State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER D-225-2
Relating to Exemptions Under Section 27156
of the Vehicle Code

CRANE CAM, INC.
COMPUCAM 2000 SERIES 2021

Pursuant to the authority vested in the Air Resources Board by Section 27156 of the Vehicle Code; and

Pursuant to the authority vested in the undersigned by Sections 39515 and 39516 of the Health and Safety Code and Executive Order G-45-5;

IT IS ORDERED AND RESOLVED: That the installation of the Compucam 2000 series manufactured by Crane Cams, Inc. of 530 Fentress Blvd., Daytona Beach, FL 32114 has been found not to reduce the effectiveness of the applicable vehicle pollution control system and, therefore, is exempt from the prohibitions of Section 27156 of the Vehicle Code for 1991 and 1992 federally-certified Ford trucks sold in California equipped with 302 CID (5.0L) or 351 CID (5.8L) V-8 gasoline engines, engine families MFM5.8T5HZC0 & NFM5.8T5HZC1, with multipoint fuel injection.

This Executive Order is valid provided that installation instructions for this Compucam 2000 Series will not recommend tuning the vehicle to specifications different from those submitted by Crane Cams, Inc.

Changes made to the design or operating conditions of the camshafts, as exempt by the Air Resources Board, which adversely affect the performance of a vehicle's pollution control system shall invalidate this Executive Order.

Marketing of this performance package using any identification other than that shown in this Executive Order or marketing of this performance package for an application other than those listed in this Executive Order shall be prohibited unless prior approval is obtained from the Air Resources Board. Exemption of the performance package shall not be construed as exemption to sell, offer for sale, or advertise any component of the kit as an individual device.

This Executive Order does not constitute any opinion as to the effect the use of this performance package may have on any warranty either expressed or implied by the vehicle manufacturer.

THIS EXECUTIVE ORDER DOES NOT CONSTITUTE A CERTIFICATION, ACCREDITATION, APPROVAL, OR ANY OTHER TYPE OF ENDORSEMENT BY THE AIR RESOURCES BOARD OF CLAIMS OF THE APPLICANT CONCERNING ANTI-POLLUTION BENEFITS OR ANY ALLEGED BENEFITS OF CRANE CAMS' COMPUCAM 2000 SERIES CAMSHAFTS.

No claim of any kind, such as "Approved by the Air Resources Board" may be made with respect to the action taken herein in any advertising or other oral or written communication.

Violation of any of the above conditions shall be grounds for revocation of this order. The order may be revoked only after ten day written notice of intention to revoke the order, in which period the holder of the order may request in writing a hearing to contest the proposed revocation. If a hearing is requested, it shall be held within ten days of receipt of the request and the order may not be revoked until a determination after hearing that grounds for revocation exist.

Executed at El Monte, California, this 25th day of September, 1991.

R. B. Summerfield
Assistant Division Chief
Mobile Source Division

State of California
AIR RESOURCES BOARD

EVALUATION OF CRANE CAMS, INC. COMPUCAM 2000 SERIES FOR EXEMPTION FROM THE PROHIBITIONS OF VEHICLE CODE SECTION 27156 IN ACCORDANCE WITH SECTION 2222, TITLE 13, OF THE CALIFORNIA CODE OF REGULATIONS

September 1991

State of California
AIR RESOURCES BOARD

EVALUATION OF CRANE CAMS, INC. COMPUCAM 2000 SERIES FOR EXEMPTION FROM THE PROHIBITIONS OF VEHICLE CODE SECTION 27156 IN ACCORDANCE WITH SECTION 2222, TITLE 13, OF THE CALIFORNIA CODE OF REGULATIONS

by

Mobile Source Division
State of California
Air Resources Board
9528 Telstar Avenue
El Monte, CA 91731

SUMMARY

Crane Cams, Inc. has applied for an exemption from the prohibitions of Vehicle Code Section 27156 for their Compucam 2000 series 2021 camshaft for installation on 1991 and 1992 federally-certified Ford trucks sold in California, equipped with 302 CID (5.0L) or 351 CID (5.8L) V-8 gasoline engines, engine families MFM5.8T5HZCO & NFM5.8T5HZC1, utilizing multipoint electronic fuel injection. Crane Cams has submitted a completed application and all the required information, as well as exhaust emissions test data performed at Crane Emissions Laboratory which demonstrated that the specified camshafts do not have any adverse effect on the exhaust emissions of the affected vehicles.

