NCRS Louisiana Chapter

Technical Seminar

ENGINE BELLHOUSING ALIGNMENT

By

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Presentation

1. **Introduction**
2. **Why is this Needed**
3. **Alignment Specifications**
4. **Tools and Equipment Required**
5. **Procedure for Dial Indicator Method**
6. **Making Corrections**
7. **Dial Indicator Examples**
8. **Alternative Method Using Browell Tool**
9. **Miscellaneous Applications**
10. **Reference Information:**

    - **Detailed Bellhousing Alignment Procedure from Classic Motorsports Group**
    - **RobbMc Performance and Lakewood Alignment Dowel Part Numbers**

Introduction

- **Providing support to Bill Folse for his 1970 Corvette rebuild and restoration**
- **ZZ502 GM crate engine (502 HP/567 FT-LBS)**
- **Keisler Tremec TKO 500 5-speed transmission**
- **Bellhousing alignment work done about 2 years ago**
- **(Pics 1-2)**

Why is this Needed

- **You are having problems with transmission operation, shifting, unusual noise(s), or pilot bushing wear.**

- **The engine has been align bored during a rebuild.**

- **Installing an aftermarket (racing) bellhousing or a replacement GM bellhousing from another car.**

- **Replacing a bronze pilot bushing with a needle pilot bearing. (Pic 2A)**

- **Replacing the transmission with a newer aftermarket type.**

- **Transmission manufacturer requires bellhousing alignment to maintain the warranty.**

- **You want to know what the alignment is on your bellhousing, and that it is installed within OEM specifications.**

- **GM usually got it right the first time. Bellhousing alignment checks are not generally needed if you are simply replacing the flywheel, clutch and pressure plate, throw-out bearing, or pilot bushing.**

Alignment Specifications

- **According to Keisler Engineering and other recognized transmission builders, mechanics, and racers, acceptable engine to bellhousing alignment is**

  Maximum concentric offset of +/- 0.005 inch

  This corresponds to a Total Indicator Reading (TIR) of 0.010 inch.

- **The specification for bellhousing face parallel alignment is +/- 0.001 inch. This corresponds to 0.002 inch TIR.**

- **The 1957 Chevrolet Service Manual states that 0.008 inch runout (offset) is acceptable for manual transmission equipped cars. Problems begin to occur at offsets greater than 0.010 inch.**

- **The reason for the tighter specification today is due to differences in transmission design and construction.**

- **A GM Muncie transmission front bearing retainer is 4.680 inch in diameter. The Tremec transmission front bearings retainer is the same.**

- **The GM bellhousing spec is 4.684 – 4.687 inch in diameter (4.685 inch is typical). A Lakewood bellhousing is typically 4.684 inch.**

- **The factory bellhousing alignment dowels and the bellhousing transmission front bearing retainer opening both have very tight tolerances, but they can still allow for a few thousands of an inch of misalignment (offset).**

Tools and Equipment

- **Dial indicator with 0.001 inch resolution and approximately a one inch overall range, or a machinist dial test indicator**

- **Magnetic or mechanical holder with adjustable arm and support**

- **Marking pens and tape**

- **Paint marker stick**

- **Pencil and paper for results**

- **Hand tools (combination wrenches, ratchet or breaker bar, extensions, sockets, hammer, pliers, screwdrivers, and Allen-head wrench set)**

- **A good quality dial indicator and magnetic stand cost about $ 100-150. Borrow one if you can.**

Procedure for Dial Indicator Method

DISCLAIMER - This procedure is based on using a standard dial indicator with a ½ to 1 inch overall travel and divisions of 0.001 inch. Inward travel of the plunger stem reads clockwise direction or to the right. This is positive (+). Outward travel of the plunger stem reads counter-clockwise direction or to the left. This is negative (-). Use of a machinist *dial test indicator* like the Starrett LAST WORD or other specialized dial indicator can slightly affect this procedure due to instrument design differences.

