Flight Advisor Corner by Hobie Tomlinson

July 2012 **<u>Flying Multi-Engine Aircraft</u> (Pt. II)**

For July we will continue our series on flying FAR Part 23 (CFR 14, Chapter 1, Subchapter C, and Part 23) certified, small multiengine airplanes. Specifically, we are addressing propeller driven aircraft; although, the generic principles also apply to turbojet powered aircraft.

I think a good place to start is a general review of **V** speeds with an emphasis on those airspeeds which are specific to multiengine aircraft.

Figure 14-1.—Airspeed indicator markings for a multiengine airplane.

FAA-H-8083-3

<u>The Part 23 Multiengine Airspeed Indicator</u> pictured above has two additional colored markings that differentiate it from the single engine airspeed indicators with which we are all familiar. They are as follows:

1. **A short** **<u>Red Radial Line</u>** located at the 85 MPH position indicates the **Vmc** **(**Velocity – Minimum Control) airspeed which was established by the airplane's manufacturer during the certification process. **Vmc** 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 into the operating engine of not more than 5 degrees. The method used to simulate critical engine failure must represent the most critical mode of powerplant failure expected in service with respect to controllability.

    - **Note:** It is important to remember that *<u>Vmc is a control speed, not a performance speed</u>*! This is the speed at which the airplane manufacturer was able to demonstrate compliance with the below noted controllability criteria, and *<u>it has absolutely nothing to do with whether the aircraft will climb or descend at that speed</u>*. Many light-multiengine airplane accidents are the result of allowing airspeed to decay while trying to "force" aircraft performance which is simply not there.

        - Once airspeed is allowed to decay below the best performance airspeed **("Blue Line"** or **Vyse)**, airplane performance actually decays.

        - When the airspeed is allowed to decrease below the minimum control speed (by still trying to force unavailable performance from the airplane), control of the airplane will be lost.

    - **Vmca** (Velocity – Minimum Control, Air) is actually a more correct definition of the term **Vmc**, and it is the minimum airspeed at which the airplane manufacturer was able to demonstrate the airplane's controllability under the following conditions:

        - Airspeed must not exceed 1.2 **Vs1** (Stall speed in takeoff configuration) at Maximum Gross Takeoff Weight.

        - Must be determined with the most unfavorable Weight and CG location.

        - Aircraft must be airborne with negligible ground effect.

        - Rudder pedal force required to maintain control must not exceed 150 pounds.

        - The aircraft must not assume any dangerous attitude.

        - It must be possible to prevent a heading change of more than 20 degrees.

- Aircraft must be in the takeoff Configuration.
  - Maximum available takeoff power initially on each engine.
  - Airplane trimmed for takeoff.
  - Flaps in takeoff position(s).
  - Landing gear retracted.
  - All propeller controls in the recommended takeoff position throughout.

- **Reciprocating engine-powered airplanes weighing more than 6,000 pounds and all non-reciprocating engine-powered aircraft** must also demonstrate satisfactory controllability at **Vmc** in the landing configuration under the following conditions:
  - Maximum available takeoff power initially on each engine.
  - Airplane trimmed for an approach, with all engines operating, flying at **Vref** airspeed and with an approach gradient equal to the steepest used in the landing distance demonstration of Part 23.75.
  - Flaps in the landing position.
  - Landing gear extended.
  - All propeller controls in the position recommended for an approach with all engines operating.

- **Vmcg** (Velocity – Minimum Control, Ground) may be determined at the option of the airplane manufacturer. **Vmcg** is the minimum control speed on the ground. **Vmcg** is the calibrated airspeed during the takeoff run at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane by using the rudder control alone (without the use of nosewheel steering) as limited by 150 pounds of rudder pedal force, and using lateral control to the extent necessary to keep the wings level, enabling the takeoff to be safely continued. **Vmcg** must be determined under the following conditions:

  - Aircraft accelerates with all engines operating along the runway centerline.

  - The Aircraft's path, from the point at which the critical engine is suddenly made inoperative to the point at which recovery to a direction parallel to the runway centerline is completed, must not deviate more than 30 feet laterally from the runway centerline at any point during the recovery.

  - **Vmcg** must be established under the following conditions:
    - The airplane in each takeoff configuration or, at the option of the manufacturer, in the most critical takeoff configuration.
    - Maximum available takeoff power on the operating engines.

