Multi-Engine Airplanes

Definitions

Absolute Ceiling: The density altitude beyond which no further climb is possible with both engines operating at maximum power. The single-engine absolute ceiling is the density altitude the airplane is capable of reaching and maintaining with the critical engine feathered and the other engine at maximum power.

Accelerate-Go Distance: The distance required to accelerate to liftoff speed, experience an engine failure, and complete the takeoff and climb to clear a 50-foot obstacle.

Accelerate-Stop Distance: The sum of the differences necessary to accelerate the airplane from a starting point to liftoff, experience an engine failure, and come to a full stop.

Accumulator: A device that assists in bringing the propeller out of the feathered position by providing a burst of oil pressure to the hub when the control lever is moved out of the feather position.

Aerodynamic Twisting Force: One of the five forces acting on a rotating propeller. The aerodynamic twisting force tends to twist the blade angle toward the feather position.

Asymmetric Thrust: Uneven thrust created by the ascending and descending propeller blades. This condition also occurs when the trust produced by the engines of a multi-engine airplane is uneven.

Balanced Field Length: A balanced field condition exists when accelerate-stop distance equals accelerate-go distance.

Critical Engine: The engine with the most adverse effect on controllability and climb performance of a multi-engine airplane if it were to fail.

Drift Down: The unavoidable descent due to the loss of an engine when above the single-engine absolute ceiling of an airplane.

Propeller Synchronization: Adjusting the propeller controls in order to operate the propellers in unison, eliminating the uncomfortable noise associated with two propellers operating at slightly different rates.

Service Ceiling: The maximum density altitude at which the airplane can produce a 100 FPM rate of climb with both engines operating. The single-engine service ceiling is reached the single-engine best rate of climb airspeed produces a 50 FPM rate of climb. This ceiling assumes the aircraft is at maximum gross weight, and in the clean configuration. For single-engine operations, the critical engine is inoperative, and the propeller feathered.

V_{MC}: The calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative. *(Reference: 14 CFR Part 23.149)*

V_{SSE}: Intentional one engine inoperative airspeed. The aircraft manufacturer develops V_{SSE}. It is considered the minimum airspeed for intentional rendering one engine inoperative in flight for pilot training. No intentional engine failure in flight should be performed below this airspeed.

V_{XSE}: Best single-engine angle of climb airspeed.

V_{YSE}: Best single-engine rate of climb airspeed.

Windmilling: The rotation of an aircraft propeller created by air flowing around it when the engine is not operating.

Zero-Sideslip: A control technique used in following an engine failure in a multi-engine aircraft where the pilot maintains an attitude that minimizes drag, alleviating the sideslip of the airplane.

Asymmetric Thrust

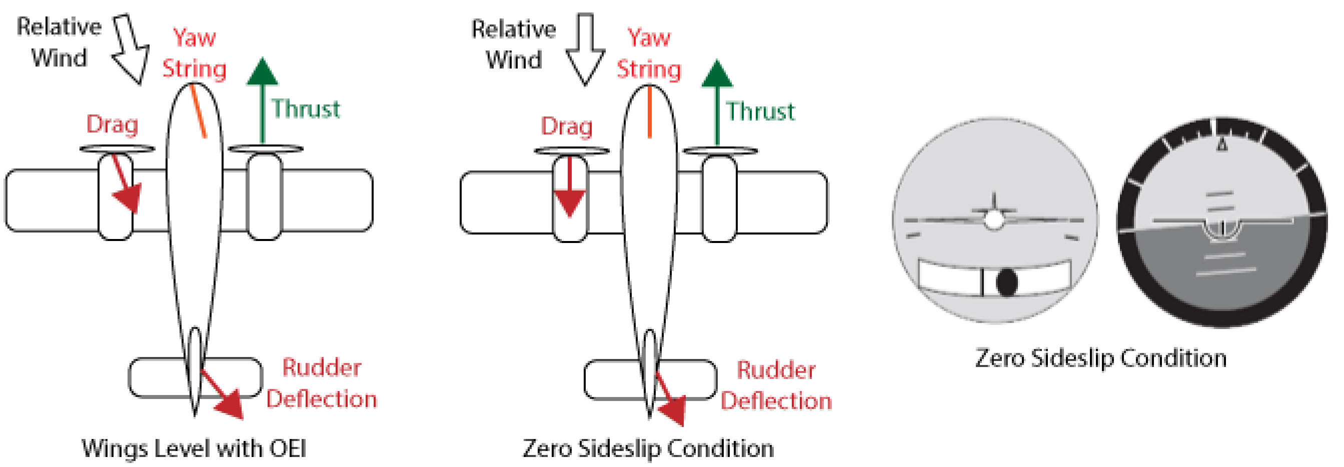
When a multi-engine aircraft experiences an engine failure and the engines are not mounted on the longitudinal axis, there will be unbalanced forces and turning moments about the CG. This will cause the following directional control and performance problems:

