V-SPEED DESIGNATOR

1. Introduction

V-speeds are standard terms used to define airspeeds important or useful to the operation of all aircraft (including fixed-wing aircraft, gliders, autogiros, helicopters, and dirigibles)

These speeds are derived from data obtained by aircraft designers and manufacturers during flight testing and verified in most countries by government flight inspectors during aircraft type-certification testing.

Using them is considered a best practice to maximize aviation safety and aircraft performance.

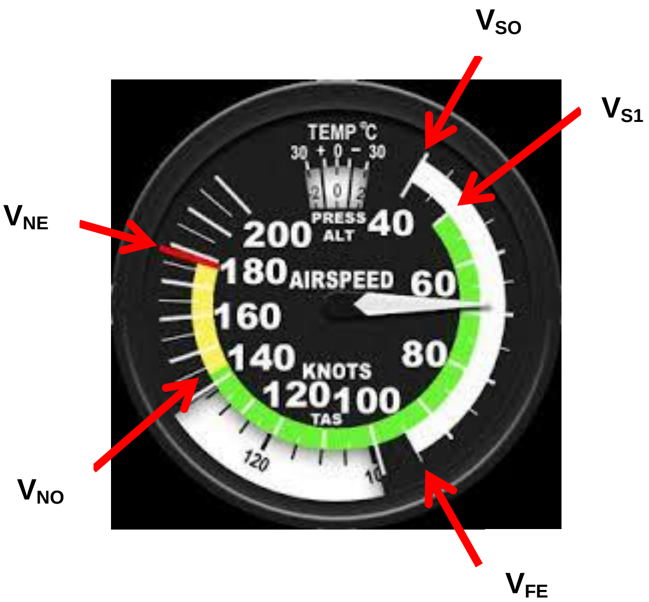
The speeds are specific to a particular model of aircraft, and are expressed in terms of the aircraft's indicated airspeed, so that pilots may use them directly, without having to apply correction factors.

Proper display of V speeds is an airworthiness requirement for type-certificated aircraft in most countries.

2. V-speed in airspeed indicator

In general aviation aircraft, the most commonly used and most safety-critical airspeeds are displayed as color-coded arcs and lines located on the face of an aircraft's airspeed indicator:

- The lower ends of the green arc is the stalling speed with wing flaps retracted
- The lower ends of the white arc is the stalling speed with wing flaps fully extended
- The upper end of the green arc is the maximum speed for normal operations
- The upper end of the white arc is the maximum flap extended speed
- The red line is the never exceed speed



3. V-speed designator and definition

V-speed designator	Description
V_1	Engine failure recognition speed or decision speed. It is the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance. V_1 also means the minimum speed in the takeoff, following a failure of the critical engine at V_{EF}, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance. If an engine failure is detected after V_1, the takeoff must be continued. This implies that the aircraft must be controllable on ground. Therefore, V_1 is always greater than V_{MCG}.
V_2	Takeoff safety speed. It is the minimum speed that needs to be maintained up to acceleration altitude, in the event of an engine failure after V_1. Flight at V_2 ensures that the minimum required climb gradient is achieved, and that the aircraft is controllable. V_2 speed is always greater than V_{MCA}, and facilitates control of the aircraft in flight. In an all-engines operative takeoff, V_2+10 provides a better climb performance than V_2.
V_3	Flap retraction speed.
V_4	Steady initial climb speed. The all engines operating take-off climb speed used to the point where acceleration to flap retraction speed is initiated. Should be attained by a gross height of 400 feet.
V_A	Design maneuvering speed. This is the speed above which it is unwise to make full application of any single flight control (or "pull to the stops") as it may generate a force greater than the aircraft's structural limitations.
V_{at}	Indicated airspeed at threshold, which is equal to the stall speed VS0 multiplied by 1.3 or stall speed V_{S1g} multiplied by 1.23 in the landing configuration at the maximum certificated landing mass. If both V_{S0} and V_{S1g} are available, the higher resulting V_{at} shall be applied. Also called "approach speed".

V-speed designator	Description
V_B	Design speed for maximum gust intensity.
V_C	Design cruise speed, used to show compliance with gust intensity loading.
V_{cef}	generally used in documentation of military aircraft performance as V_1
V_D	Design diving speed.
V_{DF}	Demonstrated flight diving speed.
V_{EF}	The speed at which the Critical engine is assumed to fail during takeoff.
V_F	Designed flap speed.
V_{FC}	Maximum speed for stability characteristics.
V_{FE}	Maximum flap extended speed.
V_{FTO}	Final takeoff speed
V_H	Maximum speed in level flight at maximum continuous power.
V_{LE}	Maximum landing gear extended speed. This is the maximum speed at which it is safe to fly a retractable gear aircraft with the landing gear extended.
V_{LO}	Maximum landing gear operating speed. This is the maximum speed at which it is safe to extend or retract the landing gear on a retractable gear aircraft.
V_{LOF}	Lift-off speed.
V_{MC}	Minimum control speed. Mostly used as the minimum control speed for the takeoff configuration (takeoff flaps) in many publications. Several V_{MC}'s exist for different flight phases and airplane configurations: V_{MCG}, V_{MCA}, V_{MCA1}, V_{MCA2}, V_{MCL}, V_{MCL1}, V_{MCL2}. Refer to the

