Departments

Recurrent Training: Ice, Snow and Frost

It was a calm day in early December, 9,000 scattered and visibility 10, when the pilot and two passengers departed from Fort Collins, Colo., in a Grumman AA-5B Tiger. According to the pilot, the aircraft used more than twice the normal runway for takeoff.

Soon after takeoff, the stall warning horn sounded continuously and the pilot could no longer maintain altitude. The aircraft struck a road sign .5 miles from the runway as the pilot attempted a forced landing on a highway median. The Grumman finally came to rest on a highway exit.

The accident investigator noted that the entire surface of the wings and horizontal stabilizer were covered with rough ice. According to the National Transportation Safety Board (NTSB) report, the 1,100-hour pilot said the ice on the surface of the airfoils had no bearing on the accident. For most pilots, the sight of ice on the wings sends shivers down their spines. Somehow, this unfortunate pilot had missed the cue.

With the onset of winter, pilots are reminded of the need to clean the wings and control surfaces of any accumulations of ice and snow because they can dramatically alter the airfoil and affect the ability to develop lift. Even something as seemingly innocuous as frost will spoil aerodynamic lift as sure as a thick coating of rough ice. Particularly on cold evenings, frost can form quickly, and disaster can strike suddenly.

It was a clear night when the pilot of a Mooney M20C and his three passengers prepared for departure from St. Marys, Pa. The pilot wanted to have the aircraft deiced, but the driver of the fuel truck told him the airport had no deicing fluid. Using credit cards and paper towels, the pilot and passengers tried to remove the frost. According to one witness, the frost reformed on the wings as quickly as they scraped it off.

The pilot attempted to take off just after 9 p.m. A witness said the takeoff roll was very long. Shortly after takeoff, the aircraft entered a steep bank and descent. It crashed into the trees near the airport and burst into flames. All aboard were killed.

FLIGHT CONTROL PROBLEMS

Ice, snow, and frost don't just affect the ability of airfoils to generate lift. The additional weight can unbalance control surfaces, which leads to a dangerous aerodynamic condition called flutter. Such was probably the case in the following accident.

A lone pilot on a personal flight to Columbia, Tenn., took off from Nashville in his Cessna 206 at approximately 4:20 p.m. on a February afternoon. According to a line worker, the pilot took off with a half-inch of solid ice on the top surfaces of the wings.

The pilot experienced a severe vibration that shook the entire aircraft soon after departure. He reduced power and the vibration subsided. Then he noticed an aileron control problem and saw that the left wing tip was moving up and down. Fearing imminent disaster, he made an emergency landing in a nearby field.

An investigation of the aircraft found that both ailerons had traveled beyond their limits and were bent, and the left wing main structure was fractured. Fortunately, it had held together long enough to get the pilot safely on the ground.

Although there are no specific regulations in Federal Aviation Regulation (FAR) Part 91 regarding aircraft operation with ice, snow, or frost on the aircraft, FAR Part 135, which regulates air taxi and commercial operators, does provide specific guidance that pilots operating under Part 91 should consider.

FAR 135.227, Icing Conditions: Operating Limitations, says pilots are not allowed to take off with frost, snow, or ice on any propeller, windshield, powerplant installation, or adhering to an airspeed, altimeter, rate of climb, or flight attitude system. This regulation also prohibits takeoffs with snow or ice on the wings, stabilizers, or control surfaces. It further states that any frost adhering to the wings, stabilizers, or control surfaces must be polished smooth. The above accident reports seem to emphasize the wisdom of this regulation.

Cold weather can cause the formation of ice on other aircraft surfaces as well. Water and slush can freeze on brakes and landing gear, and ice crystals can form in the fuel. In the following accident, ice formation inside the aircraft led to a severe control problem.

The pilot of a Lake amphibian departed Avon, N.Y., on a clear day in late March. During the preflight, he noted that the elevator would not move, but it seemed to function normally after the pilot applied some external heat. Somewhere enroute to Swanton, Vt., the pilot found that he was again unable to move the elevator. Fortunately, the elevator trim control was functional, and he was able to control the aircraft.

On final approach, the aircraft caught a gust of wind and the nose pitched down. The pilot was unable to regain control and the Lake crashed short of the runway. When the investigator examined the wreckage, he found that solid ice had formed in the hull, encasing the elevator control push-pull rod, making it immovable. The aircraft was destroyed in the crash, and the pilot was seriously injured.

This type of problem is not as uncommon as you might think. The pilot of the Lake amphibian probably figured that after the heating during preflight, the control problem was solved. But remember that unless all the water and moisture is removed in the process, the problem can recur as soon as the aircraft is operated again in freezing temperatures.

ENROUTE ICING PROBLEMS

Ice, snow, and frost are not just a problem to be considered during preflight inspections. Pilots are required to operate aircraft only in the conditions for which the aircraft is certificated. And even if an aircraft is approved for flight in known icing conditions, it's generally a good idea to avoid such situations.