- **Pitch Down:** The loss of induced airflow over the horizontal stabilizer results in less negative lift produced by the tail. Additional back-pressure will be required to maintain level flight.
- **Roll Toward the Inoperative Engine:** The loss of the accelerated slipstream air over the wing of the inoperative engine will result in a reduction of lift on that wing. Therefore, the aircraft will tend to roll towards the inoperative engine due to asymmetrical lift. This requires additional aileron pressure into the operative engine.
- **Yaw:** Asymmetrical thrust will require rudder pressure toward the operating engine.
- **Sideslip:** With one engine inoperative, holding the wings level and the ball centered will cause the relative wind to strike the fuselage at an angle, resulting in a slip.

Zero-Sideslip

Following an engine failure in flight, the airplane will yaw towards the inoperative engine due to asymmetrical thrust. Rudder pressure must be applied to maintain the aircraft's heading with the wings level. With rudder force applied, the nose of the airplane will become misaligned with the relative wind resulting in a sideslip. This condition produces a large amount of drag, which reduces aircraft performance.

To prevent the aircraft from entering a sideslip condition, the airplane should be banked towards the operative engine by 2° to 3°. Less rudder force will be needed because the horizontal lift produced aids the pilot in maintaining the aircraft heading. As the bank angle exceeds the zero-sideslip value, there is a sharp loss of climb performance. The zero-sideslip angle varies by airplane type.

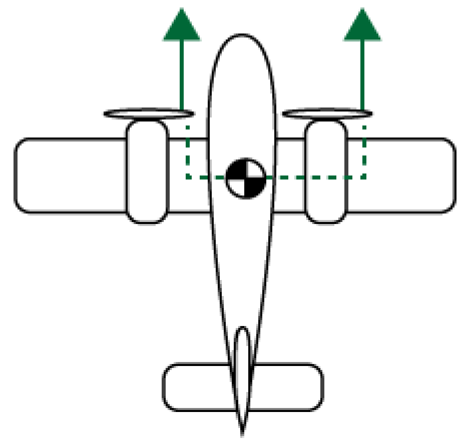


In addition to banking the airplane towards the operative engine, the pilot should apply the appropriate amount of rudder. An indication of a proper rudder pressure is displayed on the inclinometer when the ball is "split" towards the operative engine. The correct position can vary from one-third to one-half of a ball width depending on the airplane. This configuration aligns the fuselage with the relative wind.

Zero-sideslip can be demonstrated by the use of a yaw string. A yaw string is a piece of string or yarn approximately 18″–36″ in length, taped to the base of the windshield, or to the nose near the windshield, along the airplane centerline. In a zero-sideslip condition, the relative wind will cause the string to align itself with the longitudinal axis of the airplane, and it will position itself straight up the center of the windshield.

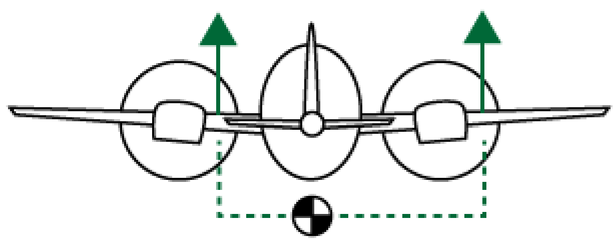
Four Factors that Make the Left Engine Critical

Note: The following factors are applicable to a conventional twin-engine airplane with both propellers turning clockwise when viewed from the cockpit.

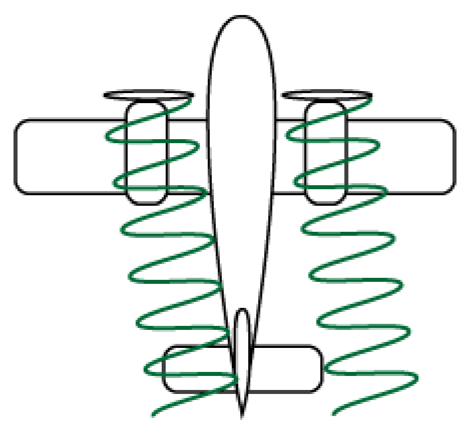


Asymmetrical Thrust (Yaw): The descending propeller blade of each engine will produce greater thrust than the ascending blade when the airplane is operated under power and at positive angles of attack. Even though both propellers produce the same amount of thrust, the descending blade on the right engine has a longer moment arm, or greater leverage, than the descending blade on the left engine. As a result, failure of the left engine will result in the most asymmetrical thrust (adverse yaw) as the right engine will be providing the remaining thrust.