- **Remove the bellhousing, pressure plate, and clutch disc. Leave the flywheel installed.**

- **Remove one of the flywheel bolts to make room for the dial indicator magnetic base. Securely tighten the remaining flywheel bolts.**

  An alternative is to fabricate and install a flat, thin rectangular steel plate between two opposing flywheel bolts across the crank centerline. This will provide for the best and most secure placement of the dial indicator magnetic base. Tighten all the flywheel bolts.

- **Make sure that the factory dowel pins, engine block and bellhousing mating surfaces, and the also the bellhousing transmission mounting pad and bore are clean and free of paint and burrs. *This is critical.* Then install the bellhousing and tighten the bellhousing bolts.**

- **Install the magnetic dial indicator base on the flywheel. Attach the dial indicator and adjust the dial plunger so that it has 0.100 inch or more of preload, and that it squarely contacts the inside edge of the transmission mounting bore of the bellhousing. See attached Bellhousing Alignment Setup picture.**

  (Pics 3-10)


Bellhousing Alignment Setup
06/07/2009

- **Rotate the engine (crankshaft) so that the dial indicator plunger is at the 12 oclock position. Move the dial indicator bezel to show zero (0) at this point.**

  You may also want to use a small bit of tape and show the (+) and (–) directions from zero on the dial face.

- **Now slowly rotate the engine in the direction of normal operation until the dial indicator needle moves to the right (+) . This indicates that the bellhousing is getting closer to the centerline of the engine crankshaft. Continue rotating the engine until the indicator needle stops moving to the right and starts to move backward. This is the point of the bellhousing opening that is closest to the centerline of the crankshaft. Stop and mark this spot on the bellhousing using masking tape and a pen. Label it *closest.***

- **Continue to rotate the engine through one complete revolution. The dial indicator needle will move to the left and begin to read negative (-) values. When the indicator needle stops moving to the left and starts moving back to the right, stop and mark this spot on the bellhousing as *farthest.***

  The *closest* and the *farthest* points should be 180 degrees apart on the bellhousing.

- **Now rotate the engine so that the dial indicator plunger returns to the *closest* point. Reset the dial indicator bezel to zero (0) .**

- **Rotate the engine in the direction of normal operation through one complete revolution and record the largest negative (-) reading from zero in thousands of an inch. Since we started at the *closest* point to the crankshaft centerline, all the dial indicator readings must be negative from this point.**

  This number is your Total Indicator Reading or TIR in thousands of an inch. It is always written as a positive number, and does not have a (+) or a (–) sign.

The largest TIR number should also occur at the *farthest* point that was determined and marked earlier in the procedure.

- **Now rotate the engine to return the dial indicator plunger to the *closest* point. Verify that the dial indicator needle returns to zero.**

- **Rotate the engine through one additional revolution to repeat the TIR measurement and confirm the reading.**

- **If the TIR is 0.010 inch or less, the bellhousing in within the correct and allowable tolerance (0.005 inch or less concentric offset or misalignment).**

  If the TIR is more than 0.010 inch, then you are outside of the allowable tolerance and will need to correct it with offset dowels.

  If the TIR is greater 0.052 inch, you have either measured incorrectly or there is a problem with the bellhousing that may require replacement.

- **If the bellhousing is within specification, the alignment check is complete and no adjustment is needed. Remove the dial indicator and stand. Install any missing flywheel bolts, and torque all the bolts to specification.**

Making Corrections

- **The recommended offset dowels to correct bellhousing misalignment are manufactured by RobbMc Performance, and are available in offsets of 0.007, 0.014, and 0.021 inch. These same dowels are also available from Lakewood. Summit, Jegs, and other speed shops sell them. Part numbers and prices are listed in the reference section at the end of this procedure.**

- **To select the correct offset dowels to install, divide the TIR reading you previously obtained by 2:**

TIR/2 Reading (inch)	Offset Dowels Needed
0.005 to 0.010	0.007
0.011 to 0.017	0.014
0.018 to 0.026	0.021

- **Mark the high point of the new dowels (maximum offset point) with a paint marker for identification.**

- **Remove the bellhousing and the factory dowels, and install the new offset dowels. Use some engine oil or antiseize on the new dowels and on the Allen-head locking screws before installing them. The dowels are a tight fit into the engine block, and tap in with a small hammer.**

  The best initial position for the dowels is with their high point marks clocked at the same position as the *closest (to crankshaft center)* mark that was made earlier on the bellhousing. Make sure that both offset dowels point in the same direction.

