Vortex generators have revolutionized the engine-out safety margins of twin-engine airplanes, and thousands of aircraft have been retrofitted with them over the last decade. But when AVweb's editor-in-chief recently had VGs installed on his Cessna T310R, he discovered that they also improve short-field performance and low-speed handling to an extent that is hard to believe until you experience it. Not just for twins anymore, VGs are rapidly gaining popularity as an effective STOL modification to single-engine airplanes from Piper Cubs to Beech Bonanzas. This in-depth pilot report reviews the history of VGs, who offers them for which aircraft, why they work so well, how they're installed, and what it's like to fly with them.

By ***Mike Busch***

Nobody's ever accused me of being an early-adopter when it comes to aviation. I'm unabashedly skeptical about aeronautical innovations until they've been proven in the field for years. When Mobil AV-1 was being touted as the greatest thing since sliced bread, I stuck with my Aeroshell W100. When Cermicrome cylinders were all the rage, I stuck with nitrided steel jugs. (Both of those proved to be mighty good decisions, too.) Heck, I'll probably be the last on my block to replace my old panel-mount LORAN with a GPS; I'm still holding off until they get WAAS figured out.

But the easily-visible fact that my T310R still wasn't VG equipped was starting to get downright embarrassing. The lack of those little bumps on my wings and vertical tail were starting to make me feel as conspicuous as I did a decade ago when Detroit introduced high-mounted stop lights and my car seemed like the only one on the road that didn't have one!

Even the most dyed-in-the-wool skeptics were unanimous that vortex generators are a major advance in piston twin safety, lowering Vmc by ten knots or so to the point that it is no longer a factor (because it is below stall speed). And as if that wasn't enough, I learned that some of the VG kits offered substantial gross weight increases and significantly slower approach and takeoff speeds.

It was time.

About the Author ...

Mike Busch is editor-in-chief of AVweb, a member of the technical staff at Cessna Pilots Association, and in a prior lifetime was a contributing editor for The Aviation Consumer and IFR Magazine. A 6,000-hour commercial pilot and CFI with airplane, instrument and multiengine ratings, Mike has been flying for 36 years and an aircraft owner for 33. For the past 14 of those years, he's owned and flown a Cessna T310R turbocharged twin, which he maintains himself. In his never-ending quest to become a true renaissance man of aviation, Mike's on the verge of earning his A&P mechanic certificate. Mike and his wife Jan reside on the central coast of California in a semi-rural area where he can't get DSL or cable TV.

How It All Began

Vortex generator installation on a Beech Bonanza wing.

The use of vortex generators is nothing new. First used in England, VGs have been used on transport jets for decades, and on bizjets since Bill Lear invented them. But historically they were used as an aerodynamic "band-aid" to deal with localized mach buffet problems at the high end of the airspeed envelope. MacDonnell Douglas engineers would routinely scoff at the VGs on Boeing jets and brag, "see, we don't need those things because we got our aerodynamics right in the first place."

The idea of using VGs to improve the low-speed performance of general aviation aircraft came from an ex-Boeing engineer named Paul Robertson. Robertson first tried out his VG idea on a Cessna 206, but while the VGs did lower the stall speed, it degraded the plane's previously docile stall characteristics, so the project was shelved.

Robertson's next VG experiment involved a D-55 Baron that belonged to his partner Mike Anderson. The Baron was famous for having a rather nasty stall characteristics on one engine, but Robertson discovered that the VGs turned the airplane into a pussycat and lowered Vmc a full ten knots to the point that it was below stall.

Convinced that VGs had great promise to make piston twins safer, Robertson started a new company called **Friday International** (located in Friday Harbor, Washington) together with partners Mike Anderson and Chuck White. In 1987, the company managed to secure the first STC for a VG kit on the Beech Barons. They also put VGs on an A36 Bonanza but never got far along enough with that project to get an STC.

Turbulence In The Industry

Beginning around 1990, the story of the VG kit business started sounding like a passage from the Old Testament. Disagreements between the partners caused Robertson and White to leave Friday International and, together with their engineering test pilot Bob Desroche, form a new firm called **Micro Aerodynamics** in Anacortes, Washington. This company went on to obtain STC approval for VG kits for numerous piston twins including the Baron 55 and 58, Twin Bonanza, Cessna 310-320-340 and 402-414-421, and Piper Aztec. More recently, the company has obtained STCs for VG kits for most of the rag-wing strut-braced Piper singles (Cub, Super Cub, Super Cruiser, Pacer andTri-Pacer) and the Maules.

