1. Assemble the stiffener plate on the block with **new** fasteners. Do NOT tighten the fasteners at this time.

NOTE

- The engine stiffening frame attaching fasteners are ONE TIME USE ONLY. New fasteners must be installed.
- The available tool, 9998649, can be used to hold stiffening frame in position while fasteners are started.

2. Install the oil pressure pipe and the crossover pipe before torque-tightening the stiffening frame.
3. Using a torque wrench, tighten the attaching fasteners in sequence according to specification.

Oil Pump Pipes and Strainer Installation

[219 MU, 219 NT]

1. Replace the O-rings on the oil pressure pipe, oil suction pipe and oil crossover pipe. Lubricate the O-rings with engine oil before installation.

NOTE

Separate the oil suction pipe from the oil strainer as needed to replace the O-ring. Clean and inspect the oil strainer, suction pipe, crossover pipe and pressure pipe for cracks. Replace if necessary.

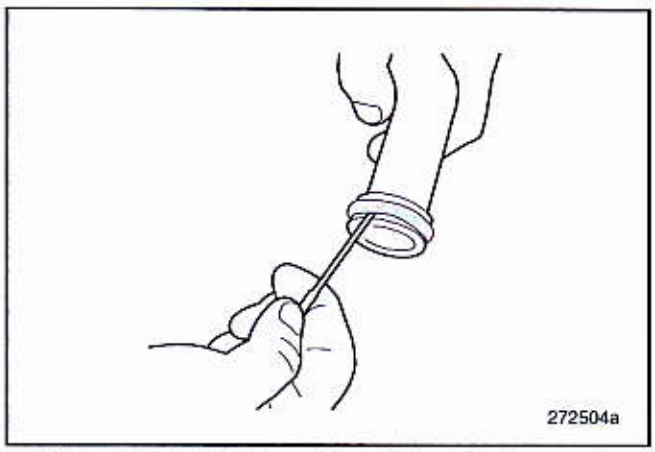


Figure 239 — Oil Pump Pipe O-Ring Replacement

2. Assemble the oil strainer, suction, pressure and crossover pipes into the pump as follows:
   - Slide the oil pressure pipe into the oil pump, position the pipe flange to the cylinder block, install the fasteners and torque-tighten to specification.
   - Position the oil crossover pipe to the skirts of the cylinder block, install the fasteners and torque-tighten to specification.
   - Assemble the oil strainer and oil pickup pipe. Slide the oil pickup pipe into the oil pump, position the oil strainer to the engine stiffening frame, install the fasteners and torque-tighten to specification.

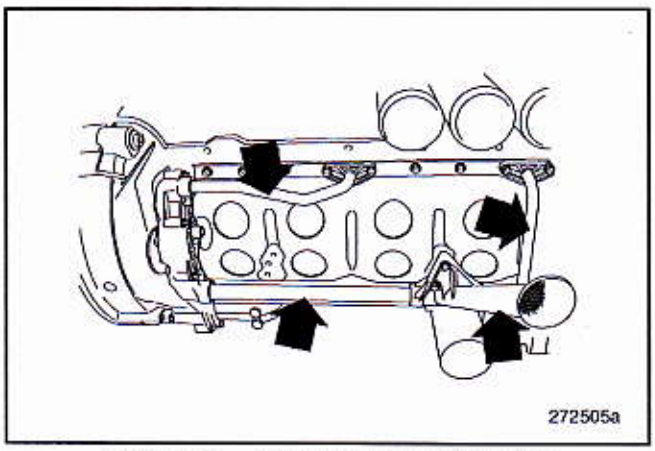


Figure 240 — Oil Pump Pipe Installation

Front Engine Support Installation

[299 GV]

1. If removed, assemble the front engine support mounting bracket to the cylinder block and tighten fasteners to specification.

NOTE

The bracket also serves as the A/C compressor mount.

2. Assemble the front engine support onto the block mounted brackets and install the six fasteners.
3. Using a torque wrench, tighten all fasteners in sequence to specification.

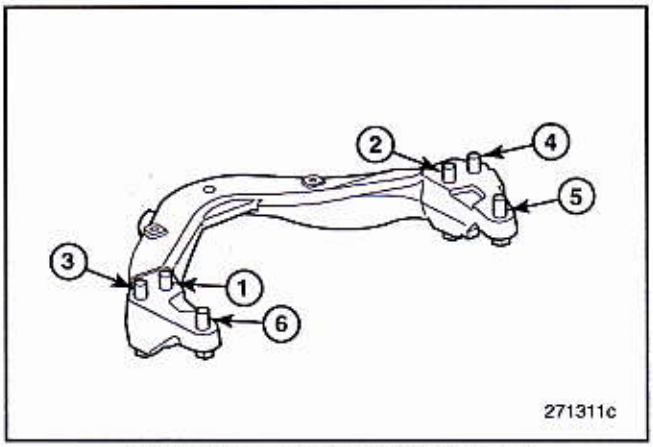


Figure 241 — Front Engine Support

Crankshaft Front Cover and Seal Installation

[211 JB]

1. Place the crankshaft front cover with spacer, 9998170, in the center on a flat surface. Install a **new** crankshaft seal with plastic ring in the crankshaft front cover. The spacer ring prevents the plastic ring from sliding off. Carefully tap the crankshaft seal into the front cover with drift, 88800021, and handle, 9992000, until the crankshaft seal is level with the front cover.

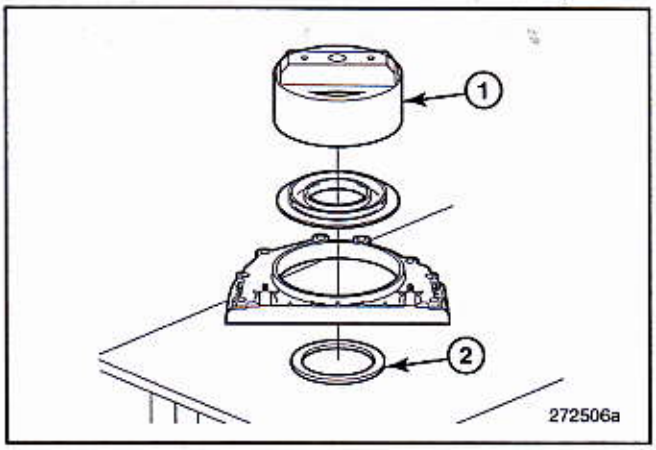


Figure 242 — Crankshaft Front Cover Seal Installation

1. Front Main Seal Remover/installer, 88800021	2. Plastic Spacer, 9998170

2. Apply a 2 mm (5/64 inch) bead of MACK-approved silicone sealant to the rear face of the cover according to the pattern shown.

NOTE

Make sure that the crankshaft front cover and block flanges are cleaned thoroughly before applying sealant.

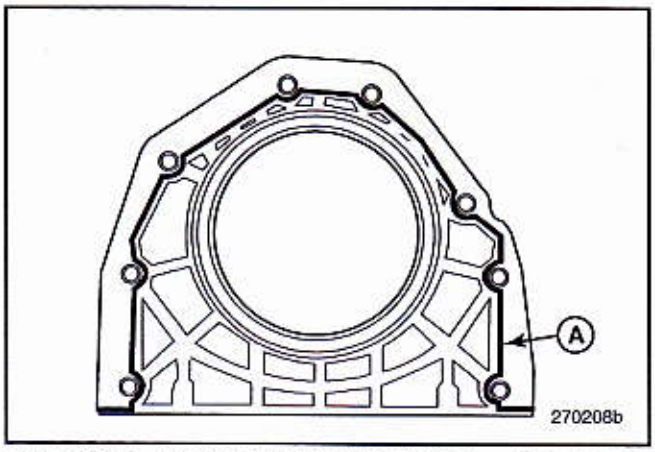


Figure 243 — Sealant Application Pattern — Crankshaft Front Seal Cover to Block

A. 2 mm (5/64 inch) bead of MACK-approved silicone sealant

3. Within 20 minutes of sealant application, install the front cover to the engine block. Center the crankshaft front cover against the crankshaft using the plastic ring.
4. Install the front cover. Note that there are two different types:

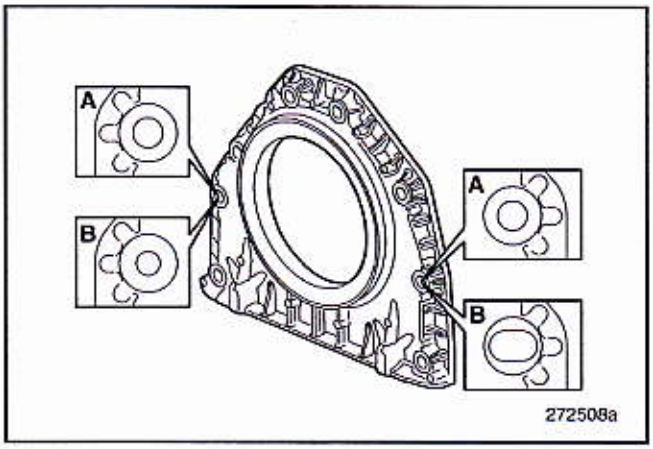


Figure 244 — Crankshaft Front Cover

- **For earlier type (A), the following installation instructions apply:**
  Install the bolts without tightening them. Using a straightedge rule, make sure the cover is flush with the lower edge of the engine block.
- **For later type (B), the following installation instructions apply:**
  Install the bolts in both bolt holes that align the cover to the correct position. Tighten by hand so that the cover is fixed. Install the remaining bolts.

NOTE

For the later type cover, the left-hand hole is smaller and the right-hand hole is oval. This change allows the later cover to be correctly aligned.

5. Using a torque wrench, tighten the capscrews in sequence according to specification.

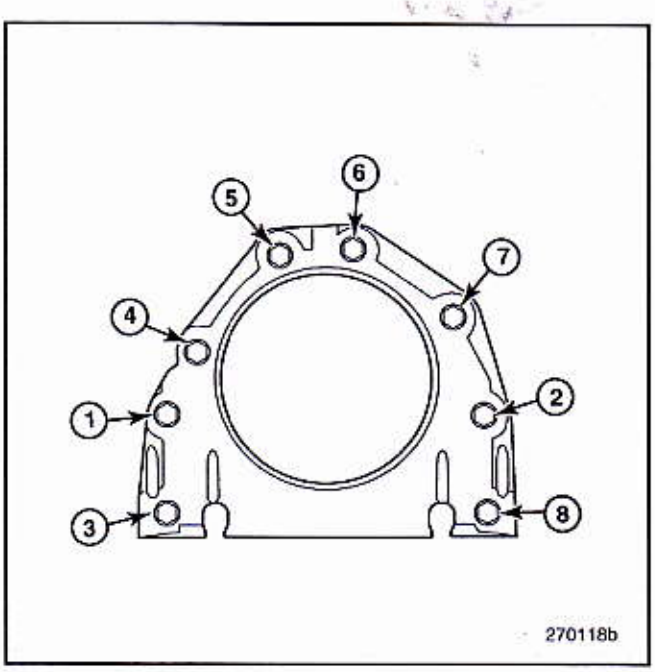


Figure 245 — Front Cover Torque Sequence

6. Remove the plastic ring from the crankshaft hub. Drive in the crankshaft seal with drift, 88800021, and handle, 9992000, until the drift bottoms against the crankshaft.

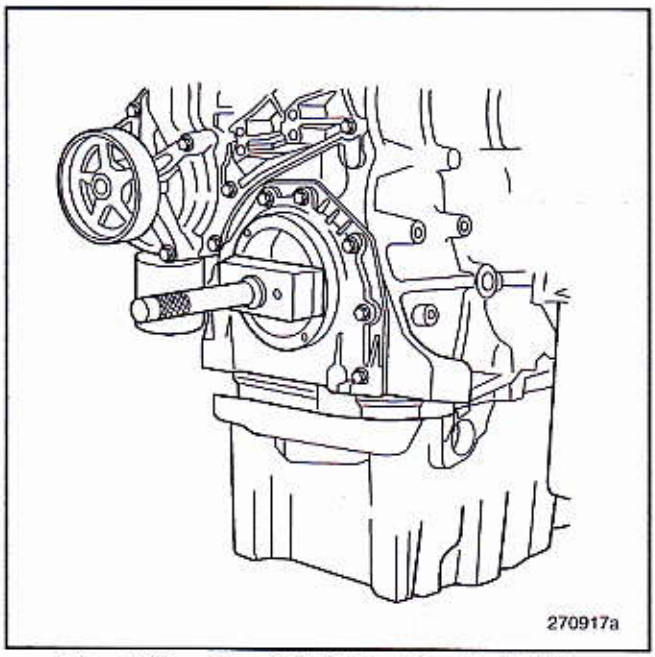


Figure 246 — Crankshaft Front Seal Installation

7. Remove the tool and check the seal to be sure it has been evenly installed.

Timing Gear Plate Installation

[211 AA]

NOTE

Rotate the engine block so the rear surface is at the top.

NOTE

If the cylinder head is installed after the timing gear plate is in place, do not apply sealant in the cylinder head area until ready to assemble the head on the block.

1. Clean the timing gear plate on both sides.
2. Clean the contact surfaces on the engine block and cylinder head. Remove sealing compound from the groove on the engine block side.
3. Apply a 2 mm (5/64 inch) bead of 342SX33 MACK approved silicone sealant (A) to the front face of the plate according to the pattern shown.

NOTE

Sealing compound must be applied **outside** the groove in the timing gear plate. This causes the excess compound to be forced down into the groove, which allows for better sealing.

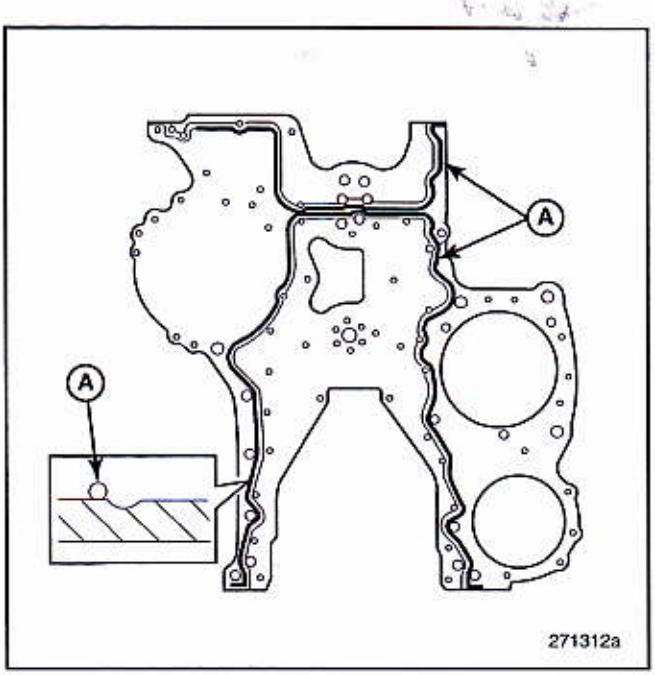


Figure 247 — Sealant Application Patterns — Head and Block to Plate

4. Within 20 minutes of the application of the sealant, assemble the timing gear plate over alignment guides, 9998267, that were installed into the block at disassembly.

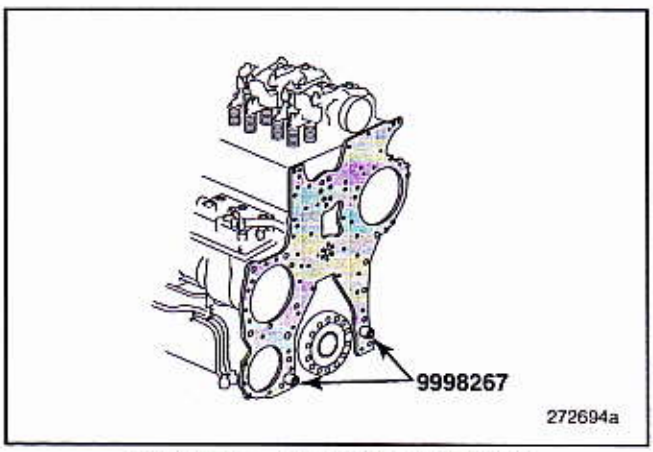


Figure 248 — Gear Plate Installation

5. With timing gear plate in position over guide pins, install **new** timing gear mounting attaching fasteners.

6. Using a torque wrench, tighten the attaching fasteners in sequence according to specification.

NOTE

Clean away excessive sealing compound before it dries.

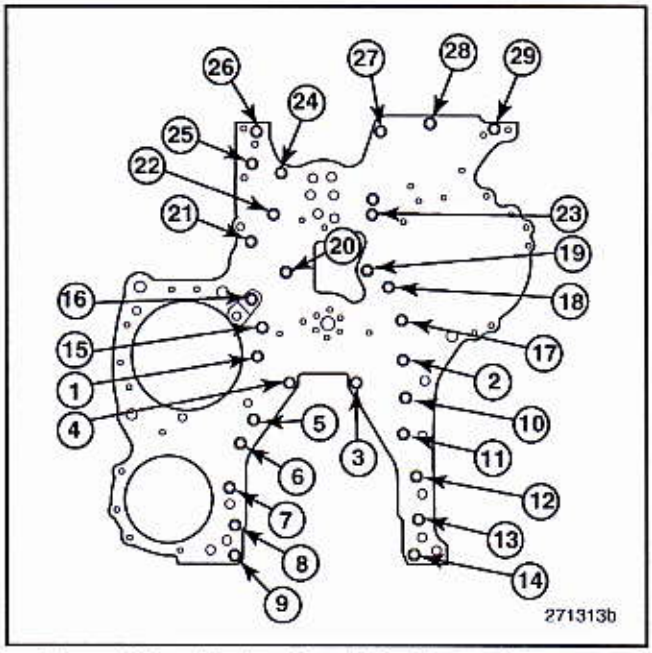


Figure 249 — Timing Gear Plate Torque Sequence

7. Install the compressor stud with a **new** sealing ring and **new** fastener.

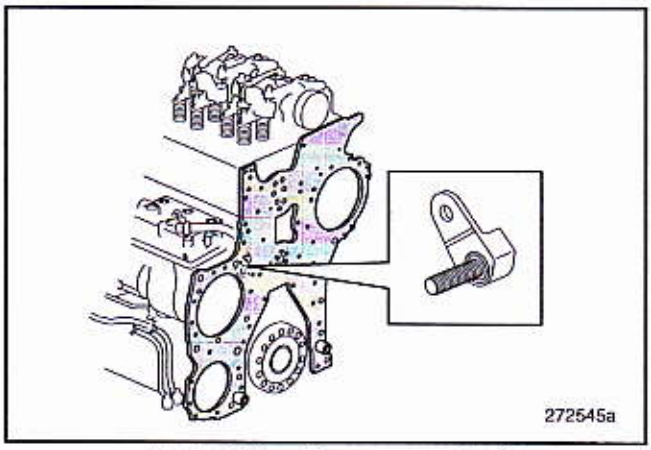


Figure 250 — Compressor Stud

8. Remove alignment guides, 9998267, from the timing gear plate.

Cylinder Head Installation [213 EV]

⚠ WARNING

The cylinder head is heavy. Do NOT attempt to install the cylinder head without the help of an assistant and the use of a suitable lifting device. Failure to heed this warning may result in severe personal injury and component damage.

NOTE

All MACK head gaskets are precoated and do not require any type of additional sealing compound.

1. If necessary, clean the unit injector copper sleeves with brush J 42885-9 and extension J 42885-1 with J 42885-25 installed to protect the fuel passages. These tools are available in kit J 42885.

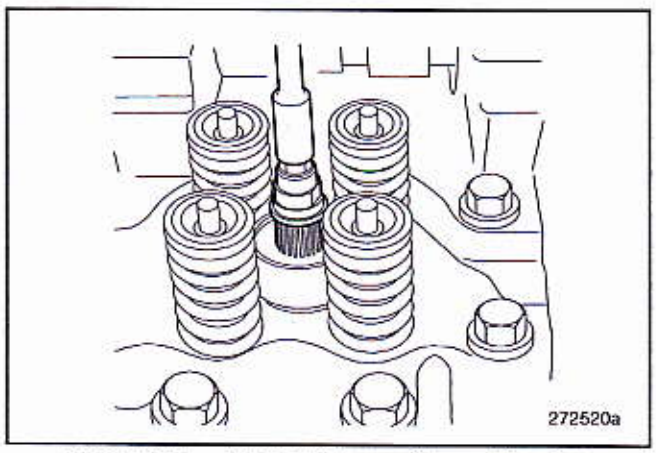


Figure 251 — Injector Copper Sleeve Cleaning

NOTE

With any cleaning of the unit injectors, **under no circumstances** may rotary wire brushes, hand wire brushes or similar tools be used on the injector nozzle. Use of such tools poses a risk that the injector holes could be damaged and blocked, causing power delivery problems. Instead, use a rag soaked in paraffin or equivalent.

2. Install fuel injector bore plugs, 9998251.
3. Ensure that the engine block and deck are clean and free from any dirt, grease or oil.
4. Carefully clean the cylinder head and install the head lifting tool, 88800188. Check that the guide washers on the engine block and cylinder head are clean and free of rust.

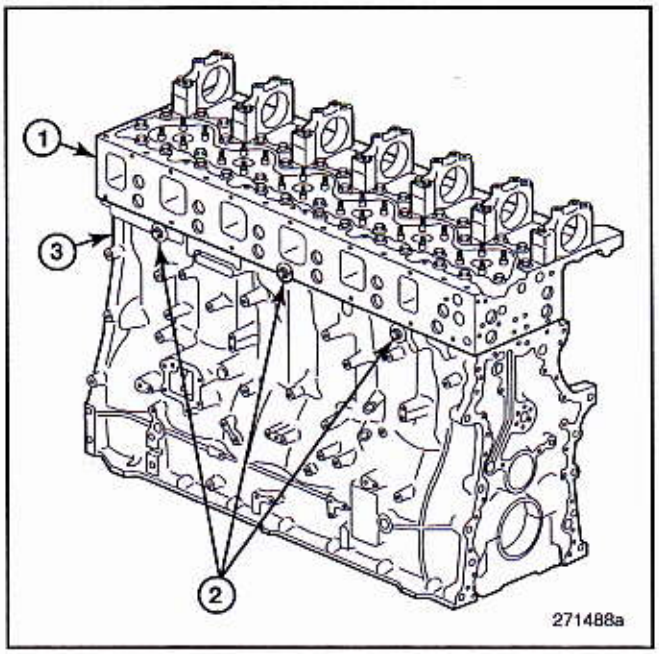


Figure 252 — Guide Washer Locations

1. Cylinder Head 2. Guide Washers	3. Cylinder Block

5. If in place, remove the cylinder liner clamping tools, 9996966, from the block.

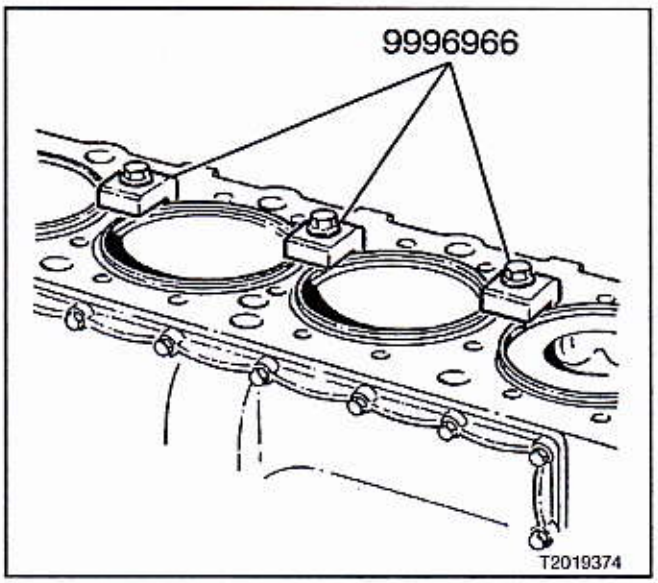


Figure 253 — Cylinder Liner Clamping Tools

6. Apply a 2 mm (5/64 inch) thick bead of silicone sealant to the surface at the side of the "track" on the timing gear plate (as shown in the illustration).

NOTE

The cylinder head must be installed and torque-tightened within 20 minutes after the sealant has been applied.

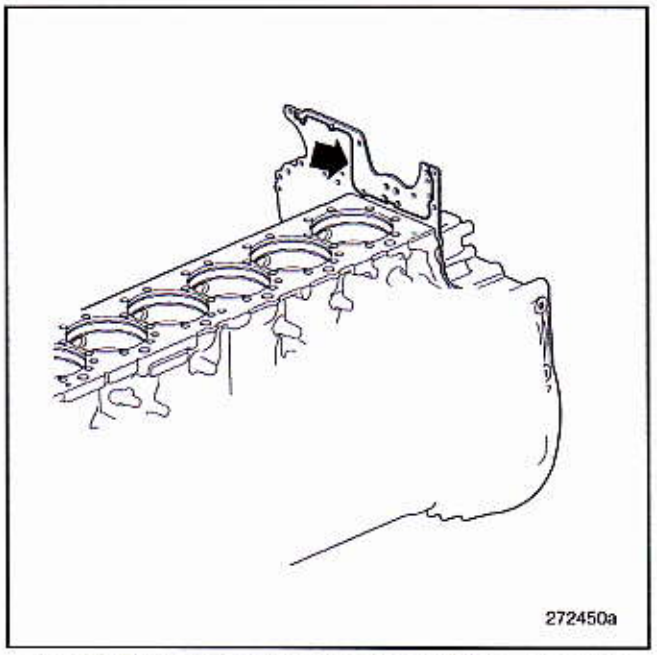


Figure 254 — Sealant Application Pattern — Head to Plate

7. Place a **new** head gasket on the engine block deck.

NOTE

- Check that the seals are correctly positioned with their holes all centered.
- There are points embossed in the gasket that will temporarily protect the seals from the head. These will be compressed when the head bolts are tightened.
- The head gasket should be discarded if the head is removed. A **new** gasket should be used when the head is installed.

8. Carefully lower the cylinder head about 9 mm (3/8 inch) forward of the gear mounting plate until it makes contact with the cylinder head gasket. Press the cylinder head against the timing gear cover and the guide washers at the left side. (There are two guide washers on the cylinder block and one on the cylinder head.)

NOTE

A three-step process is used for installation of the cylinder head.

a. It is first lowered onto the block deck and gasket, about 9 mm (3/8 inch) forward of the gear plate. As it is lowered, the guide washers ensure proper alignment of the cylinder head with the left side of the cylinder block.

b. Once lowered, screws inserted through the adjustable idler gear hub and plate are used to draw the cylinder rearward against the plate.

c. In the final step, the head bolts are inserted and tightened to specification, securing the cylinder head to the block.

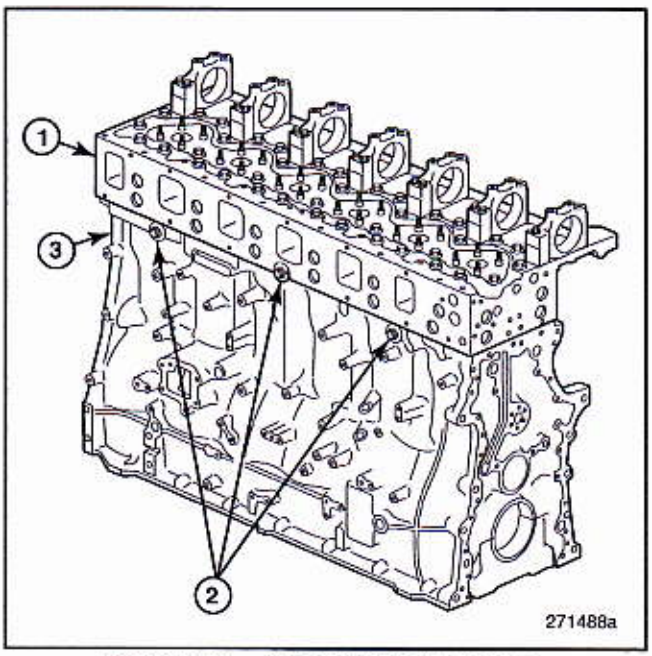


Figure 255 — Guide Washer Locations

1. Cylinder Head	2. Guide Washers 3. Cylinder Block

9. Temporarily install the adjustable idler gear hub and insert bolts through the timing gear plate and the adjustable idler gear hub. Tighten the bolts to 85 ±15 N•m (63 ±11 lb-ft) to draw the cylinder head toward the plate.

NOTE

If not loosened, there is a risk that the bolts will break when the cylinder head bolts are tightened.

10. Check the condition of the cylinder head attaching capscrews and lubricate the heads (underside) and threads with clean engine oil.

NOTE

Do NOT oil the threads in the block.

11. The cylinder head capscrews must **not** be used more than five times. Mark the cylinder head capscrews by punching them.

12. Insert four cylinder head capscrews into locations 24, 26, 28 and 30. Tighten the capscrews to specification.

13. Remove the cylinder head lifting bracket.

14. Torque-tighten and angle-tighten all cylinder head capscrews in sequence to specification.

15. Install the fasteners securing the timing gear plate to the rear of the cylinder head. Tighten the fasteners to specification.

16. Ensure that the crankshaft is at the top dead center (TDC) position and assemble the camshaft, camshaft gear and damper according to the instructions under *Timing Gear Train Installation.*

Camshaft Installation

[213 CH]

⚠ WARNING

The camshaft is heavy. Do NOT attempt to install the camshaft without the help of an assistant or the use of a suitable lifting device. Failure to heed this warning may result in severe personal injury and component damage.

1. If removed, install the camshaft bearing saddles to the original positions. Carefully tap the bearing saddles onto the guide pins using a soft-faced hammer until fully seated.
2. Insert the camshaft lower bearings and apply a generous coating of clean engine oil to the camshaft bearings.
3. Make sure there is a bearing insert on each lower bearing saddle. The bearing inserts at the No. 7 camshaft journal have integral thrust washers.

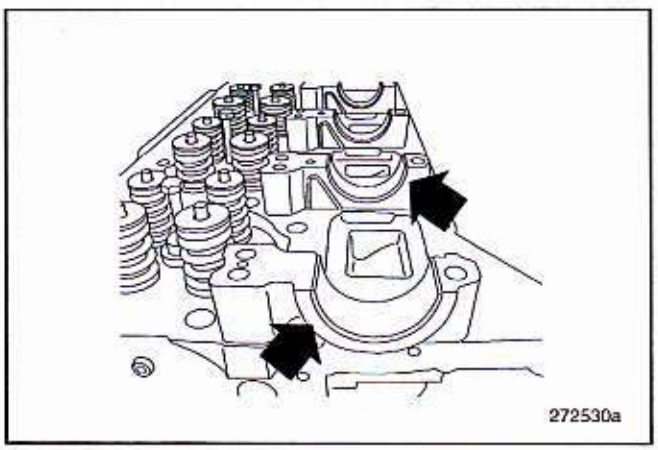


Figure 256 — No. 7 Camshaft Lower Bearing Insert

4. Clean and inspect the camshaft using solvent and compressed air.
5. Lower the camshaft carefully into place on the lower bearing saddles and remove the lifting tool, 85109034. Rotate the camshaft by hand to ensure the camshaft is not binding on the lower bearing saddles.

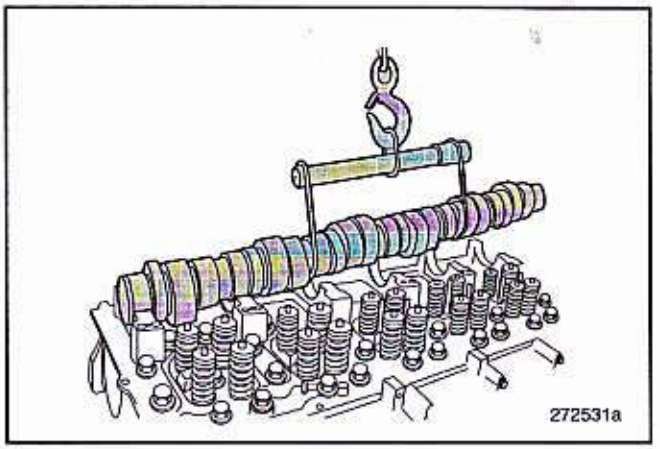


Figure 257 — Camshaft Installation

6. Install the camshaft upper bearing inserts into the camshaft bearing caps, lubricate the bearings and install the bearing caps to the respective bearing saddles. Use a soft-faced mallet to seat the bearing caps over the dowel pins.
7. Insert and hand-tighten the exhaust side bearing cap bolts and tighten to specification. Final tightening to the specified torque value will be done later when the rocker arm shaft is installed.
8. Install the bearing cap press tool (two required) at the number 7 and the number 1 bearing caps as shown in the illustration.

NOTE

The tool is used when adjusting the timing gear backlash when the rocker shaft assembly is not installed.

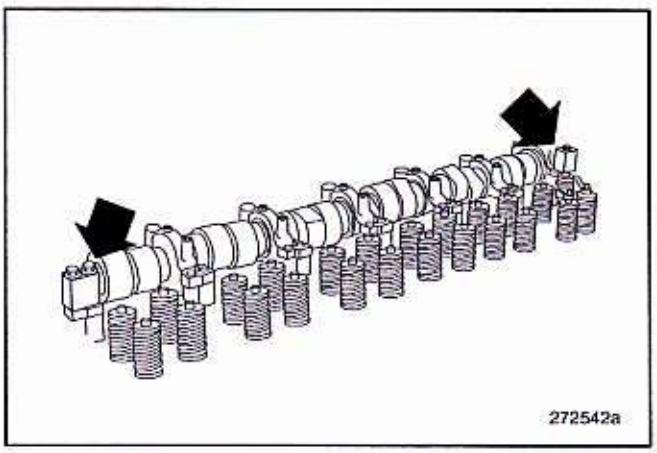


Figure 258 — Bearing Cap Press Tool

Timing Gear Train Installation

NOTE

Apply a light coat of clean engine oil to all parts before assembly.

⚠ CAUTION

DO NOT overtighten the mounting flange fasteners when installing any of the gears in the timing gear train. Overtightening the fasteners can cause stripped threads in the cylinder block.

1. Assemble a **new** O-ring on the crankshaft rear hub.
2. Apply a film of oil to the O-ring and assemble the crankshaft gear on the crankshaft hub.

NOTE

Leave two fasteners loose enough to aid in turning the crankshaft with a lever for gear alignment purposes.

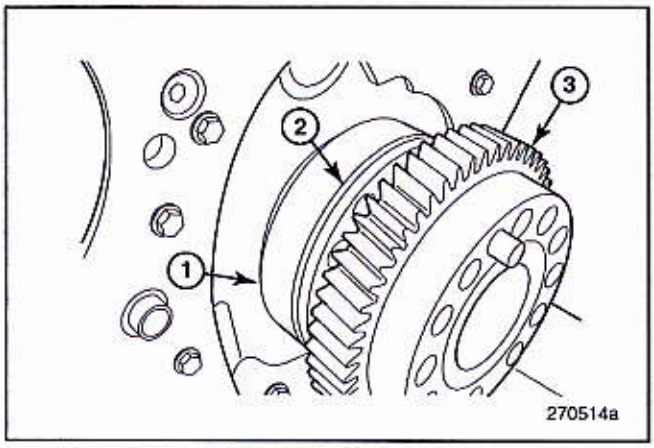


Figure 259 — Crankshaft Gear-to-Hub Assembly

1. Crankshaft Rear Hub 2. O-Ring	3. Crankshaft Gear

3. Assemble the adjustable idler gear (item 3 in Figure 260), hub, bushing, thrust washer and fasteners on the plate. Hand tighten the fasteners.

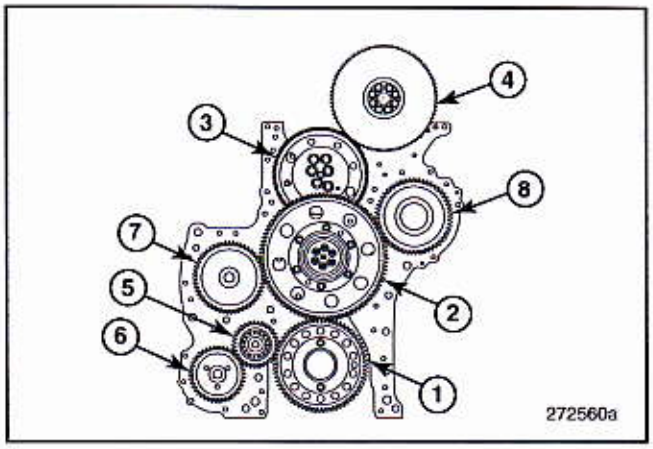


Figure 260 — Adjustable Idler Gear

1. Crankshaft Gear 2. Intermediate Idler Gearset 3. Adjustable Idler Gear 4. Camshaft Gear	5. Lower Idler Gear 6. Tandem Pump Drive Gear 7. Air Compressor Drive Gear 8. PTO Drive Gear

4. Check that the camshaft is positioned at TDC.

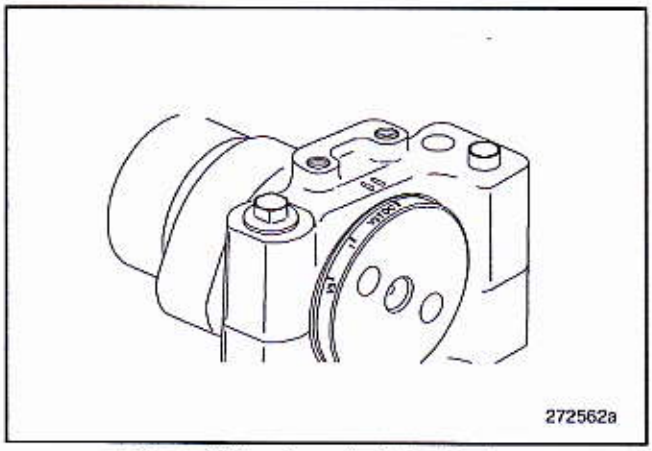


Figure 261 — Camshaft Positioning

5. Align the punch marks on the camshaft gear teeth to straddle the alignment hole in the timing gear plate and install the camshaft gear without the damper as shown in Figure 262. Install the clamp plate tool, J 44514-1A, using **Position B** of the gauge plate tool to secure the camshaft gear to the camshaft and loosely install the two retaining bolts.

