What is the Big Deal About Rocker Arm Geometry For the Air-Cooled VW Engine?

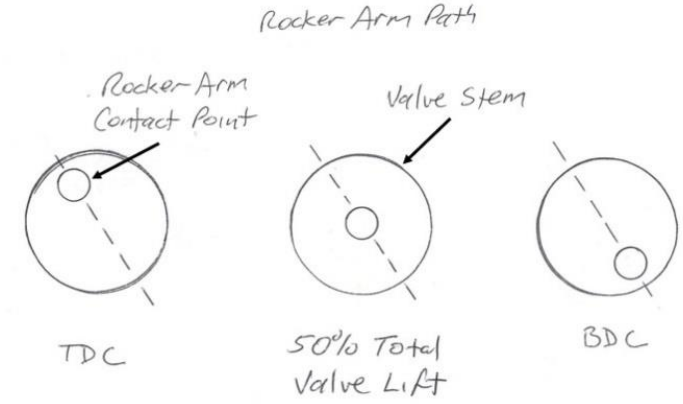
Jimmy Candelaria, March 2024

Why is determining correct rocker arm geometry and establishing the correct push rod length so important for the best functioning of the air-cooled VW engine? The simple answer is 1) maximizing performance of valve function and 2) minimizing valve guide wear. That is all, nothing more. But this is easier said than done because it takes an understanding of the factors contributing to incorrect geometry and how to measure it with accuracy, repeatability, and reproducibility. The latter two terms I have borrowed from my career Quality Engineering work experience when evaluating a measurement system or sometimes called a Gage Study.

Simply explained, repeatability is when a single user applies a measurement process (tools and methods) multiple separate times to obtain a result, usually two or three times then compare the results. Each time the measurement process is completely undone and then repeated. Reproducibility is when the same measurement process is performed multiple times by two or three persons and the result are compared. Again, each time the process is completely undone and then repeated. A robust measurement system will have a minimum of measurement error contribution from the user (or appraiser). The other sources of measurement error are tools and materials.

Over the ten years of studying rocker arm geometry by speaking with VW engine builders, reading articles, and watching video tutorials I have found that many builders, if not all of them, employ the “eyeball” method for the conclusion that the geometry is “accurate enough.” But I was not satisfied particularly because using this method will result in a different push rod length each different time this method is used and since custom length pushrods can be expensive, I wanted it to be as correct and accurate as possible. Towards this end I developed a method that achieves this objective with an acceptable amount of measurement error. When I have applied this method, it achieves repeatable accuracy to within .003”. This means that I can have confidence in the final pushrod length to be correct when they are ordered.

The first step is to adjust the side-to-side position of each rocker arm on the shaft so that it will contact the valve stem at the upper left corner, see diagram below. Follow the path of the rocker contact across the valve stem surface to fully understand it. Adjustment is done by adding or removing the shims between the rocker arms and spacers. It can be frustrating but it’s important so take the time to do it correctly. After each shim adjustment on the bench, mount the assembly on the rocker stand and torque the bolts. Since the push rods do not need to be installed it’s easy to visually examine the valve stem contact from each rocker. Remove and repeat as necessary until satisfied.



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In using this procedure, the objective is to adjust the height of the rocker arm assembly using shims under the mounting blocks so that the push rod length will extend the valve to the point of half of the Total Valve Lift and the plane on the end of the adjuster screw should be parallel to any unaffected valve stem plane that has already been set at level. This height adjustment changes the rocker arm pivot point and as such it influences valve function, lift and duration.

Rather than using the "eyeball" method, two small bubble levels are used with a small magnet attached to the underside with double back tape. One is placed on a valve stem where the rocker adjuster screw has been removed. The other is placed on the top of the adjuster screw for the valve being measured, either Intake or Exhaust. The point of further discussion is to achieve parallel of these two planes using these bubble levels.

