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Investigators Urge Restrictions On Cessna 208 Icing Operations

Recent fatal loss-of-control accidents have prompted Canadian and U.S. authorities to recommend that operators be prohibited from flying Caravans in icing conditions determined to be worse than light.

FSF Editorial Staff

Cessna 208 Caravan operations in icing conditions should be limited to trace icing or light icing, at an airspeed no lower than 120 knots, according to the Transportation Safety Board of Canada (TSB) and the U.S. National Transportation Safety Board (NTSB).[1,2]

The recommendations made by TSB and NTSB to Transport Canada (TC) and the U.S. Federal Aviation Administration (FAA) were prompted by information derived from ongoing investigations of fatal accidents in Canada and Russia in late 2005, and studies of ice-related accidents involving the single-turboprop airplane.

NTSB, in its recommendations to FAA, also urged that pilots be required to hand-fly the airplane in icing conditions, so that the autopilot does not mask signs of deteriorating performance.

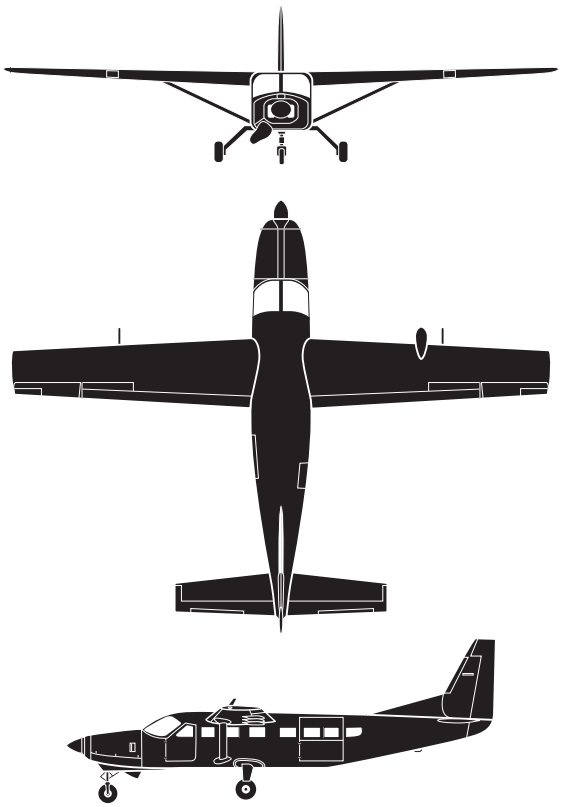
The accident in Canada occurred Oct. 6, 2005, and involved a Cessna 208B operated by Morningstar Air Express. The airplane was destroyed when it struck terrain about five minutes after taking off from Winnipeg (Manitoba) International Airport at 0537 for a cargo flight to Thunder Bay, Ontario. The pilot was killed.

Preliminary information indicates that the airplane had been stored overnight in a heated hangar and removed about 90 minutes before takeoff. Light snow was falling, and the temperature and dew point were slightly below freezing when the pilot — who held an airline transport pilot certificate and had about 4,570 flight hours, including 1,500 flight hours in type — conducted a preflight inspection of the airplane. The inspection included a tactile examination of the wings for contamination by ice or frost.

"No information gathered in the investigation to date indicates that the aircraft departed with ice or snow adhering to its critical surfaces," TSB said.

The airplane, which was equipped with a belly-mounted cargo pod, apparently had been loaded beyond its gross-weight limit.

"The Cessna 208B's certificated maximum gross weight is 8,750 pounds [3,969 kilograms], and the maximum weight for flight into known icing conditions with a cargo pod installed is 8,550 pounds [3,878 kilograms]," TSB said. "Information gathered to date indicates that the aircraft gross weight at takeoff was about 9,070 pounds [4,114 kilograms], 520 pounds [236 kilograms] over maximum gross weight for flight into known icing conditions."



Cessna 208 Caravan

Cessna Aircraft Co. began production of the Model 208 Caravan in 1985. That year, the company also certified a floatplane version and a freighter version called the Model 208A. A stretched version of the freighter, called the Model 208B Super Cargomaster, was introduced in 1986.

Four versions currently are in production: the Super Cargomaster; Caravan 675, which combines the 208/208A airframe with the 208B engine; Caravan Amphibian, which has amphibious floats; and the Grand Caravan, a passenger-carrying version of the 208B.

