# *Lesson 1: Stalls*

Fly This Lesson Now

**—by Rod Machado**

## First, a Little Theory

In our class on slow flight, I showed you how, in order to maintain sufficient lift for flight, the wing's angle of attack increased as the airspeed decreased. Perhaps you've wondered if there is a limit to how much the angle of attack could increase. After all, common sense suggests there are limits to all things. The ancient Egyptians had common-sense limits, especially regarding the size of pyramids they could build (I think this is known as Tutankh-common sense). Wings have limits, too.

A pilot's job is to work the four forces, maintain lift, and avoid the burbling air condition that results in a stall. As I mentioned in a previous lesson, this kind of stalling has nothing to do with the engine stopping.

Air begins to burble over the top of the wing when the wing reaches a large angle of attack (about 18 degrees for most airplanes). This burbling disrupts the flow of air over the wing, interfering with lift and causing a stall. The angle at which the air begins burbling followed by the wings stalling is known as the critical angle of attack.

Okay, here comes an idea that's like the biggest fish you ever caught—it's a real keeper. Since wings always stall when they exceed the critical angle of attack, you can recover from the stall by decreasing the angle of attack to less than the critical value. Everybody got that? Repeat it to yourselves 10 times, fast.

## Stall, Angle of Attack, and How the Nose Knows

To get a handle on how a stall happens, think of air molecules as little race cars moving over the wing (Figure 1-1).

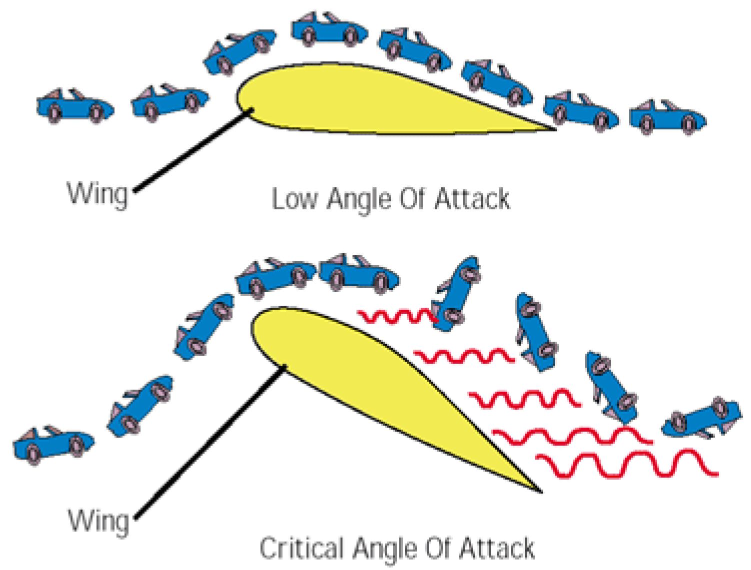


**Figure 1-1 Angle of Attack.**

Each car (and air molecule) has one objective: To follow the curve over the wing's upper cambered surface. Of course, if the wing is at a low angle of attack, the curve is not sharp, and it's a pretty easy trip (Figure 1-1).

But look at the curve made by these cars and air molecules when the wing is attacking the wind at a large angle. As the angle of attack exceeds approximately 18 degrees (known as the critical angle of attack for reasons you will soon see), these speed-racer air molecules can't negotiate the turn (Figure 1-1).

When this happens, they spin off, or burble, into the free air, no longer providing a uniform, high-velocity, laminar airflow over the wing (Figure 1-2). The wing stalls.