With the engine on its stand, it must be leveled according to the bubble level on a valve stem with its rocker arm adjuster screw having been removed. Do not use the valve cover surface on the head as the reference plane because it is machined without concern for perpendicularity to the valve stem axis. Remove all push rods except for the adjustable pushrod tool under the rocker for the valve being measured. Install the rocker arm assembly with or without shims for a best guess start. Set the valve lash as desired. Leveling can be done primarily by rotating the engine but for forward or rear lifting I have modified my engine stand with three ½-13 nuts welded to the three ends at the stand base. Then drill through each nut and through both walls of the square tube with a minor thread diameter drill size (.405”). Then chase the thread through the nut and nearside wall. Then, from the backside, drill a clearance hole a bit larger than .500”. For the adjusters, take a 24” length of ½-13 threaded rod and cut 3 x 8” lengths. After deburring the ends of the threaded rod, lock an acorn nut on one end with a jamb nut. Now each can be screwed down onto a block for support until level is achieved. Use the back two for rear lifting and the front one for front lifting with a wood block thick enough to lift the stand from its wheels.

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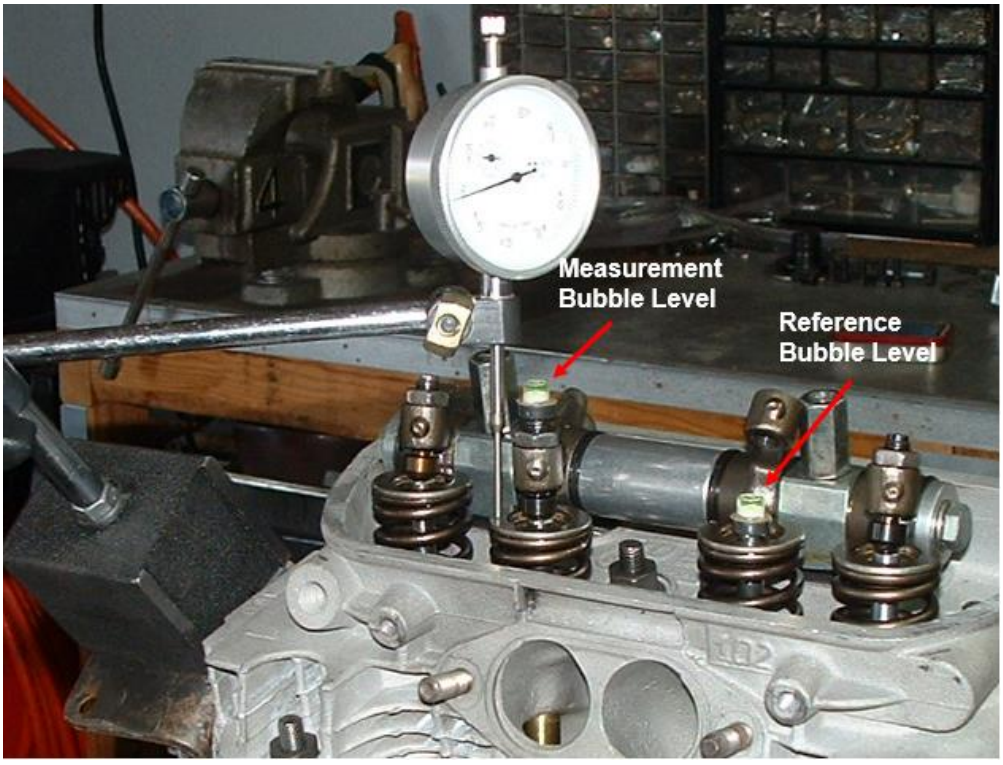
Once the engine is leveled the Total Valve Lift can be measured using a drop indicator mounted a magnetic base. Place the indicator tip on the flat surface over the spring. Be sure to align the drop indicator tip with the axis of the valve stem to minimize measurement error. I made an angle plate mounted onto the exhaust studs for the magnetic base.



