Vne Myths Explained.

By Bud Yerly

The Europa Aircraft XS POH defines the Vne in simple terms. It is 165 KIAS. **Yes, that is indicated airspeed!** However, this is not the case for all airplanes. Also, there are a number of articles and misguided people assuming that Vne is TAS or True Airspeed in all aircraft. This is patently incorrect. In some aircraft, there are true airspeed issues. In an aircraft with flexible wings, like a glider, or aircraft flying above 25,000 feet and at very high or very low speed there are other effects due to viscosity, trim changes, stability and wing aeroelastic effects that become factors. Due to the unique design of these aircraft they have indicating systems (or placards) to alert the pilot of the aircrafts unique flight limits.

Design Definition:

Vne

— Never-exceed speed — "red line." Applies only to piston-powered airplanes. This speed is never more than 90 percent of VDF. G loads imposed by any turbulence can easily overstress an aircraft at this speed. It must be readable by the pilot in the aircraft without calculation. For nearly all GA and Experimental aircraft use IAS. (The airspeed indicator of some high speed aircraft have special pointers (we call the barber pole) built into the EFIS or airspeed indicator indicating limiting Mach number.)

VDF/MDF

— Demonstrated flight diving speed. VDF is in knots indicated. MDF is a percentage of Mach number for high speed/altitude aircraft. Some aircraft are incapable of reaching VD because of a lack of power or excess drag. When this is the case, the test pilot dives to the maximum speed possible — the demonstrated flight diving speed. Otherwise the designer may set a typical class speed or structural speed set due to fabric security issues in the construction or perhaps windscreen limits. It varies.

VDF is normally 1.4 times the Vc

Vc is the design phase cruise speed in light airplanes this is 33 times the square root of the wing loading and velocity (until we figure out how fast the plane goes). Another term used is Vh. Vh is the cruise speed at maximum continuous power. Initially it was about 125 Knots in the Europa. With the 914 it was 118 KIAS at 15,000. A European standard is Vne must be above Vh X 1.4 or in our case about 165KIAS. The aircraft was flight tested to this airspeed to its maximum design G in flight testing the envelope.

Definitions out of the way, let us look at design criteria used in the Europa:

The Europa is a rigid wing aircraft with balanced controls an no aeroelastic issues which flies under 25,000 feet. It has a pitot static system which makes the indicated, calibrated and equivalent airspeeds nearly equal.

Physiological effects on the human body (evolved gas disorders) prevent flight in unpressurized aircraft above 25,000 feet MSL without proper pressure suits or other equipment to protect pilot/passengers. So this area is not a design concern.

Due to the fact the plane must be operated below 25,000 MSL, and international standards limit VFR aircraft to below FL180, **Mach number** or compressibility is not an issue, nor are very high altitude viscosity (separation) issues due to Reynolds number and velocity as the wing was built to be rigid.

After an aircraft prototype is built or in production designers find out if the aircraft has unintentional flight issues. Consider the high performance glider. You need to google the videos on glider flutter. It's a gas. Gliders have a unique problem. These aircraft are built light, and as a result the wing flexes significantly. (The Europa XS flexes ½ inch or so) These glider wings will move a few feet at the tip in normal flight. The wing is quite springy also. It casually flexes up and down as it rides through updrafts and downdrafts. At the same time the structure allows the wing to twist under the load, increasing and decreasing the angle of attack due to twist. At altitude, the dynamic pressure decreases as the density of the air (and viscosity) are significantly lower. This change in dynamic pressure changes the force imposed by lift on the wing. The wing will bend/twist a small amount in level one G flight and deflect in turbulence, maneuvering and gust load. This changes the wing deflection and at very high altitudes and speeds the wing begins to oscillate as do the ailerons in response. The lower air thickness or density at high altitude allows the wing or stabilizer to change its harmonic vibration frequency. This can lead to catastrophic wing flutter and eventual breakup of the aircraft. The Pipistrel motor glider also has some minor issues with flutter due to its aileron/flaperon linkage. Combine the wing bending with the springy flaperon control, they have a flutter issue, but the Vne is low in the glider. Combine the wing flutter, small thin tail plane and elevator and the higher anticipated Virus SW cruise speed, the plane becomes quite pitch sensitive at high speed and the limit on the Vne to keep the TAS below 140 is interesting. The requirement in the US FARs it that the stick force must increase with increase in speed. Europe has no requirement for this. I lost an acquaintance I sold and Airmaster to in the Virus SW. It was a real performance enhancer. Shame, he tried to fly below a rapidly moving front. We all tried to talk him out of it but he had thousands of hours flying airliners and did not concern himself with the squall line as the plane was carbon fiber, so it must be strong. We found the wings 5 miles from the fuselage. High speed cruise in turbulence can be catastrophically dangerous.

