

# Shop Manual

# 114 SERIES

## DIESEL ENGINE

- This shop manual may contain attachments and optional equipment that are not available in your area. Please consult your local Komatsu distributor for those items you may require.

Materials and specifications are subject to change without notice.

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## Generic Symbols

The following group of symbols have been used in this manual to help communicate the intent of the instructions.

When one of the symbols appears, it conveys the meaning defined below.



**WARNING** - Serious personal injury or extensive property damage can result if the warning instructions are not followed.



**CAUTION** - Minor personal injury can result or a part, an assembly or the engine can be damaged if the caution instructions are not followed,



Indicates a **REMOVAL** or **DISASSEMBLY** step.



Indicates an **INSTALLATION** or **ASSEMBLY** step,



**INSPECTION** is required,



**CLEAN** the part or assembly.



**PERFORM** a mechanical or time **MEASUREMENT**.



**LUBRICATE** the part or assembly.



Indicates that a **WRENCH** or **TOOL SIZE** will be given.



**TIGHTEN** to a specific torque,



**PERFORM** an electrical **MEASUREMENT**.



Refer to another location in this manual or another publication for additional information,



The component weighs 23 kg [50 lb] or more, To avoid personal injury, use a hoist or get assistance to lift the component.

## General Engine Specifications

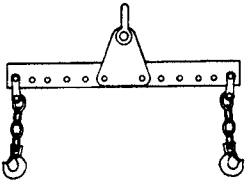
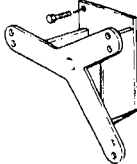
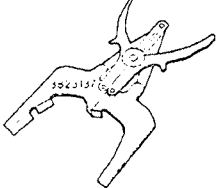
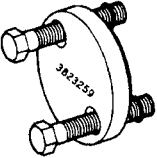

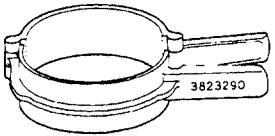
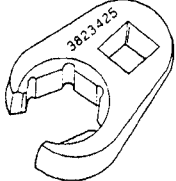
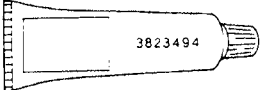
### General Engine Data

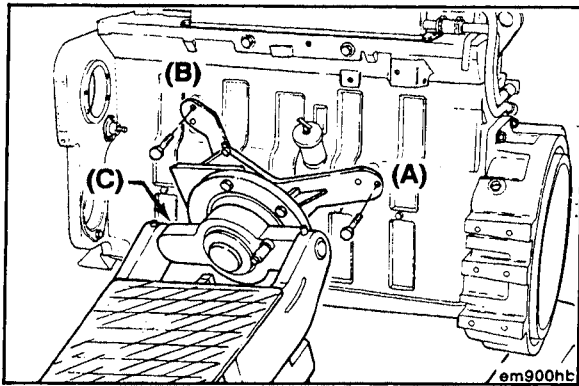
|   |   |
|---|---|
| Bore  | 114 mm [4.49 in]                          |
| Stroke  | 135 mm [5.32 in]                          |
| Displacement                                  | 8.27 liters [504.5 in <sup>3</sup> ]      |
| Compression ratio                             |   |
| 6D114E-1                                      | 16.4:1                                    |
| S6D114E-1                                     | 17.3:1                                    |
| SA6D114E-1                                    | 16.5:1                                    |
| SAA6D114E-1*                                  |   |
| High Torque                                   | 17.3:1                                    |
| Low Torque                                    | 18:1                                      |
| Firing order                                  | 1-5-3-6-2-4                               |
| Valve clearance                               |   |
| Intake  | 0.30 mm [0.012 in]                        |
| Exhaust                                       | .061 mm [0.024 in]                        |
| Engine rotation (viewed from front of engine) | Clockwise                                 |
| Aspiration                                    |   |
| 6D114E-1                                      | Naturally Aspirated                       |
| S6D114E-1                                     | Turbocharged                              |
| SA6D114E-1                                    | Turbocharged and Jacket Water Cooled      |
| SAA6D114E-1                                   | Turbocharged and Charged Air Cooled (CAC) |
| Engine weight (with standard accessories)     |   |
| Dry weight                                    | 603 to 612 kg [1330 to 1380 lb]           |
| Wet weight                                    | 635 to 658 kg [1400 to 1450 lb]           |

### Lubrication System

|  |  |
|--|--|
| Oil pressure   |  |
| At idle (minimum allowable)                                    | 69 kPa [10 psi]                          |
| At rated speed (minimum allowable)                             | 207 kPa [30 psi]                         |
| Differential pressure to open oil filter bypass valve          | 172 kPa [25 psi]                         |
| Oil flow at rated speed (less flow through pressure regulator) | 106.8 lpm [28.2 gpm]                     |
| Oil temperature at rated speed                                 | 98.9° to 126.6°C [210° to 260°F]         |
| Oil temperature thermostat                                     |  |
| Fully open   | 116°C [241°F]                            |
| Closed   | 104°C [219°F]                            |
| Oil pan capacity (all engines) (high - low)                    | 18.9 to 15.1 liters [20 to 16 U.S. Qts.] |
| Total system capacity  |  |
| 6D114E-1   | 23.6 liters [25.0 U.S. Qts.]             |
| S6D114E-1  | 23.8 liters [25.2 U.S. Qts.]             |

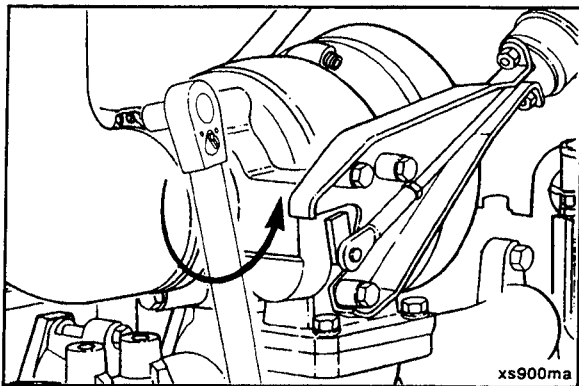
\* All emissionized engines with Charged Air Cooling are designed as "AA".

| Tool No. | Tool Description  | Tool Illustration   |
|----------|---|---|
| 3822512  | <p><b>Engine Lifting Fixture</b></p> <p>Used to lift the engine.</p>  |    |
| 3822607  | <p><b>Adapter Plate</b></p> <p>For mounting the engine to Part No. 3375194, Engine Rebuild Stand.</p>   |    |
| 3823137  | <p><b>Piston Ring Expander</b></p> <p>Used to install piston rings onto pistons without damaging or distorting the rings.</p>                       |    |
| 3823259  | <p><b>Injection Pump Drive Gear Puller</b></p> <p>Used to pull the injection pump gear.</p>   |  |
| 3823276  | <p><b>Injector Puller</b></p> <p>Used to pull injectors.</p>  |  |
| 3823290  | <p><b>Piston Ring Compressor</b></p> <p>Used to compress the piston rings while installing the pistons into the cylinder bores.</p>                 |  |
| 3823425  | <p><b>Crowfoot Wrench</b></p> <p>Used to torque high pressure fuel line nuts on A and MW Bosch fuel injection pumps. Size: 17mm, 3/8 in. drive.</p> |  |
| 3823494  | <p><b>Sealant, Three Bond (150 Gram Tube)</b></p> <p>Used for sealing "T" joints and front gear cover.</p>  |  |



Use four M10 x 1.5 x 20 mm and two M8 x 12.5 x 20 mm cap screws to install the adapter plate to the side of the cylinder block.

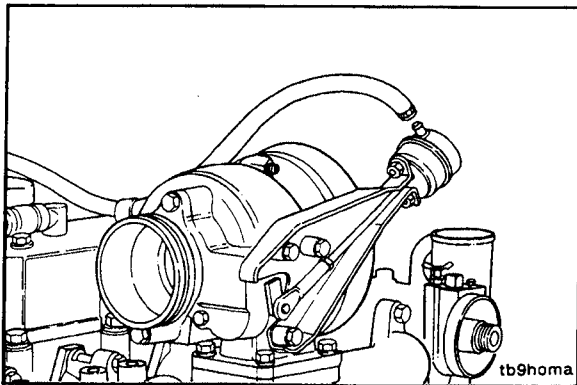
| Capscrew Location | Capscrew Size | Torque Value      |
|-------------------|---------------|-------------------|
| A                 | M8            | 24 N•m [18 ft-lb] |
| B, C              | M10           | 40 N•m [30 ft-lb] |



### Turbocharger Exhaust Outlet Connection - Removal

7/16 inch, 15 mm

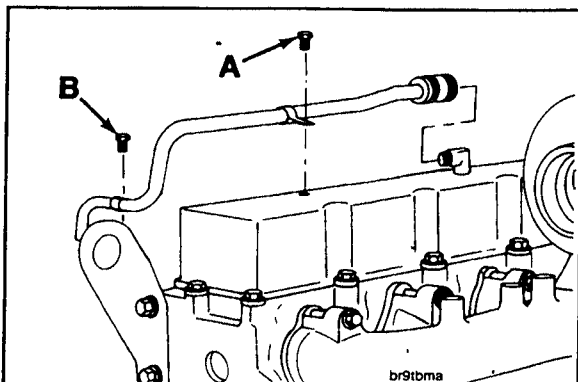
Remove the turbocharger exhaust outlet connection.



### Wastegate Actuator Hose - Removal

Screwdriver

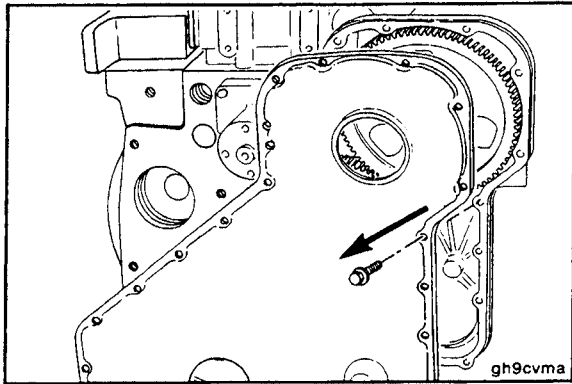
Remove the wastegate hose.



### Crankcase Breather Tube - Removal

13 mm, 18 mm

Remove the crankcase breather tube support bracket cap screws (A) and (B).

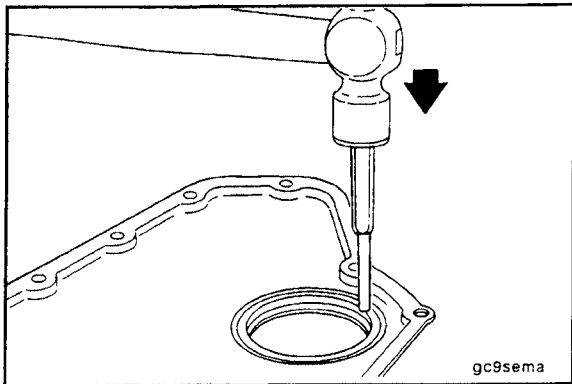


### Gear Cover - Removal



10 mm

Remove the gear cover.

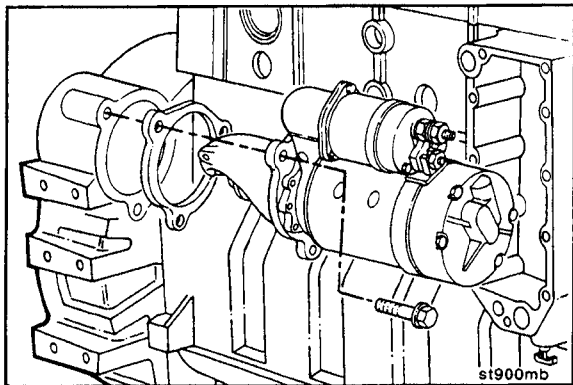


### Seal, Front Crankshaft - Removal



Hammer, Punch

Drive or press the seal out of the gear cover.

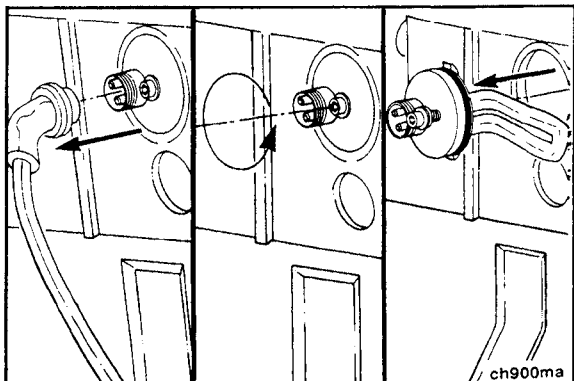


### Starting Motor - Removal



12 mm

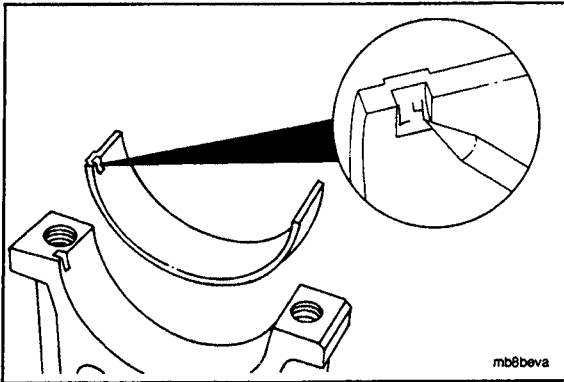
Remove the starting motor.



### Coolant Heater - Removal



Remove the engine coolant heater.

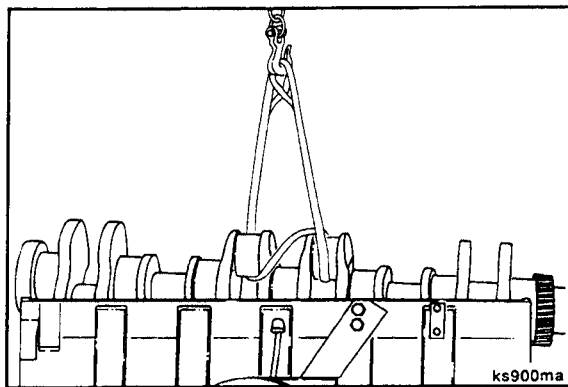


### Main Bearing (Lower) - Removal

Remove the lower main bearing shells from the main bearing caps.

Mark the main bearing shells with the journal number they were removed from in the flat surface of the main bearing tang.

Do not mark on the main bearing to crankshaft mating surface. Damage to the engine can result if the main bearings are used again.



### Crankshaft - Removal

The component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component.

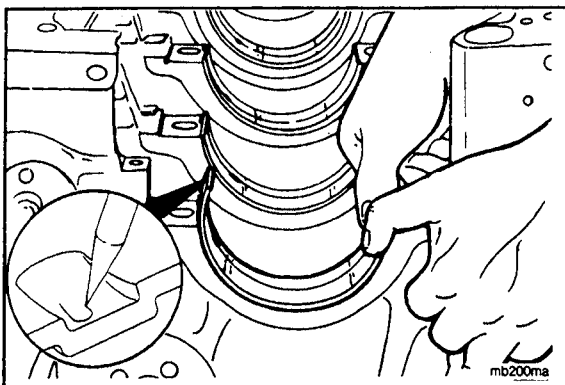
Lift the crankshaft straight up to avoid damage to the crankshaft or cylinder block.



Install the Part No. 3375957, Nylon Lifting Sling, around the number "3" and "4" rod bearing journals.



Attach the sling to a hoist and remove the crankshaft.

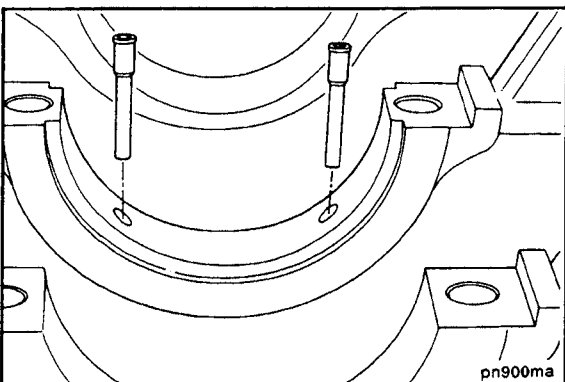


### Main Bearing (Upper) - Removal

Use both thumbs to remove the upper main bearing shells.

Mark the main bearing shells with the journal number they were removed from in the flat surface of the main bearing tang.

Do not mark on the main bearing to crankshaft mating surface. Damage to the engine can result if the main bearings are used again.

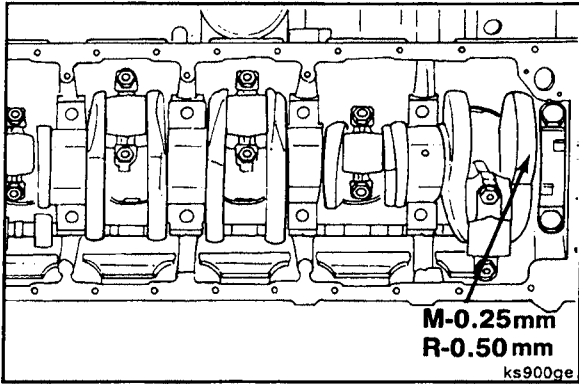


### Piston Cooling Nozzle - Removal

3/16 Inch Pin Punch

Remove and discard the piston cooling nozzles.

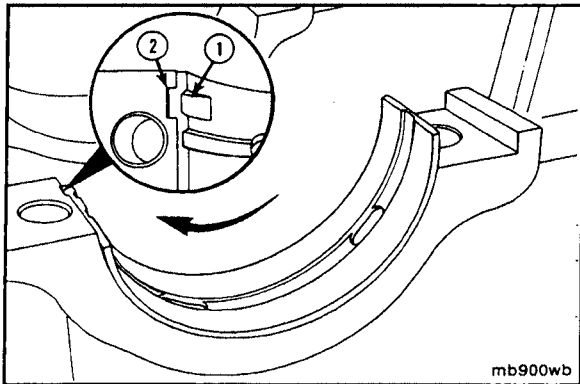




### Main Bearing (Upper) - Installation

The upper bearings contain two oil holes. The lower bearings do not. Both upper and lower main bearings are marked on the back to indicate either standard (STD) or oversize (OS) thickness.

**NOTE:** Main bearing shells are available for crankshafts which are machined 0.1 mm [0.040-inch] undersize the original diameter. Crankshafts which are machined undersize in the connecting rod and main bearing journals are marked on the front counterweight. If the crankshaft is marked, check the main bearing and connecting rod shell part numbers to make sure the correct bearing size is used.



**Caution:** The tang (1) on the bearing shell must be in the slot (2) of the bearing saddle to correctly position the bearing and prevent engine damage.

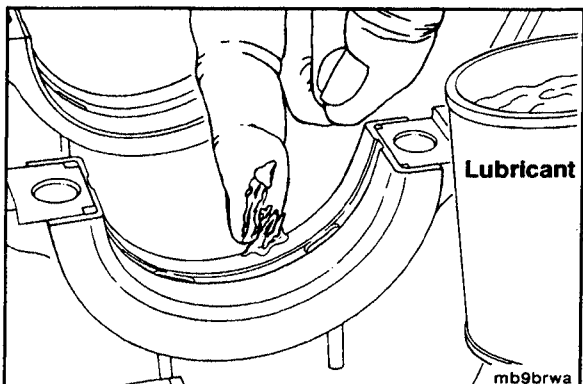


Install the upper main bearing shells.



**NOTE:** If used bearing shells are to be installed, each **must** be installed in its original location in the engine. The main bearing journal numbers should have been marked in the bearing tangs during disassembly.

**NOTE:** Do not install the combination thrust/main bearing in the center journal. Roll the combination thrust/main bearing in after the crankshaft is installed.

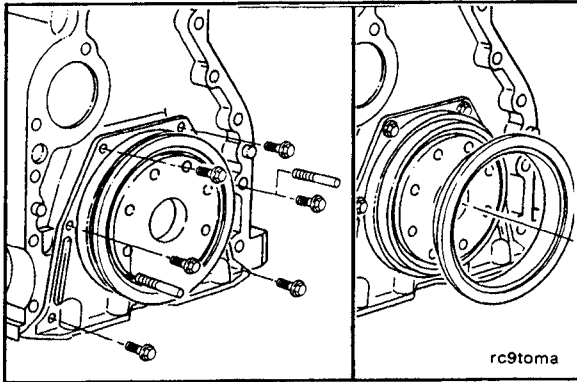


Lubricate the main bearings with Lubriplate™ 105.

Do not lubricate the back of the main bearing.



**Caution:** Prevent dirt from mixing with the lubricant. Dirty lubricant will accelerate main bearing wear.



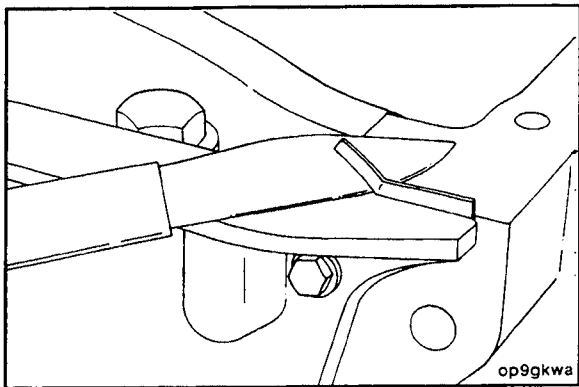
Remove the guide pins.

Install the rear cover capscrews and tighten.



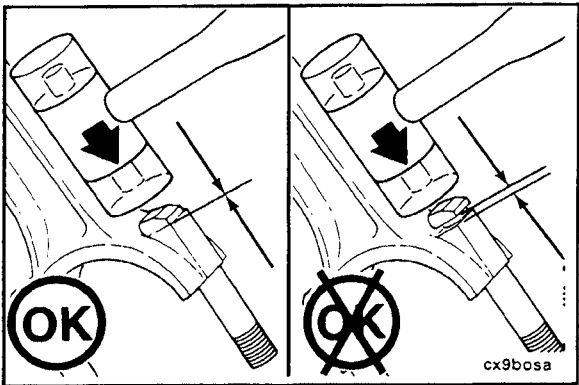
**Torque Value:** 9 N•m [80 in-lb]

Remove the rear crankshaft seal pilot tool.



Trim the rear cover gasket even with the oil pan mounting surface.

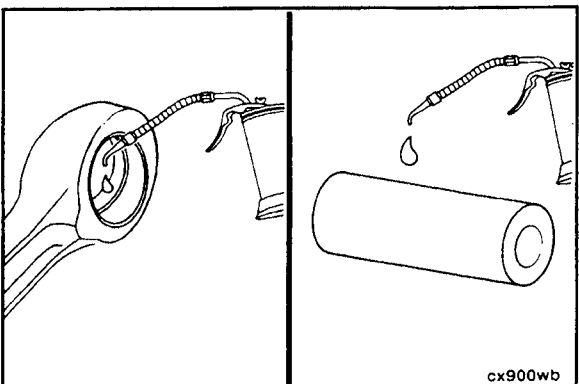
Make sure the rear cover gasket trim does **not** fall into the engine.



### Connecting Rod Bolt - Installation

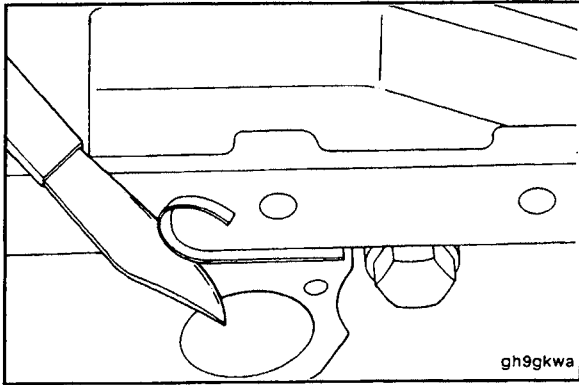
**Plastic Hammer**

Tap the connecting rod bolts in until the head is aligned and seated on the flat machined surface of the connecting rod.

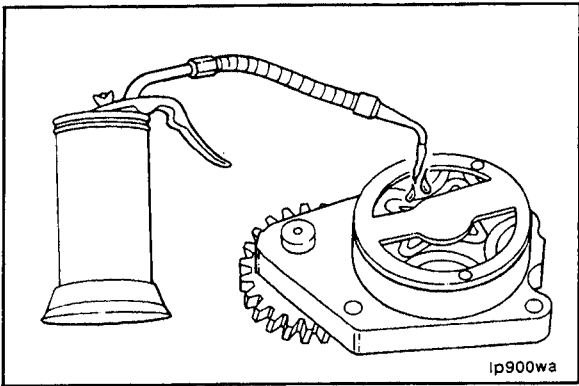


### Piston Pin - Installation

Use clean 15W-40 engine oil to coat the connecting rod piston pin bore and piston pin.



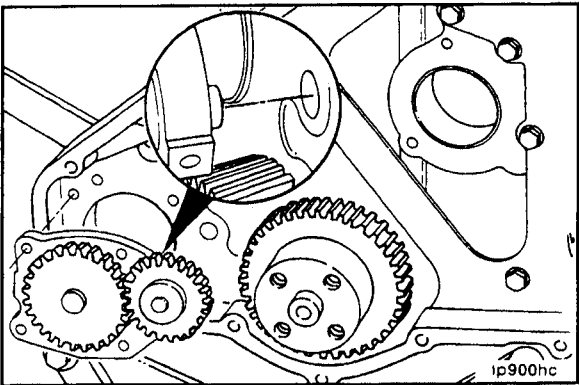
Trim the gear housing gasket off even with the oil pan rail.  
**NOTE:** Do not let the gasket trimmings fall into the engine.



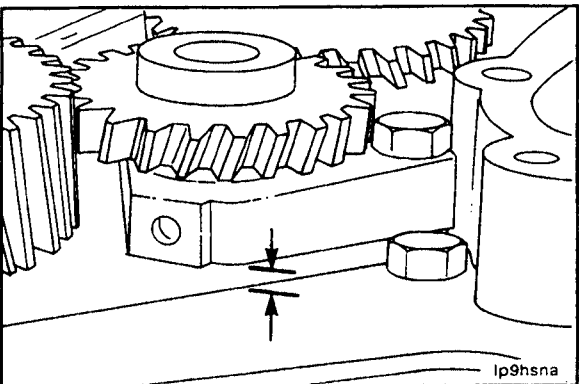
### Lubricating Oil Pump - Installation



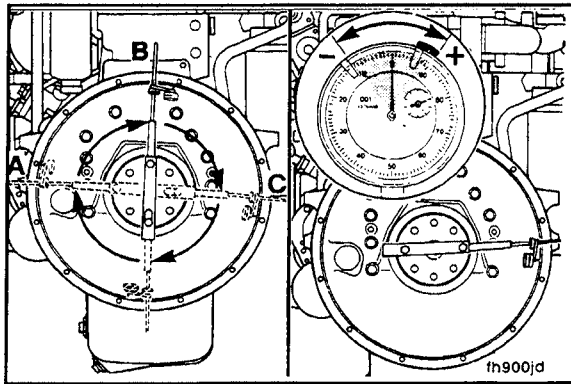
Lubricate the lubricating oil pump with clean 15W-40 engine oil.  
**NOTE:** Fill the lubricating oil pump with oil during installation to aid in quicker oil suction when the engine is started.



Make sure the lubricating oil pump idler gear pin is installed into the locating bore of the cylinder block.



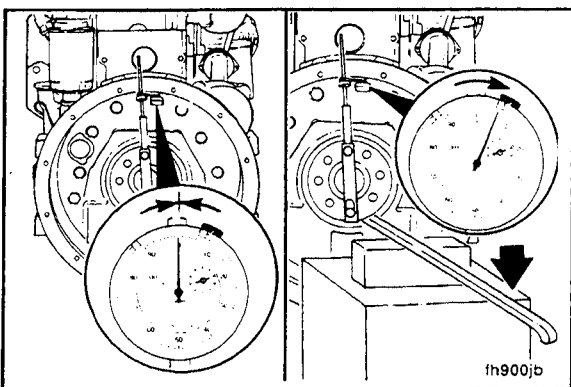
The back plate on the lubricating oil pump seats against the bottom of the bore in the cylinder block. When the pump is correctly installed, the flange on the pump will **not** touch the cylinder block.



**Part No. 3377371 Engine Barring Tool**

Slowly rotate the crankshaft. Record the readings obtained at the 9:00 o'clock, 12:00 o'clock, and 3:00 o'clock positions as [a], [b], and [c] in the concentricity work sheet. Check zero at the 6:00 o'clock position again.

The values for [a], [b], and [c] could be positive or negative. Refer to the accompanying figure to determine the correct sign when recording these values.



Rotate the crankshaft until the dial indicator is at the 12:00 o'clock position and zero the gauge.

**NOTE:** Do not force the crankshaft beyond the point where the bearing clearance has been removed. Do not pry against the flywheel housing. These actions could cause false bearing clearance readings.

Use a pry bar to raise the rear of the crankshaft to its upper limit. Record the value as [d] in the concentricity work sheet. This is the vertical bearing clearance adjustment and will always be positive.

| Concentricity Worksheet |                     |
|-------------------------|---------------------|
| 9 o'clock               | a = 0.004           |
| 3 o'clock               | c = -0.002          |
| <b>Total Horizontal</b> | <b>a - c = .006</b> |
| <hr/>                   |                     |
| 12 o'clock              | b = .003            |
| Bearing Clearance       | d = .002            |
| <b>Total Vertical</b>   | <b>b + d = .005</b> |

oi900vf

Use the concentricity work sheet to determine the values for the 'total vertical' and 'total horizontal' values.

The 'total horizontal' is equal to the 9:00 o'clock reading, [a], minus the 3:00 o'clock reading [c].

The 'total vertical' is equal to the 12:00 o'clock reading [b], plus the bearing clearance [d].

Example:

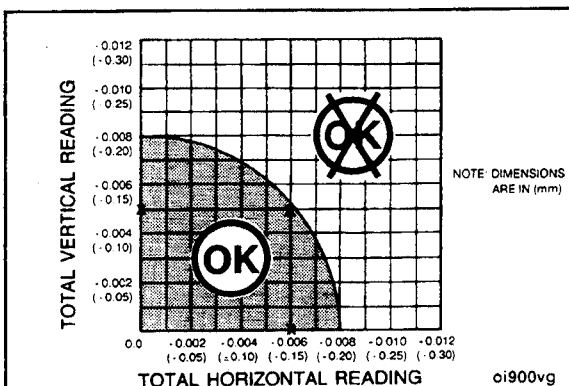
- 6:00 o'clock = ref = 0.000 mm [0.000 in].
- 9:00 o'clock = [a] = 0.102 mm [0.004 in].
- 12:00 o'clock = [b] = 0.076 mm [0.003 in.]
- 3:00 o'clock = [c] = -0.051 mm [-0.002 in.]

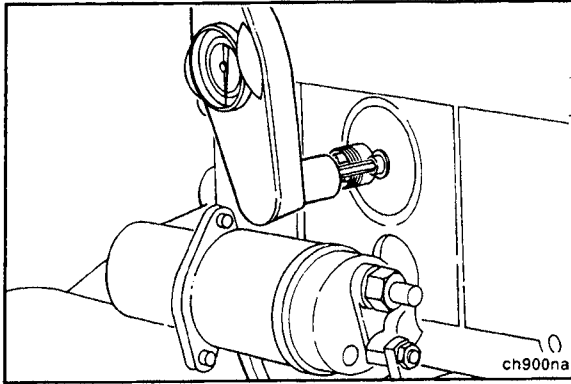
Using the work sheet and the numbers from the example, the 'total horizontal' value = 0.152 mm [0.006 in.] and the 'total vertical' value = 0.127 mm [0.005 in.]

Mark the 'total horizontal' value on the horizontal side of the chart and the 'total vertical' on the vertical side of the chart.

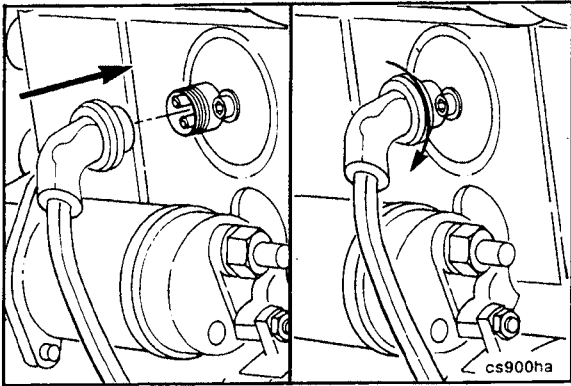
Use a straight edge to find the intersection point of the 'total horizontal' and 'total vertical' values. The intersection point **must** fall within the shaded area for the flywheel housing concentricity to be within specification.

Use the 'total horizontal' and 'total vertical' values from the previous example, the intersection point falls within the shaded area. Therefore, the flywheel housing concentricity is within specification.



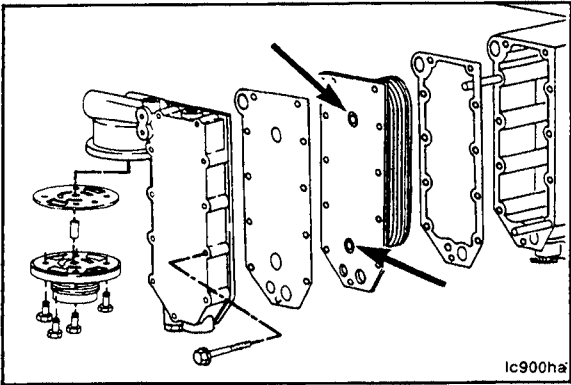


Tighten the retaining cap screw.  
Torque Value: 12 N•m [106 in-lb]



Insert the power cord into the socket, being careful to align the pins with the sockets of the power cord. Tighten the retaining nut by hand.

**Do not apply power until the cooling system is filled.**



### Lubricating Oil Cooler - Installation

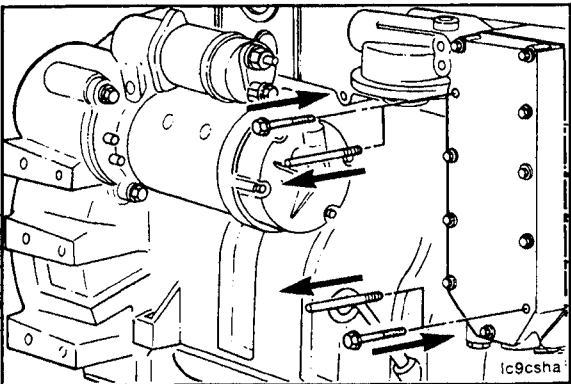
Refer to Group 07 for oil cooler assembly and rebuild instructions.

Install two M8X1.25X80 guide pins into the cylinder block.

Assemble the cooler gasket, oil cooler, and oil cooler cover gasket together over the guide pins.

**If a new element is being installed, be sure to remove the shipping plugs.**

Install nine capscrews.



10 mm

Remove the two guide pins and install the remaining two capscrews.

Tighten all the oil cooler and filter head capscrews.

Torque Value: 24 N•m [18 ft-lb]

| Chart B  |   |   |   |   |   |   |
|----------|---|---|---|---|---|---|
| Cylinder | 1 | 2 | 3 | 4 | 5 | 6 |
| Intake   |   |   | X |   | X | X |
| Exhaust  |   | X |   | X |   | X |



14 mm, Flat Blade Screwdriver

Adjust the valves indicated for Chart B.

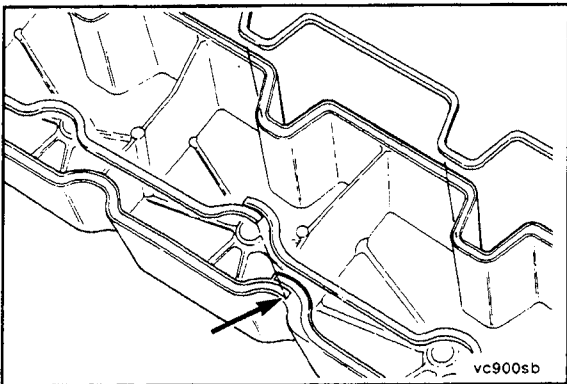


Tighten the locknut.

Torque Value: 24 N•m [18 ft-lb]



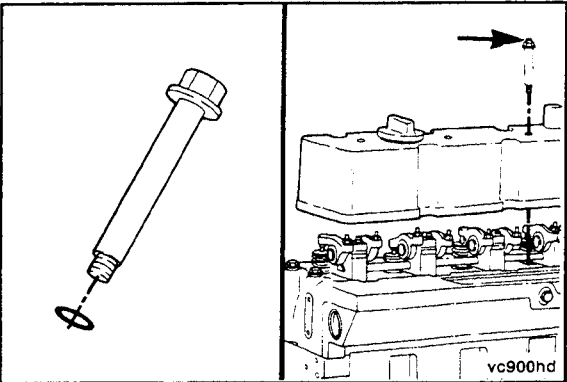
Check the valve clearance again.



