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CAUTION: READ INSTRUCTIONS CAREFULLY BEFORE STARTING PROCEDURE

INTRODUCTION

Talk to any cam grinder, engine builder, or racer and you'll find overwhelming agreement that "degreeing-in" a camshaft is a vital step along the route to optimum engine performance. At first that may seem strange because "degreeing-in" a cam pertains to checking the accuracy with which it was manufactured.

Actually, by degreeing-in a camshaft, you're insuring that valve opening and closing events are in accordance with specifications, regardless of the cause. Actual valve opening and closing events are influenced not only by accuracy with which a cam was ground, but also timing chain stretch, keyway position in the crankshaft, crank timing sprocket, and dowel pin hole position in the cam sprocket also play a major role.

Crane Cams' Tune-A-Cam Kit (Pt. No. 99030-1) contains everything needed to degree-in a cam: Degree wheel; pointer; dial indicator; positive piston stop; checking valve springs; plus a unique dial indicator mounting base that screws into a valve cover retaining bolt hole. This allows you to degree-in the cam with the heads installed, or off the engine. The mounting base is the key to Tune-A-Cam's ease of use, as the dial indicator is easily positioned for proper alignment. Minor adjustments are all that is required for optimal geometry between the dial indicator and the pushrod. This makes for consistent and more accurate cam checking, and pays off with improved performance.

WHY DEGREE-IN YOUR CAM

The purpose of degreeing a cam is to insure that the cam is phased correctly with the crankshaft, per the cam manufacturers' specifications. Some factors that may cause improper phasing are:

1. Cam or crank gears are incorrectly marked.
2. Keyways are out of position on gears.
3. Keyway in the crankshaft is misindexed.
4. Cam dowel pin or keyway is misindexed.

It is the exception, rather than the rule, that a cam may be out of phase, but this should be established to insure an accurate performance baseline or point of tune.

EQUIPMENT NEEDED

There are four essential pieces of equipment needed to properly check a cam: (1) An accurate Degree Wheel for the crankshaft. (2) A rigid pointer that can be attached firmly to the engine and indicate points on the Degree Wheel. (3) A Dial Indicator to accurately measure cam lift. (4) A Top Dead Center Piston Stop. You will find each of these pieces of equipment supplied in your Tune-A-Cam-Kit.



Tune-A-Cam Kit

The supplied Degree Wheel is a metal plate with its outer circumference divided and marked into 360 degrees. This is attached to the snout of the crankshaft, so the wheel can be rotated to adjust its reading in relation to crank angle/degree. The larger the wheel diameter, the more accurately you can read it, since there will be a greater distance between the degree points.

BEGINNING TO DEGREE YOUR CAM

1. Be sure that the timing set is installed with the cam and crank gear aligned properly per the manufacturer's specifications.
2. Remove the rocker arms.

MOUNTING THE DEGREE WHEEL

1. Attach the degree wheel (using the supplied aluminum bushings if necessary to center the degree wheel) to the crank snout or balancer. In our example, we use the crank snout. (Figure 1)
2. Attach the pointer from your kit firmly to the engine block. (Figure 1)



Figure 1.

FINDING TOP DEAD CENTER (TDC)

1. Rotate the crankshaft until you get number one piston in approximate TDC position. Next, adjust your pointer to the zero TDC position on the degree wheel. (Figure 1)
2. It is essential at this point that you have some means of rotating the crank that will not interfere with the degree wheel. The crank can be rotated from either the front or the flywheel end. The greater the leverage, the smoother you can rotate the crank for timing checks. (Do not use the starter for turning the engine while degreing).
3. Now that the Degree Wheel has been set at approximate TDC, and a means for turning the crank provided, you're ready to install and set the piston stop.