Balanced controls prevent aileron flutter. A properly balanced control will simply stay streamlined, even if the control is detached from the stick. Building errors or controls that are loose or sloppy using push pull cables have unique problems. The unbalanced aileron/elevator with slop in the control surface will begin to flutter if speeds exceed as little as 120 Knots Indicated Airspeed. Follow the manufacturers limitations for these aircraft.

Trim tabs are a unique problem. Some aircraft have trim tabs that have very poor drive systems that allow the trim tab to move or deflect like a spring under load. A trim tab is designed to impart forces on a larger control such as an aileron or elevator/stabilator for the purpose of reducing stick forces for the pilot. Some aircraft have such poor trim design that the control will flutter as the tab moves to impart more force due to air loading and or mechanism "springiness". There will be a speed that the harmonics of the surface and its attached component will resonate and may not dampen. Always ensure your trim tabs are tight.

Some aircraft have flexible wings with non-structural skins. Above certain speeds the wing skin or support structure will begin to flutter or the skin will delaminate from the ribs. This is common in LSA fabric aircraft and aircraft using sailcloth surfaces. Hence, they have very low Vne speeds.

An airplane does not feel true airspeed unless very near the mach or at extreme altitudes. An airplane feels what we aero engineers call "q". Q affects all components exposed to the airstream. The lift coefficient is a dimensionless number which determines the ability of the airfoil to lift. The equation is:

$$Cl = \frac{Lift}{(\frac{1}{2}\rho V^2)S}$$

The term $1/2\rho V^2$ is what we call "q" or dynamic pressure. **This is also the equation of Indicated Airspeed.** The wing and airframe of an aircraft only feels q. Stick your hand out the window of your car and what you feel is q or dynamic pressure. The FARs and European design standards vary, but the UK, Australia and US use indicated airspeed as the Vne indication for design and pilot information in piston powered aircraft below 12,500 pounds Gross Weight.

Note that the RV series aircraft has no POH published by Vans Aircraft. The POH varies between builders of which some are posted on the company website as examples without factory oversight. (Vans does post a warning though.) The POH is written by builders for their aircraft. The builders are not engineers for the most part. But some are professional pilots. Perhaps they see the term V in the equation above and that is the velocity in feet per second. Yes, it is the true airspeed. But that velocity is only part of the story.

