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The Pilot's Lounge #42: Of Martinis, Ice, and Tailplane Stalls

Just when you thought you'd figured out the recipe for stalls, the good folks in the pilot's lounge have shaken (not stirred) all the ingredients. AVweb's Rick Durden was there and reports that you should recover in tried-and-true fashion if the wing stalls. If the tailplane stalls, however, the required control inputs will be just the opposite and the control forces may require more strength than you possess. If you're not sure that you could differentiate between these equally likely and potentially fatal events, you won't want to miss Rick's analysis in the latest issue of "The Pilot's Lounge."

By [Rick Durden](#)

Hack started it, another, er, discussion, that's it, discussion, in the pilot's lounge here at the virtual airport. Hack was explaining to one of the yuppie pilots that no self-respecting human being would ever allow a bartender to serve him a martini with ice floating in it. Hack was explaining real loud. As the exchange got around to whether James Bond would have given a bartender a friendly warning for such a transgression or just shot him where he stood, one of the regulars whispered to me that this whole thing had evolved from a conversation about airframe icing. Hack had expressed the opinion that he thought that a lot of the fatal accidents in ice over the previous years were because the horizontal tail stalled rather than because of a wing stall, the pilots didn't know what had happened and didn't have the altitude to recover. Of course another pilot politely told Hack he was all wet and the, um, discussion escalated to more important subjects, in this case, the proper way to make a martini.

I don't like ice on airplanes and I think that once the martini leaves the shaker that ice in the glass is a sacrilege. Perhaps that's silly of me, we all have our prejudices. I've picked up and carried what I believe to be my fair share of ice on airplanes. During some of those experiences there were times that I was badly frightened. Yes, I'm a wimp but I still don't like airframe ice. I also know that because I fly around the Great Lakes, I'm going to acquire more, so I want to learn everything I



can about it in the hopes of staying alive. I wanted to hear what Old Hack had to say because he'd impressed me a lot in the time I'd known him. He'd stubbornly flown VFR for over 50 years since buying his Super Cruiser almost new in 1949 until he realized that scud running was just too dangerous, and quit flying VFR in lousy weather. His reasons had made excellent sense to me, so I'd written a [column](#) about it. He'd also gotten his instrument rating when he was over 70 years old and, to my

amazement, had become enamored of instrument flying and was now digesting everything about weather he could find. I wanted to see how Hack's information matched some I'd gotten from other sources, particularly the incredible research NASA is doing on in-flight icing and from test-pilot friends of mine who had done flight-test work regarding airframe icing. Some of the talks that I'd had with them about tailplane icing were pretty eye-watering. Hack and I talked and I made notes.

What's The Deal With the Tail?



Over the years structural icing has claimed a small but steady number of airplanes annually and many, many pilots have reported narrow escapes. Anti-ice and deice equipment has gotten more and more sophisticated. There are icing tunnels and tankers that spray water so that airplanes can fly in the spray at air temperatures below freezing. More sophisticated means of reconstructing aircraft accidents have been added to the mix and a consensus is emerging that tail stalls, rather than wing stalls, may be the more likely culprit in a substantial portion of icing accidents, particularly in the descent or approach phase of flight. While the initial reaction to a pronouncement that the airplane crashed because the tail stalled rather than because the wing stalled may be "big deal, that's like the time my professor told me The Iliad wasn't written by Homer but by another Greek with the same name," it is a big deal. The reason is that pilots have been taught how to recover from wing stalls (lower the nose, add power) but not from tail stalls, and the recovery from tail stalls is precisely the opposite (raise the nose, raise the flaps, reduce power). The penalty for using the wrong technique is obvious. Okay, if I get a load of ice and the wing stalls, I lower the nose and add power, if the tail stalls I raise the nose, retract the flaps and reduce power. Got it. Now, how do I tell which is which?

Ice Buildup Basics

Let's back up and take this a step at a time. For years we've motored around in the wintertime clag and when we started picking up ice we looked at the wing and started swallowing kind of fast and then progressed to hyperventilation as the accumulation grew. We considered its thickness and only thought about what it was doing to the wing as we watched the indicated airspeed drop. We usually didn't look at the tail, even if we could see it. What we didn't know didn't scare us.



