WHAT IS MINIMUM CONTROL SPEED V_{MC} OR V_{MCA} REALLY?

Forgotten knowledge of $V_{MC(A)}$ and its associated conditions cause fatal accidents after engine failure

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1. Introduction

Definitions of V_{MC} or V_{MCA} in most Airplane Flight Manuals (AFM) and Pilot's Operating Handbooks (POH) and in multi-engine rating course books suggest that the airplane is controllable at airspeeds down to $V_{MC(A)}$ when one of the engines fails (during takeoff) or is inoperative (in-flight), and the remaining engine(s) is/are set to provide maximum thrust, but this is definitely not true. Forgotten associated conditions apply for the AFM/POH furnished $V_{MC(A)}$ to be valid and for maintaining control when the airspeed is as low as $V_{MC(A)}$ or even as low as V_R, V_{YSE} or V_2. This will be explained below.

V_{MC} is defined in FAR/CS 23.149(a) and equivalent regulations which are for airplane design engineers and airworthiness certification: *"V_{MC} is 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, and thereafter maintain straight flight at the same speed with an angle of bank of not more than 5 degrees".* The purpose of the 5° bank and its effect on $V_{MC(A)}$ are explained below.

For pilots this means that a multi-engine airplane is designed and certificated to recover after a (sudden) engine failure and thereafter only to maintain straight flight at the minimum control speed $V_{MC(A)}$ when the asymmetrical thrust is, or is increased to maximum, provided a small bank angle of 5° or little less (as opted by manufacturer) is being maintained away from the inoperative engine. The rudder and ailerons do not have to be sized large enough to make turns at $V_{MC(A)}$, nor at the therewith derived takeoff speeds V_R and V_2. The V_{MC} must be furnished in the AFM/POH.

Maintaining straight flight and a small bank angle of 5° away from the inoperative engine are the associated conditions for the AFM/POH published $V_{MC(A)}$ to be valid when the asymmetrical thrust is maximum, and are definitely required to be observed to prevent the loss of control and/or collision with the ground.

The small bank angle does not turn the airplane but introduces a side force in the cg which reduces the sideslip due to the asymmetrical thrust, decreasing the drag, and hence increasing the remaining climb performance. It also decreases $V_{MC(A)}$ to a value closer to the AFM/POH furnished value, which also means that when the wings are kept level, the actual $V_{MC(A)}$ increases. This increase is about 6 kt for a small twin, but about 30 kt for a big 4-engine transport airplane. In addition, increasing the bank angle more than 5 degrees into the good engine requires the rudder to be reduced and reversed to confine the sum of the increasing side forces. The $V_{MC(A)}$ increase is much larger when banking further to either side (during turns); a much higher airspeed is required to maintain the equilibrium of forces and moments, and maintain control. Engine-out flight is not coordinated flight.
Although $V_{MC(A)}$ after failure of a non-critical engine is a little lower, the AFM/POH furnished $V_{MC(A)}$ (for the inoperative critical engine) applies in anticipation of and following either engine failure. Failure of a centerline or an inboard engine results in an even lower actual $V_{MC(A)}$, most probably lower than V_S (during straight flight). A low $V_{MC(A)}$ is safer.

Reducing asymmetrical thrust a little (during a turn) decreases the required rudder deflection after which the airspeed can be reduced until the rudder is again maximum, the actual $V_{MC(A)}$ is lower. Hence, the pilot controls $V_{MC(A)}$ with bank angle, thrust and also with the amount of rudder deflection. Asymmetric engine-out flight is not coordinated flight; rudder and/or aileron inputs are continuously required to counteract the thrust and/or sideslip yawing and rolling moments and maintain an equilibrium of forces and moments. When either control is near maximum deflected, Loss of Control is nearby because the equilibrium can no longer be maintained.

An *actual* $V_{MC(A)}$ does not only apply in anticipation of and following the sudden failure of any engine, but also during the remainder of the engine-out flight, and can be very much higher than the AFM-published $V_{MC(A)}$, as shown below.

FAA Flight Test Guides prescribe how $V_{MC(A)}$ must be determined during experimental flight testing, see the $V_{MC(A)}$ testing § 5 below.

A few relevant paragraphs of these Guides and Regulations are copied into a Background file, in which also a few clarifying notes are included. This file is available for download. Links to these Regulations are on the Links page. Download this Background file.

Details on $V_{MC(A)}$ are presented in papers on the Downloads page.

