National Transportation Safety Board

Washington, D. C. 20594

Safety Recommendation A-09-2105

Date: November 3, 1988

In reply refer to: A-88-134 through -142

Honorable T. Allan McArtor
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On November 15, 1987, Continental Airlines, Inc., flight 1713, a McDonnell Douglas DC-9-14, N626TX, was operating as a regularly scheduled, passenger-carrying flight between Denver, Colorado, and Boise, Idaho. The airplane was cleared to take off following a delay of approximately 27 minutes after deicing. The takeoff roll was uneventful, but following a rapid rotation, the airplane crashed off the right side of runway 35 left. Both pilots, 1 flight attendant, and 25 passengers sustained fatal injuries. Two flight attendants and 52 passengers survived.[1]

The Safety Board believes that the airplane was adequately deiced before it departed the deice pad. Evidence suggests that the combination system of fixed deicing snorkels and mobile deicing trucks used by Continental at Denver is quicker and more efficient than the use of deicing trucks alone.

Nevertheless, since the airplane was exposed to a moderate snowstorm in subfreezing conditions for approximately 27 minutes following deicing, the Safety Board believes that portions of the airframe became contaminated with a thin, rough layer of ice. The pilot of Continental flight 875 stated that he did not see any contamination on the wings of flight 1713. However, several surviving passengers on flight 1713 reported seeing some "ice" on engine inlets or in "patches" on the wing after deicing. These accounts suggest isolated fragments of contamination.

During precipitation in subfreezing ambient temperatures, ice can accumulate on airframe surfaces after a thorough deicing when the deicing solution evaporates, runs off, or is diluted with the precipitation. All three of these conditions occurred on the wings of flight 1713, with dilution of the deicing solution having been the predominant condition. Due to many variables involved, the Safety Board found it impossible to determine exactly where or exactly how much ice had formed on the wing and empennage surfaces of flight 1713. The Safety Board believes that enough wet snow (0.29 inch) fell on flight 1713 during the 27 minutes between deicing and

[1]For more detailed information, read Aircraft Accident Report--*Continental Airlines, Inc., Flight 1713, McDonnell Douglas DC-9-14, N626TX, Stapleton International Airport, Denver, Colorado, November 15, 1987* (NTSB/AAR-88/09).

takeoff to dilute the deicing fluid to the point where ice began to reform. This 0.29 inch of snow, if melted, would equate to about 0.032 inch of water.

The accumulated precipitation on the upper horizontal surfaces of the airplane probably would have been a combination of snow and melting snow or slush. Consequently, because of the dilution of the anti-icing fluid, the actual thickness of the slush probably would have been slightly greater than the water equivalent of the snow alone and would have frozen into a roughened surface. Even this modest amount of surface roughness on the wings of a DC-9-10 series wing could cause controllability problems according to McDonnell Douglas.

The contamination of the airframe surfaces of flight 1713, as thin as it may have been, could have been delayed if the airplane had been anti-iced following the deicing. According to the Association of European Airlines, a full-strength glycol anti-icing application would have prevented any ice buildup 2.8 times longer than the 38 percent glycol deicing application that flight 1713 received.

Federal guidelines concerning deicing fluid type, temperature, consistency, and application methods are summed up in Federal Aviation Administration (FAA) Advisory Circular (AC) 20-117. The AC thoroughly discusses deicing methodology in general use in the United States. It does not, however, incorporate more advanced deicing and anti-icing methods using "type II" deicing fluids that have been used by European countries for several years. The 1986 edition of the Association of European Airlines *Recommendations for De-/Anti-Icing of Aircraft on the Ground* includes specifications for ground deicing fluids, fluid dispensing equipment, quality control guidelines and procedures, application procedures and methods of ensuring proper interaction, and communication between maintenance and flightcrews. The Safety Board acknowledges that the FAA, in conjunction with the Air Transport Association (ATA) and the Society for Automotive Engineers (SAE), is actively studying the advantages and disadvantages of the use of type II deicing fluids. Also, the Board notes that several U.S. manufacturers are now experimenting with other forms of advanced deicing and anti-icing systems and new mechanical ice-detecting devices for aircraft. The Board encourages expedited research and testing in this area, under the sponsorship of the FAA. Also, the Board believes that should type II or other advanced fluids prove safe for U.S. operations, their use should be highly encouraged by the FAA.

