Europa Stall Spin Evaluation

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The intent of this document it to expand my previous flight stall test findings in the construction and flight test of numerous Europa Kit Aircraft, Classic and XS. This paper will go over the stall characteristics of a properly built and rigged aircraft. I will then attempt to expose some improper techniques which endanger the rusty or undertrained pilot when maneuvering near the stall angle of attack in a properly built aircraft. Finally, I will touch on some techniques to make the Europa stall characteristics more benign, then how to improve the rig and trim to improve a Europa which may exhibit "non-standard" stall characteristics.

The Europa Characteristics:

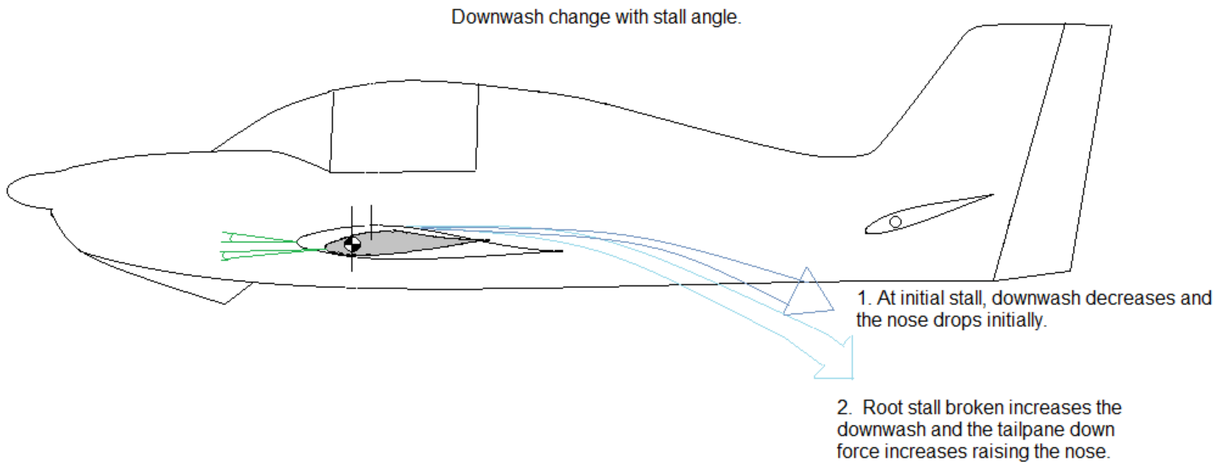
The Europa Kit aircraft has a modified laminar flow wing of mild camber for high speed cruise with a leading edge modification to improve low speed stall warning and break. The wing has a mild taper and twist added to the wing to allow a smooth progression of the stall from the root to the tip during the stall. Wing area is slightly over 100 square feet and at a maneuvering weight of about 1300 pound and a nominal 59-61 inch CG range will stall clean at nominally 49 KIAS, and with 27 degrees of flaps will stall at nominally 45KIAS. Nothing new there.

The layout of the longitudinal stability sets the main wing incidence at about 2.5 degrees positive to the longitudinal axis and the stab nominally at 0 degrees to the longitudinal axis. Pitch stability is positive in that the CG is slightly forward of the center of lift indicating the pitch stability is positive and dynamic stability is near deadbeat (rapidly corrects to pitch disturbance). The wing dihedral is nominally 2.5 degrees and the sweep is zero. Roll stability is near neutral/positive (holds its initial roll without needing additional roll correction and slowly begins a side slip which eventually rolls the aircraft toward wings level rather than diverging deeper in bank). With the wing center of lift near the CG the pitch and roll stability and yaw roll coupling are delightful. By that I mean a slight amount of rudder induces a slow controllable roll toward the rudder direction (i.e. right rudder induces right roll).

Warning: Stalls or high angle of attack maneuvering should be conducted at a safe altitude not below 3000 AGL and be done by an experienced pilot first in the test phase.