Meantime, Friday International changed its name to **VG Systems** and obtained additional STCs for VG kits on the Cessna 340 and 421B. VG Systems was acquired in 1993 by **Beryl D'Shannon** (of Bonanza mod fame), who moved the operation to Minnesota and completed the work started by Friday International to obtain STCs for VG kits for the Bonanza A36 and F33.

RAM Aircraft in Waco also decided to get into the act about the same time. Many customers were asking RAM to install Micro Aerodynamics VG kits on their Cessna 300 and 400 series twins while the airplanes were in Waco being fitted with RAM engines. Concluding it would be better to keep the money in-house, RAM obtained its own VG STCs for the Cessna 340/340A, 402C, 414/414A, 421C and 425.

About the same time, back at Anacortes, both Paul Robertson and Bob Desroche decided to depart Micro Aerodynamics to start new aircraft modification companies. Robertson founded **Aeronautical Testing Services** and proceeded to obtain VG kit STCs for most of the Cessna 300/400 twins and the Piper Seneca, and also for the Cessna 120/140, 180/185 and deHavilland Beaver. Meanwhile, Desroche formed **Boundary Layer Research** and obtained VG STCs for the Beech Duke, the Piper Navajo, Chieftain and Panther, and also for the Super Cub. Ultimately, in 1997, Robertson and Desroche decided to combine their VG businesses and Boundary Layer Research acquired rights to all of Robertson's VG STCs.

In case you lost count a few paragraphs back (entirely understandable!), this leaves four surviving players in the VG kit business: **Beryl D'Shannon**, **Boundary Layer Research**, **Micro Aerodynamics**, and **RAM Aircraft**. D'Shannon offers VGs only for Barons and Bonanzas, RAM offers kits only for Cessna twins, while both BLR and MA offer STC'd kits for a wide variety of aircraft.

VG Kits: Who Offers What?

The table below summarizes the various aircraft models for which each of these firms offers VG kits:

Beryl D'Shannon **Lakeville, MN** **800-328-4629**	**Boundary Layer Reserach** **Everett, WA** **800-257-4847**	**Micro Aerodynamics** **Anacortes, WA** **800-677-2370**	**RAM Aircraft** **Waco, TX** **254-752-8381**
BEECH Bonanza 33, 35, 36, 36TC Baron 55, 58, 58TC, 58P	**BEECH** Duke 60, A60, B60 **CESSNA** 120/140 Skywagon 180, 185 310, 310A-R, T310P-R 320D-F 335, 340, 340A 401, 401A, 401B 402, 402A, 402B, 402C 414, 414A 421, 421A, 421B, 421C 441 (Conquest II) **PIPER** Navajo PA31-310, 325C/R Colemill Panther I & II Chieftan PA31-350, T1020 Seneca II/III/IV PA34 Super Cruiser PA12, PA14 Super Cub PA18 **deHAVILLAND** Beaver Mk I **AGPLANES** Ayres Thrush, Air Tractor, Cessna 188 AgWagon, Piper PA36 Brave, Dromader, Weatherly	**BEECH** Twin Bonanza 50 Baron 55, 58 **CESSNA** 310G-R,T310R, 320 335, 340, 340A 414, 414A 402B, 402C 421C **PIPER** Aztec PA23 Cub J-3, PA11 Super Cruiser PA12 Super Cub PA18 Pacer PA20 Tri-Pacer PA22 **MAULE** M-4, M-5, M-7, MX-7 **AGPLANES** Ayres Thrush	**CESSNA** 340, 340A 402C 414, 414A 414AW, 414AW-V 421C, 421CW 425 (Conquest I)

Which VG Kit to Pick?

You might think that one VG kit is pretty much like another, but that often turns out not to be the case. Of course, if you're flying an Aztec, Bonanza, Duke, Maule or Cessna 120/140/180/185, you don't have any choice because there's only one STC available for your airplane (as you can see in the table above). But if you're flying a Baron, twin Cessna or Super Cub, you have two or three choices and some comparison shopping is in order.