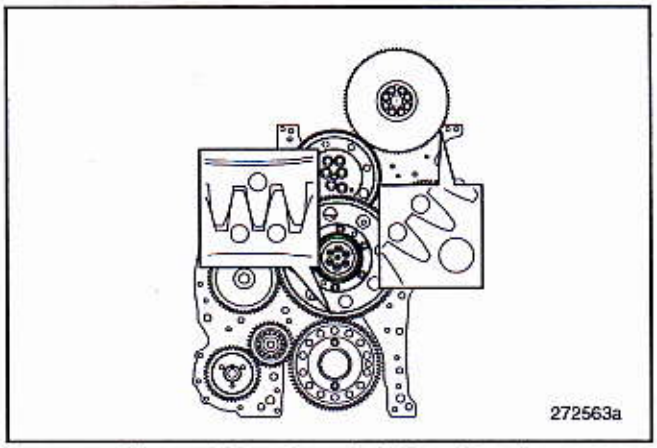


Figure 262 — Camshaft Gear Check

6. Insert the alignment tool J 47450-1, into the hole in the cylinder head to engage the camshaft gear teeth with the rod of the tool in the slot of the clamp tool. It may be necessary to rotate the camshaft until this occurs. With the alignment pin properly positioned in the clamp plate slot, check that the camshaft TDC mark is still positioned between the two timing marks on the bearing cap.

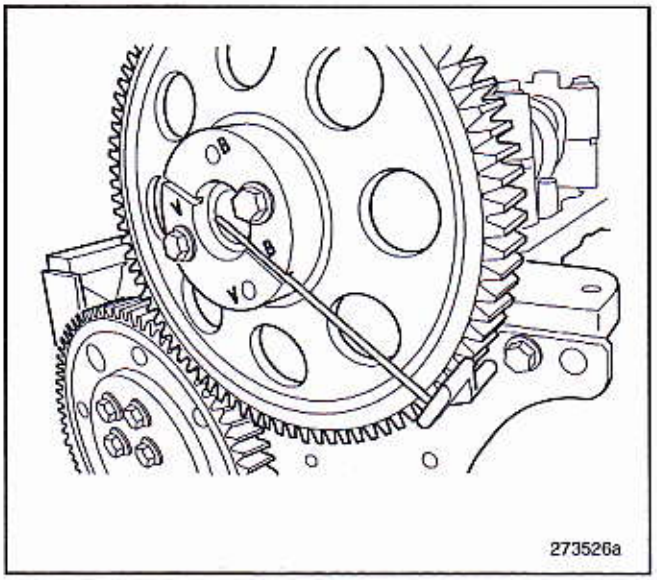


Figure 263 — Camshaft Gear Timing Marks Alignment

7. Remove the alignment pin and clamp plate tool from the camshaft gear and install the vibration damper and clamp plate using **new** fasteners. Tighten the fasteners to specification.

NOTE

Mark the bolts to aid in tightening the bolts to the degree rotation specification.

8. Insert a 0.1 mm (0.004 inch) thickness gauge. Adjust the idler gear so that there is slight pressure on the thickness gauge. Tighten the bolts by hand only.

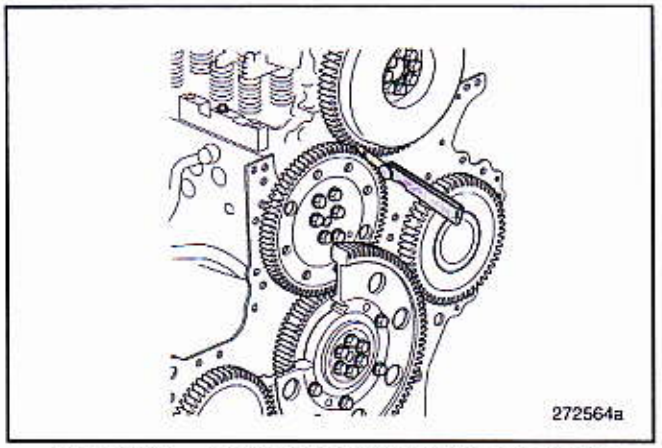


Figure 264 — Camshaft Thickness Gauge Check

9. Remove the thickness gauge.

NOTE

There should be a slight resistance on the thickness gauge when removed.

10. Install the J 44514-5 clamp assembly tool to the timing gear plate. Screw the hold-down against the adjustable idler gear so the adjustable idler gear does not rotate.

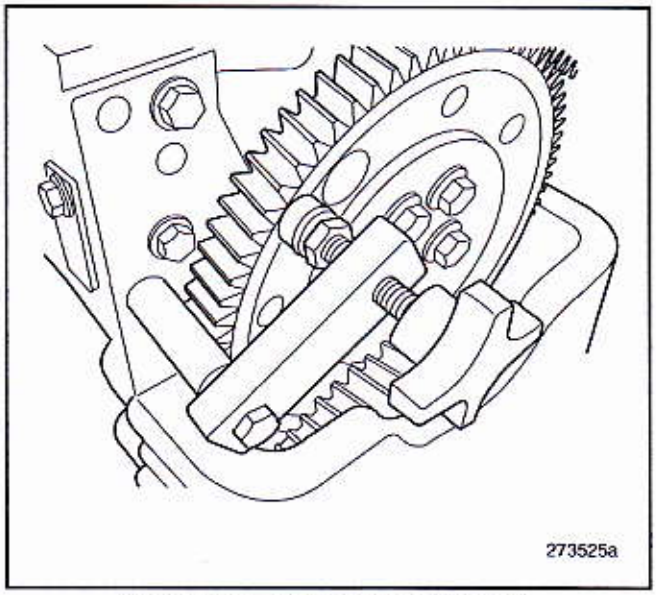


Figure 265 — Clamp Assembly Tool

11. Install the magnetic stand, 9999696, and dial indicator, 9999683, so that the tip of the dial indicator rests on a tooth of the camshaft gear.

    Check the gear backlash by rotating the camshaft gear back and forth slightly to measure the backlash. For backlash specification, refer to the SPECIFICATIONS section.

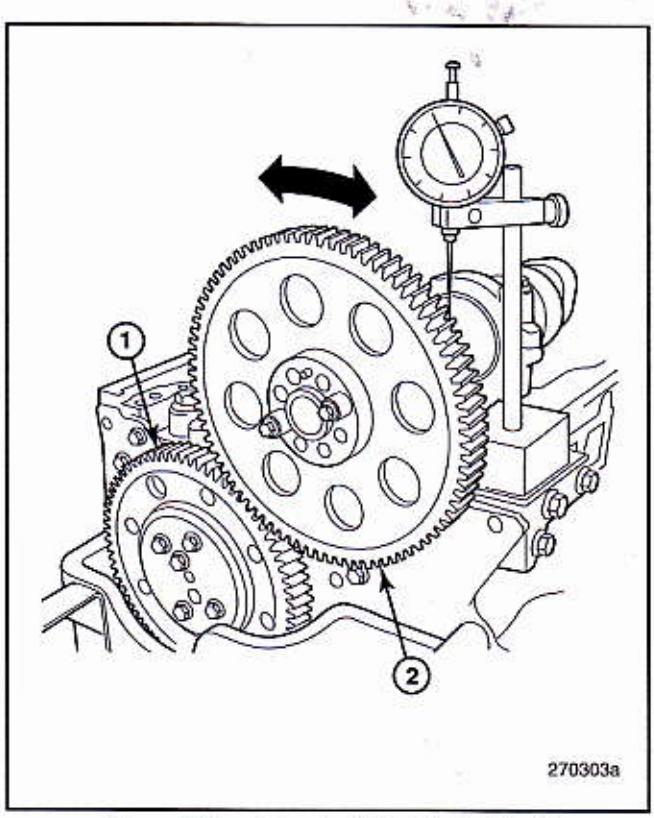


Figure 266 — Camshaft Backlash Check

1. Idler Gear	2. Camshaft Gear

12. If the backlash measurement is out of specification, adjust the gear flank clearance as follows:

    a. Loosen the J 44514-5 clamp assembly tool from the adjustable idler gear hub.

    b. Loosen the adjustable idler gear hub screws slightly. Loosening the hub screws will allow the idler gear to be moved slightly in/out from the camshaft gear.

    c. Insert a 0.1 mm (0.004 inch) thickness gauge on the pressure side of the adjustable idler gear tooth and camshaft gear tooth by using feeler gauge holder J 44935 and J 44514-6 feeler gauge.

    d. While holding the adjustable idler gear in against the thickness gauge and camshaft gear, tighten, but DO NOT torque the adjustable idler gear hub fasteners.

    e. Reinstall and tighten the J 44514-5 clamp assembly tool against the adjustable idler gear.

f. Remove the feeler gauge from the adjustable idler gear and camshaft gear.

g. Recheck the backlash. With the specified backlash attained, replace each adjustable idler gear hub screw with **new** and tighten the screws to specification one at a time so the attained backlash is not disturbed.

13. Install the intermediate idler (double idler) gearset (2) to the timing gear plate, using **new** fasteners.

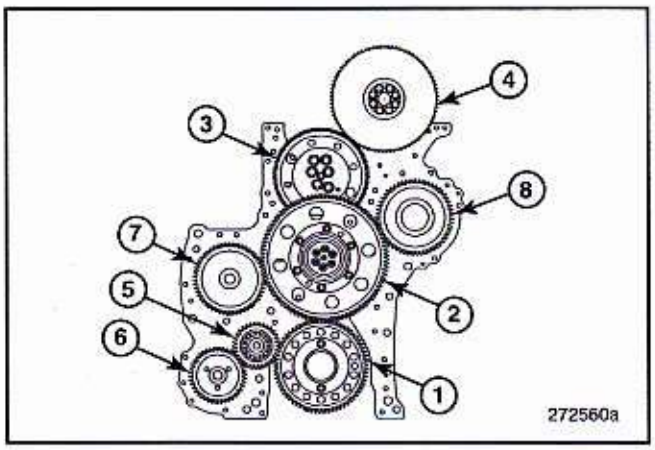


Figure 267 — Intermediate Idler (Double Idler) Gearset

1. Crankshaft Gear	5. Lower Idler Gear
2. Intermediate Idler Gearset	6. Tandem Pump Drive Gear
3. Adjustable Idler Gear	7. Air Compressor Drive Gear
4. Camshaft Gear	8. PTO Drive Gear

14. Check that the idler gear marking aligns with the markings on the crankshaft gear teeth.

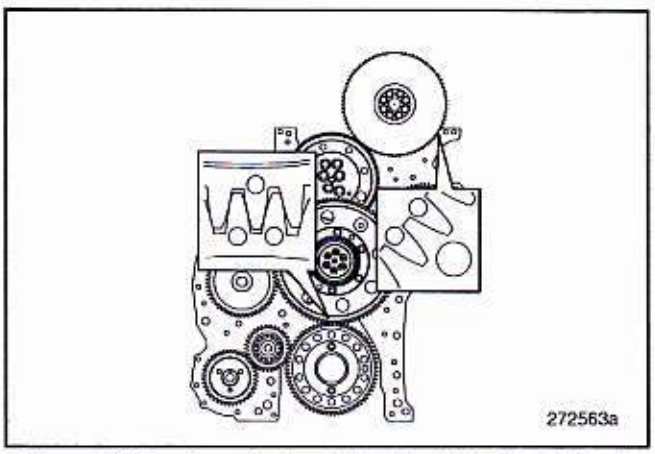


Figure 268 — Camshaft and Double Idler Gear Check

15. Tighten the intermediate gearset (double idler) mounting bolts in sequence to specification.

16. Install the auxiliary idler gear onto the timing gear plate.

17. Remove the bearing cap press tools, 85109208.

Unit Injector Installation [221 GP]

NOTE

If a unit injector is reused, it must be fitted to the bore from which it was removed.

1. If not previously performed, install protective sleeve, J 42885-25, and clean the unit injector copper sleeve with the appropriate brush and extension.

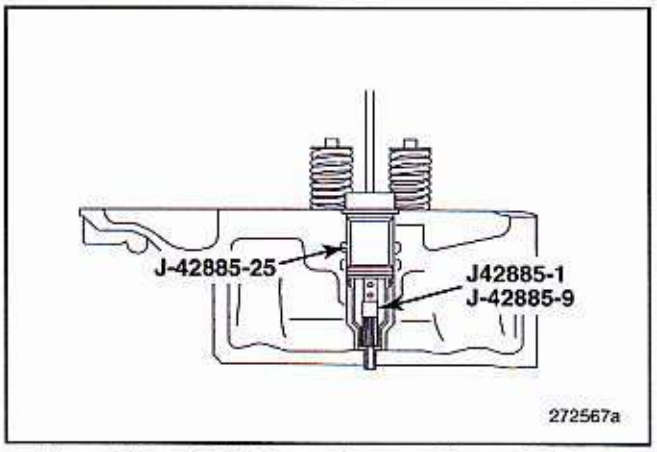


Figure 269 — Unit Injector Copper Sleeve Cleaning

NOTE

After cleaning the copper sleeve, carefully inspect the inside surface of the sleeve, especially the bottom surface where the injector seal is located. Any remaining contamination is unacceptable and must be removed. Also, if there is any indication of a discrepancy that raises concern about suitability of the sleeve for reuse, replace it with a **new** sleeve.

2. Before reusing an injector, cleaning is required to ensure suitability for reuse. Before doing any cleaning, the injector fuel inlet and outlet ports and the electrical connector opening must be covered to prevent contamination from the cleaning process. Also, there must be no lower O-ring installed in the injector. Refer to "UNIT INJECTOR CLEANING" on page 244 for further information.
3. Remove the bore protection sleeve, 9998251.

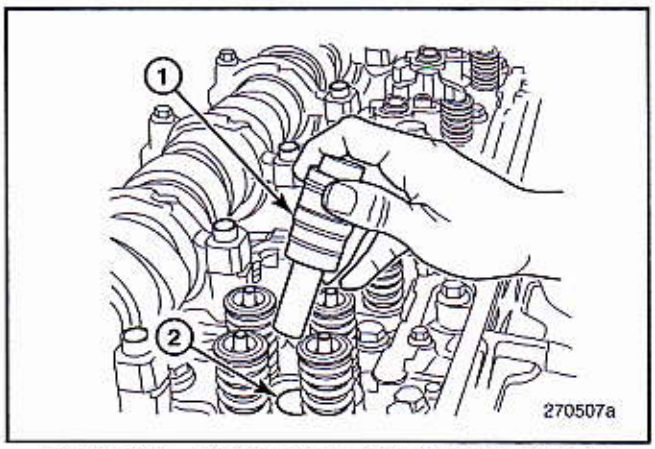


Figure 270 — Unit Injector Bore Protection Sleeve

1. Unit Injector Protection Sleeve, 9998251	2. Unit Injector Bore

4. Install **new** O-rings on the unit injector as follows:
   - Upper ring — large diameter, violet
   - Lower ring — small diameter, violet
5. Lubricate both O-rings and the cylinder head injector bore with clean engine oil.
6. Install a **new** injection nozzle gasket (flat washer) on the injector, using hand force to push it over the tip and down until it is fully seated against the bottom of the injector. DO NOT use grease or any other material to secure the gasket to the injector; the gasket must be installed dry. Three small projections (grippers) on the inside diameter of this gasket retain it to the injector during installation.

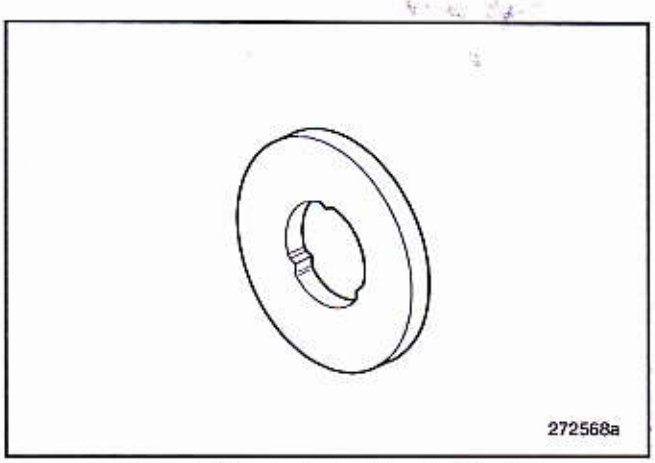


Figure 271 — Injector Nozzle Gasket

NOTE

Some early production MP8 engines used the original design copper sleeves with integral "raised bead" at the bottom of the copper sleeve. This design does NOT use a gasket (flat washer) between the injector tip and the copper sleeve. These original raised-bead design copper sleeves can be identified by a single groove, or no groove at all around the upper circumference.

The current production "flat-bottom" design copper sleeves, which require the gasket (flat washer) at the injector tip, can be identified by two grooves around the upper circumference of the sleeve.

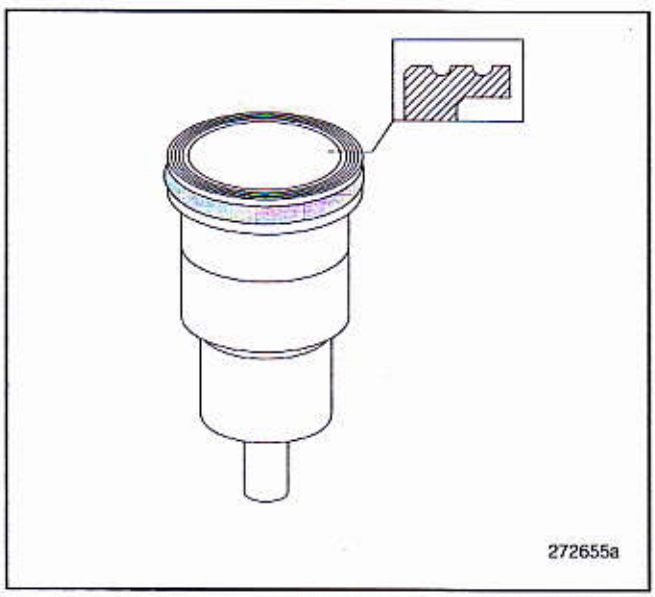


Figure 272 — Copper Sleeve (Shown Removed for Clarity)

NOTE

A revised gasket (flat washer) having a thin black rubber coating for improved sealing was implemented in production beginning mid-August 2008. Service replacement gaskets now have the rubber coating. DO NOT remove the rubber coating.

The gasket (flat washer) is preassembled on new injectors.

7. Slip the injector hold down and a **new** screw of correct length onto the unit injector.

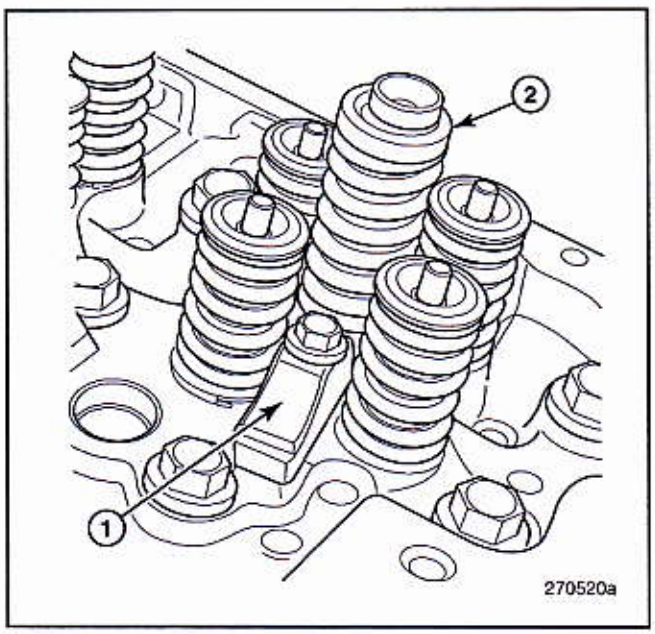


Figure 273 — Unit Injector Retainer

1. Injector Hold-Down Yoke	2. Unit Injector

8. Make sure that the injector is reinstalled to the same cylinder from which it was removed (or injector trim codes will need to be reprogrammed in the EECU).
9. Center the unit injector between the valve springs and then push down on the unit injector using hand pressure to seat the O-rings. Hand tighten the **new** hold-down screw.

NOTE

The unit injector hold-down screw must be replaced whenever it is removed from the hold-down and cylinder head

10. Ensure that the injector electrical connector is central between the valve springs with equal space on both sides. If the harness is installed, plug in the injector electrical connector until fully engaged. Push in the connector until you hear a distinct "click".

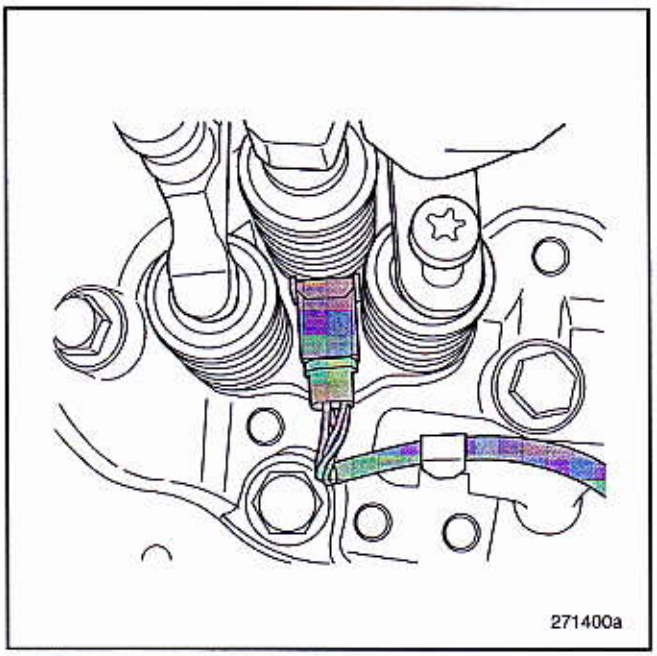


Figure 274 — Electrical Connector for Unit Injector

11. Using a torque wrench, tighten the hold-down screw in stages to specification.
12. When replacing unit injectors, the control unit must be programmed with the new injector's trim codes. The code is printed on top of the unit injector electrical connector. The programming is performed using VCADS/TT and is necessary to ensure that engine timing and emission levels are correct.

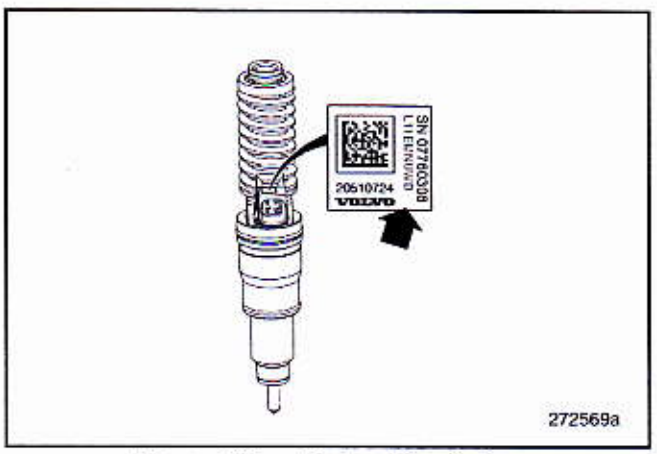


Figure 275 — Injector Trim Codes

NOTE

- Due to the Engine Electronic Control Unit (EECU) self learning capability, it is necessary to reset learned EECU parameters after servicing some engine-related components. This allows the EECU to learn the new component's behavior. After servicing is complete, perform the "Learned Data Reset" located in VCADS/TT.
- If reinstalling an injector into the same location, reprogramming is not required.

13. Repeat the installation steps for the remaining injectors.

Valve Yoke (Bridge) Installation

[213 NV]

NOTE

Used yokes have established wear patterns. Yokes being returned to service must be installed in the same cylinder location from which they were removed.

1. Lubricate the tip of a valve stem with a small drop of clean engine oil.
2. Lubricate the yoke sockets with a small drop of clean engine oil in each one.

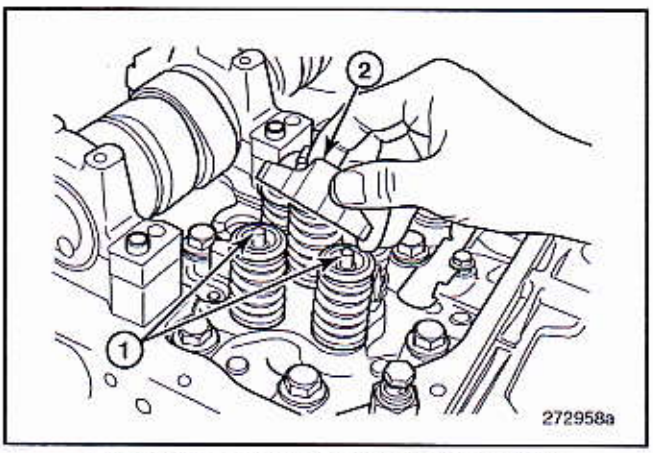


Figure 276 — Installing the Inlet Valve Yoke

1. Valves	2. Valve Yoke

3. Set the yokes on their respective valve stems. Make sure that they are properly seated.

Rocker Arm Shaft and Engine Brake Installation

[213 LP]

1. Oil the valve yokes and the camshaft lobes with engine oil.
2. Using the lifting tool, 85109250, and an assistant, place the shaft with rocker arms in position on the inboard side of the camshaft bearing caps.

NOTE

On engines with an engine brake, the exhaust rocker arm includes an integral valve and piston.

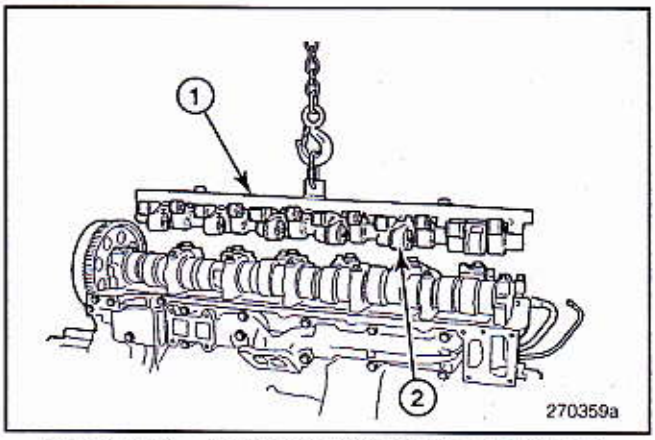


Figure 277 — Rocker Shaft Assembly Installation

1. Lifting Tool, 85109250	2. Rocker Shaft Assembly

3. Remove the lifting tool. Then, install and tighten the rocker arm shaft bolts a little at a time, evenly across the entire shaft so that the shaft does not become distorted, bent or fractured.

NOTE

Make sure that the rocker arm shaft is seated properly in the guide dowels of the camshaft bearing caps. On engines equipped with an engine brake, remove the restraints (rubber bands or tie straps) securing the exhaust rocker arm pistons.

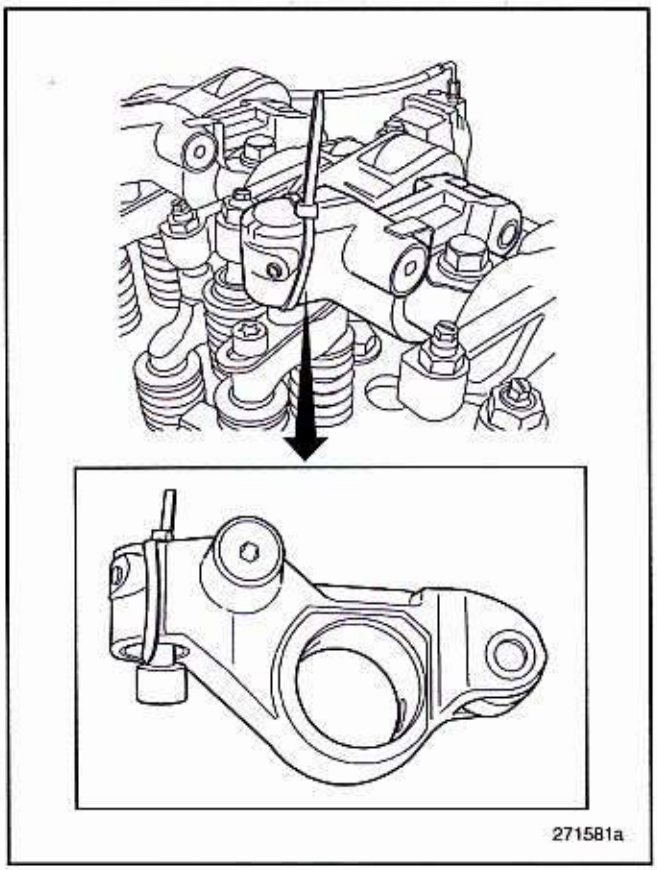


Figure 278 — Engine Brake Restraint

4. Lubricate the rocker arm rollers.
5. Insert the long fasteners (Nos. 8–20 in Figure 279) through the shaft, camshaft bearing caps and into the cylinder head.

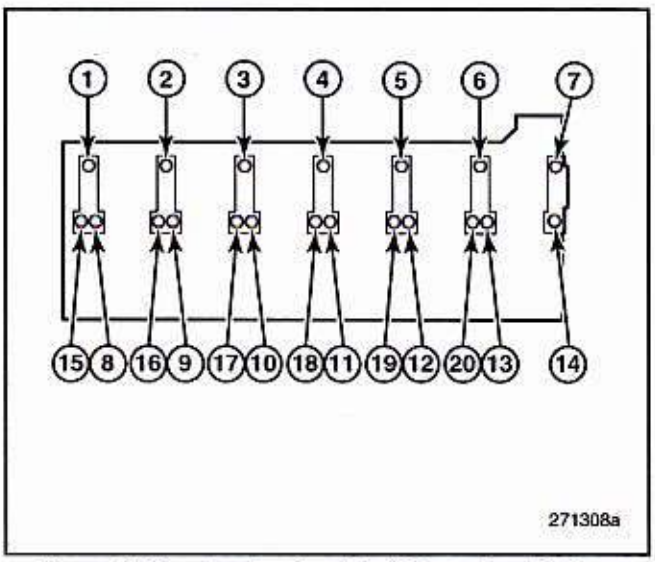


Figure 279 — Rocker Arm Shaft Screw Installation Sequence

6. Insert all remaining fasteners into the rocker arm shaft.
7. Torque-tighten and angle-tighten all camshaft bearing cap and rocker arm shaft bolts in sequence according to specification.

NOTE

The bolts have limited reusability and must be marked (A) with a punch each time they are installed in service. Bolts with four punch marks when removed have been tightened five times and must be discarded.

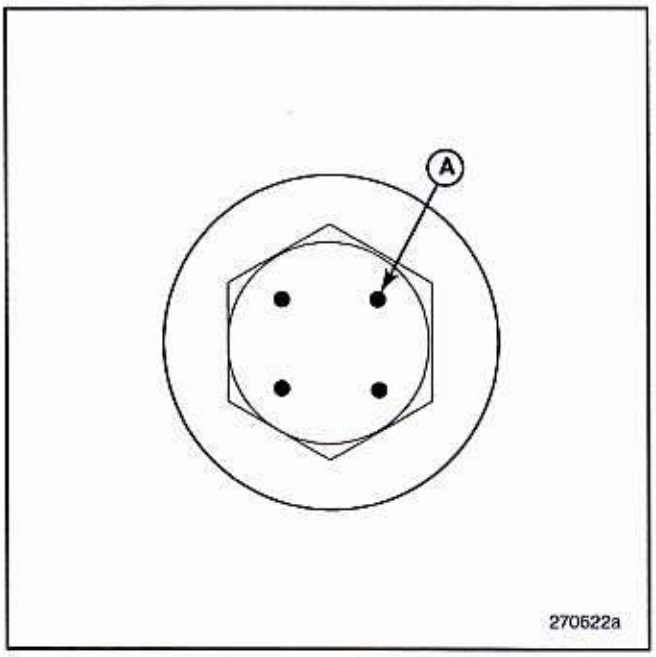


Figure 280 — Usage Marks on Rocker Fasteners

8. Replace the O-ring at the bottom of the engine brake control valve (if equipped with engine brake) or oil flow adapter.

NOTE

On engines without the engine brake, an oil flow adapter is used in place of the oil control valve. It is mounted in the same location on the cylinder head and is installed in the same manner as the engine brake control valve in steps 8 through 13. The adapter provides oil to the rocker shaft.

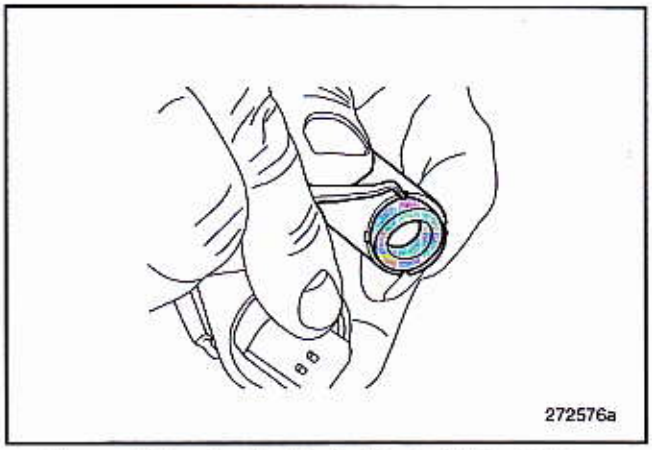


Figure 281 — Engine Brake Control Valve O-Ring

9. Clean the engine brake control valve oil pipe and replace the O-rings. Lubricate the pipe hole in the rocker arm shaft and the O-rings on the pipe.

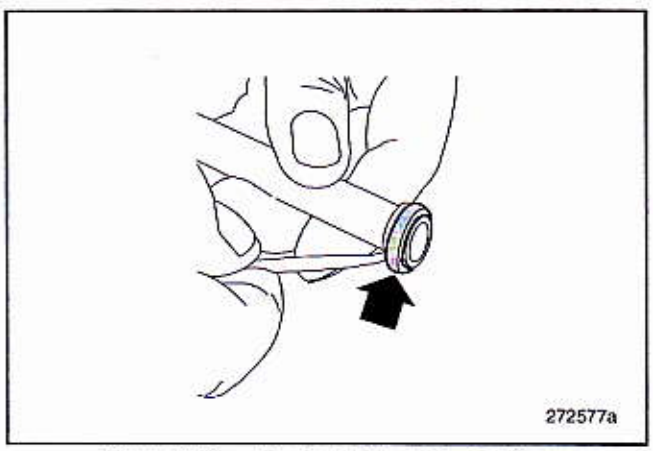


Figure 282 — Control Valve Pipe O-Ring

10. Insert the oil pipe into the oil hole of the engine brake control valve.

NOTE

Make sure that the O-ring is seated fully in the valve.