Accelerated Slipstream (Roll and Pitch): Asymmetrical thrust (P-Factor) results in a longer moment arm to the centerline of thrust of the right engine than to the left engine. Therefore, the centerline of lift is farther out on the right wing, resulting in a greater rolling tendency with a loss of the left engine. A failure of the left engine also results in a greater downward pitching moment due to the greater loss of negative lift produced by the tail.

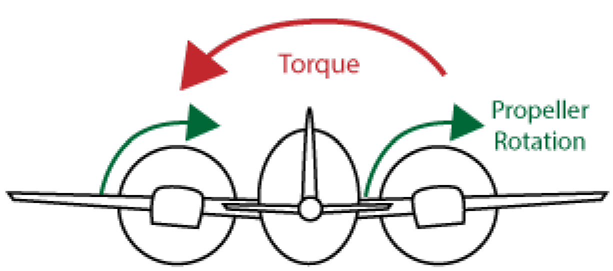


Note: With both engines operating, 18% to 30% of total lift is generated from the accelerated slipstream.



Spiraling Slipstream (Yaw): A spiraling slipstream of air from the left engine strikes the vertical stabilizer from the left. This helps counteract the yaw caused by a failure of the right engine. The right engine's slipstream does not hit the vertical stabilizer. If the left engine fails, the slipstream from the right engine will not counteract the yaw toward the inoperative engine.

Torque (Roll): For every action, there is an equal and opposite reaction. Since the propellers both rotate clockwise (right), the aircraft will have a tendency to roll counter-clockwise (left). A failure of the left engine will cause the aircraft to roll to the left. Torque will aid the roll to the left. A failure of the right engine will cause the aircraft to roll to the right, but torque will still want to roll it to the left. Torque is effectively canceling some of the roll tendency.



How the Manufacturer Determines V_{MC}

An airplane's minimum control speed (V_{MC}) is designated on the airspeed indicator by a red radial line. At V_{MC}, the rudder pedal force required to maintain control must not exceed 150 pounds and it must not be necessary to reduce power of the operative engine. During the maneuver, the airplane must not assume any dangerous attitude and it must be possible to prevent a heading change of more than 20°.

V_{MC} must be determined by the airplane manufacturer using the following requirements. While not all of the conditions are necessarily "good" for V_{MC} (i.e., lower it), they are necessary to establish a standard of measurement.

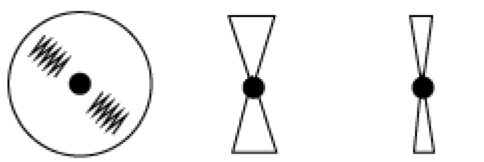
Standard Day: Aircraft manufactures must determine performance data and meet the FAA's performance requirements in still air and standard atmosphere. This requirement comes from 14 CFR Part 23.45 and generally applies to all performance data.

Most Unfavorable Weight: A heavily loaded multi-engine airplane has more inertia that a lightly loaded one, thus it will have a greater resistance to yawing than a lighter aircraft. For a given bank angle, an increase in the weight of the airplane will require more lift to maintain altitude. The vertical and horizontal components will both increase; the increase in the horizontal component of lift will require less rudder pressure to keep the aircraft from yawing. A heavier airplane will therefore have a lower V_{MC}. Weight has no effect on V_{MC} if the wings are level.

Most Unfavorable CG Location: The aft-most CG limit is the most unfavorable CG position. As the CG moves aft, the moment arm of the rudder is shortened, producing less leverage for the rudder. This will cause the rudder to have less authority in overcoming yawing forces, causing V_{MC} to increase. At the same time, the moment arm of the propeller blade is increased, aggravating asymmetrical thrust.

All Propeller Controls in the Recommended Takeoff Position (Windmilling Propeller): V_{MC} increases as drag increases on the inoperative engine. A windmilling propeller creates more drag than a stationary propeller. When the propeller is stationary, an unfeathered position creates more drag than a feathered propeller. Therefore, V_{MC} is highest when the critical engine's propeller is windmilling at the low pitch, high RPM blade angle.

Graphical Representation of Drag Profiles



Flaps in the Takeoff Position: Extending the flaps increases the drag behind the operative engine. This can have a stabilizing effect that may reduce V_{MC}.

Landing Gear Retracted: V_{MC} increases when the landing gear is retracted. Extended landing gear creates a keel effect that aids directional stability, which tends to decrease V_{MC}.