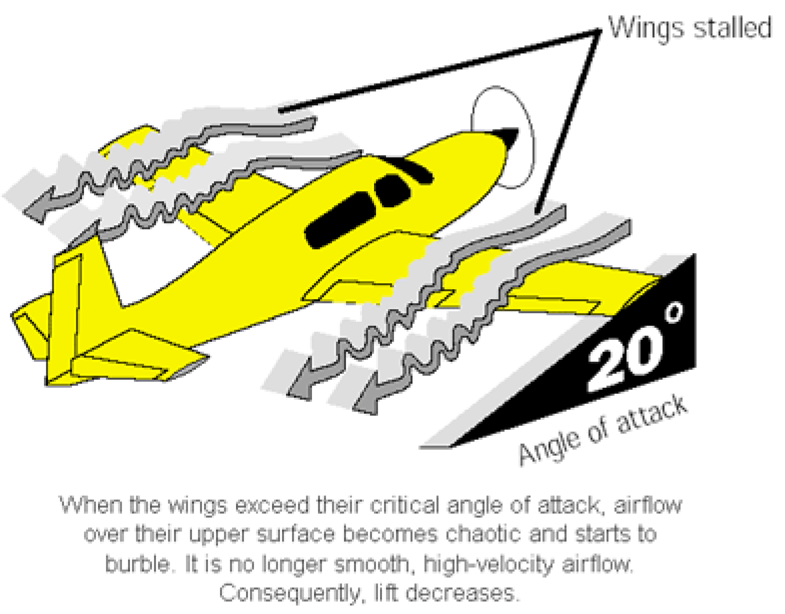


**Figure 1-2 A Wing that is Stalled..**

Remember, according to Jacob Bernoulli, lower-velocity airflow over the wing produces less lift. There is still impact lift provided by air molecules striking the underside of the wing, but we've already learned this doesn't provide nearly enough lift to sustain the airplane. When there's less lift than weight, bad things happen to good airplanes. The wing goes on strike and stalls. Abandoned by Bernoulli, gravity summons the airplane to earth on its own terms.

All wings have a critical angle of attack (the angle varies slightly among airplanes). Beyond this angle, the wing and the wind don't work and play well together. All the whispered theory in your heart won't overcome the laws of physics and aerodynamics. The wing police are always watching. Exceed the critical angle of attack, and the air molecules won't give you a lift. Sounds serious—and it can be. Fortunately, there's a readily available solution, and it is not screaming, "Here, you take it!" to the instructor. At this point, I'd like you to put your finger in your ear. Why? Because I'm about to say something really important and I don't want it to go in one ear and out the other. Here comes the important stuff again: You can unstall a wing by reducing the angle of attack. You do this by gently lowering the nose of the airplane using the elevator control (Figures 1-3A and 1-3B).

