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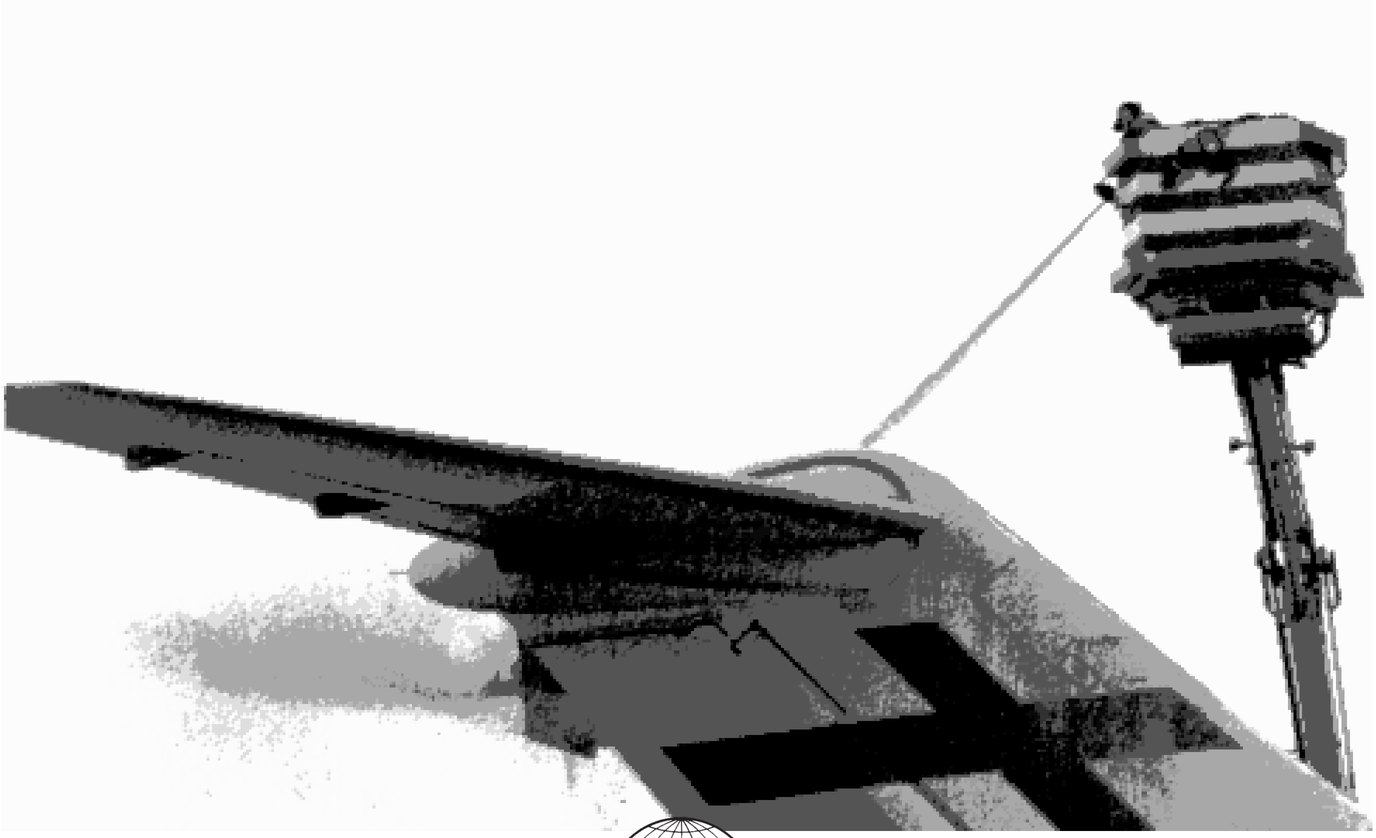
FLIGHT SAFETY DIGEST

Small Airline Continues to Win Big Battle Against Aircraft Ground Icing



Flight Safety Digest

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Flight Safety Foundation is an international membership organization dedicated to improving aviation safety. Nonprofit and independent, the Foundation was launched in 1945 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce a positive influence on aviation safety. Today, the Foundation provides leadership to 561 member organizations in 73 countries.

Small Airline Continues to Win Big Battle Against Aircraft Ground Icing

A series of recent fatal air transport accidents attributed to icing has brought regulatory changes and increased awareness of the danger of aircraft ground icing. One operator, Finnair, has had a highly successful deicing program in operation for several years.

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Editorial Staff Report

Editors Note: Flight Safety Foundation was invited by Finnair's chief pilot, Capt. Urpo Koskela, to observe the airline's ground deicing/anti-icing operations in Helsinki. He arranged for Roger Rozelle, FSF director of publications, to meet with Capt. Jorma Eloranta, director of special projects and DC-10 captain, and other Finnair employees involved in ground operations.

Eloranta remembers when ice damaged jet aircraft engines and aviation industry officials used to say "there are no icing problems." But that isn't true today. After years of research, trial-and-error and relentless advocacy spearheaded by Eloranta, Finnair has become a world leader in winning the battle against aircraft ground icing. And it has made believers out of the industry.

Capt. Jorma Eloranta

"Performance of Type I deicing fluids wasn't satisfactory," said Eloranta as he leaned across the table where he had piled several stacks of papers and reports on the subject of icing — ammunition to outline his description of the "icing problem."

"They were not giving the protection required for the airlines, especially from 1975 when traffic congestion in airports was growing, and taxi and hold times were increased," said Eloranta, who is known among colleagues for his outspoken and stubborn approach to problem-solving.

He told how many persons did not — and still do not — understand that spraying glycol is not deicing.

"It is the heated water that melts the ice," he explained. "The glycol is only there to prevent the water from refreezing. One of the most important things in deicing is the capability of the equipment to produce enough pressure to break into the ice and force the hot water under the ice to lift it from the wing."

He said that Finnair worked closely with Lufthansa German Airlines, Boeing and the Von Karman Institute in Belgium to test fluids in actual operating conditions. The Association of European Airlines also supported that project, which used a Boeing 737 airplane.

"Type II anti-icing fluids supposedly had thickening agents that kept the fluid in a solid layer on the wing until it lost adhesion — about rotation speed — caused by the airflow over the wing. But the fluids continued to stick to the wings after rotation, which caused serious drag, reduced lift and increased stall speed."

During the testing program, it was determined that wing contamination was the likely culprit in "plenty of incidents where there had been some loss of control after takeoff, especially with the DC-9s that were not equipped with leading edge wing slats, and early model Boeing 737s."

Eloranta said the fluids were designed originally under laboratory conditions and researchers were not using real-world conditions. Some fluids, he said, were made to flow off the wing when air temperatures were close to freezing, not at temperatures well below that — a problem exacerbated when the wings were often 20 degrees cooler than the surrounding air. "The skin temperature of the wing must determine the correct deicing and anti-icing procedures, not the outside air temperature," he asserted. "When the outside air temperature and the wing surfaces are well below freezing, unnecessary spraying should be avoided. After an aircraft is refueled, the situation should be reevaluated because the temperature of the wing may change significantly."

A car is equipped with a simulated aircraft aluminum fuel tank on its roof that has a Vibro-Meter electrical ice sensor built into the tank's upper surface. Various data, including wind speed, ambient temperature, fuel temperature and other information are recorded on a computer in the car. Several Finnair first officers conduct tests to determine optimum operating characteristics and standards for the sensor.

He readily admitted that today's deicing and anti-icing fluid mixtures are better than those of several years ago, but added that none of them are sure cures against aircraft ground icing. He also disagreed with U.S. reluctance to use Type II fluids.

"They have low toxicity," he claimed. "They

Finnair Crews Battle Icy Morning in Helsinki

Icing conditions. I wanted to see firsthand the deicing process into which Capt. Jorma Eloranta had immersed himself with near-evangelistic fervor.

He considered sending me further north, to Lapland, where memories from my school books of long ago called up images of thick snowdrifts, fierce cold winds, invisible bodies cloaked in fur coats and great antlered reindeer. Firsthand experience grew less appealing.

Jorma explained that winter weather tended to move across Finland in a north-south line to the east. If there was inclement weather in the north, chances were that it was reflected in the south. The best that we could do was hope.

Finally, a forecast called for snow, beginning at midnight, with the heaviest snowfall expected about 0300 and not ending until noon. Above-freezing temperatures would follow the snow. Jorma suggested that I make my own way to the airport no later than 0630, when morning operations for departing flights began in earnest. A call to the maintenance supervisor, who would be alerted to my arrival, would confirm the status of the ground deicing operations.

The snow began to fall earlier than forecast — shortly after 1800. There was a possibility that warm temperatures would melt the snow and there would be no snow or ice to remove in the morning. Jorma shrugged his shoulders and said, "Wait and see."

Just before I crawled into bed at midnight, I saw that snow was no longer falling outside are biodegradable. The pollution in the air is more harmful than using glycol in deicing. As for slipperiness, when there is already snow and ice on the ground, how much more slippery can it get? I do not believe it increases slipperiness, especially with the big aircraft."

During the 1970s and early 1980s, other problems were taking place that were not readily explained. In 1981, after a takeoff from Zürich, an engine was shut down. The DC-9 returned to the airport and landed safely. An examination revealed significant damage to one engine, and minor damage to the other, but no one was able to suggest a cause.

It was not until a passenger, who was on the aborted Zürich flight, wrote a letter to Finnair and reported that he had seen a piece of ice break away from the wing during takeoff that there seemed to be an answer to the puzzling cause behind the incident.

"It didn't ring all the bells," said Eloranta about the passenger's report. "It gave us a new perspective, but we didn't understand it. Since that was the only overnight stop, we decided that the climate was a factor."

Several incidents in the early 1980s — most at Zürich during cold weather — involved damage to engine fan blades that was not indicative of traditional foreign object damage (FOD). Damage suggested soft FOD — several blades in a section were bent, but not sharply.

Eloranta said that during that period, fuel was expensive in Zürich, so the airline calculated that it saved money by tankering fuel in the wings on the inbound flight from Helsinki to Zürich. The aircraft would be parked overnight in Zürich and return the next day to Helsinki.

It was determined, finally, that the fuel carried in the wing tanks was supercooled during the long high-altitude flight to Zürich. After landing, if there was moisture in the air or precipitation, clear ice formed on the wing. The ice was nearly invisible. During takeoff, the wings flexed at rotation and broke the ice free, and it flowed aft into the engines.

Moreover, he discovered that even in moist air

the window of my hotel room. And at 0430, when I awoke, there was little evidence of snow in the hotel courtyard, so I telephoned the airport.

"Yes, there will be deicing," said the voice of the maintenance supervisor on the telephone. "We have already started."

"Will there be any operations left for me to photograph?" I asked in an anxious voice.

"Oh yes, I think so," he said, conveying a shred of doubt.

I told him I was leaving immediately.

I was quiet during the cab ride with a sleepy-looking driver. Snow was all but absent in the city. I grew uneasy that opportunities to capture deicing procedures on film were disappearing as fast as the snow.

