AMERICAN FLYERS

FIRC Stage 2

Chapter 1 5
Stall Awareness Training 5
Aerodynamics of a Stall 5
Aerodynamics of a Spin 6
Distractions 7
Stall Recognition and Recovery Techniques 7
Types of Stalls 8
Stall Recovery 8
Secondary Stalls 9
Weight and Balance 9
Stall Training 9
Stall Avoidance Practice at Slow Airspeeds 10
Departure Stall 11
A 180-degree Turn After Engine Failure 11
Cross Controlled Stalls in Gliding Turns 11
Power-off (approach-to-landing) Stalls 12
Stalls During Go-arounds 12
Elevator Trim Stall 12
Chapter 2 13
Spin Training 13
Operating Limitations 14
Placards 15
Pilot Awareness 15
Chapter 3 17
Aircraft Operational Limitations 17
Operating Data 17
Air Density and Airplane Performance 18
The Standard Atmosphere 18
Density Altitude 19
Factors Affecting Takeoff Performance 20
Cruise Performance 21
Chapter 4 23
Introduction 23
Pilot's Responsibility 23
Load Factors and Certification 24
The Effect of Weight on Performance 25
Controllability 25
Stability 26
Chapter 5 29
AFM/POH Characteristics 29
Preliminary Pages 29
General Section (Section 1) 30
Limitations Section (Section 2) 30
Emergency Procedures (Section 3) 31
Normal Procedures (Section 4) 31
Performance (Section 5) 31
Weight and Balance/Equipment List (Section 6) 32
Systems Description (Section 7) 32
Handling, Service and Maintenance (Section 8) 32

Supplements (Section 9) 32
Safety Tips (Section 10) 33
Document Details 34

Chapter 1

Stall Awareness Training

In January 1980, the Federal Aviation Administration issued AC 61-92, "Use of Distractions during Pilot Certification Flight Tests," announcing its policy of incorporating the use of certain distractions during the performance of flight test maneuvers.

This policy came about as a result of Report No. FAA-RD-77-26, which revealed that stall/spin related accidents accounted for approximately one-quarter of all fatal general aviation accidents. National Transportation Safety Board statistics indicate that most stall/spin accidents occur in the traffic pattern (takeoff, approach and landing, go-around) and result when a pilot is distracted momentarily from the primary task of flying the aircraft.

Changes to 14 CFR part 61, completed in 1991, included increased stall and spin awareness training for recreational, private, and commercial pilot applicants. The training is intended to emphasize recognition of situations that could lead to an inadvertent stall/spin by using realistic distractions, such as those suggested in Report No. FAA-RD-77-26, and incorporated into the performance of flight test maneuvers. Although the training is intended to emphasize stall and spin awareness and recovery techniques for all pilots, only flight instructor-airplane and flight instructor-glider candidates are required to demonstrate instructional proficiency in spin entry, spins, and spin recovery techniques as a requirement for certification.

Stall Awareness Training

Aerodynamics of a Stall

An airplane will fly as long as the wing is creating sufficient lift to counteract the load imposed on it. A stall occurs when the critical angle of attack is exceeded, the smooth airflow over the airplane's wing is disrupted, and lift degenerates rapidly. Remember, the direct cause of every stall is an excessive angle of attack. There are many flight maneuvers which may produce an increase in the angle of attack, but the stall does not occur until the angle of attack becomes excessive.

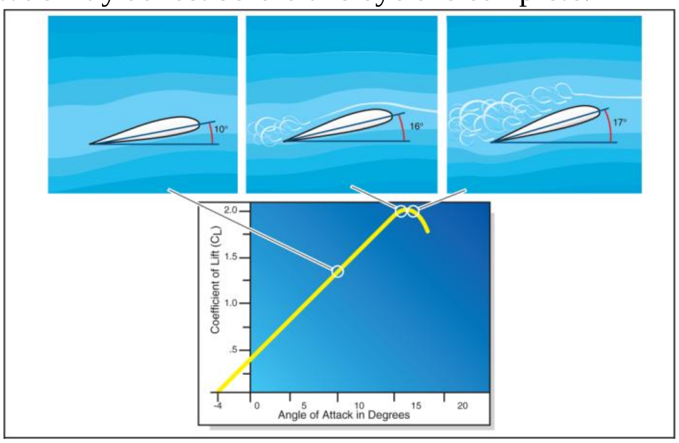
It must be emphasized that the stalling speed of a particular airplane is not a fixed value for all flight situations. However, a given airplane will always stall at the same angle of attack regardless of airspeed, weight, load factor, or density altitude. Each airplane has a particular angle of attack where the airflow separates from the upper surface of the wing and the stall occurs. This critical angle of attack varies from 16 to 20 degrees depending on the airplane design, but each airplane has only one specific angle of attack where the stall occurs.

There are three situations in which the critical angle of attack can be exceeded: low-speed flight, high-speed flight, and turning flight. The airplane can be stalled in straight-and-level flight by flying too slow. As the airspeed decreases, the angle of attack must be increased to retain the lift required for maintaining altitude. The lower the airspeed becomes, the more the angle of attack must be increased. Eventually, an angle of attack is reached which will result in the wing not producing enough lift to support the airplane and it will start settling. If the airspeed is reduced further, the airplane will stall since the angle of attack has exceeded the critical angle and the airflow over the wing is disrupted.

You must emphasize to your students that low speed is not necessary to produce a stall. The wing can be brought into an excessive angle of attack at any speed. For example, an airplane is in a dive with an airspeed of 200 knots when suddenly the pilot pulls back sharply on the elevator control. Because of gravity and centrifugal force, the airplane cannot immediately alter its flightpath but will merely change its angle of attack abruptly from quite low to very high. Since the flightpath of the airplane in relation to the oncoming air determines the direction of the relative wind, the angle of attack is suddenly increased, and the airplane would quickly reach the stalling angle at a speed much greater than the normal stall speed.

Similarly, the stalling speed of an airplane is higher in a level turn than in straight-and-level flight. This is because centrifugal force is added to the airplane's weight, and the wing must produce sufficient additional lift to counterbalance the load imposed by the combination of centrifugal force and weight. In a turn, the necessary additional lift is acquired by applying back pressure to the elevator control. This increases the angle of attack and results in increased lift. The angle of attack must increase as the bank angle increases to counteract the increasing load caused by centrifugal force. If at any time during a turn the angle of attack becomes excessive, the airplane will stall.

At this point, the action of the airplane during a stall should be examined. To balance the airplane aerodynamically, the center of lift is normally located aft of the center of gravity. Although this makes the airplane inherently "heavy," downwash on the horizontal stabilizer counteracts this condition. It can be seen then, that at the point of stall when the upward force of the wing lift and the downward tail force cease, an unbalanced condition exists. This allows the airplane to pitch down abruptly, rotating about its center of gravity. During this nose-down attitude, the angle of attack decreases and the airspeed again increases; the smooth flow of air over the wing begins again, lift returns, and the airplane is again flying. However, considerable altitude may be lost before this cycle is complete.



Critical Angle of Attack

Aerodynamics of a Spin

A spin may be defined as an aggravated stall that results in "autorotation," wherein the airplane follows a downward corkscrew path. As the airplane rotates around its vertical axis, the rising wing is less stalled than the descending wing creating a rolling, yawing, and pitching motion. The airplane is basically being forced downward by gravity, rolling, yawing and pitching in a spiral path. The autorotation results from an unequal angle of attack on the airplane's wings. The rising wing has a decreasing angle of attack where the relative lift increases and the drag decreases. In effect, this wing is less stalled. Meanwhile, the descending wing has an increasing angle of attack, past the critical angle of attack where the relative lift decreases and drag increases.

A spin is caused when the airplane's wing exceeds its critical angle of attack with a sideslip or yaw acting on the airplane at, or beyond, the actual stall. During this uncoordinated maneuver, a pilot may not be aware that a critical angle of attack has been exceeded until the airplane yaws out of control toward the lowering wing. If stall recovery is not initiated immediately, the airplane may enter a spin. If this stall occurs while the airplane is in a slipping or skidding turn, this can result in a spin entry and rotation in the direction that the rudder is being applied, regardless of which wingtip is raised.

