AIRCRAFT DEVELOPMENT
1220 RED OAK COURT
TROY, MO 63379



# ADDENDUM 261-AD1&2
# GENERAL INSTRUCTIONS FOR ADDING VORTEX GENERATORS ON HOMEBUILT AIRCRAFT

## 1.0 GENERAL

1.1 These instructions are for adding vortex generators to homebuilt aircraft to reduce the stall speed. There will be two methods described in this document as to how to add vortex generators to aircraft. One method will require no flight testing and will place the vortex generators in a position that will be at the optimum position on the wing or very close to the optimum position. In any event the vortex generators will be positioned so that you will get a definite decrease in stall speed. The second method will require a flight test program that will place the vortex generators in exactly the optimum position for maximizing the decrease in stall speed. These instructions will also give information on other areas of the aircraft that may benefit from the use of vortex generators. This kit contains Installation Procedure-Vortex Generator kit No. 261-2, addendum 261-AD1, 150 vortex generators No. 261-1, and a 3M very high strength pressure sensitive adhesive tape. If kit 261-AD2 was purchased 65 vortex generators are provided.

## 2.0 DETERMINING LOCATION OF VORTEX GENERATORS METHOD 1.

2.1 Measure the wing chord with a tape measure by starting the measurement from the trailing edge of the wing to the leading edge of the wing along the wing contour upper surface as shown in figure 1. Take that measurement and multiply it by .90. That will give you the distance along the contour of the upper surface of the wing to the leading edge of the vortex generator's position from the trailing edge of the wing. Mark that location at the wing root and near the wing tip with a felt tip pen (Sharpie extra fine point) lets call those two points A. Measure back from those locations 2.5" and mark a new positions at the wing root and near the wing tip with a felt tip pen let's call those two points B. Apply masking tape from the wing root point B to near the wing tip point B in a straight line and with the upstream edge of the masking tape adjacent to the two point B's. This masking tape will be used as a straight edge guide. See figure 2 on page 2 of 6.

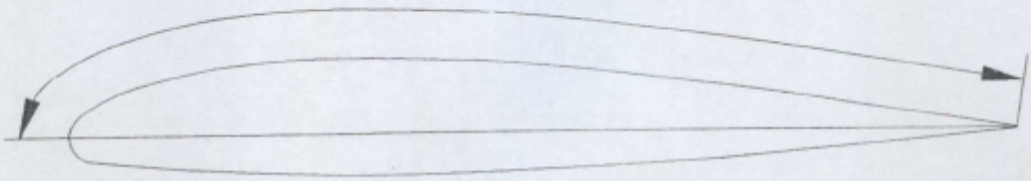

FIG. 1

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2.2 Take template 1 on the template page at the end of this installation procedure and past it to a sheet of aluminum flashing, thin wood veneer, balsa wood, or, 030" thick sheet plastic. Make a hard copy template by cutting along the lines of the paper template.

2.3 Pick up the vortex generators by the sail so as not to contaminate the bottom of the vortex generators with body oils as this will weaken the strength of the bond. Place the bottom of the 1" long vortex generator onto the 3M special adhesive tape so that the bottom of the vortex generator is entirely covered by the special adhesive tape. Place the vortex generators side by side with a small space between them. With a sharp knife cut the tape using the side of the vortex generator as a straight edge. This will leave the bottom of the vortex generator completely covered with the special adhesive tape and its protective liner paper. Press the tape to the bottom of the vortex generators to eliminate any air bubbles. If necessary pin prick any air bubbles that may not be removed by just pressing the tape to the bottom of the vortex generator. When working with this special adhesive tape the temperature must be 65° F or higher and the adhesive comes to full strength in 24 hours.

2.4 Tape the template adjacent to the masking tape and at the wing root as shown in figure 2. Stick the vortex generators to the wing by removing the backing liner paper and placing them in the five template notches making sure that the vortex generators are correctly facing forward as shown in figure 3. Move the template over so that the first template notch lines up with the last vortex generator attached to the wing. Attach four more vortex generators to the wing. Continue repeating this operation until all the vortex generators are placed on the wing panel. Then repeat this procedure for the other wing panel. Remove the masking tape when completed.