Based on the submitted information and the results of the emissions tests performed at Crane Emissions Laboratory, the staff concludes that the installation of Crane Cams' Compucam 2000 series will not adversely affect exhaust emissions on the specified vehicles.

The staff recommends Crane Cams, Inc. be granted an exemption as requested and that Executive Order D-225-2 be issued.

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EVALUATION OF CRANE CAMS, INC. COMPUCAM 2000 SERIES FOR EXEMPTION FROM THE PROHIBITIONS OF VEHICLE CODE SECTION 27156 IN ACCORDANCE WITH SECTION 2222, TITLE 13, OF THE CALIFORNIA CODE OF REGULATIONS

I. INTRODUCTION

Crane Cams, Inc. of 530 Fentress Blvd., Daytona Beach, Florida 32114, has applied for an exemption from the prohibitions of Vehicle Code Section 27156 for their Compucam 2000 series 2021 camshaft for installation on 1991 and 1992 federally-certified Ford trucks sold in California, equipped with 302 CID (5.0L) or 351 CID (5.8L) V-8 gasoline engines, engine families MFM5.8T5HZCO & NFM5.8T5HZC1, utilizing multipoint electronic fuel injection.

Crane Cams has submitted a completed application and all the required information, as well as exhaust emissions test data performed at Crane Emissions Laboratory which demonstrated that the specified camshafts do not have any adverse effect on the exhaust emissions of the affected vehicles.

II. CONCLUSIONS

Based on the submitted information and the results of the emissions tests performed at Crane Emissions Laboratory, the staff concludes that the Crane Cams, Inc. Compucam 2000 series 2021 camshaft will not adversely affect exhaust emissions from vehicles for which the exemption is requested.

III. RECOMMENDATION

The staff recommends that Crane Cams, Inc. be granted an exemption as requested and that Executive Order D-225-2 be issued.

IV. COMPUCAM 2000 SERIES DESCRIPTION

Compucam 2021 is specifically designed for installation on 1991 and 1992 federally-certified Ford trucks sold in California, powered by 302 CID

(5.0L) to 351 CID (5.8L) V-8 gasoline engines, engine families MFM5.8T5HZC0 & NFM5.8T5HZC1. The camshaft operate in conjunction with the original equipment manufacturer (OEM) computer controlled multipoint electronic fuel injection along with the emission control systems already certified with the stock engines. The purpose of using the Compucam 2000 series camshafts is to increase the overall engine performance which is a direct result of modifying the valve characteristics. An example would be the increase in valve lift and duration.

The cam lobes on the Compucam 2021 has been increased by 13.68% on the intake and 7.0% on the exhaust when compared to the OEM camshaft. These increases translate to a mild increase in valve lift allowing the engine to increase its volumetric efficiency.

V. DISCUSSION OF THE COMPUCAM 2000 SERIES

Crane Cams submitted emission test results conducted at Crane Emissions Laboratory using a 1991 federally-certified Ford F-150 truck powered by a 302 CID engine. The dynamometer inertia weight and loading used during the testing were 4500 lbs. and 15.9 hp, respectively. Emission tests conducted by Crane Emissions Laboratory consisted of cold-start CVS-75 emission tests with the Compucam 2021 installed on the test vehicle. This test was used to compare vehicle exhaust emissions in the modified configuration with the applicable emission standards. The test results are shown in Table 1.

Table 1

CVS-75 TEST RESULTS

(Crane Emissions Laboratory)

	HC	CO	NOx
Emission standards	0.80	10.0	1.7
Compucam 2021 test 1	0.17	0.9	0.77
Compucam 2021 test 2	0.17	0.88	0.71

The CVS-75 emissions test results at Crane Emissions Laboratory indicate that HC, CO and NOx emissions of the Compucam 2021 camshaft is well below the emission standards. This demonstrates that the installation of the Compucam 2000 series camshafts for installation on 1991 and 1992 federally-certified Ford trucks sold in California, equipped with 302 CID (5.0L) or 351 CID (5.8L) V-8 gasoline engines, engine families MFM5.8T5HZCO & NFM5.8T5HZC1, does not adversely affect the vehicle's emissions.

Crane Cams has submitted all the required information and fulfilled the requirements for an exemption. The test results confirmed that Crane Cams' Compucam 2000 series meets the requirements for the exemption.

APPENDIX A

CRANE CAMSHAFT INSTALLATION INSTRUCTIONS

The pictures shown in these instructions are for a small block Chevrolet. Check your engine manual for timing mark alignment for other engines.

