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MID-LIFT® G-TooL™ INSTRUCTIONS

PUB 050206GT3X

GT-3X

(Chevy 350 & Ford 302)

These instructions were originally directed at the 350 Chevy, where formulas for an even valve lifts of .500" and .700" were developed. This tool also adapts to the Ford 302 and 351W engines in all manners described here, EXCEPT the VALVE LIFT MEASURING POINTS are .522" and .732". *These formulas allow setting for ANY valve lift.*

NOTE:

Using this tool as per the instructions set forth in all MID-LIFT® rocker arms from PVS or MPG depends on the angle of the rocker studs being accurately installed as per factory tolerance dimensions. With the SB Chevy, this angle is 11-1/3 degrees toward the valve centerline. The following, however, will show and "teach" you a method of not only setting your geometry properly, but also CONFIRMING that your heads have this correct rocker stud angle. But most important, if the stud angle is NOT correct, you will learn a simple but pioneering way of how this Patent Pending tool can compensate for the error, which no one has ever presented before.

SUMMARY

The Miller G-TooL™ has two methods of setting your rocker arm geometry. The first method measures in the closed valve position and the second in the MID-LIFT® position. The first method establishes a baseline that the second method confirms, which is necessary in adjusting for any errors in your cylinder head's stud angle. It also sets the length for your pushrod before using it under full spring pressure in the actual MID-LIFT® position. Although it is unlikely to hurt anything by going directly to the MID-LIFT® method, as the instructions with our rockers explain, the closer that your required pushrod length is to what is needed, the better off you are at avoiding problems. With hydraulic tappet cams the closed valve method lets the geometry be set with the hydraulic tappet extended to its full length in the closed valve position. But to continue with the second method of checking geometry with full spring pressure at MID-LIFT®, and confirm your stud angle is accurate, a solid tappet of the same height as your hydraulic tappet is required. By adding .020" to your final measured length, you will simulate the compressed tappet length during operation. (A hydraulic tappet during these steps would collapse beyond its operating length and give an incorrect pushrod length, since there's no oil pressure.)

DESCRIPTION

The G-TooL™ has three (3) usable sides to establish geometry. All three sides are designed to lay atop the MID-LIFT® rocker's "Measuring Face™" (top of rocker body). Two sides of the tool are designed to work together by establishing a formula that you then apply to your specific valve lift in determining the final pushrod length. One side is marked ".500" VL" (Valve Lift), and the opposite side is marked ".700" VL." If you have a net valve lift (VL) of either .500" or .700", and are sure your stud angle is accurate, theoretically that side of the tool can be used to directly set your pushrod length in the closed valve position. The two step method and formula is recommended since using both confirms your stud angle. The third side, which is the bottom of the tool as you read its trademarks, is 90 degrees to the adjusting screw hole, and this is the side for checking geometry at MID-LIFT® with both the cam and valve half open and with full spring pressure.

METHOD

By installing the .500 VL side of the G-TooL™ over the rocker and extending the adjustable pushrod until the top of the rocker arm becomes flush with the bottom of the tool, you are setting the rocker's closed valve position for precisely the correct height required for operation at .500" Valve Lift. Using the opposite side, marked for .700 VL will do the same thing for .700" VL. To use a tool in the CLOSED valve position, a formula must be developed that applies specifically to the engine being measured. By checking the rocker arm's closed valve angle in the two valve lift sides of the G-TooL™, and measuring the overall length of the pushrod for each side, you create a specific reference length for your engine. This difference in pushrod length between the two measurements will be somewhere around .160". On another engine with different deck heights, valve lengths, and other valve train characteristics, this standard might be .150" or .170". Each engine's unique dimensions affect rocker geometry, which influence your final standard reference measurement. This is why each engine requires setting geometry for the NET valve lift to be used; and also why pushrods are the LAST thing you buy to finish assembling the engine.
It's also why *plastic pushrod checkers, angled plates, stepped bars and other similar gimmicks sold by everyone are worthless: because they don't adjust for valve lift!* ***Forget them!***

NOTE: Going from .500" valve lift to .700" VL will cause the pushrod length to be shortened, not lengthened. That's right, going to a higher valve lift will *shorten* the pushrod! More on this in a minute.

