# Stalls

What was your impression when you first heard that aeroplanes stall? Did you conjure a vision of an engine stopping and the aeroplane falling from the sky? And when you learnt that stalling was actually about the wings losing lift, did you then picture the aeroplane losing all its lift and plummeting earthwards like that iconic Australian predator Thylarctus Plummetus, aka the drop bear? And when you learnt stalls, practised them, and managed to pull them off in a flight test, did they still inspire some fear?

In the words of Apollo 8 commander Frank Borman, "a superior pilot uses his superior judgment to avoid situations which require the use of his superior skill". So if stalls still bother you, you'd like to take his advice and deal with stalls in this order:

- Awareness;
- Prevention;
- Recovery.

## Awareness

### Angle of attack

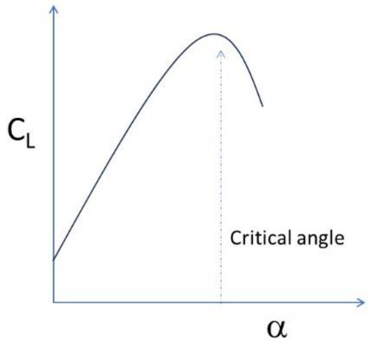
Stalling is not about speed. Once upon a time, in the early days of aviation, some pilots no doubt believed it was. Someone slowed down too much too close to the ground, the aeroplane stopped flying and a pilot died, so out went the commandment: "Thou shalt not fly too slowly, lest the earth should rise up and smite thee." But when pilots stalled in steep turns and pulling out of dives, it dawned on the smart ones that there was more to it than speed.

Question 1: What happens to lift when you increase the angle of attack ($\alpha$, or alpha) of a wing? If you instinctively said, "Lift increases", get down on the floor and do 10 push-ups as punishment. The correct answer is that it can increase, reduce, or stay the same depending on what else you're doing.

- Option 1: If you're slowing down because you'd rather fly at 80 kt than 110 kt in poor visibility, you reduce power, you lose speed, which means less lift, and you raise the nose to compensate, and maintain level flight. So you've increased $\alpha$, and total lift hasn't changed.
- Option 2: Level turn. Roll in, controls central, back pressure to increase lift to make up for the loss of vertical component of lift. So you've increased $\alpha$ and increased lift.
- Option 3: You slow down as in Option 1, raise the nose a bit but not enough to maintain level flight. So you've increased $\alpha$ but lost lift.

Now, who remembers the lift formula? Lift = $C_L \frac{1}{2} \rho V^2 S$.

$\rho$ is air density, V is TAS, and S is wing surface area. The one we're going to talk about here is $C_L$ – the **coefficient of lift.** It's a measure of the lifting ability of the wing. It includes all the other factors apart from $\rho$, V and S that affect the lift a wing generates, including camber (which we vary when we move the control surfaces), high-lift devices such as flaps and slats and vortex generators, and of course angle of attack. The little graph below shows the relationship between $\alpha$ and $C_L$. Up to the **critical angle**, if you increase $\alpha$ you'll increase the **coefficient of lift.** Whether that increases your **total lift** depends on what else is happening, such as in Options 1, 2 and 3.




But once you increase $\alpha$ beyond the critical angle, which in a typical light GA aeroplane is about 16°, you'll get less lift no matter what else you do. So while increasing $\alpha$ up to the critical angle can give you Option 1, 2 or 3 above, once you increase $\alpha$ past the critical angle, all you'll get is Option 3. The airflow has separated from the wing. There's still lift, which is why you don't fall out of the sky, but not enough lift to stay level.

## Stall speed

Question 2: What is the stall speed ($V_S$) of the aeroplane you fly most often? If you instinctively came up with a number, you're now up to 20 push-ups. As for Question 1, the correct answer is that it depends.

You can stall at any speed and any attitude – any time you increase the angle of attack beyond the critical angle, including (but not limited to) straight and level, climbing, in a turn, or pulling out of a loop. That lift formula is a good way to understand how stall speed changes. If you change the total amount of lift required, then something that produces lift – something in the "$C_L ½ \rho V^2 S$" – has to change. Some simple examples:

- If you fly straight and level, stall speed doesn't change. If you lower flaps, you change camber and so you increase $C_L$. That means something else in the "$C_L ½ \rho V^2 S$" will reduce to make up for it. So at, say, 4° angle of attack you'll only need 95 kt instead of 100 kt, and at 16° angle of attack you'll need 41 kt instead of 45 kt. If you need less speed at 16° α, that means stall speed ($V_S$) is lower.
- In a level turn, you need more lift. At 16°, you'll need more lift. Stall speed is higher.
- If you're heavier, you need more lift. At 16°, you'll need more lift. Stall speed is higher.

## How do you know you've stalled?

Control buffet and a stall warning horn are not signs that you've stalled; they're warning signs that you're about to stall if you don't do something about it.

The typical stall symptoms that we teach at RPL level are:

- Nose drops;
- You lose height;
- You may get a wing drop.