### Valve Cover - Installation

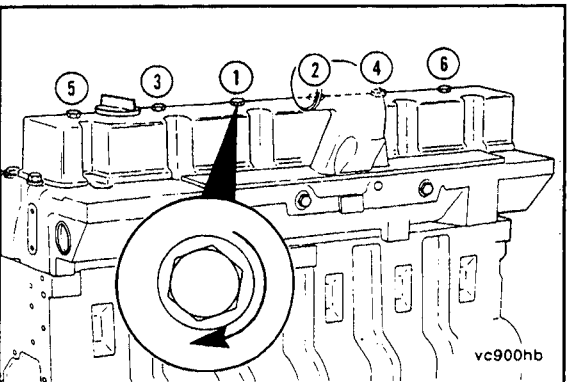


Install the rubber seal into the groove in the valve cover. Start the installation at the overlap area shown in the illustration. Do **not** stretch the rubber seal. If the seal has more overlap than shown in this illustration, trim the excess to provide the proper overlap.



Install new sealing o-rings on the valve cover cap screws.

**NOTE:** Engines equipped with wastegate turbochargers **must** have a studed cap screw installed in the third hole from the front. This is for the wastegate actuator hose clamp.



15 mm

Install the valve cover cap screws and tighten in the sequence shown.



Torque Value: 24 N•m [18 ft-lb]

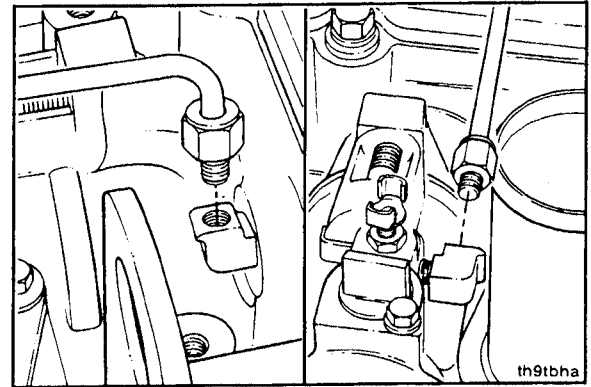


### Coolant Vent Tube - Installation

7/16 inch

Coat the threads with Teflon and install the coolant vent tube. Tighten the fitting.

**Torque Value:** 8 N•m [71 in-lb]

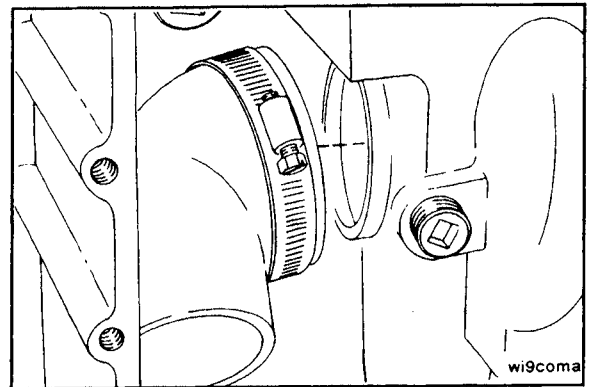


### Coolant Inlet Connection - Installation

) Install the new coolant inlet connection and tighten the clamp.

**Torque Value:** 5 N•m [44 in-lb]

The final positioning of the inlet connection may need to be made after installation of the engine in the vehicle.

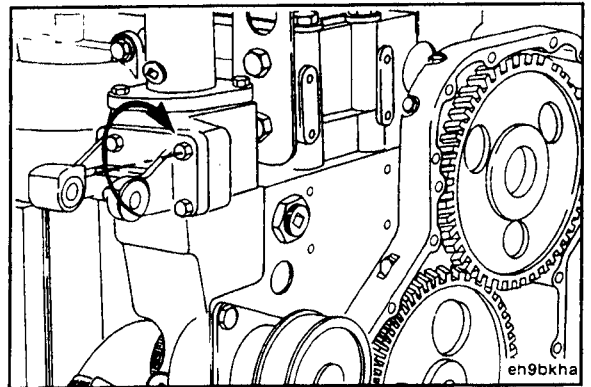


### Alternator Mounting Bracket - Installation

13 mm

Assemble the alternator bracket to the thermostat housing.

**Torque Value:** 24 N•m [18 ft-lb]

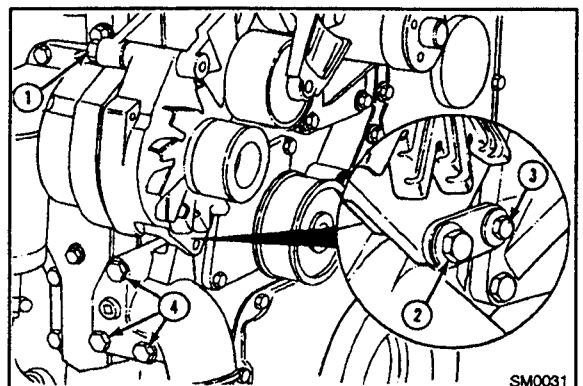


### Alternator - Installation

) Position the alternator on the bracket and install the mounting capscrews.

The capscrews should be installed with the nuts facing toward the inside of the bracket.

**Do not tighten at this time.**

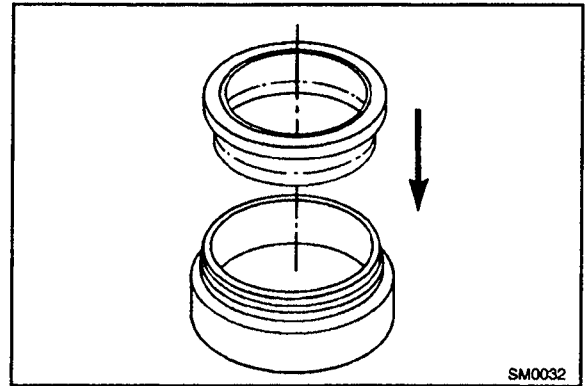


### Seal, Front Crankshaft - Installation

#### 3824499 Installation Tool

Leave the plastic pilot installation tool in the lubricating oil seal.

position the seal on the service tool, Part No. 3824499, with the lubricating oil seal dust lip facing outward.

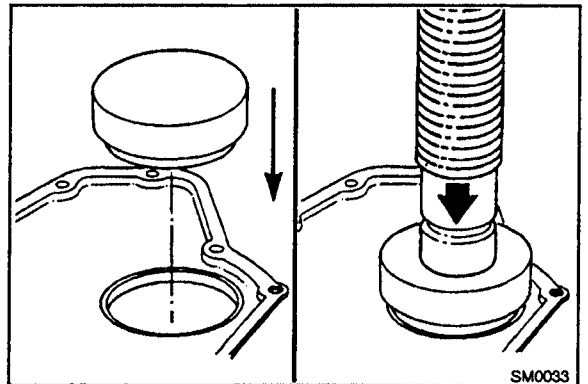


SM0032

**NOTE:** Properly support the front cover lubricating oil seal flange to prevent damage to the lubricating oil seal and front cover.

Press the lubricating oil seal into the front cover from the back side of the cover toward the front side of the cover.

press the lubricating oil seal until the service tool bottoms against the front cover.



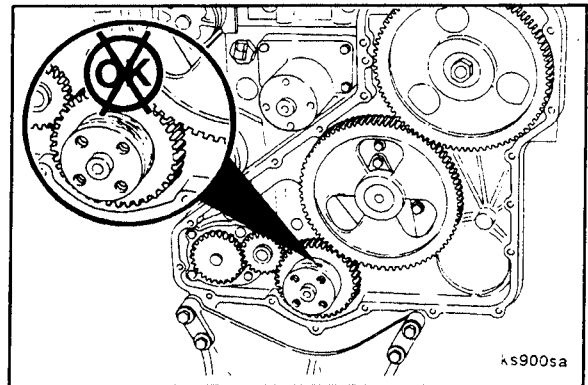
SM0033

### Wear Sleeve, Front Crankshaft - Installation

**NOTE:** Visually inspect the seal contact area of the crankshaft for a wear groove. If the seal has worn a groove deep enough to be felt with a sharp object or fingernail, it will be necessary to install a wear sleeve to prevent an oil leak.



**NOTE:** The oil seal used with the wear sleeve has a larger inside diameter than the standard seal. The two seals are not interchangeable. Refer to the appropriate Parts Manual for the correct part number.



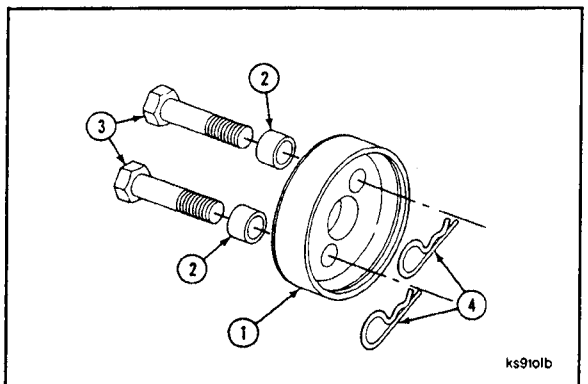
KS9005a

### Part No. 3823908 Crankshaft Front Wear Sleeve Installation Tool



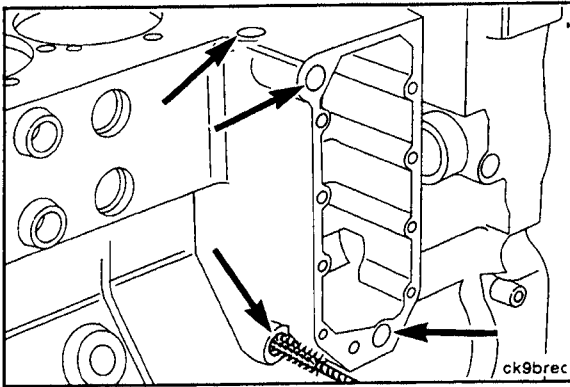
Use the driver to install the wear sleeve to the correct position on the crankshaft. The kit consists of the following:

| Ref. No. | Description           | Qty. |
|----------|-----------------------|------|
| 1        | Driver                | 1    |
| 2        | Spacer                | 2    |
| 3        | Capscrew M14X1.5X60mm | 2    |
| 4        | Hair Pin Cotter       | 2    |



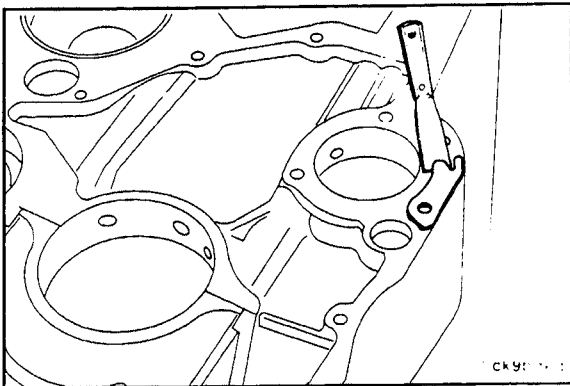
KS9101b

|  |           |
|--|-----------|
| Oil Seals . . . . .  | 9         |
| Pistons . . . . .  | 9         |
| Vibration Damper . . . . .   | 9         |
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| <b>Cylinder Block - Preparation for Cleaning . . . . .</b>                           | <b>10</b> |
| <b>Cylinder Block - Service Tools . . . . .</b>                                      | <b>4</b>  |
| <b>Cylinder Head Capscrews - Cleaning and Inspection for Reuse . . . . .</b>         | <b>64</b> |
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| Free Length - Measurement . . . . .  | 66        |
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| Cylinder Liners - Cleaning . . . . .   | 24        |
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| Engine Dataplate - Installation . . . . .  | 59        |
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| <b>Engine Lifting Brackets - Cleaning and Inspection for Reuse . . . . .</b>         | <b>66</b> |
| <b>Expansion Plug - Installation . . . . .</b>                                       | <b>19</b> |
| Pipe Plug - Installation . . . . .   | 20        |
| <b>Gear Cover - Cleaning and Inspection for Reuse . . . . .</b>                      | <b>60</b> |
| Gear Cover - Cleaning . . . . .  | 60        |
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| <b>Gear Housing - Cleaning and Inspection for Reuse . . . . .</b>                    | <b>57</b> |
| Gear Housing - Cleaning . . . . .  | 57        |
| Gear Housing - Inspection . . . . .  | 57        |
| <b>Main Bearing Caps and Capscrews - Cleaning and Inspection for Reuse . . . . .</b> | <b>38</b> |
| Cleaning . . . . .   | 38        |
| Inspection . . . . .   | 39        |
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| <b>Rear Cover - Cleaning and Inspection . . . . .</b>                                | <b>63</b> |
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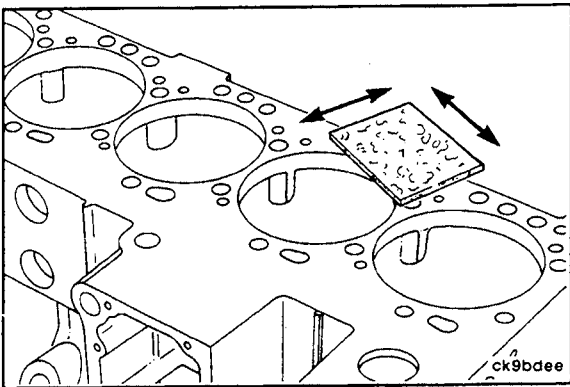


**Cleaning Brush**

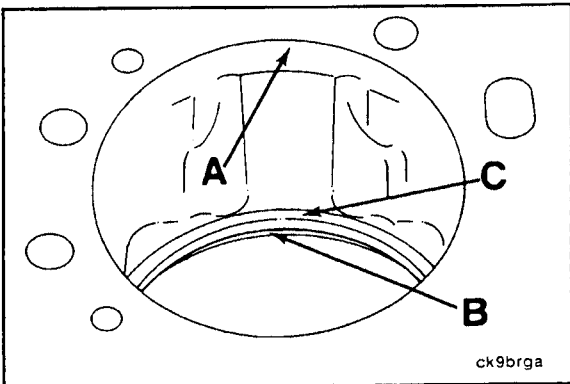
Use clean solvent and a brush to clean the oil cooler oil passages.



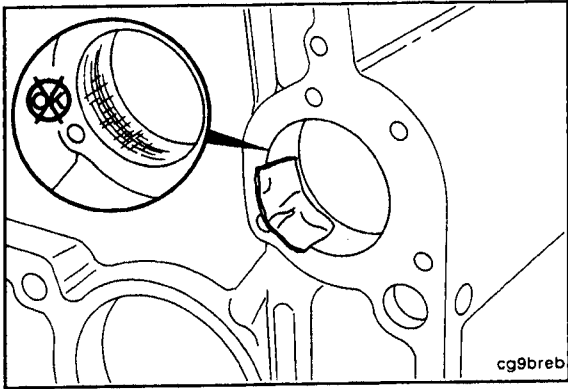
Thoroughly clean all gasket sealing surfaces.



Clean the cylinder block head deck with a Scotch-Brite® 7448 cleaning pad or equivalent and solvent.

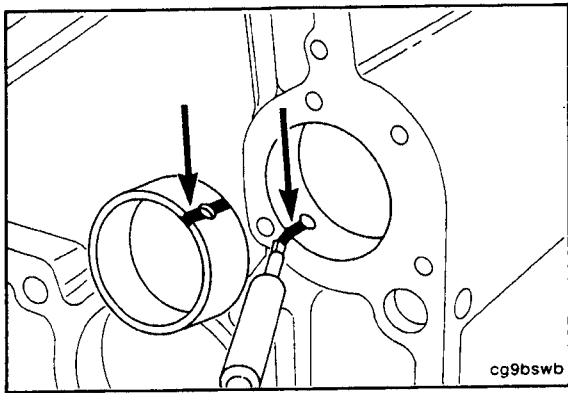


Clean the top cylinder liner press surface (A) and the mid-stop ledge (B) and (C) with a Scotch Brite® 7448 cleaning pad or equivalent and solvent.



### Camshaft Bushing Bore - Cleaning (1-10)

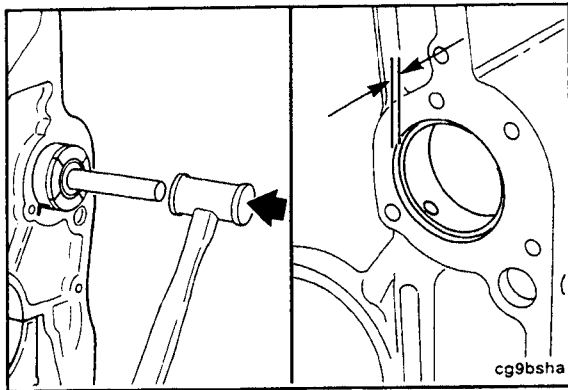
Use fine emery cloth and solvent to remove any burrs and sharp edges from the bores.



### Camshaft Bushing - Installation (1-11)

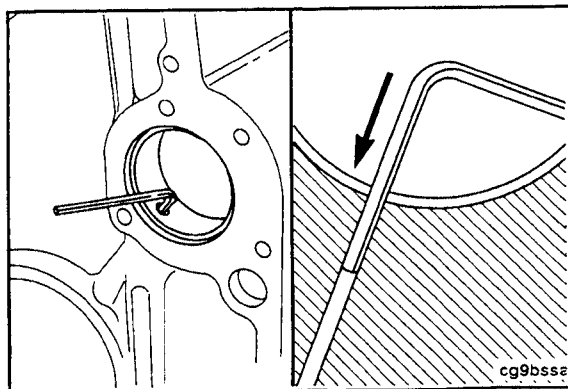
Mark the camshaft bushings and cylinder block to align the oil holes.

**NOTE:** The oil holes in the camshaft bushings should be pointing at approximately the 7:00 o'clock position when viewed from the front of the engine.



### Universal Bushing Installation Tool

**NOTE:** The front camshaft bushing should be installed to a depth of 4.5 mm [0.177 inch] below the front face of the cylinder block. All other bushings are to be installed even with the web of the camshaft bore.



**Be sure the oil holes are aligned.**

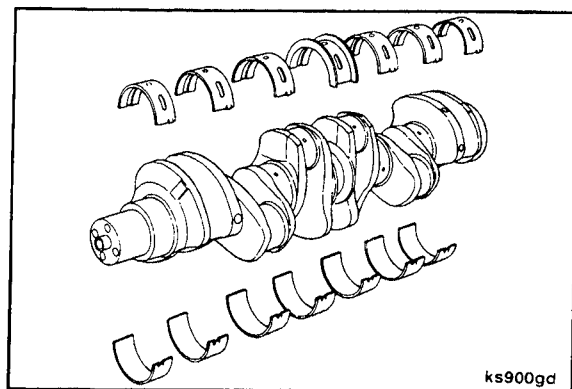
A 3.2 mm [0.128 inch] diameter rod must be able to pass freely through the camshaft bushing oil hole.

Cylinder Block - Group 01

Crankshaft - Cleaning and Inspection for Reuse (1-14)  
Page 1-31

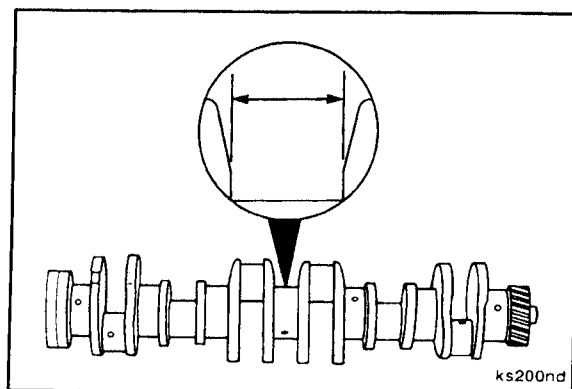
The following oversize service main and thrust bearings are available for crankshafts that have been machined undersize:

|                  | Main Bearing Diameter |       |         |         |
|------------------|-----------------------|-------|---------|---------|
|                  | Oversize              | 0.000 | 0.25 mm | 0.50 mm |
| Journal Diameter | 0.000                 | X     | X       | X       |
|                  | 0.25 mm               | X     | X       |         |
|                  | 0.50 mm               | X     |         | X       |
|                  | 0.75 mm               | X     |         |         |
|                  | 1.00 mm               | X     |         |         |



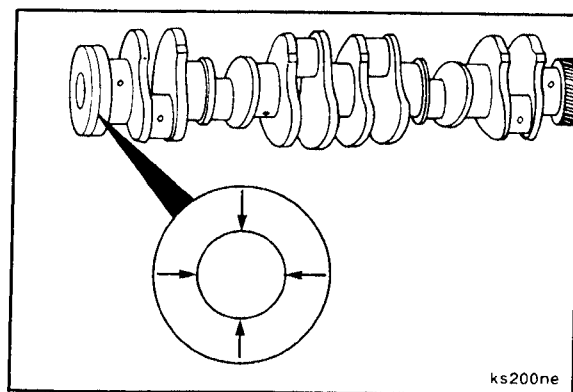
Measure the thrust face width.

| Crankshaft Thrust Face Width (Standard) |     |        |
|---|-----|--------|
| mm                                      |     | in     |
| 42.975                                  | MIN | 1.6919 |
| 43.076                                  | MAX | 1.6959 |



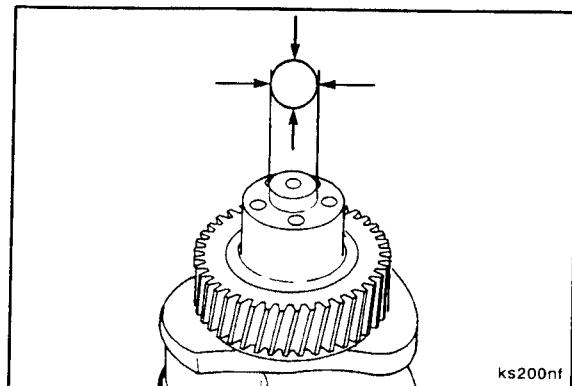
Measure the rear oil seal flange outside diameter.

| Crankshaft Rear Oil Seal Flange O.D. |     |        |
|--------------------------------------|-----|--------|
| mm                                   |     | in     |
| 129.975                              | MIN | 5.1171 |
| 130.025                              | MAX | 5.1191 |

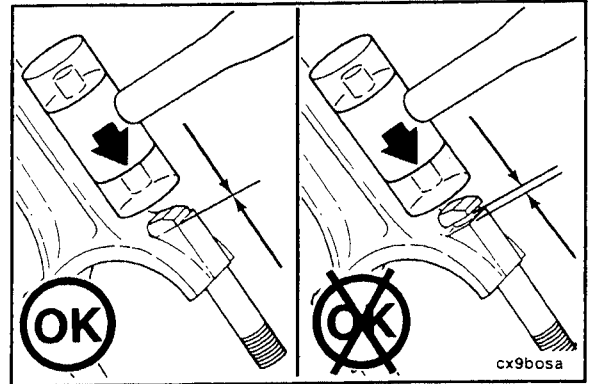


Measure the damper pilot outside diameter.

| Crankshaft Damper Pilot O.D. |     |        |
|------------------------------|-----|--------|
| mm                           |     | in     |
| 23.924                       | MIN | 0.9419 |
| 24.000                       | MAX | 0.9449 |



Tap the connecting rod bolts in until the head is aligned and seated on the flat machined surface of the connecting rod.

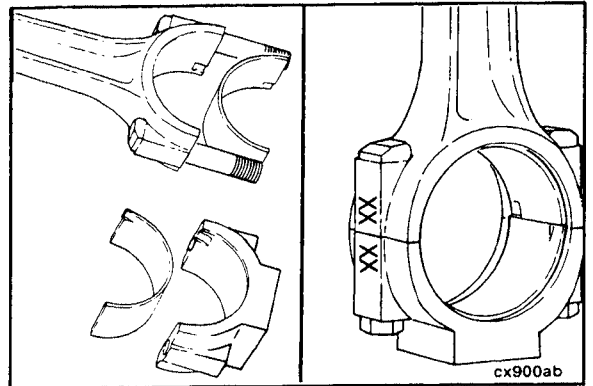


Install the bearing shells into the connecting rod and cap. Use clean 15W-40 oil to lubricate the capscrew threads. Install the connecting rod caps and connecting rod nuts.

**NOTE:** The connecting rod cap number must match the number on the connecting rod and be installed with the numbers aligned.

Tighten the connecting rod nuts in alternating sequence.

- Torque Value:**
- Step 1 - 40 N•m [30 ft-lb]
  - Step 2 - 80 N•m [60 ft-lb]
  - Step 3 - 120 N•m [88 ft-lb]



Measure the connecting rod crankshaft bore inside diameter with the bearing installed.

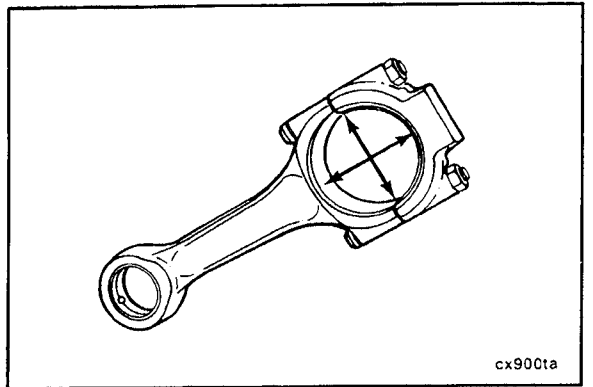


**Connecting Rod Crankshaft Bore I.D. (With Bearing)**

| mm     |     | in     |
|--------|-----|--------|
| 76.046 | MIN | 2.9939 |
| 76.104 | MAX | 2.9962 |

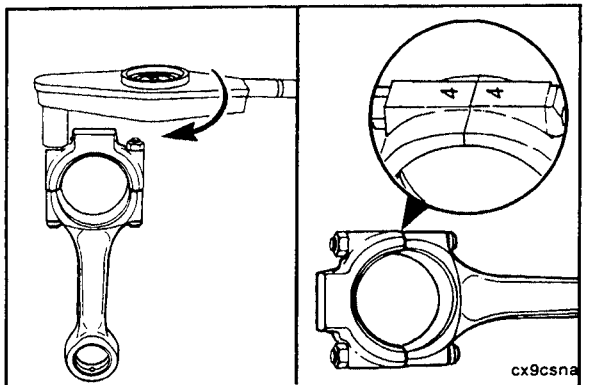
**Connecting Rod Crankshaft Bore I.D. (Without Bearing)**

| mm     |     | in     |
|--------|-----|--------|
| 80.987 | MIN | 3.1885 |
| 81.013 | MAX | 3.1895 |



**Caution:** The connecting rod must be assembled with the capscrew nuts tightened to specifications before stamping the cylinder identification number on the connecting rod.

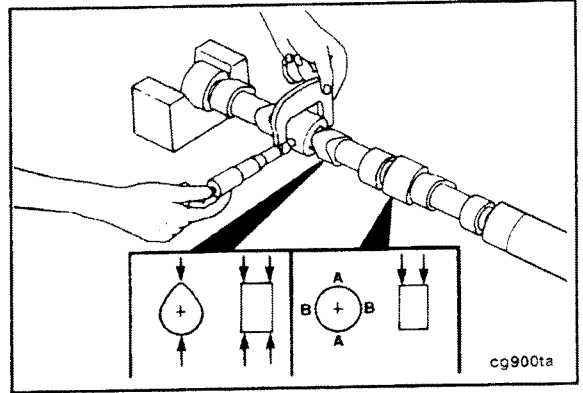
If a new connecting rod is installed, always stamp the new connecting rod with the cylinder number of the rod being replaced.



Measure across the camshaft journal.

| Camshaft Journal Diameter |     |        |
|---------------------------|-----|--------|
| mm                        |     | in     |
| 59.962                    | MIN | 2.3607 |
| 60.013                    | MAX | 2.3627 |

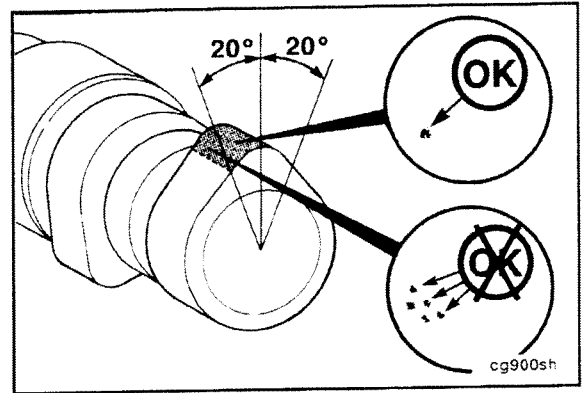
**NOTE:** Replace the camshaft if the outside diameter of any bearing surface is less than 59.962 mm [2.3607 inch].



cg900ta

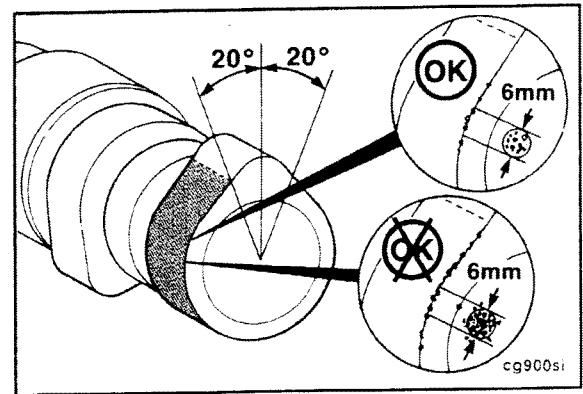
**Edge Deterioration (Breakdown)**

The area of edge deterioration **must not** be greater than the equivalent area of a 2 mm [0.079 inch] circle within + or - 20 degrees of the nose of the camshaft lobe.



cg900sh

Outside of the + or - 20 degrees of the nose of the camshaft lobe, the areas of edge deterioration **must not** be greater than the equivalent area of a 6 mm [0.236 inch] circle.

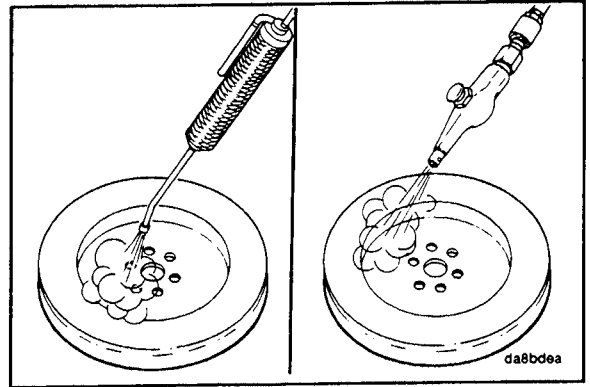


cg900si

### Viscous Vibration Damper - Cleaning

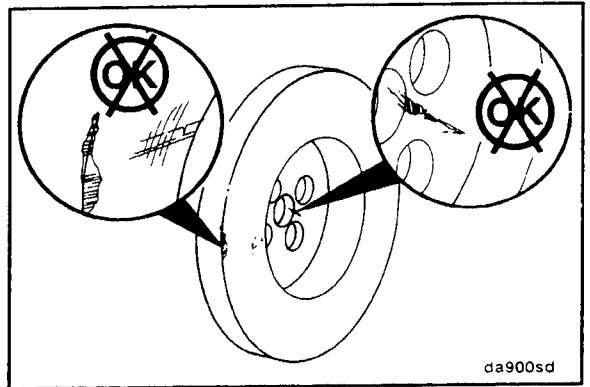
**Warning:** When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

Clean the vibration damper with a solvent cleaner or steam clean. Dry with compressed air.

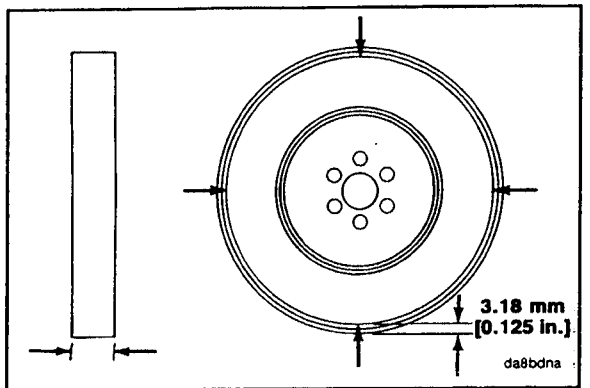


### Viscous Vibration Damper - Inspection

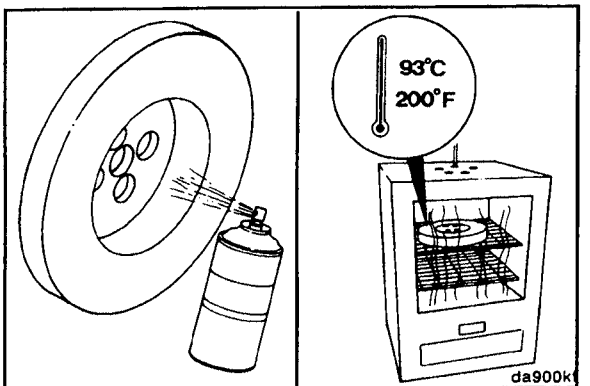
) Check the mounting web for cracks. Check the housing for dents or raised surfaces. Replace the vibration damper if any of these defects are identified.



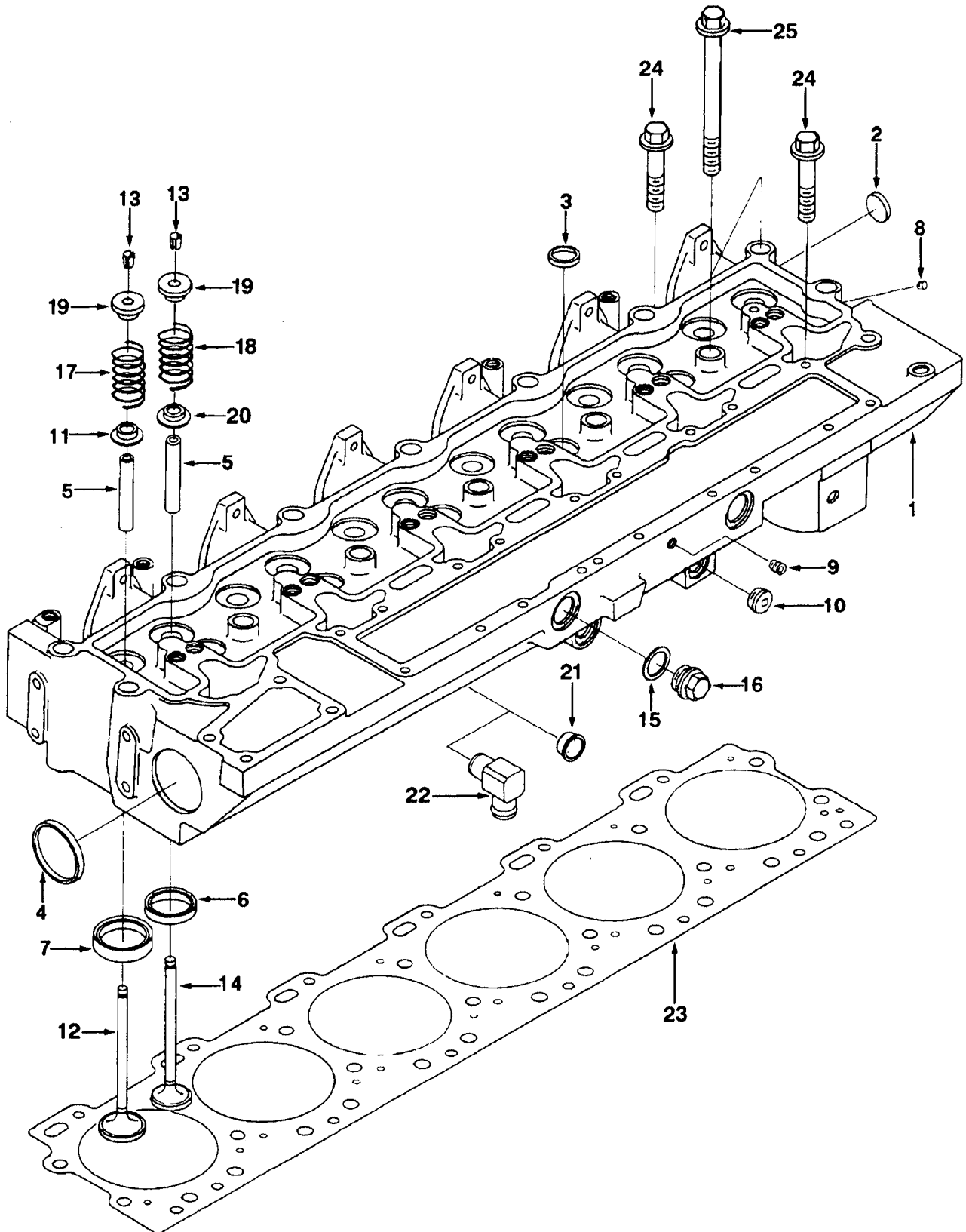
The viscous vibration damper is filled with a silicone fluid. After many hours of use, the silicone fluid can become thicker and expand. To determine if the vibration damper thickness is correct, remove the paint from the vibration damper in four locations on either side of the vibration damper. Measure and record the thickness of the vibration damper in four places. Measure the thickness 3.18 mm [0.125 inch] from the outside of the vibration damper. Replace the vibration damper if its thickness varies by more than 0.25 mm [0.010 inch].

