Angle of Bank, Load Factor, and Stalls

To make an airplane turn, you establish an angle of bank with the ailerons and then apply up elevator as needed to maintain a level turn. Everybody knows this. But what happens if you overdo it? You bank too steeply, pull on the elevator too much, and suddenly your plane is out of control – a tip stall.

In a steep turn, the wing must provide considerably more lift than in level flight. In a 60 degree bank, for example, the lift must be two times as much just to maintain altitude. We say the **load factor** in this case is 2, or we might say it's a two-g turn. In effect, the plane becomes twice as heavy and the stall speed increases as you would expect for a heavier plane.

The wing loading is affected as well. It is multiplied by the load factor. If a relatively light plane has a wing loading of 10 ounces per square foot, it will become 20 ounces per square foot in a 60 degree bank. This is getting on the heavy side, and it will fly like a heavy plane while it is in the turn.

We can calculate a **speed multiplier** to find how much the speed must be increased in order to maintain the same angle of attack that you had going into the turn. It is the square root of the load factor. For a 60 degree bank, it is the square root of 2, which is 1.414. If the stall speed in level flight is 30 mph, it will be 30 x 1.414 = 42 mph in a 60 degree bank.

The following chart gives the load factor and speed multiplier for various angles of bank. Details of the calculations are given below.

Angle of Bank, A	Load Factor	Speed Multiplier
0	1.00	1.0
15	1.04	1.02
30	1.15	1.07
45	1.41	1.19
60	2.00	1.41
70	2.92	1.71
75	3.86	1.96
80	5.76	2.40
85	11.47	3.39

Note: For a bank angle of 90 degrees, both the load factor and the speed multiplier are infinite.

Observe that there is not much effect for bank angles of 30 degrees or less, but as you reach 45 degrees and beyond, it increases dramatically. At 76 degrees (not shown in the chart) the load factor is over 4 and the speed multiplier is more than 2.

How to deal with the load factor

First, and obviously, try to avoid bank angles of more then 30 degrees. This is particularly important as you are setting up for a landing, slowing down, and getting ready to make the turns onto base and final.

If you are planning to do a steep turn, be sure to have plenty of speed going into the turn. If you are just above stall speed going in, a stall is quite likely as you apply elevator to try to maintain altitude.

If you are making a slow-speed, high-alpha pass down the runway, be sure to add power before making any turn at the end. A good mantra, no matter where you are, is “Steep turn . . . add power.” This doesn’t mean you have to go full throttle; just a little is often all you need.

The load factors and speed multipliers given above only apply to level turns in which you apply up elevator to increase the lift. If you bank into a steep turn without applying up elevator, no load factor will come into play but the nose will drop and you may lose altitude rather quickly. The plane may even pick up speed as it dives toward the earth, but it will not stall.

There is some middle ground. If you’re turning base to final, for example, and need to make a fairly steep turn, you can let the plane descend during the turn by applying only enough elevator to stabilize the descent. It is really risky to apply a lot of up elevator during the turn from base to final. If you get in a tight spot, apply full power, climb out, and go around for another try.

Question: Can you avoid the load factor and its consequences by doing a flat turn where you apply excessive rudder while holding a shallow angle of bank? This does not work very well. You may avoid the load factor but your plane will not turn efficiently at all. Further, the plane will be in a skidding turn and probably cross-controlled, and this sets the stage for an ugly stall.

Formulas and Examples

If you have access to a scientific calculator and are so inclined, you can calculate the load factor and speed multiplier for any angle of bank you wish. Here is the procedure:

(1) Select an angle of bank in degrees. Call it A.

(2) Use a scientific calculator to find Cos A (the cosine of angle A).

(3) Take the reciprocal of Cos A. This is the load factor.

(4) Take the square root of the load factor to get the speed multiplier.

Example 1

Assume a bank angle of 40 degrees.

Cos 40 = 0.766

Load factor = 1/0.766 = 1.305

Speed multiplier = Square root of 1.305 = 1.14

Example 2

Assume a bank angle of 65 degrees.

Cos 65 = 0.423

Load factor = 1/0.423 = 2.37

Speed multiplier = Square root of 2.37 = 1.54

Example 3

Assume a bank angle of 88 degrees.

Cos 88 = 0.0349

Load factor = 1/0.0349 = 28.65

Speed multiplier = Square root of 28.65 = 5.35

Final Exam

A plane with a wing loading of 11 ounces per square foot has a stall speed of 28 mph in level flight. It is placed in a steep turn at a bank angle of 65 degrees. While the plane is in the turn,

(a) What is the load factor?

(b) What is the effective wing loading?

(c) What is the stall speed?

Answers: 2.366; 26 oz per square foot; 43 mph.