As we moved away from the concrete buildings and closer to the airport, snow began to

Ice forms more readily over the wing root, where the cold fuel settles and there is more metal structure, including the landing gear components, which can contribute to colder temperatures.

as much as 15 degrees above freezing, clear ice could still form on the wings as the result of supercooled fuel. "We determined that this is not just a winter problem, and seasonal transitions created dangerous times for icing," explained Eloranta. "So we required the check for ice all year. It was the only way to put it in the minds of the people all the time to guarantee safety. Still, it took a couple of years for everyone to get used to the procedure. And you can imagine that they really called me 'crazy Eloranta.'"

He said that Finnair warned its pilots of the problem, and they reacted positively. "But the maintenance personnel were not so positive," he said. "They were being given a new set of duties to perform, but we had no tools or equipment to give them to remove the ice. And they didn't want to perform a physical check of the wing. I probably didn't present it to the maintenance people as well as I should have."

He said that Finnair management, especially Tero Mustakallio, then-vice president of operations, recognized the problem and its broad scope, and they gave him a free hand — and a nearly open-ended budget — to organize a testing program to learn as much as possible about fluids and the problems of ice.

The gentle bend in the blades is characteristic of soft foreign object damage.

As the phenomenon began to be understood by Eloranta, the airline circulated information about how to recognize the conditions that would form ice and to develop methods to reduce the problem, such as avoiding tankering of fuel and refueling the aircraft with warm fuel when possible. Pilots were also cautioned to reduce fuel in wing tanks so that the fuel did not come in direct contact with the upper surfaces of the

appear on the roadside. My spirits rose, amid a bit of guilt for hoping for the icy, freezing weather into which fellow aviators would have to launch their aircraft while I remained safely on the ground.

The tuft of parachute cord moved freely, but underneath the snow, clear ice had formed, and the cord's base was frozen solid.

I was directed to the communications center where ground operations were coordinated and the deicing trucks were assigned to specific aircraft to remove snow and ice. There were three supervisors on duty; behind them, through a large window, there were parked aircraft and deicing trucks moving on the ramp. And most important, there was snow. Snow was on the ramp. Snow was on the aircraft. Snow was on the vehicles. Snow was falling in the air.

Coveralls — in a size large enough, with high rubber boots too large — had been set aside for me. I struggled into them, and with my cap I resembled a Finnair lineman. Worried that snow, ice and deicing trucks would disappear before favorable light appeared, in spite of some assurances that would probably not be the case, I asked to be launched to the ramp, where snow wings. Bulletins cautioned pilots to respect hold-over times, to watch for signs of refrosting and, if in doubt, to check through cabin windows. They were reminded that these checks should be performed even during taxi, along with guidance that they should avoid taxiing too close behind other aircraft, which could blow snow onto their own aircraft.

"We sent out warnings internationally," he said. "They went to McDonnell Douglas, the FAA [U.S. Federal Aviation Administration], Pratt & Whitney and aircraft operators. We told them that there was a potential risk to air safety by clear ice — nearly invisible to the eye — that could accumulate on aircraft wings under certain conditions while the aircraft was parked, if the ice was not discovered and removed before flight."

He said that the reactions to his warning were negative. "It was a real experience to travel to the United States and have a 15-minute meeting with an aircraft manufacturer and be told 'there are no problems,'" he said. "No one believed me. Everyone was totally negative. 'Crazy Eloranta' they called me. But I always got a cup of coffee.

"I was frustrated, of course. But I decided that I wouldn't give up easily. And we tried to get the word out through different channels, such as talking directly to other operators."

Eloranta said he believed that if Finnair had been a major carrier, his warnings might have been heeded sooner. He said in those days it was sometimes difficult to be heard, even in safety matters, "but it isn't true today."

Then, in 1985, a Finnair DC-9 aborted a takeoff at Helsinki. When the aircraft was taken back to the hangar, large sheets of clear ice were found on the wings. During the ground roll on uneven pavement, the wings flexed and the ice broke free and damaged both engines.

"Everyone was supposed to have known by now about this problem," said Eloranta, shaking his head from side to side. "Human factors were at work. The mechanic checked and saw ice and ordered deicing. Then the me-

would fall on me.

For the next several hours, patient Finnair employees escorted me wherever I wanted to go on the ramp. Our activities were coordinated by two-way radio with a supervisor in the communications center, who advised us where the three deicing trucks on duty were located on the ramp, which was bustling with activity. Aircraft were taxied to and from the gates, and deicing trucks, along with baggage trucks and catering trucks, were moving from aircraft to aircraft. And everywhere there were mechanics and flight crews scurrying in the waning darkness of dawn.

I discovered that the occupants of deicing truck No. 7 were friendly and spoke English. Veijo Lappalainen, 27, and Tomas Cannelin, 22, had been working as a team since they met each other during training when they joined Finnair "two winters earlier." [Many Finns seemed to measure time in winters rather than years.]

Frost formed readily under the wings in the fuel tank area.

chanic and pilot checked and confirmed that there was glycol on the surface. But it was covering a solid sheet of clear ice that hadn't been removed during deicing."

A mechanic holds a sheet of ice taken from the wing of the Finnair DC-9 that aborted a takeoff at Helsinki-Vantaa Airport in 1985 after flexing wings on the uneven runway broke the ice free, and it was ingested into the engines.

He said that the incident emphasized the need for proper equipment to help confirm the presence of ice and then to remove it. Hard hand tools were being used to remove the ice, and when the tools were not available, he said that everyone just had to wait until the ice melted.

This led to Finnair taking a more active role in developing a specialized deicing truck [see "Finnair Crews Battle an Icy Morning in Helsinki"] to meet the rugged influences of Finland's weather on aircraft ground icing.

Eloranta also began to consider mechanical and electrical methods that could be used to detect ice on the wing "and again everybody just called me 'crazy Eloranta.'" He developed a small tab with alternating horizontal color bands that could be used to judge the depth of accumulated snow and ice on the wing. When clear ice was present, refracted light would distort the color bands. Triangles painted on the wings served a similar purpose.

He also used small tufts of parachute cord as indicators of clear ice on the wing; if the tufts didn't move, they were buried in clear ice. "But you have to be careful," he cautioned. "Sometimes the ice freezes only the base of a tuft and the remainder of the tuft is free. So this is not a foolproof device."

In the meantime, he said that he was able to convince Finnair to allow him to install an

Hot water under high pressure in a tight stream was required to break ice free from an aircraft wing.

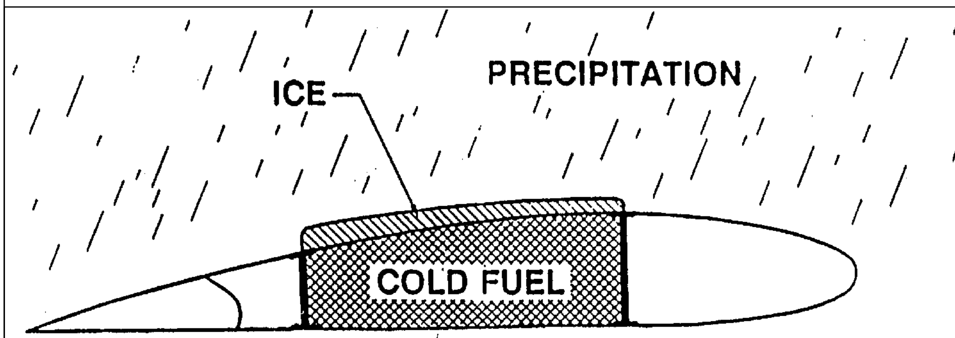
They had both completed three-year vocational training, and they were classified as "aircraft fitters." They hoped to move up the ranks to become mechanics. Both men had previous experience driving trucks, so they had no problems adjusting to driving a fully loaded deicing truck that weighed 27,000 kilograms (60,000 pounds), which included 6,500 liters (1,690 U.S. gallons) of water, 2,500 liters (650 U.S. gallons) of glycol Type I and 1,400 liters (360 U.S. gallons) of glycol Type II.

"We usually refill the truck at least once during our shift," said Veijo. "But when things are busy, we may fill up three or four times. Two or three times a year we get so much snow that there are not enough trucks and there are delays."

Water in the truck was heated, and the water temperature was maintained at about 90 degrees C (194 degrees F — 20 degrees F below boiling). It was mixed with a Type I glycol that was colored red to make it easier to see treated areas during the deicing process. The mix-ratio can be varied, but the men reported that usually equal quantities of water and glycol were maintained. The fluid that left the nozzle was probably about 60 degrees C (140 degrees F). A computer system in the truck cab kept track of the details of each deicing operation, such as the amount of each fluid that was used. This information enabled the crew to know when liquids had to be replenished and simplified Finnair's billing for the services the men performed.

electrical ice sensor in the upper surface of the wing of a DC-9. That meant electrical wiring would have to be run inside the fuel tank. He said that it helped that he was then the DC-9 fleet captain.

Typical Pattern of Fully Developed Ice from Cold Soaked Fuel Above Wing Fuel Tank. Air Temperature Outside the Fuel Tank Is Above Freezing



Not Necessarily a Cold Weather Phenomenon

Source: Finnair

"The manufacturer wasn't against the idea, but it wasn't positive either," Eloranta said, with a smile. "In Finnair, people said 'if it succeeds, it's our idea. If it goes wrong, it's crazy Eloranta's idea.'"

By 1987, Eloranta said that the installation was completed (after waiting two years, he said, to get permission to install it from the aircraft's manufacturer) in the coldest area of one wing where it was most likely to collect ice that would break off and be ingested into the engine.

"I felt challenged," he said. "I just had to convince people that this was the way to go. It was easier for me by then, because I had a good record for what I had done so far."

It was a comprehensive program that Eloranta described. The aircraft was flown on the line (the pilots supported the program) in actual operating conditions. Equipment was installed to monitor temperatures of outside air, wing sur-

The men were rarely idle, and even then it was only for a few minutes. I joined them as they moved from aircraft to aircraft and deiced each one. The driver did his best to position the truck for optimum spraying, while considering the direction of the wind and the physical location of the aircraft. The men had regularly alternated the cab-basket positions, so they each had a great deal of experience and an appreciation of all the factors that had to be considered in accomplishing the job.

Before any spraying was done, the truck crew confirmed that all doors and windows were closed to prevent the fluids from contaminating the floors with slippery liquids and soiling upholstery. They also made sure that control surfaces were in the proper position — usually neutral.

One man remained in the truck cab, which was equipped with controls that adjusted the mixture being sprayed. Tomas and I stepped into a basket that was lifted hydraulically with a system built into the truck, which promptly lifted us into the air — if necessary, more than 12 meters (40 feet) above the ground.

The wind was blowing at 16 knots from the southeast, and the air temperature was hovering around 0 degrees C to 2 degrees C (32 degrees F to 35 degrees F), and from our bird-like perch in the basket, we were well-exposed to the biting cold, made worse by a windchill temperature near -13 degrees C (9 degrees F). The extra layer of heavy waterproof clothing with a hood, eye goggles, hearing protector and gloves gave me the feeling of being well-equipped for my experience.

I stood in the basket with Tomas as he directed the fire-hose-like nozzle that sprayed the fluid onto the aircraft. I quickly recognized the rigors of this team's job. Billowing face and fuel. Pilots made notes on daily flight reports about how the ice detector system was working. McDonnell Douglas became an active participant in the program, and two companies that were involved in development of ice-detector sensors also worked closely with him.

