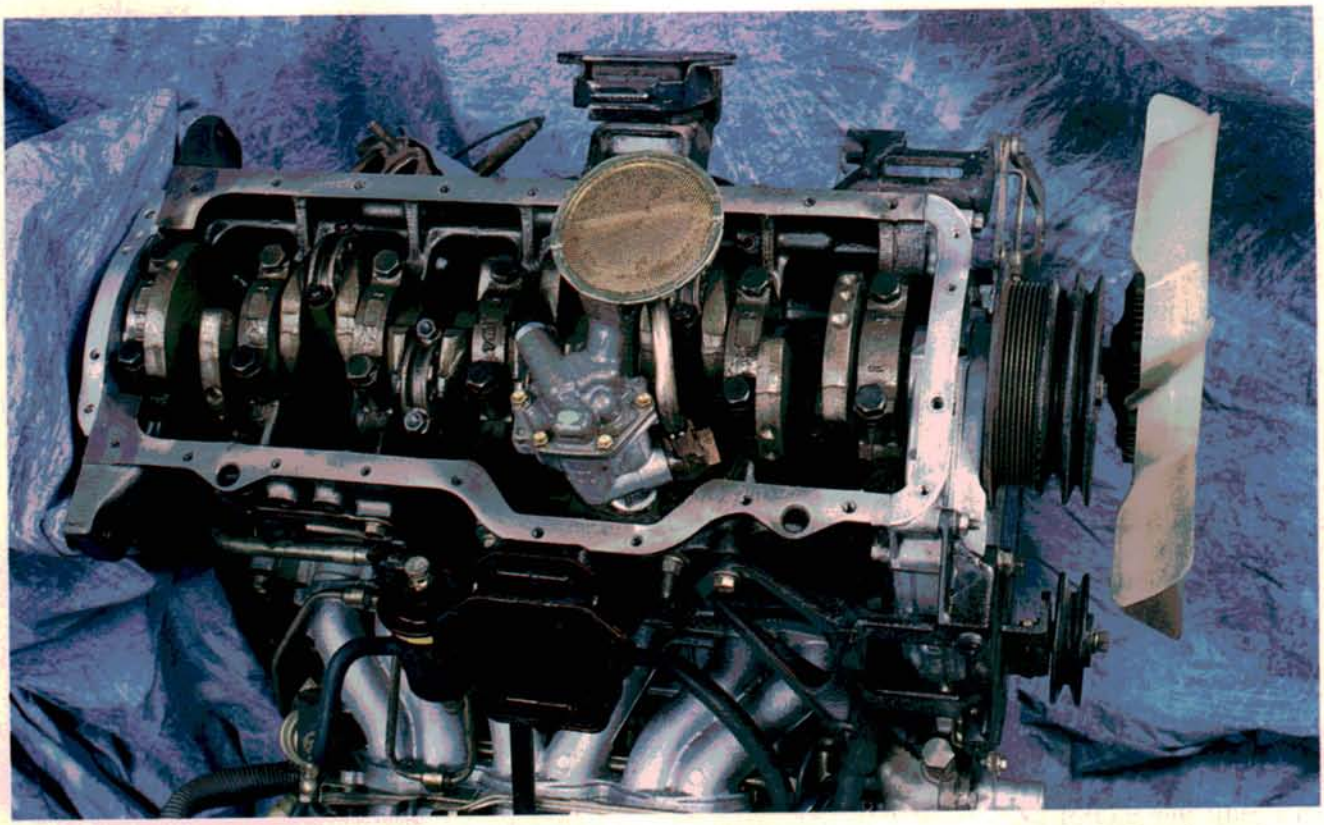
Bottoms Up



Last month we started our Toyota Cressida 5M-GE twin-cam six overhaul Head First with a complete reconditioning of the cylinder head and related components. This month we're ready to turn the Cressida's straight six Bottoms Up so that we can concentrate on lower engine inspection, overhaul, and assembly techniques.

Our 5M-GE turned out to be a perfect subject for these articles because it had a little bit of everything wrong with it. As we mentioned last month, regular oil changes weren't very important to the previous owners. Disassembly of the block revealed that many of the 5M-GE's lower engine components were suffering from a near fatal dose of oil sludge and neglect.

