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Multiengine Study Guide

AMEL: the aerodynamics, performance, and systems behind the ACS, and what the examiner expects

Organized by the multiengine Tasks of the Commercial Pilot ACS (FAA-S-ACS-7B): Area IX Tasks E, F, and G, and Area X Tasks A through D. The Tasks C and D are the same skills tested in the Instrument Rating ACS (Area VII). Multiengine sea is not covered.

Edition 1.0 · November 2026

This free sample is from the Multiengine Study Guide: Chapter 3, Vmc Explained, and the Vmc demonstration Task. Free to share in this form. Independent study material, not an FAA publication, and not a substitute for your POH/AFM or flight instruction. Always verify against current FAA sources.

Chapter 3: Vmc Explained

1. What Vmc is, in one sentence

Vmc is the **slowest speed at which the rudder can still keep the airplane flying straight** after the critical engine fails, with the other engine at full takeoff power. Below Vmc, the working engine's turning effect is stronger than the rudder can cancel, and the airplane yaws and rolls toward the dead engine.

The letters mean **V** (speed), **mc** (minimum control). The full name is the **minimum control speed with the critical engine inoperative**. On the airspeed indicator it is the **red radial line**.

2. Where the number comes from

The manufacturer finds Vmc during flight tests. The test pilot sets up a series of conditions that make Vmc as **high** as possible (the worst case), so that the number printed on your airspeed indicator is safe to rely on in almost any situation. The conditions, in the regulations (14 CFR 23.149 for most light twins), include:

- **Maximum takeoff power** on the working engine. (Most turning effect.)
- **Aft CG.** (Shortest rudder arm, so the weakest rudder.)
- **The dead engine's propeller windmilling.** (The most drag on the dead side.)
- **Gear up, flaps in the takeoff position.**
- **A bank of not more than 5 degrees toward the working engine.**
- The rudder force the pilot needs must be **no more than about 150 pounds**, and the airplane must stay controllable without exceptional skill.

Because the test is the worst case, in real flight with a lighter load or a forward CG, the airplane may be controllable a little below the red line. **Never count on that.** Real life can combine several of the worst-case factors at once (aft CG, high power, a windmilling propeller), so you treat the red line as the floor and stay well above it.

3. The factors, one by one, with the reason

Each factor changes either the turning effect from the working engine (the "push") or the rudder's ability to cancel it (the "resistance"). If you remember the reason, you do not need to memorize the list.

Factor	Effect	The reason, in simple words
More power on the working engine	Vmc goes **up**	More thrust is a bigger push. You need a faster airspeed (a stronger rudder) to cancel it.
Less power (or high altitude, thin air)	Vmc goes **down**	The engine makes less thrust, so the push is smaller.
Aft CG	Vmc goes **up**	The rudder is closer to the CG, so its arm is shorter. Same rudder force, smaller turning effect.
Forward CG	Vmc goes **down**	The rudder arm is longer.
Windmilling propeller on the dead engine	Vmc goes **up**	A windmilling propeller is like a large flat plate in the airflow. It creates a lot of drag on that side, which adds to the yaw toward the dead engine.
Propeller feathered	Vmc goes **down**	A feathered propeller has the blades edge-on to the wind, so almost no drag. This is one reason to feather quickly.
Landing gear down	Vmc goes **down** a little	The gear adds side area behind the CG, like the feathers on an arrow. It helps keep the airplane pointing straight.

Factor	Effect	The reason, in simple words
Bank toward the working engine	Vmc goes **down**	A tilt of the wings creates a small sideways force that helps push the airplane toward the good side. This is the biggest piloting technique for controlling the yaw. (See Chapter 5.)
Bank toward the dead engine	Vmc goes **way up**	It does the opposite. A small error here can make a big difference.
Open cowl flaps	Vmc goes up slightly	More drag on the working engine's side.
Flaps	Depends on the airplane	Follow the manual.

