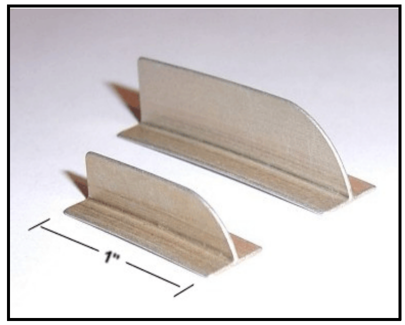
Vortex Generators for the Cherokee 235

By Bob Kirkby, June 10, 2004

In recent years the FAA has granted a number of STCs to companies that manufacture vortex generator kits for general aviation aircraft. I've been keeping an eye on these developments wondering what such a kit would do for my Piper Cherokee 235. When two friends recently installed kits on their Cessna 182s and reported spectacular results, I decided to look more closely.

The 235 is the heavy hauler of the 4-seat Cherokees. Mine is a 1964 model with an empty weight of 1567 lbs and a gross of 2900 lbs. I typically operate from short grass strips at fairly high elevations and I thought the installation of vortex generators might give me better short field, high altitude performance and provide an extra margin of safety. My home strip is 2000 feet of turf perched 3500 feet above the beach.



Two sizes of VGs are used.

How Do They Work?

Vortex generators (VGs) are usually found on STOL, multi-engine, airline transport, and military aircraft. Look out the window of any airliner and you'll see these tiny fins located at strategic points along the wing. VGs work by re-energizing the boundary layer airflow along the wing or control surface causing it to remain attached to that surface for a longer period of time (further back toward the trailing edge).

This has two beneficial effects. Used in front of a control surface, such as an aileron or elevator, the re-energized boundary layer increases control effectiveness at slow speeds, particularly during landings.

Used along the leading edge of the wing the effect is to increase the stall angle of attack and hence decrease the stall speed. The wing stalls when the boundary layer separation point moves progressively forward with higher angles of attack, eventually moving forward of the center of lift. The VGs keep the boundary layer attached further aft, which delays forward motion of the separation point, permitting a higher angle of attack. Thus, the stall speed drops below the wing's pre-VG condition.

In search of a good vortex generator kit for my Cherokee, I contacted Charles White, President of Micro AeroDynamics of Anacortes, WA. His company has been engineering VGs for several years and currently holds STC's for over 100 general aviation aircraft models and is continually adding more. White's outfit also has kits for several homebuilt aircraft. The STC for my aircraft applies to all Cherokees with the Hershey Bar wing. White had a kit in stock and ready to ship. Three days later it was on my doorstep.

Installing the VGs

Although I'd heard White's packages were very complete and easy to install, I was still amazed at the kit's completeness and straight forward installation process. Micro AeroDynamics leaves nothing to chance, including everything necessary to measure and position the VGs, even a pencil and a spool of thread! It's all there except isopropyl alcohol, which is used to clean up excess glue.

My first chore was to wash the aircraft since a clean surface is required for gluing. I recall thinking at the time that post-installation washing would become more of a chore in order to avoid damaging the VGs. I was right. One also has to be extra careful to avoid damaging the VGs when refueling.

The kit is very complete.

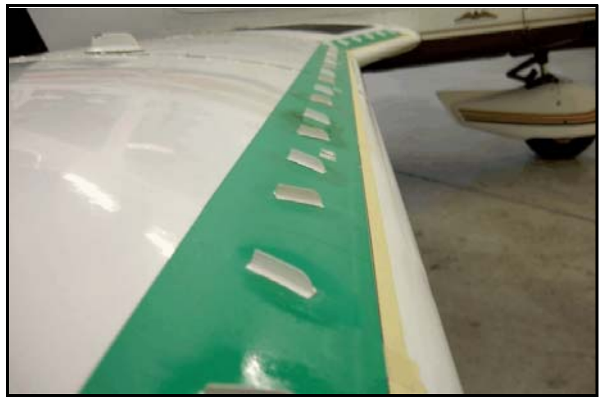
The installation instructions are very clear and easy to follow. The first step is to place the supplied masking tape on the wing in specific locations so that pencil marks can be made without damaging the paint. Then, measure from strategic seams in the wing to location points on the tape (Micro AeroDynamics even supplies a tape measure). Now, stretch the supplied thread between these points and tape it down. The thread serves as a straight line to align the templates.

The VG templates are vinyl stick-on sheets like those used to make vinyl sign lettering, and have cutouts where each generator attaches. Using the thread lines as a guide, you stick the sheets onto the wing in a specified sequence. That's all it takes to locate the VGs in their correct positions.

The next step is to glue them in place through the cutouts. This is accomplished with Loctite 330, a 2-part glue. Just spray an aerosol activator solution on the cutout hole, apply a bead of glue to the bottom of the VG and press into place. It sets in less than 1 minute and cures completely in 24 hours. Because the glue sets so quickly you have to clean up any excess as you go. You simply proceed one at a time until they're all in place. Then the vinyl template, thread and masking tape are all removed. I found the process quite easy on the wings, though I expect it would be more difficult with a high-winged aircraft.

The templates come in easy to handle sections with a cutout for each VG.

Attaching the VGs to the Cherokee's stabilator was tougher than the wings only because I had to lie on my back. Because the stabilator supplies negative lift the VGs have to go on the bottom surface. Doing the vertical stabilizer was easy, as the VGs simply attach along the trailing edge of the stabilizer just ahead of the rudder. The purpose of these VGs is to improve the low-speed effectiveness of the stabilator and rudder.



The VGs glued in place through the template slots.

All added up, there are 88 VGs on the wings, 72 on the stabilator and 24 on the vertical stabilizer, for a total of 184.
Total installation time, not including washing the plane, was 7.5 hours.

