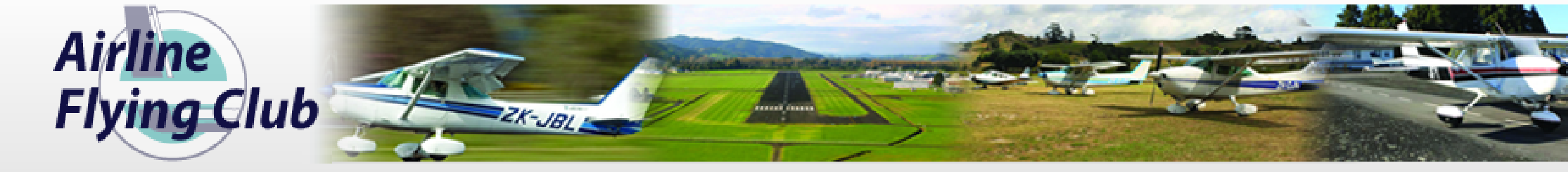



Pilot Knowledge Series

# The Sneaky Stall – Part 1

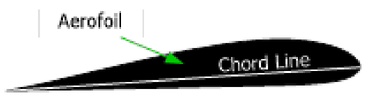
By Rob Knight

Some say that stalls are caused by flying at too low an airspeed. Others claim stalls happen when pilots try to climb too steeply. Yet others are simply so scared by the propaganda put out about stalling and its dangers they cannot overcome their trepidation and so never become conversant with them. What's the problem here? The actual cause of a stall is simple and should be well known; and stalls are predictable. Deliberate stalls are not dangerous. Pilot entered stalls are corrected/recovered from with simplistic ease and in complete safety. BUT....herein lies that all-so-important qualifying phrase – *deliberately entered stalls*. I cannot ever recall hearing or reading about any serious accident, or even an incident, involving a deliberately entered stall.

But stalls are sneaky. Stalls can appear at any time, at any speed; indeed almost a major 21st century mystery some would say. Obviously, stalls are no fairy-tale so let's take a realistic look at their simplicity and safety. Let's start by dispelling some myths.

Stalls really can occur at any airspeed, anywhere from an aeroplane's $V_{NE}$ (Note-1) down to a zero reading on the ASI. Stalls can also be experienced at any nose attitude, from vertical climb to vertical dive and anywhere in between. They can occur when an aeroplane is inverted in straight and level, or right-side-up. So is there any time when an aeroplane is safe from a stall? Can a pilot relax their vigilance? The answer is a resounding YES! An aeroplane is safe from a stall at any point in time when its angle of attack is less than the aerofoil's stalling angle. Generally, aerofoils (airfoils in Trumpland-talk) stall at about 15° angle of attack so, as long as the aeroplane's angle of attack is less than the 15°limit, the aeroplane simply cannot stall.

To better understand this we need to look at a couple of definitions. We said that the stall occurred because the angle of attack was too high i.e. greater than about 15°. The angle of attack is the angle between the chord line of the aerofoil and the relative airflow. So, what is an aerofoil? An aerofoil is the cross-sectional shape of a wing. A cross-section that displays the shapes and the curves of the upper and lower surfaces as shown above.



