The FAA thinks highly enough of V speeds to specifically define them in the federal aviation regulations. In fact, Part 1 of the FARs includes definitions for 35 separate V speeds. All of them are important, too. However, of those 35 speeds, there are six that every pilot should know, whether he is an airline captain flying a widebody over the ocean, or a student pilot guiding an LSA around the pattern.

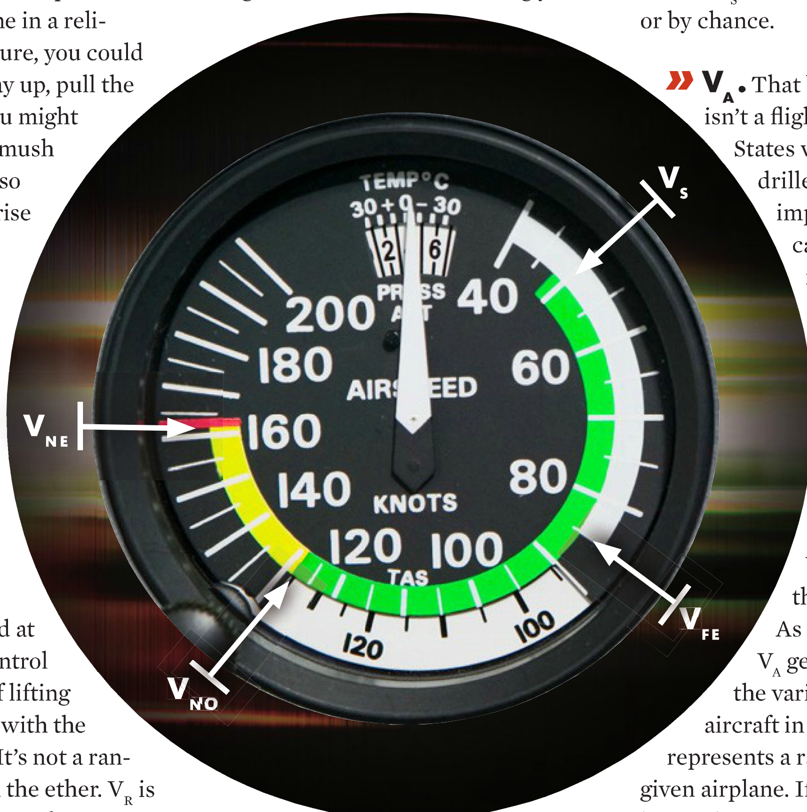
» V_R • Let's start with V_R, the speed that will set us up to get airborne in a reliable, predictable fashion. Sure, you could push the throttle all the way up, pull the controls back, and wait. You might get airborne, or you might mush along the runway creating so much drag that you never rise into the air at all. Rather than build an undesirable level of risk into our flying experience, engineers and test pilots devised the concept of a rotation speed. And that's exactly what V_R is: rotation speed.

Going back to the FARs, we can find specific information in Part 23 that tells us that V_R is "the speed at which the pilot makes a control input, with the intention of lifting the airplane out of contact with the runway or water surface." It's not a random number plucked from the ether. V_R is a specific airspeed that, for single-engine airplanes, must by regulation be no less than V_{S1}, which is the stalling speed of the aircraft in a specific configuration.

That makes sense. By establishing a rotation speed that is at or above the stalling speed in a specific configuration, you can enhance the safety of flight. If the pilot doesn't even try to get airborne until the aircraft is moving at a speed that will allow it to fly effectively, the likelihood of an inadvertent stall on takeoff is reduced considerably.

Imagine how many very short, overly exciting flights might have been turned into much longer, much less dangerous flights in the early days of aviation, had they only known of the importance of V_R.

» V_S • According to the FAA, V_S is the stalling speed, or the minimum steady flight speed at which the airplane is controllable. One knot higher and you're flying. One knot lower and you're not. Ironically, it could be argued that the key to understanding V_S isn't the airspeed at all. It is what the airspeed represents, for it is at V_S that your airplane will be at the critical angle of attack. That's assuming you



THE AIRSPEED indicator gives some V speed clues, but not all. Flap, normal flight range, stall speed, and the ominous red line are present, but maneuvering and rotation speeds will never be shown.

are in straight-and-level flight, of course. V_S is the point at which the air flowing over the upper surface of the wing can no longer flow smoothly to the trailing edge. It eddies and burbles and leaves the surface to wander aimlessly in the surrounding atmosphere. Lift is lost, drag increases, the nose drops, and a stall ensues.

Violating V_S isn't necessarily a bad thing. Pilots stall their airplanes all the time. They do it in training; they do it when they're working on proficiency in the airplane; and they stall it inches above the ground to drop it smoothly onto the runway whenever they perform a good landing. With the stall horn blaring, a slight buffet felt through the controls, and a sudden settling of the airplane back to earth, a good pilot can violate V_S on every flight and still be considered to be a good pilot. The key that separates a good stall from a bad stall is where we violate V_S, and whether we do it by choice or by chance.

» V_A • That brings us to V_A. There isn't a flight student in the United States who hasn't had the basics drilled into his head about the importance of V_A. It's often called the aircraft's design maneuvering speed, and that has caused many a pilot to misunderstand what V_A really is, and how it can be unintentionally violated—with potentially catastrophic results.

