PAUL PELLICANO

On Thin Ice:

A Little Frost Won't Hurt...*Or Will It?*

Photos by H Dean Chamberlain

It's a cold and clear winter weekend morning. Your airplane needs exercise. You don't have a lot of time—plenty of chores to do back home—but you are eager to oblige before the next round of winter storms keeps you both bound to the ground. You eagerly walk across the ramp, anticipating the freedom of the sky and the higher performance you expect in the colder and "thicker" winter air.

Uh-oh.

Your eye catches the glimmer of sunlight reflecting off your faithful flying machine, but you know that glint isn't coming from a clean or freshly waxed airplane. Rather, it is coming from sunlight shining on the layer of frost covering nearly every exposed surface of the airplane. As you draw closer, though, you see that the layer of "frosting" isn't terribly thick; in fact, the sun is already beginning to melt it away.

The ice may be thin, but the questions come thick and fast.

Where Does this Stuff Come from?

It didn't rain last night, and the morning is clear. How can there possibly be ice on your airplane? The answer is simple. When cold temperatures combine with any kind of visible moisture, some kind of ice contamination is likely. Here are some possible ways for ice to exist on an airplane parked in visual meteorological conditions:

- The airplane has residual ice from a previous flight in icing conditions.
- The airplane was exposed to snow, freezing drizzle, or freezing rain overnight.
- The airplane was exposed to active frost conditions overnight or is still in active frost conditions.

But, the Ambient Temperature Is above Freezing!

Yes, but ice contamination can still occur. Consider the example of an airplane sitting on the ramp through a clear, cold night. If the airplane's skin temperature is below freezing, and the air is humid enough, frost will form on the skin. Obviously, an outside air temperature below freezing can cause the skin temperature to be below freezing. But the skin temperature can also be colder than the air temperature. Remember from high school physics that the temperature of outer space is absolute zero. Radiant cooling to a clear nighttime sky can cause the skin temperature of your airplane to be colder than the air.

Are Some Airplanes More Susceptible?

All airplanes are susceptible to the effects of ground icing; however, smaller airplanes are generally more vulnerable than larger airplanes. High-wing airplanes account for two-thirds of general aviation icing takeoff accidents, perhaps because the upper wing is more difficult to see and reach on preflight. Pilots of high-wing airplanes should make sure they have the means, e.g., a stepladder, to access the upper wing during preflight when ground icing may be a factor.

How Much Harm Can a Little Frost Be?

Do not let your eagerness to fly lead you onto thin ice in your thinking. Many small-airplane pilots assume that the frost or ice contamination they see on the airplane is not significant enough to cause a problem. An examination of takeoff icing accidents involving small airplanes from 1982 to the present shows that, in most cases, the pilot did not de-ice the airplane before attempting to fly. In at least half of those accidents, the pilot knew about snow, ice, or frost contamination before takeoff, but did not remove it from the airplane.

Here are the cold hard facts:

- Certification of airplanes assumes that the airplane is free of ice contamination. There is no testing or analysis to demonstrate that a takeoff can be safely accomplished with contamination of any kind or amount.
- It only takes a little bit of frost or ice to do a lot of damage to your airplane and, quite possibly, to you and your passengers.
- Even small amounts of frost, ice, or snow contamination can impose large lift and drag penalties.
- Roughness similar to medium sandpaper on the wing's leading edge and upper surface can reduce maximum lift by as much as 30 percent and increase drag by 40 percent.
- Ice also increases the total weight.

To understand what this really means, think back to that basic "equation" you learned in ground school. For an airplane to remain in steady, unaccelerated flight, lift must equal weight and thrust must equal drag. Ice—even in small quantities—plays havoc with that balance. Ice reduces lift while it increases both weight and drag. In a typical light general aviation airplane, you are very unlikely to have sufficient thrust to overcome those penalties.

That's bad enough, but don't forget that ice contamination can also create control problems. Depending on where the aircraft was parked, one wing may be more contaminated than the other. This condition can lead to roll-control problems. Contamination on the tail can result in pitch-control problems.

Are All Surfaces Critical?

