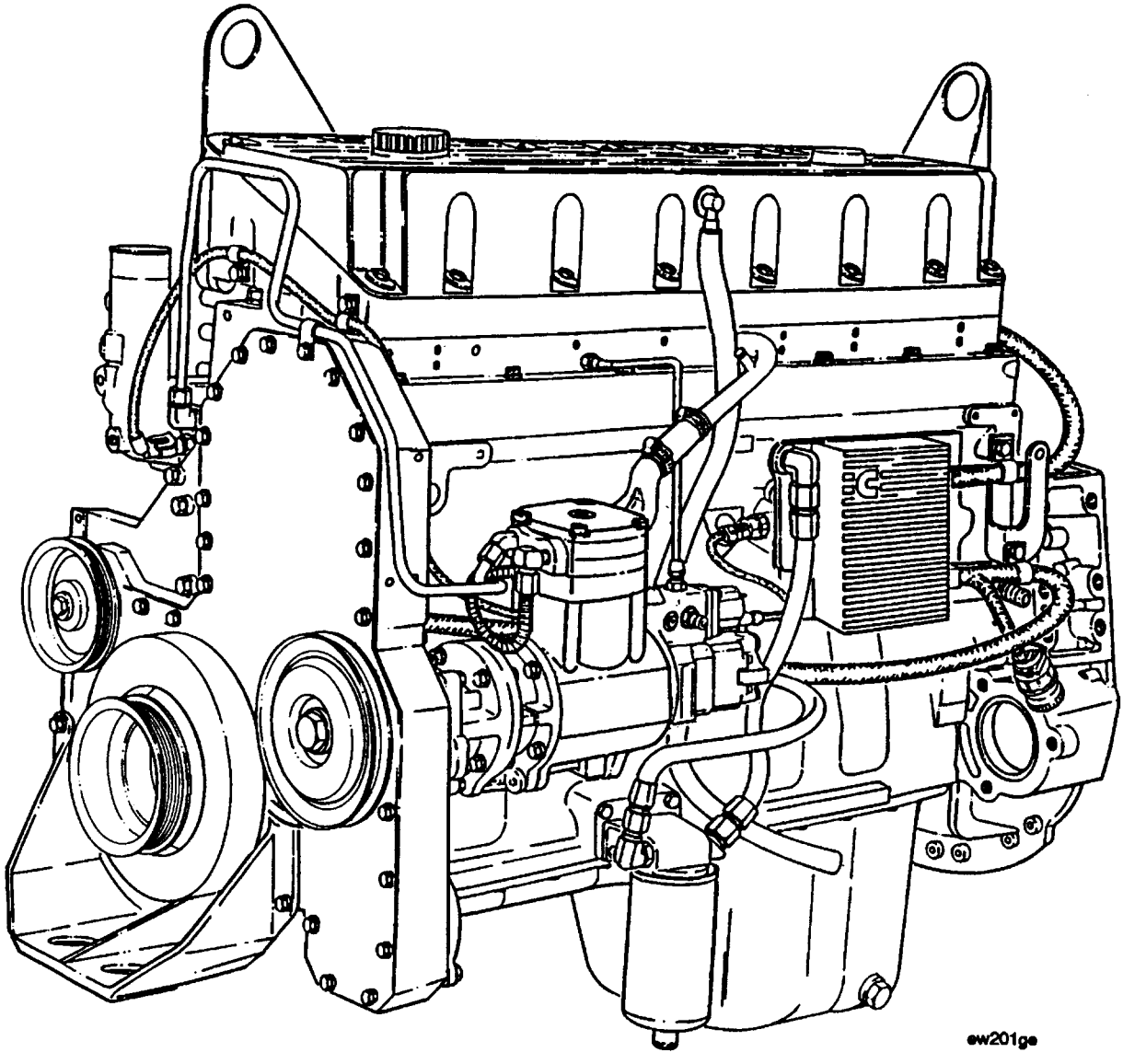
Shop Manual
M11 Series Engines



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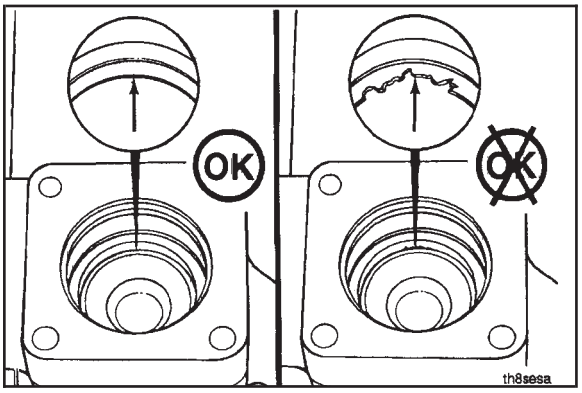
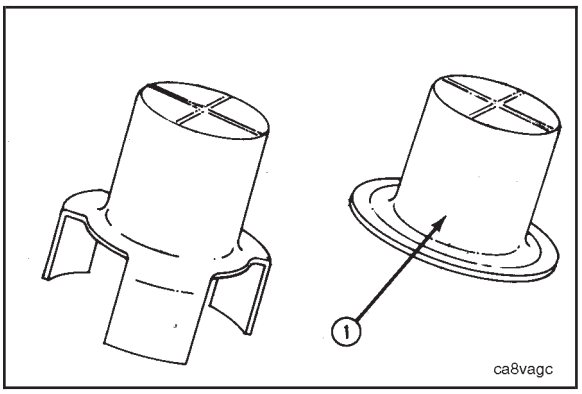
Illustrations

The illustrations used in the ″Repair Sections″ of this manual are intended to give an example of a problem, and to show what to look for and where the problem can be found. Some of the illustrations are ‘‘generic’’ and might **not** look exactly like the engine or parts used in your application. The illustrations can contain symbols to indicate an action required, and an acceptable or **not** acceptable condition.



The illustrations are intended to show repair or replacement procedures. The illustration can differ from your application, but the procedure given will be the same.



Engine Specifications

Metric [U.S. Customary]

General Engine Data

Horsepower (Refer to the engine dataplate)

Engine speed @ Maximum Output:

- Governed Speed (RPM) - Automotive 1800
- Governed Speed (RPM) - Vocational 2000
- Advertised HP (RPM) 1600

Bore and Stroke ..... 125 mm [4.921 in] X 147 mm [5.787 in]

Displacement ..... 10.8 liters [661 C.I.D.]

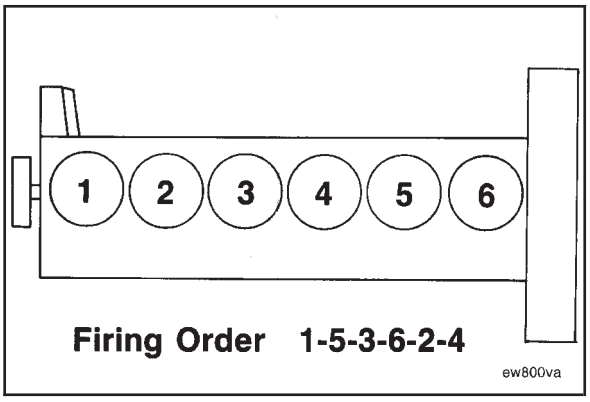
Firing Order 1-5-3-6-2-4

Engine Weight (with Standard Accessories):

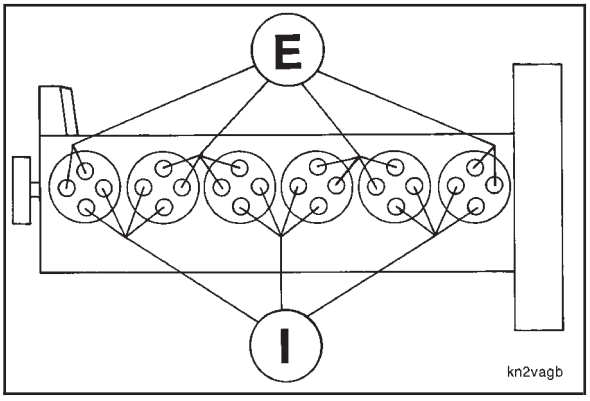
- Dry Weight ..... 940 Kg [2070 lb]
- Wet Weight ..... 996 Kg [2193 lb]

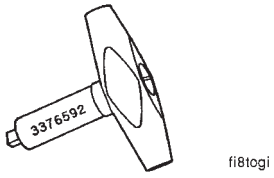
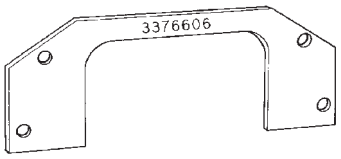
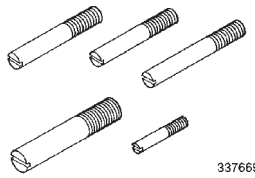
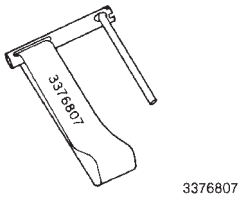
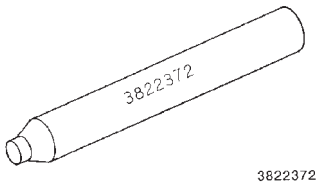
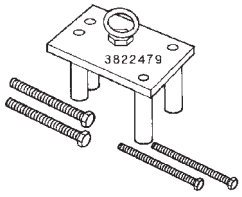
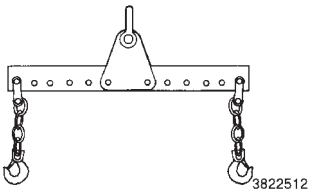
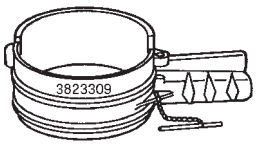
Crankshaft Rotation - (viewed from the front of the engine) ..... Clockwise

Cylinder Location and Firing Order



Intake and **Exhaust** Valve Locations



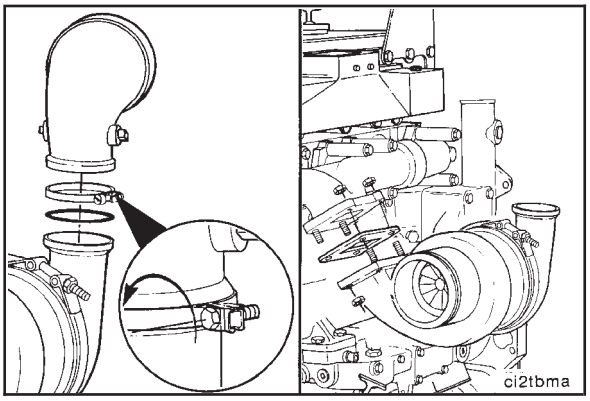
Tool No.	Tool Description	Tool Illustration
3376592	**Inch Pound Torque Wrench** Required to make consistent settings of the injector. Screwdriver socket, Part No. ST-669-13, **must** be used with this tool.	 fi8togi
3376606	**Flywheel Housing Alignment Plate** Align flywheel housing with cylinder block.	
3376695	**Guide Pin Kit** Aid during installation of flywheel, flywheel housing, vibration damper, and air manifold. The kit contains two each of guide pins, Part Nos. 3376488, 3376638, 3376696, 3376697, and 3376698.	
3376807	**Filter Wrench** Used to remove or tighten spin on fuel filter(s) and coolant filter.	
3822372	**Expansion Plug Driver** Install expansion plug to specified depth. Use with expansion plug driver handle, Part No. 3376795.	
3822479	**Cylinder Head Lifting Bracket** Remove and install cylinder head to the cylinder block.	
3822512	**Engine Lifting Fixture** Used for lifting the engine.	
3823309	**Piston Ring Compressor** Compress piston rings on pistons during installation of pistons in the cylinder block.	

Remove the v-band clamp, discharge elbow and o-ring from the turbocharger compressor discharge outlet.

Remove the four turbocharger mounting nuts.

Remove the turbocharger and gasket.

Plug the supply and drain holes in the turbocharger.



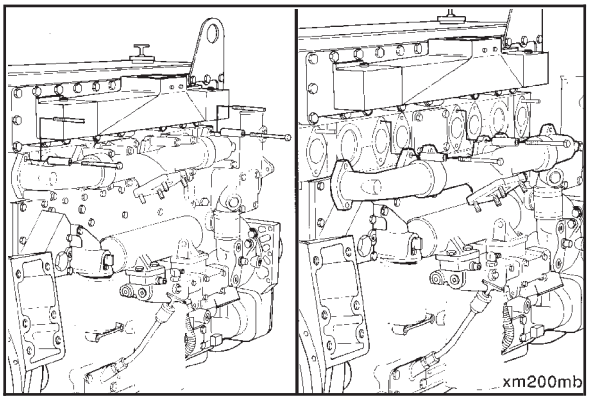
Exhaust Manifold - Removal

Caution: The exhaust manifold assembly has three sections which can separate and fall causing personal injury during removal. Hold the assembly on each end to remove it.

Remove one capscrew from each end section of the exhaust manifold and install two guide pins, Part No. 3376488.

Remove the remaining capscrews.

Remove the exhaust manifold, gaskets and the two guide pins.



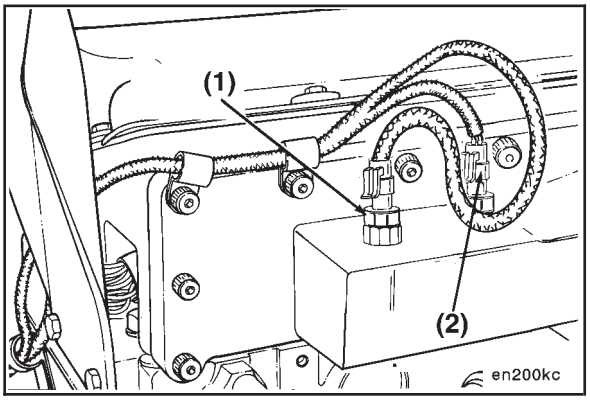
Air Intake Manifold - Removal

Remove the intake manifold pressure sensor and the intake manifold temperature sensor wire connectors from the top rear end of the intake manifold.

Tag the wires as they are removed for future identification.

Remove the boost pressure sensor (1) and the intake manifold temperature sensor (2) from the manifold.

Remove the wire clamps holding the harness to the manifold.



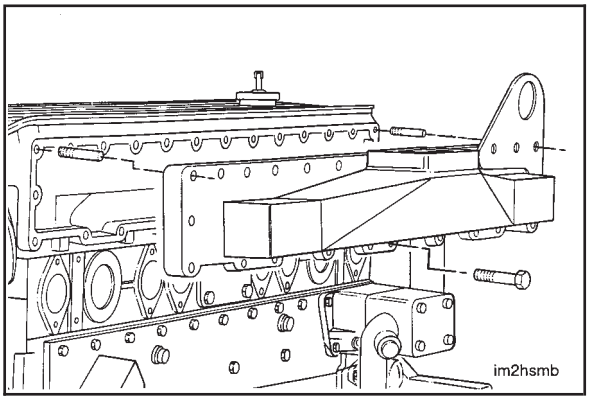
Remove the air intake connection and gasket from the top of the manifold.

Remove two of the mounting capscrews and install two guide pins, Part No. 3376488.

Remove the remaining capscrews, beginning at the ends and moving toward the center, intake manifold and gasket. Remove the guide pins.

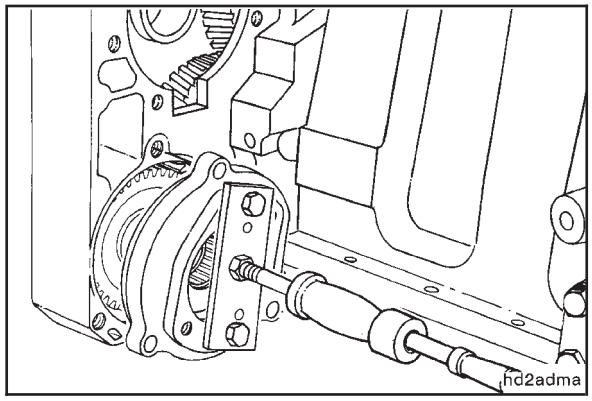
Use four (M10 x 25) capscrews and install the front lifting bracket on the rocker lever housing.

Torque Value: 47 N•m [35 ft-lb]



Caution: Do not allow the hydraulic drive gear to slide out of the adapter or the gear housing during removal. Damage to the gear will result.

Remove the hydraulic drive adapter, o-ring, and hydraulic drive gear.



Sensor Harness and Sensors - Removal

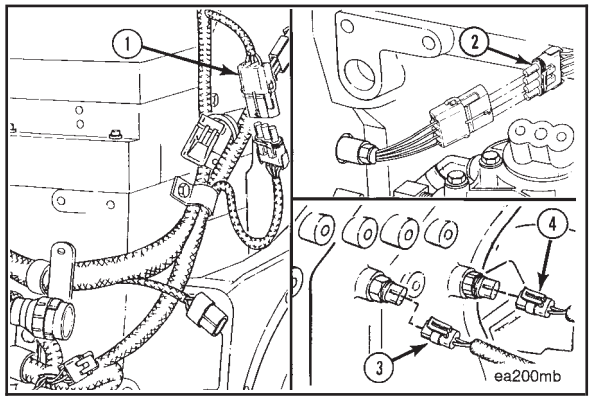
Tag all connections as they are removed for future identification.

Disconnect the connector (1) that connects the sensor and actuator harnesses.

Remove the sensor harness connectors from the following sensors:

- engine position sensor (2) (back of gear housing),
- oil temperature sensor (3) (fuel pump side of block),
- oil pressure sensor (4) (fuel pump side of block).

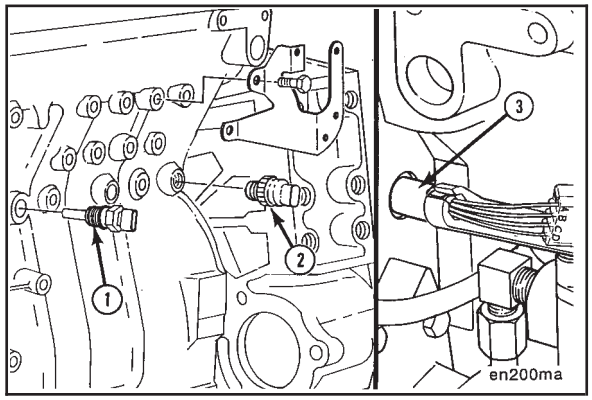
Remove all the sensor wiring harness clamps from the engine and the sensor wiring harness.



Remove the harness bracket from the cylinder block.

Remove the oil temperature sensor (1) and oil pressure sensor (2) from the cylinder block.

Remove the engine position sensor (3) from the rear of the gear housing.

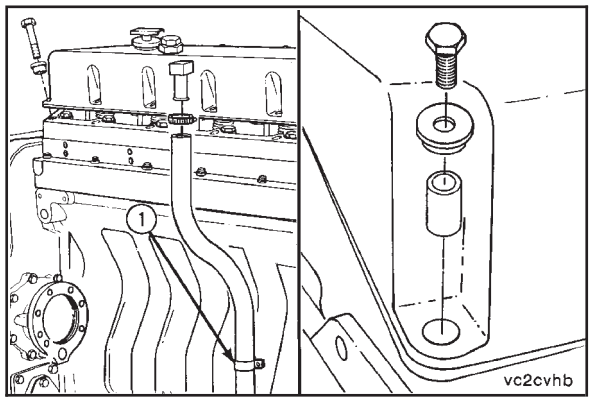


Rocker Lever Cover - Removal

Remove the breather tube and the tube retaining clip (1) from the side of the cylinder block.

Remove the 16 capscrews, isolators and spacers from the cover.

Remove the cover and gasket.

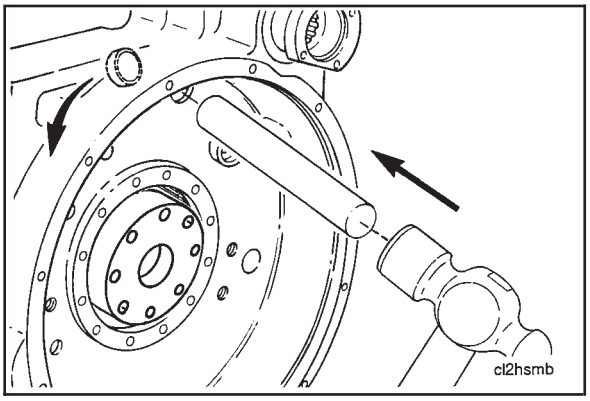


Caution: Do not attempt to back out or rotate the plugs out of the housing. The cup plug bore will be damaged and oil leakage will occur.

To gain access to the housing capscrews, use a drift to drive the cup plugs straight through into the housing.

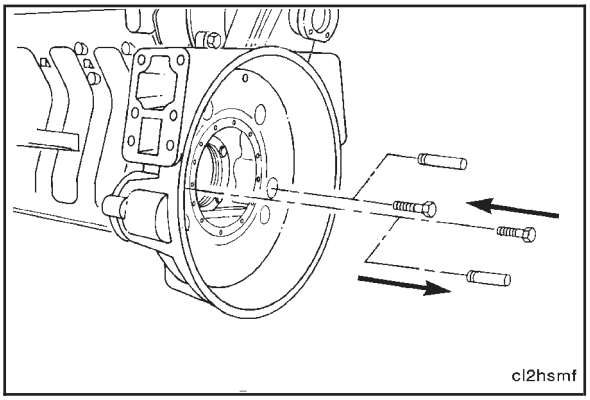
Retrieve the plugs from inside of the housing.

NOTE: Do **not** reuse the cup plugs that are removed. The cup plugs **must** be replaced with new ones.



Remove two of the mounting capscrews and install two guide pins, Part No. 3376697, to support the housing during removal.

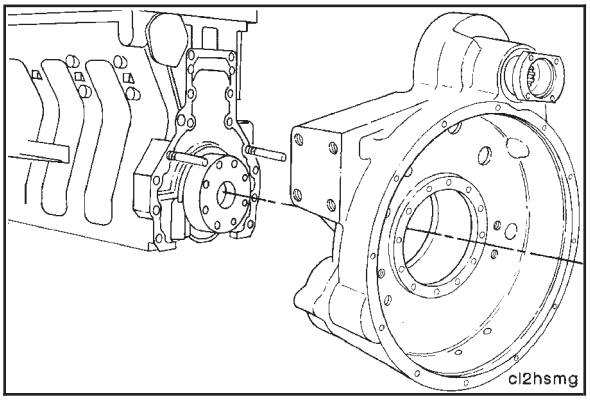
Use offset wrench, Part No. 3823711, to remove the capscrews which are **not** in view.



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

Remove the remaining capscrews. Use a rubber hammer to loosen the housing.

Remove the housing and the guide pins.



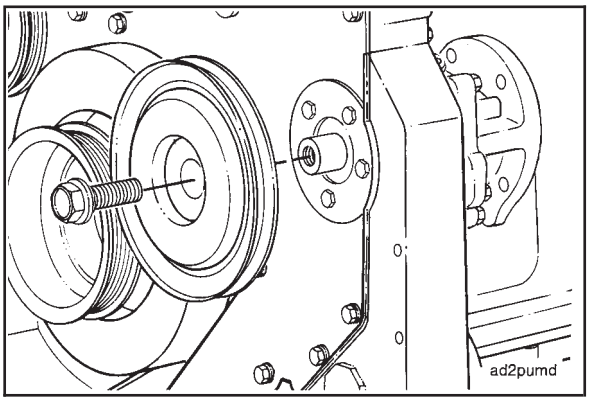
Accessory Drive Pulley - Removal

Remove the pulley retaining capscrew.

The crankshaft **must** be held in position to allow the capscrew to be removed.

NOTE: This is a slip fit pulley and does **not** require the use of a puller.

Remove the pulley.