The Safety Board has investigated three previous DC-9-10 series icing-related accidents which were similar to the circumstances of the accident involving flight 1713.[2] In two of the accidents, ice was visible to the crews before takeoff, and in the other accident, the crew failed to examine the wings before takeoff. The Safety Board believes that the November 15, 1987 accident again demonstrates that even small amounts of contamination on the upper surfaces of an airplane can seriously degrade lift. This accident underscores the critical importance for the pilot-in-command to ensure the surfaces are clean before every takeoff when in conditions conducive to contamination. The crew of flight 1713 also failed to examine the wings

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[2]Field Accident Briefs--*Trans World Airlines, Inc., Newark, New Jersey, November 27, 1978* (No. 4-0039) and *Airborne Express, Inc., Philadelphia, Pennsylvania, February 5, 1985* (No. 2662); and Aircraft Accident Report--*Ozark Air Lines, Inc., Douglas DC-9-15, N974Z, Sioux, City Airport, Sioux, City, Iowa, December 7, 1968* (NTSB-AAR-70-20)

for contamination before takeoff. Therefore, the Safety Board believes that there is no justification for questioning the FAA certification of a DC-9-10 series airplane.

The first officer's poor rotation technique probably contributed to the loss of airplane control. Evidence of trouble during the takeoff rotation was apparent from data recovered from the flight data recorder (FDR). The altitude dip associated with pitch rotation in a DC-9-14 airplane is normally about 50 to 60 feet below field elevation, consistent with a pitch angle of about 6° during liftoff. Under normal circumstances, the magnitude of the dip is porportional to the pitch attitude of the airplane while it is still on the ground. The pitch rate defines the initial slope of the dip. For the accident flight, the dip was about 120 feet, indicating a pitch attitude of about 14° while the airplane was very close to the ground. Additionally, the pitch rate appeared to be over 6° per second, twice the recommended rate. The Safety Board examined the FDR altitude traces from the six previous flights of the accident airplane and found routine altitude trace dips for all six. Comparing these altitude trace dips with the trace dip on the accident flight, it appears that the first officer rotated the airplane about twice as fast as normal or recommended.

Greater-than-normal pitch rates result in the achievement of greater-than-normal angles of attack during the transition from ground roll pitch angle to the target climb pitch angle. While the airplane is on the ground, the angle of attack equals the pitch angle. The airplane normally leaves the ground at about 6° of pitch angle, and this angle continues to increase to the target climb angle of about 15° for initial climb. The angle of attack will also increase during this maneuver, but at a slower rate. Once the pitch angle is stabilized and the climb angle is starting to increase, the angle of attack will typically decrease. For a typical takeoff with a 3° per second rotation rate, the maximum angle of attack achieved will be about 9°. If the rotation rate is 6° per second, as on the accident airplane, the maximum angle of attack achieved may rapidly increase to about 12°, which is very close to the normal stall angle of attack of about 14° on the DC-9-10 series airplane. However, ice contamination probably lowered the actual stall angle of attack on the accident airplane to some angle less than 14°. As a result, the wing began to stall and the airplane began to roll. The stall warning stick shaker did not activate because of the previously discussed reduced angle of attack due to wing contamination. The stall was probably precipitated by rapidly rotating the airplane into an unacceptable angle of attack.

The 24-day period, which had elapsed since the first officer's last flight trip sequence, was excessive for a pilot of limited experience. Although it cannot be determined to what extent this may have affected the first officer's performance, the Safety Board believes that this extended absence from flight duties probably eroded his retention of newly acquired knowledge and skills associated with his duties as a DC-9 first officer.

The Safety Board notes several decision-making deficiencies of the captain of flight 1713. The Safety Board believes that he should have realized that he was exposing the airplane to airfoil contamination for too long a period and should have returned to the deicing pad for another deicing before takeoff. In addition, he showed poor judgment in allowing an inexperienced first officer to attempt a takeoff in weather conditions such as those that existed at Denver. Further, from data recovered from the cockpit voice recorder (CVR) and the FDR, it appears that he did not attempt to arrest the first officer's rapid rotation of the airplane during the takeoff.