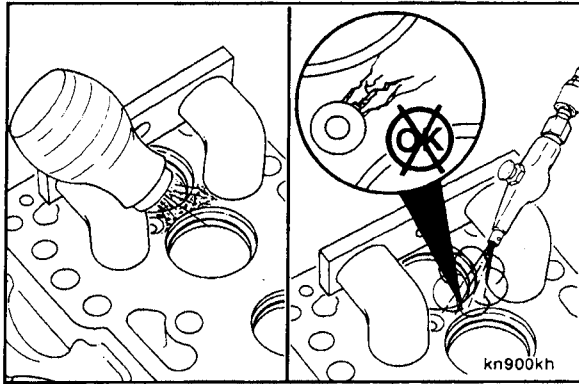


) Spray the vibration damper with spot check developer, Type SKD-NF or its equivalent. Heat the vibration damper in an oven (rolled lip side down) at 93°C [200°F] for 2 hours.



### Cylinder Head - Exploded View





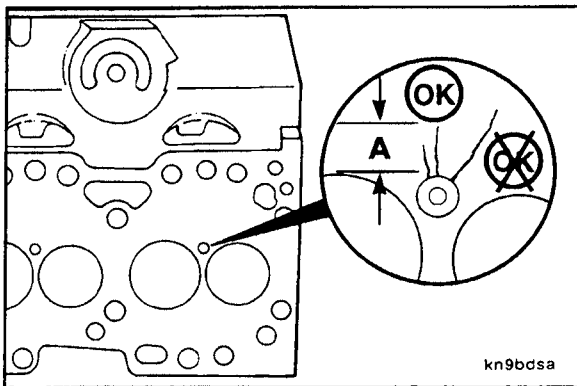
Fill the magnetic crack detector powder spray bulb one-third (1/3) full with metal powder.

Spray the powder lightly onto the combustion surface.

Use compressed air to remove the excess metal powder.

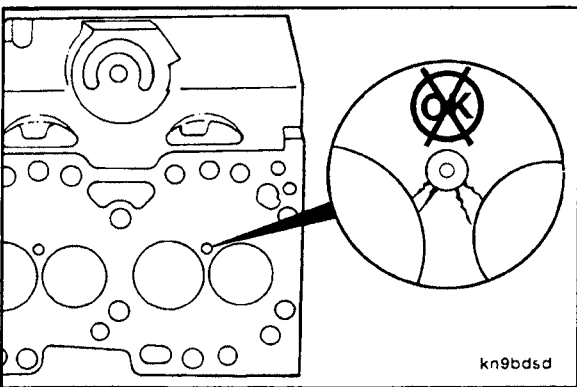
**Air Pressure:** 276 kPa [40 psi]

**NOTE:** The powder will remain in the cracks, if present, and show as a white line.

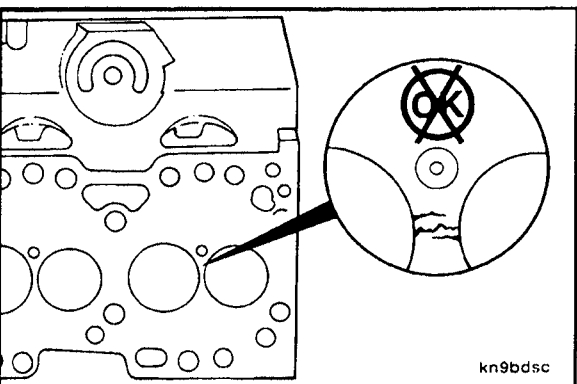


Check for cracks on the combustion surface. Cracks that extend from the injector bore away from the valve seats and are **not** over 10 mm [0.394 inch] long are acceptable.

A = 10 mm [0.394 inch]



Any cracks that extend from the injector bore toward the valve seats are unacceptable and the cylinder head **must** be replaced.

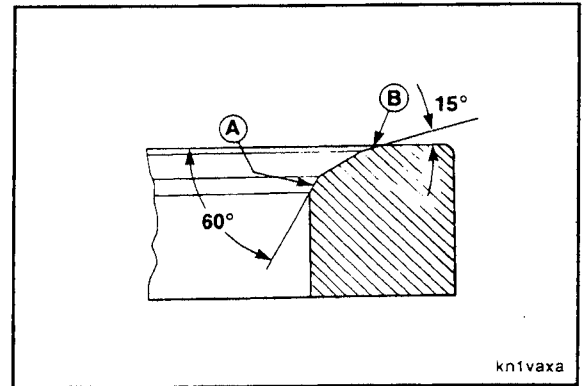


Cracks between the valve seats are **not** acceptable and the cylinder head **must** be replaced.

## Cylinder Head - Group 02

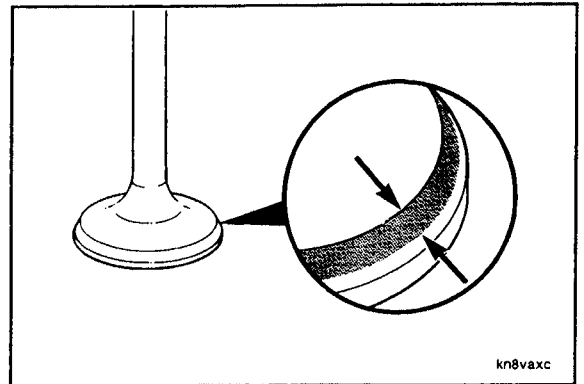
## Cylinder Head - Rebuild (2-02) Page 2-25

Grind valve seat insert area (A) with a 60-degree stone and valve seat insert area (B) with a 15-degree stone to center the seat on the valve sealing surface and to obtain the valve seat width limits.

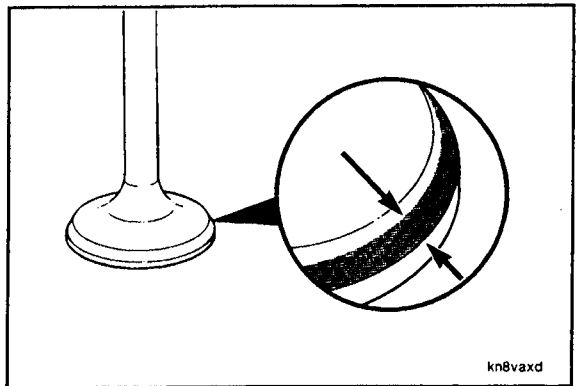


The location of the broken pencil lines on the valve sealing surface is the key to determining how much of each valve seat insert angle to grind.

If the broken lines are at the bottom of the valve sealing surface, the valve seat insert will require more grinding with the 60-degree stone than with the 15-degree stone.

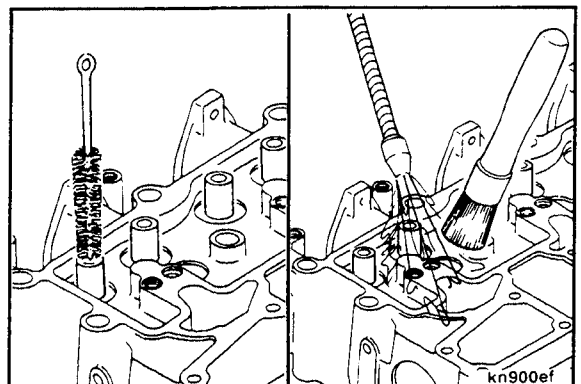


If the broken lines are at the top of the valve sealing surface, the valve seat insert will require more grinding with the 15-degree stone than with the 60-degree stone.



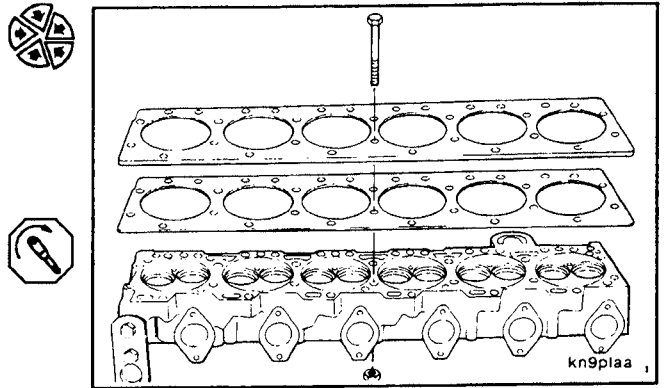
After grinding the valve seat inserts, use a bristle brush to clean the inside diameter of the valve guides.

Use solvent to clean the cylinder head. Dry with compressed air.

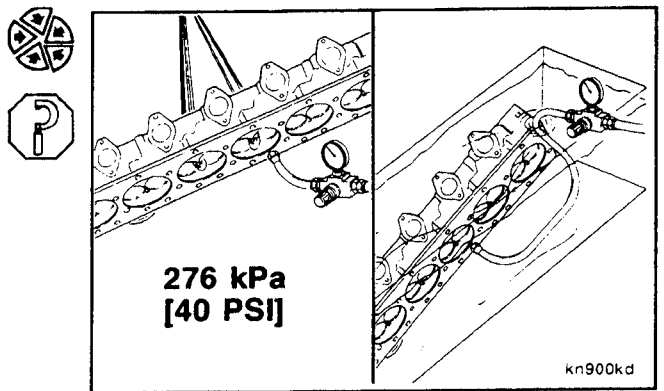


Cylinder Head - Group 02

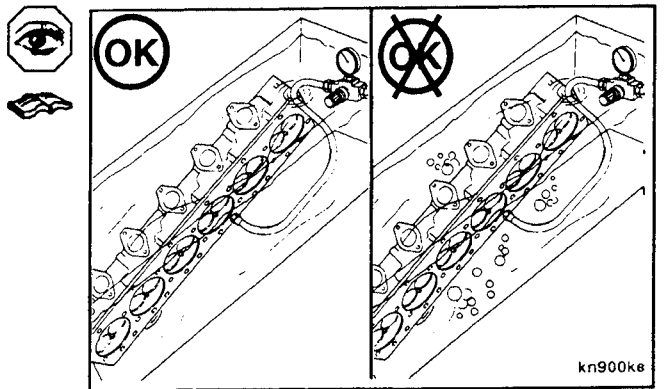
- Install the cylinder head water test fixture.
- Install a new head gasket.
- Install the test plate.
- Install the 26 cylinder head capscrews and M14 X 2.0 nuts.
- Tighten the nuts.
- Torque Value:** 45 N•m [35 ft-lb]



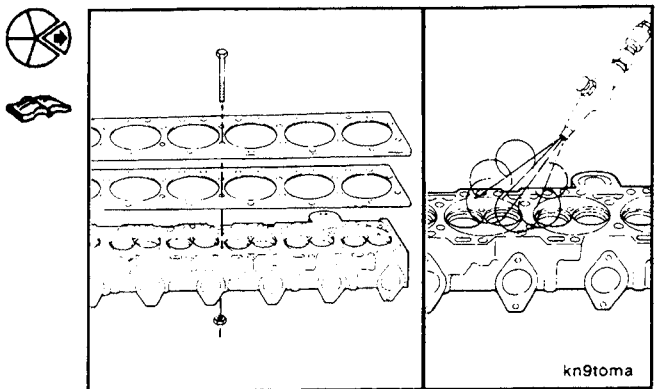
- Connect a regulated air supply hose to the test fixture plate.
- Apply air pressure.
- Air Pressure:** 276 kPa [40 psi]
- Use a nylon lifting strap and hoist to place the cylinder head in a tank of heated water.
- Temperature:** 60°C [140°F]
- Completely submerge the cylinder head in the water.

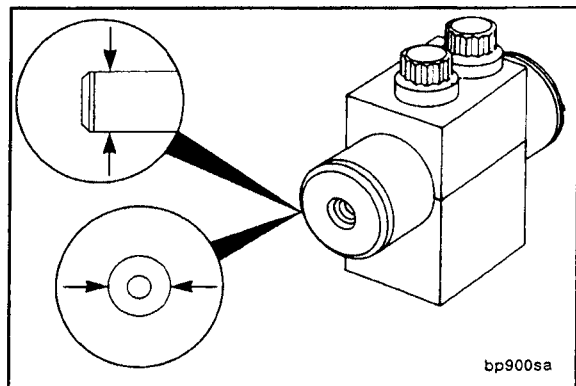


- Visually inspect for air bubbles rising from the water.
- If air bubbles are seen, replace or rebuild the cylinder head.
- Refer to Procedure (2-02).



- Remove the test equipment.
- Use compressed air to dry the cylinder head.
- Assemble the cylinder head. Refer to Cylinder Head - Rebuild - Assembly (2-02).



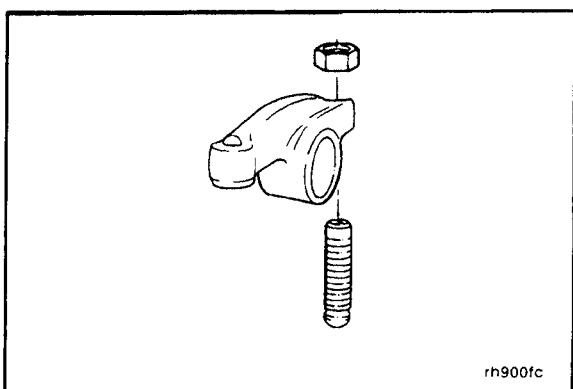


Visually inspect the rocker lever shafts for pitting, scoring or other damage.



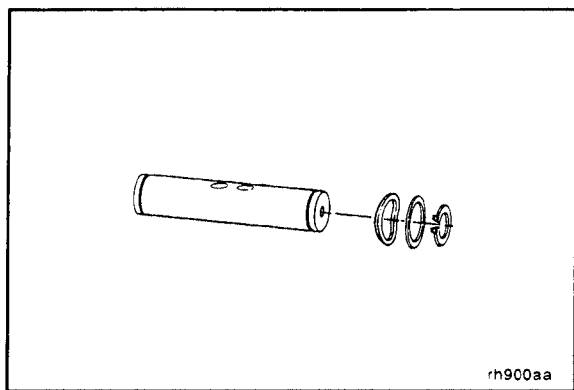
Measure the rocker lever shaft diameter.

| Rocker Lever Shaft Diameter |     |        |
|-----------------------------|-----|--------|
| mm                          |     | in.    |
| 22.199                      | MIN | 0.874  |
| 22.231                      | MAX | 0.8752 |

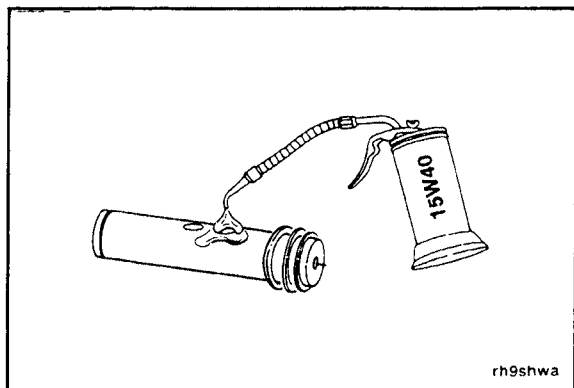


**Assembly**

Install the adjusting screw and locknut.



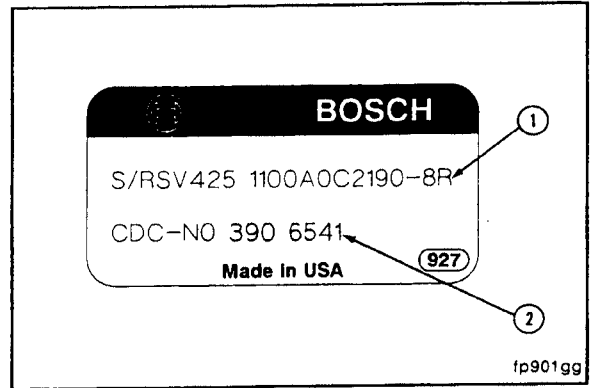
Install a retaining ring, thrust washer and wavey spring washer as illustrated.



Lubricate the shaft with engine oil.

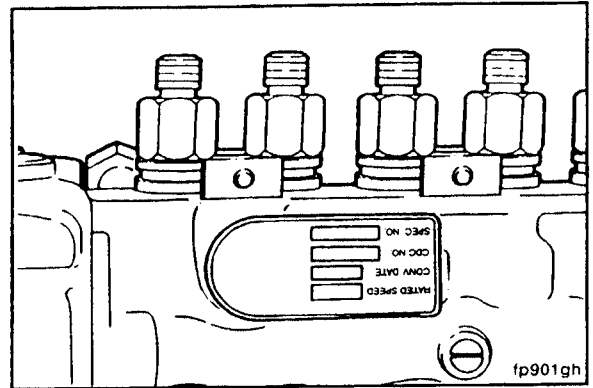
**Governor - Data Tag Information**

1. Bosch Designation Code
2. Vendor Fuel Injection Pump Part Number



**Derivative Fuel Injection Pump - Data Tag Information**

This tag is installed on the fuel injection pump when a base fuel injection pump is converted to a derivative fuel injection pump.



**Fuel Shutoff Solenoid - Wiring Requirements**

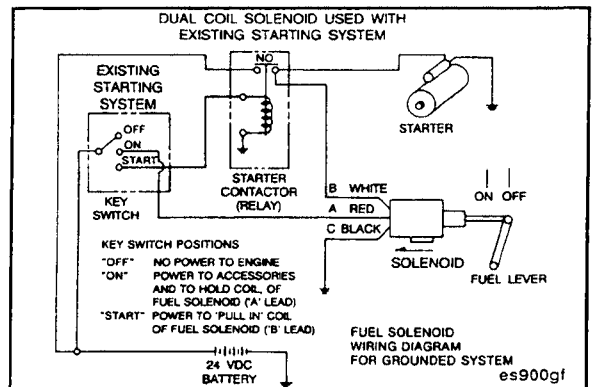
The solenoid **must** be wired properly. Refer to the chart below to find the correct gauge size and length of continuous wire for the white (pull-in) wire, which connects the solenoid wiring. The black (ground) wire **must** be the same gauge as the white (pull-in) wire regardless of its length.

| gauge | Length of Wires |          |         |
|-------|-----------------|----------|---------|
|       | 0-4.5 ft        | 0-7.0 ft | 0-11 ft |
| 14    | 14              | 12       | 10      |

14 gauge wire is required for the red (hold-in) wire, which connects to the "RUN" terminal on the ignition switch.

| Wire Gauge Size* |    |       |
|------------------|----|-------|
| mm               |    | in    |
| 1.5              | 14 | 0.060 |
| 1.9              | 12 | 0.076 |
| 2.4              | 10 | 0.096 |

\* Diameter of conductor only. Does not include insulation.



# Injectors and Fuel Lines - Group 06

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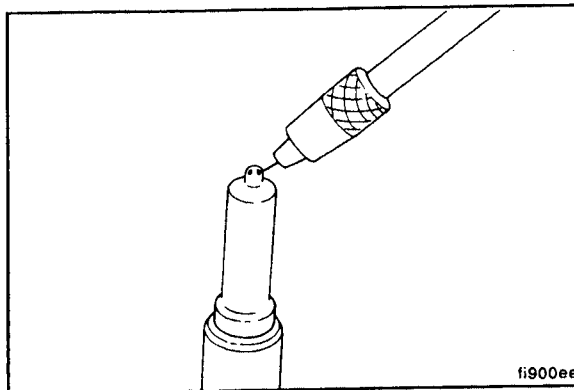
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## ) Injectors and Fuel Lines - Group 06

## Injectors - Cleaning and Inspection for Reuse (6-01) Page 6-11

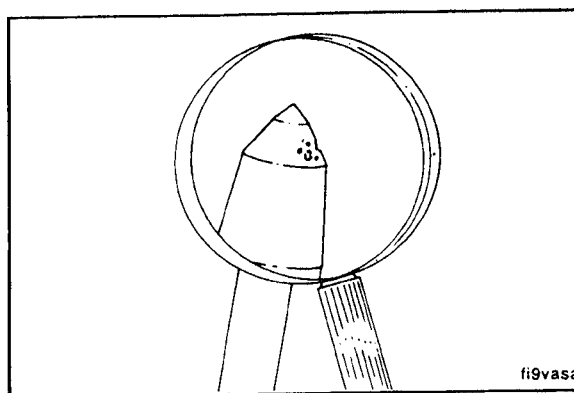
Clean the spray holes as shown with the appropriate size cleaning needle.

Remove burned-on combustion deposits on all nozzles with a commercially available cleaner. Rinse all parts in clean test oil.

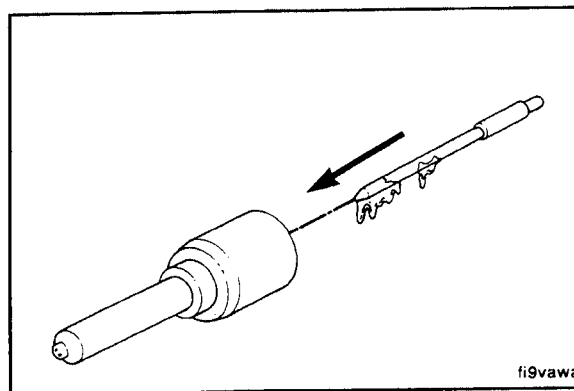


Clean the needle valve tip with a brass brush. Inspect for rough surfaces or erosion. The pressure shoulder will normally have a rough machined appearance.

**NOTE:** Deteriorated needle valves **must** be replaced as a matched unit with their compatible nozzle body.



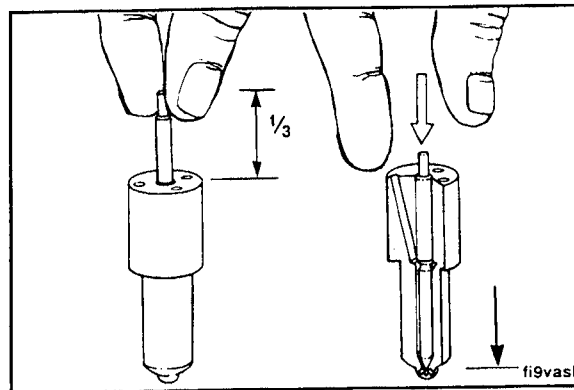
Dip the needle valve in clean test oil and insert the needle valve all the way into the nozzle body.



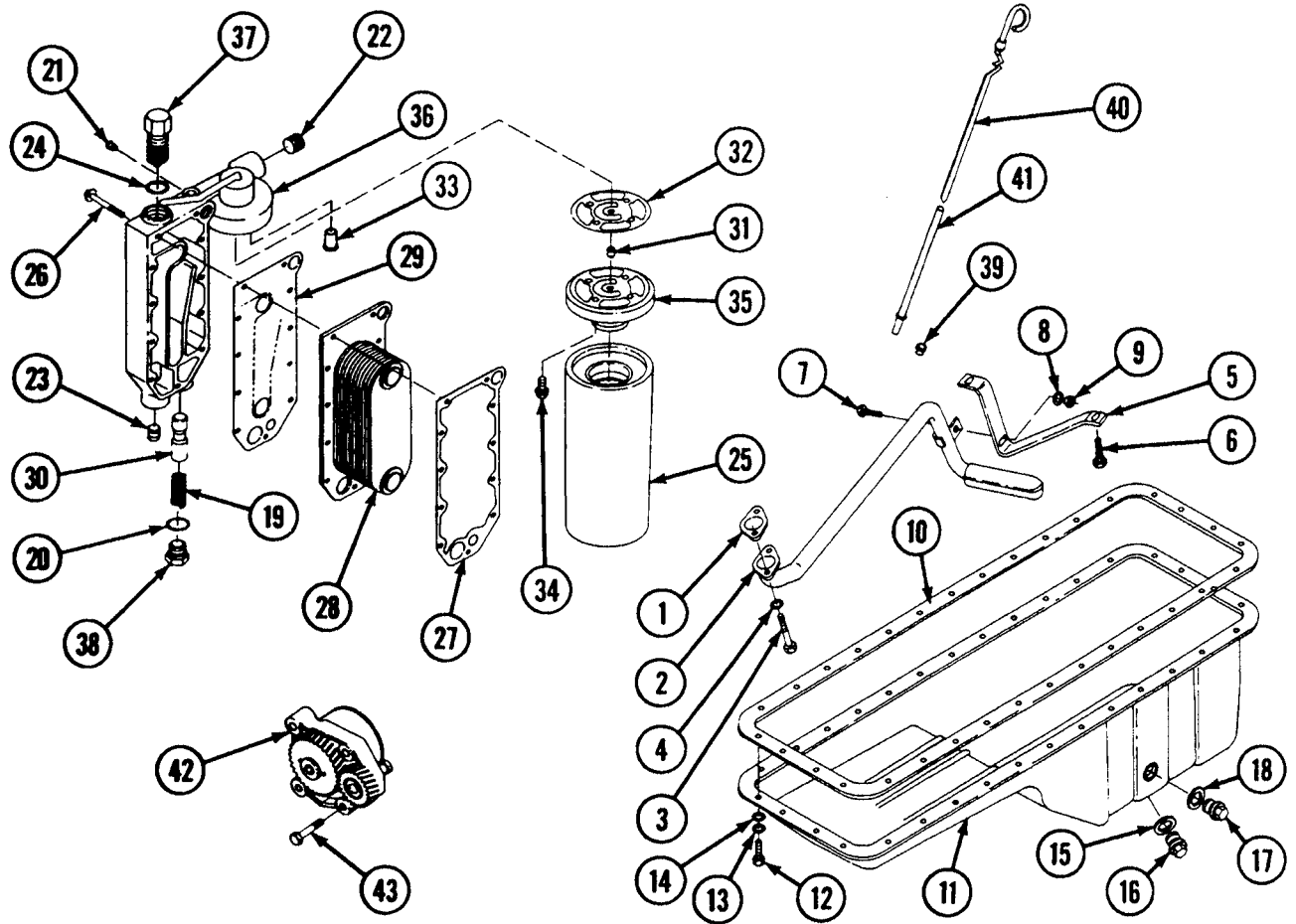
Pull the needle valve one-third of the way out of the nozzle body. With the needle valve in the vertical position, the needle valve **must** slide all the way back into the nozzle under its own weight.

If the nozzle fails the slide test, clean and test the nozzle again.

**NOTE:** Any needle valve and nozzle body assembly which does not pass this test **must** be replaced.

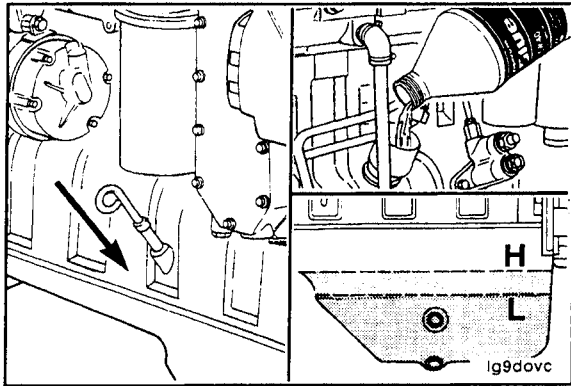


### Lubricating Oil System - Exploded View



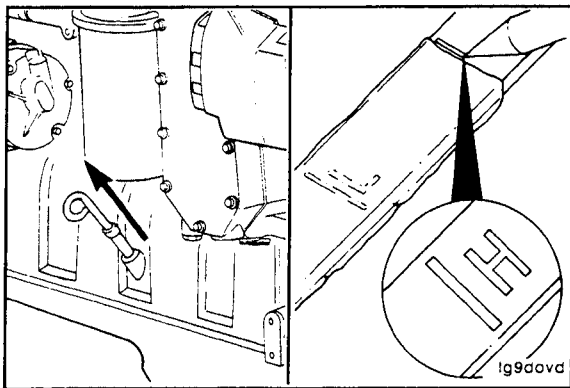
| Ref. No. | Description            | Qty |
|----------|------------------------|-----|
| 1        | Gasket, Suction Tube   | 1   |
| 2        | Tube, Lube Oil Suction | 1   |
| 3        | Screw, Socket Head Cap | 2   |
| 4        | Spacer, Mounting       | 2   |
| 5        | Brace, Suction Tube    | 1   |
| 6        | Screw, Hex Head Cap    | 2   |
| 7        | Screw, Hex Head Cap    | 1   |
| 8        | Washer, Plain          | 1   |
| 9        | Nut, Hex Flange        | 1   |
| 10       | Gasket, Oil Pan        | 1   |
| 11       | Pan, Oil               | 1   |
| 12       | Screw, Hex Head Cap    | 32  |
| 13       | Washer, Spring         | 32  |
| 14       | Washer, Plain          | 32  |
| 15       | Washer, Sealing        | 1   |
| 16       | Plug, Threaded         | 1   |
| 17       | Plug, Threaded         | 1   |
| 18       | Washer, Sealing        | 1   |
| 19       | Spring, Compression    | 1   |
| 20       | Seal, O-Ring           | 1   |
| 21       | Plug, Pipe             | 2   |
| 22       | Plug, Pipe             | 1   |

| Ref. No. | Description                  | Qty |
|----------|------------------------------|-----|
| 23       | Plug, Pipe                   | 1   |
| 24       | Seal, O-Ring                 | 1   |
| 25       | Element, Lube Oil Filter     | 1   |
| 26       | Screw, Hex Flange Head Cap   | 11  |
| 27       | Gasket, Oil Cooler Element   | 1   |
| 28       | Element, Oil Cooler          | 1   |
| 29       | Gasket, Lube Oil Cooler Cvr. | 1   |
| 30       | Plunger, Pressure Regulator  | 1   |
| 31       | Dowel, Ring                  | 1   |
| 32       | Gasket, Filter Head          | 1   |
| 33       | Valve, Bypass                | 1   |
| 34       | Screw, Hex Flange Head Cap   | 4   |
| 35       | Head, Lube Oil Filter        | 1   |
| 36       | Cover, Lube Oil Cooler       | 1   |
| 37       | Thermostat, Lube             | 1   |
| 38       | Plug, Threaded               | 1   |
| 39       | Plug, Expansion              | 1   |
| 40       | Dipstick                     | 1   |
| 41       | Tube, Oil Gauge              | 1   |
| 42       | Pump, Lubricating Oil        | 1   |
| 43       | Screw, Hexagon Head Cap      | 4   |



Install the dipstick into the dipstick tube housing.

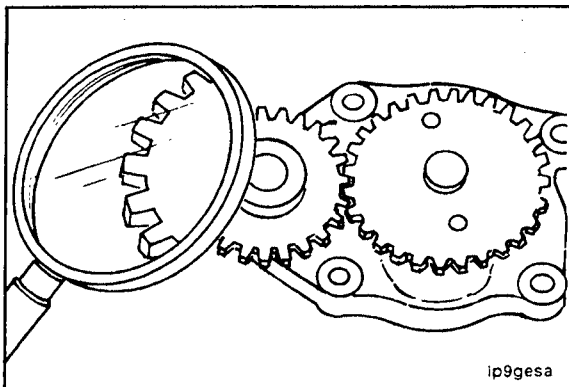
Fill the oil pan to the specified "high" oil level. Refer to Lubricating Oil System Specifications for engine oil capacity.



**Caution:** The dipstick will break if the scribe mark is too deep.



Remove the dipstick and scribe a mark across the dipstick and mark the "high" oil level with an "H".



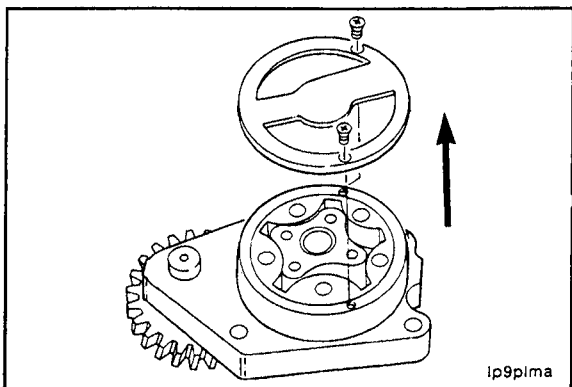
## Lubricating Oil Pump - Cleaning and Inspection for Reuse (7-08)

### Disassembly

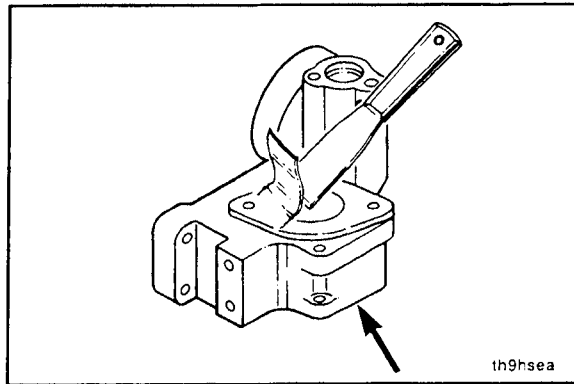


Visually inspect the lubricating oil pump gears for chips, cracks, or excessive wear.

**NOTE:** It is **not** practical to rebuild the pump. If any of the internal parts are worn beyond the specifications, the pump **must** be replaced.



Remove the back plate.

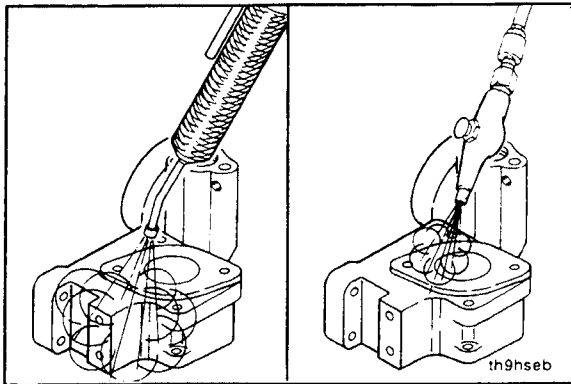


## Thermostat Housing - Cleaning and Inspection for Reuse (8-02)

### Cleaning



Use a gasket scraper to remove the gasket material from the mating surfaces of the housing.

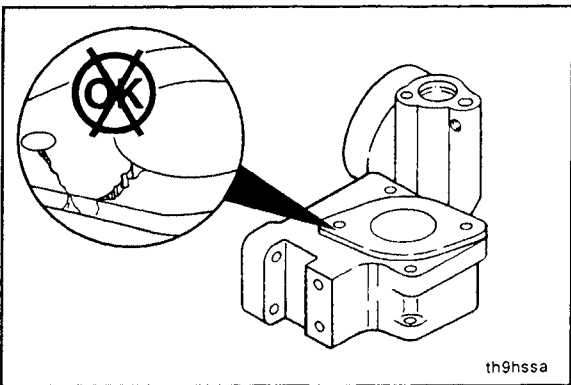


**Warning:** When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.



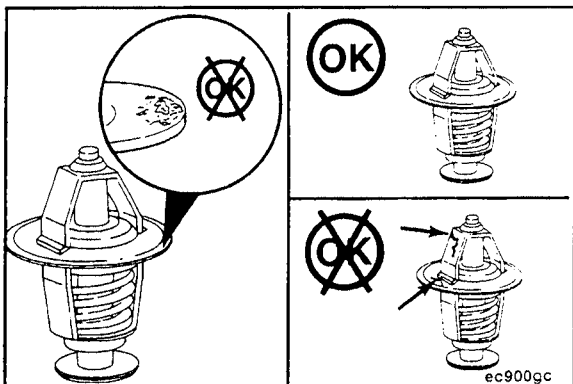
Use solvent or steam to clean the parts.

Dry with compressed air.



### Inspection

Visually inspect the thermostat housing for cracks, corrosion, or damage. Replace the thermostat housing if damaged.



## Thermostat - Inspection (8-03)

Visually inspect the thermostats for damage.

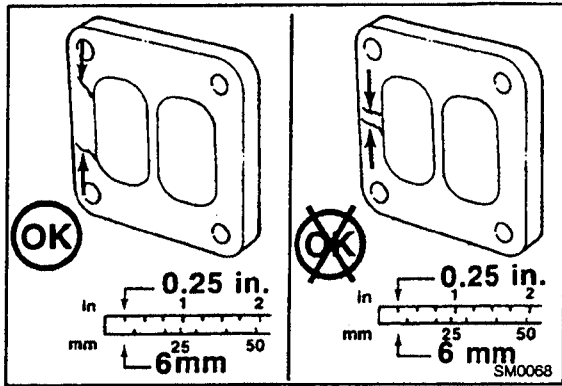
Make sure both thermostats are clean and free from corrosion.

## **Accessory Drive - General Information**

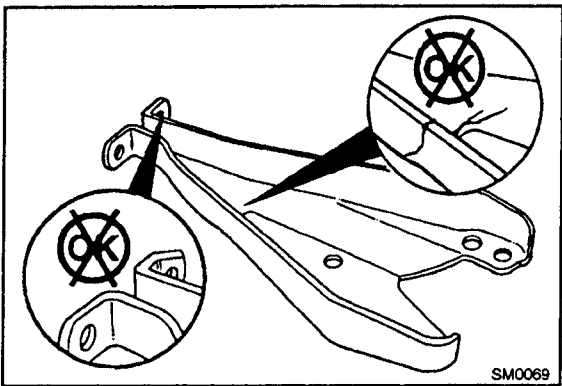
### **Accessory Drive Adapter**

The accessory drive is gear driven from the camshaft gear in the front gear train. The accessory drive is capable of driving up to a maximum of 105 ft-lb of torque. The accessory drive is equipped with either SAE A or B flange adapters.

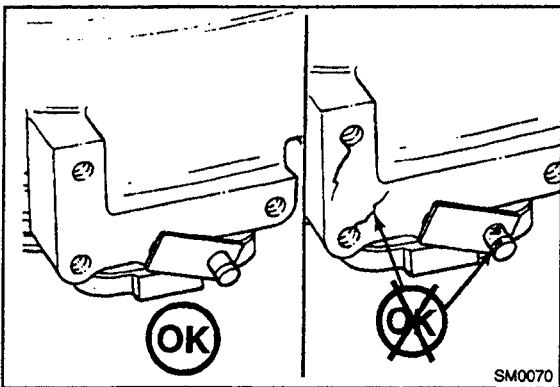
A cover plate is used for engines not equipped with an air compressor or hydraulic pump.