4. The surprise about altitude

At high altitude, a normally aspirated engine makes less power, so the push from the working engine is smaller, and the actual Vmc is lower than the red line. Stall speed (in terms of indicated airspeed) does not change much with altitude. So at some altitude, **the airplane stalls before it loses directional control**. This sounds like good news, but it is not: a stall with one engine at high power usually happens on **one wing first**, and the airplane may snap toward the dead engine. The recovery is the same: **reduce power on the working engine and lower the nose.**

5. Vmc is not the same as stall speed

Stall speed is about the **wing**. The wing stalls when it is flown at too high an angle of attack (the angle between the wing and the airflow). It does not matter how much power you have.

Vmc is about the **rudder and the engines**. It is a **control** problem. The airplane could be flying well above its stall speed and still be below Vmc.

	Stall	Loss of control at Vmc
Cause	Too high an angle of attack.	Not enough rudder strength to cancel the working engine's push.
Depends on	Weight, flap setting, bank angle (load factor).	Power on the working engine, CG, drag on the dead side, bank.
What makes it better	Lower the nose.	Reduce power on the working engine, **and** lower the nose.
What makes it worse	Holding the nose up.	Adding power, holding the nose up, banking toward the dead engine.

If you get close to both at once (for example, slowing down while holding the nose up with full power on one engine), the airplane can stall **and** yaw at the same time, which leads to a **spin**. That is why the Vmc recovery always includes **lowering the nose**.

6. What the pilot does about Vmc

- **Know your Vmc** and the other speeds. On a takeoff, you want to be above Vmc when you lift off.
- **Never slow below Vyse** with an engine out in the air. Vyse is above Vmc and gives you a margin.
- **Use the bank** toward the working engine (a few degrees).
- **Feather quickly**, because a windmilling propeller raises Vmc.

- **At the first sign of trouble** (the airplane starts to yaw and you are running out of rudder), **reduce the power on the working engine and lower the nose.** This trades climb for control. In an emergency, control comes first.

7. The red line and the blue line

Two lines on the airspeed indicator matter most with an engine out:

Line	Name	What it is
Red	Vmc	The slowest speed for control. **Do not go below it with an engine out.**
Blue	Vyse	The speed for best climb (or least descent) on one engine. This is the speed you fly.

The blue line is above the red line, so if you fly the blue line, you have a margin. Chapter 6 covers Vyse and the other speeds in more detail.

CA.X.B VMC Demonstration (AMEL, AMES)

References: FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-25; FAA-P-8740-66; POH/AFM

Objective: *To determine the applicant exhibits satisfactory knowledge, risk management, and skills associated with VMC demonstration.*

Note: See Appendix 2: Safety of Flight and Appendix 3: Aircraft, Equipment, and Operational Requirements & Limitations for information related to this Task.

WHAT THE EXAMINER IS LOOKING FOR

That you demonstrate Vmc safely and recover at the first sign of loss of directional control or the stall warning, within 20 degrees of the entry heading.

WHAT YOU NEED TO KNOW

- Factors affecting Vmc and how Vmc differs from stall speed.
- Why directional control is lost below Vmc.
- The configuration and the recovery.

WHAT YOU MAY RUN INTO

- The configuration: gear up, takeoff flaps, takeoff trim, props high RPM, critical engine at idle and windmilling, operating engine at takeoff or maximum power.
- The slow reduction of airspeed at about 1 knot per second.

COMMON MISTAKES

- Adding power on the failed side.
- Failing to lower the nose.
- Continuing past the first indication.
- A bank toward the dead engine.

HOW TO PREPARE

- Practice the recovery sequence mentally: power, nose, rudder, then speed.

> **Your airplane:** Know your airplane's Vmc, Vsse, and the AFM's recommended altitude for the demonstration.

Vmc Demonstration: What to Know, Why, and Where to Find It

What the ACS is asking, and why

The Vmc demonstration lets you feel what happens at the edge of control, so you can recognize it and avoid it. The ACS asks about what factors affect Vmc, how Vmc differs from Vs, why directional control is lost below Vmc, and how to enter and recover. You must configure the airplane, slow it down at a controlled rate, and recover at the first sign of trouble.