"Finally, the industry recognized that many soft FOD incidents had to have been caused by clear ice," said Eloranta. "The industry was asking for my help, putting on seminars about the problem, publishing information on clear ice; and they weren't calling me 'crazy Eloranta' anymore. It was satisfying."

He said that the idea behind the electrical sensor is his and that he has been working for the past seven years toward the goal of it becoming an integral part of production aircraft.

"My final goal has been that the status of the wing has to be determined in the cockpit with a backup advisory device that can provide go/no-go information just before takeoff," said Eloranta. "I'm convinced that this type of system works properly."

He expressed some ambivalence that Finnair would not share in the profits of commercial marketing of the product, an opportunity that he believes the company missed by not being more profit-oriented and not capitalizing on its knowledge. "Finnair has nothing," he said with a shrug of his shoulders, a frown on his face. "But it's not important. Really."

Finnair has continued an ongoing program to develop deicing and anti-icing procedures, including training of ground personnel and efforts to inform the aviation industry of its findings.

But he said that he was frustrated that the information was still not reaching the industry.

"I felt so sorry about the SAS accident [Scandinavian Airlines System MD-80 made an off-airport landing on Dec. 27, 1991, after ice was ingested into both engines during takeoff], because it should have never happened," he said, with emotion between gritted teeth. "A hand check of the top surface of the wing was required, but it was not performed correctly so the ice was not discovered. At least the pilot was skilled and he was able to control the off-airport landing. No one was killed.

"Ground icing can happen to all aircraft. This is not an aircraft-type problem. The information about clear ice has been available for some time, but it is obviously not getting to everyone. As an industry, we cannot be proud of our performance in this matter." ♦

The small brightly colored horizontal tab was buried in snow and clear ice, and provided a visual indication of contamination. It has no influence on the flight characteristics of the wing.

fog engulfed us. And in moments, the entire aircraft nearly disappeared below us into a grayish cloud.

Tomas communicated via a headset-intercom with Veijo, who slowly drove the truck to different locations around the aircraft that was being deiced to allow the basket operator to spray all the appropriate surfaces.

I took the thick gloves off my hands so I could operate my cameras, which were hung over my shoulders from straps and enclosed in clear plastic bags; the eyepieces and lenses protruded from holes I cut in the bags. Of course, moisture now covered all the lens

Icing Degrades Aircraft Performance; Fluids Provide Best Defense Against Ice on the Ground

Winter operations expose aircraft to weather conditions on the ground that can have a severe influence on aircraft performance, stability, control and how ailerons, rudders, sensors, flaps and landing gear mechanisms function. Most large aircraft with conventional airfoils and leading edge, high lift devices are considered less sensitive to contamination problems. Some aircraft without high lift devices appear to be more sensitive to wing contamination. Contamination of wing surfaces can result in pitching moment changes during takeoff rotation that could cause the airplane to act as if it were mistrimmed in the nose-up direction. After liftoff, degraded lateral stability calls for more and more control wheel input to keep the airplane from rolling, possibly followed by premature stall at lower than normal angles of attack.

A series of takeoff accidents attributable to wing ice accretion while the aircraft is on the ground, improper or inadequate deicing or anti-icing procedures and lack of aircrew awareness of the problems have focused attention on aircraft design and pilot training.

Regardless of the number of entities that may be involved in aircraft deicing and anti-icing, U.S. Federal Aviation Regulations (FAR) 121.629, *Icing Conditions*, and Joint Airworthiness Requirements (JAR) 91.527, *Operating in Icing Conditions,* place the ultimate responsibility on the pilot-in-command of the aircraft to ensure that the aircraft's wing and horizontal stabilizer are free of contamination and that the aircraft meets the airworthiness requirements for takeoff. Unfortunately, pilots in the cockpit cannot always see snow and ice on the wing or adequately judge the degree of contamination on aircraft that are not usually equipped with sensors that reveal the presence of contamination.

surfaces. It didn't matter though, because I couldn't see through the goggles that were supposed to protect my eyes. Precipitation, which alternated between light rain and snow, was dripping on the outside of the goggles, and they were fogged on the inside. I removed the goggles, and while I groped to reach a clean handkerchief (to wipe lenses and goggles) through three layers of clothing — all requiring various stages of being unzipped, unvelcroed and unbuttoned — I wiped a glycol-laden sleeve across my forehead. Some of the fluid made its way into my eyes and I was left with the minor stinging sensation that I had been warned about by the aircraft fitters.

Through all of this, Tomas continued spraying, but said: "This weather isn't bad at all. When it's really bad weather, it's tough working outside."

He sprayed the wings, starting forward of the leading edges and sweeping aft from each wing outboard, then inboard to the wing root. He said this procedure prevented the snow, which can be very heavy when wet, from putting too much strain on the outboard section of the wing. The tail surfaces were treated much the same as the wings.

Great care had to be taken not to direct the high-pressure stream into the cavities between the control surfaces and the airframe, Tomas said. He said there was a possibility that water could freeze in the cavities and jam the controls, and noted that slush being swept off the aircraft could create the same problem. This was one reason why it was important for the pilot to exercise the controls and confirm that they moved freely before takeoff. Anytime the deicing crew suspected such a condition, a rich mixture of anti-icing fluid and water was sprayed at a low-pressure rate into the area, he said.

Specific Weather Conditions Cause Aircraft Icing on the Ground

There are several weather conditions that can cause icing problems.

- Freezing precipitation such as snow, sleet, freezing rain or drizzle can adhere to the aircraft's surfaces.

- Frost (including hoar frost) is formed from water vapor on surfaces that are at or below 0 degrees C (32 degrees F) and results in a crystallized deposit.

- Freezing fog creates clouds of supercooled water droplets that can form an ice deposit.

- Snow is precipitation in the form of small ice crystals or flakes that can accumulate.

- Freezing rain is water condensed from atmospheric vapor that falls to the earth in supercooled drops and then forms ice.

- When the temperature of the aircraft wing surface is at or below freezing, rain or high humidity can form ice or frost.

Deicing and Anti-icing Defined

Deicing is the method by which frost, ice or snow is removed from the aircraft to clean the surface. Deicing fluid is usually applied heated at about 82 degrees C (180 degrees F) and sprayed under high pressure for maximum efficiency. The heat in the fluid melts frost as well as deposits of snow and ice. In heavier accumulations, the heat breaks the bond between the frozen deposits and the airplane structure, while the hydraulic force of the spray breaks the ice and flushes it off the aircraft. The deicing fluid may prevent refreezing for a short period of time, dependent on the temperature of the aircraft skin, ambient air temperature, the fluid used and the mixture's strength.

Anti-icing is considered a precautionary pro-

The mechanic gave a "thumbs-up" acknowledgment to the deicing truck crew that the wing surface was clean and there was no ice on it.

Tomas explained that the nozzle was adjusted normally to concentrate the Type I spray in a high-pressure stream. When ice was on the aircraft, he said that he directed the hot fluid onto a particular section of the aircraft until it melted the ice and heated the metal surface of the aircraft. He said that as the heat spread in the metal, the ice lost adhesion, and it became easier to remove it from the aircraft surface with the nozzle's high-pressure stream.

Spraying distance was less than 10 meters (33 feet), the maximum distance considered effective in maintaining thermal energy and a forceful flow. Spraying closer than 3 meters (10 feet) was avoided to prevent deformation of skin panels.

The fuselage was also sprayed from the top down, which allowed the fluid to drain down the sides of the fuselage. They reported that this reduced the likelihood of damaging the windows, which might be crazed or cracked by the sudden shock of warm fluid being sprayed directly on them, and it cedure to provide protection against the formation of frost or ice and accumulation of snow or slush on a clean surface for a limited period of time. Anti-icing fluid is usually applied cold to a clean aircraft surface.

Deicing/anti-icing is a combination of the two procedures just described and can be done either in one or two steps. When used for anti-icing, the fluid must be applied to a clean surface to provide a barrier against the buildup of frozen deposits.

One-step deicing/anti-icing is usually done with an anti-icing fluid that stays on the surface to provide a better anti-ice capability.

In a two-step procedure, deicing is followed by an application of anti-icing. The separate overspray of anti-icing fluid protects the clean surfaces and provides the greatest anti-ice capability.

Holdover time is the estimated time anti-icing fluid will prevent the formation of frost or ice and the accumulation of snow or slush on the protected surfaces of an aircraft under average weather conditions. Many variables can affect holdover time, making it inadvisable to consider table times as absolute minimums or maximums because the actual time of protection can be affected by existing weather conditions. In heavy weather conditions, holdover time can be shortened. High winds or jet blast may degrade the protective film, and the holdover time may be shortened considerably. Therefore, deicing experts recommend that indicated holdover times should be used only in conjunction with a pretakeoff inspection conducted by well-trained personnel.

Type I and Type II Fluids Vary

The Association of European Airlines (AEA), has designated fluids as either Type I or Type II to distinguish between plain deicers and anti-icers. Fluids have also been described as "Newtonian" or "non-Newtonian," which the Society of Automotive Engineers (SAE) defines as follows:

- Newtonian fluids are fluids whose vis-

exposed gaskets and seals to less deterioration. They also acknowledged that cleaning the fuselage was particularly important with center-line mounted engines to prevent snow or ice from being ingested into the engine.

When they deiced beneath the wings to remove frost, they were especially cautious not to spray the fluid onto the wheels and brake assemblies, especially when they were hot. They said that they were careful not to spray into external probes, such as pitot heads and static vents, as well as exhausts and thrust reversers.

After an aircraft was deiced, a ground mechanic or his foreman was called to inspect the aircraft's surfaces. Sometimes a mechanic carried a ladder to the aircraft so he could climb onto the wing surface. Others drove a truck equipped with a built-in walkway that extended beyond the front end of the truck and could be located over a wing. Once on the wing, the mechanic removed a glove and put his bare hand onto the wing surface, usually near the wing root, to confirm that there was no ice on the wing. He also notified the aircraft's pilot that deicing had been performed and a hand check had confirmed that the wing was clear of ice.

"If he doesn't do a hand check for ice, he

Fog formed from the hot water used in deicing, but the Type I fluid did not seem to add any slipperiness to the snow-covered ramp.

cosities are shear independent and time independent. The shear rate of a Newtonian fluid is directly proportional to the shear stress. The fluid will begin to move immediately upon application of a stress. It has no yield stress that must be achieved before flow begins. Type I fluids are considered Newtonian-type fluids.

- Non-Newtonian fluids are fluids whose viscosities are shear and time dependent and whose shear rate is not directly proportional to its shear stress. The fluid will not begin to move immediately upon application of a stress. It has a yield stress that must be achieved before flow begins. Type II fluids containing thickeners demonstrate a pseudoplastic behavior, which is defined as a decrease in viscosity with an increase in shear rate. Air must move faster across the wing surface before the thickened fluids will blow away.

Freezing Point Lowered in Type I Fluids

Type I fluids are generally considered deicing fluids and are effective because water has been heated to remove ice and snow. They have a lowered freezing point because glycol has been mixed with them. Such fluids work relatively quickly and do not cause damage to the aircraft surface. Type I mixtures contain at least 80 percent glycol that can be either monoethylene glycol, diethylene glycol, propylene glycol or a mixture of these glycols. The balance is made up of water, inhibitors and wetting agents. Inhibitors prevent corrosion, increase the flash point or comply with materials compatibility and handling requirements. Wetting agents, if used, allow the fluid to form a uniform film over the aircraft surfaces.