Turn the crankshaft to lower the piston enough in the cylinder to move the degree wheel 15-20 degrees. With the rocker arms removed, screw in the piston stop until it contacts the piston. (Figure 2) Turn the engine in the same direction until the piston comes

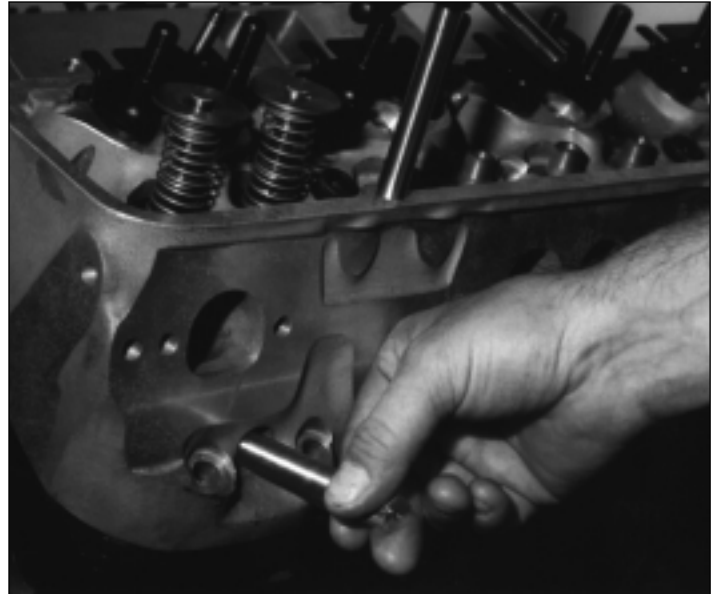


Figure 2.

back up and touches the piston stop. Make a note of what degree the pointer is on the degree wheel. Turn the engine in the opposite direction until the piston comes back up and touches the piston stop. Make a note of what degree the pointer is on the degree wheel. Add these two numbers together then divide them in half. Example: Let's say that the stop points are 16° in one direction and 20° in the opposite direction. The total would be 36 degrees. This figure divided in half would be 18 degrees. Therefore 18 degrees from either of your stop points is true top dead center. Now either move the pointer to align with the 18 degree mark on the degree wheel, or carefully loosen the degree wheel (without disturbing the position of the crankshaft) and move the degree wheel to the 18 degree mark, making sure that the piston is still against the stop. Now turn the engine in the opposite direction until the piston comes back up and touches the stop. The pointer should be aligned with the 18 degree mark on the other side of the TDC mark. If this is correct, then you have found true top dead center. It is best to repeat this to make sure that nothing has moved. If you didn't get 18°, as per our example, you will need to repeat the procedure until you get the same amount of degrees on both sides of TDC. Remove your piston stop and you are ready to properly degree your cam.

MOUNTING THE DIAL INDICATOR

1. The Dial Indicator mount in this kit is designed to attach into a valve cover bolt hole. Remove any obstructions that would hinder this mounting. We will be checking cam timing so the rocker arms must be removed. Be absolutely certain that you use the correct type of lifter for the camshaft that is being degreed. This means a flat tappet for a mechanical or hydraulic cam (do not use a hydraulic lifter, as the plunger can move), or a mechanical roller tappet for a roller camshaft. You should also take particular care to clean off any excessive oil, grease, or lubricant from the cam lobe that you are degreeding. Even the slight interference of such foreign matter can alter the readings that your dial indicator will show.



Figure 3.

2. A pushrod is needed to be used as an extension of the dial indicator. The indicator will center in the oil hole of the pushrod tip. (Figure 3) On engines with pushrods that don't have oil holes i.e., FE Series Ford and Chrysler, you will need to obtain a pushrod with an oil hole or cup end for checking purposes or use a dial indicator extension.

Install the pushrod in the intake lifter of cylinder No. 1 and mount the dial indicator. It is important that the indicator plunger be aligned as closely as possible with the lifter being measured. Any substantial angle between the axis of the plunger and the lifter will introduce geometrical errors into the lift readings. (Figure 4)

