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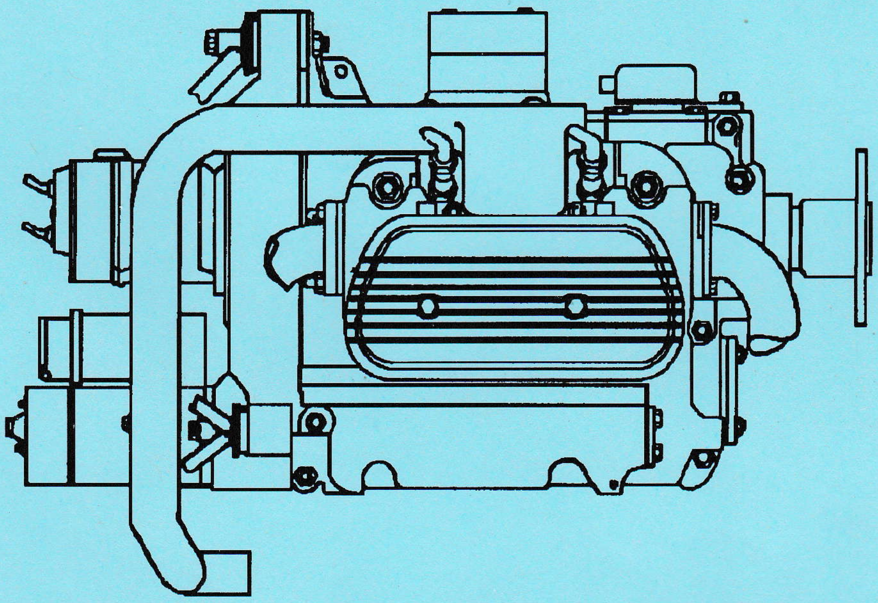
VW Engine Baffling Manual: How to keep your VW Cool!



GREAT PLAINS AIRCRAFT
7011 N 160 Avenue · Bennington, NE 68007
Information 402 493 6507 · Fax 402 493 3846
www.gpasc.com

How to Keep Your VW COOL!

Providing adequate cooling for your engine is a function of several different items.

- Your engine must be set to run at the right mixture.
- You must be sure that your engines compression ratio is set low enough to support the octane of the fuel that you are using.
- You must make sure that the engines oil is being cooled properly.
- You must make sure that there is adequate air flow through the cowling.

The key word here is YOU.

Regardless of how good an engine may be, it will last either a long time or a very short time depending upon how YOU install it.

The purpose of this manual is to provide you some good sound guidelines for VW engine cooling. If your aircraft comes with templates for engine baffling, we recommend that you follow those directions. If your aircraft has no templates or instructions, these diagrams, pictures and drawings may be used as guides. These baffling templates will not fit every VW aircraft engine installation. The templates will have to be altered to suit your particular installation. They do, however, provide a good guideline to follow.

Compression Ratios

The first order of baffling/cooling, must be done when the engine is being built. The engines compression ratio must be set low enough so that the engine will not detonate. We recommend that your engine be set no higher than 8.0:1, regardless of size. This applies only to engines that are going to be used primarily for pleasure. For racing, high compression ratios are needed.

Why only 8.0:1? For starters, a stock VW 1600cc engine is set up for only 6.6:1 to 7.3:1 depending upon the year it was built. The reason for the low compression ratio is because of the octane rating of fuels. An 6.6:1 will support any fuel with an octane rating of 88. I bet you can guess what regular leaded gas is rated at? Right, 88 octane. Now I know your next question - "If an 88 octane rated fuel will support 6.6:1, why won't 100 octane support 9.4:1?" The answer is — "The octane will support the combustion, but the engine won't."