1. Disconnect the battery, drain the cooling system, and remove the radiator. Remove all accessories necessary to make the cam, lifters, and timing chain accessible. Rotate the crankshaft slowly until the timing marks are aligned as shown in Figure 1.

2. Remove the camshaft timing sprocket as shown in Figure 2, and the timing chain. Re-install the cam sprocket and slowly remove the camshaft from the block. Excessive force *is not* required. If the camshaft can't be removed easily, stop and look for the obstruction. (Such as lifters, fuel pump rod, distributor gears, etc.)

3. **Clean the cam with mineral spirits, or equivalent solvent.** Temporarily install the cam sprocket on your new Crane cam. Then, using Crane Assembly Lube (Pt. No. 99002-1), coat all of the lobes and distributor gear (Fig. 3). Lubricate the bearing journals using SAE 30 wt. oil. It is also highly recommended that you pour a bottle of Crane Cams' SuperLube (Pt. No. 99003-1) into the engine to further fortify the initial break-in oil. We *do not recommend* the use of synthetic oils with our cams and lifters, or other additives.

4. Carefully slide your cam into the block. (Fig. 4)

5. Remove the cam sprocket, install a new Crane chain, and bolt the assembly in place. Check the timing mark alignment (Fig. 5) or your engine manual. Tighten the cam sprocket retaining bolts to correct torque specifications. (Fig. 6) This is very important as most cam damage is caused by the cam gear coming loose due to improperly torqued bolts or worn keys and keyways. If the gear loosens, the cam will slide back into the block causing the lifters to hit the adjacent lobes and bearing journals. **Proper torque and locking material should be applied to the threads for camshafts with only one bolt.** Cam gears with three bolts should have bolt heads drilled and safely wired. A camshaft bolt locking plate (Pt. No. 99168-1) is recommended for Chevrolet 262-400 and 396-454 cubic inch engines. (Fig. 7)

   Several cams require a plate that bolts to the block with a spacer between the cam gear and the front cam bearing journal. Some replacement gears have the spacer made on the gear. If so, make sure the original spacer *is not* used. To check gear alignment, put a straight edge across the timing gears from top to bottom. To verify that you have the correct spacer to cam gear combination check that the camshaft end play is .004 to .008". (This procedure is for engines with cam retaining plate only.)

NOTE: Many 1972 and later Ford-Mercury V-8 engines are originally equipped with a retarded crankshaft sprocket. This may cause idling and performance problems when installing aftermarket camshafts. Eliminate this problem by installing a pre-1972 crankshaft sprocket (The non-retarded sprocket will have the alignment dot and keyway slot directly in line with each other), or by degreeing in your camshaft, or with the appropriate Crane timing chain and gear set.

6. To help prevent premature lobe wear, **new lifters *must* be installed** with this new camshaft. (No matter how new the old lifters are). O.E.M. lifters are acceptable, but we recommend new Crane performance lifters for maximum reliability. Coat the bottom of all lifters with Crane assembly lube (Pt. No. 99002-1), and place

FIG. 1—*Turn the engine over by hand to align timing marks. Check a shop manual for exact alignment.*

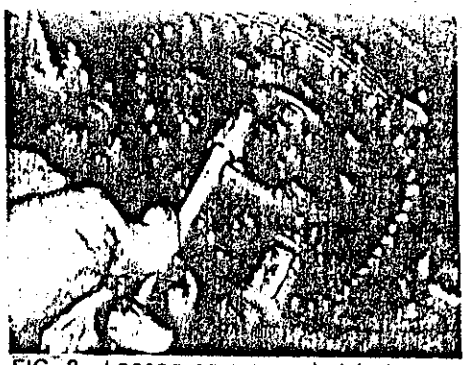


FIG. 2—*Loosen cam sprocket bolts and remove them. Place in a container and label or tag for later re-use.*

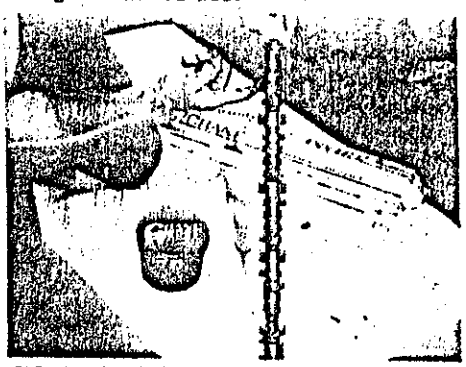
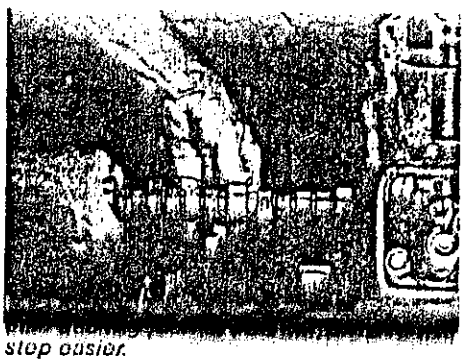


FIG. 3—*Apply lots of assembly lube to each cam lobe as shown.*



step easier.