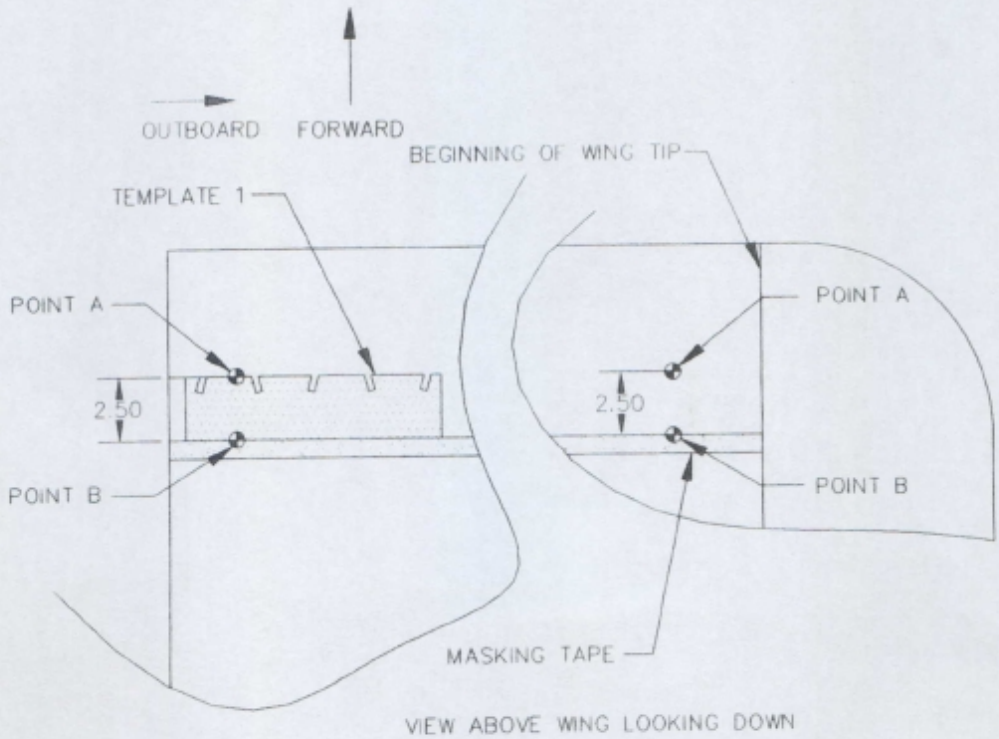


FIG. 2

## 3.0 DETERMINING LOCATION OF VORTEX GENERATORS ON HORIZONTAL TAIL

3.1 Now that the wing has vortex generators installed the wing can fly at a higher angle of attack before it stalls. Most likely the elevators were designed to allow the wing to obtain an angle of attack that just gets the wing to the stall angle of attack and not much more. However, the elevators will now have to get the wing to a higher angle of attack. This may necessitate that vortex generators will need to be installed on the under side of the horizontal stabilizer just ahead of the elevators.

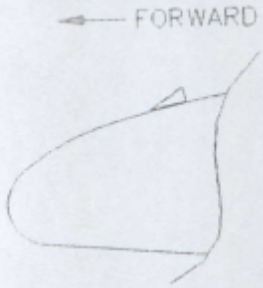


FIG. 3

3.2 The method of determining the location of the vortex generators on the bottom of the horizontal stabilizer is very similar to that used on the wing. Measure 2.6" forward of the trailing edge of the horizontal stabilizer. If there is a rivet line near the trailing edge of the horizontal stabilizer measure 2.6" ahead of the rivet line, this will ensure that the vortex generators will not interfere with the rivets. Mark that location at the root and at the beginning of the tip of the horizontal stabilizer with a felt tip pen. Apply masking tape from the horizontal stabilizer root to the beginning of the tip in a straight line with the downstream edge of the masking tape adjacent to the marked positions. This masking tape will be used as a straight edge guide. See figure 4.

