American operators

V speeds

V speeds are speeds that define certain performance and limiting characteristics of an aircraft and the "V" stands for velocity. They are established by the manufacturer during design and testing, and are specific to the aircraft model. Usually "V speeds" are relative to the air through which the aircraft is moving and are thus airspeeds. In many cases, they are defined by reference to the standard atmosphere or other specific conditions, and/or at the aircraft's maximum gross weight, and the pilot is responsible for calculating the effective value based on the actual weight and air density. In other cases the indicated airspeed, the value uncorrected for atmospheric pressure differences (height and temperature), is useful directly by the pilot. E.g. the indicated stall speed $V_s$ remains essentially constant for all heights and temperatures while the true stall speed increases as pressure lessens.

In the U.S., V speeds are stated in knots or, for older aircraft models, miles per hour. For faster aircraft, some speeds are also defined by Mach number. Typically, V speeds are given for an aircraft at maximum gross weight, and should be adjusted accordingly for lighter weights.

Speeds frequently used in General Aviation

$V_A$

design maneuvering speed (stalling speed at the maximum legal G-force, and hence the maximum speed at which abrupt, full deflection, control inputs will not cause the aircraft to exceed its G-force limit). Maneuvering speed is limited by aircraft structural characteristics. With the Cirrus SR20 and SR22, this speed is also known as $V_O$

$V_{FE}$

maximum flap extended speed (a different maximum speed may be specified for partial flap extension).

$V_{LE}$

maximum landing gear extended speed. The maximum speed at which the aircraft may be flown with the landing gear extended. $V_{LE}$ is always higher than $V_{LO}$

$V_{LO}$

maximum landing gear operating speed. The maximum speed at which the aircraft may be flying while raising or lowering the gear. $V_{LO}$ is always lower than $V_{LE}$

$V_{MC}$

minimum control speed with the critical engine inoperative.

$V_{NE}$

The VNE, or the never exceed speed, of an aircraft is the V speed which refers to the velocity that should never be exceeded due to risk of structural failure, most commonly due to wing or tail deformation or failure and less commonly due to aeroelastic flutter (usually in faster aircraft). VNE is specified as a red line on many airspeed indicators. This speed is specific to the aircraft model, and represents the edge of its performance envelope.

$V_R$

rotation speed. The speed of an aircraft at which the pilot initiates rotation to obtain the scheduled takeoff performance. It must be greater or equal to the $V_1$ speed.

$V_{NO}$
The $V_{NO}$ of an aircraft is known as the maximum structural cruising speed (the maximum speed to be used in turbulent conditions) or can refer to the velocity of normal operation. $V_{NO}$ is specified as the upper limit of the green arc on many airspeed indicators. This speed is specific to the aircraft model. The range above $V_{NO}$ is marked on the airspeed indicator as a yellow arc from $V_{NO}$ to the $V_{NE}$.

$V_{REF}$
reference landing approach speed; speed (in calm air) at the landing screen height of 50 ft. Often used by pilots as a base from which to calculate speeds to be used during landing, and calculated as a margin over the stall speed - usually $1.3 \times V_{S0}$.

$V_{S}$
the stalling speed or the minimum steady flight speed at which the airplane is controllable. Usually synonymous with $V_{S1}$. This speed is specific to the aircraft model and depends upon the weight and balance of the aircraft. The true stall speed increases as atmospheric pressure decreases. (i.e. as temperature increases and/or as altitude increases.) The indicated stall speed, i.e. the speed indicated by the airspeed indicator, remains essentially unchanged with air pressure.

$V_{S0}$
the stalling speed or the minimum steady flight speed in the landing configuration.

$V_{S1}$
the stalling speed or the minimum steady flight speed obtained in a specific configuration (usually a configuration "clean" of flaps, landing gear and other sources of drag).

$V_{X}$
speed for best angle of climb. This provides the best altitude gain per unit of horizontal distance, and is usually used for clearing obstacles during takeoff.

$V_{Y}$
speed for best rate of climb. This provides the best altitude gain per unit of time.

**Speeds used in high performance aircraft and other reference speeds**

$V_{B}$
design speed for maximum gust intensity.

$V_{C}$
The VC of an aircraft is the V speed which refers to the velocity of cruising. VC is within the green arc on many airspeed indicators. This speed varies is different for each aircraft model. VC is also called the design cruising speed or the optimum cruise speed – the latter being the speed giving the most velocity (i.e greatest distance/time) from a litre of fuel, usually utilising 75% power at Maximum Take-Off Weight (MTOW) and about 1.3 times the maximum lift-to-drag ratio (L/D) speed – $V_{br}$ above. The speed and power required decrease as the aircraft weight decreases from MTOW.

For normal category aircraft FAR Part 23 specifies a minimum design cruising speed (in knots) based on the wing loading of (weight in pounds divided by wing area in square feet). For the utility category, the minimum design cruising speed is . Many ultralight aeroplanes are unable to comply with the FAR part 23 requirement for a minimum design cruising speed.
$V_D$ design diving speed. Usually $1.4 \times V_{NO}$.

$V_{DF}/M_{DF}$ demonstrated flight diving speed.

$V_{EF}$ the speed at which the critical engine is assumed to fail during takeoff.

$V_F$ design flap speed.