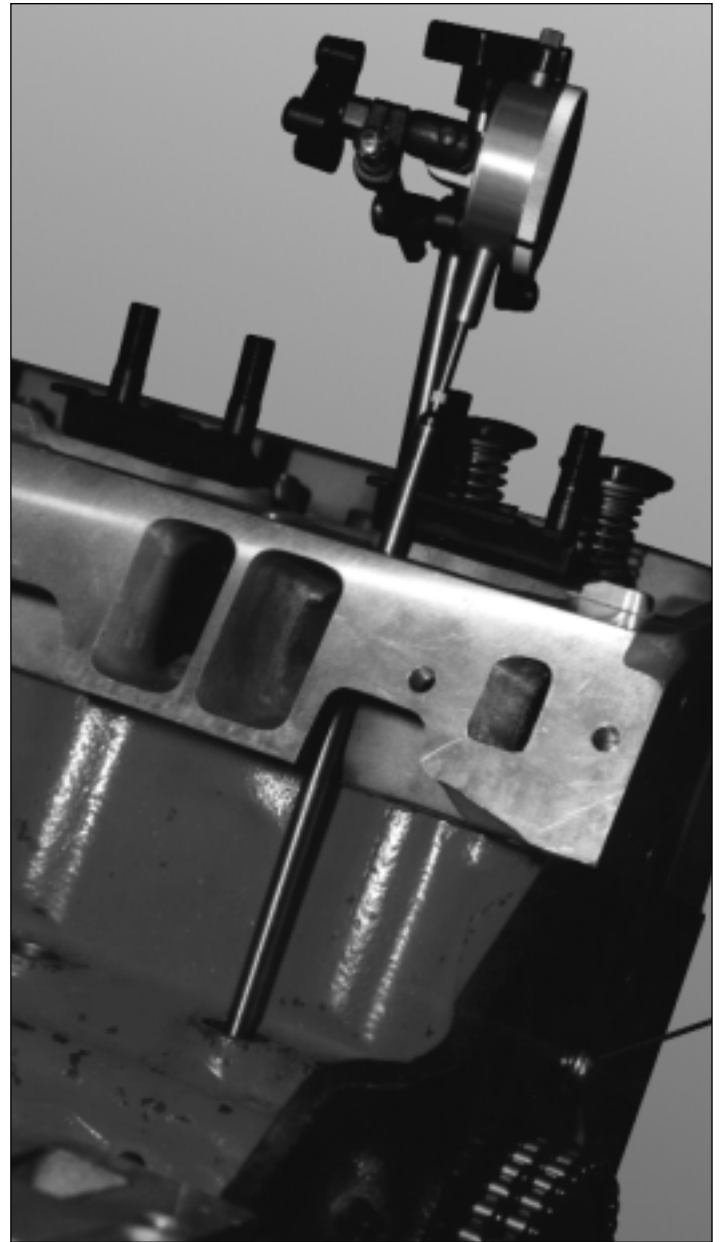


Figure 4.

CAUTION: Be sure that the indicator is supported solidly. Any looseness will introduce major errors in measurement.

3. With the Degree Wheel and its pointer accurately set, and the Dial Indicator solidly in place, rotate the crankshaft until the cam's base circle is under the lifter for the cam lobe being measured (usually starting with Number One intake). (Figure 4) Set the dial indicator to zero at this point. Be sure the Dial Indicator is pre-loaded about .300" to insure that it will not run out of travel while on the base circle. Rotate the crankshaft to raise and lower the lifter several times to verify that the dial always returns to

zero when the lifter is on the base circle. If it doesn't return to zero, there are several possible causes: (1) The dial indicator may not be mounted rigidly (2) The lifter may not be contacting the base circle solidly (3) The lifter could be sticking slightly in its bore. Find the trouble and correct it before proceeding.

It may be necessary to apply slight finger pressure against the lifter when rotating the engine. Be careful not to bump the pushrod.

Any of these camshaft checks that may be performed (base circle runout, cam timing, etc.) are also very dependent on your cam bearings being in good condition and providing the proper radial clearance for the type and size of bearing. Excessive radial clearance will distort your figures taken of tappet movement, resulting in incorrect conclusions regarding the camshaft installation and its condition.

CHECKING BASE CIRCLE RUNOUT

This is a good time to check for runout of the cam's base circle. This is out of roundness, or wobble, during rotation. If the cam lobe is concentric with the camshaft bearing journals there shouldn't be any appreciable runout. We try to hold base circle runout to less than .001 inch for optimum cam performance and ease of setting lash. If the runout on your cam measures more than .002" we suggest returning it to the manufacturer.

If there is measurable base circle runout on your cam, adjust the dial indicator so the runout is divided equally on both sides of zero. This will give the minimum error for checking the cam's timing.

CAM SPECIFICATION CARD

All the information you need for checking the timing accuracy and phasing of a camshaft is provided on the specification card that you receive with your Crane cam. (Figure 5) This will include the opening and closing timing points and the amount of lift (at the lifter) at which the timing should be checked. (Figure 5, K)

WHICH CAM DEGREEING METHOD TO USE ?