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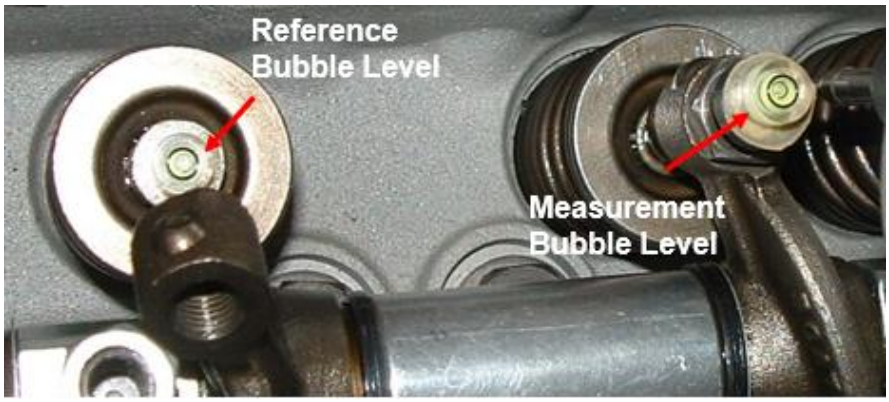
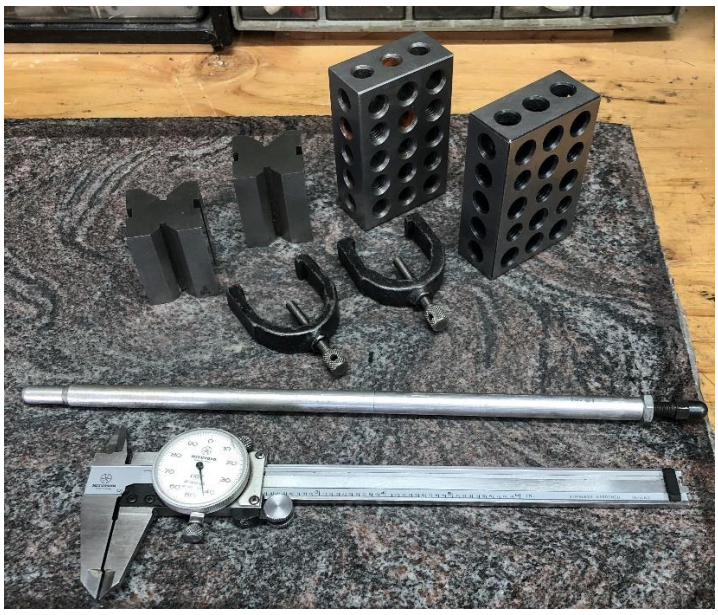
So, how are the two planes determined to be parallel? First, rotate the crankshaft so that the total valve lift can be measured. Repeat this to be comfortable that it is correct. Then, rotate it again so that when the valve is at half of total valve lift the two bubble levels should be approximately centered in their target circles. This shows the two planes are parallel. When they are not quite parallel to satisfaction, the setup needs to be torn down, remove the rocker arm assembly and change the shim thicknesses under the mounting blocks. This will likely have to be repeated several times so don't be discouraged. It will eventually work and you will get better at it. Try reducing the shim thickness and see the effect. If that didn't help then try increasing the shim thickness and see the effect. It might help to note the thickness used and the effect it had on parallel. Each time the shim thickness is changed the lash gap must be reset as well and be sure to use the same gap each time. When parallelism is achieved to satisfaction (it won't be perfect but they each should be in the target circle), then the adjustable push rod length can be measured.



Measuring a push rod that is approximately 11" long can be challenging but with the use of common tools it can be done with sufficient accuracy. I've developed two methods shown below.



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The first one uses 2 Vee Blocks with clamps, 2 1-2-3 Blocks and 6” calipers. These are stacked together on a flat surface with the clamps holding the push rod. The height of the stack components can be measured. Then the distance from the top of the stack to the top of the push rod is measured and added to the stack-up for the total pushrod length. Take several measurements to get comfortable using the depth feature of the calipers to minimize measurement error.

The second method uses a flat surface, a 1-2-3 block or suitable spacer, and a 12” caliper.

Finally, after the new custom length push rods become available measure them to verify each is the correct length then use this method again but with a new push rod. The bubble levels should align validating your previous work.

Please send me your comments and questions to Candelaria.jamesj@gmail.com. Thank you.