  As an example, if the *closest* mark is located at the 5 oclock position on the bellhousing, then the high point marks on both dowels should also be at the 5 oclock position. (Pics 11-14)

- **Re-install the bellhousing and bellhousing bolts to the engine block. Tighten the offset dowel locking screws, and then tighten the bellhousing bolts. Tighten the bellhousing bolts that are closest to the dowel pins first.**

- **Mount the dial indicator, and take another set of readings as before. Locate/verify both the *closest* and *farthest* points and measure the new TIR.**

  Depending on the offset dowels installed and their positioning, the *closest* and *farthest* points may change. The TIR will definitely change. Mark these new positions on the bellhousing if they have changed, and record the new TIR. (Pics 15-17)

- **If the bellhousing is within specification, skip the next step.**

- **If the bellhousing is not within specification, small corrections can be made by loosening the bellhousing bolts and the dowel locking screws, and turning the dowels with a wrench. Turn both dowels the same amount. Then retighten the dowel locking screws and the bellhousing bolts and take another set of readings. Keep a record of your readings and dowel positions.**

  This step requires trial and error to get the bellhousing properly aligned and within specification. Take your time.

- **Once acceptable bellhousing alignment is achieved, tighten the dowel locking screws to their final 7-8 ft-lbs torque. Then perform a final/confirming alignment check.**

  Starting at the *closest* point, verify the dial indicator reads zero, and rotate the engine through one revolution. Take the final readings every 90 degrees.

- **Document the final readings, dowel positions, and *closest* and *farthest* points.**

- **Reposition the dial indicator and perform a check of the bellhousing face parallel alignment. This specification is**

+/- 0.001 inch, or 0.002 inch TIR. Rotate the engine through one revolution, and document these readings.

- **Remove the dial indicator and stand. Install any missing flywheel bolts, and torque all the bolts to specification.**

Dial Indicator Examples

Below are two examples to help in visualizing and interpreting your dial indicator readings:

Example One:

The *closest* point found per the procedure was at the 5 oclock position.

The *farthest* point was at the 11 oclock position.

The dial indicator was reset to zero at the *closest* point and the engine rotated a full revolution.

The TIR reading obtained was 0.007 inch.

The calculated concentric offset is 0.007/2 or 0.0035 inch.

Since the TIR is less than 0.010 inch (offset less than 0.005 inch), the bellhousing alignment is acceptable as is.

Example Two:

The *closest* point found per the procedure was at the 10 oclock position

The *farthest* point was at the 4 oclock position.

The dial indicator was reset to zero at the *closest* point and the engine rotated a full revolution.

The TIR reading obtained was 0.026 inch.

The calculated concentric offset is 0.026/2 or 0.013 inch

Since the TIR is greater than 0.010 inch (offset more than the 0.005 inch), offset dowels are needed

Based on the readings, a set of 0.014 inch offset dowels should be installed. The dowel maximum offset should be installed in the 10 oclock (*closest*) position.

These dowels should overcorrect the existing 0.013 inch bellhousing offset, resulting in a new bellhousing offset of 0.001 inch in the opposite direction.

The TIR and previous *closest* point and previous *farthest* point will change.

Final dial indicator readings taken after installing these offset dowels are a TIR of 0.002 inch and concentric offset of 0.001 inch. These numbers are now within the acceptable limits, and no further adjustments are needed.

Alternative Method Using Browell Tool

- **The Browell tool is a precision engineered and precision machined GO/NO GO alignment gage for the bellhousing. It provides for approximately 0.003 inch or less of misalignment (offset). See attached Browell picture.**

- **It is a two piece design. The first piece looks like a bowling pin that mounts to the engine crankshaft flange (flywheel removed) and protrudes through the transmission opening in the bellhousing. The second piece is a 3/4 inch thick ring that fits over the first piece and centers in the bellhousing opening.**

  The fit to the engine crankshaft flange is a register fit with essentially no clearance or tolerance. The ring has very close tolerances to the pin and to the bellhousing opening. The outside diameter of the ring is 4.683 inch.

