How to Recover from Tailplane Icing

If the tail "stalls up," the nose goes down

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Tailplane Icing Review

I recently received a note from Steve Koeppel, a Gold Seal Flight Instructor, asking me to review a video with which he took issue. By way of background, Gold Seals are men and women who not only flight instruct but also have the Ground Instructor Certificates that allow them to give their students academic instruction as they progress toward their various ratings. To earn such a designation, the instructor must teach a minimum of 10 students annually and of all those instructed, 80% must attain the next highest level of accreditation as a pilot. I always have been impressed with the work these folks accomplish. In my opinion, the Gold Seals constitute the FAA's "Teachers of the Year."

The video in question is a production of NASA's Cleveland research center, which conducted a tailplane icing investigation at the FAA's request.

While the video dates back to the 1990s and was completed before the Lewis center was renamed in honor of Sen. John Glenn, I have found no more recent material to update the recommendations and procedures that it establishes for pilots who find themselves in conditions severe enough to ice up the horizontal tailplane of their aircraft.

Some Basics

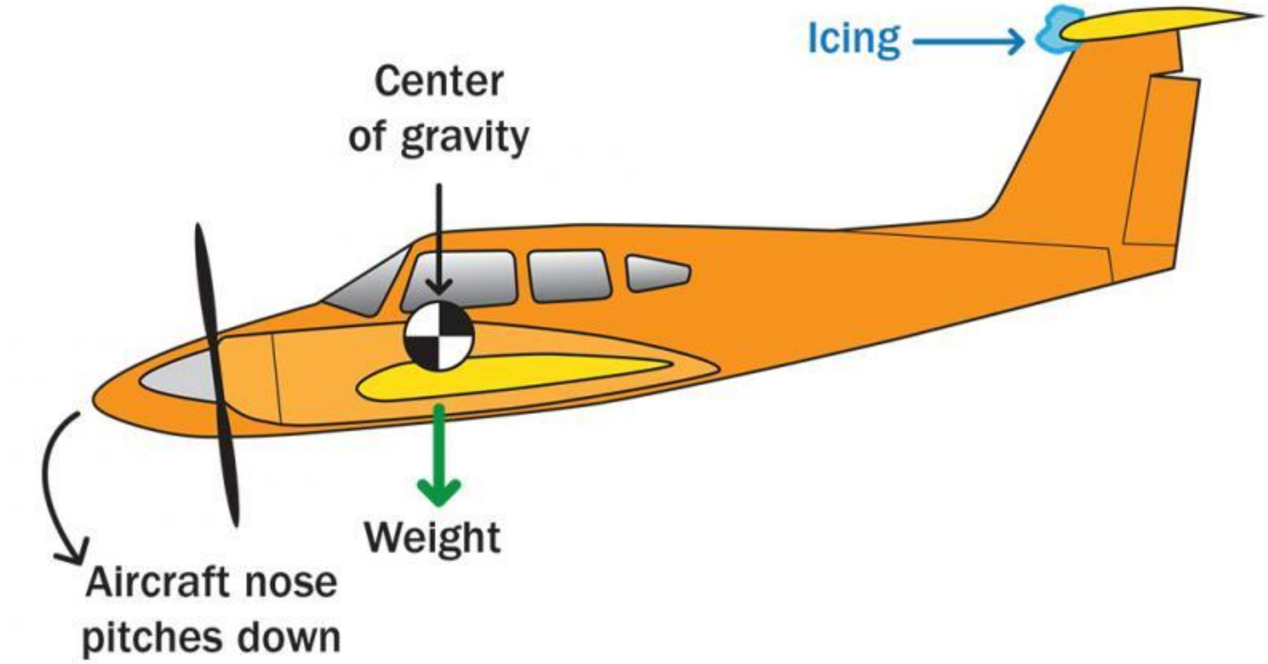
Let's review. How does an airfoil create lift? If we assume a constant altitude (air density) and a constant size of the wing (planform area), there are only two variables involved in the creation of lift. Those are the angle of attack (AOA) of the wing and the airspeed. A higher AOA means there is a higher coefficient of lift and more lift being produced at a given airspeed. Eventually, if the AOA continues to be increased, the airfoil reaches its critical AOA. Beyond that, lift is being inversely produced. That is, the higher the AOA beyond the critical angle, the less lift the airfoil is producing. Eventually, no lift is being produced by the wing.