7. If cylinder head machining capabilities are not available or desired, and stock springs and retainers are used, make certain spring travel from assembled height to coil bind is **a minimum of .060** more than the *gross* lift of the cam. Check with your Crane dealer for *available Cam-Ponent Kits* that use stock diameter springs and require no head machining. (Such as Pt. No. 11303-1, 13303-1, 52303-1, 35303-1, 36303-1, 34303-1, 80303-1, 64303-1, 69303-1, 28303-1, 86303-1.)

7A. As a general rule any cam with the same or less lift than any of our FireBall cams for any given engine should have a safe amount of piston to valve clearance if the engine, piston, cylinder head combination is stock. When using cams with the higher lift or engines with internal engine modifications to pistons and/or cylinder heads to increase compression, piston to valve clearance *must be checked.* Check with modeling clay when assembling the engine. Minimum clearance is .080 intake and .100 exhaust.

8. On engines with separate adjustable rocker arms such as small-block Chevrolet, we recommend installing the pushrods and rocker arms on one cylinder at a time and adjusting the valves on that particular cylinder. Do not tighten the adjusting nut down before adjusting the valves. (Fig. 9) If the adjustment is too tight this will cause the valve to hit the piston when you turn the engine over, resulting in bent valves, bent or broken pushrods, rocker arms studs to be pulled out of the head, and premature cam wear. On engines with shaft mounted adjustable rocker arms, back off *all* adjusters all the way before installing the assembly.

Make sure the pushrod *is in the tappet* and *in the rocker arm seat* when making valve adjustments.

For hydraulic lifter camshaft adjustment, turn the engine in the normal direction of rotation until the exhuast lifter starts to move up, then adjust the intake valve to zero lash with no preload, then ½ to 1 full turn more. Turn the engine over again until the intake is almost all the way back down. Now, set the exhaust valve to zero lash then ½ to 1 full turn more. Continue above procedure for each cylinder until all valves are adjusted the same (Fig. 10).

This procedure will give you the correct lifter preload for any hydraulic lifter cam with adjustable rocker arms. If your engine has non-adjustable rocker arms, a lifter preload of .020 to .060 must be maintained. (Fig. 11) Use the adjusting sequence as above to insure that the lifter is on the heel of the cam when preload is measured. Generally, pushrods for each cylinder should be the same unless valve stem heights are not correctly matched. When checking lifter preload make sure the valve is not open on the one you are checking. You may need to wait a few minutes for the lifter to bleed down. It may be necessary to change pushrod length, use adjustable pushrods, shim rocker stands or shafts, install straight screw in studs in place of stock bottle neck type, use allen set adjusting nuts, or machine heads for adjustable rocker arms, studs and guide plates. Part Number 99170-1 Rocker Arm Pedestal Shim Kit is available for many Ford engines with pedestal mounted rocker arms. Detailed, easy to follow instructions on correctly checking for proper lifter preload can be found elsewhere in this brochure. See "The Fast And Easy Way To Check Lifter Preload."

If the adjustment procedures are followed correctly for hydraulic lifter cams, no further adjustment is necessary for the life of the cam.

The same adjustment procedure should be used for mechanical lifter cams. Instead of lifter preload, you must use the **clearance specs on the cam card for your cam.** Mechanical lifter cams require a second adjustment after break-in, then periodically at tune-up time for the life of the cam.