Two cracks **must** be separated by a minimum of 6.4 mm [0.25 inch].

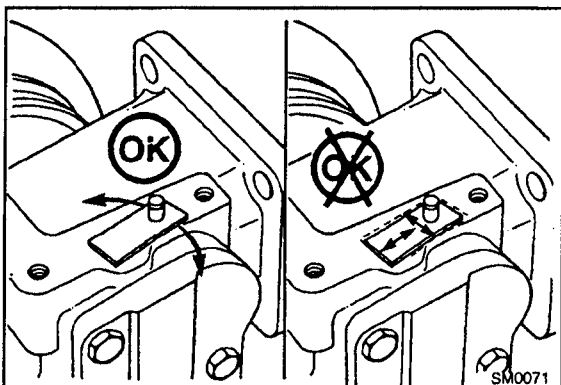


Visually inspect the wastegate actuator mounting bracket for cracks or bends. Replace if damaged.



Visually inspect the bracket mounting surface for cracks and damage.

Visually inspect the wastegate valve assembly lever pin. Replace the turbine housing if it is worn excessively.

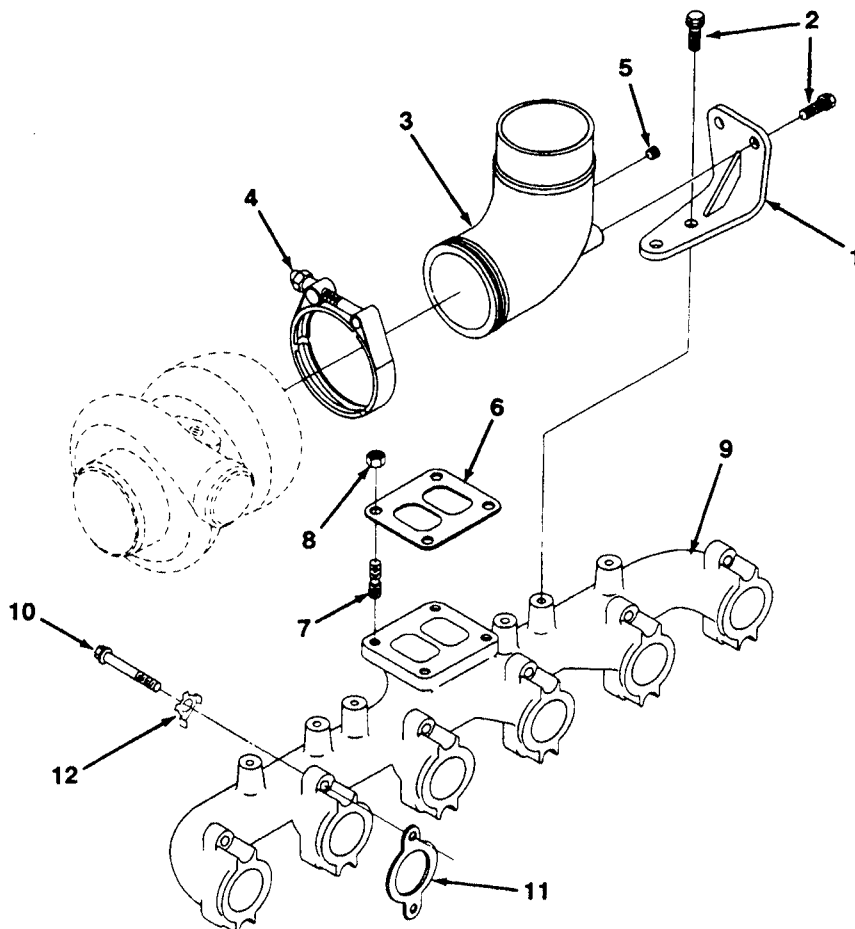


Actuate the wastegate assembly lever by hand to be sure that the shaft rotates freely and is **not** seized.

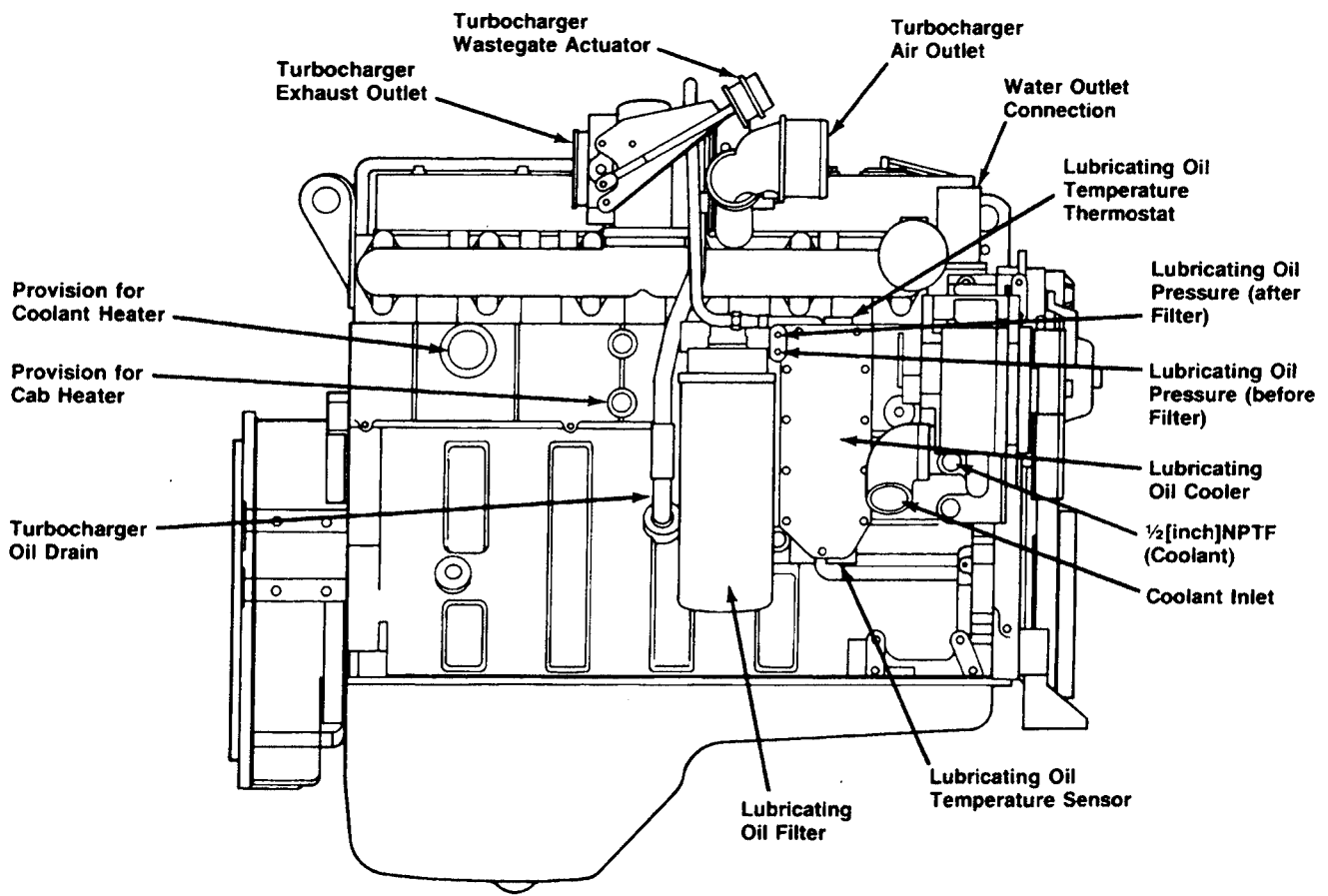
Check for excessive movement between the wastegate shaft and bushing.

Replace the turbine housing if the wastegate shaft and the turbine housing bushing are damaged or seized.

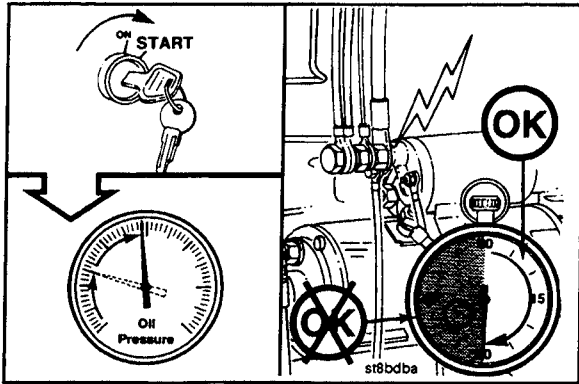
### Exhaust Manifold - Exploded View



| Ref. No. | Part Name                        | Qty |
|----------|----------------------------------|-----|
| 1        | Brace, Exhaust Outlet Connection | 1   |
| 2        | Screw, Hex Head Cap              | 4   |
| 3        | Connection, Exhaust Outlet       | 1   |
| 4        | Clamp, V Band                    | 1   |
| 5        | Pipe, Plug                       | 1   |
| 6        | Gasket, Turbocharger             | 1   |
| 7        | Stud                             | 4   |
| 8        | Nut                              | 4   |
| 9        | Manifold, Exhaust                | 1   |
| 10       | Screw, Hex Head Cap              | 12  |
| 11       | Gasket, Manifold                 | 6   |
| 12       | Lockplate                        | 12  |



Turbocharger Side View

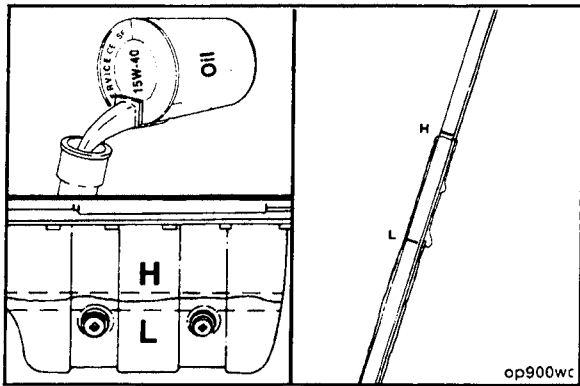


**Caution:** Do not crank the starting motor for periods longer than 30 seconds. Excessive heat will damage the starting motor.

Crank the engine until the oil pressure gauge indicates system pressure.

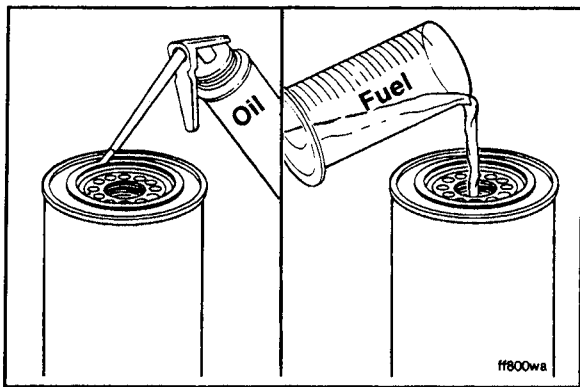
**NOTE:** Allow 2 minutes between the 30-second cranking periods so the starting motor can cool.

**NOTE:** If pressure is **not** indicated, find and correct the problem before continuing.



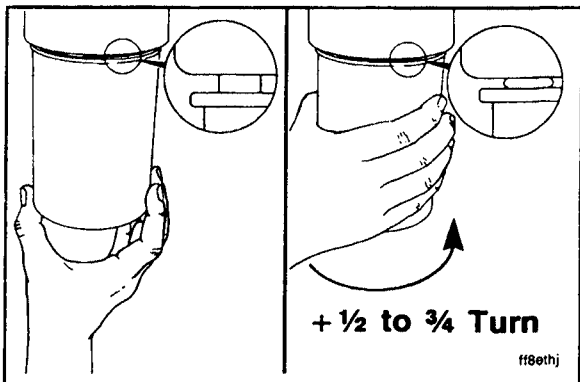
Allow the lubricating oil to drain into the oil pan, and measure the oil level with the dipstick.

Add oil as necessary to bring the level to the "High" level mark.



Lubricate the gasket on the fuel filter with clean 15W-40 engine oil.

Fill the fuel filter with clean No. 2 diesel fuel.

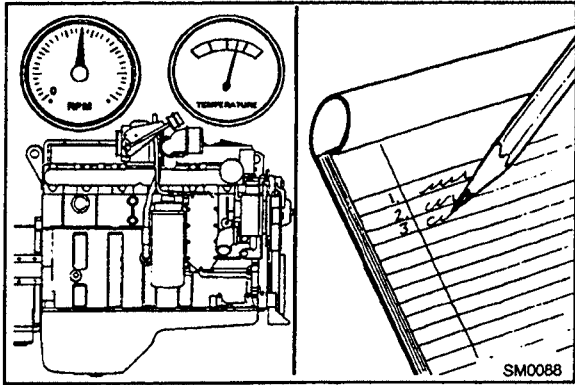


**Caution:** To prevent air leaks, make sure the filter is installed tightly but not over-tightened. Mechanical over-tightening can distort the threads or damage the filter element seal.

Install the filter as specified by the filter manufacturer. If there are no instructions, refer to the following guidelines.

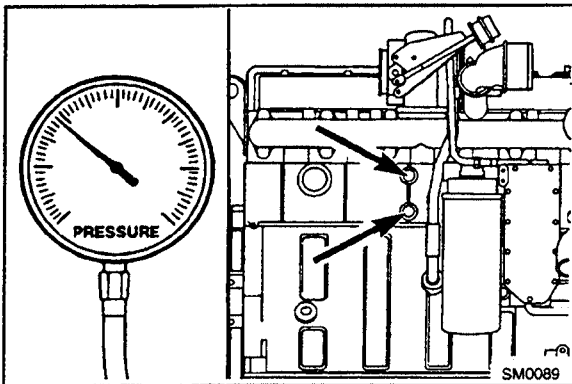
Screw the fuel filter onto the filter head until the gasket contacts the filter head surface.

Tighten the filter an additional 1/2 to 3/4 turn.



To correctly monitor an engine's performance, record the following parameters:

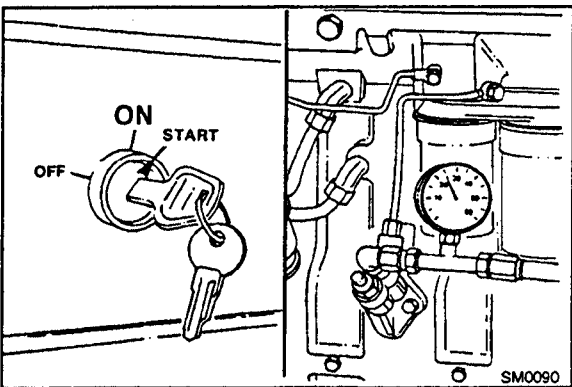
- Lubricating oil pressure (vehicle instrument panel)
- Coolant temperature (vehicle instrument panel)
- Coolant pressure
- Intake manifold pressure
- Inlet air restriction
- Blowby
- Engine speed (RPM) (vehicle instrument panel)
- Wheel horsepower (WHP) (dynamometer controls)



### Coolant Pressure

Measure the coolant pressure at the exhaust side of the cylinder block.

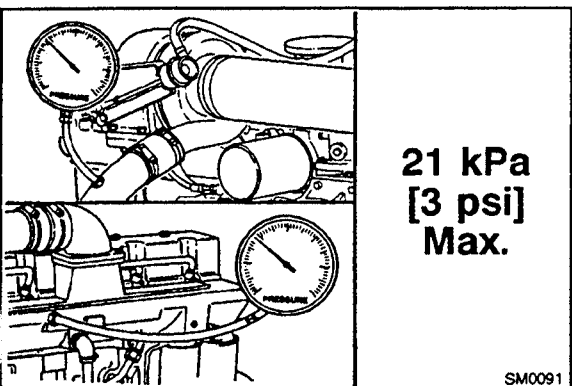
**Minimum Gauge Capacity: 415 kPa [60 psi]**



### Fuel Inlet Restriction

Measure the fuel inlet restriction. Install a vacuum gauge, Part No. ST-434, to the fuel transfer pump inlet line.

**Minimum Gauge Capacity: 760 mm Hg [30 in Hg]**



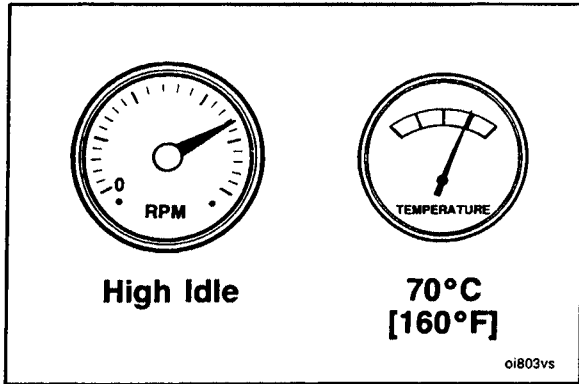
### Charge Air Cooler Restriction

Measure the intake pressure drop across the charge air cooler. This test can be done with a mercury manometer or two separate gauges, Part No. ST-1273. If two gauges are being used, calibrate both gauges on a common pressure source at 206 kPa [30 psi] to ensure consistency.

Install one pressure gauge, Part No. ST-1273, in the fitting in the turbocharger compressor outlet elbow. Install the other pressure gauge in the fitting in the intake manifold.

Observe the reading on the gauges. Pressure drop must not be greater than:

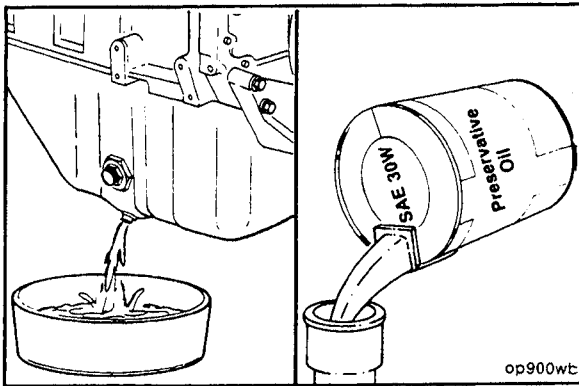
|           |             |
|-----------|-------------|
| 102 mm Hg | [4.0 in Hg] |
| 21 kPa    | [3.0 psi]   |



Be sure the cooling system and lubricating oil system are properly filled.

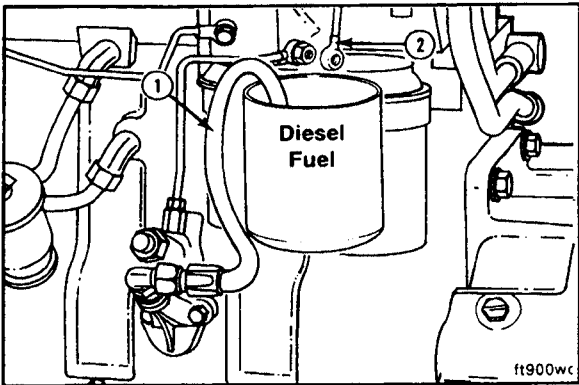
Operate the engine at the high idle throttle position until the coolant temperature is 70°C [160°F].

Shut off the engine.



Drain the lubricating oil pan. Install the drain plug, and fill the oil pan to the "High" level mark on the dipstick with preservative oil.

**NOTE:** Lubricating system preservative oil must meet Military Specification MIL-L-21260 Type E30-1 SAE 30. (Example: Shell 66202).

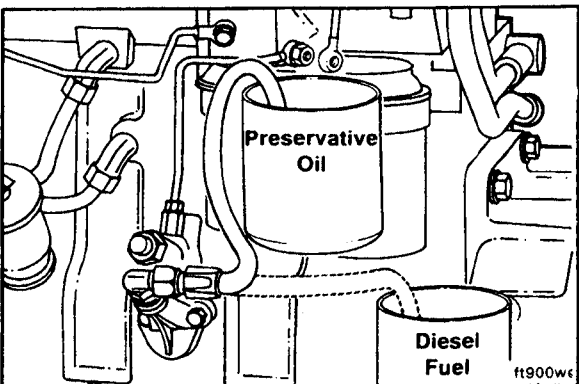


Disconnect the fuel supply tube at the fuel filter (1) and the injector fuel return tube (2).

**NOTE:** Fuel system preservative oil must meet Federal Specification VV-L-800C. (Example: Daubert Chemical NoxRust No. 518).



Fill two containers, one with diesel fuel and the other with preservative oil. Put both fuel tubes into the container of diesel fuel.



Start the engine and run until it is operating smoothly, then put the fuel supply tube into the container of preservative oil.



Remove the injector return tube from the diesel fuel container. When the preservative oil flows from the tube, shut off the engine.

Connect the fuel supply tube to the fuel filter, and put a cap on the ends of all the other fuel tubes.

## **Mounting Adaptations - General Information**

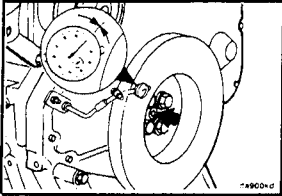
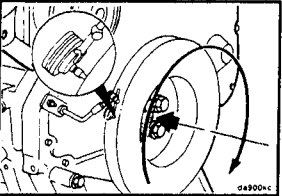
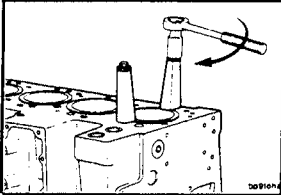
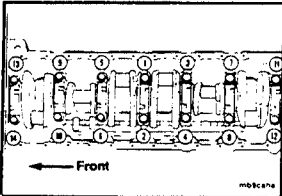
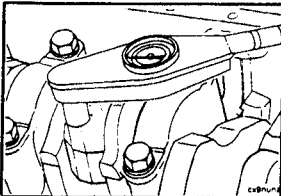
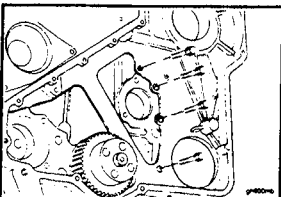
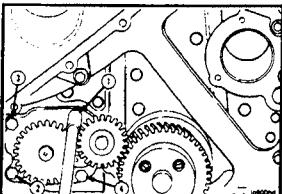
The mounting adaptations group consists of the flywheel housing, flywheel, flywheel ring gear, pilot bearing, and the front engine support.

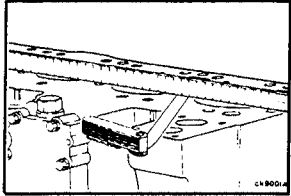
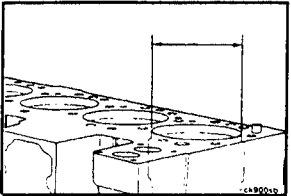
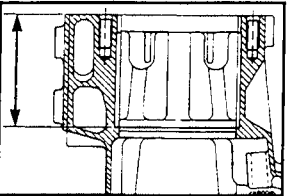
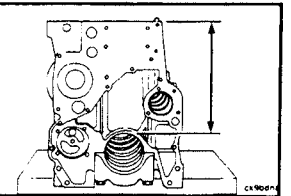
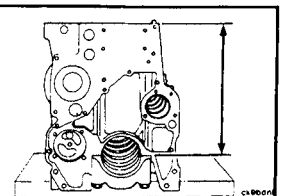
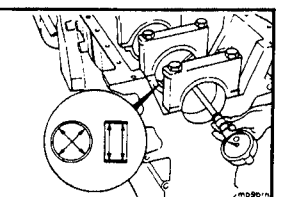
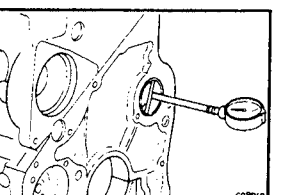
### **Flywheel Housing**

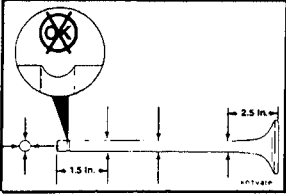
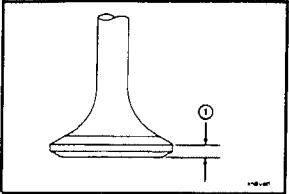
The flywheel housings are available in different sizes and styles for the various applications. Ring dowels are used to locate the housing within 0.20 mm [0.008 in] total indicated runout. Service housings are drilled for the dowels and re-dowelling is not required. Check the appropriate parts book and the engine parts listing for the correct part number for the engine application being serviced.

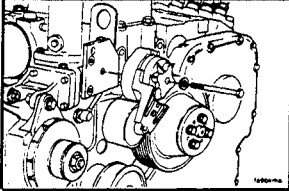
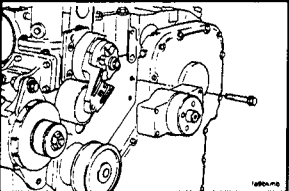
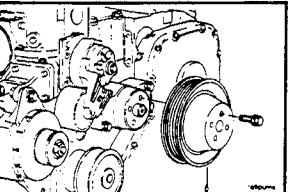
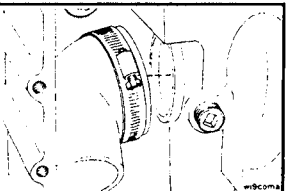
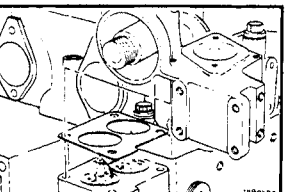
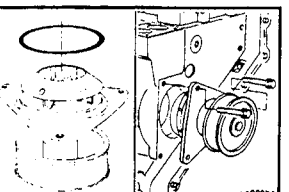
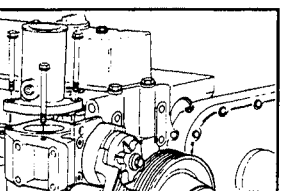
### **Flywheel and Ring Gear**

The flywheel is available only as an assembly. The assembly includes the flywheel and the ring gear. The ring gear is available for service replacement.

| Component or Assembly (Procedure)                  | Ref.No./Steps    | Metric                       | U.S.                              |   |
|--|------------------|------------------------------|-----------------------------------|---|
| Vibration Damper Face Alignment<br>(Wobble) T.I.R. |                  | 0.28 mm                      | MAX 0.011 in                      |    |
| Vibration Damper Eccentricity T.I.R.               |                  | 0.28 mm                      | MAX 0.011 in                      |    |
| <b>Engine Assembly - Torque Values</b>             |                  |                              |                                   |   |
| Cylinder Liner Clamps                              |                  | 68 N•m                       | 50 ft-lb                          |   |
| Main Bearing Cap Capscrews                         | Step 1<br>2<br>3 | 50 N•m<br>119 N•m<br>176 N•m | 37 ft-lb<br>88 ft-lb<br>129 ft-lb |  |
| Connecting Rod Nuts                                | Step 1<br>2<br>3 | 40 N•m<br>80 N•m<br>120 N•m  | 30 ft-lb<br>60 ft-lb<br>88 ft-lb  |  |
| Gear Housing Mounting Capscrews<br>M8<br>M12       |                  | 24 N•m<br>60 N•m             | 18 ft-lb<br>44 ft-lb              |  |
| Oil Pump Mounting Capscrews                        |                  | 24 N•m                       | 18 ft-lb                          |  |

| Component or Assembly (Procedure)  | Ref.No./Steps          | Metric                   |            | U.S.                   |   |
|--|------------------------|--------------------------|------------|------------------------|---|
| <b>Cylinder Block - Rebuild Specifications</b>   |                        |                          |            |                        |   |
| <b>Cylinder Block Head Deck Flatness</b><br>End-to-End<br>Side-to-Side                             |                        | 0.075 mm                 | MAX        | 0.0030 in              |    |
|  |                        | 0.075 mm                 | MAX        | 0.0030 in              |   |
| <b>Cylinder Block Upper Liner Bore I.D.</b>  |                        | 130.900 mm<br>130.990 mm | MIN<br>MAX | 5.1535 in<br>5.1570 in |    |
| <b>Cylinder Block Counterbore Depth From<br/>Cylinder Block Head Deck</b>                          |                        | 122.930 mm<br>123.000 mm | MIN<br>MAX | 4.8397 in<br>4.8425 in |   |
| <b>Cylinder Block Height From Head Deck<br/>Surface to Top of Main Bearing Bore</b>                |                        | 309.40 mm<br>309.60 mm   | MIN<br>MAX | 12.181 in<br>12.189 in |  |
| <b>Cylinder Block Height From Head Deck<br/>Surface to Centerline of the Main Bearing<br/>Bore</b> |                        | 361.90 mm<br>362.10 mm   | MIN<br>MAX | 14.248 in<br>14.256 in |  |
| <b>Main Bearing Bore Diameter</b><br>With New Bearings   |                        | 98.079 mm<br>98.125 mm   | MIN<br>MAX | 3.8614 in<br>3.8632 in |  |
|  | Without Bearings       | 104.982 mm<br>105.018 mm | MIN<br>MAX | 4.1331 in<br>4.1346 in |   |
| <b>Camshaft Bore Diameter</b><br>Without Bushing   |                        | 64.01 mm                 | MAX        | 2.520 in               |  |
|  | With Bushing Installed | 60.12 mm                 | MAX        | 2.367 in               |   |

| Component or Assembly (Procedure) | Ref.No./Steps | Metric                     | U.S.                 |   |
|-----------------------------------|---------------|----------------------------|----------------------|---|
| Valve Stem O.D.                   |               | 9.46 mm MIN<br>9.50 mm MAX | 0.372 in<br>0.374 in |  |
| Valve Head Thickness at O.D.      |               |                            |                      |   |
| Exhaust                           |               | 2.22 mm MIN                | 0.087 in             |  |
| Intake                            |               | 3.01 mm MAX                | 0.119 in             |   |

|  | Component or Assembly (Procedure)   | Ref.No./Steps | Metric | U.S.     |
|--|---|---------------|--------|----------|
|    | <p><b>Cooling System Torque Values</b><br/>Belt Tensioner Mounting Capscrew</p> |               | 43 N•m | 32 ft-lb |
|    | <p>Fan Hub Mounting Capscrew</p>  |               | 24 N•m | 18 ft-lb |
|   | <p>Fan Hub Pulley Mounting Capscrews</p>  |               | 45 N•m | 33 ft-lb |
|  | <p>Coolant Inlet Hose Clamps</p>  |               | 5 N•m  | 44 in-lb |
|  | <p>Thermostat Housing Mounting Capscrews</p>                                    |               | 24 N•m | 18 ft-lb |
|  | <p>Water Pump Mounting Capscrews</p>  |               | 24 N•m | 18 ft-lb |
|  | <p>Water Outlet Connection</p>  |               | 24 N•m | 18 ft-lb |

### Newton-Meter to Foot-Pound Conversion Chart

| N•m | ft-lb          | N•m | ft-lb | N•m | ft-lb |
|-----|----------------|-----|-------|-----|-------|
| 1   | 8.850756 in-lb | 55  | 41    | 155 | 114   |
| 5   | 44.0 in-lb     | 60  | 44    | 160 | 118   |
| 6   | 53.0 in-lb     | 65  | 48    | 165 | 122   |
| 7   | 62.0 in-lb     | 70  | 52    | 170 | 125   |
| 8   | 71.0 in-lb     | 75  | 55    | 175 | 129   |
| 9   | 80.0 in-lb     | 80  | 59    | 180 | 133   |
| 10  | 89.0 in-lb     | 85  | 63    | 185 | 136   |
| 1   | 0.737562 ft-lb | 90  | 66    | 190 | 140   |
| 12  | 9              | 95  | 70    | 195 | 144   |
| 14  | 10             | 100 | 74    | 200 | 148   |
| 15  | 11             | 105 | 77    | 205 | 151   |
| 16  | 12             | 110 | 81    | 210 | 155   |
| 18  | 13             | 115 | 85    | 215 | 159   |
| 20  | 15             | 120 | 89    | 220 | 162   |
| 25  | 18             | 125 | 92    | 225 | 165   |
| 30  | 22             | 130 | 96    | 230 | 170   |
| 35  | 26             | 135 | 100   | 235 | 173   |
| 40  | 30             | 140 | 103   | 240 | 177   |
| 45  | 33             | 145 | 107   | 245 | 180   |
| 50  | 37             | 150 | 111   | 250 | 184   |

NOTE: To convert from Newton-Meters to Kilogram-Meters divide Newton-Meters by 9.803

# CONTENTS

|  |           |
|--|-----------|
| <b>SHOP MANUAL</b> .....                         | <b>01</b> |
| <b>TROUBLESHOOTING &amp; REPAIR MANUAL</b> ..... | <b>02</b> |

## General Safety Instructions

### Important Safety Notice



### WARNING



Read and understand all of the safety precautions and warnings before performing any repair. This list contains the general safety precautions that **must** be followed to provide personal safety. Special safety precautions are included in the procedures when they apply.

- Make sure the work area surrounding the product is safe. Be aware of hazardous conditions that can exist.
- **Always** wear protective glasses and protective shoes when working.
- Do **not** wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery and discharge any capacitors before beginning any repair work. Disconnect the air starting motor if equipped to prevent accidental engine starting. Put a "Do Not Operate" tag in the operator's compartment or on the controls.
- Use **ONLY** the proper engine barring techniques for manually rotating the engine. Do **not** attempt to rotate the engine by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s) causing premature fan failure.
- If an engine has been operating and the coolant is hot, allow the engine to cool before you slowly loosen the filler cap and relieve the pressure from the cooling system.
- Do **not** work on any thing that is supported **ONLY** by lifting jacks or a hoist. **Always** use blocks or proper stands to support the product before performing any service work.
- Relieve all pressure in the air, oil, and the cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do **not** check for pressure leaks with your hand. High pressure oil or fuel can cause personal injury.
- To prevent suffocation and frostbite, wear protective clothing and **ONLY** disconnect liquid refrigerant (freon) lines in a well ventilated area.
- To avoid personal injury, use a hoist or get assistance when lifting components that weigh 23 kg [50 lb] or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the correct capacity. Make sure hooks are positioned correctly. **Always** use a spreader bar when necessary. The lifting hooks **must not** be side-loaded.
- Corrosion inhibitor contains alkali. Do **not** get the substance in your eyes. Avoid prolonged or repeated contact with skin. Do **not** swallow internally. In case of contact, immediately wash skin with soap and water. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. **IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.**
- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and **must** be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. **KEEP OUT OF REACH OF CHILDREN.**
- To avoid burns, be alert for hot parts on products that have just been turned OFF, and hot fluids in lines, tubes and compartments.
- **Always** use tools that are in good condition, Make sure you understand how to use them before performing any service work. Use **ONLY** genuine Komatsu replacement parts.
- **Always** use the same fastener part number (or equivalent) when replacing fasteners, Do **not** use a fastener, of lesser quality if replacements are necessary.