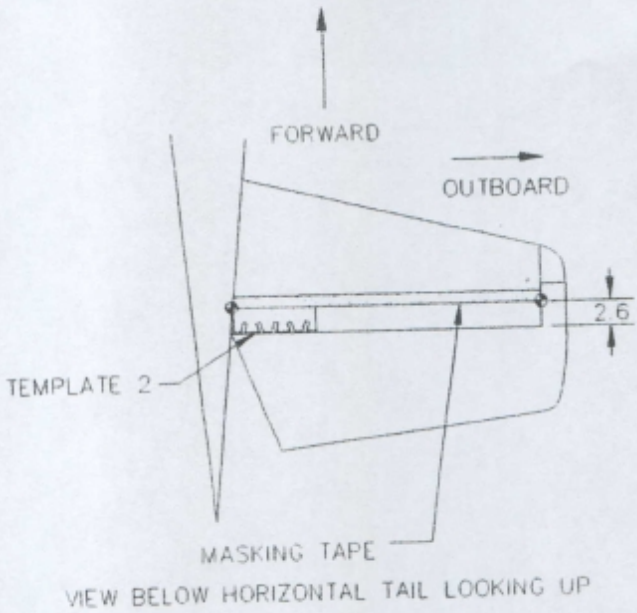


FIG. 4

3.3 Take template 2 on the template page of this installation procedure and proceed as you did in paragraph 2.2

3.4 Repeat the procedure described in paragraph 2.3.

3.5 Tape the template adjacent to the masking tape and at the horizontal stabilizer root as shown in figure 4. Stick the vortex generators to the horizontal stabilizer by removing the protective liner and placing the vortex generators in the five template notches making sure that the vortex generators are correctly facing forward as shown in figure 3. Move the template over so that the first template notch lines up with the last vortex generator attached to the horizontal stabilizer. Attach four more vortex generators to the horizontal stabilizer. Continue repeating this operation until all the vortex generators are placed on the horizontal stabilizer. Then repeat this procedure for the other horizontal stabilizer panel. Remove the masking tape when completed.

## 4.0 DETERMINING LOCATION OF VORTEX GENERATORS ON VERTICAL TAIL

4.1 With regards to the vertical stabilizer you may require vortex generators to be placed on the vertical stabilizer, however, it is less likely than the likelihood of requiring vortex generators on the horizontal stabilizer. If during the flair out and landing at your new slower speed you notice that you are lacking the rudder authority you had before the vortex generators were installed on the wing, then this is an indication that the vertical stabilizer requires vortex generators. If that is the case proceed to paragraph 4.2. Note: kit 261-AD1provides enough vortex generators for the wings and horizontal stabilizer of the average homebuilt aircraft kit 261-AD2 provides enough vortex generators for the wing of the average homebuilt aircraft. If the vertical stabilizer requires vortex generators they can be purchased as kit 261H a bag of 25 vortex generators. If you find that the vertical stabilizer does not require vortex generators then proceed to paragraph 5.1.

4.2 Measure 2.6" forward of the trailing edge of the vertical stabilizer. If there is a rivet line near the trailing edge of the vertical stabilizer measure 2.6" ahead of the rivet line, this will ensure that the vortex generators will not interfere with the rivets. Mark that location at the root and at the beginning of the tip of the vertical stabilizer with a felt tip pen. Apply masking tape from the vertical stabilizer root to the beginning of the tip in a straight line with the downstream edge of the masking tape adjacent to the marked positions. This masking tape will be used as a straight edge guide. See figure 5.

