Photo by H Dean Chamberlain

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Ice Belongs in Drinks

Any pilot who's spent a drab winter day hangar flying at the airport over a pot of hot coffee with friends has probably heard stories like these before. There was the time when Joe took his *Bonanza* up to Boston to see a Celtics game and picked up a bunch of ice during the descent into Logan. He needed almost full power just to stay on the glide slope. Or when Bill's *Warrior* looked like a hockey rink after crossing the Appalachians on his way home from Thanksgiving dinner with the in-laws last year. His wife hasn't flown with him since.

These stories are often told with a touch of bravado, the pilot feeling a sense of accomplishment for having survived an ice encounter. "I got through it that time, so I'll probably be all right next time, too."

Nothing could be further from the truth for airplanes not certificated for flight in icing conditions, because the moment ice begins to accumulate on an airplane wing, that wing's shape morphs into some new, untested airfoil design. At that moment, you become the test pilot of a new airframe, with no guarantee that the wings will keep flying as long as they're covered with ice.

What Is Airframe Icing?

The *Aeronautical Information Manual* (AIM) describes the various types of airframe icing, the conditions under which it can form, and the negative effects it can have on airplane performance. It also offers guidance to pilots on how to give a pilot report (PIREP) on in-flight icing conditions. Depending on where the icing conditions are encountered and at what temperature and altitude, ice can form as clear ice, rime ice (cloudy appearance), or some combination of the two. Ice can form quickly, often in just a few minutes—the time it takes to climb or descend a few thousand feet through a layer of juicy clouds. Unless the aircraft is equipped with some kind of anti-icing or de-icing system, ice can accumulate rapidly on the leading edges of the wings, the horizontal and vertical stabilizers, propeller, and windscreen.

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The effects of ice on an aircraft are cumulative, and it doesn't take much at all to

Photo by James Williams

severely reduce performance—as little as one-half inch of ice on an airfoil can reduce the lift it produces by up to 50 percent. Even a light coating of frost on the wings is enough to negatively affect the takeoff performance of most light airplanes.

Under what atmospheric conditions can a pilot expect ice to appear? As with many things in life, the answer is, it depends. There are many good tools on the Internet for making educated guesses about where ice is likely to be found, but there are no guarantees. AIM paragraph 7-2-21 says that a pilot can expect icing when flying in visible precipitation, such as rain or cloud droplets, and the outside air temperature is between +2 degrees and -10 degrees C. However, water can remain "super cooled" at temperatures as low as -40 degrees. Water can remain liquid at below-freezing temperatures until it contacts a solid surface like your airplane. Super-cooled large droplets, or SLD (which include freezing drizzle or freezing raindrops within or below clouds), are particularly dangerous because they can coat large areas of the wing and tail very quickly.

"Known icing conditions" are those where a reasonable pilot would expect a substantial likelihood of ice formation on the aircraft based upon all available information.

What Is "Known Icing?"

In 2003, the FAA defined "known icing conditions" as "atmospheric conditions in which the formation of ice is observed or detected in flight." This definition appears in paragraph 7-1-22 of the AIM. However, based in part on information provided by the Aircraft Owners and Pilots Association (AOPA), the FAA determined that this definition was not sufficiently broad enough to reflect the agency's current policy. The FAA issued an interpretation addressing known icing conditions and other aspects of flight in icing conditions on January 16, 2009.

In this interpretation the agency noted that "the formation of structural ice requires two elements: 1) the presence of visible moisture, and 2) an aircraft surface temperature at or below zero degrees Celsius. The FAA does not necessarily consider the mere presence of clouds (which may only contain ice crystals) or other forms of visible moisture at temperatures at or below freezing to be conducive to the formation of known ice or to constitute known icing conditions."

The letter to AOPA went on to say: "Most flight manuals and other related documents use the term 'known icing conditions' rather than 'known ice,' a similar concept that has a different regulatory effect. 'Known ice' involves the situation where ice formation is actually detected or observed. 'Known icing conditions' involve instead circumstances where a reasonable pilot would expect a substantial likelihood of ice formation on the aircraft based upon all information available to that pilot."

The letter acknowledged the challenge to pilots in deciphering the many possible weather scenarios that could lead to an icing encounter, but urged pilots to dig deeper than the area forecast to determine whether icing conditions might exist. The letter specifically advised pilots to obtain the latest surface observations, temperatures aloft, terminal area forecasts, AIRMETs, SIGMETs, and PIREPs. The letter also stated that pilots should incorporate new technology, as it becomes available, into their decision making.

The letter further noted that, "If the composite information indicates to a reasonable and prudent pilot that he or she will be operating the aircraft under conditions that will cause ice to adhere to the aircraft along the proposed route and altitude of flight, then known icing conditions likely exist."