Although the captain was an experienced pilot with apparently better-than-average flying skills, he was relatively inexperienced as captain on air carrier turbojet airplanes, and he had very little total flying time in the DC-9. He was not seasoned in either the supervision or judgment of first officers, nor was he familiar with the unique characteristics of the DC-9-10 series airplane in icing conditions. Although he was taught about DC-9 cold weather operations during his ground training and simulator sessions, he had never actually encountered ground icing conditions in a DC-9 before the accident. Also, he was remiss in at least two basic mission planning administrative duties of a Continental pilot (signing off the Read and Initial Book and telling the dispatcher of his need to declare an alternate airport before takeoff). In addition, he did not understand the intent of the company procedures concerning taxi from the gate through the deice pad and on to the runup pad. His failure to contact ground control for clearance to taxi to the deice pad precipitated a series of events that caused a portion of the 27-minute delay between deicing and takeoff. Following the accident, those procedures were modified to state that a flight should not taxi beyond the north side of concourse D until clearance is received from ground control.

Company procedures also required the captain to inspect the airplane if the takeoff is delayed for more than 20 minutes after deicing. The captain did not examine the wings or cause the wings to be examined even after 27 minutes had elapsed. Although there was no intercockpit discussion of this requirement, a comment about increasing engine power momentarily for engine anti-ice capability indicated that he was aware of the elapsed time since engine start and was aware of the need to increase engine power periodically to improve engine anti-icing airflow during icing conditions on the ground. Unfortunately, he appears to have linked icing conditions on the ground with optimum engine operation rather than optimum airfoil effectiveness. It is possible that the captain thought that since they were ready to take off approximately 20 minutes after deicing, a return to the deicing pad for more deicing was not necessary, in spite of the unanticipated additional delay of about 7 minutes.

Neither pilot had extensive experience in the DC-9, and the first officer had very little experience, in any swept-wing turbojet airplane. The Safety Board believes that the captain's basic inexperience as a DC-9 pilot together with his inexperience as a captain supervising the actions of first officers left him unprepared for the rapid rotation by the first officer into the aerodynamic stall regime. A more experienced DC-9 captain may have been better able to (a) notice that a rapid rotation was occurring, (b) arrest the rotation by blocking the yoke, and finally, (c) perhaps allowed the airspeed to build up to the point where the takeoff could be successfully completed.

In summary, the Safety Board believes that the pairing of pilots with limited experience in their respective positions can, when combined with other factors, such as adverse weather, be unsafe and is not acceptable. The Safety Board believes that although the pilots of flight 1713 had previously demonstrated competence in their duties, compromises in the decision-making process occurred as a result of inexperience in their respective positions. Subsequently, their pairing on the same flight was a factor in the accident.

As a result of its investigation of three commuter air carrier accidents,[3] the Safety Board recommended that the FAA:

> A-86-107
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> Issue an Air Carrier Operations Bulletin-Part 135, directing all Principal Operations Inspectors to caution commuter air carrier operators that have instrument flight rules authorization not to schedule on the same flight crewmembers with limited experience in their respective positions.

The FAA complied with the recommendation by issuing Air Carrier Operations Bulletin (ACOB) No. 87-2, *Commuter Flightcrew Scheduling.* The ACOB directed all principal operations inspectors (POI) to caution commuter air carrier operators who have instrument authorization not to schedule flight crewmember with limited experience in their respective positions on the same flights.

The Safety Board is pleased to note that following this accident the FAA again embraced the concept of establishing minimum experience levels when pairing pilots for scheduling purposes. In January 1988, the FAA issued a similar ACOB to the POIs of major air carriers operating under 14 CFR Part 121, recommending that operators establish procedures which would prevent pairing inexperienced crewmembers on the same flight.

The rapid growth of the aviation industry at a time when fewer experienced pilots are in the workforce has reduced the opportunity for a pilot to accumulate experience before progressing to a position of greater responsibility. This loss of "seasoning" has led to the assignment of pilots who may not be operationally mature to positions previously occupied by highly experienced pilots. An operational safeguard to reduce the effect of these circumstances would be to establish a requirement prohibiting the scheduling or pairing on the same flight of crewmembers with limited experience in their respective positions. Operational limitations in other unusual circumstances, such as the placement of a new type of aircraft into service, should be developed, but the primary method by which adverse pairings should be avoided should be determined by the regulation of airline scheduling policies. The Safety Board believes that the time has come for the FAA to establish, and the industry to accept, such a requirement.