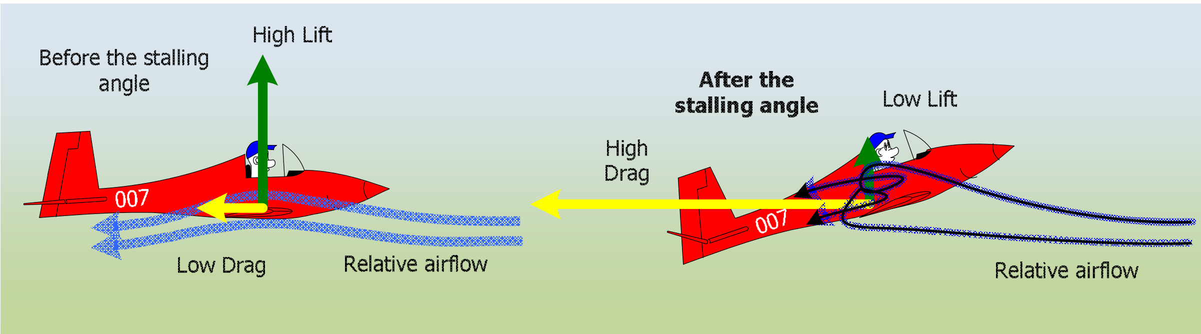

The chord line is a straight line joining the leading edge of an aerofoil as shown above and below.

The angle of attack is the angle made between the chord line and the relative airflow as shown on the right. If the angle of the chord line changes, OR the relative airflow changes direction, the angle of attack will change. In the illustration above, the angle of attack is about 4°, the angle of attack where the best lift/drag ratio occurs, and where the aerofoil is most efficient.


If the aeroplane stalls at 15° angle of attack, then we could call 14° the *critical angle* because, if we increase the angle any further, we will induce the aerofoil to stall.

Now the cause is ascertained, what actually happens when a stall physically occurs? The word stall is usually associated with something that stops and, in this sense, the same applies. However, what has stopped is not the aeroplane, but the smooth flow of air that passes over the upper surface of the aerofoil in normal flight. At the stall, the relatively smooth airflow over the aerofoil breaks away from the surface and tumbles in a series of eddies and swirling currents. As the previously relatively smooth airflow provided about 80% of the lift produced, so, at the stall, we will lose a very large proportion of lift.

So why does this air break away is the next obvious question? You are driving on a motorway and proceed around a bend. Doing 100 KPH, the time needed to drive around the bend is comfortable and there is no adverse effect caused by the vehicle mass to force you away from the curve. But what if you tried to drive around the curve at 200 KPH? It is quite possible that the vehicle will not be able to take the curve and will slide/skid/roll towards the outside of the curve and into the barrier positioned for that very purpose. The cause is that the inertia of the vehicle prevents it following the change in direction around the curve. The air behaves in the same fashion – the inertia of the air prevents it following the change in direction over the upper surface of the aerofoil aft of the point of maximum camber. And the air will behave in exactly the same manner as the vehicle. It, too, will not be able to take the bend and will "tumble/roll/spin out", breaking away into turbulent flows and eddies. Here's the simplicity of it – no smooth flow – much less lift and much more drag.