The landplane versions accommodate a pilot and nine passengers, or 3,000 pounds (1,361 kilograms) of cargo. A waiver of U.S. Federal Aviation Regulations Part 23 permits a maximum seating capacity of 14. The Super Cargomaster's power plant comprises a 675-shaft-horsepower (504-kilowatt) Pratt & Whitney Canada PT6A-114A engine and a three-blade Hartzell propeller or McCauley propeller. Usable fuel capacity is 332 gallons (1,257 liters).

The Super Cargomaster's maximum takeoff weight is 8,750 pounds (3,969 kilograms). Maximum landing weight is 8,500 pounds (3,856 kilograms). Maximum rate of climb at sea level is 925 feet per minute. Maximum cruise speed at 10,000 feet is 175 knots. Power-off stall speeds are 78 knots with flaps retracted and 61 knots with flaps extended.♦

Source: *Jane's All the World's Aircraft*

Nighttime instrument meteorological conditions (IMC) prevailed, with moderate icing conditions forecast in clouds from the surface to 16,000 feet. TC and FAA use the following International Civil Aviation Organization definitions of icing conditions: [3]

- "Trace — Ice becomes perceptible. Rate of accumulation is slightly greater than the rate of sublimation. Deicing/anti-icing equipment is not utilized unless encountered for an extended period of time (over one hour);
- "Light — The rate of accumulation may create a problem if flight is prolonged in this environment (over one hour). Occasional use of deicing/anti-icing equipment removes/prevents accumulation. It does not present a problem if the deicing/anti-icing equipment is used;
- "Moderate — The rate of accumulation is such that even short encounters become potentially hazardous and use of deicing/anti-icing equipment or flight diversion is necessary; [and,]
- "Severe — The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate flight diversion is necessary."

After departing from Runway 36 on an instrument flight rules (IFR) flight plan, the pilot conducted a right turn.

"Although the aircraft was being operated at a weight above the maximum certificated gross weight, the aircraft departed Winnipeg and climbed out without apparent difficulty," TSB said.

The airplane was about 4.5 nautical miles (8.3 kilometers) southeast of the airport when the pilot requested clearance from air traffic control (ATC) for an immediate return to the airport because of icing conditions. She did not declare an emergency. ATC was providing radar vectors to the pilot when the airplane descended below radar coverage. TSB said that examination of the wreckage indicated that the engine was producing a significant amount of power when the airplane struck terrain.

"A review of [ATC] records indicated that several aircraft operated in and out of Winnipeg at the time of the accident," TSB said. "No other incidents or control difficulties were reported."

The accident in Russia occurred about 2227 local time Nov. 19, 2005. A Cessna 208B of Aruban registry was destroyed when it struck terrain during approach in IMC to Domodedovo International Airport in Moscow. The two Russian pilots and six passengers were killed.

The airplane, which was equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR) per Russian certification requirements, had departed from Voronezh about 2110 for a personal flight. The airplane was in cruise flight at 3,000 meters (9,843 feet) about 2206 when ATC advised the flight crew of a forecast for moderate icing conditions in the clouds. The crew said that the airplane was above the clouds and that they were not experiencing icing conditions.

"Review of the airplane's CVR revealed that about five minutes later, the pilots discussed among themselves that they were experiencing 'severe icing,'" said NTSB, which is participating with the Russian Interstate Aviation Commission in the investigation. "About [2214], ATC again asked the pilots about icing conditions, and they responded that they were experiencing 'light icing.'"

As the airplane neared the airport, ATC issued a descent clearance to 1,500 meters (4,922 feet). The airplane was in level flight at 118 knots when its pitch attitude began to increase and airspeed began to decrease. Pitch attitude was about nine degrees nose-up and airspeed was 102 knots at 2226 when the airplane stalled. The stall-warning system did not activate before the stall occurred.

"Shortly thereafter, the autopilot disengaged, and the airplane descended toward the ground with bank angle excursions of 40 degrees and reached a maximum airspeed of about 226 knots just before ground impact," NTSB said.

The stall-warning system did not activate before the stall occurred.

The airplane struck terrain about 22 nautical miles (41 kilometers) southeast of the airport.[4]

NTSB said that preliminary information from the accident investigations in Canada and Russia, and the previous study of incidents and accidents, heightened its concern about "the deficiencies in the cold-weather operational procedures used by Cessna 208 pilots and the performance of the airplane in icing conditions."

The previous study, conducted in 2003 and 2004, focused on the airplane's certification for flight in icing conditions, atmospheric conditions typically encountered during cold-weather flight operations, and the experience and training of Cessna 208 pilots.[5] The study included analyses of icing-related Cessna 208 accidents from 1987 to 2003.