Now I know that sounds funny. This is why: Major engine rebuilders do a little test on all cylinder heads prior to being rebuilt. It is called a Rockwell hardness test. This simply determines the hardness of the metal, be it aluminum or steel, etc. In doing this to a VW head, what it tells the rebuilder is if the cylinder head has been overheated. If the heads have been very hot, the Rockwell reading is off and the head is junk. How does a head get too hot? In a car, it can be because of foreign material in the air cooling system, foreign material blocking the oil cooler, lack of oil and broken valves. Rarely does a car fry a head because of using the wrong octane fuel. However, those of us building our own engines for aircraft operate in a very different environment. We have no blower to cool the engine. Most of use have changed the displacement. The oil cooling system has been changed. The carburetion has also been changed. All of these factors affect cooling. A simple rule to remember is ,"Anytime you increase the bore or stroke of an engine, you have increased the compression ratio."

Compression Ratio Chart for a 2180

Compression Ratio	Octane Needed
10.7:1	105
9.6:1	100
9.0:1	99
8.1:1	96
7.5:1	94
7.0:1	91

Compression Ratio Chart for a 1835

Compression Ratio	Octane Needed
9.4:1	100
8.9:1	99
8.5:1	98
8.1:1	96
7.3:1	92
6.7:1	88

How to Determine Your Compression Ratio

1. Determine your displacement:

   BORE x BORE x STROKE = DISPLACEMENT

   Example: 92 x 92 x 82 = 2180.421CC

2. Determine the volume of 1 cylinder:

   Exampl:. 2180 DIVIDED BY 4 = 545 CC'S

3. Determine the deck volume of each cylinder. The deck volume is the distance from the top center of the piston to the top of the cylinder when the piston is at TDC (Top Dead Center) (Top Dead Center).

   Example: You measure this distance and find you have .050 deck height.

   BORE x BORE x .050 x .01996 = VOLUME CC'S

   92 x 92 x .050 x .01996 = 8.44 CC'S

4. Measure the volume in each cylinder head. With spark plug installed, cut a piece of plexiglass to fit the cylinder head opening. Drill a 1/4" hole in the center of it. Coat the cylinder head step with a light coat of grease and install plexiglass. Now, using a beaker marked in cc's fill the cylinder head with light oil and record findings for each of the four cylinder head openings. Average volume is 48 to 52 CC'S.

5. You can now determine the compression ratio of your engine, so you can adjust it accordingly.

$$\frac{\text{1 CYLINDER DISPLACEMENT + DECK CC + HEAD CC}}{\text{DECK CC + HEAD CC}}$$

$$\frac{545 + 8.44 + 51 = 604}{8.44 + 51 = 59} = 10.2:1$$

This is the compression ratio of one cylinder before any adjustments have been made. You must now find the compression ratio of the other three cylinders.

Now, I bet you want to know what happens to a cylinder head that runs at a high cylinder head temperature. First, if the cylinder head temperature runs around 500°F for any length of time, the valves, especially the exhaust valves take a tremendous punishment. For all real life, and I mean your real life consideration's, it is junk. The valve will no longer seal properly on the valve seat. The valve seat, by the way, is probably coming loose . The valve guide, because of the intense heat of the valve stem is probably worn out. The cylinder head to cylinder head mating area has warped. The top of the cylinder is no longer round. You may have cracks between the intake and exhaust valve seats and valve seats to spark plug hole. The pistons may have holes being blown in them with each stroke. The cylinder head material has been softened.

What is the main cause of all this destruction? Simply, running too high of a compression ratio in relation to the octane rating of the fuel you are using. The difference between a cylinder head temperature of an engine set up to run at 9.4:1 which is the maximum that 100 LL avgas can support and 8.0:1 using the same 100 LL avgas is as much as 50 degrees lower. At 8.0:1 your engine, which you must always remember is an automobile engine first and an aircraft engine second, will at least have a fighting chance to give you reliable service.

Ending Sermon on Compression Ratios

I know, you want all the power available. So, how much power will you loose by operating at a lower compression ratio? About 5%. Dropping your engine from 9.4:1 or higher to 8.0:1 will decrease your top RPM by about 150 RPM. So, 3400 x 5% = 170 RPM. This is the maximum loss most builders can expect to see. What will the 5% decrease in power get you? Life — could be your own. Longevity — for your engine. A sport is supposed to be fun!