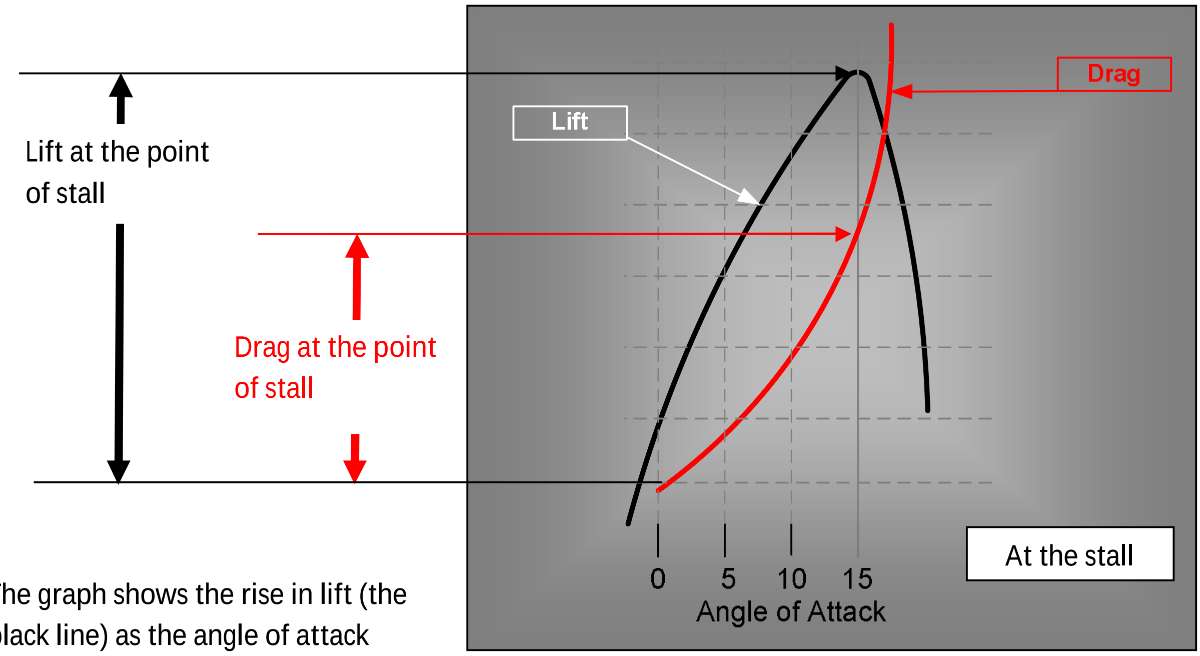



The change in lift and drag is indicated in the above sketch by the green and the yellow lines which clearly illustrate the magnitude of the change in lift and drag values.

The simplicity of the stall can now be easily seen. It is just the breakdown in smooth airflow over the wing into turbulent flow and it's caused by an angle of attack that is too great. Remove the excessive angle of attack and the aeroplane will resume normal flight – it really is as simple as that.

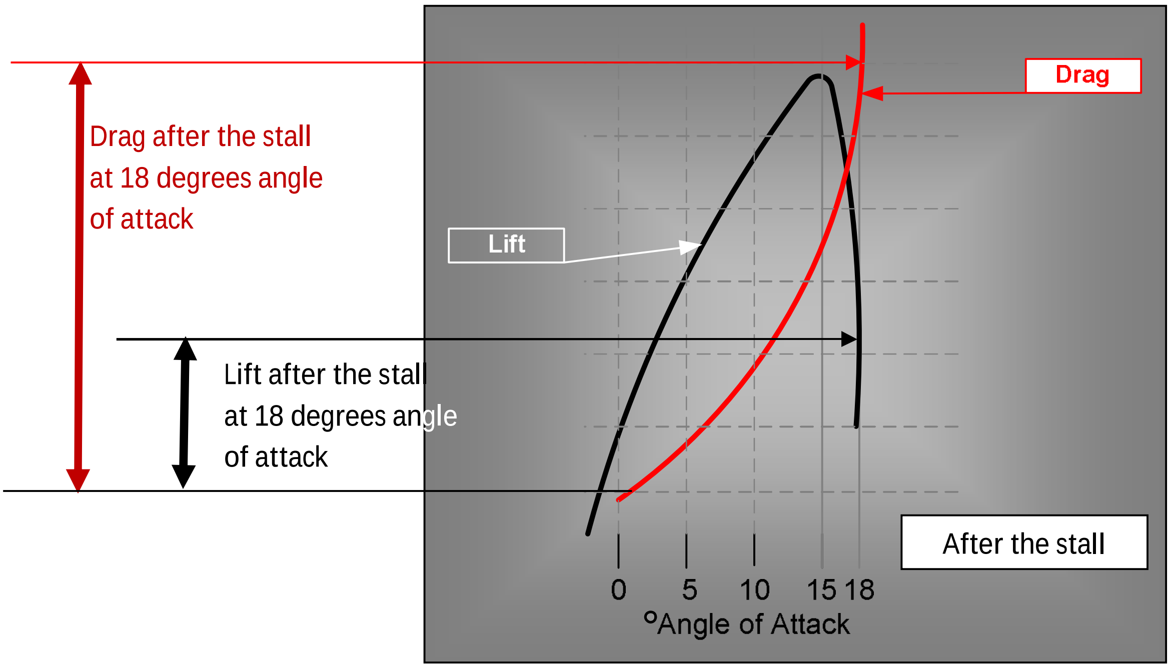
**The MOST likely pilot to need to have a good recovery technique is the pilot who NEVER does a stall because it is too frightening. If they are ever faced with an unexpected stick buffet they will not respond, just freeze. They will not instinctively check the stick forward. They have trained themselves that they don't ever stall so it just can't happen. How dangerous is THAT?**