Armed with that knowledge I will look at the typical Europa Stall from the initial root stall to the full wing stall. Then I will introduce yaw/roll in and deeply in the stall. First the drawing below. Here the tip and root sections are depicted at the point where the root of the wing begins to stall. In 1 below the root is stalled, the stalled root reduces the downwash angle and the downward force of the stabilator. The initial tendency is for the disturbed or stalled root air will impact the stabilator transmitting a small but noticeable rumble through the airframe and due to the change in downwash the nose will begin to drop.

In 2 below shows as the nose begins to drop the main wing root section is unloaded and the stall is partially broken (rumble still present) and the nose begins to rise as the stabilator negative angle of attack is increased causing a slight nose rise. This nose rise is quite fast and the untrained or desensitized pilot may pull additional back stick increasing the angle of attack just as the wing goes slightly beyond the original stall angle (that is the delta of nose rise shown). As the root again stalls the nose drops abruptly and the process of nose drop than rise repeats. Any additional back pressure at this point may accelerate the stall causing a more rapid root to tip stall.



NOTE: RECOVERY OF THE AIRCRAFT STALL SHOULD BE AT THE FIRST INDICATION OF AIRFRAME BUFFET DURING RECURRING STALL PRACTICE RATHER THAN DEEP STALL EXERCISES.

In a properly built Europa I am normally at about 1300-1350 pounds during testing and am able to use rudder, elevator, and NO AILERON, to bring the stick back to the stop and continue with a full aft stick deep stall. Many clients find this deep stall uncomfortable as the nose up and down bobble can get quite aggressive, and the airframe shutter is very pronounced. Then as the root section becomes fully stalled the nose drops and the aircraft will stay in this full deep stall exercise. Note that yaw control with the rudder is essential in this exercise and will be discussed further below. The deep stall is done only in flight testing to ascertain the fully developed stall which is useful for determining the aircrafts characteristics and corrections needed to allow the wing to be trimmed with stall strips to meet the owner's proficiency and landing needs. Tuft testing and photography may be necessary to determine the rate of stall unzip and stall strips may be necessary as well as rigging of flaps and ailerons. See the POH for stall strip discussion.

Stall Training and the Europa:
Many laminar flow winged aircraft and some flatter bottomed airfoiled aircraft exhibit wing drop during the stall and a great fear of the aircraft's stall warning is not uncommon. Normally in a properly built aircraft any wing drop is normally due to the pilot failing to maintain coordinated flight. Civil instructors draw the trainee's attention to the turn and slip indicator to determine if the aircraft is in coordinated flight. This indicator is ideal for steady state cruise but in a stall series, it draws the trainee's attention into the cockpit to an indicator that lags and is damped. In more advanced training, trainees are taught to look over the nose and watch the nose movement for precise yaw control. Instructors teach that as the aircraft begins to approach the straight-ahead stall, it is imperative that the trainee maintain the nose track of the aircraft (typically pointing precisely at a cloud). In this exercise, the pilot finds that P factor of the tractor aircraft changes noticeably with increased deck angle even at idle power. The Europa has the center of mass very near the center of pitch, yaw and roll and requires only small rudder inputs to immediately correct any out of yaw center condition. Normal certified aircraft have the engine many feet farther forward of the center of lift and the pilots are well behind the center of lift causing a larger moment of inertia and resistance to yaw to be overcome and a slower response of the controls is

evident. In the Europa, trainees find that it is not uncommon for nearly ½ inch of right rudder be added as the slow creeping up on the stall progresses. The trainee is warned and forced not to add aileron to control roll but to use rudder. When properly done, the break of the aircraft is straight ahead and benign. Recovery is immediate with a release of back pressure.