4.3 The placing of vortex generators on the vertical stabilizer is different than on the wings and under the horizontal tail. The average wing with common airfoils found on general aviation and homebuilt aircraft will stall at about 15°. It is common to have a wing incidence of around 1°. So that means that the fuselage is flying at an angle of about 14° during the final stages of landing. That also means that the airflow over the vertical stabilizer is approximately 14° above what the airflow would be when the aircraft is in the level position. In normal cruise flight the rudder has sufficient authority. However, as the angle of attack of the wing increases you want to increase the rudder authority. The best way to accomplish this is to place the vortex generators in the horizontal position when the aircraft is level, and not stager the vortex generators as was done on the wing. The vortex generators will be flying at a $0^0$ angle of attack in cruise flight and approximately 14° angle of attack in the final stages of landing, actually slightly more than 14° angle of attack since with the vortex generators on the wing it is now capable of flying at a higher angle of attack before stalling.

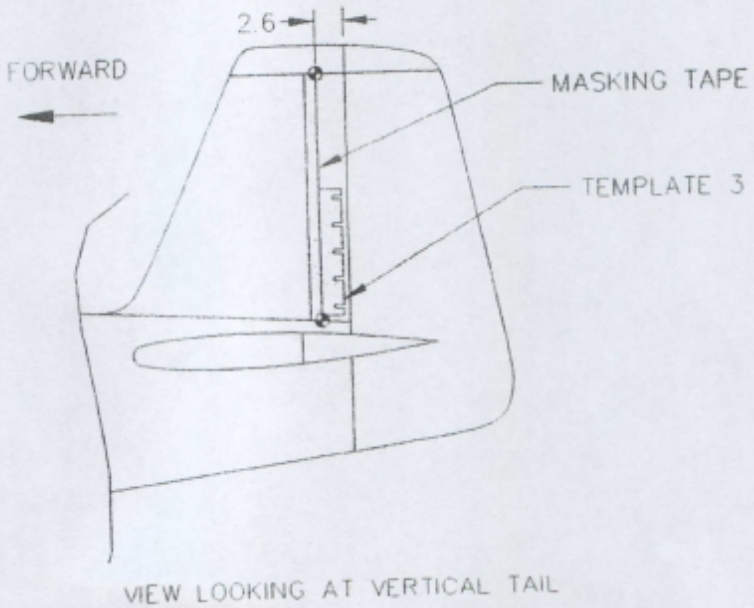


FIG. 5

4.4 Take template 3 on the template page of this installation procedure and proceed as you did in paragraph 2.2

4.5 Repeat the procedure described in paragraph 2.3.

4.6 Tape the template adjacent to the masking tape and at the vertical stabilizer root as shown in figure 5. Stick the vortex generators to the vertical stabilizer by removing the protective liner and placing the vortex generators in the five template notches making sure that the vortex generators are correctly facing forward as shown in figure 3. Move the template over so that the first template notch lines up with the last vortex generator attached to the vertical stabilizer. Attach four more vortex generators to the vertical stabilizer. Continue repeating this operation until all the vortex generators are all placed on the vertical stabilizer. Then repeat this procedure for the other side of the vertical stabilizer. Remove the masking tape when completed.

## 5.0 OTHER IMPORTANT CONSIDERATIONS

5.1 The installation procedures described above has assumed that the vortex generators are placed in a row that is perpendicular to the airstream. This may not always be the case. Some wings for example may not have a leading edge perpendicular to the airstream but have a sweepback to the airstream. In this case a template will have to be made to match the sweepback of the wing. Figure 6 illustrates what the vortex generator layout would look like if for example a wing had a 10° sweepback. It may look peculiar; however, the object is always to keep the vortex generator at an angle of 15° to the airstream. Also note that the distance between vortex generators is measured from the mid point of the vortex generator as illustrated in figure 6. If a horizontal tail has a hinge line that is swept it would be a similar situation as that shown in figure 6. The situation would be different for a vertical tail that has a swept hinge line as all the vortex generators are not staggered. This would require that all the vortex generators would need the same angle of correction. If the aircraft has a tapered wing it will be necessary to Measure the chord as shown in figure 1 at the root and tip of the wing as the distance the vortex generators must retain the same .90 distance for whatever the chord length happens to be.