The next aspect of engine cooling that must be planned for is oil cooling. The engine oil is there to provide for not only lubrication, but also heat removal. In our opinion, any VW air cooled engine used in an aircraft must use an oil cooler.

One of the most important facts in oil cooling is the location of the oil temperature sender. If it is mounted in a location where outside air is blowing over the sender, such as the bottom of the oil drain plate, it will give you a false reading in real temperatures by as much as 80° — LOW. The correct location for the temperature sender is in the right or left side of the oil supply. Toward the bell housing of the engine case, as low in the oil sump as you can locate it. We found this to be a real problem in some aircraft. Older Sonerai's for example, had a special oil drain plate for the temperature sender to screw into, and most Sonerai's used it. A typical reading of the oil temperature in a Sonerai with the temperature sender in this location is 160°, which sounds great. Actual oil temperature reading was around 240°. On every single engine that we have rebuilt for a Sonerai and put the oil temperature sender is in the side of the case, the oil temperature rose 60 to 80°. Oil coolers were added. You can expect an oil cooler to reduce the oil temperature by about 20°. The slower the aircraft, the greater the need for a larger oil cooler. Remember, the case, valve covers, pushrod tubes, and all engine parts exposed to oil, dissipate heat.

what kind of oil temperature should you have...	
cruise oil temperature	180° TO 200° F
minimum oil temperature	160° F
maximum oil temperature	210° F
never exceed oil temperature	220° F

Oil needs to run around 180°F to 200°F - just to burn off the petroleum contaminates and water in it.

Now, we can finally get around to building the engine baffling. We recommend that you use 2024 or 6061TY6 aluminum that is .035 thick. This is light weight but still stiff enough to resist bending. You will also need to buy or make some baffling sealing material. You can purchase a roll of it from aircraft supply companies, or you can make your own. To make your own, you will need a piece of glass, some wax, 6 oz. fiberglass cloth and some clear 100% silicone caulking.

To make your baffling material, simply do the following. Wax the glass, lay one layer of 6 oz. cloth on it and fill with silicone. Lay a second layer of cloth on and fill with silicone followed by a third layer filled with silicone. When the cloth is dry, your baffling material is done. You can cut it to size as needed. We recommend that the glass be about 2' by 2'. This way you will have plenty just in case you wind up building baffles twice.

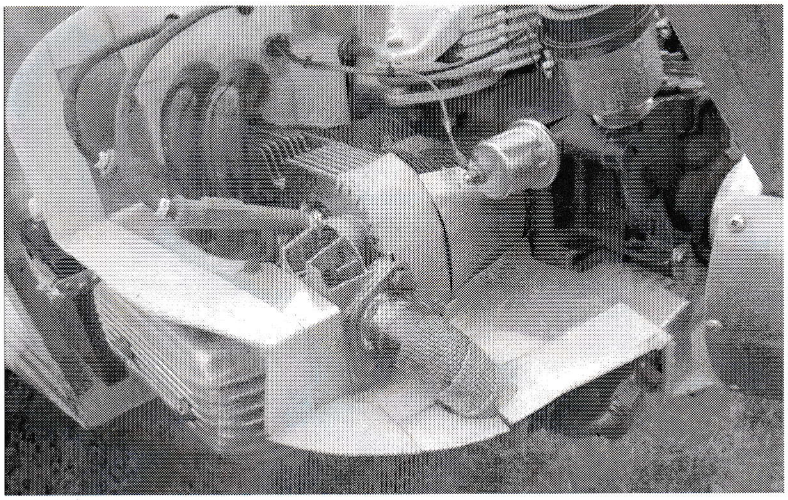
Before you cut any material, go to the airport and look at production aircraft to see how their engines are cooled. Notice the large, generous air inlets and outlets in most cowlings. Look at how the baffles go around the back of the engine and how the gasket material meets the cowling. Look how the various sender tubes and wires pass through the baffling. If you have a VW powered homebuilt in your area, by all means, make a date with the owner to see how they did their engine installation and baffling. If there are no other VW powered aircraft around, make a point to get to a fly-in so you can look at several VW engine installations.