We found the worst damage in the number 5 cylinder bore. Hardened oil sludge had stuck the piston rings to their ring grooves and the piston had also begun to gall. Several long scratches extended down the side of the cylinder wall. Not surprisingly, compression from number 5 had also been lower than normal.

The sludge-covered oil pump pickup screen had the oil pump sipping oil through an area the size of a drinking straw. Oil starvation hadn't done the engine bearings and crankshaft a whole lot of good. The bearing material had worn off several bearings, although the crankshaft hadn't been scored yet. All in all, she was in pretty sad shape.

When To Seek Professional Help

We've been stressing the importance of increasing your involvement in the engine rebuilding process. But it's unlikely that many independent repair shop owners have the necessary equipment to rebore cylinders, regrind crankshafts, or recondition connecting rods.

These are jobs that have traditionally been turned over to a well-equipped automotive machine shop. That leaves the repair shop owner with the responsibility of disassembling the engine, determining what work needs to be performed, deciding what work needs to be sublet to the machine shop, then handling the final assembly.

The 5M-GE block needed help in several areas requiring machine shop equipment, so our next step was to take the block and all related components to

Dana Corporation's Technical Training Center in Ottowa Lake, Michigan. In spite of the serious problems we had found, Engine Department Training Manager Bill McKnight determined that the 5M-GE block was still fixable.

We won't spend a lot of time describing the operating procedures for the various pieces of specialized machine shop equipment that we used. Like we said, many of you will probably be farming out this part of the job anyway. We will concentrate on proper inspection, measurement, and assembly techniques.

However, if you are an automotive machinist, we should mention that Dana Corporation offers a complete course of instruction in engine overhaul at their training center. Our thanks goes to Dana for the technical assistance of their instructors, the use of their machine shop equipment, and also for providing the parts necessary to overhaul the 5M-GE block.

Selective Bearing Systems

The same month our 5M-GE engine was produced, Toyota introduced a selective fit main and rod bearing system. Several manufacturers, both import and domestic, have adopted similar systems since 1984. It's important to understand these systems during an overhaul, especially when new bearings or other parts are being installed along with the original parts.

A selective bearing system allows the manufacturer to hold crankshaft oil clearances to a minimum while also allowing for very slight variations in engine block and crankshaft production tolerances. The engine block and crankshaft are machined, precisely measured, then stamped with code numbers to identify each measurement. During engine assembly, individual bearings are matched to their mating parts to achieve very close oil clearances.

Any time the cylinder block, a crankshaft, a connecting rod, or any of the engine bearings are replaced, the selective bearing system must be used to achieve proper oil clearances. The new bearings must be installed and measured one at a time. The following is a brief description of Toyota's selective fit bearing system. Other manufacturer's systems are similar.

Main Bearings:

- There are three main bearing housing bore inside diameter ranges (numbers 1,2,3). The range from smallest (1) to largest (3) is 0.018 mm (0.0007 in).
- There are three main journal outside diameter ranges (numbers 0,1,2). The range from smallest (2) to largest (0) is also 0.018 mm (0.0007 in).
- Five selective bearing sizes (numbers 1 through 5) are used to adjust the oil clearance to an acceptable range of 0.034-0.058 mm (0.0013-0.0023 in). The maximum clearance allowed is 0.08 mm (0.0031 in).

When selecting main bearings, add the housing bore number (1,2,3) to the crankshaft journal number (0,1,2). The housing bore numbers are located on the right oil pan mounting boss and the journal numbers are stamped on the crankshaft. The total of these two numbers (1 through 5) gives you the correct selective bearing size for each main bearing.

Install the main bearings and crankshaft dry, then measure the oil clearance of each main bearing with Plastigauge™. If the oil clearance isn't within specifications, a different bearing size must be used. The larger the bearing size number, the greater the bearing wall thickness. So if the oil clearance is too great with a number 3 bearing, substitute a number 4 or 5 to decrease the clearance. If the oil clearance is too small, substitute a number 1 or 2 to increase the oil clearance.

If the proper oil clearance can't be achieved using any of the selective bearing sizes, the crankshaft is probably worn beyond production tolerances. The crankshaft must be reground to a standard undersize and an undersized bearing set must be used.

