major in transportation, was called as a witness before this Commission. In direct examination he claimed that de-icing and airport safety was not his area of responsibility and alleged that his "safety" responsibility referred to "environmental safety." In cross-examination he was shown his own six-page job description, the relevant portions of which are as follows:

> GENERAL ACCOUNTABILITY
>
> The Director General, Safety and Technical Services is responsible for technical leadership and direction within the Airports Group, covering life-cycle management* of airport facilities ... airport planning and the development and delivery of major capital projects ... technically-oriented projects with national application. The Director is also responsible for the development and implementation of national operation policies and guidelines governing the provision of airside, terminal and ground-side services ... for the provision of functional advice and direction in these areas to the Senior Director General, Airports and to the Airport General Managers at Toronto and Montreal.

> * "Life-cycle management" is the co-ordinated management of the planning, design, costing, scheduling, construction and/or acquisition, maintenance and rehabilitation/repair of airport facilities or equipment.
>
> (Exhibit 666, p. 1)
>
> NATURE AND SCOPE
>
> The mandate of the Airports Group (AG) of Transport Canada (TC) is to operate the existing airports system in the most effective, efficient, secure and safe manner possible ...
>
> Typical of the many complex and significant challenges in this position, is that of meeting the demands of the aviation industry which, since de-regulation is changing rapidly and has a short, decreasing planning horizon, for flexible facilities and services ... Another example of the challenges and tough trade-offs faced in this position, although perhaps on a lesser scale, AKP [a three-letter designation assigned by Transport Canada identifying a particular branch or directorate] is beset by a demand to find (urea) de-icing materials while still ensuring that there are no accidents involving aircraft skidding on, or off, runways or failing to take-off safely due to ice build-up on wings: the demands for the safety of the 50 million passengers versus environmental protection, with the public clamouring for both, in a climate of severe economic restraint.
>
> (Exhibit 666, pp. 3–4)

This job description speaks for itself. Dr McCoomb, who apparently has no operational aviation background, subsequently conceded in cross-examination that the subject of aircraft ground de-icing in bad weather was indeed a safety problem and within his area of responsibility.

When further pressed in cross-examination, Dr McCoomb admitted he had been unaware of any safety problems with lengthy departure delays in bad weather at Pearson International Airport until this was drawn to his attention by Mr Frank Black, senior technical advisor of this Commission, approximately two months before his appearance at this Inquiry:

> Q. Well, I take it we've now settled the interpretation issue of the word "safety," and we're now agreed, are we, that if you've got planes holding in Pearson for 45 minutes in bad weather waiting to take off, are we now agreed that that is a safety problem?
>
> A. Yes.
>
> Q. All right. Thank you. When did you realize that that was a safety problem?
>
> A. Well, it was brought to my attention by, as I indicated in my earlier testimony, by Mr. Black.

Q. All right. You haven't made up your mind just now; you've felt that way for some time, have you?
A. That that was a –
Q. A safety problem, that the line-ups were a safety problem at Pearson; have you felt that way for some time?
A. No, I think the earliest it was raised to my attention was by Mr. Black, that it was something we ought to, you know, be very conscious of.

(Transcript, vol. 86, p. 102)

Dr McCoomb was questioned in cross-examination about this communications gap:

Q. ... And you've admitted to me that that's part of your job description – how could you possibly just learn about this safety problem when Frank Black called you?
Isn't it your job – wasn't it your job to know that that existed without Frank Black having to call you?
A. Well, as I indicated to you, we have normal ways that we would find out. One, the Commission raised it, in this particular case. The airlines might have – might have raised the issue. It would have come up through AOCI [Airport Operator Council International] and the discussions of the Chicago experiment, which is just getting going; or the SAE would publish it – publish that information, and we would become aware of it at that point.
I would fully expect –
Q. Well, how can you explain – what's wrong with your information-gathering system? Why is it so poor that you didn't know about this safety problem?
A. Again, that's ... an interesting point and one that concerns me. I would have – I guess what disturbs me was John Holm's testimony about the – about the evidence that he gave about being concerned about the problem and the fact that that information never made it to the regulatory people who – who would have, you know, I think, raised the consciousness with the airlines or – and ourselves on this issue once it was reported.
That – that's a problem – that's an issue that concerns me a great deal.

(Transcript, vol. 86, p. 102)

Q. Well, he was the superintendent of Air Operations.
A. Of Air Operations, that's right.
Q. Now, I'm going to suggest to you that someone that high up in the chain who had these very serious concerns that did not get communicated to you, that reveals a grievous problem with communication within your organization; would you agree with that?

It's more than an interesting concern, sir, isn't it? It's a serious breakdown in communication, is it not?

A. Well, in the light of this, yes, I would agree that we – there was a breakdown in communication in this instance.

(Transcript, vol. 86, pp. 104–5, 109)

This evidence reveals an appalling breakdown of communication lines between the lower- and upper-level management in Transport Canada. There also appears to be an impenetrable bureaucratic wall preventing lower-level management from communicating urgent concerns to the decision-making level of management.

Dr McCoomb, in cross-examination, displayed almost total ignorance of the Dryden crash and admitted he had not read the Interim Report of this Commission or the proceedings of the 1988 SAE Deicing Conference held in Denver, at which Transport Canada was in fact represented.

The evidence shows, as already mentioned, that Mr John Holm, Transport Canada's superintendent of air operations and chairman of the Aviation Safety Committee at Pearson International, had, for the last two or three years, been reporting the lengthy departure delays at Pearson International Airport to his superiors as constituting a dangerous situation. It appears that his was a voice crying in the bureaucratic wilderness. I am left with the distinct impression from the evidence that Transport Canada has adopted a "head-in-the-sand" attitude and a "pass-the-buck" policy with respect to the question of ground de-icing and the growing safety problems generated at Pearson International Airport in conditions of adverse winter weather. The evidence before the Commission leaves no doubt that Transport Canada has emphasized the question of cost to the exclusion of safety with regard to the problems at Pearson International. Mr Holm's testimony is instructive as to the attitude of the Airports Authority Group of Transport Canada:

Q. All right. You said it seemed like the only factor looked at was cost, not safety or operational factors.

Now, who is it that you're referring to when you say they only looked at cost, it seems? Who is "they"?

A. "They," in this case, I was referring to the Airports Authority Group. Of course, everybody has to be cost concerned. I'm not saying that you should do anything no matter what the cost is.

Q. Sure, you're saying cost should legitimately be a factor in any decision but by no means the paramount factor when safety is concerned?

A. That's true.

Q. And, specifically, one of the safety factors that you felt was subjugated to cost was the safety problem of having these aircraft queued up for an hour after having been de-iced?

A. Yes.

(Transcript, vol. 78, pp. 134–35)

Mr Holm went on to say that the Airports Authority Group considered the problem of aircraft line-ups at Pearson International Airport in bad weather to be not a safety issue but a service problem that was the responsibility of the carriers. This was precisely the same position taken by Transport Canada with respect to the funding of crash fire rescue facilities at airports, a position that was completely reversed following the appearance in the fall of 1989 of Transport Canada Crash Fire Rescue management witnesses before this Commission. As Mr Holm testified:

> Q. ... And that problem, to your knowledge, at least, has apparently been ignored by the Airports Authority Group?
> A. Well, it has simply been passed on as being the responsibility of the air carriers.
> Q. All right. It's not a safety problem; it's some kind of service, so the carriers can provide it?
> A. That's true.
> Q. That's the attitude?
> A. That's the attitude, yes.
> Q. It's strange; I think we've heard that attitude before at this Inquiry.
> A. Yes.
> Q. Not a safety issue, Crash Fire Rescue is not a safety issue; it's a service problem. Is that the same kind of attitude that you ran into when you were trying to say, look, fellows, we've got a safety problem here with 30 aircraft lined up in icing weather? Were you met with that kind of response, that's a service, let the carriers provide it?
> A. Basically, yes. And, of course, in this case, what was referred to was that de-icing of aircraft and airworthiness was part of the responsibility of the airlines and, therefore, why should we worry about it.
> Q. Any doubt in your mind that this impacts directly on safety, that this is a serious safety problem to have this kind of line-up?
> A. No, there was absolutely no doubt in my mind.
> Q. Now, look, you've got some expertise as a safety pilot; you've got a great deal of expertise as a pilot. Do you agree with Mr. Vasey that this line-up of planes waiting to take off in bad weather after they've been de-iced, do you agree with him that that potentially is a disaster waiting to happen?
> A. Absolutely.
>
> (Transcript, vol. 78, pp. 135–36)

The evidence that surfaced during the crash fire rescue phase of the hearings of this Commission disclosed that in the case of a "safety" concern it was mandatory for Transport Canada to provide such funding as necessary to satisfy the concern. In the case of a "service" concern it is not mandatory that funds be provided. It is, then, a discretionary matter whether funds will be provided.

A similar mindset was revealed by Dr McCoomb when he was asked whether the instrument landing system at Pearson International Airport is "part of providing a safe environment at Pearson." After being pressed by counsel, he agreed an instrument landing system was necessary for safety, but then he added: "I qualify it by saying that there is the dimension of convenience" (Transcript, vol. 86, pp. 70–71).

It can be seen that by the simple ruse of labelling a safety concern as a service concern, Transport Canada is able to refuse to provide funds to remedy what is an actual safety problem. This is the second occasion in which the use of such devious tactics has been exposed by the hearings of this Commission. It must be a matter of grave concern to the Canadian public that a major aviation safety issue is being treated in so cavalier a fashion in the interest of cost-cutting.

Environmental Control

There is no recovery of de-icing fluid at Pearson International Airport. Approximately 1.5 million gallons of glycol de-icing fluid are allowed annually to drain into storm sewers, which empty into Etobicoke Creek and ultimately drain into Lake Ontario. Transport Canada is the owner-operator of this airport. There is an obvious environmental concern to be addressed.

Mr Holm stated that in 1988 the Airports Authority Group made a commitment to implement environmental control by December 1991 at Pearson with regard to glycol used in de-icing. He testified he was concerned that the safety aspects of de-icing were not even being considered:

> A. Now, I also saw that as being the main chance to sort of mix the issue of safety and environmental impact. It was quite apparent that the safety issues and that side of it was not looked upon and even being considered by the national headquarters of the Airports Authority Group. There had been no correspondence relating to that, and in my discussions with – at various meetings, I had no indication of this being the case.
>
> At – we started to – I started pushing on the airports level, to management there, that these were really two issues that could be resolved more efficiently if we combined both of them.
>
> Q. And they were, in part, intertwined?
>
> A. They were intertwined very much, and we could resolve both problems at the same time and possibly at equal-to or lower cost than the cost projected to just look after the environmental matters.
>
> (Transcript, vol. 78, p. 61)

The evidence of Dr McCoomb previously referred to in fact confirms Mr Holm's perception that the safety side of the de-icing issue was not being considered by the national headquarters of the Airports Authority

Group. The national headquarters was not even aware there was a safety problem at Pearson related to long line-ups in bad weather.

Addressing the subject of locating de-icing pads near to the take-off end of a runway, Mr Holm gave the following evidence:

> A. Now, of course again, my main interest was to get the whole de-icing operation as far away from the apron as we could, as close to the takeoff point as absolutely possible.
>
> At that time, I already had a fairly good idea how these de-icing pads or de-icing aprons should be designed; however, it was still a long way from acceptance by any group.
>
> Q. What sort of impact did your concern have on the desire to perhaps make a collection pond?
>
> A. What happened was that the headquarters was informed, the Airports Authority Group headquarters was informed, that we didn't fully agree with their suggestion and we would like to study the matter further and come up with a solution that was more in agreement with our perceived safety problem and environmental problem and also to make it more cost-efficient.
>
> (Transcript, vol. 78, p. 65)

The evidence of Mr Holm is that both Air Canada and Canadian Airlines were interested in a plan to construct runway-end de-icing pads. This was later confirmed in testimony by Mr Jensen of Air Canada and Mr Triolaire of Canadian Airlines.

Mr Holm also suggested that one agency, perhaps a company started jointly by the carriers, perform all de-icing, much the same as is now done in the refuelling of aircraft. This, in my view, is an eminently sensible suggestion, which reflects the practice in the AEA countries of Europe, inasmuch as it permits standardization of fluids, equipment, and procedures.

Captain Charles Simpson, senior vice-president of flight operations for Air Canada, indicated a preference in his testimony, at least on the part of Air Canada, for the carriers to operate the de-icing system at Pearson:

> Q. So it's – in many ways, I think, and Mr. Wagner referred to this somewhere as well, you are now coming down to an issue of allocation of resources of some sort in that where are you going to put all your apples, where are you going to spend your money. And that, in fact, becomes a corporate decision?
>
> A. Well, I think if the air carriers or the operators are allowed to operate the system, it will probably function quite successfully.

The problem is, we can't afford to have Transport Canada build a system in isolation. They have already proven to be less than adequate in the ATC system.

So if we are going to have improved de-icing, then it's up to the carriers to get together and bring it about.

(Transcript, vol. 123, p. 42)

Runway-End De-icing Pads

Mr Holm outlined the advantages of runway-end de-icing pads:

Q. Now, what's the real advantage of having de-icing facilities right near the end of the runway just prior to takeoff?

A. There are several advantages: One, of course, is that you don't have to worry about hold-over times.

Two, there should be no requirement for use of type 2 fluids, which are significantly more expensive than the type 1 fluid, almost double the price, in fact.

...

Q. And also, I take it that there would be no weight penalty, because that would have to be added to the aircraft as a result of use of type 2 fluid?

A. Theoretically, the development of the type 2 fluids – the European type 2 fluids now have been modified and are – should not give any weight penalty to the aircraft; the same with the fluid that was designed by Air Canada, should not give any weight penalty either.

...

Q. ... basically, what you're using is de-icing fluid?

A. That's right.

Q. And probably another advantage is you wouldn't have aircraft having to taxi back down the active runway to go and get de-iced?

A. That's about the worst scenario you could ever want, because, as Clare Vasey pointed out yesterday, you lose at least one slot every time you do that.

Q. So, as you see it – and I take it this has been as a result of a number of years of being around the airport and analyzing what's going on – you see this as being the remote facilities at 06 right, 06 left and at 15/24 right to be probably the optimum solution for de-icing at Pearson International; that's in your view?

A. In my view, it's a good start point. Things can always be improved, and there's no doubt this proposal can be equally improved, but I feel it's a very good start.

(Transcript, vol. 78, pp. 106–8)

While for the most part I can support Mr Holm's views, I am not convinced that runway-end de-icing pads would require the use of type I fluids only. Evidence put before me indicated quite clearly that type I fluid offered little or no hold-over protection in freezing rain conditions. I would therefore believe that under such conditions type II fluids could be used to good advantage at runway-end de-icing pads.

In frustration because of the inertia of his superiors at Transport Canada in responding to the congestion problem at Pearson, Mr Holm, to his credit, prepared detailed scale drawings for de-icing pads at Pearson International on his own initiative (appendix H). Using Transport Canada guidelines, he also prepared cost estimates for the construction of such a facility, including fluid-collection tanks. His estimated cost for one complete runway-end de-icing pad is $6.39 million (appendix I). He recommends the construction of a minimum of three runway-end de-icing pads in the first phase of providing such facilities.

It is impossible in this report to review in detail his plans and recommendations. However, I would urge that those responsible would be well advised to look at what is obviously a well-thought-out and researched plan for what I perceive, from an aviation safety point of view, to be urgently required facilities at Pearson International Airport.

Mr Holm urged that the highest priority be given to the installation of at least one runway-end de-icing pad at Pearson International by the end of 1990:

A. I still feel that you should – you should at least – you shouldn't throw up your arms already. There should be an attempt made to find a way to install one pad by the end of this year. They may be slightly late. They may be a little bit into the de-icing season. However, it may pick up the last portion of it, and that's better than nothing.

What you want with the first one is to gain experience and, perhaps, make changes that may be required for the next ones coming in.

