

XI.A. Maneuvering During Slow Flight

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

Objectives	To develop an understanding and proficiency of the flight characteristics and degree of controllability of an aircraft in slow flight. A “feel” for the airplane at very low speeds should be developed to avoid inadvertent stalls and to operate the aircraft with precision. In flight, the student should perform the maneuver in varying configurations to PTS standards.
Key Elements	<ol style="list-style-type: none">1. Pitch for Airspeed2. Power for Altitude3. Coordination
Elements	<ol style="list-style-type: none">1. Defining Slow Flight2. Relationship of Power to Flight Characteristics and Controllability3. Relationship of Maneuvering Loads to Flight Characteristics and Controllability4. Relationship of Weight to Flight Characteristics and Controllability5. Relationship of the CG to Flight Characteristics and Controllability6. Relationship of the Maneuver to Critical Flight Situations7. Slow Flight and the Senses8. Flight at Minimum Controllable Airspeed
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 lesson is complete when the student understands factors affecting flight characteristics and controllability and shows the ability to control the airplane effectively in different configurations of slow flight.

Instructors Notes:

Introduction:

Attention

Interesting fact or attention grabbing story

When the aircraft is flying at just above the stall speed, there is little margin for error. This maneuver will greatly improve your piloting skills.

Overview

Review Objectives and Elements/Key ideas

What

Slow flight is flight at a speed which any further increase in angle of attack or load factor, or reduction in power will cause an immediate stall.

Why

Maneuvering during slow flight demonstrates the flight characteristics and degree of controllability of an aircraft at less than cruise speed. The student must develop the awareness and ability of the characteristics, feel and control responses during flight at slow speed (takeoff, climb, landings and go-arounds) to maintain safe flight, and avoid unintentional stalls.

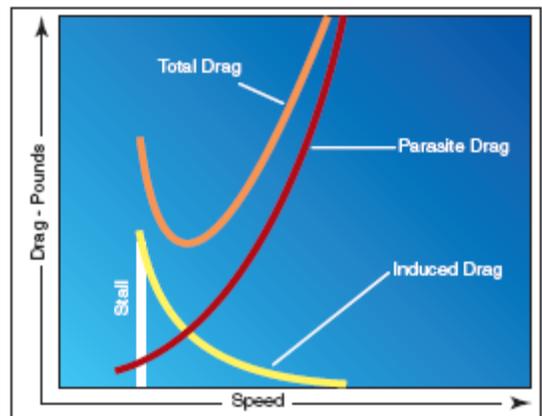
How:

1. Defining Slow Flight

- A. Speed that is less than cruise speed
 - i. However, in pilot training, it can be broken down into two distinct elements
 - a. The establishment, maintenance of, and maneuvering of the airplane at airspeeds and in configurations appropriate to takeoffs, climbs, descents, landing approaches and go-arounds
 - Below cruise speed
 - b. Flight at a speed which any further increase in angle of attack or load factor, or reduction in power will cause an immediate stall

2. Relationship of Power to Flight Characteristics and Controllability

- A. When performing slow flight, it is important to know the relationship between parasite drag, induced drag, and the power needed to maintain a given altitude at a selected airspeed
 - i. As airspeed decreases from cruise to L/D_{MAX} , total drag and thrust required decrease to maintain a constant altitude
 - ii. As airspeed decreases below L/D_{MAX} , additional power (thrust) is required to maintain a constant altitude
 - a. Total drag is now increasing because induced drag increases faster (due to higher the angle of attack) than parasite drag decreases
 - b. This is known as the 'backside of the power curve' or the 'region of reverse command'
 - The Region of Reverse Command means that more power is required to fly at slower airspeeds while maintaining a constant altitude