When it came time for me to decide which company to select to put bumps on my T310R, the choice turned out to be pretty easy. Three of the four VG firms offer STC'd kits for twin Cessnas. RAM's VG kit price ($2,150) is the lowest of the three companies, but none of RAM's VG kits offer any gross weight increase — undoubtedly because RAM's principal business is selling increased horsepower engines, and a big selling point of those engines is that they offer more useful load. I also discovered that while RAM offers VGs for most of the twin Cessnas, they don't presently have an STC for the 310 or T310. So I crossed RAM off my list.

That left Boundary Layer Research and Micro Aerodynamics, both of whom offer VG kits for the T310R (and for most other twin Cessna models as well). Both kits looked good, and both offered comparable gross weight increases. But BLR's was priced $500 less ($2,450 vs. $2,950) and offered slightly better numbers than MA's. The clincher was that the BLR STC increased the Zero Fuel Weight of the T310R by 385 pounds (effectively eliminating ZFW) while the MA STC offered no ZFW increase. I concluded that Boundary Layer Research's STC for the T310R was both less expensive and better (at least on paper), and I decided to go that route.

Rather than order the kit and install it myself, I decided to fly the airplane up to Everett, Washington, and have BLR do the installation. Although the VG installation is simple enough (one might even go so far as to call it idiot-proof) and can be easily done in one day, going up to Everett would give me the chance to learn how these little bumps do their aerodynamic magic, and to do a little flying with the master, BLR president Bob Desroche, who undoubtedly has more test-pilot time certifying VGs on light twins than any man on earth.

I'd also been looking for an excuse to fly up to Everett's Paine Field (PAE) because that's where Boeing builds its widebodies (747, 767, 777) and I've long wanted to take a tour of that facility. So I made an appointment with BLR for the first week in August (while everyone else was off at Oshkosh) and had a glorious flight from SMX to PAE in an easy four hours.

BLR Rolls Out The Welcome Mat

Monday morning at 0800, I taxied the airplane to Hangar C-75 where Boundary Layer Research makes its home. I was greeted by BLR's office manager Jean Wieser and introduced to BLR founder and president Bob Desroche. Bob in turn introduced me to Jay Falatko, BLR's resident FAA-Designated Engineering Representative (DER) and a former Boeing aerodynamicist, and to Dale Lundgren who would be assisting Jay with the installation of my VG kit.

BLR's spotless hangar contained Bob's Beech Duke which was in the process of being fitted with prototypes of BLR's new wet wingtips (aux tanks), and a Super Cub belonging to Bob's wife Monika that bristled with an eye-catching menagerie of VGs and body strakes. (Monika is an accomplished pilot and vice-president of BLR.) Bob and Jay pulled Monika's Super Cub out of the hangar and pushed in my Cessna 310. Within minutes, Jay, Dale and Jean were busily at work on my VG installation.

Jean and Jay apply wing template using a taut string.

Installing The VG Kit

My VG kit included about 90 one-inch-long vortex generator tabs machined from a tee-shaped aluminum extrusion and prepainted to match the airplane's primary paint color — white Imron in my case. VGs located over trim stripes may be painted with touch up paint after installation, if desired, although the five-color paint scheme on my 310 is so complex that I'll probably just leave my VGs white.

Positioning the VGs correctly is important, but the kit makes that easy by providing a complete set of peel-and-stick templates with little rectangular cutouts where each VG is to go. In many cases, such as the vertical stabilizer and stub wings on my 310, the templates are positioned along a nearby skin lap. In the case of the outboard wing section of the 310, no convenient skin lap exists so a string is pulled taut between two reference points and the template is aligned with the string.

Jay installs vertical stabilizer template along a skin lap. (That giant VG below Jay's right arm is my VOR antenna!) .

Once the templates are in position, it's simply a matter of roughening the paint at each VG location with a Scotchbrite pad (or a chisel in the case of the 310's wing-walk area), and then gluing the VG tab in place using the provided two-part adhesive (Loctite 330).

Most of the twin kits also come with a pair of nacelle strakes that act like large VGs for the wing-to-nacelle interface. Another peel-and-stick template is used to locate mounting holes that are drilled in the sides of the nacelles. The strakes are then simply bolted in place.