FORD 302/351W

As mentioned in the opening paragraph, if this tool is being used on PVS Ford PA3060 or PA3070 rocker arms, ***all calculations in the closed valve steps and formula are to substitute .522" in lieu of .500" and .732" in lieu of .700" respectively. All steps remain the same.***

MEASUREMENT STEPS

1. Check the actual lobe lift of your cam, and multiply it times the ratio of rocker arm you have bought to get your theoretical valve lift. If you have a mechanical cam, subtract your valve lash from this figure. This final valve lift is still theoretical but will be used to divide in half for noting what your MID-LIFT® point is, so write this down. (For an example engine we will use .600" valve lift.)

2. Install your rocker arm with an adjustable pushrod on the engine when the cam is closed.

3. Install the G-TooL™ with its .700" VL side down against the top of the rocker's "Measuring Face™" and lengthen or shorten your pushrod until the top of the rocker arm is flush beneath the G-TooL™.

4. Leaving the pushrod length set from step 3 (above), remove the G-TooL™ and rocker arm to accurately measure the pushrod's length. (Order Miller's P-TooL™ or 12" Calipers if you don't have accurate measuring tools for your pushrods.) Write your measurement down.

5. Reinstall the adjustable pushrod, rocker arm, and the G-TooL™ using its .500" VL side this time. Lengthen your pushrod until the top of the rocker arm is once again flush beneath the G-TooL™, and repeat the removal and measuring of your pushrod for this second measurement and write this LONGER length down ABOVE your .700 VL measurement.

6. Subtract the shorter .700 VL measurement from the .500VL length, and write this difference down next to the theoretical valve lift of your cam. Lets assume it is somewhere around .165" for example.

CALCULATING STEPS

7. To get our "formula" you now need to divide this difference by the .200" spread of our two measurements: .165"/.200"= 0.825". Don't be confused, this is only a "formula," not valve lift. What this formula is saying is that for every 10 thousandth of an inch (.010") change in valve lift the pushrod will change eight thousandths of an inch (.00825" rounded off).

8. Use a calculator (if necessary) to subtract the theoretical valve lift of your cam from the .700" to determine how much you must compensate our G-TooL's .700" valve lift for your engine's actual NET valve lift. For our example engine's .600" VL this would be an even .100" (.700" minus .600"= .100").

9. The remaining sum is what you now apply your formula to by MULTIPLYING the two together, so multiplying .825" to our sample engine's difference of .100" equals .0825"

10. Whatever length the pushrod came to for measuring on the .700" VL side of your G-TooL™, you would ADD .082" to this dimension for this .100" change (.600"VL) on our example engine. You can see in our example that my choice of .600" valve lift is a nice, even difference between .500" and .700". Accordingly, what is needed for a change in pushrod length is exactly half the difference of our two measurements. If you happen to have a valve lift which is more than .700" you would still use the .825" formula figure (or .082" per .100" of valve lift), but you would go the other direction with changing your pushrod length. Instead of making it longer than the .700" test dimension, you would subtract your answer from the .700" test length, because the pushrod needs to keep getting shorter.
    NOTE: With HYDRAULIC Tappets, **ADD** .020" to your FINAL PR length above; *you are **DONE** at this point. HYDRAULIC Tappet engines SKIP Steps 11 through 14, or USE a SOLID TAPPET of same length to continue MID-LIFT® check and STUD ANGLE verification.*

11. Once you've adjusted the pushrod length to your prescribed dimension from our closed valve procedure, you can now put the rocker arm back on for testing at MID-LIFT® with full spring pressure. Before you do however, first rotate the engine one full revolution of the valve you are working with to check the actual NET valve lift. Be sure to set valve lash and allow for this in your measurement. If this is a hydraulic tappet/cam, then this step is not needed (unless you have the solid mockup tappet). Confirming the net valve lift must be done before any final decisions on pushrod length is made. If the NET valve lift is NOT within .015" of the theoretical valve lift you previously calculated with, you will have to adjust your pushrod length for your true NET valve lift. The formula you came up with will still be the same, so just do the math for what your pushrod length needs to be based upon your true net valve lift, instead of the theoretical valve lift you first started with. **REPEAT STEP 8 using your NET Valve Lift.**

12. Once STEP 11 is finished and CONFIRMED, you can now confirm your STUD ANGLE is correct by going directly to the MID-LIFT® procedure (Hydraulic cams require solid tappet for this step). If the stud angle is incorrect, so too is your geometry, so this step is necessary to fix it. Turn the engine over to exactly MID-LIFT® with your full operational valve springs, taking a reading directly from the valve spring retainer. Set the G-TooL's bottom side atop the rocker's "Measuring Face" to confirm it is flush across the entire rocker's top surface. If it shows any angular gap to the front or the rear of the rocker arm, this error is how much your mounting stud is off.

