FLIGHT SAFETY FOUNDATION
Airport Operations
Vol. 19 No. 6 *For Everyone Concerned with the Safety of Flight* November/December 1993

Accidents Show Need for Comprehensive Ground Deicing Programs

An alarming number of fatal accidents continue to occur because of ground icing. While problems related to deicing fluids still need to be resolved, there are proven steps that can be taken immediately to reduce risks.

by
Robert M. MacIntosh
Senior Air Safety Investigator
U.S. National Transportation Safety Board

For more than 30 years, the U.S. National Transportation Safety Board (NTSB) has compiled an unofficial list of ground icing takeoff accidents. Today, the list contains about 55 accidents. About 60 percent occurred in the United States. But aviation professionals have been aware of the dangers of aircraft ground icing for decades, and long before the start of the jet age.

Following are major air carrier accidents linked to ground icing during the last 25 years:

- Dec. 27, 1968, Sioux City, Iowa. An Ozark Air Lines DC-9-15 crashed after taking off from Sioux City Airport. The crew was aware that there was ice on the wings when they took off. When the first officer retracted the landing gear, the aircraft began rolling abruptly and violently to the right. The captain attempted to recover from the roll, but when the right wing came up, it continued to rise until the left wing struck the runway. The NTSB determined that the loss of control was a result of airfoil icing. There were 10 minor injuries and three serious injuries among the 70 people on board. The aircraft was destroyed.

- Nov. 27, 1978, Newark, New Jersey. Shortly after rotation, at an altitude of 65 feet (20 meters), control of a Trans World Airlines (TWA) DC-9 was lost. The aircraft impacted in a tail-low attitude, and came to rest 3,800 feet (854 meters) from the site of first impact. The temperature that day was 27 degrees Fahrenheit (-2.8 degrees Celsius), with blowing snow and rain. The aircraft had not been deiced. No serious or fatal injuries were reported; damage to the aircraft was minor.

  In this instance, the NTSB undertook a special study on aircraft icing avoidance and protection. The study report was adopted in 1981, and concluded that many pilots are either insufficiently trained or lack respect for potentially hazardous icing conditions.

- Jan. 13, 1982, Washington, D.C. An Air Florida Boeing 737 took off from Washington National Airport with snow and/or ice adhering to the aircraft. The aircraft had been deiced at the gate, but 49 minutes elapsed between deicing and takeoff because of ground delays. A snowstorm had temporarily closed the airport, delaying the flight's scheduled departure by nearly two hours. Seconds after takeoff, the plane crashed into the northbound side of the 14th Street Bridge, which spans the Potomac River. Only five of the 79 people on board survived. In addition, seven motor vehicles were hit when the 737 struck the bridge. Four people on the bridge were killed, and four others were seriously injured. The aircraft was destroyed. Among the probable causes cited by the NTSB report on the accident were the flight crew's failure to use engine anti-ice during ground operations and takeoff and its decision to take off with snow and ice on the aircraft's airfoil surfaces.

- Feb. 5, 1985, Philadelphia, Pennsylvania. An Airborne Express DC-9-10 took off in light freezing drizzle and snow. The crew did not see any snow or ice adhering to the wings, nose section, windshield or above the door, and the pilot declined deicing. Just after liftoff, the aircraft rolled left, and both engine compressors stalled. The pilot aborted the takeoff. Two people were seriously injured and the aircraft was destroyed. The plane was contaminated with ice.

- Nov. 15, 1987, Denver, Colorado. A Continental Airlines DC-9-14 was cleared to take off 27 minutes after it had been deiced. The takeoff roll was uneventful, but following a rapid rotation, the airplane crashed off the right side of the runway. The NTSB determined that the probable cause of the accident was the captain's failure to have the aircraft deiced a second time before takeoff. Twenty-eight of the 82 people on board died, and the aircraft was destroyed.

- Feb. 17, 1991, Cleveland, Ohio. A Ryan International Airlines DC-9-10 crashed during takeoff from Cleveland-Hopkins International Airport. Only two pilots were on board. They were killed, and the aircraft was destroyed. The NTSB determined that the probable cause of the accident was the flight crew's failure to detect ice on the wings. The NTSB said the icing led to wing stall and loss of control during the attempted takeoff.

- March 22, 1992, New York, New York. A USAir Fokker F-28 crashed during an attempted takeoff from La Guardia Airport. Of the 51 people on board, 27 people died, eight were seriously injured, and 11 reported minor injuries. The airplane was destroyed. The NTSB determined that the probable cause of the accident was the flight crew's decision to take off without positive assurance that the wings were free of ice despite a 35-minute gap between deicing and takeoff. The NTSB also cited the failure of the airline industry and the U.S. Federal Aviation Administration (FAA) to provide flight crews with procedures, requirements and criteria compatible with the realities of departure delays in icing conditions.