The BLR kit also comes with a re-marked dial face for the airspeed indicator, and installing that turned out to be the only difficult part of the job. Unfortunately, my airplane came equipped with a "true airspeed" indicator that has a long non-detachable capillary tube connecting the instrument to an air temperature probe on the belly of the aircraft, and it's almost impossible to remove this instrument from the aircraft without destroying the capillary tube. (I'd love to get my hands on the yo-yo who came up with that design!) So a technician from the local instrument shop had to come over to open up the instrument *in the aircraft*, install the new dial, and recheck the instrument calibration. That turned out to be a two-hour job.

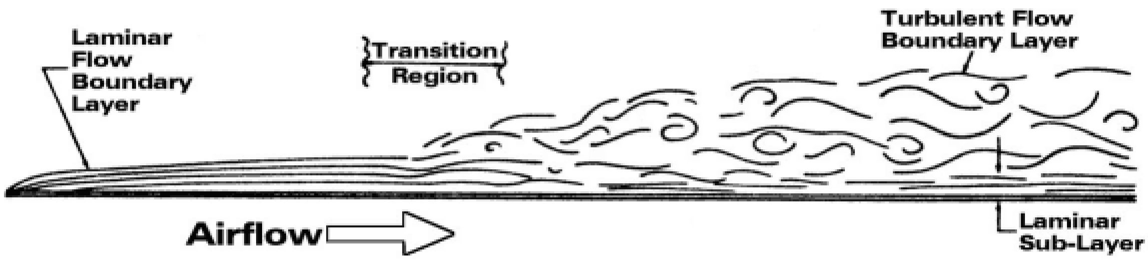
Nacelle strakes bolt on .

How VGs Work

With the installation well underway, I asked Bob Desroche and Jay Falatko if they could explain to me the theory behind how vortex generators reduce stall speeds and Vmc. What ensued was a cram course in Aerodynamics 101 which I found illuminating and fascinating.

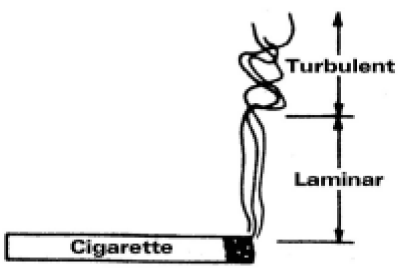
VGs are *boundary layer control devices*, so it isn't surprising that to understand how they work you first need to know something about the boundary layer. I'd certainly heard the term before, but never really understood its significance. Bob and Jay were glad to fill me in, and here's what I learned.

When an airplane is in flight, we usually think in terms of air passing over the top of the wing at the airspeed of the aircraft. But it turns out that the viscosity of the air and the friction of the wing surface cause the air molecules in contact with the wing to adhere to its surface and therefore have zero velocity. Air molecules slightly farther away from the wing surface will be slowed due to friction with the zero-velocity molecules but won't be completely stopped. As we move still farther away from the wing surface, the air molecules will be slowed less and less, until at some distance from the surface a point is reached where the air molecules are not slowed at all. *The layer of air from the surface of the wing to the point where there is no measurable slowing of the air is known as the boundary layer.*



Boundary layer changes from laminar to turbulent flow as it moves aft along the wing.

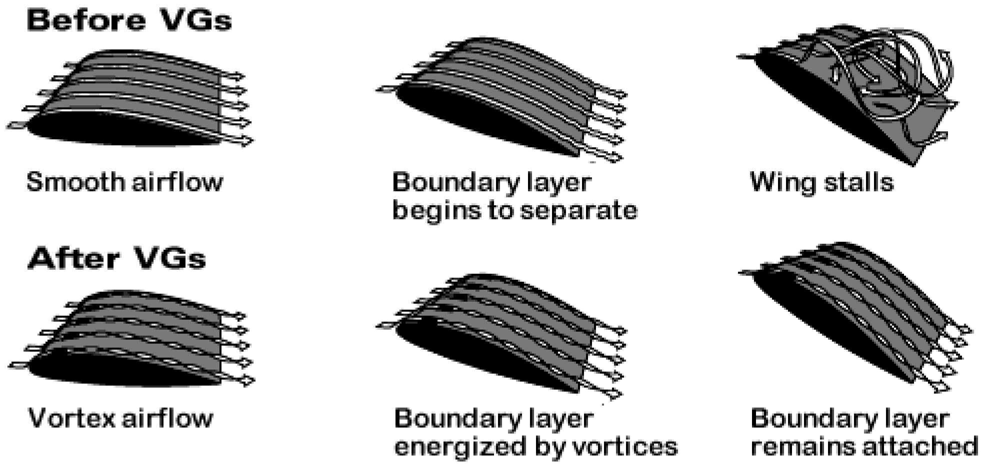
Near the leading edge of the wing, the boundary layer is very thin, and the air molecules in it move smoothly and parallel to the wing surface. This is known as *laminar flow*. But as the airflow progresses aft from the leading edge, the boundary layer becomes progressively thicker and more unstable, and transitions to *turbulent flow* in which intermixing of faster and slower air molecules starts to take place. (Another easily-seen example of laminar and turbulent flow can be seen by watching the smoke rise from a lighted cigarette in a draft-free room.)