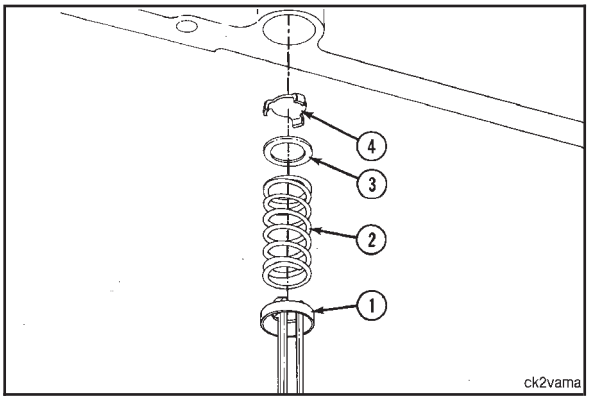
High Oil Pressure Regulator - Removal

Warning: Use caution while removing the retainer plug (1). The pressure regulator spring (2) is under compression. Wear face and eye protection.

Use light duty puller kit, Part No. 3375784, to remove the retainer plug (1).

Remove the pressure regulator spring (2), washer (3), and valve disc (4).

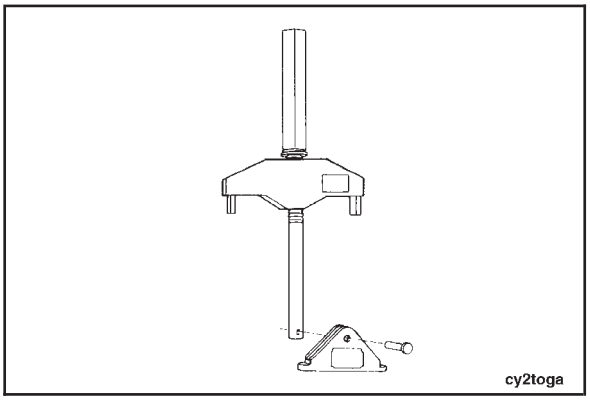
NOTE: The high oil pressure regulator seat will remain in the cylinder block.



Cylinder Liners - Removal

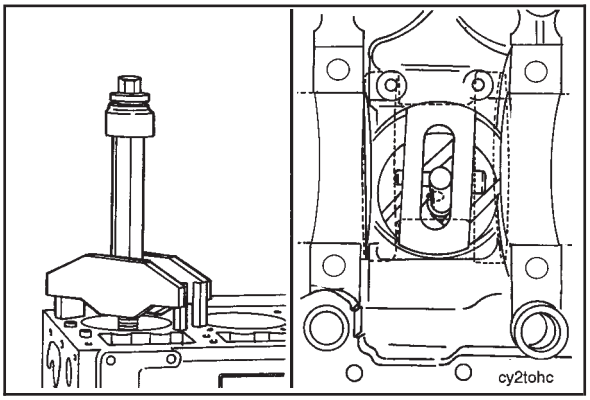
Rotate the engine on the rebuild stand so the head deck is facing up.

Use universal liner puller, Part No. 3375629, with plate, Part No. 3376049, to remove the cylinder liners.



Caution: The liner puller must be installed and used as described to avoid damage to the cylinder block. The puller plate must be parallel to the main bearing saddles and must not overlap the liner outside diameter.

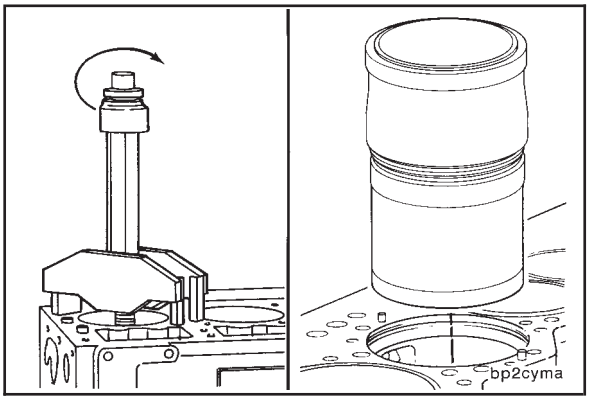
Remove the liners with universal liner puller, Part No. 3375629.



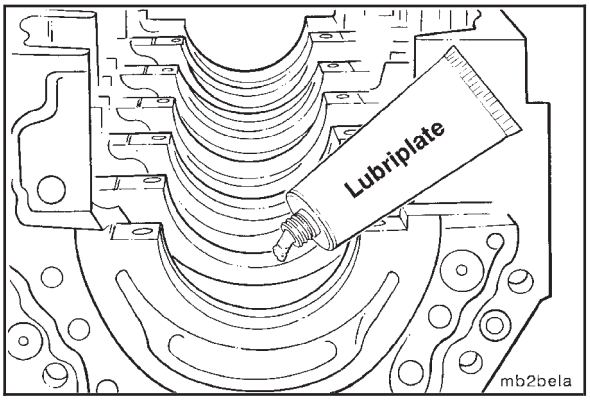
The liner puller **must** be centered on the top of the cylinder block to prevent damage to the cylinder block.

Turn the puller jackscrew **clockwise** to loosen the liner from the cylinder block.

Use both hands to remove the liners.



Use Lubriplate® 105, or equivalent, to coat the bearings.



Crankshaft - Installation

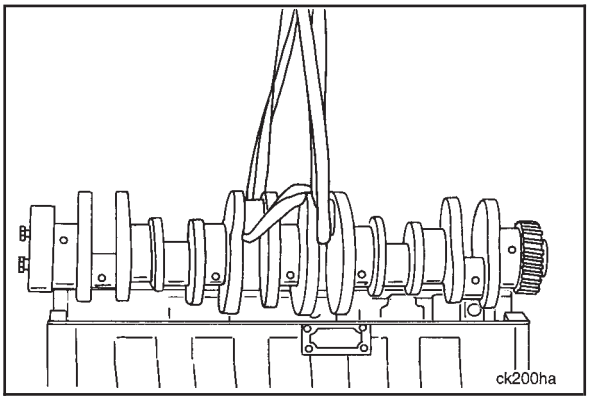
The component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component.

Use a hoist and nylon lifting sling, Part No. 3375957.

Install the sling around the numbers ''3'' and ''4'' rod bearing journals.

Do not damage or move the bearing shells when the crankshaft is installed.

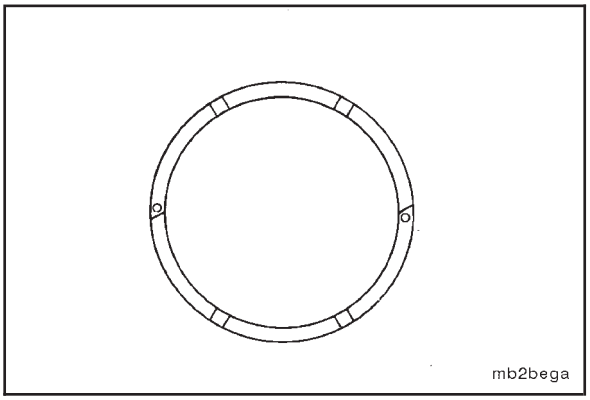
Install the crankshaft.



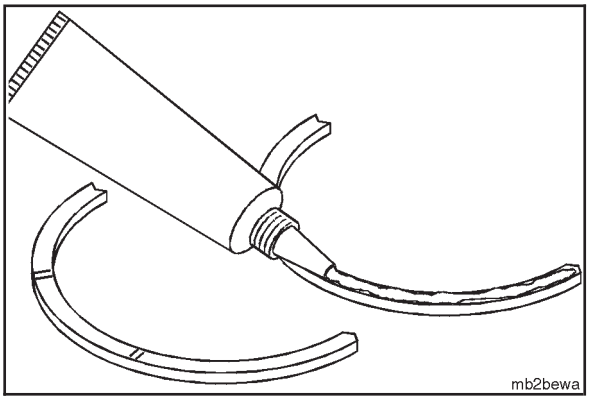
Thrust Bearings, Lower Bearing Shells and Main Bearing Caps - Installation

Production thrust bearings, Part No. 3822062, include an interlocking design to make sure the bearings are installed correctly.

NOTE: 0.25 mm [0.010 inch] oversize thrust bearings, Part No. 3050589, are available if required.

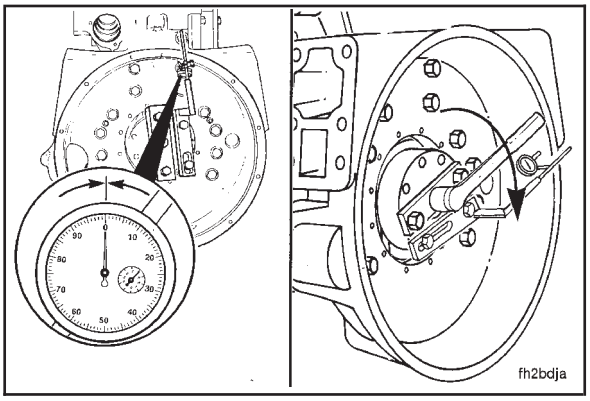


Use Lubriplate® 105, or equivalent, to coat the upper thrust bearings.



Repeat the above steps until the maximum bore TIR is within specifications for the determined housing size.

NOTE: If the bore alignment is **not** within specifications and the bore is **not** round, the housing **must** be replaced.



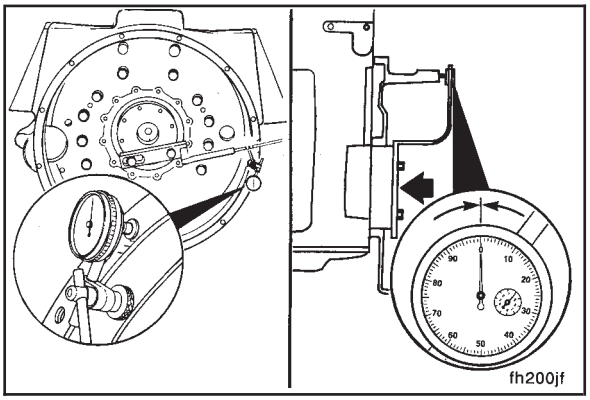
Flywheel Housing Face Alignment - Measurement

Caution: If the tip of the gauge enters the capscrew holes, the gauge will be damaged.

Position the contact tip of the gauge against the flywheel housing face.

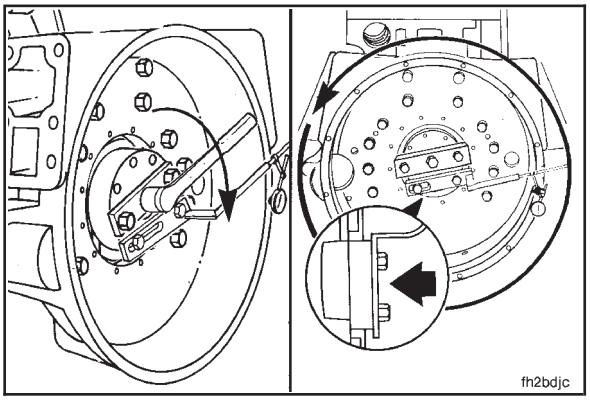
Push the crankshaft toward the front of the engine.

Adjust the gauge dial to "0" (zero).

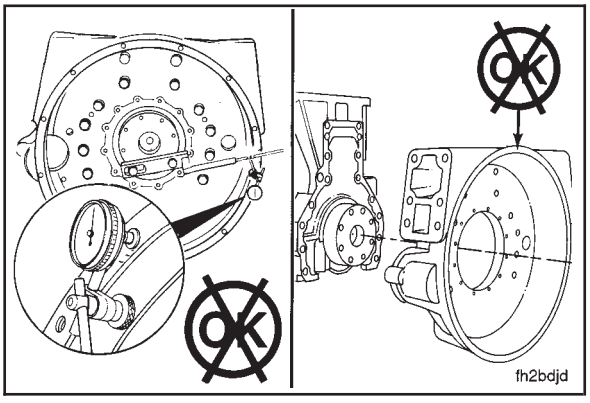


Rotate the crankshaft one complete revolution (360 degrees) while keeping the crankshaft end thrust pushed forward, and record the TIR.

Flywheel Housing Face Alignment Maximum TIR		
mm	SAE No.	in
0.31	00	0.012
0.25	0	0.010
0.25	1/2	0.010
0.20	1	0.008
0.20	2	0.008
0.20	3	0.008

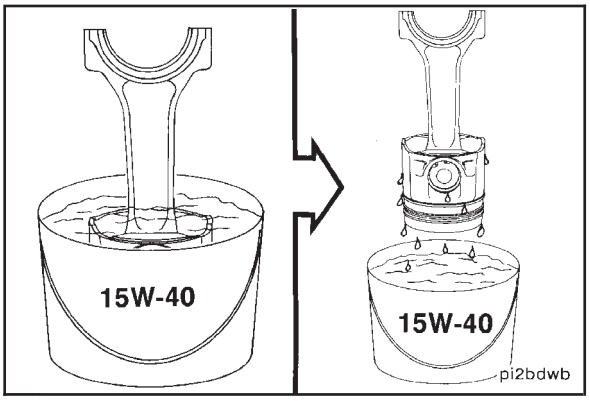


If the maximum face alignment does **not** meet the specifications, check for nicks, burrs and foreign material between the cylinder block mounting face and the flywheel housing mounting surface. If none is found, the housing **must** be replaced.



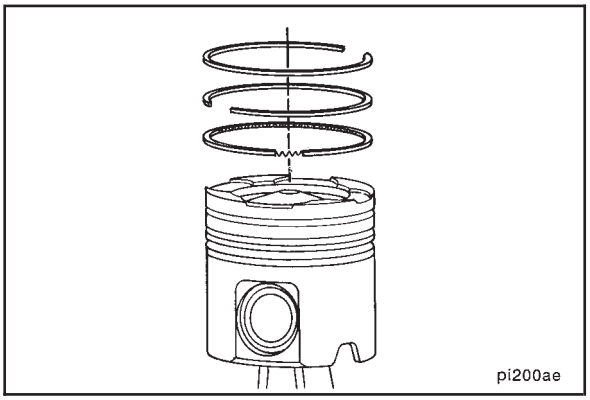
Install the piston and ring assembly into a container of clean 15W-40 oil.

Remove the piston and ring assembly from the container and let the excess oil drain from the piston.



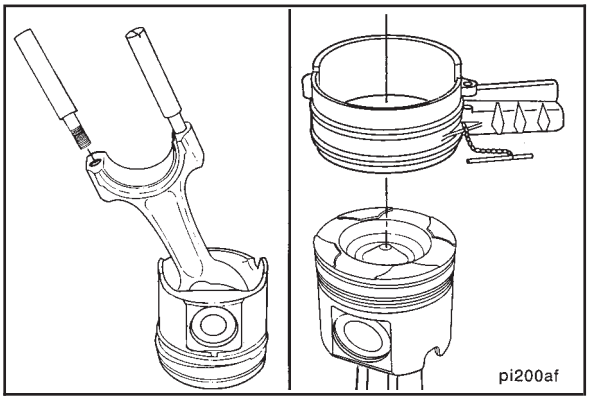
Rotate the rings to position the ring gaps as shown.

NOTE: The ring gap of each ring **must not** be aligned with the piston pin or with any other ring gap. If the ring gaps are **not** aligned correctly, the rings will **not** seal properly.



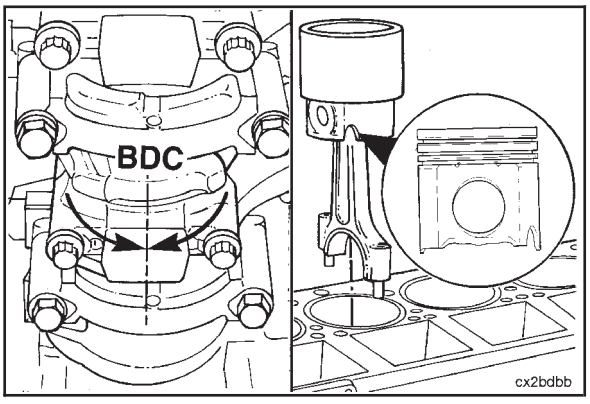
Install the connecting rod guide pins, Part No. 3376038, into the connecting rod.

Use piston ring compressor, Part No. 3823309, to compress the rings.



Rotate the crankshaft so the connecting rod journal of the connecting rod being installed is at bottom dead center.

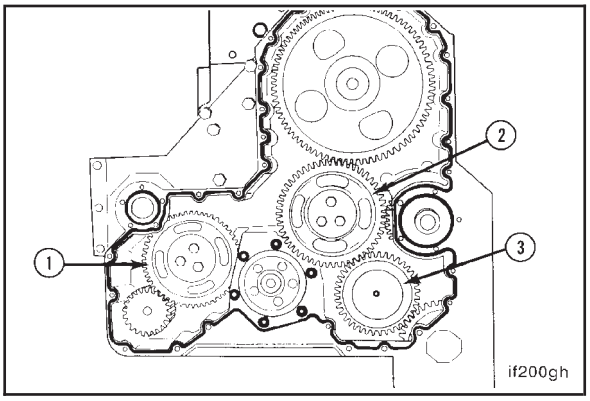
Insert the connecting rod through the cylinder liner until the ring compressor contacts the top of the liner.



Idler Gear Assemblies - Installation

Three idler gear assemblies are used:

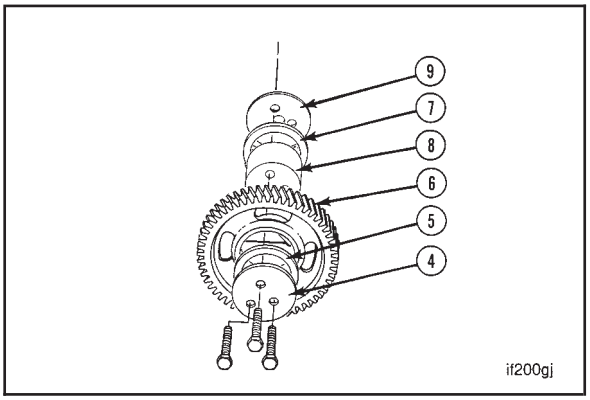
- water pump/lube pump idler gear (1),
- camshaft idler gear (2),
- hydraulic pump idler gear (3).



Each idler gear assembly consist of:

- three retaining capscrews,
- gear retainer (4),
- front thrust bearing (5),
- idler gear (6),
- rear thrust bearing (7),
- idler gear shaft (8).

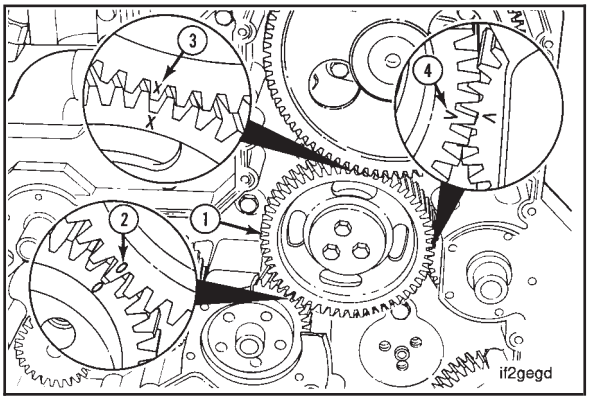
The camshaft idler gear assembly includes a wear plate (9).



Camshaft Idler - Installation

When installing the camshaft idler gear (1), make certain the timing mark '0' on the crankshaft gear (2), timing mark 'X' on the camshaft gear (3) and timing mark 'V' on the accessory drive gear (4) are aligned as shown.

The marks on the idler gears should match the same mark on each of the other gears.

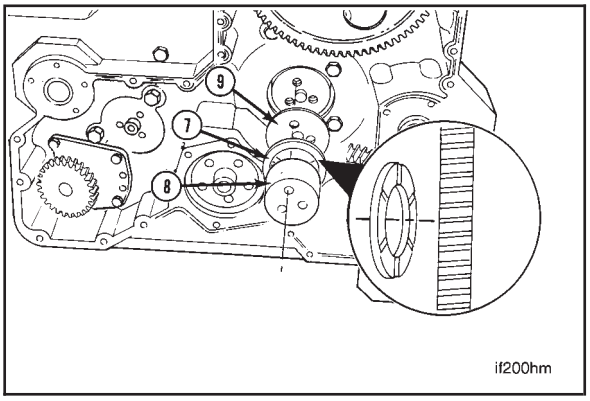


Use Lubriplate® 105, or equivalent, to lubricate the wear plate, thrust bearing and idler gear.

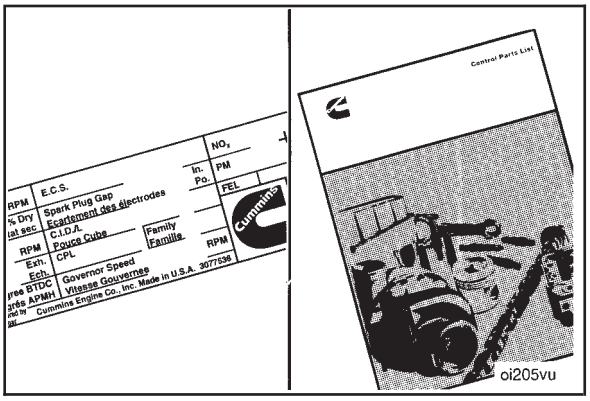
Install the camshaft idler gear wear plate (9).

Caution: The grooved side of the rear thrust bearing must be facing toward the gear to prevent damage to the gear and engine during engine operation.

Install the idler gear shaft (8) and rear thrust bearing (7).



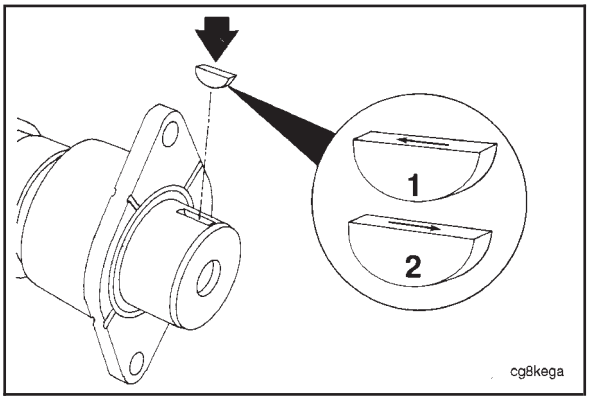
To verify the correct static injection timing for a particular engine, check the control parts list (CPL) number on the engine dataplate, then refer to the CPL Bulletin No. 3379133. Timing codes are listed as two letter alpha characters, for example, an ''HZ'' code indicates a nominal setting of 5.97 mm [0.235 in]. Refer to the accompanying chart.



M11 static injection timing can be adjusted by removing the camshaft gear and changing the camshaft key. The camshaft key controls the position of the camshaft lobes during the operating cycles of the engine.

If an offset camshaft key is installed with the arrow marked on the top of the key pointing toward the engine (1), the timing will be **retarded**. If the offset key is installed with the arrow pointing away from the engine (2), the timing will be **advanced**.

Retarded timing (1) begins the fuel injection process **later** and advanced timing (2) begins the fuel injection process **earlier** relative to the ''TDC'' position of the piston.



Refer to the accompanying chart for a list of offset keys by part number and degree of offset.