- **The tool is specific to a given engine and bellhousing combination, and is not universal.**

- **If the ring can be gently pushed over the pin and through the bellhousing opening, then alignment is within acceptable specifications for proper transmission operation.**

- **If the ring cannot be gently pushed through the bellhousing opening, then the bellhousing alignment must be adjusted by using offset dowels as described earlier. (Browell Pics 1-5)**

- **The Browell tool does not measure bellhousing face parallel alignment.**

- **This tool *may not* work in every situation due to clearance stackup and limited selection of offset dowels. However, this would be rare.**

- **Tool cost new is approximately $135. The tool can also be purchased used.**

Browell Bellhousing Alignment Tool

Miscellaneous Applications

A dial indicator and magnetic stand combination can also be used to measure and troubleshoot other Corvette problems:

Problem	Measurement	Max Limit
Clutch chatter	Flywheel flatness or surface runout	0.004 inch
Air in brake system from brake rotor air pumping	Front and rear brake rotor runout	0.005 inch
	Total system runout including wheel bearing	0.009 inch
Camshaft checkout or degreeing	Cam lobe lift and duration	Varies

Reference Information

Mulder
September 2012
Rev 1

Classic Motorsports Group

Bellhousing Alignment Instructions

Before installing your new TKO transmission, it is important to make sure that your bellhousing or scattershield is properly aligned with the centerline of the crankshaft. The alignment process is called "dial indicating". If using a stock GM bellhousing or a scattershield (blow proof bell housing), dial indicating is necessary before installing your transmission. The *Classic Motorsports Group* bellhousings and the Quicktime scattershields are built and checked to be within the manufacturer's specifications (.005" tolerance). If you are using one of these bellhousings ***and your motor has not been align bored,*** in theory, dial indicating is not necessary as these units have been built and checked to be within the required Tremec tolerance***. However, checking any bellhousing for proper alignment is a good idea. Installing a bellhousing that is not centered with the crank can result in poor shifting, clutch engagement problems, worn pilot bearing, as well as accelerated wear on the transmission itself.

Unfortunately checking the alignment can be a tedious task, especially if the engine is still in the car. To check for proper alignment, you will need a dial indicator, some basic tools, and a bit of patience.

Checking bellhousing alignment

1. Make sure that dowel pins and the mating surface of the engine block are clean and free from dirt and/or paint. Next, mount the bellhousing securely to the engine block. If using a scattershield be sure to mount the block saver plate as well. Torque all bellhousing-to-engine bolts to specification.
   Note: If using a scattershield, make sure that the dowel pins protrude out far enough to let the scattershield and block plate fit on the flat part of the dowel (not on the tapered part of the dowel). If the scattershield is resting on the tapered part this will cause inaccurate measurements. It may be necessary to tap the stock dowels out far enough to allow this. Alternatively, you can purchase longer dowel pins if required.

2. Install magnetic dial indicator base on the flywheel/end of crankshaft and adjust the dial plunger so that it contacts the inside edge of the register bore of the bellhousing **(Fig. 1).** If you need to create space for the dial indicator base to sit flat on the flywheel, remove two of the flywheel bolts that are directly across from one another. Please note that the dial indicator base does not need to be dead-centered on the crank during this process but it must be solidly mounted. If you do not have a dial indicator, Summit Racing has an inexpensive one with a magnetic base for about $30 (Summit part #SUM-900016-1).