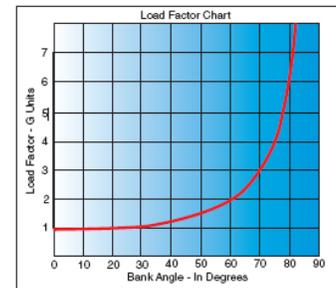


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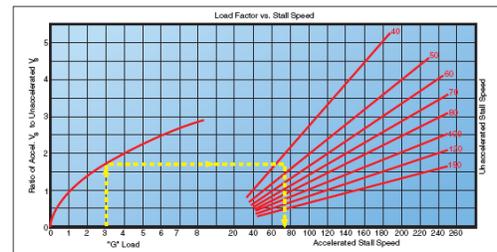
- B. While straight and level flight is maintained at a constant airspeed, thrust is equal in magnitude to drag, and lift is equal to weight, but some of these forces are separated into components
 - i. In slow flight, thrust no longer acts parallel to and opposite to the flight path and drag.
 - a. In slow flight, thrust has two components:
 - One acting perpendicular to the flight path in the direction of lift
 - One acting along the flight path
 - ii. Because the actual thrust is inclined, its magnitude must be greater than drag if its component acting along the flight path is equal to drag
 - a. The forces acting upward (wing lift and the component of thrust) equal the forces acting downward (weight and tail down force)
 - iii. Wing loading is actually less during slow flight because the vertical component of thrust helps support the airplane
 - C. The flight controls in slow flight are less effective than at normal cruise due to the reduced airflow over them
 - i. As airspeed decreases, control effectiveness decreases disproportionately
 - a. There is a loss of effectiveness when the airspeed is reduced from 30 to 20 knots above the stall speed, but there is a considerably greater loss as the airspeed is reduced to 10 knots above the stall speed
 - ii. Anticipate the need for right rudder to counteract the left turning tendencies in a low airspeed, high power setting condition
 - iii. Large control movements may be required
 - a. This does not mean rough or jerky movements

3. Relationship of Maneuvering Loads to Flight Characteristics and Controllability

- A. Load factor is the ratio of the total load acting on the airplane to the gross weight of the airplane
 - i. Expressed in terms of G's
- B. Any increase in the load factor increases the stall speed
- C. Turns
 - i. Increased load factors are a characteristic of all banked turns
 - ii. Load factor increases at a high rate after 45°-50° of bank
 - a. At approx 63° of bank the stall speed is increased by approximately ½



- D. Stalls
 - i. The normal stall will not produce added load factors beyond the 1 G of straight and level flight
 - a. As the stall occurs, however, this load factor may be reduced to zero
 - b. In the event the recovery is made by snapping the elevator control forward, negative load factors may be produced
 - c. During the pull-up following recovery, significant load factors are sometimes induced
 - Abrupt pull-ups at high diving speeds may impose stressful loads on aircraft structures and may produce a secondary stall
- E. Spins
 - i. A stabilized spin is no different from a stall except that yaw is involved; the same load factors apply
- F. Rough Air
 - i. Gust load factors increase with increasing speed
 - ii. Do not exceed V_A (maneuvering speed)

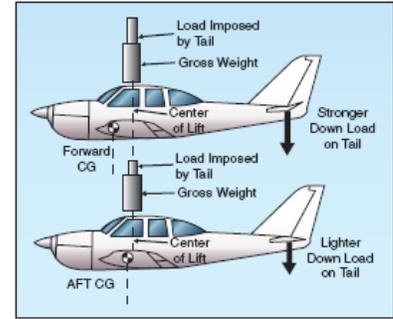


4. Relationship of Weight to Flight Characteristics and Controllability

- A. The heavier the plane is, the more lift necessary
- B. As more lift is required, the angle of attack is increased
 - i. This brings the aircraft closer to the critical angle of attack, therefore the stall speed is increased

5. Relationship of the CG to Flight Characteristics and Controllability

- A. An airplane with forward loading
 - i. The aircraft acts heavier, and consequently slower than the same airplane with a further aft CG
 - a. Nose up trim is required which requires the tail surfaces to produce a greater download which adds to the wing loading and the total lift required from to maintain altitude
 - ii. Requires a higher angle of attack, resulting in more drag and a higher stall speed
 - iii. The airplane is more controllable though
 - a. This is due to the longer arm from the elevator to the CG
- B. With aft loading (aircraft acts lighter), the airplane requires less download allowing for a faster cruise speed
 - i. Faster cruise because of reduced drag
 - a. Reduced drag is a result of a smaller angle of attack and less downward deflection of the stabilizer
 - ii. The tail surface is producing less down load, relieving the wing of loading and lift required to maintain altitude
 - a. Results in a lower stall speed
 - iii. Recovery from a stall becomes progressively more difficult as the CG moves aft
 - a. Moving the CG aft shortens the arm from the elevator, reducing the amount of force it can apply



6. Relationship of the Maneuver to Critical Flight Situations

- A. The maneuver demonstrates the flight characteristics and controllability of the airplane in slow flight
 - i. It is very important the pilot understands the control responses of the airplane during slow flight
 - a. This is necessary to avoid stalls at slower airspeeds and close to the ground
 - Characteristics of takeoffs, climbs, landings, and go-arounds

7. Slow Flight and the Senses

- A. Visually
 - i. As you pitch up, you will be looking at more sky (nose above the horizon)
 - a. There will be few if any visual references at this point
 - Possibly a couple of clouds
 - ii. Hearing
 - a. Initially, with the reduction of power, sound will decrease
 - b. As you approach the stall, the stall warning horn will sound
 - c. When power is reintroduced, the sound of the engine increases
 - The sound of the plane moving through the air stays softer due to the slower airspeed
 - iii. Feel
 - a. As the aircraft's speed continues to decrease, the controls will become progressively less responsive
 - Larger control movements will be necessary to control the airplane as the air flow over the control surfaces has been reduced
 - b. Right rudder will be necessary as the plane begins to yaw to the left
 - This is due to the left turning tendencies upon reintroduction of power