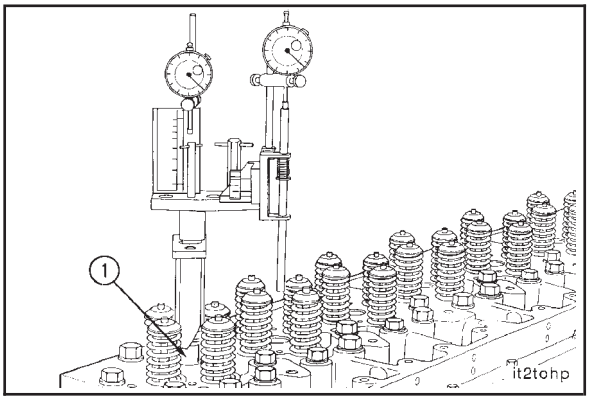
Camshaft Keys

Key Part No.	Degree of Offset (To the Camshaft)	Change in Push Rod Travel mm	Change in Push Rod Travel in.
3009953	0.00	0.000	0.0000
3030893	0.25	0.051	0.0020
3009948	0.50	0.102	0.0040
3030894	0.75	0.152	0.0060
3009949	1.00	0.203	0.0080
3030895	1.25	0.254	0.0100
3009950	1.50	0.305	0.0120
3030896	1.75	0.356	0.0140
3009951	2.00	0.406	0.0160
3030897	2.25	0.457	0.0180
3030898	2.50	0.508	0.0200

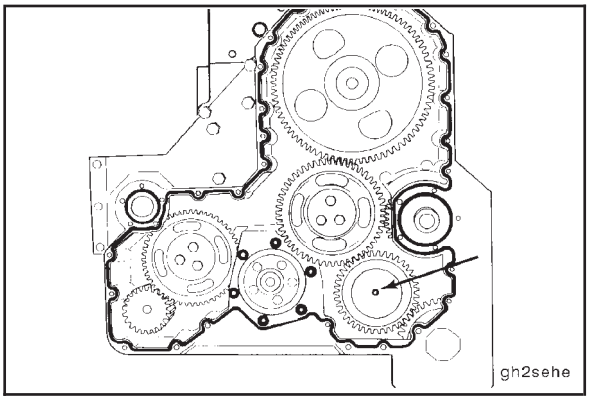
It200nb

Static Injection Timing - Checking

Install the piston plunger rod (1) of the injection timing tool, Part No. 3823451, into the injector bore of the number one cylinder.



Install a new o-ring at the front of the hydraulic drive idler retainer mounting spacer. The spacer **must** be in the proper position.



Install the gear cover and 22 mounting capscrews (M8-1.25 x 20).

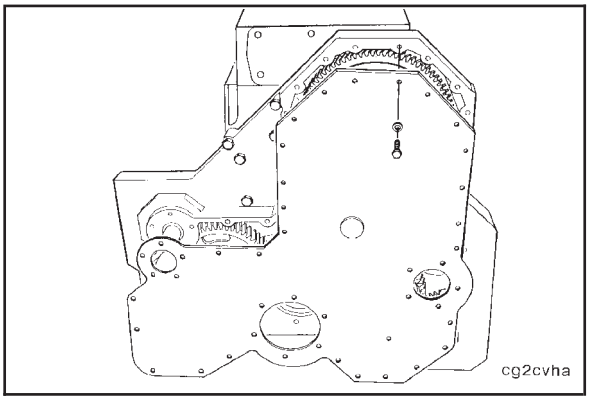
NOTE: Do **not** install the front engine support capscrews at this time.

NOTE: Applications equipped with an automatic belt tensioner refer to the next block of text for installation of the belt tensioner bracket before tightening the mounting capscrews.

NOTE: This is **not** the final torque value.

Tighten the capscrews.

Torque Value: 6 N•m [55 in-lb]

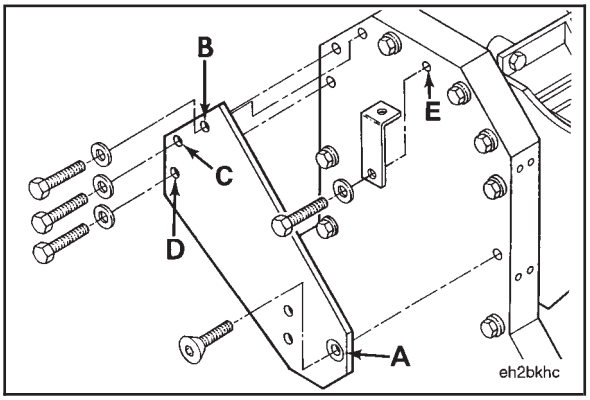


If the engine is equipped with an automatic belt tensioner, install the belt tensioner bracket with the countersunk hole (A) facing away from the gear cover. Use flat head capscrew (M8 x 25) at location (A).

Use three capscrews (M8 x 30) and plain washers at (B, C and D).

Tighten the capscrews. Capscrew (A) **must** be tightened before (B, C and D).

Torque Value: 6 N•m [55 in-lb]



Apply a coating of sealant, Part No. 3823494, to the three capscrews at locations (1), (2) and (3).

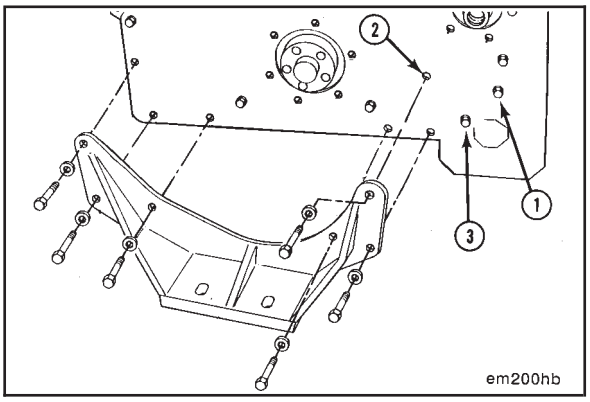
Install the front engine support with five mounting capscrews (M10-1.50 x 100) and one mounting capscrew (M10-1.50 x 35).

NOTE: The capscrew (M10-1.50 x 35) is used in the mounting hole aligned with the hydraulic drive idler gear.

Tighten the capscrews.

Torque Value: 6 N•m [55 in-lb]

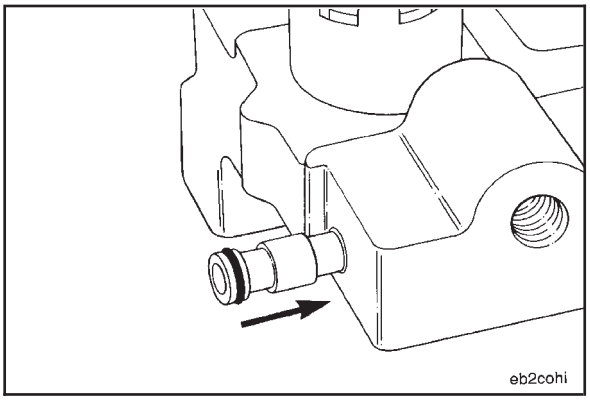
NOTE: This is **not** the final torque value.



Use clean 15W-40 oil to lubricate the o-rings.

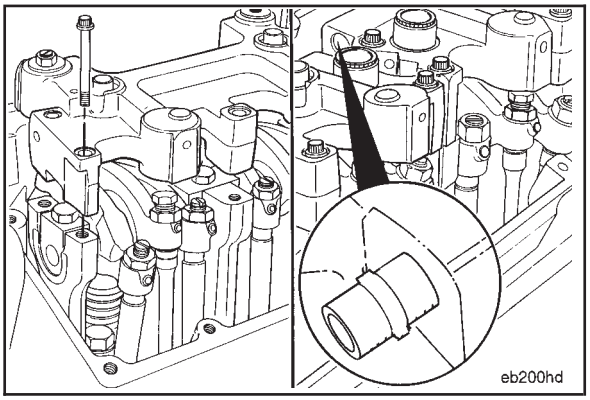
Press the connector all the way into the front housing by hand.

When installing the front housing, be sure the oil connector and o-ring are in position to be pushed into the rear housing.



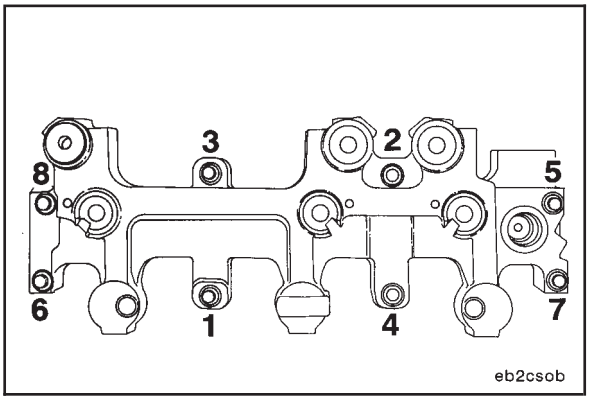
Install the front Jacobs® Engine Brake housing on the front rocker lever supports.

Center the oil connector between the front and rear housings before tightening the capscrews.



Tighten the capscrews in the sequence shown.

Torque Value: 81 N•m 60 ft-lb]



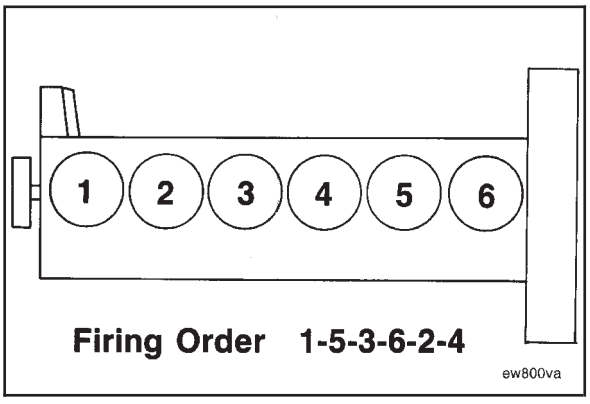
Overhead - Adjustment

This procedure describes the valve and injector adjustment procedures for CELECT™ engines.

The crankshaft rotation is **clockwise** when viewed from the front of the engine.

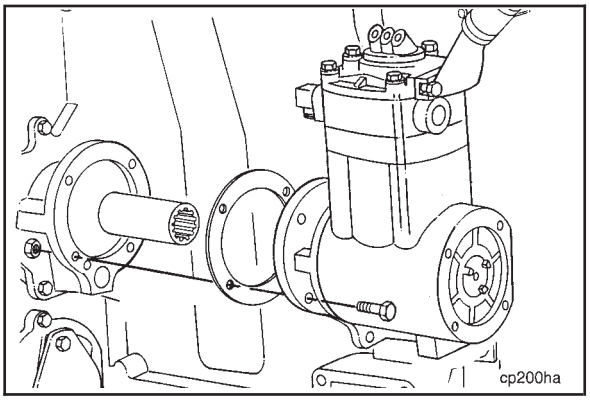
The cylinders are numbered from the front gear housing end of the engine.

The engine firing order is 1-5-3-6-2-4.



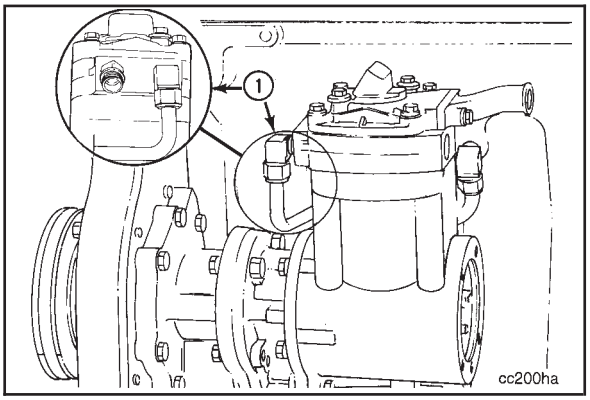
Use a new gasket and install the air compressor using four capscrews (7/16 - 14 x 1 7/8 inch) and two nuts (7/16 x 14).

Torque Value: 65 N•m [50 ft-lb]



Install the coolant inlet hose on the air compressor fitting (5) and tighten.

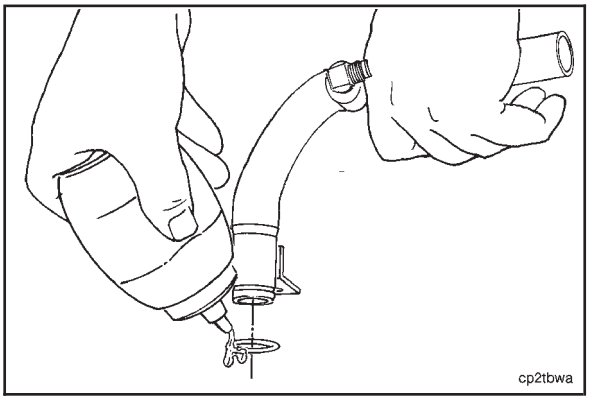
Torque Value: 40 N•m [30 ft-lb]



Air Compressor Air Supply Tube - Installation

Install the o-ring on the air supply tube.

Use vegetable oil to lubricate the o-ring.



Install a new hose (1) and two new hose clamps 1-3/4 inch (2) on the tube.

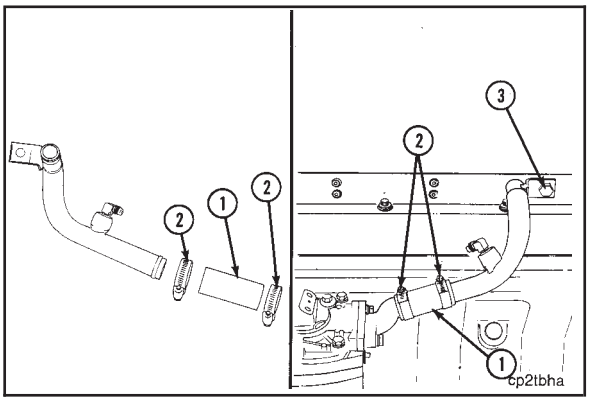
Use one capscrew (M10-1.50 x 20) to install the tube into the side of the cylinder head at location (3).

Torque Value: 47 N•m [35 ft-lb]

Install the hose (1) on the air compressor air supply connection.

Tighten the hose clamps (2).

Torque Value: 5 N•m [40 in-lb]

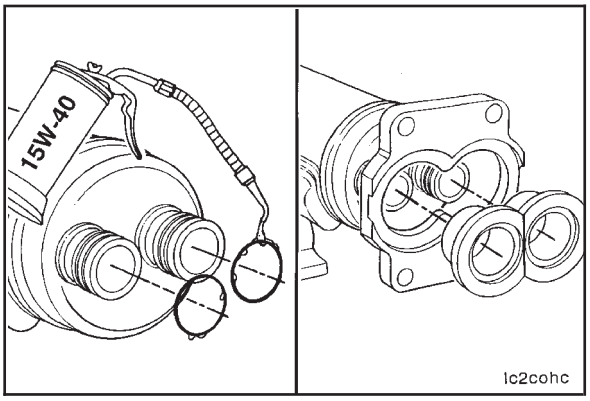


Lubricating Oil Cooler - Installation

Install two new o-rings on the water inlet and outlet transfer tube ends of the oil cooler.

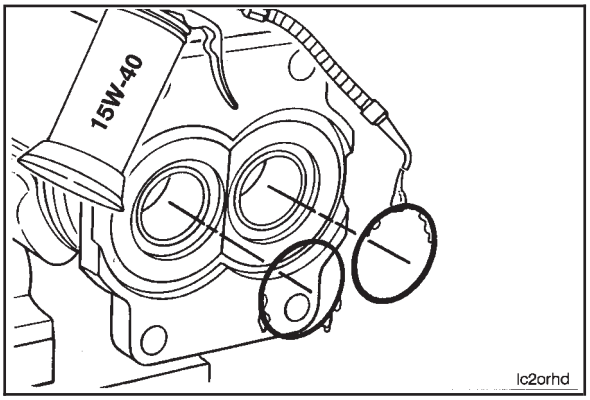
Lubricate the o-rings with clean 15W-40 engine oil.

While holding the retainer connection in place, install both o-ring adapters onto the oil cooler tube ends as far as possible. The straight edges of the o-ring adapters **must** face each other when installed.



Install two new o-rings on the ends of the o-ring adapters.

Lubricate the o-rings with clean 15W-40 engine oil.

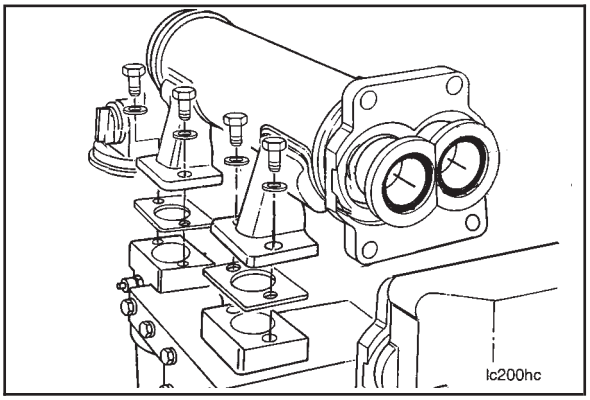


Install two new gaskets on the lubricating oil filter head.

Install the oil cooler on the engine with mounting capscrews (M10-1.50 x 30).

Tighten the capscrews alternately and evenly.

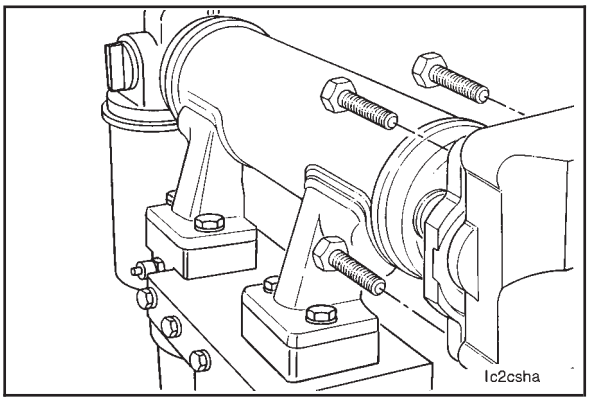
Torque Value: 47 N•m [35 ft-lb]



Install the four retainer connection mounting capscrews.

Tighten the capscrews alternately and evenly.

Torque Value: 47 N•m [35 ft-lb]



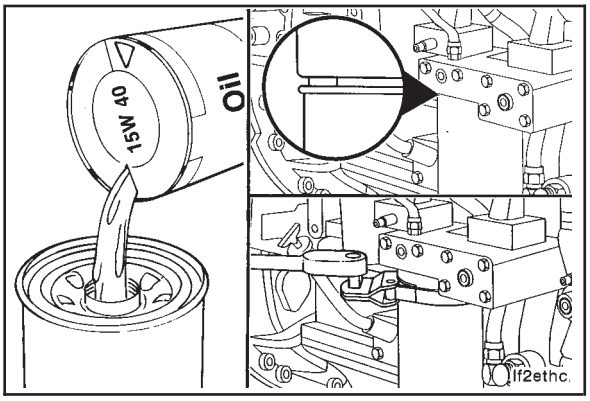
Fill the filter with clean 15W-40 oil.

Install the filter on the filter head.

Caution: To prevent damage to the filter threads or filter head, do not over-tighten the filter.

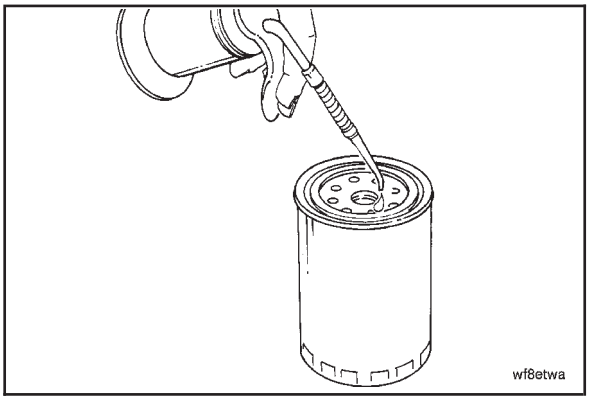
Tighten the filters until the gasket contacts the filter head surface.

Use oil filter wrench, Part No. 3375049, to tighten the filter an additional three-fourths to one (3/4 to 1) turn or follow the instructions supplied with the filter.



Coolant Filter - Installation

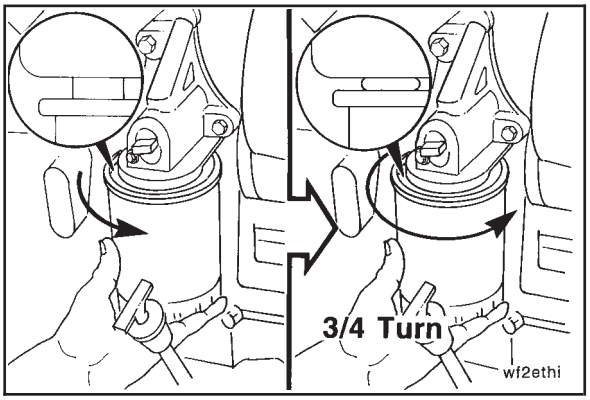
Use clean 15W-40 oil to lubricate the filter sealing ring.



Caution: To prevent damage to the filter threads or filter head, do not over-tighten the filter.

Install the new filter and tighten until the sealing ring contacts the filter head surface.

Tighten the filter an additional one-half to three-fourths (1/2 to 3/4) turn or refer to the filter manufacturer's instructions.

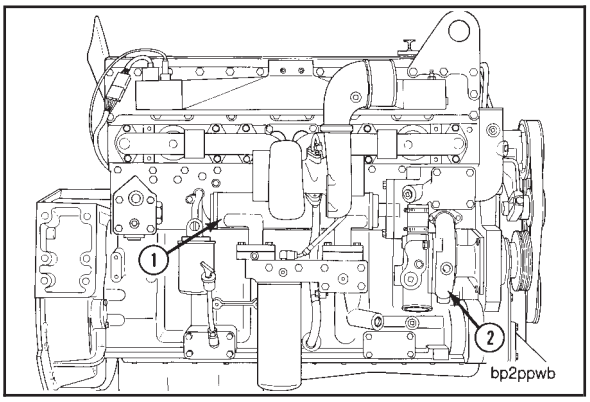


Drain Plugs - Inspection

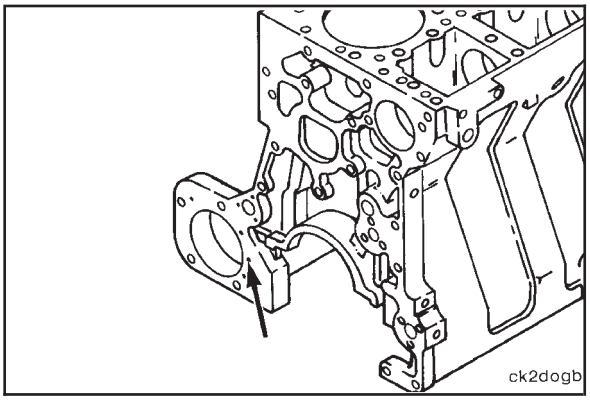
Inspect the coolant and oil drain plugs to make sure they are tightened to the correct torque value.

Tighten the plug in the end of the lubricating oil cooler, thermostat housing and the bottom of the water pump housing.

Torque Value: 20 N•m [15 ft-lb]

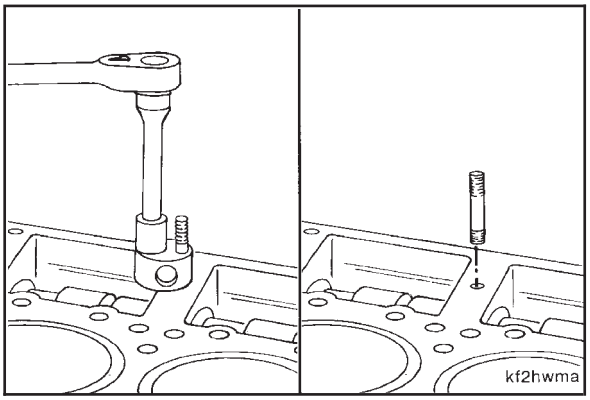


- Lubricating oil pump alignment dowel pin



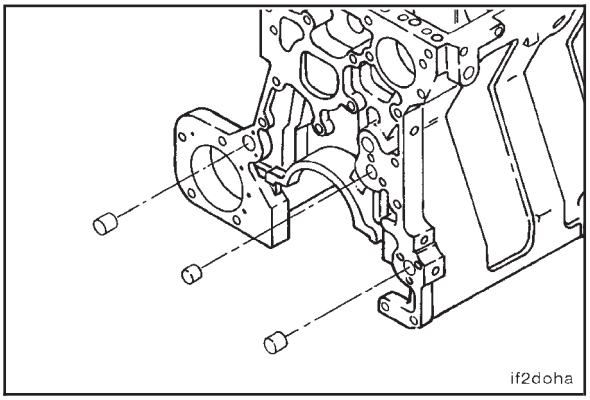
Cam Follower Studs - Removal

Use a 11 to 13 mm [7/16 to 1/2 inch] stud extractor to remove the seven cam follower studs.