So, you are ready to start. More guidelines to follow. All air is supposed to enter the top of the cowling and be forced down through and around the cylinder heads and cylinders. Any air that leaks through the engine compartment is wasted power/performance. Your baffling should come to within about 1/2" of the cowling. The gasket material you made will fill the final gap.

Remember that these templates are guides only. We can guarantee that your engine baffling will be different than these drawings.

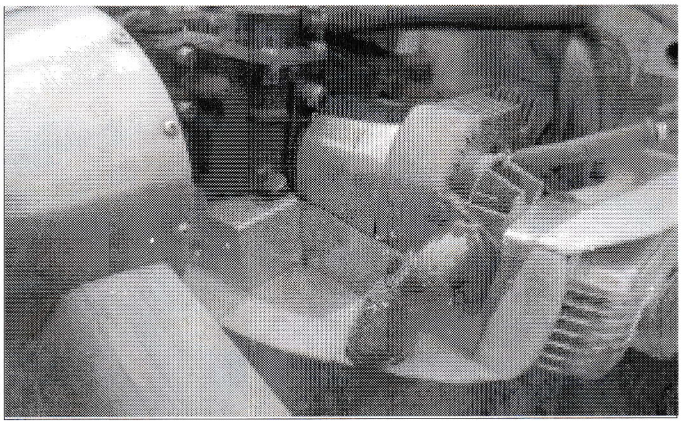
Right Front of Engine

Notice how the gasket material is attached to the baffling. It may be glued on with silicone, wired on or pop riveted on. Notice that the exhaust pipe is fairly well sealed with the gasket material and how the aluminum covers the front of the cylinder head and cylinder.



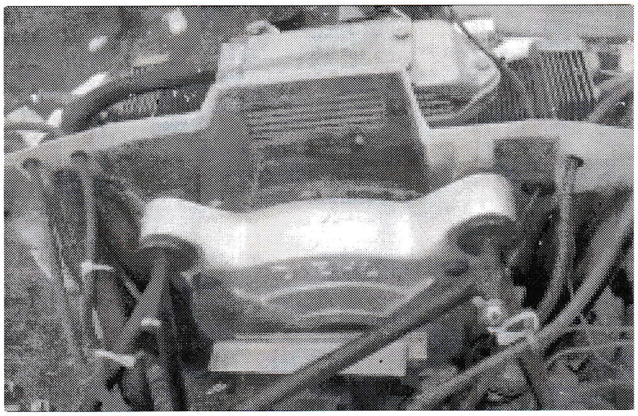
Left Front of Engine

Again, notice how the baffling is very close to the engine case and cylinders. The gasket material is sealing the exhaust pipe. Remember your goal is to make all incoming air be useful by cooling the engine.