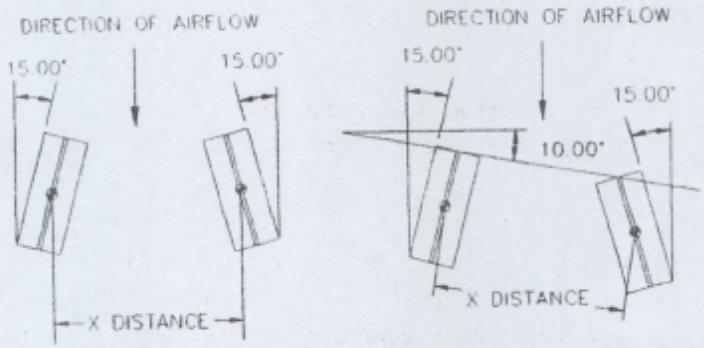


FIG. 6

5.2 If you have a full flying tail (stabilator) which requires more authority because of the installation of vortex generators on the wing think of the stabilator as a wing. Therefore the vortex generators will be located at about the .90 position from the trailing edge on the bottom of the stabilator with the 1.5" spacing that is used for the horizontal stabilizer.

5.3 Vortex generators can also be used to reduce drag at locations on the aircraft that have flow separation. Areas such as at the junction of the aft windshield and the leading edge of the canopy, or those cowlings that have stream line shapes around the cylinders especially if its a pusher aircraft, and wing roots with faired intersections.

## 6.0 DETERMINING LOCATION OF VORTEX GENERATORS METHOD 2

6.1 In method 1 a procedure for locating the vortex generator was given that will bring the vortex generator very close to the ideal chord wise position on the wing. In method 2 we will give a procedure that will optimize the location of the vortex generator on the chord wise position on the wing. It will require flight testing to determine that location.

6.2 Cut pieces of yarn 6" long. These are called tuffs. Cut enough pieces of yarn to cover approximately a 2.5' X 2.0' area of wing with the yarn spaced approximately 3" span wise and 6" chord wise. Stick the tuffs to the wing approximately at mid span with regular scotch 810 mending tape starting close to the leading edge of the wing and working your way back. Temporarily stick 3 vortex generators in a staggered manner at the 3.5" spacing given on template 1 with the leading edge vortex generator at the .90 chord position from the trailing edge. With the template correctly positioned take a felt marker with water soluble ink (Mr. SKETCH water color markers manufactured by Sanford) and draw the outline of the location of 3 vortex generators using the template as a guide. Place double sticky tape over the marked outlines for the position of the 3 vortex generators. Use scotch double sticky tape 665, also 665 tape comes in a dispenser identified with the number137DM-2. Then stick the vortex generators to the double sticky tape. See figure 7 for a typical layout. Note the normally clear vortex generators have been painted black for better picture contrast.