The first officer received all of his initial operating experience (IOE) while actually performing the duties of a second-in-command in accordance with Continental's policy. Therefore, the Safety Board believes that his IOE was not a factor in this accident. The Safety Board is concerned, however, that the current provisions of 14 CFR 121.434 permit completion of the IOE by a first officer while only observing from a jumpseat position in the cockpit. The regulation does not adequately satisfy the purpose and intent of the IOE and, in fact, reduces the

[3]Aircraft Accident Reports--*Bar Harbor Airlines Flight 1808, Beech B-99, N300WP, Auburn-Lewiston Airport, Auburn, Maine, August 25, 1985* (NTSB/AAR-86/06); *Henson Airlines Flight 1517, Beech B-99, N339HA, Shenandoah Valley Airport, Grottoes, Virginia, September 23, 1985* (NTSB/AAR-86/07); and *Simmons Airlines Flight 1746, an Embraer Bandeirante, EMB-11OP1, N1356P, near Alpena, Michigan, March 13, 1986* (NTSB/AAR-87/02)

opportunity for the "hands on" aspects of the IOE, and a loss of the check pilot's ability to evaluate the performance of the first officer.

Under the present FAA regulations, it is possible, depending on the simulator used in initial training, that the first time a first officer touches the controls of an actual airplane could be with a full load of passengers aboard and with an inexperienced captain in the left seat. In such a case, it would be legal for the first officer to perform the flying pilot's duties without having accrued any actual airplane flight time whatsoever. The Safety Board believes that this possibility is unacceptable and believes that the regulations should be amended to eliminate the provision which permits the completion of all IOE by a second-in-command from an observer's position in the jumpseat.

The approach control supervisor testified at the Safety Board's public hearing on the accident that the maximum number of arriving airplanes that had been established on the day of the accident was 33 per hour and that the number of airplanes that the air route traffic control center was actually delivering to Denver was about 30 per hour throughout the day. He stated that 30 was a comfortable number of arrivals to work with; however, all the controllers from Denver tower testified that they believed that no more airplanes could have been worked in the hour before the accident. According to air traffic control recorded radar data, the actual number of arriving flights from 1 hour before the accident to the time of the accident was 29. According to the Safety Board calculations, had a true 4.5 miles separation been used between arrivals, the amount of arrivals that the airport would have been able to accommodate during this same time would have been 25.9 flights. In other words, to keep the flow balanced between arrivals and departures, using 4.5 miles as a minimum separation between arriving airplanes, for the purpose of departing one airplane between these arrivals, an inbound flow of a maximum of 26 flights per hour would have been required. It appears then that the 33 airplanes per hour from the FAA engineer performance standard is not a safe number for the conditions on the day of the accident. The Safety Board believes that the FAA should revise its flow management engineer performance standards to include reduced airport capacities which normally occur when deicing operations are in progress.

The encounter with a wing tip vortex from the landing Boeing 767 on runway 35R was eliminated as a probable cause in this accident when the Safety Board examined and eliminated as viable factors those conditions that would have made it possible for dangerous vortices to intercept the flightpath of flight 1713. However, the Safety Board wishes to emphasize that it has not eliminated the possibility that on a different day with different conditions and different aircraft, a potential problem might exist concerning wingtip vortices. Therefore, the Board believes that the FAA should initiate a research project to acquire data from dedicated sensors to determine what consideration, if any, should be given to wake vortices in a parallel offset runway situation.

The Safety Board is concerned that Continental's background check of the first officer did not reveal he had been discharged by a previous employer because of an inability to pass a flying check ride. Contrary to fact, the background check characterized the first officer's work as "very good" and went on to state that he left that company on his own accord. The Board believes that had Continental been aware of the first officer's employment background it would have had the option of not hiring him in the first place or of emphasizing areas in his DC-9 training where he had previously demonstrated weakness. The Board believes that the FAA should require commercial operators to examine applicants' records of previous flight

experience and their safety records through the use of FAA accident/incident files and enforcement history records. Furthermore, a review of the training and performance records of previous employers for at least the preceding 5 years should be mandated, and an examination of criminal and driver records should be included. The use of a civil release signed by each applicant would facilitate the release of information from previous employers who might be reluctant to provide it otherwise.