But does that always happen? In our nice stable, docile, forgiving club aeroplane, that really doesn't want to stall, you can get back to stall speed and the nose just won't pitch down. But you're drifting down, losing height despite your best efforts to hold the nose up. Your elevator isn't responding. You're stalled. Time to recover.

## Prevention

So much for the theory of it all. As long as you understand that it's angle of attack and not speed that's the critical factor, you just need to avoid increasing $\alpha$ beyond the critical angle. Okay, that's easy, but in what scenarios can $\alpha$ get dangerously high, and in what scenarios might you feel the need to increase $\alpha$ and get too close to that critical angle? They're the scenarios you want to avoid. Here are some scenarios that have caused stalls:

- Overshooting the turn on to final, and either pulling too hard into a steep turn, or using rudder instead of aileron because your instructor told you to never ever exceed 30° bank turning final, so you're pushing the nose towards the ground, so you pull up. Correct option: go around.
- Engine failure after take-off. Get the nose down immediately. Maintain best glide speed, and even if you fall short of the paddock, you'll touch down in controlled flight, which you will almost certainly survive. If you raise the nose trying to stretch the glide, and you stall and hit the ground in uncontrolled flight, you will probably be a statistic.
- Going around with full flap and lots of nose-up trim, and allowing the nose to get too high when you apply full power. Be ready for it, keep your eyes outside, and push!
- Steep turns down low, where stall speed increases, drag increases so your speed reduces if you don't add enough power (that's why you add power in a steep turn – not for lift, but to overcome drag), and the two speeds meet without enough height to recover. This was what the ATSB found as the cause of the crash of the Grumman Mallard into the Swan River during the 2017 Skyshow. And at the risk of boring you dear reader, with another "There I was" moment, those club members who trained at Pearce back in the 80s will remember doing 60° bank turns at 200 ft AGL, but at 240 kt we were comfortably (by about 100 kt) above the 2g stall speed, with nowhere near full power. Save your steep turns for when you have a good bit of air underneath you.

Of all the possible stall scenarios, note the above are ones that happen close to the ground, with limited height to recover. If you stall in a steep turn or in an aero at 4000 ft AGL, big deal. Recover the thing and have another crack at it!

## Recovery

Awareness and prevention are better than recovery. If you've inadvertently stalled and you're at the recovery stage, you're already stressed, and we all know what that does to performance.

If you've stalled, you need to reattach the airflow to the wing. That means you need to reduce the angle of attack. That's the most important thing – more important than gaining speed or minimising height loss or preventing yaw. Take a scenario where, for a reason you'll have a lot of trouble explaining in the bar, you stall 300 ft above the ground. At that height, pushing the nose down is a very counter-intuitive thing to do, but that's what you need to do to unstall the wing. As US instructor and author Rich Stowell said in a recent discussion with podcast specialist Trent Robinson, you can afford to lose 299 feet doing that, because if you don't reattach the airflow to the wing, and thereby regain control of the aeroplane, nothing else matters.

If you've stalled with the nose above the horizon, you typically don't need to lower the nose anywhere below a straight and level attitude. Full power will help to minimise height loss, but if you apply full power and stick the nose below the horizon, that's a dive, which is not minimising height loss. If you've stalled in a nose-low attitude, lower the nose, unstall the wing first, and only then get the nose up, apply full power as the nose comes above the horizon, and get yourself climbing.

The other thing we all learnt in basic stalling was the idea of one wing stalling before the other, and dealing with a wing drop. While the wing is stalled, aileron won't help you, and in some aeroplanes (but not a 172) it will even punish you. Opposite rudder is the go. And remember what rudder does – picking up a wing means rolling, and rudder doesn't do that. The secondary effect of roll is yaw, which if left unchecked, leads to roll, then yaw, then roll, then yaw, then a spin. Applying opposite rudder doesn't pick up a dropped wing, but it stops the roll from turning into a spin. Once you're unstalled, then you can use aileron and level the wings.

And if you're going to practise them (which of course most people only bother to do when their instructor demands it in a Flight Review), don't forget to check it's safe to do it. The list we teach is HASELL:

- Height – enough to recover by 3000 ft AGL, so in our training area you want to be at least 4000 ft on the altimeter;
- Airframe – flaps up, gear up if it's not down and bolted;
- Security – nothing loose in the cabin;
- Engine – a normal 10-minute T's and P's check;
- Location – over a clear area, away from airfields, built-up areas and cloud;
- Lookout – a nice wingover in a low-wing aeroplane, or in a high-wing a couple of normal medium turns through 90° to check underneath you, since you're about to lose height.

Forgetting those in a flight test will probably cost you the test, and in a Flight Review it will cost you a 6-pack!

## Thanks

And finally, thanks to all those who turned up last month to help me mark 20 years of instructing at the club. It's good to feel valued! Special thanks to Dave the barman, and Marg, Heather and Sue for their catering.