CLICK HERE TO **DOWNLOAD** THE COMPLETE MANUAL

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### Cooling System

Thermostats

|                |                             |
|----------------|-----------------------------|
| Begins to open | 81° to 83°C [178° to 182°F] |
| Fully open     | 95°C [203°F]                |

Top tank temperature

|                     |               |
|---------------------|---------------|
| Maximum allowable   | 100°C [212°F] |
| Minimum recommended | 70°C [158°F]  |

|                                      |                |
|--------------------------------------|----------------|
| Pressure cap for 99°C [210°F] system | 50 kPa [7 psi] |
|--------------------------------------|----------------|

|                                       |                  |
|---------------------------------------|------------------|
| Pressure cap for 104°C [220°F] system | 103 kPa [15 psi] |
|---------------------------------------|------------------|

|  |                               |
|--|-------------------------------|
| Water Pressure (Upper manifold) at 2000 RPM engine speed | 103 to 276 kPa [15 to 40 psi] |
|--|-------------------------------|

|  |                  |
|--|------------------|
| Coolant flow (thermostats fully opened, engine speed 2000 RPM) | 258 lpm [68 gpm] |
|--|------------------|

Coolant capacity (engine only)

|                                   |                              |
|-----------------------------------|------------------------------|
| 6D114E-1, S6D114E-1, SAA6D114E-1* | 9.9 liters [10.5 U.S. Qts.]  |
| SA6D114E-1                        | 10.9 liters [11.5 U.S. Qts.] |

### Intake Air and Exhaust System

Maximum allowable intake restriction at rated speed and load (with dirty air filter element)

|                                     |   |
|-------------------------------------|---|
| 6D114E-1                            | 50.8 cm H <sub>2</sub> O [20 in H <sub>2</sub> O] |
| S6D114E-1, SA6D114E-1, SAA6D114E-1* | 63.5 cm H <sub>2</sub> O [25 in H <sub>2</sub> O] |

Maximum turbocharger outlet restriction at rated speed and load

|                                   |  |
|-----------------------------------|--|
| 6D114E-1, S6D114E-1, SAA6D114E-1* | 76.2 mm Hg [3 in Hg]                               |
| 6D114E-1, SAA6D114E-1*            | 101.6 cm H <sub>2</sub> O [40 in H <sub>2</sub> O] |
| SA6D114E-1                        | 82 in H <sub>2</sub> O [6 in Hg]                   |

### Fuel System

Fuel transfer pump maximum inlet restriction

|   |                       |
|---|-----------------------|
| 6D114E-1, S6D114E-1, SA6D114E-1, SAA6D114E-1* | 100 mm Hg [4.0 in Hg] |
|---|-----------------------|

Fuel transfer pump minimum output pressure at rated speed

|  |                  |
|--|------------------|
| 6D114E-1, S6D114E-1, SA6D114E-1 Low Flow | 83 kPa [12 psi]  |
| SAA6D114E-1* High Flow                   | 172 kPa [25 psi] |

|   |                   |
|---|-------------------|
| Minimum pressure to fuel pump inlet (all in-line) | 1.2 Barr [18 psi] |
|---|-------------------|

|  |                |
|--|----------------|
| Fuel filter restriction (maximum pressure drop across filters) | 35 kPa [5 psi] |
|--|----------------|

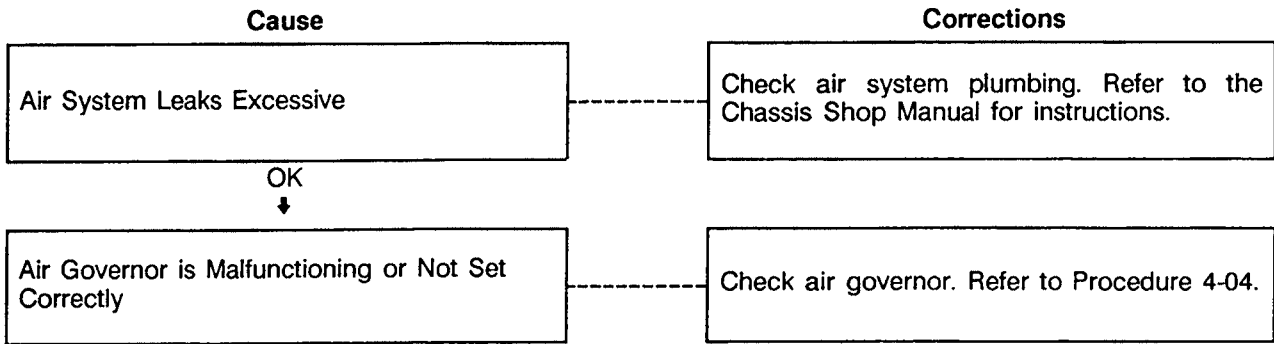
|   |                  |
|---|------------------|
| Fuel pump gallery pressure minimum at rated speed high flow | 140 kPa [20 psi] |
|---|------------------|

|  |                |
|--|----------------|
| Fuel pump gallery pressure minimum at rated speed low flow | 48 kPa [7 psi] |
|--|----------------|

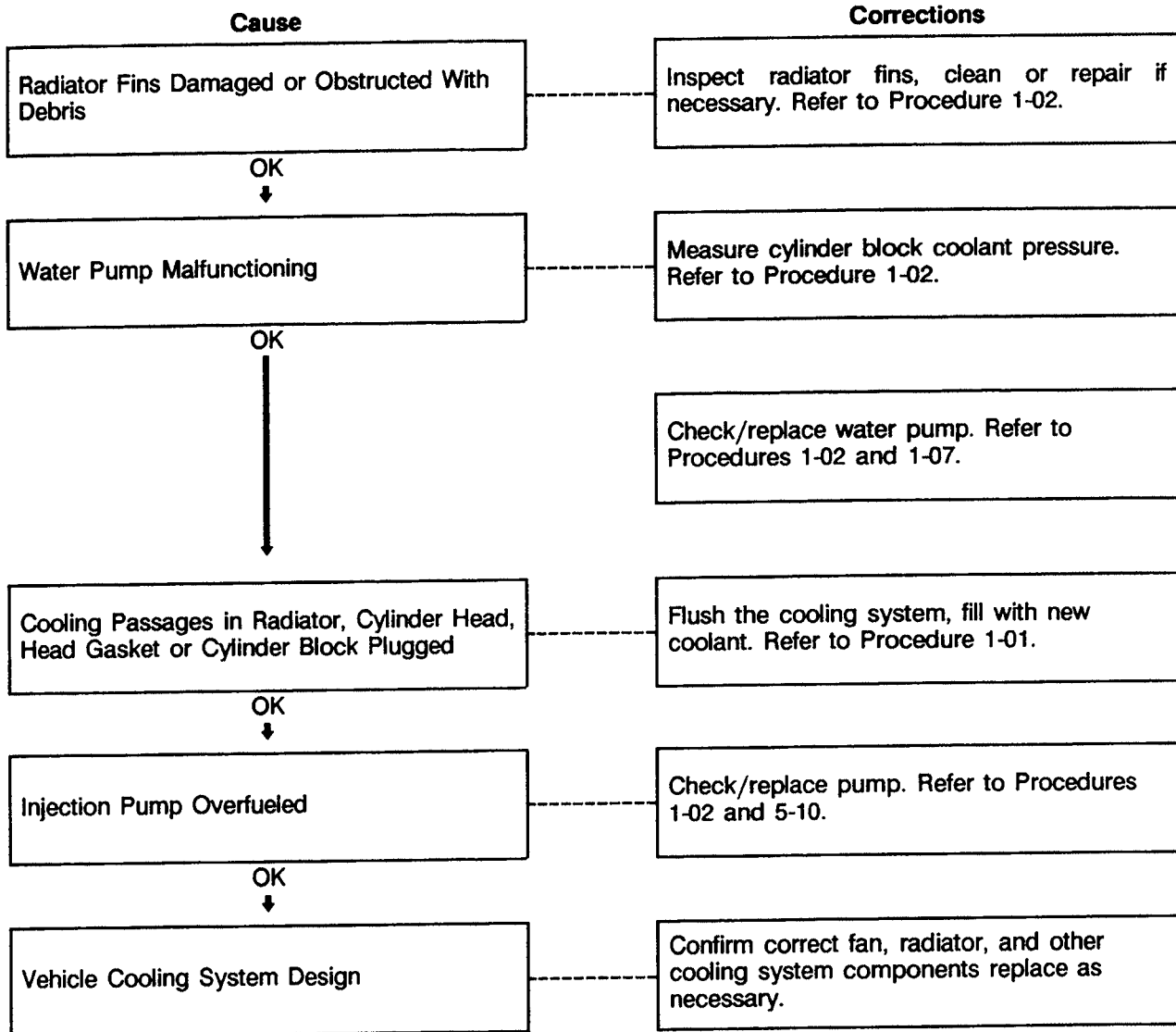
|                                   |                        |
|-----------------------------------|------------------------|
| Fuel return restriction (maximum) | 518 mm Hg [20.4 in Hg] |
|-----------------------------------|------------------------|

\* All emissionized engines with Charged Air Cooling are designed as "AA".

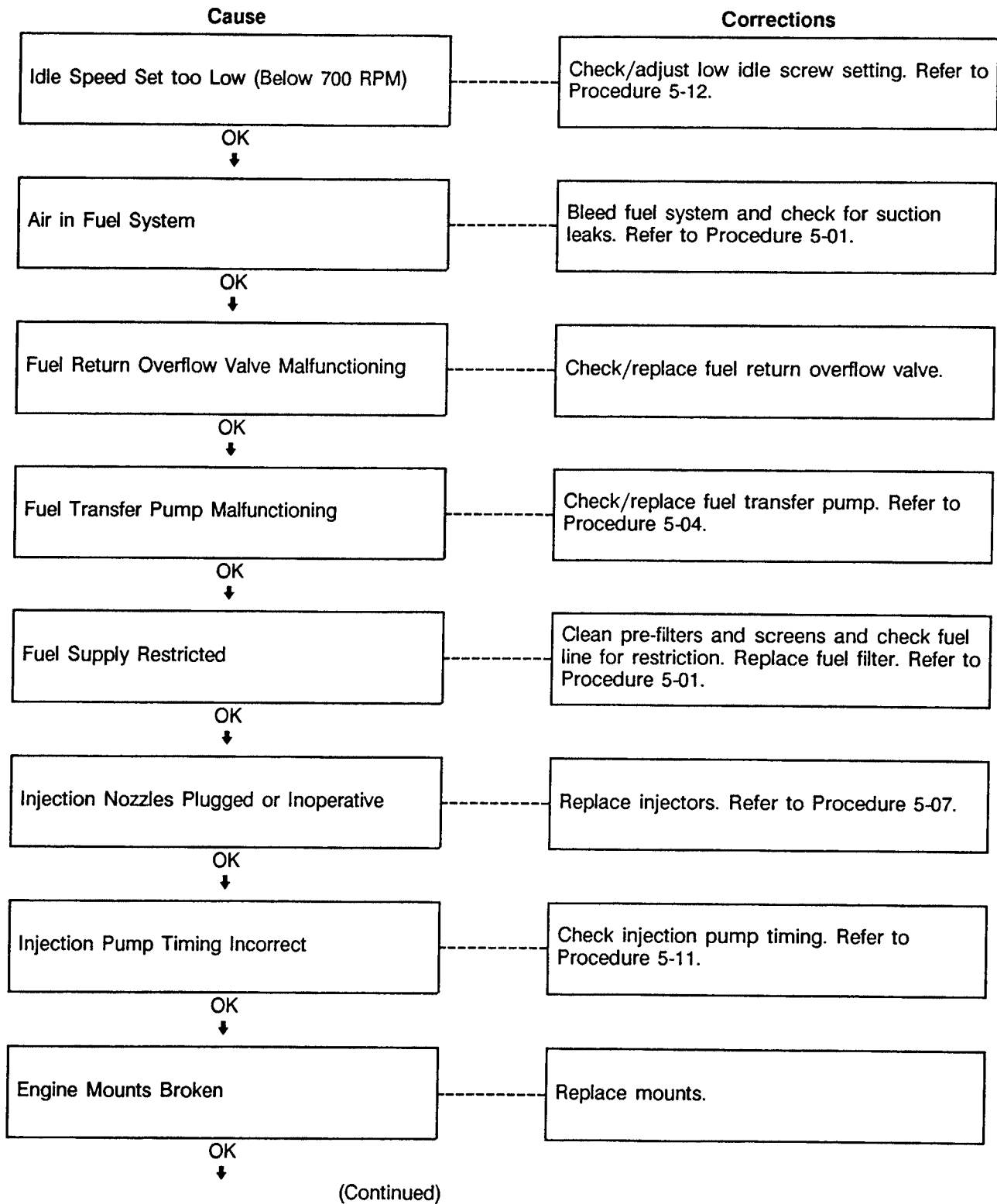
**Air Compressor Will Not Maintain Adequate Air Pressure (Not Pumping Continuously)**



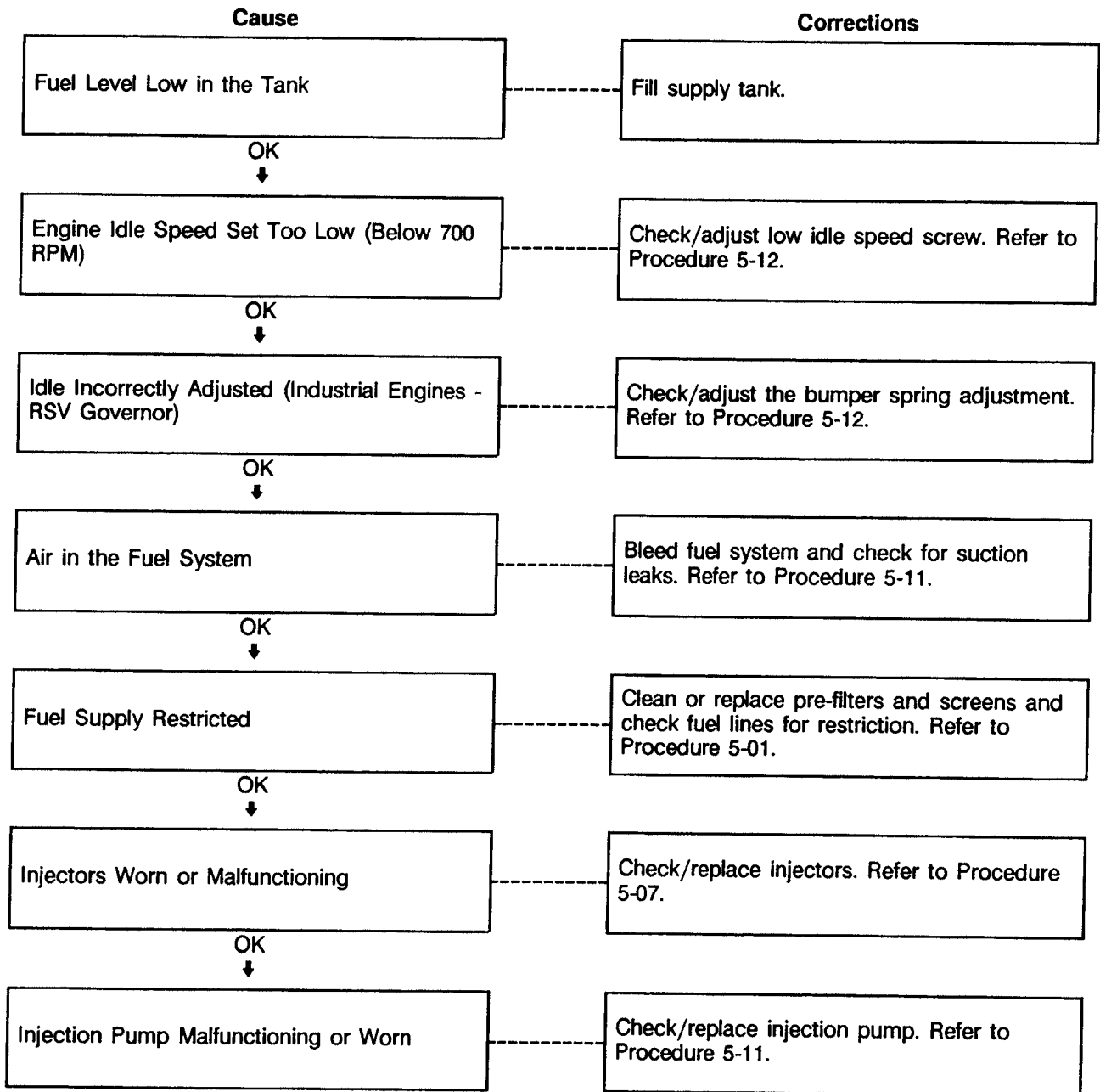
**Coolant Temperature Above Normal - Gradual Overheat (Continued)**



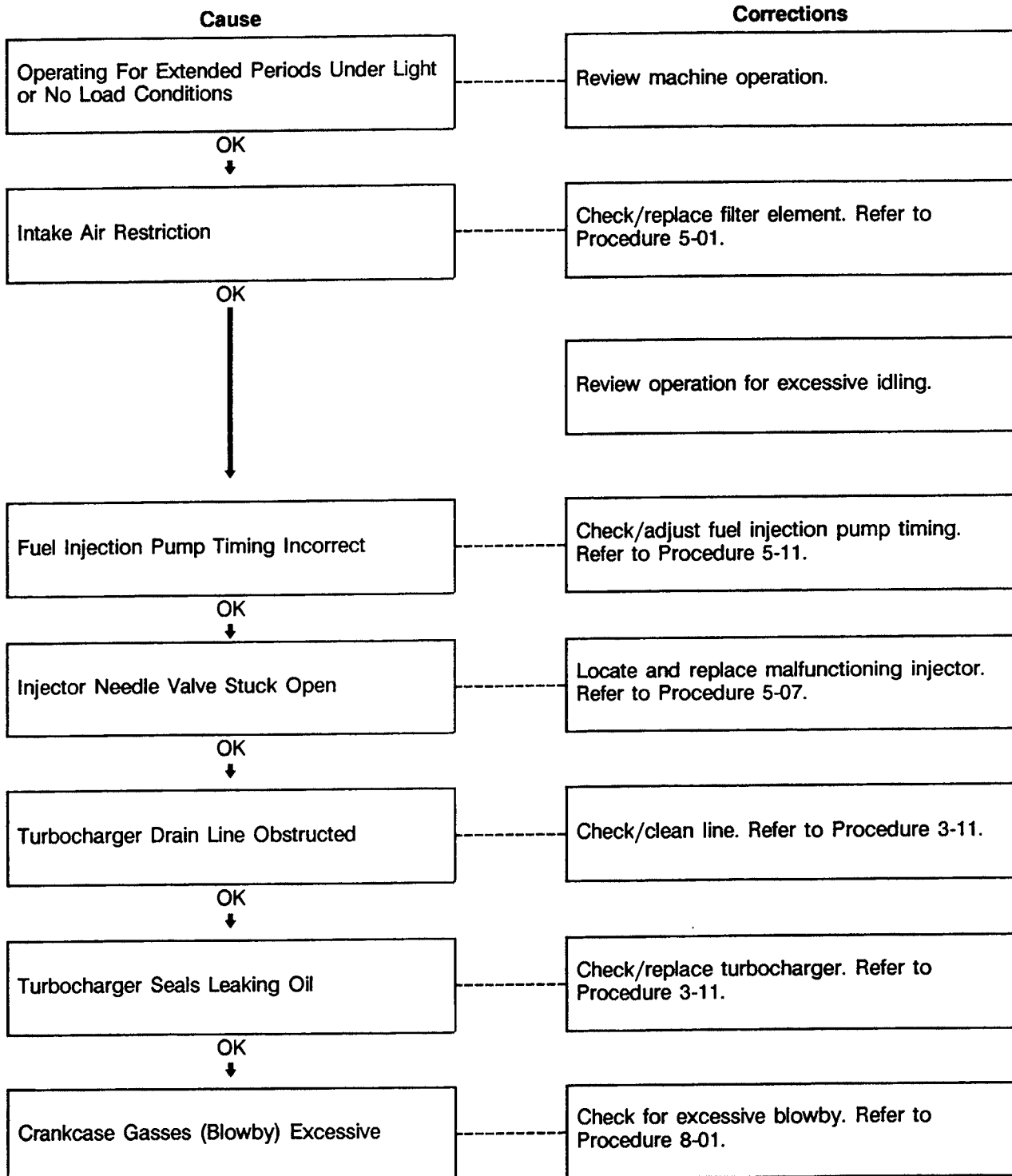
### Engine Idle Rough, Warm Engine



### Engine Surges at Idle



**Fuel or Oil Leaking from Exhaust Manifold**



### Oil Consumption Report

Customer Name \_\_\_\_\_  
 Engine Model \_\_\_\_\_  
 Engine Serial No. \_\_\_\_\_  
 Machine Make/Model \_\_\_\_\_

Dist./Dir. \_\_\_\_\_  
 Mi/Km/Hr \_\_\_\_\_  
 CPL No. \_\_\_\_\_  
 Date \_\_\_\_\_

1. Review of maintenance history.

List any previous failures that could have had a detrimental effect on cylinder component life. Failures could include fuel, coolant, and/or foreign abrasives in the oil, second ring groove beat-out, filter plugging, etc.

|                             |          |
|-----------------------------|----------|
| <b>Lube Oil Used</b>        |          |
| Brand                       |          |
| Viscosity                   |          |
| Change Interval             | Mi/Km/Hr |
| <b>By-pass Oil Filter</b>   |          |
| Model                       |          |
| Element                     |          |
| Change Interval             | Mi/Km/Hr |
| <b>Full Flow Oil Filter</b> |          |
| Model                       |          |
| Element                     |          |
| Change Interval             | Mi/Km/Hr |
| <b>Air Cleaner</b>          |          |
| Make and Model              |          |
| Change Interval             |          |

2. List any external engine leaks.

3. Visually Check for any internal leaks and list. Check turbocharger seals, valve guides, air compressor, etc.

4. Had the fuel pump been tampered with? \_\_\_\_\_ What is maximum rail pressure readings? \_\_\_\_\_ If Yes, the pump must be reset to factory specifications and the customer sent out to re-evaluate his oil consumption rate and the eligibility requirements must be met again.

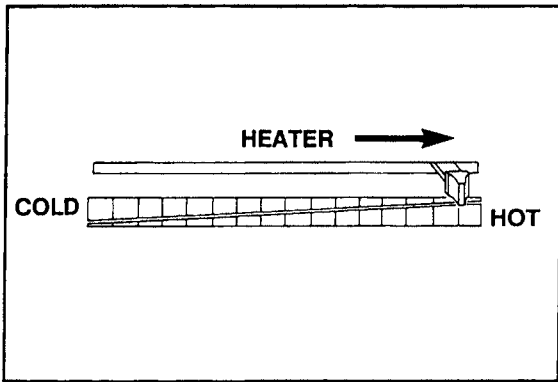
5. Drain and refill oil pan to check dipstick markings and note findings.

6. Only after above checks are completed, leaks corrected and proper documentation is completed, dis-assemble engine to determine cause for the failure and repair as required.

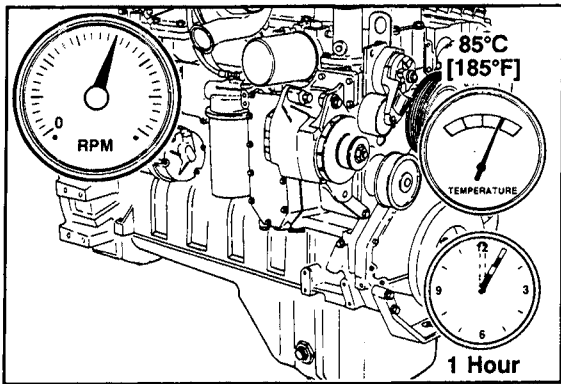
7. State reason for oil consumption.

Signed: \_\_\_\_\_

Turn the cab heater temperature switch to high to allow maximum coolant flow through the heater core. The blower fan does **not** have to be on.

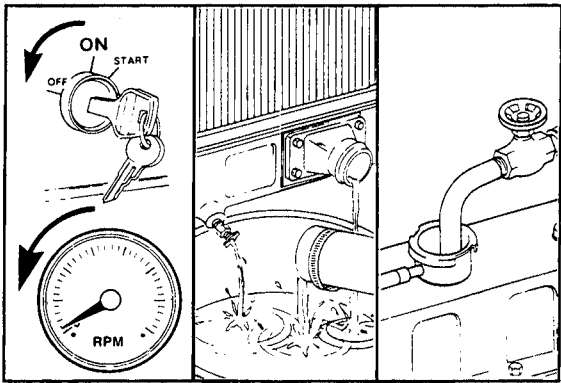



Operate the engine at 2100 RPM at normal operating temperatures (at least 85°C [185°F]) for 1 hour.

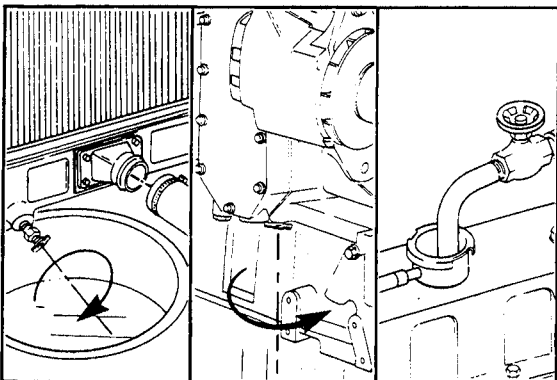


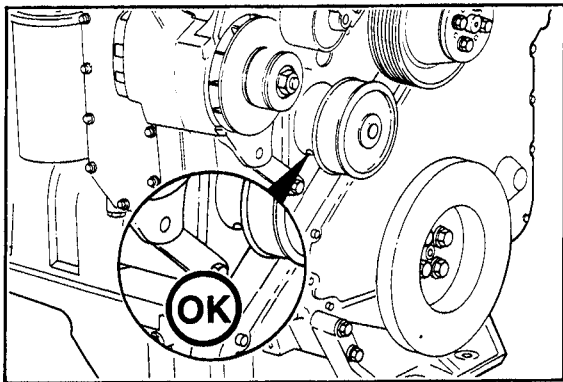
Shut off the engine, and drain the cooling system.

Use running water to flush the majority of the contaminated mixture, leaving all draincocks open.

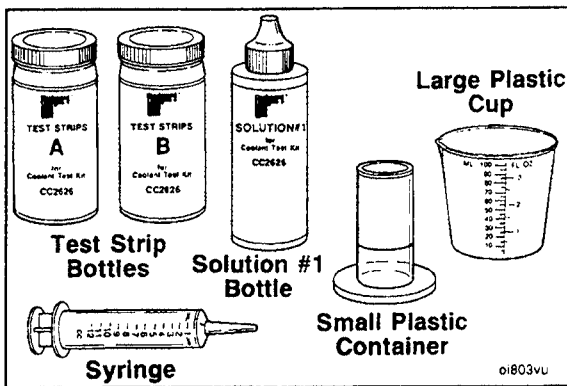


 Connect all hoses, close all draincocks and fill the cooling system with clean water (and neutralizer if the cleaner used requires).





If no leakage is observed from the weep hole under operating conditions, do not replace the water pump.

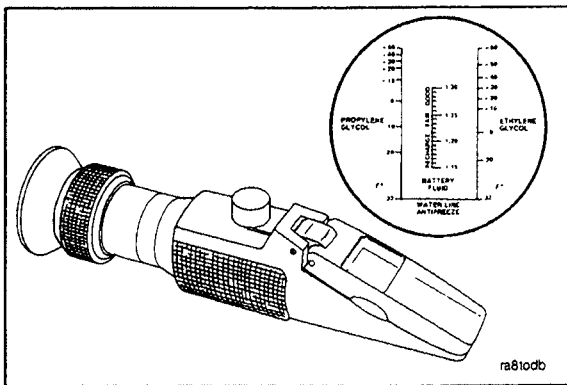


If coolant is observed to be dripping from the weep hole:

- Use Fleetguard® coolant test kit, Part No. CC-2626, to check the coolant inhibitor level, and adjust the inhibitor level per the test kit chart.



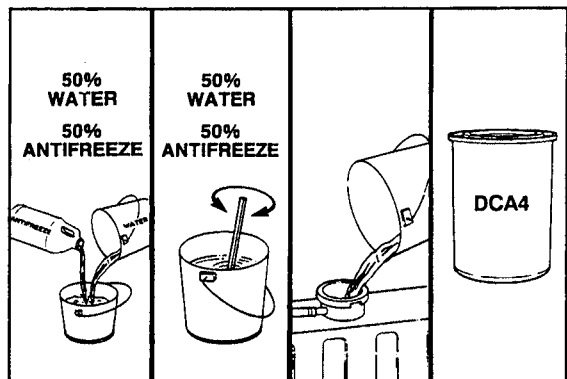
**NOTE:** Supplemental coolant additive concentrations exceeding 2.0 units per gallon will cause water pump seal leakage.



- Use Fleetguard® refractometer, Part No. CC-2800, to check the antifreeze level of the coolant.

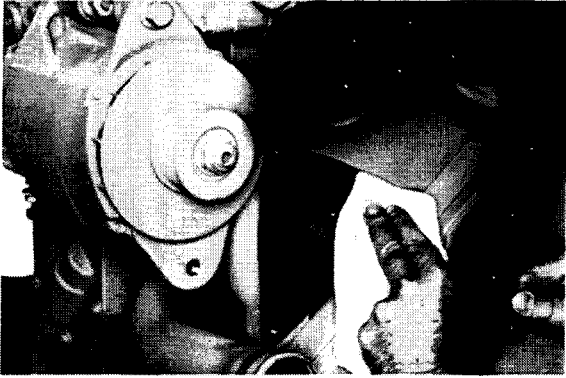


**NOTE:** Ethylene glycol type antifreeze concentration exceeding 70 percent will adversely affect freeze point protection and will contribute to water pump seal leakage.



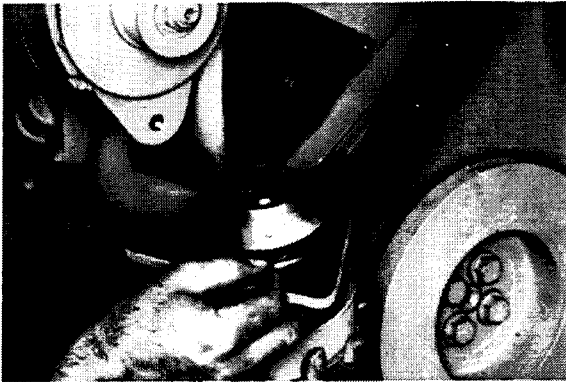
If the antifreeze concentration is above 60 percent, drain all the coolant and add make up water to bring the antifreeze concentration to a minimum of 40 percent to a maximum of 60 percent. Replace the coolant filter, add new coolant inhibitor to the recommended levels as outlined in the Chassis Operation and Maintenance Manual.





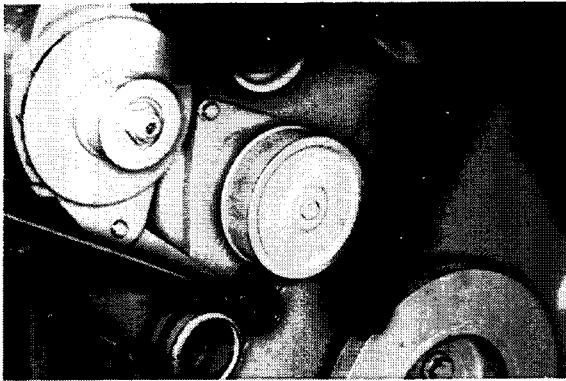
**Cleaning**

Clean the sealing surface on the cylinder block.



**Installation**

Install a new o-ring into the groove in the water pump.



**10 mm, 19 mm**

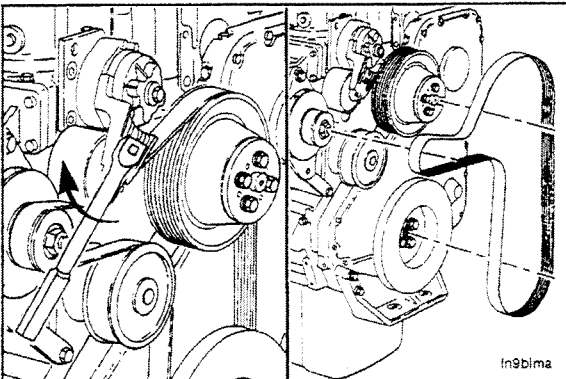
Install the water pump and alternator link.



**Torque Value:**

(Water Pump) 24 N•m [18 ft-lb]

(Alternator Link) 43 N•m [32 ft-lb]



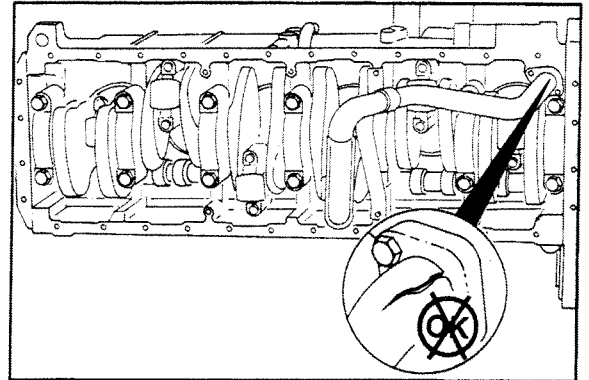
Lift the tensioner arm and pulley to install the drive belt.

## Lubricating Oil System - Specifications

|  |                                |
|--|--------------------------------|
| Oil Pressure - Low Idle (Minimum Allowable) . . . . .                    | 69 kPa [10 psi]                |
| At Rated Speed (Minimum Allowable) . . . . .                             | 207 kPa [30 psi]               |
| Differential Pressure to Open Oil Filter Bypass Valve . . . . .          | 138 kPa [20 psi]               |
| Oil Flow at Rated Speed (Less Flow Through Pressure Regulator) . . . . . | 57 lpm [16 gpm]                |
| Oil Temperature at Rated Speed . . . . .                                 | 99° to 126.6°C [210° to 260°F] |
| Oil Capacity of Pan (All Engines):                                       |                                |
| - Low Level . . . . .  | 15.1 liters [16.0 U.S. Qts.]   |
| - High Level . . . . .   | 18.9 liters [20.0 U.S. Qts.]   |
| Total System Capacity  |                                |
| 6D114E-1 . . . . .   | 23.6 liters [25.0 U.S. Qts.]   |
| S6D114E-1 . . . . .  | 23.8 liters [25.2 U.S. Qts.]   |

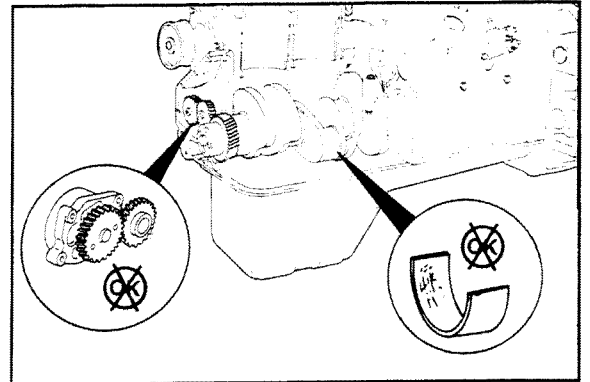
### Oil Suction Tube

A loose suction tube, damaged gasket or crack in the suction tube can cause a temporary loss of prime for the oil pump. The engine will have low pressure or no oil pressure at starting, followed by normal or low oil pressure.



### Bearings and Oil Pump

A steady decrease in oil pressure over a long period of time can be an indication of worn bearings or excessive oil pump wear. Refer to Procedure 2-02 to check for internal engine damage.

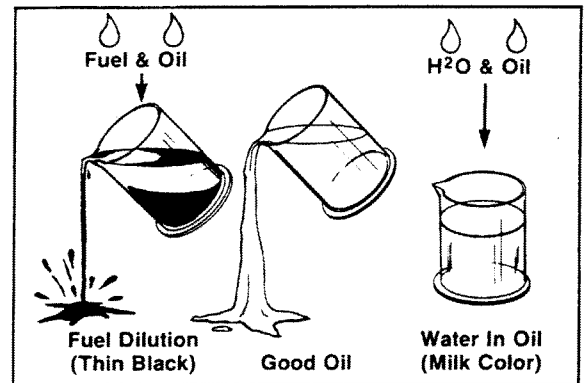


### Oil Dilution

Diluted oil can cause severe engine damage

Check the condition of the oil.

- Thin, black oil is an indication of fuel in the oil.
- Milky discoloration is an indication of coolant in the oil.



### Coolant Diluted Oil

Coolant in the oil results from a crack or leak between the coolant and oil circuits.

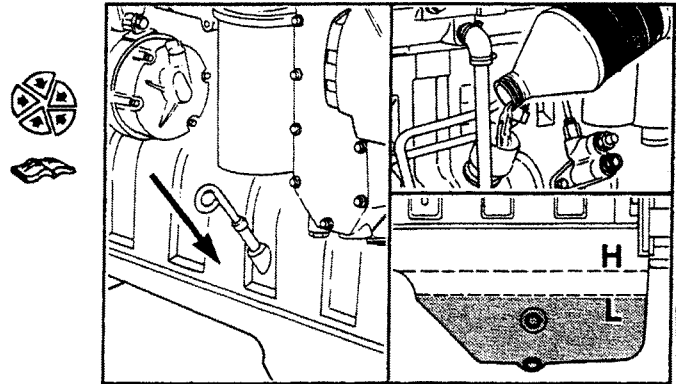
The possibility for intermixing can occur in these components:

- Oil cooler
- Aftercooler
- Core plugs in cylinder head
- Cylinder liner seals
- Head gasket
- Cylinder liner (crack)
- Cylinder head (cracked passage)
- Cylinder block (cracked passage)
- Air compressor (coolant cooled)

## Lubricating Oil Dipstick - Calibration (2-08)

Install the dipstick in the dipstick tube housing.

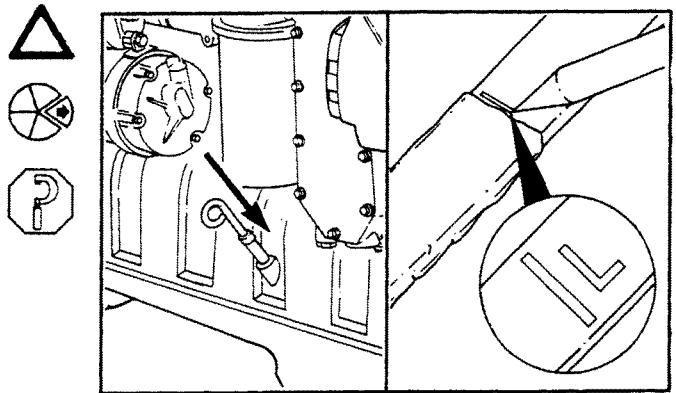
Use clean 15W-40 oil to fill the oil pan to the specified "low" oil level. Refer to Lubricating Oil System Specifications, page 2-5, for engine oil capacity.



**Caution:** The dipstick will break if the scribe mark is too deep.

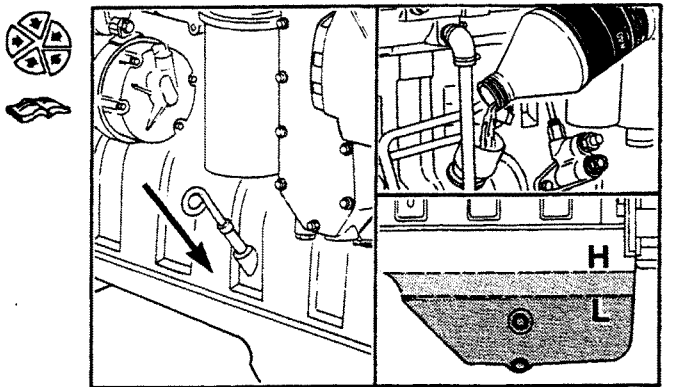
Remove the dipstick and scribe a mark across the dipstick and mark the "low" oil level with an "L".