Let's put some proportions in this change in lift and drag. Let's look at how the lift and the total drag on the aerofoil change with changing angle of attack. The easiest way to display this is on a graph. The graph displays the value changes in both lift and drag plotted against the angle of attack




The graph shows the rise in lift (the black line) as the angle of attack increases until, at 15°, the stall occurs. Notice how rapidly the lift decreases after the stall angle has been exceeded.

BUT… also notice how quickly the drag (the red line) soars upwards with the increasing angle of attack. At the stall angle its rise is almost exponential.



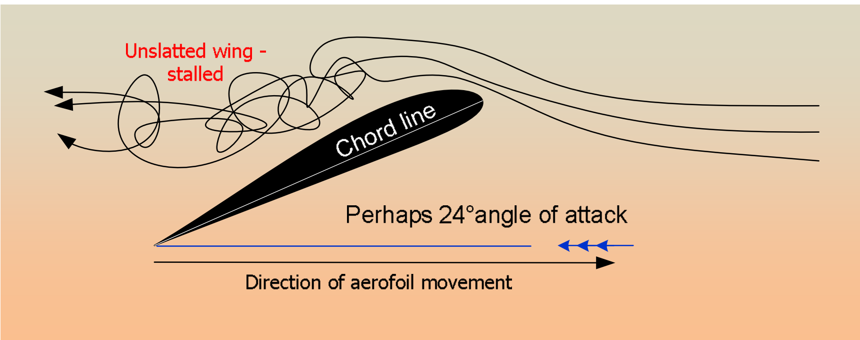

So what does this mean to a pilot? It means that, if you exceed the stalling angle of attack, the loss of lift may be savage, but the rise in drag can be extreme.

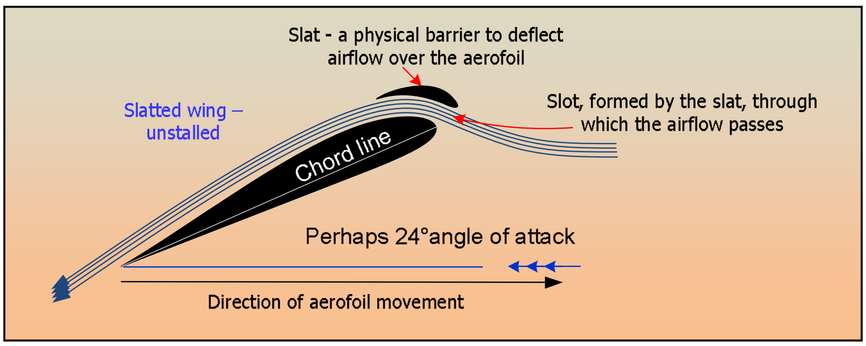
With all this emphasis on the stalling angle, where does the reference to stalling speed come from? That's the term that everyone's talking about. Alas, to consider that an aeroplane stalls at a stated airspeed is something of a misnomer, perhaps even a dangerous one. The often-flight-manual quoted stalling speed is the speed the aeroplane reaches the stalling angle of attack in straight and level flight when being flown by a test pilot, with no slip or skid, perhaps with power and all the available high lift devices applied. This is most often quoted as being applicable on approach which, of course, it can't be because it is in level flight where this speed is ascertained. As previously discussed, an aeroplane stalls at an angle of attack so an aeroplane can stall at any speed.