The Airplane out of Ground Effect: Ground effect decreases drag and increases V_{MC}.

The Airplane Trimmed for Takeoff: Since the airplane is normally trimmed to a neutral position on takeoff, having the airplane pre-trimmed as an aid to an engine failure would be cheating.

Not More than 5° of Bank towards the Operating Engine: V_{MC} is highly dependent on bank angle. To prevent claims of an unrealistically low V_{MC}, the manufacturer is permitted to use a maximum of 5° of bank toward the operative engine. The horizontal component of lift generated by the bank assists the rudder in counteracting the asymmetrical thrust of the operative engine.

For every 1° of bank towards the operative engine up to the bank angle providing maximum aerodynamic efficiency, V_{MC} decreases by approximately three knots. Conversely, banking away from the operating engine may increase V_{MC} as much as three knots per degree of bank.

The 5° bank does not inherently establish zero-sideslip or give the best single-engine climb performance. Zero-sideslip occurs at bank angles less than 5°, typically around 2° or 3°. The determination of V_{MC} in certification is solely concerned with the minimum speed for directional control under a very specific set of circumstances. It does not necessarily provide the optimum configuration for climb performance.

Maximum Available Takeoff Power Initially on Each Engine (Engine Failure Should Happen Suddenly): V_{MC} increases as power is increased on the operating engine.

Reference: 14 CFR Part 23.149

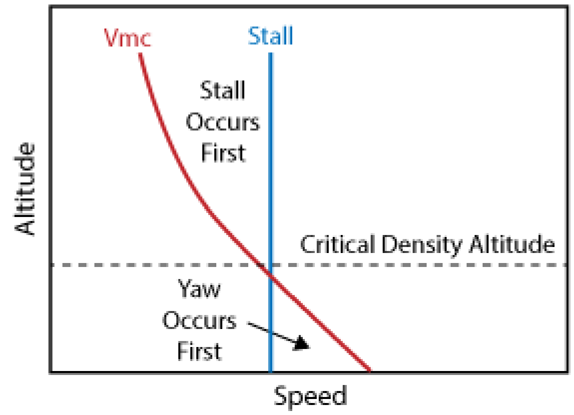
Factors Affecting Control and Performance

Factor	V_{MC} (Airspeed)	V_{YSE} (Performance)
Below Maximum Weight	Increases	Increases
Maximum Weight	Decreases	Decreases
Landing Gear Up	Increases	Increases
Landing Gear Down	Decreases	Decreases
Wing Flaps Retracted	Increases	Increases
Wing Flaps Extended	Decreases	Decreases
Forward CG	Decreases	Decreases
Aft CG	Increases	Increases
Cowl Flaps Open	Decreases	Decreases
Cowl Flaps Closed	Increases	Increases
Windmilling Propeller	Increases	Decreases
Feathered Propeller	Decreases	Increases
Above Standard Temperature	Decreases	Decreases
Below Standard Temperature	Increases	Increases
1° to 5° Bank	Decreases	Increases
No Bank	Increases	Decreases
> 5° Bank	Decreases	Decreases
Out of Ground Effect	Increases	Decreases
In Ground Effect	Decreases	Increases

Approximate Drag Factors for Light-Twins

- **Full Flaps:** -275 FPM
- **Windmilling Propeller:** -200 FPM
- **Gear Extended:** -250 FPM

Critical Density Altitude



With normally aspirated engines, an increase in altitude or temperature results in reduced engine performance and also propeller efficiency. This results in a lower V_{MC} as altitude is increased. The calibrated stall speed does not change with altitude. So, there exists an altitude where each of the following exists:

- V_{MC} is less than Vs (stall occurs first);
- V_{MC} is the same as Vs; and
- V_{MC} is greater than Vs (yaw occurs first).

The density altitude where V_{MC} and Vs are equal is called the **critical density altitude**. At this altitude, the airplane will reach V_{MC} and Vs at the same time. Flight at this airspeed can be very dangerous when operating with one engine at full power with the other engine failed or at idle power. The airplane could experience an abrupt change in attitude or enter into a spin.

Above the critical density altitude the airplane will reach the calibrated stall speed before V_{MC}. Below the critical density altitude the airplane will reach V_{MC} before the calibrated stall speed.

Certification Requirements

14 CFR Part 23 sets the standards for certification of light aircraft (12,500 pounds or less). It does not require that all light twins be able to hold altitude on one engine, even at sea level.