There are two popular methods for degreeing a cam: (1) using the opening and closing figures at .050" tappet lift off the base circle of the cam; (2) using the intake centerline method.

We believe that degreeing the cam using the opening and closing at .050" lift is much more accurate. The problem with the centerline method is it has you finding the theoretical centerline of the intake and/or exhaust lobe. It makes the assumption that the lobe you are checking is symmetrical, with its opening side being the exact same shape as the closing side of the lobe. Most modern cam lobes are asym-

metrical, with the opening side of the lobe being much more aggressive and the closing side being more gentle. Therefore when you attempt to locate the middle (or centerline) of the asymmetrical lobe there is an automatic error. It could be as little as 2° or as much as 6° depending on the actual lobe design. Also, the centerline method does not really indicate if your camshaft was properly produced, as no confirmation of the duration occurs. Since the opening and closing at .050" lift method is not affected by the lobe design, it is more accurate to degree this way. This method will also verify your actual duration figures.

When checking, always turn the engine in the normal direction of rotation because of possible slack in the timing chain or gear drive.

DEGREEING YOUR CAM

Using the intake opening and closing at .050" cam lift, obtained from the information on your cam spec card (Figure 5, K), turn the engine in the normal direction of rotation. Watch the dial indicator. When it moves up .050", stop rotating the engine. Record the degree wheel number that the pointer is on. (In our example it is 12° BTDC, Figure 6). Then continue to rotate the engine in the same direction. Watch the dial indicator, it will change direction at maximum



Figure 6.

lobe lift. Record the cam lobe lift. Continue to rotate the engine in the same direction until you reach .050" before closing. (In our example it is 42° ABDC). (Figure 7) If you go past either of the .050" marks, back up at least .100" and rotate the engine in the normal direction again until you reach the .050" mark on the indicator.

488

A PART NO: 114561
B GRIND NUMBER CCH-296-2
C ENGINE IDENT. 1957-1987 CHEVROLET V-8 262 THRU 400 CU. IN. HYDRAULIC SPECIAL

VALVE SETTING: INTAKE .000	EXHAUST .000	HOT
INTAKE @ CAM 315	@ VALVE 473	ROCKER ARM RATIO 1.50
LIFT: EXHAUST @ CAM 325	@ VALVE 488	ALL LIFTS ARE BASED ON ZERO LASH AND THEORETICAL ROCKER ARM RATIOS
CAM TIMING @ .004	OPENS INTAKE 37 BTDC	CLOSES EXHAUST 79 ABDC
TAPPET LIFT	EXHAUST 81 BBDC	ADVERTISED DURATION 296
		304

SPRING REQUIREMENTS				RECOMMENDED RPM RANGE, WITH MATCHING COMPONENTS
TRIPLE	DUAL	OUTER	INNER	
PART NUMBER 99838				MINIMUM RPM 3000
LOADS: CLOSED 110 LBS.	@ 1.688	OR 1 11/16		MAXIMUM RPM 6500
OPEN 312 LBS.	@ 1.228			VALVE FLOOR 6500

CAM TIMING @ .050	OPENS INTAKE 12 BTDC	CLOSES EXHAUST 42 ABDC	MAX LIFT 105	DURATION 234
TAPPET LIFT	EXHAUST 56 BBDC	@ 6 ATDC	115	242

M REMARKS:

CRANE CAMS, INC.
 530 FENTRESS BLVD, DAYTONA BCH, FL 32114 904-258-6174

- A Part Number** These events are not meant for degreeing the cam. You must use the events (K) at .050 lifter rise (tappet lift) only.
- B Grind Number** refers to engineering design information only. (This is not a part number).
- C Identification** of the engine series.
- D Recommended valve setting** for the particular camshaft profile. This represents the running clearance or Valve Lash required. This setting is chosen for maximum performance and valve train reliability.
- E Cam lobe lift** as measured at the lifter (tappet) with a dial indicator having .500 inch minimum travel capacity.
- F The valve lift** data is determined by multiplying the cam lobe lift by the rocker arm ratio.
- G The rocker arm ratio** listed is the engine manufacturer's standard specified ratio.
- H The cam timing** events used to compute advertised duration. The opening and closing events, and at what lifter rise (tappet lift) they were taken at, show how the **advertised duration** is calculated.
- I The valve spring** requirements shown represent the maximum safe closed and open spring loads, and the most reliable valve springs for the camshaft profile and valve train combination.
- J Recommended RPM** range is to be used as a guideline. This will vary depending on equipment combinations.
- K Cam timing** figures at .050 lifter rise (tappet lift) are provided for degreeing of the camshaft. They are expressed in degrees of crankshaft rotation.
- L The maximum lift** (centerline) figures shown represent the theoretical maximum lift points of the intake and exhaust lobe centerlines. Due to most modern cam lobe designs being non-symmetrical this may not be the actual point at which the centerline occurs. This figure is provided as a point of reference and should not be used to degree a camshaft.
- M** When necessary, special instructions are provided at the bottom of the cam card.
- Example:**
- | | |
|---------------|----------------------------|
| 37° | B.T.D.C. Intake Opening |
| + 180° | Crankshaft Rotation |
| + 79° | A.B.D.C. Intake Closing |
| <u>= 296°</u> | <u>Advertised Duration</u> |

Figure 5.

Again record the degree wheel number that the pointer is on. Continue on to zero lift and verify that the dial indicator has returned to zero. The opening and closing figures should be within ± 1 degree. If your figures are not within ± 1 degree, go through the procedure again to check for possible error. If your opening and closing figures are still not correct you will need to move the cam in relation to the crankshaft in order to correct your opening and closing figures. If the cam is opening early, the cam is too far advanced, and will need to be moved in the opposite direction of the cam rotation. If the cam is opening late, the cam is too far retarded, and will need to be moved in the direction of cam rotation. Depending on the engine being used, there are usually offset bushings, offset keys, or multi-indexed gears to accomplish this movement.



Figure 7.

If your opening and closing figures at .050" are not the same as your cam card they should be "off" the same amount of opening as closing, and the intake and exhaust should all be "off" the same amount. If this is the case, the correct bushing or key will bring everything in place. Always recheck your opening and closing figures when moving the cam. If the opening and closing figures are not off the same amount or the intake and exhaust are not off the same, this would mean that the duration, and/or lobe separation is different than your specification card. If you have this type of problem contact your cam manufacturer for more information.

Do not remove the degree wheel if you are going to check piston to valve clearance at this time. Reference the piston to valve section of these instructions.

If your cam card does not show the opening and closing at .050" lift (All Crane and Cam Dynamics cam cards do!) then you must use the intake centerline method to degree your cam. We believe that degreing the cam using the opening and closing at .050" lift is much more accurate. The problem with the centerline method is it has you finding the theoretical centerline of the intake and/or exhaust lobe. It makes the assumption that the lobe you are checking is symmetrical, with its opening side being the exact same shape as the closing side of the lobe. Most modern cam lobes are asymmetrical, with the opening side of the lobe being much more aggressive and the closing side being more gentle. Therefore when you attempt to locate the middle (or centerline) of the asymmetrical lobe there is an automatic error. It could be as little as 2° or as much as 6° depending on the actual lobe design. Since the opening and closing at .050" lift method is not affected by the lobe design, we believe it is more accurate to degree this way. This method will also verify your actual duration figures. To understand cam timing specifications, you must first understand the difference between intake and exhaust centerline and lobe centerline (which should be more understandably stated as lobe separation). Lobe centerline (or separation) is the distance in cam degrees between the maximum lift point (centerline) of the intake lobe and the maximum lift point (centerline) of the exhaust lobe. This separation is ground in the cam and can't be changed unless the cam is reground. Intake and exhaust centerline relates to the phasing (timing) of the cam to the crankshaft.

To locate the intake or exhaust centerline you must find maximum lift of that lobe. As in finding TDC, you must begin by using an arbitrary figure, such as thousandths of an inch instead of degrees, say .050". With the dial indicator on the intake lifter, rotate the engine in the normal direction until you reach maximum lift. This is where the dial indicator changes direction. At this point set the dial indicator at zero. Back the engine up until the dial indicator reads .100". Turn the engine back in the normal direction of rotation until the dial indicator reads .050". At this point, record the degree number that the pointer is on. Continue to rotate in the normal direction of rotation until the dial indicator goes past zero to .050" on the other side of maximum lift. Record the degree number that the pointer is on. Add the two degree numbers together and divide by two. That number will be the location of the maximum lift point of the intake lobe in relation to the crankshaft. As you can see, this method does not tell you anything about the cam, or how accurately it is made.