Rod Bearings:

- There are three connecting rod inside diameter ranges (1,2,3). The range from smallest (1) to largest (3) is only 0.03 mm (0.0012 in).
- There are three crankshaft pin outside diameter ranges (0,1,2). The range from smallest (2) to largest (0) is only 0.024 mm (0.0009 in).
- Five selective bearing sizes (1 through 5) are used to adjust the oil clearance to a range of 0.021-0.053 mm (0.0008-0.0021 in). Maximum allowed clearance is 0.08 mm (0.0031 in).

Use the same method when selecting new connecting rod bearings. Add the connecting rod number (stamped on the side of the connecting rod) to the crankshaft pin number (stamped on the crankshaft counterweights) to determine the correct selective bearing size.

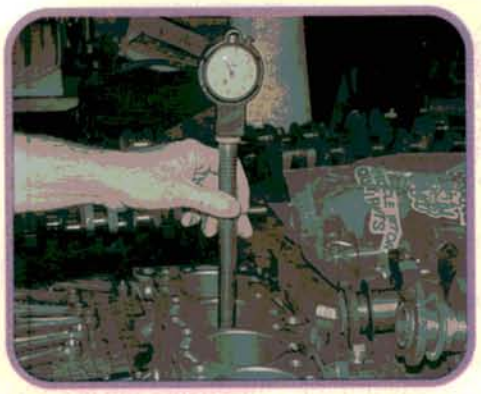
Install the connecting rod and upper bearing on the crankshaft dry, apply a strip of Plastigauge to the crank pin, install the bearing cap and lower bearing, then torque the rod nuts to specifications. Loosen the rod nuts, remove the bearing cap, then measure the Plastigauge.

If the oil clearance isn't within specifications, a different rod bearing size must be used. The rod bearing numbering system works the same as the main bearings. The larger the bearing size number, the greater the bearing wall thickness. Move up or down a size to either decrease or increase the bearing oil clearance.

Once again, if the proper clearance can't be achieved using the five selective rod bearing sizes, the crankshaft must be reground and an undersized bearing set must be used.

—By Karl Seyfert

Bottoms Up

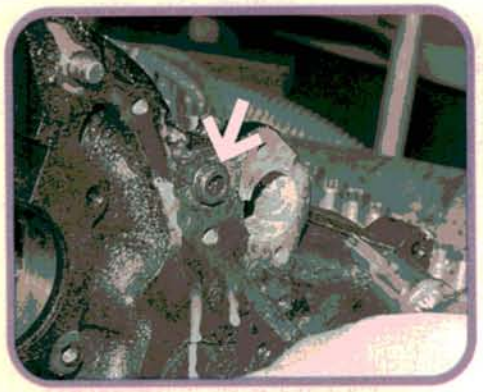


1

We checked cylinder measurements to make sure the block was rebuildable. We knew we had one damaged cylinder. Amazingly, the five remaining cylinders were practically unworn after 100,000 miles. Cylinder taper and out-of-round measurements were both within Toyota's 0.02 mm (0.0008 in) limit.

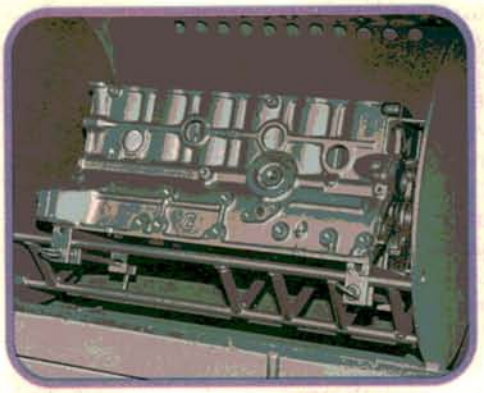
2

Next we checked for block deck warpage. Toyota doesn't permit deck resurfacing on the 5M-GE. Deck warpage was within the 0.05 mm (0.0020 in) specification. A new head gasket that includes formed-in-place sealing beads will seal the minor surface erosion surrounding the cooling system passages (arrow).