9. Clean all parts and gasket surfaces, install new gaskets and re-assemble the engine. (Fig. 12)

FIG. 5—*Timing marks must be exactly lined up. Our small-block Chevy has a "dot over dot" arrangement, as shown. Consult your shop manual for exact arrangement of your engine.*

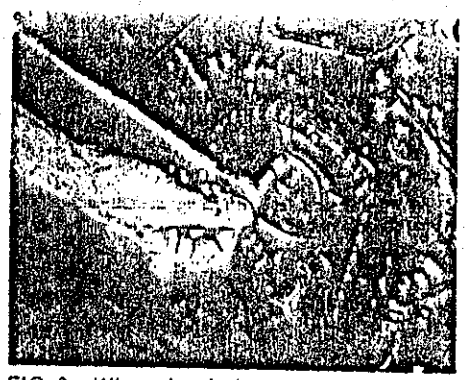


FIG. 6—*When the timing marks have been correctly aligned (check and re-check this before proceeding!) you can re-install the cam sprocket bolts. Use a vibration dampening adhesive, such as Loc-Tite compound. Torque each bolt to factory specs.*

FIG. 7—*Crane Cams offers this unique camshaft locking plate and bolt kit for both small and big block Chevy's. It has tabs that can be bent over to prevent cam bolts from working loose... good "insurance."*

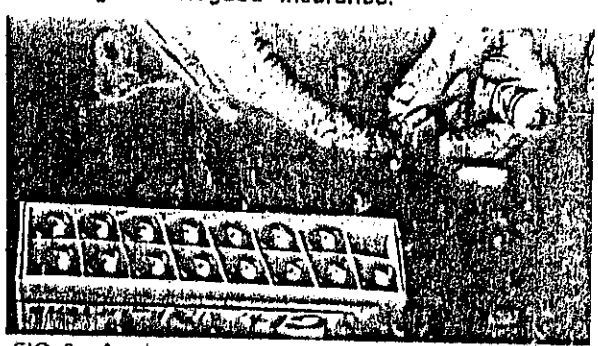


FIG. 8—*Apply a generous amount of assembly lube to each lifter bottom.*

10. Rotate the crankshaft until the number one cylinder is coming up the compression stroke, then align the timing mark on the damper with the recommended factory initial timing setting on compression stroke, both valves will be closed. Install the distributor with rotor pointing to #1 in the cap.

11. Use SF, SG grade, or racing oil and add an 8 oz. bottle of Crane Super Lube (Pt. No. 99003-1), for initial break-in. Fill the new oil filter with oil before installing it.

12. IMPORTANT! Don't allow the engine to run at less than 1500 RPM during the first half hour of operation. Slow engine speeds invite premature cam and lifter wear and may cause their ultimate failure. **Change RPM frequently to direct oil splash to different areas of the camshaft. Vehicle may also be driven during break-in period.**

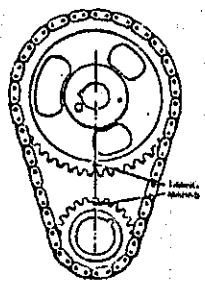
13. After the first hour or 100 miles of operation, change the oil and filter and re-adjust the valves, (if mechanical lifters), adjust them while the engine is warm.

Some aids to help set lifter pre-load on non-adjustable rocker arm equipped engines are: Pt. No. 99170-1 Rocker Arm Pedestal Shim Kit for Ford engines with pedestal mounted rocker arms. Pt. No. 99179-1 Rocker Arm Bridge Shim Kit for Oldsmobile and some AMC V-8 and 6 cyl. engines with pivot bridge mounted rocker arms.

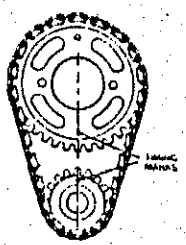
If you don't understand these instructions, please feel free to contact one of our Performance Consultants at 904/258-6174.

Valve timing marks

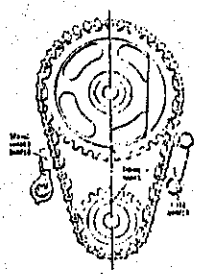
The valve timing marks shown are for camshaft installation use only and are not to be used for installing the distributor. See step 10 for distributor installation.



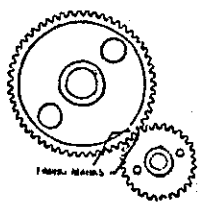
AMERICAN MOTORS V8



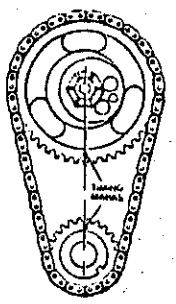
BUICK & BUICK SPECIAL V8-350, 400, 430, V8-455



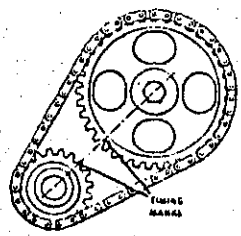
BUICK, OLDS V6



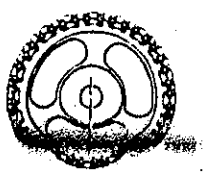
CHECKER, SIX
CHEVROLET LINE FOUR & SIX
BUICK SPECIAL, 6-250
OLDS F-85, 6-250
PONTIAC TEMPEST, 6-250