Ready to Test

I wanted to do a good before-and-after performance comparison. Obviously low speed handling characteristics would be a qualitative judgement but stall speed and cruise speed changes could be measured quantitatively. I enlisted the services of my friend and frequent co-pilot, Wilf Stark, to be the data recorder and we set up some comparative tests to be run before and after the VG installation.

The vortex generators installed on the right wing.

Prior to installing the generators I filled the tanks with exactly 420 lbs of fuel. The Cherokee tanks have a convenient marker tab at the filler neck for this. I carefully noted every loose item in the aircraft and estimated its weight so we could duplicate the weight for the post-installation flight. Wilf even noted what he'd eaten for breakfast, but I wasn’t so meticulous. Our total take-off weight was 2327 lbs, or 80% of gross. We were going to do all tests at a pressure altitude of 6000 feet so I noted the altimeter adjustment and off we went.

We would start our test sequence exactly 10 minutes into the flight so that the weight would be identical for each test. This allowed time to get to the appropriate altitude, adjust the mixture and reach a location of little conflicting traffic.

We did the cruise speed test first which consisted of flying on three headings 90 degrees to each other and recording the GPS ground speed once stabilized. Later a complicated equation would resolve the three vectors and produce a true airspeed, assuming the wind didn't change for the 5 minutes it took to gather the data. We repeated this at three different power settings, using the MP and RPM settings from charts in the POH for 55%, 65% and 75%. By repeating this precisely on the post-installation flight we'd be able to determine how the VGs affected cruise speed.

The VGs are installed on the bottom of the stabilator and up the trailing edge of the vertical stabilizer.

Next, we did our stall tests. The plan was to measure indicated airspeed at the stall in three configurations: no flaps, 10 degrees of flap, and 40 degrees of flap. We did this at idle power with full fine prop pitch and recorded the indicated air speed as close to the break as we could. The Cherokee stall is noted for being very gentle. There's good warning with a strong buffet and it starts to mush well before the nose drops. It rarely drops a wing.

As we progressed through each step of the evaluation, Wilf made meticulous notes on the test card.

The Results

Now to find out what the vortex generators actually do. The next good weather day Wilf and I did the post-installation test flight, which duplicated the first one.

I'll present the quantitative results first. I fully expected some increase in drag with a corresponding decease in cruise speed. I also expected this decrease to vary with airspeed. The effect was less than expected with virtually no variation at the different power settings. The pre-installation TAS ranged from 137.0 mph to 158.1 mph. At 55% power TAS decreased by 1.9 mph and at 75% power by 2.1 mph. The average penalty seems to be 2.0 mph, which is only 1.3% at a typical cruise of 150 mph.

The stall speed tests showed a more remarkable difference (see Table 1). The POH really skimps on providing stall speed numbers. It merely states a stall speed of 70 mph without flaps and 60 mph with flaps, ignoring the fact that there are three flap settings. Of course this is at full gross and under standard conditions at sea level. We were at 80% of gross.

Wilf and I recorded the IAS and later converted to TAS. Before the VG installation the numbers are very

Stall Speed Test

	No Flaps	10° Flaps	40° Flaps
Before VG			
IAS	60	55	54
TAS	65	60	59
After VG			
IAS	58	50	45
TAS	63	55	50
Change			
IAS	-2	-5	-9
TAS	-2	-5	-9

Table 1

close to the book value. After the VG installation the stall speed decrease ranged from 2 mph with no flaps to 9 mph with full flaps. Micro Aerodynamics claims a stall speed reduction of 5 mph, which is what we averaged over the three configurations.

Low speed handling characteristics definitely changed. First, at the stall I noticed a more abrupt break and a definite left wing drop every time. This is not necessarily a bad thing, it just means the Hershey Bar wing now behaves a bit more like other wings.

Low speed control is significantly improved. The ailerons are more responsive and maintain more effectiveness right up to the stall. During gusty conditions on landing the Cherokee now has tighter response in all axes and reduced control movements.

The most improved control surface is the stabilator. In the flare and while floating down the runway the stabilator is noticeably more sensitive to the point where I've had to remind myself to be more delicate with it. Rudder effectiveness has improved as well, although not as much as the other two controls. Since installing the VGs the strongest cross wind I've found was 12 kts which isn't enough to test the limit. This particular landing was quite gusty, too. I did notice overall smoother results than I'm used to, and not just because I was just having a better day.

One of my original objectives was shorter take-off and landing rolls. Or put another way, an improved margin of safety when operating from short grass strips in the high country. I'm certain the VGs have helped me achieve this, although it's hard to quantify.

My short field grass strip takeoff technique is to first accelerate with flaps up. At 60 mph indicated I simultaneously apply back pressure and pull on 25 degrees of flap with the fast-acting Johnson bar flap lever. The 235 typically lifts off quickly at that point and I continue accelerating in ground effect before climbing out. With the VGs installed it literally leaps off the runway when I pull the flap level. I'm now using this technique at 50 mph which means my takeoff roll has decreased significantly. This performance correlates with the improved effectiveness of the flaps demonstrated in the stall tests.

Previously, I'd set the maximum comfortable take off weight from my 2000 feet grass strip at 2750 lbs at 15 degrees Celsius, which gives me a 1500 foot take-off roll. Based on what I've seen so far I suspect that takeoff roll will decrease to about 1300 feet.

The bottom line is the VGs performed as good as or better than advertised at low speed with very little penalty at cruise speed. Whether you look at the addition of vortex generators as giving you more performance, or just adding a safety margin, they definitely do make a difference.

For more information visit Micro Aerodynamics' web site at www.microaero.com.