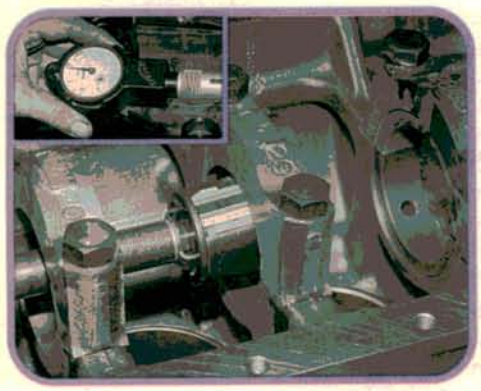
3

We removed the freeze plugs and oil gallery plugs so the oven could clean both inside and outside the block. The gallery plugs were held in place with high strength thread locker. We heated the plugs with a torch, then applied beeswax. The wax penetrates the threads to loosen the plugs.



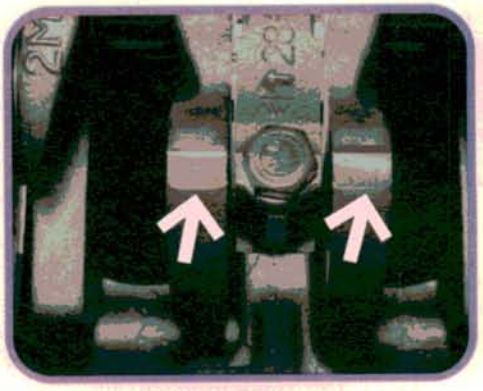
4

The block came out of the pyrolitic oven looking like it had been nickel plated. The oven heats the built up oil, dirt, and internal deposits and reduces them to a fine dust. Oven cleaning is a whole lot easier than the soaking and scraping routine that we're used to. Toxic waste is kept to a minimum too.



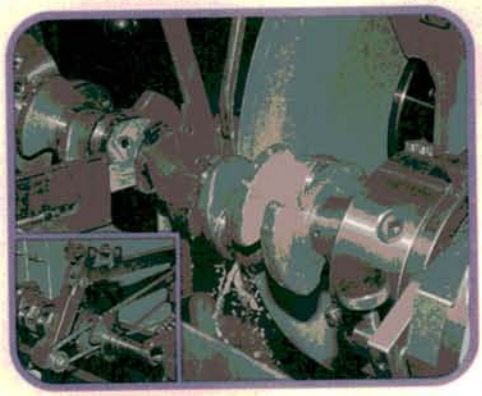
5

After torquing the main bearing cap bolts, we measured the housing bore diameters with a bore gauge to make sure they were all the same diameter. Toyota started a selective bearing system the same month our 5M-GE was built. Refer to the introduction to this article for a description of this system.



6

The crank, block, and connecting rods are all graded by size at the factory. Rod and main journal diameters are each identified by single number markings on the crankshaft counterweights (arrows). Number codes for main bearing housing bore diameters are stamped on the oil pan mounting boss.

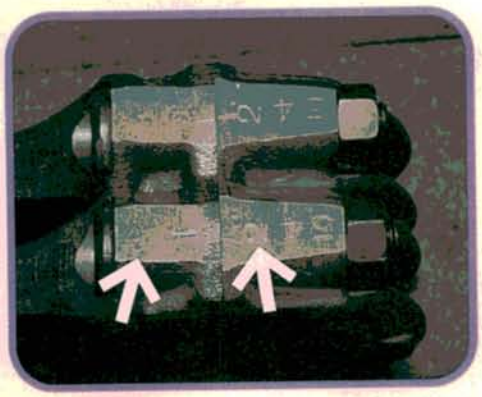


7

The combination of many miles and a general lack of maintenance had worn the crankshaft enough to make the selective bearing system unusable. We selected a 0.25 mm undersize bearing set, then ground and polished the crankshaft main and rod journals to accept the new bearings.

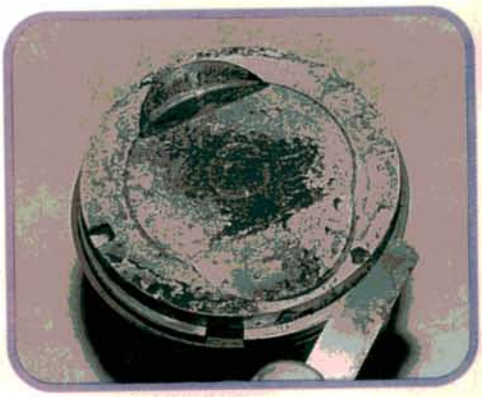
8

For proper valve clearance, the pistons must be installed with their notches facing forward. To assure correct piston and rod reassembly, look for an identifying mark on the connecting rod before removing the old piston. If there are no identifying marks, mark the rods with a punch as we did.