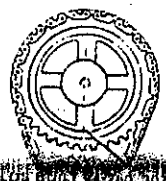
CHRYSLER LINE V8



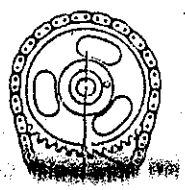
FORD 6-144, 170, 200, 250



FORD LINE V8



OLDS LINE 1975-76 V8-350 & 455
OLDS BUILT 1977-79 V8-350 V.I.N. CODE R & V8-403 V.I.N. CODE K



PONTIAC
FIREBIRD & TEMPEST V8

FIG. 9—*Install the rocker arms carefully, making sure that everything is in place and seated properly. Run the adjusting nuts down just enough to keep everything in place.* DO NOT TIGHTEN THEM BEFORE ADJUSTING THE VALVES!

FIG. 10—*Valve lash adjustment can be easily and accurately performed by following the steps outlined in the text. Be absolutely sure of each valve before you go on to the next one.*

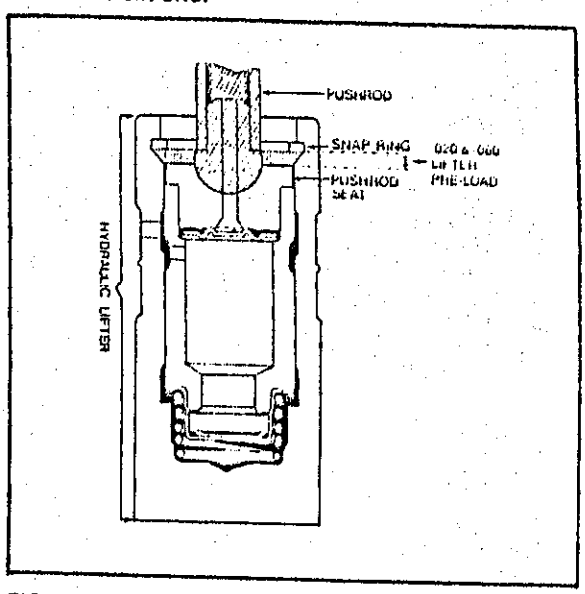
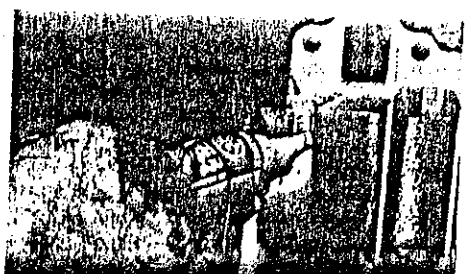


FIG. 11—*Lifter preload is the distance between the pushrod seat in the lifter and the snap ring, when the lifter is on the heel of the cam and the valve is closed.*



Should be used on end-rails as shown. This prevents annoying oil leaks. Do it right the first time and forget it!

THE FAST AND EASY WAY TO CHECK HYDRAULIC LIFTER PRE-LOAD

6-88

One of the most important steps in hydraulic camshaft installation is checking the lifter "preload." This is the distance that the pushrod has extended into the lifter. Accurately checking that this amount is correct (usually about .020" to a maximum of .060") is critical to engine operation and life of the cam lobes, lifters and the engine's valve train itself. If your engine has too little or no lifter preload the valve train will be very noisy when the engine is running. If your engine has too much lifter preload it may idle roughly, have low manifold vacuum and poor low-end performance and may stall when put into gear.

The most accurate method of checking lifter preload is by use of a dial indicator, but if you don't have a dial indicator, or don't know how to use one, there's an easy way that will work just as well.

Follow the instructions in your repair manual (you do have one, don't you?) and torque all the bolts in their proper sequence. You'll be ready to check lifter preload when you reach the step where you're ready to adjust the valve lash.

First, allow a couple of minutes for the lifter to bleed down after you have placed some preload on it. This bleed-down period must be allowed to remove any of the oil that the lifter may have inside it. Many new lifters (of course, you must use new lifters with *any* new cam installation) come with some amount of oil in them, and you should allow one or two minutes for this bleed-down to occur.

Using the valve cover gasket surface of the cylinder head as a guide, lay a marking implement (metal scribe, etc.) flat on the reference guide. You'll be making two marks, so be sure your guide is flat and easily accessible.