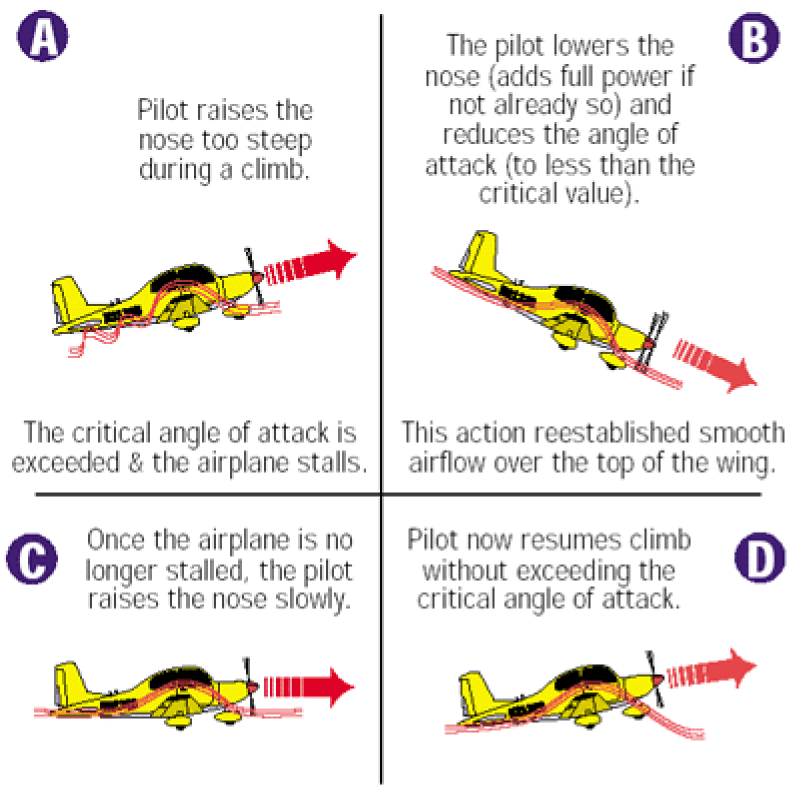


**Figure 1-3 Stalling and exceeding the critical angle of attack.**

Easy does it here, Tiger. Once the angle of attack is less than its critical angle, the air molecules flow smoothly again over the top of the wing and production of lift resumes. It's as simple as that. Now the airplane can resume flying and doing what airplanes are supposed to do (Figures 1-3C and 1-3D). Please don't ever forget this. Okay, you can take your finger out of your ear now.

Why am I making such a big deal out of this? Because in a moment of stress (having the wing stop flying creates stress for many pilots), you will be inclined to do exactly the opposite of what will help. Pilots have a natural inclination to pull or push on the elevator control to change the airplane's pitch attitude. During a stall, as the airplane pitches downward, your untrained instinct is to pull back on the elevator control. You could yank that critter back into your lap, and the result will not be good. The wing will remain stalled, and you, my friend, will have the look of a just-gelded bull.

If the wing stalls, you need to do one very important thing: Reduce the angle of attack to less than its critical value. Only then does the wing begin flying again. Adding full power also helps in the recovery process by accelerating the airplane. The increase in forward speed provided by power also helps reduce the angle of attack.

Don't just sit there with stalled wings. There's a reason why you are called the pilot in command. Do something. But do the right thing.

## Stall at Any Attitude or Airspeed

You should realize that airplanes can be stalled at any attitude or at any airspeed. Put your finger back in your ear. It makes no difference whether the nose is pointed up or down or whether you are traveling at 60 knots or 160 knots. Whether an airplane exceeds its critical angle of attack is independent of attitude or airspeed. Figure 1-4A shows one instance of how this might happen.