Q. All right. Now, you heard the testimony of Captain Reg Smith, you've heard the testimony of Clare Vasey, and you've – and I'd like to ask you some questions with respect to aviation safety generally.

You were a flight safety officer, you are an experienced pilot, and I take it you spent some time on this de-icing issue.

Let's deal in terms of safety: I mean, how urgent do you think we should be moving on establishing at least one pad?

A. I feel this is something that we should have dealt with several years ago. So, it's definitely a very urgent matter, and I feel that it should have the highest priority that it could be given.

(Transcript, vol. 78, pp. 114–18)

Mr Holm, like Mr Vasey, was of the opinion that one of the main problems at Pearson International was simply the availability of concrete. He made a detailed study of European de-icing facilities and procedures. In the fall of 1987 he chaired a civil aeronautics meeting at Pearson International, attended by representatives of the carriers, air traffic control, airport standards, Airports Authority Group, construction group, Public Works, and airport operations supervisors. At this meeting Mr Holm indicated there was a safety problem at the airport because hold-over periods were being significantly violated. He recommended that something should be done about it on a joint-venture basis between the airport authority and the carriers. Mr Holm testified that, while acknowledging they should look at improvements, neither the airport management group nor the carriers were prepared to accept responsibility for doing anything about the problem. Nothing changed until the summer of 1988, when there was an organizational restructuring at the airport; at that time the Airports Authority Group began a move to implement environmental control with respect to glycol by December 1991, but ignored the operational safety problems at the airport.

Mr Holm stated that, following the Dryden crash on March 10, 1989, he attempted to obtain a commitment from the Airports Authority Group of Transport Canada to build de-icing pads on aprons at the end of the runways. He described the response he received as follows: "Again, the philosophy of Airports simply was it's the air carriers' responsibility, it will be up to them to finance and build such pads" (Transcript, vol. 78, p. 78). Mr Holm also pointed out that de-icing pads are part of a complete airport facility. He made an interesting comment regarding Transport Canada's position that the carriers are responsible for installing de-icing pads:

> The second thing is that I feel precedence has already been set in this area and the Airports Authority are operating a complete facility and this is part of a complete facility. To me, it's the same thing as you ask somebody who is coming to a hotel and staying in a hotel room to bring their own vacuum cleaner.
>
> (Transcript, vol. 78, p. 140)

The carriers, in contrast, took the not unreasonable position that the owner of the airport, Transport Canada, is responsible for capital outlays to its facility. The result has been a stalemate in an area of great safety concern, caused by the issue of cost.

By the end of their respective sojourns on the witness stand, the two representatives of the major carriers, Messrs Jensen and Triolaire, and Dr McCoomb on behalf of Transport Canada acknowledged the need for renewed efforts on these issues. Each one undertook to work together on an urgent basis to set up a joint group, at the decision-making level, to expedite planning and construction of runway-end de-icing facilities at Pearson International Airport.

As of November 15, 1990, it has been determined by my Commission officials that Transport Canada continues to disclaim any responsibility for the installation of de-icing pads at Pearson International Airport.

Because of the implications for aviation safety, the concerns about the present hierarchical reporting system in Transport Canada and the alleged lack of action by upper-level management on safety problems at Pearson International will be investigated in the Transport Canada phase of this Inquiry, which has just commenced, and will be addressed in detail in my Final Report.

Europe

The evidence before this Commission reveals that runway-end de-icing pads are in use in Europe. In Sweden and several other European countries the Swedish Kallax de-icing system is in place. This system consists of a fixed, computer-controlled giant gantry, similar to a large automatic carwash, under which aircraft pass for de-icing and anti-icing near the departure end of a runway. De-icing and anti-icing of an aircraft are accomplished in approximately two minutes. This system permits de-icing to be accomplished with the aircraft engines running. The de-iced aircraft immediately enters the runway for take-off.

By way of example, evidence before the Commission indicates that the new international airport at Munich, Germany, which is to be opened in the near future, will be equipped with four Kallax de-icing installations, one at each end of two major runways. (All airport facilities at Munich are being funded entirely by the airport authority.)

The other major de-icing system in use in Europe employs mobile trucks equipped with a boom, at the top end of which is an enclosed cab for the operator. This system is known as the Elephant-Beta system and is also in use in the United States.

United States

On February 6, 1990, my senior technical advisor, Mr Frank Black, and I inspected the Kallax de-icing system installed on a concrete de-icing pad at the Standiford Field Airport in Louisville, Kentucky, by United Parcel Services. This company operates a fleet of some 107 heavy jet transport aircraft daily out of Louisville. This computer-controlled de-icing system was highly lauded by officials of that company and was an extremely impressive facility. It is capable of applying either type I or type II fluid in close proximity to aircraft surfaces. A Boeing 757 can be de-iced with engines running in approximately two minutes using minimal amounts of de-icing fluid. The de-iced aircraft then proceeds directly to the runway for take-off. The fluid is recovered in underground tanks, thus eliminating environmental concerns, and the system has a potential recycling capability. It is one of the available de-icing systems options.

Subsequently, I instructed Mr Black to accept an invitation from Mr Jack Lampe, the manager of cargo services for United Airlines in Chicago, to inspect the new runway-end de-icing pad facilities at O'Hare International Airport and the Elephant-Beta de-icing system in use there. Mr Black travelled to Chicago, in the company of Mr Vasey and Mr Holm, who were invited by this Commission to attend for informational purposes. Mr Lampe was persuaded to appear as a witness before this Commission. He provided invaluable information and advice from which Transport Canada and the Canadian carriers can, in my view, greatly benefit. I commend a transcript of his evidence to them as a resource document. O'Hare International Airport in Chicago was chosen as a venue to inspect because of its similarities to Pearson International Airport in Toronto in terms of geography – both cities are located on one of the Great Lakes and experience similar winter weather conditions – and because of the current development of runway-end de-icing facilities there and the use of Elephant-Beta de-icing equipment.

Mr Lampe, who has a 30-year career background with United Airlines, is also responsible for ramp operations for United Airlines in Chicago. In 1981 he was commissioned to upgrade the United Airlines de-icing procedures, which he described as primitive at the time, and to make them more efficient. After spending many months studying methods and facilities and examining concepts in use by other carriers in the United States and Europe, he proceeded to replace antiquated equipment and methods. He was responsible for the introduction of AEA type II anti-icing fluid not only at O'Hare International Airport in Chicago but also into the entire United Airlines domestic system. He indicated that United Airlines and United Express operate more than 1000 of the 2500 to 3000 flights a day out of O'Hare International Airport.

Mr Lampe was instrumental in the introduction of runway-end de-icing pads at O'Hare. In 1987 there were 45- to 90-minute departure delays at O'Hare in bad weather. Mr Lampe persuaded the airport management group, despite their initial lack of interest, to experiment with the placement of runway-end de-icing pads. The procedure began in 1988 with the construction of runway-end pads and aprons to hold mobile de-icing trucks near the ends of three runways. Because of the successful experience with these first three de-icing pads, nine further pads are in the process of being built at O'Hare.

All secondary runway-end de-icing at O'Hare is accomplished with one aircraft engine running and with hot type I fluid, using conventional equipment. Departure delays after de-icing have now been reduced to an average of five to six minutes at O'Hare, with the ultimate objective being zero time de-icing delays. Mr Lampe stated that his carrier's intention is to fly on schedule in all conditions.

Another interesting disclosure was that the runways at O'Hare are snow-plowed in winter only as a last resort. Contamination is eliminated, or reduced, by applying de-icing fluid on the runways – a procedure which Mr Lampe stated takes only 12 minutes for a 14,000-foot runway as opposed to 45 minutes for plowing. The evidence indicates that in heavy snowfall conditions a runway at Pearson is shut down for one to two hours for plowing.

Mr Lampe's evidence was that for the 1990–91 winter season United Airlines plans to use 100 per cent undiluted AEA type II fluid for anti-icing aircraft after primary de-icing at Chicago and Denver, and that equipment is being modified for use of type II fluid at other airports as well. As of January 1, 1991, he has been authorized by airport authorities to accomplish runway-end de-icing at Dulles International Airport in Washington, and he is currently working towards this end with airport authorities at Cleveland, Detroit, and Minneapolis. The idea is also being entertained at Kennedy International in New York and Logan Field in Boston:

> Q. As you said, type 2 will be implemented next year in Chicago and Denver. Has United taken any steps throughout its system, either throughout the United States – or internationally, towards implementing runway-end de-icing, or are there plans to do so?
>
> A. We started last year or – as an assignment of mine, and I visited seven airports last year to speak to them about end-of-runway opportunities.
>
> I was successful in Dulles, and as of January 4, '91, we were authorized to accomplish end-of-runway de-icing in Dulles, basically using the same procedures that you're familiar with here, except tailored to the Dulles station.
>
> Currently, I'm working with Cleveland and Detroit and Minneapolis, and I've met preliminarily with the airport managers from those three locations, and I don't have an indication at this point as to whether we'll be successful there or whether we won't.
>
> But our objective would be to expand it to as many stations as possible.
>
> Our senior vice-president has petitioned all of his reports to talk to the airports administration regarding opportunities to do that, and I think they're expected to respond by 9/1 this year in terms of whether they have anybody that has an interest.
>
> And, of course, at small stations, many of our outlying stations, we wouldn't have equipment in position and so forth to do that, so we might have to shift resources or purchase, or it may not be a requirement if we could introduce type 2.
>
> (Transcript, vol. 2, pp. 69–70)

Based on his experience in Chicago, Mr Lampe described the Elephant-Beta de-icing equipment as an excellent runway-end de-icer that protects the operator, who is otherwise exposed to the fluid spray and the elements for periods of six or seven hours. He had planned to purchase additional units for Chicago as of last July.

Mr Lampe also spoke of the development in progress by McDonnell Douglas of a wing-ice detector system that United Airlines is ordering for installation in future Boeing Aircraft deliveries. Indications are that retro-fitting will be possible. He and other witnesses also suggested the use of video cameras to assist flight crews in inspecting aircraft surfaces.

Mr Lampe described the system in Chicago for the collection of de-icing fluids from the ramp and gate areas into a man-made lake on the airport property, where it is environmentally treated. He indicated that environmental and health testing (under the Occupational Safety and Health Act) of type I and type II fluids concluded that type II fluid is much less of a hazard than type I.

Speaking of airport funding in the United States, Mr Lampe testified that 50 to 75 per cent consists of federal funding, with the balance made up by the airport authority and by levies on the carriers. He also provided statistics on the cost of type I and type II fluids in the United States. In the 1990–91 season the costs will be U.S.$5.75 per gallon for type I and U.S.$7.00 per gallon for type II.

As to the use of inspectors to check aircraft wings before take-off, Mr Lampe agreed with the evidence of some other witnesses that runway-end inspection to check aircraft wings for contamination is difficult and dangerous when aircraft engines are running. In addition, it would take about as long to inspect an aircraft as it would to provide a secondary de-icing. Obviously, if an inspector declared a need for de-icing following an inspection, then the time delay for the inspection and the de-icing is essentially doubled. This, in the words of Mr Lampe and others, doesn't make much sense. If in doubt, it is simpler to de-ice at the runway-end de-icing pads. Nevertheless, the existence of runway-end de-icing bays provides the option of conducting pre-take-off wing inspections from cherry-picker equipped de-icing trucks.

Mr Richard Adams, an aeronautical engineering consultant from Newport News, Virginia, specializing in aircraft ground de-icing, testified at this stage of the Inquiry. He is regarded as the dean of aircraft ground de-icing in the United States, having had a distinguished career in the Federal Aviation Administration, with which he was the project manager for aircraft de-icing research in the United States. He was the chairman and organizer of the international SAE aircraft ground de-icing conference held in Denver in 1988 and was the principal author of the "clean aircraft" FAA advisory circular (AC 20-117) following the Air Florida crash in 1982 at Washington, DC. He produced a list of major aircraft icing-related crashes in North America in the last 20 years (appendix E), and remarked that after the Denver crash in 1987 it was decided to "hit the carriers with a 2 × 4 between the eyes" in order to awaken them to the dangers posed by wing contamination.

Referring to the 20-minute hold-over time after de-icing "rule of thumb" prevalent in the aviation industry, Mr Adams unequivocally dismissed it as unreliable. He stated that something needs to be done at the end of the runway other than looking out the aircraft window. In his opinion, given the many variables that affect the hold-over time, either a physical, hands-on inspection prior to take-off or a runway-end de-icing, in addition to continuing education of air crews, is the only practical solution to the ground-icing problem. He emphasized that enforcement is also part of the game.

Referring to Air Canada's use of hot water to de-ice an aircraft, followed by application of type II anti-icing fluid, Mr Adams's testified he did not know of any other airline that used hot water to de-ice before application of type II fluid. He stated, in the strongest terms, that type II fluid should never be used without first de-icing with a glycol solution and said that FAA publication AC 20-117 addresses this issue (appendix J). He described this document as the "most comprehensive de-icing document in existence." He said it is distributed by the FAA and he could not imagine Canada's having no provision for dissemination of such information. In his opinion the *Aeronautical Information Publication (A.I.P. Canada)*, published by Transport Canada and distributed to all pilots, is a fine vehicle to transmit such information. He said the FAA would welcome Transport Canada's distribution of AC 20-117 to pilots and carriers in Canada. This is an offer that should be taken up with dispatch. There is a crying need for distribution of this extremely valuable and comprehensive de-icing document to all Canadian carriers and pilots.

In cross-examination Mr Adams stated that, in his opinion, runway-end de-icing pads at Pearson International Airport should be considered immediately. He suggested that John Holm's de-icing plans, which he had examined, were suitable reference documents. Runway-end de-icing facilities, he pointed out, would accomplish two things:

- provide the possibility for last-minute inspection of aircraft immediately before departure; and
- provide for runway-end de-icing immediately before take-off, if needed.

In cross-examination Mr Adams was asked how he accounted for the fact there had been no major airline crashes related to icing in Europe since 1970, compared with 14 such crashes recorded in North America in the same period. He replied that he attributed this record, among other things, to the European aviation industry's development and use of AEA type II fluid.

5 CONCLUSION

The evidence clearly confirms that a serious safety problem exists at Toronto's Pearson International Airport. It may well exist to a lesser extent at other major Canadian airports.

Air traffic delays for departing aircraft in adverse winter weather at Pearson exceed by wide margins the hold-over times provided by type I de-icing fluids currently in use by Canadian carriers. Evidence has shown that major Canadian carriers are well aware of the limited hold-over times of type I fluids. Notwithstanding this fact, aircraft are routinely dispatched in conditions of freezing precipitation after being treated with type I fluid. The final decision to take off is left with the pilot-in-command, who has at his or her disposal, in many instances, less than adequate guidance to make such a decision. Contrary to some opinions, the ground de-icing and departure delay problem is not new but has been discussed and recorded as a concern in airport advisory committee meetings at Pearson International Airport for at least two years prior to these hearings.

It became quite clear from the evidence adduced that this safety problem was well known to pilots, to ramp attendants whose job it was to de-ice aircraft, to air traffic controllers, and to the airport operations personnel. The reason the problem was not adequately addressed by either the carriers or the airport authority – by the provision of runway-end facilities for secondary de-icing of aircraft – was primarily one of cost. Transport Canada still takes the position that this is an air carrier problem for which carriers should bear the total cost. In contrast, the carriers have considered, in my view quite properly, remote or runway-end de-icing pads to be airport facilities and therefore not their responsibility. The end result has been a stalemate.

Evidence before this Commission revealed that de-icing fluid hold-over criteria provided to pilots were at best a guide. One expert witness indicated there are at least 37 variables which could influence the length of time that de-icing fluid would effectively protect against re-freezing of aircraft surfaces in adverse weather. Several senior airline captains gave evidence that it is difficult, indeed impossible in some aircraft, for a pilot-in-command to determine from inside the aircraft whether the wing and tail surfaces are clean at the time take-off clearance is received. Darkness, precipitation, dirty or crazed windows, physical distance limitations, and aircraft design can all influence the ability of a flight crew member to observe accurately from the flight deck or the cabin the condition of the aircraft's lifting and control surfaces.