Idler Shaft Ring Dowels - Removal

Use puller kit, Part No. 3375784, to remove the three idler gear ring dowels.

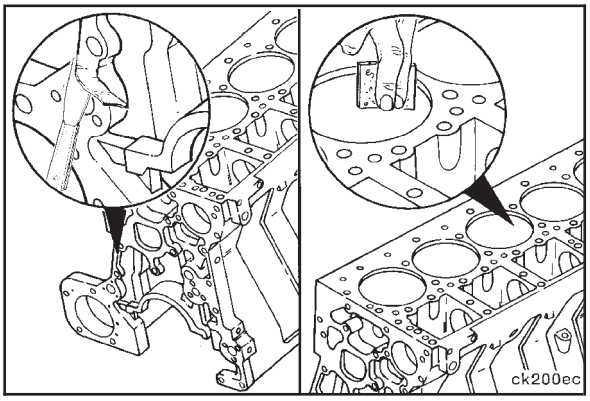


Cleaning

Caution: Do not damage the machined surfaces when using a wire brush or gasket scraper.

Use a Scotch-Brite® pad, emery cloth, or gasket scraper to clean the following cylinder block areas:

- Gasket surfaces
- Cylinder liner bores



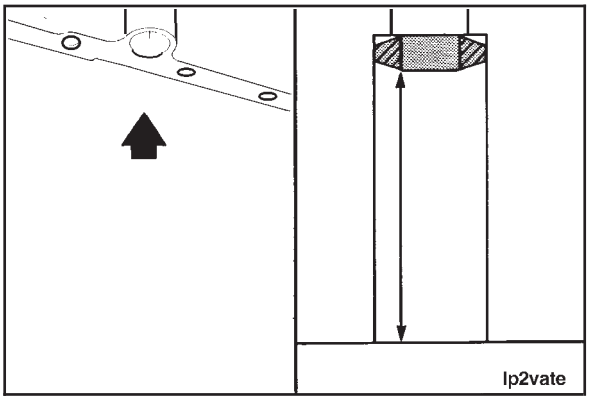
High Oil Pressure Regulator Seat Depth - Measurement

Measure the relief valve seat depth in the cylinder block.

High Oil Pressure Relief Valve Seat Depth		
mm		in
62.62	MIN	2.465
63.62	MAX	2.505

NOTE: If the relief valve seat is **not** at the specified depth, or is loose or **not** level in the cylinder block, the seat **must** be removed and inspected. Use puller kit, Part No. 3375784, to remove the seat.

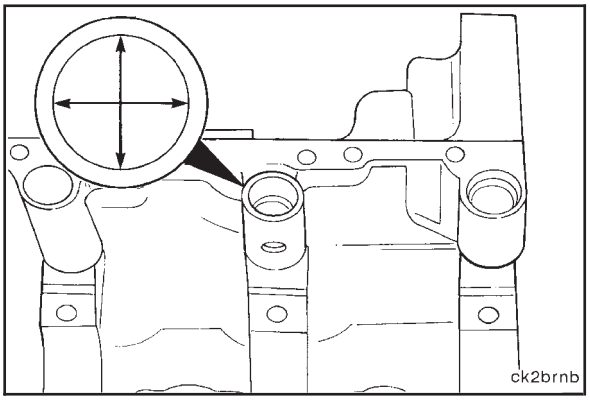
If the seating surfaces are free of indentations, the seat can be reused. If the surfaces have indentations, the seat **must** be replaced. Use regulator valve seat driver, Part No. 3376486, to install the seat.



Main Oil Pressure Regulator Valve Bore - Measurement

Measure the inside diameter of the main oil pressure regulator valve bore.

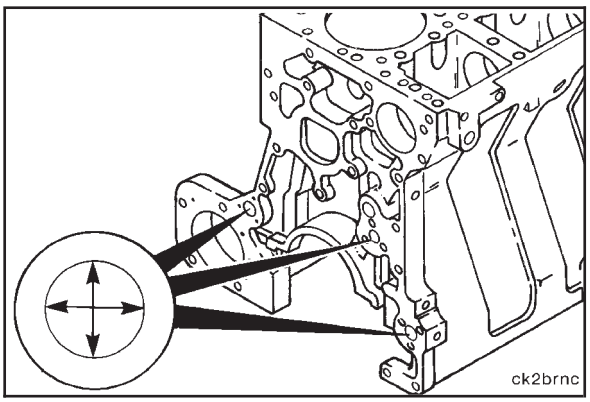
Main Oil Pressure Regulator Valve Bore I.D.		
mm		in
22.226	MIN	0.8750
22.301	MAX	0.8780



Idler Gear Ring Dowel Bore - Measurement

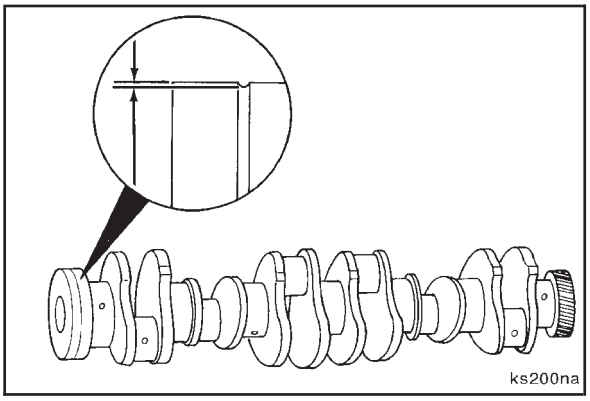
Measure the inside diameter of the three idler gear ring dowel bores.

Idler Gear Ring Dowel Bore I.D.		
mm		in
19.175	MIN	0.7549
19.215	MAX	0.7565



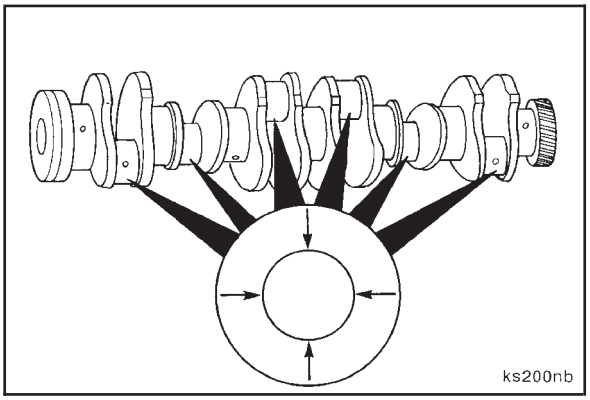
Measure the front and rear oil seal wear grooves.

Crankshaft Rear Oil Seal Wear Groove		
mm		in
0.25	MAX	0.0098



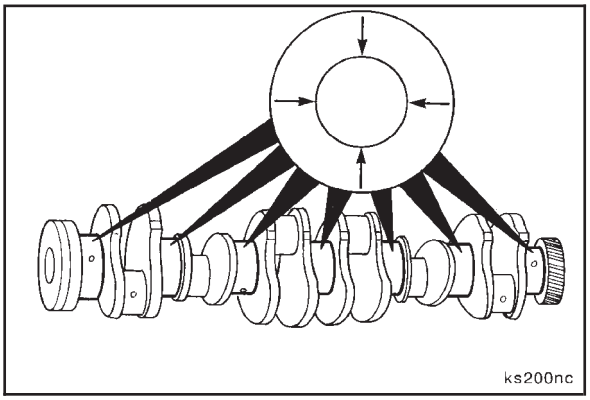
Measure the connecting rod journals outside diameter.

Crankshaft Connecting Rod Journal O.D.		
mm		in
78.950	MIN	3.1083
79.013	MAX	3.1107



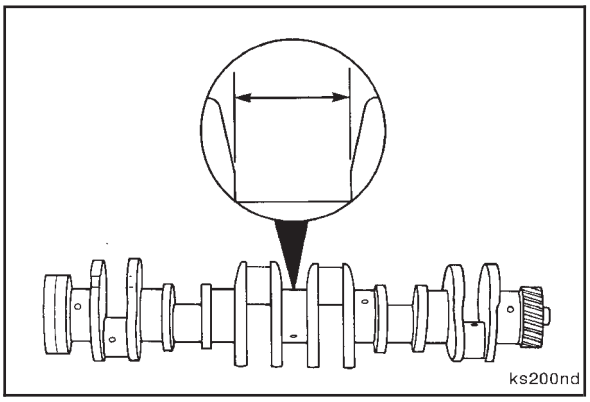
Measure the main bearing journals outside diameter.

Crankshaft Main Bearing Journal O.D.		
mm		in
114.015	MIN	4.4888
114.055	MAX	4.4903



Measure the thrust face width.

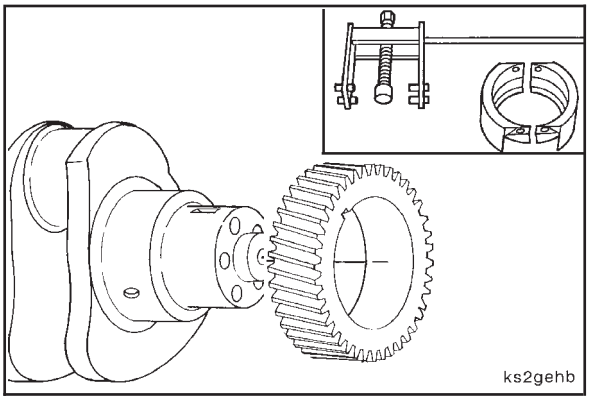
Crankshaft Thrust Face Width		
mm		in
49.975	MIN	1.9675
50.100	MAX	1.9724



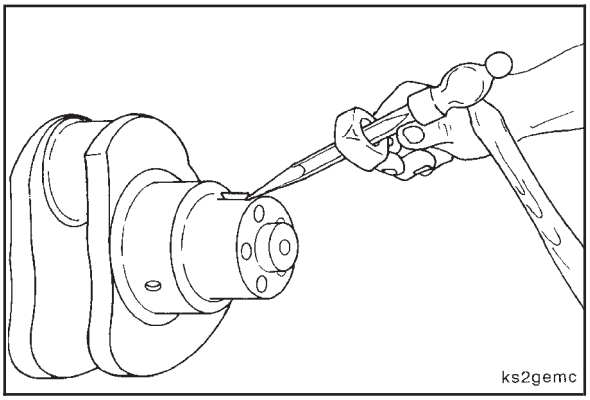
Crankshaft Gear - Replacement (1-11)

Removal

Use gear puller, Part No. 3375840, with jaws, Part No. 3375839, to remove the crankshaft gear.



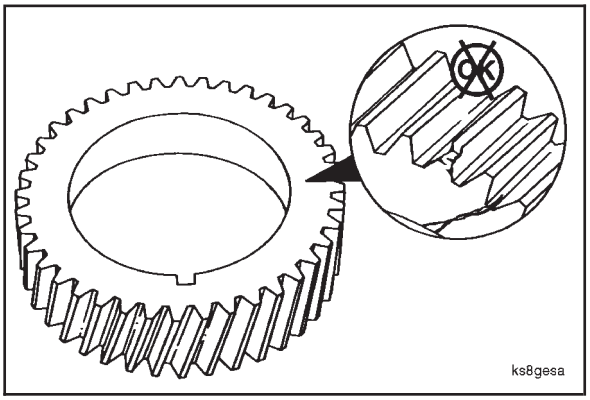
Use a flat chisel and a hammer to remove the key.



Inspection

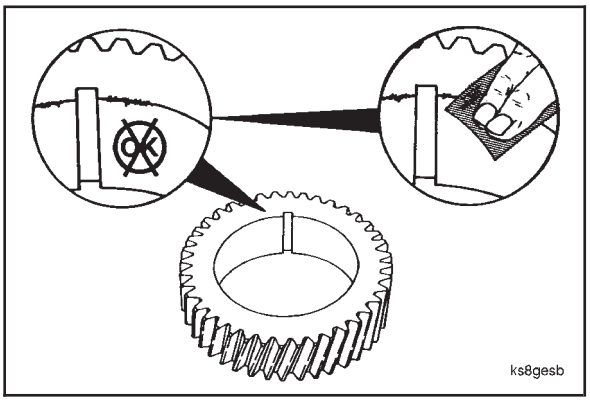
Visually inspect the crankshaft gear for cracks and broken or chipped teeth.

The gear **must** be replaced if it is damaged.



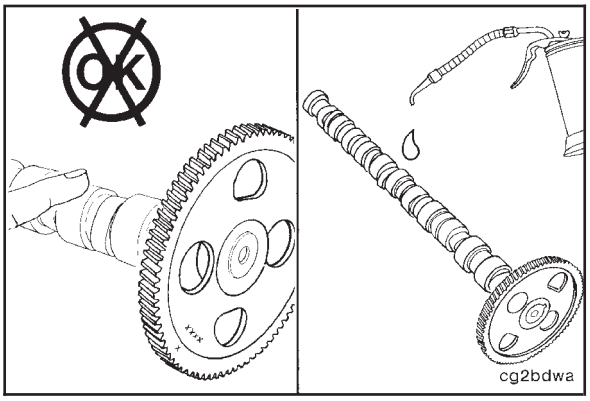
Visually inspect the gear and keyway for nicks or burrs.

Use crocus cloth to remove nicks and burrs.



After the camshaft has been steam cleaned, do **not** touch the machined surfaces with bare hands. This will cause rust to form.

Use clean 15W-40 oil to lubricate the camshaft.

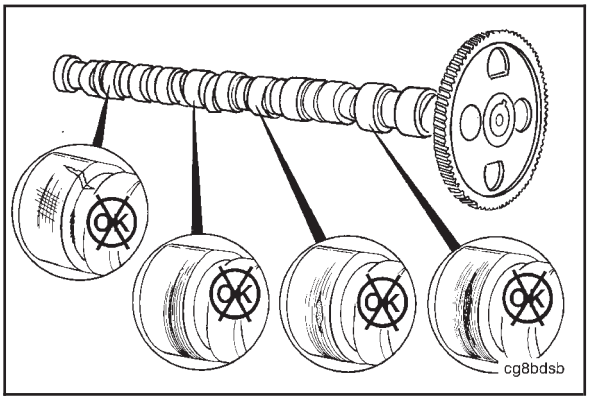


Inspection

Visually inspect the valve and injector lobes for damage.

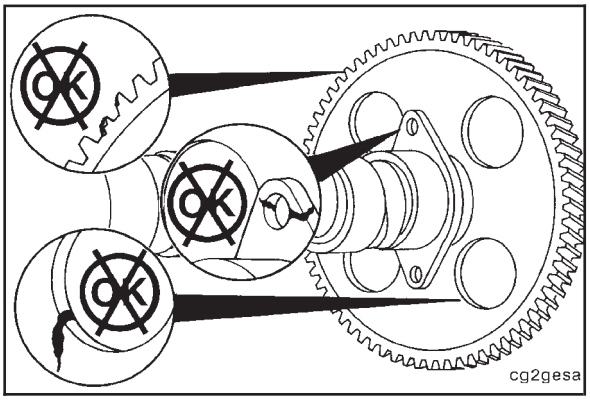
NOTE: Cummins Engine Co., Inc., does **not** recommend repairing camshafts by grinding the valve or injector lobes.

If the camshaft is damaged, it **must** be replaced.



Visually inspect the gear for broken or chipped teeth, and cracks.

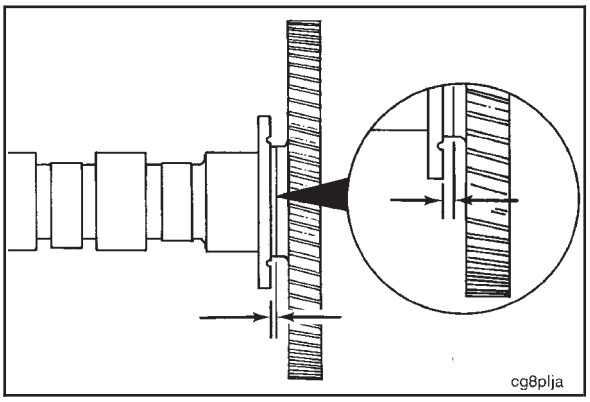
Visually inspect the thrust bearing for cracks.



Measure the camshaft thrust plate clearance.

Camshaft Thrust Plate Clearance		
mm		in
0.180	MIN	0.0070
0.330	MAX	0.0130

If the clearance is **not** within specifications, check for proper gear seating against the camshaft. Remove the gear and check for burrs.

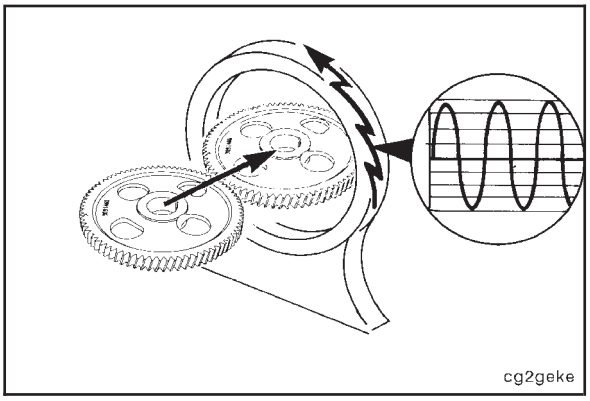


Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

Caution: The gear must have all magnetism removed completely and cleaned thoroughly. The small metal particles will cause engine damage.

Remove all magnetism from the gear.

Use solvent or steam to clean the gear and dry with compressed air.

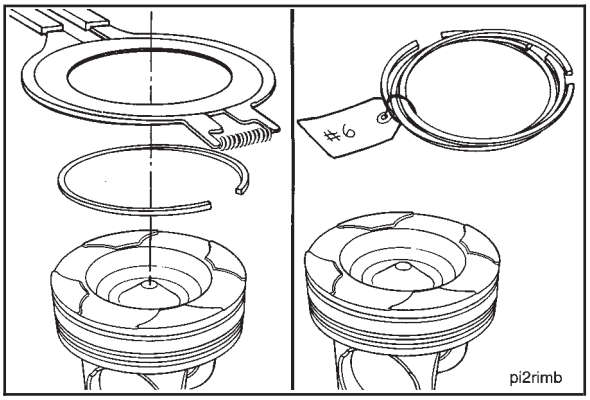


Piston - Cleaning and Inspection for Reuse (1-20)

Piston Rings - Removal

Use piston ring expander, Part No. ST-821, to remove the piston rings.

Place a tag on the rings and record the cylinder number of the piston on the tag.

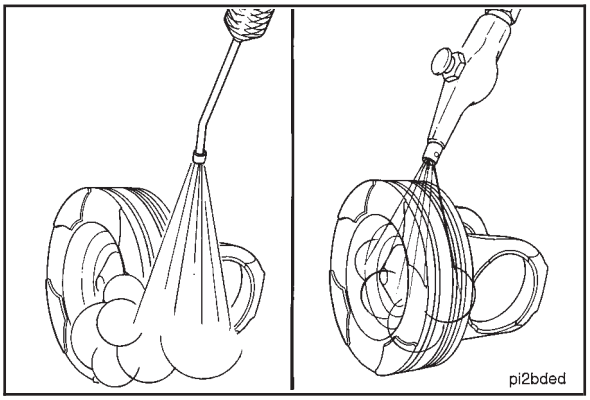


Cleaning

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

Use steam to clean the carbon from the piston.

NOTE: A plastic bead media, Part No. 3822735, has been released for cleaning the piston dome or crown and the ring grooves. Do **not** bead blast the piston skirt.



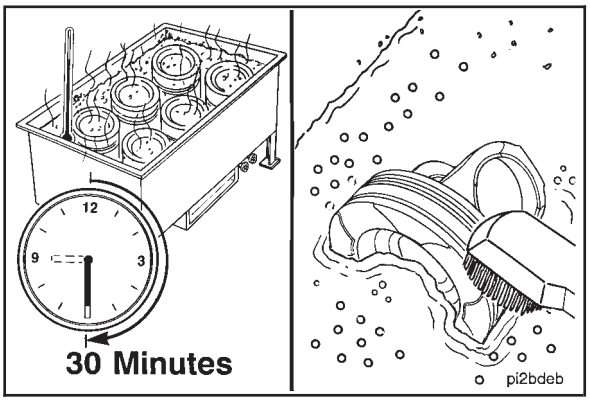
Caution: The cleaning solvent must be approved for aluminum to prevent damage to the pistons.

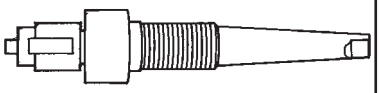
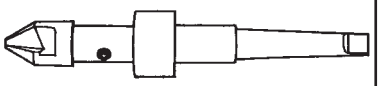
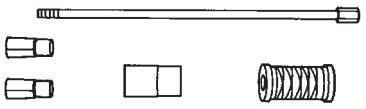
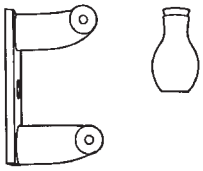
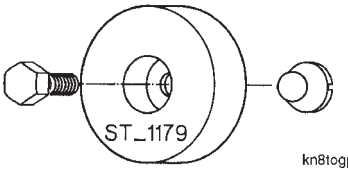
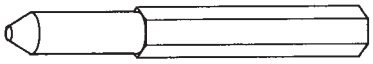
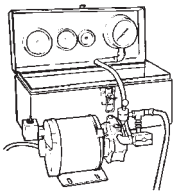
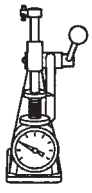
Use a kerosene emulsion based solvent that can be heated to 95°C [200°F] and a cleaning tank that will constantly mix and filter the solvent.

NOTE: Do **not** use a solvent that has a pH higher than 9.5, or a solvent that contains chlorinated hydrocarbons with cresols, phenols, or cresylic components.

Put the pistons into the solvent and allow them to soak for a minimum of 30 minutes.

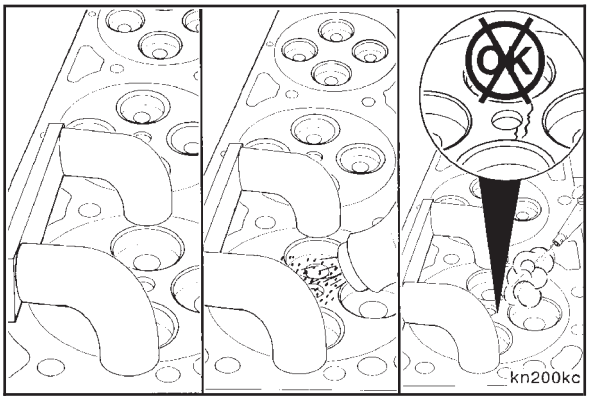
NOTE: Soak the pistons several hours or overnight for best results.