To determine certification requirements, multi-engine airplanes are divided into two subcategories:

- **Aircraft Not Requiring Single-Engine Climb Performance:** Multi-engine reciprocating engine aircraft that weigh less than 6,000 pounds and with a V_{S0} airspeed under 61 knots have no minimum performance criteria specified. The single-engine rate of climb must only be determined at 5,000'. The rate of climb may even be a negative number.
- **Aircraft Requiring Single-Engine Climb Performance:** Aircraft weighing above 6,000 pounds or aircraft with a V_{S0} above 61 knots must demonstrate a positive engine-out rate of climb at 5,000' with one engine inoperative and feathered and the aircraft in a clean configuration. The single-engine rate of climb must be equal to 0.027 V_{S0}^2. For twins certified after February 1991, the single-engine rate of climb is expressed as a climb gradient, which is 1.5%.

Preflight Performance Planning

In addition to the planning required for a single-engine airplane, the pilot or a multi-engine airplane should become aware of:

- The accelerate-go distance;
- The accelerate-stop distance;
- The expected climb performance after takeoff with one engine inoperative (OEI) and the landing gear retracted; and
- The single-engine service ceiling.

Note: Manufacturers of light multi-engine aircraft certified under 14 CFR Part 23 frequently publish accelerate-stop distances as advisory information. When such information is not placed in the limitations section, it is not a limitation. Operators who do not observe such advice are not exhibiting good judgment and may be in violation of 14 CFR Part 91.9.

Before taking the runway, the pilot should know if the airplane will reasonably be able to continue its climb following an engine failure. The option of continuing the takeoff probably does not exist unless the published single-engine rate of climb performance is at least 200 FPM. Turbulence, wind gusts, engine and propeller wear, or poor technique in airspeed, bank angle, and rudder control can easily negate even a 200 FPM rate of climb.

For contingency planning, the takeoff distance to 50' AGL and the landing distance from 50' AGL should be added together. If the resulting value is longer than the runway length, a return landing cannot be made without overrunning the runway.

Single-Engine Performance

The loss of one engine results in a 50% loss of power, but an approximate 80% loss of performance. This performance decrease can be seen by comparing the climb performance charts for one engine operating and two engines operating under the same atmospheric conditions.

See Also: Preflight Preparation: Aircraft Performance

Taxi Procedures

Taxiing a multi-engine airplane generally involves the same procedures as taxiing a single-engine airplane, but with the following recommendations used.

- Use caution while taxiing in confined areas. Multi-engine airplanes are normally larger and have longer wingspans than single-engine airplanes.
- Directional control may be obtained through the use of differential thrust from the engines, but steering is primarily accomplished by the use of the nosewheel.
- In crosswind conditions, increasing the thrust on the upwind engine can help with directional control.
- Avoid overusing the brakes.

Takeoff Procedures

Briefing: Before the airplane should be taxied into position on the runway, an emergency contingency plan and safety brief should be clearly understood.

See Also: Appendix: Sample Crew Briefings and Callouts (AMEL)

Normal Procedures: The manufacturers recommended rotation speed (V_R) or liftoff speed (V_{LOF}) should be used during normal operations. If no takeoff speeds are published by the manufacturer, a minimum of V_{MC} plus five knots should be used for V_R.

Crosswind Procedures: With a crosswind, the pilot can prevent side drift by rotating more positively and/or at a higher speed. However, the pilot should keep in mind that the Aircraft Flight Manual/Pilot's Operating Handbook (AFM/POH) performance figures were calculated at the recommended V_R or V_{LOF}.

Short-Field Procedures: Just after rotation and lift-off, the airplane should be allowed to accelerate to V_X and make the initial climb over obstacles at V_X. The transition to V_Y should be made as obstacles are cleared.

Soft-Field Procedures: Soft-field procedures would allow the airplane to become airborne before reaching V_{MC}. These procedures are not tested during pilot certification and should not be practiced.

Abnormal Procedures: If an engine fails below V_{MC} while the airplane is on the ground, the takeoff must be rejected. Once the decision to reject a takeoff is made, the pilot should promptly close both throttles and apply maximum braking applied while maintaining directional control. If it is necessary to shut down the engine due to a fire, the mixture control should be brought to the idle cutoff position and the ignition turned off.

Climb Procedures

After leaving the ground, altitude gain is more important than achieving an excess of airspeed. Excessive speed cannot be effectively converted into altitude in the event of an engine failure. However, excessively high climb attitudes can limit forward visibility and reduce climb performance.

Normally, gear retraction should occur only after a positive rate of climb is established and the plane is past the point where a safe landing could be made on the remaining runway or overrun. If an excessive amount of runway is available, it may not be prudent to leave the gear down for an extended period of time and sacrifice climb performance and acceleration. A general recommendation is to raise the landing gear not later than V_{YSE} airspeed, and once the gear is up, consider it a “Go” commitment if climb performance is available.