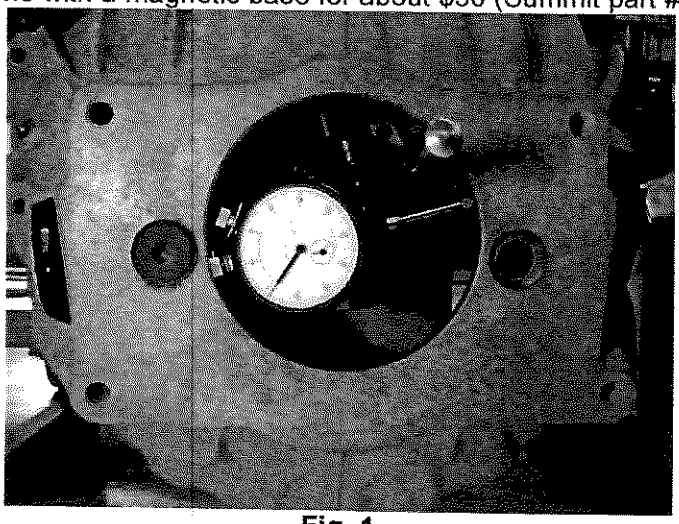


Fig. 1

3. Once you are ready to measure, there are **two** steps in aligning your bell housing.

The first step is to see what direction the bell housing is out of spec. Remember zero is the spec and .005" is the out of spec tolerance. **The second step is to see how far out of spec the bell housing is and how far you need to move it to be within the .000"- .005" spec.**

Step One:
Determine if bellhousing is in, or out, of allowable alignment tolerance
First start out with the dial indicator anywhere in the circle - it is not necessary to start at any given point. Rotate the engine (crank) until the needle on the indicator moves to the right. The needle moving to the right indicates that the bellhousing is getting closer to the centerline of the crank shaft. Continue rotating the engine until the indicator stops moving to the right and starts to move backward. Stop at this spot and put a mark on the bellhousing at this point. This is the point of the housing that is closest to the centerline of the crank shaft. For example: If the indicator finds the closest point to be at 2:00 o'clock you would need to move the housing in that direction to correct the mis-alignment (i.e. towards 2:00 o'clock and away from 8:00 o'clock). After completing this step, you will know which direction to move the housing to correct an out-of-tolerance mis-alignment.

Step Two:
Determining how far the bellhousing needs to be moved if the bellhousing is out of allowable alignment limits (greater than .005").
After finding the closest point to the centerline of the crankshaft from step 1, set the dial indicator to "zero". From this point forward as you rotate the crank, the needle on the indicator should move only to one side of zero. If it moves to the positive side of zero, you must re-zero the indicator as described in step 1. After rotating the crank (and therefore the dial indicator) 360* and watching the read out on the indicator, if your maximum measurement (needle movement) is .010" or less, your bellhousing is within allowable tolerance. *If this is the case you are finished with this process and can proceed with your installation.* If your indicator readings show more than .010", your bellhousing is NOT within allowable tolerance and you will need to correct it with offset dowel pins as described below. To understand how far out of tolerance your bellhousing is, take the highest reading on the indicator and divide this number by two. For example: If your maximum read out is .016", .016 divided by 2 is .008". In this case a set of .007" offset dowel pins will be able to correct the alignment to within .001". Offset dowel pins are available in the following sizes: ".007, .014" and .021".

Tremec, GM, Ford, Chrysler and most other manufacturers specify a maximum misalignment, or "runout" of .005". If you have more than .005" runout you will need to correct this by using offset dowel pins. If your reading is .005" or less, your bellhousing is within tolerance and you are finished with this process. If you have between .005" – .040" misalignment, you can correct the misalignment by using the correct size offset dowel pins. If this is the case with your bellhousing proceed to step #4. If your misalignment is greater than .040" you have either measured incorrectly or there is a problem with your bellhousing and it will likely need to be replaced.

4. To correct misalignment, you will need to use offset dowel pins. These dowel pins come in various sizes. Select the offset dowel pin set that is closest to ½ of the runout reading (i.e. if runout is .016" then ½ of .016" = .008"; in this instance you would select .007" dowels). If your runout is .014" you would use the, .007" dowels. If you are at .010", you also use the .007" dowels as they are closest. *We recommend RobbMC Performance Products (www.robbmcperformance.com) for a good set of adjustable dowel pins.*

5. Before installing your dowel pins It is important to mark each dowel at it's highest point which will help you to install them correctly. You can use a permanent marker and your dial indicator to do this. Doing this will assist you when you install the dowels to keep them clocked the same as each other. When you install and position your dowels they should be set with your marked high points clocked at the same position as your closest to center of the crankshaft mark that you made on the bellhousing in step 1. For example: If your closest to the center line mark is at 3 o'clock then your markings on the dowels should be at 3 o'clock.