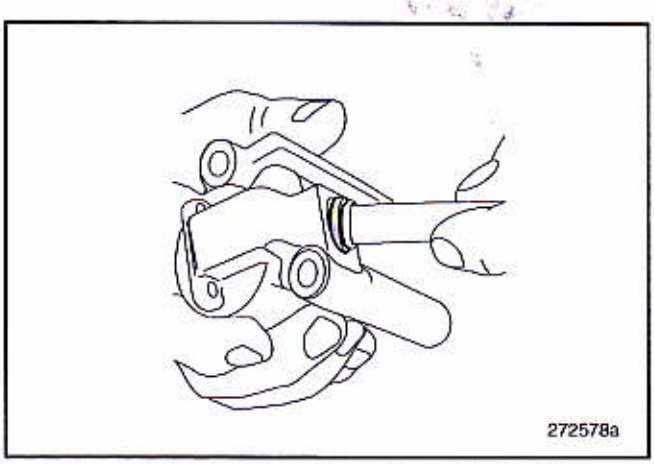


Figure 283 — Engine Brake Control Valve Pipe Installation

11. Position the control valve on the cylinder head.

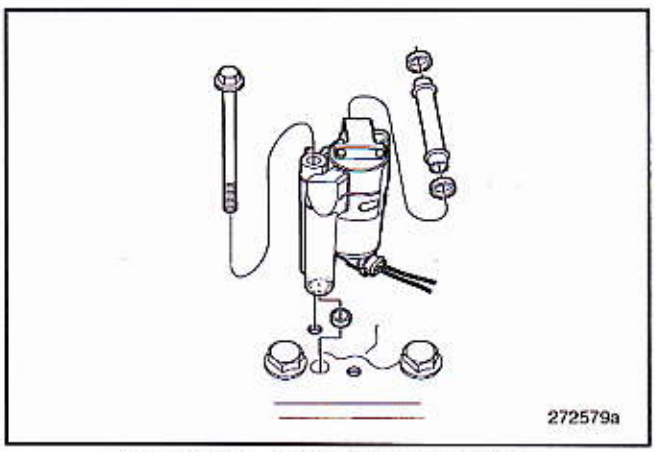


Figure 284 — Control Valve Position

12. Align the engine brake oil pipe and O-ring with the hole in the rocker shaft.

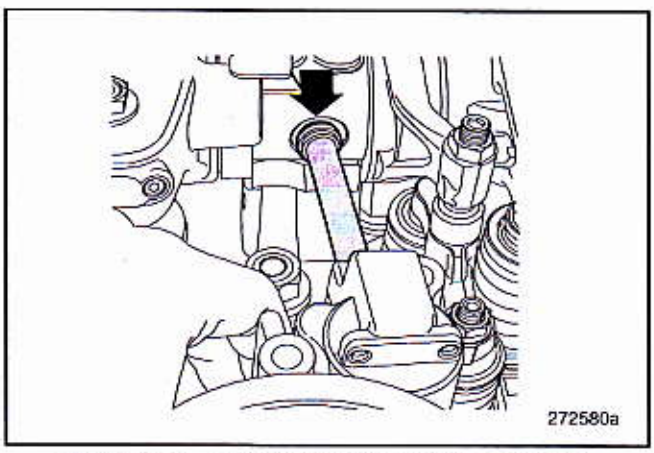


Figure 285 — Engine Brake Control Valve Pipe Installation

NOTE

Make sure the engine brake oil pipe O-ring is fully seated.

13. Install the control valve bolts and tighten to specification.

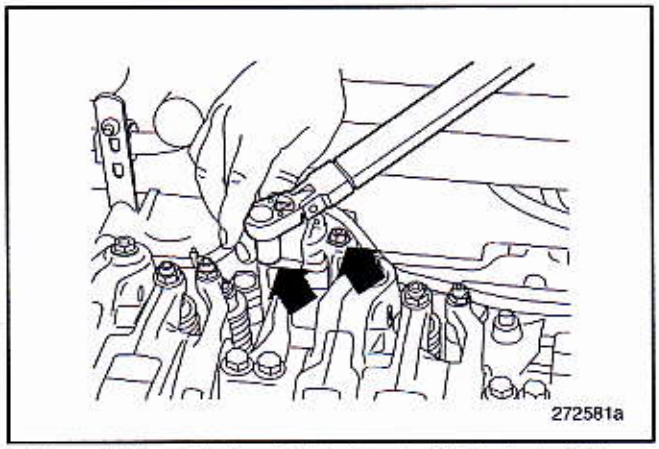


Figure 286 — Engine Brake Control Valve Installation

14. If harness is installed on engine, plug in the control valve harness connector.

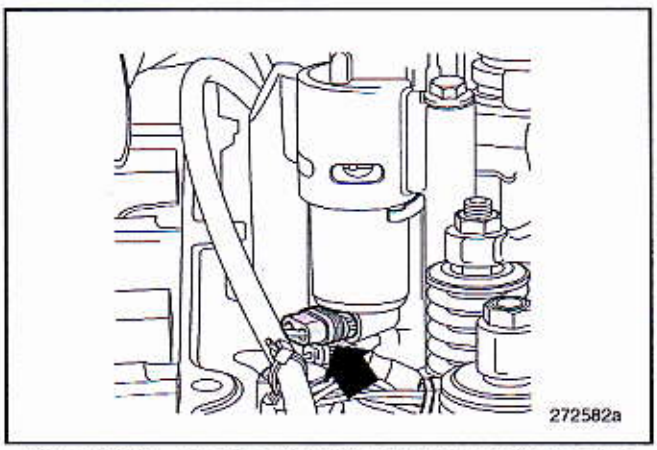


Figure 287 — Engine Brake Control Valve Connector

15. If installed, reposition the fuel injector harness over the control valve and secure with high temperature tie straps (983472).

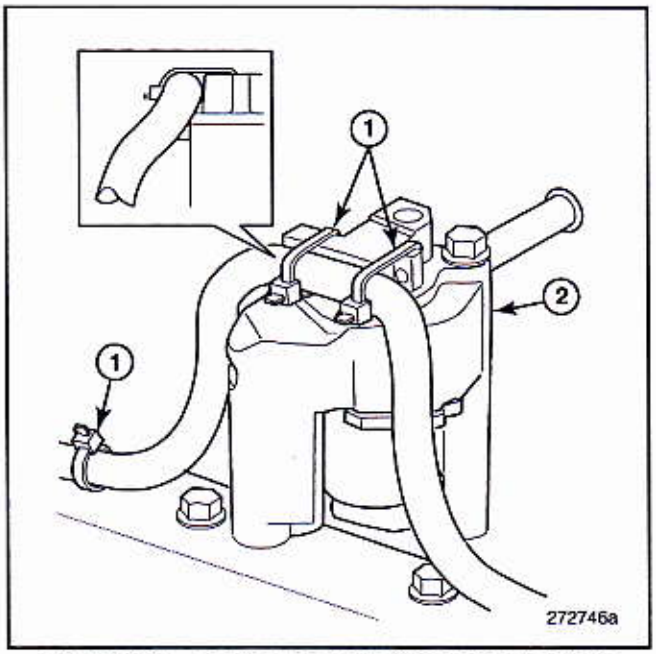


Figure 288 — Harness Routing Over Engine Brake Control Valve

1. Tie Straps	2. Control Valve

Flywheel Housing Installation [211 HD]

Inspect the flywheel housing machined surfaces, bolt holes and pilot locations for cracks or wear. Replace the housing if cracks are evident.

1. Thoroughly clean the sealing area in the flywheel casing and the sealing surface against the crankshaft.
2. Apply an even 2 mm (5/64 inch) thick bead of MACK-approved sealant to the timing gear plate side of the flywheel housing according to the pattern shown.

NOTE

The flywheel housing must be installed within 20 minutes of the sealant being applied.

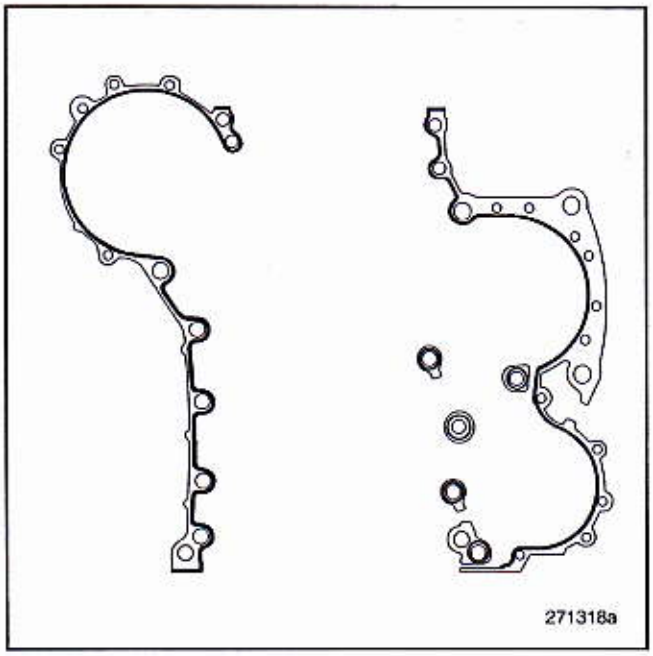


Figure 289 — Flywheel Housing Sealant Application Pattern

NOTE

Be sure to apply beads of sealant around the holes in the bosses as shown in the graphic.

Temporarily install guide pins in the two lower flywheel housing mounting holes in the timing gear plate/engine block.

3. Within 20 minutes of the application of the sealant, assemble the flywheel housing over the guide pins in the timing gear plate.
4. Insert and hand-tighten the attaching bolts. Remove the two guide pins and install the remaining bolts.

NOTE

If the engine was originally built with the longer idler gear bolts, the flywheel housing may need to be updated to block the idler gear bolt hole with a plug and washer from plug kit 21090322. Use the following procedure to thread the hole and install the plug:

a. Using a 3/4-16 UNF x 11.5 tap, thread the hole indicated in Figure 290.

b. Apply thread locking compound (Loctite® 277 or equivalent) to the threads of the plug.

c. Insert the plug with washer and tighten to specification.

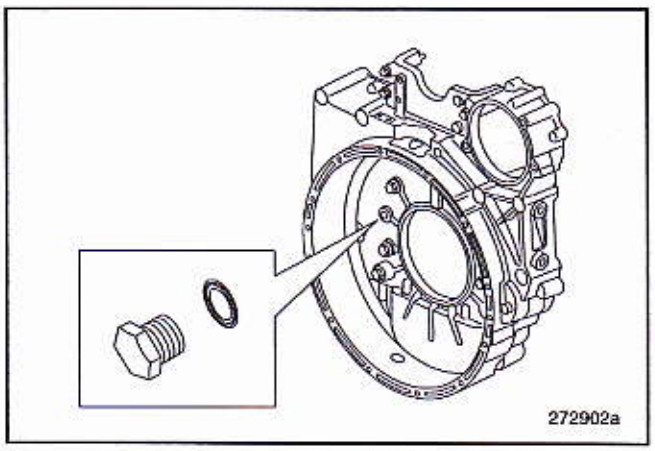


Figure 290 — Flywheel Housing Plug

5. Using a torque wrench, tighten the attaching bolts in sequence according to specification.
6. Remove any excess sealant.
7. Install the timing gear plate to the flywheel housing bolts (item 2 in Figure 291).

NOTE

- Item 1 secures the power steering and fuel pump mounting and is not installed at this time.
- Item 3 secures the rear engine mount to the flywheel housing and will be install upon installation into the chassis.

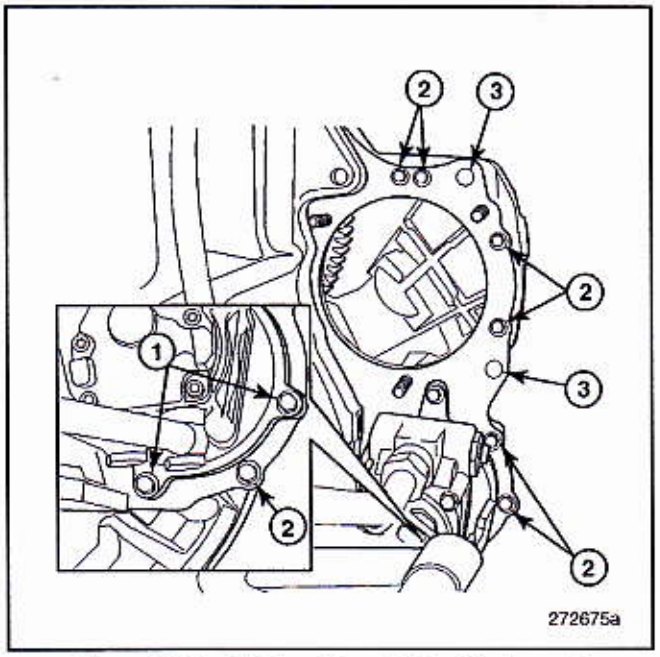


Figure 291 — Timing Gear Plate Attachment

1. Power Steering Attaching Bolts 2. Timing Gear Plate-to-Flywheel Attaching Bolts	3. Rear Engine Mount-to-Flywheel Housing Attaching Bolt and Nut

Crankshaft Rear Seal Installation

[212 JH]

1. If not previously done, thoroughly clean the sealing surfaces of the flywheel housing and the crankshaft gear wheel.

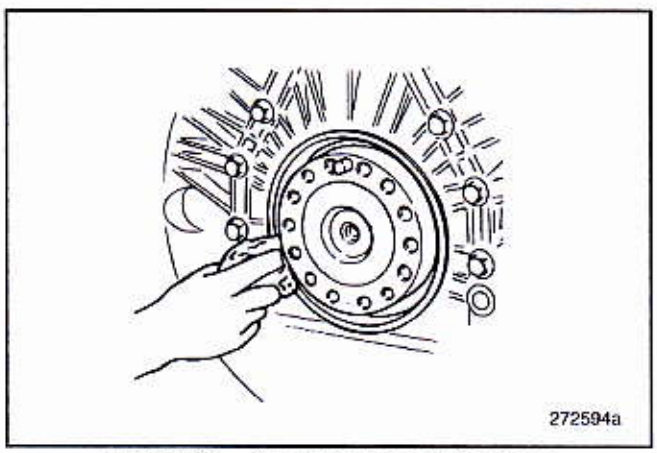


Figure 292 — Cleaning Sealing Surfaces

2. Lubricate the seal lips with clean engine oil.
3. Insert the handle, 9992000, in the remover/installer, 9998238.

⚠ CAUTION

Inspect the remover/installer carefully. Any damage on the tool will destroy the seal.

4. Position the **new** seal on the drift, making sure that the seal is turned in the proper direction. Carefully tap the seal into the flywheel housing using the handle and drift until the drift evenly contacts the crankshaft gear.

NOTE

Position the drift so that it does not interfere with the alignment dowel during installation. The rear crankshaft seal depth is set by the drift tool when fully seated.

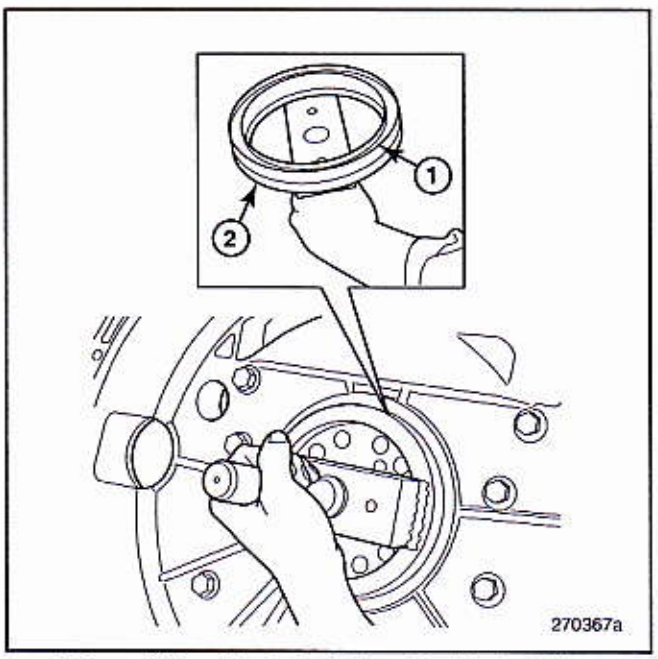


Figure 293 — Crankshaft Rear Seal Installation

1. Rear Main Seal	2. Rear Main Seal Installer, 9998238

5. Remove the tools.
6. Inspect the seal ring for proper seating.

Flywheel and Pilot Bearing Installation

[212 VC]

⚠ CAUTION

After resurfacing, any flywheel with drilled balance holes on the clutch side requires rebalancing by a machine shop.

NOTE

On vehicles equipped with an automatic transmission, it may be necessary to install different components to the flywheel retaining fasteners. Refer to the Automatic Transmission Drive Arrangement Assembly Instructions, 5-902, for installation instructions.

1. Clean the surface in the places where the flywheel lies flush against the crankshaft gear wheel.

   Clean the flywheel. Check that the grooved surfaces for the flywheel sensor are clean.

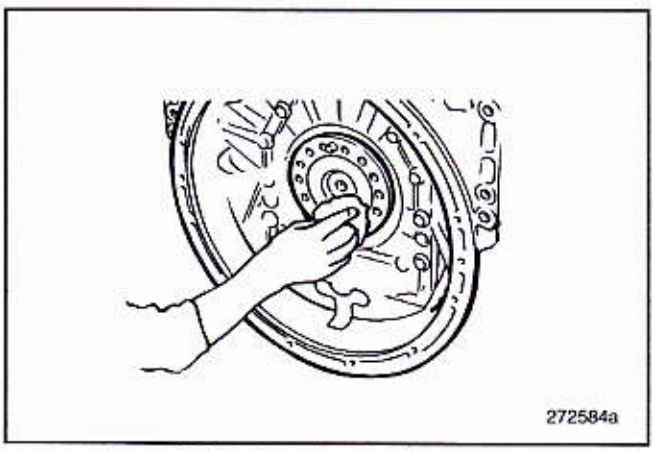


Figure 294 — Cleaning Sealing Surfaces

2. Make sure that the flywheel guide pin is correctly inserted in the crankshaft gear wheel. Ensure that there is no damage or leakage at the rear crankshaft seal.
3. Insert two alignment studs in the crankshaft flange to aid in installation.
4. With the aid of the two lifting bolts (M10 x 100), position the flywheel over the dowel pin and alignment studs on the flywheel mounting surface at the rear of the crankshaft.

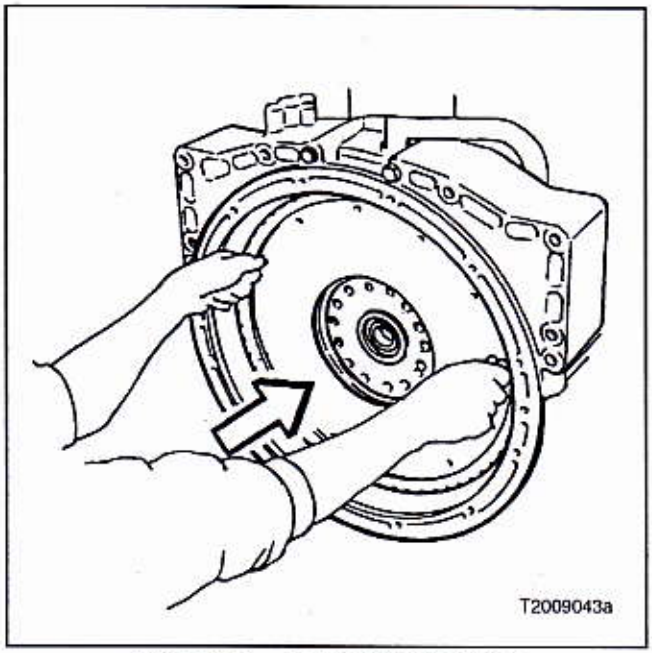


Figure 295 — Flywheel Installation

5. Install the flywheel mounting bolts in the exposed mounting holes. At this time, tighten the bolts finger-tight only.
6. Remove the two alignment studs and insert the remaining mounting bolts.
7. Remove the plug from the flywheel housing and install cranking tool, 88800014, and a handle as a counterhold.

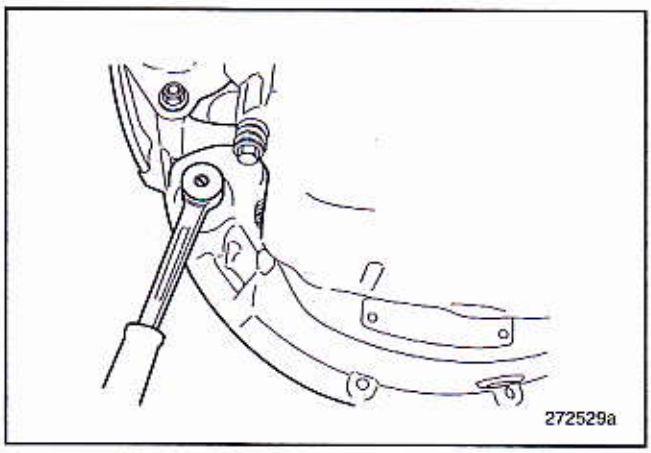


Figure 296 — Flywheel Turning Tool

8. Using a torque wrench, tighten the fasteners in sequence according to specification.

⚠ CAUTION

Do not tighten adjacent screws sequentially. Doing so can result in uneven flywheel alignment. Failure to heed this caution can result in severe engine damage.

9. Remove the cranking tool. Insert the plug.
10. Using tool assembly, 9991801 and 9992564, install a **new** pilot bearing in the flywheel bore.

⚠ CAUTION

*For this engine, **NO** snap ring is required on the pilot bearing. Do **NOT** substitute pilot bearings that do not bear the correct part number for this application. Failure to heed this caution may result in severe engine damage.*

11. Check for proper flywheel-to-position sensor clearance using the sensor depth gauge to determine if shims are required for sensor depth. The flywheel position sensor clearance specification is 0.3–1.0 mm (0.0118–0.0393 in.).
    a. Rotate the engine using the flywheel turning tool until a tooth of the flywheel toothed wheel is aligned with the sensor bore.
    b. Insert the tool into the sensor bore until the outer part of the tool is fully seated against the flywheel housing.
    c. Loosen the thumb screw of the tool and push the inner part of the tool until it contacts a tooth of the toothed wheel.
    d. Tighten the thumb screw to secure the inner part of the tool.
    e. Carefully remove the tool from the flywheel sensor bore and observe the location of the steps between the inner and outer portions of the tool:
        - Both steps below the surface of the tool = no shims required.
        - One step below the surface of the tool = one shim required.
        - Both steps above the surface of the tool = two shims required.

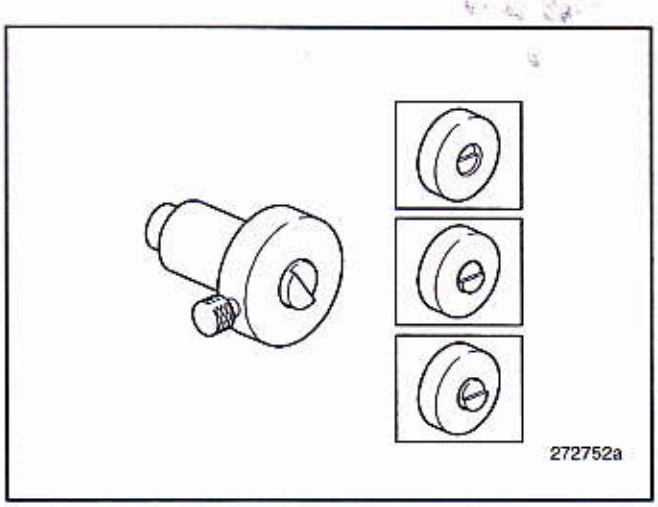


Figure 297 — Depth Sensor Gauge

12. Carefully install the flywheel position sensor with the appropriate shim(s) and **new** O-ring. Secure the sensor with a bolt tightened to specification and plug in the harness connection.

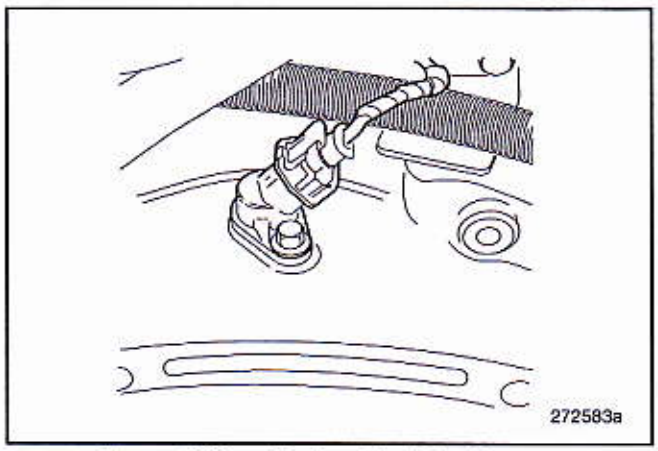


Figure 298 — Flywheel Position Sensor

Oil Pan Installation

[211 NB]

1. Apply a 2 mm (0.079 inch) wide bead of MACK-approved sealant at the seams between the flywheel housing and the timing gear mounting plate. Also, apply a 2 mm (0.079 inch) wide bead of sealant at the seams between the timing gear mounting plate and the engine block.

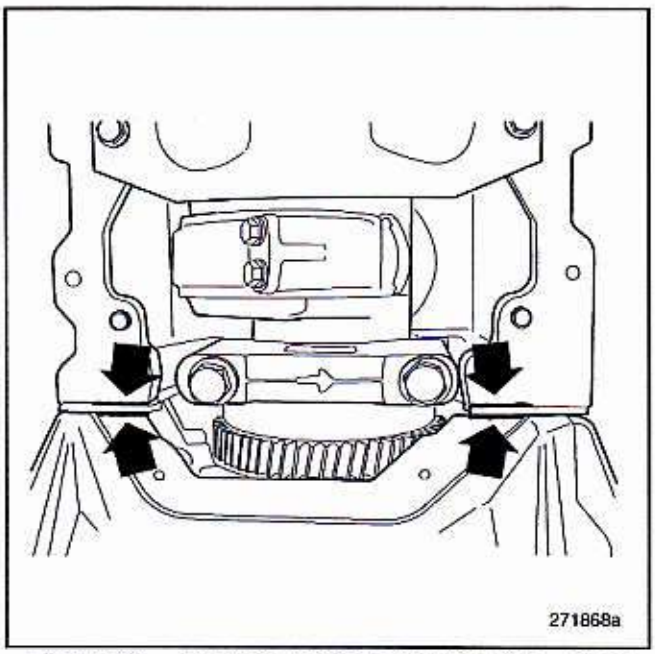


Figure 299 — Sealant Application for Oil Pan — Rear

2. Apply a 2 mm (0.079 inch) bead of MACK-approved sealant to the seam between the front seal cover and the block.

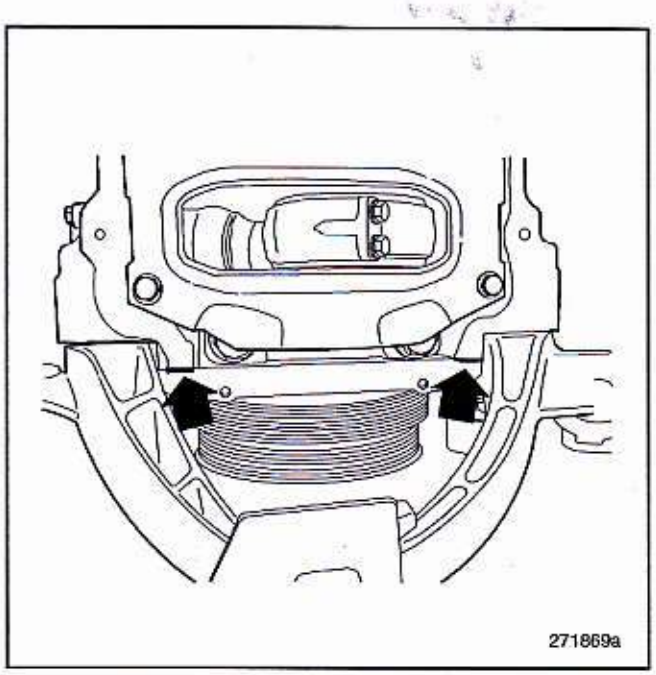


Figure 300 — Sealant Application for Oil Pan — Front

3. For plastic pan applications, install the oil pan seal into the groove of the oil pan. Check that the seal locating tabs are properly aligned and seated in the locating holes on the mounting flange.

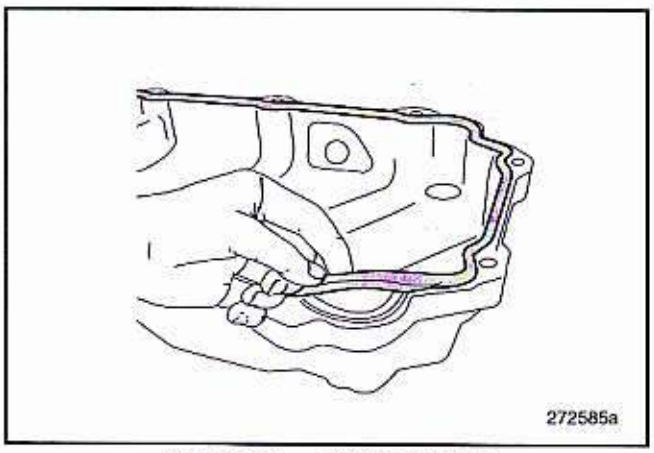


Figure 301 — Plastic Oil Pan

4. For steel pan applications, install the oil pan gasket on the oil pan flange. Check that the gasket locating tabs are properly aligned and inserted in the correct holes on the mounting flange.

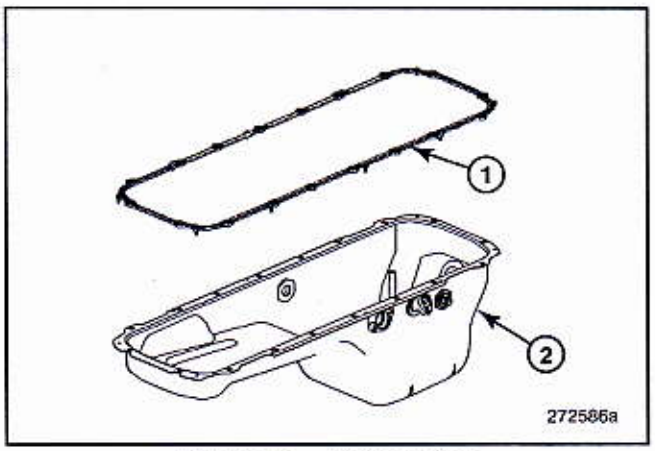


Figure 302 — Steel Oil Pan

1. Gasket	2. Oil Pan

5. With assistance, position the oil pan to the engine block and install the bolts marked A and B. Torque-tighten the bolts to specification.

NOTE

- Use care to prevent damage to the oil pickup.
- The oil pan must be installed within 20 minutes of the sealant being applied.

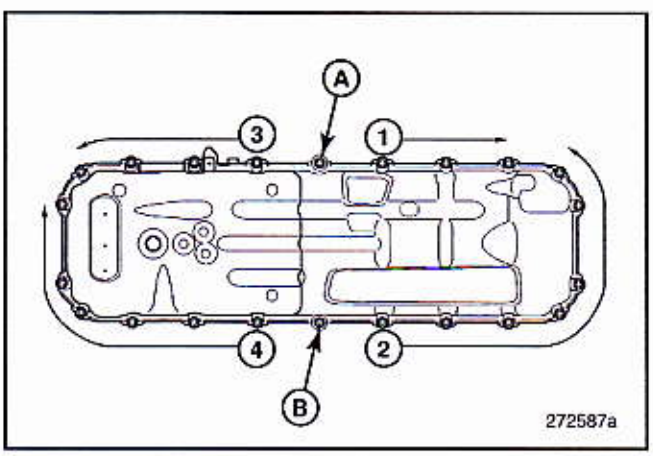


Figure 303 — Oil Pan Installation

6. Tighten the bolts from the middle and outwards in order 1–4 as shown. Torque-tighten the bolts to specification. Finish by checking the torque for bolts A and B.

NOTE

Install the transmission oil cooler bracket studs in locations marked previously.

7. Install the oil drain plug and torque-tighten to specification.

⚠ CAUTION

Do not use a copper washer with the hex-head oil drain plug. Always use the steel washer with the rubber gasket.

NOTE

Do not use air tools when installing the oil drain plug.

8. Ensure that the 12 locating pins on the seal are properly seated in the locating holes in the mounting flange.

NOTE

Be sure the oil pan seal is properly placed before tightening the fasteners.

9. If harness is installed, reconnect the oil level/temperature sensor connector to the side of the oil pan.

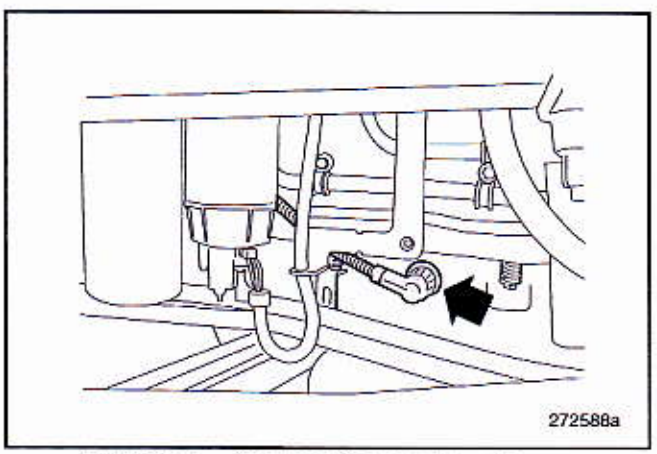


Figure 304 — Oil Level/Temperature Sensor

Oil Filler Pipe and Dipstick Pipe Installation

1. Install a **new** O-ring on the oil fill tube and install the tube to the side of the oil pan. Install the oil fill tube fasteners and tighten to secure.

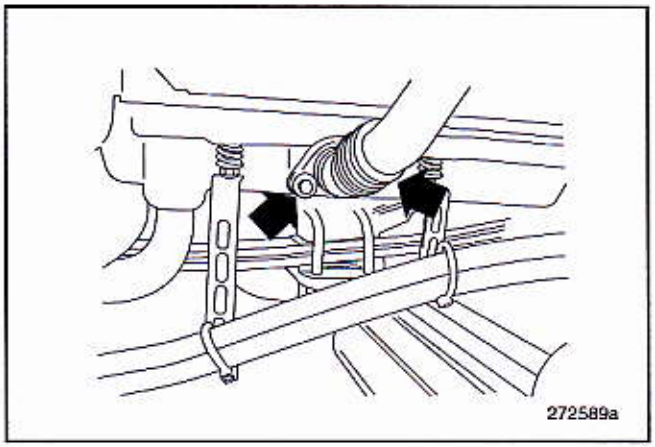


Figure 305 — Oil Fill Tube

2. Install a **new** O-ring on the dipstick tube, then install the tube and secure with the fastener. Install the dipstick.

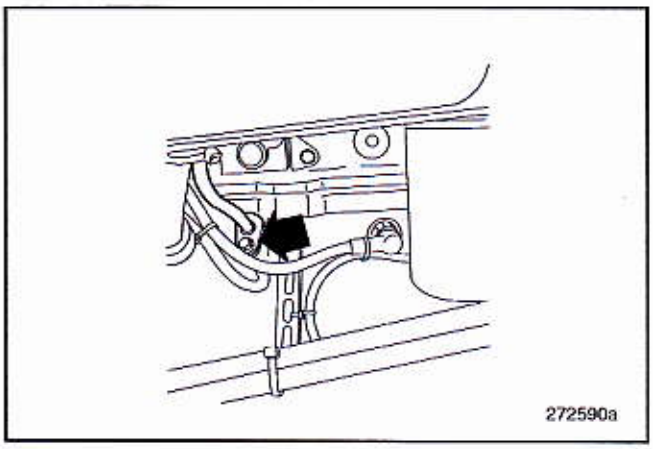


Figure 306 — Oil Dipstick

Power Take-Off Installation

If equipped with a power take-off (PTO), install the assembly using this procedure.

1. Lubricate and assemble a seal in the groove in the PTO assembly housing.

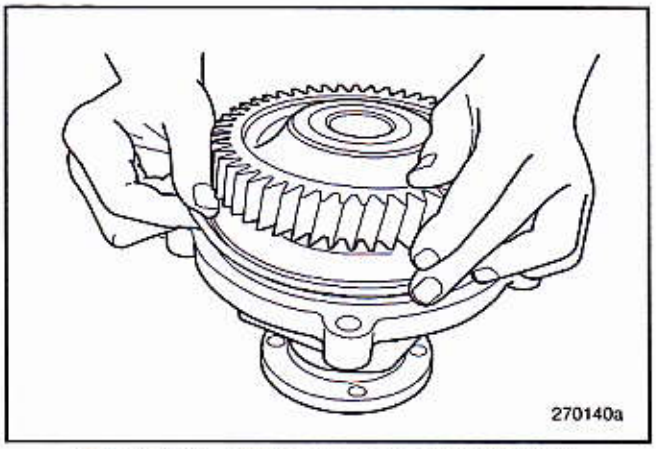


Figure 307 — PTO Housing Seal Installation

2. Assemble the PTO assembly on the flywheel housing.

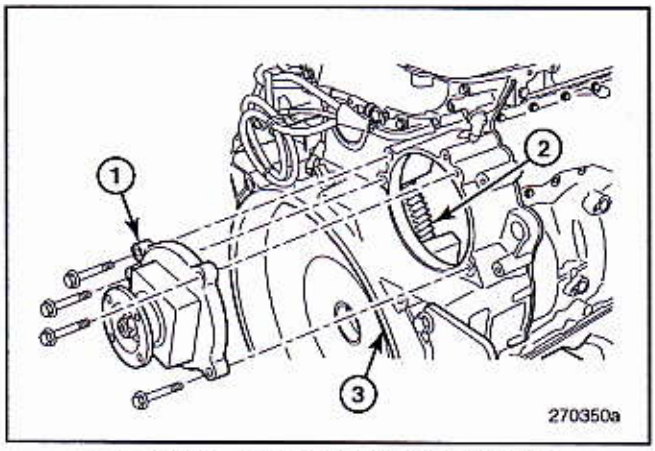


Figure 308 — Power Take-Off Installation

1. PTO Housing 2. Intermediate Idler Gearset	3. Flywheel Housing

3. Using a torque wrench, tighten the fasteners according to specification.

Timing Gear Cover Installation [211 AA]

1. Apply sealant in the bottom corners where the timing gear plate and the flywheel housing meet. Also apply sealant to the top of the timing gear plate (in the corner) next to the cylinder head.