... many pilots are either insufficiently trained or lack respect for potentially hazardous conditions.

The NTSB believes that takeoff accidents caused by icing can be linked to perceptions held by manufacturers, the FAA, operators and pilots, and are also influenced by the training given to maintenance personnel, dispatchers and pilots. It appears that some people in the industry, particularly pilots and others responsible for decision making, do not fully realize that minute amounts of surface contamination can cause great difficulties, especially in certain types of airplanes. In each of the accidents cited above, the pilots truly believed their wings were either uncontaminated or not contaminated enough to cause control difficulties. They used normal or near-normal takeoff techniques that would have resulted in successful takeoffs if their wings had not been contaminated.

Studies performed by Fokker after the La Guardia accident revealed that one to two cubic millimeters of ice per square centimeter of surface can cause lift losses of 22 percent to 33 percent, in ground effect and in free air, respectively. This amount of contamination is virtually invisible from the cockpit, and probably invisible from the cabin, except under perfect viewing conditions. During the F-28 investigation, contamination was simulated by lightly sprinkling salt on pieces of white and silver paper, then attempting to see the salt from the cockpit and cabin at distances of 30 to 40 feet (9 to 12 meters). The contamination was not detectable. Among other conclusions, the NTSB made the following determinations after its investigation of the La Guardia accident:

- The flight crew check was ineffective. Crews cannot visually detect minute amounts of ice from cockpit windows;

- The airplane experienced a wing-lift deficiency because of ice contamination; and,

- The accident history shows that nonslatted, turbojet transports have been involved in a disproportionate number of ground icing takeoff accidents.

The NTSB also noted that there was no specific company requirement for exterior inspection during periods of freezing precipitation. The airplane was deiced twice at the gate and was clear of contamination, but the delays and taxi of 35 minutes exceeded the holdover time of Type I deicing fluid.

The NTSB recommended that the FAA work with the U.S. National Aeronautics and Space Administration (NASA) to establish a wind-tunnel or flight-test program to study the aerodynamic degradation of both nonslatted and slatted airplane wings with upper surface contamination. According to the NTSB, the study should define lift, drag and pitching moment changes related to ice contamination. The NTSB also asked the FAA to work with NASA to determine any differences in takeoff performance and stall margin when upper wing ice contamination is present on slatted and nonslatted planes and to include any operational and aerodynamic factors that might explain the disproportionate number of takeoff icing accidents involving nonslatted planes.

A recommendation issued after the Continental accident in Denver in 1987 asked the FAA to require all DC-9-10 series operators to establish detailed procedures for detecting upper wing ice before takeoff. [The aircraft involved in that accident was a DC-9-14, a DC-9-10 configured to Continental Airlines' specifications. The wing and the length of the fuselage are the same as those of the DC-9-10.] In a letter dated Jan. 30, 1989, the FAA said that the DC-9-10 series did not have any unique traits — including the absence of slats — warranting special ice detection procedures.

Nevertheless, when the FAA responded to safety recommendations stemming from the Ryan Air accident, it issued an Airworthiness Directive (AD) effective Jan. 17, 1992, that required the airplane flight manual for McDonnell Douglas DC-9-10 series airplanes to include a cautionary note stating that wings without leading edge devices are particularly susceptible to loss of lift from wing icing and that minute amounts of ice or other contamination on the leading edges or wing upper surfaces can cause a significant reduction in the stall angle-of-attack.

The FAA said increased stall speed can be well above the stall-warning-activation speed.

Minute amounts of ice or other contamination on the leading edges or wing upper surfaces can cause a significant reduction in the stall angle-of-attack … .

Another NTSB recommendation, which stemmed from the Ryan Air accident, called for the FAA to evaluate the need for special ground deicing actions for other types of transport-category turbojet airplanes without leading edge devices and that are particularly susceptible to flight control problems arising from small amounts of frost, ice or snow on the wings.

The FAA said that it had conducted a survey of Boeing, McDonnell Douglas (other than the DC-9-10 airplane) and Lockheed airplanes without leading edge devices, and found that these airplanes are not considered particularly susceptible to flight control problems arising from small amounts of contamination. The FAA was continuing its effort to identify other transport-category turbojet airplanes when the USAir F-28 accident occurred in New York.

Also following the Ryan Air accident, the FAA issued an AD (effective Jan. 17, 1992) revising the Airplane Flight Manual Limitations Section. The AD, which was applicable to DC-9-10s, said that if the outside air temperature is below 43 degrees F (6 degrees C), and the difference between the dew point temperature and the outside air temperature is less than 3 degrees C (or visible moisture is present), takeoff may not be initiated unless the flight crew verifies that the leading edge and upper wing surfaces have been examined visually and physically.