WHAT TO DO IF YOUR STUD ANGLE IS OFF

13. If your stud angle is off, there will be a gap between the rocker body and the tool, at one end or the other. While you are still at the MID-LIFT® point in STEP 12 (above) slowly rotate the engine in the direction required to close the gap, while taking note of how many thousandths of an inch it takes the valve to move until this gap between the G-TooL™ and the rocker is removed and the tool lays FLUSH. Since this is being checked at the VALVE, the rocker RATIO is then used to calculate what change in PUSHROD length is needed. The error seen during the MID-LIFT check was actually created during the first steps of setting pushrod length at closed valve. The rocker arm was making its .500"VL and .700"VL references from an inaccurate stud. Rotating the engine while at MID-LIFT® exposes how much the error is at the valve. To correct the error at the pushrod we need to divide the valve's motion by the rocker ratio. Let's say that our .600" VL sample engine, which was set at .300" VL for the MID-LIFT® check, required .030" more valve lift to let the tool fall flat on top of the rocker. (This would indicate the gap above the pushrod cup end of the rocker, so the STUD was leaning TOWARD the valve centerline more than it should.) Our example rocker ratio is 1.50:1, so we divide the extra valve lift of .030" by this ratio (.030/1.50=.020) and we see that the pushrod length needs to be SHORTENED by .020". Don't get confused by which way you have to go in making the correction. When you need to INCREASE the MID-LIFT point beyond what your prescribed valve lift dictate to make the tool lay flush, then you need to DECREASE the PUSHROD length to adjust the error. Obviously the opposite is true.

NOTE: *When the stud angle is found to be wrong during your MID-LIFT® check, you can only make this adjustment to the pushrod length **one time** through the above method. This step MUST follow the closed valve procedure to show the error. Once you've corrected your pushrod length (.030" in our example) you are done. Don't look to see the G-TooL™ lay flush at MID-LIFT® when you rotate around again, it won't. The stud angle is WRONG and the tool will always show this gap. But by doing the first and second steps back-to-back, you've compensated for it.*

WHAT YOU CAN DO IF YOUR STUD ANGLE IS ACCURATE

14. The instructions that accompany the PVS and Miller rocker arms describe going directly to MID-LIFT® for setting rocker geometry, and they caution that this is only as accurate as the stud angle in the head is to factory design specifications. If you have accurate stud angle, here's the information again.
    a. Set your TAPPET/CAM at exact MID-LIFT®, and keep it there.
    b. Have a dial indicator take a reading directly from the valve spring retainer and Install the rocker arm with the adjustable pushrod, then begin OPENING the VALVE by turning the rocker's adjusting screw down, being careful that the pushrod tip is seated properly in the rocker's cup, until the valve has opend to its MID-LIFT® position. LEAVE the engine frozen in this cam/valve MID-LIFT® position for the following step.
    c. Install the G-TooL™ atop the rocker arm to check for angular difference beneath it, which you will most likely have, depending on how far off your pushrod length is for what is required. Change the adjustable pushrod length in the necessary direction to correct this.
    d. Note that you will also be changing your valve lift as you change your pushrod length, so it is imperative that you correct for this to keep the valve at the same exact MID-LIFT® point. To do this, back off your adjusting nut so that the valve lift stays the same while you change your pushrod length as needed. When the G-TooL™ is flush atop the rocker, while keeping the valve at MID-LIFT®, turn the engine over again to confirm your net valve lift is accurate.

HYDRAULIC TAPPETS

With regard to HYDRAULIC tappets, either flat tappet or roller, using the G-TooL™ in the CLOSED VALVE setting is optimum and pretty much negates any checking in the MID-LIFT® position for the reasons mentioned at the beginning of these instructions. The valve action of a hydraulic tappet operates about .015" to .020" below its fully extended (new) length. Numerous factors affect final dimensions, such as valve springs, hydraulic pressure bleed-off (or bleed-down), cam rate (violence) and of course RPM's. Because a hydraulic tappet has all these variables, the .010" to .020" margin of error that can be expected in setting geometry by adding .020" more length to your pushrod measurement is immensely more accurate than any other method previously offered by other companies. But if you REALLY want high performance from your valve train, then throw your hydraulic cam away and go for a solid flat tappet. Unless sanctioning rules require them, hydraulic tappets are a very limiting compromise compared to solid links between the cam and valve (either flat tappet or roller).
For more information on cam choosing priorities, order a copy of "*CAM PRINCIPLES*."