- Due to reduced control effectiveness, more right rudder than normal is required
- c. Just prior to stalling the aircraft will begin to buffet

8. Flight at Minimum Controllable Airspeed

A. Definition

- i. Flight at a speed which any further increase in angle of attack or load factor, or reduction in power will cause an immediate stall

B. Purpose

- i. Demonstrates the flight characteristics and degree of controllability of the airplane at its minimum flying speed

C. Performing The Maneuver

i. Overview of the Basics

a. Pitch for Airspeed, Power for Altitude

- This is necessary on the backside of the power curve
- b. Use both instrument indications and visual references
 - Frequently reference the instruments, especially the attitude indicator
 - A “feel” for the airplane at very low speeds must be developed to avoid inadvertent stalls and to operate the plane with precision

ii. The Maneuver

a. Properly clear the area

b. Configuration

- Different configurations can be used in order to develop a feel for the airplane in different situations
 - a The ‘dirtier’ (more flaps) the airplane, the slower we can get
 1. Stall speed is reduced
 - b The ‘cleaner’ the airplane, the higher the stall speed; therefore a higher airspeed is required for slow flight
- **CE** - Failure to establish specified gear and flap configuration
- c. Begin slowing the airplane by gradually reducing the throttle (to approximately 1500 RPM)
 - Maintain altitude as power is lost
 - a The position of the nose in relation to the horizon should be noted and raised as necessary to maintain altitude
 - b Maintain adequate back pressure to ensure no loss in altitude as power is reduced
 - c Don’t use excessive back pressure as power is reduced resulting in a climb followed by a rapid reduction in airspeed

d. Continually trim the aircraft

- Add nose up trim to maintain altitude, this will make the maneuver considerably easier
- Re-trim as often as necessary to compensate for changing control pressure
- **CE** - Improper trim technique

e. Full flaps should be lowered incrementally as the airspeed reaches the allowable airspeed limits

- Incremental flap application will allow for easier adjustments in pitch attitude to maintain altitude
 - a Extending full flaps immediately is more difficult to control than incremental changes
 - b Anticipate changes in lift as flaps are extended or retracted
 1. Lowering the flaps will require nose down pitch to compensate for increased lift

f. Note the feel/sounds

- As speed decreases, the pilot should note the feel of the flight controls (especially elevator)
- Also note the sound of the airflow as it lessens

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- g. Flight Control Effectiveness
 - Much less effective with the reduction in airspeed
 - a Elevators become less responsive
 - b Flight control inputs are not as smooth to control the airplane
 - 1. Larger movements are needed for the aircraft to respond
- h. Reintroduce power
 - Additional power will be required as airspeed decreases below L/D_{MAX} to maintain altitude
 - a As the airspeed is approaching the specified maneuver speed (approximately 40 knots) additional power will be required to maintain airspeed and altitude just above the stall
 - The additional produces a strong yaw
 - a Considerable right rudder is necessary to maintain coordinated flight
 - b **CE** - Uncoordinated use of flight controls/Improper correction for torque effect
 - 1. Anticipate the need for right rudder
 - 2. Use coordinated rudder and aileron to maintain heading
 - a. Uncoordinated flight (too much or too little rudder to compensate for torque) combined with a stall can quickly result in a spin
 - Avoid losing too much speed/using too little power
 - a Losing too much speed/too little power requires further back pressure which may result in a loss of altitude or stall
 - b Proactively increase power to the approximate setting that will maintain altitude at the specified maneuver speed
 - **CE** - Unintentional stalls
 - a Avoid being aggressive with the power and pitch applications
 - b Small, controlled corrections are most effective in maintaining control during slow flight
 - **CE** - Inappropriate removal of hand from throttles
 - a Keep your hand on the throttles as much as possible
 - 1. Due to the proximity to a stall, immediate power may be necessary
- i. Establish the desired pitch attitude to maintain airspeed
 - Continually cross check the attitude indicator, altimeter, and airspeed indicator, as well as outside references to ensure that accurate control is being maintained
 - Do not fixate on any instruments, primarily the airspeed indicator and altimeter
 - Throughout the maneuver, be proactive in fixing altitude, heading, etc. changes
 - a Don't let the airplane get away as this will result in larger control inputs to correct
 - b **CE** - Failure to establish and maintain the specified airspeed
 - 1. Increase power approximately 5 knots prior to the slow flight speed
 - a. This should result in the airspeed settling at the desired speed
 - 2. Adjust pitch to maintain the desired airspeed
 - a. If fast, pitch up – use very small changes in pitch (1-2° at a time)
 - b. If slow, pitch down – very small changes in pitch (1-2° at a time)
 - 3. If the pitch adjustment affects altitude, increase or decrease power as necessary to maintain altitude
 - a. Continue adjusting pitch and power to maintain airspeed and altitude
 - c **CE** - Excessive variations of altitude and heading when a constant altitude and heading are specified
 - 1. Use small, controlled changes in pitch and power to maintain heading and altitude
 - a. Know the approximate pitch and power setting required to maintain slow flight in the aircraft; set that pitch and power and make small adjustments from there