$V_{FC}/M_{FC}$ maximum speed for stability characteristics.

$V_{FTO}$ final takeoff speed

$V_H$ maximum speed in level flight with maximum continuous power.

$V_{LOF}$ lift-off speed.

$V_{MO}/M_{MO}$ maximum operating limit speed.

$V_{MU}$ minimum unstick speed.

$V_{SR}$ reference stall speed.

$V_{SR0}$ reference stall speed in the landing configuration.

$V_{SR1}$ reference stall speed in a specific configuration.

$V_{SW}$ speed at which onset of natural or artificial stall warning occurs.

$V_{TOSS}$ takeoff safety speed for Category A rotorcraft.

$V_1$ critical engine failure recognition speed. $V_1$ is the minimum speed in the takeoff, following a failure of the critical engine at $V_{EF}$, at which the pilot can continue the takeoff with only the remaining engines. Any problems after $V_1$ are treated as inflight emergencies. In the case of a balanced field takeoff, $V_1$ 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 and the minimum speed at which the takeoff can be continued and achieve the required height above the takeoff surface within the takeoff distance. In this context, $V_1$ is the takeoff decision speed.

$V_2$ takeoff safety speed. Also called takeoff screen speed, the minimum speed in the second segment of a climb following an engine failure.

$V_{2\text{min}}$ minimum takeoff safety speed.
Non-regulatory speeds

These values are not defined by FAA regulations.

$V_{BE}$
best endurance speed; the speed that gives the greatest airborne time for fuel consumed. This may be used when there is reason to remain aloft for an extended period, such as waiting for a forecast improvement in weather on the ground.

$V_{BG}$
best power-off glide speed; the speed that provides maximum lift-to-drag ratio and thus the greatest gliding distance available.

$V_{XSE}$
speed for best angle climb with the critical engine inoperative.

$V_{YSE}$
speed for best rate of climb with the critical engine inoperative.

$V_2$
t/o safety speed

$V_3$
steady initial climb speed with all engines operating

$V_4$
steady climb speed with all engines operating to be achieved by 400 ft gross height

$V_a$
design maneuvering speed

$V_c$
design cruising speed.

$V_{clmax}$
max coefficient of lift speed.

$V_d$
design diving speed

$V_{dmin}$
minimum drag

$V_{df}$
demonstrated flight diving speed

$V_{ef}$
the CAS at which the critical engine is assumed to fail

$V_f$
design flap speed

$V_{fe}$
max flap extended speed

$V_{fto}$
final t/o speed

$V_{imd}$
minimum drag

$V_{imp}$
minimum power

\( V_h \)
max speed in level flight with max continuous power.

\( V_{le} \)
max landing gear extended speed

\( V_{lo} \)
max landing gear operating speed

\( V_{lof} \)
lift-off speed

\( V_{mb} \)
max brake energy speed

\( V_{md} \)
minimum drag

\( V_{mc} \)
minimum control speed with critical engine inoperative

\( V_{mca} \)
minimum control speed, air
Air minimum control speed is the minimum flight speed at which the airplane is directionally controllable as determined in accordance with Federal Aviation Regulations. Airplane certification conditions include one engine becoming inoperative and windmilling, not more than a 5 degree back towards the operative engine, takeoff power on the operative engine, landing gear up, flaps in takeoff position, and most rearward C of G.

\( V_{mcg} \)
minimum control speed, ground

\( V_{mcl} \)
minimum control speed, approach and landing

\( V_{me} \)
max endurance

\( V_{mo} \)
max operating limit speed

\( V_{mp} \)
minimum power

\( V_{mr} \)
max range

\( V_{mu} \)
minimum unstick speed

\( V_{nd} \)
max structural cruising speed

\( V_p \)
aquaplaning speed.

\( V_{ra} \)
rough air speed

\( V_{ref} \)
reference landing speed
\( V_s \)

- V-stall

\( V_{so} \)

- stall speed in landing configuration

\( V_{s1} \)

- stall speed in a specified configuration

\( V_{s1g} \)

- one g stall speed

\( V_{sr} \)

- reference stall speed

\( V_{sse} \)

- safe single engine speed

\( V_t \)

- threshold speed

\( V_{tmax} \)

- max threshold speed

\( V_x \)

- best angle of climb

\( V_{xe} \)

- best angle of climb, single engine

\( V_y \)

- best rate of climb

\( V_{yse} \)

- best rate of climb single engine

**Speeds indicated on Airspeed Indicator**

Airspeed Indicator

V speeds are nearly always given as **Indicated Airspeed** (IAS), so that pilots can read them directly off the **airspeed indicator** (ASI). ASIs carry color-coded markings that give the pilot an immediate reference, as follows:
- $V_{S0}$
  
  bottom of white arc.

- $V_S$
  
  bottom of green arc.

- $V_{FE}$
  
  top of white arc.

- $V_{NO}$
  
  top of green and bottom of yellow arcs. The yellow arc is a caution, as speeds in this region may add dangerous stress to the aircraft, and are only to be used in smooth air when no turbulence or abrupt control inputs are expected.

- $V_{NE}$
  
  red line and top of yellow arc.

- In addition, on a light multi-engine aircraft, $V_{YSE}$ is indicated by a blue line, and $V_{MC}$ is indicated by a red line near the bottom of the green arc.
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