1. The configuration (ACS skill X.B.S1)

Unless the manufacturer says otherwise, set up the airplane in the configuration that makes Vmc highest, which is the same as the certification condition (Chapter 3):

Item	Setting
Landing gear	Retracted
Flaps	Takeoff position
Cowl flaps	Takeoff position
Trim	Takeoff position
Propellers	High RPM (forward)
Critical engine	Reduced to idle, propeller windmilling (the examiner sets zero thrust or the procedure in the AFM)
Operating engine	Takeoff or maximum available power

2. The entry and the maneuver

- **Altitude:** enter at an altitude that lets you recover no lower than 3,000 feet AGL (or the manufacturer's value), over a place where you can land.
- **Speed:** establish a single-engine climb attitude at about 10 knots above Vsse.
- **Bank:** about 5 degrees or less toward the operating engine, as needed for best performance.
- **Slow down:** raise the pitch slowly so that the airspeed decays at about 1 knot per second. Add rudder as needed to hold the heading.
- **Watch for the first indication:** the rudder runs out of authority and the heading starts to turn toward the dead engine, or the stall warning (or buffet) comes first. At the first indication, recover.

3. The recovery (ACS skills X.B.S5 to S8)

Step	Action	Reason
1	Reduce the power on the operating engine enough to restore directional control. Do not add power to the simulated failed engine.	Removing the cause (the asymmetric thrust) restores control.
2	Lower the nose to decrease the angle of attack and regain airspeed.	It recovers a stall that may be present at the same time and raises the airspeed above Vmc.
3	Hold the heading with rudder, recovering to within 20 degrees of the entry heading.	The ACS standard.
4	When the airspeed is back to Vsse or Vyse (±5 knots), advance power smoothly on the operating engine.	Adding power too early re-creates the problem.

4. Why the stall and Vmc must be separated

At the entry altitude of 3,000 feet AGL, the density altitude may be high enough that Vmc is lower than the stall speed. In that case the airplane will stall before it loses directional control. The recovery is still to lower the nose and reduce the power on the operating engine (as the stall warning demands), but you will not feel the Vmc roll. The training value is still in knowing that the airplane stalls on one engine, and that the stall is asymmetric and may drop a wing toward the dead engine.

5. Common errors

- Adding power to the failed engine, or leaving the throttle open on the operating engine.
- Holding the nose up and trying to keep the altitude.
- Reducing the airspeed faster than 1 knot per second, which makes the recovery sudden.
- A bank toward the failed engine.
- A recovery that exceeds 20 degrees of heading change.
- Not knowing the airplane's actual Vmc and Vsse.

6. Risk management

- This is a high-risk training maneuver, and many accidents have happened during it. Do it at altitude with a good visual scan and an instructor or examiner who is ready to take the controls.
- Never simulate a Vmc demonstration at low altitude, close to the ground, or in marginal weather.
- Know the way out: power down on the good engine and the nose down.

Where to find it

- Airplane Flying Handbook (FAA-H-8083-3): the section on Vmc demonstration in the multiengine chapter.
- Flying Light Twins Safely (FAA-P-8740-66).
- Your airplane's POH or AFM: Section 2 (Vmc marking), Section 3, and the manufacturer's recommended altitude and procedure.
- Commercial ACS (FAA-S-ACS-7B), Task X.B and Appendix 2 (Multiengine Considerations); 14 CFR §23.149 for the Vmc certification conditions.

That was a sample.

The full guide explains every Task the same way.

The full Multiengine Study Guide (54 pages) includes:

- Twelve plain-language chapters, from the first twin lesson to the practical test
- Every multiengine ACS Task: what it asks, why, and where to find it
- The takeoff decision and an engine failure, step by step
- A numbers-to-know quick reference, a glossary, and a checkride scenario bank

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