In a safety-recommendation letter based on the study, NTSB said that 15 accidents during the period resulted from in-flight encounters with icing conditions and 10 accidents involved "inadequate removal of ice that had accumulated while the airplane was on the ground before takeoff."[6]

One in-flight icing encounter involved a Cessna 208B that was en route on a cargo flight from Presque Isle, Maine, U.S., to Manchester, New Hampshire, on Nov. 4, 2003. During a preflight briefing, the pilot — who had 4,800 flight hours, including 2,800 flight hours in type — had been told that occasional moderate rime icing and mixed icing were forecast in precipitation and clouds up to 20,000 feet. According to the pilot, the airplane encountered freezing rain (severe icing) during cruise flight at 8,000 feet.

"The pilot stated that he activated the airplane's deice and anti-icing systems when he saw ice accumulating on the left wing and the windshield," NTSB said. "Despite this action, ice continued accumulating on the wings and windshield. When the pilot observed a five-knot decrease in airspeed, he requested a descent to an altitude of 6,000 feet, where he hoped flying conditions would be better."

The icing conditions were worse at 6,000 feet. The pilot said that his forward visibility was reduced to a small area on the heated windshield panel. He requested and received clearance from ATC to divert the flight to Bangor, Maine.

"The pilot stated that, as he descended in rain and sleet, the windshield became completely covered with ice and that he observed ice on the left wing aft of the deice boots," NTSB said. "He further stated that the airplane's controls felt 'sluggish.'"

During the approach to Bangor in nighttime visual meteorological conditions (VMC), the pilot maintained a faster-than-normal approach speed and did not extend the flaps. He gauged the airplane's height above the runway by looking out the left cockpit window. The airplane landed hard, resulting in minor damage when the nose gear collapsed and the propeller struck the runway. The pilot was not injured.

"Photographs taken before the airplane was moved off the runway showed ice on the deice boots and ice accumulations aft of the wing deice boots on the upper and lower surfaces of the wing," NTSB said.[7]

One accident involving inadequate ice removal before flight occurred in Dillingham, Alaska, U.S., on Oct. 10, 2001. Daylight VMC prevailed when the pilot — who had about 3,100 flight hours, including 74 flight hours in type — conducted a preflight inspection of the Cessna 208B before departing for a charter flight to King Salmon, Alaska. The airplane had been parked overnight on the ramp and exposed to rain, snow and temperatures below freezing.

"Because of these conditions, ramp personnel deiced the accident airplane with a heated mixture of glycol and water," NTSB said. "The ramp supervisor who conducted the deicing stated that he thought that the wings' upper surface was clear of ice but that he did not touch the wing to check for ice accumulation."

Investigators did not determine whether the pilot checked the upper surfaces of the wings and horizontal stabilizer after the airplane was deiced.

A witness said that, on initial climb, the airplane's tail abruptly swung right and the wings rolled left until they were perpendicular to the ground.

"The witness said the airplane appeared to 'hang in the air' as it turned left, then the nose of the airplane dropped 'directly down' and the airplane descended out of sight behind a hill," NTSB said.

The pilot and nine passengers were killed when the airplane struck terrain about 0.7 nautical mile (1.3 kilometers) from the runway.[8]

Based on the findings of the 2003–2004 study, NTSB in December 2004 made the following recommendations to FAA:

- "Require all pilots and operators of Cessna 208 series airplanes equipped for flight into known icing conditions to undergo seasonal training for ground deicing and flight into icing conditions on an annual basis. This seasonal training should be timed to precede the operator's cold-weather operations and should specifically address: (1) the limitations of the Cessna 208 in icing situations; (2) the Cessna 208 deicing and anti-icing systems and controls and their use; (3) pilot actions during cold-weather ground operations, with emphasis on the need for careful visual and tactile examination of the wing and horizontal stabilizer upper surfaces during the preflight inspection to ensure that they are free of ice before takeoff; (4) pilot actions during cold-weather flight operations, with emphasis on the timely recognition of potentially dangerous accumulations of ice and the importance of having an appropriate strategy for escaping the icing conditions and acting on that strategy promptly; (5) the hazards of performance degradation caused by ice that remains after activation of the deice boots; and (6) *Cessna 208 Pilot Operating Handbook* [POH] icing-related limitations, warnings and notes;

- "Require Cessna Aircraft Co., working with Cessna 208 operators, to develop effective operational strategies (e.g., cold-weather preflight strategies in remote locations, viable methods of collecting icing-related weather information before and during flight, ice detection and monitoring cues, optimal use of anti-ice and deice systems, minimum airspeeds for all phases of flight, proper use of flaps and engine power in icing conditions, and development of ice accumulation limitations and exit strategies for pilots in icing conditions) and related guidance materials to minimize the chance of Cessna 208 ground and in-flight icing accidents or incidents; the FAA should then verify that these strategies and guidance materials are incorporated into Cessna 208 operator manuals and training programs in a timely manner;