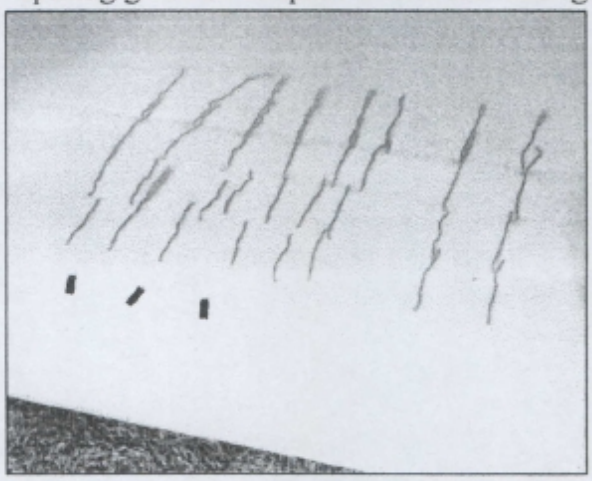

FIG. 7

6.3.1 Fly the aircraft at a safe altitude and slowly enter a stall. Figure 8 is a picture of the tuffs with the aircraft approaching the stall speed. Observe the tuffs during the stall. If the tuffs are behaving the same across the span of the wing, that is the tuffs all scrambled and in disarray that tells you that the vortex generators are to far aft. The next test flight will require that the vortex generators will need to be moved forward. If the tuffs are laying flat against the wing behind the vortex generators but in disarray to the side of the vortex generators, that tells you that the vortex generators are in the optimum position or to far forward. The next test flight the vortex generators should be moved aft. The reason for moving the vortex generators further aft in the next test flight is to determine if the optimum position might be further aft. If the vortex generators are to far forward they will reduce the stall speed, however, they will also be creating more drag than is necessary thus reducing the speed of the aircraft. So the procedure is to run a series of test flights and zero in on the optimum position for the vortex generators.

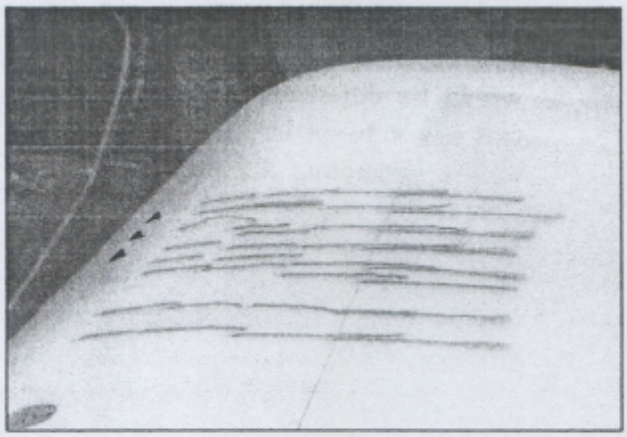

FIG. 8

Figure 9 is a picture of the tuffs as the aircraft is starting to stall notice that the tuffs not behind the vortex generators are starting to get disorganized. Figure 10 is a picture of the tuffs with the aircraft more steeply in the stall mode. As can be seen the tuffs not behind the vortex generators are scrambled and in disarray. In fact the rear most tuffs are actually pointing forward indicating the air is not only separated from the wing but the air is moving forward and outboard on the wing.

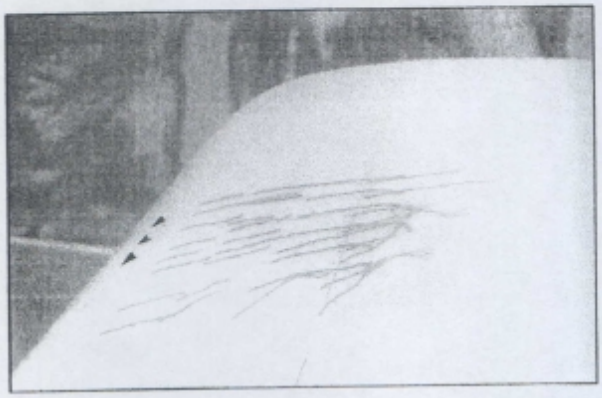

FIG. 9

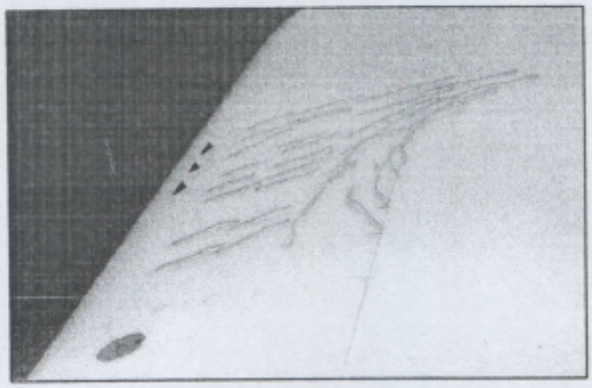

FIG. 10

6.4 With regards to determining the angle of airflow on the vertical stabilizer a similar procedure is used as was used with the wing, which is using tuffs to determine the airflow direction on the vertical stabilizer near the stall.