Many airplanes have to be forced to spin and require considerable judgment and technique to get the spin started. These same airplanes that have to be forced to spin may be accidentally put into a spin by mishandling the controls in turns, stalls, and flight at minimum controllable airspeeds. This fact is additional evidence of the necessity for the practice of stalls until the ability to recognize and recover from them is developed. Often a wing will drop at the beginning of a stall. When this happens, the nose will attempt to yaw in the direction of the low wing. This is where use of the rudder is important during a stall. The correct amount of opposite rudder must be applied to keep the nose from yawing toward the low wing. By maintaining directional control before stall recovery is initiated, a spin will be averted. If the nose is allowed to yaw during the stall, the airplane will begin to slip in the direction of the lowered wing and will enter a spin. An airplane must be stalled in order to enter a spin; therefore, continued practice in stalls will help the pilot develop a more instinctive and prompt reaction in recognizing an approaching spin. It is essential to learn to apply immediate corrective action any time it is apparent that the airplane is nearing spin conditions. If it is impossible to avoid a spin, the pilot should immediately execute spin recovery procedures.

Distractions

Improper airspeed management resulting in stalls are most likely to occur when the pilot is distracted by one or more tasks such as locating a checklist or attempting a restart after an engine failure, flying a traffic pattern on a windy day, reading a chart, making fuel and/or distance calculations, or attempting to retrieve items from the floor, back seat, or glove compartment. Pilots at all skill levels should be aware of the increased risk of entering an inadvertent stall or spin while performing tasks that are secondary to controlling the aircraft.

Pilots Perform Simultaneous Tasks

Stall Recognition and Recovery Techniques

There are several ways to recognize that a stall is impending. When one or more of these indicators is noted, initiation of a recovery should be instinctive (unless a full stall is being practiced intentionally from an altitude that allows recovery above 1,500 feet AGL for single-engine airplanes and 3,000 feet AGL for multi-engine airplanes). One indication of a stall is a "mushy" feeling in the flight controls and less control effect as the aircraft's speed is reduced. This reduction in control effectiveness is attributed in part to reduced airflow over the flight control surfaces. In fixed-pitch propeller airplanes, a loss of revolutions per minute (RPM) may be evident when approaching a stall in power-on conditions. For both airplanes and gliders, a reduction in the sound of air flowing along the fuselage is usually evident. Just before the stall occurs, buffeting, uncontrollable pitching, or vibrations may begin. Many aircraft are equipped with stall warning devices that will alert the pilot when the airflow over the wing(s) approaches a point that will not allow lift to be sustained. Finally, kinesthesia (the sensing of changes in direction or speed of motion), when properly learned and developed, will warn the pilot of a decrease in speed or the beginning of a "mushing" of the aircraft. These preliminary indications serve as a warning to the pilot to increase airspeed by adding power, and/or lowering the nose, and/or decreasing the angle of bank.

Stall Recognition

Types of Stalls

Stalls can be practiced both with and without power. Stalls should be practiced to familiarize the student with the aircraft's particular stall characteristics without putting the aircraft into a potentially dangerous condition. In multi-engine airplanes, single-engine stalls must be avoided. A description of some different types of stalls follows:

1. ***Power-off stalls*** (also known as approach-to-landing stalls) are practiced to simulate normal approach-to-landing conditions and configurations. Many stall/spin accidents have occurred in these power-off situations, such as crossed-control turns from base leg to final approach (resulting in a skidding or slipping turn), attempting to recover from a high sink rate on final approach by using only an increased pitch attitude, and improper airspeed control on final approach or in other segments of the traffic pattern.
2. ***Power-on stalls*** (also known as departure stalls) are practiced to simulate takeoff and climb-out conditions and configurations. Many stall/spin accidents have occurred during these phases of flight, particularly during go-arounds. A causal factor in such accidents has been the pilot's failure to maintain positive control due to a nose-high trim setting or premature flap retraction. Failure to maintain positive control during short field takeoffs has also been an accident causal factor.
3. ***Accelerated stalls*** can occur at higher-than-normal airspeeds due to abrupt and/or excessive control applications. These stalls may occur in steep turns, pull ups, or other abrupt changes in flight path. Accelerated stalls usually are more severe than unaccelerated stalls and are often unexpected because they occur at higher-than-normal airspeeds.

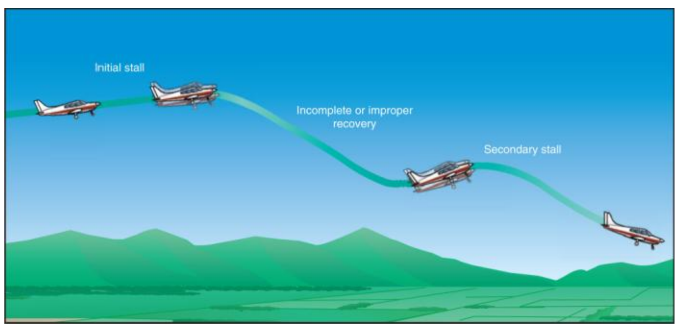
Stall Recovery

The key factor in recovering from a stall is regaining positive control of the aircraft by reducing the angle of attack. At the first indication of a stall, the angle of attack must be decreased to allow the wings to regain lift. Every aircraft in upright flight may require a different amount of forward pressure to regain lift. It should be noted that too much forward pressure can hinder recovery by imposing a negative load on the wing. The next step in recovering from a stall is to smoothly apply maximum allowable power (if applicable) to increase the airspeed and to minimize the loss of altitude. Certain high performance airplanes may require only an increase in thrust and relaxation of the back pressure on the yoke to effect recovery. As airspeed increases and the recovery is completed, power should be adjusted to return the airplane to the desired flight condition. Straight and level flight should be established with full coordinated use of the controls. The airspeed indicator or tachometer, if installed, should never be allowed to reach their high-speed red lines at any time during a practice stall.

Stall Recovery

Secondary Stalls

If recovery from a stall is not made properly, a secondary stall or a spin may result. A secondary stall is caused by attempting to hasten the completion of a stall recovery before the aircraft has regained sufficient flying speed. When this stall occurs, the back elevator pressure should again be released just as in a normal stall recovery. When sufficient airspeed has been regained, the aircraft can then be returned to straight-and-level flight.



Secondary Stall

Weight and Balance

Minor weight or balance changes can affect an aircraft's spin characteristics. For example, the addition of a suitcase in the aft baggage compartment will affect the weight and balance of the aircraft. An aircraft that may be difficult to spin intentionally in the utility category (restricted aft CG and reduced weight) could have less resistance to spin entry in the normal category (less restricted aft CG and increased weight) due to its ability to generate a higher angle of attack and increased load factor. Furthermore, an aircraft that is approved for spins in the utility category, but loaded in the normal category, may not recover from a spin that is allowed to progress beyond one turn.

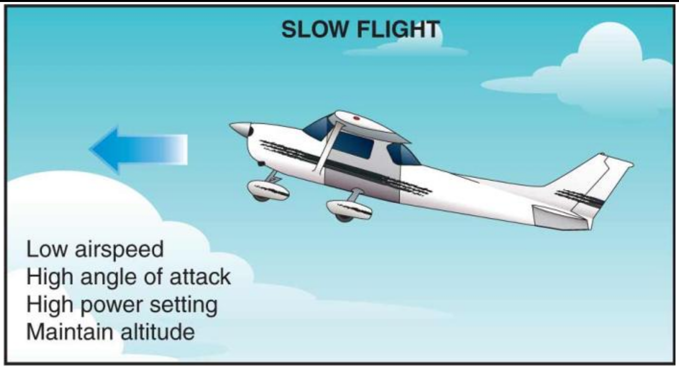
Stall Training

Flight instructor-airplane and flight instructor-glider applicants must be able to give stall training. The flight instructor should emphasize that techniques and procedures for each aircraft may differ and that pilots should be aware of the flight characteristics of each aircraft flown. Single-engine stalls should not be demonstrated or practiced in multi-engine airplanes. Engine-out minimum control speed demonstrations in multi-engine airplanes should not be attempted when the density altitude and temperature are such that the engine-out minimum control speed is close to the stall speed, since loss of directional or lateral control could result. The flight training required by 14 CFR part 61 does not entail the actual practicing of spins for other than flight instructor-airplane and flight instructor-glider applicants, but emphasizes stall and spin avoidance. The most effective training method contained in Report No. FAA-RD-77-26 is the simulation of scenarios that can lead to inadvertent stalls by creating distractions while the student is practicing certain maneuvers. Stall demonstrations and practice, including maneuvering during slow flight and other maneuvers with distractions that can lead to inadvertent stalls, should be conducted at a sufficient altitude to enable recovery above 1,500 feet AGL in single-engine airplanes and 3,000 feet AGL in multi-engine airplanes.