Tool No.	Tool Description	Tool Illustration
ST-880	**Injector Sleeve Expander** Roll and seal the upper portion of the injector sleeve in the cylinder head.	 kn8togl
ST-884-1	**Injector Seat Cutter** Used with pilot, Part No. ST-379-2, and cutter, ST-884-3, to machine the injector sleeve seat to the proper depth to allow the specified injector protrusion through the cylinder head.	 kn8togm
ST-1134	**Dowel Pin Extractor** Remove the dowel pins from the cylinder head.	 kn8togn
ST-1166	**Magnetic Crack Detector** Used to inspect the cylinder head combustion face for cracks in the injector bore and valve seat areas. The kit includes powder spray bulb, Part No. ST-1166-7, used for spraying the metal powder, ST-1166-8.	 kn8togo
ST-1179	**Injector Sleeve Holding Tool** Hold the injector sleeve in place when rolling the upper portion of the sleeve and testing the cylinder head.	 kn8togp
ST-1227	**Injector Sleeve Driver** Install the injector sleeve into the cylinder head.	 kn8togq
ST-1257	**Valve Vacuum Tester** Used with vacuum cup, Part No. 3376100. Vacuum test the cylinder head to determine if the valves are properly seated.	 kn8togr
3375182	**Valve Spring Tester** Measure the cylinder head valve spring tension.	 kn8togs

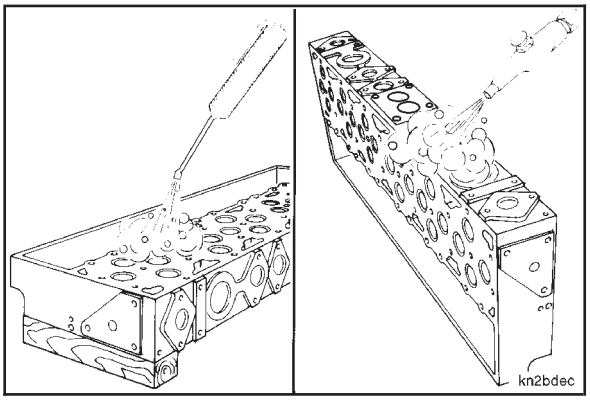
Place the magnetizing head on the combustion face as shown to check for cracks that run lengthwise of the cylinder head.

Repeat the procedure as outlined above.



Remove all magnetism and use solvent to clean the cylinder head. Dry with compressed air.

NOTE: The cylinder head **must** be thoroughly cleaned after using the magnetic crack detector to remove all of the iron fragments.



Measure the flatness of the cylinder head gasket surface as follows:

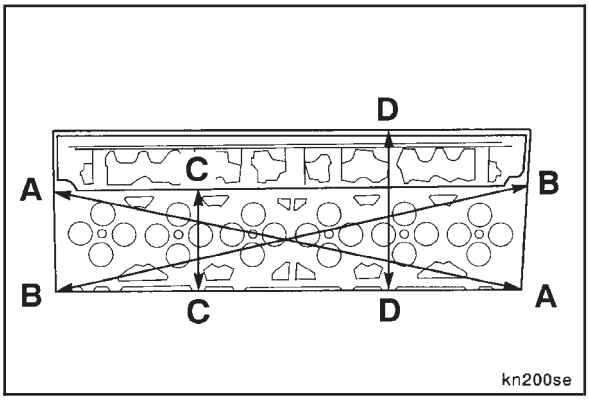
- AA and BB (corner to corner)
- CC (across combustion face)
- DD (across entire head surface)

NOTE: Dimensions CC and DD **must** be checked from front to rear of cylinder head.

Cylinder Head Flatness

	mm		in
AA and BB	0.200	MAX	0.008
CC	0.076	MAX	0.003
DD	0.127	MAX	0.005

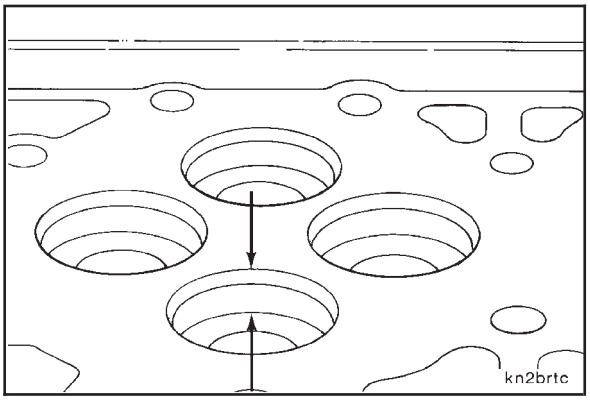
If the cylinder head combustion face is pitted, grooved or worn, the cylinder head surface **must** be machined or cut. Refer to the Alternative Repair Manual, Bulletin No. 3810310.



Measure the valve seat insert bore depth in the cylinder head.

Insert Bore Depth (Standard Insert)		
mm		in
9.40	MIN	0.370
9.50	MAX	0.374

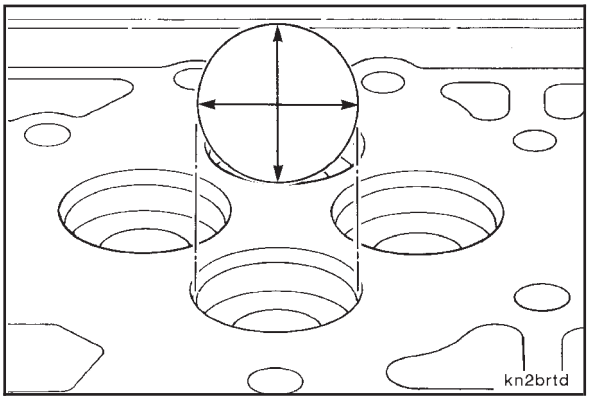
If the valve seat insert bore depth does **not** meet the specifications given, refer to Cylinder Head Oversize Valve Seat Insert - Installation (2-05).



Measure the inside diameter of the valve seat insert bore in the cylinder head.

Insert Bore I.D. (Standard Insert)		
mm		in
45.920	MIN	1.8073
45.935	MAX	1.8085

If the valve seat insert bore inside diameter does **not** meet the specifications given, refer to Cylinder Head Oversize Valve Seat Insert - Installation (2-05)



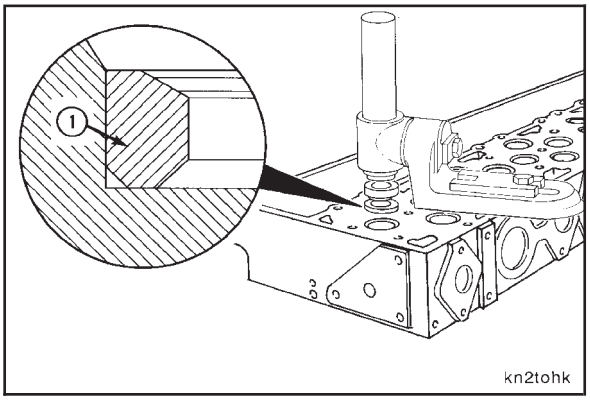
Assembly

Install the base and swivel of valve seat insert tool, Part No. ST-257, on the cylinder head to guide the valve seat driver. Install valve guide arbor, Part No.ST-804-1.

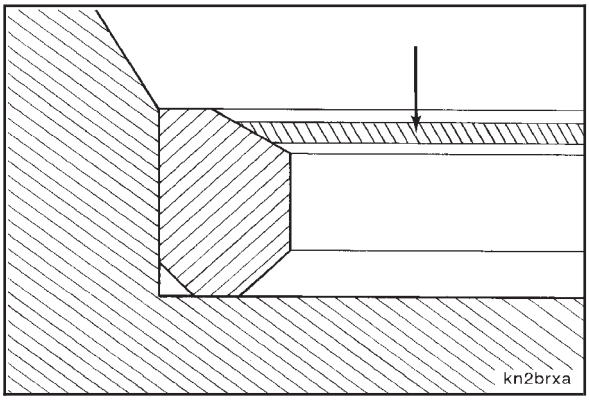
NOTE: The insert chamfer (1) **must** be installed toward the bottom of the counterbore.

Use valve seat driver, Part No. 3376105, to drive the valve seat insert into the counterbore.

Make sure the insert is at the bottom of the counterbore.



Use valve seat grinding machine, Part No. ST-685, and valve guide arbor set, Part No. 804, to grind the new valve seat inserts. Refer to Valve Seats - Grinding in Procedure (2-02).

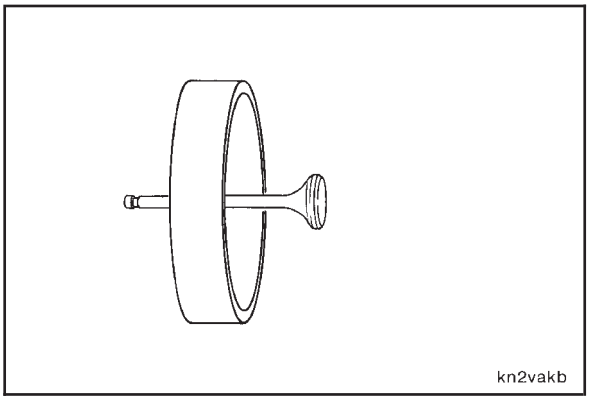


Cylinder Head Valves - Magnetic Crack Inspection (2-10)

Use the magnetic particle residual method to inspect the valves for cracks.

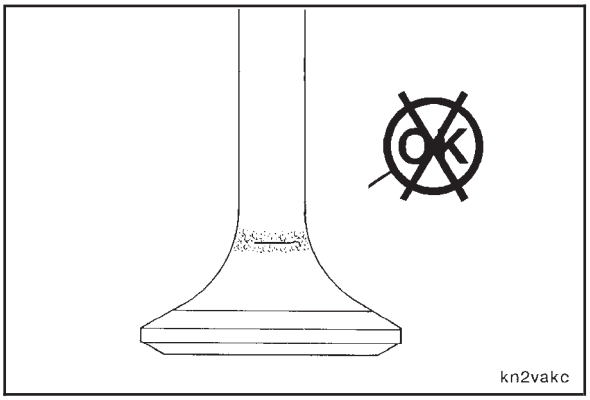
The exhaust valves contain two types of metal, and **must** be inspected by the coil shot method. There will be a magnetic leakage apparent at the point where the two metals are welded together. The leakage will appear as a wide pattern of magnetic particles.

Magnetize the valves in a coil of 100 to 200 amperes.



Inspect the valves with residual magnaglo.

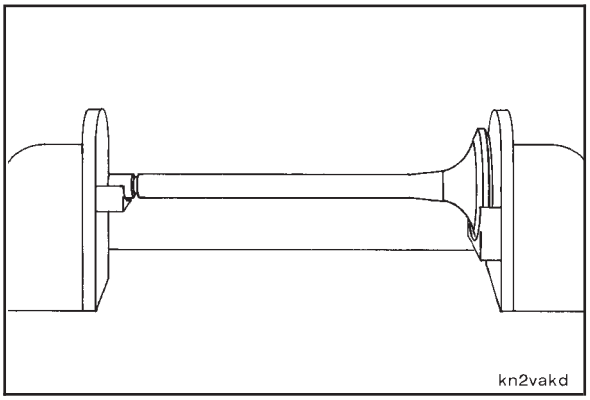
A broad fuzzy pattern will appear at the welded joint on the exhaust valves. If there is a distinct line in the pattern, the valve **must** be replaced.



The intake valves contain only one type of metal, and **must** be magnetized and inspected in two directions. Use the magnetic coil method and inspect with residual magnaglo the same as exhaust valves.

Magnetize the intake valves again with a headshot at 500 to 700 amperes.

Inspect the valves again with residual magnaglo.



Acceptance Criteria (Exhaust and Intake Valves)

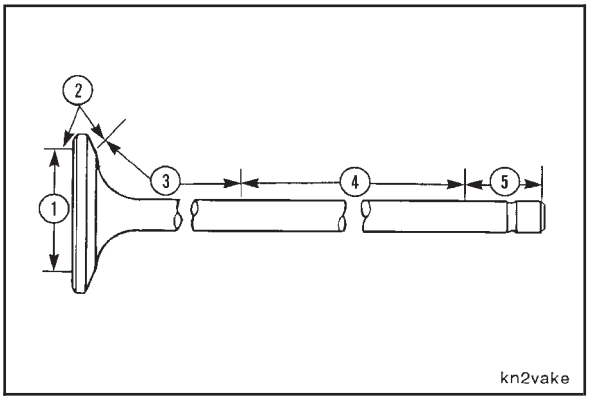
NOTE: ''Visible'' means an indication of a crack can be seen through a three power magnifying glass after the magnetic particle suspension is removed.

Area (1), **no** indication longer than 12.70mm [0.500 inch].

NOTE: There **must** be no more than five indications or no indications closer together than 3.18mm [0.125 inch].

Areas (2, 3, 4 and 5) **must not** have any magnetic indications or visible indications.

Remove all magnetism and clean the acceptable valves.



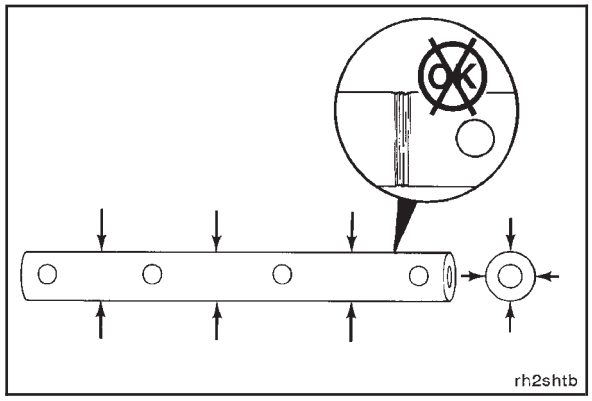
Visually inspect the rocker lever shafts for pitting, scoring or other damage.

Measure the outside diameter of the rocker lever shafts.

Rocker Lever Shaft O.D.		
mm		in
34.837	MIN	1.3715
34.864	MAX	1.3726

Refer to Overhead Reuse Guidelines, Bulletin No. 3810388, to identify wear patterns and excessive wear.

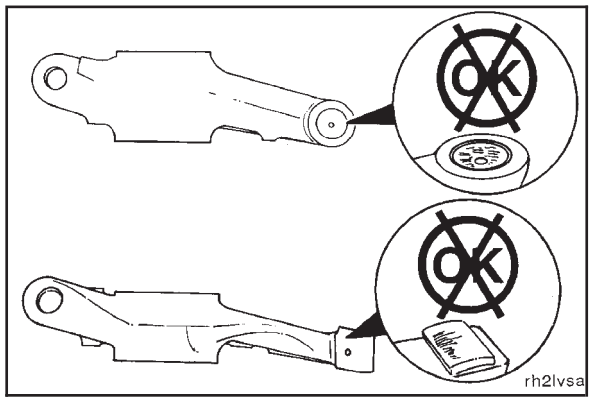
If worn or damaged parts are found, or the rocker lever bushings or shafts are **not** within the specifications given, the rocker lever assemblies **must** be rebuilt. Refer to Rocker Lever Assembly - Rebuild (3-02).



Visually inspect the sockets in the injector rocker levers for wear or damage.

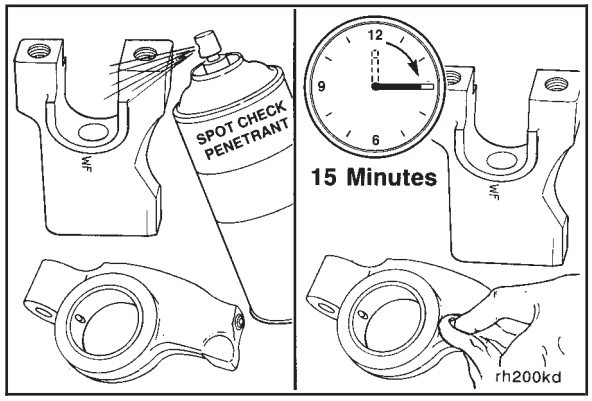
Visually inspect the valve rocker lever pads for wear, cracks or other damage.

If wear, cracks or other damage is found, the rocker lever **must** be replaced.



Use crack detection kit, Part No. 3375432, to inspect the rocker lever shaft supports for cracks or damage.

If cracks or damage is found, the rocker lever shaft support **must** be replaced.

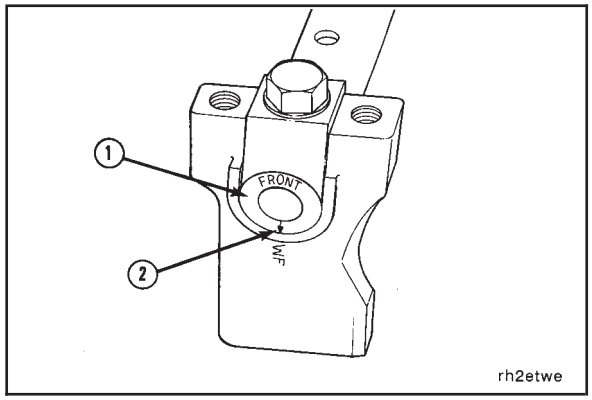


Assembly

Caution: Ensure that the rocker lever shafts are installed with the arrow on the end of the shafts pointed downward. Failure to do so will prevent oil from lubricating the rocker levers.

The rocker lever shafts are labeled front and rear on the end of the shafts (1). The arrow (2) on the end of the shaft **must** be pointed downward to ensure an oil flow to the rocker levers.

The shaft end supports are **not** interchangeable.

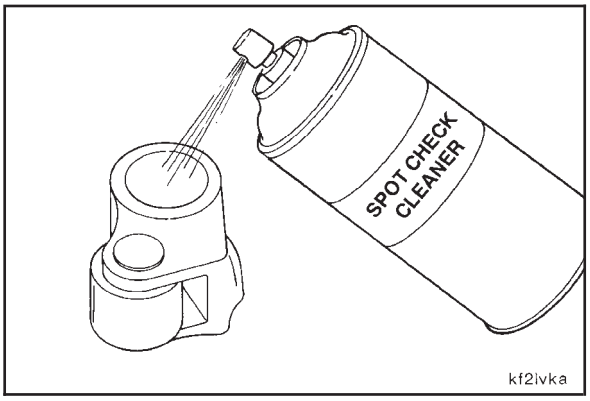


Section 4 - Cam Follower Assembly - Group 04

Section Contents

Use the crack detection kit, Part No. 3375432, to inspect the cam follower levers and supports for cracks.

Use the crack detection cleaner, Part No. 3375433, to clean the levers and supports. Dry with compressed air.

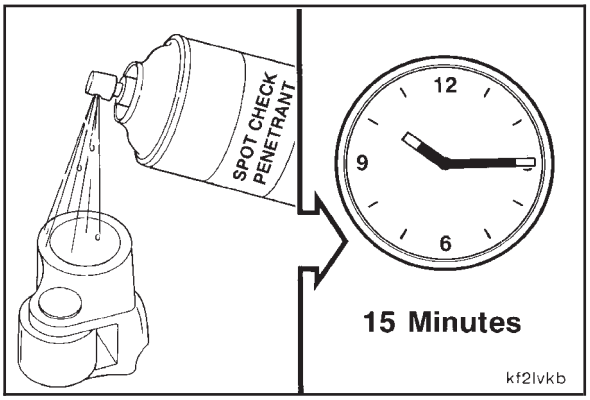


Use the crack detection penetrant, Part No. 3375435, to spray the levers and supports.

NOTE: Do **not** dry the penetrant with compressed air.

Allow the penetrant to dry for 15 minutes.

Remove the excess penetrant with a dry cloth.



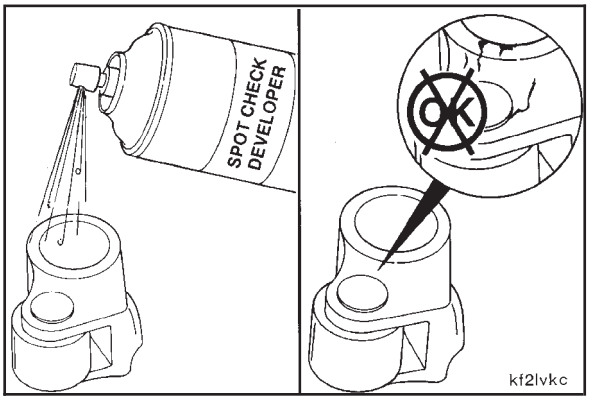
Use the crack detection developer, Part No. 3375434, to spray the levers and supports.

Visually inspect the levers and supports.

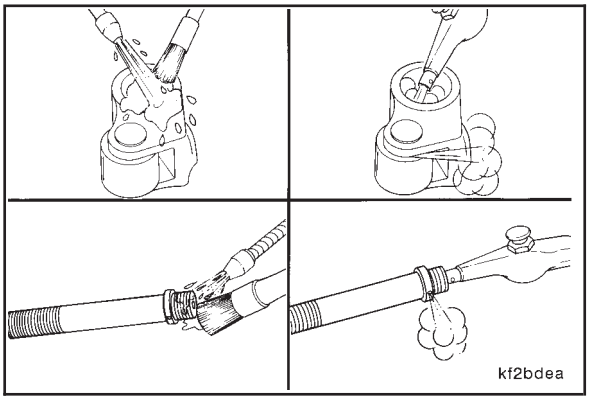
Cracks will appear as a solid bright line.

Cavitation in the casting will appear as a small round mark.

If cracks or cavitation are found the part **must** be replaced.



Use solvent to clean the acceptable levers and supports. Dry with compressed air.



Section 5 - Fuel System - Group 05

Section Contents

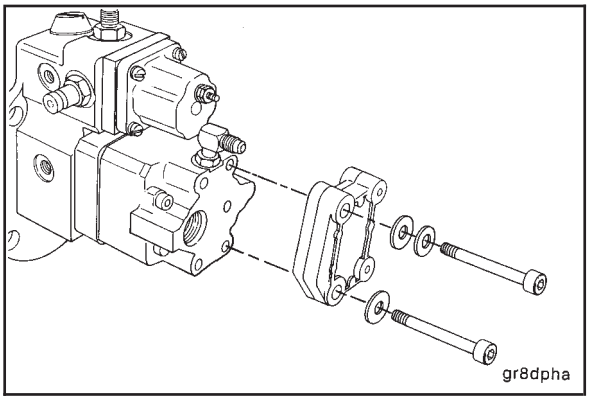
Remove the two damper mounting capscrews. Install the damper assembly with a new o-ring on the gear pump. Tighten the capscrews.

Torque Value: 18 N•m [13 ft-lb]

NOTE: If a fuel filter and damper assembly are mounted on the gear pump, remove the four mounting capscrews.

Install the fuel inlet connection. Be careful **not** to let dirt enter the pump.

Check for free rotation of the gear pump.

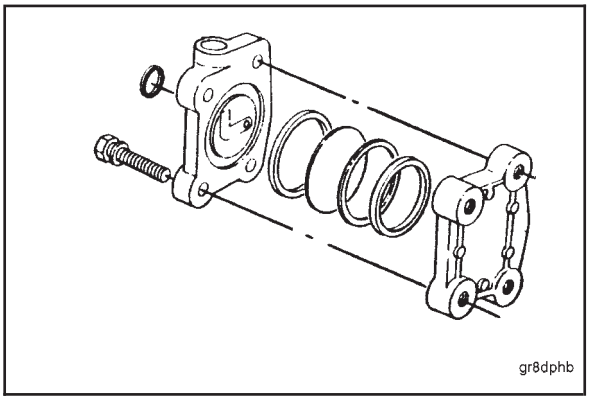


Fuel Damper - Disassembly and Inspection

Remove the housing from the cover. Remove the spring steel diaphragm. Discard the o-rings. Inspect the nylon washer, discard if damaged.

Check for corrosion, wear, or cracks in the cover or the diaphragm. Replace the damaged parts.

To check the diaphragm for hidden cracks, drop it on a flat, hard surface. It **must** have a clear ring. If it has a flat sound, replace the diaphragm.



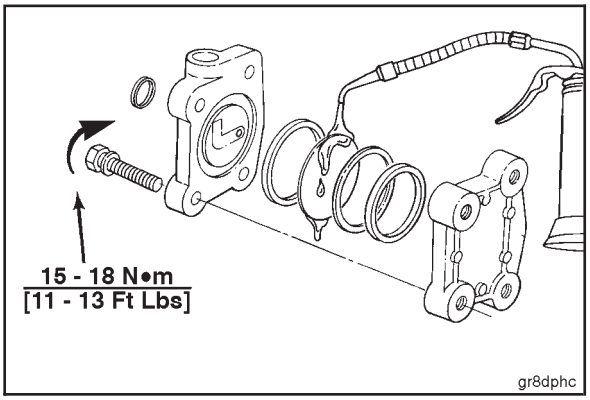
Fuel Damper - Assembly

Install new o-rings in the grooves and a new nylon washer.

Clean the diaphragm. Coat the diaphragm with clean engine oil. Install the diaphragm in the cover.