The untrained test pilot, builder and some engineers would notice in the write ups of some of our on line RV brethren, that the analysis of flutter in their aircraft can be analyzed differently than a true airspeed issue. As Ken Kreuger wrote in an article, he was diving at 185 KIAS which at about 10,000 feet was 235 KTAS. He experienced elevator flutter. Why? The RV 4 does not have a rigid elevator but it is balanced. Grab one when the owner's not looking, fix the tip weight and push on the inboard rib and watch it bend. Note that Van's does not produce a Vne in a POH or even its on line information. They produce performance figures in sales brochures and individual owners provided their POH on the Vans website. Dick Vangrunsen has always preferred owner operators not deviate from the engine and prop recommendations in their aircraft. Those who don't deviate do not seem to have issues. But Americans are guilty of the more power more performance idea and unfortunately make modifications that Van's does not recommend. As a result of one flutter incident nearly all the copy cat RV owners use TAS as their Vne because that is the way everyone else does it. Due to the unique trim/elevator setup, it is best to keep the early RV series under 220 indicated. If you exceed somewhere around 200-240 KIAS in a dive with the trim tab deflected to trim off the up force from an oversized engine, the elevator may in some instances flex slightly. The trim on the RV is also rather vague. Vans has never made a fix such as Fletner strips to improve trim performance. As one trims, nothing happens because the trim tab is in the boundary layer rather than the free stream. The pilot trims more then suddenly the tab enters the free stream and pushes the elevator. This is a minor annoyance to most but I'm afraid my American Countrymen tend to buy aircraft designed for 150 HP and put 290 HP engines on their stock aircraft. This is a problem with the RV4. The tail works harder to hold up the larger engine, the plane is flying in a speed range not flown by the factory and these issues are coming to a head. Unfortunately, the Vans factory cannot force owners to be smart or cautious in overpowering their aircraft beyond its structural design. The later RV series from the big tail 7 on up has a redesigned tailplane and I hope to check one of these out soon. I know the RV8 is much tougher and is reasonable to trim out. On a side note, the only factory POH Van's produces is for the RV 12iS which is a factory built LSA aircraft and as such it must have a factory POH to sell under SLSA rules. Vne is 136 KIAS.

Vne is not just flight control related. Some aircraft have very thin windscreens and or poor canopy locking and these components can collapse or depart at excessive speed. The test pilot becomes very uncomfortable when the windscreen or canopy starts to depart.

Can you dive the Europa XS to 165KIAS from 15,000 feet. I do it frequently in my flight tests of 914 aircraft to check for flutter. I've never had any. Of course, these are new airplanes for the most part. So you say, what if I do this in an older Europa, or even a Classic. My Classic POH has a 160KIAS Vne and I have dived the plane from 15,000 in smooth air to Vne. Personally, I take my Classic out with clients who are building in the shop and say "Lets go do 140 KIAS" because it will do it in level flight. I then push over in smooth air to 160KIAS. I gently pull out at a 2-2.5 G pull out. Note, I do this in smooth air. I also have a very tight aircraft for its 14 year old 500 hour airframe. I respect the turbulent air penetration speed, Va of 97 KIAS, and the Vno, of 131 KIAS prior to entering the bumpy hot air below 5000 feet MSL in Florida.

So, can any Europa XS be flown with reckless abandon to 165KIAS? **NOOOO!** In the UK a Vne test must be accomplished annually. But consider this before your dump the nose over and dive recklessly:

1. Are your stabilators solid? There should be no slop between the stabs or the push rod.
2. Are your trim tabs secure and the trim bar operates without any slop?
3. Do you have trim tab Fletner strips of proper size?
4. Are your ailerons balanced. With the wings off they should both be level if the wing is level.
5. Are your pushrods nice and solid? Main controls and aileron trim tab if installed.
6. Are your wing lift pins tight and is the root area free of cracks. Are the pin mods done.
7. Are the flaps held up securely?
8. Are the door latches imbedded into the fuselage at least 3/8 inch or 10mm to prevent the doors from bulging and detaching.
9. Is the prop and engine capable of achieving the speed. A fixed pitch climb prop will overspeed the engine in a high speed dive.
10. Are the gear leg covers secure on the trigear? They should not move or they will flutter.
11. Finally, look for delaminations in the skins. Any delams must be fixed.
12. **Always complete a Vne check in smooth air!**

If you have all the above, creep up on the Vne in smooth air with confidence. If any of the above are a concern, fix it. A properly rigged and trimmed Europa is a very solid aircraft and was well tested. The POH is well written. I urge you to go on line (I know, "If it is on the internet it must be true" (note the sarcasm)) and revisit **authoritative** sources before you arbitrarily set Vne speed changes to your Europa.

References:
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https://www.aviationsafetymagazine.com/features/vne-revisited/

LAMAC Design Standards for Advanced Light Sport Aircraft (design criteria in plane words)
https://tc.canada.ca/sites/default/files/migrated/2004_lamac__ds_10141_ultralight_design_standard.pdf

FAR Part 23 Design standards for criteria.

Europa Gross Weight Increase Shows the Europa VN diagram with gust loading.
See Techniques www.customflightcreations.com