It takes a number of exercises to break the trainee's bad habit of adding aileron to correct roll in a stall. Most of today's aircraft have the wing tip to root twist at nearly 2.5 to 3 degrees of twist lowering the root to tip. However, it also allows the inattentive pilot to add aileron when in a root stall to control the roll as a 3-degree twist is significant and nearly 3-4 degrees of down aileron can be tolerated by the wing before the down aileron forces the tip to stall due to the lowering aileron. This bad habit worsens with time. This wing twist is a safety measure that unfortunately breeds improper pilot technique. Using any aileron in the stall is improper technique, the down aileron stall can result in a rapid wing drop opposite to the pilots stick input (i.e. right stick to counter the roll to the left lowers the left aileron so the stall will break into a left roll with right stick). This sudden stall is not expected by the trainee, normally he adds more aileron to counter the wing drop which exacerbates the stall further causing a serious roll and perhaps a spin entry due to failing to neutralize controls and pitch to break the stall. Continued increasing of aileron and backstick control inputs in a wing drop will cause a stall spin. Note I do not call this an un-commanded roll as it is induced deep stall pro spin control entered by the pilot that is causing this tendency for the rapid roll and stall. Nearly all aircraft exhibit this tendency. This is a training deficiency that must be corrected through practice and proper control input. The lax or un-proficient pilot (myself included) has been lulled into adding aileron during the stall occasionally or encountering a secondary stall by overcontrolling the recovery from time to time. Training prevents this recurrence of bad habbits.

Let us look back to a more traditional and proper control input needed during the approach to a stall.

As the trainee approaches the stall, he must maintain the flight path with rudder. As the nose rises with the increase in back pressure, the P factor draws the nose left and right rudder is needed to hold the nose steady on the point. As the root stall begins, the close proximity of the CG and low yaw moment of inertia allows the P factor to have a more significant effect on the yaw of the aircraft. A solo pilot on the left side also has a minor effect as roll to trim will be essential in some aircraft. As the stall begins and the nose initially drops, it becomes quite evident of how much rudder is necessary. Normally, the trainee is impressed that the stall is straight forward and the recovery pleasant. I then train the pilot trainee to perform the stall in a more rapid manor by increasing the decrease in speed and speed of back pressure increase. Unless he already did it to himself. If the trainee was aggressive about getting to the stall as the burble began, he learns quickly how much rudder is needed for a straight ahead break.

To further the exercises the trainee then is introduced to the accelerated stall. The accelerated stall has to be worked up to as the inexperienced pilot may not be comfortable flying beyond 15-30 degrees of bank and his ability to maintain bank, pitch and speed in a level steep bank turn may need to be cleaned up. The accelerated stall is normally begun above maneuvering speed. In this exercise the stall is not approached with a one to two knot speed bleed off. We are accelerating the approach to the stall at a much faster rate, therefore there are some cues that are not going to be as evident and the accelerated stall will quickly amplify any poor control technique.

Typically, I begin at about 120 KIAS three mistakes high. Normally stall strips have yet to be installed. I begin a warmup with 60 degree bank level turns and using power as necessary to maintain a level turn. Once warmed up, I do a series of hard turns followed by a quick unload and turn reversal to determine my and the aircraft's ability to roll left and right using aileron and rudder while max performing the aircraft. In the hard turns small amounts of rudder control, slight nose up and down pressure, and aileron is necessary to correct minor roll in the turn. To reverse the turn I teach an unloaded roll with aileron and rudder and re-establish the turn in the opposite direction to assess feel.

Note: Not unlike an auto tire, the tire can either accelerate or brake at maximum or turn at maximum, it cannot do both at the same time or traction will be lost. A wing can pull to its maximum lift, or it can roll at maximum rate, but it cannot do both at the same time. UNLOAD to roll, and when the aircraft begins any un-commanded pitch or roll due to overcontrol UNLOAD IMMEDIATELY.

Back to the accelerated stall. Once established in a 60-degree bank and 2 G turn, back pressure is steadily and smoothly increased until the airframe begins to rumble. Normally, the recovery is at this point. For deep stall testing, the same is accomplished until into the rumble then back pressure is increased until the hard break occurs. Any un-commanded roll during the approach to the stall must not be countered with aileron. The rudder will be needed depending on the rate of approach to the stall and more importantly to overcome overbank and natural roll stability of the aircraft or roll correction of the pilot. P factor is fairly constant in this drill so not a lot of rudder is needed in the turn to control yaw into the stall. The trainee many times has his eyes straight ahead or on the attitude indicator attempting to fly a precise turn and does not notice the aircrafts flight path. In advanced pilot training pilots learn that the aircraft flies to where his eyes are looking. In a low wing or canopied aircraft, I rotate my head to look for the point or position on the horizon I intend to maintain. By keeping one's head outside the cockpit the eyes and peripheral vision become God's attitude and slip indicator. This allows small rudder input to correct the flight path and typically the Europa responds with a rumble, then a noticeable stall unload break as the aircraft root to tip stall progresses very quickly. Simply unload for control and recover to level flight.