It is apparent that the ability to conduct an external inspection at or near the take-off point would ensure that the aircraft was clean and safe for flight immediately prior to take-off. It is further apparent that remote and runway-end de-icing facilities are recognized in other countries as viable alternatives at locations where lengthy departure delays are experienced.

Evidence was also heard from witnesses regarding smaller regional airports, particularly those airports located beyond immediate air traffic control radar coverage, with no control service other than area control. Prior to 1985 and the implementation of Economic Regulatory Reform (ERR), many of these airports were served by larger aircraft with one or two flights a day. ERR, however, has resulted in the use of smaller aircraft and more frequent service. The net result from a de-icing perspective is the potential for increased departure delays due to arriving aircraft. Although not as serious as the concern at major airports, possible departure delays at smaller airports are a problem that should be investigated and, if necessary, corrected.

Although air crews may be generally aware of the hazards of wing contamination, it is clear from the evidence that some pilots do not fully appreciate the effect that even minor and apparently insignificant surface roughness can have on the aerodynamic performance of wings and control surfaces. The authoritative FAA publication AC 20-117, "Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing," published in 1982, is a comprehensive document which has not been widely circulated among Canadian air crew. At the time of these hearings the Canadian *Aeronautical Information Publication* (*AIP Canada*), which should contain similar information, had only two short paragraphs on the subject of wing contamination. In my view, this coverage is entirely inadequate.

In September 1988 the Society of Automotive Engineers held an aircraft ground de-icing conference at Denver, Colorado, the site of a major aircraft accident in 1987 in which wing contamination was an important contributing factor. For three days, internationally recognized technical experts presented papers on virtually all aspects of aircraft ground de-icing and anti-icing technology. Although Transport Canada, one of the largest airport operators in the world, sent an observer to the conference, there is no evidence of its subsequent participation in the ongoing subcommittee work that is setting out design criteria and recommending operating practices for remote and runway-end de-icing facilities. An Air Canada representative also attended the conference and presented a paper.

Research carried out on various AEA type II fluids has resulted in improved third-generation fluids that provide substantially increased hold-over times over the present type I fluids and that are deemed safe for industry use. North American experience has shown that proper introduction of a domestic type II fluid into an airline – including development research, production, storage, handling, training of flight and ground crews, and development of effective quality-control procedures –

can take from three to five years. Rather than simply accepting the proven AEA type II fluids, as has been done in the United States, Air Canada has been developing its own type II fluid. The evidence shows that Air Canada's type II fluid at this stage provides only half the hold-over protection provided by the AEA type II fluids. Canadian Airlines, the other major Canadian carrier, uses only type I fluids, which provide almost no hold-over protection in freezing precipitation.

These hearings have brought to light a serious concern with respect to Transport Canada's ability to monitor, identify, and correct safety deficiencies in the Canadian air transportation infrastructure. At present, Transport Canada's Safety Programmes Branch encourages Canadian carriers to put in place flight safety management programs. Such programs are designed to monitor, identify, and resolve safety concerns before an accident occurs. Usually a carrier's safety manager reports directly to the carrier's chief executive officer. This system is designed to ensure that the CEO is apprised of the safety status of the carrier and that prompt corrective action is taken when and where required. The management and operation of an airport the size of Pearson International is at least as complex a task as operating an airline. However, I can see no evidence that a similar safety program exists within Transport Canada's Airports Authority Group at Pearson.

Because of cost implications, there would appear to be a reluctance on the part of the airport management and the carriers, first, to recognize the safety problem; second, to recognize some responsibility with respect to the problem; and, third, to take some action, either collectively or individually, to resolve it. The matter of jurisdiction is not the cause of the impasse. Jurisdiction, it seems to me, is a fairly straightforward issue. Wing contamination affects the airworthiness of an aircraft. Airworthiness is a regulatory compliance matter. Should an aircraft require certain facilities such as runway-end de-icing pads in order to meet airworthiness requirements, such pads would most likely be constructed on airport property and therefore would involve the Airports Authority Group. The degree of involvement of Transport Canada would evolve from negotiations between it and the carriers. If such negotiations are to be concluded successfully, there must first be a recognition of the problem and a will to resolve it. Otherwise, the existing impasse will continue until an accident occurs.

Interim Findings

From the evidence I have heard, I find as follows:

1 Aircraft ground de-icing at Toronto's Pearson International Airport is a significant safety concern that should be addressed on an urgent basis. Whether or not similar problems exist at other Canadian airports can be determined only through investigation.

2 Air traffic departure delays at major Canadian airports are not likely to decrease substantially in the foreseeable future.
3 Newer AEA type II anti-icing fluids offer significantly increased hold-over capability compared with that of type I de-icing fluids in use in Canada, with little if any degradation in aerodynamic performance.
4 Departure delays at some major Canadian airports clearly exceed hold-over times of type I de-icing fluid and may exceed type II anti-icing fluid hold-over times under certain meteorological and ground operating conditions.
5 Remote and runway-end de-icing/anti-icing facilities provide the capability to ensure that aircraft will be able to take off in a clean condition.
6 Responses to both the safety and the environmental concerns associated with aircraft ground de-icing and anti-icing requirements are compatible.
7 The Canadian aviation community requires further, more intensified, and continued education on the hazards of operating aircraft with contaminated lifting and control surfaces.
8 Transport Canada needs to take a more active role in all aspects of aircraft ground de-icing and anti-icing technology and education.
9 International standards for de-icing and anti-icing fluids, equipment, and procedures are essential.
10 The Airports Authority Group within Transport Canada should staff each of its major airports with individuals who have substantial flight operations expertise. They in turn should have the authority to report directly to the airport manager on any issue related to safety. Furthermore, there should be a mandatory reporting process to ensure that aviation safety-related issues are brought to the immediate attention of management and to ensure that such issues are addressed promptly.
11 Transport Canada should determine whether normal departure and de-icing/anti-icing procedures and operational facilities are safe at Canadian airports or whether amended procedures and additional facilities are required.

Interim Recommendations

The problems at Pearson International Airport can be resolved by long-term and short-term solutions. Over the long term, there is an obvious need for more concrete areas at the airport, including additional ramps, runways, and taxiways to relieve congestion. Permanent runway-end de-icing facilities should also be provided for the secondary de-icing of aircraft immediately before take-off in severe weather conditions. It can be expected that these long-term measures will take approximately three to five years to implement. The carriers, for their part, should upgrade their de-icing equipment and procedures and should use type II anti-icing fluids that meet AEA type II specifications to ensure that any departure delays are within the margin of safety. It is expected that these measures can be implemented within a much shorter time frame.

In the short term, several interim measures should be put in place immediately at Pearson International Airport. ATC gate-hold procedures should be developed and implemented to ensure that departure delays are minimized. Temporary runway-end de-icing facilities for secondary de-icing of aircraft before take-off should be provided. These facilities would include the peripheral expansion of existing taxiways near the end of runways to support de-icing equipment and crews. In keeping with environmental concerns, any excess fluids at these locations should be collected and disposed of in an appropriate manner.

INTERIM RECOMMENDATION 1

Transport Canada should, on a priority basis and in co-operation with major Canadian air carriers, implement interim runway-end de-icing/anti-icing facilities at Pearson International Airport. The target should be to have the first of such facilities in place on an interim basis as early as possible in the 1990–91 icing season. Subsequent permanent installations should be designed and constructed to satisfy both safety and environmental concerns.

INTERIM RECOMMENDATION 2

Transport Canada should examine and, if feasible, implement air traffic control gate-hold procedures at Pearson International Airport as a means of reducing departure delays during conditions of freezing precipitation.

INTERIM RECOMMENDATION 3

In addition to the already announced feasibility studies for two new runways and supporting taxiways at Pearson International Airport, Transport Canada should investigate and, if feasible, proceed to implement an expansion of existing ramp space on the airport to reduce congestion and consequent departure delays. This undertaking should be given high priority.

Interim Recommendation 4

Transport Canada should strongly encourage and support the use by Canadian air carriers of type II anti-icing fluids that meet AEA specifications for turbo jet aircraft and, where applicable, for propeller-driven aircraft.

Interim Recommendation 5

Transport Canada should, in the interest of employee safety and in order to facilitate reliable inspection of aircraft surfaces after de-icing/anti-icing, ensure that adequate and sufficient exterior lighting exists in all gate and ramp areas where de-icing and anti-icing operations are conducted at Pearson International Airport and at other major airports in Canada.

Interim Recommendation 6

Transport Canada should, on a priority basis, provide, where necessary, enforcement resources to ensure that the *clean aircraft* regulation is complied with, including runway-end spot checks of aircraft surfaces in adverse winter weather.

Interim Recommendation 7

Transport Canada should strongly encourage Canadian air carriers to form joint entities to provide all air carrier de-icing/anti-icing services at Pearson International Airport and at other major airports in Canada, and to have available, for use when necessary, equipment capable of applying both type I and type II fluids.

Interim Recommendation 8

Transport Canada should require that air carriers produce aircraft ground de-icing/anti-icing procedures and training standards for both flight and ground personnel. Implementation of such procedures and standards should be made a mandatory requirement of an air carrier's operating certificate.

Interim Recommendation 9

Transport Canada's Airports Authority Group should place on the staff of each of its major airports, individuals with substantial flight operations expertise. Such individuals should report directly to the airport manager on any issue related to operational safety. Furthermore, a mandatory reporting process should be put in place to ensure that aviation safety-related issues are promptly brought to the attention of the appropriate decision-making level of senior management and to ensure that such issues are addressed within a specified period of time.

Interim Recommendation 10

Transport Canada should examine, on a priority basis, Canadian airports served by air carriers to ascertain if the incompatibility between departure delays and de-icing/anti-icing fluid hold-over times, as identified at Toronto's Pearson International Airport, exists at other sites. Should such incompatibilities be found, Transport Canada should ensure that appropriate corrective measures are taken.

Interim Recommendation 11

Transport Canada and/or the air carriers should, in the interests of ramp employee safety and for environmental reasons, maintain suitable equipment and develop appropriate procedures for the clean-up and disposal of de-icing/anti-icing fluids in areas utilized by air carriers.

Interim Recommendation 12

Transport Canada should take an active and participatory role in the work currently underway within the international aviation community to advance aircraft ground de-icing/anti-icing technology. This should include involvement in the development of international standards, development of guidance material for remote and runway-end de-icing facilities, and development of more reliable methods of predicting de-icing/anti-icing fluid hold-over times.

INTERIM RECOMMENDATION 13

Transport Canada should strongly encourage Canadian air carriers to provide their flight crews with de-icing/anti-icing fluid hold-over time charts that are based on the most recent technological information. These charts should be used as guidelines.

APPENDICES

Appendix A

P.C. 1989-532

CANADA

PRIVY COUNCIL

Certified to be a true copy of a Minute of a Meeting of the Committee of the Privy Council, approved by Her Excellency the Governor General on the 29th day of March, 1989.

The Committee of the Privy Council, on the recommendation of the Minister of Transport, advise that a Commission do issue under Part I of the Inquiries Act and under the Great Seal of Canada, appointing the Honourable Virgil Peter Moshansky, a Justice of the Court of Queen's Bench of Alberta, to be a Commissioner to inquire into the contributing factors and causes of the crash of Air Ontario Flight 363 Fokker F-28 at Dryden, Ontario, on March 10, 1989, and report thereon, including such recommendations as the Commissioner may deem appropriate in the interests of aviation safety; and

The Committee do further advise that

(a) the Commissioner be authorized to adopt such procedures and methods as he may from time to time deem expedient for the proper conduct of the inquiry;

(b) the Commissioner be authorized to sit at such times and in such places as he may decide;

(c) the Commissioner be authorized to rent such space and facilities as may be required for the purposes of the inquiry, in accordance with Treasury Board policies;

(d) the Commissioner be authorized to engage the services of such experts and other persons as are referred to in section 11 of the Inquiries Act, at such rates of remuneration and reimbursement as may be approved by the Treasury Board;

(e) the Commissioner be directed to advise the Governor in Council as to which, if any, of the groups or individuals that may appear before him, should receive assistance with respect to the legal costs they may incur in respect of those

P.C. 1989-532

\- 2 -

appearances, and the extent of such assistance, where such assistance would, in the opinion of the Commissioner, be in the public interest;

(f) the Commissioner be directed

(i) to submit an interim report, in both official languages, to the Governor in Council not later than six months after the date of the appointment of the Commissioner and to submit any other interim reports to the Governor in Council, in both official languages, as, in the opinion of the Commissioner, may be required; and

(ii) to submit a final report, in both official languages, to the Governor in Council not later than March 30, 1990; and

(g) the Commissioner be directed to file the records and papers of the inquiry as soon as reasonably may be after the conclusion of the inquiry with the Clerk of the Privy Council.

CERTIFIED TO BE A TRUE COPY - COPIE CERTIFIÉE CONFORME

CLERK OF THE PRIVY COUNCIL - LE GREFFIER DU CONSEIL PRIVE

P.C. 1990-625

CANADA

PRIVY COUNCIL

Certified to be a true copy of a Minute of a Meeting of the Committee of the Privy Council, approved by His Excellency the Governor General on the 29th day of March, 1990

WHEREAS the Commission of Inquiry into the Air Crash at Dryden, Ontario was directed to submit a final report, in both official languages, to the Governor in Council not later than March 30, 1990;

AND WHEREAS the Commission will not be in a position to submit its final report on or prior to March 30, 1990 and the Commissioner has requested an extension until June 30, 1991 to prepare and submit his report;

Therefore, the Committee of the Privy Council, on the recommendation of the Prime Minister, pursuant to Part I of the Inquiries Act, advises that a commission do issue amending the commission issued pursuant to Order in Council P.C. 1989-532 of 29th March, 1989, by deleting therefrom the following paragraph:

"(f) the Commissioner be directed

(ii) to submit a final report, in both official languages, to the Governor in Council not later than March 30, 1990; and"

and by substituting therefor the following paragraph:

"(f) the Commissioner be directed

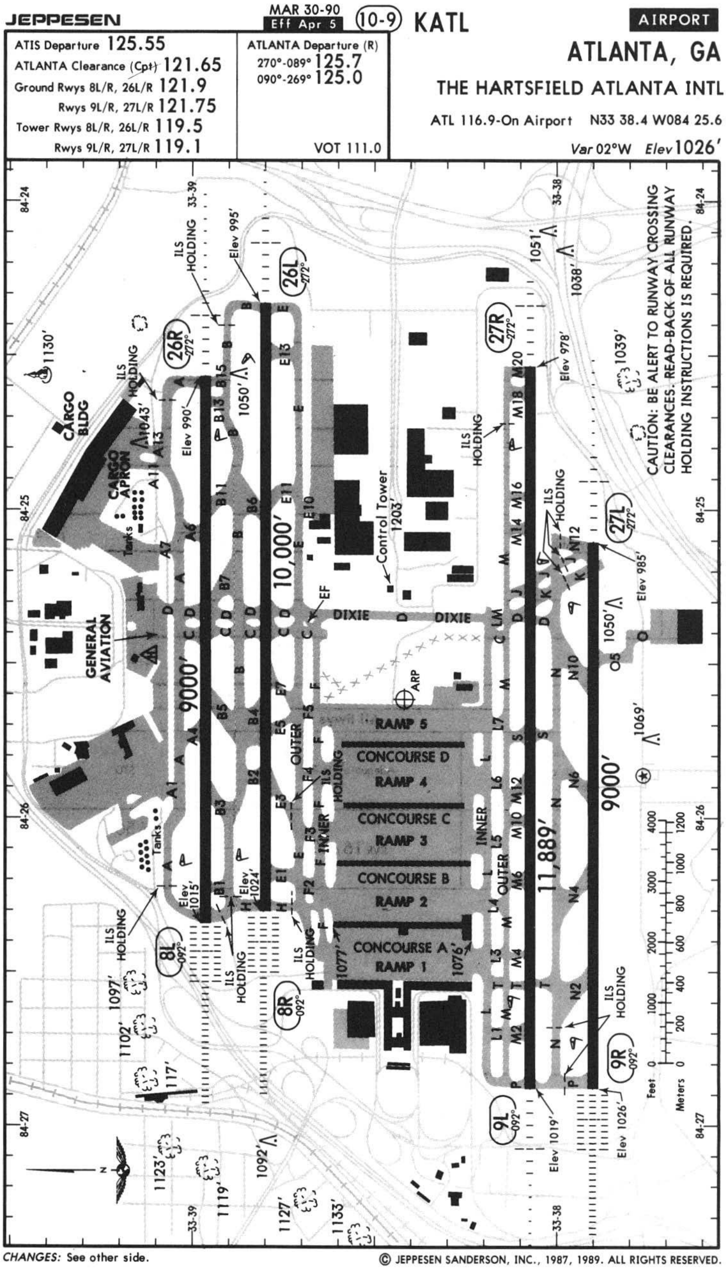
(ii) to submit a final report, in both official languages, to the Governor in Council not later than June 30, 1991; and"