Glycols can be diluted with water. The freezing point of a water/glycol mixture varies with the content of water. Type I fluids are usually diluted with water of the same volume. In a 50/50 mixture of water and glycol, the mixture has a

goes back to work in the hangar and loses his certificate for a year," said Veijo. Precipitation and temperatures hovering around freezing required that anti-icing fluids be applied, so a Type II solution was sprayed immediately onto the aircraft's clean surfaces.

The men said that the Type II fluid contained at least 50 percent glycol and a thickening agent; no coloring was added, so the fluid was clear [it appeared white to me] when it was applied. They said that it had to be handled properly, from storage to application, to prevent degradation of fluid performance. It was kept at about 20 degrees C (68 degrees F), which was much cooler than Type I.

To apply the Type II fluid, the nozzle's spray pattern was widened and the flow pressure was reduced. The fluid was applied until it was beginning to drip off the leading and trailing edges of the aircraft. After the anti-icing was completed, the driver advised the pilot that Type II fluid had been applied and in what percentage it had been mixed with water. He also reported the time that holdover had begun (the time started from when Type II was first applied to the aircraft).

The information provided to the pilot about deicing and fluids is mandatory and it is the final clearance for airworthiness; the mechanic's report is required by the cockpit checklist in Finnair's aircraft.

Moreover, as long as the aircraft remains at the gate, the ground mechanic is responsible for the airworthiness of the aircraft, and he must ensure that the aircraft remains free of ice. If, for example, there is a gate hold and the holdover time is exceeded, the mechanic must make sure that if any additional deicing or anti-icing is required, it will be performed. Even if there is no ice, conditions such as worsening weather and a continued gate hold may still require that the aircraft be deiced and, if required, anti-iced.

lower freezing point than the concentrated fluid and, because of its lower viscosity, it flows off the wing more easily. It is generally agreed that the fluid does not present a hazard (i.e, increasing slipperiness) to runway operations.

Viscosity, or the measure of the resistance to flow caused by a fluid's internal friction, is dependent on temperature. Type I fluids show a relatively low viscosity that changes with temperature. The type of glycol used will also influence viscosity. Propylene-based fluids show higher viscosities than monoethylene-based fluids.

Type I fluids provide minimal holdover time, so they have little benefit in situations that require substantive anti-icing protection.

Type II Fluids Provide Best Anti-icing Protection

Type II fluids are considered anti-icing. They contain at least 50 percent per volume diethylene glycol or propylene glycol, different inhibitors, wetting agents and a polymer that acts as thickening agent to give the fluids a high viscosity, similar to that of molasses. About 45 percent to 48 percent of the mixture is water.

The viscosity of the fluid and the wetting agents allow fluid sprayed on the clean aircraft to adhere to the surface and act as a protective cover. If the wing already has snow or ice on it, the surface must be cleaned, usually with a a Type I fluid before the Type II fluid can be applied.

During takeoff roll, the fluid flows off the airfoil and onto the runway to leave a clean surface. Preliminary tests show no evidence that small amounts of Type II fluid affect the runway condition to any appreciable extent. However, an aircraft design working group has noted that when a gel-like Type II anti-icing fluid is applied to an aircraft, not all of the fluid flows smoothly from the wings on takeoff. The Boeing Co. has advised that residue "generally results in measurable lift losses and drag increases" during takeoff.

The deicing truck crew said that such situations do not occur very often because when the airport is busy, their supervisors go into the control tower and work closely with the controllers to coordinate the deicing procedures in concert with air traffic control arrivals and departures.

Sometimes Tomas and Veijo operated their truck together with another crew's truck to spray a large aircraft or to expedite a departure. When conditions are "bad" and an aircraft such as a DC-9 or MD-80 has several inches of snow on its surfaces, 1,500-2,000 liters (390-520 U.S. gallons) of fluid and about 20-minutes time will be required to remove the snow, they said. They agreed that a more routine task, such as removing frost from under the wings, may require only 40 liters (10.6 U.S. gallons) of fluid and a mere two-minutes time.

They explained that in their training they had been told that up to 3 mm (.12 inch) of frost and up to 2 mm (.08 inch) of ice could be allowed to remain on the underside of the wings (per manufacturer's operating approval) in the area of the fuel tanks. However, the pilot had to be informed of the condition so that he could make adjustments to takeoff calculations. Ice or frost outside the area of the fuel-tank area was not allowed and had to be removed.

Typically, an aircraft's engines were shut down (but when they were operating, they were at very low power settings); usually, the auxiliary power unit (APU) was operating. The two aircraft fitters used a minimum of fluid in the engine areas and avoided spraying into the engine inlets. Fluid sprayed into the APU created smoke in the cabin, a situation that they felt was embarrassing, as well as potentially harmful to the equipment. The driver communicated with the pilot and requested shutdown of the air conditioning system when spraying began in the empennage area.

Type II fluids have been used extensively in Europe for more than 20 years, while only a few major airlines have used Type II in the United States during the past few years. Some industry observers say some U.S. reluctance to accept Type II fluids has been because the products are proprietary to European airlines and the cost for Type II fluids can be double that of Type I fluids.

Comprehensive Deicing Procedures New to U.S. Airlines, And Questions Linger about Type II Fluids

While European airlines rely on AEA handbooks and holdover tables, both of which have proved to be highly reliable in standardizing their deicing/anti-icing operations, the U.S. has had no similar standards. [The FAA just released a *Pilot Guide for Large Aircraft Ground Deicing.*]

A Society of Automotive Engineers (SAE) committee, composed of representatives from aircraft manufacturers, makers of deicing equipment and fluids, the airlines, the Air Line Pilots Association (U.S.), the FAA and European experts, has been developing U.S. specifications for fluids, procedures and ground equipment used in deicing with both types of fluids. SAE also has been conducting various tests that include measuring how fast contamination accumulates on test strips of metal at airports and on wing surfaces. By working with airplane manufacturers, SAE anticipates publication of flight training materials to educate pilots.

Deicing experts are not in agreement that Type II fluids are the answer for all icing problems. Type I fluid performs well if used on the aircraft shortly before takeoff, or when freezing precipitation is not a factor. However, only a few U.S. airports allow for remote deicing near the departure end of the active runway. Taxiing long distances for takeoff from a deicing facility or waiting in line for takeoff limits the benefits of Type I deicing because of its short holdover time.

Local governments or airport authorities can impose restrictions that prevent U.S. carriers from using Type II fluids based on their concerns about liabilities, cost and damage to the environment from the runoff of the glycol. ♦

During a brief period, when there were no aircraft to be deiced, the men talked about their work and sipped hot coffee poured from a thermos bottle. Both men spoke with confidence and seemed to have a clear understanding of not only what they did, but why they did it.

"We don't need sugar in the coffee," one of the fitters said with a big smile on his face. "It's sweet already." I understood what he really meant, because deicing fluid had finally made its way to my lips. It had a sweet taste.

During the non-winter periods, when deicing was not required, their duties changed, and they became responsible for changing seats, covers and cushions in the aircraft, or changing the physical configuration of an aircraft from tourist-class to business-class. They both agreed that they liked their work, but they looked forward to advancing and becoming mechanics "in a warm hangar."

The men recognized that they had very responsible positions that were related directly to the safety of Finnair's passengers, crews and aircraft. They expressed no misgivings about their responsibilities and said that they believed that they were well-equipped and well-trained to perform their work.

"We know our work is important," said Tomas and echoed by Veijo, each of them looking forward to a long shower and hot sauna at the end of the shift. "The pilots never hurry us to do the job. They treat us with respect."♦

— RR

New U.S. Rules Established for Aircraft Ground Deicing and Anti-icing

The U.S. Federal Aviation Administration (FAA) has established (by way of an Interim Final Rule, which became effective November 1, 1992) a requirement for Federal Aviation Regulations (FAR) Part 121 certificate holders to develop an FAA-approved aircraft ground deicing and anti-icing program and to comply with that established program anytime conditions are such that frost, ice or snow could adhere to an aircraft's wings, control surfaces, propellers, engine inlets and other critical surfaces.

The FAA deemed the rule necessary following a number of accidents attributed to aircraft icing. The FAA said that the U.S. National Transportation and Safety Board (NTSB) attributed at least 13 accidents in the past 24 years (Table 1, page 17) to the failure to deice aircraft adequately before takeoff. It was noted that contamination on the aircraft surfaces during takeoff was the cause or a contributing cause.

The NTSB has also issued 30 safety recommendations that cover such subjects as informing operators about the characteristics of deicing/anti-icing fluids; informing flight crews about ice formation after deicing; reviewing information that air carrier operators provide to flight crews on runway contamination and engine anti-ice during ground operations; requiring flight crew checks before takeoff if takeoff is delayed following deicing; emphasizing to air carrier maintenance departments the impor-

An Unofficial Official Reports on Winters in Finland

The bellboys grunted as they passed the first bag into the back of his cab, and he chuckled. He was my kind of taxi driver. Even in their foreign tongue, I understood that they were all complaining to the somewhat rotund taxi driver dressed in a thin leather jacket and warning him about the very heavy bags.

"Schwarzenegger," I spoke, and lifted my arms as a weightlifter might, and the two bellboys laughed loudly. (Later, I wondered if they laughed at the joke or perhaps at the mighty sag that must have been pushed over my belt as I raised my arms.) The taxi driver chuckled and carefully arranged the computer bag (11 kilos), camera bag (14 kilos), and the soft bag (22 kilos) of clothing and other paraphernalia, now stuffed with booty [trinkets] acquired during my trip, and stacks of paper from Capt. Eloranta.

Taxi drivers, in my experience, are often great storehouses of local knowledge, and during the ride to the airport to catch the Finnair flight to New York, the next stop on my way home to Washington, D.C., the driver of the black Opel lived up to my expectations.

The 60-year-old man, with thinning dark hair, a balding forehead and dark-rimmed glasses, spoke in halting and thickly accented English, but he was easily understood. He said that he had been driving cabs for 30 years. Yes, sometime by the middle of those years he could say that he knew all of Helsinki's streets. But today, he had forgotten many of them. He chuckled.

Asked about the weather, he said the newspaper had reported that the Finnish winter of 1991-1992 was the shortest one during this century — a mere 47 days had been recorded with temperatures of freezing or below. He offered his own weather observations based on a digital weather system installed at his home within the city: The lowest temperature recorded by the device during the winter was -17 degrees C (1 degree F) and the highest was +9 degrees C tance of maintaining ground support equipment; and requiring air carrier training programs to examine the effect of wing leading edge contamination on aerodynamic performance.

A contributing factor in the FAA's decision to publish this rule was a determination made during the 1992 International Conference on Airplane Ground Deicing that (under existing procedures at the time) the pilot-in-command might be unable to determine effectively whether the aircraft's critical surfaces were free of all frost, ice or snow prior to takeoff.

The FAA rule is designed to provide an added level of safety to flight operations in adverse weather conditions and to provide enhanced procedures for safe takeoffs in such conditions.