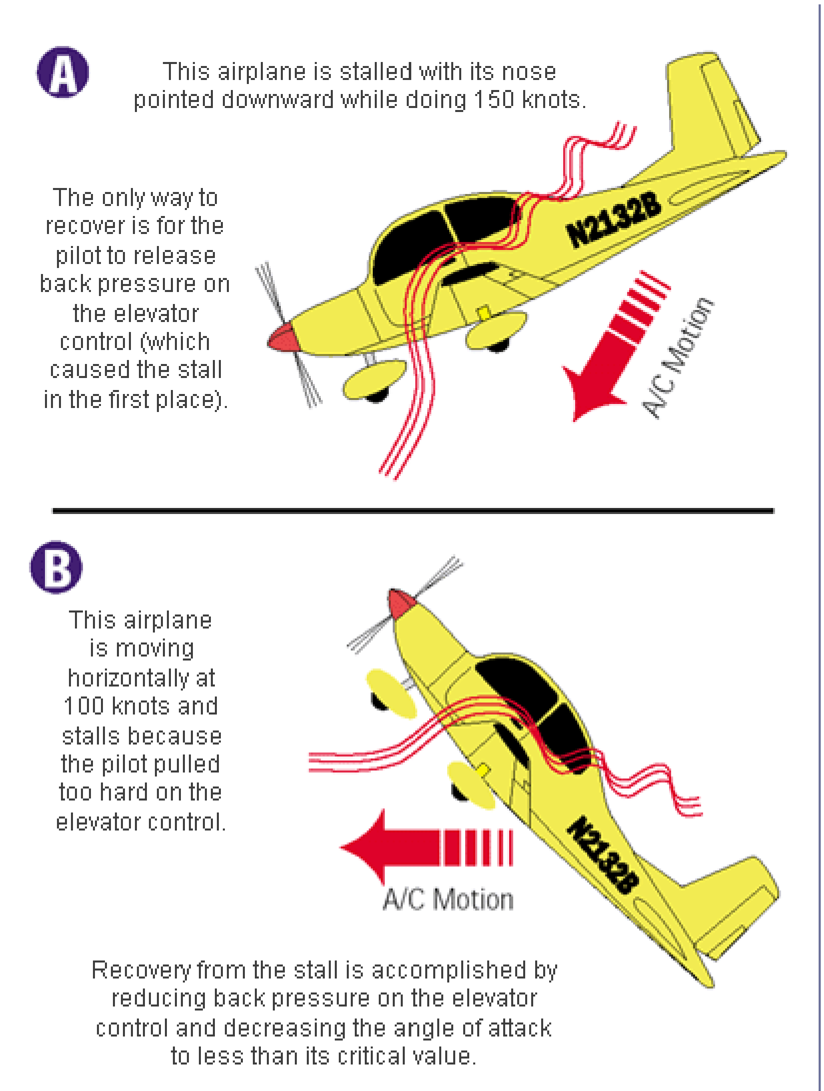


**Figure 1-4 Stall recovery when exceeding the critical angle of attack.**

Airplanes have inertia, meaning they want to keep on moving in the direction they are traveling. Airplane A is pointed nose down, diving at 150 knots (don't try this at home!). The pilot pulled back too aggressively, forcing the wings to exceed their critical angle of attack, and the airplane stalled. Wow! Imagine that. It stalls nose-down at 150 knots! Figure 1-4B shows an instance of an airplane stalling at 100 knots in level flight after the pilot pulled too abruptly on the elevator control.

What must the pilot do to recover? The first step is to decrease the angle of attack by moving the elevator control forward or by releasing back pressure on the joystick (remember, pulling back on the elevator control was probably responsible for the large angle of attack that induced the stall in the first place.) This re-establishes the smooth, high-velocity flow of air over the wings. The airplane is once again flying.

The second step (if necessary) requires applying all available power to accelerate the airplane and help reduce the angle of attack.

Once the airplane is no longer stalled, it should be put back in the desired attitude while making sure you don't stall again. Stalling after you've just recovered from a previous stall is known as a secondary stall. Unlike secondary school, it is not considered a step up, especially by the participating flight instructor. (You'll know your instructor is unhappy when you hear her make subtle statements like, "Hmm, come to think of it, childbirth wasn't all that painful.")

Stalling an airplane intentionally, at a safe altitude, is actually fun, or at least educational. Stalls are relatively gentle maneuvers in most airplanes. Stalling an airplane close to the ground, however, is serious business because it is usually not an intentional act. During flight training, you'll have ample practice in stall recovery.

Managing a stalled airplane is one thing; managing your natural instincts, however, is another. For example, a typical stall trap you could (literally) fall into involves a high sink rate (that is, a high rate of descent) during landing. While on approach, you might apply back pressure on the elevator attempting to shallow the descent. If you exceed the critical angle of attack, the airplane will stall. The runway now expands in your windshield like a low-orbit view of a supernova.

If you follow your untrained instincts and continue to pull backwards on the elevator, the stall deepens. Trained pilots know better.

They are aware of the possibility of stalling and apply the appropriate combination of elevator back pressure and power during landing to change the airplane's glide path without exceeding the critical angle of attack. (Your instructor will show you the appropriate use of elevator and power during landing). How do pilots know the proper amount of rearward movement to apply to the elevator? How do they know they won't stall the airplane?

If there was an angle-of-attack indicator in your airplane, stall recognition would be easy. You'd simply keep the angle of attack less than what's critical for that wing. Angle-of-attack indicators, although valuable, are rare in small airplanes. In Flight Simulator, the main clue you have to the onset of a stall is the stall horn, which will activate when you're a few knots above stall speed. You'll also have the luxury of seeing the word STALL appear on your screen. You won't have this in an actual airplane, of course. You may, however, have a red stall warning light activate, which is almost the same thing.

Now that you have a good foundation in stall aerodynamics, let's examine the details of stall recovery.