Stall Avoidance Practice at Slow Airspeeds

The following training elements are based on Report No. FAA-RD-77-26:

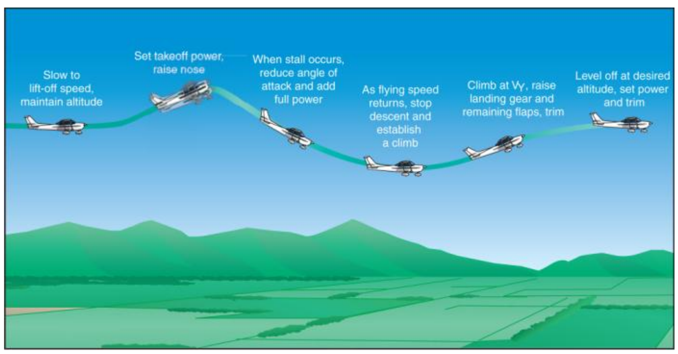
1. Assign a heading and an altitude. Have the student reduce power and slow to an airspeed just above the stall speed, using trim as necessary.
2. Have the student maintain heading and altitude with the stall warning device activated.
3. Demonstrate the effect of elevator trim (use neutral and full nose-up settings) and rudder trim, if available.
4. Note the left turning tendency and rudder effectiveness for lateral/directional control.
5. Emphasize how right rudder pressure is necessary to center the ball indicator and maintain heading.
6. Release the rudder and advise the student to observe to the left yaw.
7. Adverse yaw demonstration: while at a low airspeed, have the student enter left and right turns without using rudder pedals.
8. Have the student practice turns, climbs, and descents at low airspeeds.
9. Demonstrate the proper flap extension and retraction procedures while in level flight to avoid a stall at low airspeeds. Note the change in stall speeds with flaps extended and retracted.
10. Realistic distractions at low airspeeds. Give the student a task to perform while flying at a low airspeed. Instruct the student to divide his/her attention between the task and flying the aircraft to maintain control and avoid a stall. The following distractions can be used:
    a. Drop a pencil. Ask the student to pick it up.
    b. Ask the student to determine a heading to an airport using a chart.
    c. Ask the student to reset the clock to Universal Coordinated Time.
    d. Ask the student to get something from the back seat.
    e. Ask the student to read the outside air temperature.
    f. Ask the student to call the Flight Service Station (FSS) for weather information.
    g. Ask the student to compute true airspeed with a flight computer.
    h. Ask the student to identify terrain or objects on the ground.
    i. Ask the student to identify a field suitable for a forced landing.
    j. Have the student climb 200 feet and maintain altitude, then descend 200 feet and maintain altitude.
    k. Have the student reverse course after a series of S-turns.
11. Fly at low airspeeds with the airspeed indicator covered. Use various flap settings and distractions.



Slow Flight

Departure Stall

1. At a safe altitude, have the student attempt coordinated power-on (departure) stalls straight ahead and in turns. Emphasize how these stalls could occur during takeoff.
2. Ask the student to demonstrate a power-on (departure) stall and distract him/her just before the stall occurs. Explain any effects the distraction may have had on the stall or recovery.



Power On (Departure) Stall and Recovery

A 180-degree Turn After Engine Failure

This demonstration will show the student how much altitude the airplane loses following a power failure after takeoff and during a 180-degree turn back to the runway, and why returning to the airport after losing an engine is not a recommended procedure. This can be performed using either a medium or steep bank in the 180-degree turn, but emphasis should be given to stall avoidance.

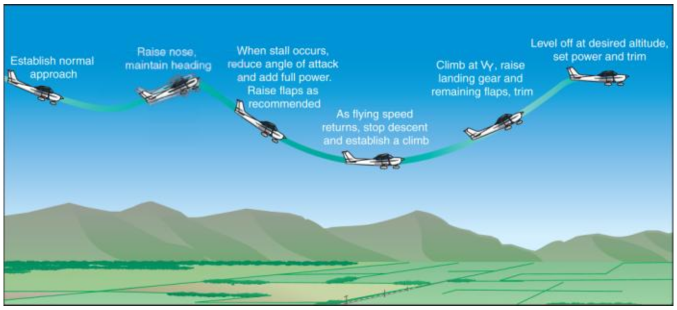
1. Set up best rate of climb (Vy).
2. Reduce power smoothly to idle as the airplane passes through a cardinal altitude.
3. Lower the nose to maintain the best glide speed and make a 180-degree turn at the best glide speed.
4. Point out the altitude loss and emphasize how rapidly airspeed decreases following a power failure in a climb attitude.

Cross Controlled Stalls in Gliding Turns

1. Perform stalls in gliding turns to simulate turns from base to final. Perform the stalls from a properly coordinated turn, a slipping turn, and a skidding turn. Explain the difference between slipping and skidding turns.
2. Show the effect of improper control technique and emphasize the importance of correct control usage. Explain the ball indicator position in each turn and the aircraft behavior in each of the stalls.

Power-off (approach-to-landing) Stalls

1. Have the student perform a full-flap, gear extended, power-off stall with the correct recovery and cleanup procedures. Note the loss of altitude.
2. Have the student repeat this procedure and distract the student during the stall and recovery and note the effect of the distraction. Show how errors in flap retraction procedure can cause a secondary stall.



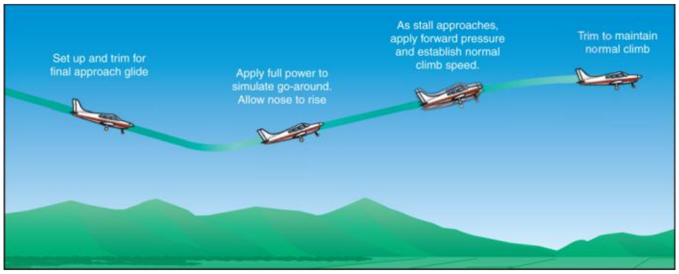
Power Off Stall and Recovery

Stalls During Go-arounds

1. Have the student perform a full-flap, gear extended, power-off stall, then recover and attempt to climb with flaps extended. If a higher than normal climb pitch attitude is held, a secondary stall will occur. (In some airplanes, a stall will occur if a normal climb pitch attitude is held.)
2. Have the student perform a full-flap, gear extended, power-off stall, then recover and retract the flaps rapidly as a higher than normal climb pitch attitude is held. A secondary stall or settling with a loss of altitude may result.

Elevator Trim Stall

1. Have the student place the airplane in a landing approach configuration in a trimmed descent.
2. After the descent is established, initiate a go-around by adding full power, holding only light elevator and right rudder pressure.
3. Allow the nose to pitch up and torque to pull the airplane left. At the first indication of a stall, recover to a normal climbing pitch attitude.
4. Emphasize the importance of correct attitude control, application of control pressures, and proper trim during go-arounds.