Again, in practice the trainee should recover on the initial rumble until confidence and technique are fine tuned.

In training/proficiency and techniques, are summarized as follows:

1. The Europa is designed to have a benign root to tip stall progression.
2. Stall characteristics of the Europa are straight forward and can be made more benign through the use of stall strips but in many cases satisfactory with no stall strip.
3. Pilot technique is essential to keep the sensitive yet easy to fly Europa under control at high angles of attack. The rudder at high AoA is the primary roll control and pilot proficiency is essential in its use in any aircraft.
4. Aileron for roll control is to be avoided at high AoA in any aircraft.
5. In any event of un-commanded roll due to mis-applied controls unload for control.

Note: In any aircraft, a spin entry from a stall is pilot induced. Once an uncommanded roll or pitch begins, unloading the pitch to zero breaks the stall and control is immediately regained. Simply recover to level flight.

Only once the clean stall is analyzed with the trainee, may I go onto deep stalls with the flaps extended. This is a silly exercise mostly as there is no operational need for full flap maneuvering or accelerated stalls. However, there are important things to check in stalls with flaps.

Initially testing is in level flight begins with simply slowing to 80 knots straight and level and extend the flaps with hands free and determine the roll and pitch. Typically, a small roll is not uncommon and there is a tendency for initial pitch up. Normally 5 clicks of down trim settles the plane to a 75 knot glide. Roll is first corrected with rudder then aileron to determine the amount of aileron needed to correct roll due to flap extension. Flaps are retracted and the roll is noted again. If roll is very low stalls tend to be straight ahead or when turning (30 degrees of bank max is normal). The aircraft power is pulled to idle and speed decreases rapidly with flaps fully down. As the stall is approached the buffet is noted about 3 knots prior to a slight nose bobble. Control stick forces suddenly lighten prior to the burble and is my first indication of an impending stall. Once the burble begins the typical nose rise is less than clean and the stall is quite abrupt. Stall strips do not give much more advance warning in my opinion but the stick force lightening is very evident as is a pre stall buffet warning. Pitch control is noticeably lighter so it is easy to overcontrol during the stall recovery. At the stall, full power and smooth pitch input to break the stall and arrest the rate of descent must be practiced due to light pitch control feel. As flaps are retracted slowly continue the climb. At any time once the initial nose drop has occurred followed by the nose rise with full flaps, aileron input to control roll can and will greatly increase the chance of severe wing drop. Failure to relax the back pressure with aileron will lead to a quick over-rotation and unless the stick is centered immediately a rapid spin entry is possible. To improve pilot technique I fly a slow flight drill in or near the burble at bank angles of 15 degrees and roll rates that are fairly aggressive to allow the trainee to become familiar with low speed maneuvering near the stall with flaps.

Note: I also do a drill flying down the runway fully configured in ground effect inches off the runway placing the left gear on the centerline, then the right then on centerline to increase the pilots proficiency flying close to the runway near the touchdown speed and then go around.

If there is noticeable roll with the flap extension or retraction in flight, after landing, the flaps are remeasured. Since the flap tube is rather springy, I will look to see if there is binding or drag on extension that I may have missed and normally the difference is a slightly crooked flap tube or difference in flap hanging causing about a degree difference in flap extension. I personally don't mind if a couple clicks of aileron trim zeros out the roll in flight, but anything approaching 2-5 degrees of roll per second must be corrected. There are three primary techniques I use. If cruise trim is perfect clean then I know the only issue is with the flap geometry.