2. TAS, CAS, And IAS Explained

FAR 23.149(a) and equivalent require $V_{MC(A)}$ to be furnished as Calibrated Airspeed (CAS).

NEW As many pilots (and airplane manufacturers) struggle with the difference between Calibrated Airspeed (CAS) and Indicated Airspeed (IAS), these airspeeds will be briefly explained first, as taught at test pilot schools.

Pilots only work with Indicated Air Speed (IAS), don't they? Well, IAS is the speed indicated on the Air Speed Indicator (ASI), but it is not the airspeed at which the airplane is plowing the air, which provides the wing lift and control power, and which is used to furnish limiting and operational speeds in AFM or POH; this speed is called the Calibrated Air Speed (CAS). The Indicated Air Speed (IAS)

has/includes unavoidable measuring and instrument errors of up to 9 knots, as allowed by airworthiness regulations. IAS is also the abbreviation of Inaccurate Air Speed; it requires error corrections to be of value for piloting.
Competent pilots work with CAS. For their flying task, pilots read the airspeed on the ASI, but have to apply corrections to be able to find the airspeed at which the airplane and its wings and aerodynamic control surfaces are indeed plowing the air (in CAS), or to find the IAS that corresponds to the limiting and operational speeds, such as V_S, V_R, V_2 or $V_{MC(A)}$, that are furnished as CAS in the POH/AFM. More corrections are required to find the True Airspeed (TAS) and the Ground Speed (GS), both for navigation purposes.
The following airspeeds are used by pilots:

- **IAS** is the airspeed indicated by an airspeed indicator, and is CAS including the error due to the position of the pitot tube in disturbed air and the ASI instrument error. IAS is an In-Accurate Speed which becomes only valuable when corrected for instrument and position errors; then the IAS corresponds to the CAS of the airplane.

- **CAS** is the calibrated airspeed, which is the speed of the airplane in the undisturbed airstream with respect to the standard atmospheric pressure and temperature at sea level. The lift of the wings, and the control power of the aerodynamic control surfaces are proportional to the CAS. Limiting and operational speeds are furnished as CAS. CAS is the airspeed for piloting.

- **TAS** is the true airspeed with respect to the ambient pressure and temperature, and is the CAS corrected for ambient pressure and temperature (at altitude). TAS is the airspeed for navigating.

- **GS** is the airspeed relative to the ground, and is the TAS corrected for the wind.

These airspeeds, and also the minimum control speed in the air ($_{MC(A)}$), are often incorrectly defined, explained, and used in Pilot Operating Handbooks and in Airplane Flight Manuals. IASs do not belong in a common generic POH/AFM that applies to a series of airplanes of the same type, because the instrument errors in each individual airplane differ, and $V_{MC(A)}$ and takeoff speeds in IAS might turn out to be too low. This also applies to electronic displays (which should be calibrated and programmed to display CAS).
An IAS always requires the pilot to apply corrections, while a CAS doesn't need corrections and is therefore more convenient to use. Operational and limiting speeds are required to be furnished as CAS in POH/AFMs for a good (safety) reason.

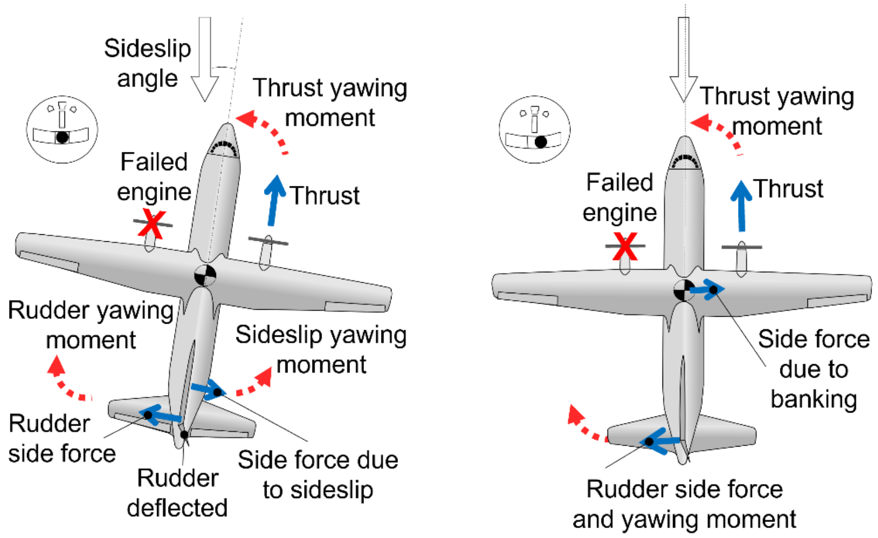
Avio*Consult* wrote a paper in which these airspeeds are better explained, and proper definitions are provided as taught at universities and test pilot schools. Reference is made to downloadable MSc-level course books but not to books or articles generated by AI, published on Wikipedia, and on forums, or to pamphlets or trash on social media that are written by incompetent writers. Test pilot schools teach all students to calibrate pitot-static systems in theory and in-flight; they know what they are talking about. Download this paper.