The new FAA rule also follows a July 23, 1992, Notice of Proposed Rulemaking (NPRM) that allowed only 15 days for comments. Many industry observers felt that this was insufficient time to develop adequate in-depth responses. The new Interim Final Rule allows for additional comments until April 15, 1993. Those comments must be marked Docket No. 26930 and should be mailed in triplicate to: Attention: Rules Docket (AG-10) Docket No. 26930, Federal Aviation Administration, Office of the Chief Counsel, 800 Independence Ave., SW, Washington, DC 26930. The FAA states that it will consider all comments received and that it will make changes to the Interim Final Rule, if warranted.

The Interim Final Rule reads as follows:

The Amendment

In consideration of the foregoing, the Federal Aviation Administration amends Part 121 of

(48 degrees F) he said.

He said that the next shortest winter had been recorded in 1929-1930, when there were 58 days of freezing temperatures or below. That one, he said, was followed by the longest recorded winter, in 1931, when there were 210 freezing days.

He said that the population seemed evenly divided about the cause or causes behind the unusually warm weather. News reports blamed dust from the recent volcanic eruption of Mount Pinatubo in the Phillippines. Others, he said, just followed an old Finnish tradition based on waiting: We wait for spring, we wait for summer, we wait for winter. And this year we wait for winter next year. He chuckled.

During the 18-kilometer (11-mile) ride to the Helsinki-Vantaa Airport, he explained that a river over which the road passed was usually frozen with thick ice. Today, he said, it is already moving to the sea, a trip that usually doesn't begin until early May. And a short distance from Helsinki, a historic fortress is built on an island. During winter it is usually accessible by auto. This year, he said, a boat is the preferred transportation to the island.

Winter has been difficult for the children. When they get skates and skis, there is no place to use them, he said — for three years it has been like this.

The white birch trees — plentiful and sharing the roadside with modern, low-rise business buildings and an occasional small, wooden cottage — hugged dark earth and brown grasses. Occasionally, there were small mounds of dirty snow, apparently the remnants of piles cleared from roads. No winter here.

And how is winter in Washington, he asked, as he placed my bags, without a grunt or a visible sign of strain, on the concrete outside the terminal?

Just like it is here in Helsinki, I said. Maybe colder.

He took the 130 Finnish marks from me for the fare, which included a small tip, waved goodbye and wished me a safe trip. And he chuckled. ♦ —RR

Table I
13 Jet Transport Accidents Attributed to Ice Accumulation During Past 24 Years

Date	Airline	Aircraft	Location	Fatalities	Survivors
12/27/68	Ozark	DC-9	Sioux City, Iowa	68	0
02/25/69	Lufttransport	F-28	Lagenhagen, Germany	0	11
01/26/74	Turkish	F-28	Cumaovasi, Turkey	66	7
01/13/77	Japan AL	DC-8	Anchorage, Alaska	5	0
11/27/78	TWA	DC-9	Newark, N.J .	0	83
01/13/82	Air Florida	B-737	Washington, D.C.	78	5
02/05/85	Airborne Express	DC-9	Philadelphia, Penn.	0	0
12/12/85	Arrow Air	DC-8	Gander, Newfoundland	256	0
11/15/87	Continental	DC-9	Denver, Colo.	28	54
03/10/89	Air Ontario	F-28	Dryden, Ontario	24	45
11/25/89	Korean	F-28	Seoul, Korea	0	48
02/16/91	Ryan Air	DC-9	Cleveland, Ohio	2	0
12/27/91	Scandanavian	MD-80	Stockholm, Sweden	0	129

Source: U.S. Federal Aviation Administration

the Federal Aviation Regulations as follows:

PART 121 — CERTIFICATION AND OPERATIONS: DOMESTIC, FLAG, AND SUPPLEMENTAL AIR CARRIERS AND COMMERCIAL OPERATORS OF LARGE AIRCRAFT

1. The authority citation of Part 121 continues to read as follows:

Authority: 49 U.S.C. 1354(a), 1355, 1356, 1357, 1401, 1421-1430, 1472, 1485, and 1502; 49 U.S.C. 106(g) (revised, Pub. L. 97-449, January 12, 1983).

2. Section 121.629 is amended by revising current paragraph (b) and by adding new paragraphs (c) and (d) to read as follows:

121.629 Operation in icing conditions.

(b) No person may take off an aircraft when frost, ice, or snow is adhering to the wings, control surfaces, propellers, engine inlet, or other critical surfaces of the aircraft or when the takeoff would not be in compliance with paragraph (c) of this section. Takeoffs with frost under the wing in the area of the fuel tanks may be authorized by the Administrator.

(c) Except as provided in paragraph (d) of this section, no person may dispatch, release, or take off an aircraft any time conditions are such that frost, ice, or snow may reasonably be expected to adhere to the aircraft, unless the certificate holder has an approved ground deicing/anti-icing program in its operations specifications and unless the dispatch, release, and takeoff comply with that program. The approved ground deicing/anti-icing program must include at least the following items:

(1) A detailed description of:

(i) How the certificate holder determines that conditions are such that frost, ice or snow may reasonably be expected to adhere to the aircraft and that ground deicing/anti-icing operational procedures must be in effect;

(ii) Who is responsible for deciding that ground deicing/anti-icing operational procedures must be in effect;

(iii) The procedures for implementing ground deicing/anti-icing operational procedures;

(iv) The specific duties and responsibilities of each operational position or group responsible for getting the aircraft safely airborne while ground deicing/anti-icing operational procedures are in effect.

(2) Initial and annual recurrent ground training and testing for flight crew members and qualification for all other affected personnel (e.g., aircraft dispatchers, ground crews, contract personnel) concerning the specific requirements of the approved program and each person's responsibilities and duties under the approved program, specifically covering the following areas:

(i) The use of holdover times;

(ii) Aircraft deicing/anti-icing procedures, including inspection and check procedures and responsibilities;

(iii) Communications procedures;

(iv) Aircraft surface contamination, (i.e., adherence of frost, ice, or snow) and critical area identification, and how contamination adversely affects aircraft performance and flight characteristics;

(v) Types and characteristics of deicing/anti-icing fluids;

(vi) Cold weather preflight inspection procedures;

(vii) Techniques for recognizing contamination on the aircraft.

(3) The certificate holder's holdover timetables and the procedures for the use of these tables by the certificate holder's personnel. Holdover time is the estimated time deicing/anti-icing fluid will prevent the formation of frost or ice and the accumulation of snow on the protected surfaces of an aircraft. Holdover time begins when the final application of deicing/anti-icing fluid commences and expires when the deicing/anti-icing fluid applied to the aircraft loses its effectiveness. The holdover times must be supported by data acceptable to the Administrator. The certificate holder's program must include procedures for flight crew members to increase or decrease the determined holdover time in changing conditions. The program must provide that takeoff after exceeding any maximum holdover time in the certificate holder's holdover timetable is permitted only when at least one of the following conditions exists:

(i) A pretakeoff contamination check, as defined in paragraph (c)(4) of this section, determines that the wings, control surfaces, as defined in the certificate holder's program, are free of frost, ice, or snow;

(ii) It is otherwise determined by an alternate procedure approved by the Administrator in accordance with the certificate holder's approved program that the wings, control surfaces, and other critical surfaces, as defined in the certificate holder's program are free of frost, ice or snow;

(iii) The wings, control surfaces, and other critical surfaces are redeiced and a new holdover time is determined.

4. Aircraft deicing/anti-icing procedures and responsibilities, pretakeoff check procedures and responsibilities, and pretakeoff contamination check procedures and responsibilities. A pretakeoff check is a check of the aircraft's wings or representative aircraft surfaces for frost, ice, or snow within the aircraft's holdover time. A pretakeoff contamination check is a check to make sure the wings, control surfaces and other critical surfaces as defined in the certificate holder's program, are free of frost, ice, and snow. It must be conducted within five minutes prior to beginning takeoff. This check must be accomplished from outside the aircraft unless the program specifies otherwise.

(d) A certificate holder may continue to operate under this section without a program as required in paragraph (c) of this section, if it includes in its operations specifications a requirement that, any time conditions are such that frost, ice or snow may reasonably be expected to adhere to the aircraft, no aircraft will take off unless it has been checked to ensure that the wings, control surfaces, and other critical surfaces are free of frost, ice and snow. The check must occur within five minutes prior to beginning takeoff. The check must be accomplished from outside the aircraft.

NPRM Comments Reviewed

A review of some of the comments the FAA received to its July NPRM and FAA's response to those comments may be useful in understanding how the FAA decided what the Interim Final Rule should contain:

Takeoff Remains Pilot's Decision

Several respondents expressed concern that nothing in the proposed rulemaking should change the existing policy that places the ultimate responsibility for a takeoff on the pilot-in-command. Others believed that the dispatcher's role in releasing an aircraft, possibly including the determination of holdover times jointly with the pilot-in-command, should be made clear.

The FAA agreed that nothing in its rule would change FAR Part 91.3(a), which states that, "The pilot-in-command of an aircraft is directly responsible for, and is the final authority as to the operation of that aircraft." The new approach is to give the pilot-in-command (and certificate holders) additional guidance, developed procedures and, under certain conditions, ground personnel support in determining the aircraft's airworthiness in potential icing conditions. Even though the pilot-in-command and supporting personnel will receive additional training and the certificate holder establishes additional procedures, FAA states that the ultimate authority and responsibility for the operation of the aircraft remain with the pilot-in-command."

The FAA did not agree that the role of the dispatcher needed to be addressed any further in paragraph 121.629(c), which clearly states that "no person may dispatch … an aircraft any time conditions are such that frost, ice, or snow may reasonably be expected to adhere to the aircraft, unless the certificate holder has an approved deicing program and unless the dispatch, release, and takeoff comply with that program."

The FAA said the dispatcher is part of the team that will initially determine whether it is safe for a flight to be dispatched in existing and anticipated icing conditions. However, a dispatcher might not have all or the most current icing and weather information that becomes available to the pilot-in-command and that is used by that pilot in initially determining and possibly changing a holdover time.

Pretakeoff Checks Aimed At Contamination

Numerous questions were raised concerning the pretakeoff contamination check and the optional outside check. The most frequently raised concern was that the proposed five-minute limitation is impractical because most airports did not have a facility at a location close enough to the end of the takeoff runway to perform these checks. Other concerns were: pretakeoff contamination checks with the engines running (particularly propeller drive aircraft) are inherently unsafe; a pretakeoff contamination check should be required following ground operations in all icing condition operations, not just when holdover times are exceeded; checks from within the aircraft should be allowed in all cases, according to some commenters, and should never be allowed, according to others.

The FAA responded that the rule would allow a takeoff after the expiration of a holdover time if a check conducted within five minutes prior to takeoff determined that the wings, control surfaces, and other critical surfaces were free of frost, ice, or snow and if the check was "accomplished from outside the aircraft unless the program specifies otherwise." The rule would also allow for a check that must be conducted within five minutes prior to takeoff as an optional alternative for a certificate holder who does not have a deicing program, but this check must be accomplished from outside the aircraft.