- "Require pilots and operators of Cessna 208 series airplanes to conduct a visual and tactile examination of the wing and horizontal stabilizer leading edges and upper surfaces to ensure that those surfaces are free of ice and/or snow contamination before any flight from a location at which the temperatures are conducive to frost or ground icing; [and,]

- "Evaluate its current procedures for surveillance of operators of Cessna 208 series airplanes equipped for flight into known icing conditions to determine whether the surveillance effectively ensures that these operators are in compliance with [FAA] deicing requirements and, if necessary, modify the surveillance procedures to ensure such compliance."

As of Jan. 31, 2006, the recommendations were classified by NTSB as "open" with "acceptable response" from FAA. Among the actions taken by FAA in response to the recommendations was participation with Cessna in conducting flight tests in natural icing conditions.[9]

To evaluate the effectiveness of the airplane's stall-warning system, FAA and Cessna were developing ice shapes that will be used during flight tests to simulate critical ice accretions.

"The FAA considers critical ice accretions as ice shapes that represent edge-of-the-envelope ice conditions, 'runback' ice formations developed during relatively warm freezing conditions, [deice boot] intercycle ice and ice adhering to the unprotected areas of the airframe," NTSB said.

In March 2005, FAA issued Airworthiness Directive (AD) 2005-07-01, requiring revision of the POH.

"The revision stated that pilots should exit icing conditions immediately if they are unable to maintain 120 knots and should sacrifice altitude to maintain a minimum of 105 knots," NTSB said. "This, in effect, established 105 knots as the minimum operating airspeed in icing conditions. The [POH] was also revised to instruct pilots to maintain 120 knots until on short final."

NTSB said that information derived from the investigation of the accident in Moscow indicates that 105 knots does not provide an adequate margin of safety during operations in icing conditions.

"The airplane departed controlled flight [at an airspeed] only three knots slower than the published minimum operating icing airspeed of 105 knots, and no stall warning was provided to the pilots," NTSB said.

A flight test conducted in a Cessna 208B by the manufacturer and FAA in March 2005 was terminated nine minutes after encountering natural icing conditions because airspeed had decreased from 133 knots to 120 knots.

"Cessna flight-test pilots used a minimum safe speed in icing of 120 knots [and] successfully exited the icing conditions when they could no longer maintain that speed," NTSB said. "In the process of exiting, the flight-test airplane slowed to 117 knots. … The minimum safe speed [should not be designated as] simply the lowest speed at which control can be maintained; rather, the minimum safe speed is the speed that provides a substantial margin above the speed at which loss of control occurs. The minimum safe speed should also provide pilots adequate time to successfully exit icing conditions with consideration that airplane performance is likely to degrade further while the airplane is leaving icing conditions."

Certification for flight in known icing conditions does not include severe icing conditions. The icing conditions encountered during the March 2005 test flight and the October 2005 accident in Canada were not severe; the test-flight icing conditions were characterized as moderate. The accident in Canada occurred about three minutes after the pilot reported that she needed to return to the airport.

The accident in Canada occurred about three minutes after the pilot reported that she needed to return to the airport.

"The time available to escape less-than-severe icing conditions was extremely limited," NTSB said. "The airplane's failure to continue flight for more than three minutes in less-than-severe icing conditions calls into serious question the certification of the Cessna 208 for flight into known icing conditions."

TSB said, "The aircraft's deteriorating performance and the pilot's inability to maintain control of the aircraft indicate that the procedures identified in [the POH] are not adequate to ensure the safe operation of the aircraft in the forecast moderate icing conditions which prevailed at the time of the accident."

Flight data from the airplane that stalled on approach to Moscow indicated that the pilot had been using the autopilot and, therefore, did not recognize cues that might have prompted him to take direct and aggressive action to avoid the stall, NTSB said.

"Specifically, the decrease in airspeed and increase in pitch attitude preceding the upset were gradual, and the changing control inputs required to maintain altitude were masked by the pilots' use of the autopilot," NTSB said. "It is difficult for pilots to effectively monitor control inputs made by an autopilot and detect changes in the magnitude and direction of these inputs as the airplane's performance degrades due to icing conditions. If the pilots involved in the Moscow accident had been flying the airplane manually (without the autopilot engaged), they likely would have noticed the increased control wheel force needed to maintain altitude, [would have] become aware of the airplane's altered performance characteristics and [would have] increased their airspeed or otherwise altered their flight situation to avoid the loss of control."