CERTIFIED TO BE A TRUE COPY - COPIE CERTIFIÉE CONFORME

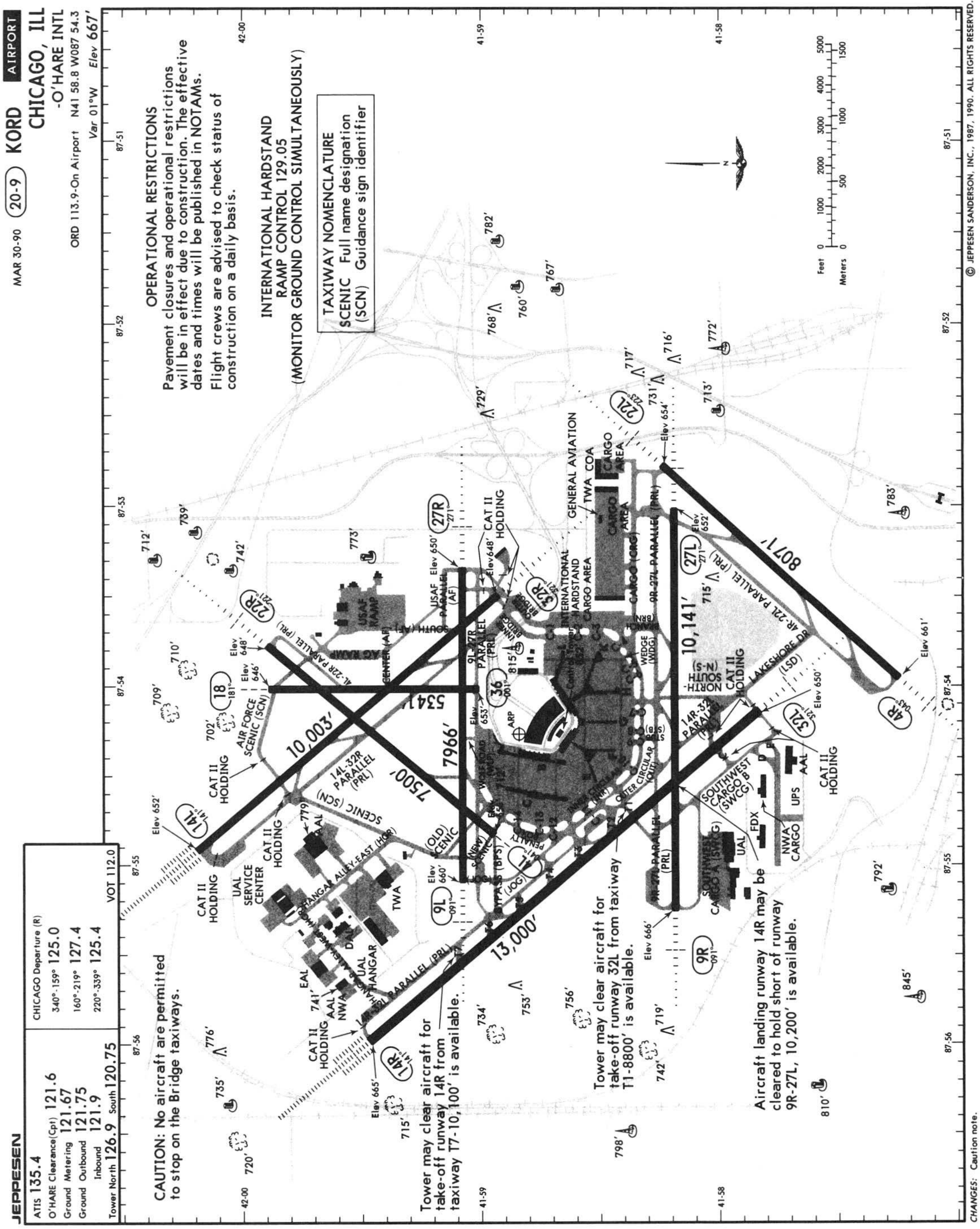
CLERK OF THE PRIVY COUNCIL - LE GREFFIER DU CONSEIL PRIVE

Appendix B

Scale Drawings of the Hartsfield Atlanta International Airport at Atlanta, Georgia, O'Hare International Airport at Chicago, Illinois, and Los Angeles International Airport at Los Angeles, California



Source: Jeppesen Sanderson, Inc.



JEPPESEN
MAR 30-90
20-9
KORD
AIRPORT
CHICAGO, ILL
-O'HARE INTL
ORD 113.9-On Airport N41 58.8 W087 54.3
Var 01°W Elev 667'
ATIS 135.4
O'HARE Clearance(Cpt) 121.6
Ground Metering 121.67
Ground Outbound 121.75
Inbound 121.9
Tower North 126.9 South 120.75
CHICAGO Departure (R)
340°-159° 125.0
160°-219° 127.4
220°-339° 125.4
VOT 112.0
OPERATIONAL RESTRICTIONS
Pavement closures and operational restrictions will be in effect due to construction. The effective dates and times will be published in NOTAMs.
Flight crews are advised to check status of construction on a daily basis.
INTERNATIONAL HARDSTAND RAMP CONTROL 129.05 (MONITOR GROUND CONTROL SIMULTANEOUSLY)
TAXIWAY NOMENCLATURE
SCENIC Full name designation
(SCN) Guidance sign identifier
CAUTION: No aircraft are permitted to stop on the Bridge taxiways.
Tower may clear aircraft for take-off runway 14R from taxiway T7-10,100' is available.
Tower may clear aircraft for take-off runway 32L from taxiway T1-8800' is available.
Aircraft landing runway 14R may be cleared to hold short of runway 9R-27L, 10,200' is available.
13,000'
10,003'
10,141'
8071'
7966'
7500'
5341'
14R
14L
32L
32R
22R
22L
4R
9L
9R
27R
27L
18
36
CAT II HOLDING
UAL SERVICE CENTER
UAL HANGAR
TWA
EAL
AAL
NWA
DAL
USAF RAMP
GENERAL AVIATION
TWA COA
CARGO AREA
INTERNATIONAL HARDSTAND CARGO AREA
SOUTHWEST CARGO A (SWCG)
SOUTHWEST CARGO B (SWCG)
FDX
UPS
NWA CARGO
ARP
Feet
Meters
CHANGES: Caution note.
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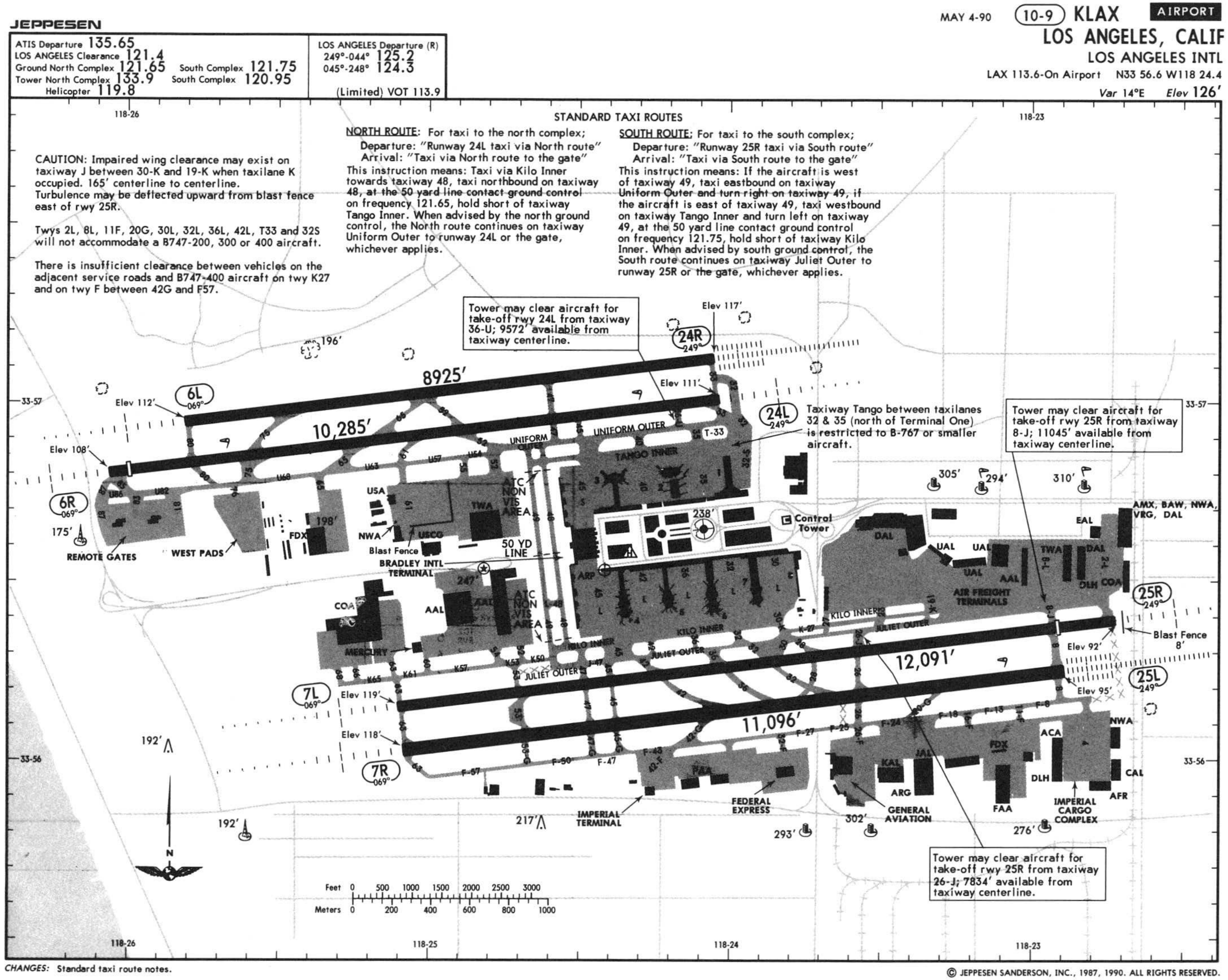
JEPPESEN
ATIS Departure 135.65
LOS ANGELES Clearance 121.4
Ground North Complex 121.65 South Complex 121.75
Tower North Complex 133.9 South Complex 120.95
Helicopter 119.8
LOS ANGELES Departure (R)
249°-044° 125.2
045°-248° 124.3
(Limited) VOT 113.9
MAY 4-90
10-9 KLAX
AIRPORT
LOS ANGELES, CALIF
LOS ANGELES INTL
LAX 113.6-On Airport N33 56.6 W118 24.4
Var 14°E Elev 126'
STANDARD TAXI ROUTES
NORTH ROUTE: For taxi to the north complex;
Departure: "Runway 24L taxi via North route"
Arrival: "Taxi via North route to the gate"
This instruction means: Taxi via Kilo Inner towards taxiway 48, taxi northbound on taxiway 48, at the 50 yard line contact ground control on frequency 121.65, hold short of taxiway Tango Inner. When advised by the north ground control, the North route continues on taxiway Uniform Outer to runway 24L or the gate, whichever applies.
SOUTH ROUTE: For taxi to the south complex;
Departure: "Runway 25R taxi via South route"
Arrival: "Taxi via South route to the gate"
This instruction means: If the aircraft is west of taxiway 49, taxi eastbound on taxiway Uniform Outer and turn right on taxiway 49, if the aircraft is east of taxiway 49, taxi westbound on taxiway Tango Inner and turn left on taxiway 49, at the 50 yard line contact ground control on frequency 121.75, hold short of taxiway Kilo Inner. When advised by south ground control, the South route continues on taxiway Juliet Outer to runway 25R or the gate, whichever applies.
CAUTION: Impaired wing clearance may exist on taxiway J between 30-K and 19-K when taxilane K occupied. 165' centerline to centerline.
Turbulence may be deflected upward from blast fence east of rwy 25R.
Twys 2L, 8L, 11F, 20G, 30L, 32L, 36L, 42L, T33 and 32S will not accommodate a B747-200, 300 or 400 aircraft.
There is insufficient clearance between vehicles on the adjacent service roads and B747-400 aircraft on twy K27 and on twy F between 42G and F57.
Tower may clear aircraft for take-off rwy 24L from taxiway 36-U; 9572' available from taxiway centerline.
Taxiway Tango between taxilanes 32 & 35 (north of Terminal One) is restricted to B-767 or smaller aircraft.
Tower may clear aircraft for take-off rwy 25R from taxiway 8-J; 11045' available from taxiway centerline.
Tower may clear aircraft for take-off rwy 25R from taxiway 26-J; 7834' available from taxiway centerline.
6L 069°
6R 069°
7L 069°
7R 069°
24R 249°
24L 249°
25R 249°
25L 249°
8925'
10,285'
12,091'
11,096'
Elev 112'
Elev 108'
Elev 117'
Elev 111'
Elev 92'
Elev 95'
Elev 119'
Elev 118'
Blast Fence 8'
REMOTE GATES
WEST PADS
UNIFORM OUTER
TANGO INNER
KILO INNER
JULIET OUTER
ATC NON VIS AREA
50 YD LINE
BRADLEY INTL TERMINAL
Blast Fence
Control Tower
AIR FREIGHT TERMINALS
AMX, BAW, NWA, VRG, DAL
FEDERAL EXPRESS
GENERAL AVIATION
IMPERIAL CARGO COMPLEX
IMPERIAL TERMINAL
MERCURY
Feet 0 500 1000 1500 2000 2500 3000
Meters 0 200 400 600 800 1000
CHANGES: Standard taxi route notes.
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Appendix C

AIR ONTARIO INC.
PILOT BULLETIN
[illegible]

January 20, 1988

The following information is offered to make pilots more aware of what deicing fluid will, and perhaps more importantly, <u>will not</u> do for you.

1. The de-icing fluid used at all stations is a mix of glycol and water. At temperatures near or just below the freezing point, (-7 degrees celcius and higher) the fluidity of the de-icing mixture is not appreciably lessened by light snow or freezing rain, and the aircraft surfaces should remain wet and suitable for take-off for periods in excess of 15 minutes after a spray.

2. As the OAT decreases, or the precipitation rate increases, the length of protection diminishes. At temperatures of -13 degrees celcius and below, in light to moderate precipitation, slushing may occur; while in a heavy snow condition, the dilution rate of de-icing fluid is accelerated.

3. <u>CAUTION:</u> Effectiveness of anti-icing spray is modified by intensity of precipitation and length of time between spray application and take-off. Use of reverse, or exhaust of other aircraft may also adversely affect the spray effectiveness, and may cause ice build up on the wing.

