wave downdraft may exceed the climb capability of your airplane. Avoid mountain wave downdrafts.

*VFR AT NIGHT*

When flying VFR at night, in addition to the altitude appropriate for the direction of flight, pilots should maintain a safe minimum altitude as dictated by terrain, obstacles such as TV towers, or communities in the area. This is especially true in mountainous terrain, where there is usually very little ground reference. Minimum clearance is 2,000 feet above the highest obstacle enroute. Do not depend on your ability to see obstacles in time to miss them. Flight on dark nights over sparsely populated country can be the same as IFR.

*VERTIGO - DISORIENTATION*

Disorientation can occur in a variety of ways. During flight, inner-ear balancing mechanisms are subjected to varied forces not normally experienced on the ground. This, combined with loss of outside visual reference, can cause vertigo. False interpretations (illusions) result, and may confuse the pilot's conception of the attitude and position of his airplane.

Under VFR conditions, the visual sense, using the horizon as a reference, can override the illusions. Under low visibility conditions (night, fog, clouds, haze, etc.) the illusions predominate. Only through awareness of these illusions, and proficiency in instrument flight procedures, can an airplane be operated safely in a low visibility environment.

Flying in fog, dense haze or dust, cloud banks, or very low visibility, with strobe lights or rotating beacons turned on can contribute to vertigo. They should be turned off in these conditions, particularly at night.

Motion sickness often precedes or accompanies disorientation and may further jeopardize the flight.

Disorientation in low visibility conditions is not limited to VFR pilots. Although IFR pilots are trained to look at their instruments to gain an artificial visual reference as a replacement for the loss of a visual horizon, they do not always do so. This can happen when: the pilot's physical condition will not permit him to concentrate on his instruments, when the pilot is not proficient in flying instrument conditions in the airplane he is flying, or when the pilot's work load of flying by reference to his instruments is compounded by such factors as turbulence. Even an instrument rated pilot encountering instrument conditions, intentional or unintentional, should ask himself whether or not he is sufficiently alert and proficient in the airplane he is flying to fly under low visibility conditions and the turbulence anticipated or encountered.

All pilots should check the weather and use good judgement in planning flights. If any doubt exists, the flight should not be made or it should be discontinued as soon as possible.

The result of vertigo is loss of control of the airplane. If the loss of control is sustained, it will result in an excessive speed accident. Excessive speed accidents occur in one of two manners - either as an inflight airframe separation or as a high speed ground inpact, and they are fatal accidents in either case. All airplanes are subject to this form of accident.

Excessive speed accidents occur at airspeeds greatly in excess of two operating limitations which are specified in the manuals (Maximum maneuvering speed and the "red line" or maximum operating speed). Such speed limits are set to protect the structure of an airplane. For example, control surfaces are designed to be used to their fullest extent only below a the airplane's maximum maneuvering speed. As a result, the control surfaces should never be suddenly or fully deflected above maximum maneuvering speed. Turbulence penetration should not be performed above that speed. The accidents we are discussing here occur at airspeeds greatly in excess of these limitations. No airplane should ever be flown beyond its FAA approved operating limitations.

*FLIGHT WITH ONE ENGINE INOPERATIVE*

Safe flight with one engine out requires an understanding of the basic aerodynamics involved, as well as proficiency in engine-out procedures.

Loss of power from one engine affects both climb performance and controllability of twin-engine airplanes. Climb performance depends on an excess of power over that required for level flight. Loss of power from one engine obviously represents a 50% loss of power but, in virtually all twin-engine airplanes, climb performance is reduced by at least 80%. A study of the charts in your Pilot's Operating Handbook and FAA Approved Airplane Flight Manual will confirm this fact. Single-engine climb performance depends on four factors:

| | |
|---|---|
| **Airspeed** | Too little, or too much, will decrease climb performance |
| **Drag** | Gear, flaps, and windmilling prop |
| **Power** | Amount available in excess of that needed for level flight |
| **Weight** | Passengers, baggage, and fuel load greatly affect climb performance |

Loss of power on one engine creates yaw due to asymetric thrust. Yaw forces must be balanced with the rudder. Loss of power on one engine also reduces airflow over the wing. In addition, yaw affects the lift distribution over the wing causing a roll toward the "dead" engine. These roll forces may be balanced by banking slightly (up to 5°) into the operating engine.

