Accident Prevention Program

SAFE FLYING FOR AGRICULTURAL AVIATION

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The basic safety elements, method for executing an applicator swath run and turnaround at the end of a swath run, are discussed in the following paragraphs.

The turn-around procedure is based on the flight performance of the particular airplane being flown, and is a safe, conservative method that allows for a considerable margin of error which may arise from pilot fatigue and other operational hazards which may confront the aerial applicator pilot during the course of flying.

This discussion is not a cure-all for poor operational practices, such as failing to look over a field for obstructions before beginning operations in the field, not taking every precaution for the safe handling of chemicals, improper design and maintenance of equipment, and the lack of good common sense and judgment. It is a method of flying combined with airplane performance that will give a constant, safe flight performance which, when combined with other practices, will lead to a safe and sane operation.

In the past, during the turnaround, speed has usually been considered the safest thing a pilot could have. It was like having money in the bank. This notion has not always been correct as we will attempt to demonstrate. A safe speed, coupled with altitude, allows for a much safer margin during a turnaround. By safe speed, we mean speed above the stall speed in relation to the load being carried, the angle of bank, and the time involved in turning around at the end of a field.

We think you will agree that speed high above stall speed will require a greater time to complete the turnaround, and require a greater angle of bank to turn within a specified area, which is necessary in order not to overshoot the next swath run. By increasing the angle of bank we increase the stall speed, therefore, our overall airspeed is not a good criteria for safety, especially when we confine the turning radius to a small area such as is necessary in aerial application.

The following table shows the speed required for various angles of bank, the radius of turn for various angles of bank, and the time necessary to complete 270 degrees of turn with the various angles of bank. Essentially, 270 degrees of turn is the aerial applicator turn - 45 degrees turn downwind, reverse the turn for 225 degrees to return to the new swath run. The airplane chosen for this chart could be flown safely at a minimum speed of 60 mph.

Angle of bank	0 deg.	15 deg.	30 deg.	45 deg.	60 deg.
Ratio of lift	1.0	1.04	1.15	1.41	2.0

Speed required	60	61.7	64.5	71.3	85
Radius of turn	--	940 ft.	485 ft.	340 ft.	280 ft.
Time to turn 270 deg.	--	49 sec.	24 sec.	15.4 sec.	10.6 sec.
Added time for banking and unbanking	--	2 sec.	4 sec.	6.4 sec.	8.0 sec.
Total Turn Time	**--**	**51 sec.**	**28 sec.**	**21.4 sec.**	**18.6 sec.**

From this chart, you may readily see that the best angles of bank for aerial applicator turns fall between 30 and 45 degrees. Using these banks, one has not materially increased the stalling speed and the time required to execute the turn is quite acceptable.

Note that a 30 degree bank, on this airplane, has only increased the safe speed 4.5 mph, and the time required to execute the turn 6.6 seconds; a 60 degree bank has raised the safe speed 25 mph and only cut the time required for the turn 2.8 seconds. It appears that any banks above 45 degrees yield very small gains for the hazards involved.

The question is how may we clear obstructions at the end of a field and safely execute a turn at speeds slower than we have considered safe in the past? The answer lies in knowing a little about airplane performance and the basis for it, and a lot about the performance of the airplane you happen to be flying.

Airplane performance is based on many factors, such as wing loading, power loading, temperature, humidity, altitude, etc. These are factors over which you are not able to exercise a great deal of control. You then want to know what may you do to make your flying safer and get to know your airplane performance better. There are a number of things you can do which, when completed, will have taught you almost exactly what your airplane will do loaded and with all of the distributing apparatus hung on it.

We have to begin somewhere so we will start with standard air. Standard air is 59 degrees Fahrenheit. Standard air temperature decreases 3.6 degrees Fahrenheit per 1,000 feet of altitude, and from this we can compute standard air for any altitude we wish.