4. It is not possible or desirable to create hard and fast rules that cater to all the weather variables encountered during winter operations. Good judgement, pilot awareness and caution are required to ensure the safe operation of our flights. It is the Captain's responsibility to ensure that the wings are clear of ice and snow accumulations for take-off.

R.V. Nyman
Director of Flight Operations

Appendix D

Air Canada Aircraft De-icing and Anti-icing Hold-over Guidelines

PUB 550
CHAP 9
PAGE 27
89 11 23

Environmental Factors

8 AIRCRAFT DE-ICING AND ANTI-ICING (cont.)

.03 Spray Effectiveness Considerations: (cont.)

5 HOLDOVER GUIDELINES: (cont.)

AMBIENT TEMP. °C	HOLDOVER GUIDELINES FOLLOWING ANTI-ICING TYPE 1 FLUID (50/50)					HOLDOVER GUIDELINES FOLLOWING ANTI-ICING TYPE 2 FLUID (50/50)				
	FROST	FREEZING DRIZZLE	SNOW LT	SNOW MED	SNOW HVY	FROST	FREEZING DRIZZLE	SNOW LT	SNOW MED	SNOW HVY
	60 MINS	8 MINS	15 MINS	9 MINS	4 MINS	12 HOURS	28 MINS	63 MINS	28 MINS	15 MINS
0°C										
	45 MINS	5 MINS	11 MINS	6 MINS	3 MINS	8 HOURS	20 MINS	45 MINS	19 MINS	13 MINS
-8°C										
	30 MINS	3 MINS	11 MINS	6 MINS	3 MINS	6 HOURS	13 MINS	32 MINS	14 MINS	9 MINS

Key to snow intensity:

VISIBILITY
LT = more than 1 mile
MED = 1/2 to 1 mile
HVY = less than 1/2 mile

6 FACTORS THAT REDUCE HOLDOVER TIME: Where conditions are worse than those given in the tables, holdover time will be reduced, occasionally to the point where operations must be suspended.

In general, precipitation which is high in moisture content, e.g. wet snow or freezing rain, can drastically reduce holdover time.

Since engine exhaust can disturb the anti-icing coating, or blow snow or slush onto the aircraft:

- Use pushback rather than powerback
- Maintain greater than normal distance between aircraft during taxi.
- Do not reverse thrust on snow or slush-covered ramps or taxiways unless absolutely necessary. If reverse is used, the airplane must be reinspected.

Source: Air Canada, *550: Flight Operations Manual*

PUB 550
CHAP 9
PAGE 28
83 09 30

Environmental Factors

9 CONTAMINATED RUNWAY OPERATION

.01 Departing Before Runway has been Inspected: When a flight is scheduled for departure before the runway has been inspected or used by another aircraft, pilots must back-track the aircraft on the runway prior to take-off to ensure that the runway is serviceable for departure.

.02 Definitions of Slush and Wet Snow: AOMs specify that take-off will not be made when certain snow or slush conditions exist. For the purpose of these limitations, wet snow and slush are defined as follows:

1 WET SNOW: Heavy, easily packed snow which may exude water when compressed.

2 SLUSH: Snow which is combining with water either from its own melting or from rain.

Basically, if it splashes, it's slush; if it makes a good snowball, it's wet snow.

.03 Control & Stopping on Slippery Runways:

1 HYDROPLANING PHENOMENA: Hydroplaning can occur in three different forms: dynamic, viscous, and rubber reversion hydroplaning. The most commonly experienced form of hydroplaning is dynamic hydroplaning which is caused by standing water on a runway that is not displaced from under tires fast enough for the tire to completely come into contact with the runway. The tires will therefore ride on a film of water over all (total hydroplaning) or part (partial hydroplaning) of the tire footprint area. When the tire is fully detached from the runway surface, the center of pressure in the tire footprint moves forward and can cause the wheel to stop rotating if hydroplaning lasts long enough.

When this occurs, of course, available wheel braking is reduced to zero. The lowest speed at which this occurs is considered the minimum total hydroplaning speed. Partial and full hydroplaning, Figure 9, have been determined to be primarily a function of tire inflation pressure. Partial hydroplaning may occur at considerably lower speeds.

Appendix E

MAJOR GROUND DEICING RELATED ACCIDENTS

Expanded List

3/10/89 - Air Ontario F-28 - Dryden, Ontario, Canada
Not Deiced - Snowfall Conditions

11/15/87 - Continental Airlines DC 9-14 - Denver
Deiced 27 Minutes BTO - Engine Surge

12/15/85 - Arrow Air DC-8-63 - Gander Newfoundland
Not Deiced

2/5/85 - Airbourne Express DC-9-15 - Philadelphia
Not Deiced - Engine Spooldown

1/13/82 - Air Florida B-737 - Washington, DC
Deiced 45 Min. BTO

2/16/80 - Red Coat Air Cargo - Bristol Britannia -
Billerica, MA - Deiced 45 to 60 Min BTO

2/12/79 - Allegheny Airlines - Nord 262 - Clarksburg, WV
Not Deiced - Snow and Ice on Wings

1/19/79 - General Aviation Lear Jet - Detroit
Not Deiced? - Wing Ice

12/20/78 - General Aviation Lear Jet - Minneapolis, MN
Not Deiced? - Snow & Ice on Wings

11/27/78 - TWA DC-9-10 - Newark, NJ
Not Deiced?

1/4/77 - B-737 Frankfort - Light Snow - Rime Ice on Wing
One of 22 Pitch Up Roll Off Incidents (Ref 11)

1/13/77 - Japan Air Lines DC-8-62F - Anchorage, Alaska
Not Deiced

- F-28 - Hanover Germany

1/26/74 - THY - F-28 - Cumaovas, Turkey
Not Deiced - Frost Accretion on Wings

12/27/68 - Ozark Airlines DC-9-15 - Sioux City, Iowa

Dick Adams - June 6, 1990

Source: Compiled by Richard Adams, June 6, 1990

Appendix F

BOEING

SERVICE LETTER

Customer Support FIELD SERVICE ENGINEERING • BOEING COMMERCIAL AIRPLANES • P.O. BOX 3707 • SEATTLE, WASHINGTON 98124

707-SL-12-6
727-SL-12-6
737-SL-12-7
747-SL-12-5
757-SL-12-5
767-SL-12-8

ATA: 1230-10

May 31, 1989

SUBJECT: USE OF DEICING/ANTI-ICING FLUIDS

MODELS: 707, 727, 737, 747, 757, and 767 Series

APPLICABILITY: All Airplanes

REFERENCE: Service Letter 707-SL-12-3-A, 727-SL-12-3-A, 737-SL-12-3-A, 747-SL-12-2-A, 757-SL-12-1-A, 767-SL-12-2-A, dated 2 December 1982

BACKGROUND:

As a result of our 1982 small scale, two-dimensional wind tunnel testing that evaluated the aerodynamic influences of airplane ground deicing/anti-icing fluids on airfoil performance, Boeing issued the reference all-model service letter to advise airlines of adverse aerodynamic effects that may result from undesirable characteristics of the fluids at low ambient temperatures. These tests disclosed that the fluids did not completely flow off aerodynamic surfaces during simulated ground roll and initial takeoff. We advised that the residual fluid film on these surfaces may degrade lift and increase drag.

To better understand the aerodynamic effects of the deicing/anti-icing fluids, Boeing, the Association of European Airlines (AEA), and NASA have accomplished additional testing during the past several years. This testing confirmed that residual fluid films remain on the wing at rotation and that new formulation fluids have significantly improved flow-off characteristics, as compared to previously manufactured fluids, resulting in less adverse aerodynamic effects.

This service letter provides a summary of our recent conclusions and suggestions to further assist airlines in their winter operations.

DISCUSSIONS:

The following definitions are offered to facilitate a better understanding of the information contained in this service letter:

1. Deicing consists of the application of heated water or a heated glycol/water mixture to remove accumulated ice, snow, and frost from the airplane surfaces.

2. Anti-icing consists of the application of concentrated or diluted glycol-based fluid to prevent ice, snow, and/or frost from adhering to the treated surfaces.

The recent activities with respect to deicing/anti-icing fluids are summarized as follows:

1. Fluid Specifications

As discussed in the reference service letter, the deicing/anti-icing fluids can be classified into two types. The Type I fluids are unthickened and contain a minimum of 80 percent glycols. Several specifications exist for Type I fluids, such as AMS 1425, AMS 1427, MIL-A-8243 Type 1 and Type 2, and AEA Type I. Type I fluids provide minimum "holdover" times (until they may need to be reapplied).

The Type II fluids are thickened and contain a minimum of 50 percent glycols. These fluids were developed primarily for anti-icing. Available data indicates that they provide significantly longer holdover periods than Type I fluids.

Several fluid manufacturers have developed "new formulation" Type II fluids, because testing and experience has shown that Type II fluids manufactured prior to September 1988 ("old" Type II fluids) have a greater effect on lift and drag than Type I fluids. Boeing, the AEA, and NASA have evaluated the aerodynamic affects of these new formulation Type II fluids which reportedly provide holdover times similar to those of old Type II fluids. Tests have shown that, at temperatures ranging from minus 10 to minus 20 degrees Celsius, the aerodynamic effects of the new formulation Type II fluids are similar to those of Type I fluids.

The AEA has issued a specification for deicing/anti-icing fluids, which reflects the new formulation Type II fluids. This specification includes specific holdover time requirements for the new formulation Type II fluids which are identical to those for the old Type II fluids. The AEA intends to include an aerodynamic acceptability performance test in this specification when such a test is defined. Boeing is coordinating with the AEA, the Society of Automotive Engineers (SAE), the International Standards Organization (ISO), the Air Transport Association of America (ATA), and the Aerospace Industry Association (AIA) to develop industry-wide Type I and Type II fluid specifications. These specifications will also include an aerodynamic acceptability performance test.

2. Fluid Evaluations

To better understand the aerodynamic effects of the Type II fluids, the AEA performed research and large-scale wind tunnel tests in 1986 and 1987. In January 1988, Boeing and the AEA completed a flight test program using a Model 737-200 ADV (advanced) airplane at Kuopio, Finland. The flight tests included evaluation of representative Type I and (old) Type II fluids available at that time.

Additionally, in 1988, Boeing, NASA, and the AEA performed a series of wind tunnel tests at the NASA Lewis Icing Research Tunnel. These tests involved the flight tested Type I and old Type II fluids and several new formulation Type II fluids.

These tests confirmed that the residual fluid films of both Type I and Type II fluids remained on the wing at rotation and resulted in adverse effects on aerodynamic performance. However, the test results showed that the old Type II fluids caused greater adverse aerodynamic effects than the Type I fluids. The test results also showed that the aerodynamic effects of the new formulation Type II fluids are significantly improved as compared to those of old Type II fluids, and are similar to those of Type I fluids.

3. Effect of Fluid Use on Takeoff Performance

Following our analyses of the data obtained during the aforementioned testing, we determined that, although some fluid remains on the aerodynamic surfaces during rotation and initial climb, the fluids listed below demonstrated acceptable flow-off characteristics, and that they may be used without a requirement for any takeoff performance adjustments for all Boeing model airplanes except for Model 737-100 and 737-200 NON-ADV (non-advanced) airplanes (Line Positions 1 through 279). However, on all model airplanes no reduced thrust takeoffs (assumed temperature method) should be performed when the fluids are being used. Also, on Model 737-200 ADV airplanes, takeoff flap position ten or greater should be used whenever operational conditions allow. On Model 737-100 and 737-200 NON-ADV airplanes, takeoff weight and speed adjustments are necessary, depending on outside temperature, to ensure adequate performance margins when using these fluids.

Presently, the use of the following fluids (including fluids made under licensed production) does not require any performance adjustments, except as stated above:

Type I fluids meeting the following specifications -

AMS 1425
AMS 1427
MIL-A-8243D Type 1 and Type 2
AEA Type I

Type II fluids-

Kilfrost - ABC3
Hoechst - 1704 LTV/88
Union Carbide - UCAR AAF PM6412
Union Carbide - UCAR AAF 250-3
SPCA AD 104

Note: Only Kilfrost ABC3 and Hoechst 1704 LTV/88 fluids reportedly meet the AEA Type II fluid specification, including holdover time requirements.

As previously discussed, industry-wide deicing/anti-icing fluid specifications are presently being prepared. Other fluids, Type I or new formulation Type II, developed by the fluid manufacturers may also be used as described above, provided that they meet the requirements of the forthcoming approved specifications.

Please note that Boeing does not make recommendations with regard to specific fluids. However, we do advise that operators use only those fluids that have passed the materials compatibility tests as described in Boeing Document D6-17487. These tests are not intended to judge aerodynamic or deicing/anti-icing performance. We understand that all of the aforementioned fluids have passed the materials compatibility tests, and the aforementioned fluid specifications contain substantially equivalent materials compatibility requirements. Specific materials compatibility information can be obtained from the fluid manufacturers.

FURTHER BOEING ACTION:

We are revising the Pilot Training Manual and the Operations Manual to provide information associated with the use of deicing/anti-icing fluids as discussed above. We have scheduled these changes to be released by 31 August 1989.

For the Model 737-100 and 737-200 NON-ADV airplanes, the takeoff performance adjustments will be contained in Section 4A-2, Takeoff and Landing, of the manually produced Operations Manual, and in Section 23.10, Flight Planning, of the automated Operations Manual. This data has been scheduled for release by 1 June 1989.

We are also revising Chapter 12 of the Maintenance Manual, Cold Weather Operation, to provide the aforementioned information regarding deicing/anti-icing fluids. These changes have been scheduled for release by 19 July 1989.

The Operations and Maintenance Manual revisions will be provided to all operators, regardless of whether they are active or non-active holders of Operations and Maintenance Manuals.

SUGGESTED OPERATOR ACTION:

Operators are advised to carefully review their application of deicing/anti-icing fluids and to select fluids based on their specific requirements, including holdover times.

The fluids should be applied using appropriate ground equipment and procedures as described in the applicable specifications, or as specified by the fluid manufacturer. Holdover times should be established based on fluid specification requirements, operators' experience, and the recommendations of the fluid manufacturer.

We strongly recommend that operators do not perform reduced thrust takeoffs (assumed temperature method) on any Boeing model airplane when using deicing/anti-icing fluids. Caution must be exercised when using any fluid, because of a transitory decrease in lift and increase in drag during rotation and initial climbout due to residual fluid. Additionally, on Model 737-200 ADV airplanes, takeoff flap position ten or greater should be used whenever operational conditions allow. For Model 737-100 and 737-200 NON-ADV airplanes, we recommend takeoff weight and speed adjustments as contained in the forthcoming revisions to the Operations Manual.

For additional information on cold weather operations, see the 1982 through 1988 October-December issues of the Boeing Airliner magazine.

Robert B. Nous
for T. J. Taylor for
707/727/737/747/757/767
Service Engineering Managers

KdJ:gp
6046A

Appendix G

Transport Canada Transports Canada

Aviation Aviation

N-AME-AO 13/88R1	1/1
DATE 20 November 1989	

NOTICE TO AIRCRAFT MAINTENANCE ENGINEERS AND AIRCRAFT OWNERS

USE OF AEA TYPE II DE-ICING/ANTI-ICING FLUIDS

(Supersedes N-AME-AO 13/88)

Background

This N-AME-AO is issued as an update to N-AME-AO 13/88, dated 23 November 1988, concerning the effects of AEA (Association of European Airlines) Type II de-icing/anti-icing fluids on aircraft performance. Although Type II fluids had provided superior anti-icing capability, adverse aerodynamic effects had been attributed to excess fluid adhering to aerodynamic surfaces at take-off. Since N-AME-AO 13/88 was written, AEA has revised the Type II fluid specification and a new generation of Type II fluids has become commercially available.

Current Situation

Most Type II fluids now being produced meet the revised AEA specification. AEA and Boeing have carried out tests which indicated that the new generation Type II fluids have very similar aerodynamic effects to the old unthickened Type I fluids. Boeing is the only manufacturer so far to have recommended performance adjustments when using de-icing/anti-icing fluids and these are confined to the Boeing 737-100 and -200 NONADV models.