1. Check the flap geometry and correct the flap arm lengths or position as required to get the flap extensions close to equal.
2. Check the fore and aft position of the flap pivot point as one flap may be ¼ inch different in its distance to the closeout. If so, disassemble and rebuild the flap brackets to get things equal.
3. Check the flap extension does not bias the flap tube one way or the other due to the angle of the flap drive tube.

Correcting for build errors:

Let's now look at what can be done to tweak the stall characteristics to improve the "flyability" of the Europa aircraft for pilots that allow their proficiency to wane or for the novice or new to the Europa pilot to more easily transition to this aircraft. In Custom Flight Trimming 101 I give three (more) techniques on how to check, correct roll, trim ailerons from a construction and flight test standpoint to correct roll due to trim. Of course, if the incidence between wings is off by more than 1/4 degree, get with your club, maintainer or other experts in composite repair and fix the darned thing. Once the incidence is corrected, if the flaps are off by more than 1/16 inch (one flap drooping) fix it. This is fairly easy and techniques are in my writings. At the same time, if the ailerons have bias or spring in the mechanism, again, correct this until the ailerons will stay wherever you put the stick on the ground. That is if I set the stick at full right, it should stay, then check center, then left. If the stick springs back or the only thing holding the roll is the autopilot servo, again fix it.

I have found some wings have slight twist differences between the root and tip between wings. Again, checking the incidence and getting assistance in how much to adjust wing flap and aileron can correct the trimming of this twist and placement of stall strips can correct the stall characteristics to get excellent cruise trim and stall characteristics.

Similarly, if the rudder is not centered, adjust the rudder spring/cable length. If the engine offset is not per the book, adjust it. Square up the aircraft. If you bought the aircraft because it was cheap or you didn't want to build one, then I suggest you pay the money to find a new aircraft better built or correct the one you have.

Once we have a square aircraft then proper adjustment of stall characteristic can be accomplished. My first go to of stall break or progression control is to add stall strips. The POH warns of the stall strip may cause too early of a root stall. Adjustment of these strips in size (I've done from 5mm to 12mm sized strips of about 9 inches long and adjusted the elevation until I get the right blend of pre-stall warning of about 4-5 knots and the proper rumble when the stall is accelerated. I adjust also to assure each root stalls about the same time when perfectly coordinated. Again, only through flight test and slight adjustments can these stall strips be adjusted to get the stall warning and prevent adverse "in ground affect full stall" landing characteristics.

NOTE: ELECTRONIC STALL WARNING DEVICES AND OR AUTOPILOTS ARE NO REPLACEMENT FOR PROPERLY TUNED STALL CHARACTERISTICS. (Like auto antiskid, traction control and lane or autopilot, assistance in your auto, they cannot correct a damaged or poor suspension.)

A quick review of the POH Section 9 explains positioning and effects of the stall strip. I can't emphasize enough that the width, angle and position of the stall strip all have effects. Also, the minute positioning changes of the strips makes a difference in the stall warning characteristics.

In my paper "Stall Warning/Low Speed Warning/AOA Systems to consider for Europa Classic Tri-gear N12AY" contains more detail on warning devices as well as stall strip and placement.

In summary, if the plane is not square, fix it. Pay attention to rig and trim during construction. Correct any deviations. Ensure flap and aileron movements are spot on Annex E limits. In flight test and analysis of the stall characteristics can only be determined by a proficient, current and well-trained test pilot. No pilot should attempt flight testing of deep stalls unless he is current and proficient. Routine proficiency training and review and proper flight evaluation is the key to a safe pilot who will be in good control of his aircraft.

No pilot maintains proficiency without practice. Pilot practice should include recurrent stall training and flight evaluations. Do not relay on only flying one aircraft. Proficiency and practice in multiple aircraft assures a breadth of knowledge and improves discipline in preflight planning and skills. Never just plan to fly around. Plan your flight, your training events, emergency procedures for at least part of every flight. Then relax and enjoy your flight. Return to the field and squeak on that landing.

References mentioned are online at https://www.customflightcreations.com