3. V_{MCA} As Tail Design Factor

$V_{MC(A)}$ is about forces and moments acting on an engine-out airplane. You will remember that a body is in equilibrium if both the sum of the forces and the sum of the moments (forces times the

perpendicular distance to the cg) acting on the body are zero.
When an engine fails or is inoperative in-flight, rudder is required to counteract the asymmetrical thrust yawing moment, and roll effects are to be counteracted by the ailerons. The counteracting forces generated by these aerodynamic control surfaces are proportional to the square of the airspeed (V^2), to the area of the surfaces (S) and to the air density (ρ). So, for given sizes of the vertical tail with rudder and the ailerons, there is a speed below which the generated control forces are not large enough anymore to counteract the forces and moments due to asymmetrical thrust, being the speed below which the controls are not effective anymore: the heading and/or bank angle, i.e. the equilibrium of forces and moments, can no longer be maintained by the aerodynamic controls below this speed; control is lost. This speed is called Minimum Control speed (V_{MC}) or more appropriate: Minimum Control speed in the Air (V_{MCA}). $V_{MC(A)}$ is influenced by all factors that affect the lateral and directional forces and moments that act on the airplane, not only by the asymmetrical thrust.

$V_{MC(A)}$ is already determined (i.e. assumed and used) by the airplane design engineer for sizing the vertical tail (fin), because a vertical tail may not be made that small that $V_{MC(A)}$ increases above 1.2 V_S (during straight flight - FAR/CS 23.149). On the other side, a large tail results in a lower $V_{MC(A)}$ but in higher weight and production cost.
FAR/CS 23.149 allows the design engineer to use a small bank angle but maximum 5º (away from the failed engine) which generates a side force in the cg that can replace the side force due to sideslip when the thrust is asymmetric. This side force acts in the cg and hence, generates no yawing moment. The rudder does not have to overcome the sideslip side force and yawing moment anymore, allowing the rudder deflection to be smaller or a smaller vertical tail with maximum rudder at $V_{MC(A)}$. This is illustrated in the figures below for straight flight.
Hence, a small bank angle allows for a smaller – cheaper and lighter – vertical tail, reduces the sideslip (drag) to a minimum for maximum takeoff performance and results in a lower $V_{MC(A)}$ (for straight flight). The effects of other bank angles will be shown below.



Equilibrium of (a few) forces and moments after rudder input, wings level: sideslip not zero

Equilibrium of (a few) forces and moments after banking 5° into good engine: sideslip zero

Airplane design professor Dr. Jan Roskam (KU) in his college book for sizing control surfaces: **"The V_{MC} value ultimately used ties take-off performance to engine-out controllability."**

However, the saved hardware weight of a smaller tail needs to be replaced by a quite 'heavy' software condition for pilots (on paper in the AFM/POH) when an engine is inoperative, which is to maintain straight flight only when the asymmetrical thrust is or is increased to maximum, and to maintain a small bank angle away from the inoperative engine for minimum drag and lowest actual $V_{MC(A)}$, hence maximum Rate of Climb.

Read more in this paper, and/or view the video *The Real Value of $V_{MC(A)}$ – How to Prevent a Dead Engine from Turning into a Killing Engine*:

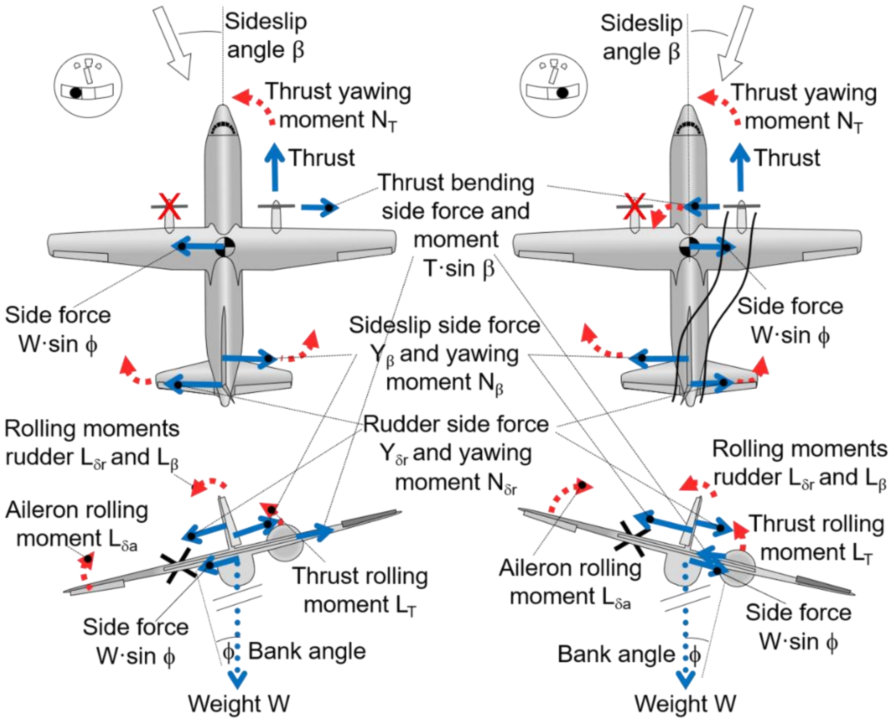
A 42 min. video lecture, in which the real value of the minimum control speed airborne ($V_{MC(A)}$) is explained as taught at all formal Test Pilot Schools and most aeronautical universities, including the review of two accidents using views from the cockpit, is available on YouTube. Click here.

A pdf file with slides and script used in this video can be downloaded here.

The courses on asymmetric powered flight that two test pilot schools teach can be downloaded from the USArchives via the Links page, click here.

4. $V_{MC(A)}$ During Banking

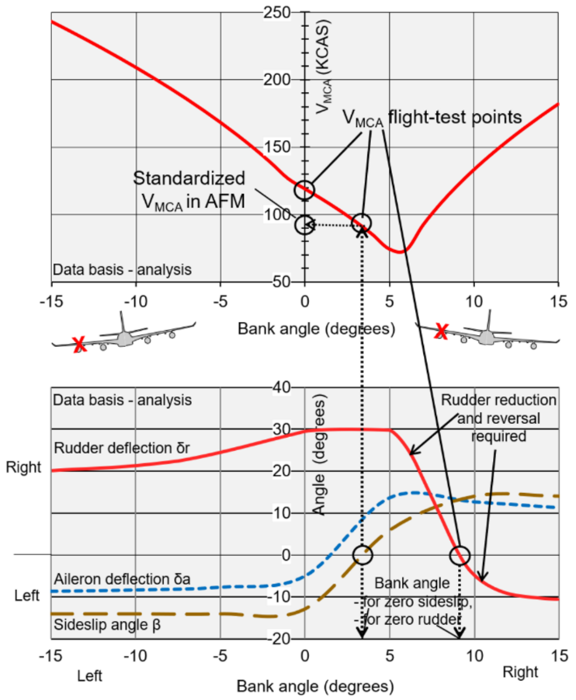
The most important forces and moments acting on an engine-out airplane during banking 15° into and away from the failed engine are shown in the following figure.



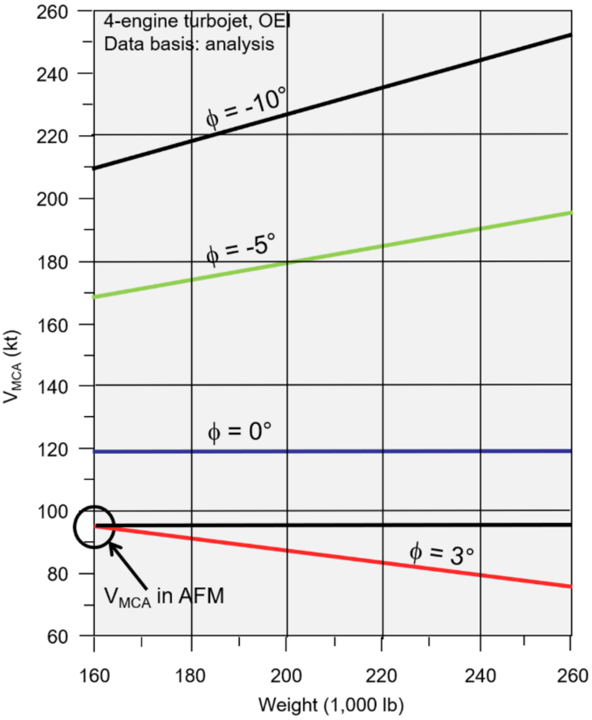
Lat-Dir forces and moments during turn 15° bank into the failed engine