0 feet	59.0 deg. F
500 feet	57.2 deg. F
1000 feet	55.4 deg. F
1500 feet	53.6 deg. F
2000 feet	51.8 deg. F
2500 feet	50.0 deg. F
3000 feet	48.2 deg. F
3500 feet	46.4 deg. F
4000 feet	44.6 deg. F

4500 feet	42.8 deg. F
5000 feet	41.0 deg. F
5500 feet	39.2 deg. F
6000 feet	37.4 deg. F
6500 feet	35.6 deg. F
7000 feet	33.8 deg. F
7500 feet	32.0 deg. F
8000 feet	30.2 deg. F
8500 feet	28.4 deg. F

You may say, "So What," to this. Well, hold on a minute and we will show you the so what, but remember this standard air chart. It's a neck saver!

Now, the next item is to dust off Ye Old Duster or Sprayer and let's see what it will do. First, let's pick a day that is calm and the temperature is as close to standard air as possible for your airport elevation. Use the chart we have just discussed. Tune up the engine and check over the airplane, so that you are sure everything is up to snuff. Then fill it up with the maximum load it will carry. Take off and climb up to about 1,500 feet, level out and see how fast it will fly at cruising power. Make a note of the speed on a slip of paper. Now keep cruising power and pull up into a very gradual climb, until you reach a point where the airplane will no longer climb, will not lose altitude, and will not stall. In other words, you are flying as slowly as possible, at cruise power, without losing or gaining altitude or stalling. Make a note of this speed.

While you are up, you might as well practice stalls, etc., to brush off the barnacles. While you are practicing stalls, gradually increase the angle of attack and decrease the speed slowly until stall occurs and see what happens. The stall you get will surprise you and is essentially the stall that occurs during pull-ups from swath runs, and in turnarounds. Also, stall the airplane in the same way out of climbing turns and level flat turns with a little bottom rudder, then top rudder, and see how easy the airplane will snap under or over the top into a spin, if you are not nimble on the controls. This little trick, I think, will dispel any ideas about uncoordinated turns which you may have.

While you are practicing stalls, try jamming on full throttle during the recovery while holding the stick full back until aircraft drops to level flight attitude, then try leaving the throttle exactly as set during the recovery while smoothly easing aircraft down to level flight attitude, and notice the difference in the loss of altitude. You will find that by leaving the throttle set as is, will allow a recovery from a stall with noticeably less loss of altitude. If you don't believe this, try it again at around 300 to 400 feet altitude where small changes in altitude are very noticeable. This is where the aerial applicator stalls with less than 100 feet altitude so your stall recovery technique is of prime importance, second only to stall detection.

There are two prime reasons for not using full throttle until after the stall has been broken and recovery is on the way. The first is called P1 effect and has to do with the airblast from the propeller over the center section of the wing. Violent increases in rpm momentarily disturb this airflow over the center section causing further loss of lift and further stalling. The other reason is that the sudden increased slipstream speed strikes the elevators, which are deflected upward, causing a slight pitching upward of the nose, therefore increasing the angle of attack, which is already at the angle for stalling, and further stalls the wing. Remember - NEVER blast the throttle at the moment of stall. Drop to level flight attitude, and when you are flying again, then smartly open the throttle, but NEVER jam it open.

After you have finished your little flight, let's see what you have done besides practice and perhaps learned something new about stalls. You have found out how slow and how fast your airplane will fly at a given power setting and load. This is called V minimum and V maximum, in the engineer's language.

What good will this do us? Plenty. You have taken the first step in determining the performance of your airplane. Now the next step is mathematical. You wish to determine the best angle of climb speed to be used in takeoff and climbing out of fields. The best angle of climb speed is also the best angle of glide speed, so when you compute this piece of data you will kill two birds with one stone.

Take the V minimum speed and subtract it from the V maximum speed, then take one-third of this sum and add it to the V minimum speed. The total will be the best angle of climb speed for your airplane, loaded and ready for spraying.