V-speed designator	Description
	minimum control speed article for a thorough explanation.
V_{MCA}	Minimum control speed in the air (or airborne) for maintaining steady straight flight when an engine fails or is inoperative and with the corresponding opposite engine set to provide maximum thrust, provided a small (3° –) 5° bank angle is being maintained away from the inoperative engine and the rudder is used up to maximum to maintain straight flight. The exact required bank angle should be provided by the manufacturer with $V_{MC(A)}$ data. Refer to the minimum control speed article for a description of (pilot-induced) factors that have influence on V_{MCA}. V_{MCA} is also presented as V_{MC} in many manuals.
V_{MCG}	Minimum control speed on the ground is the lowest speed at which the takeoff may be safely continued following an engine failure during the takeoff run. Below V_{MCG}, the throttles need to be closed at once when an engine fails, to avoid veering off the runway.
V_{MCL}	Minimum control speed in the landing configuration with one engine inoperative.
V_{MO}	Maximum operating limit speed.
V_{MU}	Minimum unstick speed. It is achieved by pitching the aircraft up to the maximum (tail on the runway, for aircraft that are geometrically-limited) during the takeoff roll. The speed at which the aircraft first lifts off is V_{MU}. Therefore, lift-off is not possible prior to V_{MU}.
V_{NE}	Never exceed speed.
V_{NO}	Maximum structural cruising speed or maximum speed for normal operations.
V_{O}	Maximum operating maneuvering speed.
V_{R}	Rotation speed. The speed at which the aircraft's nose wheel leaves the ground during take-off.
V_{rot}	Used instead of V_{R} (in discussions of the takeoff performance of military aircraft) to denote

V-speed designator	Description
	rotation speed in conjunction with the term V_{Ref} (refusal speed).
V_{Ref}	Landing reference speed or threshold crossing speed. V_{Ref} stands for refusal speed for military aircrafts. Refusal speed is the maximum speed during takeoff from which the air vehicle can stop within the available remaining runway length for a specified altitude, weight, and configuration.
V_S	Stall speed or minimum steady flight speed for which the aircraft is still controllable.
V_{S0}	Stall speed or minimum flight speed in landing configuration.
V_{S1}	Stall speed or minimum steady flight speed for which the aircraft is still controllable in a specific configuration.
V_{SR}	Reference stall speed.
V_{SR0}	Reference stall speed in landing configuration.
V_{SR1}	Reference stall speed in a specific configuration.
V_{SW}	Speed at which the stall warning will occur.
V_{TOSS}	Category A rotorcraft takeoff safety speed.
V_X	Speed that will allow for best angle of climb.
V_Y	Speed that will allow for the best rate of climb.

> Whenever a limiting speed is expressed in terms of Mach number, it is expressed as an "M speed", e.g. V_{MO}: Maximum operating limit speed (in knots), M_{MO}: Maximum operating limit Mach.

4. Conditions affecting V-speeds

There are some conditions which can affect the value of V-speeds:

- V-speeds change relative to aerodrome conditions, aircraft weight and configuration.
- Gross take-off weight, pressure altitude, and temperature all affect aircraft performance.
- WAT- weight, altitude, temperature.
- Aircraft configuration affects V-speeds (flap setting, slat setting, bleeds, anti-ice, a/c off/on, anti-skid inoperable), and can be used to improve performance.
- Runway conditions also affect V-speeds. (contaminated runway)

5. Relation between V-speed

These relationships will always hold true, but the speeds themselves will change according to aircraft weight, atmospheric conditions, aircraft configuration, and runway conditions.
The specific speeds are obtained by consulting the performance charts or quick reference cards.

5.1. V_1

V_1 must always be:

- $V_1 > V_{MCG}$
- $V_1 < V_{MBE}$
- $V_1 \leq V_R$

5.2. V_R

V_R must always be:

- $V_R \geq V_1$
- $V_R > V_{MCA}$

5.3. V_{LO}

V_{LO} must always be:

- $V_{LO} \geq V_R$
- $V_{LO} > V_{MCA}$
- $V_{LO} > V_S$
- $V_{LO} > V_{MU}$

5.4. V_2

V_{LO} must always be:

- $V_2 > V_R$
- $V_2 > V_{MCA}$
- $V_2 > V_S$