Airplanes that meet certain design criteria can be certificated in the normal, utility, acrobatic, or commuter categories under Title 14 Code of Federal Regulations part 23 for "flight into known icing conditions." These aircraft are equipped with systems that not only prevent ice from forming on critical surfaces like the wings, tail, and propeller, but can shed ice that's already formed—within certain limitations. Such systems (often called Flight Into

Known Ice, or FIKI, systems) typically use pneumatic boots that expand and push the ice off, heating elements, a solution that is mechanically distributed over the surfaces, or some combination of these systems. Aircraft that do not meet these regulatory criteria can still be equipped with ice-protection systems (such as the TKS™ system that comes standard on the Cirrus SR22) but they are not legal to fly into known icing conditions.

Find Ice, Then Avoid It

There are several really good tools available on the Internet for sleuthing the potential for in-flight icing. NOAA's Aviation Digital Data Service has a fabulous Web site that pilots can use to supplement the official Flight Service preflight briefing. From the home page, click on the Icing tab to view graphical depictions of the latest icing advisories, pilot reports of icing, and forecast freezing levels.

Click on the Supplementary Icing Information link to see plots of where icing is predicted to be severe, including the forecast location and altitude where you are likely to encounter SLD. The Current Icing Product (CIP) uses input from weather sensors to produce an hourly snapshot of where ice is likely to be found right now. The Forecast Icing Potential (FIP) is an automatically-generated forecast of icing potential. FIP examines numerical weather prediction model output (from the Rapid Update Cycle, or RUC) to calculate the potential for in-flight aircraft icing conditions. This icing potential demonstrates the confidence that an atmospheric location, represented by a three-dimensional model grid box, will contain super-cooled liquid water that is likely to form ice on an aircraft.

RUC diagrams (also known as SkewT diagrams) provide another way to evaluate where ice might be found. The diagrams offer an easy way to figure out where the clouds are (and thus the potential for icing) in a given location, if you know what to look for. Go to http://rucsoundings.noaa.gov and in the form, type in the three-letter identifier for an airport along your route. Then, click the button that says "Simple java plots." If there are data available for that location, you will see a chart with a blue line (dew point) and a red line (temperature). The numbers on the right-hand vertical axis show pressure altitude in thousands of feet. The altitudes at which the blue and red lines come together are where you are most likely to find clouds—and if the temperature is below freezing at that altitude, there is a potential for ice to form. (You can find a NOAA article on RUC diagrams at: http://aviationweather.gov/general/pubs/front/docs/feb-04.pdf.)

If you are flying an aircraft that is not certificated for flight into known icing, you need to get out of the clouds at the very first sign of ice.

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You're in Ice...Now, Get Out!

If you are flying an airplane that is not certificated for flight into known icing, you need to get out of the clouds at the very first sign of ice. Don't hesitate to tell ATC that you are picking up ice and need to exit the icing condition immediately. Declare an emergency if you are not able to maintain altitude. Above all else, don't rely on the autopilot. Fly the airplane!

The January 2009 interpretation reiterates that, "Pilots should not expose themselves or others to the risk associated with flying into conditions in which ice is likely to adhere to an aircraft. If ice is detected or observed along the route of flight, the pilot should have a viable exit strategy and immediately implement that strategy so that the flight may safely continue to its intended destination or terminate at an alternate landing facility. If icing is encountered by a pilot when operating an aircraft not approved or equipped for flight in known icing conditions, the FAA strongly encourages the submission of PIREPs and immediate requests to ATC for assistance."

Don't hesitate to tell ATC that you are picking up ice and need to exit the icing condition immediately.

Engage whatever equipment you have available to keep the situation from getting worse. Turn on the pitot heat if it's not on already. If you have an anti-icing system, such as TKS™, turn it on, too. Depending on how much ice has already accumulated, it might be too late for the fluid to have an effect. Be sure to note the time you turned on the system pump so you can keep track of fluid usage, as some systems only carry enough fluid for about a half an hour of continuous use. When flying at night in IMC in near-freezing conditions, carry a high-powered flashlight you can shine out onto the wings to check for ice accumulation.

Depending on where you are flying and your clearance from terrain and obstacles, descend to a lower altitude where temperatures might be above freezing. If you are picking up ice while skimming the tops of a cloud layer, climb a few hundred feet to get above the clouds, but only if you are positive there is clear air above and the airplane has climb capability. If you are wrong, you could end up spending more time in the clouds and accumulating even more ice. Maintain airspeed with ice on your airplane, and don't rely on your airplane's stall warning system.

When you do your preflight planning to avoid ice, you should also plan your exit strategies. Use all available resources to exit icing conditions as quickly and safely as you can. Ice belongs in drinks, not on airplanes.

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For More Information

NOAA Aviation Weather Center
http://aviationweather.gov

NOAA Aviation Digital Data Service
http://adds.aviationweather.noaa.gov/

SkewT Diagrams: New Tools For Vertical Analysis
http://aviationweather.gov/general/pubs/front/docs/feb-04.pdf

NASA computer-based training module (CBT): A Pilot's Guide to In-Flight Icing
http://aircrafticing.grc.nasa.gov/courses_inflight.html