There are several excellent reasons to avoid flight in icing conditions. Ice can form on the pitot tube and static vent, rendering the airspeed indicator, altimeter, and vertical speed indicator (VSI) inoperative. It can build up on antennas, distort radio signals, and result in loss of navigational and communication capabilities.

When ice accumulates on the wings, it alters the shape of the airfoil, reduces the amount of lift produced, and increases the stall speed. Combine this with the increased weight of the aircraft and the reduced efficiency of an ice-covered propeller, and an aircraft can quickly become a block of ice hurtling toward the ground.

Even when operating aircraft equipped with deice or anti-ice equipment, pilots must understand the limitations of the equipment. Most systems only remove ice from specific, critical locations, such as the leading edges of the wings, windshield, and propellers. That leaves plenty of airframe and appendages, including the vertical and horizontal stabilizers, upon which ice can form. Although deice boots may remove ice from the leading edges, ice can still accumulate on other portions of the wing. This can be a problem, particularly during departure and approach phases of flight, when the aircraft is operating at a low airspeed and a high angle of attack.

Take, for example, the Cessna 310 making an ASR (airport surveillance radar) instrument approach into Lubbock, Texas, one foggy December afternoon. The ceiling was partially obscured, 400 feet broken, and the pilot was flying from the right seat. His passenger, a rated private pilot, was in the left seat.

The twin-engine Cessna began accumulating ice during the approach, and the pilot activated the deicing equipment several times, removing ice from the wing leading edges and props. The aircraft broke out of the clouds at 400 feet and, due to the heavy ice accumulation, continued a high rate of descent.

As is typical with many deicing systems, only the left side of the windshield had a window heater, so the pilot's visibility through the right windshield was restricted during the final approach. The pilot made a hard landing, lost directional control, and crashed into a concrete wall. Fortunately, neither the pilot nor the passenger were injured.

According to the Airman's Information Manual, the most severe in-flight structural icing conditions occur when it's 0?C and colder. Although it can occur in clear skies, icing is most prevalent in conditions of visible moisture, such as in clouds.

A thorough evaluation of cloud bases and tops along with temperatures aloft can be an important preflight consideration. But remember that multiple icing levels are possible, and even if you can safely fly above icing conditions, you may be required to make an approach through them. The consequences of even a short exposure to icing conditions can be disastrous, to say nothing of what could accumulate during a lengthy hold or a missed approach procedure.

All clouds at subfreezing temperatures have the potential for ice formation, but the type of ice formed depends on several factors, including water droplet size and distribution, and the aerodynamic effects of the aircraft. There are no hard-and-fast rules that determine whether ice will or will not form in specific conditions.

Ice comes basically in three varieties: rime ice, clear ice, and a mixture of the two. Rime ice is brittle and frost-like. It usually forms in conditions where the droplet sizes are small, such as in stratus clouds and light drizzle. Air is trapped within the ice as it forms, giving it a white or milky appearance. It primarily accumulates on wing leading edges and the front of anything projecting into the airstream, such as landing gear, antennas, and horizontal and vertical stabilizers. Its rough shape is particularly effective in reducing aerodynamic efficiency, but due to its brittle nature, it is more easily removed than clear ice.

Clear ice forms when water droplets spread out on the surface before freezing. The result is a clear, hard ice that adheres to all areas of the airframe and is very difficult to remove. It generally forms in rain and cumuliform clouds, and it can accumulate quite rapidly.

If icing conditions are encountered in flight, take action immediately. A 180-degree turn, climb, descent, or some combination of these maneuvers is recommended. If you're flying under instrument flight rules (IFR), don't let ATC push you into continuing on or waiting before taking evasive action. If necessary, declare an emergency and do what you must to get out of the ice. Icing can build tremendously fast, disabling aircraft in minutes, or in some cases, just seconds.

COMPOUNDING THE ERRORS

The pilot of a Piper Saratoga took off IFR with two passengers from Lima, Ohio, one dark night in February. Visibility was 4 miles in fog, the ceiling was 800 feet broken, and a heavy wet snow was falling. The pilot said he cleared the snow off the wings, but not off the top of the T-tail.

Slush from the runway was thrown up and over the aircraft during the takeoff roll, but he continued and climbed to 1,100 feet mean sea level (MSL). At this point, the airspeed decayed to about 60 knots and the landing gear automatically extended. The pilot maintained control of the aircraft by instrument references and crashed in a nearby field. Miraculously, nobody was injured.

Winter flying poses a number of hazards to pilots, and the problems of ice, snow, and frost are just the tip of the proverbial iceberg. But with proper training, knowledge, and judgment, pilots can avoid the perils and pitfalls and effectively deal with the demons of winter.

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For more information

For more information on the subject of icing and operations in cold environments, refer to the following:

Advisory Circular 91-51
Airplane De-Ice and Anti-Ice Systems

Advisory Circular 91-13C
Cold Weather

Operation of Aircraft

Advisory Circular AC 00-6A
Aviation Weather, Chapter 10: Icing

Accident Prevention Pamphlet FAA P 8740-24
Tips on Winter Flying

By Robert N. Rossier

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