Lat-Dir forces and moments during turn 15° bank into good engine, rudder reversed for balance

For maintaining control, that is for preventing the loss of control, an equilibrium of forces and moments that act on the airplane is required. The aerodynamic forces are proportional to the square of the airspeed. $V_{MC(A)}$ is the lowest airspeed at which an equilibrium of the lateral-directional forces can be maintained, like the stall speed V_S is for the longitudinal forces. $V_{MC(A)}$ in the Limitations Section of the AFM and on the airspeed indicator (red line) is a constant number, which is determined not only for maintaining straight flight, but also for calculating takeoff speeds V_R and V_2. In-flight though, aerodynamic forces not only vary with airspeed, but also with bank angle, engine thrust, rudder and aileron deflections, and other variables which will change the equilibrium of forces and moments. So, the question is whether and how much (an actual) $V_{MC(A)}$ varies with these variables as well. This is analyzed in this paper using $V_{MC(A)}$ prediction with stability derivatives in lateral-directional equations of motion as taught at the USAF Test Pilot School.
The graphs out of the paper on the left side below show (the actual) $V_{MC(A)}$, the required rudder and aileron deflections, and the resulting sideslip angle versus bank angles between -15° and +15° of a sample airplane after failure of the left engine (#1) while the asymmetrical thrust is maximal.



Effect of bank angle on V_{MCA}, required rudder and aileron, and the resulting sideslip angle for equilibrium flight while engine #1 inoperative.



Effect of weight and bank angle ϕ on V_{MCA}, while engine #1 inoperative.

The airspeed that results from the bank angle for which the sideslip is zero (minimum drag, max. ROC) is the $V_{MC(A)}$ that will be furnished in the AFM (here 95 kt). At bank angles larger than 6° away from the failed engine, for this sample airplane, the rudder needs to be reversed to limit the sideslip angle which, nevertheless, increases to 14°, being the fin stall angle of attack. The airspeed needs to be increased to prevent the fin from stalling at larger bank angles, hence, the actual $V_{MC(A)}$ increases. *Notice that the actual $V_{MC(A)}$ for wings level (120 kt) of this sample airplane is 25 kt higher than the AFM-furnished $V_{MC(A)}$.*
This leads to the **limitation** that the pilot should not turn, but maintain the exact bank angle that was used to design the vertical tail and at which the drag is minimal (in this example ≈3°, usually 5°),

when the airspeed decreases to or is equal to the AFM-furnished $V_{MC(A)}$ while the asymmetrical thrust is maximal.

At higher airspeeds, the bank angle can be smaller; at V_{YSE}, 3° of bank might result in minimum drag, as shown in the figure above.
This small bank angle does not result in a turn, but reduces both the drag and (actual) $V_{MC(A)}$. Engine-out flight is never coordinated flight, because control inputs are required to counteract the asymmetrical thrust and side effects. The centripetal force that pilots use to explain turns is reduced or enhanced by the counteracting forces of rudder and/or ailerons. Banking away from the favorable 5° results in sideslip, hence drag, as the figure above proves.
$V_{MC(A)}$ applies after failure of either engine, not only the critical engine.

The right figure above shows the effect of weight and bank angle on $V_{MC(A)}$. When the wings are level, weight has no effect ($W \cdot \sin \phi = 0$). With a 3° bank angle, when the sideslip angle is minimal, $V_{MC(A)}$ is highest at low weight, which is the reason why low weight is used to determine $V_{MC(A)}$, it is the worst-case weight for $V_{MC(A)}$ (for straight flight as required for the AFM-furnished $V_{MC(A)}$ in FAR 23.149). Lockheed C-130 pilots know this figure from their performance manual SMP 777.