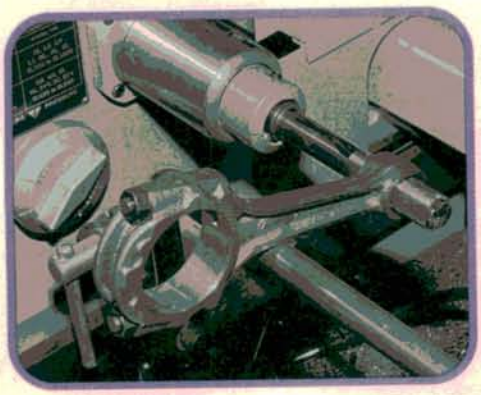
9

There are several numbers at the end of each connecting rod, but none of them refers to which cylinder the rod came out of. The number closest to the parting line refers to the selective bearing system (right arrow). Mark the rods and bearing caps with a punch for cylinder location (left arrow).



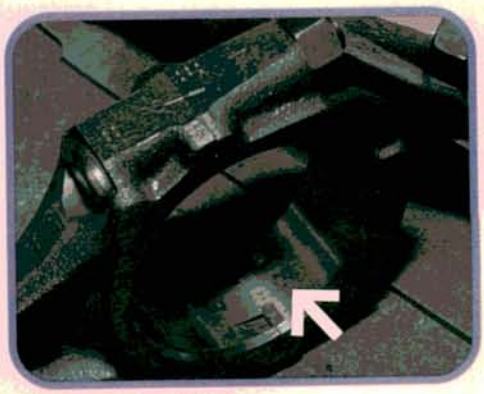
10

The pistons must be heated in hot water to 60 degrees C (140 degrees F) for piston pin removal. If you're reusing the pistons, clean the ring grooves, then use new rings to measure the ring groove clearance. A 0.03 to 0.07 mm clearance is required on the top groove and 0.02 to 0.06 mm on the second groove.



11

We measured a new piston pin to determine the connecting rod bushing oil clearance. We expected the rod bushings to be worn oversize. Five rod bushings were within specifications, while the sixth was slightly undersized. A light honing brought the sixth bushing to the 0.005 to 0.011 mm oil clearance.

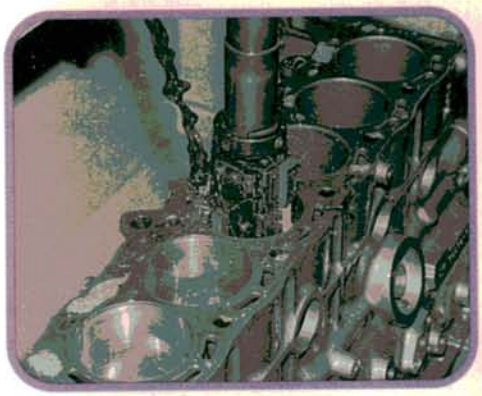


12

Measurements at the crankshaft end of the rods showed that all were within specifications and didn't require reconditioning. This photo shows the impression left inside the rod by a number 3 selective rod bearing (arrow). A number 3 is the middle of the road selective bearing size.

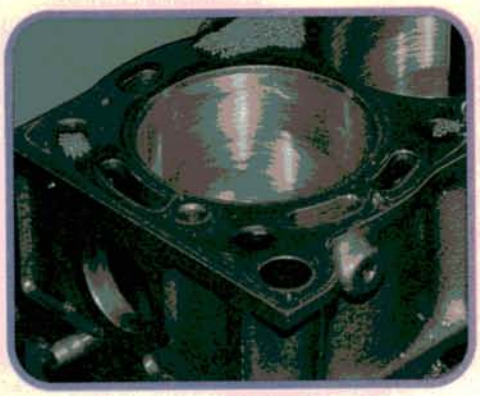
13

To determine the proper cylinder boring dimension, measure piston diameter 90 degrees away from the piston pin at the recommended distance from the top or bottom of the piston. The pistons must be at room temperature because the aluminum piston diameter will change with temperature.