**NOTE:** If a new blank dipstick is being used, cut the dipstick off approximately 38 mm [1.5 inch] below the "low" oil level mark.

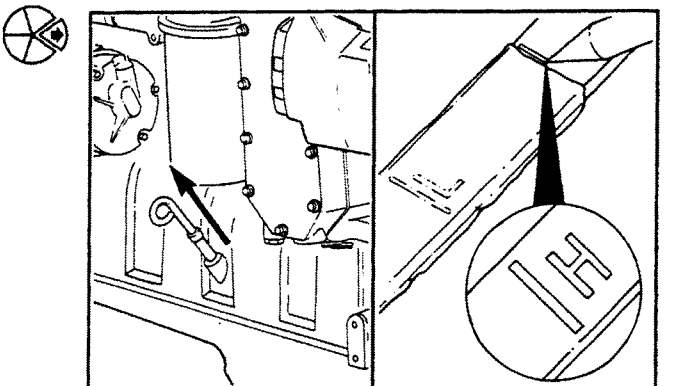


Install the dipstick into the dipstick tube housing.

Fill the oil pan to the specified "high" oil level. Refer to Lubricating Oil System Specifications, page 2-5, for engine oil capacity.



Remove the dipstick and scribe a mark across the dipstick and mark the "high" oil level with an "H".

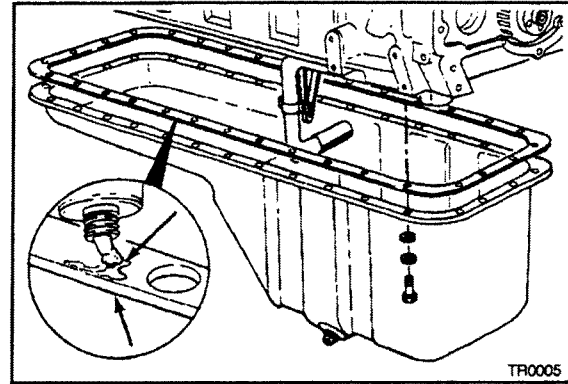


Section 2 - Lubricating Oil System

Apply a 2 mm [1/16 inch] bead of Three Bond Sealant, Part No. 3823494, to both sides of the new lubricating pan gasket.

Install the gasket.

Install the lubricating oil pan.

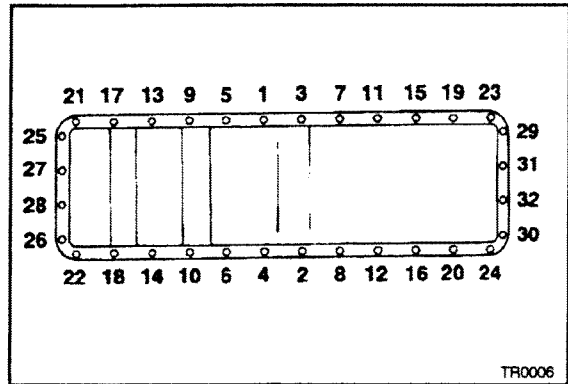


10 mm

Assemble the washers and capscrews to secure the lubricating oil pan as illustrated.

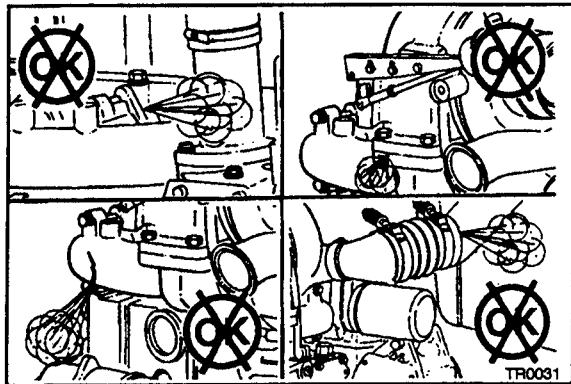
Tighten all capscrews in the sequence shown to the right.

**Torque Value:** 24 N•m [18 ft-lb]



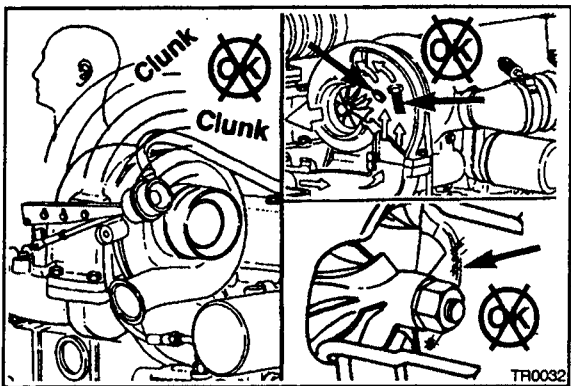
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|  |             |
|--|-------------|
| <b>Turbocharger Wastegate Actuator - Replacement</b> .....       | <b>3-15</b> |
| Air regulator with pressure gauge .....                          | <b>3-15</b> |
| <b>Turbocharger Wastegate Actuator - Visual Inspection</b> ..... | <b>3-13</b> |

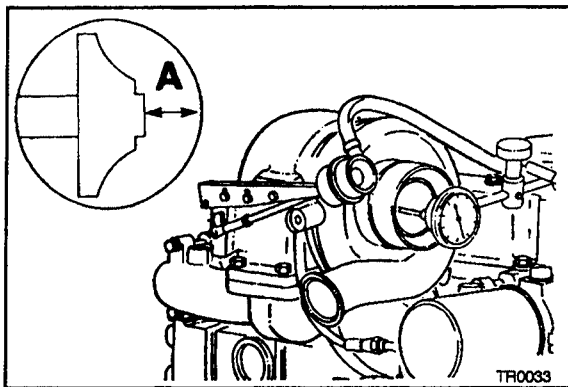


Before removing the turbocharger, make sure that the noise complaint is not caused by leaks in the air system components.

Look for loose turbocharger mounting, exhaust manifold gasket leaks, and cracks in the exhaust manifold.



Lower pitch sounds or rattles at slower engine speeds can indicate debris in the system or the rotor assembly is touching the housings.



### Rotor Assembly Clearance - Measurement

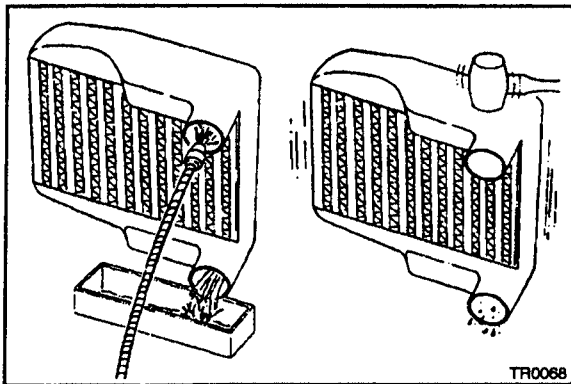
Part No. ST-537, Dial Depth Gauge

Measure the shaft end play.

|    |      | End Play (A) |         |
|----|------|--------------|---------|
|    |      | mm           | in.     |
| *  | 0.10 | MIN          | [0.004] |
|    | 0.16 | MAX          | [0.006] |
| ** | 0.03 | MIN          | [0.001] |
|    | 0.08 | MAX          | [0.003] |

\* For turbochargers with a serial number **before** 840638.

\*\* For turbochargers with a serial number **840638 and after**.



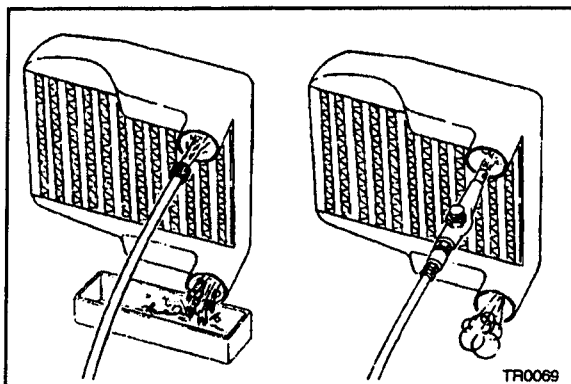
**Caution:** Do not use caustic cleaners to clean the CAC. Damage to the CAC will result.

**NOTE:** Make sure that the tubes are in the vertical direction when flushing.

Flush the CAC internally with solvent in the opposite direction of normal air flow. Shake the CAC and lightly tap on the end tanks with a rubber mallet to dislodge trapped debris. Continue flushing until all debris or oil is removed.

Use a flashlight and mirror to visually inspect the CAC for internal debris.

**NOTE:** If internal debris cannot be removed, scrap the CAC.

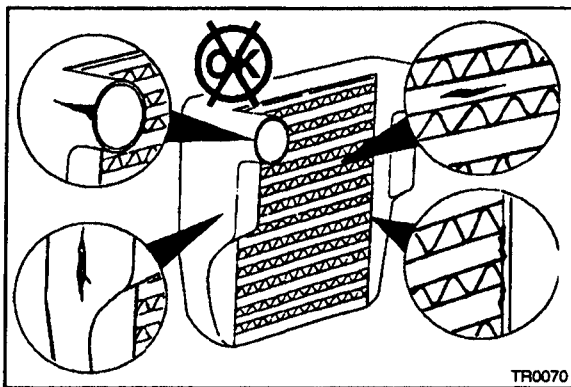


After the CAC has been thoroughly cleaned of all oil and debris with solvent, wash the CAC internally with hot soapy water to remove the remaining solvent. Rinse thoroughly with clean water.



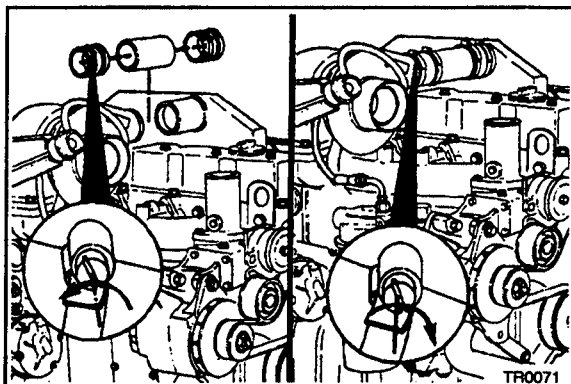
Blow compressed air into the CAC in the opposite direction of normal air flow until the CAC is dry internally.

**Caution:** The CAC must be rinsed, dried, and free of solvent, oil, and debris or engine damage will result.



Visually inspect the CAC for cracks, holes or damage.

Inspect the tubes, fins and welds for tears, breaks or other damage. If any damage causes the CAC to fail the air leak check mentioned earlier in this Procedure, the CAC must be replaced. Install the CAC on the vehicle. Refer to the vehicle manufacturer for instructions.



### Air Crossover Tube - Replacement (3-08)

#### Removal and installation



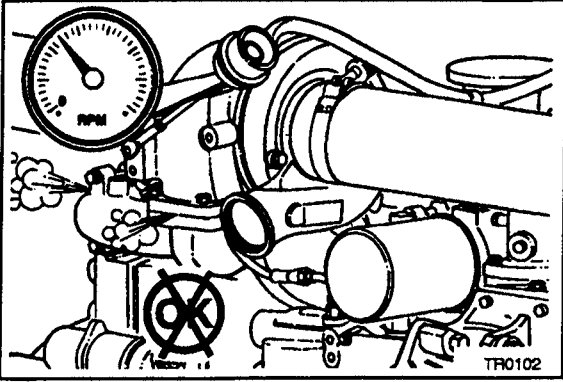
8 mm or Screwdriver

Loosen the hose clamps and position the hose so the crossover tube can be removed.



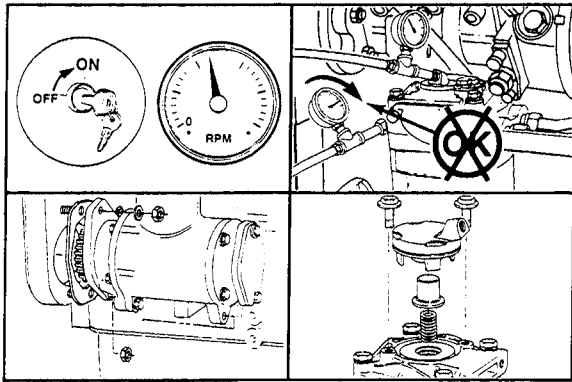
Use new hose and clamps as required to install the crossover tube.

**Torque Value:** 5 N•m [44 in-lb]

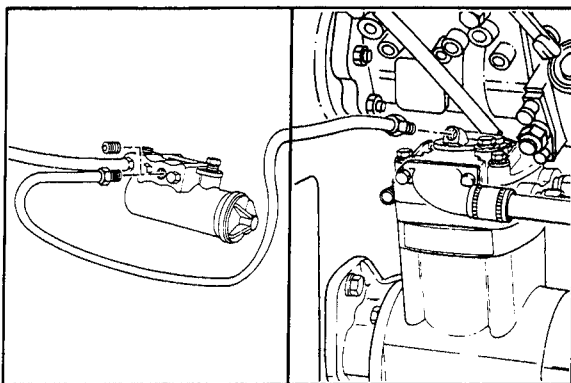


Install the parts previously removed. Operate the engine and check for leaks.





If the air compressor continues to pump (air pressure continues to rise), the unloader valve is malfunctioning and **must** be repaired or replaced. Remove the air compressor for repair. Refer to Procedure 4-05.



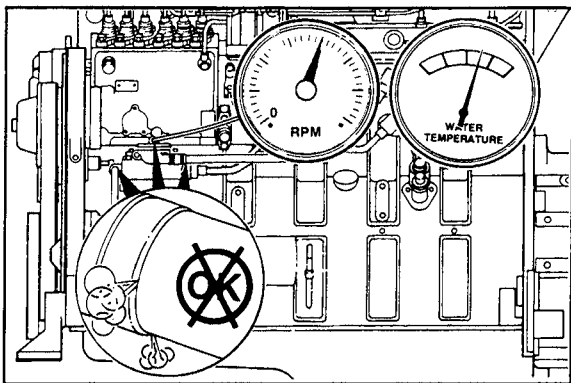
Remove the pipe plug from the governor port used for the accessory air line.

Remove the regulated shop air.



Install and tighten the accessory air line.

Connect the line between the compressor unloader valve and the air governor.


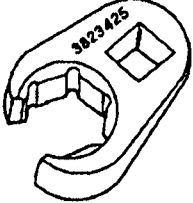


Operate the engine and check for air leaks.

## Air Compressor - Replacement (4-05)

### Preparator Steps:

- Steam clean the air compressor and dry with compressed air.
- Drain the engine coolant.

| Tool No.       | Tool Description  | Tool Illustration  |
|----------------|---|--|
| <p>3823276</p> | <p><b>Injector Puller</b><br/>Used to pull injectors.</p>                   |  <p style="text-align: right;">TR0108</p> |
| <p>3823425</p> | <p><b>Wrench, Crowfoot</b><br/>Used to torque high pressure fuel lines.</p> |  <p style="text-align: right;">TR0110</p> |

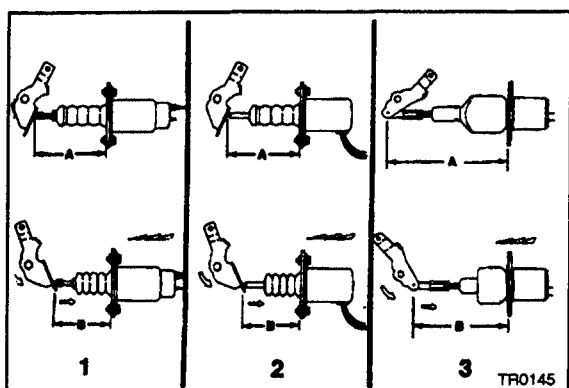
### Electrical Shut Down Devices

Engines using the RSV Governor are equipped with either the Synchro-Start or Trombetta cylinder block mounted fuel shutoff solenoid to actuate the shutoff lever. Both 12 VDC and 24 VDC external fuel shut-off solenoids are available.



**Warning:** Solenoid surface temperature can exceed 175°C [347°F] which can cause serious burns to the skin in event of contact.

**NOTE:** Values are taken at 20°C [68°F] and rated voltage. Minimum values are for 25 mm [1.00 inch] maximum plunger travel. As the temperature of the solenoid increases the voltage and resistance requirements increase, while the amperage requirements decrease.



The solenoid specifications are as follows:

#### 1. Synchro-Start Cylinder Block Mount

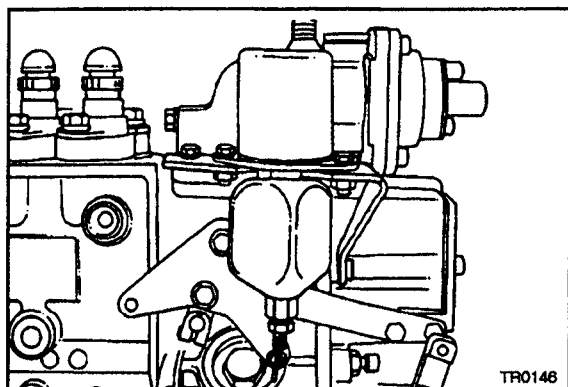
| Battery Voltage | Min Voltage |         | Resistance Min Ohms |         | Min Amperes |         |
|-----------------|-------------|---------|---------------------|---------|-------------|---------|
|                 | Pull-in     | Hold-in | Pull-in             | Hold-in | Pull-in     | Hold-in |
| 12              | 7.5         | 3.0     | 0.28                | 19.9    | 44          | 0.61    |
| 24              | 15.0        | 6.0     | 1.04                | 79.9    | 23          | 0.30    |

#### 2. Trombetta Cylinder Block Mount

| Battery Voltage | Min Voltage |         | Resistance Min Ohms |         | Min Amperes |         |
|-----------------|-------------|---------|---------------------|---------|-------------|---------|
|                 | Pull-in     | Hold-in | Pull-in             | Hold-in | Pull-in     | Hold-in |
| 12              | 10          | 4.5     | 0.17                | 13.6    | 58.8        | 0.33    |
| 24              | 20          | 9.0     | 0.68                | 50      | 29.4        | 0.18    |

#### 3. Direct Link, Cylinder Block Mount

| Battery Voltage | Min Voltage |         | Resistance Min Ohms |         | Min Amperes |         |
|-----------------|-------------|---------|---------------------|---------|-------------|---------|
|                 | Pull-in     | Hold-in | Pull-in             | Hold-in | Pull-in     | Hold-in |
| 12              | 5.3         | 2.8     | 0.22                | 11.1    | 55          | 1.1     |
| 24              | 10.6        | 5.6     | 0.82                | 41.3    | 29          | 0.5     |



Engines using the Robert Bosch PES6P fuel injection pump with the RQVK governor are equipped with the Synchro-Start fuel shutoff solenoid to actuate the shutoff lever. Both 12 VDC and 24 VDC external fuel shut-off solenoids are available.

The solenoid specifications are as follows:

#### Synchro-Start Governor Mount

| Battery Voltage | Min Voltage |         | Resistance Min Ohms |         | Min Amperes |         |
|-----------------|-------------|---------|---------------------|---------|-------------|---------|
|                 | Pull-in     | Hold-in | Pull-in             | Hold-in | Pull-in     | Hold-in |
| 12              | 6.5         | 4.0     | 0.22                | 11.1    | 55          | 1.10    |
| 24              | 13.0        | 8.0     | 0.82                | 41.3    | 29          | 0.60    |

### Fuel Drain Manifold - Replacement (5-06)

#### Removal and Installation

10 mm

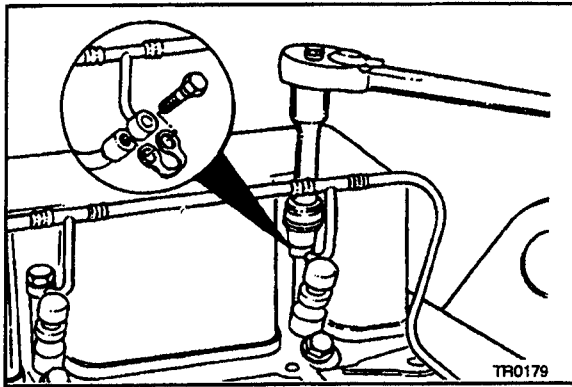
Clean debris from around the fuel drain manifold.

Remove the banjo capscrews from the injectors and fuel filter head.

Install the fuel drain manifold in the reverse order of removal.

#### Torque Value:

|                   |                   |
|-------------------|-------------------|
| Filter Head Banjo | 15 N•m [11 ft-lb] |
| Injector Banjo    | 9 N•m [80 in-lb]  |



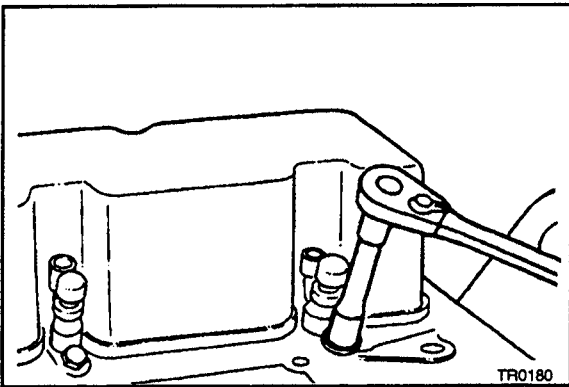
### Injector - Replacement (5-07)

#### Preparatory Steps:

Thoroughly clean around the injectors.

Disconnect the high pressure fuel lines. Refer to Procedure 5-05.

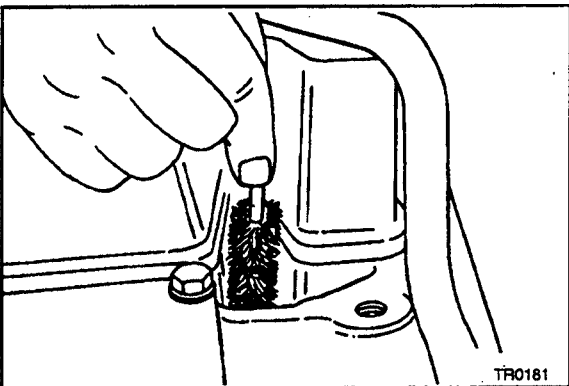
Disconnect the fuel drain manifold. Refer to Procedure 5-06.



#### Removal

10 and 13 mm, Part No. 3823276 Injector Puller

Remove the injectors.



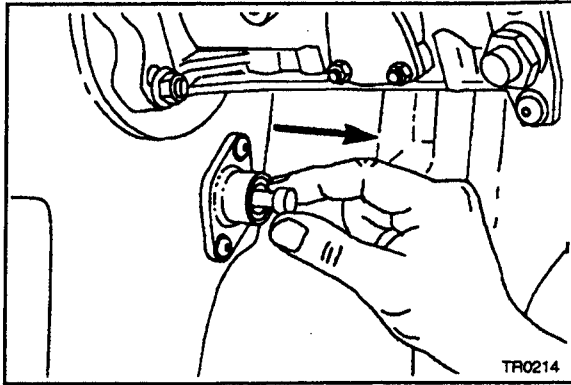
#### Cleaning and Inspection

Part No. 3822510 Injection Bore Brush

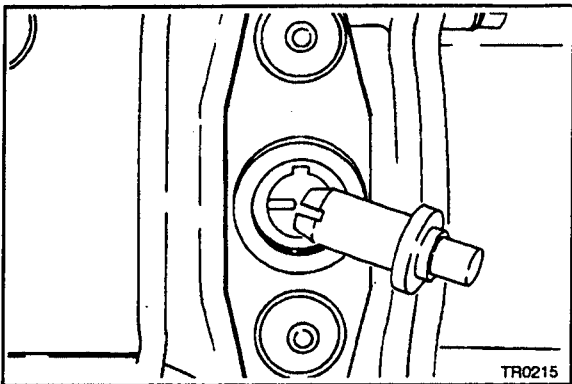
Clean the injector nozzle bore.

**NOTE:** If the injector sealing sleeves are melted, it is an indication the engine has been operating in an overheated condition. Refer to the troubleshooting Logic Chart for "Coolant Temperature Above Normal".





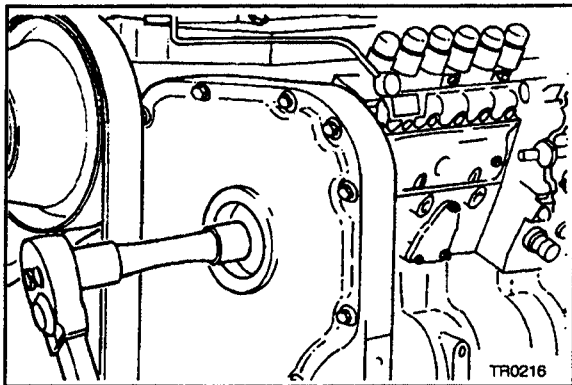
Disengage the engine timing pin.



24 mm

Remove the fuel injection pump timing pin plug. Reverse the position of the timing pin and install the timing pin, plug, and the sealing washer.

Torque Value: 15 N•m [11 ft-lb]



22 mm (PES6A Fuel Injection Pump)  
27 mm (PES6MW Fuel Injection Pump)  
30 mm (PES6P Fuel Injection Pump)



Tighten the fuel injection pump drive gear nut.

Torque Value:

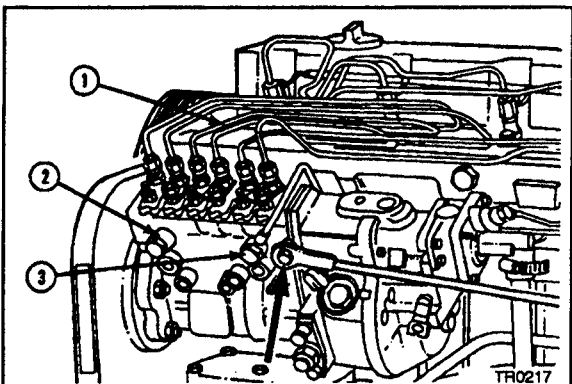
PES6A Fuel Injection Pump 92 N•m [ 68 ft-lb]

PES6MW Fuel Injection Pump 104 N•m [ 77 ft-lb]

PES6P Fuel Injection Pump 165 N•m [122 ft-lb]



Install the gear cover access cap hand tight.



Install the fuel lines and control linkage.

Torque Value:

1. High Pressure Fuel Lines 30 N•m [22 ft-lb]

2. Pressure Relief Valve Fitting 32 N•m [24 ft-lb]

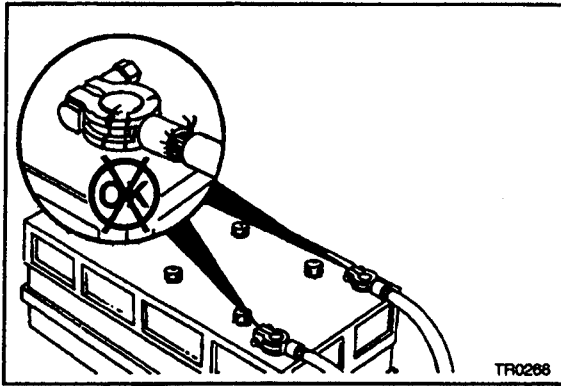
3. Low Pressure Fuel Supply Fitting 32 N•m [24 ft-lb]



## Section 6 - Electrical System

### Section Contents

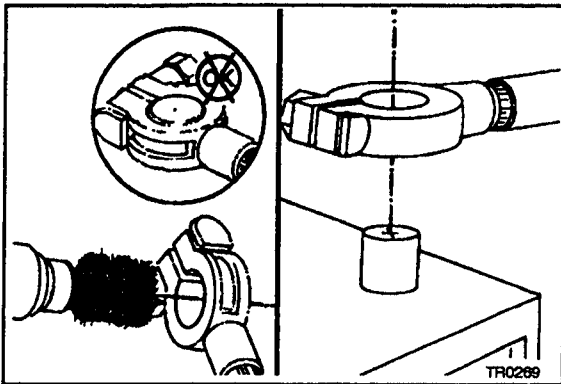
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**Battery Terminal Connections - Checking**

Visually inspect the battery terminals for loose, broken, or corroded connections.

Repair or replace broken cables or terminals.

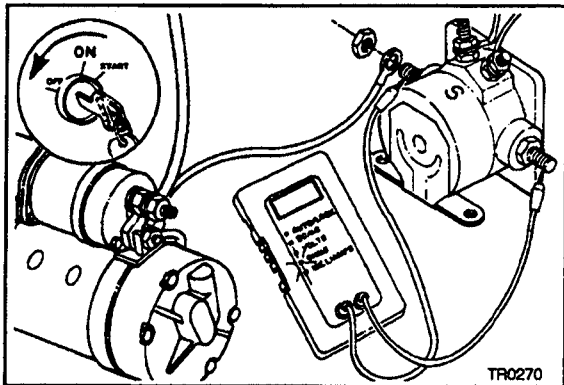


If the connections are corroded, remove the cables and use a battery cable brush to clean the cable and battery terminals.

Install and tighten the battery cables.



Use grease to coat the battery terminals to prevent corrosion.



**Starting Circuit - Checking**

**Magnetic Switch - Checking**

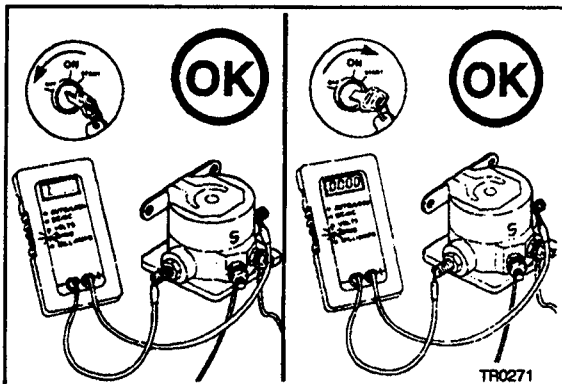


**Warning:** Be sure the starting motor switch is in the "OFF" position to prevent electrical shock and personal injury.



Remove the cable connecting the magnetic switch to the starting motor solenoid from the magnetic switch terminal.

Connect the leads of Part No. 3376898 Digital Multimeter to the two large switch terminals.



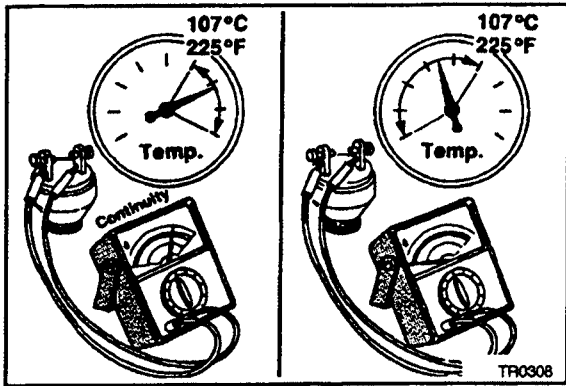
Set the multimeter to measure resistance (OHMS).

With the starting motor switch in the "OFF" position, the multimeter **must** indicate resistance at infinity.



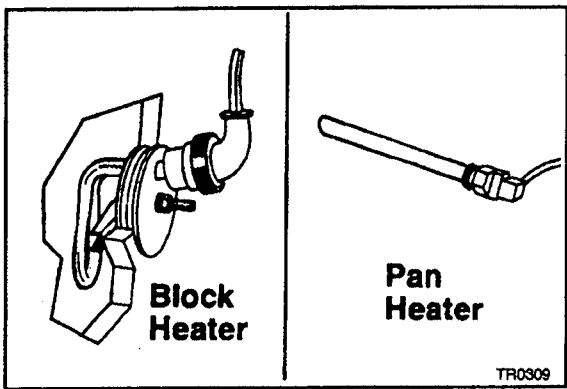
Turn the starting motor switch to the "START" position.

The multimeter **must** indicate zero or very little resistance.



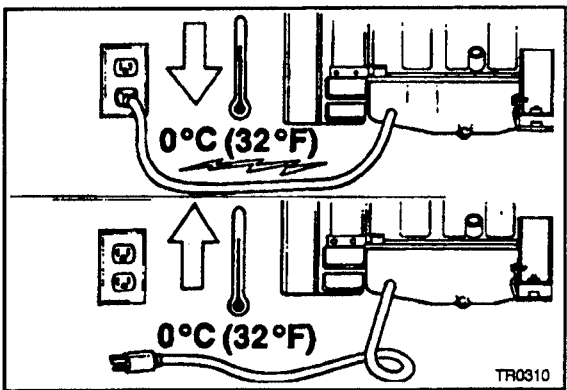
**Checking the Temperature Sensor**

Check for continuity. The sensor will have continuity only when coolant temperature is above 107° C [225° F].



**Coolant or Pan Heaters - Checking**

When functioning properly, the engine block or oil pan heater should make an audible sound when activated. The adjacent parts should be warm to the touch.

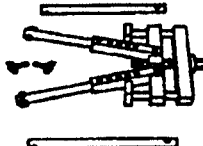
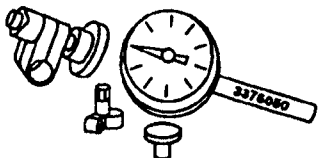
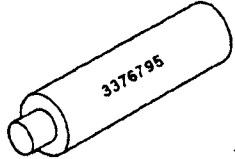

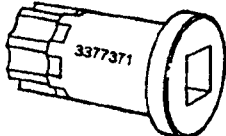
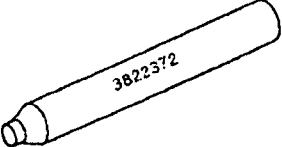
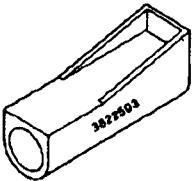
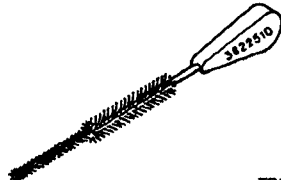


Some heaters will operate continuously when plugged into the correct voltage electrical socket. Operate them only below 0° C [32° F] ambient temperature.

**Starting Motor - Replacement (6-02)**

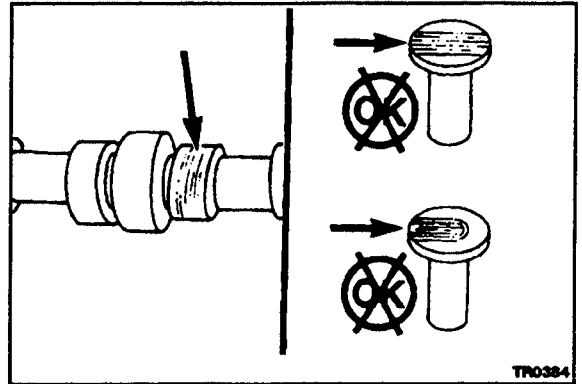
**Preparatory Steps:**

- Disconnect the ground cable from the battery.
- Identify each electrical wire with a tag indicating location.

| Tool No. | Tool Description  | Tool Illustration   |
|----------|---|---|
| 3376015  | <p><b>Cylinder Liner Puller (Universal)</b></p> <p>Remove cylinder liners from the cylinder block. Requires two Par No. 3376649 Puller Arm Extension Feet.</p>                            |  <p>TR0333</p>   |
| 3376050  | <p><b>Dial Indicator and Sleeve Assembly</b></p> <p>Use with Part No. ST-1325 Dial Gauge Attachment to measure flywheel and flywheel housing runout.</p>                                  |  <p>TR0334</p>   |
| 3376795  | <p><b>Expansion Plug Driver Handle</b></p> <p>Used with all expansion plug drivers larger than 0.375 inch diameter.</p>   |  <p>TR0335</p>  |
| 3376816  | <p><b>Expansion Plug Driver</b></p> <p>Install 1.00 inch expansion plug to specified depth. Used with expansion plug driver handle, Part No. 3376795.</p>                                 |  <p>TR0336</p> |
| 3377371  | <p><b>Engine Barring Gear</b></p> <p>Used to engage the flywheel ring gear to rotate the crankshaft.</p>  |  <p>TR0337</p> |
| 3822372  | <p><b>Expansion Plug Driver</b></p> <p>Install 0.375 inch expansion plug to specified depth.</p>  |  <p>TR0338</p> |
| 3822503  | <p><b>Cylinder Liner Clamp Set</b></p> <p>Used to clamp the liner into the bore of the cylinder block.</p> <p>Note: Requires two cylinder head bolts (not included in the clamp set).</p> |  <p>TR0339</p> |
| 3822510  | <p><b>Injector Bore Brush</b></p> <p>Used to clean carbon from injector bores.</p>  |  <p>TR0340</p> |

) **Section 7 - Base Engine Components**

Loose rocker levers and the need to reset the valve clearance frequently can also indicate cam lobe or tappet wear. If an inspection of the levers, valve stems and push rods does not show wear, then tappet and/or cam lobe wear can be suspected. Refer to Procedures 7-22 and 7-24.