The NTSB has been considering the following steps to improve the icing accident record this winter:

- Regulators and operators must resolve the conflict between the rapid breakdown of Type I fluid vs. the regulatory phrase, "Inspect, if clear, take off within five minutes."

  After the La Guardia accident, the NTSB concluded that the FAA should require airlines to establish a way of informing flight crews of the type of deicing fluid and mixture used, the current moisture accumulation rate and the available holdover time; and,

- If visual inspection by the flight crew is necessary, the flight crew must be taught to recognize particle sizes and the density of contamination that could result in lift loss. This level or degree of contamination is airplane-type specific.

The Ryan Air accident prompted the NTSB to issue recommendation No. A-91-125, which asked the FAA to require

principal operations inspectors (POIs) to review certificate holders operating DC-9-10 airplanes to determine the adequacy of flight crew training programs related to airframe icing conditions. The FAA responded on Feb. 27, 1992, by saying it agreed with the intent of the recommendations, and planned to issue an air carrier operations bulletin (ACOB) directing POIs to ensure that flight crew training programs of certificate holders operating DC-9-10 ensure the adequacy of training objectives, methods, media and evaluation techniques that involve instruction for airframe icing conditions. ACOB No. 3-92-1 *Airframe Icing Training for Aircrews Operating DC-9-10 Series Airplanes, DC-9-80 Series Airplanes and Model MD-80 Airplanes (NTSB Safety Recommendation A-91-125)*, was issued by the FAA on April 17, 1992.

Staff at the NTSB also considered the following after the La Guardia accident:

- Airport authorities and FAA air traffic services should undertake airport and national airspace improvements to reduce end-of-runway winter takeoff clearance delays to intervals that are compatible with state-of-the-art anti-ice holdover time;

- Airport authorities, operators and U.S. Federal Aviation Regulations (FAR) Part 139 certification administrators should make maximum use of off-gate, facilities-pooled equipment and departure-end deicing/anti-icing sites to reduce the holdover problem to an absolute minimum;

- Flight crews and ground personnel, through technological advances, should be provided with aircraft surface ice detector systems that eliminate go/no-go decisions based on observation. The NTSB envisions a ground ice accumulation warning system similar to the cockpit ground proximity warning systems (GPWS) and wind shear alert systems; and,

- Alternative procedures should be provided for aircraft not modified with ground ice detection warning systems. Manufacturers and regulators should study any added level of safety gained through the alternative of delayed rotation to increase takeoff speed margins. [In the April 6, 1993, *Boeing Flight Operations Review*, Boeing Commercial Airplane Group warned flight crews against delayed and shallow rotations. "Delaying and/or executing a 'shallow' rotations ... unnecessarily exposes the takeoff to risks by extending the takeoff distance by an unscheduled amount, resulting in a lower takeoff flight path and reduced obstacle clearance," it said.]

The FAA and manufacturers must recognize that ice contamination is an ongoing problem and that the current momentum on ground icing should be maintained. Fatal accidents should not be allowed to be the only catalysts for development.♦

About the Author

Robert M. MacIntosh has been a senior air safety investigator of the major investigations division of the U.S. National Transportation Board (NTSB) since 1988. Prior to joining the NTSB, MacIntosh was the director of safety for an international airline in the Middle East, and a staff engineer with an aircraft manufacturer. MacIntosh holds an airline transport pilot certificate, is a certified flight instructor and has logged more than 7,500 hours of flight experience.

AIRPORT OPERATIONS

Staff: Roger Rozelle, director of publications; Girard Steichen, assistant director of publications; Kate Achelpohl, editorial assistant; and Ashton Alvis, production coordinator

Subscriptions: US$55 (U.S.-Canada-Mexico), US$60 Air Mail (all other countries), six issues yearly. • Include old and new addresses when requesting address change. • Flight Safety Foundation, 2200 Wilson Boulevard, Suite 500, Arlington, VA 22201-3306 U.S. • telephone: (703) 522-8300 • telex: 901176 FSF INC AGTN • fax: (703) 525-6047

What's Your Input?

In keeping with FSF's independent and nonpartisan mission to disseminate objective safety information, Foundation publications solicit credible contributions that foster thought-provoking discussion of aviation safety issues. If you have an article proposal, a completed manuscript or a technical paper that may be appropriate for *Airport Operations*, please contact the director of publications. A manuscript must be accompanied by a stamped and addressed return envelope if the author wants material returned. Reasonable care will be taken in handling a manuscript, but Flight Safety Foundation assumes no responsibility for material submitted. The publications staff reserves the right to edit all published submissions. Payment is made to author upon publication. Contact the Publications Department for more information.