Lesson learned (I hope): The vertical tail with rudder and/or the ailerons are not designed large enough for maintaining control during turns into or away from the inoperative engine while maximum asymmetrical thrust is set, but only for maintaining straight flight. Therefore, before turning to either side, even at small bank angles, increase the airspeed first (in this example by at least 30 kt), or reduce the asymmetrical thrust a little.
At any sign of inadequate remaining control power (near full rudder or max. aileron), i.e. impending loss of control, decrease thrust (a little) and recover to straight flight. After establishing straight flight with the favorable small bank angle, asymmetrical thrust can be increased again.

5. How Is $V_{MC(A)}$ Measured In-Flight

The airplane is brought in the $V_{MC(A)}$ test configuration, i.e. lowest weight possible and aft center of gravity, which result in the highest, worst case $V_{MC(A)}$ at which straight flight can be maintained.
In-flight, at a safe altitude of 5000 ft AGL, an airspeed is attained well above the anticipated $V_{MC(A)}$ (at least V_{SSE}). Then the critical engine is shut down, or set at torque for zero thrust, and the opposite engine at maximum thrust. $V_{MC(A)}$ with the critical engine inoperative is a little higher than $V_{MC(A)}$ while another engine is inoperative, being the worst case for straight flight. Then the airspeed is slowly decreased until the increasing rudder and/or aileron inputs cannot maintain the heading and/or wings level anymore. The airspeed at which this occurs is $V_{MC(A)}$ with the wings level; also mind the large unavoidable sideslip, i.e. drag. Then, the bank angle is slowly increased into the operating engine, to a maximum of 5° or until the sideslip is zero, and the airspeed is further decreased until again the heading can no longer be maintained with rudder and/or ailerons. The airspeed at which this occurs is ***the $V_{MC(A)}$*** of the airplane that will, after extrapolation to sea level, be furnished in the AFM.
This $V_{MC(A)}$ is valid for straight flight only! Regulations do not require the much higher actual $V_{MC(A)}$'s for other bank angles and during turns to be determined, because of the resulting huge amount of data, the use of which by pilots would be prone to errors.

In some cases, the test pilot also increases the bank angle to the point where the rudder deflection is zero, as indicated in the left figure above; then the required airspeed is larger, and the sideslip/drag is large as well.

Please refer to the formal FAA or EASA Flight Test Guides for the safe conduct of this test, via the Links page.

6. $V_{MC(A)}$ Definition for Pilots

The selected tail size imposes a limitation on, i.e. a constraint to pilots. The $V_{MC(A)}$ definition for use by pilots is therefore different than the $V_{MC(A)}$ definition in FAR/CS 23.149 which is for manufacturers, for designing and certification of multi-engine airplanes:

$V_{MC(A)}$ is the minimum speed for maintaining straight flight only when an engine fails or is inoperative and the corresponding opposite engine is set to provide maximum thrust, provided a bank angle is being maintained of 3 – 5 degrees (exact number to be provided by the manufacturer) away from the inoperative engine. $V_{MC(A)}$ increases considerable during banking away from this favorable bank angle, i.e. during turns.

In addition, the manufacturer should specify the bank angle and the configuration (flaps, gear, etc.) for which the AFM-furnished $V_{MC(A)}$ is valid.

7. Display Of $V_{MC(A)}$

On the airspeed indicator of **Part 23** twin-engine airplanes, the standardized AFM-furnished $V_{MC(A)}$ is indicated by a red radial line, in this example at 80 kt. However, neither a placard on the instrument panel nor a note or warning in the AFM tells the pilot that the redlined $V_{MC(A)}$ is valid only when a bank angle of 3 to 5 degrees (to be specified by the manufacturer) is maintained away from the inoperative engine. A larger bank angle, or a bank angle into the inoperative engine results in a much higher actual $V_{MC(A)}$, a 14 or more-degree sideslip, hence large drag, and to the loss of climb performance and possibly loss of control after which an accident cannot be avoided (when asymmetrical thrust is not reduced).

The airspeed for maximum single-engine rate of climb V_{YSE} is indicated by a blue radial line, here at 105 kt. In the legend of some Performance Data Tables of Graphs, a note tells the pilot that the presented performance data, including the performance at V_{YSE}, are valid only if a small bank angle is being maintained of 2 - 3 degrees away from the inoperative engine. For other bank angles, the maximum climb performance, or the performance to maintain altitude (i.e. to prevent drifting down) is not guaranteed.