The airplane should be accelerated to and maintain V_Y until a safe maneuvering altitude, at least 400’ AGL, is obtained. Any speed above or below V_Y reduces the performance of the airplane.

Once the single-engine maneuvering altitude has been reached, the transition to an en route climb speed should be made. This speed is higher than V_Y and is usually maintained to cruising altitude to provide for better visibility, increased engine cooling, and a higher groundspeed. Takeoff power can be reduced, if desired, as the transition to en route climb speed is made. If flaps were extended for takeoff, they should be retracted as recommended in the AFM/POH.

Single-Engine Climb Procedures

The Go/No-Go Decision

In the event of an engine failure shortly after takeoff, a decision must be made to continue flight or land, even off-airport. This is called the **area of decision**. The position of the landing gear is a critical factor is a critical factor in making the decision.

If single-engine climb performance is adequate for continued flight, and the airplane is correctly configured, the climb may be continued. If a climb is unlikely or impossible, a landing has to be made in the most suitable area. What must be always be avoided is continued flight when it is not within the airplane’s capability to do so.

Landing Gear Not Selected Up

The position of the landing gear is a critical factor in making the decision to abort or to continue the takeoff. As a general rule, if the landing gear lever has not been moved into the up position, the pilot should abort the takeoff roll and use the remaining runway and overrun area to slow the airplane in the event of an engine failure.

Landing Gear Selected Up, Single-Engine Climb Performance Inadequate

If the airplane experiences an engine failure after liftoff and single-engine climb performance has been determined to be inadequate, a landing must be accomplished on whatever lies ahead. The greatest hazard in this situation would be to attempt to maneuver the airplane when it is not within the performance capability of the airplane. Higher engine-out landing success rates have been encountered when the airplane is landed under positive control.

Landing Gear Selected Up, Single-Engine Climb Performance Adequate

A pilot attempting a climb with one engine inoperative will experience a high workload while addressing the critical factors of directional control, climb, and configuration that will determine the successful outcome of the maneuver.

Directional Control: The rudder and aileron should be used, aggressively if necessary, to counteract the yaw and rolling tendencies. At least a 5° of bank should initially established into the operating engine to help maintain directional control. The amount of lift lost by banking up to 5° is negligible, but exceeding 5° of bank rapidly decreases climb performance. If the yaw cannot be controlled, reducing thrust on the operative engine is the only alternative.

Airspeed: The airspeed must always stay above V_{MC} following the engine failure. A pitch attitude for V_{YSE} (or V_{XSE} if appropriate) should be made as soon as possible. It is important that the airplane is not pitched up or down excessively causing V_{YSE} to be overshot. Doing so may cause an unnecessary loss of altitude or decrease in climb performance.

During the initial climb out, V_{XSE} can be maintained to clear an obstacle with an engine inoperative. V_X and V_{XSE} are often very close to V_{MC}, leaving little margin or error. If the airplane is not flown with the same bank angle used to determine V_{MC}, the actual V_{MC} may increase above V_{XSE} and cause controllability problems.

Climb: As soon as directional control is established and the airplane configured for climb, the bank angle should be reduced to obtain the best climb performance and a zero-sideslip condition established.

Configuration: Memory items from the AFM/POH should be accomplished to establish the airplane in the optimum climb configuration. Upon reaching a safe maneuvering altitude, refer to the printed checklist. Most procedures direct the pilot to assume V_{YSE}, set takeoff power, retract the flaps and landing gear, identify, verify, and feather the failed engine.

The “identify” step is for the pilot to initially identify the failed engine. Identification should be primarily through the control inputs required to maintain straight flight, not the engine gauges. Remember, “*dead foot, dead engine.*”

The “verify” step directs the pilot to retard the throttle of the engine thought to have failed. No change in performance when the suspected throttle is retarded is verification that the correct engine has been identified as failed.

Engine Failure After Takeoff – Sample Checklist	
Airspeed	Maintain V_{YSE}
Directional Control	Maintain Heading
Mixtures	Full Forward
Propellers	Full Forward
Throttles	Full Forward
Gear and Flaps	Retract
Identify	Dead Engine
Verify	By Closing Throttle
Propeller	Feather

Communicate: An emergency should be declared with ATC once workload permits. The pilot should make ATC aware of the severity of the problem as well as his or her intentions.

Single-Engine Approach and Landing Procedures

The approach and landing with OEI is essentially the same as a two-engine approach and landing. Flight in the traffic pattern with one engine inoperative should be similar to a normal traffic pattern, but with the following recommendations used.