Laminar vs turbulent.

It turns out that laminar flow is a good-news/bad-news situation. The good news is that laminar flow provides greatly reduced drag compared to turbulent flow. The bad news is that laminar flow permits the boundary layer to separate easily from the wing surface at high angles of attack. That's why so-called "laminar flow airfoils" (which are designed to move the transition to turbulent flow further aft) tend to provide low drag at cruise but nasty stall characteristics.

Turbulent flow in the boundary layer produces more drag, but is much more resistant to separation (and therefore to stalling). However, even in areas of turbulent flow, there tends to be a thin sub-layer of laminar flow in the immediate vicinity of the wing surface which becomes increasingly slow-moving and stagnant toward the trailing edge of the wing. It is this "aerodynamically dead" sub-layer that allows airflow to separate and the wing to stall.



By energizing the boundary layer, VGs allow the airfoil to operate at higher angles-of-attack without airflow separation. (Copyright Micro AeroDynamics)

If we could find a way to energize this sublayer, flow separation would be supressed and the onset of stall delayed. This is precisely what vortex generators do. Each VG creates a pencil-thin tornado-like cone of swirling air that stimulates and organizes the turbulent flow of the boundary layer on the aft portion of the wing. The swirl of the vortices pull fast-moving air down through the boundary layer into close proximity to the wing surface, energizing the previously-dead air there. The result is a wing that can fly at significantly higher angles of attack before the onset of boundary layer separation, and can therefore achieve a significantly higher maximum lift coefficient.

When mounted on the wings, VGs reduce stall speed and increase climb capability. When mounted on the vertical tail, they increase rudder effectiveness and lower Vmc.

Gross Weight Increases

The performance improvements resulting from the VG installation on my T310R are shown below:

Performance specifications for Cessna T310R, before and after BLR VG kit. (Weights shown in pounds, speeds shown in knots.)			
	Original	**With VGs**	**Difference**
Ramp Weight	5535	5720	+185
Gross Takeoff Weight	5500	5684	+184
Zero Fuel Weight	5015	5400	+385
Landing Weight	5400	5400	No Change
Minimum Control (Vmc)	80	70	-10
Stall, Clean (Vs)	79	75	-4
Stall, Dirty (Vso)	72	69	-3
Liftoff Speed (Vlof)	85	75	-10
Approach Speed (Vref)	94	87	-7

While the numbers mostly speak for themselves, a few explanations are probably in order.

The gross weight increase offered by the VG STC is a direct result of the reduction in stall speed. Under the FARs, light twins are required to have an engine-out rate-of-climb (in feet/minute) equal to .027 times the square of Vso (in knots). If you lower Vso by a few knots, the required single-engine ROC goes down. At the same time, the VGs actually increase single-engine ROC by increasing the maximum lift coefficient of the wings at high angles-of-attack. Thus, the aircraft now has more single-engine climb performance than the regs require. The solution: increase the gross weight!

Landing weight is a different story. It has structural implications, not just aerodynamic ones. For an STC to obtain a landing weight increase would involve a landing gear beef-up and a series of very costly "drop tests" to prove that the aircraft could handle the additional weight without structural damage. BLR actually did this for the Piper Chieftain, but it required strut modifications and new torque links, and was quite expensive. It's therefore understandable why none of the twin Cessna VG STCs offer a landing weight increase.

So if you take off at the new higher maximum takeoff weight, better plan on flying far enough to burn of a few hundred pounds of fuel...or land gently and don't tell anyone!