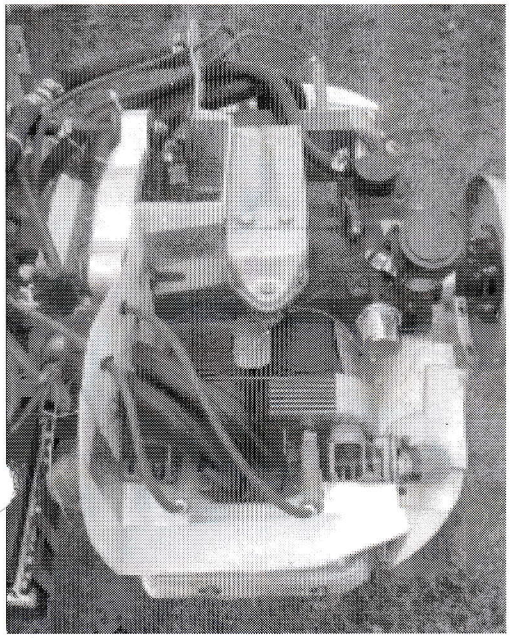


Back Dam of Engine Baffling

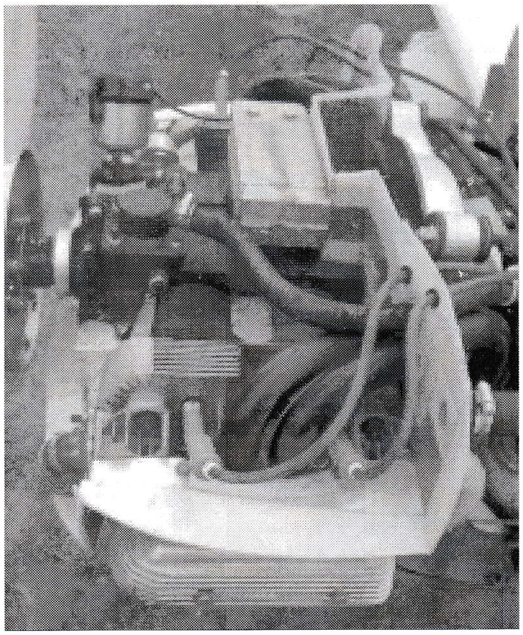
This is usually the hardest area to make, because it has curves to it. One of the easier ways to get the right shape is to simply remove the top of the cowling and place it on end on a large piece of cardboard. You can then trace the outline of the cowling on to the cardboard. This will give you a good indication of the outline for the baffling. Remember that the baffling should be 1/2" away from the cowling. Note how the baffling exposes oil coolerr to low pressure side of the cowling on back.



Right and Left Side of Engine



Look closely at the intake manifolds and spark plug wires to see how they pass through the back baffling. Grommets are used where ever wire goes through the baffling. A fiberglass and silicone gasket is used for the intake manifolds. Any small holes that cannot be sealed with gasket material are sealed with silicone.



There is no trick to building and installing your engine baffling. You must pay very close attention to cutting and trimming the aluminum and gasket material.

Many years ago, research was done on cooling the VW engine in the automobile. It was found at the time, that by simply leaving the seal off the spark plug wire, that it raised the temperature of the cylinder almost 20 degrees. Now we are talking about an area only as large as a 50¢ piece. From this illustration, you can really see how important it is to install a good, tight baffling system.

There are some common problems associated with baffling VW's in homebuilt aircraft. First, you must make sure that the air inlets and outlets are large enough to provide enough cooling air for your engine. As an example: an 2180cc engine that will cruise at 150 mph, needs a total air inlet that is about the size of an 8 1/2" x 11" sheet of paper. The outlet should be about 1 1/2 as large. The outlet area must be in an area of low pressure. Make sure that your cowling exit area is not pressurized when the aircraft is at high angles of attack, such as during take off or a go around. the pressure differential causes air to move through the engine compartment.

Other problems? On some VW powered aircraft, we have found that if a spinner is not used, because your saving a few bucks until you can afford one, that the airflow into the engine is greatly disturbed. Solution? Wait to fly until you can install your spinner.

Another common problem that is associated with cooling and engine baffling is mixture control. If you are running your engine too lean, it won't matter how well your cooling system is because the engine is producing so much heat that it is in a self destruct mode. Remember, that air cooled engines need excess fuel to help cool the engine, especially the cylinder heads, pistons, and valve train.

The cylinder heads themselves are often the cause of an overheated engine. When installing the cooling system, pay very close attention to the finned area of the cylinder heads. Make 100% sure that all of the air passages in the cylinder heads are open. Many times flashing left over from when the cylinder heads were cast is not cleaned out. Air must flow around the heads to absorb and dissipate the heat produced from combustion. It cannot do this if flashing is in the way.

This manual covers the major problems that we have found associated with installing a cooling system. Remember that many times, the problem is not with the cooling system, but can be found in mixture control, low octane fuel, mismatched parts and lack of an oil cooler. A VW engine is cooled by air, fuel and oil/cooler. Remove any one and the other two must pick up the heat transfer load.

If you need any additional assistance, please feel free to call, email or write. Great Plains Aircraft is always ready to help you anyway we possibly can.

Think and practice safety.

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