That critical AOA is the only constant when discussing airfoil stalls. The so-called "stall speed" of an airplane is only the stall speed in level flight at a constant altitude, with no bank angle and at given weight. Change any of those variables and the airfoil will stall (reach its critical AOA) at a different indicated airspeed. For instance, at 60 deg. of bank, the wing has to produce twice as much lift as at level flight, just to keep the airplane level. This is because in a turn the lift vector is tilted and not all of the lift is working against gravity.

To the point, assume we are flying straight and level at an airspeed only 1 kt. above level flight stall speed and therefore just shy of the critical AOA. As we bank and add back pressure to create the additional lift needed for level flight, even if we add power to keep the airspeed constant, the wing exceeds the critical angle and stalls. The speed at which we were just able to maintain level flight before is not high enough in the turn.

Center of Gravity Effects

Another factor that needs discussion is the location of the center of gravity of an airplane when its wing stalls. As an airplane flies through the air, it is desirable that the c.g. be in front of the center of lift. This is called a forward c.g. If the c.g. is aft of the center of lift, when the wing stalls the aircraft will pitch up, thus deepening the stall. An airplane that pitches up when it stalls is considered to be dynamically unstable. As departure from controlled flight worsens, the nose will continue to pitch up and increase the AOA on the already stalled wing.



By contrast, a dynamically stable airplane will pitch down when stalled. When headed down, lift on the wings increases until the airplane noses up again and, if power is not applied, eventually stalls again. As the airplane continues through a series of stalls and recoveries, if it is dynamically stable, it eventually will resume nose-down un-stalled flight, descending.

In flight, an airplane with a forward c.g. needs to be counterbalanced by some force or the airplane will merely descend until it impacts the ground ("the ground is the final arbiter of all decisions made in the air"). Therefore, in order to maintain a nose-level attitude, the aircraft's tailplane must "lift down." Thus the tail acts in the same direction as the weight of the airplane — that is, down. Therefore, the wing has to create additional lift to overcome the downward lift that the tailplane produces.

This is why it is desirable to have a c.g. farther aft when attempting long-range flights. Mind you, that's not aft of the center of lift but simply farther aft. As the c.g. moves rearward toward the center of lift, the "downward lift" of the tailplane can be reduced. By doing this, the total amount of lift that the wing must produce is decreased. With decreased lift requirements imposed on the wing, AOA decreases along with induced drag and power required, thereby increasing range.