6.5 If your intention is to do the flight testing to determine the optimal position be prepared to spend quite a bit of time and effort in the flight test program. There may be need to have a chase plane involved in some of the flight testing or rig a pencil camera to the aircraft so that the tuffs can be observed.

## 7.0 SAFETY CONSIDERATIONS

7.1 Adding vortex generators to your aircraft can significantly change the handling characteristics of your aircraft. Don't then go out and try a short field landing just after you installed the vortex generators. Go to a safe altitude and get a feel for how the aircraft now stalls and how to make short field landings. See if at these slower speeds you need to add vortex generators to the horizontal or vertical stabilizer. Practice maneuvers at a safe altitude before trying them close to the ground. If you're conducting flight tests per method 2 remember you're in the process of expanding the flight envelope be cautious you might possibly encounter some surprises. Practice practice practice before trying maneuvers close to the ground.

AIRCRAFT DEVELOPMENT

TITLE: Installation Procedure-Vortex generator kit NO. 261-2

DATE OF ISSUE 12/30/04 REVISION

| KIT SELECTED | ADDENDUM NUMBER | PURPOSE OF ADDENDUM |
|---|---|---|
| A | 261-AD1 | DELINEATES A PROCEDURE FOR DETERMINING WHERE VORTEX GENERATORS SHOULD BE PLACED ON AN AIRCRAFT TO DECREASE STALL SPEED BY EMPIRICAL DATA OR THROUGH FLOW VISUALIZATION USING SIMPLE FLIGHT TESTS. THIS KIT CONTAINS 150 VORTEX GENERATORS |
| A | 261-AD2 | DELINEATES A PROCEDURE FOR DETERMINING WHERE VORTEX GENERATORS SHOULD BE PLACED ON AN AIRCRAFT TO DECREASE STALL SPEED BY EMPIRICAL DATA OR THROUGH FLOW VISUALIZATION USING SIMPLE FLIGHT TESTS. THIS KIT CONTAINS 65 VORTEX GENERATORS |
| A | 261-RV1 | INSTRUCTIONS FOR ADDING VORTEX GENERATORS TO RV-3 AIRCRAFT TO REDUCE STALL SPEED. |
| A | 261-RV1 | INSTRUCTIONS FOR ADDING VORTEX GENERATORS TO RV-4 AIRCRAFT TO REDUCE STALL SPEED. |
| A | 261-RV1 | INSTRUCTIONS FOR ADDING VORTEX GENERATORS TO RV-6/ 6A AIRCRAFT TO REDUCE STALL SPEED. |
| A | 261-RV1 | INSTRUCTIONS FOR ADDING VORTEX GENERATORS TO RV-7/ 7A AIRCRAFT TO REDUCE STALL SPEED. |
| A | 261-RV1 | INSTRUCTIONS FOR ADDING VORTEX GENERATORS TO RV-8/ 8A AIRCRAFT TO REDUCE STALL SPEED. |

*AIRCRAFT DEVELOPMENT*
1220 RED OAK COURT
TROY, MO 63379

Title: Installation procedure-vortex generator kit


Issue Date 12/30/04
Rev.

No. 261-2

**1.0 PURPOSE**
To explain the installation procedure for this kit in the safest, most cost and time effective manner.

**2.0 SCOPE**
This procedure is applicable to all kits sold by Aircraft Development with the kit numbers having the digits 261-( X...X )

**3.0 GENERAL**
All work must be accomplished per Aircraft Development Installation Procedure 261-2. This kit contains Installation Procedure 261-2, with an addendum for the specific model of aircraft being modified or how to generally modify aircraft with vortex generators.