Airspeed is the key to safe single-engine operations. For most twin-engine airplanes there is:

| **Symbol** | **Description** |
|---|---|
| $V_{MCA}$ | Airspeed below which directional control cannot be maintained |
| $V_{SSE}$ | Airspeed below which an intentional engine cut should never be made |

| | |
|---|---|
| $V_{YSE}$ | Airspeed that will give the best single engine rate-of-climb (or the slowest loss of altitude) |
| $V_{XSE}$ | Airspeed that will give the steepest angle-of-climb with one engine out |

### *AIR MINIMUM CONTROL SPEED ($V_{MCA}$)*

$V_{MCA}$ is designated by the red radial on the airspeed indicator and indicates the minimum control speed, airborne at sea level. $V_{MCA}$ is determined by FAA regulations as the minimum airspeed at which it is possible to recover directional control of the airplane within 20 degrees heading change, and therefore maintain straight flight, with not more than 5 degrees of bank if one engine fails suddenly with:

- Takeoff power on the operative engine
- Rearmost allowable center of gravity
- Flaps in takeoff position
- Propeller on failed engine windmilling (feathered if Auto-Feather system is required)

However, sudden engine failures rarely occur with all factors listed above, and therefore, the actual $V_{MCA}$ under any particular situation may be a little slower than the red radial on the airspeed indicator. Most airplanes will not maintain level flight at speeds at or near $V_{MCA}$. Consequently, it is not advisable to fly at speeds approaching $V_{MCA}$, except in training situations or during flight tests. Adhering to the practice of never flying at or below the published $V_{MCA}$ speed for your airplane will virtually eliminate loss of directional control as a problem in the event of an engine failure.

### *INTENTIONAL ONE-ENGINE-INOPERATIVE SPEED ($V_{SSE}$)*

$V_{SSE}$ is specified by the airplane manufacturer and is the minimum speed to perform intentional engine cuts. Use of $V_{SSE}$ is intended to reduce the accident potential from loss of control after engine cuts at or near minimum control speed. $V_{MCA}$ demonstrations are necessary in training but should only be made at safe altitude above the terrain and with power reduction on one engine made at or above $V_{SSE}$.

### *ONE-ENGINE-INOPERATIVE BEST RATE-OF-CLIMB SPEED ($V_{YSE}$)*

$V_{YSE}$ is designated by the blue radial on the airspeed indicator. $V_{YSE}$ delivers the greatest gain in altitude in the shortest possible time, and is based on the following criteria:

- Critical engine inoperative, and its propeller in the minimum drag position.
- Operating engine set at not more than the maximum continuous power.
- Landing gear retracted.
- Wing flaps in the most favorable (i.e., best lift/drag ratio) position.
- Airplane flown at recommended bank angle.

Drag caused by a windmilling propeller, extended landing gear, or flaps in the landing position, will severely degrade or destroy single-engine climb performance. Since climb performance varies widely with weight, temperature, altitude, and airplane configuration, the climb gradient (altitude gain or loss per mile) may be marginal - or even negative - under some conditions. Study the Pilot's Operating Handbook and FAA Approved Airplane Flight Manual for your specific airplane and know what performance to expect with one engine out.

### *ONE-ENGINE-INOPERATIVE BEST ANGLE-OF-CLIMB SPEED ($V_{XSE}$)*

$V_{XSE}$ is used only to clear obstructions during initial climb-out as it gives the greatest altitude gain per unit of horizontal distance. It requires more rudder control input than $V_{YSE}$.

### *SINGLE ENGINE SERVICE CEILING*

The single engine service ceiling is the maximum altitude at which an airplane will climb at a rate of at least 50 feet per minute in smooth air, with one engine inoperative.

The single-engine service ceiling graph should be used during flight planning to determine whether the airplane, as loaded, can maintain the Minimum Enroute Altitude (MEA) if IFR, or terrain clearance if VFR, following an engine failure.

### *BASIC SINGLE ENGINE PROCEDURES*

Know and follow, to the letter, the single-engine emergency procedures specified in your Pilot's Operating Handbook and FAA Approved Airplane Flight Manual for your airplane. However, the basic fundamentals of all the procedures are as follows:

1. Maintain airplane control and airspeed at all times. **THIS IS CARDINAL RULE NUMBER ONE.**
2. Usually, apply 100% torque to the operating engine. However, if the engine failure occurs at a speed below $V_{MCA}$, or during cruise or in a steep turn, you may elect to use only enough power to maintain a safe speed and altitude. If the failure occurs on final approach, use power only as necessary to complete the landing.
3. Reduce drag to an absolute minimum.
4. Secure the failed engine and related sub-systems.

The first three steps should be done promptly and from memory. The check list should then be consulted to be sure that the inoperative engine is secured properly and that the appropriate switches are placed in the correct position. The airplane must be banked about 5° into the live engine, with the "slip/skid" ball slightly out of center toward the live engine, to achieve rated performance.

ANOTHER NOTE OF CAUTION. Be sure to identify the dead engine positively, before securing it. Remember: First identify the suspected engine (i.e., "Dead foot means dead engine"), second, verify with cautious throttle movement, then secure.

## ENGINE FAILURE ON TAKEOFF

If an engine fails before attaining $V_1$, the only proper action is to discontinue the takeoff. If the engine fails after $V_1$, the takeoff may be continued using the procedures specified in the Pilot's Operating Handbook and FAA Approved Airplane Flight Manual.