TR0384

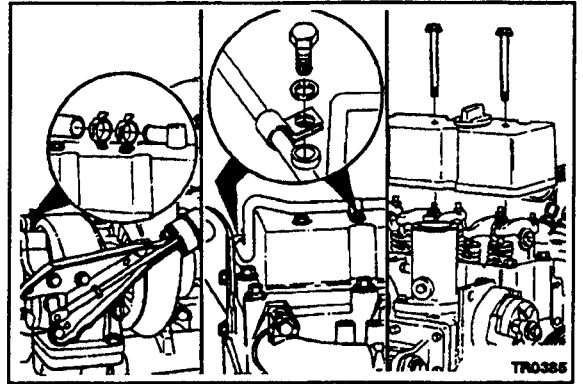
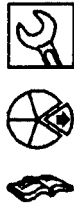
) **Rocker Lever - Replacement (7-05)**

**Removal**

13 mm, 15 mm, 18 mm

Remove the crankcase breather tube and hose. Refer to Procedure 7-03.

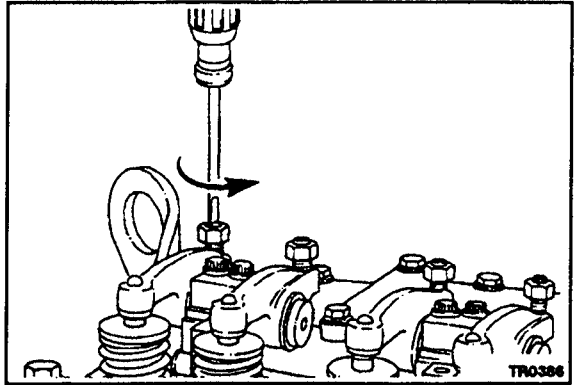
Remove the valve cover. Refer to Procedure 7-02.



TR0385

14 mm, Screwdriver

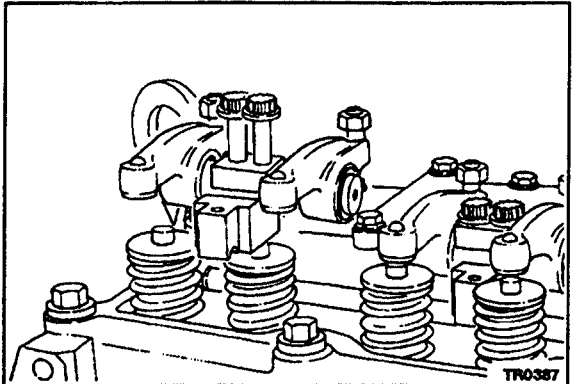
Loosen the adjusting screw locknuts. Loosen the adjusting screws until they stop.



TR0386

10 mm

Remove the capscrews, retaining clamps, rocker lever assemblies and supports.



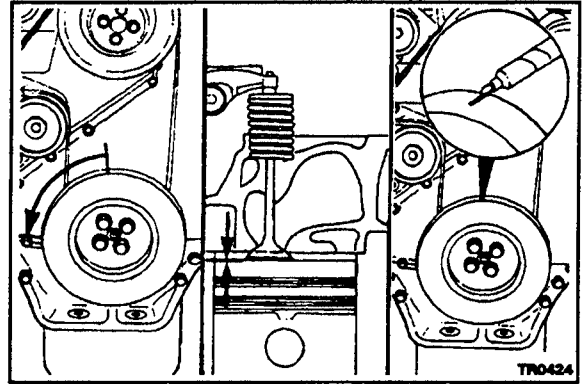
TR0387

) Section 7 - Base Engine Components

**Caution:** Use extreme care when rotating the crankshaft. Use of too much force could damage the valve or push rod.

Rotate the crankshaft slowly in the opposite direction of normal engine rotation until the piston touches the intake valve.

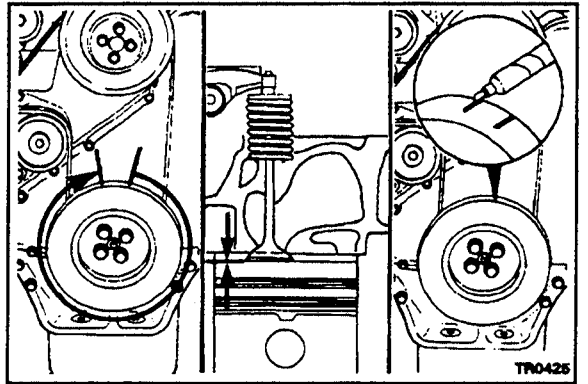
Mark the vibration damper at the wire pointer.



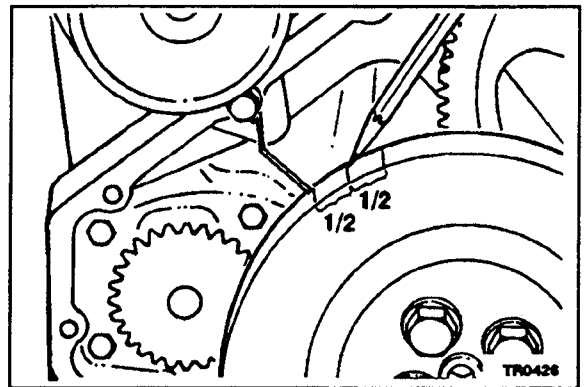
**Caution:** Make sure that the piston touches the intake valve with approximately the same amount of force as in the previous step.

Rotate the crankshaft in the direction of normal engine rotation until the piston touches the intake valve.

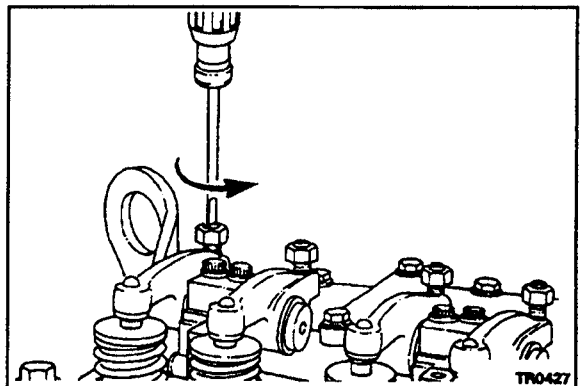
Mark the vibration damper at the wire pointer.



Measure the distance and mark the vibration damper at one-half the distance between the two marks. This mark is the TDC mark.



**Caution:** Completely loosen the intake valve adjusting screw. Failure to do so will result in damage to the intake valve or push rod when the crankshaft is rotated.



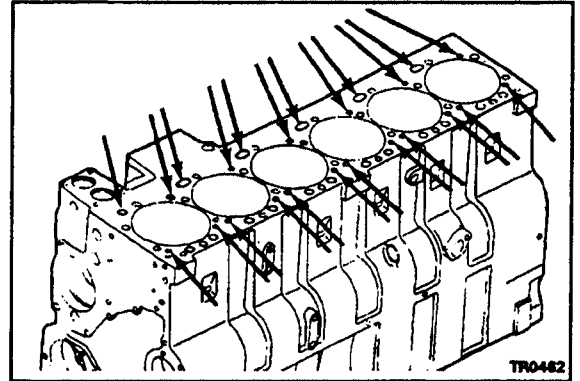
Inspect the coolant passages.

Build-up of deposits in the coolant passages can cause engine overheating.

A large build-up of rust and lime will require removal of the cylinder block for cleaning in a hot tank.

Be sure the coolant passages are clean.

**NOTE:** Excessive deposits may be cleaned in an acid tank, but the camshaft bushings must first be removed to prevent damage.

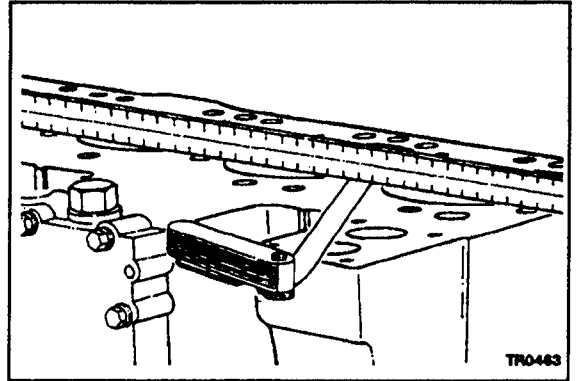


TR0462

**Straight Edge and Feeler Gauge**

Visually inspect the top surface for damage.

Check the top surface for flatness between each cylinder.



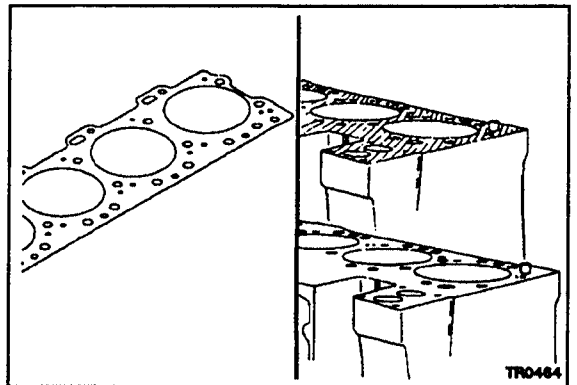
TR0463

**Cylinder Block Flatness Specification**

| mm    |              | in    |
|-------|--------------|-------|
| 0.075 | End-to-End   | 0.003 |
| 0.075 | Side-to-Side | 0.003 |

**Caution:** Do not proceed with the repair if the cylinder block head deck is damaged or not flat. The engine will have to be removed for resurfacing the block.

**NOTE:** The cylinder block head deck can be resurfaced in a machine shop and a thicker surface head gasket installed to keep the piston-to-head clearance the same.

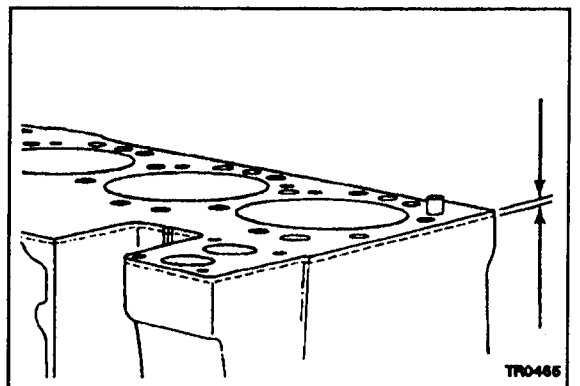


TR0464

The cylinder block head deck can be resurfaced two times. The first resurface should be 0.25 mm [0.010 inch]. If additional resurfacing is required, an additional 0.25 mm [0.010 inch] can be removed.

**Cylinder Block Resurface Limits**

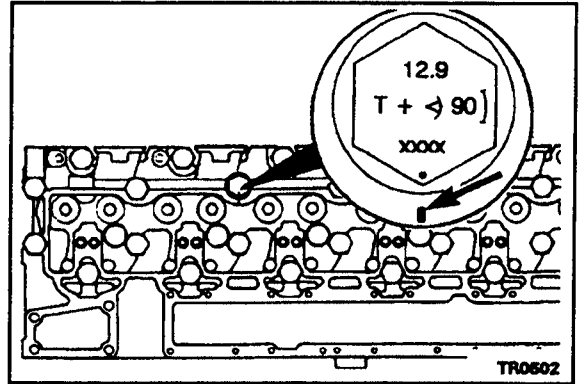
| mm   |                  | in    |
|------|------------------|-------|
| 0.25 | First Resurface  | 0.010 |
| 0.25 | Second Resurface | 0.010 |
| 0.50 | Total Allowed    | 0.020 |



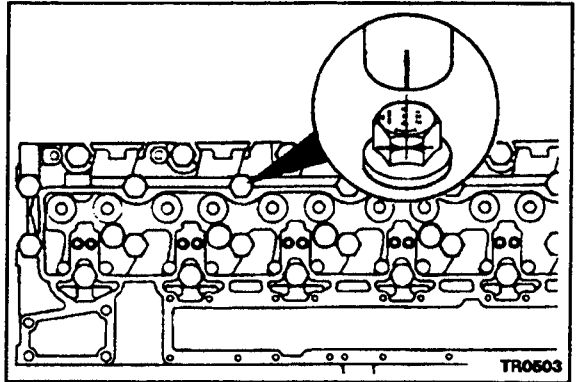
TR0465

Section 7 - Base Engine Components

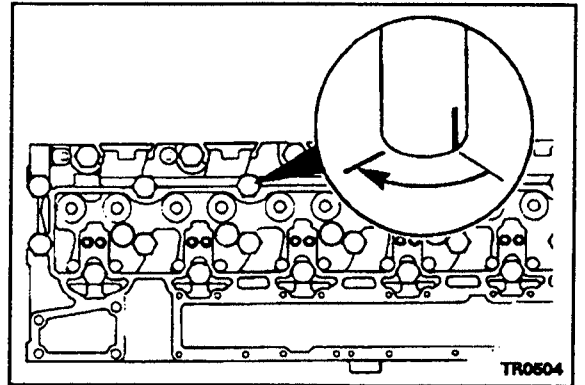
After the torque has been completed, mark the cylinder head at the location of the dot.



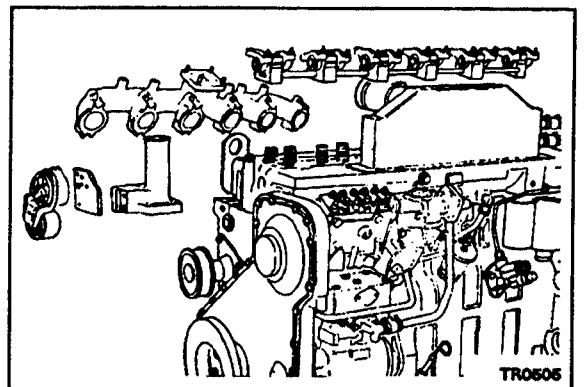
Position the socket on the capscrew such that the mark on the socket is at the same point as the window on the capscrew.



Turn the socket until the mark of the socket aligns with the mark on the cylinder head.



- Install the thermostat housing. Refer to Procedure 1-08.
- Install the belt tensioner and bracket. Refer to Procedure 1-04.
- Install the exhaust manifold. Refer to Procedure 3-12.
- Install the rocker lever oil manifold. Refer to Procedure 7-05.
- Install the rocker assemblies. Refer to Procedure 7-05.

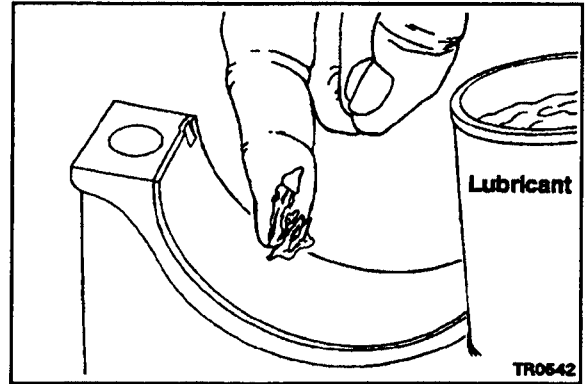


Section 7 - Base Engine Components

Install the lower main bearings into the bearing caps.

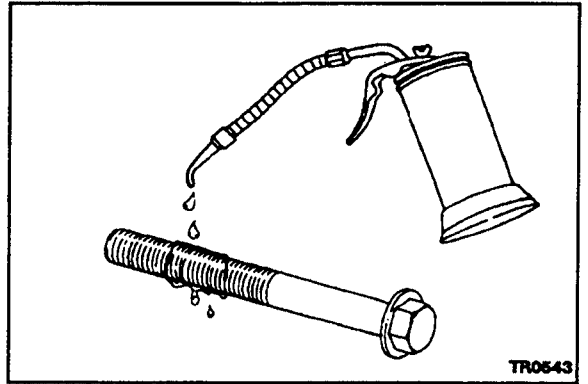
Make sure the tang of the bearing shell is in the slot of the cap:

Use clean Lubriplate® 105 or its equivalent to lubricate the bearing shells.



Use clean 15W-40 oil to lubricate the capscrew threads.

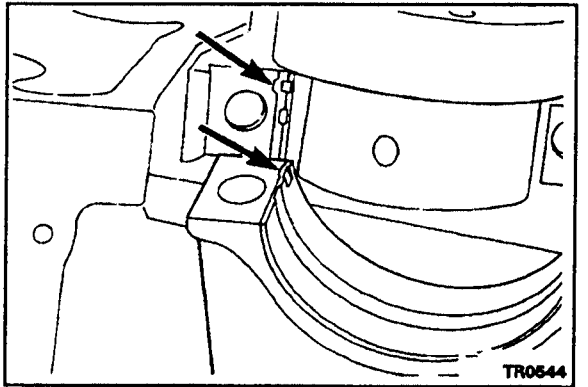
Drain the excess oil from the capscrews before installing them.



**NOTE:** The main bearing caps are numbered for location. No. 1 starts with the front of the block, and the numbers face the camshaft side of the engine.



When correctly installed, the tangs (slots) should both be on the same side.

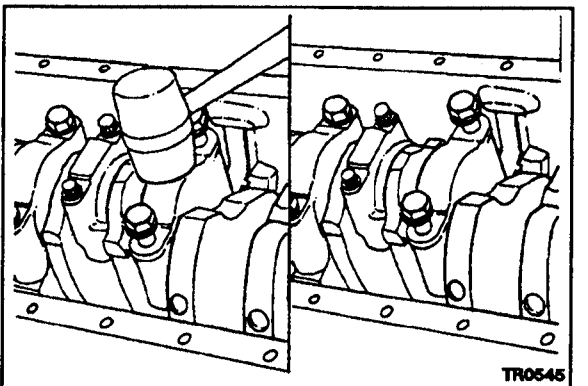


**Small Plastic or Rubber Mallet**

Tap the main cap gently into position.

**NOTE:** Make sure the bearing does not become dislodged from the cap.

When seated, the main bolts can be threaded in by hand.



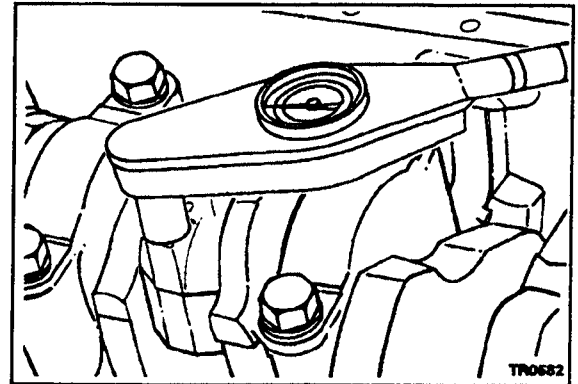
**Section 7 - Base Engine Components**

**19 mm Socket, Torque Wrench**

Tighten the connecting rod capscrew nuts in alternating sequence.

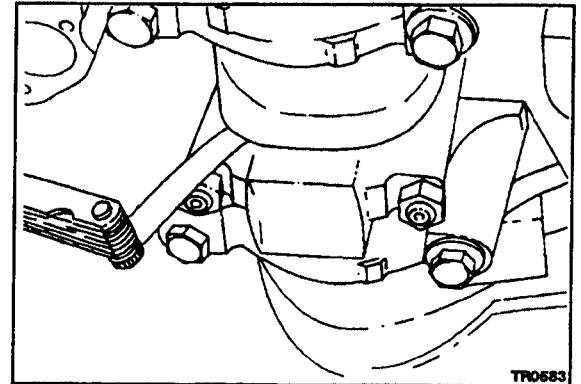
**Torque Value:**

- Step 1 - 40 N•m [30 ft-lb]
- Step 2 - 80 N•m [60 ft-lb]
- Step 3 - 120 N•m [88 ft-lb]



TR0682

Measure the side clearance between the connecting rod and crankshaft.



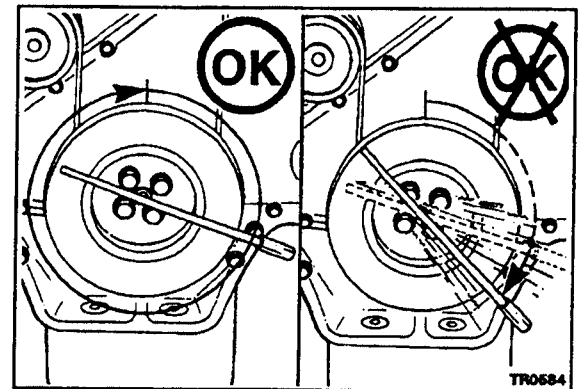
TR0683

**Connecting Rod Side Clearance**

| mm   |     | in    |
|------|-----|-------|
| 0.10 | MIN | 0.004 |
| 0.33 | MAX | 0.013 |

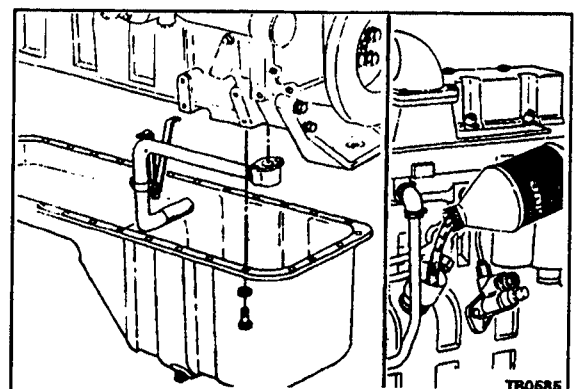
**NOTE:** The crankshaft must rotate freely.

Check for freedom of rotation as the caps are installed. If the crankshaft does not rotate freely, check the installation of the rod bearings and the bearing size.



TR0684

- Install the oil suction tube. Refer to Procedure 2-13.
- Install the lubricating oil pan. Refer to Procedure 2-13.
- Fill the lubricating oil pan. Refer to Procedure 2-05.

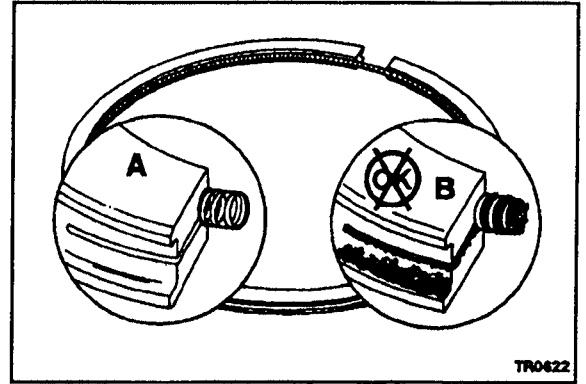


TR0685

Section 7 - Base Engine Components

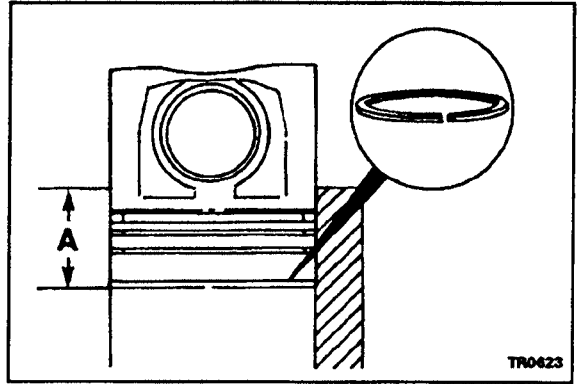
Oil ring plugging is indicated by the deposits in the oil ring grooves (B). Plugging of the ring drains restricts oil drain back which floods the ring belt area resulting in a loss of oil control. The condition can be caused by:

- Low engine operating temperatures - long periods of idling or a cooling system malfunction
- Extended oil change intervals, the wrong grade of oil or poor quality oil

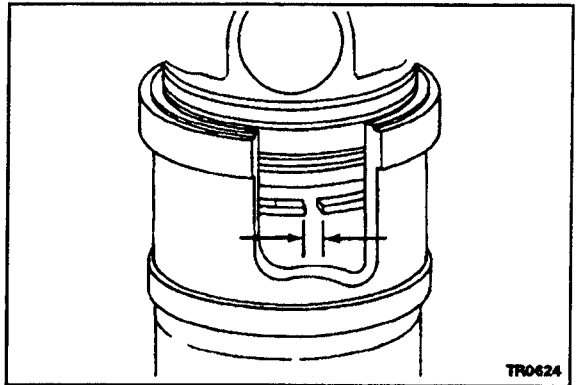


To check the piston ring gap, use the top end of a piston to align the piston rings in the wear area of the cylinder liner in which they will be used.

A = 89 mm [3.5 inches]



Use a feeler gauge to measure the piston ring end gap. Replace the ring if it does not meet the following specifications:

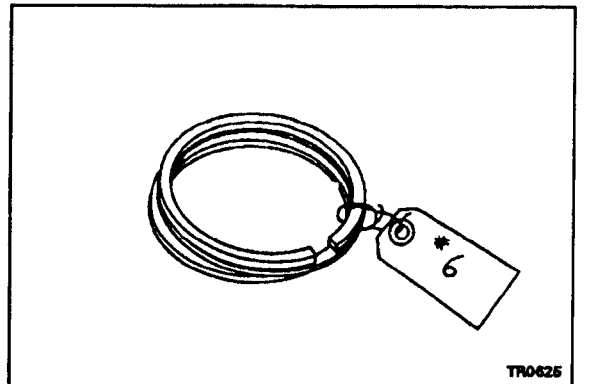


**New Piston Ring End Gap**

|               | mm   |     | in    |  |
|---------------|------|-----|-------|--|
| Top:          | 0.40 | MIN | 0.016 |  |
|               | 0.70 | MAX | 0.028 |  |
| Intermediate: | 0.40 | MIN | 0.016 |  |
|               | 0.70 | MAX | 0.028 |  |
| Oil Control:  | 0.30 | MIN | 0.012 |  |
|               | 0.60 | MAX | 0.024 |  |

**NOTE:** Add 0.09 mm [0.004 in] for every 0.03 mm [0.001 in] of bore wear up to the maximum worn limit.

Identify the ring sets for installation in the cylinder in which the end gap was measured.

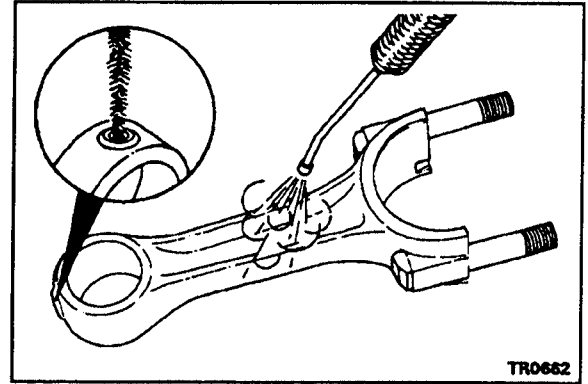


**Cleaning and Inspection**

Use a nylon bristle brush to clean the oil drillings.

**Warning:** When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

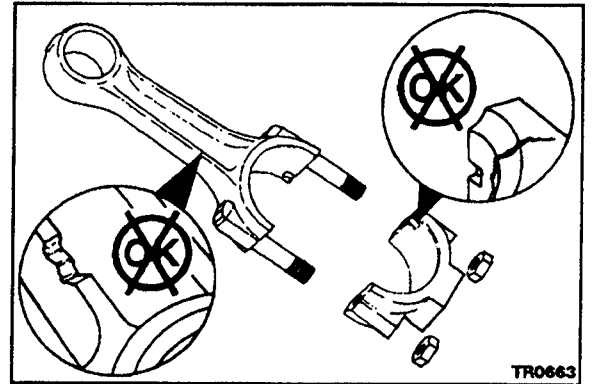
Use steam or solvent to clean the connecting rods. Dry with compressed air.



TR0662

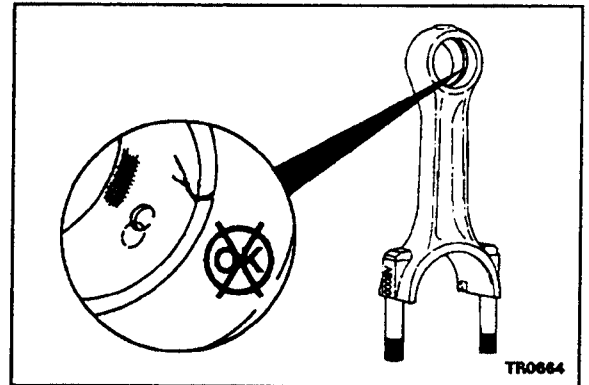
Inspect the connecting rods and caps for damage.

Replace the connecting rod if the "I-beam" is nicked or damaged.



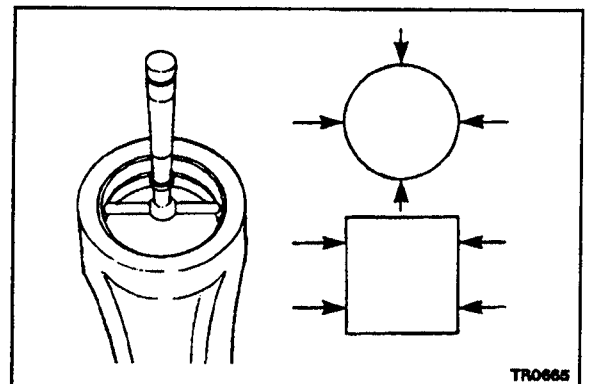
TR0663

Visually inspect the connecting rod pin bore bushing for damage or misalignment of the oil passage and bushing.



TR0664

Measure the connecting rod piston pin bushing inside diameter.



TR0665

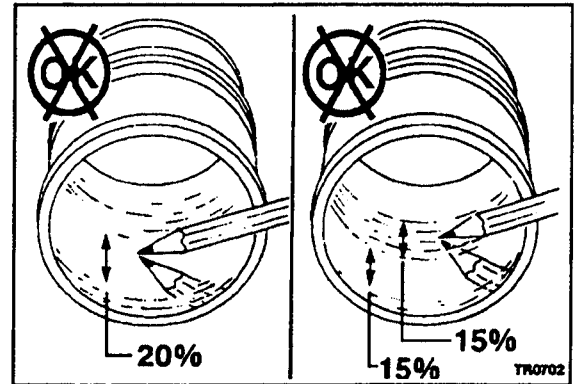
**Connecting Rod Pin Bore Specifications**

| mm     |     |  | in     |
|--------|-----|--|--------|
| 45.023 | MIN |  | 1.7726 |
| 45.060 | MAX |  | 1.7740 |

**Section 7 - Base Engine Components**

Replace the liner if:

- A heavy polish is present over 20 percent of the piston ring travel area.
- Both moderate and heavy polish over 30 percent of the piston ring travel area and one half (15 percent) is heavy polish.

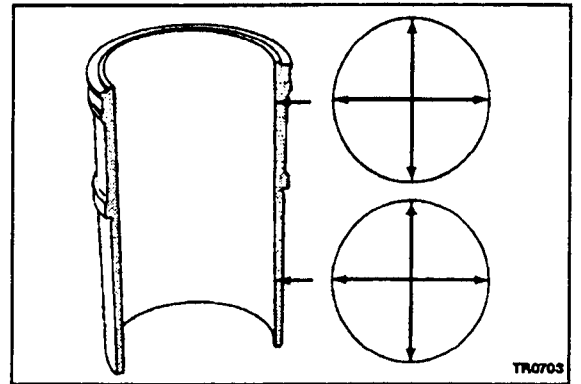


**Part No. 3375072, Dial Bore Gauge**

Measure the liner inside diameter in four places 90 degrees apart at the top and bottom of the piston travel area.



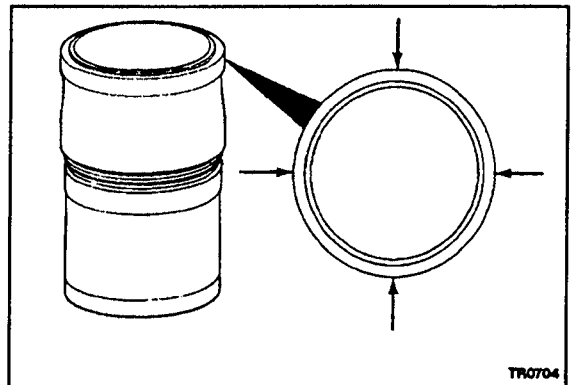
| Cylinder Liner I.D. |     |        |
|---------------------|-----|--------|
| mm                  |     | in     |
| 114.000             | MIN | 4.4882 |
| 114.04              | MAX | 4.9897 |



Measure the outside diameter of the liner top press fit area.



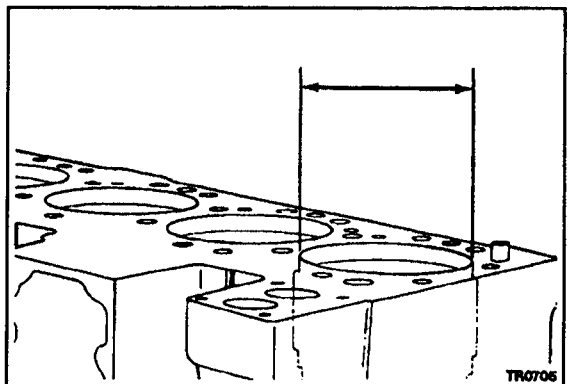
| Cylinder Liner O.D. (Top Press Fit) |     |        |
|-------------------------------------|-----|--------|
| mm                                  |     | in     |
| 130.938                             | MIN | 5.1550 |
| 130.958                             | MAX | 5.1558 |



Measure the cylinder liner bore in the block.



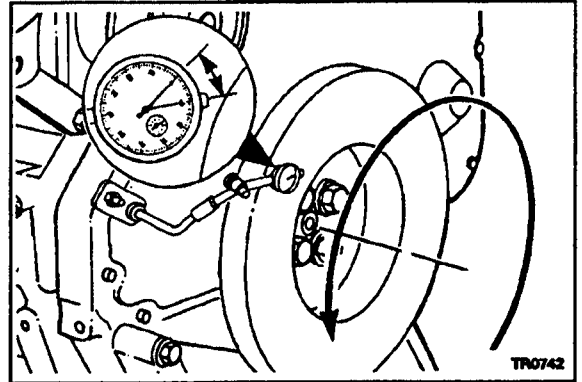
| Cylinder Liner Bore in Block (Press Fit Bore) |     |        |
|---|-----|--------|
| mm  |     | in     |
| 130.900                                       | MIN | 5.1535 |
| 130.950                                       | MAX | 5.1570 |



Rotate the crankshaft 360 degrees, maintaining the position of the crankshaft (either toward the front or the rear) in relation to the cylinder block.

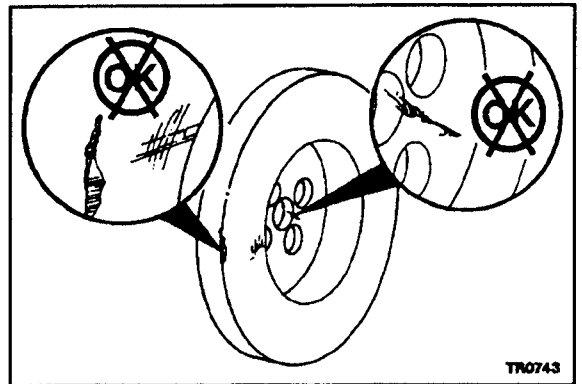
Record the total indicator motion.

Replace the damper if wobble exceeds 0.18 mm [0.007 inch] per 25.4 mm [1.0 inch] of radius. Refer to replacement procedure in this section.



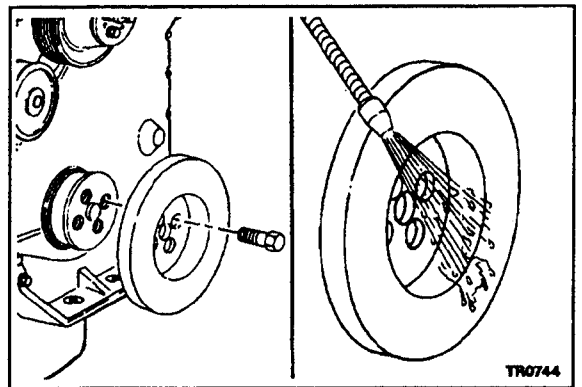
### Viscous Vibration Damper - Inspection

Check the mounting web for cracks. Check the housing for dents or raised surfaces. Replace the damper if any of these defects are identified. Refer to replacement procedure in this section.

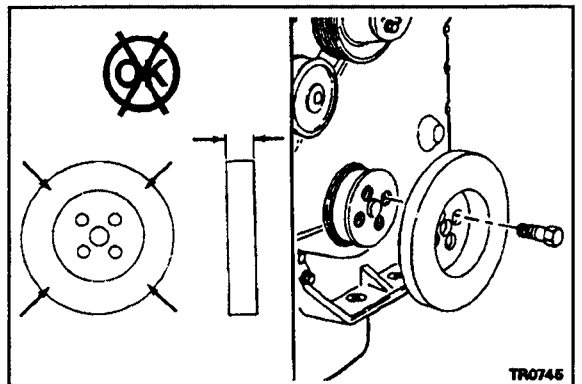


Remove the viscous vibration damper. Refer to replacement procedure in this section.

Clean the damper with a solvent cleaner.

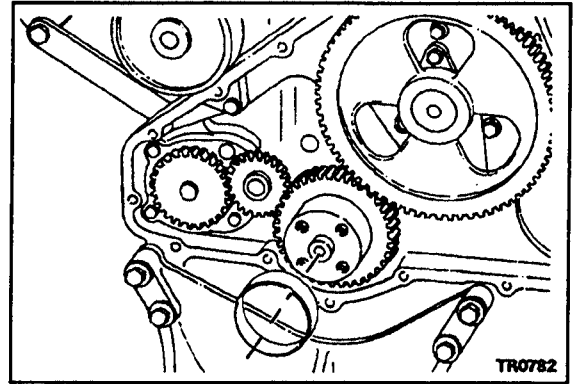


The viscous damper is filled with a silicone fluid. After many hours of use, the silicone fluid may become thicker and expand. To determine if the damper thickness is correct, remove the paint from the damper in four locations on either side of the damper. Measure and record the thickness of the damper in four places. Measure the thickness 3.175 mm [0.125 inch] from the outside of the damper. Replace the damper if its thickness varies by more than 0.25 mm [0.010 inch].