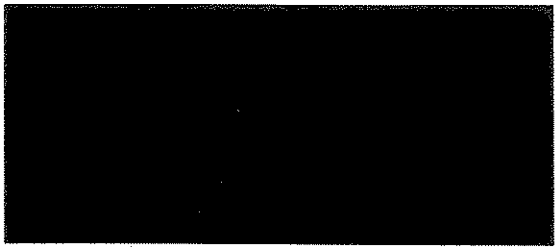
6. To remove the stock dowel pins drive them through from the front of the car towards the rear using a brass drift or by using gripper pliers or vice grips and pulling them out. Properly clean engine block dowel pin holes and lightly coat with lubricant.

7. Lubricate new offset dowel pins and install them into engine block. Remember, you must find the high spot on the dowel with the dial indicator and mark it so the dowels can be installed equal to one another. Refer to the adjustable dowel pin installation instructions supplement included with this manual.

8. Install bellhousing and torque bolts to specification. Re-mount the dial indicator and recheck runout by repeating step #2. Small corrections can be made by loosening the bellhousing bolts and turning the dowels with a wrench to bring the bellhousing within limits.

Congratulations – you have completed an important step.

**** If you are using a McLeod scattershield and you choose to check alignment, do so without the silver register ring installed in the register hole – checking alignment with this ring in place will give you a false reading.*



RobbMc Offset Dowel Pins
Installation Instructions

To correct a misaligned bellhousing, RobbMc offset dowel pins are designed for easy installation into your engine block and provide for a much simpler bellhousing alignment process.

1. After determining the direction the bellhousing needs to move, remove the bellhousing and existing dowel pins from your engine block. In most cases, it is possible to drive the existing dowels out of the block from the front side using a blunt punch and a hammer. If the front of the dowels cannot be accessed for whatever reason, the dowels can often be removed by twisting and pulling with vice grips. If this fails, the pins can sometimes be removed by drilling and tapping the ends of the dowels and using a slide hammer. If the pin is in a blind hole, it may also be possible to drill and tap all the way through the pin and then drive a screw through the pin. As the screw comes in contact with the back wall of the blind hole it will push the pin out as the screw is turned.

2. Before inserting the pins into the block, make sure the allen screws in the pins are not tight or the pins will not slip into the block. Insert the dowels into the block with the slit end of the dowel facing towards the block. The dowels should be a slip fit (or perhaps a very light press fit) into the block. If the pins do not slip in check for burrs on the pins and/or in the holes in the block. Insert the pins into the block until the offset prevents the pins from going any further.

3. Rotate the pins so that the offsets of the pins are pointing in the desired direction. Note that the two flats machined into the pins are parallel with the pin's offset. If necessary, an open end wrench can be used to turn the pins. The flats on the two pins must be parallel to one another (i.e. the pins must be rotated to the same angle) or the bellhousing will not fit over the pins. Tighten the allen head screws in the pins lightly (just enough so that the pins won't move accidentally while installing the bellhousing).

4. Re-install the bellhousing and check for alignment using your dial indicator. If the bellhousing is still not within specification (.005"), loosen the bellhousing bolts and rotate the dowels slightly using an open end wrench. Re-tighten the bellhousing bolts and recheck the alignment.

5. Once the bellhousing is aligned within .005", hold the dowels in place with an open end wrench and tighten the allen head screws to secure the dowels and lock them in place. Do not over tighten the allen head screws (8 lbs. of torque maximum). If the dowel pin needs to be turned again, the screw can be loosened and the pin can be turned to a new angle. It is not necessary to remove the pin from the block to reposition it.

6. If it is not possible to achieve proper alignment, pins with a different amount of offset may be required. Call us if you need a different set of dowels.