Pilots—especially those in a hurry—may be tempted to assume that some surfaces are aerodynamically more important than others. Before you fly off with ice adhering to some "non-critical" part of the airplane, remember that any amount of frozen contamination on any surface of a small airplane can result in a significant drag penalty. The safest approach is to clear the entire airplane of all frozen contamination. Don't forget the propeller: The blades are airfoils, and the ability to climb depends on their ability to generate thrust. Also, don't forget about engine inlets, pitot probes, static ports, and angle-of-attack or stall-warning sensors.

Do not let eagerness to fly lead you onto thin ice in your thinking.

What about Polishing Frost?

Pilots sometimes assume that the roughness associated with frost is the main problem, and that they can overcome it by smoothing, or "polishing," frost instead of removing it. This practice is a factor in about 15 percent of the small airplane takeoff icing accidents. Dispense with the idea that smooth or polished frost on lift-generating surfaces is an acceptable preflight condition. Instead, take the time to ensure that you clear all contaminants, including frost (polished or not), from wings and stabilizing or control surfaces. In addition to an aerodynamic penalty, the FAA has no data to

support practical guidance on determining how to polish frost on a surface to make it acceptably smooth, other than completely removing the frost. Subsequently, the FAA issued two Safety Alerts for Operators (SAFOs)—06002 and 06014— advising against the practice of polishing frost.

Do I Need to Do a Tactile (Touch) Check?

It is difficult to determine visually whether a wing is simply wet, or whether it has a thin film of ice. Also, ice accumulation on the wing upper surface may be difficult to detect from the cockpit, cabin, or front and back of the wing because it may be the same color as the wing. Don't forget to do a tactile check after de-icing, because you need to make sure that no ice or other contamination remains.

The safest approach is to clear the entire airplane of all frozen contamination.

What about Using Anti-Icing Fluid?

It depends. Consult your Airplane Flight Manual (AFM) or Pilot Operating Handbook (POH) for specific information on this topic. The AFM/POH information governs what you can and cannot do, but the following general guidance may be useful.

The key factor is rotation speed. If your airplane has a rotation speed of fewer than 60 knots, you should only consider Type I fluid. If the rotation speed is 60 knots or more, you can use Type III fluid, if approved by the airframe manufacturer. Only if your rotation speed is 110 knots or more, should you use Type II or IV fluid—and then only if approved by the airframe manufacturer.

Other than Type I (orange in color in North America and mostly glycol), you need positive authorization from the manufacturer to use Types II (clear or straw color, rarely used in North America), III (bright yellow color, not yet widely available in the United States), and IV (green). The Type II and IV fluids have thickening agents that may not flow off prior to takeoff on small airplanes, thus causing lift loss and large increases in the control force required to rotate. These thickened fluids may leave residue that, if not washed off, can rehydrate and refreeze at altitude and cause control difficulties.

Please note that all anti-icing fluids provide protection only for a limited time. For Type I fluids, this time is generally short (about five minutes, or less in some conditions). Always check just before takeoff to ensure that the fluid is still preventing contamination.

As for using any other fluids to de-ice your airplane, see the references at the end of the article for examples of fluids you can use.

Other Assumptions to Avoid

- Never assume that snow contamination will blow off during takeoff. Even if the snow does blow away, another problem arises if it is simply concealing a layer of ice.
- Don't think it's enough to clean just the leading edge of the wing or only around vortex generators. You need to clear all contaminants from the entire wing surface, including flaps and ailerons. Don't forget the horizontal tail and elevator.

The bottom line: Make sure your airplane is free of any and all ice contamination prior to takeoff in ground-icing conditions.

Paul Pellicano is an aerospace engineer in the FAA's Small Airplane Directorate and resides in Atlanta, Georgia.

For More Information

AOPA Air Safety Foundation's Safety Brief SB02-12/06 "Cold Facts: Wing Contamination" provides excellent advice on how to clean contamination off your airplane. This publication is available at:
http://www.aopa.org/asf/publications/safety_briefs.html

NASA has an on-line course titled "A Pilot's Guide to Ground Icing." This course is available at:
http://icebox-esn.grc.nasa.gov/education/products.html

Read FAA Safety Alerts for Operators (SAFO), including SAFOs 06002 and 06014 on ground de-icing and polished frost, at:
http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/

Advisory Circular 91-74A, Pilot Guide: Flight in Icing Conditions is available at
http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/74471

Read FAA Information for Operators (InFO) 09016 on the effects of frost, snow, ice, or slush on the aircraft control and performance at:
http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/info/all_infos/