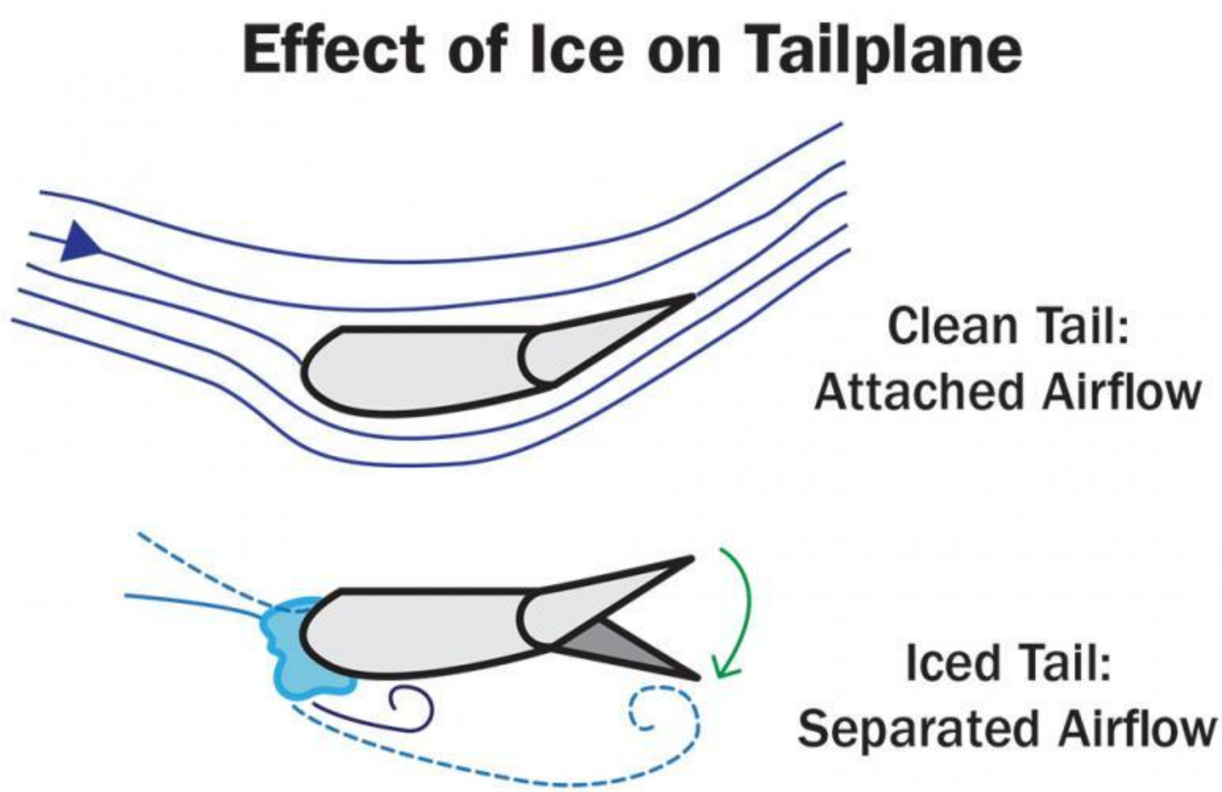
Since the tail must lift down, it can be thought of as an upside-down airfoil. When the tailplane creates more lift, the tail goes down and the nose comes up. When we pull back on the controls of the airplane to climb, the AOA on the tail increases, the tail goes down and the nose comes up. Simple.

The NASA video correctly states that when a wing stalls, the way to recover is to let the nose fall through, thus reducing the AOA. One need not ride through the subsequent oscillations as power can be added to achieve level flight quicker. Where Steve, and now I, would like to question the video is in its assertion that when tailplane icing is even considered a possibility, the pilot's first corrective action is to aggressively pull back on the yoke of the airplane.

Ice Effects

Ice on an airfoil essentially changes the airfoil's shape so that the air moving over it behaves as if a much higher AOA had already been reached. The ice disturbs the flow of air at a lower AOA and makes that flow separate from the top (bottom for tail) surface sooner (slower airspeed and/or lower AOA) than normally would occur.

The folks making this video were all test pilots and not for a moment do I suggest equivalent expertise in aerodynamic knowledge. It is for the purposes of discussion and understanding that I am writing and readily admit I don't understand any circumstance under which the first step to recover a stalled airfoil to normal flight is to aggressively increase the AOA on it.



The video is made using a Twin Otter as the test airplane. The test crews "iced" the tailplane of the de Havilland turboprop by fixing irregular shapes to simulate ice that had formed to the tail surface of a similar airfoil in a wind tunnel. In an attempt to keep other factors constant, the wing was not "iced" during the flight tests.