**4.0 GENERAL INSTALLATION PROCEDURE**

4.1 It is important that the surface to which the vortex generators are going to be applied be clean and dry. This can be accomplished by cleaning with a 50:50 mixture of isopropyl alcohol and water. Where heavy oils or greases are present there may be a need to first cut the oil with a degreasing solvent, but this should always be followed with an isopropyl water cleaning to help ensure that any residue or film is cleaned off. If there is oxidation on the paint or a grimy finish to the aircraft that will not clean off easily with the 50:50 mixture, first clean the surface with a steel wool soap pads (such as Brillo) and water. Then use the 50:50 solution. One way to assess cleanliness is that a surface prepared for the vortex generators should be as clean as one being prepared for painting. Spray or wipe the 50:50 cleaning solution onto the surface and scrub with a clean lint free rag or paper towel until the surface is clean.. Dry the surface with another clean lint free rag or paper towel. Be sure to change rags or towels often to avoid smearing the dirt around or contaminating already clean surfaces.

**5.0 GENERAL INFORMATION ON VORTEX GENERATORS INSTALLATION**

5.1 After the aircraft surface to which the vortex generators are to be applied, has been determined to be clean and dry, determine that the bonding surface of the vortex generators are clean. The vortex generator comes basically as a clean surface; however, it is a good idea to wipe the bonding surface of the vortex generator with the 50.50 solution to make sure the bonding surface is also clean. In using the 3M adhesive tape it is a good idea to apply the tape to the vortex generators and let the tape have 24 hours curing time to come to full strength.

## 6.0 GENERAL INSTRUCTIONS FOR INSTALLING VORTEX GENERATORS

6.1 This kit comes with a 3M very high strength pressure sensitive adhesive tape that is very simple and easy to use. Aircraft Development conducted testing on this adhesive tape and has determined that it is of sufficient strength to adequately support the vortex generators. Extra adhesive tape comes with this kit. Store this tape in a cool dry area as you may need it should you decide to expand this kit at a later date. For those that may have concerns about using a pressure sensitive tape for this application there are stronger adhesives available, though less user friendly. Listed below are some stronger adhesives that may be used.
General Electric's RTV-6802 tinted white, RTV-6803 tinted black, RTV-6008 translucent.
Lockite's Prism 401 with 770 primer

## 7.0 GENERAL IINFORMATION

7.1 The deluxe generic vortelator kit 261-AD1 contains enough vortex generators to do most homebuilt aircraft wings and if necessary the underside of the horizontal tail. In the case of an exceptionally large homebuilt aircraft or a biplane additional vortex generators may be required and can be purchased 25 at a time in kit 261H for $68.75. The generic vortex generator kit 261-AD2 is the same as the 261-AD1 kit except it has enough vortex generators to do the wings of the average homebuilt aircraft. Some aircraft will not require that vortex generators be placed on the underside of the horizontal tail. This kit gives you the option of buying the less expensive kit and if need be purchase additional vortex generators later. The vortex generator kits that Aircraft Development has created for specific aircraft models thru flight testing contain the number of vortex generators dictated through flight test. If the kit did not denoted the use of vortex generators on the underside of the horizontal stabilizer or both sides of the vertical stabilizer it is because adequate control can be maintained without vortex generators at those locations. However, it may be possible to further improve the controllability of those aircraft by adding vortex generators at those locations. These kits are designed to be the most cost effective kits. For those that might want to further enhance the performance of their aircraft the installation manual does have information on how to vortex generate those parts of the aircraft. Again additional vortex generators can be purchased in quantities of 25 by ordering kit 261H.

## 8.0 SAFTY CONSIDERATIONS

8.1 Adding vortex generators to your aircraft can significantly change the handling characteristics of your aircraft. Don't then go out and try a short field landing just after you installed the vortex generators. Go to a safe altitude and get a feel for how the aircraft now stalls and how to make short field landings. See if at these slower speeds you need to add vortex generators to the horizontal or vertical stabilizer. Practice maneuvers at a safe altitude before trying them close to the ground. If you're conducting flight tests per method 2 given in 261-AD1 or -AD2 remember you're in the process of expanding the flight envelope, be cautious you might possibly encounter some surprises. If your in the process of installing additional vortex generators from your flight testing and don't have enough vortex generators to finish the job please do not fly the aircraft until you have acquired enough vortex generators to finish the job. It is important that you not fly the aircraft partially completed or with asymmetrically installed vortex generators.