If the cam card you are using does not state what the intake centerline is, don't assume that any number on that spec card is the intake centerline. In most cases the lobe separation (lobe centerline) is not the same as the intake centerline. The Crane/Cam Dynamics cam card notes this information (Figure 5, L).

Once the cam is phased with the crank, per the manufacturer specs, then a baseline can be established. From that baseline of performance you can dial the cam exactly to your combination. The cam can be advanced or retarded from the card specs up to 6 degrees. Advancing the cam will move the power band down in the RPM range. (Increased low-rpm torque). Whatever you gain on the bottom end you will lose on the top. Retarding the cam will move the power band up in the RPM range. If 6 degrees is not enough, a different camshaft profile would be needed. Be aware that when you advance the cam you will lose intake piston to valve clearance, and when retarding the cam you will lose exhaust piston to valve clearance. Now would be a good time to check the cam advanced and retarded and with the highest ratio rockers you will use.

CHECKING PISTON TO VALVE CLEARANCE

When you install a high performance cam, it is possible that there may not be sufficient clearance between valves and pistons when near TDC on overlap. Even if they don't touch when you rotate the crankshaft slowly by hand, they may hit and damage the engine at high revs due to slight "Floating" of the valves, stretch in the rods, deflection in the valve train, and other causes.

We recommend at least .080" clearance between intake valves and pistons at all times, and at least .100" for exhaust valves, which expand more with heat. Add .030" to these figures if you have aluminum rods in the engine to allow for their expansion and stretch.

If you are using aftermarket heads, many of them have modified valve positions and/or valve angles. This may cause valve to piston valve relief alignment problems. If your engine is equipped with an aftermarket head of this type, we recommend checking piston to valve over a broader range.

The easiest way of checking piston to valve clearance in an engine, with the cylinder heads installed, is to install a pair of light checking springs in place of the valve springs. These light checking springs (supplied in the Crane Tune-A-Cam kit) will allow you to depress the valve easily at any time during the entire rotation of the engine, enabling you to measure the piston to valve clearance.

If you are going to use rocker arms with a higher than stock rocker ratio now or in the future, you will need to check piston to valve clearance with the higher ratio rocker at this time. (Higher ratio rockers increase gross valve lift).

After the light checking springs are installed in place of the standard valve springs, install the rocker arms and then adjust valve lash to zero, zero lash will work best to give you flexibility if at any time you want to tighten or loosen lash to change performance characteristics, you'll know that you have sufficient clearance. Be absolutely certain that you use the correct type of lifter for the camshaft that is being

checked. This means a flat tappet for a mechanical or hydraulic cam (do not use a hydraulic lifter, as the plunger can move), or a mechanical roller tappet for a roller camshaft. Remember, always use a flat tappet lifter on a flat tappet cam and a roller lifter on a roller cam.

As a general rule, the closest point of piston to valve clearance during the rotation of an engine, is between 15 degrees and 5 degrees before top dead center overlap for the exhaust valve, and between 5 degrees and 15 degrees after top dead center overlap for the intake valve. This sequence takes place during the overlap cycle when both valves are open, 360 degrees from the top dead center compression stroke.