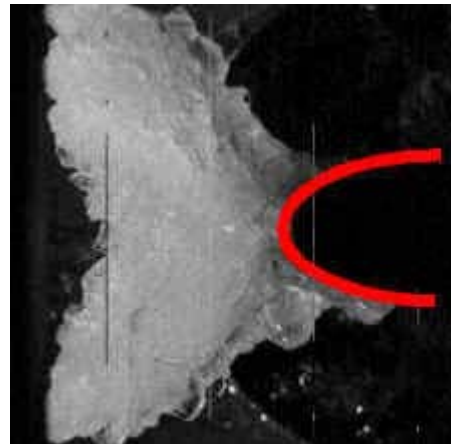
What we didn't know may have killed more than a few of us.

All airframe ice accumulation testing has revealed one very interesting fact. In general, the smaller the radius of the curve of a leading edge, the faster and wider the ice buildup. That is to say, the horizontal stabilizer collects a greater percentage of its radius in ice than does the wing. It's the nature of the beast. Next time you look at an airplane that has landed carrying ice, look at the amount of ice on the wing, tail and the antennas. The antennas and the tail will have built more ice as a percentage of their thickness than the wing. By a great deal. Even with but a half inch of ice on the wing there may be an inch or more of ice sticking out from the

antennas and tail at interesting angles. It is also the reason that it's not unusual for antennas to get to vibrating/fluttering badly with an ice buildup and break off. Ice buildups tend also to take on some fascinating shapes, they rarely just go forward into the slipstream, and they usually branch out, often forming what appears, in cross section, to be horns.

The net effect is that the smaller airfoil, the tail, gets relatively more ice, so the flow over it is more disturbed than the flow over the wing.

The shape of the ice, the buildup of ice in front of the lifting surface, is the source of much of the problems with ice. The wing and tail create lift partially because of a smooth airflow across the airfoil. When there is ice on the front of the airfoil, the airflow across the lifting surface (the top of the wing, the bottom of the tail) is no longer attached to the surface because it has had to cross an ice berm. Aft of the berm there is airflow separation from the surface, creating what amounts to a void that has to be filled. The air coming over the ice berm rotates toward the wing (or horizontal stabilizer) and then flows forward, creating a sort of rotor or vortex of disturbed air in the area of flow separation. This reverse flow means that portion of the airfoil is stalled, not providing lift. Not a good thing. The size of this disturbed area or airflow separation is of concern. The more ice, the greater the size of the disturbed airflow. The higher the angle of attack, the greater the size of the area of disturbed airflow. If the area of disturbed airflow gets large enough, the entire airfoil stalls. Before that, if it moves aft far enough to cross the hinge line of the elevator, it has the effect of tending to pull the elevator toward it.



Oh, Yeah, The Tail Lifts Downward

This all becomes important because the tail of an airplane almost always is lifting downward to overcome the nose-down pitching moment of the wing in normal flight (overly simplified, the center of lift of the wing is behind the center of gravity so as the wing lifts upward, the center of gravity pulls the front portion of the wing down). In cruising flight icing is not as much of a concern for the tail as it is for the wing because the tail is not working very hard. It is acting at a low angle of attack, nowhere near its performance limits, so the burble or rotor behind the ice buildup stays close to the buildup and the vast majority of the tail has airflow that is attached and effective. Videos of the underside of a tail that has been "tufted" (2-inch strips of yarn are taped in rows under the tail; they move with the airflow and depict, rather dramatically, what is happening along the surface of the tail) show that in cruising flight the tufts just aft of the ice buildup are pointed forward due to the rotational effect of the air filling the void behind the ice. Aft of that point the

airflow reattaches to the tail (again, simplified, we aren't going to get into boundary layer dynamics here) and the tufts point aft, showing the airflow is more or less smooth. In cruise configuration, the problem with ice buildup is sheer magnitude on the airframe and the wings. That's where you get so much drag and lose so much lift that you can't hold altitude, the stall speed increases and you may either sink into the ground or stall the airplane and lose control.