Now scribe a line on the pushrod.

Next, unbolt the rocker assembly and loosen the bolts so that the pushrod will stand free in the pushrod seat of the lifter. You'll also note that the pushrod seat in the lifter will be forced up against the snap ring in the top of the lifter by the plunger spring in the lifter.

Now scribe another mark on the pushrod. You'll now have two marks on the pushrod. The difference between the two marks is the amount of travel that the pushrod made into the lifter, or the lifter preload!

You should maintain .020" to a maximum of .060" lifter preload. In most installations you'll normally find that you have either the correct amount of preload or too much preload.

Should you find that you have too little lifter preload, or you have free-play between the rocker arm and pushrod you can also remedy this problem. Simply measure the amount of free-play between rocker arm and pushrod and then add .030" to this figure. This will allow you to buy new Crane pushrods in "longer than stock" length, or the stock length plus that amount you've measured out. Don't forget to add the .030" extra to allow extra length needed to finally get the correct amount of preload that you were after in the first place. We can make pushrods to any length you desire, but your measurements must be accurate, so check yourself a couple of times... just to be sure.

Normally, you'll only need to check two pushrods per cylinder head, one each intake and exhaust. However, if the valve stem heights of all the valves in the head are uneven (measure from spring seat to the top of the valve) or different from factory specs (found in your manual), then it will be necessary to check lifter preload on each valve.

If you're having a valve job done on your head(s), you can ask the machinist to check valve stem height for you. This is actually a normal part of a properly done performance job, but you might want to ask anyway. The end result will allow you to lay a straight-edge across all the valve stems on the assembled head and have valve stem height check the same across the stems.

On other engines which have individual studs, shoulder bolts or pedestals (such as the popular 151 cu. in. Pontiac 4 cylinder) it is still relatively easy to check lifter preload quick and easy. For those engines which have "bottle neck" type studs we have special adjusting nuts which simplify the preload checking process. This type of stud has a shoulder that is *larger* than the thread, and the adjusting nut is tightened down to the shoulder, thus eliminating any adjustment. Our special adjusting nuts are tubular in design with an allen head set-screw in the top. These nuts are also counter-bored at the bottom so that they actually fit *over* the shoulder part of the stud!

These special adjusting nuts allow you to achieve the proper lifter preload as previously outlined. Tighten the adjusting nut down until you reach zero lash (no preload and no lash), then tighten it ½ to 1 full turn more. Hold the nut with an end wrench and tighten the allen head set-screw tight against the top of the stud. Continue this process until all of the valves have been adjusted the same.

On engines with pedestal or shoulder bolt mounted rocker arms you can use shims (available from Crane Cams, see 99193-1 catalog) under the pedestal or shoulder to reduce the preload. If preload is too little, or there's none at all, you'll need to have longer than stock pushrods made. Use the same procedure outlined earlier to determine lifter preload and the amount longer your pushrods must be.

On engines that have individually mounted rocker arms you should be able to achieve correct lifter preload by first tightening the adjusting nut or bolt down to zero valve lash. Now torque into place the adjusting nut or bolt by tightening ¾ to 1 full turn of torque wrench rotation. This should place the pushrod at the correct lifter preload point. If for some reason you cannot achieve the correct lifter preload (.020" to .060") with ¾ to 1 full turn tighter, then you'll have to follow the instructions outlined earlier and use the appropriate Crane shim kit or longer than stock pushrods.

If you do not understand the previously mentioned steps, or you have additional problems, STOP. Before you make a mistake that will damage your new cam or valve train, take the time to call one of our trained Performance Consultants for advice on your problem. The phone number is shown elsewhere in this brochure.

TROUBLE SHOOTING GUIDE

ADJUST VALVE LASH PROPERLY—All engines have a means for changing their valve lash. Be sure and follow the instructions included with the cam, lifters, or rocker arms. Take the extra time required to check the items mentioned **before** you fire up the engine.

CHECK FOR ROCKER ARM INTERFERENCE—Installing a Crane camshaft usually means that you are increasing the maximum valve lift over that of the stock camshaft. On engines which have stud mounted rocker arms be sure and check the rocker arm slot that allows the rocker to pivot at maximum lift. Be sure that there is some slight amount (.060") of additional travel left in this slot when the valve is at maximum lift. Be sure that the rocker arm contacts only the valve tip, and not the valve spring or valve spring retainer.