## Stop Flying; Start Stalling

Pulling way back on the joystick causes the wings to exceed their critical angle of attack and stall. During the stall, airflow burbles instead of flowing smoothly over the top of the wing. This results in insufficient lift for flight, causing the airplane to pitch forward (provided that the baggage, passengers, and fuel are loaded properly in the airplane). This automatic nose-down pitch is somewhat like doing the Heimlich maneuver on yourself; the airplane reduces its own angle of attack to less than the critical value and regains its ability to fly.

If airplanes are built to recover from stalls themselves, why do you need to learn any of this? The problem is that pilots often do things that prevent stall recovery. You need to know what these things are. Also, an accidental stall close to the ground requires that you know how to quickly recover in order to minimize your altitude loss. Let's try another stall, but this time, let's see what happens if you prevent the airplane from pitching forward on its own.

### Doing the Wrong Thing in a Stall

What happens if we stall and prevent the airplane from recovering from the stall?

The answer is that the airplane will remain stalled with the joystick held full aft (that's all the way back). It will not climb no matter how hard you pull on that joystick. Think about this carefully: You could remain stalled all the way to the ground while the joystick is pulled full aft, which doesn't bring you much joy, right? Holding the joystick full aft keeps the wing's angle of attack at or beyond its critical value. Unfortunately, this is what some pilots do after stalling an airplane.

### Doing the Right Thing in a Stall

That's why we learned that you must release any back pressure on that joystick and move it forward until the wings are at less than their critical angle of attack. The proper attitude for recovery is subject to many variables, so in the Interactive Lessons, we'll use a 5- to 10-degree nose-down pitch for simulator stall recoveries. You don't want an excessively steep nose-down attitude since it results in excessive altitude loss and airspeed increase.

How do you know if you've decreased the angle of attack sufficiently? In a simulator, you should experience these things: the stall horn stops blaring, the word STALL disappears from the screen, the airplane begins to fly again, the airspeed begins to increase, and the flight controls become more responsive. If your instructor were on board, his or her voice would also reduce in pitch, and whales would no longer be inclined to beach themselves.

With a few exceptions, this is the way pilots have always recognized stalls and recovered from them. You'll also want to add full power immediately after reducing the angle of attack. This helps accelerate the stall recovery process. Be careful not to let the nose pitch up as you add power. This might, once again, increase the angle of attack sufficiently to induce another stall. When the airplane is no longer stalled (that is, the stall horn stops blaring), raise the nose to climb attitude, and establish climb airspeed.

## Departure Stalls

What happens if you stall with full power already applied? Let's say that you've just lifted off from an airport and are climbing with full power (as you normally do in this airplane). Suddenly, you find a big bumblebee in the cockpit. You're distracted and forget to fly the airplane as you swat the critter with both hands. Of course, all your flailing in the air makes the cockpit look like the set of a kung fu movie as the airplane stalls. What do you do?

Well, Grasshopper, all the kung fu in the world won't help you now unless you do one thing: Reduce the wing's angle of attack to less than its critical value. Once the airplane is no longer stalled, you can recover back to climbing attitude. Don't worry about touching the throttle, since full power is already applied.

There you have it: your first introduction to the aerial theme park known as Stall World. The only problem, however, is that you didn't visit one corner of the park called Reality Land. Here's what you missed.

It's easy to remember that airplanes stall because they exceed their critical angle of attack. But don't forget that this can happen in any attitude, at any airspeed, and at any power setting. Time now for more truth.

In reality, if the airplane was pointed straight down and you pulled back hard enough on the controls, the airplane would stall. Of course, we wouldn't do this in the actual airplane (even if it was a rental). Remember, this is a simulator. We can do things you'd never dream of doing in a real airplane. It's like visiting Fantasy Land, in that we're not exposed to great risk in the demonstration. So we can take advantage of our technology and see what others only talk about and never actually do.

Now it's time for you practice stalls. Click the **Fly This Lesson Now** link to practice what you just learned. Have fun!

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