Descent and Approach

As you near the destination you pitch down a bit, let the speed build and start to think you can carry the ice through landing. Maybe you pick up a little more ice in the descent, but you still are able to hold altitude and you figure you've got this knocked. You set up for the ILS and drop approach flaps, 7 to 15 degrees, depending on the airplane. Suddenly you notice that it's difficult to trim the airplane, and the elevator seems a little funky, it's lighter than usual. The control wheel will move forward very easily but it's difficult to pull it back. As you motor down the ILS, picking up a little more ice, you find that you've got some mild PIO (pilot induced oscillation) going in pitch, and you can't seem to damp it out entirely.

Full Flaps

You break out, spot the runway, sigh in relief and figure you want a little more margin above the stall, so you extend the flaps all the way. Suddenly, the airplane pitches down 45 degrees, you try to pull the wheel back, but it's immovable. Your last sight is the windshield full of ground and approach lights.

What happened? You have either stalled the tail, or the flow separation under the tail moved so far aft that it reached the elevator and caused the elevator to

deflect radically downward. The result is the same, the nose pitches down violently, and, as we'll see, the methods of recovering are identical.

As you set up for the approach and dropped some flaps you took the first step toward stalling the tail. Flap extension does two things to an ice-contaminated horizontal stabilizer, both bad. It changes the airflow aft of the wings, deflecting it downward, which causes increased downwash over the tail, increasing its angle of attack, whether it is a high- or low-wing airplane. With an increased angle of attack and an ice buildup on the leading edge, the flow separation on the underside of the tail, the lifting part, is made worse, and the rotor, the area of disturbed air, gets



bigger and moves aft. Tuft testing shows that more and more of the tufts on the underside of the horizontal stabilizer are pointing forward or at random angles rather than pointing aft. Flap deflection has the second effect of moving the center of lift of the wing aft, farther away from the center of gravity. This causes an increase in nose-down pitching force. To compensate, the tail must exert greater lift downward, thus increasing its angle of attack still more and causing it to work nearer to its performance limit.

Increasing the angle of attack increases the area of flow separation behind the ice buildup. When the area of flow separation reaches the hinge line for the elevator the relative low pressure of the flow separation or rotor acts to pull the elevator toward it, that is, downward. The size of the disturbed airflow area is changing constantly with the small changes in pitch of the airplane. The changing amount of "pull" on the elevator causes changing forces to feed back to the yoke. The pilot feels a buffeting in the wheel and also feels that it is easy to move the wheel forward (elevator down into the area of flow separation and lower pressure) but difficult to pull it aft. As the pilot fights this, PIO (pilot induced oscillation) may start. PIO adds to the rapidly changing angle of attack of the elevator, further changing the size of the area of airflow separation, and further increasing the rate of change to the downward-acting force on the elevator. Things are building on themselves, but the pilot may still be able to control things.

At this point the pilot feels that the controls are "light," they are easy to move forward, but difficult to pull aft; he or she will have a lot of trouble trimming the airplane in pitch and may feel a buffet in the control wheel (not the airframe, which one feels literally through the seat of the pants).

When full flaps are added, the combination of increased downwash and the aft movement of the center of lift further increase the angle of attack of the elevator. The area of flow separation may get so big that either the horizontal tail simply stalls and quits lifting downward, allowing the nose-down pitching moment of the wing to act unopposed, or the elevator is physically pulled downward into the area of flow separation. In either case, the pitch down is sudden and violent. Pilots who have experienced it describe either getting light in their seats or actually being thrown against the seat belt.

Recovery

The recovery technique requires reducing the angle of attack of the horizontal stabilizer and getting the elevator away from the area of flow separation. That means raising the flaps, at least to the previous position. It also means physically pulling the elevator away from the area of flow separation by pulling back on the wheel. There are reports that on some commuter turboprops the force necessary to pull the wheel back and get the nose up to the horizon may be as high as 400 pounds. The more realistic load for smaller aircraft is as high as the 100 to 125 pound range. That is still a huge amount of force.