NOTE

2° to 3° BANK TOWARD OPERATING ENGINE

This note is included in the legend of the Climb Performance Chart - One Engine Operating in the Piper PA-44 Pilot's Information Manual. It is included, because not maintaining this bank angle renders the presented performance data invalid; the airplane might not even be able to maintain altitude. The bank angle is smaller than 5 degrees, because the presented performance data

requires V_{YSE}, the blue line speed, which is higher than $V_{MC(A)}$. The vertical tail is more effective at higher speed.
Keeping the wings level or turning means loss of performance; altitude cannot be maintained on most multi-engine airplanes if this NOTE is neglected.

ONE ENGINE INOPERATIVE
AIR MINIMUM CONTROL
SPEED 80 KCAS

A similar placard is to be installed in full view of pilots of Part 23 commuter airplanes to comply with Aviation Regulations (23.1563). The required small bank angle for the listed $V_{MC(A)}$ to be valid is regrettably not included on the placard, because this is not required by Aviation Regulations, but is essential for flight safety and performance.

Not maintaining the small bank angle (i.e. straight flight) at airspeeds as low as or near V_{MC}, such as V_{YSE} or V_2, while the power setting of the remaining engine is high, is the real cause of most engine failure related accidents.

$V_{MC(A)}$ is 80 KCAS, provided
straight flight is maintained
while banking 5° toward
operating engine

It is recommended to require a placard like this one in all Part 23 airplanes. KIAS can be used on placards of individual airplanes if both the position and the instrument errors of the installed ASI are used to calculate the $V_{MC(A)}$ as KIAS, as done for the red radial line.

More text options are possible.

8. V_R And V_{2MIN}

The standardized, AFM-furnished V_{MC} is one of the factors for calculating the rotation speed V_R of all multi-engine airplanes, and for calculating V_1 and minimum takeoff safety speed V_{2MIN} if applicable. Since this V_{MC} is valid only while maintaining a bank angle of 3 to 5 degrees, as to be specified by the manufacturer, away from the inoperative engine, both the calculated V_R and V_{2MIN} are also valid only when maintaining the same bank angle (when the thrust setting is maximum takeoff). If the pilot does not attain and maintain the small bank angle, the takeoff speeds should be increased for maintaining control.
Refer to the paper for Investigators and Flight Instructors for a thorough explanation of takeoff speeds.

9. $V_{MC(A)}$ For Piloting

Minimum Control speed V_{MC} or V_{MCA} is the lowest calibrated airspeed which can be obtained with full directional and/or lateral control inputs when one (outboard) engine of a multi-engine airplane fails or is inoperative, and the opposite engine is set at maximum thrust.
$V_{MC(A)}$ varies with the magnitude of control inputs, with the level of asymmetrical thrust, with weight, with bank angle, and with asymmetrical drag caused by cowlings, hatches, unfeathered propeller, inadvertent opened thrust reversers, etc., with anything that affects the balance of lateral and directional forces and moments that act on the airplane in-flight. Hence, $V_{MC(A)}$ is a quite complicated airspeed limitation; an airplane has many $V_{MC(A)}$'s.

To simplify the matter, regulations FAR/CS 23.149 and 25.149, and equivalent, require only one V_{MC} to be determined and furnished in the Limitations Section of the Airplane Flight Manual, the V_{MC} while maintaining straight flight with a small favorable bank angle of 3 to 5 degrees (exact number to be provided by the manufacturer) away from the inoperative engine, for lowest V_{MC} and minimum sideslip and hence, minimum drag, and maximum climb performance, being the V_{MC} which is useful for takeoff, for calculating takeoff speeds. This furnished standardized V_{MC} is therefore valid only for takeoff when both straight flight and a small bank angle away from the inoperative engine are being maintained. At other bank angles, and during the remainder of the engine-out flight, a much higher actual $V_{MC(A)}$ applies, see § 4 above.

WARNING: When keeping the wings level, or when banking away from the small favorable bank angle (which is 3 to 5 degrees away from the inoperative engine) to either side, the ***actual*** $\mathbf{V_{MC(A)}}$ that a pilot will experience in-flight will increase to a **much higher** value than the AFM-published standardized $V_{MC(A)}$, because $V_{MC(A)}$ varies with the asymmetrical thrust setting and bank angle. Then also the sideslip, hence drag, will increase considerable, further reducing the Rate of Climb. See the figure above.
When banking during takeoff, the ***actual*** $\mathbf{V_{MC(A)}}$ might increase above V_2 or V_{YSE}, causing an unexpected and often fatal loss of control.
It is a myth that the safety margin is larger when turning into the good engine, and that the actual $V_{MC(A)}$ that the pilot will experience in-flight is always as low as the AFM published $V_{MC(A)}$. The pilot controls $V_{MC(A)}$ with bank angle, thrust, and amount of rudder.