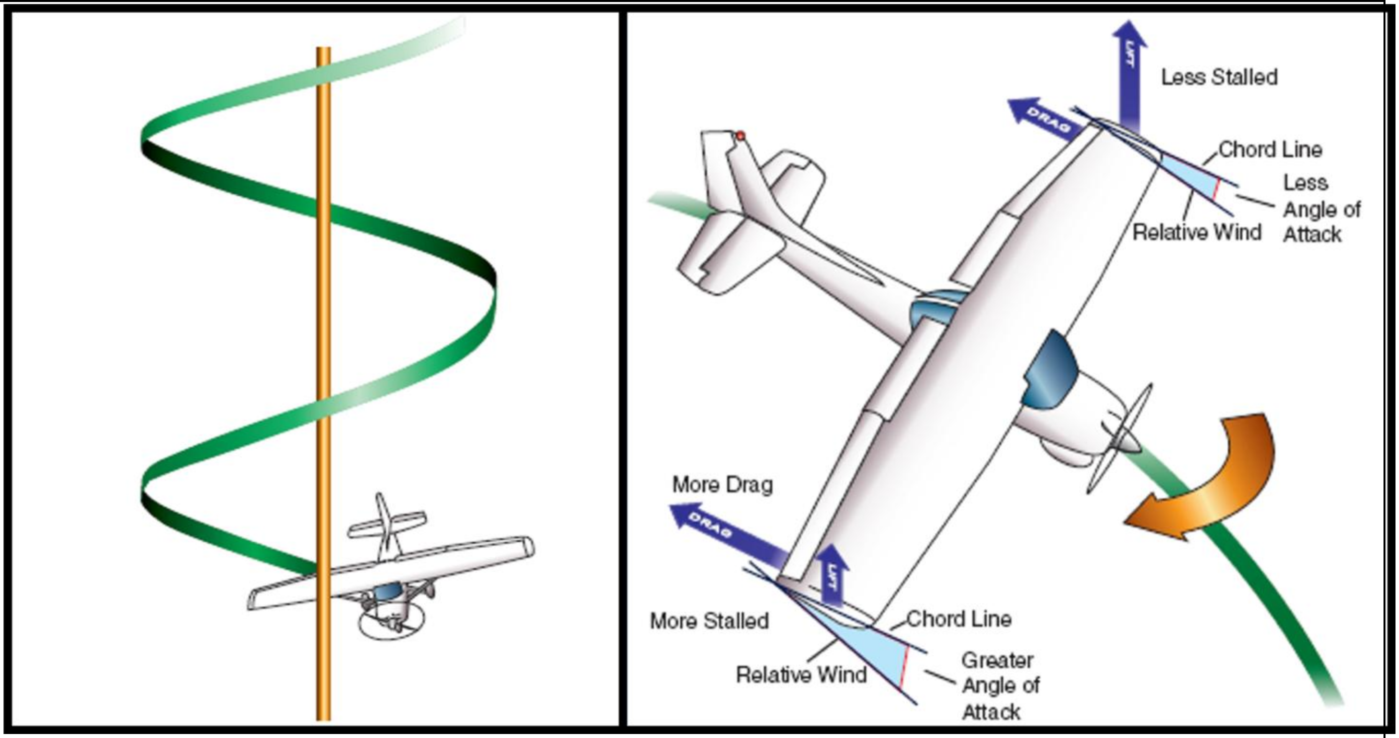
Elevator Trim Stall and Recovery

Chapter 2

Spin Training

Spin training is required for flight instructor-airplane and flight instructor-glider applicants only. Upon completion of the training, the applicant's logbook or training record should be endorsed by the flight instructor who provided the training. A sample endorsement of spin training for flight instructor applicants is available in AC 61-65, "Certification: Pilots and Flight Instructors," current edition.

1. Spin training must be accomplished in an aircraft that is approved for spins. Before practicing intentional spins, the AFM or POH should be consulted for the proper entry and recovery techniques.
2. The training should begin by practicing both power-on and power-off stalls to familiarize the applicant with the aircraft's stall characteristics. Spin avoidance, incipient spins, and actual spin entry, spin and spin recovery techniques should be practiced from an altitude above 3,500 feet AGL.
3. Spin avoidance training should consist of stalls and maneuvering during slow flight using realistic distractions such as those listed in Chapter 2. Performance is considered unsatisfactory if it becomes necessary for the instructor to take control of the aircraft to avoid a fully developed spin.
4. Incipient spins should be practiced to train the instructor applicant to recover from a student's poorly performed stall or unusual attitude that could lead to a spin.
    a. Configure the aircraft for a power-on or power-off stall and continue to apply back elevator pressure. As the stall occurs, apply right or left rudder and allow the nose to yaw toward the stalled wing.
    b. Release the spin-inducing control pressures and recover as the spin begins by applying opposite rudder and forward elevator pressure. The instructor should discuss control application in the recovery.
5. Spin entry, spin, and spin recovery should be demonstrated by the instructor and repeated, in both directions, by the applicant.
    a. Apply the entry procedure for a power-off stall. As the airplane approaches a stall, smoothly apply full rudder in the direction of desired spin rotation and continue to apply back elevator to the limit of travel. The ailerons should be neutral.
    b. Allow the spin to develop, and fully recover no later than one full turn. Observe the airspeed indicator during the spin and subsequent recovery to ensure that it does not reach the red line (Vne).
    c. Follow the recovery procedures recommended by the manufacturer in the AFM or POH. In most aircraft, spin recovery techniques consist of retarding power (if in a powered aircraft), applying opposite rudder to slow the rotation, neutralizing the ailerons, applying positive forward-elevator movement to break the stall, neutralizing the rudder as the spinning stops, and returning to level flight.



Spin - Aggravated Stall and Autorotation

Operating Limitations

Operating limitations are imposed for the safety of pilots and their passengers. Operations contrary to these restrictions are a serious compromise of safety. It is therefore most important that all pilots, flight and ground instructors, and pilot examiners apply the following information on spinning to pilot training and flight operations.

1. ***Normal Category.*** Single-engine normal category airplanes are placarded against intentional spins. However, to provide a margin of safety when recovery from a stall is delayed, these airplanes are tested during certification and must be able to recover from a one-turn spin, or a three-second spin, whichever takes longer, in not more than one additional turn with the controls used in the manner normally used for recovery. In addition:
    - For both the flaps-retracted and flaps-extended conditions, the applicable airspeed limit and positive limit maneuvering load factor may not be exceeded. For the flaps-extended condition, the flaps may be retracted during recovery;
    - There may be no excessive back pressure during the spin recovery; and
    - It must be impossible to obtain uncontrollable spins with any use of the controls.

    Note: Since airplanes certificated in the normal category have not been tested for more than a one-turn or three-second spin, their performance characteristics beyond these limits are unknown. This is the reason they are placarded against intentional spins.

2. ***Acrobatic Category.*** An acrobatic category airplane must meet the following requirements:
    - The airplane must recover from any point in a spin up to and including six turns, or any greater number of turns for which certification is requested, in not more than one and one-half additional turns after initiation of the first control action for recovery. However, beyond three turns, the spin may be discontinued if spiral characteristics appear.

    - The applicable airspeed limits and limit maneuvering load factors must not be exceeded. For flaps-extended configurations for which approval is requested, the flaps must not be retracted during the recovery.
    - It must be impossible to obtain unrecoverable spins with any use of the flight or engine power controls either at the entry into or during the spin.
    - There must be no characteristics during the spin (such as excessive rates of rotation or extreme oscillatory motion) that might prevent a successful recovery due to disorientation or incapacitation of the pilot.
3. ***Utility Category.*** A utility category airplane must meet the requirements for either the normal or acrobatic category. Permissible Maneuvers:
    - All operations in the normal category.
    - Spins (if approved for that airplane).
    - Lazy eights, chandelles, and steep turns in which the angle of bank is more than 60°.

Placards

Under 14 CFR section 23.1567, all airplanes type certificated under 14 CFR part 23 must have a flight maneuver placard containing the following information:

- For normal category airplanes, there must be a placard in front of and in clear view of the pilot stating: "No acrobatic maneuvers, including spins, approved."
- Additionally for those utility category airplanes with a certification after March 1978 that do not meet the spin requirements for acrobatic category airplanes, there must be an additional placard in clear view of the pilot stating: "Spins Prohibited."
- For acrobatic category airplanes, there must be a placard in clear view of the pilot listing the approved acrobatic maneuvers and the recommended entry airspeed for each. If inverted flight maneuvers are not approved, the placard must include a notation to this effect.

Pilot Awareness

The pilot of an airplane placarded against intentional spins should assume that the airplane may become uncontrollable in a spin. In addition, stall warning devices should not be deactivated for pilot certification flight tests in airplanes for which they are required equipment.

Chapter 3

Aircraft Operational Limitations

Instructors know that if a pilot is not intimately knowledgeable of their aircraft's operational limitations, they have an increased risk of having an incident. Students must demonstrate that they do not ignore the limitations of the aircraft, either deliberately or through ignorance. The importance of knowing how to perform a weight-and-balance calculation for their aircraft and the use of the information in their approved flight manual needs to be emphasized by the instructor and demonstrated by the student from the beginning of their training. It is therefore important to develop techniques and methods that will convey the importance and implications of operating within an aircraft's limitations.