The FAA said that those who commented confused the pretakeoff contamination check in 121.629(c)(3) and (c)(4) with the outside-the-aircraft check that is required by 121.629(d). The following describes the different procedures and checks in the final rule:

Pretakeoff check. This check is completed any time the aircraft is deiced or anti-iced and is integral to the use of holdover times. It is accomplished within the holdover time and is normally accomplished by the flight crew from inside the aircraft who will check the aircraft's wings or representative aircraft surfaces for contamination. For clarification, and to be consistent with the intended use of holdover timetables, this check is included in 121.629(c)(4).

Pretakeoff contamination check. This check is to determine the condition of an aircraft after the maximum holdover time has been exceeded and may be performed from either inside or outside the aircraft depending on the type aircraft, lighting and weather conditions, as specified in the certificate holder's approved program. When the pretakeoff contamination check is used, it must be accomplished within five minutes of beginning the takeoff. The aircraft's critical surfaces, as defined in the certificate holder's program, must be checked.

Part 121.629(d) outside-the-aircraft check. This check is required only if a certificate holder does not have an approved program and must be accomplished from outside the aircraft within five minutes of beginning the takeoff.

The FAA points out that none of the aforementioned checks are substitutes for any Airworthiness Directive requirements. As to the feasibility of the five-minute limitation on pretakoff contamination checks or outside-the-aircraft checks, the FAA recognized that in many situations neither of the checks may be viable at certain airports, at certain peak departure times or during certain weather conditions. The FAA observed that in the long term, as airport remote deicing and checking facilities are built or expanded, those checks would be more feasible. However, the FAA pointed out that the five-minute limitation would arise in only two situations. One is when a certificate holder does not have an approved ground deicing/anti-icing program. The other is after a maximum holdover time is exceeded.

The FAA assumed that a certificate holder would elect not to have an approved ground deicing/anti-icing program only if it concluded that it would be more cost-effective to operate without such a program. In electing not to have an approved program, the certificate holder has to take into consideration the possibility that it would have to delay or cancel flights in icing conditions. As a practical matter, the FAA did not expect that such a certificate holder's operations under its rule would differ significantly from its past operations.

The outside-the-aircraft check conducted within five minutes of beginning takeoff would be the only alternative means of operating in icing conditions in the absence of an approved program under paragraph (c). Even if a certificate holder was to use the deicing facilities of another certificate holder who has an approved program, the first certificate holder could not use the holdover times of the deicing certificate holder. This, said the FAA, is because the five-minute limitation under 121.629(d) recognizes that pilots who operate without an operator-approved program, as compared to pilots who operate under an approved program, may lack proper training and knowledge to determine effectively whether the aircraft is free of contamination prior to takeoff. Without the proper training provided under an approved program, the pilot-in-command in possession of a holdover time could easily make an uninformed decision in attempting to take off. In the absence of an approved program, the FAA will require the aircraft to be checked from outside the aircraft within five minutes of beginning takeoff.

To certificate holders with an approved program where a maximum holdover time is exceeded, the FAA noted three alternatives. The aircraft can be redeiced and a new holdover time established. The aircraft can take off if the certificate holder has obtained approval of an alternate procedure (e.g., a new technology) that is capable of determining that the wings, etc., are clean. The third alternative is to accomplish a pretakeoff contamination check and begin the takeoff within five minutes of completing the check. If the takeoff could not be initiated within the five-minute limitation, and if no alternate procedure has been established, the worst-case scenario for the certificate holder is that the aircraft must be redeiced and a new holdover time established. The FAA did not consider the potential delay to be unacceptable given the risks of taking off when there would be considerable uncertainty about the possibility of aircraft surface contamination.

Underwing Frost Allowed

Comments expressed concern that the proposed rule could lead to rescinding previous FAA policy that allows takeoffs with a small amount of frost on the underside of the wing in the area of fuel tanks when consistent with the aircraft manufacturer's operating and servicing instructions.

The FAA responded that it did not intend to change its policy of permitting takeoff with small amounts of frost on the underwings caused by cold soaked fuel within aircraft manufacturer-established limits accepted by FAA aircraft certification offices and stated in aircraft maintenance manuals and aircraft flight manuals. Language was added to the final rule to make it clear that takeoffs with frost under the wing in the area of the fuel tanks are permitted if authorized by the Administrator. The FAA said that affected certificate holders should include the type of aircraft involved and justification for these operations, including manufacturer-supplied data showing how these operations are safely accomplished, as part of their proposed deicing program.

Type-specific Holdover Times Not Required

More than half of the comments addressed the issue of the use of holdover times, and the majority of the comments concerned the following issues: Appropriateness of holdover times being specific either to a certificate holder or to an aircraft type; use of holdover times as mandatory rather than as guidelines; and determining or changing holdover times.

The FAA's rule requires certificate holders to develop holdover times with data acceptable to the FAA. The FAA acknowledged that the only holdover time data currently available to the industry and acceptable to the FAA are those developed by the Society of Automotive Engineers (SAE) and the International Organization for Standardization (ISO). Studies have been initiated to develop more precise holdover timetables, and, as new data become available, new tables will be developed and made available to the industry. Certificate holders may develop other tables, but they should be aware that the FAA may need considerable time to verify the acceptability of newly developed tables.

SAE/ISO-developed holdover times have been compiled into tables that are specific to fluid type (Type I or Type II) rather than being specific to any aircraft. The tables use outside air temperature (OAT) ranges, fluid concentrations or freezing point (FP) limitations and the general type of contamination (i.e., frost, freezing fog or rain, snow and rain on a cold soaked wing) to determine an approximate holdover time range (Tables 2 and 3, page 22).

The tables state that "the responsibility for the application of these data remains with the users" and caution that they are for use in departure planning only and that they shall not be used as substitutes for a pretakeoff check. The tables provide approximate time ranges and are subject to individual interpretation. The FAA determined that takeoff after exceeding any maximum holdover time in a certificate holder's table is permitted only when acceptable alternatives are taken to ensure that the aircraft surfaces are free of contamination.

Several comments objected to the proposed language of 121.629(c)(3), which states that an approved deicing program must include "the certificate holder's holdover times, specific to each aircraft type" and stated that holdover times should not be aircraft-type specific. Most believed that holdover times should be standard for all certificate holders.

In response, the FAA repeated that the only holdover timetables available were those developed by the SAE/ISO and that these times are not aircraft-specific. Because holdover times

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

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

OAT		Type II Fluid Concentration Neat-Fluid/Water [% by Volume]	Approximate Holdover Times Anticipated Under Various Weather Conditions (hours: minutes)				
°C	°F		FROST	FREEZING FOG	SNOW	FREEZING RAIN	RAIN ON COLD SOAKED WING
0 and above	32 and above	100/0	12:00	1:15-3:00	0:25-1:00	0:08-0:20	0:24-1:00
		75/25	6:00	0:50-2:00	0:20-0:45	0:04-0:10	0:18-0:45
		50/50	4:00	0:35-1:30	0:15-0:30	0:02-0:05	0:12-0:30
below 0 to -7	below 32 to 19	100/0	8:00	0:35-1:30	0:20-0:45	0:08-0:20	CAUTION! clear ice may require touch for confirmation
		75/25	5:00	0:25-1:00	0:15-0:30	0:04-0:10	
		50/50	3:00	0:20-0:45	0:05-0:15	0:01-0:03	
below -7 to -14	below 19 to 7	100/0	8:00	0:35-1:30	0:20-0:45		
		75/25	5:00	0:25-1:00	0:15-0:30		
below -14 to -25	below 7 to -13	100/0	8:00	0:35-1:30	0:20-0:45		
below -25	below -13	100/0 if 7°C (13°F) Buffer is maintained	A buffer of at least 7°C (13°F) must be maintained for Type II used for anti-icing at OAT below -25°C (-13°F). Consider use of Type I fluids where SAE or ISO Type II cannot be used.				

THIS TABLE DOES NOT APPLY TO OTHER THAN SAE OR ISO TYPE II FPD FLUIDS.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

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

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

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

OAT		Approximate Holdover Times Anticipated Under Various Weather Conditions (hours:minutes)				
°C	°F	FROST	FREEZING FOG	SNOW	FREEZING RAIN	RAIN ON COLD SOAKED WING
0 & above	32 & above	0:18-0:45	0:12-0:30	0:06-0:15	0:02-0:05	0:06-0:15
below 0 to -7	below 32 to 19	0:18-0:45	0:06-0:15	0:06-0:15	0:01-0:03	CAUTION! Clear ice may require touch for confirmation
below -7	below 19	0:12-0:30	0:06-0:15	0:06-0:15		

THIS TABLE DOES NOT APPLY TO OTHER THAN SAE OR ISO TYPE I FPD FLUIDS.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

Source: U.S. Federal Aviation Administration, Advisory Circular 120-58, 9/30/92, *Pilot Guide for Large Aircraft Ground Deicing.*

are generally given as acceptable ranges, the FAA said, it is conceivable that a rational analysis could lead to an acceptable deicing program in which type-specific holdover times are provided within the ranges of acceptable holdover times given in the SAE/ISO tables. In the final rule, the language does not prohibit the use of type-specific holdover times, but they are not required.

Several comments stated that holdover times were developed as guidelines and not as mandatory times. One comment suggested that the holdover guidance provided in current and proposed advisory circulars was too general to be of genuine use and that the FAA should commission SAE to recalibrate its charts to match standard U.S. National Weather Service reporting criteria.

The FAA reiterated that each certificate holder must develop its own holdover times with data acceptable to the FAA and, if the maximum holdover time developed by the certificate holder is exceeded, other actions must be accomplished before the aircraft can take off. The FAA will continue to work with the NWS to enhance reporting criteria.

Dispatchers commented that the proposed rule did not adequately reflect the role of the dispatcher under existing Part 121 rules. They recommended that the dispatcher's role be reflected in the rule language and that the dispatcher and pilot-in-command must work together in determining holdover times. One suggested that the dispatcher would be in a better position to enforce holdover times than the pilot-in-command. Several suggested that the proposed rule placed an unreasonable burden on the pilot-in-command, particularly in a case where the pilot would be expected to increase or decrease the determined holdover time based on changing conditions. Other comments suggested that it would be better to have each airport establish one central agency to determine and revise, as appropriate, holdover times for all certificate holders operating at that airport.

The FAA responded that the information required to determine or change the proper holdover time includes outside air temperature, type and concentration of fluid, weather conditions, and time the last application of fluid began. This information is most readily available to the pilot-in-command, allowing the pilot to determine quickly from the holdover timetable the appropriate holdover time. The certificate holder's program may include holdover coordination with the dispatcher, but the information required to determine or change the proper holdover time may be available only to the pilot-in-command.

Certificate Holder Determines Type of Fluid Used

Several comments recommended that the FAA mandate or at least encourage the use of Type II fluids, while others raised questions about using Type II fluids, ranging from potential environmental problems to higher cost and limited availability.

The FAA responded that it was up to the certificate holder to determine the type of fluids it would use, as each type has its benefits and intended usage. The FAA said that all the information available indicated that there is no availability problem with Type II fluids.

Other general comments included statements that NTSB accident statistics related to icing problems do not address the thousands of successful takeoffs made annually during icing conditions and that the NTSB investigation of the 1982 Air Florida accident showed that improper engine thrust was the main cause of the accident and that perhaps icing problems alone were not the problem. The FAA responded that the NTSB's recommendations are based on its accident investigations and its other studies and do, in effect, consider successful operations. In its investigation of the Air Florida accident, NTSB cited as one of the probable causes the flight crew's decision to take off with snow and ice on the aircraft's airfoil surfaces.