Effects of the Twin Otter Configuration

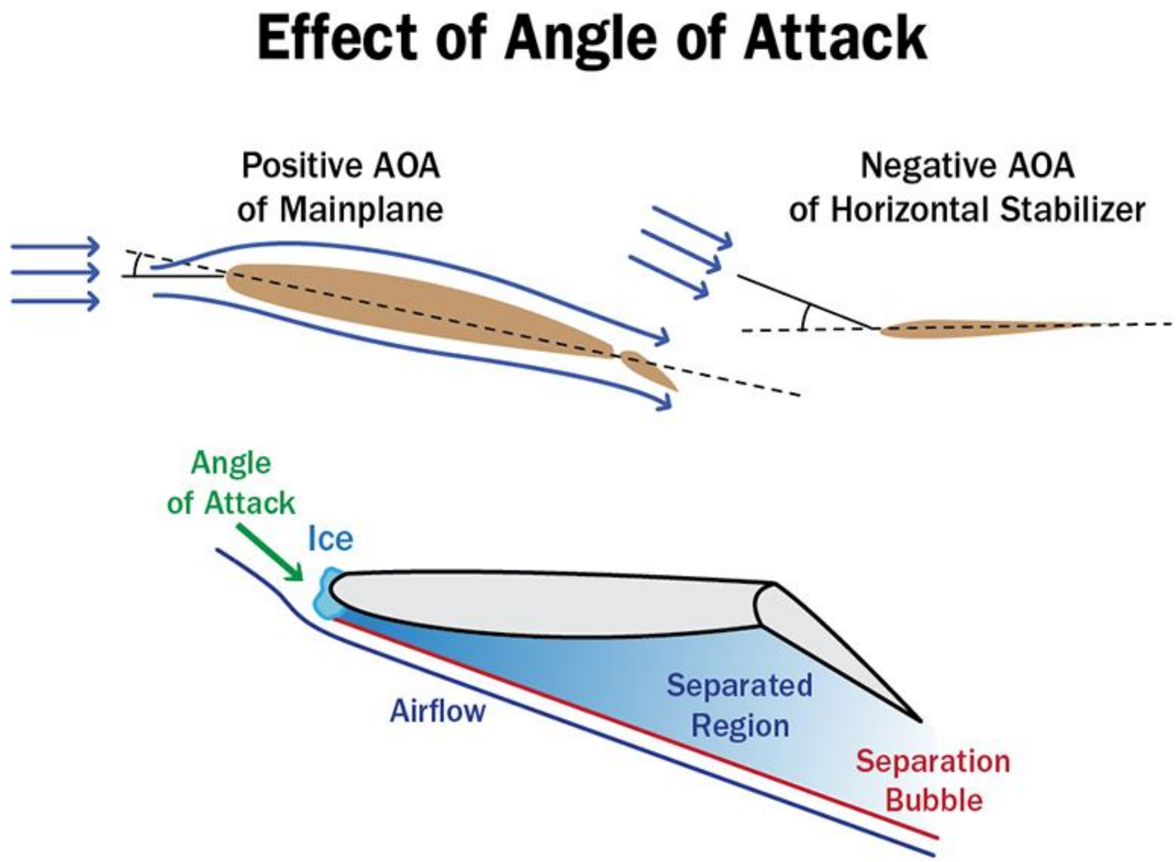
It should be noted that the test pilots readily admit that there are certain characteristics in play in the Twin Otter and other such airplanes in which power or flap settings would affect them more than many other airplane types. The DHC-6's propellers are located above the tailplane and thus the airflow from them tends to flow over the wing and assume a downwash trajectory as it moves toward the tailplane. The thrust from these engines is well above the c.g. of the airplane. This can cause nose-down tendencies with increases in power and nose-up tendencies with decreases in power. The de Havilland's flaps are large and create another large downwash vector over the tail, which increases the AOA on it. That means the tail moves down and the nose moves up. I believe these characteristics in the Twin Otter "style" of airplane are critical to the understanding of this problem. Nevertheless, the recommended procedure from the video was not limited to Twin Otter type airplanes.

The test crews slow the airplane tailplane with various flap and power settings. Light material tufts, attached to the tail surface, show that as the airplane slows and as the power is increased to maintain level flight, or as the airplane speed increases with full flaps deployed, the AOA of the tail increases dramatically and the tufts show a nearly stalled airfoil. Pilot indications of the impending stall are control force lightening; control, not airframe, buffet; and loss of effect of the tail, *i.e.* it became easier to let the nose fall off than to hold it up. In one of the flights, the test pilot allowed the airplane to stall. In the video, you can see the nose of the airplane pitch down when this happens. Shortly thereafter the pilot exerts a large pull on the yoke and the airplane recovers.

Pull Back First?

After watching that, it seemed remarkable to me that the experts concluded that when a tailplane stall occurs, the method of recovery is to first aggressively increase the AOA on that surface by pulling back on the yoke. I don't understand how you can chase after separated flow by trying to move an airfoil back beyond where the separation occurred. I need a better explanation than "In an impending tail stall situation, the recovery is [to] pull back on the yoke, reduce flaps and, on some aircraft, ease off on power." At one point, a test pilot advises that in a tail stall, "The no brainer is to pull the yoke back." To my long understanding, by pulling back as the aircraft stalls, the pilot would make the airplane dynamically unstable, with one stall leading to another and another without recovering.