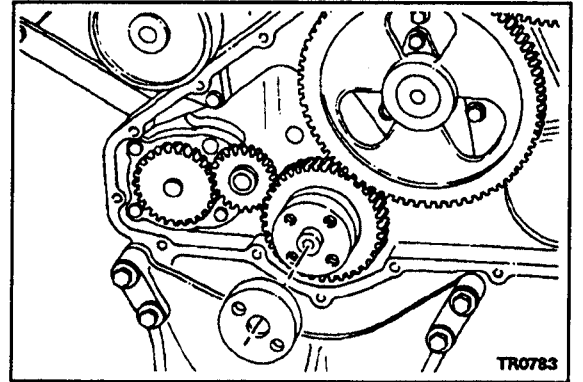


) **Section 7 - Base Engine Components**

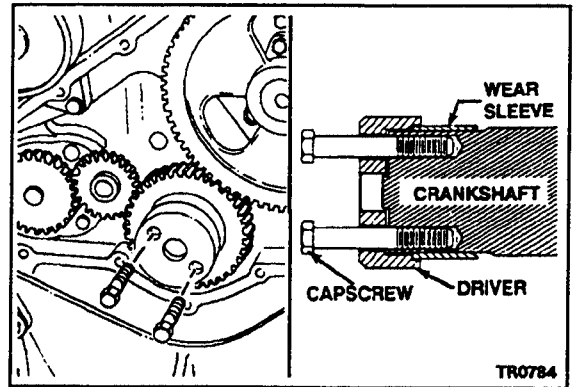
Position the chamfered end of the wear sleeve onto the end of the crankshaft.



) Position the counterbore end of the driver onto the wear sleeve.



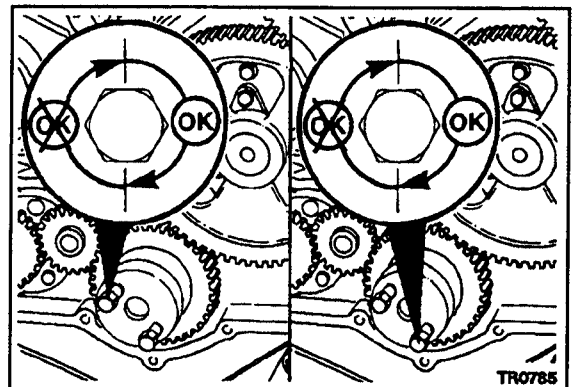
) Install two capscrews (without spacers or hair pin cotters) through the driver and into the crankshaft cap screw holes. Align the wear sleeve and driver perpendicular with the crankshaft. Tighten the capscrews "finger tight".



) Alternately tighten the capscrews until the sleeve is installed to a depth of approximately 16 mm [0.625 inch].

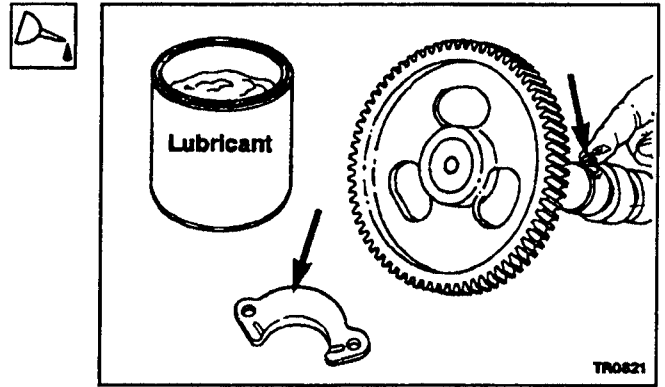
**NOTE:** To prevent damage to the wear sleeve, do not exceed 1/2 revolution of each capscrew.

Approximate torque value: 20 N•m [15 ft-lb]



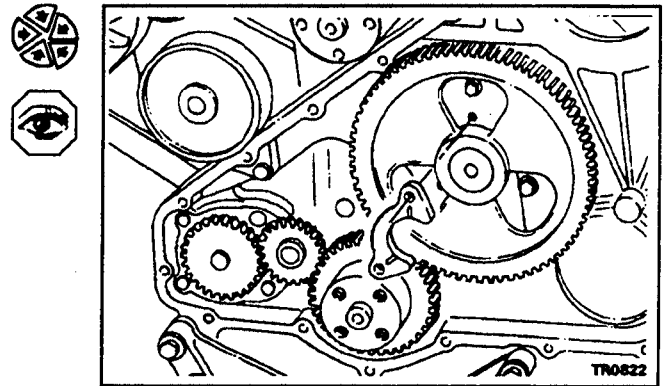
) **Section 7 - Base Engine Components**

Lubricate the camshaft and thrust plate with Lubriplate™ 105.



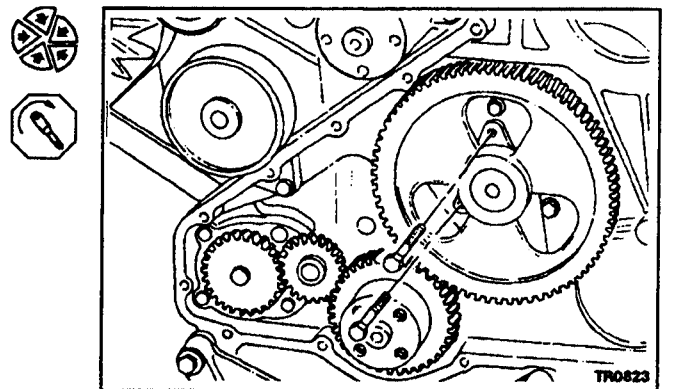
Install the camshaft/thrust plate.

) **Make sure the timing marks on the camshaft and camshaft gears are aligned.**



Install the thrust plate capscrews.

**Torque Value: 24 N·m [18 ft-lb]**



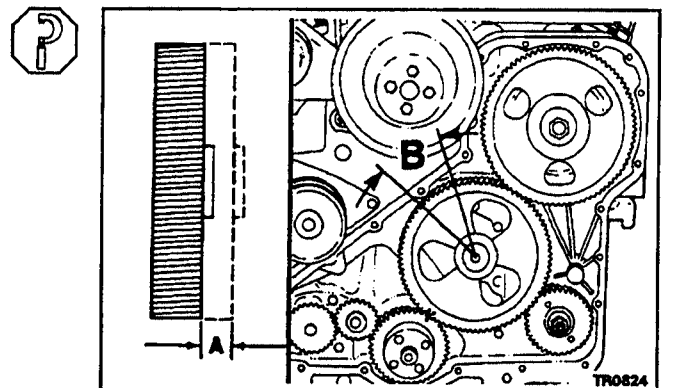
Verify the camshaft has proper backlash and end play. End play is controlled by the thickness of the thrust plate and the groove in the camshaft.

**Camshaft End Clearance (A)**

| mm   |     | in     |
|------|-----|--------|
| 0.12 | MIN | 0.0047 |
| 0.46 | MAX | 0.018  |

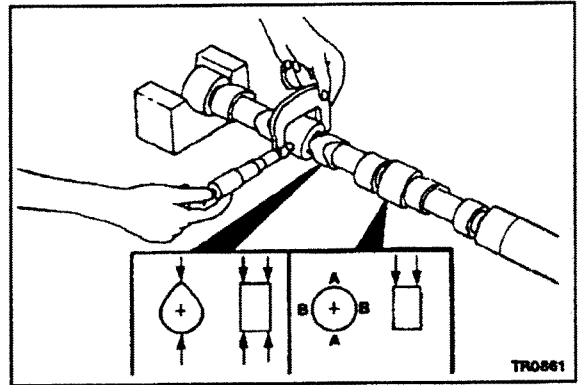
**Camshaft Gear Backlash Limits (B)**

| mm   |     | in    |
|------|-----|-------|
| 0.08 | MIN | 0.003 |
| 0.33 | MAX | 0.013 |



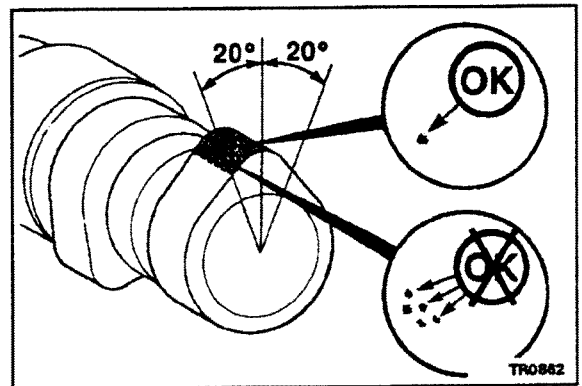
| Camshaft Journal Diameter |     |        |
|---------------------------|-----|--------|
| mm                        |     | in     |
| 59.962                    | MIN | 2.3607 |
| 60.013                    | MAX | 2.3627 |

**NOTE:** Replace the camshaft if the outside diameter of any bearing surface is less than 59.962 mm [2.3607 inch].

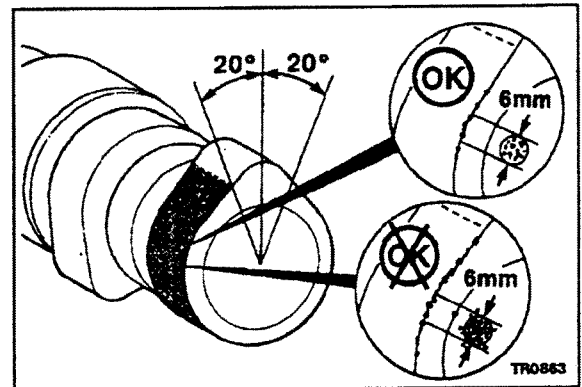


**Edge Deterioration (Breakdown)**

The area of edge deterioration should **not** be greater than the equivalent area of a 2 mm [0.079 inch] circle within + or - 20 degrees of the nose of the camshaft lobe.

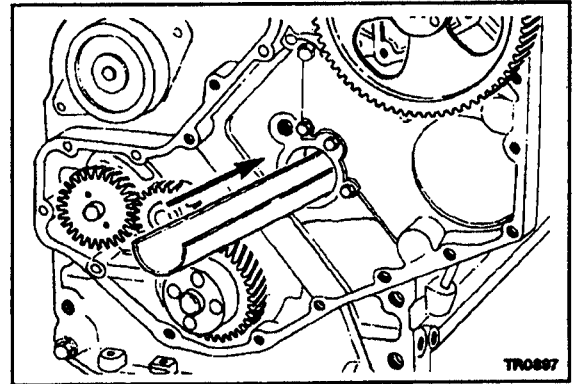


Outside of the + or - 20 degrees of the nose of the camshaft lobe, the areas of edge deterioration should not be greater than the equivalent area of a 6 mm [0.236 inch] circle.

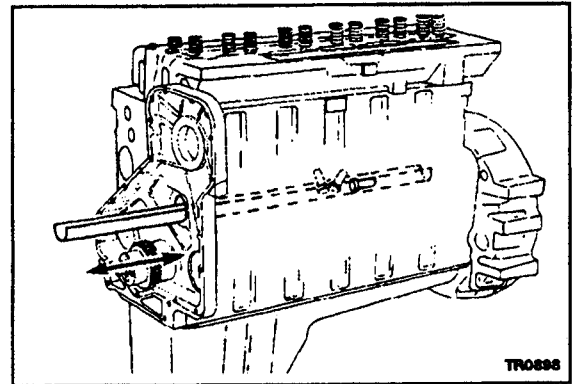


) **Section 7 - Base Engine Components**

Insert the tray (1) to the full length of the camshaft bore.

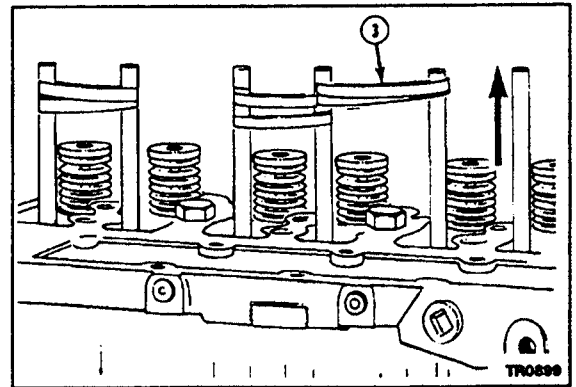


) Make sure the tray is positioned so it will catch the tappet when the wooden dowel is removed.

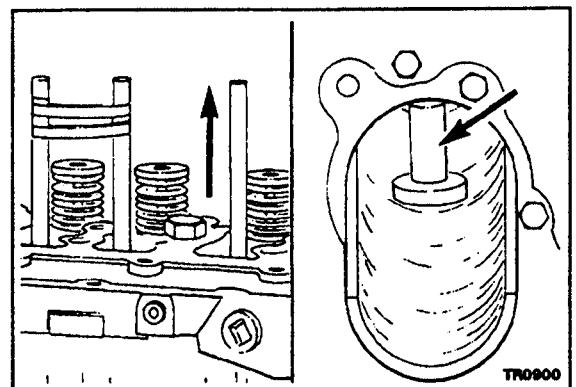


) **NOTE:** Only remove one tappet at a time.

Remove the rubber band (3) from the two companion tappets, securing the tappet not to be removed with the rubber band.



) Pull the wooden dowel from the tappet bore allowing the tappet to fall into the plastic tray.



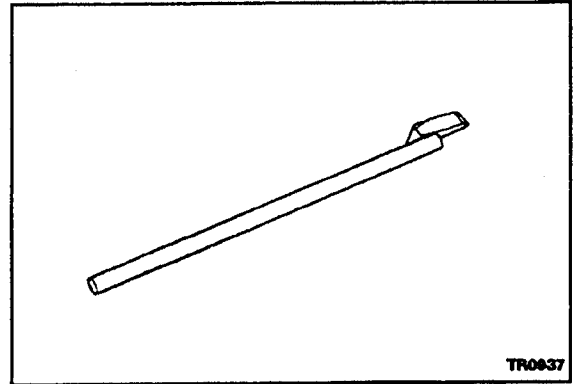
**Part No. 3823585, Crankshaft Gear Splitter**

**Caution:** Safety glasses are required when using this tool.

**NOTE:** Trying to accomplish this task with a cold chisel will result in damage to the engine gear housing gasket surface.

**Caution:** Use care to avoid damage to the polished surfaces of the crankshaft by driving the point of the tool into the crankshaft.

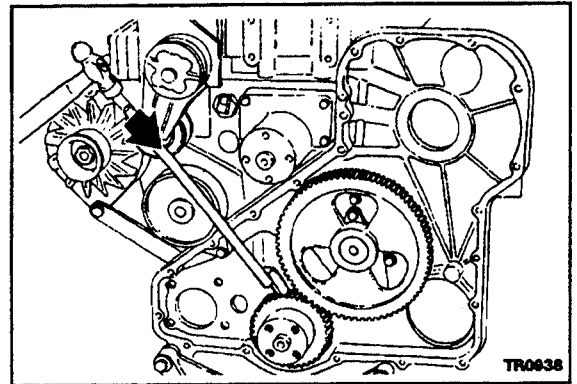
**NOTE:** Do not use gear splitter on steel gears.



Place the point of the chisel between two gear teeth.

Strike the splitter with a two or three pound steel hammer.

Repeat this step if necessary.



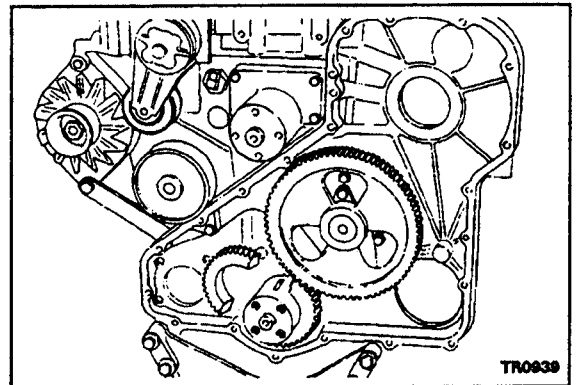
Remove the crankshaft gear.

**NOTE:** The camshaft gear will rotate slightly as the teeth follow the gear helix.

**Caution:** Use great care to not disturb the position of the camshaft gear after the crankshaft gear has been removed.

**Caution:** Do not damage the crankshaft when removing the key.

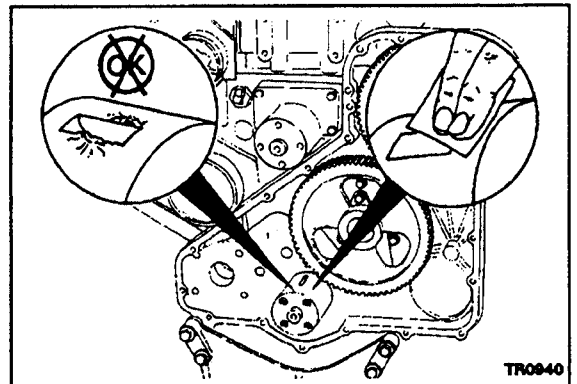
Use a flat chisel and a hammer to remove the crankshaft gear key.



**Cleaning and Inspection**

Visually inspect the crankshaft gear journal for burrs or damage.

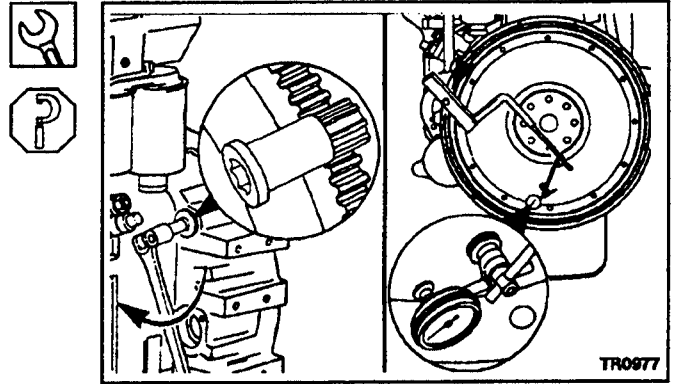
Remove any burrs with Scotch-Brite® 7448, Part No. 3823258, or equivalent.



Section 7 - Base Engine Components

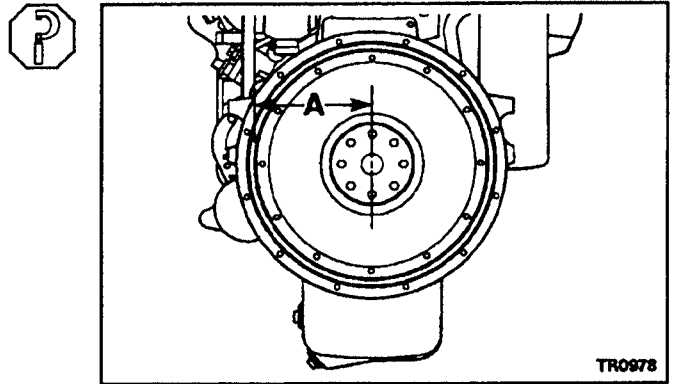
Use the engine barring gear, Part No. 3377371, to rotate the crankshaft one complete revolution. Measure the flywheel runout at four equal points on the flywheel.

**NOTE:** The flywheel **must** be pushed toward the front of the engine to remove the crankshaft end clearance each time a point is measured.

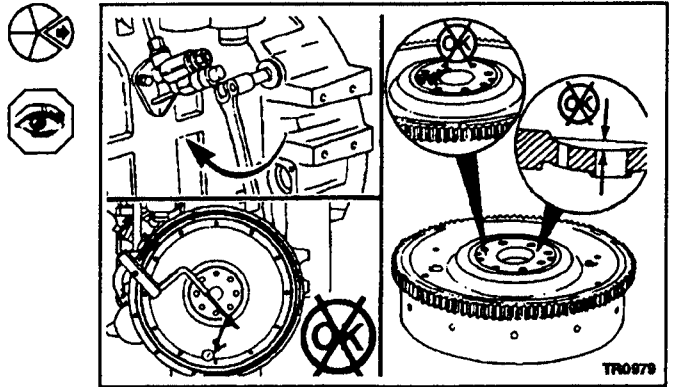


The total indicator reading (TIR) **must not** exceed the following specifications:

| Flywheel Radius (A) |    | Maximum (TIR) of Flywheel Face |       |
|---------------------|----|--------------------------------|-------|
| mm                  | in | mm                             | in    |
| 203                 | 8  | 0.203                          | 0.008 |
| 254                 | 10 | 0.254                          | 0.010 |
| 305                 | 12 | 0.305                          | 0.012 |
| 356                 | 14 | 0.356                          | 0.014 |
| 406                 | 16 | 0.406                          | 0.016 |

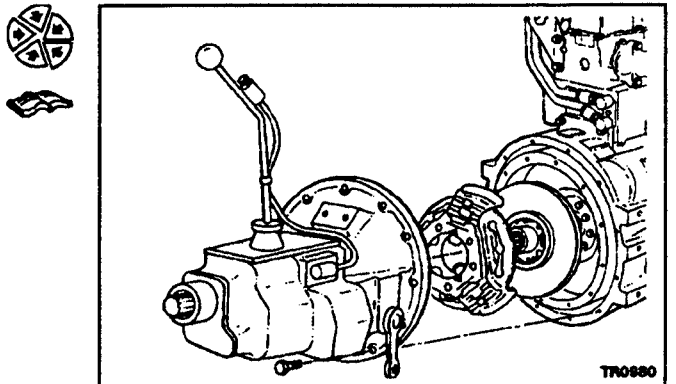


If the flywheel face runout is **not** within specifications, remove the flywheel. Check for nicks, burrs, or foreign material between the flywheel mounting surface and the crankshaft flange.



Install the clutch discs, pressure plate, transmission and drive line (if equipped) in **reverse** order of removal. Refer to the manufacturer's instructions.

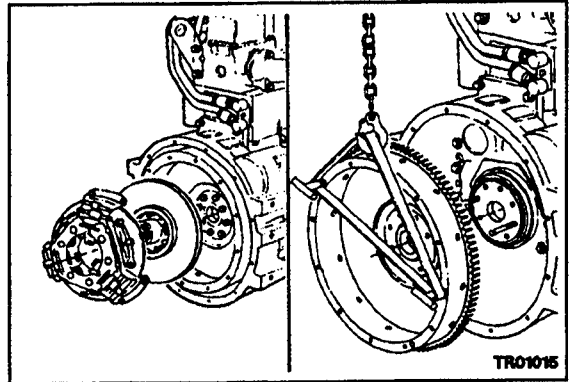
**NOTE:** Align the universal joints on each end of the drive shaft to prevent vibration.



) **Section 7 - Base Engine Components**

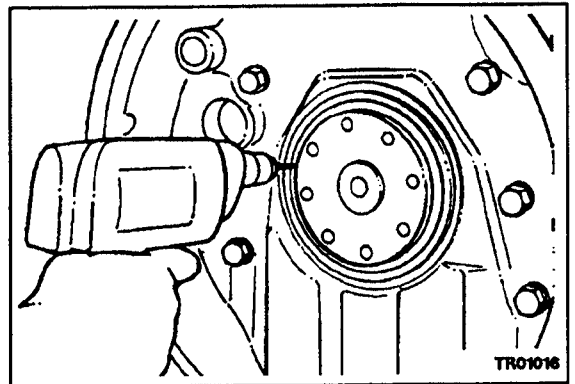
**19 mm**

Remove the clutch and flywheel, if equipped. Refer to Procedure 7-26.



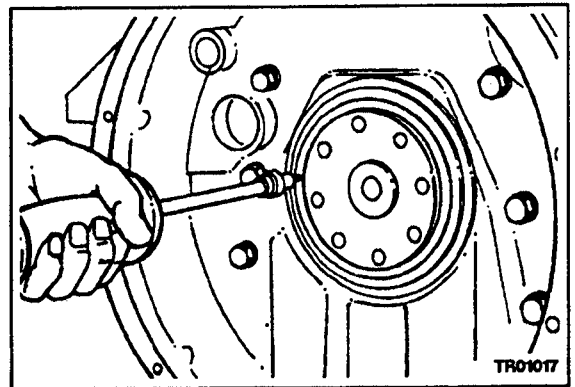
**3 mm Drill Bit, Drill Motor**

) Drill two holes, 180 degrees apart, into the outside metal part of the seal.



**No. 10 Sheet Metal Screw, Slide Hammer**

Remove the seal.

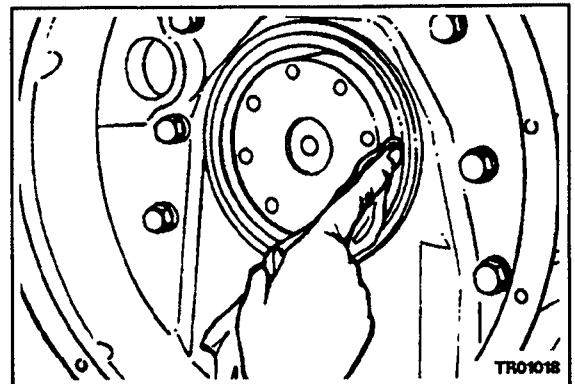


**Cleaning and Inspection**

Use a crocus cloth to remove any rust or other deposits from the crankshaft flange.

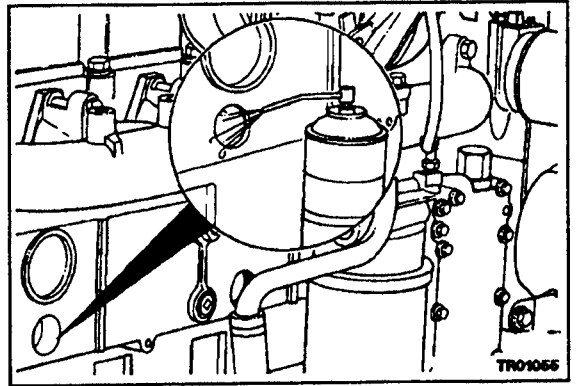
Use a clean cloth to clean the crankshaft flange.

**NOTE:** Do not use any kind of lubricant to install the seal. The oil seal must be installed with the lip of the seal and the crankshaft clean and dry.



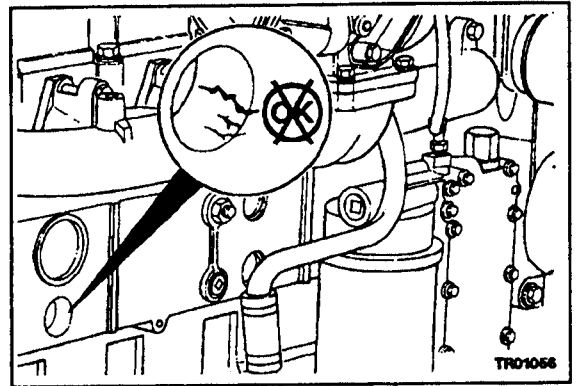
**Cleaning and Inspection**

Use spray cleaner, Part No. 3375433, or equivalent to clean the cup plug bore.



Visually inspect the cup plug bore for damage. Repair the bore if necessary.

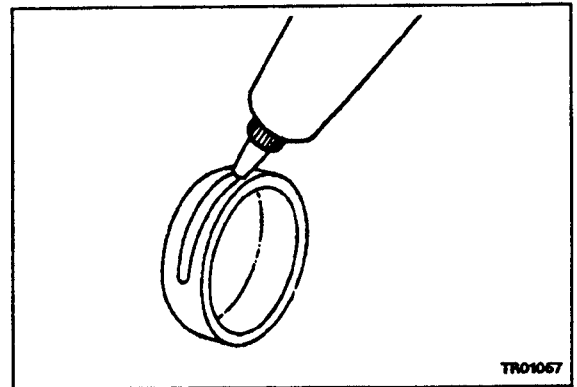
**NOTE:** Refer to Section V, "Engine Component Specifications," for cylinder block cup plug bore dimensions and cup plug dimensions.



**Installation**

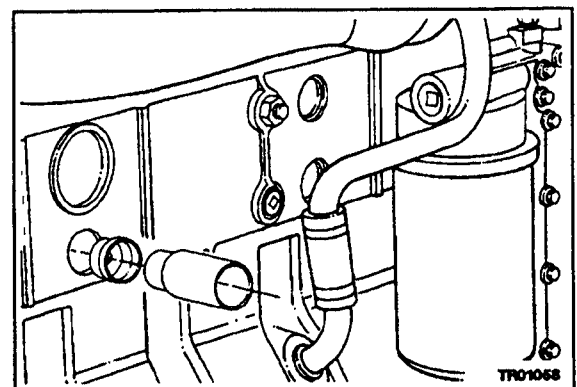
**Caution:** Excessive sealant can run back into the engine and cause damage to other components. Allow the sealant to dry for a minimum of 2 hours before operating the engine. The plug can come out of the bore if the sealant is not dry.

Apply a 2 mm [1/16 inch] bead of cup plug Lock'N Seal, Part No. 3375068, or equivalent to the outside diameter of the cup plug and the inside diameter of cup plug installation bore.



**NOTE:** Use a cup plug driver to install the cup plug to the correct depth in the cup plug bore.

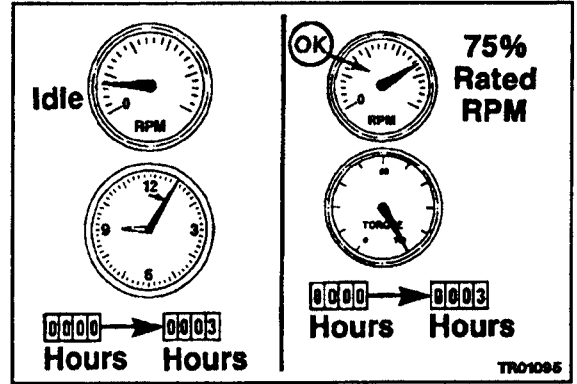
Use the following cup plug drivers:



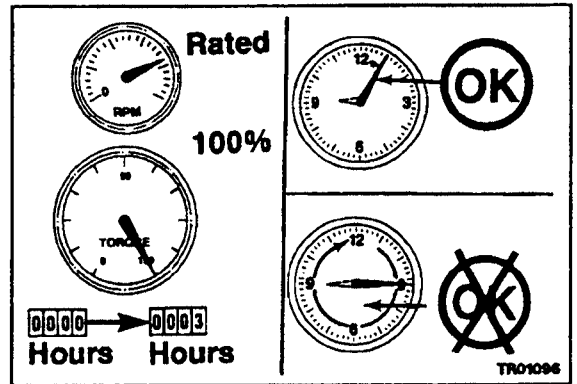
| Tool P/N | Cup Plug P/n | Cup Plug Dimension |
|----------|--------------|--------------------|
| 3822372  | 3900955      | 0.375 inch         |
| 3823521  | 3902606      | 0.8125 inch        |
| 3376816  | 3900957      | 1.00 inch          |
| 3823522  | 156075       | 1.1875 inch        |
| 3823523  | 3905401      | 1.375 inch         |
| 3823524  | 3900965      | 2.250 inch         |

**Section 8 - Engine Testing**

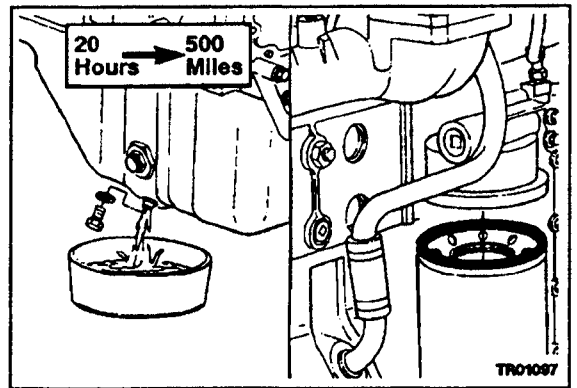
1. Do **not** idle the engine for more than 5 minutes at any one time.
2. Operate the engine at 75 percent throttle while loaded.



3. Do **not** operate the engine at rated speed (RPM) and full load for more than 5 minutes at any one time.



Change the lubricating oil and filter after 800 km [500 miles] or 20 hours of operation. Refer to Procedure 2-04.



# Section V - Engine Component Specifications

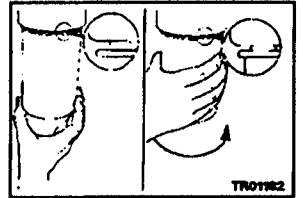
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) Section V - Engine Component Specifications

**Fuel Filter**

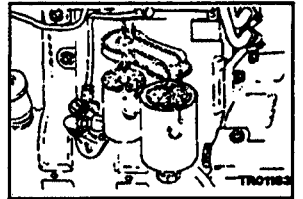
**Caution: Hand tighten only. Mechanical tightening will damage the fuel filter**



**Fuel Filter Head Adapter  
Fuel Filter Adapter Nut**

4 N•m  
32 N•m

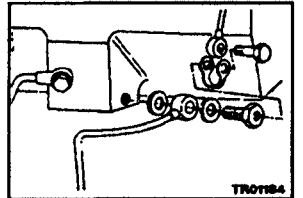
35 in-lb  
24 ft-lb



) **Fuel Filter Banjo Fittings**

24 N•m

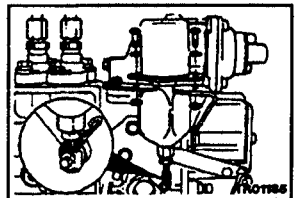
18 ft-lb



**Fuel Pump Solenoid Mounting Capscrews**

10 N•m

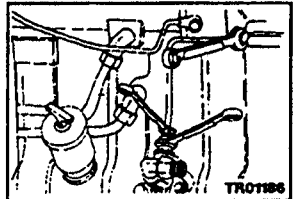
89 in-lb



**Fuel Transfer Pump  
Fuel Line Fittings**

24 N•m

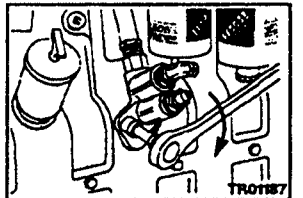
18 ft-lb



**Fuel Transfer Pump Mounting Capscrews**

24 N•m

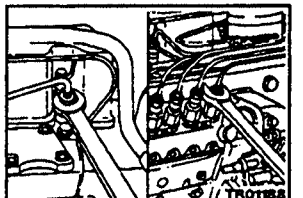
18 ft-lb



**High Pressure Fuel Line Fittings**

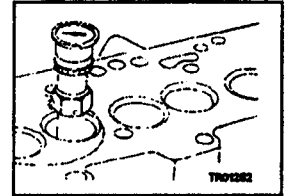
30 N•m

22 ft-lb



**Valve Seat-to-Valve Guide Concentricity (360 Degrees)**

0.05 mm      MAX      0.002 in

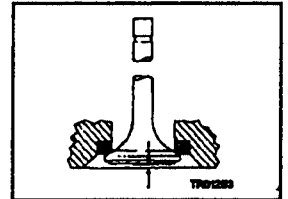


**Valve Recess in Cylinder Head**  
Exhaust

1.09 mm      MIN      0.043 in  
1.62 mm      MAX      0.064 in

Intake

0.59 mm      MIN      0.023 in  
1.12 mm      MAX      0.044 in

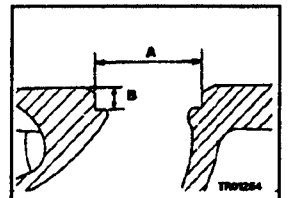


**Valve Insert Bore I.D. (Standard Insert)**  
Intake

A      53.930 mm      MAX      2.1231 in

Exhaust

47.027 mm      MAX      2.8515 in

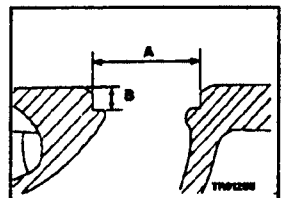


**Valve Insert Bore Depth (Standard Insert)**  
Intake

B      12.20 mm      MAX      0.480 in

Exhaust

9.83 mm      MAX      0.387 in



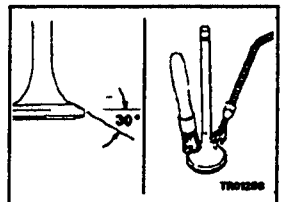
**Valve Face Angle**

Intake

30°

Exhaust

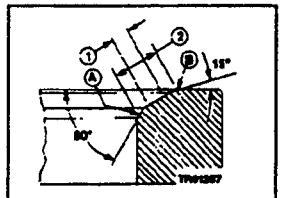
45°



**Valve Seat With Limit**

Grind area (A) with a 60 degree stone, and (B) with a 15 degree stone to center the seat on the valve face and obtain the valve seat width limits.

1.5 mm      MIN      0.060 in  
2.0 mm      MAX      0.080 in



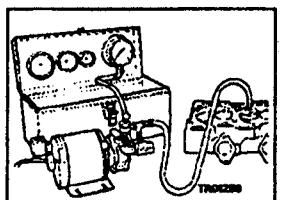
**Valve Seat Leakage (Hg)**

New

635 mm Hg      MAX      25 in Hg

Used

457 mm Hg      MAX      18 in Hg



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