

XI.B. Power-On Stalls

References: AC 61-67; FAA-H-8083-3; POH/AFM

Objectives	The student should develop knowledge of stalls regarding aerodynamics, factors associated with stall speeds, as well as proper recovery techniques. The student will understand situations in which power on stalls are most common and most dangerous and will have the ability to perform a power-on stall as required in the PTS.
Key Elements	<ol style="list-style-type: none">1. Critical Angle of Attack2. A Stall can Occur at any Airspeed, Attitude, Power Setting3. Recovery (Reduce the Angle of Attack)
Elements	<ol style="list-style-type: none">1. Aerodynamics2. Various Factors and their Effect on Stall Speed3. Possible Situations for a Power-On Stall4. Entering the Maneuver5. Recognizing the Stall6. The Recovery
Schedule	<ol style="list-style-type: none">1. Discuss Objectives2. Review material3. Development4. Conclusion
Equipment	<ol style="list-style-type: none">1. White board and markers2. References
IP's Actions	<ol style="list-style-type: none">1. Discuss lesson objectives2. Present Lecture3. Ask and Answer Questions4. Assign homework
SP's Actions	<ol style="list-style-type: none">1. Participate in discussion2. Take notes3. Ask and respond to questions
Completion Standards	The student will become familiar with the conditions that produce power-on stalls and will develop the habit of taking prompt preventative or corrective action when in a situation resulting in a stall.

Instructors Notes:

Introduction:

Attention

Interesting fact or attention grabbing story

Stalls can be intimidating and frightening but understanding how they work and practicing them will make you more comfortable with them and a much safer pilot. A stall can occur at any airspeed, in any attitude, or any power setting, depending on the factors affecting the particular airplane.

Overview

Review Objectives and Elements/Key ideas

What

A stall occurs when the critical angle of attack is exceeded. When this happens, the smooth airflow over the wing is disrupted resulting in a loss of lift and increased drag. Power on stalls (also known as departure stalls) are practiced to simulate stalls in the takeoff and climb-out conditions and configuration.

Why

Stalls in general are practiced to become familiar with an aircraft's particular stall characteristics and to avoid putting the aircraft into a potentially dangerous situation. Power-on stalls are essential to safety in the aircraft. It is important to understand how they happen, how to avoid them, and how to recover from them.

How:

1. Aerodynamics

A. Basically...

- i. A stall occurs when the smooth airflow over the wing is disrupted and lift decreases rapidly
 - a. This is caused when the wing exceeds its critical angle of attack (AOA)
 - b. This can occur at any airspeed, in any attitude, with any power setting

B. More Specifically...

- i. When the AOA is increased to approximately 15°-20° (usually 18°) the air can't follow the upper curvature of the wing
 - a. This is the critical AOA
- ii. As the critical AOA is approached, the air begins separating from the rear of the upper wing surface
 - a. As the AOA is further increased, the airstream is forced to flow straight back
 - This causes a swirling/burbling of air attempting to flow over the upper surface
 - b. When the critical AOA is reached, the turbulent airflow spreads over the entire upper wing
 - This results in a sudden increase in pressure on the upper surface and a decrease in lift
 - a Due to the loss of lift and the increase in form drag (large area of the wing/fuselage is exposed to the turbulent airstream) the remaining lift can't support the plane and the wing stalls
- iii. Stall Characteristics
 - a. Most wings are designed to stall progressively outward from root to tip
 - This is done by designing the wings with *washout* - the wingtips have less angle of incidence (AOI) than the roots
 - a AOI – Angle between the chord line of the wing and longitudinal axis of the airplane
 - b Therefore, the tips of the wings have a smaller AOA than the wing roots

- This is done so the ailerons are still effective at high AOA's and the plane has more stable stalling characteristics