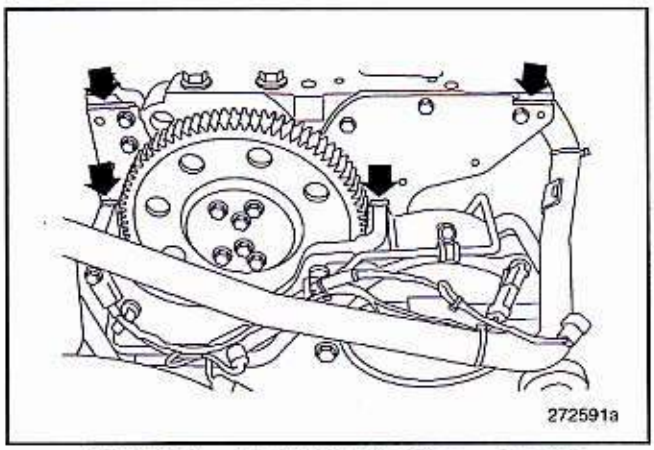


Figure 309 — Sealant Application — Engine

2. Install the timing gear cover seals and gaskets.

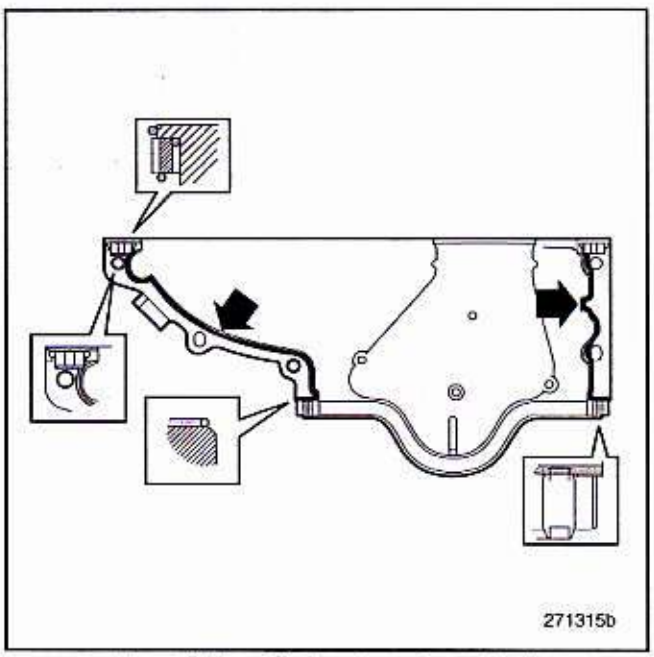


Figure 310 — Timing Gear Cover Seals

3. Apply sealant to the mating surfaces of the timing gear cover.

4. Position the timing gear cover on the flywheel housing at the rear of the cylinder head. Install the fasteners marked 1 and 2.

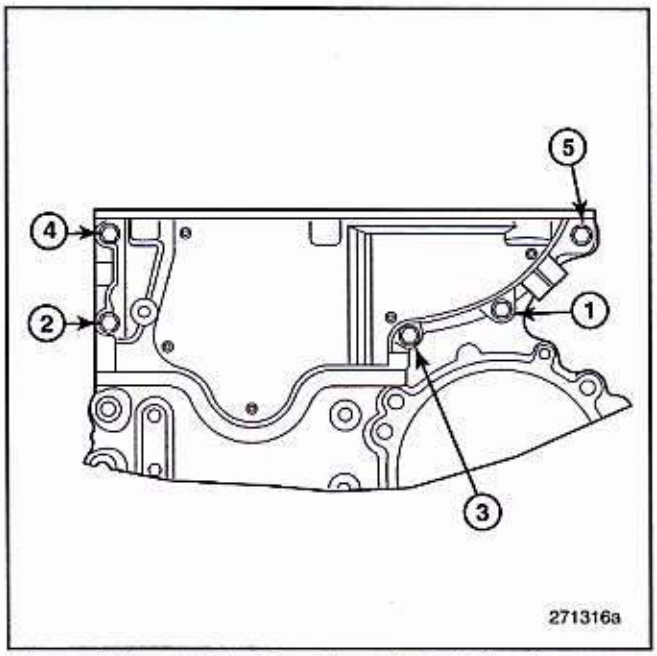


Figure 311 — Timing Gear Cover Installation Sequence

5. Install the timing gear cover alignment tools, 85111422-A and 85111422-B, to the cylinder head and timing gear cover as illustrated. Cover surface must be flush with the seal surface of the cylinder head.

NOTE

The timing gear cover must be installed within 20 minutes of the sealant being applied.

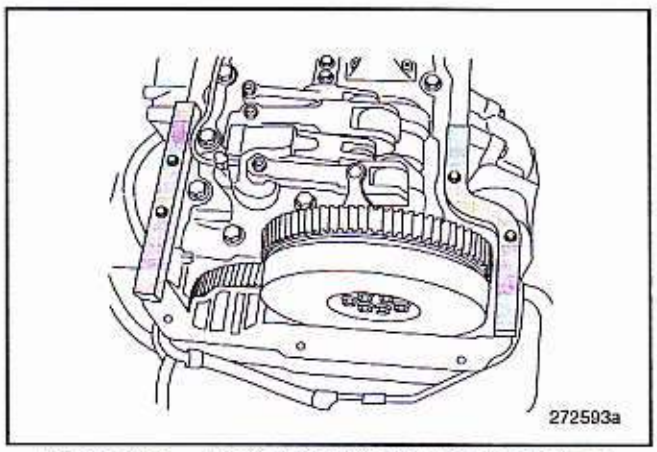


Figure 312 — Timing Gear Cover Alignment Tools

6. Install the remaining fasteners, 3, 4 and 5. Torque all of the timing gear cover fasteners to specification.
7. Remove the timing cover clamp tools.
8. Position the rear support bracket onto the rear of the engine and install the support bracket fasteners to secure.
9. Install all tie straps, P-clamps and other retainers used to restrain the engine harnesses, oil lines and coolant tubes to the rear of the engine.

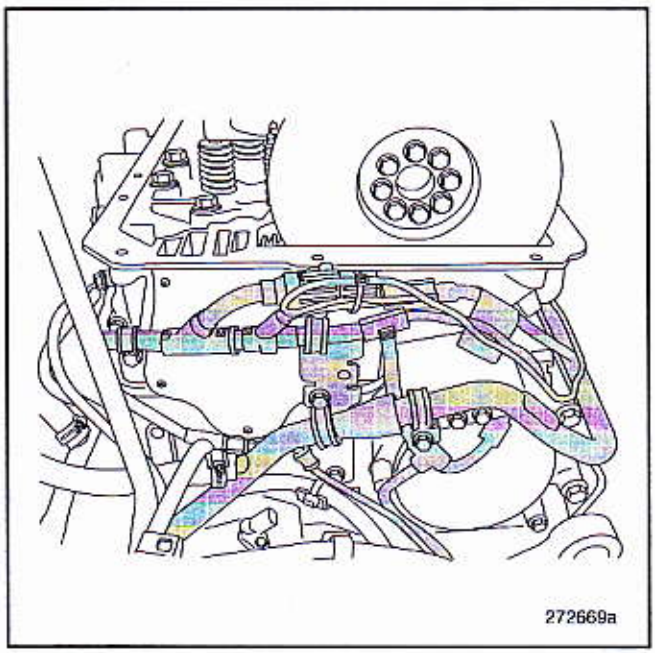


Figure 313 — Rear of Engine

CAMSHAFT SENSOR DEPTH, CHECK

1. Remove the plug from the flywheel housing and install the flywheel turning tool.

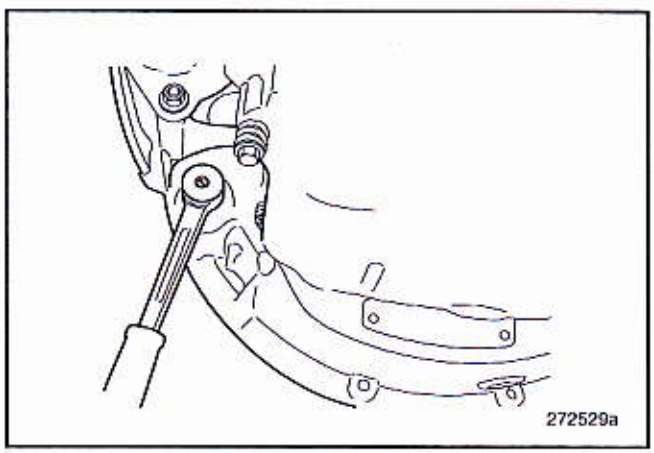


Figure 314 — Flywheel Turning Tool

2. Check for proper camshaft position sensor clearance using the sensor depth gauge, 88800031, to determine if shims are required for sensor depth.

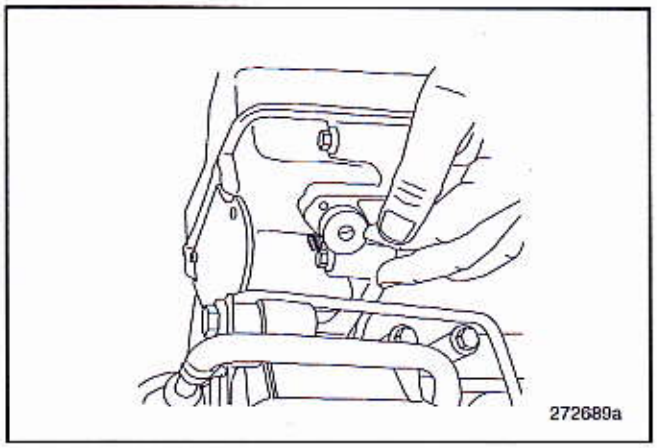


Figure 315 — Camshaft Position Sensor

a. Rotate the engine until a tooth of the camshaft toothed wheel is aligned with the sensor bore.

b. Insert the depth gauge into the sensor bore until the outer part of the gauge is fully seated against the timing gear cover.

c. Loosen the thumb screw of the gauge and push the inner part of the gauge in until it contacts a tooth of the toothed wheel.

d. Tighten the thumb screw to secure the inner part of the gauge.

e. Carefully remove the gauge from the camshaft sensor bore and observe the location of steps between the inner and outer portions of the gauge:

- Both steps below the surface of the gauge = no shims required.
- One step below the surface of the gauge = one shim required.
- Both steps above the surface of the gauge = two shims required.

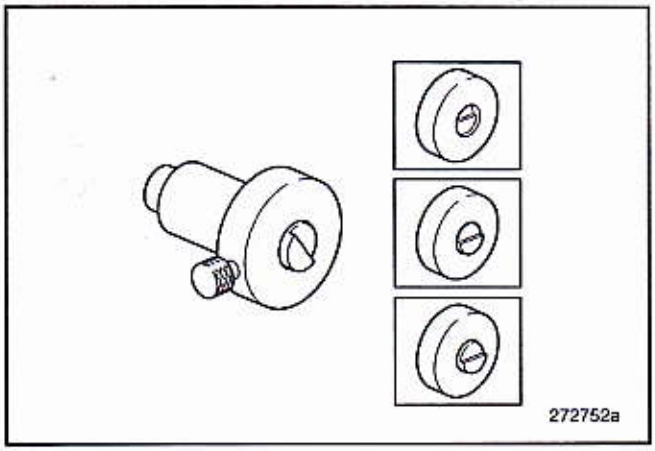


Figure 316 — Depth Sensor Gauge

3. Install the camshaft position sensor with the appropriate shim(s) and **new** O-ring. Secure the sensor with a bolt and plug in the harness connector.

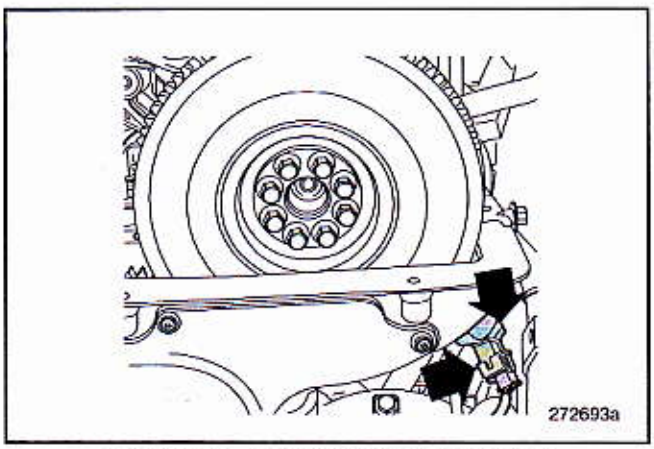


Figure 317 — Camshaft Position Sensor

Coolant Pump Installation

[215 SW, SG, SR]

1. If removed, place the coolant pump base plate in position at the front of the cylinder block and install the mounting bolts. Tighten the bolts to specification.
2. Press a **new** sealing ring into the groove of the replacement coolant pump.

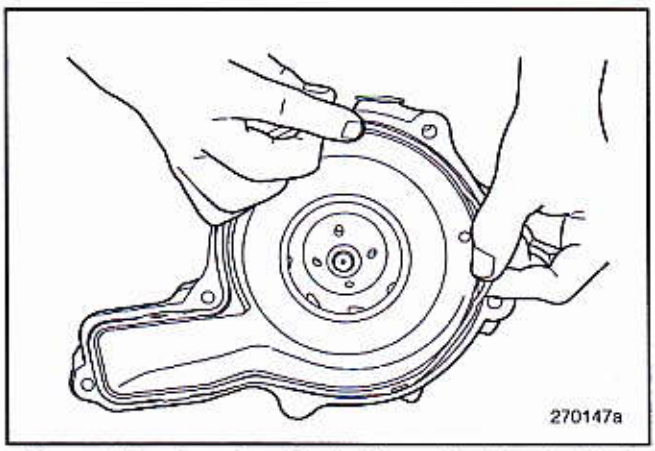


Figure 318 — Inserting Coolant Impeller Housing Seal

3. Position the replacement coolant pump impeller housing on the base plate and align the bolt holes.

NOTE

Make sure the sealing ring remains seated in the groove of the pump impeller housing.

4. Use care to ensure that the sealing ring remains properly seated and install the coolant pump bolts and tighten to specification.
5. Position the tensioner pulley on the front of the engine and install the tensioner bolts. Tighten the bolts to specification.

Thermostat and Cover Installation [215 NU, NG & LD]

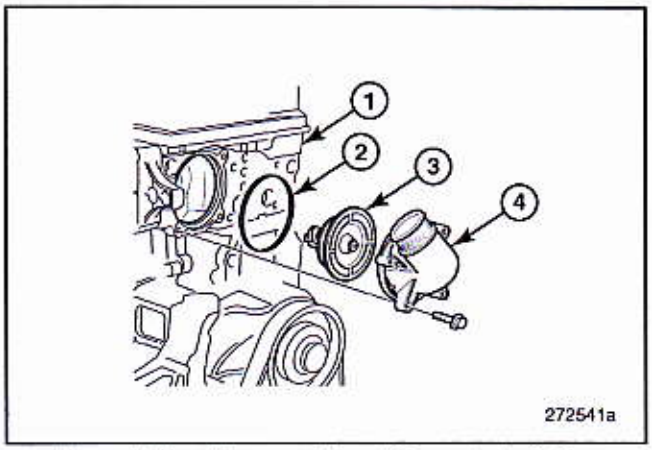


Figure 319 — Thermostat and Cover Installation

1. Cylinder Head 2. Thermostat Seal	3. Thermostat 4. Thermostat Cover

1. Use crocus cloth to remove any surface nicks, burrs, sharp edges and tool marks from the thermostat cover and cylinder head.
2. Lubricate the inner surface of the cover.
3. Install the **new** thermostat.

NOTE

Make sure that the rubber seal remains properly seated.

4. Position the thermostat cover to the cylinder head and install the bolts. Using a torque wrench, tighten the fasteners in a cross pattern according to specification.

Coolant Pipe Installation [215 SW]

UPPER COOLANT PIPE (BYPASS) HOUSING

1. Lubricate and assemble a **new** seal in the upper coolant pipe housing flange.

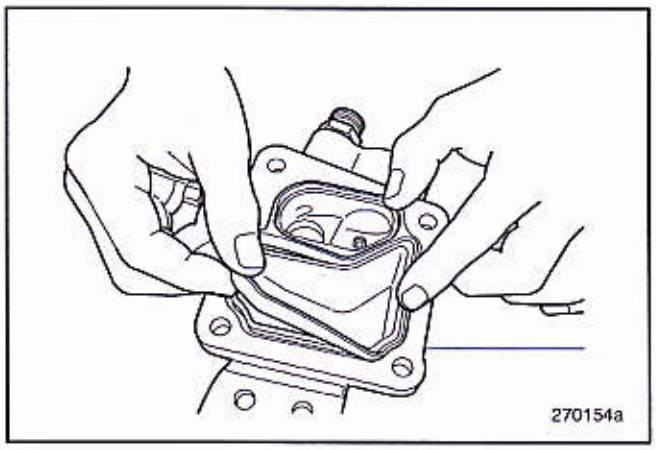


Figure 320 — Seal Installation — Upper Coolant Pipe Housing

2. Assemble the upper coolant pipe housing flange on the head.

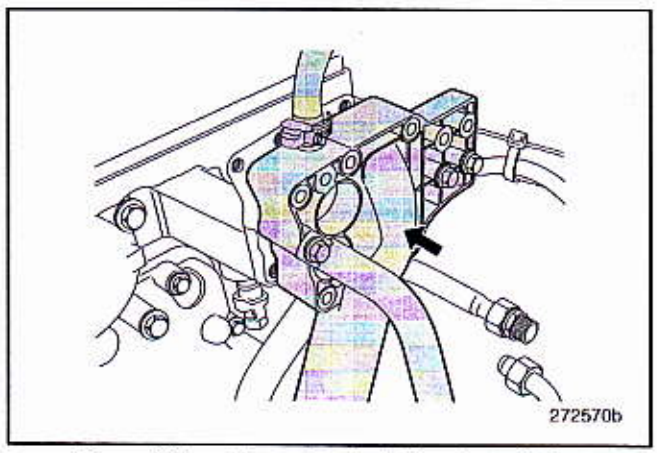


Figure 321 — Upper Coolant Pipe Installation

3. Using a torque wrench, tighten the upper coolant pipe fasteners in sequence according to specification.
4. Assemble the fan ring bracket to the upper coolant pipe housing.
5. Using a torque wrench, tighten the fasteners according to specification.

PUMP INLET HOUSING

1. Lubricate and assemble **new** sealing rings on the pump inlet pipe at the joint with the bypass connector.
2. Place the inlet housing in position between the upper coolant pipe and the pump inlet. Replace and lubricate all sealing O-rings.

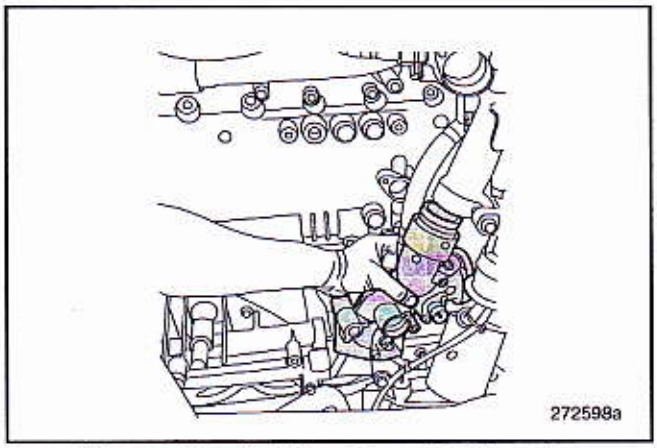


Figure 322 — Installing Pump Inlet Housing

3. Install the M8 fasteners and tighten to specification. Then, install the M10 fastener and tighten to specification.

NOTE

Secure the inlet housing flange to the pump first and then to the cylinder block.

Oil Cooler and Cooling Duct Cover Installation

[215 DW, 219 EP]

The oil cooler must be attached to the cooling duct cover before attaching the cover to the cylinder block.

OIL COOLER INSTALLATION

1. Using a sharp pick, carefully remove the rubber seal (molded gasket) from the groove in the oil cooler cover, if not already done. Clean the cover of any dirt, adhesives and inspect for damage to the sealing surface. Also, inspect the cylinder block and ensure the sealing surface is clean and undamaged.
2. Install a **new** formed gasket in the groove of the cover.

NOTE

Apply a minimal amount of silicone sealant in the seal groove to hold the seal in place during assembly. Install the cover within 20 minutes of applying the sealant.

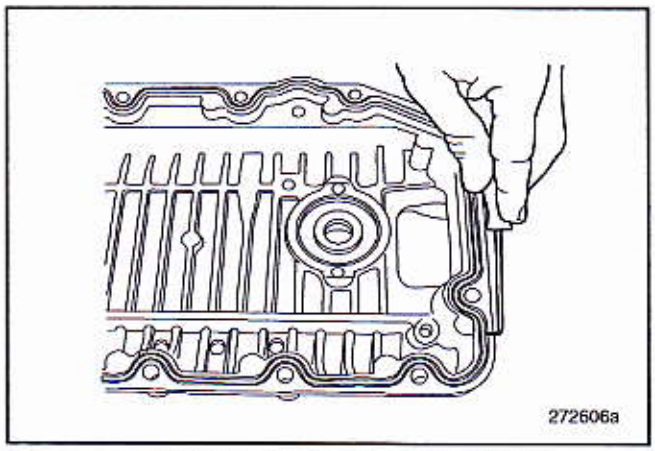


Figure 323 — Oil Cooler Cover Gasket

3. Install **new** oil cooler sealing O-rings between the oil cooler and cover. Install the sealing O-rings into the grooves in the cover.

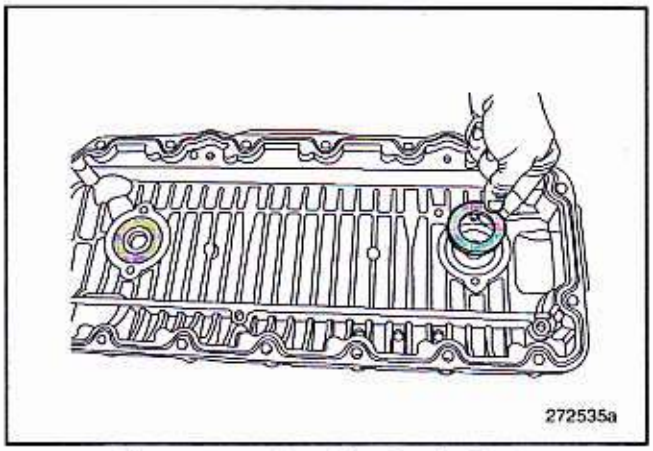


Figure 324 — Installing Cooler Seals

4. Install the oil cooler in the oil cooler cover.

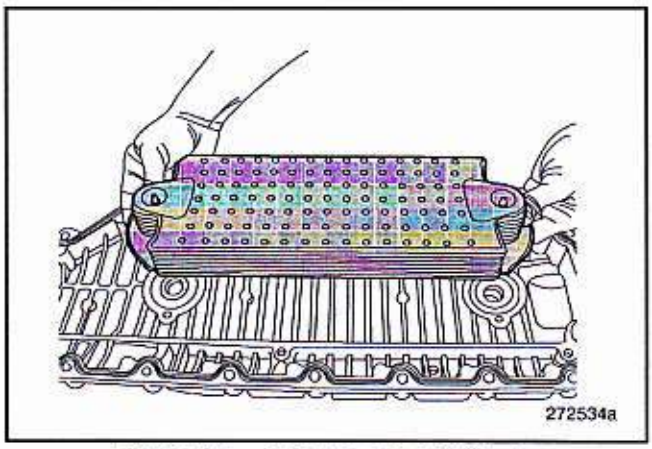


Figure 325 — Installing the Oil Cooler

5. Using a torque wrench, tighten the fasteners in sequence according to specification.
6. Install the oil cooler flow plate over the oil cooler. Tighten fasteners to specification.

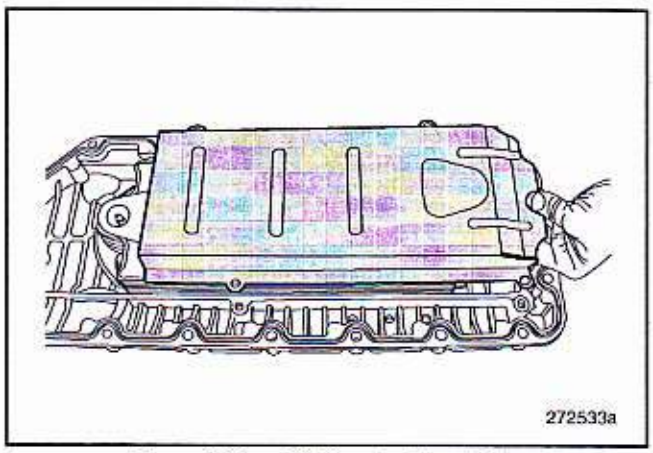


Figure 326 — Oil Cooler Flow Plate

COOLING DUCT COVER INSTALLATION

1. Replace the water pump inlet housing formed rubber gasket with a **new** gasket. Lubricate new gasket upon installation.

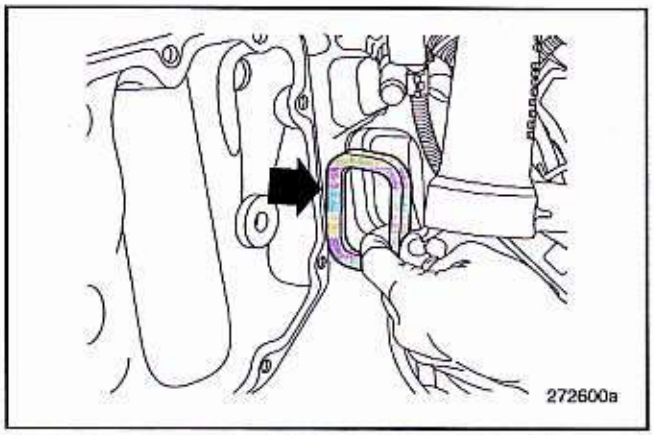


Figure 327 — Water Pump Inlet Housing Formed Gasket

2. With assistance, set the cooling duct cover assembly in place. Install the upper left corner fastener.

NOTE

This mounting location is slotted for adjustment.

3. Using the assembly tool, 88800022, push the cover forward to compress the formed rubber gasket at the water pump inlet. Install the upper right corner fastener.

NOTE

A small piece of metal stock should be used to keep from deforming the stamped cover that the tool foot is pressing against.

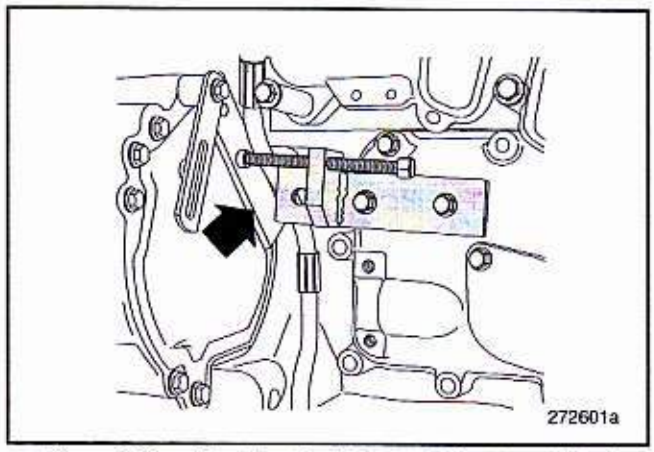


Figure 328 — Cooling Duct Cover Adjustment Tool

4. Adjust cover as required to allow upper and lower center fasteners to be installed.

NOTE

The upper center mounting location has a tighter tolerance than other mounting locations.

5. Start all remaining cover fasteners and torque-tighten fasteners to specification.

Oil Filter Housing Installation

[219 EP]

1. Install the rear pipe to the oil cooler cover with a **new** gasket. Place the retaining clamps in position on the oil cooler duct cover, install the fasteners and tighten to specification.

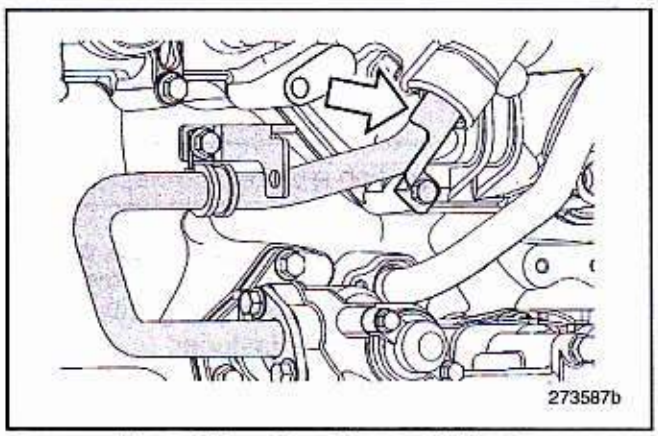


Figure 329 — Rear Pipe to Oil Cooler

2. Install two alignment pins — to hold the gasket in place and to aid in the alignment of the housing.

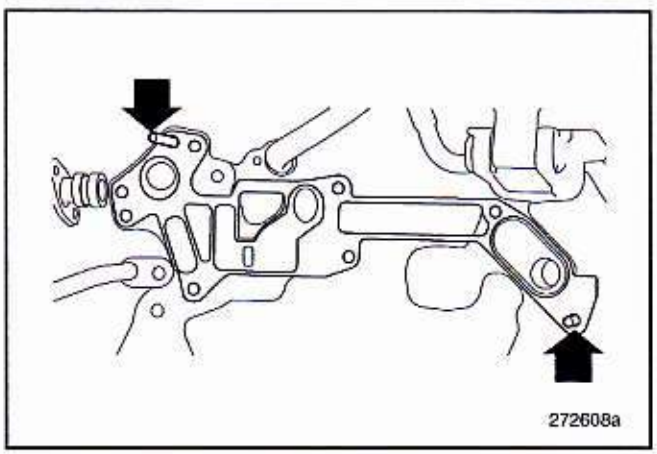


Figure 330 — Alignment Pins and Gaskets

3. Install the gasket to the engine block.
4. Install the oil filter housing onto the engine block and position the rear pipe. Torque the bolts to specification.
5. Install the fasteners to the rear pipe in the oil filter housing. Torque the bolts to specification.
6. Install the front pipe with **new** seals between the oil filter housing and the oil cooler cover.

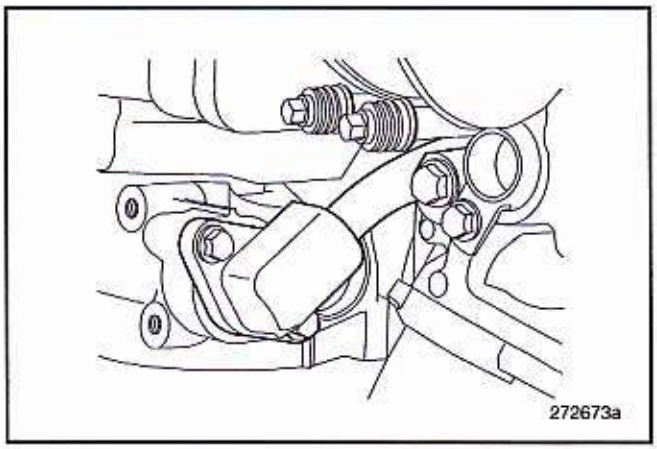


Figure 331 — Front Pipe Installation

7. Install all hard pipes (coolant and oil) to the oil cooler cover. Replace and lubricate all sealing O-rings. Also, replace sealing washers for the banjo fitting on the oil cooler cover. Tighten banjo fittings to specifications.

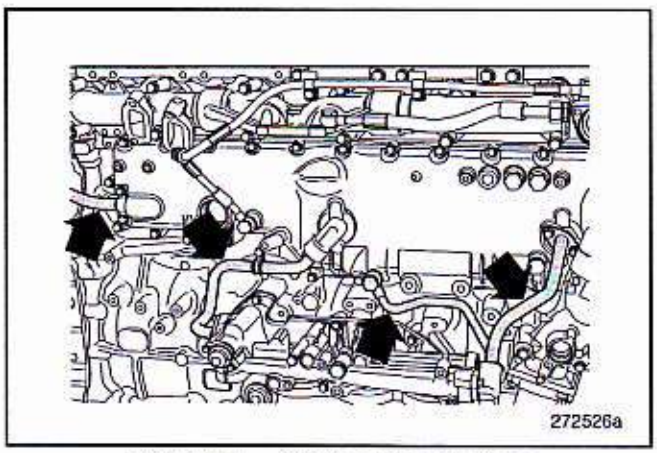


Figure 332 — Oil Cooler Hard Pipes

Exhaust Manifold Installation

[214 EG]

NOTE

The exhaust manifold mounting fasteners can be used five times unless the manifold is being replaced. If the manifold is being replaced, use **new** fasteners.

1. Clean the manifold mounting surface on the cylinder head.
2. Temporarily install an alignment stud at each exhaust manifold flange location on the cylinder head.

NOTE

This is done to hold the manifold while positioning the manifold gaskets for installation of the bolts and spacers.

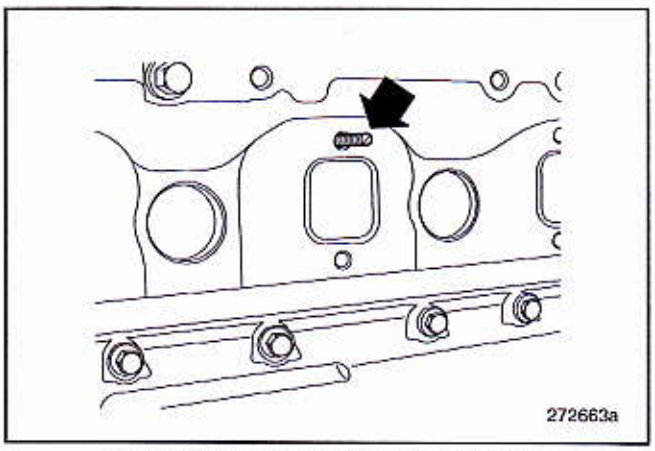


Figure 333 — Alignment Pin Installation

3. Install **new** gaskets onto the alignment pins with the seal side facing the cylinder head.

NOTE

The gaskets are marked "MANIFOLD SIDE" to aid in installation. Make sure to place this side of the gasket toward the exhaust manifold. The graphite fiber side of the gasket faces the cylinder head.

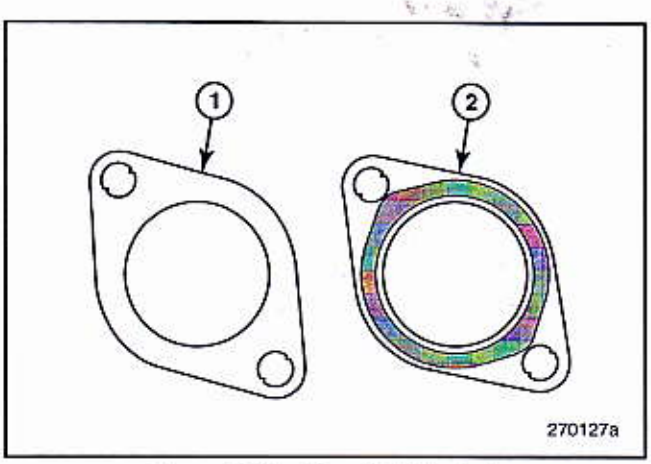


Figure 334 — Manifold Gasket

1. Manifold Side (Metal)	2. Cylinder Head Side (with Seal)

4. Apply anti-seize compound to the threads and under the heads or contact surfaces of all the manifold fasteners.

NOTE

Anti-seize helps prevent fastener oxidation corrosion and reduces friction to help achieve the intended clamp load on the component when tightening the fasteners to specification.

5. Install the exhaust manifold over the alignment pins. Install fasteners with spacers in the lower holes. Now the upper alignment pins can be removed one at a time and replaced with mounting fasteners and the original spacers.

NOTE

- Make sure the spacers are seated properly in the manifold step bore hole location.
- Exhaust manifold fasteners can be used up to five times.

6. Tighten the fasteners to specification.

Turbocharger Installation

[214 SC]

⚠ CAUTION

- *Use only **new** and approved gaskets at the various air, oil and exhaust connections to the turbocharger. Avoid the use of sealing or joint compounds at all flanged connections.*
- *Thorough cleanliness is required. Small particles can cause severe rotor damage if inducted during high-speed operation. Be sure to plug the inlet and outlet ports while handling the turbocharger.*
- *After completing engine reassembly, fill the turbocharger oil passage with clean engine oil before starting the engine. Refer to the procedure under Turbocharger in the **ENGINE PREPARATION AND OPERATIONAL CHECK** section.*

1. Inspect the intake and exhaust systems leading to and from the turbocharger to make sure there is no foreign material including burrs and loose lining fragments.
2. Clean the contact surface on the exhaust manifold, oil return/drain back pipe and adapter block.
3. Retain the protective caps over the turbocharger ports to keep debris and dirt out of the turbocharger as engine reassembly progresses.
4. Apply anti-seize compound to the threads and under the heads or contact surfaces of the fasteners. Anti-seize helps prevent fastener oxidation corrosion and reduces friction to help achieve the intended clamp load on the component when tightening the fasteners to specification.
5. Install **new** high-temperature gaskets between the turbo flange and exhaust manifold.
6. Position the turbocharger and gaskets against the exhaust manifold.