Assemble the cover to the housing. Tighten the capscrews.

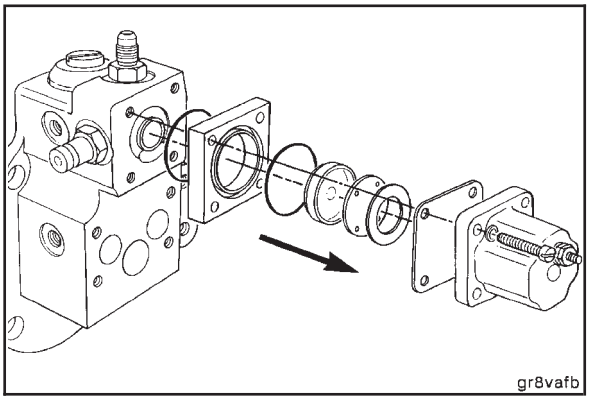
Torque Value: 18 N•m [13 ft-lb]



Fuel Shutoff Valve - Disassembly

Remove the coil housing and the fuel shield. Discard the o-ring.

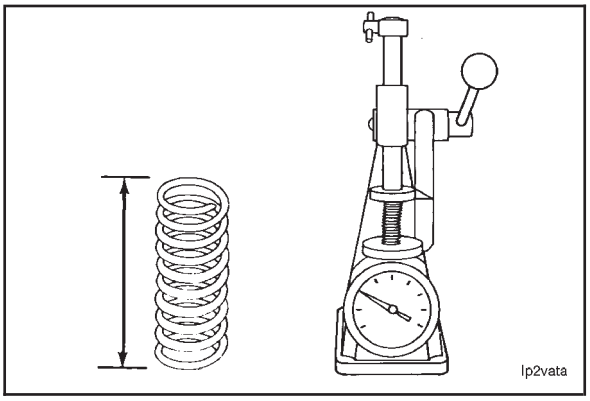
Remove the spring washer, valve disc, actuator disc, and actuator spacer from the valve housing. Discard the o-ring.



Section 7 - Lubricating Oil System - Group 07

Section Contents

Use valve spring tester, Part No. 3375182, to inspect the operating condition of the bypass valve spring.



Spring Specifications (Free Length)		
mm		in
37.68	MIN	1.483
38.52	MAX	1.517

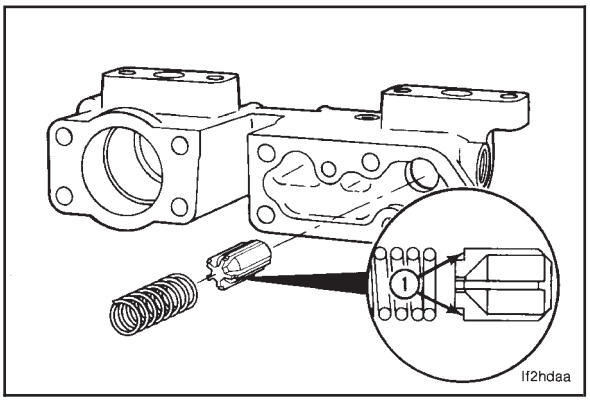
Spring Specifications at 29.65 mm [1.167 in] Load		
N		lbf
110.1	MIN	24.751
121.7	MAX	27.359

If damaged parts are found, or the bypass spring is **not** within the specifications given, the parts **must** be replaced.

Assembly

Install the bypass valve into the filter head. The notched end of the valve (1) **must** face the engine side of the filter head.

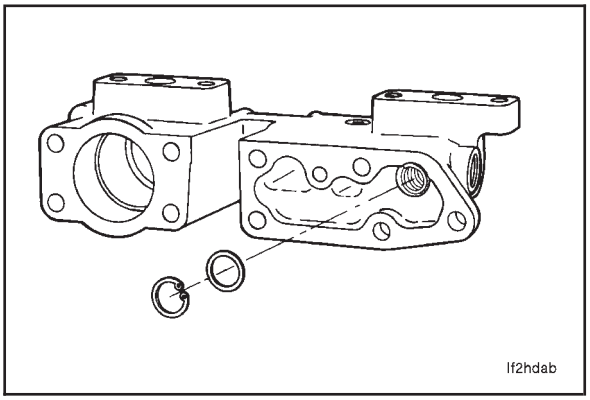
Insert the spring into the bore. Check to be sure the spring is properly located over the notched end of the valve (1).



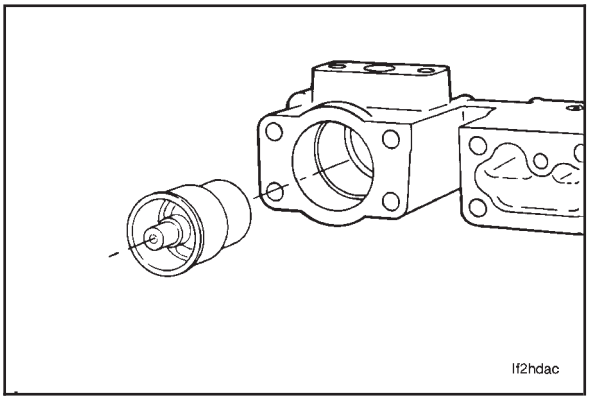
Caution: The valve spring must be compressed to install the snap ring. To avoid personal injury, wear face and eye protection.

Place the washer on top of the spring.

Using snap ring pliers, install the snap ring into the groove inside the bore.



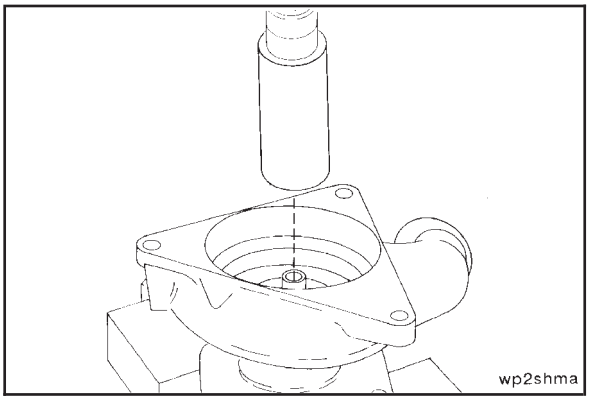
Insert the thermostat into the filter head as shown.



Section 8 - Cooling System - Group 08

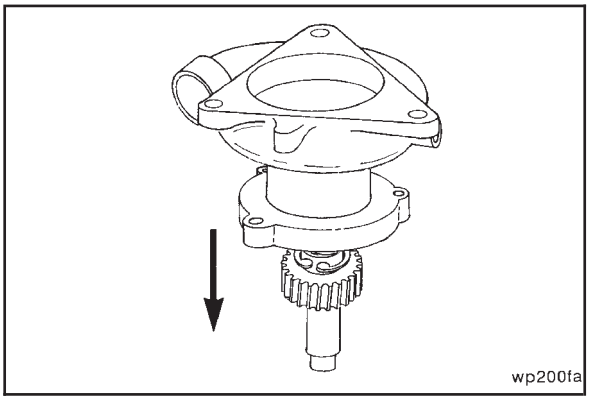
Section Contents

Install the water pump in an arbor press with the front mounting surface facing down.



Caution: To avoid damage to the water pump shaft, do not allow the shaft assembly to fall when pushed from the water pump body.

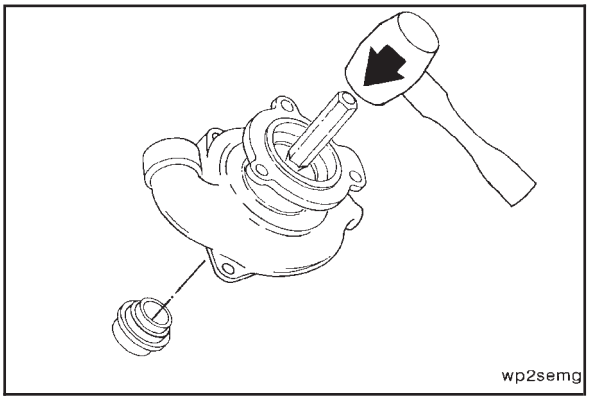
Press the shaft assembly from the water pump body.



Caution: To prevent future water pump failure, do not damage the water seal bore when removing the water seal.

Install the water pump body on a bench with the front mounting surface facing up.

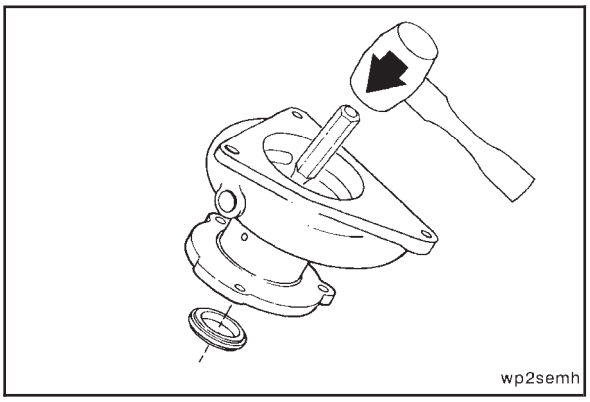
Use a punch and hammer to remove the water seal. Discard the seal.



Turn the water pump body over with the front mounting surface facing down.

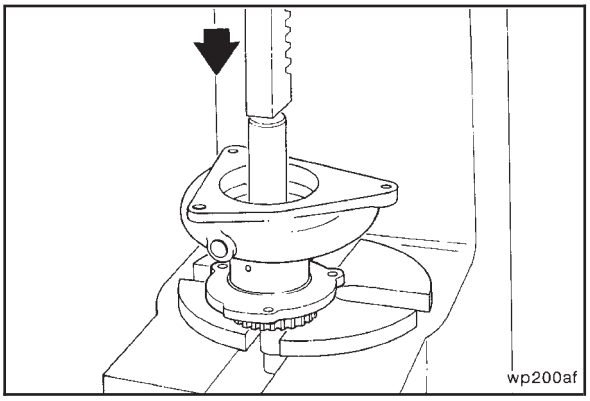
Caution: To prevent future water pump failure, do not damage the oil seal bore when removing the oil seal.

Use a punch and hammer to remove the oil seal.

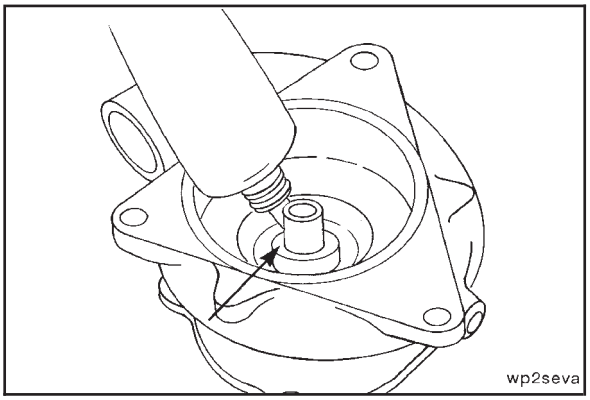


Caution: The use of any tool other than Part No. 3823815 can result in seal damage.

Use the water pump seal driver, Part No. 3823815, to press the seal into the water pump body.

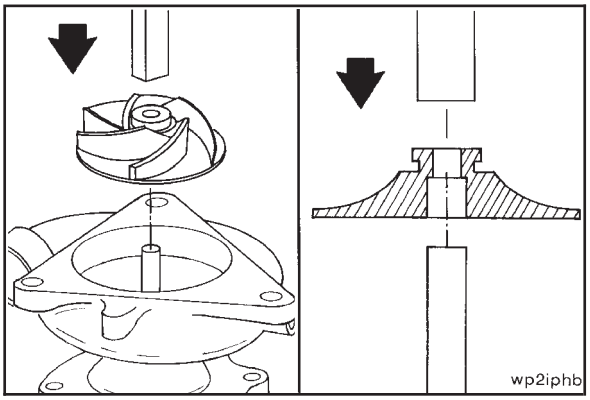


Apply one drop of Loctite 290™, Part No. 3823682 or equivalent, to the joint between the water pump shaft and the water pump seal.



Install the water pump body in an arbor press with the impeller end of the shaft facing up. Support the bottom end of the shaft.

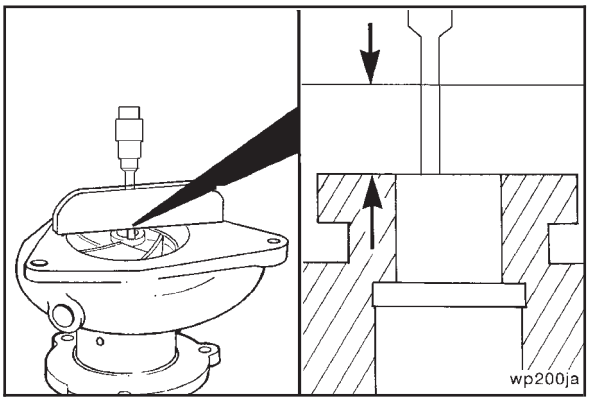
Press the impeller on the shaft until the step inside the impeller bore contacts the shaft.



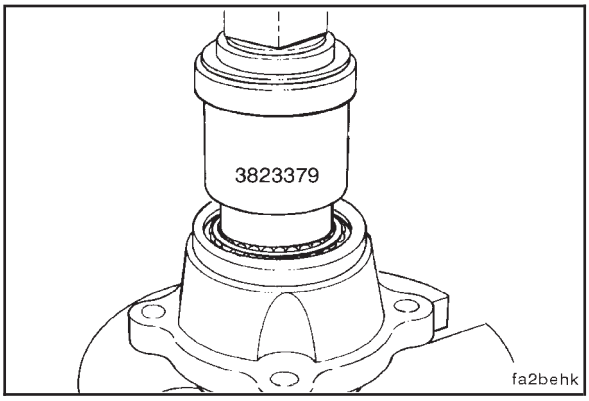
Use a dial depth gauge to measure the distance from the impeller hub to the water pump body surface.

Impeller Hub to Body Surface		
mm		in
13.52	MIN	0.532
13.72	MAX	0.540

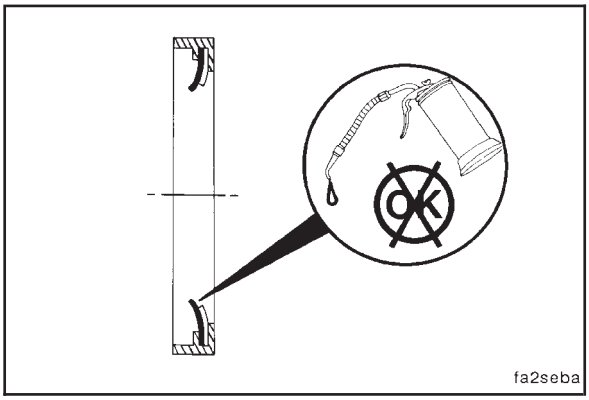
If the distance from the impeller hub to the body surface is greater than the maximum specification, use the water pump impeller puller kit, Part No. 3376542, to move the impeller to the correct distance.



Use the small end of bearing driver, Part No. 3823379, to press the front bearing onto the shaft until the inner race of the bearing contacts the bearing spacer.



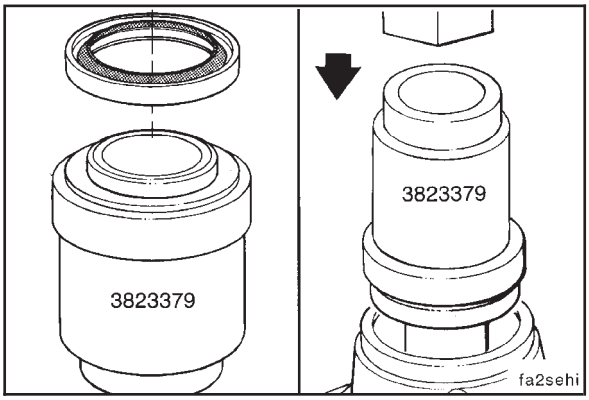
Caution: Do not lubricate the grease seal. The seal must be installed with the lip of the seal clean and dry to provide a proper sealing surface and prevent hub damage. Make sure the seal installation tool and flange are clean and dry when the fan hub is assembled.



The sealing lip of the grease seal **must** be installed away from the seal driver.

Place the seal on the large end of bearing driver, Part No. 3823379, with the open side of the seal facing away from the driver.

Press the seal into the hub until the driver contacts the hub.

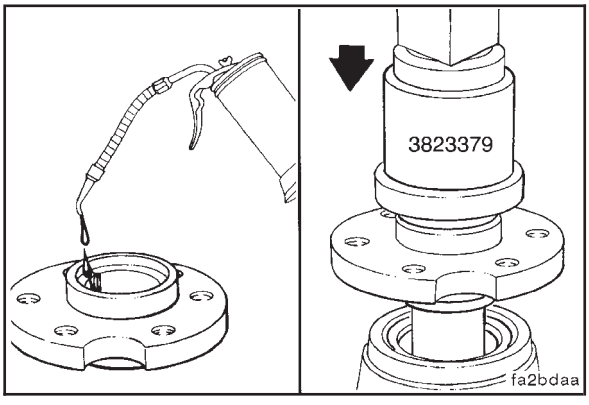


If the shaft is shorter than 95.2 mm [3.75 inch], support the shaft with spacer, Part No. 217008 or equivalent.

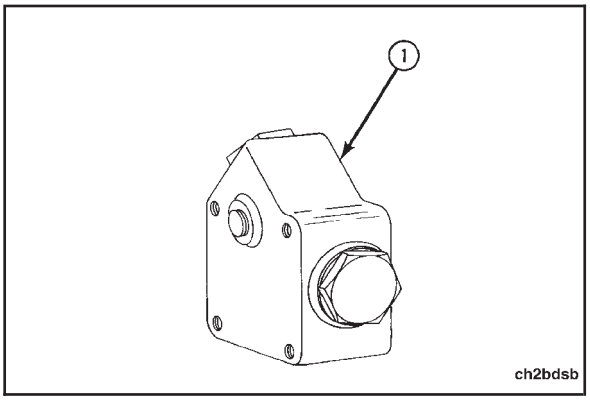
Place the hub on an arbor press with the tapered (fan mounting) end facing up.

Apply a thin film of oil into the bore of the fan hub flange.

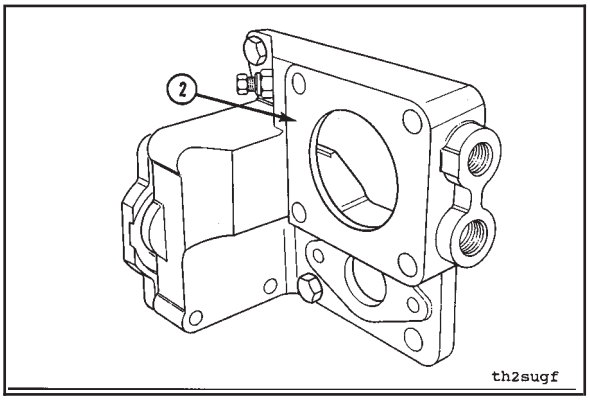
Use the large end of bearing driver, Part No. 3823379, to press the flange onto the shaft until it contacts the front bearing.



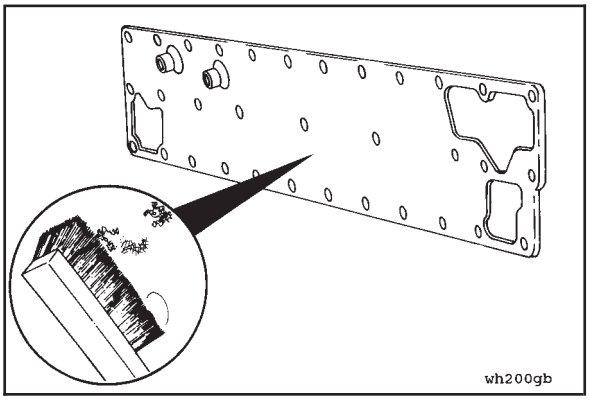
Use a wire brush to remove the rust and corrosion from the engine heater housing surface (1).



Use a wire brush to remove the rust and corrosion from the thermostat support surface (2).

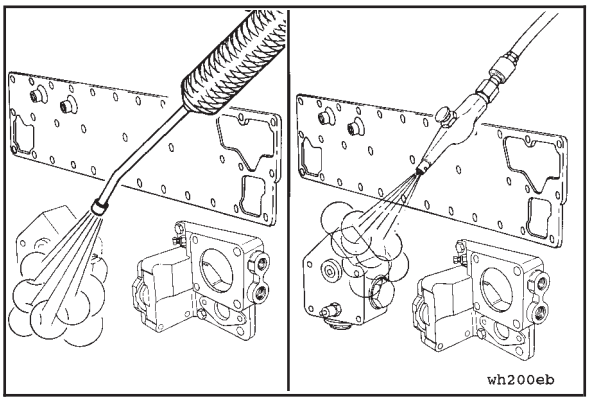


Use a wire brush to remove the rust and corrosion from the water header cover surfaces (3 and 4).

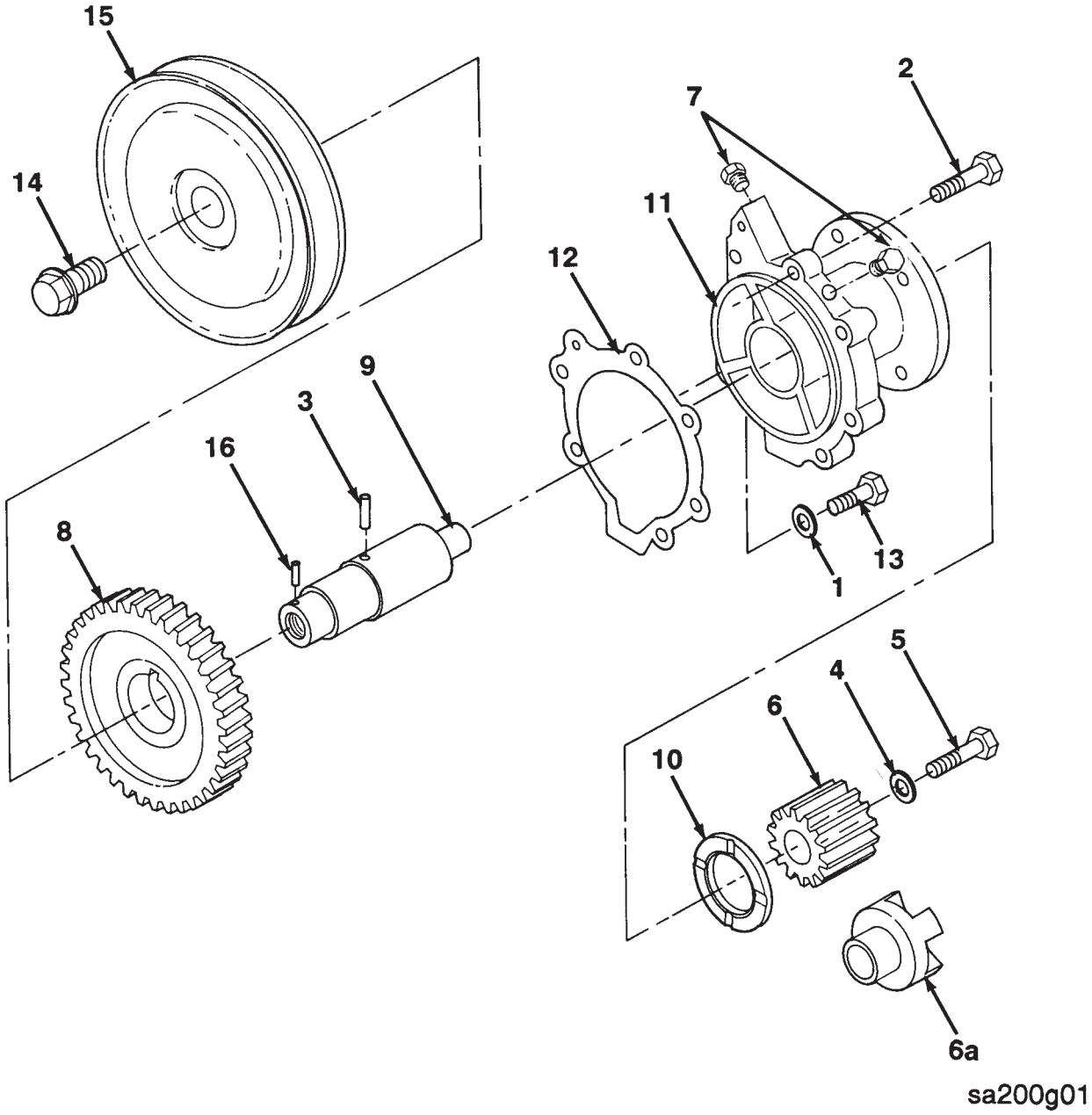


Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

Use steam to clean the parts. Dry with compressed air.