In the area of the aft tailcone exit, impact damage and debris delayed passenger evacuation 7 to 10 minutes. Contributing to the delay was the fact that outside rescuers were hampered by limited visibility around the hatch area. The only instruction printed on the outside of the hatch was the word "Pull" on a placard near the hatch release handle. The hatch was then upside down because the fuselage was inverted. To assist future rescue attempts, the Safety Board believes that the FAA should issue an airworthiness directive to require more complete operating instructions on the exterior side of the tailcone exit hatch of DC-9 airplanes. The instructions should include both actions that are required to unlock and open the hatch: (1) Pull the release handle and (2) Push the latch into the cabin. A precautionary instruction also should be included to advise rescuers that inward movement of the hatch may be blocked by occupants of the aft jumpseat.

Therefore, as a result of its investigation, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Until such time that guidelines for detecting upper wing surface icing can be incorporated into the airplane flight manual, issue an air carrier operations bulletin directing all principal operations inspectors to require that all McDonnell Douglas DC-9-10 series operators anti-ice airplanes with maximum effective strength glycol solution when icing conditions exist. (Class II, Priority Action) (A-88-134)
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> Expedite the evaluation of the effectiveness of Association of European Airlines guidelines concerning the use of European types I and II deicing and anti-icing fluids. If European methodology is more effective than current U.S. methodology, incorporate their guidelines into the next version of Advisory Circular 200-17. (Class II, Priority Action) (A-88-135)
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> Require all DC-9-10 series operators to establish detailed procedures for detecting upper wing ice before takeoff. (Class II, Priority Action) (A-88-136)
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> Establish minimum experience levels for each pilot-in-command and second-in-command pilot, and require the use of such criteria to prohibit the pairing on the same flight of pilots who have less than the minimum experience in their respective positions. (Class II, Priority Action) (A-88-137)
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> Amend 14 CFR 121.434 to require that a second-in-command pilot complete initial operating experience for that position while actually performing the duties of a second-in-command under the supervision of a check pilot. (Class II, Priority Action) (A-88-138)

Review and revise, as necessary, the engineer performance standards for appropriate airports to account for the reduced airport capacities that occur when deicing operations are in progress. (Class II, Priority Action) (A-88-139)

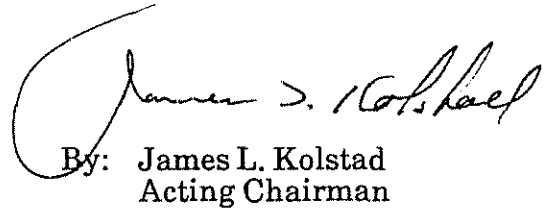
Initiate a research project to acquire data from dedicated sensors to determine what consideration, if any, should be given to wake vortices in a parallel offset runway situation. (Class II, Priority Action) (A-88-140)

Require commercial operators to conduct substantive background checks of pilot applicants which include verification of personal flight records and examination of training, performance, and disciplinary records of previous employers and Federal Aviation Administration safety and enforcement records. (Class II, Priority Action) (A-88-141)

Issue an airworthiness directive to require more complete operating instructions on the exterior side of the tailcone exit hatch of DC-9 airplanes. The instructions should include both actions that are required to unlock and open the hatch: (1) PULL the release handle and (2) PUSH the hatch into the cabin. A precautionary instruction also should be included to advise rescuers that inward movement of the hatch may be blocked by occupants of the aft jumpseat. (Class II, Priority Action) (A-88-142)

Also, as a result of its investigation, the Safety Board issued Safety Recommendations A-88-143 to the National Fire Protection Association, A-88-144 to the American Association of Airport Executives and the Airport Operators Council International, and A-88-145 and -146 to Continental Airlines, Inc.

KOLSTAD, Acting Chairman, and BURNETT, LAUBER, NALL, and DICKINSON, Members, concurred in these recommendations.



By: James L. Kolstad
Acting Chairman

Safety Recommendation Reiteration List

SR Number	Reiteration Number	Report Number	Report Date	Accident Description	Accident City	Accident State	Accident Date
A-88-134	1	AAR-91-09	11/16/1991	Ryan intl Airlines DC-9-15, N565PC Loss of Control on Takeoff	Cleveland	OH	2/17/1991

Safety Recommendation Reiteration List

SR Number	Reiteration Number	Report Number	Report Date	Accident Description	Accident City	Accident State	Accident Date
A-88-137	1	AAR-93-03	3/2/1993	Controlled Collision with Terrain GP Express Airlines, Inc., Flight 861 A Beechcraft C99, N118GP	Anniston	AL	6/8/1992