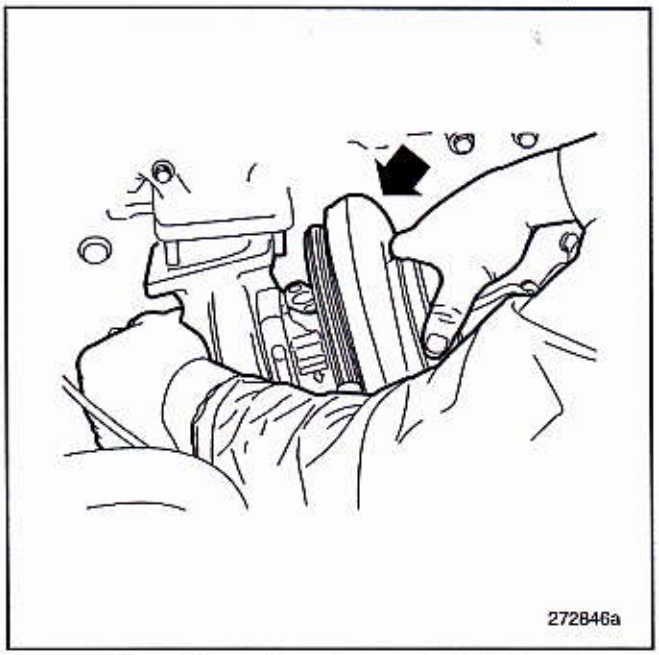


Figure 335 — Turbocharger Installation

7. Install the turbocharger flange nuts and spacers to the exhaust manifold and torque-tighten to specifications.

NOTE

Apply anti-seize compound to the threads and under the contact surfaces of the fasteners.

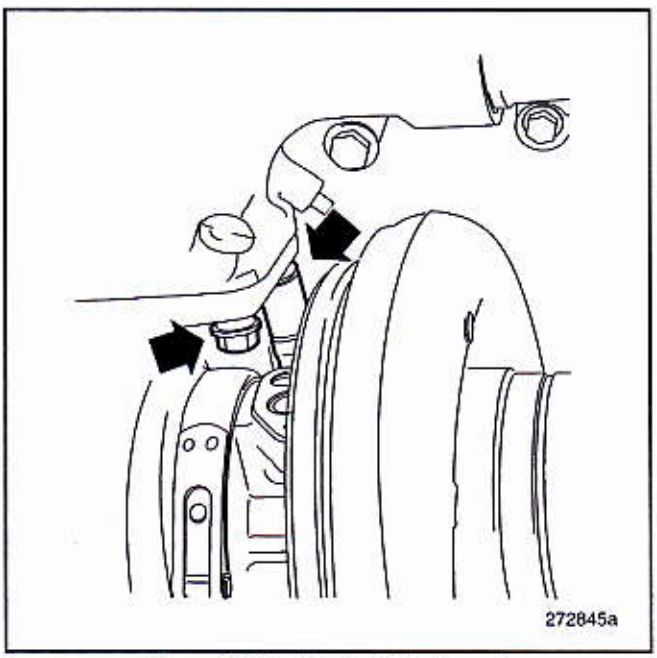


Figure 336 — Turbo Attachment

8. Install the turbocharger oil return pipe (lower) with a **new** gasket.

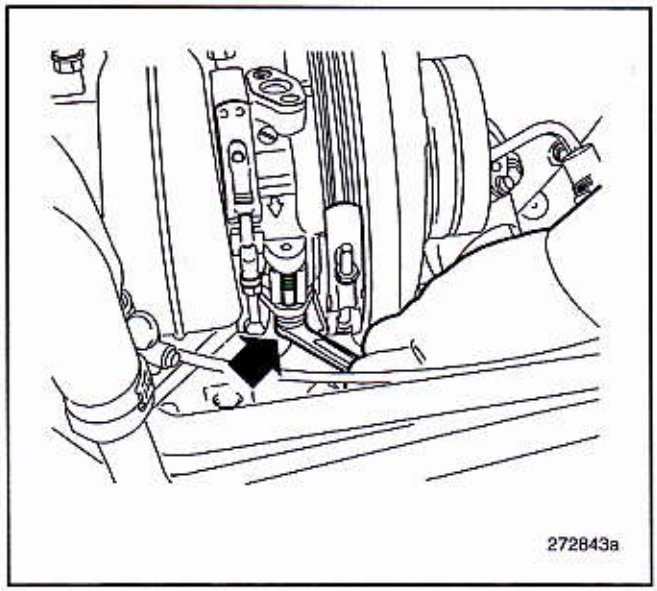


Figure 337 — Turbo Oil Return

9. Install the oil supply line (upper) with a **new** gasket. Torque-tighten the bolts to specification.

⚠ CAUTION

Pre-fill the turbocharger with clean engine oil. Starting the engine without oil pressure and a "dry" turbocharger can damage the turbo.

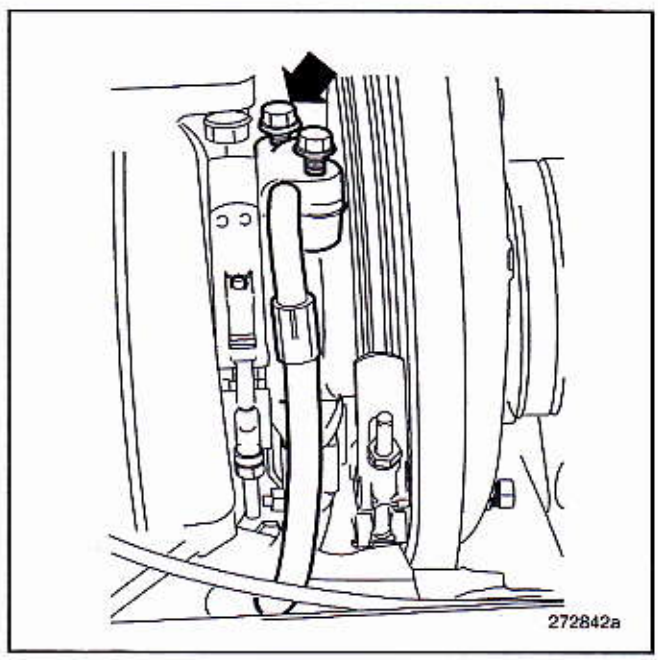


Figure 338 — Turbo Oil Supply

Exhaust Pressure Governor (EPG) Installation

234 BD

1. Lower the EPG housing into position between the exhaust pipe and turbocharger.
2. Install a **new** high-temperature gasket EPG housing and exhaust pipe.

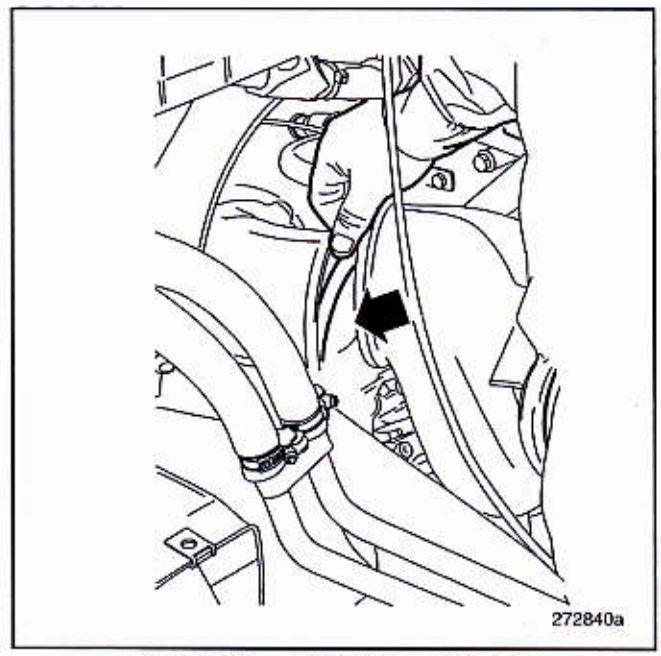


Figure 339 — EPG Housing Gasket

3. Tighten the clamp attaching the exhaust pipe-to-EPG housing.

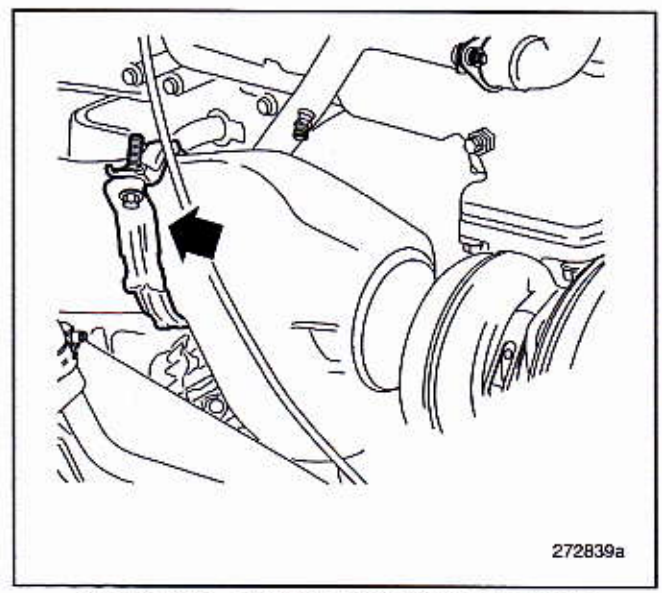


Figure 340 — Exhaust Pipe-to-EPG Housing

4. Install the exhaust clamp from the EPG-to-turbocharger.

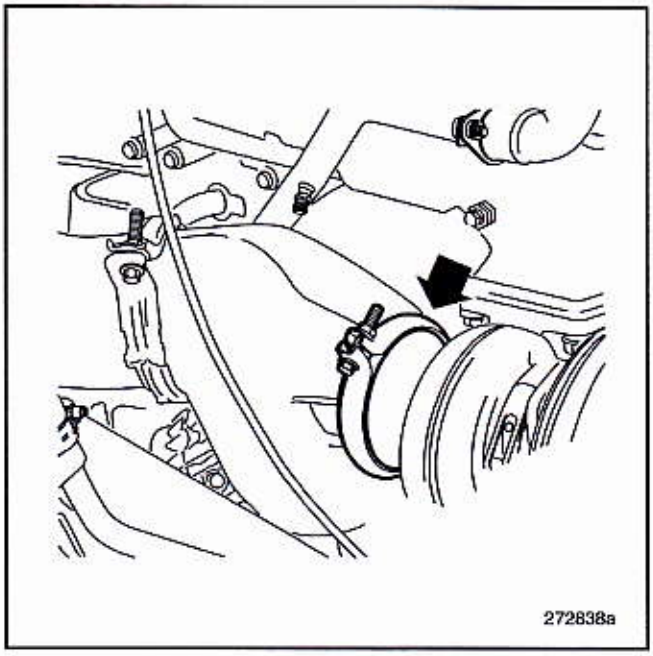


Figure 341 — EPG-to-Turbo Clamp

5. Connect the air supply line to the EPG.

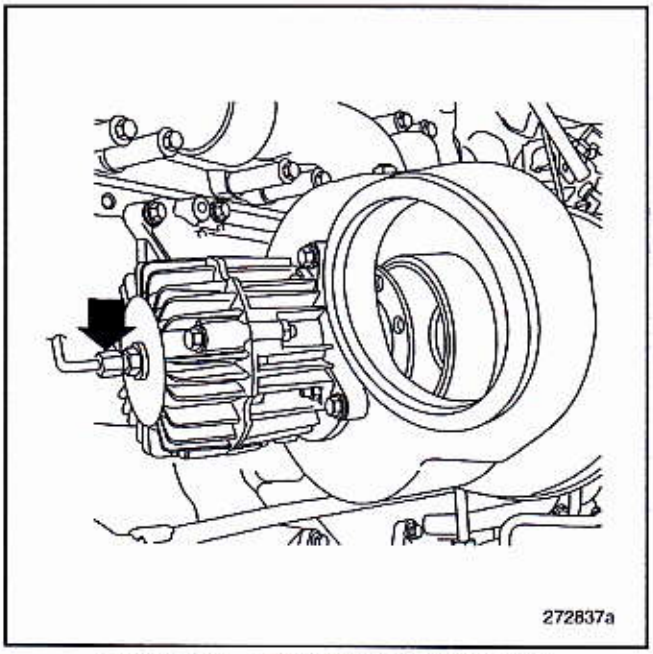


Figure 342 — EPG Air Line Attachment

Starter Installation

[272 DH]

The starter is held in place by nuts assembled over studs inserted in the block. If a stud is missing, replace it.

1. Using a torque wrench, tighten replacement studs according to specification.
2. Assemble the starter on the studs in the flywheel housing.

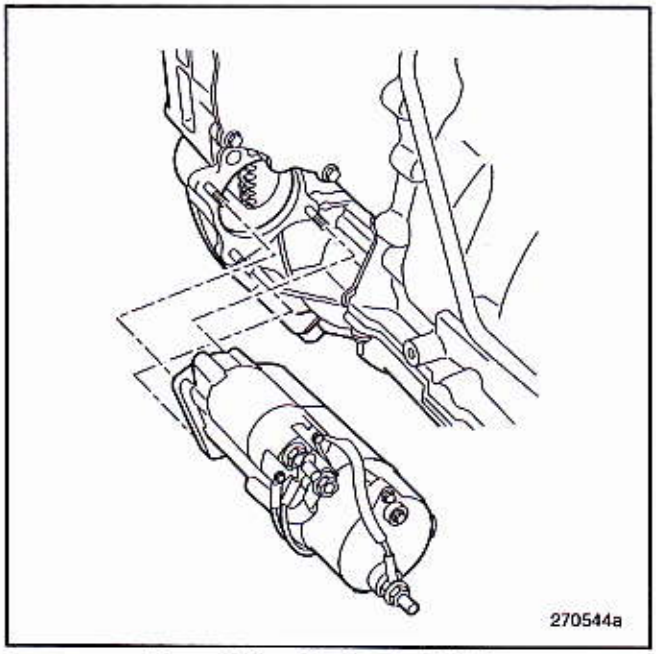


Figure 343 — Starter Installation

3. Using a torque wrench, tighten the nuts according to specification.

Air Compressor Installation

[261 CK]

1. Install a **new** seal in the air compressor housing mounting flange.

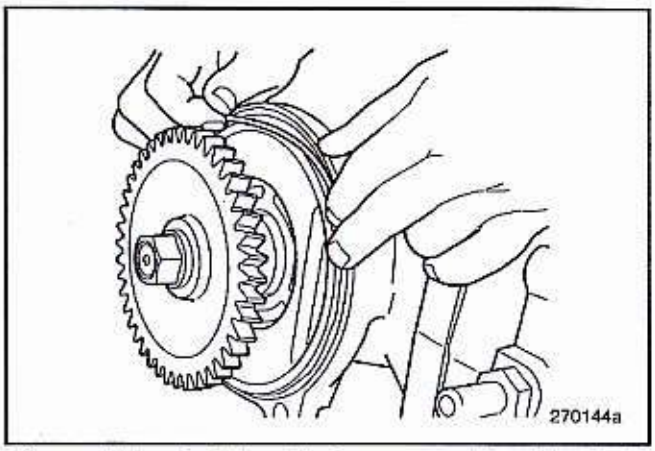


Figure 344 — Installing Air Compressor Mounting Seal

2. Assemble the air compressor on the mounting flange of the timing gear plate.

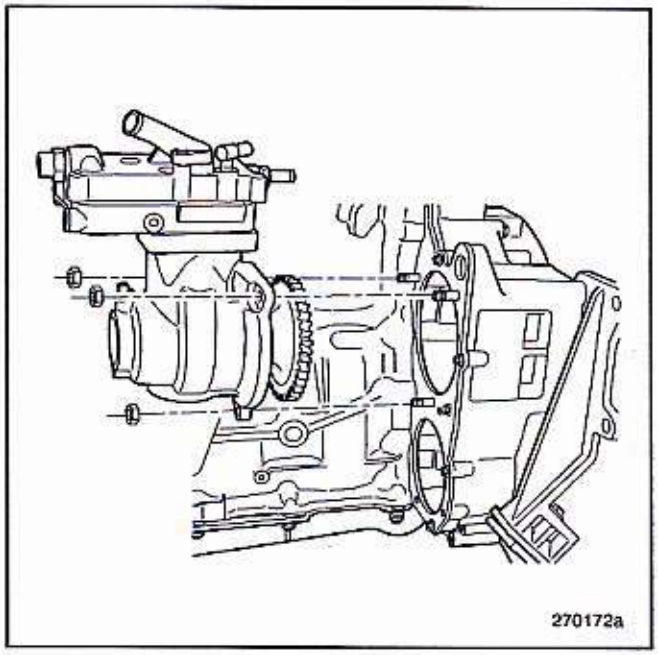


Figure 345 — Air Compressor Installation

3. Using a torque wrench, tighten the attaching nuts in two stages according to specification.

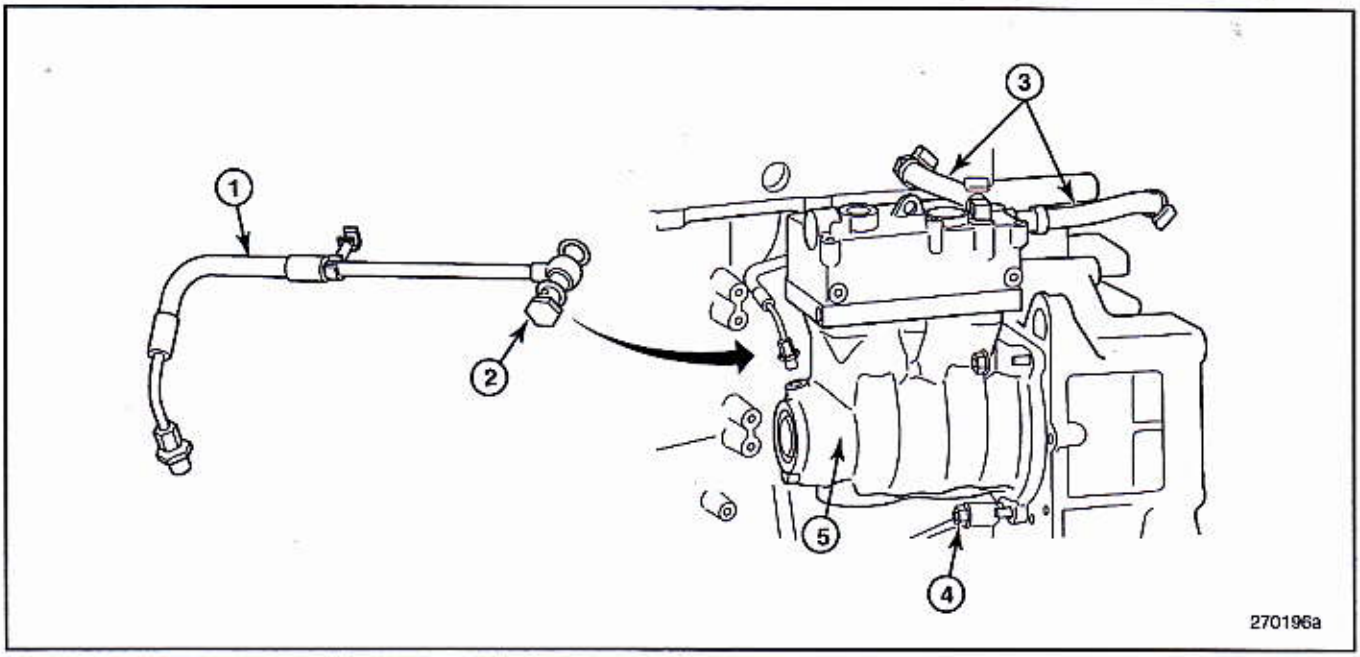


Figure 346 — Air Compressor Coolant and Lubrication Fittings

1. Lubrication Line 2. Banjo Fitting 3. Coolant Lines	4. Attaching Stud and Nut 5. Air Compressor

4. Install the coolant lines to the air compressor.
5. Install the lubrication lines to the air compressor.

Tandem Pump (Fuel and Power Steering) Installation

[231 AA, 262 EB]

1. Install a **new** O-ring in the groove on the tandem pump mounting flange.
2. Assemble the tandem pump on the flywheel housing.

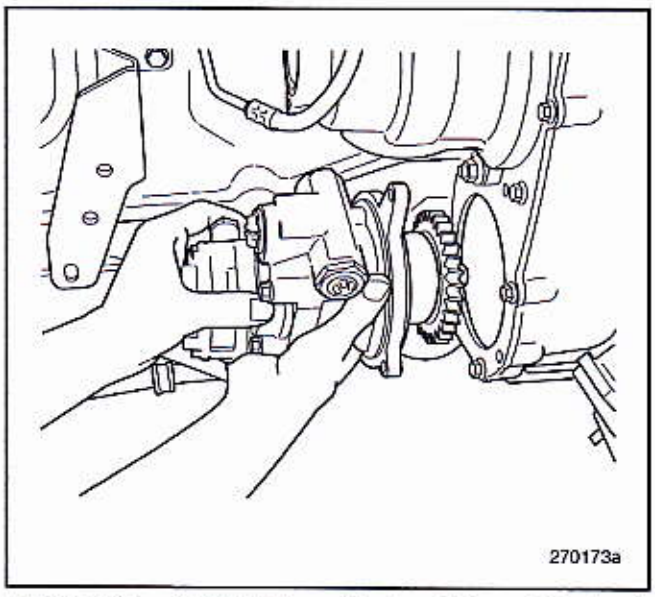


Figure 347 — Tandem Pump (Fuel and Power Steering) Installation

3. Using a torque wrench, tighten the attaching fasteners according to specification.

Inlet Manifold Installation

[214 HD]

1. Using a sharp pick, carefully remove the rubber seal (molded gasket) from the groove in the intake manifold, if not already done. Clean the manifold of any dirt, adhesives and inspect for any damage to the sealing surface. Also, inspect the cylinder head and ensure the sealing surface is clean and undamaged.
2. Install a **new** rubber seal (molded gasket) into the groove of the intake manifold.

NOTE

Apply a minimal amount of silicone sealant in the seal groove to hold the seal in place during assembly. Install the manifold within 20 minutes of applying sealant.

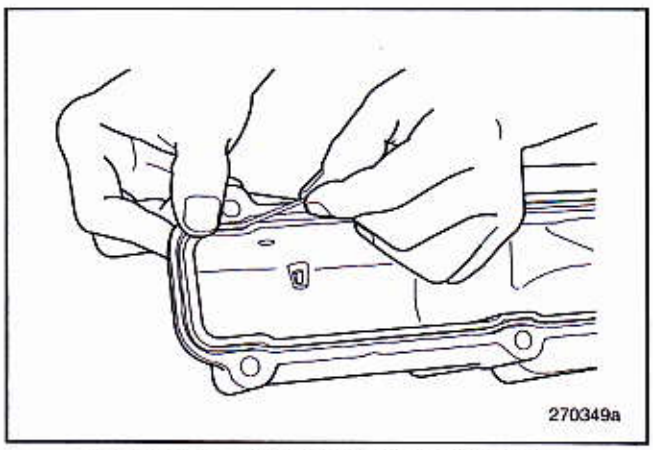


Figure 348 — Installing Inlet Manifold Seal

3. Position the intake manifold onto the two previously installed alignment pins. Start two mounting bolts with mounting spacers to hold the manifold in place, then remove the alignment pins and install the remaining manifold bolts with spacers.

NOTE

Use **new** screws with mounting spacers when installing the intake manifold.

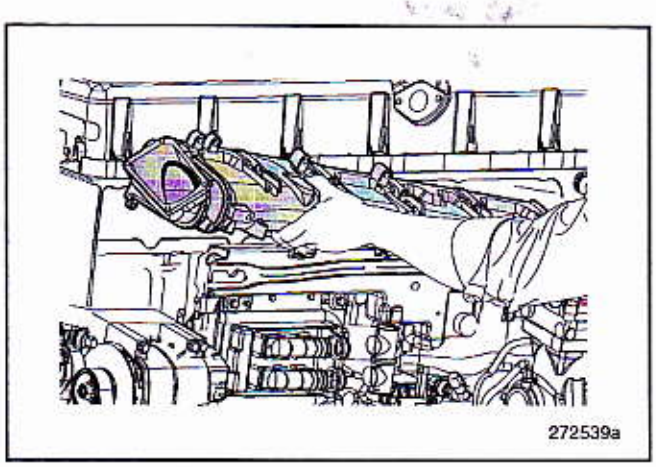


Figure 349 — Intake Manifold

4. Torque-tighten the intake manifold bolts in sequence to specification.
5. Secure the engine harness to the intake manifold using previously removed P-clamps.
6. Install the electrical connector to the charge air temperature sensor located on the top of the intake and secure the harness with tie straps.

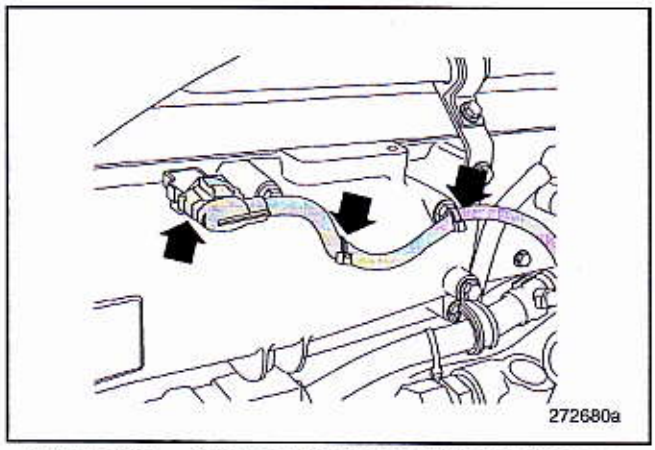


Figure 350 — Charge Air Temperature and Pressure (Boost) Sensor

7. Using a torque wrench, tighten the sensor according to specification.

Engine Preheater/Spacer Installation

[214 HL]

1. Clean the forward sealing surface on the intake manifold, air preheater or spacer, and inlet adapter.
2. Position the inlet adapter and inlet air preheater (if equipped), or spacer block with **new** gaskets onto the intake manifold. Next, start the bolts to hold the assembly to the intake manifold.

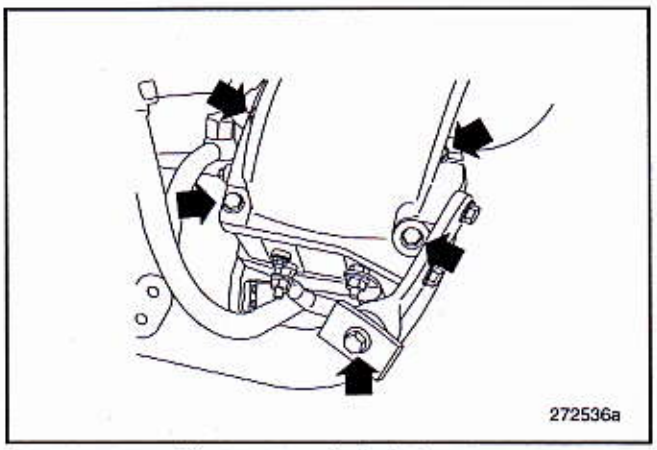


Figure 351 — Inlet Adapter

3. Using a torque wrench, tighten the fasteners in a cross pattern according to specification.
4. Install the fan ring support bracket mounting fastener. Torque-tighten the bolt to specification.
5. If equipped, position and install the inlet air preheater relay bracket (with relay attached) to the mounting surface on the intake manifold. Connect and secure the power and ground cables as marked at disassembly.

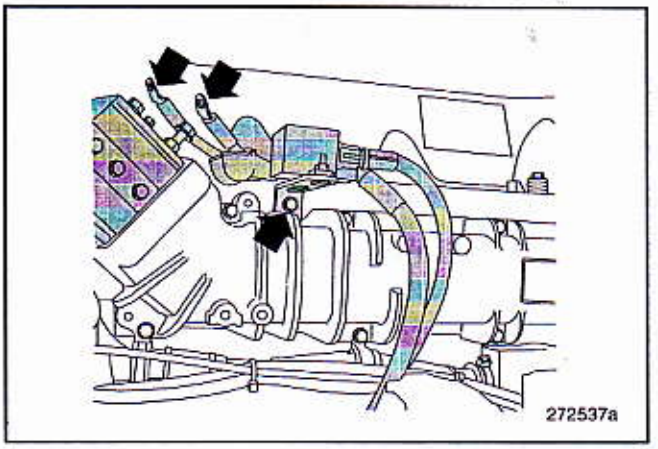


Figure 352 — Inlet Air Preheater Relay

EECU and Cooler Installation

[230 EK]

NOTE

The sequence in which the fuel filter valve housing, fuel lines and EECU are assembled on the engine depends on the type of engine stand used. For engine stands that use an adapter plate attached to the left side of the engine, these components cannot be installed until after the engine has been removed from the repair stand.

Fuel fresh from the tank serves as coolant for the EECU. The cooler connects into the line carrying the fuel from the tank into the fuel pump.

NOTE

Make sure the cooling plate and EECU mating surfaces are clean.

1. Position the EECU on the engine block and install the mounting fasteners.

NOTE

Make sure that rubber isolators are correctly installed and that the ground strap is grounded to the engine block.

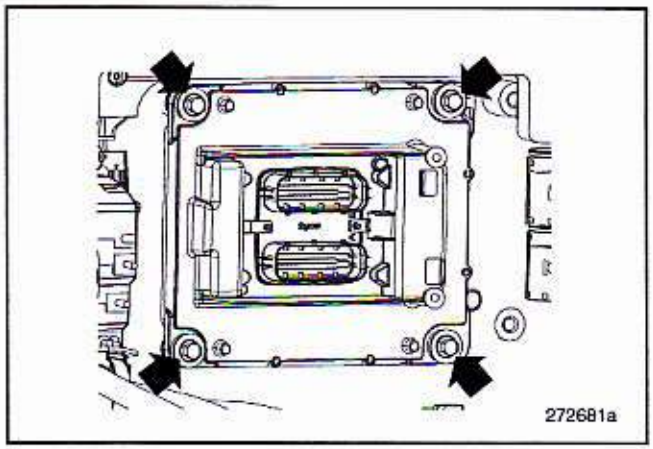


Figure 353 — EECU Installation

2. Using a torque wrench, tighten the fasteners according to specification.
3. Assemble the cooler on the EECU. When positioning the module, make sure that the small ground strap at the upper right of the unit is properly secured and pressed in close.

NOTE

If the EECU is painted in the region contacting the cooler, remove the paint to provide for the most efficient cooling.

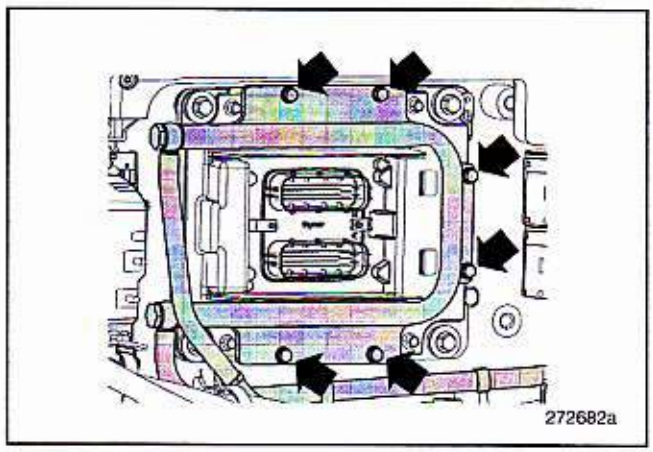


Figure 354 — EECU Cooling Plate

4. Using a torque wrench, tighten the fasteners in sequence according to specification.

Fuel Lines and Filter Housing Installation

NOTE

The sequence in which the fuel filter housing, fuel lines and EECU are assembled on the engine depends on the type of engine stand used. For engine stands that use an adapter plate attached to the left side of the engine, these components cannot be installed until after the engine has been removed from the repair stand.

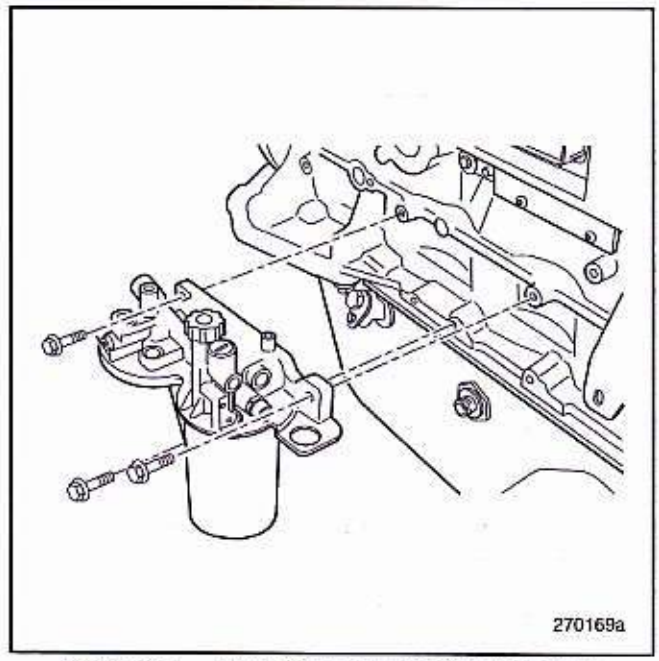


Figure 355 — Fuel Filter and Housing Assembly

1. Assemble the fuel filter housing on the block.
2. Using a torque wrench, tighten the fasteners according to specification.
3. Attach the pipe between the side of the head at the rear and the filter housing.

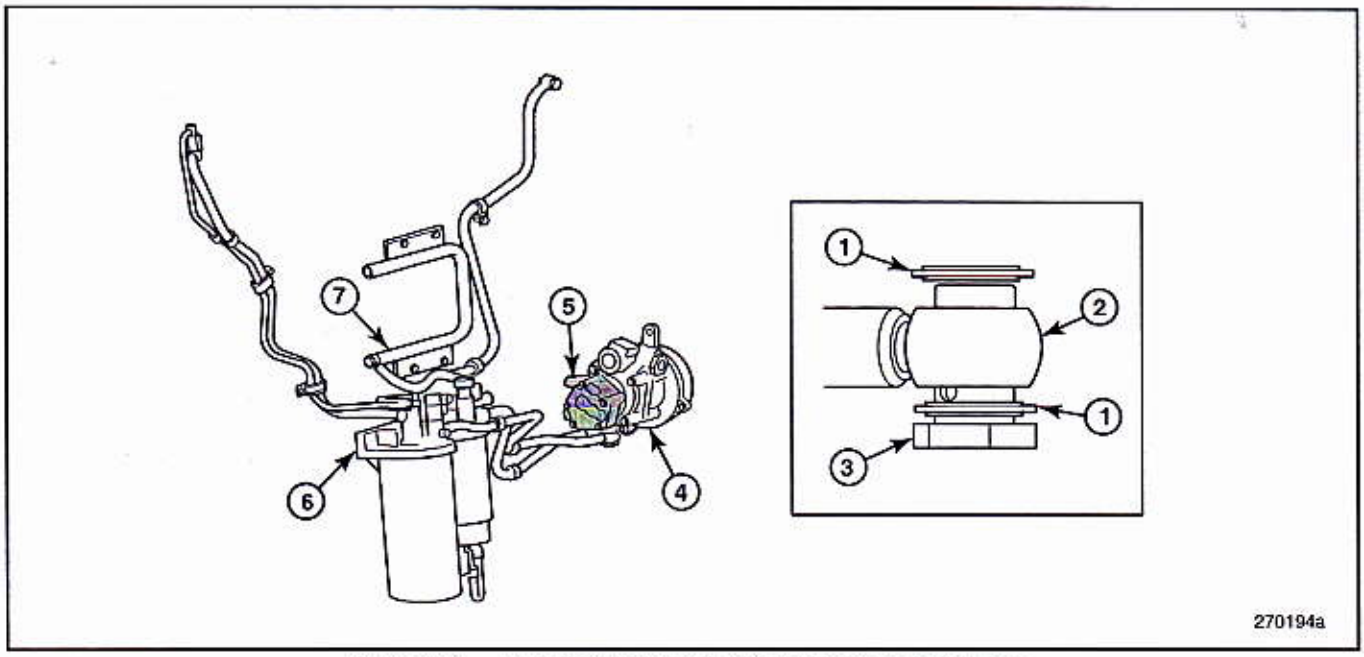


Figure 356 — Fuel Supply Pump, Filter Assembly and Lines

1. Seal Rings 2. Banjo Coupling 3. Hollow Screw 4. Power Steering Pump	5. Low-Pressure Fuel Supply Pump (Mounted to Power Steering Pump) 6. Filter Valve Housing 7. EECU Cooler

4. Attach the line to the block with a P-clamp.
5. Install the fuel return line between the cylinder head at the front and the filter valve housing.
6. Install the line to the block with P-clamps.
7. Install the fuel return line connecting the filter valve housing to the EECU cooler.
8. Install the fuel supply and return lines between the fuel pump and the filter housing.
9. Using a torque wrench, tighten the banjo fittings according to specification.