Transport Canada Recommendations

Although there have been significant improvements in Type II fluid characteristics within the last year, operators should continue to review the use of the fluid with aircraft manufacturers to determine if any procedural changes and/or performance adjustments are recommended. It should be confirmed that fluids being used meet the latest AEA specifications for Type II fluids. Users of turbo-propeller and other aircraft having low rotation speeds compared with jet transport aircraft should continue to take particular care as speed is the main factor governing the flow of fluid off the wing during take-off.

Future Action

Transport Canada will continue to review the situation with aircraft manufacturers and operators, particularly with respect to low speed aircraft, and the Transport Canada Development Centre is promoting research into various aspects of Type II fluids.

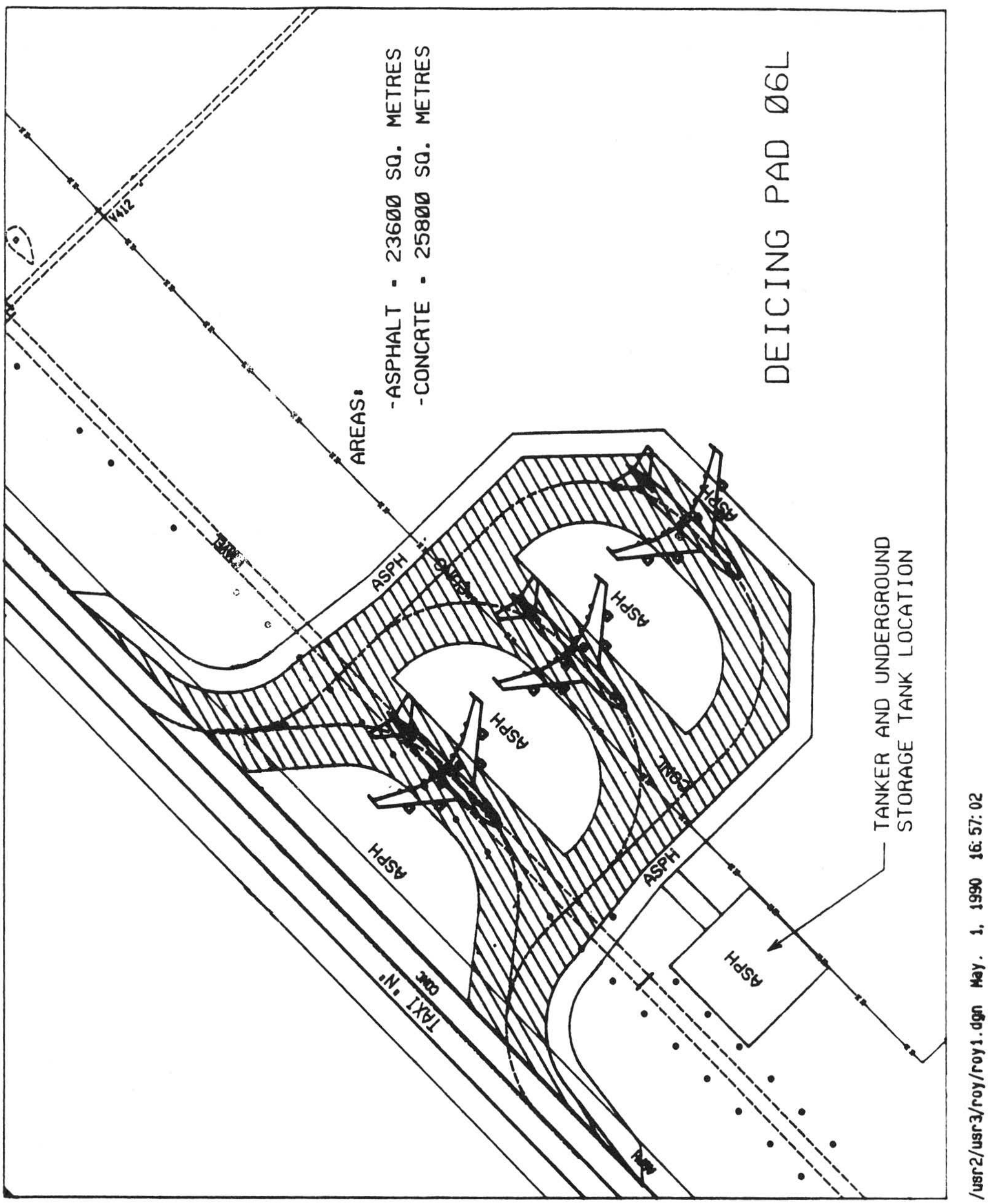
For Minister of Transport

James A. Torck
Director, Airworthiness

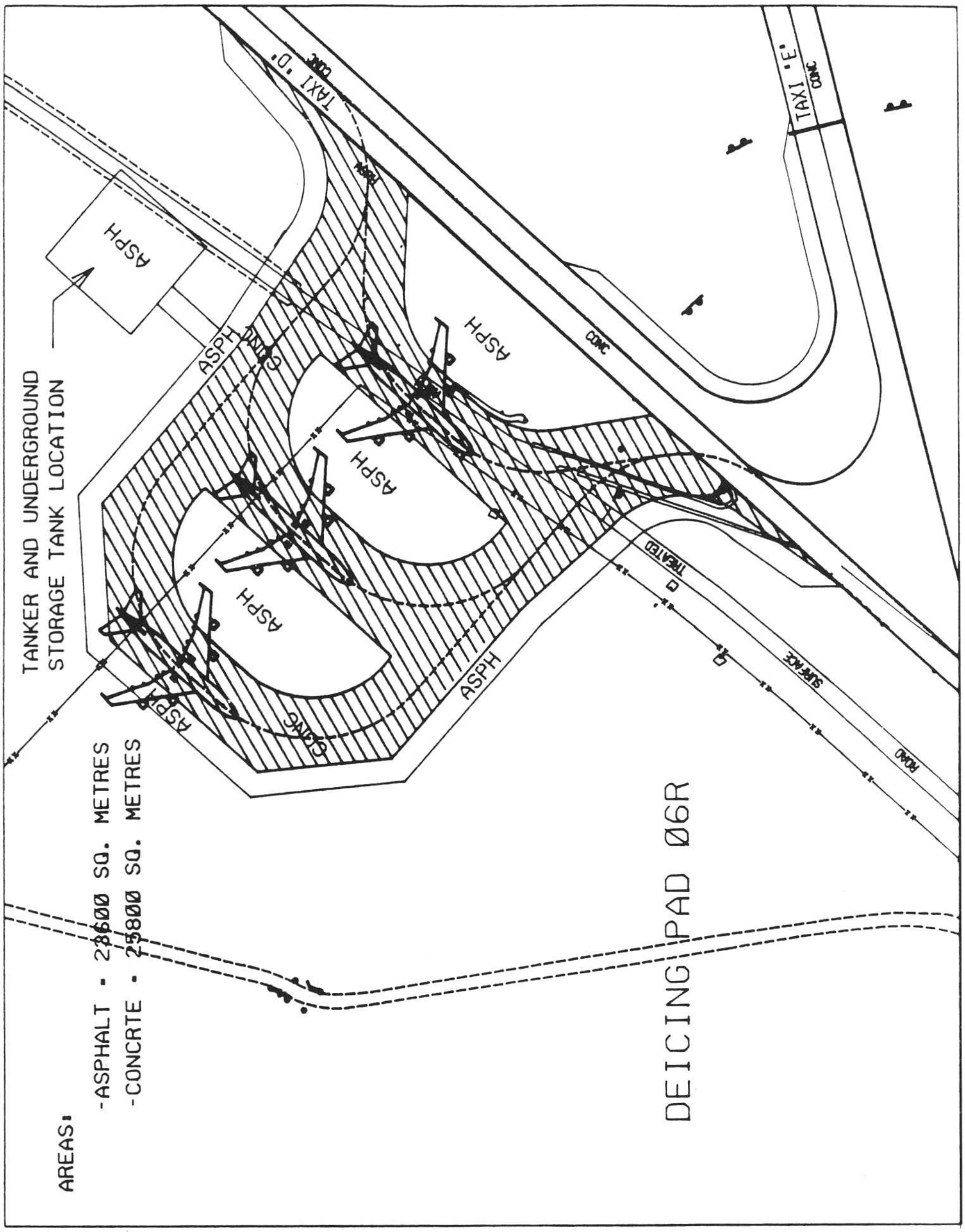
Canada

Appendix H

Drawings for De-icing Pads at Pearson International Airport



Source: Prepared by John Holm, Transport Canada



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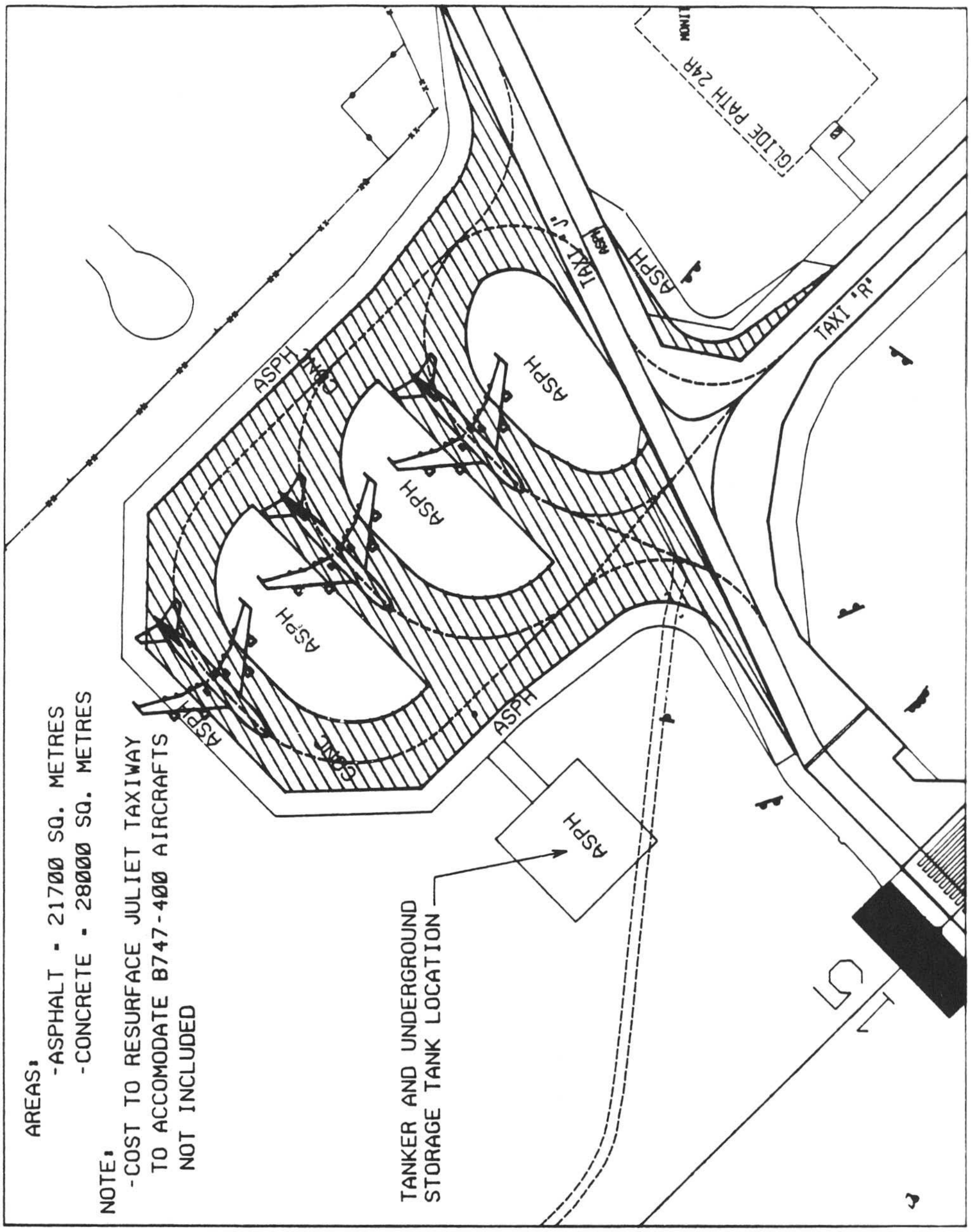

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Appendix I

Cost Estimates for Construction of De-icing/Anti-icing Pads

Transport Canada | Transports Canada
Airports Authority Group | Groupe de gestion des aéroports

CAPITAL COST SUMMARY SHEET

1. PROJECT

Date of Estimate May/90 Site LBPIA Project No

Class of Estimate 'D' Title DE/ANTI ICE PADS -- RUNWAY 06L

Purpose of Estimate APD

Remarks: Inflation Rates as per AKAD Memo of April 7, 1989

This estimate supersedes estimate of

Constant Dollar Year 1990/91

	IMPLEMENTATION YEAR(S)	Constant Dollar Year 1990/91
2. CONSTRUCTION		
#1		
#2 BASIC	4621.7	
#3		
#4		
Sub total	4621.7	4621.7
3. PROJECT MANAGEMENT		
Preliminary Design (Consultant)	122.9	
Final Design (Consultant)	184.4	
Construction Supervision (Consultant	462.2	
T.C. Administration Services	46.2	
Capital Person Years (Dollars)	460.0	
Sub Total	1275.7	1275.7
4. CONTINGENCIES		
DESIGN	30.7	
CONSTRUCTION	462.2	
Sub Total	492.9	492.9
5. PROJECT TEC (CONSTANT DOLLARS)		6390.3
6. PROJECT PHASING AND INFLATION		
Project Phased & Inflated Costs	0.0	
Person Year Requirements	9.2	
Year:	1990/91 19 19	
7. PROJECT TEC (CURRENT DOLLARS)		6390.3

CHECKED BY:

CERTIFIED BY: Profit Centre Manager

PROJECT SUMMARY SHEET

Canada

Source: Prepared by John Holm, Transport Canada

Airports Authority Group / Groupe de gestion des aéroports

... International Airport

CONSTRUCTION COSTS

CLASS OF ESTIMATE

- [X] D
- [ ] B
- [ ] C
- [ ] A

PURPOSE OF ESTIMATE

- [ ] APD.
- [ ] PAD
- [ ] 100 % PRELIMINARY
- [ ] AMENDED APD
- [ ] AMENDED PAD
- [ ] PRE TENDER

PROJECT DESCRIPTION : DE/ANTI ICE PADS - RUNWAY 06L

PROJECT NUMBER : ______ SITE : LBPIA

COST ELEMENT (S) : BASIC

CONSTANT YEAR : 1990/91

SHEET 1 OF 2

ITEM No.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	BASIC COST (x1000)
1	EXCAVATION	40000	M^3	4.0	160.0
2	SUB-GRADE COMPACTION	49400	M^2	1.0	49.4
3	GRANULAR SUB-BASE	44100	TONNE	15.7	692.4
4	GRANULAR BASE	50000	TONNE	16.9	845.0
5	HOT MIX ASPHALT	3000	TONNE	58.4	175.2
6	PORTLAND CEMENT	3000	TONNE	198.8	596.4
7	CONCRETE PAVING	9800	M^3	83.3	816.3
8	SUB-DRAIN	2250	M	135.9	305.8
9	MANHOLES	10	EACH	3206.4	32.1
10	CATCHBASIN	10	EACH	2227.6	22.3
	TOTAL				3694.9

ESTIMATE PREPARED BY : R. HERNANDEZ Phone #: 4637 Date ______

ESTIMATE CHECKED BY : [illegible] Phone #: 3534 Date [illegible]

Canada

JUNE 86

PROJECT SUMMARY SHEET 1

Authority Group — gestion des aeroports

... International Air...