For questions, please call Classic Motorsports Group at 760.438.2244

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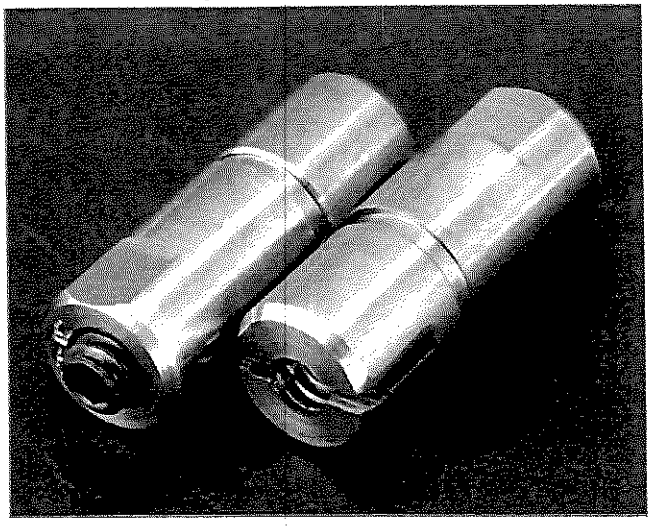
Bellhousing Alignment Dowels



Kits are $28 Each
Each kit contains two offset dowels and two screws. Three sizes and three offsets are available.

	Lakewood Part #
GM Offset Dowel Kits (.621 diameter) Fit most GM 6/8 cylinder	15907
Add to Cart PN 1011 .007 offset	
Add to Cart PN 1012 .014 offset	15914
Add to Cart PN 1013 .021 offset	15921
Ford Offset Dowel Kits (.500 diameter) Fit most Ford 6/8 cylinde	
Add to Cart PN 1014 .007 offset	
Add to Cart PN 1015 .014 offset	
Add to Cart PN 1016 .021 offset	
Mopar Offset Dowel Kits (.496 diameter) Fit most Mopar 6/8 cylinder	
Add to Cart PN 1017 .007 offset	
Add to Cart PN 1018 .014 offset	
Add to Cart PN 1019 .021 offset	

Bellhousing alignment is critical to ensure smooth shifting and maximum clutch life. The hole in the rear face of the bellhousing should be concentric with the crankshaft within .005" (.010 TIR).

Unfortunately, many aftermarket (and even some stock) bellhousings are not as concentric as they should be. This may be due to a problem with the bellhousing and/or the engine block.

Once the amount and direction of the misalignment are determined, offset dowels can be used to correct the problem. Unfortunately, a bit of trial and error is usually required to get the offset dowels pointed in the right direction.

At least two other companies currently make offset bellhousing dowels. Both brands make their dowels with a screwdriver slot which is to be used to rotate the dowels.

"Brand L" dowels are designed to be pressed into the block. Unfortunately they either fit so tight they have to be removed in order to rotate them, or they fit so loose they won't stay at the proper angle. (The instructions that come with the "Brand L" pins even state that the alignment must be rechecked every time the bellhousing is removed). "Brand L" dowels come in two sizes; one for GM and one for Ford/Mopar. The Ford/Mopar size is a compromise. This means they fit so tight in a Mopar engine block that they usually have to be pounded in with a big hammer and are nearly impossible to remove let alone rotate.

"Brand M" dowels slip easily into the engine but the block must be drilled and tapped in two places so that set screws can be installed to prevent the dowels from rotating once they are pointed in the correct direction. This is difficult at best and nearly impossible if the engine is still in the vehicle. "Brand M" dowels are available only for GM engines.

RobbMc bellhousing dowels are unique. They slip easily into the engine block and are designed to be turned with an open end wrench rather than a screwdriver. Once they are pointed in the correct direction, a screw (which runs down the center) is tightened which prevents the dowel from rotating. No need to pound the pins in and out. No drilling and tapping required. No need to recheck the alignment if the bellhousing is removed. Three sizes are available so they fit each engine correctly. Dowels are longer than stock so engine plates can be used.

RobbMc Alignment Dowels Installation Instructions
Note: Microsoft Word is required to view/print this document.

Top of Page

Back to Products Page