Fuel Pump and Compressor Drive - Exploded View



Ref. No.	Description	Qty.
1.	Washer, Copper Sealing	1
2.	Capscrew	5
3.	Pin, Groove	1
4.	Washer, Plain	1
5.	Capscrew	1
6.	Gear, Splined Coupling	1
6a.	Coupling, Hub	1
7.	Plug, Straight Thread O-ring	2
8.	Gear, Fuel Pump and Compressor Drive	1

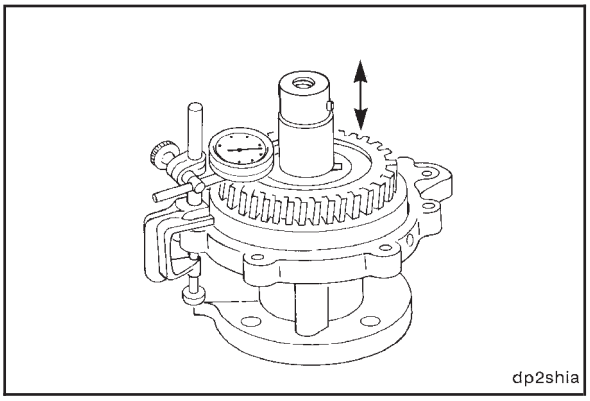
Ref. No.	Description	Qty.
9.	Shaft, Accessory Drive	1
10.	Bearing, Thrust	1
11.	Support, Accessory Drive	1
12.	Gasket, Accessory Drive Support	1
13.	Capscrew	1
14.	Capscrew, Captive Washer	1
15.	Pulley, Accessory Drive	1
16.	Pin, Dowel	1

Rotate the drive shaft to check for correct assembly.

Measure the drive shaft end clearance.

Drive Shaft End Clearance		
mm		in
0.10	MIN	0.004
0.30	MAX	0.012

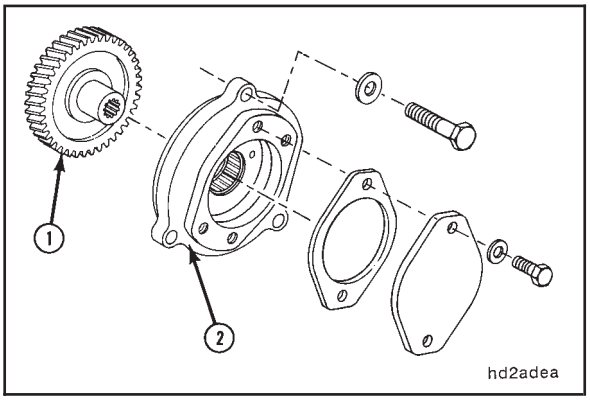
If the drive shaft end clearance does **not** meet these specifications, disassemble the drive and inspect the gear and thrust bearing positions. If the drive gear and thrust bearing are within specifications, the fuel pump and compression drive housing **must** be replaced.



Hydraulic Pump Drive - Cleaning and Inspection for Reuse (9-03)

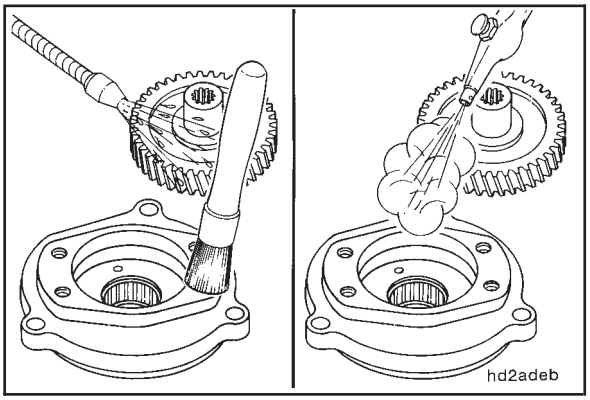
Cleaning

Remove all gasket and o-ring material from surfaces (1) and (2). Discard the gaskets and o-ring.



Clean the parts with solvent, dry with compressed air.

NOTE: Do not remove the gear from the shaft. If the parts are damaged refer to Hydraulic Pump Drive - Rebuild (9-04).



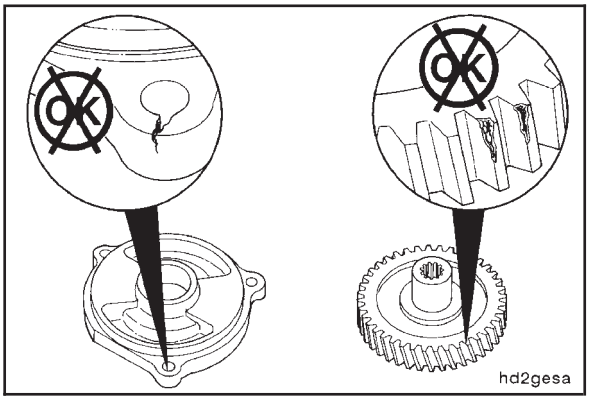
Inspection

Visually inspect the hydraulic pump drive and rear adapter for cracks and fretting on the pump flange mounting surface.

Visually inspect the gear for broken or abnormally worn teeth.

Inspect the shaft inner spline for wear.

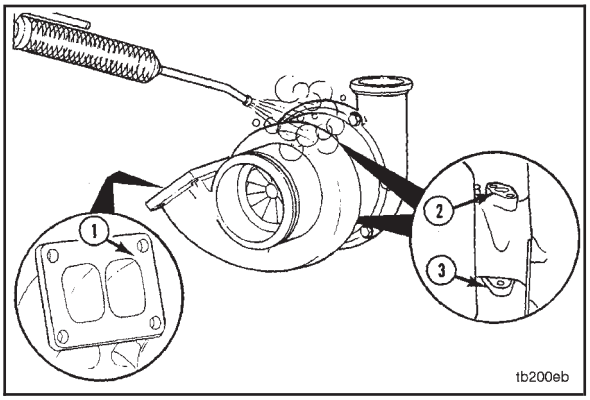
Replace any parts that are damaged.



Turbocharger - Cleaning and Inspection for Reuse (10-01)

Cleaning

Remove all carbon deposits and gasket material from surfaces (1), (2) and (3).



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

Caution: Tape or plug all openings to prevent solvent or steam from damaging the oil cavities in the turbocharger.

Use solvent or steam to clean the exterior of the turbocharger. Dry with compressed air.

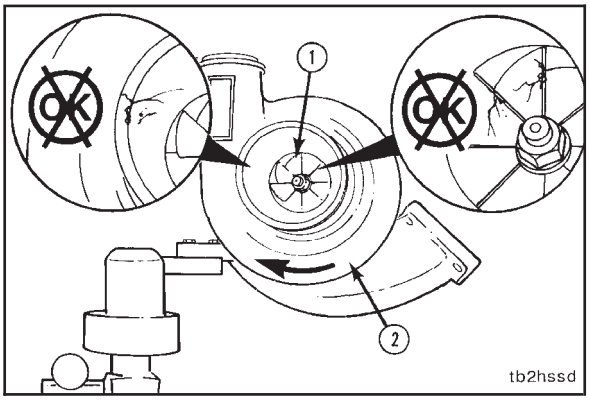
Inspection

Visually inspect the housings for damage.

Visually inspect the turbine wheel and compressor impeller (1) for fretting, cracked or broken vanes.

Turn the impeller in the direction shown with arrow (2), to inspect the turbine shaft for freedom of rotation. The shaft **must** rotate freely.

Replace damaged parts.



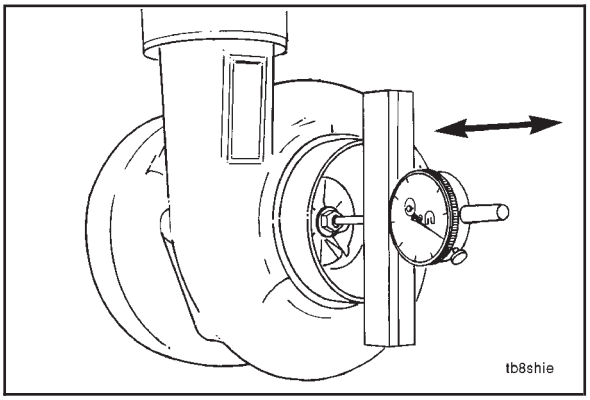
Measure the turbocharger shaft axial movement with the dial depth gauge, Part No. ST-537.

Push the rotor assembly away from the gauge.

Set the gauge on zero.

Push the rotor assembly toward the gauge and record the data.

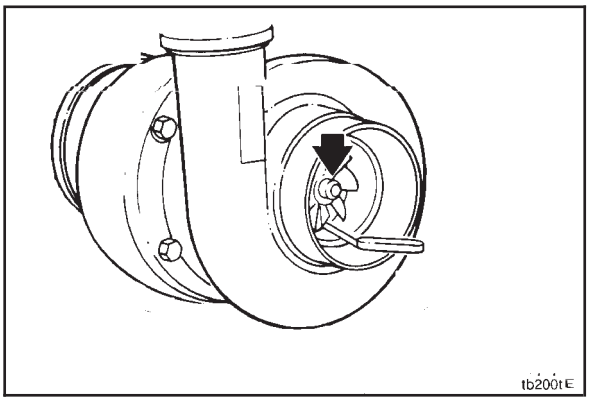
Turbocharger Shaft Axial Movement		
mm		in
0.038	MIN	0.0015
0.089	MAX	0.0035



Push the compressor impeller by hand toward the compressor housing.

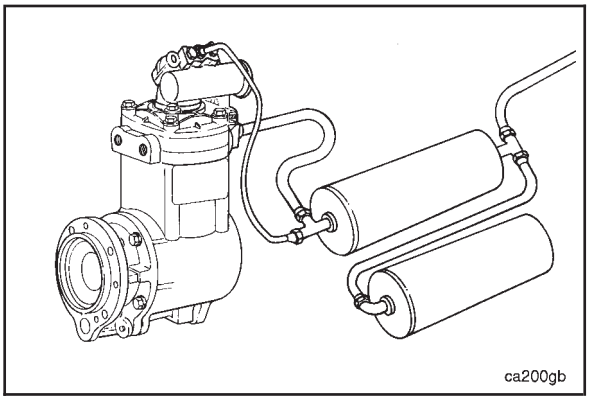
Install a wire feeler gauge, at the minimum clearance point, between the impeller and the housing to measure the clearance.

Record this clearance.

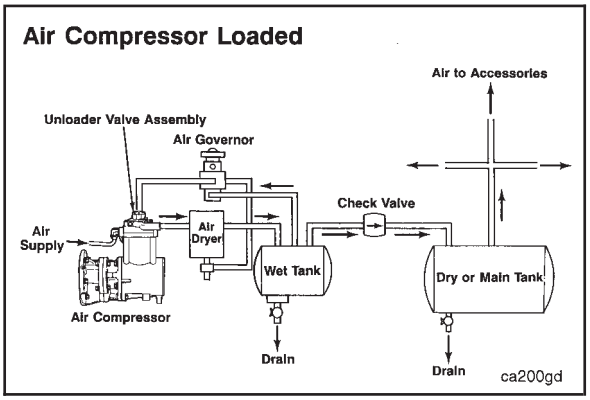


The compressed air system normally consists of a gear driven air compressor, an air governor, air tanks and all necessary plumbing.

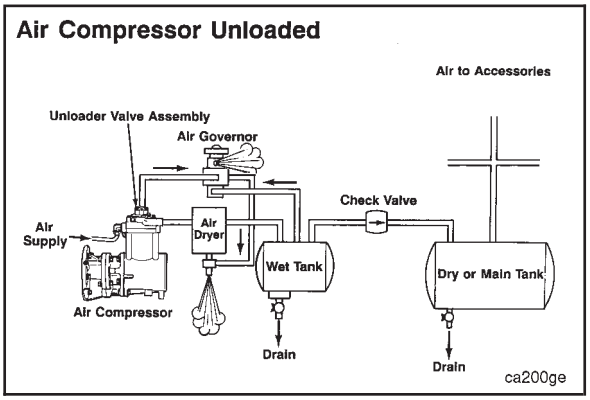
The Holset single and two cylinder air compressors are engine-driven piston-type compressors which supply compressed air to operate air activated devices. The compressor runs continuously but has a loaded and unloaded operating mode.


ca200gb

The operating mode is controlled by a pressure-activated governor and the compressor unloading assembly. When the air system reaches a predetermined pressure, the governor applies an air signal to the air compressor unloader assembly causing the unloader valve to hold the compressor intake valve open and compressed air stops flowing into the air system.

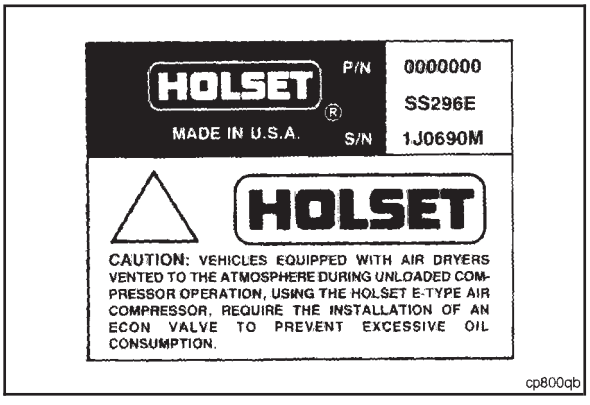


As the air in the air system is used, the pressure drops. At a predetermined pressure the governor exhausts the air signal to the compressor unloader assembly allowing the compressor to again pump compressed air into the air system.



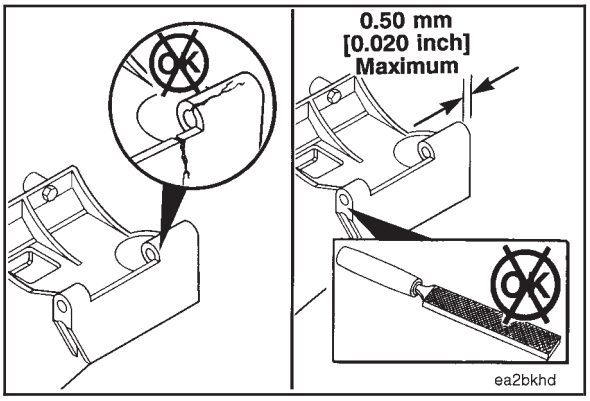
E-Type Air Compressor

Air compressors built with the E-Type unloader can be identified by the letter ''E'' (SS296E), and by the caution on the dataplate.



Inspect the lower bracket and mounting capscrews. If the bracket is cracked, it **must** be replaced.

The front and rear faces of the lower bracket, where the lower bracket and upper bracket contact, **must** be flat and parallel. If these surfaces are **not** flat, the rear face ONLY can be re-faced by milling a maximum of 0.50 mm [0.020 inch] deep to clean up. However, the minimum dimension allowed from the front to rear contact faces of the lower bracket is 210.7 mm [8.30 inch]. **Do not** re-face the front surface. If the front surface needs re-faced, or the dimension is less than the minimum allowed, the bracket **must** be replaced.

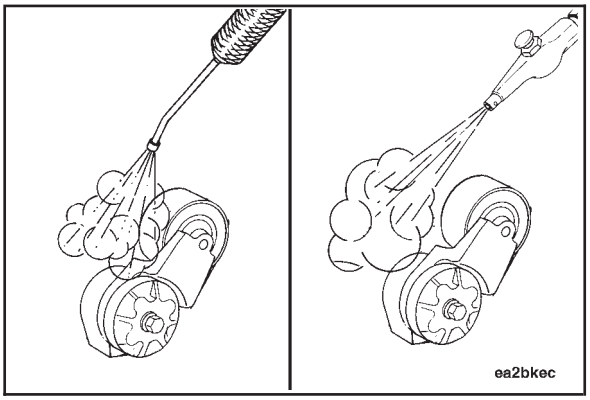


Automatic Belt Tensioner (Bus Applications) - Cleaning and Inspection for Reuse (13-05)

Cleaning

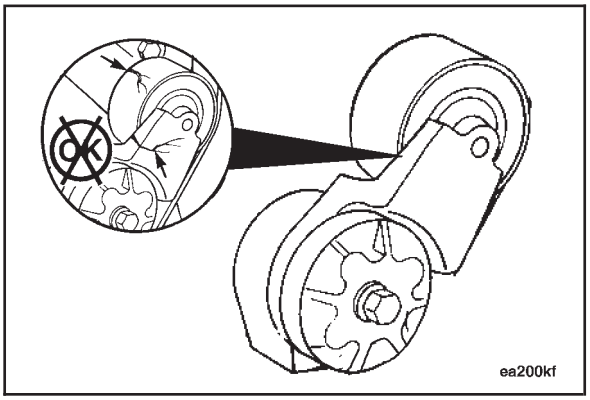
Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

Steam clean the automatic belt tensioner. Dry with compressed air.

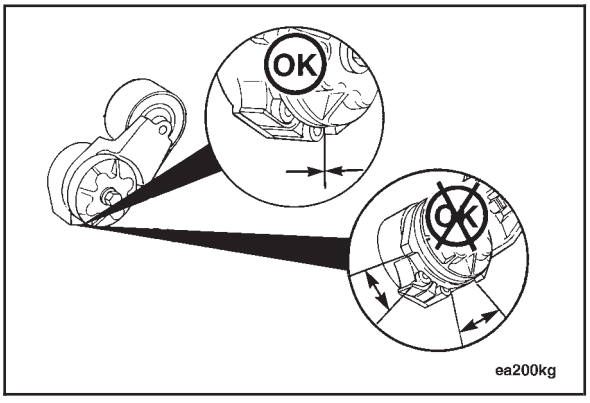


Inspection

Check the tensioner pulley and body for cracks. If any cracks are noticed, the tensioner **must** be replaced.

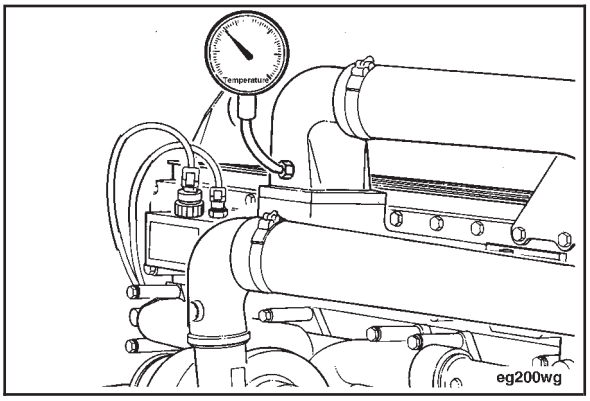


Check that the bottom tensioner arm stop is in contact with the bottom tensioner arm stop boss on the tensioner body. If these two are **not** contacting, the tensioner **must** be replaced.



2. Measure the intake manifold temperature at the 1/8 inch NPT tap near the air horn connection with the intake manifold. Measure this temperature as close as possible to the inlet of the intake manifold.

Alternately, intake air temperature can be measured by using Compulink™ in the ‘‘monitor’’ mode.



Dynamometer Worksheet

Date _____ Repair Order No. _____ Operator _____

ESN _____ CPL _____ Fuel Pump Code _____

Complaint _____ SC Code _____

PARAMETER	CODE SPECIFICATIONS	ACTUAL READING
Fuel Pressure (psi @ RPM)	150 to 180 at Governed	
Fuel Rate (lb/hr)		
Intake Mfd. Pressure (in.Hg)	See Fuel Pump Code	
Intake Mfd. Temperature		
*Intake Air Restriction	25 in. H_20, Maximum	
*Exhaust Air Restriction	3 in. Hg, Maximum	
*Fuel Inlet Restriction	10 in. Hg (Dirty Filter), Maximum	
*Fuel Drain Line Restriction	3.5 in. Hg	
Engine Blowby	12 in. H_20 New Engines, Max. 18 in. H_20 Used Engines, Max.	

*Recorded at Maximum Horsepower Speed and Full Load

Road Speed Limit _____ **Engine High Speed Limit** _____

Check Oil Level ____ Low ____ High ____ OK **Fuel Quality** ____ **OK** ____ **Not OK**

Engine Speed	Fuel *Rate/Press		Fuel Temp	Turbo Inlet Air Temp	Intake Manifold Temp/Press		Coolant Temp/Press		Engine Blowby	Lube Oil Press	Horse power or Torque

* Be sure that the fuel rate is corrected for temperature.

Fuel Temperature	Correction for Flow Rate
Less than 7°C[45°F]	Flow meter **not** accurate
7 to 13°C[45 to 55°F]	Subtract 2% from flow rate reading
13.0 to 20.0°C[55 to 68°F]	Subtract 1% from flow rate reading
20.0 to 29°C[68 to 85°F]	No Correction
29 to 42°C[85 to 108°F]	Add 1% to flow rate reading
42 to 56°C[108 to 132°F]	Add 2% to flow rate reading
56°C above [132°F]	Flow meter **not** accurate.

Pressure Conversions
1 in. H_20 = 0.074 in. Hg = 0.036 psi 1 in. Hg = 13.514 in. H_20 = 0.491 psi 1 psi = 2.036 in. Hg = 27.7 in. H_20

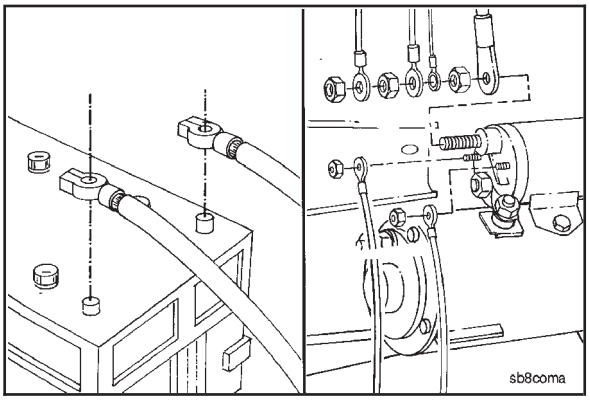
This Page Can Be Copied For Your Convenience.

Starting Motor

Inspect the voltage rating on the starting motor before installing the electrical wiring.

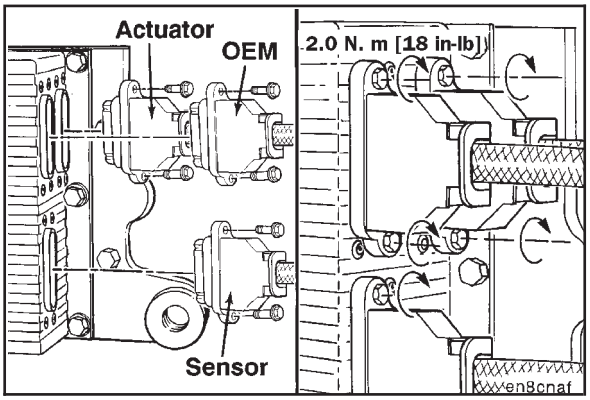
Install the electrical wiring to the starting motor and batteries, if used.

NOTE: If another method of starting the engine is used, follow the manufacturer's instructions to make the necessary connections.