However, using the stall speed as a guide does have one attribute. It allows us to compare the effects of various high lift devices that we can apply to the aeroplane. For example, if we accept that an aeroplane stalls at 40 knots without flap or power applied, we can then see how effective the use of flap or power is to aid lift by noting how much slower we can fly before we reach the stalling angle. Thus, if the aeroplanes stalls at 38 knots with flap down, we can accept that we have a lower stall speed when the flaps are lowered. Not that it will always stall at 38 knots now the flaps are down, because it won't, just that we need less speed to fly with flaps lowered so we might have an increased safety margin.

We also talk about the stall speed because we don't have a simple means of measuring or seeing the angle of attack. Without a practical angle of attack indication, we use a rule of thumb system which, if we follow, should mean that we are not about to stall. Alas, the stall/crash statistics clearly indicate there needs to be a better understanding of the whole issue so a realistic appraisal can be made by pilots instead of feeling happy because their airspeed is above the stall speed. This will only assist SOMETIMES.

Earlier I used an analogy of a motorway with a physical metal barrier to stop vehicles leaving the roadway – the safety barrier. Slats are exactly the same thing and provided for the same reason – to force the airflow around the curve of the aerofoil and delay the stall until an angle of attack higher than the aforesaid 15° occurs. Slats can raise the stalling angle of attack to as much as 25°. Note that a slot is the gap between the wing and the slat, and that some wings have slots built into them so there is no drag-creating protuberance above the wing to kill cruise speed. Slats are not a new invention. They were fitted by de Havillands to Tiger Moths in the 1930s, and to airliners ever since then. Storch make great use of them to aid their



STOL capabilities, and Cessna 177 Cardinals have an inverted slot on the leading edge of their horizontal tail surfaces to delay the stall and thus improve pitch control when the stick is pulled right back.

Flaps vary from simple hinged surfaces to flap types that descend below the lower wing surfaces and extend rearwards to increase the wing area and provide slots as depicted above to prohibit the flaps stalling. These specifically are called Fowler flaps and excellent details are provided via the internet if one Googles *aircraft wing flaps, fowler flap, slotted flap, or jetted flap*. Fowler flaps can make very substantial changes to an aeroplane's slow speed flight profile but come with weight, complexity, and cost penalties.

Again – what does this mean to a pilot? It simply means that the aeroplane fitted with one or more of these high lift devices can fly in level flight at a lower speed. But don't be complacent – any aeroplane can and will stall, and will stall at any airspeed if the angle of attack exceeds the stalling angle of attack.

However, there are also other things that can change the stall speed. I refer to changing aeroplane weight. Not only does this include additional weight at take-off, but also loading[Note-2]. The greater the turn rate or rate of pull up from a dive, the greater will be the lift required from the wings, so the greater will be the stall speed. Flying the aeroplane with slip or skid will cause shielding over part of one of the wings and this, too, will provide a raised stalling speed. Imagine the scenario – a lovely day, set up on approach, descending through 600 feet AGL, turning from left base onto finals, add a bit more into-turn rudder to pull the nose around and, Oh, there's a bit of G load. Then a sudden buffet against the stick back pressure you're holding. What's that you wonder? Then, before you can answer your own question, the port wing just falls out of the sky. The aeroplane snaps and rolls in a fraction of a second. Now the nose is pointing vertically down. The left wing is still dropping – the world turns in front of your windscreen. With the nose so low all you can think to do is pull back on the stick to try and pull it up but it's not moving. The world is rotating even faster and the trees and buildings on the ground are screaming up to you…………

In Part 2 we will be looking at what happens to the aeroplane, its potential; movement and direction of motion changes, at and post stall.

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| Note-1 | Vne | Aeroplane never exceed speed |

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| Note-2 | Loading | An apparent increase in weight caused by the acceleration experienced by changing direction your flight path |

To be continued ..