- The airspeed should be held above V_{YSE} until a safe landing is assured.
- On the base leg, if performance is adequate, the flaps may be extended to an intermediate setting. The final flap setting may be delayed until the landing is assured or the airplane may be landed with partial flaps.
- On final approach, a normal, 3° glidepath to a landing is desirable. VASI or other vertical path lighting aids should be utilized if available. Slightly steeper approaches may be acceptable, but a long, flat, low approach should be avoided. A single-engine go-around may not always be possible to perform due to the airplane’s weight and the density altitude.
- Anticipate the need for changes in rudder pressure during the roundout and flare. Drag created by the windmillling propeller may require rudder pressure towards the failed engine. This effect will be intensified if rudder trim was previously used to compensate for adverse yaw.
- The direction of the traffic pattern, and therefore the turns, is of no consequence as far as airplane controllability and performance are concerned if the airspeed is controlled properly. It is then acceptable to make turns toward the failed engine.

Single-Engine Go-Arounds

A single-engine go-around must be avoided. Most light-twins do not have the performance to climb on one engine with the landing gear and flaps extended. When the landing gear and flaps are retracted, altitude losses of 500’ or more are not unusual. As a practical rule for single-engine approaches, once the airplane is on final approach with landing gear and flaps extended, it is committed to land.

Engine Failure During Cruise Flight

An engine failure during cruise generally offers more time to diagnosis and resolve engine problems. In general, the initial procedures for an engine failure after takeoff can also be used for an engine failure in flight, but propeller feathering may be delayed until it is apparent that the engine will not restart.

If an engine failure occurs while in a turn, the inclinometer should be used to determine which engine has failed. If the pilot attempts to identify a failed engine by adjusting the throttle, changes in manifold pressure could be observe and mistakenly interpreted as the engine operating normally.

If the airplane is above its single-engine absolute ceiling at the time of engine failure, it will slowly lose altitude. The pilot should maintain V_{YSE} to minimize the rate of altitude loss. The drift down rate will be greatest immediately following the failure and will decrease as the single-engine ceiling is approached.

Precautionary Shutdown

A precautionary shutdown is an engine failure with a twist. The engine is failing but not failed. In this scenario the PIC must determine if an engine failure is imminent and if the best course of action is to secure the engine. To make the determination, engine indicators should be checked and a visual inspection should be conducted, if possible, for signs of imminent failure or damage.

Although it is a natural desire among pilots to save an ailing engine with a precautionary shutdown, the engine should be left running if there is any doubt as to needing it for further safe flight. Catastrophic failure accompanied by heavy vibration, smoke, blistering paint, or large trails of oil, on the other hand, indicate a critical situation. The affected engine should be feathered and the “Secure” checklist completed. The pilot should divert to the nearest suitable airport and declare an emergency with ATC for priority handling.

One Engine Inoperative Flight Training

Recommended Flight Instructor Actions

Rudder Controls: While simulating engine failures, the instructor’s foot should be in position to keep the opposite rudder from moving backwards. If the instructor fails the left engine, his or her foot should be blocking the right rudder from moving backwards. The opposite is true for a simulated failure of the right engines. This will prevent the student from applying incorrect rudder application into the inoperative engine, but will not hinder his or her ability if the appropriate rudder is pressed.

“Pull right, block left; Pull left, block right” is an easy way to remember to which rudder (left or right) should be blocked as a power lever is reduced (pulled).

Altitude permitting, the instructor should give the student one verbal warning if the student inputs the incorrect rudder control. If they do not respond to the verbal warning, the instructor should take the flight controls and return to normal operation.

Throttle Quadrant: In critical phases of flight and while conducting OEI training, the instructor must protect the throttle quadrant. It is not uncommon for a student or rush through a checklist and attempt to or actually feather the propeller at low altitude, simulate feathering the wrong propeller, or cutoff the wrong mixture. The instructor should have one hand on the throttle quadrant to prevent an inadvertent control input.

Simulating Engine Failures

One goal of multi-engine instruction is to teach the student how to handle engine out emergencies in all segments of flight.

The FAA dictates that engine failures are taught and evaluated on practical tests in four phases of flight:

- Engine failure on takeoff (below 50% of V_{MC});
- Engine failure after liftoff (above 500’ AGL);
- Engine failure in cruise flight (above 3,000’ AGL unless otherwise specified by the aircraft manufacturer); and
- Single-engine approach and landing.

Practicing these types of emergencies has inherent risks, proper procedures and mind sets can mitigate these risks and allow for effective and safe training.

Note: No engine failure should ever be introduced below V_{SSE}. If no V_{SSE} is published, use V_{YSE}.