- The most unfavorable center of gravity.
- The airplane trimmed for takeoff.
- The most unfavorable weight in the range of takeoff weights.

▪ **Note: The Actual Vmcg Experienced** will be affected by any existing crosswind occurring during the airplane's takeoff roll.

- Failure of the downwind engine will produce a lower Vmcg airspeed due to the weathervaning tendency of the crosswind acting to reduce the yawing force experienced.

- Failure of the upwind engine will produce a higher Vmcg airspeed due to the weathervaning tendency of the crosswind acting to exacerbate the yawing force experienced.

o **Additional Directional Control Requirements** in addition to **Vmc** issues are as follows:

▪ The airplane must be able to safely make sudden changes in heading of up to 15 degrees in both directions, while holding the wings level within 5 degrees. This ability must be shown at airspeed of 1.4 **Vs1** with a rudder pedal force of not more than 150 pounds. This ability must be demonstrated under the following conditions:
  - Critical engine inoperative and its propeller in the minimum drag position.
  - Remaining engine at maximum continuous power.
  - Landing Gear both retracted and extended.
  - Flaps retracted.

▪ The airplane must demonstrate the ability to regain full control without exceeding a bank angle of 45 degrees, reaching a dangerous attitude, or encountering dangerous characteristics in the event of a sudden and complete failure of the critical engine(s). This ability must be demonstrated while making an allowance for a two second delay in the initiation of a recovery action appropriate to the situation. The aircraft must initially be "in trim" and in the following conditions:
  - Maximum continuous power on each engine
  - Wing flaps retracted.
  - Landing gear retracted.
  - Speed equal to that used for Part 23.69(a) compliance (all engine climb gradient – i.e. **Vy**)

- All propeller controls in the position at which compliance with Part 23.69(a) was shown.

- The airplane must be safely controllable without the use of the primary lateral control system (ailerons) in any all-engine configuration(s) and at any airspeed or altitude within the approved operating envelope. The airplane's flight characteristics may not be impaired below a level needed to permit continued safe flight and the ability to maintain altitudes suitable to allow for a controlled landing without exceeding the operational and structural limitations of the airplane.

- **Some Additional Teaching Points** about **Vmc** are as follows:

  - ***Vmc** is actually a condition, not a single speed*!

    - **Vmc** varies with bank.

      - Manufacturer's determine **Vmc** using a 5 degree bank into the operating engine

      - **Vmc** airspeed increases approximately 2 – 3 Kts for each degree of reduced bank into the operating engine (i.e. *Reducing the bank from 5 degrees into the operating engine to "wings level" flight will increase the **Vmc** by 10 to 15 Kts!*)

    - **Vmc** varies with engine power available.

      - **Vmc** airspeed decreases as engine power decreases with altitude (occurs at training altitudes and is especially noticeable with non-supercharged engines).

      - **Vmc** airspeed can decrease below the aircraft's **Vs1** airspeed (Velocity – Stall, clean configuration).

        - Multiengine training accidents happen when the aircraft is allowed to stall during a **Vmc** demonstration.

        - Asymmetric thrust produces more than adequate yawing moment for an instantaneous spin entry and light-multiengine airplanes have a high propensity toward flat spins. *This is doubly true when a stall occurs during high aileron deflection*.

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- *Never use ailerons to try to compensate for inadequate rudder authority*. Instead either airspeed must be increased or power on the operating engine must be reduced.

- Being at an airspeed above the **Red Radial Vmc** mark on the multiengine airspeed indication does not automatically assure that you will be able to maintain directional control in the event of a sudden engine failure under any existing conditions. That assurance usually occurs at airspeeds at or slightly above the **Blue Radial** Line (**Vyse**).

2. **A Short Blue Radial Line** located at the 110 MPH position indicates the **Vyse** (Best Single Engine Rate of Climb) airspeed. **Vyse** is the airspeed at which the airplane manufacturer demonstrated the maximum rate of climb obtainable with an engine inoperative at the airplane's Maximum Takeoff Gross Weight.

    - **Note: Vyse** is a performance airspeed. *Performance airspeeds always assure control, but control airspeeds seldom assure performance!* Performance airspeeds are always higher than control speeds.

    - **Vyse performance data** is obtained during "Zero Sideslip" flight. This is typically obtained with approximately a 2 degree bank into the operating engine, not the 5 degree bank into the operating engine which is used to determine the **Vmc** airspeed.

    - **Vyse** decreases slightly as the airplane's weight decreases.