Your Pilot's Operating Handbook and FAA Approved Airplane Flight Manual contains charts that are used in calculating the runway length required to stop if the engine fails at $V_1$ speed and also has charts showing the single-engine performance after takeoff.

Study your charts carefully. No airplane is capable of climbing out on one engine under all weight, pressure altitude, and temperature conditions. The maximum take-off weight must be limited to achieve the required performance as specified in the LIMITATIONS section.

## WHEN YOU FLY $V_X$, $V_Y$, $V_{XSE}$ AND $V_{YSE}$

During normal two-engine operations always fly the published take-off speeds on initial climb out. Then, accelerate to your cruise climb airspeed after you have obtained a safe altitude. Use of cruise climb airspeed will give you increased inflight visibility and better fuel economy. However, at first indication of an engine failure during climb out, or while on approach, establish $V_{YSE}$ or $V_{XSE}$, whichever is appropriate. (Consult your Pilot's Operating Handbook and FAA Approved Airplane Flight Manual for specifics.)

## STALLS, SLOW FLIGHT AND TRAINING

The stall warning system must be kept operational at all times and must not be deactivated by interruption of circuits or circuit breakers. Compliance with this requirement is especially important in all high performance multi-engine airplanes during engine-out practice or stall demonstrations, because the stall speed is critical in operation of high-performance airplanes.

The single-engine stall speed of a twin-engine airplane is generally slightly below the power off (engines idle) stall speed for a given weight condition. Single-engine stalls in multi-engine airplanes are not recommended. Single-engine stalls should not be conducted in high performance airplanes by other than qualified engineering test pilots.

$V_{MCA}$ demonstrations should not be attempted when the altitude and temperature are such that the engine-out minimum control speed is known, or discovered to be, close to the stalling speed. Loss of directional or lateral control, just as a stall occurs, is potentially hazardous.

$V_{SSE}$, the airspeed below which an engine should not be intentionally rendered inoperative for practice purposes, was established because of the apparent practice of some pilots, instructors, and examiners, of intentionally rendering an engine inoperative at a time when the airplane is being operated at a speed close to, or below, the flight idle stall speed. Unless the pilot takes immediate and proper corrective action under such circumstances, it is possible to enter an inadvertent spin.

It is recognized that flight below $V_{SSE}$ with one engine inoperative, or simulated inoperative, may be required for conditions such as practice demonstration of $V_{MCA}$ for multi-engine pilot certification. Refer to the procedure set forth in the Pilot's Operating Handbook and FAA Approved Airplane Flight Manual for your airplane. This procedure calls for simulating one engine inoperative by reducing the power lever on one engine to zero thrust while operating at an airspeed above $V_{SSE}$. Power on the other engine is set at maximum, then airspeed is reduced at approximately one knot per second until either $V_{MCA}$ or stall warning is obtained. During this transition, rudder should be used to maintain directional control, and ailerons should be used to maintain a 5° bank toward the operative engine. At the first sign of either $V_{MCA}$ or stall warning (which may be evidenced by inability to maintain longitudinal, lateral or directional control, aerodynamic stall buffet, or stall warning horn sound), recovery must be initiated immediately by reducing power to zero thrust on the operative engine and lowering the nose to regain $V_{SSE}$. Resume normal flight. This entire procedure should be used at a safe altitude of at least 5,000 feet above the ground in clear air only.

If stall warning is detected prior to the first sign of $V_{MCA}$, an engine-out minimum control speed demonstration cannot be accomplished under the existing gross weight conditions and should not be attempted.

## SPINS

A major cause of fatal accidents in general aviation airplanes is a spin. Stall demonstrations and practice are a means for a pilot to acquire the skills to recognize when a stall is about to occur and to recover as soon as the first signs of a stall are evident. IF A STALL DOES NOT OCCUR - A SPIN CANNOT OCCUR. It is important to remember, however, that a stall can occur in any flight attitude, at any airspeed, if controls are misused.

Your airplane has not been tested for spin recovery characteristics, and is placarded against intentional spins.

The pilot of an airplane placarded against intentional spins should assume that the airplane may become uncontrollable in a spin, since its performance characteristics beyond certain limits specified in the FAA regulations have not been tested and are unknown. This is why airplanes are placarded against intentional spins, and this is why stall avoidance is your protection against an inadvertent spin.

Pilots are taught that intentional spins are entered by deliberately inducing a yawing moment with the controls as the airplane is stalled. Inadvertent spins result from the same combination - stall plus yaw. That is why it is important to use coordinated controls and to recover at the first indication of a stall when practicing stalls.

In any twin engine airplane, fundamental aerodynamics dictate that if the airplane is allowed to become fully stalled while one engine is providing lift-producing thrust, the yawing moment which can induce a spin will be present. Consequently, it is important to immediately reduce power on the operating engine, lower the nose to reduce the angle of attack, and increase the airspeed to recover from the stall.