Based on this information, NTSB on Jan. 17, 2006, made the following recommendations to FAA:

- "Require all operators of Cessna 208 series airplanes to maintain a minimum operating airspeed of 120 knots during flight in icing conditions, even if a descent is required to do so;
- "Prohibit all operators of Cessna 208 series airplanes from conducting flight into any icing conditions determined to be more than light icing; [and,]
- "Require all operators of Cessna 208 series airplanes to disengage the autopilot and fly the airplane manually when operating in icing conditions."

The accidents in Canada and Russia were among 19 Cessna 208 icing-related accidents and incidents worldwide from 1990 through 2005 that were studied by TSB. The study indicted that stall speed can increase from 78 knots to 92 knots because of residual ice on the airplane.

"As well, the manufacturer's data indicate that the operation of the deicing equipment can increase the stall speed of the aircraft by 10 knots, resulting in a possible stall speed of over 100 knots in icing conditions while the deicing equipment is operating," TSB said. "The manufacturer has set a minimum operating airspeed of 105 knots in icing conditions, which provides little threshold above an impending stall. In addition, the operation of the aircraft's stall-warning system in icing conditions may not be reliable due to the effects of residual ice."

Based on this information, TSB on Jan. 31, 2006, issued the following recommendations to TC:

- "Take action to restrict the dispatch of Canadian Cessna 208, 208A and 208B aircraft into forecast icing meteorological conditions exceeding 'light,' and prohibit continued operation in these conditions, until the airworthiness of the aircraft to operate in such conditions is demonstrated; [and,]
- "Require that Canadian Cessna 208 operators maintain a minimum operating airspeed of 120 knots during icing conditions and exit icing conditions as soon as performance degradations prevent the aircraft from maintaining 120 knots."

TSB made the following recommendations to FAA:

- "Take action to revise the certification of Cessna 208, 208A and 208B aircraft to prohibit flight into forecast or in actual icing meteorological conditions exceeding 'light,' until the airworthiness of the aircraft to operate in such conditions is demonstrated; [and,]

- "Require that Cessna 208 operators maintain a minimum operating airspeed of 120 knots during icing conditions and exit icing conditions as soon as performance degradations prevent the aircraft from maintaining 120 knots."♦

Notes

1. U.S. National Transportation Safety Board (NTSB). Safety Recommendation A-06-01 through A-06-03. Jan. 17, 2006.

2. Transportation Safety Board of Canada. Aviation Safety Recommendations A06-1 and A06-2. Aviation Safety Recommendations A06-3 and A06-4. Jan. 31, 2006.

3. U.S. Federal Aviation Administration (FAA). *Aeronautical Information Publication*. February 2005.

4. NTSB preliminary accident report NYC06RA032.

5. FAA Type Certificate Data Sheet A37CE shows that the Cessna 208, 208A and 208B are certified as normal category airplanes under U.S. Federal Aviation Regulations (FARs) Part 23, *Airworthiness Standards: Normal, Utility, Acrobatic and Commuter Category Airplanes*. For certification for operation in icing conditions, Part 23.1419, "Ice Protection," requires that "tests of the ice-protection system … be conducted to demonstrate that the airplane is capable of operating safely in continuous maximum and intermittent maximum icing conditions," which are described in Appendix C of Part 25, *Airworthiness Standards: Transport Category Airplanes*. NTSB said that icing certification requires that the airplane be equipped with functional deice boots on the leading edges of the wings and tail, a wing-ice-detection light, anti-ice boots on the propeller blades, an anti-ice panel on the windshield, heated pitot-static system and stall-warning system, a standby electrical system, and an inertial-separator system that alters the flow of engine-intake air to reduce ice ingestion.

6. NTSB. Safety Recommendation A-04-64 through A-04-67. Dec. 15, 2004.

7. NTSB accident report NYC04IA023 said that the probable cause of the accident was "the pilot's inability to see through the windshield, which was obscured due to icing conditions. This resulted in the pilot's inadequate flare and a subsequent hard landing." The report said that a contributing factor was "the wing icing."

8. NTSB accident report DCA02MA003 said that the probable cause of the accident was "an in-flight loss of control resulting from upper surface ice contamination that the pilot-in-command failed to detect during his preflight inspection of the airplane." The report said that a contributing factor was "the lack of a preflight inspection requirement for [Cessna 208] pilots to examine at close range the upper surface of the wing for ice contamination when ground icing conditions exist."

9. FAA letter to NTSB. Sept. 13, 2005.

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