Another comment suggested that the FAA should include in the docket any studies that it relied on to reach its conclusions, such as the conclusion that non-slatted aircraft wings are more susceptible to lift loss than slatted aircraft wings. The

FAA stated that it has included in the docket a summary of wind tunnel tests of hard leading edge wings and slatted leading edge wings completed by the U.S. National Aeronautics and Space Administration's Lewis Research Center, although the difference in accident history of these designs may not be fully explained by design differences. Pilot techniques, said the FAA, including rotation rates and angles, are also important factors to be considered in assessing stall propensity, along with the rotation speed and the initially computed climb speed. A single factor has not been isolated as the major explanation for differences in accident rates, the FAA said.♦

In addition to the persons quoted in the icing-related articles, the following Finnair personnel contributed information:

Rolf Selin, supervisor; Paul Ruponen, supervisor; Tina Kunnas, secretary, flight simulator department; Antero Harras, head of security; Jussi Ekman, pilot; Tapani Vanttinen, supervisor, line stations maintenance and training; Paavo Turtiainen, former manager line maintenance; Tapani Hakola, head of simulator department; and Kaj Grundstrom, vice president, investor relations & cooperation projects.

Tapio Kilpinen, director of Finland's Civil Aviation Administration, also contributed information.

Aviation Statistics

U.S. Federal Aviation Administration Releases Aviation Safety Data

FAA Interprets 1992 Data Trends

Near Midair Collisions Reported Voluntarily

The reporting of a near midair collision (NMAC) is voluntary and depends in part on an individual's perception of a situation.

Incidents do not necessarily involve the violation of regulations or errors by air traffic controllers, nor do they necessarily represent an unsafe condition.

Significant factors involved in the submission of a report may include items such as the proximity of the aircraft involved, the element of surprise in the encounter, and the expectations of the flight crew to the possibility of the occurrence of a NMAC because of an increase in publicity concerning NMACs or midair collisions.

Conversely, some NMACs, including those that may involve unsafe conditions, may not be reported.

Reasons for not reporting incidents include failure to see another aircraft or to perceive accurately the distance from another aircraft due to restricted visibility or the relative angle of approach, fear of penalty, or lack of awareness of the reporting system.

Pilot Deviations Identify Trends

While pilot deviations (PD) data are considered useful in identifying possible trends associated with PD occurrences, there are certain limitations that should be considered when using the data presented in this report. The information reflects a mix of preliminary and final reports. Thus, the data are subject to minor changes.

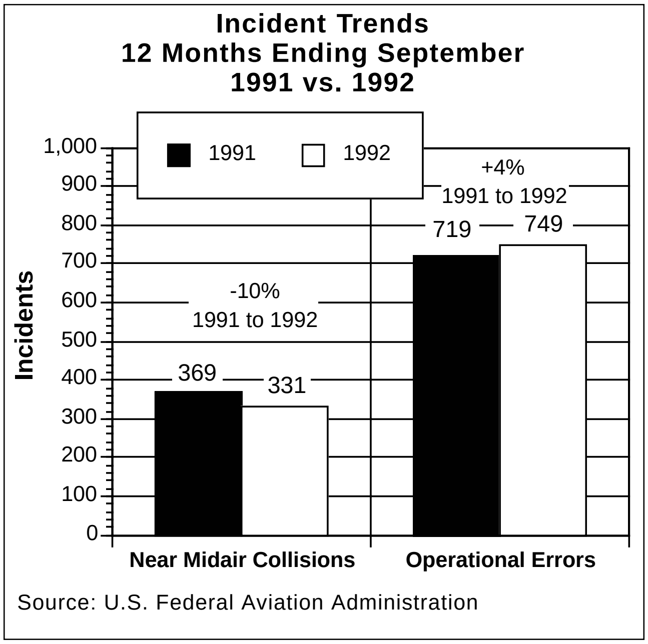


Figure 1

1992 Incident Trend: Operational Errors Increase

Figure 1 shows incident trends for near midair collisions and operational errors compiled from data through September 30, 1992.

A near midair collision is defined as:

An incident associated with the operation of an aircraft in which a possibility of collision occurs as a result of proximity of less than 500 feet to another aircraft, or an official report is received from an aircrew member stating that a collision hazard existed between two or more aircraft.

An operational error is defined as:

An occurrence attributable to an element of the air traffic control system that results in less than the applicable separation minima between two or more aircraft, or between an aircraft and terrain or obstacles as required by Handbook 7110.65 and supplemental instructions. Obstacles include: vehicles/equipment/personnel on runways.

Near midair collisions decreased while operational errors increased during the 12-month period ending September 1992 when compared to the same period in 1991.

Figure 2 shows pilot deviations and runway incursions compiled from data through June 30, 1992.

A pilot deviation is defined as:

The actions of a pilot that result in the violation of a Federal Aviation Regulation or a North American Aerospace Defense Command Air Defense Identification Zone tolerance.

A runway incursion is defined as:

Any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in loss of separation with an aircraft taking off, intending to take off, landing, or intending to land. (Note: Runway incursions result from one of the following four types of airport surface occurrences: pilot deviations, operational errors, vehicle operator/pedestrian deviations, and pilot/vehicle operator/pedestrian judgmental errors.)

Pilot deviations and runway incursions decreased during the 12-month period ending June 1992 when compared to the same period in 1991. Pilot deviation and runway incursion monthly totals usually require 90 days to stabilize. Therefore, comparisons do not include the most recent 90-day period.♦

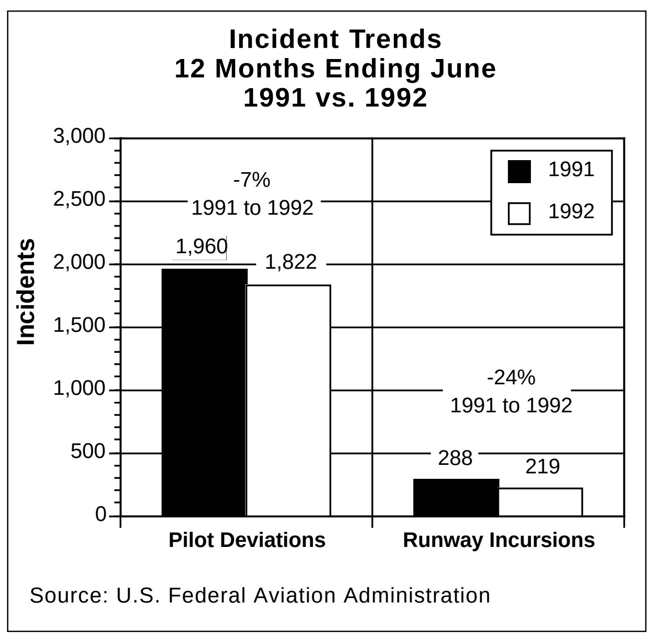


Figure 2

Reports Received at FSF Jerry Lederer Aviation Safety Library

Updated Reference Materials (Advisory Circulars, U.S. FAA)

Numbers	Month/Year	Subject
21-29A	July 1992	*Detecting and Reporting Suspected Unapproved Parts* (Cancels AC 21-29, dated August 6, 1991).
150/5220-4B	July 1992	*Water Supply Systems for Aircraft Fire and Rescue Protection* (Cancels AC 150/5220-4A, dated December 11, 1985).
183.29-1AA	August 1992	*Designated Engineering Representatives* (Cancels AC 183.29-1Z, dated July 12, 1991).

New Reference Materials

Advisory Circular 120-57, 9/04/92, Surface Movement Guidance and Control System. Washington, D.C. U.S. Federal Aviation Administration, 1992. 27 p. in various paging. Appendices included.

Summary: This Advisory Circular (AC) describes standards and provides guidance in the development of a Surface Movement Guidance and Control System (SMGCS) plan for U.S. airports conducting operations in visibility conditions less than 1,200 feet runway visual range (RVR).

Reports

Identifying Ability Requirements for Operators of Future Automated Air Traffic Control Systems/ Carol A. Manning, Dana Broach. Washington, D.C.: U.S. Federal Aviation Administration, Office of Aviation Medicine; Springfield, Virginia, U.S. Available through the National Technical Information Service*, [1992]. Report No. DOT/FAA/AM-92/26. 26 p. in various pagings. Includes bibliographical references (p. 12-14).

Keywords
1. Air Traffic Controllers — United States — Selection and Appointment.
2. Air traffic control — United States — Automation.
3. Ability — Testing.
4. United States — Federal Aviation Administration — Officials and Employees — Selection and Appointment.

Summary: The purpose of this study was to explore a method for identifying selection requirements for the Air Traffic Control Specialist (ATCS) occupation in anticipation of increased automation of air traffic control systems. The Federal Aviation Administration (FAA) plans to introduce increasingly sophisticated levels of automation into air traffic control facilities over the next 20 years. As ability requirements for ATCSs change, it will be necessary to develop or modify selection procedures for future air traffic controllers. Accurate identification of ability requirements depends on knowledge of the job tasks to be performed. Currently, only general information is available on job tasks associated with later developments of air traffic control automation. In this study, nine air traffic controllers who had

analyzed operational requirements for a future stage of automation described how controllers would perform four job tasks using the automation; assessed the degree to which nine specific abilities were likely to be required to perform the automated tasks; and assessed whether the amount of each ability required to perform the automated tasks would be different than the amount of the ability required to perform the equivalent tasks in the current system. While the controllers agreed that some changes will occur in the presentation of information, they suggested that the future controller will need about the same skills currently required to perform the tasks included in the study. These controllers did not think that any new abilities would be required to perform the job using extensive automation aids. As more information becomes available about the functioning of the automation and the controllers' interaction with it, it will be easier to define the associated ability requirements. The study also includes both an appendix comparing ATCS tasks under two air traffic control systems and an appendix of task flow charts.[Modified abstract and introduction]

Performance of Color-Dependent Tasks of Air Traffic Control as a Function of Type and Degree of Color Vision/ Henry W. Mertens, Nelda J. Milburn. Washington, D.C. U.S. Federal Aviation Administration, Office of Aviation Medicine; Springfield, Virginia, U.S. Available through the National Technical Information Service*, [1992]. iii, 9, A-5 p.: charts. Includes bibliographical references (p. 8-9).

<u>Keywords</u>
1. Air Traffic Controllers.
2. Color Vision — Testing.
3. Video Display Terminals.

Summary: This report details an experiment conducted to expand initial efforts to validate the requirement for normal color vision in Air Traffic Control Specialist (ATCS) personnel whose tasks involve discerning critical color-coded information at en route center, terminal, and flight service station facilities. A comparison was made between the performance of subjects with normal color vision and that of subjects in various classifications of color vision deficiency on a battery of color-dependent ATCS tasks. A comparison showed that mean errors were significantly higher at every level of color vision deficiency than those with normal vision. These findings provide support for the requirement of normal color vision in initial medical screening of ATCS personnel. [Modified abstract]

Aircraft Accident Report: Britt Airways, Inc., Continental Express Flight 2574 In-Flight Structural Breakup EMB-120RT, N33701 Eagle Lake, Texas September 11, 1991/ National Transportation Safety Board. Washington, D.C. National Transportation Safety Board; Springfield, Virginia, U.S. Available through the National Technical Information Service*, 1992. v, 87 p.: ill.