SUMMARY

a. Install the G-TooL™ atop the closed valve rocker arm and adjust pushrod to flush their contact surface.
b. Measure the two pushrod lengths for .500" and .700" VL, respectively, and subtract the difference.
c. Calculate YOUR NET valve lift into a percentage of the .200" spread you've measured (b).
d. Apply that percentage of difference to the valve lift measurement between the two (.500" or .700").

EXAMPLE

.500" VL pushrod length is: 8.115"
.700" VL pushrod length is: 7.950"
Difference is: 0.165" (Formula: 200/165= 0.825, or .008" Pushrod per .010" VL change)

Actual NET valve lift is: .650" (Example)

A .650" VL is only 25% less than the total .200" range we're testing from the .700" VL measurement. So we only need to ADD 25% of the .165" FORMULA to our pushrod length taken at .700". This would be .040" (25% of .165" rounded off) ADDED to 7.950" gives a total length of 7.990".

CLOSING POINTS

Why does the pushrod get shorter for more valve lift when the industry has always taught you that you need longer pushrods for bigger cams**?** For the most part, using longer pushrods has always been referred to in relation to exchanging stock rocker arms for roller tip. In this case, it is true that longer pushrods are needed, but no one that I know of has ever explained why. The reason is that the measuring point between a stock rocker arm's geometry and that of a roller tip rocker arm is elevated by the **radius** of the roller, all else being equal (no change in valve lift). On a shoe tip rocker arm the contact point of the shoe itself has always been the reference point to design by. But with a roller tip rocker arm this is measured at the axis of the roller, not the bottom diameter which lays atop the valve tip. So when you increase valve lift you LOWER the MID-LIFT® point in regards to measuring 90 degrees to the valve centerline. So accordingly the rocker sits lower in relation to the valve tip, which is the starting point for all angular motion. Remember, the VALVE TIP is the key stepping stone for where all leverage of rocker motion begins. You can also set MID-LIFT® Geometry in the closed valve position by measuring how high the roller pin's axis is above the trunnion. It's simply the opposite perspective of the same answer. The trunnion should be the same height BELOW the roller pin when the valve is closed, as HALF of the valve lift. As soon as the valve opens to MID-LIFT®, the roller's axis has aligned with the rocker's axis, perpendicular with the valve. If you're asking yourself the same question I asked in 1973, there's an interesting point of history to how the cam and rocker arm industry missed all this, then ignored it. It's explained in "*History of Mid-Lift*". The reason other companies never "corrected" their designs is because the MID-LIFT® principle received a US Patent in 1982; so advertising these errors *after all this time wasn't in their favor!*

TWO POINTS**:**

(1) The MID-LIFT® point moves HALF of whatever change you make in VALVE LIFT (VL). This may be obvious, but it's often miscalculated. If you change cams from .700" to .800", this .100" change will affect your rocker height (at the trunnion/shaft) by half this amount, or .050", but the pushrod needs to be changed .080" to move the trunnion .050".

(2) I've said it *a million times***:** Where the roller sits on the valve has **NOTHING** to do with geometry**!** Geometry is "angles of motion" and using a linear reference to where the roller sits is irrelevant**!** Because the stud angle leans into the valve any changes in valve length and other factors will move the roller's distance from the stud to the valve. As long as the wear pattern is in the middle 60% of the valve's diameter, don't worry!

Finally, don't be confused by the length of these instructions. All you are doing is freezing moving parts in a fixed position that is exactly half of their operating range, so you can set the rocker height in *relation to the tip of the valve*. Only this divides the arc evenly. There's no other way to do it, and there's no other geometry to use. Period. *Remember, the difference between a **MID-LIFT**® rocker and "everybody else's" is: MID-LIFT® accomplishes setting BOTH sides of the rocker perpendicular by only setting ONE side*. Other companies were never able to explain the value of precision *pushrod-to-valve* geometry *(the essence of proper design)*, so there was never an installation reference to the pushrod, *which is the MOST important side of the rocker arm*. **MID-LIFT** rockers set this for you.

Good luck.
–jim Miller

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