CHECK SPRING AND RETAINER ASSEMBLY FOR TOTAL TRAVEL—High lift cams open the valves considerably more than the stock cams. The spring travel of some late model engines, especially Fords with exhaust rotaters, have very short spring travel. Sometimes barely enough for the stock cam, much less an aftermarket cam. The only correct way to check spring and retainer travel is to measure the assembled height of the spring when it is assembled on the head. Then (with the piston out of the way) depress the spring and retainer assembly with an on-head spring compressor or pry bar until the assembly stops moving. Measure the spring height at the point. The difference between the two measurements is the total travel. **This travel must be at least .060" more than the valve lift of the cam you are using.**

CHECK THE VALVE-TO-PISTON CLEARANCE—Many times inexperienced or first-time camshaft installers forget to check the engine's valve-to-piston clearance and end up by bending some, or all, of the engine's valves when they strike the piston. This is especially critical on an engine with domed pistons, or where the camshaft being installed has more duration and/or maximum valve lift than that of the previous cam. Check this clearance before you fire up the engine. Several ways can be used, the easiest being to use modeling clay placed atop the valve area of a piston and then bolting the cylinder head in place and torquing it to specs. Adjust the valves, (don't forget to use the gasket for an accurate clearance check) then rotate, by hand, the engine several times. Remove the head(s) and carefully peel off the clay and measure it with a micrometer. Allow a minimum clearance of .100" intake and .120" exhaust.

BENT PUSHRODS MEANS MECHANICAL INTERFERENCE—If you bend one, two or several pushrods for no apparent reason, then you are experiencing some form of definite mechanical interference in the engine's valve train. Check for rocker arm to stud interference, valve spring coil binding, interference between the retainer and valve seal or retainer and valve guide. Also, high RPM might be showing valve-to-piston clearance problems that are causing your valves to strike the pistons and then bending the pushrods. If this occurs, and you suspect valve-to-piston clearance problems, it's a good idea to also check for bent, or leaking, valves and possible piston damage.

NEVER ADVANCE OR RETARD YOUR CAM TIMING WITHOUT FIRST TAKING THE TIME TO "DEGREE IN" THE CAMSHAFT IN THE ENGINE—A cam change that doesn't seem to have enough "low end" power might not be at fault. Frequently, retarded cam timing due to factory retarded timing gears is common. Always degree-in the cam before you make any timing changes. Instructions on how to do this are included in the Crane's "Winner's Handbook" technical guide to camshafts and valve train components.

ALWAYS INSTALL NEW LIFTERS ON A NEW (OR USED) CAM—Never install used (even for just a couple of running minutes) lifters on a new camshaft. The only situation where you can install used lifters on a camshaft, is if the lifters came from the camshaft and are to be replaced onto the same lobe that they were originally run on the cam and in the same engine.

BE SURE AND PROPERLY LUBE THE CAM—Many cams are ruined in the first couple of minutes of their life when they are installed dry or improperly lubricated. Be sure and follow the instructions included with the camshaft for correct pre-lubrication of the cam and lifters before you fire up the engine.

FOLLOW CAM BREAK-IN INSTRUCTIONS—ESPECIALLY WITH REGARDS TO OIL AND FILTER REPLACEMENT—Dirty oil and clogged, old oil filters mean abrasives in the oiling system and wear for the camshaft, lifters and all other engine components as well! Spend a couple of extra dollars and buy high quality oil, and filters, and above all, change both frequently. This will add life to not only your cam and lifters, but the entire engine assembly as well.

BREAKING ROCKER ARM PUSHROD SEATS—We have found this to be a somewhat common problem, especially when an engine has several thousand miles of usage on the rockers. This usually occurs when a cam is installed that has a higher lift than the cam previously used. The additional amount of travel required of the rocker arm tends to relocate the load generated by the valve train and concentrates it partially in the already worn area of the rocker arm pushrod seat, and partially in the area not yet worn. The result is a concentration of this loading in an area of thinner metal, and breaking through or "punching out" the pushrod seat often occurs. The cure is to install new stock-type steel rocker arms, or a set of Crane aluminum rockers.

WE DO NOT RECOMMEND THE USE OF SYNTHETIC OILS DURING BREAK-IN—While considerable progress has been made in developing synthetic motor oils, we do not recommend their use during break-in of regular flat faced hydraulic or mechanical (non-roller) lifter style camshafts. Instead, use a quality grade of naturally formulated, non-synthetic motor oil during this period. Most major synthetic oil manufacturers agree with this procedure. If you choose to use synthetic oil after the break-in period, follow the manufacturer's instuctions to insure proper lubrication.