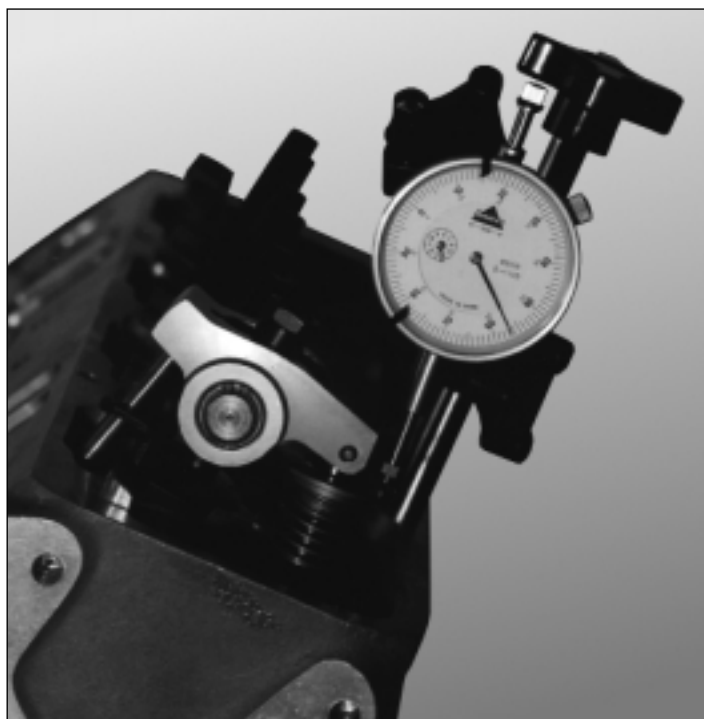


Figure 8.

1. With your degree wheel still mounted to the engine in correct TDC position, and the valves adjusted to zero lash, turn the engine in its normal direction of rotation until you come to 15 degrees before top dead center overlap on your degree wheel, then set the tip of the dial indicator on the exhaust valve spring retainer, in line with the movement of the valve. (Figure 8) Preload the dial indicator to about the mid-point of travel, and set to zero. Depress the valve with your finger by pressing on the valve end of the rocker arm until the exhaust valve contacts the piston, make a note of the reading on the dial indicator, and record the clearance. Now, continue turning the engine in its normal direction two degrees at a time, checking and recording the clearance every two degrees until you reach top dead center, on your

degree wheel. Remember, since the valve will be moving, the dial indicator will not return to zero. You can either subtract the difference or reset the dial indicator back to zero each time before you make your clearance check.

2. Move the dial indicator to the intake retainer and start checking the intake piston to valve clearance the same way you checked the exhaust, except begin at top dead center and continue to 15 degrees after top dead center, turning the engine in its normal direction of rotation. The actual position of closest piston to valve clearance will depend on how far advanced or retarded your cam is. Remember, as you advance your cam you will lose intake piston to valve clearance and as you retard your cam you will lose exhaust piston to valve clearance.

CHECKING CRANKSHAFT END PLAY

Crankshaft end play is the maximum forward versus the maximum rearward movement of the crankshaft when installed in an engine with the main cap bolts torqued to specifications.

On engines with a locating dowel (or pin) for the thrust main cap, and using a wick or rope seal, it may be easier to check end play with rear main seal removed.

After the crankshaft is installed and the main cap bolts are torqued, mount the dial indicator stand to the front of the engine block. Use a front cover bolt hole in a appropriate location to facilitate the use of the dial indicator, contacting the front end of the crank snout and parallel with the crankshaft. Set the dial indicator to zero when the crankshaft is

either in the most forward or most rearward position. Move the crankshaft in the opposite direction. The movement of the dial indicator indicates end play. Pry the crankshaft back and forth several times to insure accuracy. If end play was checked with rear main seal removed, install the seal if proper crankshaft end play has been achieved and torque the main cap bolts.

On engines with no locating dowel (or pin) for the thrust main cap, you will need to use the crank thrust flange to properly locate the thrust main cap and bearing. This is done by forcing the crank both forward and rearward by prying between the crankshaft counterweight and block. (This operation is done with main cap bolts torqued to 15 ft. lb.). This should properly align the thrust main cap and bearing. Check the crankshaft end play. Torque main cap bolts to specs and check end play again. The end play should not change more than .005". If end play changes more than .005" this indicates that the thrust main cap and bearing are not properly aligned. Loosen only the thrust main cap bolts and repeat this procedure.

The recommended crankshaft end play tolerances can range from .003" to .013" and are too numerous to mention. Check your engine overhaul manual. In race applications .004" to .008" is generally used. Here again, it is best to check with crankshaft and bearing manufacturers or high performance engine builders for specific applications.

It is also advantageous to check crankshaft end play once the engine is installed and drive train is in place. You should have the same end play as you checked it on the engine stand. This will insure that nothing (clutch, converter, input shaft, misaligned drive train, etc.) can cause excessive pressure on the thrust bearing.