Accelerate in Ground Effect

Operating Data

The performance or operational information section of the Airplane Flight Manual/Pilot's Operating Handbook (AFM/POH) contains the operating data for the airplane; that is, the data pertaining to takeoff, climb, range, endurance, descent, and landing. The use of this data in flying operations is mandatory for safe and efficient operation. Considerable knowledge and familiarity of the airplane can be gained through study of this material. It must be emphasized that manufacturer's information and data furnished in the AFM/POH is not standardized. Some provide the data in tabular form, while others use graphs. In addition, the performance data may be presented on the basis of standard atmospheric conditions, pressure altitude, or density altitude. The performance information in the AFM/POH has little or no value unless the user recognizes those variations and makes the necessary adjustments. To be able to make practical use of the airplane's capabilities and limitations, it is essential to understand the significance of the operational data. The pilot must be cognizant of the basis for the performance data, as well as the meanings of the various terms used in expressing performance capabilities and limitations. Since the characteristics of the atmosphere have a predominant effect on performance, it is necessary to review some of the dominant factors--pressure and temperature.

Pilot's Operating Handbook

Air Density and Airplane Performance

Air density refers to the amount of air within a given volume. Changes in air pressure or temperature cause the density of the air to change.

Low pressure and high temperature cause the air to expand. This results in a decrease in air density. Although not an obvious factor when calculating aircraft performance, the amount of water vapor in the air also has an effect on air density; high relative humidity, if pressure and temperature are constant, causes air density to decrease, increasing takeoff distance.

Changes in air density have a dramatic effect on airplane performance. A wing must move through the air at a certain speed before it will produce lift. If the volume of air surrounding the airplane is less dense, the wing must move faster to produce lift. The higher speed necessary for takeoff will lengthen the ground roll.

As density altitude increases, the true airspeed and, therefore, the groundspeed required for takeoff or landing increase. Indicated airspeed is not affected by density altitude.

Reduced air density decreases engine power which results in a longer takeoff ground roll. The propeller produces less thrust due to the same aerodynamic factors affecting the wing. After liftoff, the decreased engine power and reduced propeller efficiency result in decreased climb performance.

The Standard Atmosphere

The International Standard Atmosphere (ISA) is based on the following:

- Sea level standard pressure is 29.92" Hg. This pressure decreases at an approximate rate of 1" Hg for each 1000-foot increase in altitude.
- Standard sea level temperature is 15 degrees C (59 degrees F). This temperature decreases at 2 degrees C (3.5 degrees F) per each 1000-foot increase in altitude.

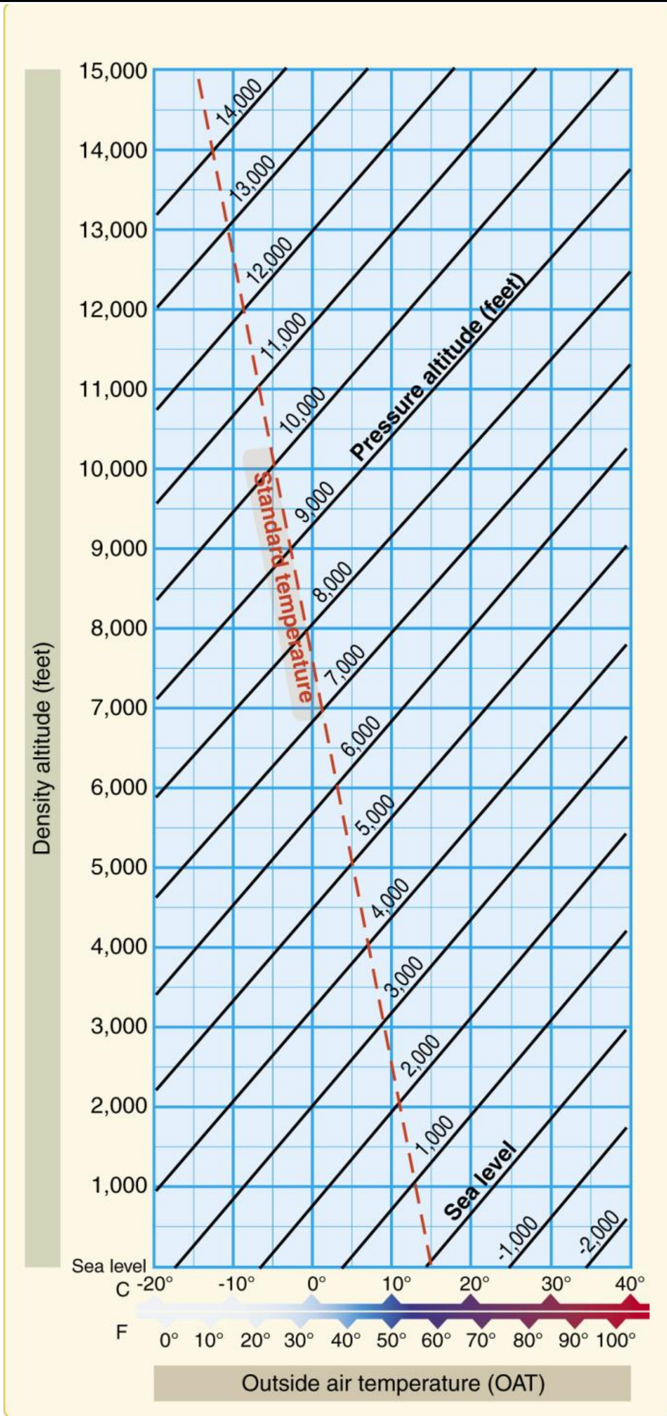
The standard datum plane of 29.92" Hg is the reference for altitude in the standard atmosphere. Pressure altitude is height measured from this plane.

Standard Atmosphere			
Altitude (ft)	Pressure (Hg)	Temperature	
		(°C)	(°F)
0	29.92	15.0	59.0
1,000	28.86	13.0	55.4
2,000	27.82	11.0	51.9
3,000	26.82	9.1	48.3
4,000	25.84	7.1	44.7
5,000	24.89	5.1	41.2
6,000	23.98	3.1	37.6
7,000	23.09	1.1	34.0
8,000	22.22	-0.9	30.5
9,000	21.38	-2.8	26.9
10,000	20.57	-4.8	23.3
11,000	19.79	-6.8	19.8
12,000	19.02	-8.8	16.2
13,000	18.29	-10.8	12.6
14,000	17.57	-12.7	9.1
15,000	16.88	-14.7	5.5
16,000	16.21	-16.7	1.9
17,000	15.56	-18.7	-1.6
18,000	14.94	-20.7	-5.2
19,000	14.33	-22.6	-8.8
20,000	13.74	-24.6	-12.3

Properties of Standard Atmosphere

Density Altitude

Correcting pressure altitude for nonstandard temperature gives the actual density of the air. Locating this density value on an ISA chart will give the altitude at which this density occurs in the standard atmosphere. This is density altitude. Under standard conditions, pressure altitude and density altitude are equal. When conditions are not standard, density altitude may be higher or lower than pressure altitude.



Density Altitude Chart

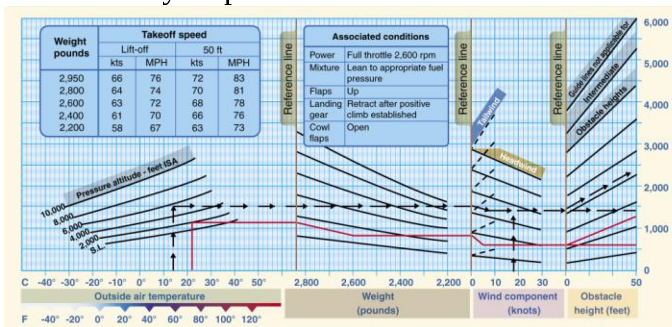
Factors Affecting Takeoff Performance

The factors affecting takeoff performance are density altitude, wind, gross weight, and runway condition and slope.

Increasing the weight of the airplane will decrease performance. At a given power output, acceleration decreases as weight increases. A higher weight also requires a higher speed to achieve enough lift for takeoff.

A soft runway surface or tall grass will slow acceleration and lengthen the takeoff roll. An uphill runway slope also reduces acceleration and increases takeoff distance.

A headwind will shorten takeoff distance. As a general rule, a headwind equal to ten percent of the takeoff speed will reduce the takeoff distance by 20 percent.



Takeoff Distance Graph

Cruise Performance

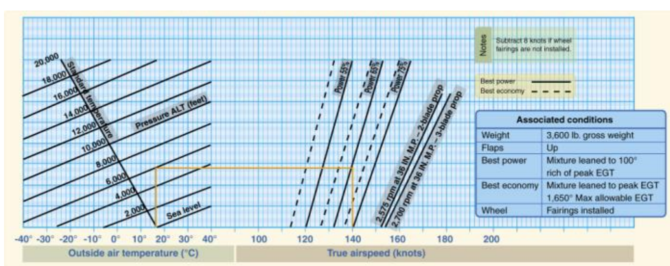
Your choice of altitude and power setting for cruise is affected by many variables: trip length, usable fuel, available refueling stops, winds and weather. Manufacturers provide cruise performance graphs or tables to assist you in this choice.