Example:

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V Minimum      50 mph
V Maximum       90 mph
Sum            40 mph Difference

1/3 of 40 equals 13-1/3 mph
V Minimum       50
                 63 mph.  Call it 65 mph because that is easy to read
                           on the airspeed indicator.
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Now let us take our loaded airplane aloft again and practice climbs from level flight until we have fixed in our minds the angle of attack necessary to produce this best angle of climb speed. Gradually get away from the airspeed indicator and more to the angle of attack and power setting required to produce this airspeed. Soon you will be able to set the desired angle of attack and the airspeed will automatically take care of itself. Remember - a stall cannot occur until the angle of attack has been increased to the point where the airflow is disturbed sufficiently that lift is lost. If you do not produce the angle of attack for a stall, the airplane will not stall.

Perhaps you will think the angle of attack is excessively steep, but remember this, the airplane is able to continue to climb indefinitely at this best angle of climb speed, that you are flying 15 mph above the V minimum speed, and actually about 20 mph above a stall. If the engine quits, all you have to do is lower the nose (reduce angle of attack) to the best angle of glide speed (best gliding angle of attack) and you are all set to glide for a forced landing, plenty of speed, no excess, just the right amount for the best possible glide.

Now, how does this apply to a spray or dusting run and turnaround at the end of the field? Well, let's see. Let's put what we have learned to use. Make a run across a field at 80 mph. When we have come to the end, place the airplane in the best angle of climb speed angle of attack. You will climb very rapidly, because you have excess speed and are climbing at the best angle of climb for clearing obstructions. When obstructions are cleared, turn 45 degrees downwind while still climbing at best angle of climb angle of attack. After turning 45 degrees, reverse your turn. Here you will note that your airspeed will have settled down to the best angle of climb speed, the nose of the airplane will have a natural tendency to lower, and you are at a very good speed for turning, so let the nose lover to a level turn and roll into about a 30 to 40 degree angle of bank, and complete your turnaround. You will find that you will turn around quickly, lineup with the next swath very easily, have gained from 100 to 150 feet altitude, be at a very safe speed and angle of attack, and have an excellent downward view into the field and next swath. After completing your turn, lower the nose, and as you descend into your next swath and level out, you will find that the airplane will fall right into the desired swath speed.

Repeat this procedure at the other end of the field. With a little practice, you will find you have developed a procedure and timing that will gain you maximum safe performance which can be repeated almost mechanically at each turnaround point.

The next question you are asking is how can this performance be maintained through various temperatures and altitudes during takeoff? The answer is by reducing the load, but how much reduction in load is the $64 question. Guessing is not very accurate.

First, let us see how our airplane performs for takeoff. Go back to standard air for your airport and a calm day and let's measure takeoff performance. Let's take a sod, rough portion of the airport, for this test, because that will more nearly demonstrate the airplane performance under the conditions you usually find in actual operation. Pick out a section about 1,200 feet long and place a stake every 100 feet. Paint the footage on these stakes so you can see them during takeoff. Now take your loaded airplane to the end of the runway, open the throttle, and takeoff. Don't pulloff, just let the plane fly off normally, level out, accelerate to the best angle of climb speed, place the best angle of climb speed angle of attack on the airplane and climb to 50 feet altitude. Note the distance it took the airplane to become airborne and the distance to clear a 50-foot obstacle.

Repeat this performance several times so that you are sure of the performance figures you have just obtained; for you have obtained the takeoff and obstacle clearing performance figures for your loaded airplane at standard air for your airport in a calm wind.

You are probably saying, "but we usually have a wind under actual operation conditions." This is true and wind will shorten your takeoff run, if you takeoff into the wind. But remember, under most conditions, your spray turns are crosswind and wind will be of little assistance to you here. So, in the overall picture, we might as well forget wind unless you are forced to spray up and downwind. In this case, be careful on the downwind pullup and be very lightly loaded.

Now back to takeoff performance and how we can maintain this performance through wide ranges of temperature and altitude, and also maintain our performance through spray runs and turnarounds.