Of course, there's no law that says you *must* use the gross weight increase. Another huge benefit of VGs on twins is that if the airplane is flown at its *original* (pre-increase) max takeoff weight, the VGs provide a big improvement in engine-out climb performance — so much so that it is often possible (if the density altitude isn't too high) to actually FLY a VG-equipped light twin when an engine fails shortly after takeoff, rather than automatically having to throttle back and put the airplane down off-airport. Naturally, if you load the airplane up to its increased maximum takeoff weight, single-engine climb will be just as anemic as it was before...although with the VGs you still have a much better chance of keeping the airplane under control.

Zero fuel weight only comes into play when you want to carry a maximum payload for a short distance. For example, on a stock T310R with a 3900 pound empty weight, it says that of the 1600 lbs of useful load, no more than 1115 lbs may be passengers and cargo; the rest must be fuel. By increasing the ZFW to 5400 lbs (same as landing weight), the VG kit effectively makes ZFW disappear, because if you loaded the aircraft to ZFW you'd have to land on fumes (or overweight)!

Reduced Airspeeds: Vso, Vmc, Vref, Vlof

The most significant airspeed change resulting from the VG installation is the virtual elimination of Vmc. Technically, Vmc still exists, but at 70 knots loss of control occurs at a lower airspeed than the airplane will fly unless it's extraordinarily light.

My re-marked airspeed dial. Vmc is now below Vs.

Bob Desroche told me a funny story from his early VG days with Paul Robertson when they were getting the original Cessna 340 STC. Since Vmc is predicated on failure of the critical (left) engine, Robertson originally applied VGs only to the left side of the 340's vertical stabilizer. Les Berven of the Seattle FSDO did those original certification flights, and after numerous left engine cuts, he was bubbling over about the reduction of Vmc. Then Les tried something totally unexpected: he cut the right engine, and discovered (to everyone's astonishment) that Vmc occurred at a higher airspeed…the right engine had become critical! Needless to say, Robertson quickly added VGs to the right side of the vertical tail and re-flew the tests!

While the reduction in Vmc gets all the glory, the 10-knot reduction in liftoff speed and 7-knot reduction in approach speed makes a big difference in everyday flying. Twin Cessnas are not especially good short-field airplanes, so these improvements are especially welcome.

VGs are applied to <u>both</u> sides of the vertical tail!

If you've been paying close attention, you might have noticed an apparent discrepancy in the airspeed figures in Table 2. How can approach speed (Vref) be reduced by 7 knots when the dirty stall speed (Vso) has been reduced by only 3 knots? After all, Vref is by definition 1.3 times Vso. I had the same question, and the answer is straightforward: the published Vso is certified at maximum takeoff weight (5684 lbs with the VGs), while Vref is based on maximum landing weight (5400 lbs) at which Vso is lower. Naturally, at lighter weights, approach speeds should be even less than the published 87 knot Vref.

So What's the Downside of VGs?

Okay, I thought, this all makes sense. But I still had the feeling that there must be some downside. After all, my daddy always taught me that there's no such thing as a free lunch. For instance, those 90 VGs stick up into the airflow and must produce some drag, right? Won't that slow the airplane down at cruise?

Bob Desroche explained that while the VGs do produce some drag, they also reduce drag by reducing the thickness of the boundary layer on the aft portion of the wing. The net result is about a "push" with no measurable degradation in cruise speed.

BLR founder, president and chief test pilot Bob Desroche in a typical pose: on the phone with a customer.

Here's where proper placement of VGs is critical, Jay chimed in. If they're placed too far forward, they'll hasten the transition from laminar to turbulent flow and therefore increase drag. On the other hand, if they're placed too far aft, their effectiveness will be compromised. The trick is to mount the VGs right at the boundary layer's transition zone from laminar to turbulent flow.

How about icing, I asked? Won't the VGs pick up ice?

Not unless they're tall enough to poke up through the boundary layer, Bob replied. That's one reason why the VGs are sized to a height of about 80% of the boundary layer thickness. The VGs have been tested extensively in icing conditions during FAA certification, and do not pick up ice except possibly when flying in freezing rain or supercooled drizzle drops — conditions in which no portion of the airframe is completely immune from icing.

Another question that has come up frequently is whether the addition of vortex generators has an adverse effect on Design Maneuvering Speed (Va). Since the VG kit reduces stall speeds, it would seem to follow that Va should also be reduced. Looking through the POH supplement that accompanied my new VG kit, I did not see anything about an amended Va, and I asked Bob why. Bob said it was a good question, and that there were really two quite distinct answers: a regulatory answer and an aerodynamic answer.