Power

With some flap deflection while on an approach, adding power makes a situation involving an ice-contaminated tail worse. Power is destabilizing. In addition, adding

power adds to the downwash effect, increasing the angle of attack of the tail. While the effect of a power increase on increasing the size of the area of airflow separation is not nearly as great as flap deployment, a power increase nevertheless does increase the size of the area of flow separation. Thus, in the event of a tail stall, while you are retracting the flaps and pulling for all you are worth, reduce power as much as you can (I know that's hard to do if you are near the ground).

Speed

Odd as it may seem, increasing speed increases the area of flow separation under the horizontal stabilizer. It doesn't seem to matter in cruise because the tail is at a very low angle of attack; however, once the flaps have been deployed, a speed increase will make matters worse. That is exactly opposite to the technique of dealing with wing icing and the need to stay well above the stall speed for the wing. With flap deflection in the equation, additional speed does not help. The solution? If you get into ice, leave the flaps up. (Yes, the Pilot Operating Handbooks for a number of airplanes recommend leaving the flaps up in ice. They are not kidding.)

Diagnosis

How do you know if the icing problem you are wrestling is impending wing or tail stall? There are some general rules. If the flaps are up and you are in cruise configuration, the pressing concern is wing stall. To the extent it gives any warning it will be in the form of airframe buffet. If you feel shaking through the seat of your pants, the problem is probably the wing approaching its critical angle of attack as redesigned by ice.

An impending tail stall gives a different set of warnings. If the pitch control gets "lighter," particularly if it becomes easier to push forward on the yoke than it is to pull aft, be suspicious. It may become difficult, if not impossible, to trim the airplane in pitch and you may enter PIO. Further warning is given via buffeting in the control wheel itself, not buffeting of the airframe. If you have any amount of flap deployed and you experience shaking in the control wheel, it's a good bet that it's the tail that's at risk of stalling.

So, Waddaya Do?

I'll state the obvious, stay out of icing conditions. Is the trip really that important? I know the pressures. I know how hard it is to either delay a trip or cancel. I did my time flying charter in the days when the FAA was looking the other way and pilots who cancelled for weather got fired. As a result, it took me a while to be able to cancel a trip because of a concern about ice and then not second-guess myself. I've finally gotten to the point where my passengers know that in the wintertime we might not go at all, and if we do, we may come home a day or four early or late because I despise ice and try to avoid it.



I'm also realistic. Sometimes you get fooled and, despite all your careful planning, you pick up a load of the stuff that should not be served in martini glasses. The overwhelmingly important thing is to leave the flaps up on the approach and landing. The airplane was doing fine with the flaps up, don't change anything. Remember the different warnings of wing and tail stalls: buffet in the airframe versus the control wheel; lightness in the controls, difficulty in trimming in pitch and PIO.

A great deal of the information in this column came directly from NASA. NASA is doing significant research into in-flight icing using the most sophisticated equipment and analysis that currently seems to be available in the general aviation field. Some of what is coming out of NASA's work is challenging "accepted" truths on dealing with ice, but the work is backed up with hard data and, in many cases, films showing the behavior of the airfoil in icing conditions. I am just starting to learn about the extent of the research NASA is doing into areas that may help keep those of us who fly general aviation airplanes alive. I have seen one excellent NASA video on icing and am aware of others, as well as in-flight training material on compact disc. When I find out how pilots can obtain this material, I will pass the information along. In addition, I'll put in an unabashed plug: if you feel that the research NASA is doing for general aviation is beneficial, let your representatives in Congress know. NASA is fighting for crumbs. When they get research dollars, we benefit.

Oh, yes, two other secrets for surviving an icing event: When you come down final with the flaps up and extra speed to avoid wing stall, cross the runway threshold about 10 feet high, not lower, because the snowplow operator may have left a pile of snow on the end of the runway and with an iced-up windshield, you may not be able to see it. Also, when you flare, don't close the throttle, leave it right where it is until the wheels roll. There is a good chance that you are flying above the power-on stall speed, but below the power-off speed. A lot of pilots have broken landing gear and damaged airplanes when they closed the throttle at about 10 feet and the airplane literally fell the rest of the way to the runway.

Hope your winter, like a good martini, brings you no ice.

See you next month.