2. Various Factors and their Effect on Stall Speed

- A. A stall can occur at any airspeed, attitude, or power setting, depending on the total factors affecting the plane
- B. Configuration (Gear and Flaps)
 - i. Extension of flaps and/or landing gear in flight will increase drag
 - ii. Flaps
 - a. Extension will generally increase the lifting ability of the wings, reducing the stall speed
 - The effects can be seen on the airspeed (lower limit of the white arc vs. the green arc)
- C. Weight
 - i. As the weight of the airplane is increased, the stall speed of the airplane increases
 - a. Added weight requires a higher AOA to produce the additional lift needed to support the plane
- D. Center of Gravity
 - i. Forward Center of Gravity (CG)
 - a. "Heavier" and consequently slower than the same airplane with a further aft CG
 - The tail surface produces more download, adding wing loading and lift to hold altitude
 - b. Requires a higher AOA, which results in more drag and produces a higher stalling speed
 - c. The airplane is more controllable due to the longer arm from the CG to the elevator
 - ii. Aft CG
 - a. "Lighter," so the airplane requires less download allowing for a faster cruise speed
 - b. Faster cruise because of reduced drag
 - Reduced drag is a result of a smaller AOA and less downward deflection of the stabilizer
 - c. The tail surface produces less download, relieving wing loading and lift required to hold altitude
 - Results in a lower stall speed
 - d. Recovery from a stall becomes progressively more difficult as the CG moves aft
 - The elevator has a shorter arm to the CG, and thus produces less force making recovery more difficult
- E. Load Factor
 - i. The ratio of the total load acting on the airplane to the gross weight of the airplane
 - ii. The airplane's stall speed increases in proportion to the square root of the load factor
 - a. EX: An airplane that stalls at 45 knots can be stalled at 90 knots when subjected to 4 G's
 - iii. Situations: Accelerated Stalls - Steep turns, or pulling out of a steep descent
- F. Bank Angle
 - i. Increased load factors are a characteristic of all banked turns
 - ii. Tremendous loads are imposed on an airplane as the bank is increased beyond 45°
 - a. At a 60° bank, a load factor of 2 G's are imposed on the airplane structure
 - b. At a 70° bank, a load factor of approximately 3 G's are placed on the airplane
- G. Snow, Ice, and Frost
 - i. Even a small amount can increase the stall speed
 - a. The wing's shape is changed, disrupting the smooth airflow, increasing drag and decreasing lift
- H. Turbulence
 - i. Turbulence can cause the airplane to stall at a significantly higher airspeed than in stable conditions
 - a. A vertical gust/wind shear can cause a quick change in the relative wind and an increase in AOA

3. Possible Situations for a Power-On Stall

- A. Takeoff and climbout phases of flight, particularly go-arounds

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- i. Factors in go-arounds include failure to maintain control due to nose high trim, early flap retraction, and quickly increasing power

B. Short-field takeoffs - Maintaining positive control during the high AOA climb (closer to the stall speed)

4. Entering the Maneuver

A. Differences - Considerably Louder and Steeper than a power-off stall

B. Entry

- i. Pre-Maneuver Checklist: Fuel Pump ON, Mixture RICH, Lights ON, Gauges GREEN
- ii. Clearing the Area
- iii. Select an altitude - Must be able to recover prior to 1,500' AGL
- iv. Takeoff Configuration: Takeoff Flaps (Can be practiced clean as well)
- v. Note the Heading (bug the heading)
- vi. **CE** - Failure to establish the specified landing gear and flap configuration prior to entry