From a certification standpoint, he explained, there is no requirement for the published Va speed to be revised downward after the installation of a VG kit. The regulation that requires the publication of Va for Part 23 aircraft (specifically, FAR 23.335 "Design Airspeeds") states in part "...Va *may not be less than* Vs*SQRT(n)..." where Vs is the flaps-up stall speed at max gross weight and n is the design limit load factor (typically 3.8 G's for a Normal Category aircraft). Thus, while the reduced Vs provided for by VGs would permit Va to be reduced accordingly, the FARs do not *require* such a reduction and BLR has chosen instead to substantiate the aircraft structure to the originally published Va.

From an aerodynamic standpoint, Bob explained that Va is a speed that is poorly understood by many pilots. Most of have been taught to use Va as a turbulence penetration speed. But Va is *not* a manufacturer-recommended turbulence penetration speed, and in fact there is no requirement that a turbulence penetration speed be published for Part 23 aircraft. (The situation is different for Part 25 aircraft like bizjets.) Unless you plan to do snap rolls or other abrupt-control-deflection maneuvers, Va is a figure that has little relevance to everyday flying.

Va is a purely *theoretical* figure that represents the maximum speed at which abrupt control deflection will not stress the aircraft beyond its designed load limit. But Va is not a speed determined from flight test, is not verified during FAA certification, and is never required to be demonstrated by the manufacturer. Bob pointed out that if you attempted to verify Va by intentionally stalling the aircraft at Va at the design load limit of the airframe, you'd have to enter the maneuver *at an airspeed significantly higher than Va*, then perform an abrupt pull-up or accelerated stall that would produce load-limit G-forces and reduce the airspeed to Va precisely at the point where the airplane stalled.

Va as published in the POH is a computed figure based on maximum aircraft weight. At lower weights, Vs is lower and therefore Va is also lower. The aerodynamic effect of VGs on manuvering speed is substantially identical to the effect of flying at less than maximum weight.

Why Are VG Kits So Pricey?

While I had Bob's ear, I figured I might as well go for broke and ask him the $2,500 question: why do VG kits cost so much when the materials cost is clearly not very great? Of course, I already knew the answer — it costs a lot to get the FAA to certify these things — but Bob gave me some details that helped put things into true perspective.

He said that it can easily cost between $250,000 and $500,000 to get a VG kit certified. Why so much? In essence, the FAA requires that almost all of the airplane's original flight testing be repeated. For instance, for twins that were certificated for known-icing (i.e., most of them), the icing tests have to be reflown (which means finding sufficiently bad natural icing condition, flying behind a spray plane, or gluing styrofoam "shapes" to the unbooted areas of the aircraft to simulate ice). For singles, the spin tests have to be reflown (which means fitting the aircraft with a spin chute and water ballast).

To make matters worse, the market for most of these costly-to-get STCs is depressingly small. BLR's first VG STC was for the Beech Duke, of which only about 500 are flying. You might think the situation would be a lot better with more popular models like the Cessna 310, but you'd be wrong. Separate STCs (and flight tests) are required for the "tuna tank" models, the narrow-chord aileron models, wide-chord aileron models, the long-nose R-model, and the turbocharged models. So the market for each of those STCs is still pretty small. To make matters worse, the popular models like Barons and Twin Cessnas have two or three companies competing for the limited market.

It's a tough business. Work the numbers. I think I'll stick to writing.

Enough Talk...Lets Go Flying!

With the VGs installed, the airspeed dial changed, and the logbooks and 337 forms signed, it was time to go flying. Bob likes to go up with new VG customers for 45 minutes or so to give them a checkout in their new-and-improved airplane before turning them loose. It didn't take long for me to see why.

We taxied out to PAE's 9000-foot main runway, did our runup, and Bob briefed me for the takeoff. "I want you to rotate at 75 knots — the new Vmc plus five — and climb to pattern altitude at 85 knots…no faster." Bob warned me that this would feel at first like an unnatural act.

He was right…it took all the faith and backpressure I could muster, and the airplane (with three people aboard) broke ground early and climbed at an awesome deck angle with the VSI nailed at 2,000 FPM. Thirty seconds later, we were at pattern altitude and hadn't even crossed the departure end of the runway yet.