CONSTRUCTION COSTS

CLASS OF ESTIMATE

[X] D ☐ B

☐ C ☐ A

PURPOSE OF ESTIMATE

☐ APD ☐ PAD ☐ 100 % PRELIMINARY

☐ AMENDED APD ☐ AMENDED PAD ☐ PRE TENDER

PROJECT DESCRIPTION : DE/ANTI ICE PADS - RUNWAY 06L

PROJECT NUMBER : ______ SITE : LBPIA

COST ELEMENT (S) : BASIC

CONSTANT YEAR : 1990/91

SHEET 2 OF 2

ITEM No.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	BASIC COST (x1000)
	SUBTOTAL CARRIED FORWARD				3694.9
11	EDGE LIGHTING	40	EACH	600.0	24.0
12	45500 LITRE UNDERGROUND STORAGE & COLLECTION TANKS & ALL APPURTENANCES	4	EACH	25000.0	100.0
13	SECURITY	L.S.			20.0
14	HYDRAULIC SEEDING	1.6	HECTARE	7800.0	12.5
	SUB-TOTAL				3851.4
15	NIGHTWORK PREMIUM (20% OF SUB-TOTAL)				770.3
	TOTAL				4621.7

ESTIMATE PREPARED BY : R. HERNANDEZ Phone # 4637 Date ______

ESTIMATE CHECKED BY : [illegible] Phone # 3535 Date ______

Canada

JUNE 86

PROJECT SUMMARY SHEET 2

Transport Canada | Transports Canada
Airports Authority Group | Groupe de gestion des aéroports

CAPITAL COST SUMMARY SHEET

1. PROJECT

Date of Estimate May/90 Site LBPIA Project No

Class of Estimate 'D' Title DE/ANTI ICE PADS - RUNWAY 06R

Purpose of Estimate APD

Remarks: Inflation Rates as per AKAD Memo of April 7, 1989

This estimate supersedes estimate of

	IMPLEMENTATION YEAR(S)	Constant Dollar Year 1990/91
2. CONSTRUCTION		
#1		
#2 BASIC	4621.7	
#3		
#4		
	Sub total 4621.7	4621.7
3. PROJECT MANAGEMENT		
Preliminary Design (Consultant)	122.9	
Final Design (Consultant)	184.4	
Construction Supervision (Consultant	462.2	
T.C. Administration Services	46.2	
Capital Person Years (Dollars)	460.0	
	Sub Total 1275.7	1275.7
4. CONTINGENCIES		
DESIGN	30.7	
CONSTRUCTION	462.2	
	Sub Total 492.9	492.9
5. PROJECT TEC (CONSTANT DOLLARS)		6390.3
6. PROJECT PHASING AND INFLATION		
Project Phased & Inflated Costs	0.0	
Person Year Requirements	9.2	
Year:	1990/91 19 19	
7. PROJECT TEC (CURRENT DOLLARS)		6390.3

CHECKED BY: [signature]

CERTIFIED BY: [signature]
~~Profit Centre~~ Manager

PROJECT SUMMARY SHEET

Canada

Airports Authority Group — Groupe de gestion des aéroports

CONSTRUCTION COSTS

CLASS OF ESTIMATE

[X] D [ ] B
[ ] C [ ] A

PURPOSE OF ESTIMATE

[ ] APD [ ] PAD [ ] 100 % PRELIMINARY
[ ] AMENDED APD [ ] AMENDED PAD [ ] PRE TENDER

PROJECT DESCRIPTION : DE/ANTI ICE PADS – RUNWAY 06R

PROJECT NUMBER : ______ SITE : LBPIA

COST ELEMENT (S) : BASIC

CONSTANT YEAR : 1990/91

SHEET 1 OF 2

ITEM No.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	BASIC COST (x1000)
1	EXCAVATION	40000	M^3	4.0	160.0
2	SUB-GRADE COMPACTION	49400	M^2	1.0	49.4
3	GRANULAR SUB-BASE	44100	TONNE	15.7	692.4
4	GRANULAR BASE	50000	TONNE	16.9	845.0
5	HOT MIX ASPHALT	3000	TONNE	58.4	175.2
6	PORTLAND CEMENT	3000	TONNE	198.8	596.4
7	CONCRETE PAVING	9800	M^3	83.3	816.3
8	SUB-DRAIN	2250	M	135.9	305.8
9	MANHOLES	10	EACH	3206.4	32.1
10	CATCHBASIN	10	EACH	2227.6	22.3
	TOTAL				3694.9

ESTIMATE PREPARED BY : R. HERNANDEZ Phone : 4637 Date : ______

ESTIMATE CHECKED BY : [illegible] Phone : 3535 Date : [illegible]

Canada

JUNE 86

PROJECT SUMMARY SHEET 1

Authority Group   gestion des aeroports

CONSTRUCTION COSTS

CLASS OF ESTIMATE

[X] D   [ ] B
[ ] C   [ ] A

PURPOSE OF ESTIMATE

[ ] APD   [ ] PAD   [ ] 100 % PRELIMINARY
[ ] AMENDED APD   [ ] AMENDED PAD   [ ] PRE TENDER

PROJECT DESCRIPTION : DE/ANTI ICE PADS - RUNWAY 06R

PROJECT NUMBER : ______ SITE : LBPIA

COST ELEMENT (S) : BASIC

CONSTANT YEAR : 1990/91

SHEET 2 OF 2

ITEM No.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	BASIC COST (x1000)
	SUBTOTAL CARRIED FORWARD				3694.9
11	EDGE LIGHTING	40	EACH	600.0	24.0
12	45500 LITRE UNDERGROUND STORAGE & COLLECTION TANKS & ALL APPURTENANCES	4	EACH	25000.0	100.0
13	SECURITY	L.S.			20.0
14	YDRAULIC SEEDING	1.6	HECTARE	7800.0	12.5
	SUB-TOTAL				3851.4
15	NIGHTWORK PREMIUM (20% OF SUB-TOTAL)				770.3
	TOTAL				4621.7

ESTIMATE PREPARED BY : R. HERNANDEZ   Phone # 4637   Date ______

ESTIMATE CHECKED BY : [illegible]   Phone # 3535   Date [illegible]

Canada

JUNE 86

PROJECT SUMMARY SHEET 2

Transport Canada / Transports Canada
Airports Authority Group / Groupe de gestion des aéroports

CAPITAL COST SUMMARY SHEET

1. PROJECT

Date of Estimate May/90 Site LBPIA Project No

Class of Estimate 'D' Title De/Anti Ice PADS - Runway

Purpose of Estimate APD 15

Remarks: Inflation Rates as per AKAD Memo of April 7, 1989

This estimate supersedes estimate of

	Implementation Year(s)	Constant Dollar Year 1990/91
2. CONSTRUCTION		
#1		
#2 BASIC	4951.4	
#3		
#4		
	Sub total 4951.4	4951.4
3. PROJECT MANAGEMENT		
Preliminary Design (Consultant)	131.7	
Final Design (Consultant)	197.5	
Construction Supervision (Consultant	495.1	
T.C. Administration Services	49.5	
Capital Person Years (Dollars)	495.0	
	Sub Total 1368.8	1368.8
4. CONTINGENCIES		
DESIGN	32.9	
CONSTRUCTION	495.1	
	Sub Total 528.0	528.0
5. PROJECT TEC (CONSTANT DOLLARS)		6848.2
6. PROJECT PHASING AND INFLATION		
Project Phased & Inflated Costs	0.0	
Person Year Requirements	9.9	
Year:	1990/91 19 19	
7. PROJECT TEC (CURRENT DOLLARS)		6848.2

CHECKED BY:

CERTIFIED BY: ~~Profit Centre~~ Manager

PROJECT SUMMARY SHEET

Canada

Airports Authority Group — Groupe de gestion des aéroports

L.B. Pearson, International Air

CONSTRUCTION COSTS

CLASS OF ESTIMATE

- [x] D
- [ ] B
- [ ] C
- [ ] A

PURPOSE OF ESTIMATE

- [ ] APD
- [ ] PAD
- [ ] ICO % PRELIMINARY
- [ ] AMENDED APD
- [ ] AMENDED PAD
- [ ] PRE TENDER

PROJECT DESCRIPTION : DE/ANTI ICE PADS - RUNWAY 15

PROJECT NUMBER : ______ SITE : L.B.P.I.A.

COST ELEMENT (S) : BASIC

CONSTANT YEAR : 1990/91

SHEET 1 OF 2

ITEM No.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	BASIC COST (x1000)
1	EXCAVATION	41000	M^3	4.0	164.0
2	SUBGRADE COMPACTION	50400	M^2	1.0	50.4
3	GRANULAR SUB-BASE	45000	TONNE	15.7	706.5
4	GRANULAR BASE	51000	TONNE	16.9	861.9
5	HOT MIX ASPHALT	3000	TONNE	58.4	175.2
6	PORTLAND CEMENT	3000	TONNE	198.8	596.4
7	CONCRETE PAVING	9800	M^3	83.3	816.3
8	SUB-DRAIN	3600	M	135.9	489.2
9	MANHOLES	18	EACH	3206.4	57.7
10	CATCHBASINS	18	EACH	2227.6	40.1
	TOTAL				3957.7

ESTIMATE PREPARED BY : R. HERNANDEZ Phone # 4637 Date ______

ESTIMATE CHECKED BY : N. Lulic Phone # 3535 Date ______

Canada

JUNE 86

PROJECT SUMMARY SHEET 1

Airports Authority Group / Groupe de gestion des aéroports

L.B. Pearson International Air

CONSTRUCTION COSTS

CLASS OF ESTIMATE: [X] D [ ] B [ ] C [ ] A

PURPOSE OF ESTIMATE: [ ] APD. [ ] PAD [ ] 100 % PRELIMINARY [ ] AMENDED APD [ ] AMENDED PAD [ ] PRE TENDER

PROJECT DESCRIPTION : DE/ANTI ICE PADS - RUNWAY 15

PROJECT NUMBER : ______ SITE : L.B.P.I.A.

COST ELEMENT (S) : BASIC

CONSTANT YEAR : 1990/91 SHEET 2 OF 2

ITEM No.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	BASIC COST (x1000)
	SUBTOTAL				3957.7
11	EDGE LIGHTING	60	EACH	600.0	36.0
12	UNDERGROUND STORAGE & COL-				
	LECTION TANKS & ALL APPUR-				
	TENANCES	4	EACH	25000.0	100.0
13	SECURITY	L.S.			20.0
14	HYDRAULIC SEEDING	1.6	HECTARE	7800.0	12.5
	SUB-TOTAL				4126.2
15	NIGHTWORK PREMIUM				
	(20% of SUB-TOTAL)				825.2
	TOTAL				4951.4

ESTIMATE PREPARED BY : R. HERNANDEZ Phone # 4637 Date ______

ESTIMATE CHECKED BY : A. [illegible] Phone # 5535 Date ______

Canada

JUNE 86

PROJECT SUMMARY SHEET 2

Appendix J

U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

CONSOLIDATED REPRINT

This consolidated reprint incorporates
Change 1

Subject: HAZARDS FOLLOWING GROUND DEICING AND GROUND OPERATIONS IN CONDITIONS CONDUCIVE TO AIRCRAFT ICING

Date: 12/17/82
Initiated by: AWS-100

AC No: 20-117
Change:

1. PURPOSE. To emphasize the "Clean Aircraft Concept" following ground operations in conditions conducive to aircraft icing and to provide information to assist in compliance.

2. RELATED FEDERAL AVIATION REGULATIONS (FAR) SECTIONS. Sections 121.629, 91.209, and 135.227.

3. BACKGROUND. Recent accidents involving large transport and small general aviation aircraft indicate that misconceptions exist regarding the effect of slight surface roughness caused by ice accumulations on aircraft performance and flight characteristics and the effectiveness of Freezing Point Depressant (FPD) ground deicing and anti-icing fluids. During development of information contained herein it was recognized that guidance information should be directed to all segments of aviation to include aircraft manufacturers; airline engineering, maintenance, service and operations organizations; aircraft maintenance and service personnel; and aircrews of all aircraft types and categories. Information contained herein therefore is general in nature for basic understanding purposes to facilitate development of standardized procedures and guidance by various segments of the aviation industry. The FAA will assist in development of specific industry standards and will publish additional advisory information as necessary.

4. DISCUSSION.

a. Regulations were established by the Civil Aeronautics Board (CAB) in 1950 prohibiting takeoff of aircraft when frost, snow, or ice is adhering to wings, propellers, or control surfaces of the aircraft. These regulations remain in effect as cited under FAR 121.629, 135.227, and 91.209. The basis of these regulations, which are commonly referred to as the clean aircraft concept, is known degradation of aircraft performance and changes of aircraft flight characteristics when ice formations of any type are present. These effects are wide ranging, unpredictable, and dependent upon individual aircraft design. The magnitude of these changes is dependent upon many variables and is thus unpredictable, but these changes can be significant. Wind tunnel and flight tests indicate that ice, frost, or snow formations on the leading edge and upper surface of a wing, having a thickness and surface roughness similar to medium or coarse sandpaper, can reduce wing lift by as much as 30 percent and increase drag by 40 percent. These changes in lift and drag will significantly increase stall speed, reduce controllability and alter aircraft flight characteristics.

Thicker or rougher ice accumulations in the form of frost, snow, or ice deposits can have increasing effects on lift, drag, stall speed, stability, and control, but the primary influence is surface roughness relative to critical portions of an aerodynamic surface. It is therefore imperative that takeoff not be attempted unless it has been ascertained, as required by regulation, that all critical components of the aircraft are free of adhering snow, frost, or other ice formations.

b. Most transport aircraft used in commercial transportation as well as some other aircraft types are certificated for flight in icing conditions. It is emphasized that to date rotorcraft and most small, general aviation fixed wing aircraft have not been certificated by the FAA for flight in icing conditions. Aircraft so certificated have been designed and demonstrated to have the capability of penetrating supercooled cloud icing conditions in the forward flight regime. This capability is provided either by ice protection equipment installed on critical surfaces (usually the leading edge) or demonstration that ice formed, under supercooled cloud icing conditions, on certain unprotected components will not significantly affect aircraft performance, stability and control. Ice, frost, or snow formed on these surfaces on the ground can have a totally different effect on aircraft flight characteristics than ice formed in flight. Exposure to weather conditions on the ground that are conducive to ice formation can also cause accumulation of frost, snow, or ice on ice protected areas of the aircraft that are designed for inflight use only and that are not designed for use during ground operation. In addition, aircraft are considered airworthy and are certificated by the FAA only after extensive analyses and testing have been accomplished. With the exception of analyses and testing to ascertain the flight characteristics of an aircraft during flight in icing conditions, all analyses and certification testing are conducted with a clean aircraft flying in a clean environment. If ice formations are present, other than those considered in the certification process, the airworthiness of the aircraft may be invalid and no attempt should be made to fly the aircraft until it has been restored to the clean configuration. The ultimate responsibility for this determination rests with the pilot in command of the aircraft.

c. Common practice developed by the North American and European aviation community over many years of operational experience is to deice an aircraft prior to takeoff. Various techniques of ground deicing were also developed. The most modern of these techniques is use of FPD fluids to aid the ground deicing process and to provide a protective film of FPD (anti-icing) to delay formations of frost, snow, or other ice.

d. In scheduled airline operations, where large numbers of aircraft are dispatched, the process of assuring airworthiness must be a team effort where each member of the team has specific duties and responsibilities. In the case of private aircraft operations, all functions may be performed by only one person, the pilot. In all cases, the pilot has the ultimate responsibility of ascertaining that the aircraft is in a condition for safe flight.

e. The only method currently known of positively ascertaining that an aircraft is clean prior to takeoff is by close inspection. Under conditions of precipitation or where moisture can be splashed, blown, or sublimated onto critical surfaces in subfreezing weather, many factors influence whether ice, frost, or snow may accumulate and result in surface roughness.