3. **Vsse (Velocity – Safe Single Engine)** is an airspeed which is unmarked on the multiengine airspeed indicator and exists between the **Vmc and Vyse** airspeeds.

    - **Vsse** is an airspeed used during multiengine training and checking and is the minimum speed with which to intentionally render the critical engine inoperative.

    - **Vsse** must be established and designated as the safe, intentional, one-engine-inoperative airspeed by the airplanes Manufacturer.

    - Multiengine airplanes certified under the older CAR 3 (Civil Air Regulations) do not have a designated **Vsse** airspeed. In that event, use **Vxse** (Best Single Engine Angle of Climb Speed) in lieu of **Vsse.**

    - **Vsse (or Vxse)** is typically the slowest airspeed at which a light-multiengine aircraft is capable of accelerating in level flight with an engine inoperative, its propeller feathered and flaps and landing gear up.

- **Vef** is the airspeed at which the critical engine is assumed to fail during takeoff.

4. **Common Airspeeds** for both Multiengine and Complex Single Engine Airplanes are as follows:
   - **Vso** is the stalling speed in landing configuration (Bottom of White arc).
   - **Vs1** is a specified config. stalling speed (Bottom of Green arc is flaps up).
   - **Vr** is the airspeed at which rotation is initiated during takeoff.
   - **Vmu** is minimum "unstick" airspeed required to lift-off from the runway.
   - **Vlof** is the actual lift-off airspeed during takeoff.
   - **Vx** is the best angle of climb speed – two engines.
   - **Vy** is the best rate of climb speed – two engines.
   - **Va** is the design maneuvering speed (i.e. the airframe will withstand full deflection of one control in a single axis, in one direction, one time.)
   - **Vno** is the maximum structural cruising airspeed (i.e. maximum speed in turbulent air) and is identified by the Top of the Green arc.
   - **Vne** is the never exceed airspeed **(Long Red Radial Line** at 272 MPH).
   - **Vle** is the maximum airspeed with the landing gear extended.
   - **Vlo** is the maximum airspeed for operating the landing gear.
   - **Vfe** is maximum airspeed with landing flaps extended (Top of White arc).
   - **Vref** is the reference landing speed

5. **Part 25 Airspeed Indicators in Transport Category Airplanes** are marked differently than those in Part 23 airplanes, and some of their defined airspeeds are different. Even though Part 25 airplane performance airspeeds are not directly applicable to Part 23 multiengine airplanes, comparing them to equivalent Part 23 airspeeds aids in understanding the issues involved during a multiengine takeoff.

   - **V1max** is the maximum airspeed during a takeoff at which the pilot must initiate the first action (i.e. apply brakes, reduce thrust, deploy speed brakes) in order to be able to stop the aircraft within the runway remaining. As the aircraft weight increases and/or the runway length decreases, **V1max** decreases. **V1max** can never be greater than **Vr** or less than **V1min.**

   - **V1min** is the minimum airspeed during a takeoff at which, following a failure of the critical engine, the pilot is able to continue the takeoff and achieve 35 feet above the takeoff surface within the takeoff distance available. As the aircraft weight increases and/or the runway length decreases, **V1min** increases. **V1min** can never be less than **Vmcg** or greater than **V1max**. A "***Balanced Field***" combination of runway length and aircraft weight occurs when **V1min** and **V1max** merge at a single airspeed value. This is the shortest runway and/or heaviest aircraft weight allowed for a Part 25 airplane takeoff.

   - **V2** is the takeoff safety airspeed, typically about 1.2 times **Vs1**, which is stalling speed in the takeoff configuration. (**V2min** is the minimum

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takeoff safety speed in order to preclude controllability issues at very light takeoff weights.) At heavy weights adequate performance becomes the defining issue, while controllability is the issue at very light weights.

This looks like a good point to break for this month. Next month we will continue with our series on flying multiengine airplanes.

The thought for this month is as follows: ***"Beware of endeavoring to become a great man in a hurry. One such attempt in ten thousand may succeed. These are fearful odds."*** **Benjamin Disraeli ~ British Prime Minister.**

So until next month, be sure to ***"Think Right to FliRite!***

Cessna T50/UC-78 (Bamboo Bomber) WWII Multi-Engine Trainer

M/E Trainer used during my Dad's (Kenneth N. Tomlinson) Civilian Pilot Training Instructor days -*Wikipedia Image*

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