2. Large inputs will result in chasing the airspeed and altitude
 - j. **CE** - Improper entry technique
 - Follow the specified procedures to help ensure a smooth, controlled entry
 - It is very important to maintain positive control of the aircraft during entry
 - a A sloppy entry can easily result in a stall
 - **CE** - Unintentional stalls
 - k. Maintain straight and level flight and perform required level turns at a constant altitude
 - During turns, the pitch attitude and power may need to be increased to maintain airspeed and altitude
 - Maintaining bank angle
 - a In slow flight, putting in a small amount of bank (5°) results in the airplane wanting to continue banking
 1. Opposite aileron will be necessary to maintain the 5° bank angle
 - Adverse Yaw
 - a The downward deflected aileron produces more lift and therefore more drag
 - b The airplane will try to yaw toward the outside wing during the turn
 1. The plane must be kept coordinated
 2. Right rudder is necessary to maintain straight flight (like in a climb), right turns will require more right rudder, while left turns will require less right rudder (anticipate some right rudder pressure even in a left turn)
 - c **CE** - Uncoordinated use of flight controls
 - Extreme Bank
 - a Extreme bank situations, like steep turns, are not used in slow flight
 1. As banks exceeds 30° , the stall speed noticeably increases
 - a. Obviously, this is unsafe already close to the stall speed
 - l. Maintain coordinated flight as climbs/descents or climbing/descending turns are performed
 - Adjust the power to begin the climb or descent, and simultaneously adjust the pitch attitude as necessary to maintain the desired airspeed
 - a You will gain altitude by increasing power and adjusting pitch to maintain airspeed
 1. Anticipate increased right rudder with any increase in power, and vice versa
 2. In some situations you may have to pitch down to maintain airspeed in a climb
- iii. Reestablishment of cruise flight
- a. Just like a stall recovery
 - Full Power
 - Nose Down (forward pressure)
 - Clean up the airplane
 - a Flaps
 - b Gear (If necessary)
 - b. Increase the power and lower the nose to begin building airspeed
 - Don't dive, apply forward pressure to maintain altitude as the aircraft accelerates
 - c. Remove the first increment of flaps
 - Anticipate the change in lift to maintain altitude
 - The aircraft will have a tendency to sink, increase back pressure slightly to counter this
 - d. As airspeed increases and the aircraft exceeds V_Y (65 knots) remove the second increment of flaps
 - Again, anticipate the change in lift to maintain altitude
 - e. As airspeed increases, right rudder pressure will need to be reduced to maintain coordination

Common Errors:

- Failure to establish specified gear and flap configuration
- Improper entry technique
- Failure to establish and maintain the specified airspeed
- Excessive variations of altitude and heading when a constant altitude and heading are specified
- Uncoordinated use of flight controls
- Improper correction for torque effect
- Improper trim technique
- Unintentional stalls
- Inappropriate removal of hand from throttles

Conclusion:

Brief review of the main points

Understanding the characteristics that affect slow flight and how to perform this maneuver is an extremely important part of a pilot's training. Slow flight develops the student's awareness of the characteristics, feel and control responses during flight at slow speed (takeoff, climb, landings and go-arounds) to maintain safe flight, and avoid unintentional stalls.

PTS Requirements:

To determine that the applicant:

1. Exhibits instructional knowledge of the elements of maneuvering during slow flight by describing:
 - a. Relationship of configuration, weight, center of gravity, maneuvering loads, angle of bank, and power to flight characteristics and controllability.
 - b. Relationship of the maneuver to critical flight situations, such as a go-around.
 - c. Performance of the maneuver with selected landing gear and flap configurations in straight-and-level flight and level turns.
 - d. Specified airspeed for the maneuver.
 - e. Coordination of flight controls.
 - f. Trim technique.
 - g. Reestablishment of cruise flight.
2. Exhibits instructional knowledge of common errors related to maneuvering during slow flight by describing:
 - a. Failure to establish specified gear and flap configuration.
 - b. Improper entry technique.
 - c. Failure to establish and maintain the specified airspeed.
 - d. Excessive variations of altitude and heading when a constant altitude and heading are specified.
 - e. Uncoordinated use of flight controls.
 - f. Improper correction for torque effect.
 - g. Improper trim technique.
 - h. Unintentional stalls.
 - i. Inappropriate removal of hand from throttles.
3. Demonstrates and simultaneously explains maneuvering during slow flight from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to maneuvering during slow flight.

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