

## XI.C. Power-Off Stalls

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References: FAA-H-8083-3; POH/AFM

Objectives	The student should develop knowledge of power-off stalls regarding aerodynamics, factors associated with stall speeds, as well as proper recovery techniques. The student will understand situations in which power off stalls are most common and most dangerous and will have the ability to perform a power-off stall as required in the PTS.
Key Elements	<ol style="list-style-type: none"><li>1. Critical Angle of Attack</li><li>2. A Stall can Occur at any Airspeed, Attitude, Power Setting</li><li>3. Recovery (Reduce the Angle of Attack)</li></ol>
Elements	<ol style="list-style-type: none"><li>1. Aerodynamics</li><li>2. Various Factors and their Effect on Stall Speed</li><li>3. Possible Situations</li><li>4. Entering the Maneuver</li><li>5. Recognizing the Stall</li><li>6. The Recovery</li></ol>
Schedule	<ol style="list-style-type: none"><li>1. Discuss Objectives</li><li>2. Review material</li><li>3. Development</li><li>4. Conclusion</li></ol>
Equipment	<ol style="list-style-type: none"><li>1. White board and markers</li><li>2. References</li></ol>
IP's Actions	<ol style="list-style-type: none"><li>1. Discuss lesson objectives</li><li>2. Present Lecture</li><li>3. Ask and Answer Questions</li><li>4. Assign homework</li></ol>
SP's Actions	<ol style="list-style-type: none"><li>1. Participate in discussion</li><li>2. Take notes</li><li>3. Ask and respond to questions</li></ol>
Completion Standards	The student will become familiar with the conditions that produce power-off stalls and will develop the habit of taking prompt preventative or corrective action when in a power-off stall.

**Instructors Notes:**

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**Introduction:**

**Attention**

Interesting fact or attention grabbing story

Stalls can be intimidating/frightening but understanding how they work and practicing them will make you more comfortable with them and a safer pilot. 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.

**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 off stalls are practiced to simulate stalls in the landing and approach 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-off stalls are essential to safety in the airplane. 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

- A. Normal as well as emergency approach to landing conditions and configurations
  - i. Crossed-control turns from base to final

- ii. Attempting to recover from a high sink rate without using a combination of pitch and power
  - a. Just pitching, can quickly slow and stall the aircraft resulting in a further increased sink rate
- iii. Improper airspeed control on final and other segments of the pattern
- iv. Trying to stretch a glide

#### 4. Entering the Maneuver

##### A. Entry

- i. Pre-Maneuver Checklist: Fuel Pump ON, Mixture RICH, Lights ON, Gauges GREEN
- ii. Clearing the Area
- iii. Select an altitude – Recover prior to 1,500' AGL
- iv. Landing Configuration: Landing Flaps
  - a. Use the same procedure as entering slow flight but maintain (descend at) 65 knots
- v. Note the Heading
- vi. **CE** - Failure to establish the specified landing gear and flap configuration prior to entry

##### B. Getting into the Straight Stall

- i. Slow to normal approach speed (65 knots) while maintaining the originally established altitude
  - a. Extend the flaps (Landing Flaps)
  - b. Visually - Find a reference off the nose to maintain direction and to assist with pitch attitude
- ii. Then, smoothly nose down to the normal approach attitude to maintain approach speed (65 knots)
- iii. Once stabilized, power should be reduced to idle and the nose should be smoothly raised to and held at an attitude that will induce a stall
  - a. Simulate a flare to landing
  - b. Maintain directional control with rudder, wings level with ailerons, pitch with elevator until a stall occurs
- iv. **CE** - Improper pitch, heading, yaw, and bank control during straight-ahead stalls
  - a. Visual references and instruments are used
- v. **CE** - Rough and/or uncoordinated use of the flight controls
  - a. Just like in slow flight, use smooth movements in controlling the airplane, nothing jerky

##### C. Getting into the Turning Stall

- i. In a descending turn, the same procedures apply as a straight ahead stall, except a specified bank angle is maintained
  - a. When the power is set and the descent established, establish the desired bank angle
  - b. Aileron pressure must be continually adjusted to keep the bank constant
    - Opposite aileron may be necessary when slow due to the overbanking tendency
  - c. Whatever control pressures are necessary should be applied to maintain coordination even though they may be crossed
- ii. **CE** - Improper pitch, yaw, and bank control during turning stalls
  - a. 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. 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
- **CE** - Failure to recognize the first indications of a stall/Poor stall recognition and delayed recovery
- F. **CE** - Failure to achieve a stall
  - i. Ensure a stall has developed

## 6. The Recovery

- 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 Reduce the AOA, then adjust the pitch attitude to the desired climb attitude ( $V_Y$ )
        - b Avoid a 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. In a power-off stall, power is essential to establishing a climb and gaining altitude
    - c. **CE** - Improper torque correction
      - As power is advanced, right rudder will be necessary to maintain coordination
  - iii. Third, maintain directional control with coordinated use of aileron and rudder and climb out at  $V_Y$
- B. Ailerons and Recovery
- i. Most airplanes are designed to stall progressively outward from the wing root
    - 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
- D. Common Errors During Recovery
- i. **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

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- b. Excessive speeds and nose low attitudes close to the ground are extremely hazardous
- ii. **CE** - Poor stall recognition and delayed recovery
  - a. Do not delay recovery, recover at the first indication of stall (unless required otherwise by the PTS for training purposes) - At slow airspeeds, in a descent, close to the ground any delay could be hazardous
- iii. **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
- iv. **CE** - Rough and/or uncoordinated use of the flight controls
  - a. Just like in slow flight, use smooth movements in controlling the airplane, nothing jerky
  - b. A smooth controlled recovery is the goal, this will also help to avoid a secondary stall

### 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 stalls
- Improper pitch, yaw, and bank control during turning stalls
- Rough and/or uncoordinated use of the flight controls
- 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-off stalls, in descending flight (straight or turning), with selected landing gear and flap configurations by describing:
  - a. Aerodynamics of power-off 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-off stalls may occur.
  - d. Entry technique and minimum entry altitude.
  - e. Performance of power-off stalls in descending flight (straight or turning).
  - f. Coordination of flight controls.
  - g. Recognition of the first indications of power-off stalls.
  - h. Recovery technique and minimum recovery altitude.
2. Exhibits instructional knowledge of common errors related to power-off stalls, in descending 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.

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- b. Improper pitch, heading, yaw, and bank control during straight-ahead stalls.
  - c. Improper pitch, yaw, and bank 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-off stalls, in descending 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-off stalls, in descending flight (straight or turning), with selected landing gear and flap configurations.