Crankcase Ventilation Separator

1. Clean the crankcase ventilation separator mating surface on the engine block. Install a **new** rubber gasket into the separator housing groove.

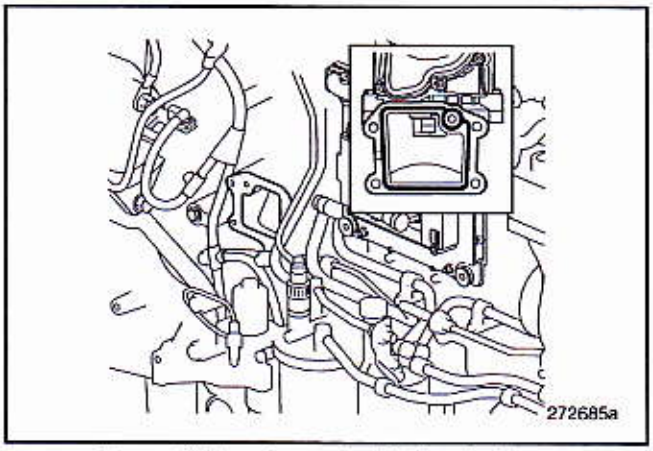


Figure 357 — Separator Mating Surface

2. Assemble the separator on the block and install fasteners.

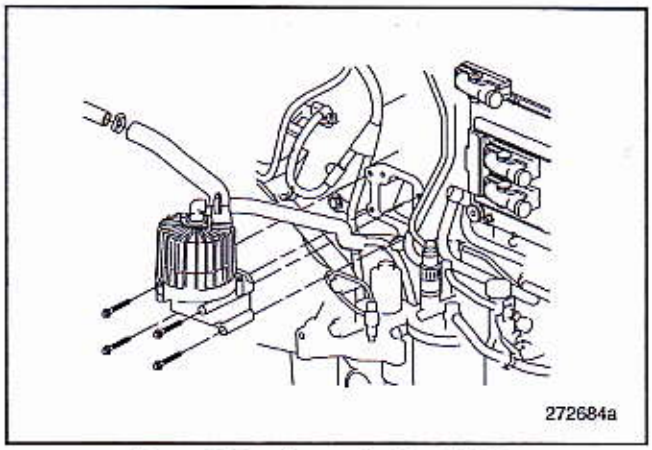


Figure 358 — Separator Installation

3. Using a torque wrench, tighten the fasteners according to specification.
4. Assemble the outlet hose on the separator outlet connector and install hose clamps.
5. Using a torque wrench, tighten the hose clamp fasteners according to specification.
6. Assemble the inlet hose on the separator inlet and prepare for valve cover connection in a future step. Install hose clamps.
7. Using a torque wrench, tighten the hose clamp fasteners according to specification.

Crankshaft Vibration Damper and Fan Pulley Installation

[212 RB, 216 1A]

⚠ CAUTION

When handling a vibration damper, be careful not to damage the housing. Dents in the outer housing will render the damper ineffective. The vibration damper cannot be repaired. Failure to heed this caution may result in severe engine damage.

Inspect the vibration damper for dents, nicks or fluid leaks in the outer housing. If any of these are evident, the damper must be replaced. Due to the close clearance between the damper housing and the rotor inside, dents or nicks may cause contact between the two components. Fluid loss will deteriorate the dampening effect of the damper.

1. Assemble the crankshaft vibration damper and fan pulley on the crankshaft hub using **new** fasteners.

NOTE

Fasteners are one-time use only. Do **NOT** reuse fasteners.

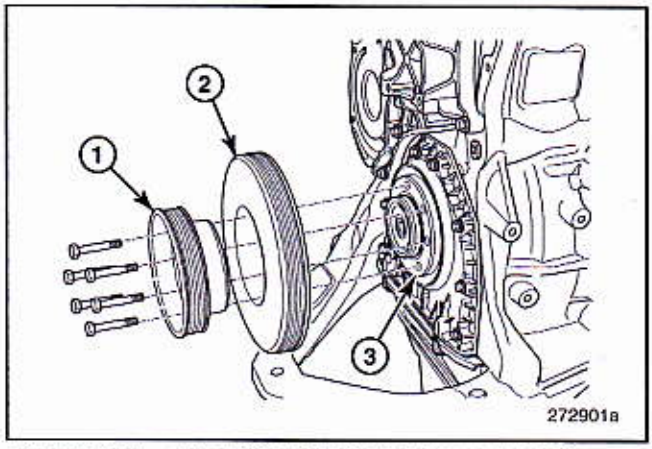


Figure 359 — Fan Drive Pulley and Crankshaft Damper Assembly

1. Fan and Coolant Pump Drive Pulley	2. Vibration Damper 3. Crankshaft Hub

2. Using a torque wrench, tighten the attaching fasteners in sequence in two steps according to specification.
3. Assemble the front engine power take-off (FEPTO) if equipped. Tighten the attaching fasteners in sequence in two steps according to specification.

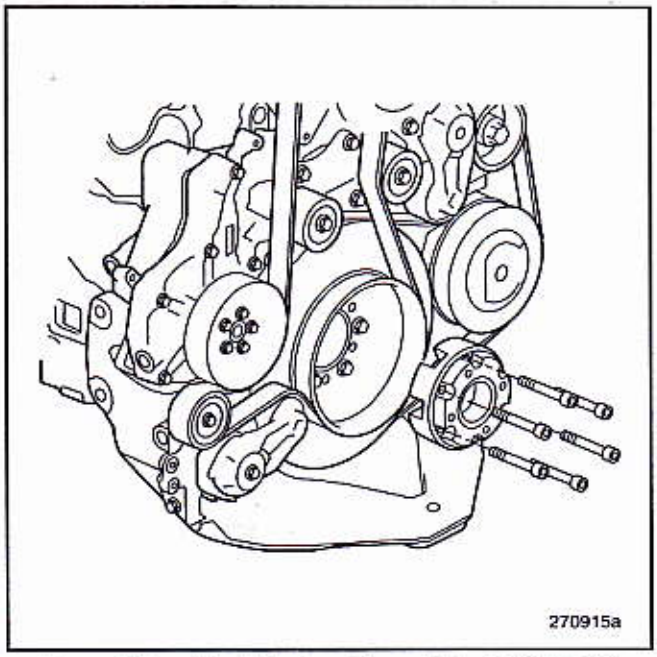


Figure 360 — Front Engine Power Take-Off (FEPTO) Assembly

Alternator and Refrigerant Compressor Installation

[271 CB, 264 DP]

1. Assemble the alternator mounting bracket onto the cylinder block. Tighten the fasteners according to specification.
2. If removed and not previously installed, assemble the front engine support mounting bracket on the cylinder block. This bracket also provides the mounting points for the A/C compressor.
3. Using a torque wrench, tighten the fasteners for the bracket and mount according to specification.
4. If removed, assemble the belt tension idler on the bracket.
5. Using a torque wrench, tighten the fasteners according to specification.
6. Assemble the alternator and refrigerant compressor on their pads.

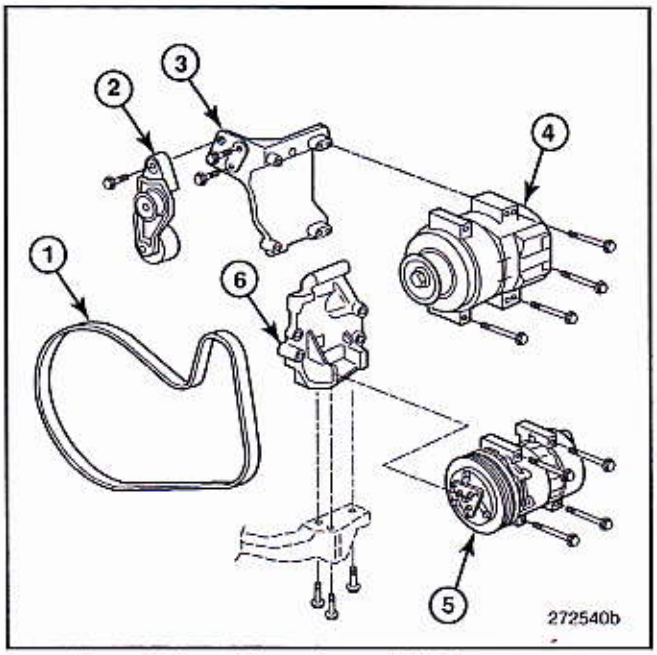


Figure 361 — Alternator and A/C Compressor

1. Drive Belt	4. Alternator
2. Belt Tensioner	5. A/C Compressor
3. Alternator Mounting Bracket	6. Mounting Bracket, Front Engine Support

7. Using a torque wrench, tighten the fasteners according to specification.
8. If a harness is installed, securely connect the electrical wiring as tagged during disassembly.
9. Assemble the belt pulleys on the alternator and compressor hubs, if removed.

Wiring Harness Installation

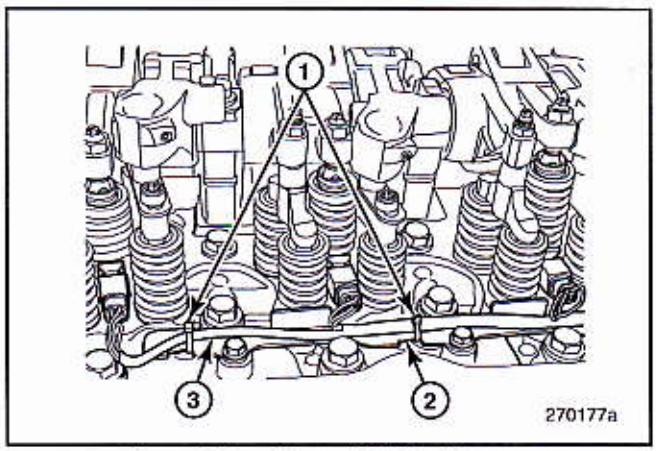


Figure 362 — Internal Wiring Harness

1. Tie Straps 2. Tie Bar Notch	3. Wiring Harness

1. Route and position the harness on the engine as noted during disassembly.
2. Insert the unit injector portion of the harness through the hole in the timing gear housing.
3. Connect the harness to each injector.
4. Connect the harness to the engine brake control valve if installed.
5. Using high-temperature wire ties, 983472, attach the harness to the cylinder head.
6. If not previously done, carefully route the wiring harness over the engine brake control valve. Secure the harness to the control valve as shown in Figure 363. Make sure that the harness is positioned to the side of the boss at the top of the valve assembly.

⚠ CAUTION

Do NOT route the harness over the boss at the top of the engine brake control valve. There is not enough clearance between the valve and the valve cover for the harness when the cover is installed. The harness must be positioned to the side of the boss to avoid damage to the harness.

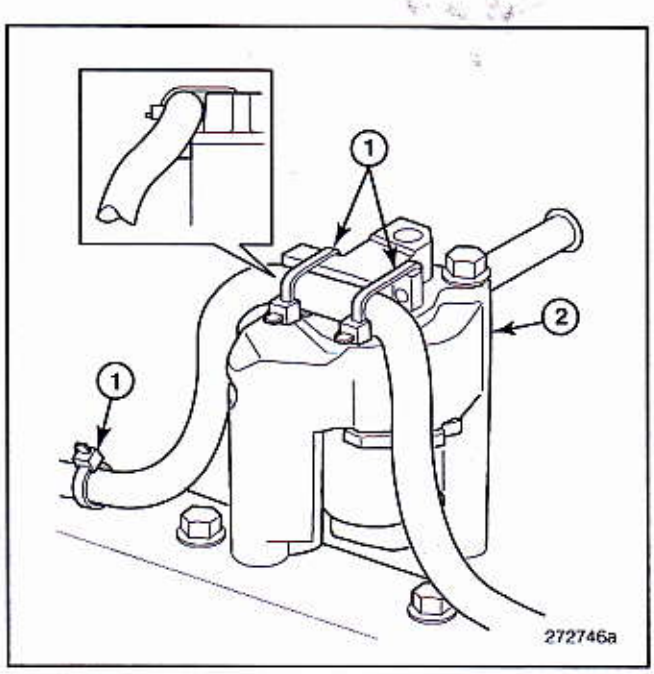


Figure 363 — Harness Routing Over Engine Brake Control Valve

1. Tie Straps	2. Control Valve

The external portion of the wiring harness is encased in accordion tubing. There are several units each of which is fitted with end connectors that permit convenient stringing, joining and attachment to the block in various locations.

CONNECTING THE EECU

1. Check the tension of the terminal connector pins using the test pins tool kit 9990008.

NOTE

If terminal pins are damaged or corroded, replace as necessary.

2. Carefully engage the upper and lower wiring harness connectors to the EECU. Verify that the connectors are latched and properly locked in position.

⚠ CAUTION

Use care to ensure that the EECU terminal pins are straight and undamaged.

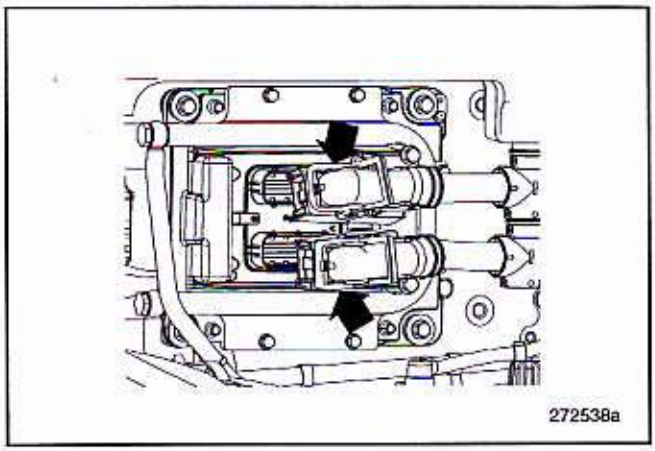


Figure 364 — EECU Harness Connectors

3. Install the bolts to secure the wiring harness clamps to the EECU.

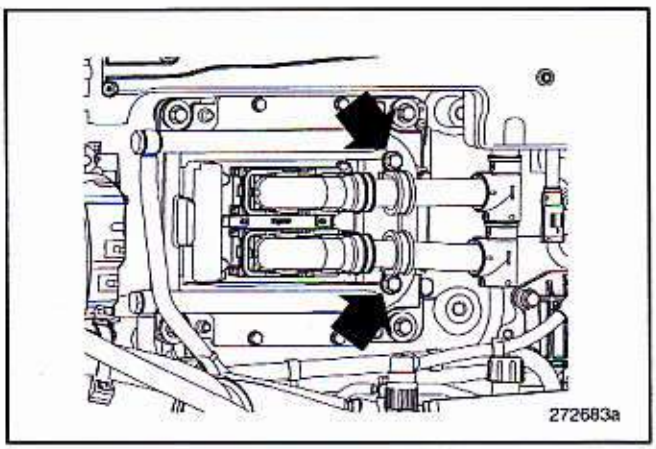


Figure 365 — EECU Harness Clamps

4. Connect the various terminals as tagged at disassembly to all sensors, relays and components such as the starter, alternator and refrigerant compressor among others.
5. Attach the clamps to hold the harness on the block.

Cylinder Head (Valve) Cover Installation

[211 JB]

1. Clean the gasket sealing surface of the cylinder head. The surfaces should be clear of any dirt or debris and free of any oil.
2. Inspect the gasket for damage. If replacement is necessary, carefully place a **new** gasket into the channel, making sure that it is properly seated and follows the contour of the channel.

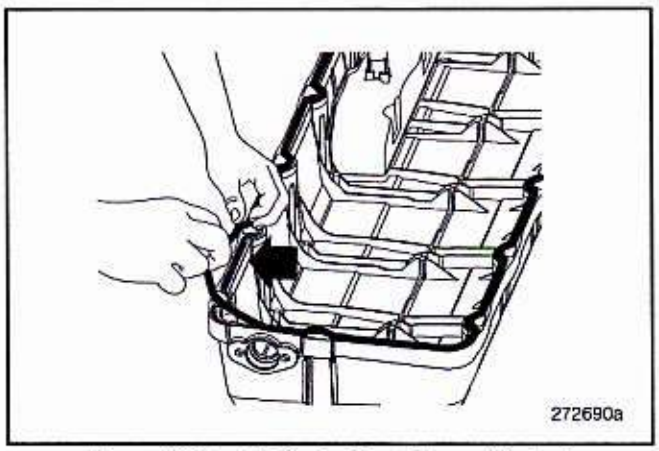


Figure 366 — Cylinder Head Cover Gasket

3. Apply a 2 mm (0.079 inch) bead of MACK sealant to the area where the timing cover and the cylinder head meet. This parting line is on both sides of the cylinder head. Carefully position the valve cover on the cylinder head and make sure that the seal remains properly seated.

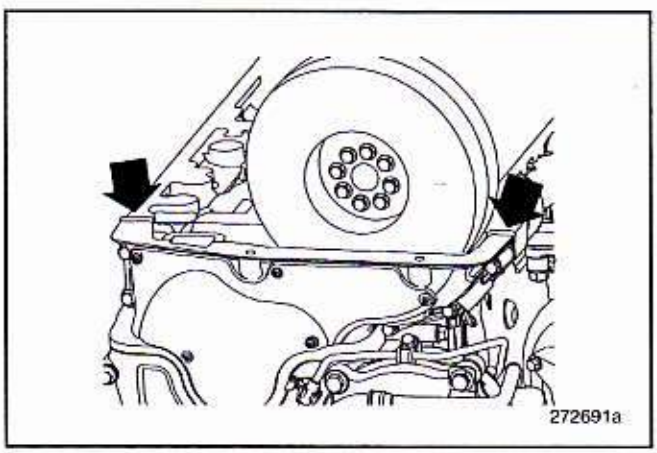


Figure 367 — Sealant Application

4. Install the spring-loaded bolts in the valve cover. Torque-tighten the valve cover bolts in sequence to specification.

NOTE

- The cylinder head cover must be installed within 20 minutes of the sealant being applied.
- The bolt springs provide even tension on the valve cover gasket.

5. Install the fasteners securing the crankcase ventilation tube and bracket to the valve cover and intake manifold. Torque-tighten the fasteners to specification.

NOTE

Inspect the crankcase ventilation tube O-ring and replace if necessary.

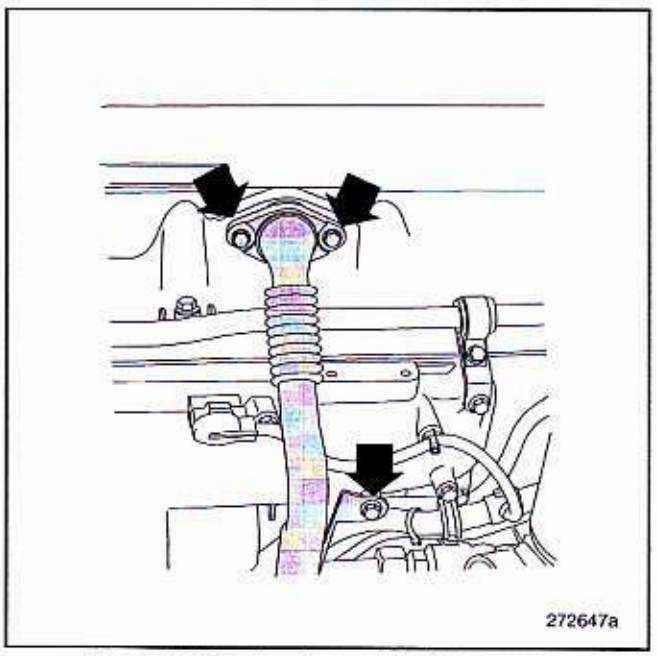


Figure 368 — Crankcase Ventilation Tube

Fan Hub and Drive Belt Installation [216 AA]

1. Place the fan hub bracket assembly in position at the front of the cylinder head and block. Install the mounting fasteners and tighten to specification.

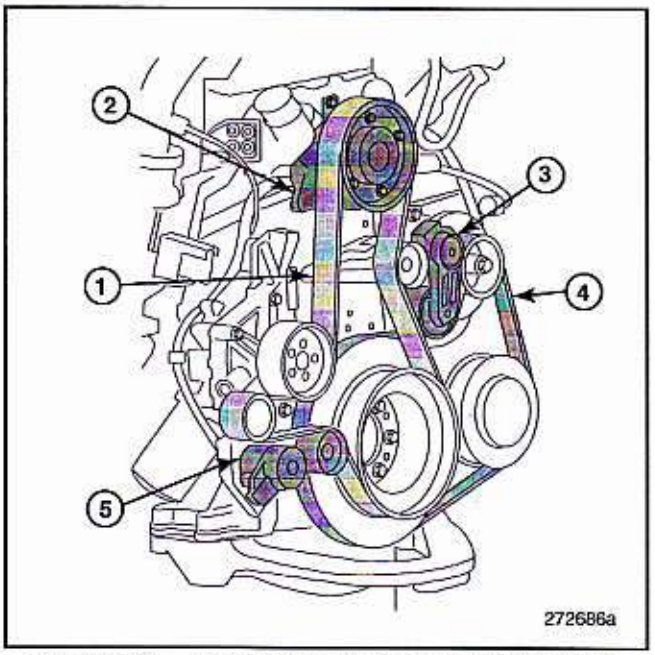


Figure 369 — Fan Hub and Accessory Drive System

1. Fan Drive Belt 2. Fan Hub Bracket 3. Accessory Drive Belt Tensioner	4. Accessory Drive Belt 5. Fan Drive and Coolant Pump Belt Tensioner

2. Place the fan drive and pump drive belt tensioner in position on the coolant pump housing. Install the fasteners and tighten to specification.
3. If not already done, place the accessory drive belt tensioner in position on the cylinder block. Install the fasteners and tighten to specification.
4. Check the condition of both of the original A/C/alternator and water pump/fan belts. Check for dry cracks or scuff marks and replace with new belts if any of these conditions are present.
5. Per the accessory routing decal, route the A/C/alternator and fan/water pump belts.

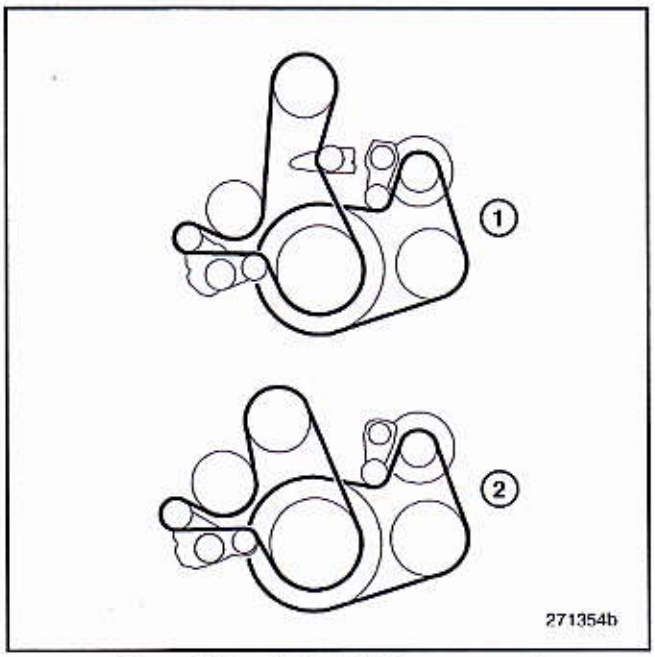


Figure 370 — Drive Belt Arrangement

1. Conventional	2. LCF

6. Place a 1/2-inch ratchet or special tool J 44392 in the accessory drive belt tensioner notch. Install the drive belt by prying the tensioner away from the belt to relieve the tension on the adjuster and allow the belt to slip onto the A/C compressor pulley. Release the tension and remove the tool.

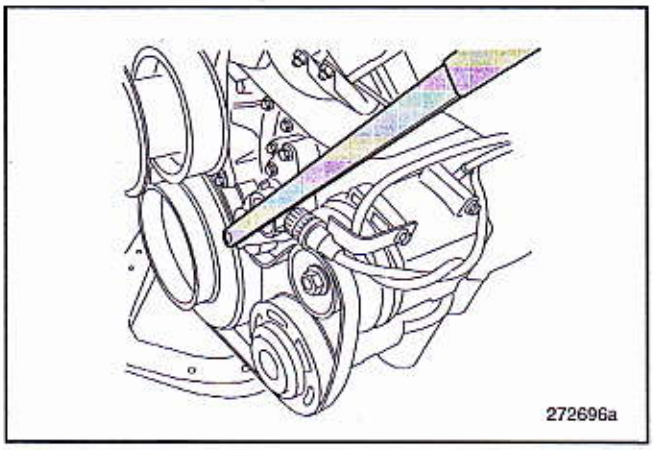


Figure 371 — Accessory Drive Belt Installation

7. Using tool J 44392, pry the belt tensioner away from the fan and water pump drive belt and install the belt. Release the tension and remove the tool.

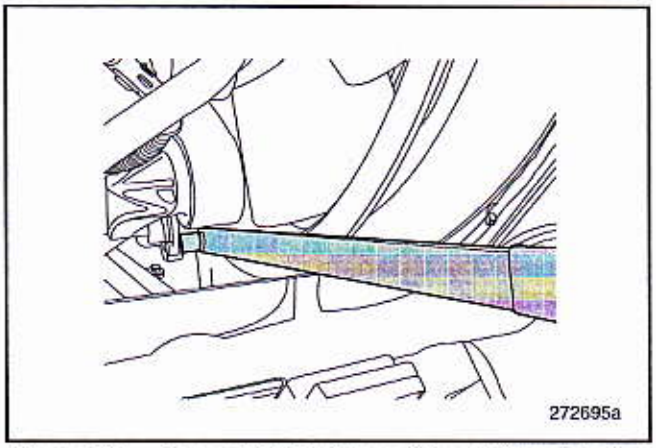


Figure 372 — Fan and Water Pump Drive Belt Installation

Removing Engine from Engine Stand

[200 EB]

⚠ DANGER

The engine is very heavy and extreme caution must be exercised while it is being lifted from the stand. Failure to use proper equipment and failure to keep your body clear may result in serious personal injury or death if the engine should fall or suddenly shift out of position.

1. Attach engine lifting tools J 47038-1, J 47038-6 and J 47038-8 as follows:
   a. Slide the center engine lifting bar over the cylinder head cover and install the clevis pin. Connect the center lifting bar clevis to the chain on the hoist.
   b. Place the lifting chain to the engine lift eyes and secure the chain to the bracket.
   c. Slide the rear lifting plate into the center lifting bar and install the pin.
   d. Bolt on the front section of the engine lifting bracket to the cylinder head and install the pin in the bar.
   e. Torque-tighten lifting bracket fasteners to specification.

⚠ DANGER

Use only the chains, clevis and lifting plate provided with these special tools. Failure to use the correct special tool components may allow the engine to fall, causing serious personal injury or death.

2. Support the weight of the engine using a mobile floor crane such as OTC 16-1813 or equivalent crane capable of lifting the engine. Position the crane and hook up to the bar as close as possible. Raise the crane slightly to apply tension to the chain.
3. With the lifting device now supporting the engine weight, remove the mounting fasteners from the engine stand.
4. Using the engine hoist, place the engine in a suitable support rack or install the engine in the vehicle (see *Engine Installation* in the **REPAIR INSTRUCTIONS, PART 1** section).

Filters and Miscellaneous Components Installation

[219 EV, 215 LD]

This section covers installation of filters and other components that might get in the way of other assembly operations and to which nothing is assembled.

NOTE

The sequence in which the fuel filter valve housing, fuel lines and EECU are assembled on the engine depends on the type of engine stand used. For engine stands that use an adapter plate attached to the left side of the engine, these components cannot be installed until after the engine has been removed from the repair stand.

1. If not already done, assemble the following components on the engine using the procedures covered earlier in this section.
   - Engine wiring harness
   - Crankcase ventilation tubing
   - EECU and cooling plate
   - Fuel filter valve housing and fuel lines
   - Crankcase ventilation separator

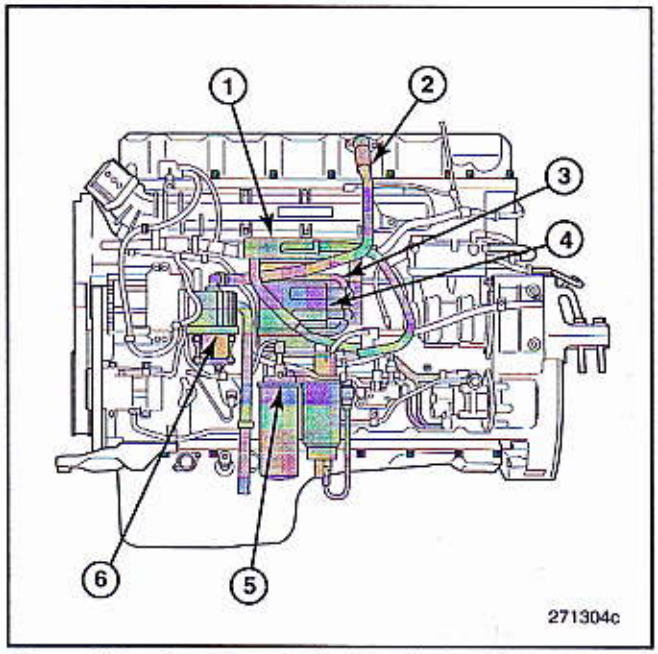


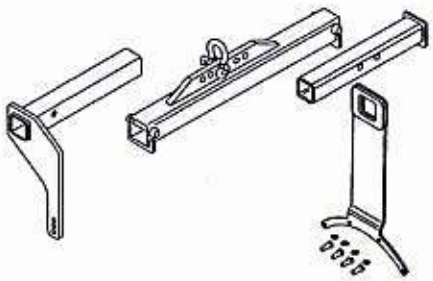
Figure 373 — Components for Installation After Removal from Repair Stand

1. Engine Wiring Harness	4. EECU
2. Crankcase Ventilation Tubing	5. Fuel Filters
3. EECU Cooler	6. Crankcase Ventilation Separator

2. Assemble the full-flow oil filters and tighten to contact plus 3/4 to 1 turn.
3. Assemble the bypass oil filter and tighten to contact plus 3/4 to 1 turn.
4. Assemble the coolant filter and tighten to contact plus 3/4 to 1 turn.

ENGINE INSTALLATION

Special Tools

Tool No.	Description	Image
DBT2V700	Coolant Extractor/Injector	006940a
J 47038-3 J 47038-4 J 47038-6 J 47038-8	Engine Lifting Tool Set	 006927b

General Instructions

Details of the engine installation procedure vary from one vehicle to another. This section provides general guidelines for installing an MP8 engine in a vehicle.

NOTE

Before installing the engine, make sure tools and equipment are inspected for safety and available for use.

1. Position the vehicle on a flat, level surface with ample work space.
2. Apply the parking brake and block the wheels. Observe all safety precautions.

NOTE

Refer to the **SPECIFICATIONS** section for information about the fasteners mentioned below. Some groups of fasteners must be tightened in a specific sequence. Patterns of sequence are also specified in the torque specification section.

Installation

⚠ WARNING

The engine is obviously heavy and difficult to handle. Obtain a helper and provide a suitable lifting device to support it safely during installation. Failure to heed this warning may result in severe personal injury.

⚠ CAUTION

While installing the engine, watch for obstructions that may interfere, such as engine and chassis components, brackets, clamps and other parts attached to the frame and cab. Failure to heed this caution may result in severe damage to the engine and other components.

1. Remove the valve cover.
2. Cover the valve mechanism and gear train with a suitable cloth or similar covering to prevent dirt and debris from entering the engine.
3. Attach the engine lifting tool, J 47038, to the engine. Secure the engine lifting tool to the front of the cylinder head and to the rear at the flywheel housing. Adjust the tool to assume the load.

⚠ DANGER

Ensure all bolts and pins are correctly positioned prior to removing the engine from the engine stand. Failure to properly install all bolts and pins of the engine lifting tool can result in personal injury and/or death.

4. Using the engine lifting tool, J 47038, and with the aid of the helper, lift and lower the engine into position.
5. Align the engine with the transmission.
6. Install and, using a torque wrench, tighten the rear engine support attaching screws according to specification.
7. Install and, using a torque wrench, tighten the front engine support attaching screw according to specification.
8. Remove the engine lifting tool from the engine.
9. Apply an even 2 mm (5/64 inch) bead of sealant at the joint lines between the cylinder head and the timing cover.

NOTE

Install the valve cover within 20 minutes of applying the sealant.

10. Install the valve cover.
11. Install the transmission and, using a torque wrench, tighten the transmission attaching screws according to specification.
12. Withdraw the transmission jack.
13. As applicable:
    a. If manual transmission, attach the clutch linkage and bracket retaining screws.
    b. If automatic transmission, attach the torque converter access panel and torque converter.
14. Attach the hood rest crossmember if applicable.
15. Connect starter wires and cables.
16. Attach the power steering hoses and reservoir if applicable.
17. Attach the exhaust system brackets.
18. Attach the exhaust system to the turbocharger.

⚠ WARNING

The radiator and CAC assembly is heavy and difficult to handle. Provide a suitable lifting device and a helper to support it safely during installation. Failure to heed this warning may result in severe personal injury.

19. Attach the radiator and CAC assembly.
20. Attach the fan assembly.

NOTE

To allow for chassis articulation in severe service applications, the fan ring rubber seal does not fit flush against the shroud on GU model chassis. A gap of 15–20 mm (0.59–0.79 inch) exists between the front face of the aluminum fan ring to the back face of the fan shroud.

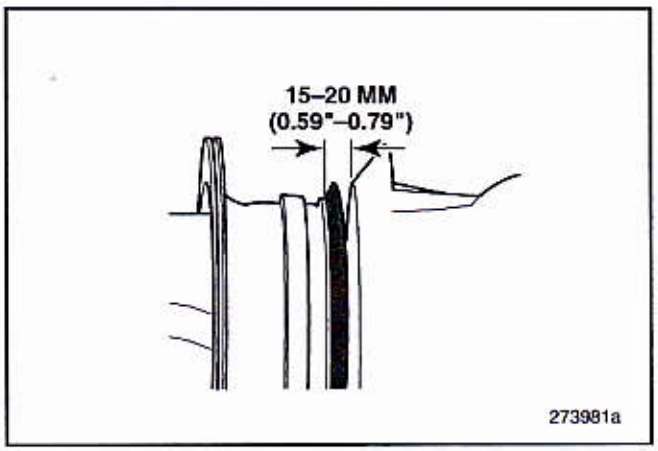


Figure 374 — Fan Ring-to-Shroud Clearance

21. Connect the fan actuator.
22. Connect the engine coolant temperature sensor.
23. Attach the charge air cooler outlet components.
24. Attach the charge air cooler inlet components.
25. Attach the coolant expansion tank.
26. Attach the lower radiator tube.
27. Connect the cab heater and fuel heater coolant return lines to the lower radiator tube.
28. Attach the upper radiator tube.
29. If the vehicle is equipped with air conditioning:
    a. Connect the A/C compressor discharge hose.
    b. Connect the A/C line at the receiver/dryer.
    c. Connect the pressure switch on the receiver/dryer.
    d. Connect the low pressure cutout switch.
    e. Recharge the A/C system with refrigerant using refrigerant recovery and recycling equipment for R134A.
30. Install the inlet air system components including the filter.
31. Connect the inlet air heater if present.
32. Attach the oil and fuel filters and the coolant conditioner.
33. Close all drains and drain valves.
34. Connect all sensors and actuators.
35. Install the drive belts.
36. Add oil and coolant. If available, use coolant extractor/injector when adding coolant.
37. Attach the hood, or replace the tilted cab.

REPAIR INSTRUCTIONS, PART 2

IN-CHASSIS PART/COMPONENT PROCEDURES

This section presents standalone replacement operations which can be done in-chassis without a complete engine overhaul. These operations include:

- CAMSHAFT BEARING BRACKETS, REPLACEMENT
- OIL THERMOSTAT AND PRESSURE SAFETY VALVE REPLACEMENT
- CRANKSHAFT FRONT SEAL REPLACEMENT
- CRANKSHAFT REAR SEAL REPLACEMENT
- CRANKCASE VENTILATION (CCV) SEPARATOR REPLACEMENT
- OIL PUMP REPLACEMENT
- INJECTOR COPPER SLEEVE REPLACEMENT
- UNIT INJECTOR CLEANING
- VALVE STEM HEIGHT MEASUREMENT PROCEDURE
- VALVE STEM SEAL REPLACEMENT

Due to the Engine Electronic Control Unit (EECU) self-learning capability, it is necessary to reset learned EECU parameters after servicing some engine-related components. This allows the EECU to learn the new component's behavior. After servicing is complete, perform the "Learned Data Reset" located in VCADS/PTT.