When the rudder and/or aileron control input is/ are already near maximum for maintaining control, don't further increase the bank angle or the thrust, but maintain straight flight while banking 5° into the good engine (same side as the rudder pedal) or reduce asymmetrical thrust (a little to stop the yawing or rolling).
Safest is to climb straight ahead to a safe altitude while maintaining the small favorable bank angle for minimum sideslip, hence drag, and lowest actual $V_{MC(A)}$. If a turn is required, increase the airspeed and/or decrease the asymmetrical thrust a little first. Why? To prevent the Loss of Control, reduce the directional forces and moments caused by the asymmetrical thrust, which reduces the required counteracting aerodynamic forces and moments generated by rudder and ailerons; rudder and aileron deflection are then smaller.

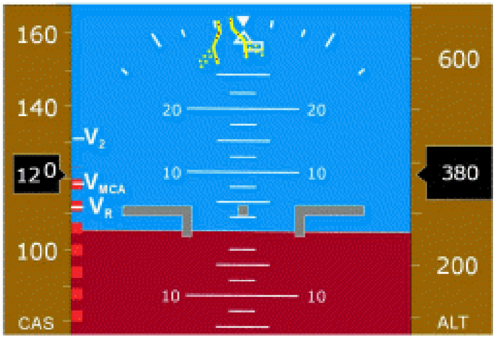
If the pointer of the airspeed indicator is at or near the red $V_{MC(A)}$ line and the thrust on the remaining engine(s) is or is increased to maximum, only straight flight should be maintained while maintaining a bank angle of 3 to 5 degrees away from the inoperative engine.
If the airspeed is at the blue line (V_{YSE}), still a small bank angle is required for minimum sideslip/drag.

When an engine fails during takeoff after V_1, bank 5 degrees immediately after liftoff to the same side as rudder pressure. When the airplane starts to bank (unintended) into the dead engine, apply up to maximum rudder and or aileron to counteract. If these controls are ineffective, actual $V_{MC(A)}$ already increased above IAS; control is lost. The only options to save your souls are to reduce asymmetrical thrust a little (temporarily), regain straight flight, attain the small bank angle, and throttle up again, or close the throttles and land wings-level in the dirt, which is more survivable than with a large bank angle.

For turning safely while the asymmetrical thrust is high, gain altitude first during straight flight to allow for some altitude loss during reduced thrust turns, because of the increased sideslip (drag) during turns. It is safer to reduce the thrust a little during the turns to keep the actual $V_{MC(A)}$ low. Also consider a long straight-in approach rather than a tight final turn during which the thrust might have to be increased to maximum for maintaining the glide path (and control will be lost because actual $V_{MC(A)}$ increases above the indicated airspeed).

10. V_{MC} or V_{MCA}?

V_{MCA}, the Minimum Control speed in the Air (or Airborne), is one of the Minimum Control speeds (V_{MC}'s) of a multi-engine airplane that is published as operational limitation in its Airplane Flight Manual (AFM). Other published V_{MC}'s are Minimum Control speed on the Ground (V_{MCG}) and, in some cases, also the Minimum Control speed during approach and Landing (V_{MCL}). V_{MCA2} for two engines inoperative should still be published for 4- or more engine airplanes.
V_{MC} is often used in (older) manuals in relation to engine failure during takeoff. Regulations, however, are changing V_{MC} into V_{MCA}, because "V_{MCA} is more commonly used". A V_{MCA} applies during the whole flight, in anticipation of or following an engine failure, and definitely not only during takeoff. The actual $V_{MC(A)}$ that a pilot will experience in-flight increases considerably during turns, as was shown above. For now, $V_{MCA} = V_{MC}$.



This figure, a safety improving suggestion of Avio*Consult*, shows that the actual $V_{MC(A)}$ in this example has become higher than V_R because the wings are kept level. Bank angle and rudder advisories are presented to decrease the actual $V_{MC(A)}$ to a safe level to prevent the loss of airplane control. The bank angle advisory widens up as the airspeed increases.
Note that CAS is displayed, not the inaccurate IAS.

Refer to the formal FAA and EASA Flight Test Guides via the Links page. In the reference list on the Downloads page, only the $V_{MC(A)}$ testing paragraphs can be downloaded.

For further details, refer to the paper for investigators and flight instructors presented on the Downloads page.