The first oddity about V_A is that it changes with the weight of the aircraft. As the airplane gets lighter, V_A gets lower. That quirk of the various sciences affecting aircraft in flight means that V_A represents a range of airspeeds for any given airplane. If the airplane is loaded to its maximum weight, its design maneuvering speed is higher. As the fuel burns off and a passenger gets out at an intermediate stop, taking a suitcase with him, the airplane gets lighter, which results in V_A becoming a lower speed.

Knowing what V_A really is and sticking to it is tremendously important to anyone who plans to be safe in the air. In an unstable air mass where air currents cause a bumpy ride, those bumps are imposing momentary increases in load factor on the airplane. If you're at or below V_A, the airplane will stall before the structure is damaged by excessive loads. But if your airspeed sneaks above

I FEEL THE NEED FOR SPEED

The various V speed definitions from FAR Part 1

V_A	design maneuvering speed
V_B	design speed for maximum gust intensity
V_C	design cruising speed
V_D	design diving speed
V_{DF}	demonstrated flight diving speed
V_{EF}	speed at which the critical engine is assumed to fail during takeoff
V_F	design flap speed
V_{FC}	maximum speed for stability characteristics
V_{FE}	maximum flap extended speed
V_H	maximum speed in level flight with maximum continuous power
V_{LE}	maximum landing gear extended speed
V_{LO}	maximum landing gear operating speed
V_{LOF}	lift-off speed
V_{MC}	minimum control speed with the critical engine inoperative
V_{MO}	maximum operating limit speed
V_{MU}	minimum unstick speed
V_{FTO}	final takeoff speed
V_{MU}	minimum unstick speed
V_{NE}	never-exceed speed
V_{NO}	maximum structural cruising speed
V_R	rotation speed
V_{REF}	reference landing speed
V_S	stalling speed or the minimum steady flight speed at which the airplane is controllable
V_{SO}	stalling speed or the minimum steady flight speed in the landing configuration
V_{S1}	stalling speed or the minimum steady flight speed obtained in a specific configuration
V_{SR}	reference stall speed
V_{SRO}	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_X	best angle of climb
V_Y	best rate of climb
V_1	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
V_2	takeoff safety speed
V_{2MIN}	minimum takeoff safety speed

V_A and a gust causes a sudden, substantial increase in load factor, it could be the structure that fails. As you can imagine, an in-flight structural failure—which may be as severe as the loss of the tail section—tends to shift an otherwise uneventful flight in the direction of an unpleasant outcome.

Even if the structure doesn't fail, nobody wants to get back home to see wrinkled skin on their aircraft.

Many pilots mistakenly believe the term "design maneuvering speed" means that, as long as you are at or below V_A, you can move the controls from stop to stop repeatedly without doing damage to the aircraft. That's not really true. In fact, the FAA was concerned enough about this misunderstanding of the term to add a statement to Part 25 of the FARs for Transport category aircraft. Although this part doesn't come into play in the certification of general aviation aircraft, the science is still valid. The FAA says, in part, "flying at or below the design maneuvering speed does not allow a pilot to make multiple large control inputs in one airplane axis or single full control inputs in more than one airplane axis at a time without endangering the airplane's structure."

The crux of that statement is, essentially, cool it. Stay at or below V_A in rough air, and avoid large control inputs that might cause significant damage to the aircraft.

» V_{FE} • One important V speed doesn't actually apply to all pilots—at least not in every airplane they fly. V_{FE} is the maximum flap extended speed, and it is represented by the top of the white arc on the airspeed indicator. Below this speed you can hang the flaps out all day long. Above V_{FE} is a different story entirely. If your airspeed rises above the top of the white arc while your flaps are down, you may damage or even lose one or both of your flaps. Where it gets confusing is in airplanes where partial flaps are allowed above V_{FE}. When this happens, often a placard will remind the pilot of the maximum partial-flap speed.

Admittedly, not all airplanes have flaps. Most do, though, especially those built since the mid-1950s. So even Cub and Champ drivers who are used to motoring around in an airplane that is flap-free will find it useful to remember the meaning of V_{FE}. One day you may borrow, rent, buy, or become a partner in an airplane with a more modern wing that benefits from the additional lift and drag flaps can offer.

» V_{NO} • Many pilots unwisely may be tempted to flirt with V_{NO}. It's easily identifiable as the speed that corresponds with the upper limit of the green arc on the airspeed indicator. Maximum structural cruising speed is the highest speed you can safely pilot your aircraft in smooth air. Above that limit you may cause damage to the airplane. Then again, you may fly into an area of less-than-smooth air that can cause damage at less than V_{NO}. All the more reason to be cautious when dealing with the speed of your aircraft.

» V_{NE} • The one airspeed that contains no mystery at all is V_{NE}. Don't go there. Never-exceed speed is an absolute limit, and the name suggests exactly how important this airspeed restriction is. The manufacturer, its engineering staff, and the test pilots who brought the airplane to market are all in agreement: You should never attempt to fly your airplane faster than V_{NE} for any reason. Even the color code—a red line on the airspeed indicator—says stop. So take their word for it.

Of course the upshot of all this is simple. The goal is to be safe, maintain the structural integrity of the airplane, and enjoy each and every flight as much as possible. That's a tough goal to reach if parts are bending, breaking, or falling off the airplane. A good pilot can prevent that from happening by simply knowing and observing the V speeds established for his or her airplane.

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