These variables are described in appendix 3 of this advisory circular (AC) but for convenience are listed as follows:

- Ambient Temperature
- Aircraft Surface Temperature
- Presence of Deicing Fluid
- Deicing Fluid Type
- Deicing Fluid Aqueous Solution (Strength)
- Precipitation Type and Rate
- Deicing Fluid Application Procedure
- Relative Humidity
- Solar Radiation
- Operation in Close Proximity to other Aircraft, Equipment, and Structures
- Operation on Snow, Slush, or Wet Surfaces
- Wind Velocity and Direction
- Aircraft Component Inclination Angle, Contour, and Surface Roughness

f. Aircraft maintenance and operations personnel neither have the capability to quantify the occurrence or the effects of the many variables that can influence whether ice, frost, or snow may form prior to takeoff, the surface roughness of ice formations, nor the effect that surface roughness may have upon aircraft performance and handling characteristics. Therefore, the time that may be considered a safe interval between ground deicing and takeoff cannot be estimated. Calculations of time incorporating the effects of only a few of these variables (e.g., ambient temperature of 20°F, fluid strength of 50 percent, precipitation rate of 1/2 inch/hour, assumed water content of snow of 0.1, and assumed surface film thickness of FPD fluid of 0.1 mm) reveals that aircraft surfaces may remain free of ice formations (onset of FPD fluid crystallization) for approximately 10 minutes. Other variables listed above could reduce this time. Since neither the pilot in command nor ground support staffs have even these limited facts on hand, quantitative judgements of time available between the ground deicing or anti-icing process and takeoff cannot be made.

g. The essence of flight safety following ground operations in conditions conducive to icing is the clean aircraft concept. To understand the need for the clean aircraft concept requires thorough knowledge of: (1) The adverse effects that ice, frost, or snow can have on aircraft performance and handling qualities; (2) the various procedures that are available for aircraft ground deicing and anti-icing; (3) the capabilities and limitations of these procedures; (4) the variables that will influence the effectiveness of these procedures; (5) the critical areas of the particular aircraft; and (6) recognition that final assurance for a safe takeoff rests in pretakeoff inspection. Additional information to assist in development of this understanding and knowledge may be found in the appendices of this AC. The success of the aviation community to date is attributed to many years of experience on the part of many companies where this knowledge has been gained, through experience, and passed on in the form of policy, procedures, quality assurance programs, and training programs.

5. ACCEPTABLE PRACTICES.

a. General. The clean aircraft concept is essential. The FAR makes the clean aircraft concept law. This law exists for flight safety reasons. The FAR states a general requirement but allows operators to comply with the requirement in an appropriate manner, depending upon local circumstances. The clean aircraft concept has been in effect since 1950. Many techniques of complying with the clean aircraft concept have been developed over the years by the aviation industry. Many of these techniques were developed prior to 1950 because of the need recognized by the aviation community. The consensus of the aviation community and the conclusion reached by the FAA is that the only method of assuring flight safety following ground operations in conditions conducive to aircraft icing, is by either close inspection prior to takeoff to ascertain that critical aircraft components are clean (free of ice, frost, or snow formations) or a determination that any formations are not adhering to critical surfaces and will blow off in the early stages of takeoff roll. This consensus is valid regardless of the use of currently available FPD deicing fluids or the use of manual techniques of deicing. FPD fluids commonly used today should not be considered to have anti-icing qualities for a finite period of time because a multitude of variables make it impractical to estimate that time. However, under certain condition FPD fluids are known to be effective in retarding the formation of frost, snow, or ice and in this sense may be considered to have anti-icing qualities (to prevent the formation of ice) for a period of time during ground storage (overnight or during brief layover) thus making the process of deicing (removing ice formations) simpler and in many cases negating further deicing or treatment. It is emphasized, however, that the need for close inspection prior to takeoff remains. The following paragraphs are intended to provide suggested methods of assuring the clean aircraft concept.

(1) Aircraft Deicing and Anti-Icing.

(i) An airplane may be cleaned of ice formations (deiced) by any suitable manual method, by use of water, by use of FPD fluids, or mixtures of FPD fluids and water. To date manufacturers of rotorcraft have not approved use of FPD fluids for application to rotorcraft. Heated water, FPD fluids or aqueous solutions of FPD fluids are more effective in the deicing process. The deicing and anti-icing process may be performed in one stage or multiple stage processes as desired depending upon prevailing conditions, concentration of FPD utilized, facilities available and deicing methods. In any case the freeze point of residual fluids (water, FPD fluids or mixtures) should not be greater than 20°F below ambient or surface temperature whichever is less. Unheated FPD fluids or aqueous solutions are more effective in the anti-icing process than heated fluids.

(ii) In conditions of freezing precipitation or high humidity when aircraft surface temperatures are near or below freezing and when it cannot be determined that snow or other ice crystal accumulations are not adhering and will blow off during initial stages of takeoff, surfaces should be anti-iced to retard the formation of ice prior to takeoff.

(iii) FPD freeze point can be determined using refractive index techniques. FPD fluid manufacturers can suggest or supply suitable equipment.

(iv) Critical surface temperatures under many circumstances are found in the vicinity of integral wing fuel tanks. When fuel temperatures are higher than ambient, critical surface temperatures will occur at other locations. These temperatures can be determined by direct measurement or by estimating fuel temperature. If surface temperature is not measured or estimated then the freeze point of residual fluids should be the lowest possible with available fluids.

(v) In conditions of nonprecipitation an anti-iced aircraft should be closely inspected to assure the freeze point of residual fluids remain 20°F below ambient or surface temperature whichever is lower. This is especially important when relative humidity is high.

(vi) Underwing frost should be removed and, where practical, the surface anti-iced to delay re-formation of frost. See appendix 3 for additional information on this subject.

(2) Preflight Inspection. Preflight inspection should be performed immediately following or during the ground deicing and anti-icing process. Areas to be inspected depend upon the aircraft design and should be identified in an inspection checklist. The inspection checklist should include all items recommended by the aircraft manufacturer and may be supplemented, as necessary, to include special operational considerations, but this checklist should include the following general items:

- Wing leading edges, upper surfaces, and lower surfaces

- Stabilizing device leading edges, upper surfaces, lower surfaces, and side panels

- High lift devices such as leading edge slats and leading or trailing edge flaps

- Wing lift spoilers

- All control surfaces and control balance bays

- Propellers

- Rotor Blades, rotor heads and controls

- Critical rotor system devices such as droop stops

- Engine inlets, particle separators and screens

- Windshields and other transparencies necessary for vasibility

- Antennas

- Fuselage sections forward of stabilizing, control and lifting surfaces, propellers, rotors, or engine air inlets

- Exposed instrumentation devices such as angle-of-attack vanes, pitot-static pressure probes, and static ports

- Fuel tank and fuel cap vents

- Cooling and APU air intakes/inlets/exhausts

- Undercarriage

(3) Once it has been determined through pre-flight inspection that the aircraft is clean and adequately protected, the aircraft should be released for takeoff as soon as possible. This is especially important in conditions of precipitation or high relative humidity.

(4) Pretakeoff Inspection.

(i) Fixed Wing Aircraft

(A) Just prior to taking the active runway for takeoff or just prior to initiating takeoff roll, a visual pretakeoff inspection should be made. The components to be inspected depend upon aircraft design. In some aircraft, the entire wing and portions of the empennage are visible from the cockpit or the cabin. In other aircraft, these surfaces are so remote that only portions of the upper surface of the wings are in view. Undersurfaces of wings and undercarriage are not viewable in any but high-wing type aircraft. A practice in use by some operators is to perform close visual inspection of wing surfaces, leading edges, engine inlets, and other components of the aircraft that are in view either from the cockpit or cabin (whichever provides maximum view). If surfaces have not been treated with FPD fluid, evidence of melting snow and possible freezing is sought. Also evidence of any ice formation that may have been induced by taxi operations is sought. If the aircraft has been treated with FPD fluids, evidence of a glossy smooth and wet surface is sought. If, as a result of these inspections, evidence of ice, snow, or frost formations is observed, the aircraft should be returned to a maintenance area for additional deicing.

(B) The fact that it is impractical for an aircraft crewmember to disembark at the end of a runway and perform pretakeoff inspections, means that the crewmember should perform that inspection from the best vantage point available from within the aircraft. The crewmember may elect to open windows, doors, or hatches to improve the view, but in many aircraft even this is impractical. In the darkness of night the crewmember must rely upon wing and other aircraft illumination lights that may not provide sufficient reflection to make appropriate visual observations. The crewmember may, where practical, call upon the assistance of qualified ground personnel. If under any circumstance, the pilot in command cannot ascertain that the aircraft is clean, takeoff should not be attempted.

(C) Conducting pretakeoff inspection in the manner described relies upon the pilot in command to be knowledgeable of ground deicing procedures, that the ground deicing process was conducted in a thorough and uniform manner, and that critical surfaces or components not in view during pretakeoff inspection will also be clean. The decision to takeoff, following pretakeoff inspection remains the responsibility of the pilot in command.

(ii) Rotorcraft.

(A) Only rotorcraft that have been certificated for flight in icing conditions should be operated in conditions conducive to icing such as freezing fog. To date none have been so certificated by the FAA.

(B) Rotorcraft certificated for flight in falling and blowing snow may operate in such conditions. In this case pretakeoff inspection of rotor systems should be conducted just prior to starting rotors turning. Rotor systems should not be started unless blade surfaces and other critical components are free of ice, frost or adhering snow.

b. Common practices or suggested practices necessary to assure the pilot has every advantage for his judgements:

(1) Establish training programs to continually update pilots on the hazards of winter operations, adverse effects of ice formations on aircraft performance and flight characteristics, proper use of ice protection equipment, ground deicing and anti-icing procedures, and preflight and pretakeoff inspection procedures following ground deicing or anti-icing and operations in conditions conducive to aircraft icing.

(2) Establish training programs for maintenance or other personnel who perform aircraft deicing to assure thorough knowledge of the adverse effects of ice formations on aircraft performance and flight characteristics, critical components and specific ground deicing and anti-icing procedures for each aircraft type, and the use of ground deicing and anti-icing equipment including detection of abnormal operational conditions.

(3) Establish quality assurance programs to assure that FPD fluids being purchased and used are of the proper characteristics, that proper ground deicing and anti-icing procedures are utilized, that all critical areas are inspected, and that all critical components of the aircraft are clean prior to departure.

(4) Perform thorough planning of ground deicing activities to assure that proper supplies and equipment are available for forecast weather conditions and that responsibilities are specifically assigned and understood. This is to include maintenance service contracts.

(5) Monitor weather conditions very closely to assure that planning information remains valid during the ground deicing or anti-icing process and subsequent aircraft operations. FPD fluids, deicing or anti-icing procedures and departure plans should be altered accordingly.

(6) Use FPD concentrations that will delay ice formations for as long a period as possible under the prevailing conditions.

(7) Deice or anti-ice areas that may be viewed by the pilot (from inside the aircraft) first so that during pretakeoff inspection he may have assurance that other areas of the aircraft are clean since areas deiced or anti-iced first will generally freeze first.

(8) Use the two-stage deicing process where ice deposits are first removed, and then all critical components of the aircraft are coated with an appropriate mixture of FPD fluid (anti-icing) to prolong effectiveness.

(9) Assure thorough coordination of the ground deicing and anti-icing process so that final treatments are provided just prior to takeoff.

(10) Use remote sites near the take-off position, where feasible, for deicing or anti-icing to reduce the time between deicing and takeoff or to provide additional FPD fluid to prolong anti-icing effectiveness.

(11) Use multiple aircraft deicing or anti-icing units for faster and more uniform treatment during precipitation.

(12) Use FPD fluids that are approved for use by the aircraft manufacturer. Some fluids may not be compatible with aircraft materials and finishes and some may have characteristics that impair aircraft performance and flight characteristics or cause control surface instabilities.

(13) Do not use substances that are approved for use on pneumatic boots (to improve deicing performance) for other purposes unless such uses are approved by the aircraft manufacturer.

c. Suggested practices for pilots to assure the clean aircraft concept.

(1) Be knowledgeable of the adverse effects of surface roughness on aircraft performance and flight characteristics.

(2) Be knowledgeable of ground deicing and anti-icing practices and procedures being used on your aircraft whether this service is being performed by your own company, a service contractor, or a fixed-base operator.

(3) Do not allow deicing or anti-icing until you are familiar with the ground deicing practices and quality control procedures of the service organization.

(4) Be knowledgeable of critical areas of your aircraft and assure these areas are properly deiced and anti-iced, proper precautions are being taken during the deicing process to avoid damage to aircraft components, and

proper preflight inspections are performed even though this is also the responsibility of other organizations or personnel.

(5) Be knowledgeable of ice protection system function, capabilities, limitations, and operation.

(6) Perform additional preflight inspections related to deicing or anti-icing as necessary or required.

(7) Be aware that no one can accurately determine the time of effectiveness of an FPD deicing or anti-icing treatment because of the many variables that can influence this time.

(8) Be knowledgeable of the variables that can reduce time of effectiveness and their general effects.

(9) Assure that deicing or the anti-icing treatment is performed at the last possible time prior to taxi to the takeoff position.

(10) Do not start engines, propellers, or rotor blades until it has been ascertained that all ice deposits are removed. Ice particles shed from rotating components under centrifugal and aerodynamic forces can be lethal.

(11) Be aware that certain operations may produce recirculation of ice crystals, snow or moisture.

(12) Be aware that operations in close proximity to other aircraft can induce snow, other ice particles, or moisture to be blown onto critical aircraft components, or allow dry snow to melt and refreeze.

(13) Do not takeoff if snow or slush is observed splashing onto critical areas of the aircraft, such as wing leading edges, during taxi.

(14) Always perform pretakeoff inspections just prior to takeoff.

(15) Do not takeoff if positive evidence of a clean aircraft cannot be ascertained.

M. C. BEARD
Director of Airworthiness, AWS-1

GLOSSARY OF TERMS AND ACRONYMS

AEA	Association of European Airlines
AIP	Aeronautical Information Publication
ATC	Air traffic control
Button	The point on a runway in the immediate vicinity of the threshold from which take-off normally begins
CALPA	Canadian Air Line Pilots Association
De-icing checker	A person assigned by a carrier to ensure that the de-icing/anti-icing of an aircraft was completed in a satisfactory manner
Elephant Beta	A de-icing vehicle developed in Sweden that is capable of de-icing and anti-icing an aircraft
FAA	Federal Aviation Administration, the U.S. government agency responsible for the safety regulation of aircraft
Flow control	An air traffic procedure designed to restrict the flow of aircraft during periods of excessive traffic congestion
Hold-over time	The time during which a de-icing or anti-icing fluid is considered to offer protection against the formation of contaminants on an aircraft
IFALPA	International Federation of Air Line Pilots Associations
IFR	Instrument Flight Rules
Kallax De-icing System	A gantry-type of structure that has the capability to de-ice and anti-ice aircraft
NTSB	National Transportation Safety Board, the U.S. government agency responsible for investigating and reporting on aircraft accidents

Runway designations	Runways are designated according to their orientation to the nearest 5 degrees magnetic. Where two parallel runways exist they are further designated Left and Right.
RVR	Runway visual range, a series of transmissometers that indicate the visibility along a runway equipped with an instrument landing system
SAE	Society of Automotive Engineers
SAS	Scandinavian Airline System
Slot time	A time assigned to a pilot by air traffic control at which a departure clearance may be expected
Type I	A de-icing fluid composed of a mixture of glycol, water, anti-corrosive, and wetting agents that is heated and sprayed on aircraft. The fluid removes contaminants and offers limited protection against icing.
Type II	A glycol based anti-icing fluid containing corrosion inhibitors, wetting agents, and polymeric thickeners. This pseudo-plastic fluid, applied at ambient temperatures, provides increased hold-over times.
V1 and associated performance	The airworthiness definition of V1 prior to 1977 was "the critical engine failure speed." The present definition is "the take-off decision speed."
VFR	Visual flight rules
Zamboni-type vacuum machine	A machine used to remove de-icing/anti-icing fluids from ramps