C. Getting into the Straight Ahead Stall

- i. Reduce power to slow to normal lift off speed ($V_R - 44$ knots) while maintaining altitude
 - a. Visually - The nose will pitch above the horizon, use a cloud, etc. to maintain direction
- ii. At V_R , increase power to 2200 RPM and maintain a climb attitude (12° - 15°) until the stall occurs
 - a. The nose will have a tendency to further pitch up and yaw to the left
 - Establish and maintain the desired pitch attitude
 - a. As airspeed decreases, and controls become less effective, continue increasing back pressure in order to maintain the pitch attitude
 - Maintain heading with the necessary right rudder, keeping coordinated
 - a. Apply right rudder to keep coordination when applying power
 - b. As airspeed decreases, increase right rudder pressure to maintain coordination
 - c. **CE** - Improper torque correction
 1. Right pedal pressure must be used to counteract torque
- iii. **CE** - Improper pitch, heading, yaw, and bank control during straight ahead and turning stalls
 - a. Maintain directional control with rudder, wings level with ailerons, and pitch attitude with the elevator
 - b. Visual references and instruments are used
- iv. **CE** - Rough or uncoordinated control procedure
 - a. Just like in slow flight, use smooth movements to control the aircraft, nothing jerky

D. Getting into the Turning Stall

- i. Aerodynamics
 - a. Overbanking Tendency - When in a nose high turning attitude, bank has a tendency to increase
 - With airspeed decreasing, the airplane begins flying in a smaller and smaller arc
 - a. Since the outer wing travels a larger radius, and travels faster than the inner wing, it has more lift causing an overbanking tendency
- ii. In a climbing turn, the same procedures apply as a straight ahead stall, except a specified bank angle is maintained
 - a. When power is applied and the aircraft pitched up for the climb establish the desired bank angle
 - b. Aileron pressure must be continually adjusted to keep the bank constant
 - Opposite aileron will likely be necessary to maintain the bank angle, if left alone, bank will increase on its own due to the overbanking tendency
 - c. Whatever control pressures are necessary should be applied to maintain coordination even though they may be crossed
- iii. **CE** - Improper pitch and bank control during turning stalls
 - a. Anticipate the overbanking tendency
 - b. Increase control pressure as the aircraft slows and controls become less effective

5. Recognizing the Stall

- A. Announce the onset of the stall
 - i. Stall Warning Horn
 - ii. Reduced Control Effectiveness
 - iii. Buffet
 - iv. Stall
- B. Sight
 - i. Attitude of the airplane
- C. Sound
 - i. Stall warning horn
 - ii. Loss of RPM is noticeable due to the increased load on the propeller
 - iii. Noise will tend to decrease with airspeed and the lessening flow of air around the aircraft
- D. Kinesthesia (The sensing of changes in direction or speed of motion)
 - i. Probably the most important and best indicator to the trained pilot
 - ii. If developed, it will warn of a decrease in airspeed or the beginning of the airplane settling/mushing
- E. Feel
 - i. Control pressures become progressively less effective (mushy)
 - a. The lag between control movements and response of the aircraft become greater
 - ii. Buffeting, uncontrollable pitching or vibrations just before the stall
 - a. The buffet is caused by the turbulent air flowing over the fuselage/horizontal stabilizer
 - iii. Leaning back
- F. **CE** - Failure to recognize the first indications of a stall
- G. **CE** - Failure to achieve a stall
 - i. Ensure a stall has developed

6. The Recovery

- A. 3 Step Process
 - i. First, the pitch attitude and angle of attack must be decreased positively and immediately
 - a. Since, the basic cause of a stall is always an excessive AOA the cause must be eliminated
 - b. This lowers the wing to an effective AOA
 - The object is to reduce the AOA but only enough to allow the wing to regain lift
 - a **CE** - Reduce the AOA, then adjust the pitch attitude to the desired climb attitude (V_V)
 - b **CE** - Secondary stall - Don't rush the recovery to level flight or a climb
 - ii. Second, maximum allowable power should be applied to increase airspeed and help reduce the AOA
 - a. Power is not essential to stall recovery, reducing the AOA is the only way of recovering
 - b. Right rudder will be required to maintain coordination/heading
 - Outside references are very helpful in maintaining coordination - as power is introduced add rudder pressure in order to keep the nose from yawing across the horizon
 - iii. Third, maintain directional control with coordinated use of aileron and rudder and climb out at V_V
 - iv. **CE** - Excessive altitude loss or excessive airspeed during recovery
 - a. Only lower the nose enough to break the stall, after the stall is broken establish a climb
 - b. Excessive speeds and nose low attitudes close to the ground are extremely hazardous
 - v. **CE** - Secondary stall during recovery
 - a. Once the stall is broken, do not aggressively lift the nose to reestablish a climb as this can quickly result in a secondary stall
 - b. Use smooth, controlled inputs monitoring the aircraft's performance to ensure it is ready to climb
- B. Ailerons and Recovery
 - i. Most airplanes are designed to stall progressively outward from the wing root