Two variables in cruise performance are range and endurance. Maximum range means getting the most *distance* from the available fuel. Maximum endurance means getting the most *time* from a tank of fuel.

To get the maximum range, you must operate the airplane at its maximum lift to drag ratio (L/Dmax)--the angle of attack where maximum lift and minimum drag occur. This angle of attack permits the highest proportion of speed and power, i.e. you will attain the highest speed using the least amount of power.

Fuel burned during flight will reduce the gross weight of the airplane and affect the speed or altitude at which maximum range is obtained. As the weight of the airplane decreases, less lift is needed to maintain level flight. To maintain a constant angle of attack, (L/Dmax), reduce speed or air density. Reducing power will reduce speed, climbing to a higher altitude will reduce the air density.

Maximum endurance is obtained when operating at a speed where minimum power and minimum fuel flow are required to maintain level flight. At gross weight, the speed for maximum range in a fixed gear, single engine airplane is about 1.5 times Vs_1. A ten percent decrease in weight results in a five percent decrease in the speed for maximum range. Maximum endurance speed will be about 1.2 times Vs_1 for such airplanes.



Cruise Performance Graph

Chapter 4

Introduction

As evidenced by the performance considerations in the previous pages, there are many factors that lead to efficient and safe aircraft operation. Among these vital factors is proper weight and balance control. The weight and balance system commonly employed consists of three equally important elements: the weighing of the aircraft, the maintaining of the weight and balance records, and the proper loading of the aircraft. As the subject name "weight and balance" suggests, the concern is not only with the weight of the airplane but also the location of its center of gravity.

The POH or AFM includes tables or charts that give the pilot an indication of the performance expected for any weight. An important part of careful preflight planning includes a check of these charts to determine that the aircraft is loaded properly so the proposed flight can be safely made. Many of these charts and tables have mechanical load adjusters of one type or another, the use of which eliminates most or all of the mathematics involved in weight and balance. Since there are many types of charts and graphs they will not be covered here, but it is important that they be learned and understood for the particular aircraft that the pilot is flying.

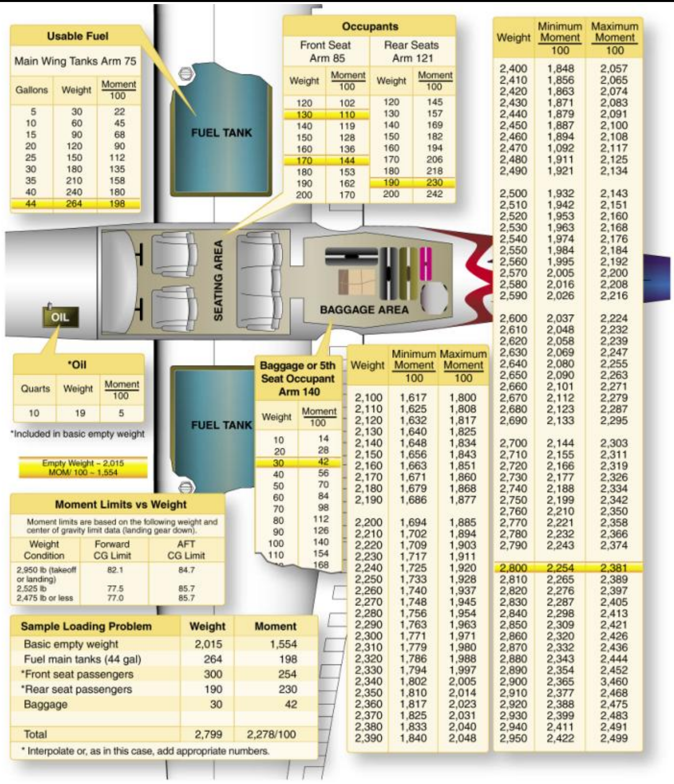
Weight and balance limitations are placed on airplanes for two principal reasons:

- The effect of weight on the airplane's primary structure and performance characteristics; and
- The effect the location of this weight has on flight characteristics, particularly stability, stall, and spin recovery.

The following discussion on certification, controllability and stability is background information into some of the reasons why weight and balance conditions are important to the safe flight of an airplane.

Pilot’s Responsibility

The pilot in command of the aircraft has the responsibility on every flight to know the maximum allowable weight of the aircraft and its CG limits. This allows the pilot to determine during preflight inspection that the aircraft is loaded in such a way that the CG is within the allowable limits.



Loading Schedule Placard

Load Factors and Certification

The manufacturers of modern airplanes furnish weight and balance data with each airplane produced. Generally, this information may be found in the FAA-approved Airplane Flight Manual or Pilot's Operating Handbook (AFM/POH). With the advancements in airplane design and construction in recent years has come the development of more user-friendly charts for determining weight and balance data. Increased performance and load carrying capability of these airplanes require strict adherence to the operating limitations prescribed by the manufacturer.

Deviations from these recommendations can result in structural damage or even complete failure of the airplane's structure. Even when an airplane is loaded within the maximum weight limitations, it is imperative that weight distribution be within the limits of center of gravity location.

It is easy for some pilots to develop a sense of complacency about weight and balance, particularly when operating a familiar airplane. This is exacerbated when the operation is viewed as routine, such as instructional flights or repetitive cross-country flights being made to the same airport with a similar payload.

Knowledge of load factors imposed by flight maneuvers and gusts will emphasize the consequences of an increase in the gross weight of an airplane. The structure of an airplane experiencing a load factor of 3Gs in recovery from a steep dive must be prepared to withstand an added load of 300 pounds for each 100-pound increase in weight. It should be noted that this would be imposed by the addition of about 16 gallons of unneeded fuel in a particular airplane.

If this is accepted as indicative of the load factors that may be imposed during operations for which the airplane is intended, a 100-pound overload imposes a potential structural overload of 380 pounds if normal category load limits are reached. The same consideration is even more impressive in the case of utility and acrobatic category airplanes, which have maximum load factors of 4.4 and 6.0Gs respectively. Structural failures which result from overloading may be dramatic and catastrophic, but more often they affect structural components progressively in a manner which is difficult to detect and expensive to repair. The additional stress placed on structural parts by overloading is believed to accelerate the occurrence of metal fatigue. One of the most serious results of habitual overloading is that its effects tend to be cumulative and may result in structural failure later during completely normal operations.

The FAA-certificated civil airplane has been analyzed structurally and tested for flight at the maximum gross weight authorized and within the speeds posted for the type of flight to be performed. Flight at weights in excess of this amount is quite possible and often is well within the performance capabilities of an airplane. Nonetheless, this fact should not be allowed to mislead the pilot, as the pilot may not realize that loads for which the airplane was not designed are being imposed on all or some part of the structure.

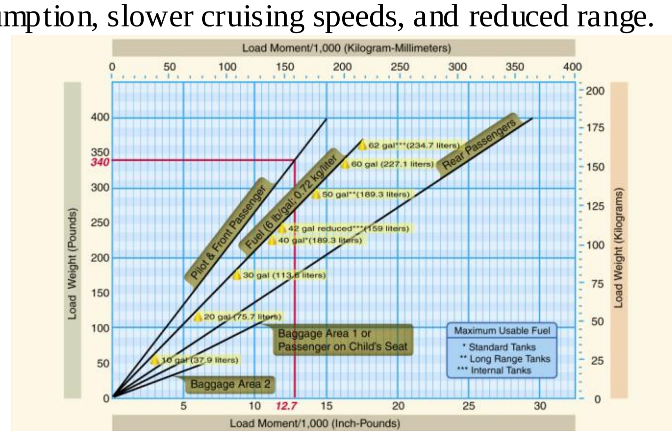
In loading an airplane with either passengers or cargo, the structure must be considered. Seats, baggage compartments, and cabin floors are designed for a certain load or concentration of load. As an example, a light plane's baggage compartment may be placarded for 20 pounds because of the limited strength of its supporting structure, even though the airplane may not be overloaded or out of center of gravity limits with more weight at that location.