The Test Pilot Didn't Pull Back First



Here's the *big* point I would like to make as I continue this academic discussion. In the video, when the airplane tail surface does stall, the pilot does not immediately pull back on the yoke. Rather, he correctly lets the nose fall off. Then, it is clear that the first thing he does after that is reduce the power on the engines. He says words to the effect of "there she goes" (stall) and pulls the power back with his right hand before anything else. The nose of the airplane appears to fall through, dynamic stability, and then, after a very brief delay, he exerts a great aft pressure and the airplane recovers. He calls for "flaps up" and the copilot states, "They're already moving. I started them up as soon as it went over." In other words, the major causes of the unstable airflow over the tail of the airplane or nose-down tendencies were reduced before the aft stick was applied.

The video evidence, the recommendations and practical experience lead to the following questions about the Twin Otter tests:

1 Once fitted with simulated icing on the tailplane, were stalls tried with the flaps in the up position?

2 Once fitted with simulated icing on the tailplane, were stalls tried with power at idle?

3 Once fitted with simulated tailplane icing were stalls attempted with no flaps and no power at the same time?

4 What would the recovery have looked like if the pilot had left the power on and the flaps where they were when the stall occurred and first violently pulled back on the yoke? I maintain that the airplane would have entered a deeper stall and rolled off.

5 What would the recovery have looked like if it was attempted at a high enough altitude that the pilot could have left the nose down, let the airspeed increase? The tail may not have been recoverable as the downwash from the flaps may have continued to increase the AOA on the tailplane, causing it to enter a deeper and deeper stall. Flap position is the key though, not aft pressure on the yoke.

Alternative Method of Treating Tailplane Icing

It is inarguable that the yoke must be pulled back shortly after the stall is broken, but there is a difference between doing that to break the stall, or doing that after breaking the stall, to avoid impacting the ground. I submit that you cannot un-stall any airfoil by increasing the AOA on that surface. However, I am open to an explanation from anyone who can graphically show me how that can happen.

If tailplane stall occurs relatively close to the ground, something has to be done immediately, and pulling back on the stick after reducing power and decreasing the flap angle to un-stall the tail airfoil may be the only out. Obviously, a better solution is to prevent the stall in the first place.

Included is a picture that gives me chills. I would not volunteer to be aboard a Twin Otter if they ever do more simulated icing stalls. That also gives me chills, and I hand it to the pilots who conducted those tests for our benefit. Back to the picture.

This pilot entered virga in the clear and wound up with the wing and tailplane with this mind-boggling load of ice. What did he do to survive?

1 He refrained from extending flaps.

2 He attempted to maintain the AOA that was present when he iced up the airfoil. In other words, as he neared the approach end of the runway he did not greatly decrease airspeed from the speed at which he accumulated the load of ice. For that reason, on a descending final, the power he required on approach was probably less than normal.

3 When very low, over the very long runway, he maintained level flight, put the gear down and let the airplane stagger onto the runway. It worked.

If you suspect tailplane icing, do not extend flaps — if used at all — past approach. Speed, if slowed at all, should not be lowered below the point at which the first indications of tailplane stall occur. The landing gear should remain retracted until the aircraft is very low and level over the runway.

In these circumstances, I would declare an emergency since the landing would be hot. And I'd much rather risk the results of trying to stop on an icy runway after a mile or so of reverse thrust than land nose first just short of it.

I think that if a pilot were to mix up the order of the steps that the test pilot *actually* did in the video test, and repeatedly pull back on the yoke at the indication of a stall, without reduction of power and/or flaps, the results could be disastrous.

Editor's Note: The author's long aviation career has included stints as a flight instructor, line pilot and chief pilot, during which he accumulated considerable time flying everything from the F-4 Phantom and C-5 Galaxy to Gulfstreams, Globals and every model of Falcon Jet. Periodically, when matters of pilotage and aerodynamics become subjects of debate, he likes to step back, don a figurative mortarboard and conduct an open, interactive class to examine the subject. And so another session begins.