CAMSHAFT BEARING BRACKETS, REPLACEMENT (MACK MP8 ENGINE) [213 CJ]

This information covers guidelines when replacing factory or aftermarket camshaft bearing brackets (lower journals) on the MACK MP8 engine.

Preliminary Steps

The following components need to be removed for access to the camshaft bearing brackets:

- Valve Cover
- Compression Brake Solenoid Valve
- Rocker Arm Shaft
- Camshaft Assembly

General Information

Camshaft bearing journals are numbered 1–7, with matching upper and lower halves. Be sure to note and mark the corresponding journal numbers and install them in the correct sequence with matched upper and lower halves.

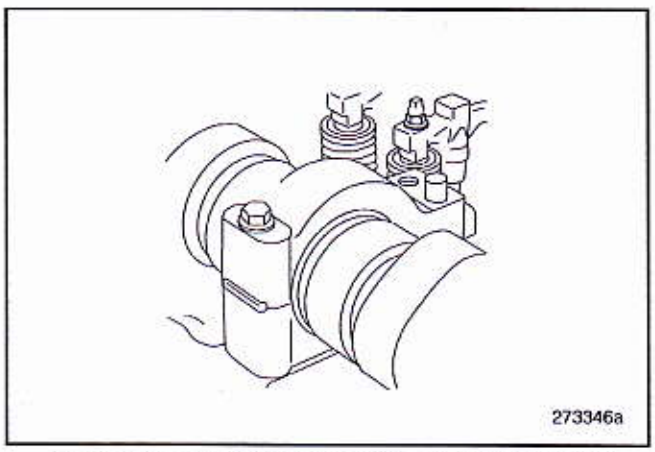


Figure 375 — Camshaft Bearing Bracket Installed

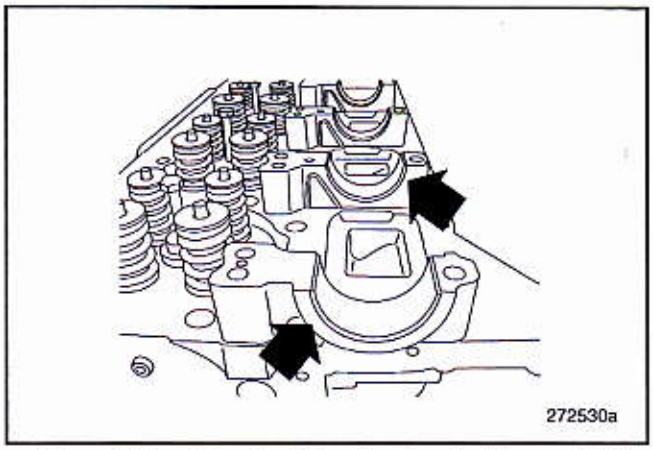


Figure 376 — Camshaft Bearing Bracket Lower Half

WHEN REPLACING FACTORY-INSTALLED JOURNALS

- If a camshaft journal has seized, DO NOT MIX a replacement bearing bracket with the original factory-installed bearing brackets. This is because the original bearing brackets were align-bored when the engine was manufactured. All seven brackets must be replaced.
- When replacing a cylinder head, do not mix new bearing brackets with original bearing brackets from the old cylinder head. Use only new bearing brackets on a new cylinder head.

WHEN REPLACING/INSTALLING AFTERMARKET JOURNALS

- If there are already replacement bearing bracket assemblies on the engine, and one or more assemblies are damaged, all seven assemblies must be replaced. Replacement bracket assemblies can be identified by the oval-shaped alignment pin holes.
- For replacement bracket assemblies used in locations 2 through 6, both alignment pin holes are oval-shaped for side-to-side adjustment. For brackets used in locations 1 and 7, one alignment pin hole is oval-shaped for front-to-rear adjustment; the second pin hole is round with an alignment pin preassembled in it.
- Mark the bearing caps to indicate that aftermarket bearing bracket and cap assemblies have been installed.

Camshaft Inspection

To avoid unnecessary overhauling, conduct a thorough inspection of the camshaft before reinstalling it after replacing the bearing bracket assemblies.

Bracket Replacement Procedure

1. Remove the lower bearing brackets using a pry bar. The rearmost No. 7 bracket can be removed by using a soft-faced mallet and tapping side to side. (The alignment pins should come off the cylinder head with the brackets. If not, remove the pins.)

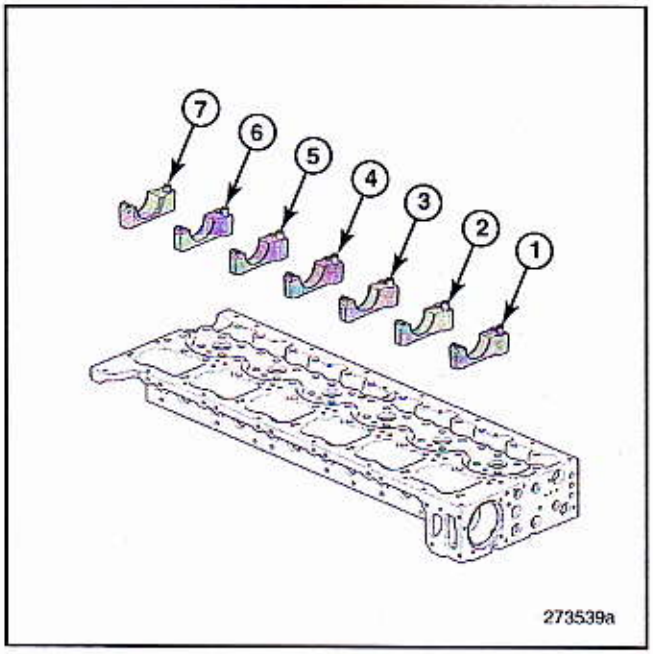


Figure 377 — Camshaft Lower Bearing Brackets

2. Clean the contact surfaces of the cylinder head and the lower bearing brackets.
3. Using a metal stamp or electric etching tool, mark the **new** bearing brackets and caps with the numbers, 1 through 7, indicating the location at which each assembly will be installed.

⚠ CAUTION

Do not use excessive force to punch the bracket assemblies when marking their position on the cylinder head. Damage to components can result.

4. Install 12 **new** locating pins from the parts kit at the cylinder head locations illustrated (Figure 378). Use a plastic mallet so as not to damage the locating pins.

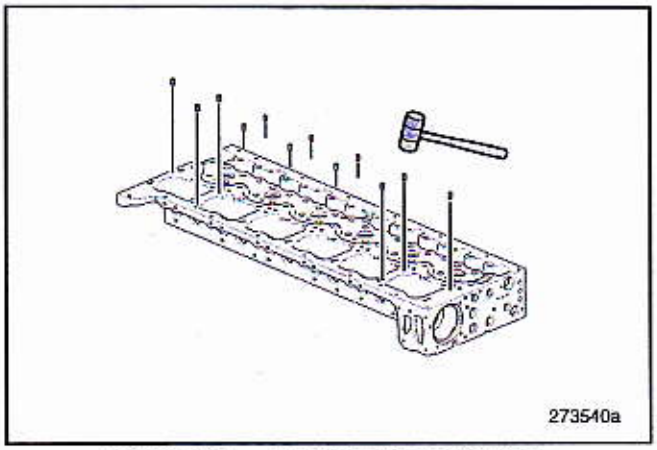


Figure 378 — Locating Pin Installation

5. Install the **new** lower bearing brackets at their respective marked positions on the cylinder head.
6. Check that the bearing brackets can move slightly on the locating pins.
   - Bracket Nos. 1 and 7 should turn slightly forward and back at one side.
   - Bracket Nos. 2 through 6 should move slightly side to side.

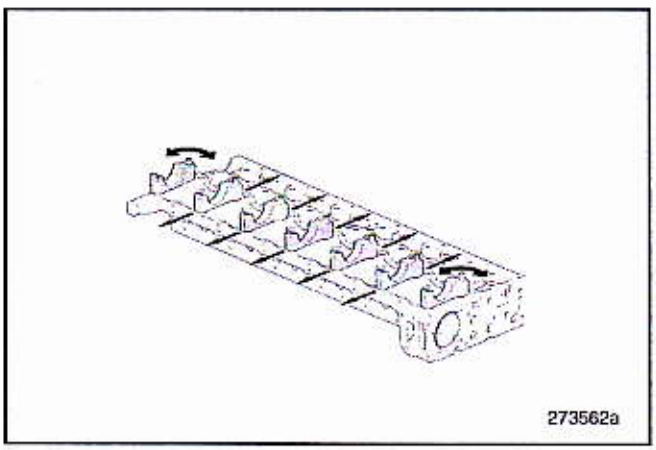


Figure 379 — Bracket Movement on Alignment Pins

Final Steps

Install the following components which were removed for access to the camshaft bearing brackets (see appropriate component for installation procedures):

- Camshaft Assembly
- Rocker Arm Shaft
- Compression Brake Solenoid Valve
- Valve and Unit Injector Adjustment
- Valve Cover Assembly

1. Install all previously removed cables to the ground (negative) battery terminals.
2. Start the engine, check for leaks and proper operation.

OIL THERMOSTAT AND PRESSURE SAFETY VALVE REPLACEMENT

Pressure Safety Valve Removal

Before attempting to remove the oil pressure safety valve, apply the parking brake, shift into neutral and thoroughly clean around the safety valve cover.

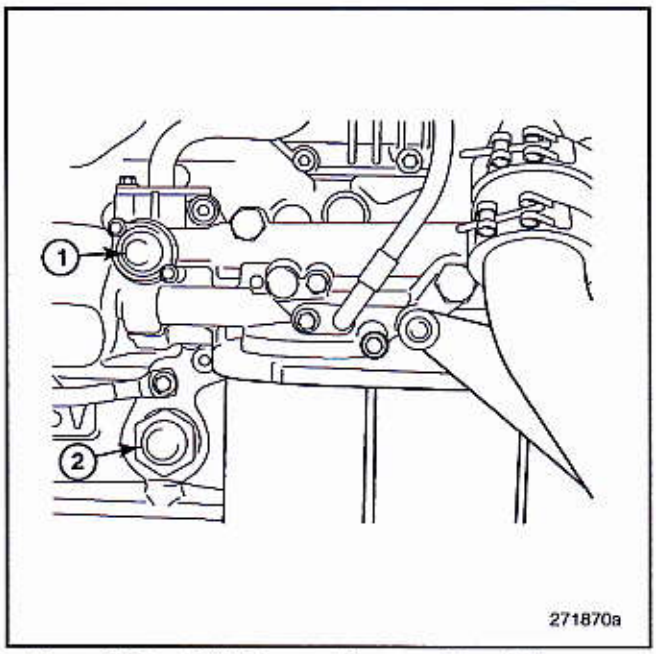


Figure 380 — Oil Valves — Thermostat and Pressure Safety

1. Thermostat Valve	2. Oil Pressure Safety Valve

1. Using the oil valve socket, J 43051, remove the safety valve cover and valve as a unit. Ensure that the seal is also removed with the cover and valve. Dispose of the valve.

Figure 381 — Oil Pressure Safety Valve and Cover

2. Clean the cover and cylinder block sealing surface.
3. Replace the O-ring on the cover.

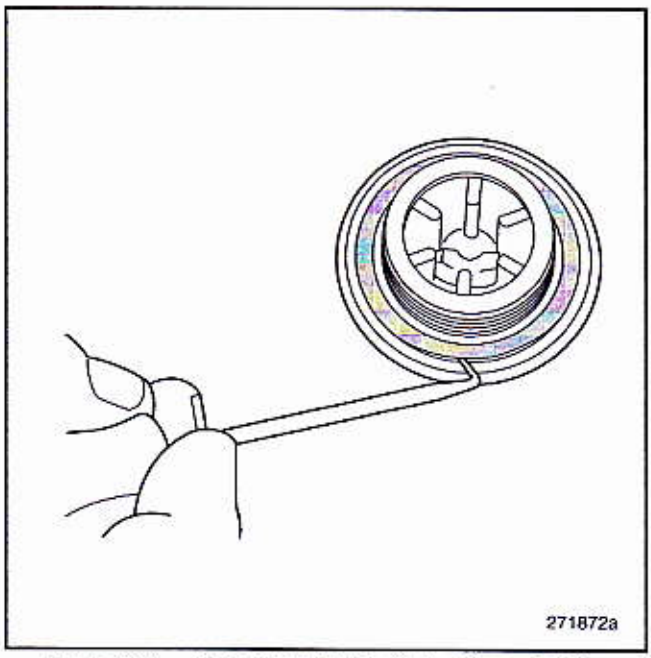


Figure 382 — Removing Safety Valve Cover O-Ring

4. Install a **new** valve in the cover.
5. Install the **new** valve and cover into the cylinder block.
6. Using a torque wrench, tighten the valve according to specification.

Oil Thermostat Valve Replacement

Before attempting to remove the thermostat valve, apply the parking brake, shift into neutral and thoroughly clean around the valve head.

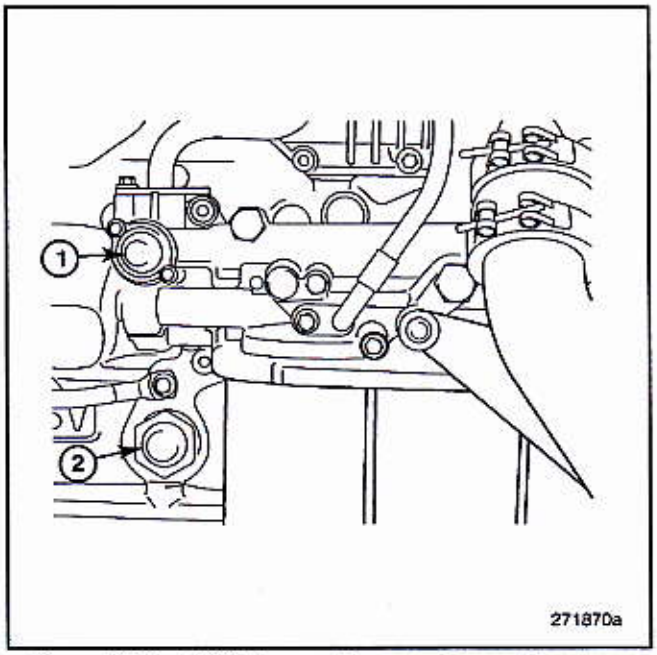


Figure 383 — Oil Valves — Thermostat and Pressure Safety

1. Thermostat Valve	2. Oil Pressure Safety Valve

1. Remove the thermostat valve from the oil filter housing and discard.
2. Replace the O-ring.

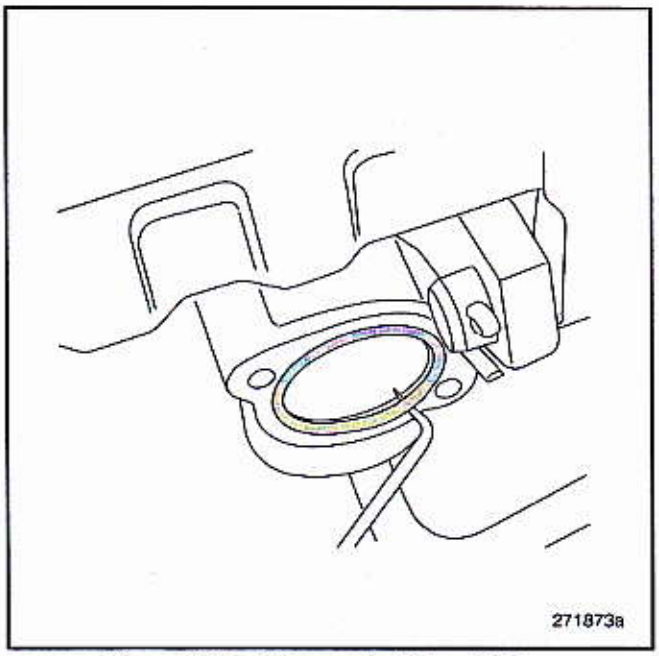
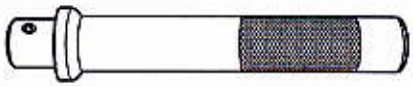
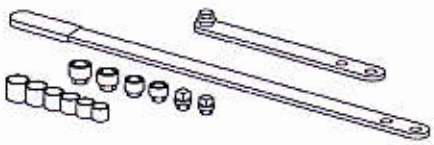
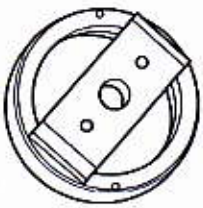


Figure 384 — Thermostat Valve O-Ring

3. Install a **new** thermostat valve with a **new** gasket.
4. Start the engine and check for leaks.

CRANKSHAFT FRONT SEAL REPLACEMENT

Special Tools

Tool No.	Description	Image
9992000	Handle with various uses (fits 25 mm hole) (Essential)	 006785a
J 44392	Drive Belt Tensioner Tool	 272697a
88800021	Front Main Seal Remover/Installer (Essential)	 006774a

Seal Removal

1. Remove the fan blade from the fan clutch hub.
2. Compress the belt tensioner (using J 44392) to release pressure on the fan and coolant pump drive belt and remove the belt.

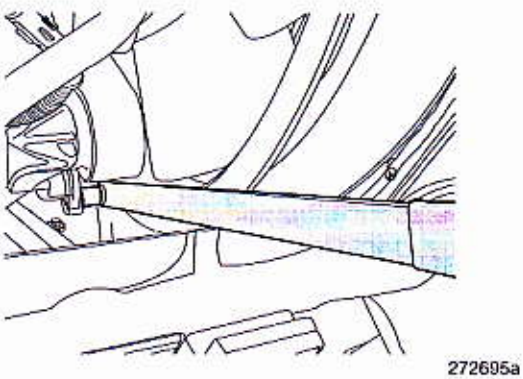


Figure 385 — Drive Belt Tensioner Tool

3. Compress the accessory belt tensioner (using J 44392) and remove the drive belt from the vibration damper pulley, refrigerant compressor pulley and alternator pulley.
4. If equipped, remove the front engine PTO fasteners and PTO.
5. Remove the mounting fasteners that secure the drive belt pulley and vibration damper to the crankshaft hub. Separate the pulley and damper from the hub.

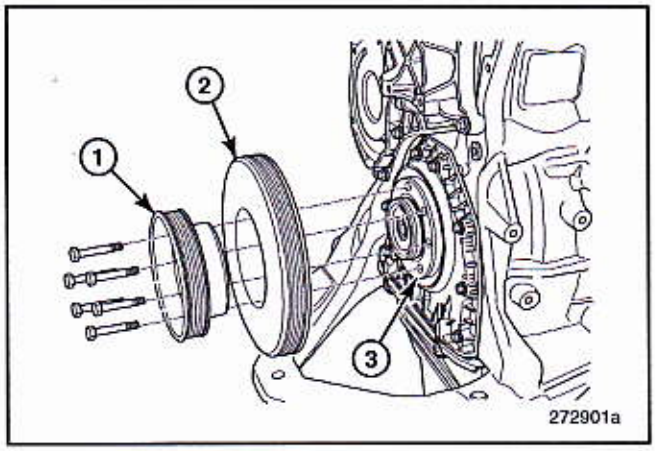


Figure 386 — Vibration Damper and Pulley Removal

1. Fan and Coolant Pump Drive Pulley 2. Vibration Damper	3. Crankshaft Hub

⚠ CAUTION

When handling a vibration damper, be careful not to damage the housing. Dents in the outer housing can render the damper ineffective. If damaged, the vibration damper cannot be repaired and must be replaced.

6. Remove the crankshaft seal as follows:
   A. Drill two 3.5 mm (0.138 inch) holes in the metal rim of the crankshaft front seal. Use the holes in the rim of the front main seal remover/installer (88800021) as a guide.

NOTE

Apply grease on the end of the drill bit to prevent chips from getting into the engine.

   B. Using two self-tapping M5 screws of suitable length, attach the crankshaft front seal remover/installer to the seal.
   C. Using two M10 fasteners threaded into the crankshaft front seal remover/installer, remove the crankshaft front seal.

Seal Installation

1. Clean the seal seating surface in the crankshaft front cover and the sealing surface of the crankshaft hub.
2. Assemble the handle (9992000) and front main seal remover/installer (88800021).
3. Place a **new** crankshaft front seal on the crankshaft front seal remover/installer.

NOTE

The crankshaft front seal should be installed dry. No sealant or lubricant is necessary.

4. Position the crankshaft front seal remover/installer and new seal over the crankshaft hub and crankshaft front cover. Carefully drive the seal into the cover until the tool bottoms against the crankshaft hub and front cover.

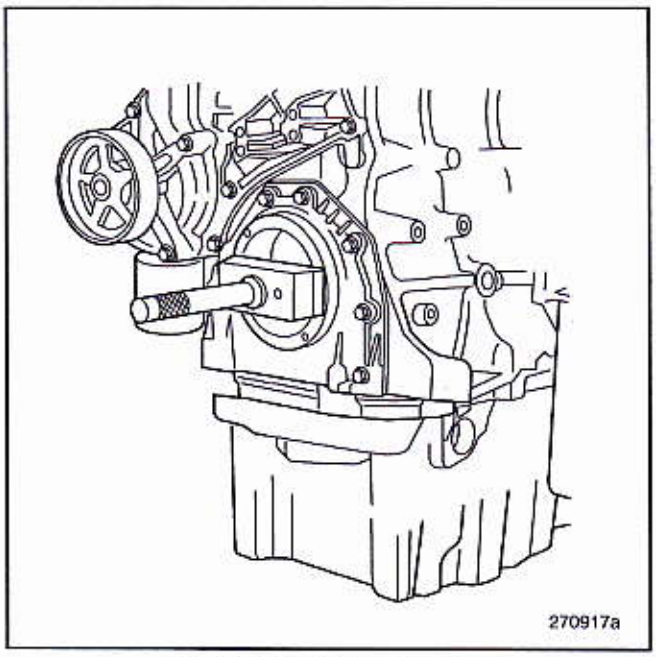


Figure 387 — Seal Installation

5. Remove the tool and inspect the seal to make sure that it is properly installed.
6. Place the vibration damper and fan pulley on the crankshaft hub and align the fastener holes. Install and tighten the mounting fasteners in two steps to specification.

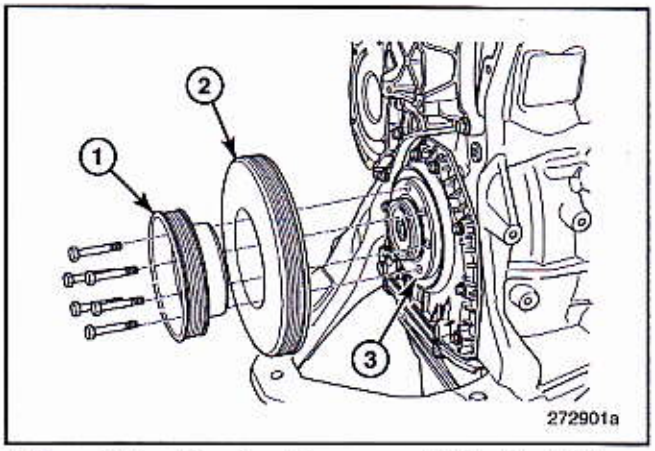


Figure 388 — Vibration Damper and Pulley Installation

1. Fan and Coolant Pump Drive Pulley 2. Vibration Damper	3. Crankshaft Hub

7. If equipped, install the front engine PTO and fasteners. Tighten the mounting fasteners to specification.

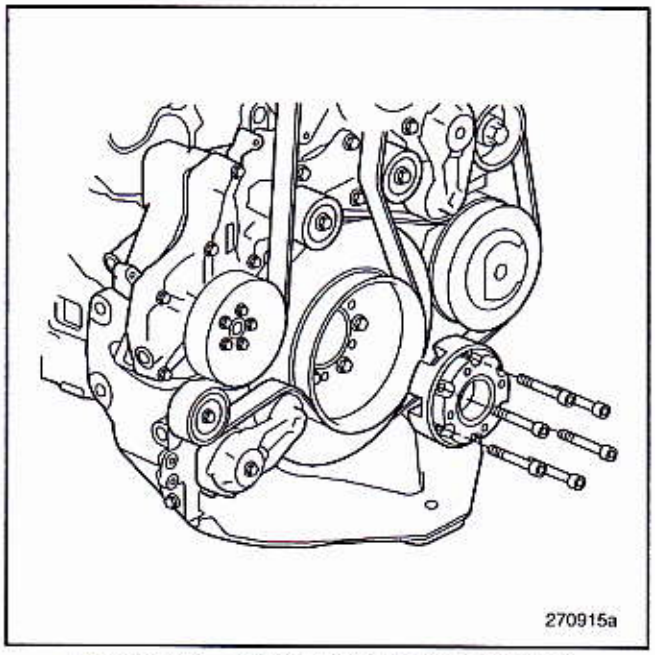


Figure 389 — Front Engine PTO Installation

8. Compress the accessory drive belt tensioner (using J 44392) and install the drive belt over the crankshaft pulley, fan drive pulley and coolant pump pulley.
9. Compress the lower belt tensioner (using J 44392) and install the drive belt over the crankshaft pulley, fan drive pulley and coolant pump pulley.

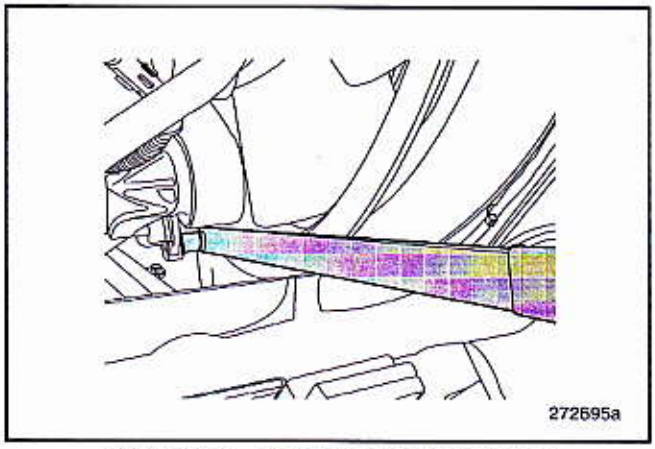
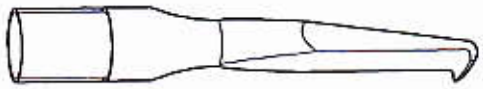
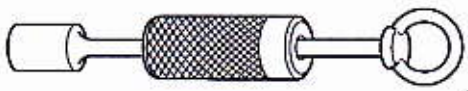
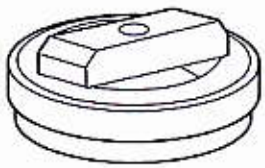


Figure 390 — Drive Belt Tensioner Tool

10. Place the fan blade on the fan clutch hub, install the mounting fasteners and tighten to specification.

CRANKSHAFT REAR SEAL REPLACEMENT

Special Tools

Tool No.	Description	Image
9990192	Crankshaft Seal Puller	 006896a
9992000	Handle with various uses (fits 25 mm hole) (Essential)	006785a
9996400	Slide Hammer	 006897a
9998238	Rear Main Seal Remover/Installer, for neoprene type seal (Essential)	 006780a

Neoprene Seal Removal

⚠ CAUTION

The flywheel is heavy. Do not attempt to remove the flywheel without the help of an assistant or a suitable lifting device. Failure to heed this caution may result in severe personal injury and property damage.

1. Carefully remove the flywheel sensor.
2. Install two M10 screws to use as handles to aid in removal.
3. Remove the flywheel.
4. Using the puller, 9990192, and the slide hammer, 9996400, carefully remove the seal.

Neoprene Seal Installation

1. Clean the flywheel, housing and crankshaft sealing surfaces.
2. Align properly and assemble the new seal on the seal installer, 9998238.

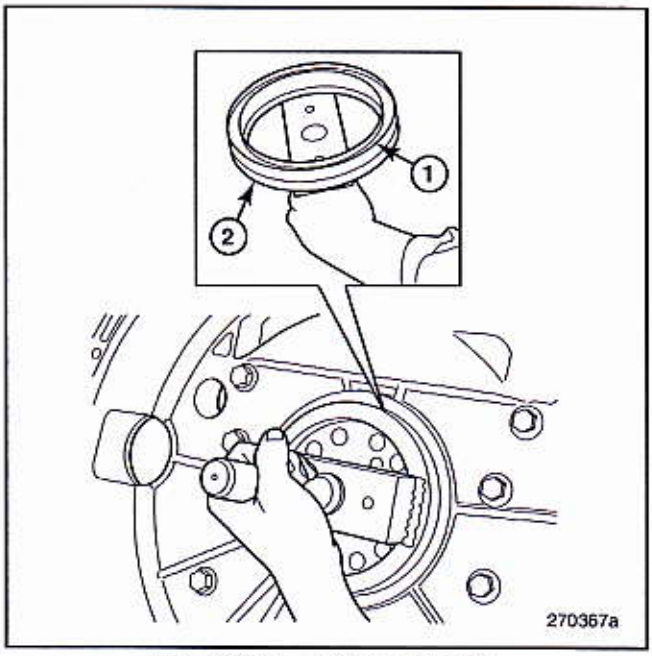


Figure 391 — Seal Installation

1. Rear Main Seal	2. Seal Installer, 9998238

3. Using the handle, 9992000, and the seal installer, carefully tap the seal into the flywheel housing until there is even contact.
4. Using the M10 screws as handles, with the help of an assistant or a lifting device, assemble the flywheel over the dowel and alignment studs on the mounting surface.

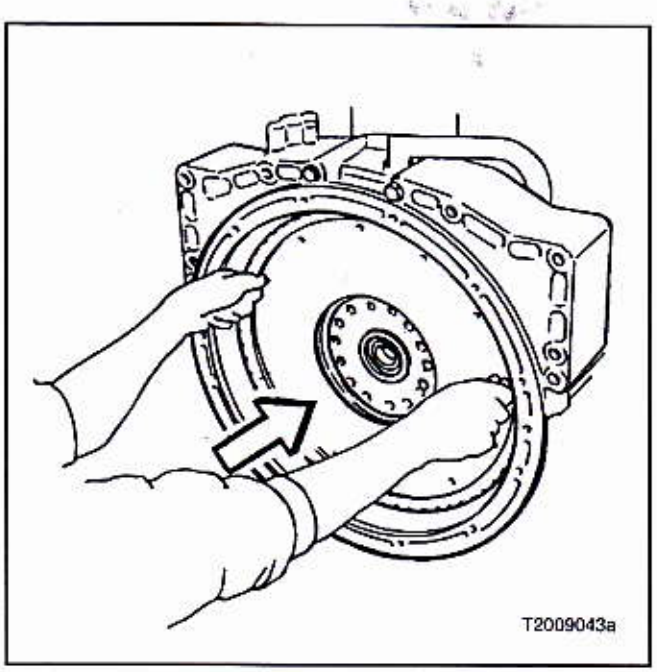


Figure 392 — Flywheel Installation

5. Insert the flywheel mounting screws finger tight. Remove the M10 screws to insert the remaining mounting screws.
6. Using a torque wrench, tighten the mounting screws in sequence according to specification.
7. Carefully install the flywheel sensor and connect it to the harness.

Teflon® Seal Removal

⚠ CAUTION

The flywheel is heavy. Do not attempt to remove the flywheel without the help of an assistant or a suitable lifting device. Failure to heed this caution may result in severe personal injury and property damage.

1. Remove the clutch assembly.
2. Carefully remove the flywheel sensor.
3. Install two M10 screws to use as handles to aid in removal.
4. Remove the flywheel.
5. Using the puller, 9990192, and the slide hammer, 9996400, carefully remove the seal. Make sure that the tools are free of burrs and dirt.

NOTE

Take care not to damage the crankshaft or flywheel sealing surfaces. Slant the tools inward to get a good grip on the crankshaft rear seal.

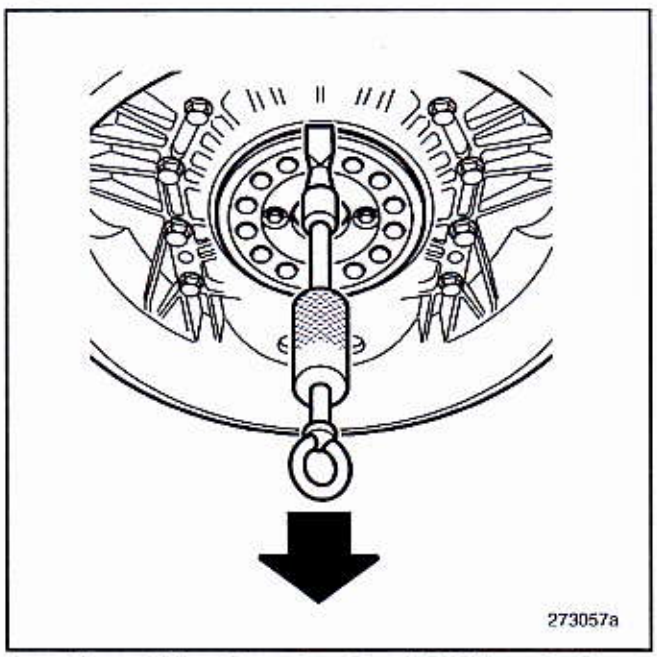


Figure 393 — Removing Crankshaft Rear Seal

6. Tap out the crankshaft rear seal.
7. Thoroughly clean the sealing surfaces of the flywheel, flywheel housing and crankshaft.

Teflon® Seal Installation

1. Install the plate and thrust screw part of tool, 9990166, to the crankshaft. Tighten the assembly screws securely.

NOTE

Make sure that the plate of the tool is positioned properly in the crankshaft internal guide and is flat against the crankshaft before tightening the screws.

Figure 394 — Install Plate and Thrust Screw Assembly

2. Install the spacer, 88880013, of tool, 9990166, on the thrust screw.

NOTE

The spacer is important because it determines the installation depth of the crankshaft rear seal.

3. The sealing ring is supplied with a plastic installation ring that should be left in place during installation.

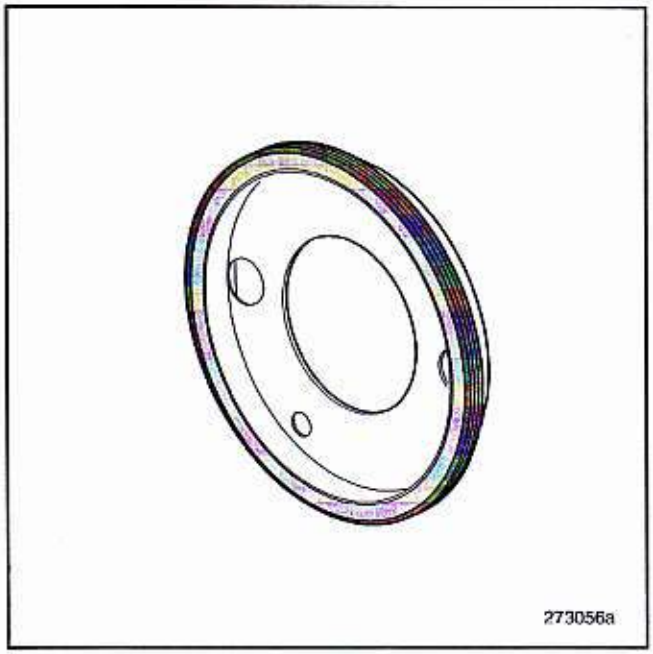


Figure 395 — Crankshaft Rear Seal

4. Install the seal without removing the installation ring over the thrust screw, spacer and plate assembly.

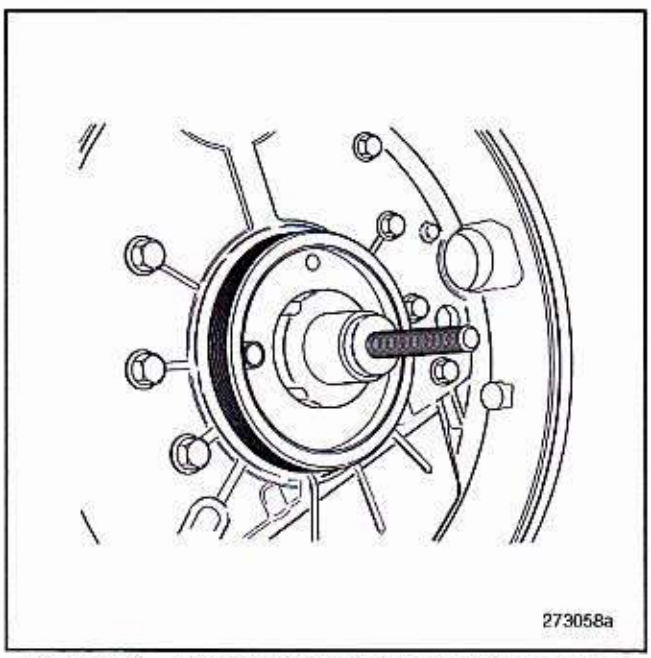


Figure 396 — Crankshaft Rear Seal Positioned on Tool

5. Install the cover and handle over the assembly. Center the cover over the crankshaft rear seal and thread the handle to keep the cover in position.