During Takeoff

Instructors simulating an engine failure on takeoff must do so before the airplane obtains 50% of the V_{MC} airspeed. Since airspeeds this low are not normally indicated on the airspeed indicator, this failure should be simulated as soon as practicable once the takeoff roll is started.

Applying rudder pressure or dragging a brake are practical ways of simulating an engine failure or partial power loss. The only correct action for the student to take is to abort the takeoff by retarding both throttles to idle, apply the wheel brakes, and maintain directional control. Any variation from these actions could result in a rapid departure from the runway. The instructor should recover immediately.

Another method of simulating an engine failure is to pull a mixture lever to cutoff. As the student responds correctly by pulling the throttles to idle, the instructor should increase the mixture to restore power. If the student does not respond promptly and correctly, the instructor should cutoff the other mixture as well. It is better to be on the runway with two inoperative engines rather than in the grass.

Common Errors

- Attempting to control the aircraft with rudder instead of aborting the takeoff
- Reducing only one throttle to idle
- Not recognizing the problem resulting in a loss of control

After Liftoff

Teaching engine failures after takeoff has increased risk due to the close proximity to the ground. Extreme caution must be exercised to prevent the student from applying pressure to the wrong rudder pedal or reducing power on the operating engine.

No engine failure after liftoff should be conducted below 500’ AGL. Engine failures should be simulated by reducing power with the throttle only. The student should immediately perform the proper checklist from memory, if applicable, while controlling the aircraft. The instructor should set a zero-thrust setting after the proper engine has been identified, verified, and the correct propeller lever has been moved slightly towards feather to simulate securing (or as appropriate if equipped with an auto-feather feature). The instructor’s hand should be guarding the throttle quadrant to prevent a full feather or an inadvertent mixture cutoff.

Any deviation from the correct control inputs or loss of control must be quickly corrected. In the interest of safety, the instructor should not take the flight controls and try to teach through the proper steps in this phase of flight. Instead, he or she should recover to a safe altitude and latter correct any deficiencies in the student’s performance.

Common Errors

- Rushing through the checklist
- Misidentifying the failed engine
- A loss of control of the aircraft
- Failing to pitch for and maintain V_{YSE}
- Failing to feather the propeller on the inoperative engine

During Cruise Flight

Above 3,000’ AGL (or higher altitude if specified by the aircraft manufacturer) engines can be failed by either the mixture or the throttle, though the mixture is preferred. The instructor should use caution when failing engines to avoid rapid throttle movements.

Feathering for pilot flight training and testing purposes should be performed only at a safe altitude and when the aircraft is in a position where a safe landing at an established airport can be readily accomplished, in the event difficulty is encountered during the engine restart process. The instructor should locate the nearest suitable airport before simulating an engine failure.

At a safe altitude, the engine with the simulated failure can be secured which means to stop of the rotation of the propeller through the use of feathering. Securing begins when the propeller lever is moved to idle. In the event that the aircraft drifts down to an unsafe altitude, the instructor should take over the controls to restore power.

After securing the engine, the student should be taught to reduce power on the operating engine (if conditions permit), declare an emergency, and find a suitable place to land. This trains the student to think through the emergency scenario and separates the engine securing and engine restart checklists.

If the engine will not restart, the instructor must evaluate when to discontinue the restart attempt, feather the inoperative engine's propeller and land. This should be considered an emergency.

Common Errors

- Failure to follow prescribed emergency checklist
- Failure to recognize an inoperative engine
- Hazards of improperly identifying and verifying the inoperative engine
- Failure to properly adjust engine controls and reduce drag
- Failure to establish and maintain the best engine inoperative airspeed
- Improper trim procedure
- Failure to establish and maintain proper bank for best performance
- Failure to maintain positive control while maneuvering

During Approach and Landing

The approach and landing with one engine inoperative is essentially the same as a two-engine approach and landing, but a higher-than-normal power setting will be necessary on the operative engine.

The student should be taught to increase/decrease rudder with the corresponding increase/decrease of throttle to maintain stability and control. A rapid power increase at low airspeeds and in close proximity to the ground can be very hazardous if not accompanied by a corresponding rudder input.

Single-engine go-arounds should not be practiced. During training, the instructor should brief that below 400' AGL, the student has both throttles are available for a go-around. Both throttles should be increased together to eliminate and avoid asymmetrical thrust situations.

Common Errors

- Flying faster than normal because one engine is inoperative
- Not flying a stabilized approach
- Increasing or decreasing throttle without a corresponding rudder inputs which destabilizes the approach
- Not completing a checklist from being distracted from the emergency