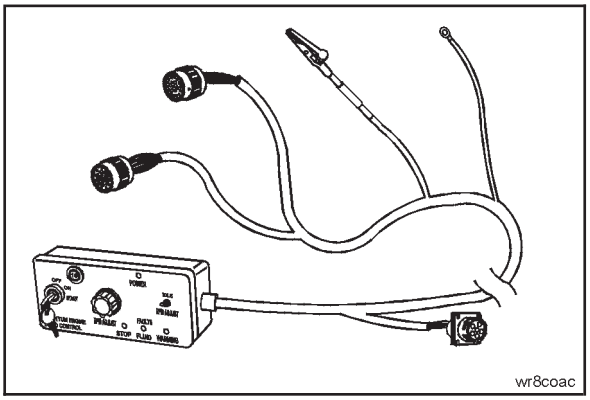


Engine Throttle Control

Engines which are run on an engine dynamometer require that the sensor and actuator harness be installed, and connected to the engine. Additionally, a special engine dynamometer version of the OEM wiring harness and throttle control **must** be installed.

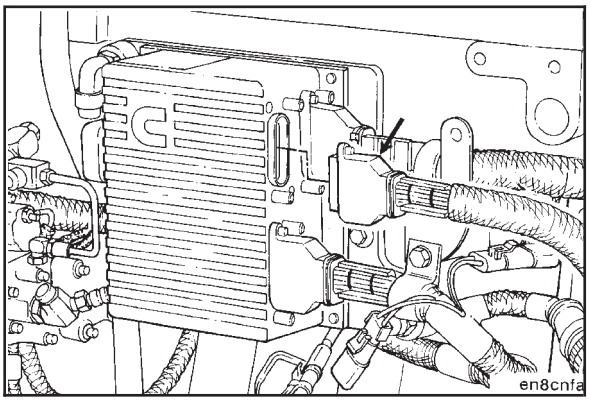


A special wiring harness and throttle control, Part No. 3823948, has been developed to enable engine operation out of chassis.

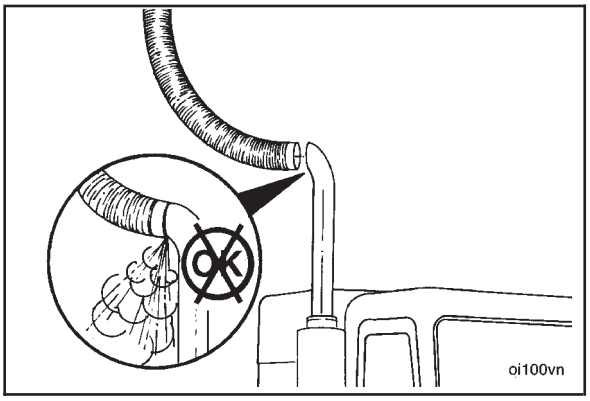


Connect the dynamometer test OEM wiring harness amp connector to the ECM. Tighten the connector capscrews to the ECM.

Torque Value: 2.0 N•m [18 in-lb]



- Adjust the vehicle and dynamometer room exhaust system to make sure all exhaust gases are removed from the room.
- Refer to the chassis dynamometer and vehicle manufacturer's recommendations and specifications for testing procedures.

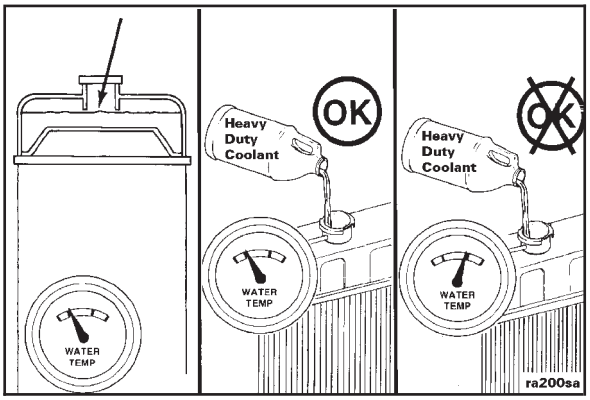


General Test Procedure

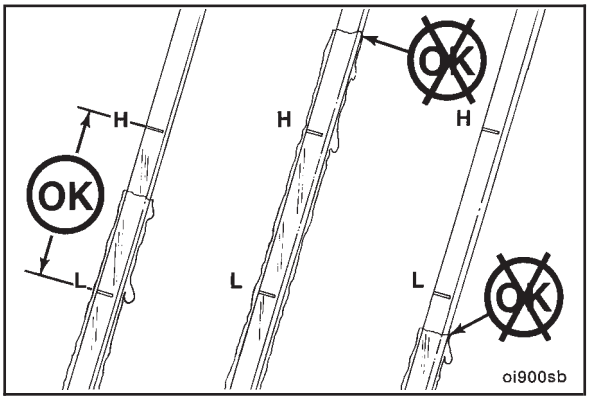
Check the engine coolant level to be sure it is filled to the proper level.

Warning: Check the coolant level only when the engine is stopped. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Failure to do so can cause personal injury from heated coolant spray.

Caution: Do not add cold coolant to a hot engine. This can cause engine casting damage. Allow the engine to cool to below 50°C [120°F] before adding coolant.



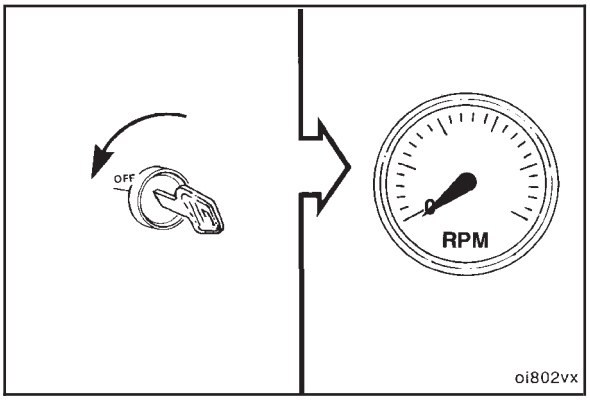
Check the engine lubricating oil level to be sure it is filled to the proper level.



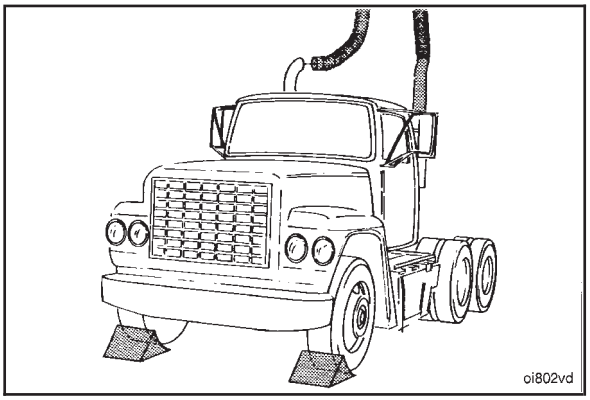
NOTE: Use a known source of ''good'' quality No. 2 diesel fuel. This is very important since No. 1 diesel fuels, along with most other alternate fuels, are lighter (lower specific gravity, higher API gravity) than No. 2 diesel fuel. The lighter the fuel, the lower the energy content (BTU) per gallon (liter, etc).

Caution: Do not shut off the engine immediately after the run-in is completed. Allow the engine to cool by operating it at 700 to 900 RPM for a minimum of 3 to 5 minutes to avoid internal component damages. This allows the turbocharger and other components to cool.

Shut off the engine.



Make sure all instrumentation is removed before removing the vehicle from the chassis dynamometer.

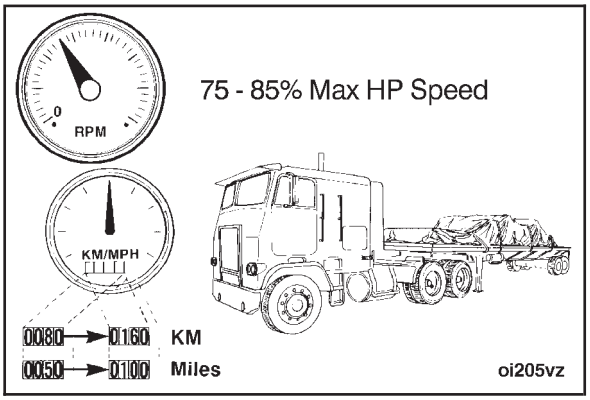


Engine Run-In Procedure - Without Dynamometer (14-05)

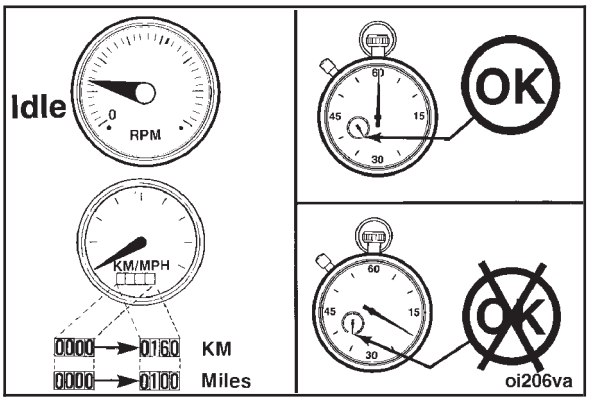
On-Highway

Caution: Refer to ''Engine Testing - General Information'' and ''Engine Testing - Specifications'' at the front of this section before operating the engine to avoid internal component damage.

Operate the vehicle pulling heaviest available trailer allowed for the first 80 to 160 km [50 to 100 miles] after rebuild. Operate vehicle in highest gear possible within the normal operating RPM range of the engine. It is necessary to operate the engine at or near full throttle at 75 percent to 85 percent of maximum horsepower RPM indicated on the data plate.



Do **not** idle the engine for more than 5 minutes at any one time during the first 160 km [100 miles] of operation.



Section 15 - Instruments and Controls - Group 15

Section Contents

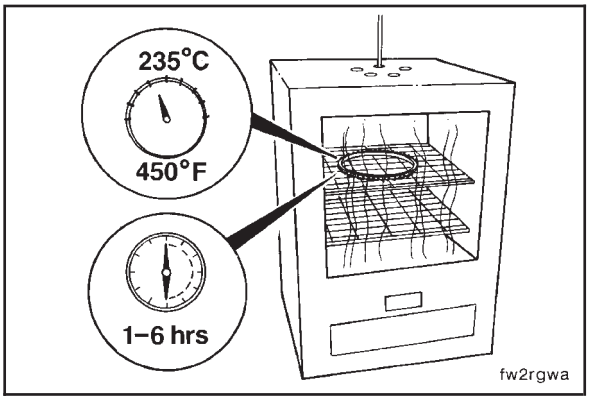
Assembly

Do **not** attempt to install the ring gear without using heat.

Use an oven to heat the new ring gear for a minimum of one hour. Do **not** heat the ring gear for more than six hours.

Temperature: 235°C [450°F]

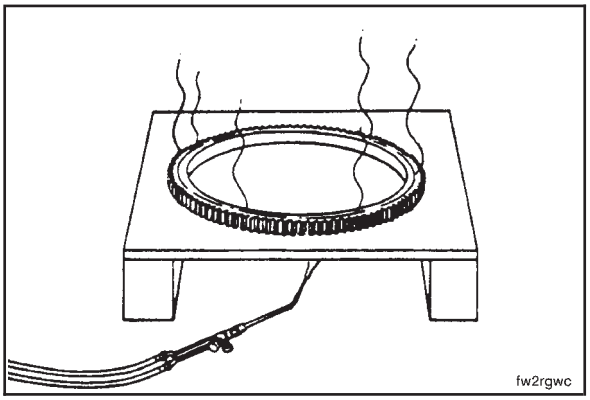
NOTE: Do **not** exceed the specified time or temperature.



If an oven is **not** available, use a heating torch to heat the gear. Use a Tempilstik® crayon, or equivalent, to check the temperature of the gear.

Temperature: 235°C [450°F]

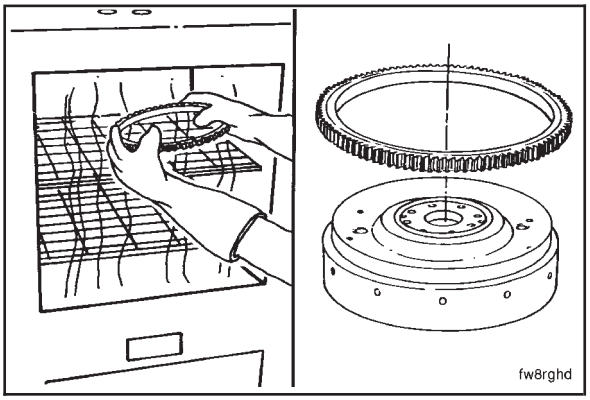
NOTE: A more even temperature is obtained by placing the ring gear on a metal plate, then heating the bottom side of the plate with the torch. Do **not** exceed the specified temperature.



Caution: Wear protective gloves when handling parts that have been heated to prevent personal injury.

Install the ring gear on the flywheel before it cools.

Allow the air to cool the gear. Do **not** use water or oil to reduce the cooling time.

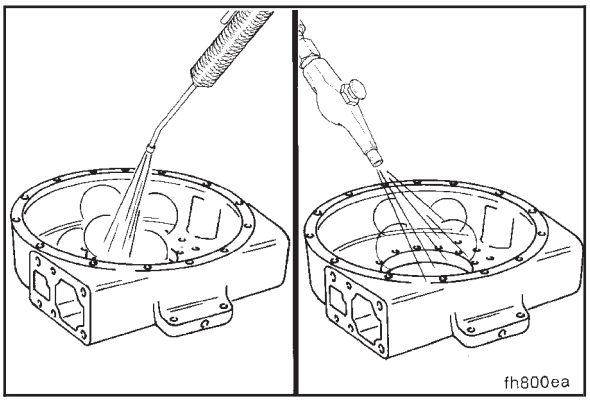


Flywheel Housing - Cleaning and Inspection for Reuse (16-03)

Cleaning

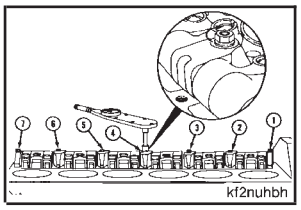
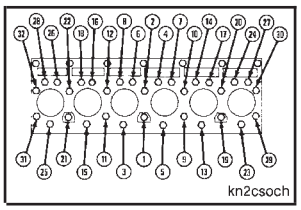
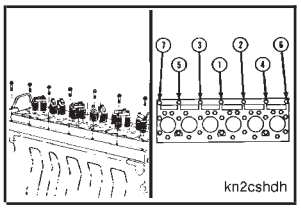
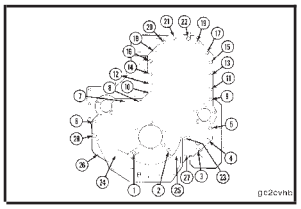
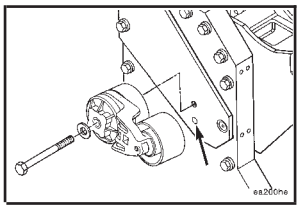
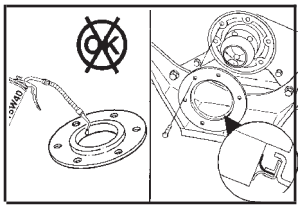
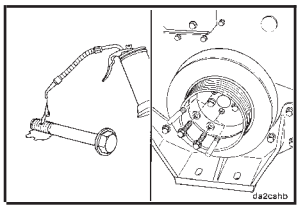
Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

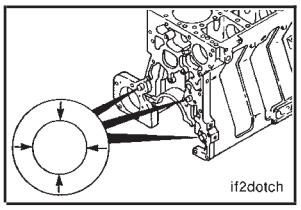
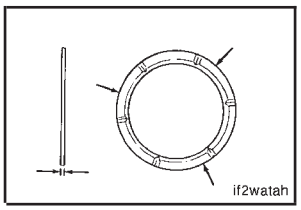
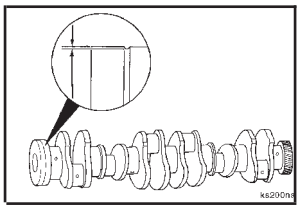
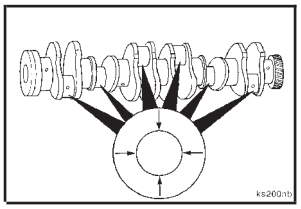
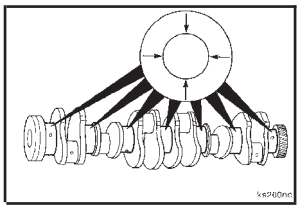
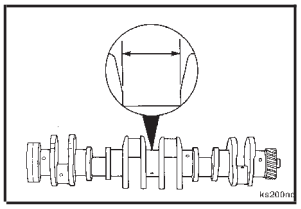
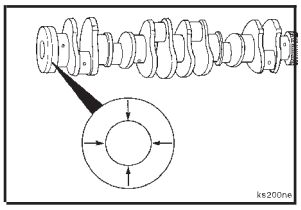
Use solvent or steam to clean the flywheel housing. Dry with compressed air.

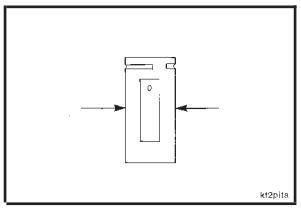
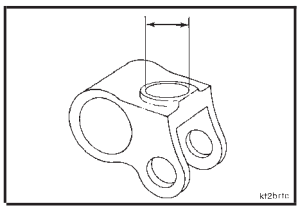
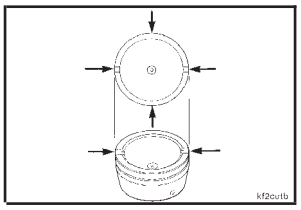


Section V - Specifications - Group 18

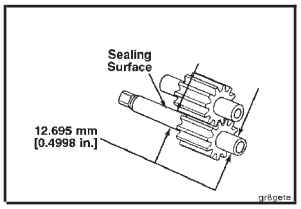
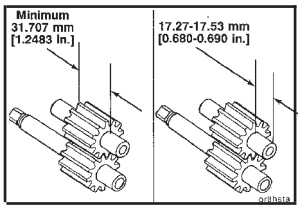
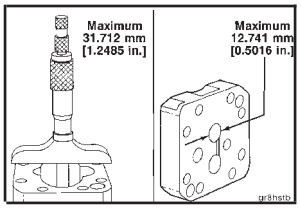
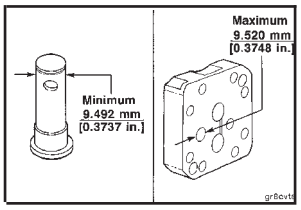
Section Contents

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
Cam Follower Support Nuts		47 N•m	35 ft-lb	 kf2nuhbh
Cylinder Head **Note:** Tighten the cylinder head capscrews in the sequence shown. **Note:** Rotate at least one flat, but not more than two.	1 2 3	136 N•m 217 N•m	100 ft-lb 160 ft-lb Rotate 90 Degrees	 kn2csoch
Cylinder Head (Fuel Pump Side) Tighten the capscrews in the sequence shown.		47 N•m	35 ft-lb	 kn2cshdh
Gear Cover Capscrews 1 through 22 Capscrews 23 through 28 **Note:** Tighten the capscrews in the sequence shown.		20 N•m 68 N•m	15 ft-lb 50 ft-lb	
Automatic Belt Tensioner		43 N•m	32 ft-lb	 ea200ne
Front Crankshaft Oil Seal	1 2	7 N•m 20 N•m	60 in-lb 180 in-lb	
Vibration Damper and Crankshaft Pulley **Note:** Tighten the capscrews in a star pattern.		203 N•m	150 ft-lb	 da2cshb

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.	
Idler Gear Ring Dowel O.D.		19.217 mm 19.243 mm	MIN MAX	0.7566 in 0.7576 in	
Idler Gear Thrust Washer Thickness		2.400 mm 2.470 mm	MIN MAX	0.0945 in 0.0972 in	
Crankshaft Rear Oil Seal Wear Groove		0.25 mm	MAX	0.0098 in	
Crankshaft Connecting Rod Journal O.D.		78.950 mm 79.013 mm	MIN MAX	3.1083 in 3.1107 in	
Crankshaft Main Bearing Journal O.D.		114.015 mm 114.055 mm	MIN MAX	4.4888 in 4.4903 in	
Crankshaft Thrust Face Width		49.975 mm 50.100 mm	MIN MAX	1.9675 in 1.9724 in	
Crankshaft Rear Oil Seal Flange O.D.		164.965 mm 165.035 mm	MIN MAX	6.4947 in 6.4974 in	

Component or Assembly (Procedure)	Ref.No./Steps	Metric		U.S.	
Cam Follower Roller Pin (New) O.D.		19.065 mm 19.073 mm	MIN MAX	0.7506 in 0.7509 in	
Cam Follower Lever Socket Bore I.D.		19.024 mm 19.050 mm	MIN MAX	0.7490 in 0.7500 in	
Cam Follower Lever Socket (New) O.D.		19.062 mm 19.088 mm	MIN MAX	0.7505 in 0.7515 in	

Fuel Pump - Rebuild Specifications

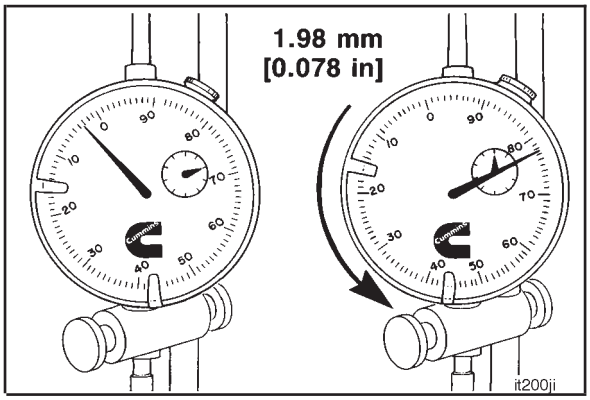
Gear Pump Shaft Bearing Surface O.D.		12.695 mm	MIN	0.4998 in	
Gear Width		31.707 mm	MIN	1.2483 in	
Gear Installed Depth		17.270 mm 17.533 mm	MIN MAX	0.6799 in 0.6903 in	
Note: Measure from the body end of the shaft.					
Body Gear Hole Depth		31.704 mm 31.712 mm	MIN MAX	1.2482 in 1.2485 in	
Body Shaft Bore I.D.		12.733 mm 12.741 mm	MIN MAX	0.5013 in 0.5016 in	
Body Regulator Bore I.D.		9.510 mm 9.520 mm	MIN MAX	0.3744 in 0.3748 in	

Injection Timing Codes

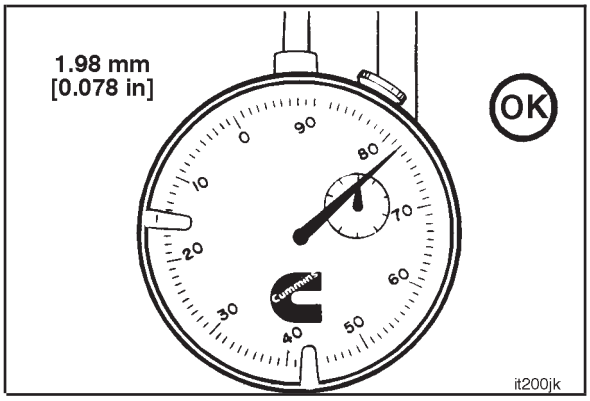
Note: Injection timing is measured at 5.161 mm [0.2032 inch] BTDC piston travel.

Timing Code	Push Rod Travel Range mm	Push Rod Travel Range in	Reference Camshaft Key Part No.	Key Configuration	Amount of Offset mm [in]
CELECT™					
HZ	-5.92 to -6.02	-0.233 to -0.237	3009953	Straight Key	0.000 [0.0000]

Read the push rod travel gauge **counterclockwise** from ''0''. This travel represents the injection timing value. In the example shown, the value is 1.98 mm [0.078 inch].



Injection timing can be changed by removing the camshaft gear and installing an offset key.



Section L - Service Literature

Section Contents