Bob directed me to a practice area over Puget Sound and had me fly a series of steep turns, slow flight exercises, and stalls. I found the airplane rock solid at indicated airspeeds so low that they'd have freaked me out before. We flew a series of low-speed maneuvers with the stall warning horn blaring continuously, yet roll and pitch control remained crisp and responsive.

Then we did a series of stalls, with and without power, clean and dirty, level and turning. It was really interesting: as the airplane eventually approached a stall (with indicated airspeeds down in the 60s), it would start buffeting like a bucking bronco, yet with no loss of altitude. Bob explained that this was the airflow separating over the stub wings (between the fuselage and nacelles), but that the nacelle strakes created a large vortex that acts like a stall fence and prevents the stall from propagating outboard of the nacelles. All I know is that even with the stall warning horn disconeected and the airspeed indicator covered up, you'd still have to be comatose to get the airplane into an unintentional stall.

It doesn't look very different, but it flies like a new wing!

We were running out of time, so we decided to skip the Vmc demonstration and head back to PAE for a couple of landings. I made my approaches at 85 knots indicated (7 knots slower than the 92 Vref I was accustomed to using) and found that I was still arriving at the flare with too much energy and floating a bit much. We agreed I would have to spend some time on my own nibbling at the edge of the envelope to determine what short-field approach speed would work best.

Creature of Habit

During the weeks following the VG installation, I made a point of trying ever slower over-the-fence speeds on landing to get a feel for the new slow-speed characteristics of the airplane. I found this surprisingly unnerving — after a decade of landing this airplane with indicated airspeeds in the low 90s (not to mention some rather "firm" touchdowns when I let the airspeed decay into the high 80s), it took a fair amount of courage to fly a final approach at speeds in the low 80s and high 70s. Despite the numbers in the POH supplement that came with BLR's VG kit, and despite my all-to-short checkout in Everett, it just felt wrong flying the airplane that slow. My head kept telling me that it was okay, but my gut kept saying "are you sure your hull insurance is paid up?"

As a CFI, I know that this is a common problem with pilots who add STOL kits to their airplanes. The STOL kit doesn't improve the airplane's short-field performance unless the pilot can teach himself to fly slower approaches. That often takes a surprising amount of time and self-discipline, because we're all creatures of habit to whom change doesn't come easy.

After flying a number of approaches "by the book" at various weights, I found that I invariably had more than enough speed at the flare and would float more than I really wanted. On a couple of occasions, I'd do a full-dirty power-off stall just prior to landing to establish what Vso actually was at my landing weight, then would multiply that IAS by 1.3 and use it for my landing Vref speed. What I discovered was that actual Vso was invariably considerably lower than the book figure, and the same held true of landing speeds. I called Bob Desroche and asked him about this. Bob explained that the book figures that BLR provides are extremely conservative, and are based on worst-case conditions (like full-forward CG) that are seldom encountered in actual flight.

In any event, it's now obvious to me that it's going to take me awhile longer before I feel really comfortable flying my VG-equipped airplane as slow as it really should be flown. At the same time, I already have vastly greater confidence in my ability to operate the T310R out of short fields than I did before.

VG Kits for Singles

Before leaving Everett for the flight home, I asked Bob what new projects he saw coming up for BLR, he told me that the company was focusing increasingly on VG kits for single-engine airplanes. While the VG market for twins has become quite mature over the past decade, the surface has just barely been scratched when it comes to singles.

For instance, BLR secured an STC to install VGs on the Cessna 180 and 185 Skywagons, and the results were quite impressive. For the Cessna 180, Vso was reduced by 8-10 knots (depending on CG), and low-speed handling was significantly improved.

Bob thinks that similar results could be achieved on the Cessna 182, and expects that BLR will start working on the STC for the Skylane in a few months. At this point, Bob is on the lookout for a few 182 owners who'd be willing to make their airplanes available for VG certification work. (He'll need both straight-tail and swept-tail airplanes, with and without leading-edge cuffs.) If you're a 182 owner and think you might be interested, drop Bob Desroche an e-note at bdesroche@avweb.com.

BLR also has obtained approval for VG kits for a variety of other single-engine aircraft, including the Cessna 120/140, the Piper Super Cub and Super Cruiser, the deHavilland Beaver, and a bunch of ag-planes. I predict this is only the beginning...after seeing first-hand what VGs did for the low-speed handling and short-field performance of my machine, I can see VG kits becoming the STOL modification of choice on all sorts of airplanes.