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- a. The wings are designed in this manner so that aileron control will be available at high AOA and give the airplane more stable stalling characteristics
 - b. During the recovery, the return of lift begins at the tips and progresses towards the roots
 - Thus, ailerons can be used to level the wings
 - ii. If the wing is fully stalled (aileron included), using the ailerons can result in an aggravated stall condition
 - a. EX: If the right wing dropped, and excessive aileron was applied to raise the wing, the right wing (aileron down) would produce a greater AOA and more (induced) drag
 - Increasing the AOA on an already stalled wing will aggravate the stall on that wing
 - The increase in drag and aggravated stall on one wing will yaw the aircraft in the direction of the wing and could result in a spin
- C. Rudder and Recovery
- i. Even if excessive aileron was applied, a spin won't occur if yaw is maintained by rudder pressure
 - a. Therefore, it is important that the rudder be used properly during the entry and recovery
 - ii. The primary use of rudder is to counteract any tendency of the airplane to yaw or slip
 - iii. One wing will often drop in a power-on stall
 - a. Maintaining directional control with the rudder is vital in avoiding a spin

Common Errors:

- Failure to establish the specified landing gear and flap configuration prior to entry
- Improper pitch, heading, yaw, and bank control during straight ahead and turning stalls
- Improper pitch and bank control during turning stalls
- Rough or uncoordinated control procedure
- Failure to recognize the first indications of a stall
- Failure to achieve a stall
- Improper torque correction
- Poor stall recognition and delayed recovery
- Excessive altitude loss or excessive airspeed during recovery
- Secondary stall during recovery

Conclusion:

Brief review of the main points

Exceeding the critical angle of attack causes a stall. A stall can occur at any airspeed, in any attitude, or any power setting, depending on the total number of factors affecting the particular airplane.

PTS Requirements:

To determine that the applicant:

1. Exhibits instructional knowledge of the elements of power-on stalls, in climbing flight (straight or turning), with selected landing gear and flap configurations by describing:
 - a. Aerodynamics of power-on stalls.
 - b. Relationship of various factors, such as landing gear and flap configuration, weight, center of gravity, load factor, and bank angle to stall speed.
 - c. Flight situations where unintentional power-on stalls may occur.
 - d. Entry technique and minimum entry altitude.
 - e. Performance of power-on stalls in climbing flight (straight or turning).
 - f. Coordination of flight controls.
 - g. Recognition of the first indications of power-on stalls.

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- h. Recovery technique and minimum recovery altitude.
 2. Exhibits instructional knowledge of common errors related to power-on stalls, in climbing flight (straight or turning), with selected landing gear and flap configurations by describing:
 - a. Failure to establish the specified landing gear and flap configuration prior to entry.
 - b. Improper pitch, heading, yaw, and bank control during straight ahead stalls.
 - c. Improper pitch, bank, and yaw control during turning stalls.
 - d. Rough and/or uncoordinated use of flight controls.
 - e. Failure to recognize the first indications of a stall.
 - f. Failure to achieve a stall.
 - g. Improper torque correction.
 - h. Poor stall recognition and delayed recovery.
 - i. Excessive altitude loss or excessive airspeed during recovery.
 - j. Secondary stall during recovery.
 3. Demonstrates and simultaneously explains power-on stalls, in climbing flight (straight or turning), with selected landing gear and flap configurations, from an instructional standpoint.
 4. Analyzes and corrects simulated common errors related to power-on stalls, in climbing flight (straight and turning), with selected landing gear and flap configurations.