14

After we figured the piston diameter, the cylinders were bored to the size of the replacement pistons. Then the cylinders were honed to the finished dimension including oil clearance. At least 0.05 mm (0.002 in) should be removed by honing to remove the roughened cylinder wall material caused by boring.

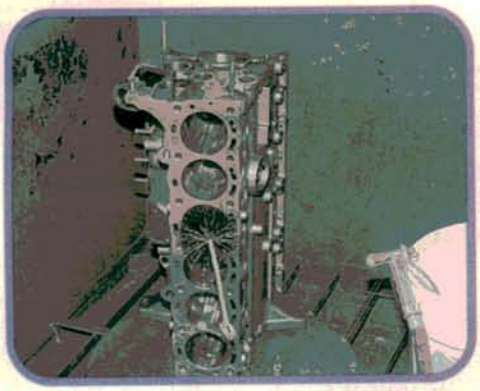


15

The crosshatch angle should be between 20 and 60 degrees. The smoothness of the cylinder wall finish is actually more important than the crosshatch angle. Use a 220 grit stone for finish honing with cast iron and chrome rings and a 280 grit stone for moly piston rings.

16

The finished cylinder dimension should be within 0.013 mm (0.0005 inch) for out-of-round and taper measurements. Some blocks require a deck plate during boring and honing. The deck plate simulates the stress caused by bolting the head to the block which may pull the cylinder walls slightly out of round.

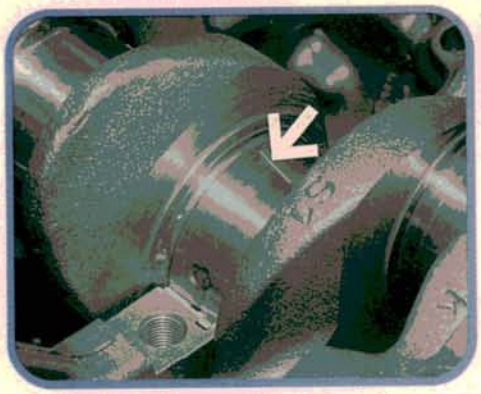


17

Cleaning the block after boring and honing is probably the most important step in an overhaul. Scrub the engine with hot water and soap. Keep scrubbing until you can wipe a white cloth over the cylinder walls without picking up any metal fragments, honing stone, or oil on the cloth.

18

Use an inverted piston to square a ring in the cylinder bore to measure ring end gap. Toyota recommends ring replacement if ring end gap is incorrect (no filing allowed). Our cylinders were honed to a precise dimension so the rings fit perfectly without modification. Test fit the pistons to their bores.

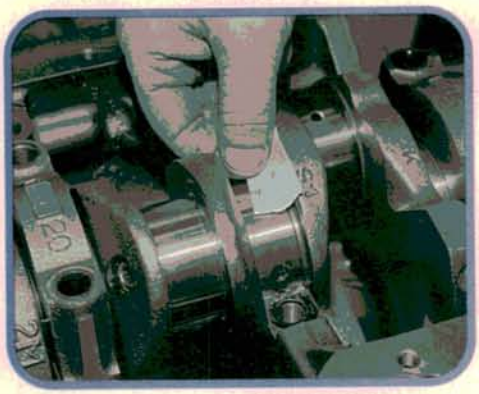


19

Install the crankshaft and bearings. Pay attention to the location of any special bearings or oil holes. The back side of the new bearings and the housing bores in the block must be clean and dry. Lay a strip of Plastigauge across the crankshaft journal to measure the oil clearance (arrow).

20

The new main bearing and crank journal should be clean and dry for an accurate measurement. Install the main bearing cap, then torque the bolts to specifications. Don't rotate the crankshaft during your measurements. Loosen the bolts, then carefully remove the bearing cap.