<u>Keywords</u>
1. Aeronautics — Texas — Eagle Lake — Accidents.
2. Airplanes — Maintenance and Repair — Safety Measures.
3. Aeronautics — Accidents.
4. Airframe — Fatigue — Accidents.

Summary: This report details the September 11, 1991 in-flight structural breakup and crash of an Embraer 120, Continental Express Flight 2574, near Eagle Lake, Texas. The two flight crew members, one cabin crew member and 11 passengers aboard the airplane were killed. The National Transportation Safety Board (NTSB) report concluded that under normal operation as the airplane descended through 11,500 feet, the leading edge of the left horizontal stabilizer separated from the airframe, resulting in an aerodynamic stall and creating a large nose-down pitching moment. While large airloads on the airplanes structure, high airspeed and roll rate contributed to the in-flight structural breakup sequence, the NTSB concluded, from the engineering simulation, the Flight Data Recorder (FDR) and examination of the wreckage, that the accident sequence was initiated by the loss of the left leading edge of the horizontal stabilizer. The NTSB determined that the probable cause of this accident was the failure of Continental Express maintenance and inspection personnel to adhere to proper maintenance and quality assurance procedures for the airplane's horizontal stabilizer leading edge and the immediate severe nose-down pitchover and breakup of the airplane. The NTSB further determined that the failure of the Continental Express management to ensure compliance with the approved maintenance procedures and the failure of FAA surveillance to detect and verify compliance with approved procedures also contributed to the cause of the accident. The report includes the NTSB recommendations made to the FAA. [Modified executive summary and conclusions]

Aviation Safety: Additional Actions Needed for Three Safety Programs: Statement of Kenneth M. Mead, Director, Transportation Issues, Resources, Community, and Economic Development Division, before the Subcommittee on Aviation, Committee on Public Works and Transportation, U.S. House of Representatives/ United States General Accounting Office. Washington, D.C. U.S. General Accounting Office**, [1992]. Report No. GAO/T-RCED-92-90. 8 p. Includes bibliographical references.

Keywords
1. Aeronautics — United States — Safety Measures — Evaluation.
2. United States — Federal Aviation Administration.
3. Airplanes — United States — Maintenance and Repair.
4. Airlines — United States — Databases.
5. Airplanes — United States — Collision Avoidance.

Summary: This report covers director Mead's testimony on three Federal Aviation Administration (FAA) programs to improve aviation safety. These programs relate to ensuring the safety of aging aircraft with new maintenance and repair requirements issued over the past two to three years; reducing the risk of runway incursions through such programs as the new Airport Surface Detection Equipment (ASDE-3) radar; and implementing the Traffic Alert/Collision Avoidance System (TCAS). Mead reports that although the FAA has made progress in the three safety programs, additional actions need to be taken. Recognizing that the FAA is making efforts to address the safety risks of older aircraft by issuing new requirements to modify these aircraft structurally and proposing the establishment of a database to monitor compliance with the requirements, Mead states that he does not see significant follow-through on this intention in the locations where safety inspections and compliance monitoring actually take place — the maintenance bays and hangars around the country. Mead restates the importance of FAA's efforts to develop and maintain an industry-wide, periodically updated database for aging aircraft and make compliance inspections of these aircraft an integral part of safety inspectors' assignments. The FAA should continue with steps taken to enhance airport safety through the Runway Incursion Plan and revise criteria for which airports receive the new ASDE-3 ground radar system. Mead supports the implementation of this system but believes the FAA should take further steps to correct the phenomenon of split-target radar display . While he recognizes that progress is being made in correcting the unnecessary collision alerts given by the TCAS system, Mead states that controversy over the system has diminished in light of the FAA's commitment to complete a rigorous quality check of the TCAS's original software and the modifications in January 1993. [Modified summary and conclusion] ♦

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Accident/Incident Briefs

Air Carrier

This information is intended to provide an awareness of problem areas through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

Checklist Complacency Results In Landing Surprise

Boeing 727-200. Substantial damage. No injuries.

On final approach during daylight to an Asian airport, the flight crew of the Boeing 727 did not perform the landing procedure checklist and the aircraft landed wheels up, skidding to a stop on the runway. There were no injuries to the seven crew members and 120 passengers aboard.

An inquiry found that the flight crew did not operate the gear selector or confirm that the three green indicator lights for gear-down were on. In addition, the flight engineer pulled the circuit breaker when the warning horn activated. The crew was cited for violation of cockpit procedures and negligence.

Heavy Feet Lead to Wheel Lock

Boeing 727-100. Minor damage. No injuries.

The international flight landed uneventfully at Paris' Orly International Airport. However, a few seconds into the landing roll, the four main wheels locked, and the tires failed almost simultaneously.

The flight crew was able to stop the aircraft on the runway and the flight's 102 passengers were evacuated through the rear door without incident. The four main wheels, the main gear doors and legs suffered considerable damage.

An investigation determined that the cockpit crew's work had been disturbed by discussions with a passenger present on the flight deck. In addition, the aircraft was not equipped with a mechanical option to avoid wheel locking. It was concluded that the likely cause of the tire blowouts and wheel locking was a crew member pressing on the rudder bars.

Steep Descent, Recovery Injures Passengers

Airbus A310. Minor damage. Nine serious injuries and 19 minor injuries.

The pilot initiated a descent from 39,000 feet to 25,000 feet, with profile mode and flight management system engaged.

After the descent began, the overspeed warning came on. The autopilot was then switched to the control wheel steering mode and the aircraft started to pitch up. Recovery was made in the manual mode, although the abrupt maneuvering seriously injured seven passengers and two crew members. Another 17 passengers received minor injuries, along with two other crew members.

Following the incident, the manufacturer issued bulletins concerning operational limitations of control wheel steering and overspeed in descent with profile mode.

Snowy Runway Not Long Enough for Commuter Jet

Cessna Citation II. Substantial damage. No injuries.

After a normal touchdown, the pilot shut down one engine during the ground roll. The aircraft failed to reduce speed, and the second engine was shut down.

Although there was some runway friction, the runway was so slick that the aircraft overran the end by 30 meters. The aircraft was not equipped with thrust reversers. The runway was 1,500 meters long.

Thunderstorm Sends Commander on Wild Ride

Commander 690. Substantial damage. No injuries.

During cruise, the aircraft was struck suddenly by lightning and simultaneously encountered extreme turbulence.

The aircraft suffered substantial overstress damage during a rapid, uncontrolled descent from 14,000 feet to 3,000 feet, when the pilot finally recovered control of the aircraft. Despite the damage, the pilot landed the aircraft safely, and there were no injuries.

Engine Failure Forces Convair Down

Convair CV580. Substantial damage. Five minor injuries.

While cruising at 20,000 feet, the flight crew noticed that the oil pressure indicator of the right engine gearbox had illuminated. The engine was immediately secured, the propeller was feathered and the crew turned back to the departure airport.

A short time later, the left engine failed. Neither engine would restart, so the pilot executed an emergency landing on a dirt road. The aircraft rolled 2,500 feet before striking a fence and a log pile. The nose gear collapsed on impact.

An investigation determined that the right engine failed because of a faulty lubrication system. It was found that the left engine's turbine section had overheated, with turbine blades severely damaged by heat. Five of the 26 passengers received minor injuries.

Engine Failure on Takeoff Ends in Fiery Crash

Beech 65/70 Queen Air. Aircraft destroyed. Three minor injuries.

Moments after takeoff, at an altitude of 500 feet, the aircraft yawed suddenly to the right.

The pilot attempted to feather the right propeller but moved the mixture control to the idle cutoff position because the propeller did not immediately go into feather. He lowered the gear and executed an emergency landing on a highway. During the descent, the aircraft struck a power line and light pole and caught fire after striking the ground. The pilot and two passengers were able to escape with minor injuries.

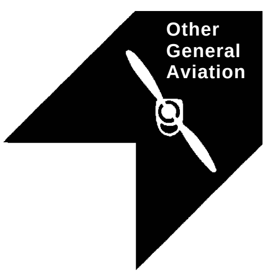
Crippled Twin Survives Crash Landing

Cessna 310. Substantial damage. No injuries.

During cruise, the pilot reported that one engine was running rough, and he diverted to a nearby airport.

As the aircraft touched down, the pilot realized that the right propeller and the right main landing gear were missing. The aircraft skidded to a stop, and the pilot was able to evacuate the aircraft without injury.

An investigation could not determine the cause of the propeller separation, which apparently caused the damage to the landing gear.



Low Turn Results in Classic Stall

Cessna 150M. Aircraft destroyed. Two fatalities.

The pilot was engaged in maneuvers for an upcoming air show event. The aircraft was observed to stall in a tight, low-level turn before impacting the ground and catching fire. The pilot and a passenger were killed.

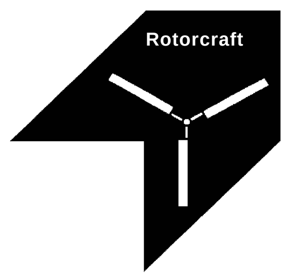
The aircraft was making a downwind turn at about 500 feet in a 30-knot wind. The bank appeared to vary in turbulence before the nose dropped and the aircraft fell to the ground.

Student Pilot Flips Piper

Piper PA38 Tomahawk. Substantial damage. One minor injury.

The student pilot was engaged in his first solo practice forced landing. The approach was too high, leaving the aircraft further down the runway than planned and too close behind a departing BAe146.

Just before touchdown, the aircraft rolled right and inverted. The aircraft skidded along the runway inverted, but the pilot suffered only minor injuries. Wake turbulence from the departing jet was suspected of causing the rapid loss of control. The pilot was cited for not keeping air traffic control advised of his position and for failing to initiate a go-around when it was clear that the landing would be too long. He had logged a total of 24 flying hours in the Tomahawk.



Sudden Yaw Ends With Water Crash

Bell 206B. Aircraft destroyed. No injuries.

As the helicopter was flying out of ground effect at about 20-knots forward airspeed, the pilot said the nose started an uncommanded right turn.

The pilot was unable to arrest the turn, and the aircraft descended uncontrolled until it crashed into a lake. The pilot reported later that he "did not feel that there was a mechanical failure with the helicopter." The elevation of the lake was about 6,000 feet above sea level. The certificated commercial pilot and four passengers were not injured in the daylight accident. Visual meteorological conditions prevailed at the time of the crash.

Pinnacle Approach Practice Run Ends on Ridge

Hughes 269C. Aircraft destroyed. One fatality. One serious injury.

The helicopter was on an instructional flight to conduct practice pinnacle approaches and landings to a ridge line, about 4,000 feet above mean sea level.

Witnesses said that after several practice runs, the helicopter struck the side of the mountain just below the ridge and tumbled down the mountainside, breaking apart and catching fire.

The instructor was thrown from the helicopter about 500 feet down the side of the mountain from the point of impact. The wreckage fell another 500 feet before coming to rest. The aircraft was destroyed by the impact and post-crash fire. The instructor received serious injuries. The student pilot was killed. The crash occurred in visual meteorological conditions.♦

FLIGHT SAFETY FOUNDATION

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