In some airplanes, it is not possible to fill all seats, baggage compartments and fuel tanks, and still remain within approved weight or balance limits. As an example, in several popular four-place airplanes the fuel tanks may not be filled to capacity when four occupants and their baggage are carried. The effect of additional weight on the wing structure of an airplane is not readily apparent. Airworthiness requirements prescribe that the structure of an airplane certificated in the normal category (in which acrobatics are prohibited) must be strong enough to withstand a load factor of 3.8Gs caused by maneuvering or gusts. This means that the primary structure of the airplane can withstand a load of 3.8 times the approved gross weight of the airplane without structural failure occurring.

In certain two-place airplanes, no baggage may be carried in the compartment aft of the seats when spins are to be practiced. When certifying an airplane in the utility category to permit intentional spins, the aft center of gravity limit is usually established at a point several inches forward of that which is permissible for certification in the normal category.

The Effect of Weight on Performance

The takeoff, climb, and landing performance of an airplane are determined on the basis of its maximum allowable takeoff and landing weights. A heavier gross weight will result in a longer takeoff run and shallower climb, a faster touchdown speed and longer landing roll. Even a minor overload may make it impossible for the airplane to clear an obstacle. The detrimental effects of overloading on performance are not limited to the immediate hazards involving takeoffs and landings. Overloading has an adverse effect on all climb and cruise performance which leads to overheating during climbs, added wear on engine parts, increased fuel consumption, slower cruising speeds, and reduced range.



Loading Graph

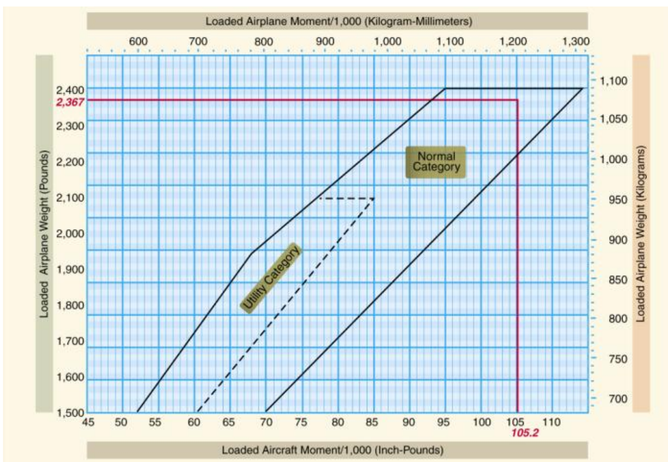
Controllability

Controllability is the measure of response of an aircraft relative to the pilot's flight control inputs. A factor affecting controllability, which is becoming more important in current designs of large airplanes, is the effect of long moment arms on the positions of heavy equipment and cargo.

The effects of the distribution of an airplane's useful load have a significant influence on its flight characteristics, even when that load is within the center of gravity limits and the maximum permissible gross weight. Important among these effects are changes in controllability, stability, and the actual load imposed on the wing. Generally, an airplane becomes less controllable, especially at slow flight speeds, as the center of gravity is moved further aft. An airplane which cleanly recovers from a prolonged spin with the center of gravity at one position may fail completely to respond to normal recovery attempts when the center of gravity is moved aft by one or two inches. It is common practice for airplane designers to establish an aft center-of-gravity limit that is within one inch of the maximum, which will allow normal recovery from a one-turn spin.

An airplane may be loaded to maximum gross weight within its center of gravity limits by concentrating fuel, passengers, and cargo near the design center of gravity or by dispersing fuel and cargo loads in wingtip tanks and cargo bins forward and aft of the cabin. With the same total weight and center of gravity, maneuvering the airplane or maintaining level flight in turbulent air will require the application of greater control forces when the load is dispersed. This is true because of the longer moment arms to the positions of the heavy fuel and cargo loads, which must be overcome by the action of the control surfaces.

An airplane with full outboard wing tanks or tip tanks tends to be sluggish in roll when control situations are marginal, while one with full nose and aft cargo bins tends to be less responsive to the elevator controls.



CG Moment Envelope

Stability

Stability is an airplane design characteristic that allows an airplane to correct for conditions that may disturb its equilibrium, and to return to its original flightpath.

An airplane that is observed to be quite stable and controllable when loaded normally may be found to have very different flight characteristics when it is overloaded. Although the distribution of weight has the most direct effect on this, an increase in the airplane's gross weight may be expected to have an adverse effect on stability, regardless of location of the center of gravity.

An airplane with forward loading is "heavier" and consequently slower than the same airplane with the center of gravity further aft. With forward loading, nose-up trim is required in most airplanes to maintain level cruising flight. Nose-up trim involves setting the tail surfaces to produce a greater down load on the aft portion of the fuselage, which adds to the wing loading and the total lift required from the wing if altitude is to be maintained. This requires a higher angle of attack of the wing, which results in more drag. This in turn produces a higher stalling speed.

With aft loading and nose-down trim, the tail surfaces will exert less down load, relieving the wing of that much loading and lift required to maintain altitude. The required angle of attack of the wing is less, resulting in less drag and allowing for a faster cruise speed. Theoretically, a neutral load on the tail surfaces in cruising flight would produce the most efficient overall performance and fastest cruising speed, but would also result in instability. Consequently, modern airplanes are designed to require a down load on the tail for stability and controllability. Remember that a zero indication on the trim tab control is not necessarily the same as "neutral trim" because of the force exerted by downwash from the wings and the fuselage on the tail surfaces.

The rearward center of gravity limit of an airplane is determined largely by considerations of stability. The original airworthiness requirements for a type certificate specify that an airplane in flight at a certain speed will dampen out vertical displacement of the nose within a certain number of oscillations. An airplane loaded too far rearward may not do this; instead when the nose is momentarily pulled up, it may alternately climb and dive, becoming steeper with each oscillation. This instability is not only uncomfortable to occupants, but could become dangerous by making the airplane unmanageable under certain conditions.

The recovery from a stall in any airplane becomes progressively more difficult as its center of gravity moves aft. This is particularly important in spin recovery, as there is a point in rearward loading of any airplane at which a "flat" spin will develop. A flat spin is one in which centrifugal force, acting through a center of gravity located well to the rear, will pull the tail of the airplane out away from the axis of the spin, making it impossible to get the nose down and recover. An airplane loaded to the rear limit of its permissible center-of-gravity range will handle differently in turns and stall maneuvers and have different landing characteristics than when it is loaded near the forward limit.

The forward center-of-gravity limit is determined by a number of considerations. As a safety measure, it is required that the trimming device, whether tab or adjustable stabilizer, be capable of holding the airplane in a normal glide with the power off. A conventional airplane must be capable of a full stall, power-off landing in order to ensure minimum landing speed in emergencies.

A tailwheel airplane loaded excessively nose heavy will be difficult to taxi, particularly in high winds. It can be nosed over easily by use of the brakes, and it will be difficult to land without bouncing since it tends to pitch down on the wheels as it is slowed down and flared for landing.

Steering difficulties on the ground may occur in tricycle-gear airplanes loaded to a forward center of gravity, particularly during the landing roll and takeoff.

- The CG position influences the lift and angle of attack of the wing, the amount and direction of force on the tail, and the degree of deflection of the stabilizer needed to supply the proper tail force for equilibrium. The latter is very important because of its relationship to elevator control force.
- The airplane will stall at a higher speed with a forward CG location. This is because the stalling angle of attack is reached at a higher speed due to increased wing loading.
- Higher elevator control forces normally exist with a forward CG location due to the increased stabilizer deflection required to balance the airplane.
- The airplane will cruise faster with an aft CG location because of reduced drag. The drag is reduced because a smaller angle of attack and less downward deflection of the stabilizer are required to support the airplane and overcome the nose-down pitching tendency.
- The airplane becomes less stable as the CG is moved rearward. This is because when the CG is moved rearward it causes an increase in the angle of attack. Therefore, the wing contribution to the airplane's stability is now decreased, while the tail contribution is still stabilizing. When the point is reached that the wing and tail contributions balance, neutral stability exists. Any CG movement further aft will result in an unstable airplane.
- A forward CG location increases the need for greater back elevator pressure. The elevator may no longer be able to oppose any increase in nose-down pitching. Adequate elevator control is needed to control the airplane throughout the airspeed range down to the stall.