There is a simple rule of thumb which comes into being at this point. Simply stated, it is as follows: "Reduce the load 1-1/4 pounds per 1,000 pounds of gross weight of airplane for each degree of temperature above standard air."

Example: During our test, we found the airplane weighed 4,000 pounds when fully loaded and carried 600 pounds at our airport, which was 2,500 feet above sea level and the standard air was 50 degrees. Our tests which we ran showed that the airplane would takeoff and climb to 50 feet at best angle of climb speed in 1,000 feet. How can we maintain the performance when the airport elevation is 5,000 feet and the temperature is 90 degrees Fahrenheit? Standard air for 5,000 feet elevation is 41 degrees. The difference between standard air and 90 degrees is 49 degrees. We unload 1-1/4 pounds per 1,000 pounds of gross weight of airplane for each degree above standard air temperature at your location, or 4 x 1-1/4 equals 5 pounds x 49 degrees (this is the difference in degrees between standard air temperature and actual temperature at your location), which equals 245 pounds, the amount we should lighten the airplane to maintain the performance we had at our home airport at standard air.

Now, obviously, we cannot stop to compute this as the temperature rises during the day or we move to higher or lower elevations, but we can make a loading chart which will show how much load in pounds or gallons to place in the plane for any given set of circumstances. Such a chart is easy to construct, and with the investment in a good thermometer the answer can be obtained very quickly.

All of this may sound a little complicated to you. It isn't. It is very simple and with very little study and a couple of practice problems worked out, you will be able to make a loading chart for your particular airplane in about one evening of work.

This loading chart applies to the exampled 4000 pound gross load
Aircraft with a 600 pound payload
Read figures right and down. Top figure=pounds, lower figure=gallons (at 8 pounds per gallon)

Temperature in Fahrenheit														
		40	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**	**105**	**110**

Altitude	**500**	600 75	600 75	600 75	600 75	591 74	566 71	541 67	516 64	491 61	466 58	441 55	416 52	391 47	366 45	341 42
	1000	600 75	600 75	600 75	600 75	577 72	552 69	527 66	502 62	477 59	452 56	427 53	402 50	377 47	352 44	327 40
	1500	600 75	600 75	600 75	593 74	568 70	543 68	518 64	493 61	468 58	443 55	418 52	393 49	368 46	343 43	318 39
	2000	600 75	600 75	600 75	584 73	559 69	534 66	509 63	484 60	459 57	434 55	409 51	384 48	359 44	334 42	309 38
	2500	600 75	600 75	600 75	575 72	550 68	525 65	500 62	475 59	450 56	425 53	400 50	375 47	350 43	325 40	300 37
	3000	600 75	600 75	591 74	566 71	541 67	516 64	491 61	466 58	441 55	416 52	391 49	366 46	341 42	316 39	291 36
	3500	600 75	600 75	582 73	557 69	532 66	507 63	482 60	457 57	432 54	407 51	382 48	357 45	332 41	307 38	282 35
	4000	600 75	598 74	573 72	548 69	523 64	498 62	473 59	448 56	423 53	398 50	373 47	348 43	323 40	298 37	273 34
	4500	600 75	588 73	563 70	538 67	513 64	488 61	463 58	438 55	413 52	388 49	363 45	338 42	313 39	288 36	263 33
	5000	600 75	580 72	555 69	530 66	505 63	480 60	455 57	430 54	405 51	380 47	355 44	330 41	305 38	280 35	255 32

One evening's work is small compared to the disastrous results of being so heavily loaded that you get into ground effect and dribble off the runway into the woods, or pullup at the end of a spray run and mush through some trees or a powerline. This chart will help solve these problems.

In closing, I wish to emphasize the use of shoulder harness and a good crash helmet. The shoulder harness must be anchored to the major, structure of the airplane or it is of little value. Crash helmets can be made comfortable by obtaining the proper size and making adjustments to the head lining.

Unless the cockpit is pressurized, you should be wearing a good, approved respirator.

Flying is a discipline...
safety is an attitude.

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