21

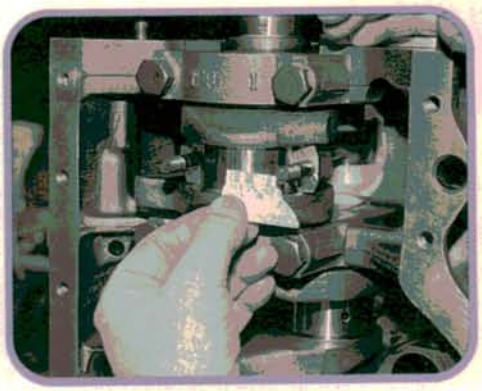
Our oil clearance was less than 0.04 mm (0.0016 in). Remove the crank and apply assembly lube to the main bearings and crank journals. All bearing cap bolts and bolt holes should be clean and lightly oiled. Follow the recommended bearing cap torque sequence. Make sure the crank turns freely and isn't binding.

22

Install the new pistons on the connecting rods. Clamp the rods in a soft jawed vice, then install the new piston rings. These low tension rings slipped over the piston without a ring expander. Follow the manufacturer's recommendations for proper ring end gap positioning.

23

Place protective sleeves over the connecting rod bolts to avoid scratching the crank pins. Install the upper rod bearing. Dip the piston in oil. Compress the rings with a ring compressor, then carefully push the piston into the cylinder. Make sure the rod bolts straddle the crank pin.



24

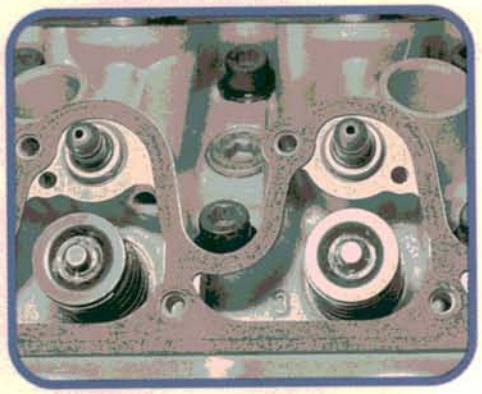
Lay a strip of Plastigauge across the crank pin, install the rod bearing and cap dry, then torque the rod cap nuts. Remove the bearing cap to check the oil clearance. Apply assembly lube to the rod bearing, put a dab of thread locker on the rod nuts, then retorque the nuts to specifications.

25

Toyota enlarged the oil pump capacity on later production 5M-GEs. The smaller original pump (on right) is no longer available. A deeper oil pan must be installed to clear the new oil pump's larger gear set and deeper housing. The new pump delivers more oil to the improved camshaft lubrication system.

26

The slightly oversize sealing rings on this Fel-Pro head gasket will accommodate up to a 1 mm (0.040 in) cylinder overbore and chamfer. This design ensures proper clearance and prevents detonation or pre-ignition caused by the head gasket sealing rings protruding into the combustion chambers.



27

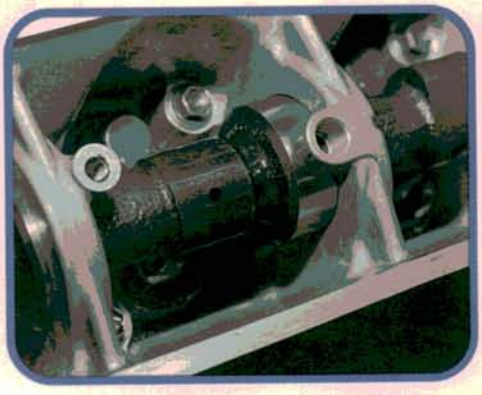
5M-GEs occasionally develop oil leaks between the cam housings and the cylinder head. Our aftermarket replacement gasket (arrow) was thicker than the OE paper gasket, and included an embossed sealing ridge to prevent oil leakage. We applied a thin coating of Hylomar to position the gasket during assembly.

28

Move the pistons away from TDC to prevent valve interference. Install the head, then torque the lubricated head bolts using a three step process. The dense head gasket material doesn't compress and will hold the original torque specification. We rechecked the bolt torque several days later and found no change.

29

The oil pressure regulator (arrow) is a very important part of the upper engine lubrication system. We disassembled the regulator for cleaning and found the regulator valve was stuck solid. A stuck regulator will starve the upper engine for oil and will cause noisy lash adjuster operation.



30

After installing the pan, we filled the engine with oil. Then for a final assembly check before installing the timing belt, we turned the auxiliary shaft pulley until the oil pump delivered oil to the cam lobe lubricating holes. We wanted these parts to get plenty of oil as soon as the engine started.