Chapter 5

AFM/POH Characteristics

An Airplane Flight Manual is a document developed by the airplane manufacturer and approved by the Federal Aviation Administration. It is specific to a particular make and model airplane, by serial number and registration number, and contains operating procedures and limitations. Title 14 of the Code of Federal Regulations (14 CFR) part 91 requires that pilots comply with the operating limitations specified in the approved airplane flight manuals, markings, and placards.

Originally, flight manuals followed whatever format and content the manufacturer felt was appropriate. This changed with the acceptance of the General Aviation Manufacturers Association's (GAMA) Specification for Pilot's Operating Handbook, which established a standardized format for all general aviation airplane and rotorcraft flight manuals. The Pilot's Operating Handbook (POH) is developed by the airplane manufacturer and contains the FAA-approved Airplane Flight Manual (AFM) information. However, if *Pilot's Operating Handbook* is used as the main title instead of *Airplane Flight Manual*, a statement must be included on the title page indicating that sections of the document are FAA-approved as the Airplane Flight Manual.

An airplane owner/information manual is a document developed by the airplane manufacturer containing general information about the make and model of airplane. The airplane owner's manual is not FAA-approved and is not specific to a particular serial-numbered airplane. This manual provides general information about the operation of the airplane and is not kept current, and therefore cannot be substituted for the AFM/POH. Besides the preliminary pages, a POH may contain as many as ten sections. These sections are: General, Limitations, Emergency Procedures, Normal Procedures, Performance, Weight and Balance/Equipment List, Systems Description; Handling, Service and Maintenance, and Supplements. Manufacturers have the option of including a tenth section on Safety Tips, as well as an alphabetical index at the end of the POH.

Pilot's Operating Handbook

Preliminary Pages

While the AFM/POH may appear similar for the same make and model of airplane, each manual is unique since it contains specific information about a particular airplane, such as the equipment installed and weight and balance information. Therefore, manufacturers are required to include the serial number and registration on the title page to identify the airplane to which the manual belongs. If a manual does not indicate a specific airplane registration and serial number, it is limited to general study purposes only.

General Section (Section 1)

The General section provides the basic descriptive information on the airplane and power plant(s). This section serves as a quick reference in becoming familiar with the airplane. The last segment of the General section contains definitions, abbreviations, explanations of symbology, and some of the terminology used in the POH.

Limitations Section (Section 2)

The Limitations section contains only those limitations required by regulation or that are necessary for the safe operation of the airplane, powerplant, systems, and equipment. It includes operating limitations, instrument markings, color-coding and basic placards. Some of the limitation areas are: airspeed, powerplant, weight and loading distribution, and flight.

Airspeed

Airspeed limitations are shown on the airspeed indicator by color-coding and on placards or graphs in the airplane.

Power Plant

The Power Plant Limitations area describes operating limitations on the airplane's reciprocating or turbine engine(s). These include limitations for takeoff power, maximum continuous power, and maximum normal operating power, which is the maximum power the engine can produce without any restrictions and is depicted by a green arc. Other items that can be included in this area are the minimum and maximum oil and fuel pressures, oil and fuel grades, and propeller operating limits.

Weight and Loading Distribution

The Weight and Loading Distribution area contains the maximum certificated weights, as well as the center of gravity range. The location of the reference datum used in balance computations is included in this section. Weight and balance computations are not provided in this area, but rather in the Weight and Balance section of the AFM/POH.

Flight Limits

This area lists authorized maneuvers with appropriate entry speeds and flight load factor limits. It also indicates those maneuvers that are prohibited, such as spins, acrobatic flight, and operational limitations such as flight into known icing conditions.

Placards

Most airplanes display one or more placards that contain information having a direct bearing on the safe operation of the airplane. These placards are located in conspicuous places within the airplane and are reproduced in the Limitations section or as directed by an Airworthiness Directive (AD).

Placards

Emergency Procedures (Section 3)

Checklists describing the recommended procedures and airspeeds for coping with various types of emergencies or critical situations are located in the Emergency Procedures section. Some of the emergencies covered include: engine failure, fires, and systems failures. Procedures for in-flight engine restarting and ditching may also be included. Manufacturers may first show the emergencies checklists in an abbreviated form with the order of items reflecting the sequence of action. Amplified checklists that provide additional information on the procedures follow the abbreviated checklist. To be prepared for emergency situations, memorize the immediate action items and after completion, refer to the appropriate checklist. Manufacturers may include an optional area titled "Procedures." This section describes recommended procedures for handling malfunctions that are not considered emergencies.

Normal Procedures (Section 4)

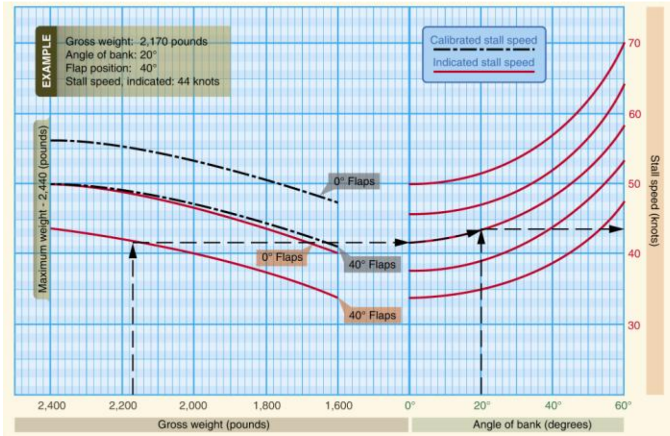
This section begins with a listing of the airspeeds for normal operations. The next area consists of several checklists that may include preflight inspection, before starting procedures, starting engine, before taxiing, taxiing, before takeoff, takeoff, climb, cruise, descent, before landing, balked landing, after landing, and post flight procedures. An Amplified Procedures area follows the checklists to provide more detailed information about the various procedures.

To avoid missing important steps, always use the appropriate checklists whenever they are available. Consistent adherence to approved checklists is a sign of a disciplined and competent pilot.

Performance (Section 5)

The Performance section contains all the information required by aircraft certification regulations and any additional performance information the manufacturer feels may enhance a pilot's ability to safely operate the airplane. Information the manufacturer provides on performance charts, tables, and graphs has been gathered from test flights conducted in a new aircraft, under normal operating conditions while using average piloting skills, and with the aircraft and engine in good working order. Some examples of the performance information found in most flight manuals include a graph or table for converting calibrated

airspeed into true airspeed, stall speeds in various configurations, and data for determining takeoff and climb performance, cruise performance, and landing performance.
It is important to remember that the data from the charts will not be accurate if the aircraft is not in good working order or when operating under adverse conditions. Always consider the necessity to compensate for the performance numbers if the aircraft is not in good working order or piloting skills are below average.



Stall Speed Chart

Weight and Balance/Equipment List (Section 6)

The Weight and Balance/Equipment List section contains all the information required by the FAA to calculate the weight and balance of the airplane. Manufacturers include sample weight and balance problems.

Systems Description (Section 7)

The Systems Description section is where the manufacturer describes the systems in enough detail for the pilot to understand how the systems operate.

Handling, Service and Maintenance (Section 8)

The Handling, Service, and Maintenance section describes the maintenance and inspections recommended by the manufacturer and the regulations. Additional maintenance or inspections may be required by the issuance of Airworthiness Directives applicable to the airplane, engine, propeller, and components. This section also describes preventive maintenance that may be accomplished by certificated pilots, as well as the manufacturer's recommended ground handling procedures. This includes considerations for hangar, tie-down, and general storage procedures for the airplane.
An Airworthiness Directive (AD) is a regulatory notice that is sent out by the FAA to the registered owners of aircraft informing them of the discovery of a condition that keeps their aircraft from continuing to meet its conditions for airworthiness. For further information, see 14 CFR part 39.

Supplements (Section 9)

The Supplements section describes pertinent information necessary to safely and efficiently operate the airplane when equipped with various optional systems and equipment not provided with the standard airplane. Some of this information may be supplied by the airplane manufacturer or by the manufacturer of the optional equipment. The appropriate information is inserted into the flight manual at the time the equipment is installed. Autopilots, navigation systems, and air-conditioning systems are examples of equipment described in this section.

Pilot's Operating Handbook Supplements

Safety Tips (Section 10)

The Safety Tips section is an optional section containing a review of information that enhances the safe operation of the airplane. Some examples of the information that might be covered include: physiological factors, general weather information, fuel conservation procedures, high altitude operations, and cold weather operations.

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