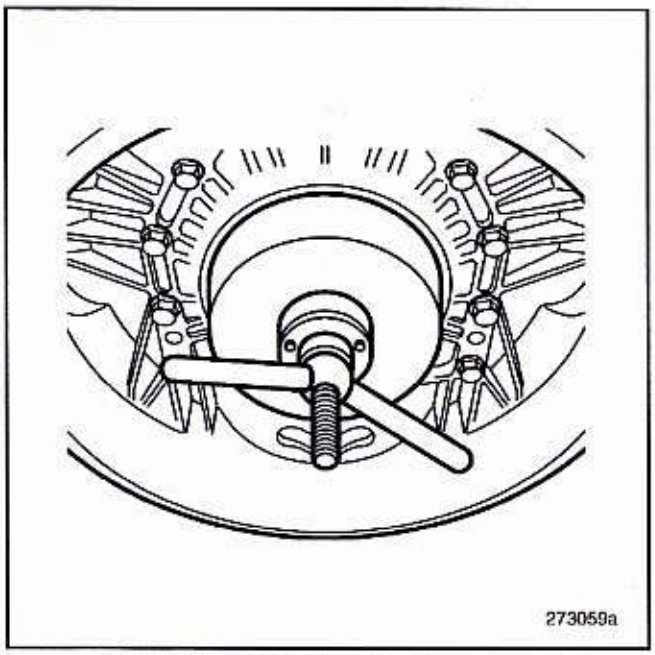


Figure 397 — Cover and Handle Installed

6. Turn the handle to press the crankshaft rear seal over the crankshaft and into the flywheel housing. When the cover bottoms out against the spacer, the rear seal is in proper position.
7. Remove the crankshaft rear seal installation tools.

8. Using the M10 screws as handles, with the help of an assistant or a lifting device, assemble the flywheel over the dowel and alignment studs on the mounting surface.

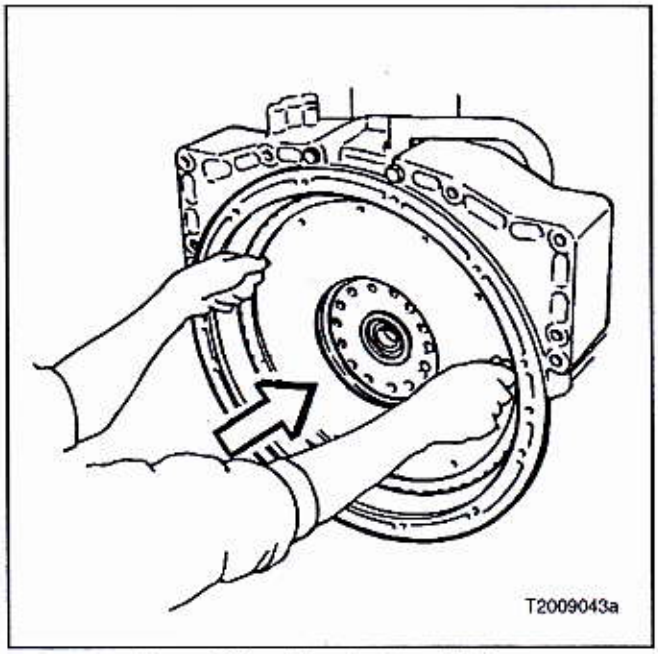


Figure 398 — Flywheel Installation

9. Insert the flywheel mounting screws finger tight. Remove the M10 screws to insert the remaining mounting screws.
10. Using a torque wrench, tighten the mounting screws in sequence according to specification.
11. Carefully install the flywheel sensor and connect it to the harness.

CRANKCASE VENTILATION (CCV) SEPARATOR REPLACEMENT

CCV Separator Removal

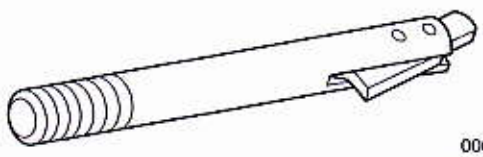
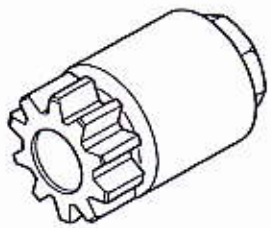
1. Disconnect the batteries, or turn off the main switch.
2. Clean the cylinder block around the CCV separator mounting.
3. Detach the CCV hoses.
4. Remove the CCV separator from the cylinder block.

CCV Separator Installation

1. Clean the mounting surfaces on the cylinder block and the CCV separator.
2. Using a **new** gasket, assemble the CCV separator on the cylinder block.
3. Using a torque wrench, tighten the screws according to specification.
4. Attach the CCV hoses.
5. Turn on the main switch, or reconnect the batteries.
6. Start the engine and check for leaks.

OIL PUMP REPLACEMENT (IN CHASSIS) [219 MU]

Special Tools

Tool No.	Description	Image
9998649	Block Stiffener Plate Assembly Tool	 006894a
88800014	Flywheel Turning Tool (Essential)	 271485a

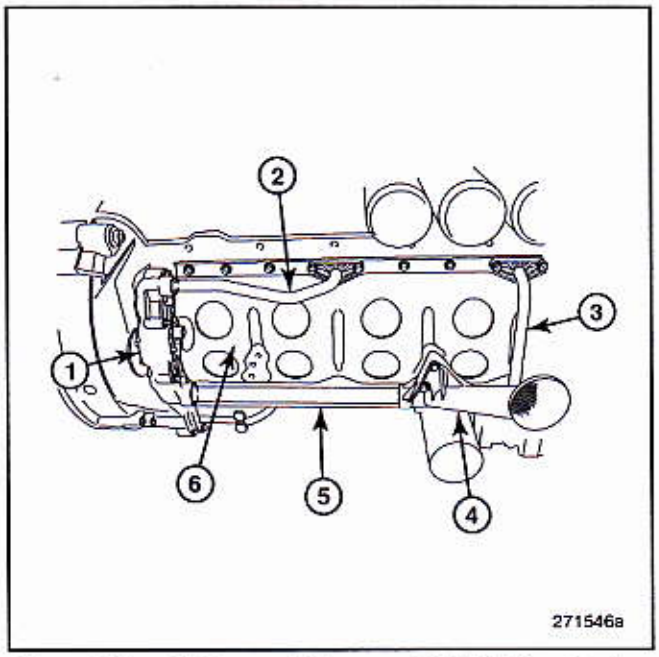


Figure 399 — Oil Pump, Pickup and Distribution System

1. Oil Pump	4. Strainer
2. Pump Outlet Pipe	5. Pump Inlet Pipe
3. Crossover Pipe	6. Block Stiffener Plate

Oil Pump Removal

1. If not already done, remove the oil pan.
2. Remove the pump inlet pipe and strainer.
3. Remove the pump outlet pipe.
4. Remove the crossover pipe.
5. Remove the block stiffener plate.

⚠ CAUTION

Wear gloves when handling the block stiffener plate. It has sharp edges. Failure to heed this caution could result in severe personal injury.

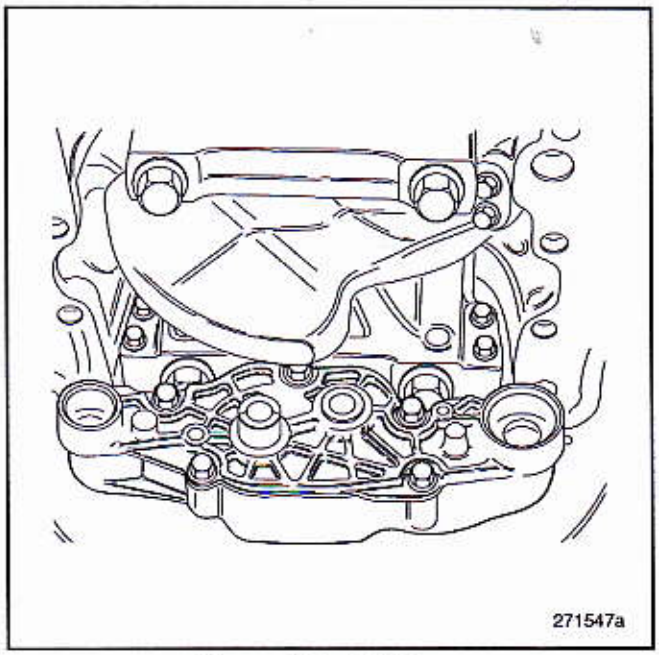


Figure 400 — Oil Pump

6. If necessary, rotate the crankshaft out of the way using flywheel turning tool, 88800014.
7. Remove the oil pump from the bearing cap.

Oil Pump Installation

1. Clean all parts to be reused.
2. Attach the oil pump to the No. 7 main bearing cap.
3. Using a torque wrench, tighten the screws according to specification.

⚠ CAUTION

Make certain that the bearing insert is in good condition and properly installed on the bearing cap. Failure to heed this caution may result in severe component damage.

4. Using **new** screws and assembly tool, 9998649, attach the block stiffener plate to the block. Do NOT torque-tighten the screws at this time.
5. Lubricate and assemble **new** O-rings on the inlet, crossover and outlet pipes.

6. Assemble the crossover and outlet pipes in the pump housing and install the mounting screws to secure the pipe flanges to the stiffener plate and block.
7. Using a torque wrench, tighten the stiffener plate screws (including pipe flange screws) in sequence according to specification.
8. Assemble the inlet pipe and strainer.
9. Assemble the pipe and strainer in the pump housing and on the block.
10. Using a torque wrench, tighten the screws according to specification.
11. Inspect the oil pan seal and replace it if necessary. Lubricate and assemble the seal on the oil pan.

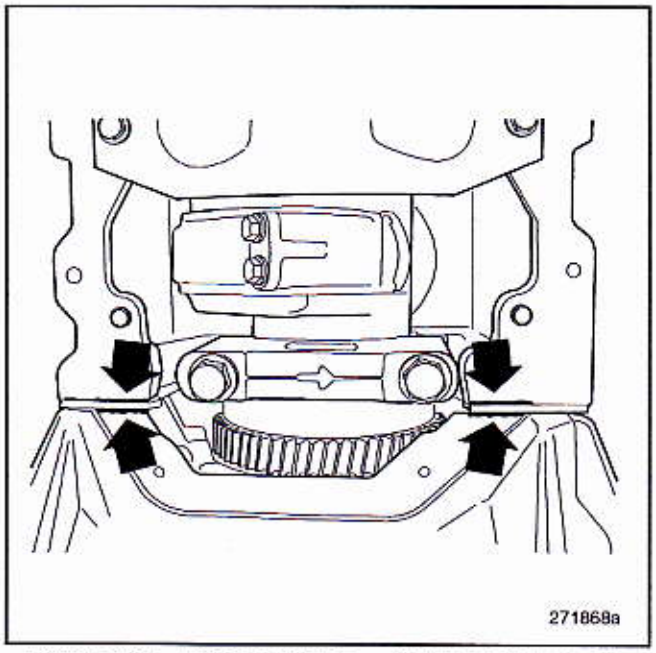


Figure 401 — Sealant Points — Flywheel Housing to Timing Gear Plate and Plate to Block

12. Apply a 2 mm (5/64 inch) bead of 342SX33 MACK-approved sealant to the seams between the flywheel housing and timing gear plate and between the mounting plate and the cylinder block.

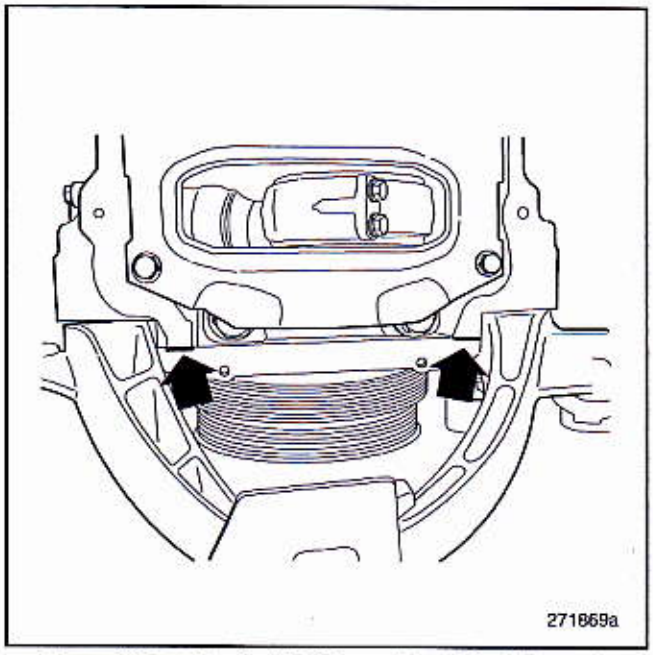


Figure 402 — Sealant Points — Front Seal Cover to Block

13. Apply a 2 mm (5/64 inch) bead of 342SX33 MACK-approved sealant to the seams between the front seal cover and the cylinder block.
14. Attach the oil pan to the cylinder block.
15. Using a torque wrench, tighten the screws in sequence according to specification.

⚠ CAUTION

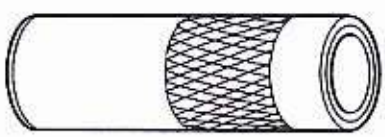
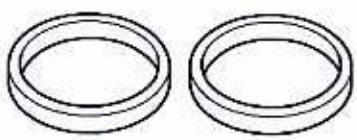
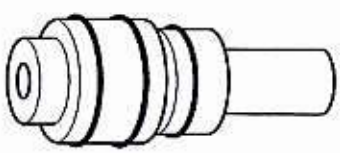
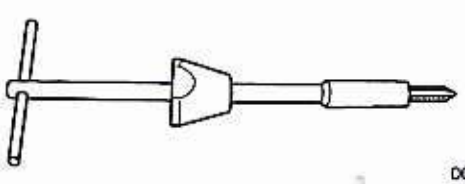
Use a steel washer. Do not use a copper washer. Do not use an impact wrench to install the drain plug. Failure to heed this caution may result in property damage.

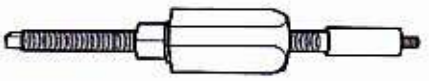
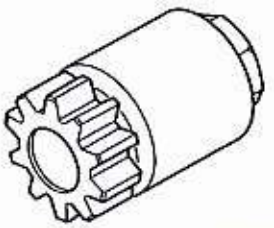
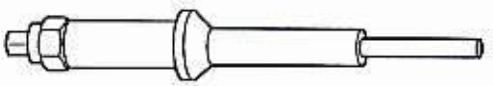
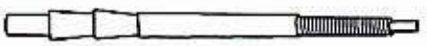
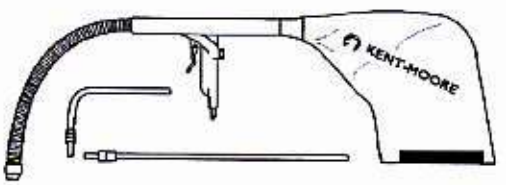
16. Install the drain plug.
17. Check system oil pressure through the pressure sensor port in the oil filter housing.

INJECTOR COPPER SLEEVE REPLACEMENT [213 EV]

Tools and Equipment

SPECIAL TOOLS

Tool No.	Description	Image
9809667	Injector Copper Sleeve Tap (Essential)	006961a
9809668	Injector Copper Sleeve Extractor (Essential)	006916a
9998249	Unit Injector Protection Sleeves (Essential)	 006798a
9998250	Unit Injector Bore Gallery Sealing Rings (Available)	 006799a
9998251	Unit Injector Bore Sealing Plug (Essential)	 006800b
9998252	Unit Injector Sleeve Tap (Essential)	 006801a

Tool No.	Description	Image
9998253	Unit Injector Sleeve Remover (Essential)	 006802a
88800014	Flywheel Turning Tool (Essential)	 271485a
88800196	Swedging Tool for Installing Unit Injector Copper Sleeve (Essential)	 006805a
88880010	Swedging Tip for Copper Sleeve Swedging Tool (Available separately)	 006842a
J 42885	Unit Injector Bore Cleaning Kit (Essential)	006926a
PT-2900	Chip Vacuum (Essential)	 006962a

Preliminary Steps

The following components need to be removed for access to the injector copper sleeves (see ENGINE DISASSEMBLY for procedures):

- Cylinder Head Cover
- Rocker Arm Shaft
- Unit Injector(s)

Copper Sleeve Removal

1. If the injector sleeve is not being removed immediately, install the protective plug into the unit injector bore of the cylinder head to protect it from debris.

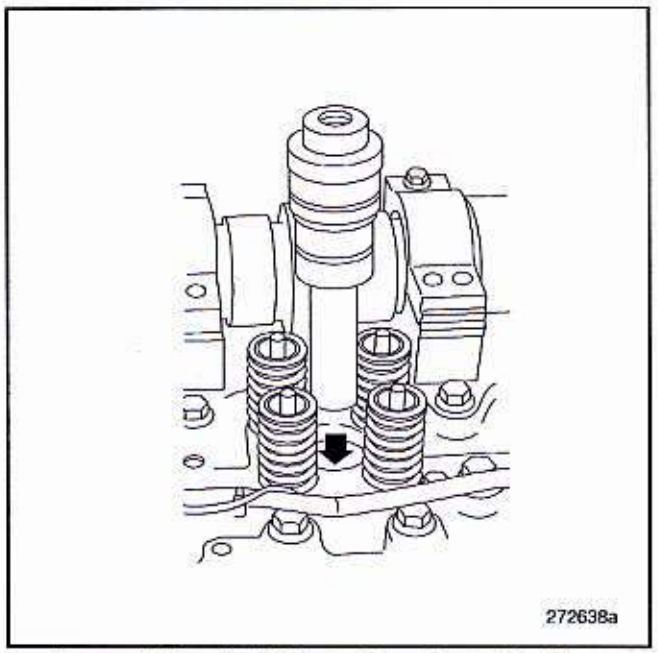


Figure 403 — Unit Injector Bore Protective Plug

2. Install two sealing rings to prevent dirt from entering the fuel gallery when the copper sleeve is removed.

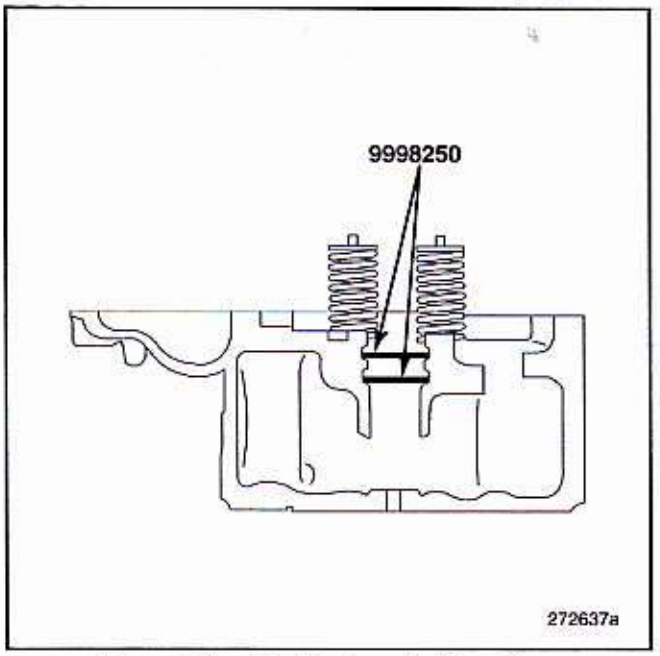


Figure 404 — Fuel Gallery Sealing Rings

NOTE

Two sealing rings are required to cover the fuel gallery.

3. Remove the plug from the lower front side of the flywheel housing and install the flywheel turning tool. Turn the flywheel until the piston is at its lowest position in the cylinder.

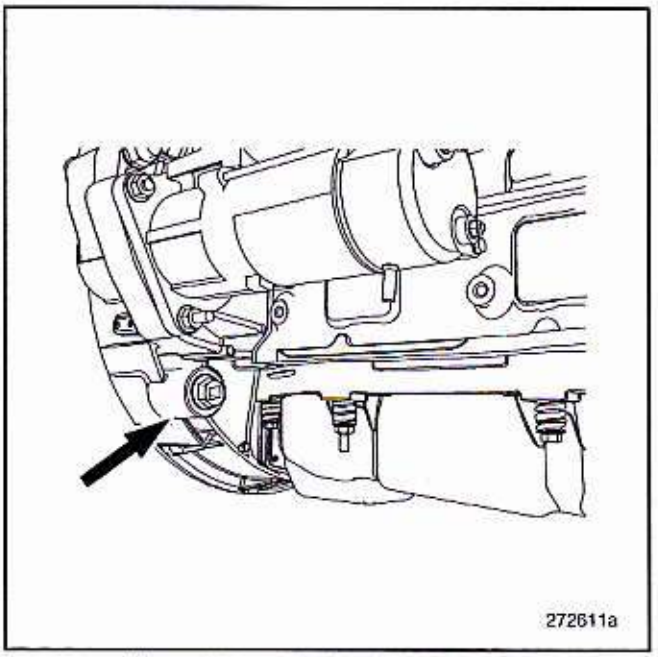


Figure 405 — Flywheel Turning Tool

NOTE

This is to ensure that the copper sleeve tapping tool does not damage the piston due to tool length.

Ensure the turning tool is well greased before attempting to turn the flywheel.

4. Adjust the 9 mm tap so that it extends a minimum of 25 mm or 1 inch (dimension A) from the end of the tapping tool.

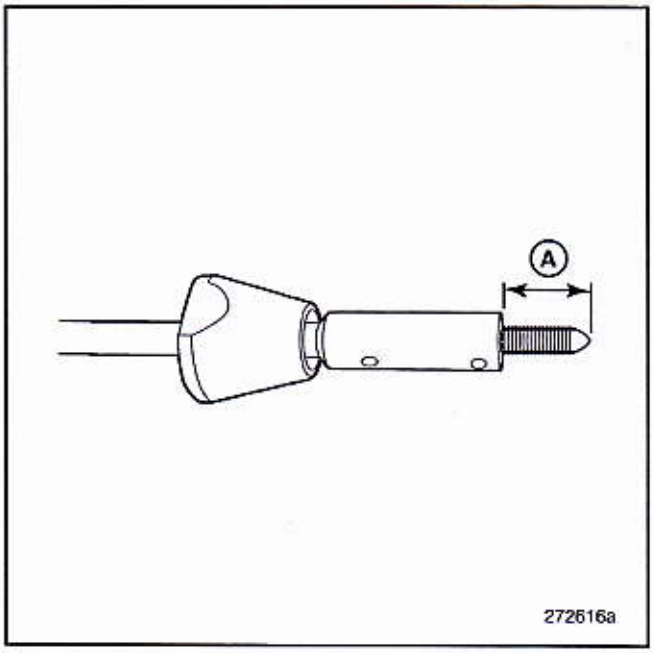


Figure 406 — Copper Sleeve Tapping Tool

NOTE

This ensures that the tip of the copper sleeve is tapped all the way through.

⚠ CAUTION

If the copper sleeve is not completely tapped through to the opening of the tip, an end piece of the tip can break off and fall into the cylinder during removal.

5. Lubricate the tip of the 9 mm tap with grease.

NOTE

Applying grease will capture copper cuttings and prevent them from falling down into the cylinder.

6. Thread the tap in small increments. Remove the tap and wipe off the grease and copper sleeve shavings. Apply fresh grease, reinstall the tapping tool and thread more of the copper sleeve. Continue this process to thread the tap all the way through the copper sleeve until no resistance is felt and the tap turns freely. Tapping in small increments and removing the shavings minimizes the chance of shavings falling into the cylinder and the sleeve turning in the cylinder head. Ensure that the tap is completely through the copper sleeve.

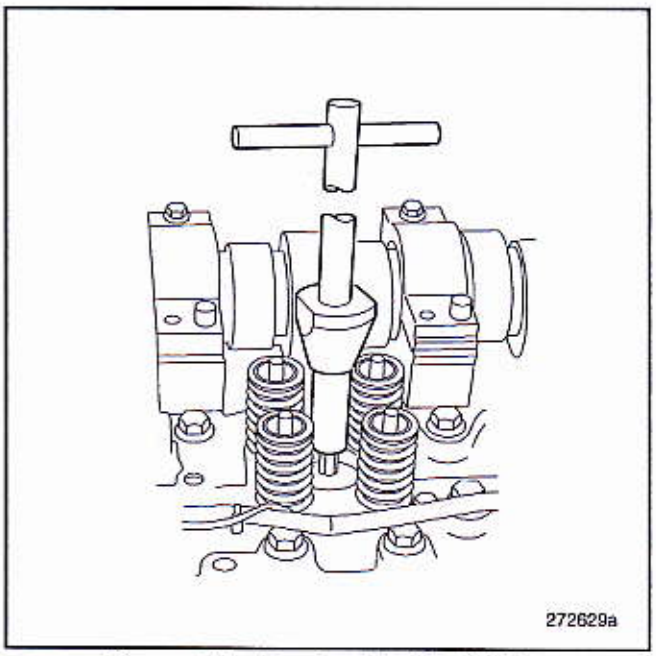


Figure 407 — Tapping Tool Installation

⚠ CAUTION

If threads are not cut completely through the tip of the copper sleeve, the tip can break off and fall into the cylinder. This can result in damage to the cylinder, piston, valves or turbocharger.

7. Remove the tap and tapping tool.
8. Using the chip vacuum, remove any remaining shavings from the copper sleeve.

9. Install the extractor bolt into the end of the extractor tool. Adjust the bolt until it extends approximately 22 mm (0.9 inch) beyond the end of the tool (dimension A).

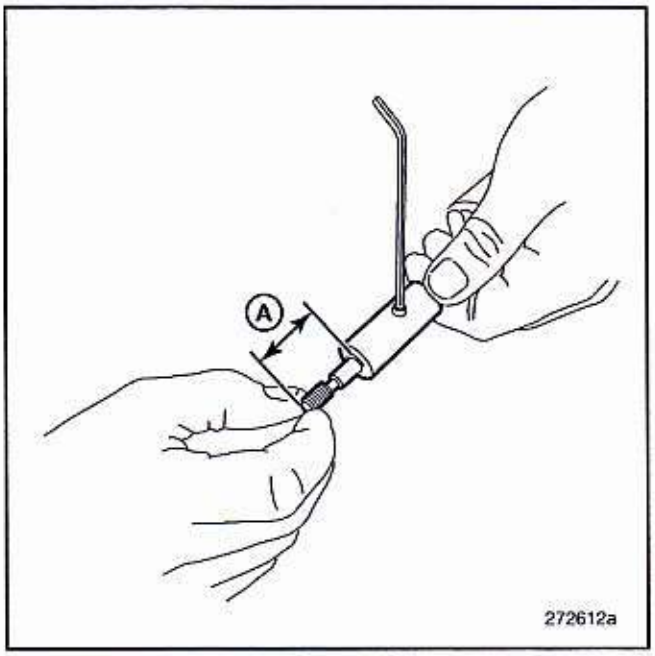


Figure 408 — Adjusting Copper Sleeve Extractor Bolt

10. Tighten the set screw of the extractor tool to secure the bolt. Make sure that the set screw is seated against the flat part of the extractor bolt.
11. Place the extractor tool with the bolt into the injector bore. Make sure the nut on the spindle is backed off so that the threaded end can be completely installed through the copper sleeve tip. Hand tighten until the bolt bottoms out in the sleeve.

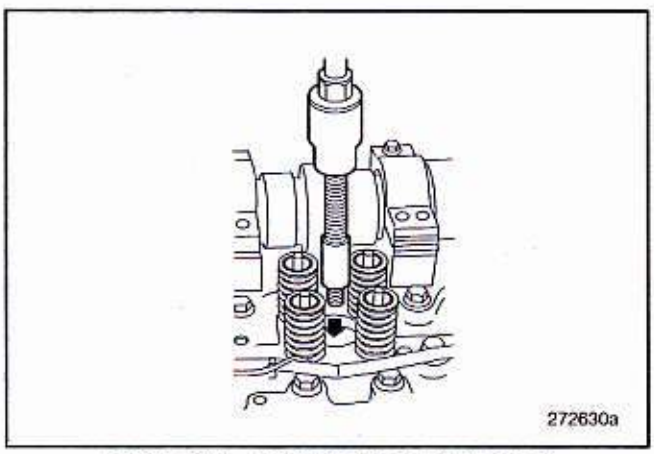


Figure 409 — Extractor Tool Installation

⚠ CAUTION

Make sure the extractor bolt is threaded completely into the copper sleeve before attempting to remove it or the tip of the sleeve may break off as it is removed. This broken sleeve tip can seriously damage the piston, valves or turbocharger.

12. While holding the top of the tool stationary, turn the large nut clockwise to extract the copper sleeve.

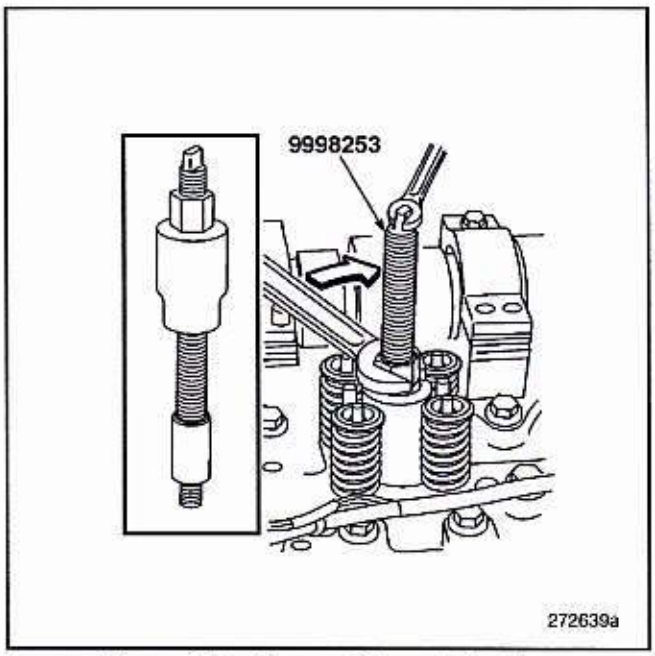


Figure 410 — Copper Sleeve Extraction

NOTE

When the copper sleeve is removed, make sure that the extractor bolt is extended at least one thread beyond the copper sleeve. If not, make sure that no part of the copper sleeve has broken off and fallen into the cylinder.

⚠ CAUTION

Do not use air tools to remove copper sleeves, or damage to the injector bore can result.

13. Remove the two sealing rings from the fuel passage. Using the chip vacuum, remove any remaining debris from the injector bore.

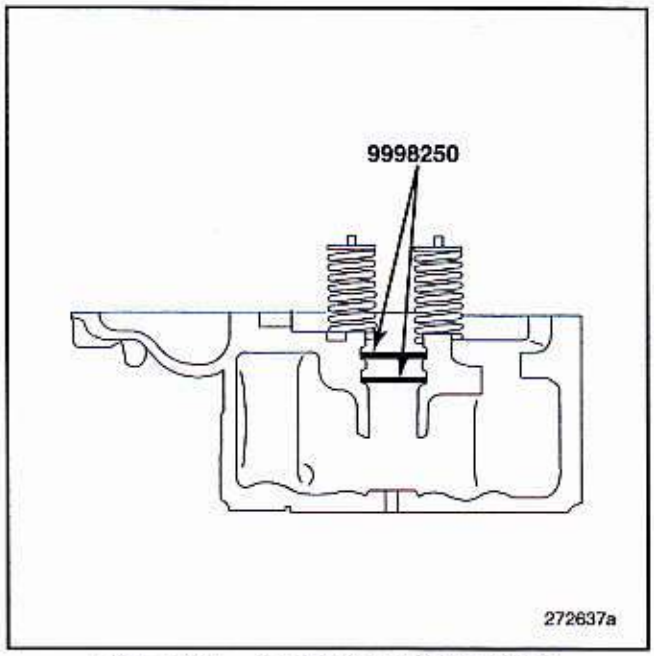


Figure 411 — Fuel Gallery Sealing Rings

14. Install the injector bore sealing tool (J 42885-25) to protect the fuel passage area and prevent debris from entering. Use the unit injector hold down bolt to secure the tool in the cylinder head.
15. Using the injector bore cleaning kit, clean the copper sleeve seat of the cylinder head.

NOTE

The injector bore sealing tool must be used to prevent dirt from entering the fuel passage.

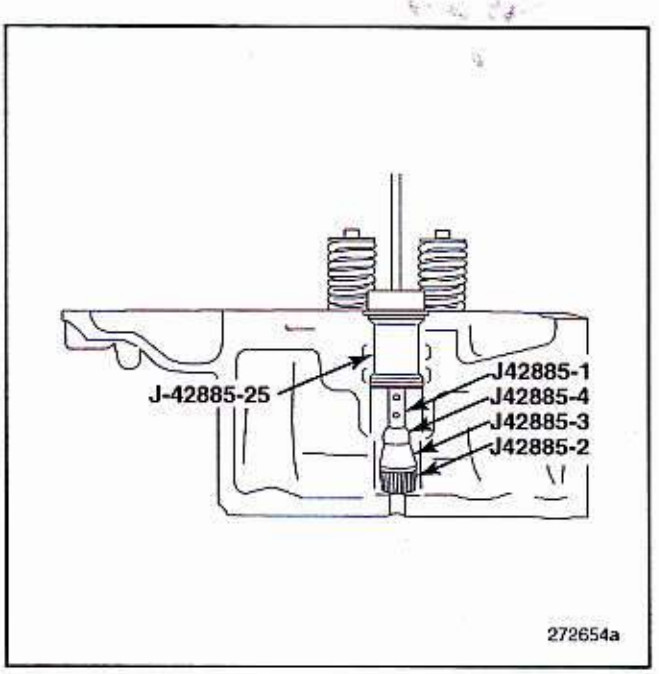


Figure 412 — Cleaning Copper Sleeve Seat

16. Using the brush, clean the cylinder head injector bore walls for the copper sleeve.

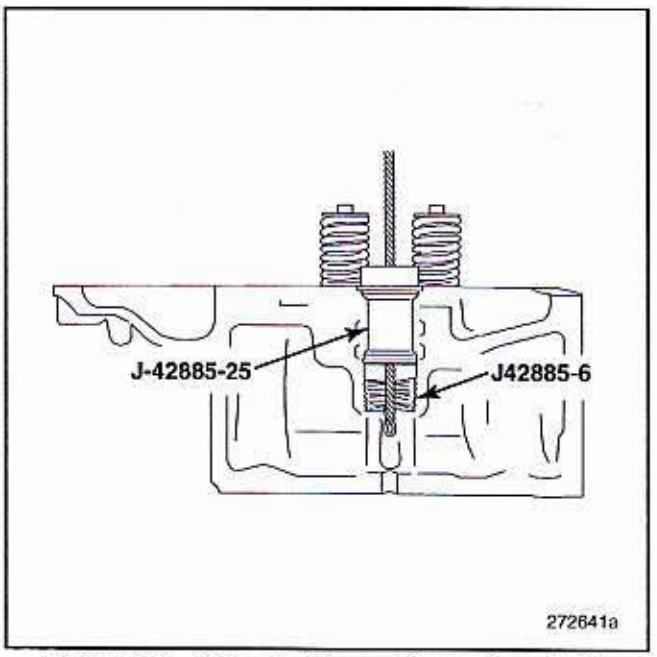


Figure 413 — Cleaning Copper Sleeve Bore Walls

NOTE

The injector bore sealing tool must be used to prevent debris from entering the fuel passage.

17. Using the brush, clean the copper sleeve opening in the cylinder head.

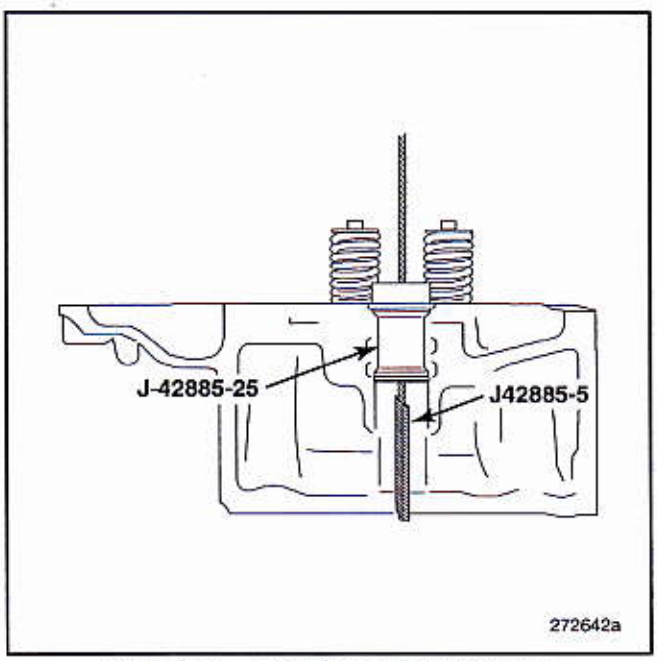


Figure 414 — Cleaning Injector Tip Bore

NOTE

The injector bore sealing tool must be used to prevent debris from entering the fuel passage.

When replacing the copper sleeves, it is important to check that the sleeve bore in the cylinder head is free from any carbon deposits or other residue (i.e., pieces of O-ring, etc.) before installing a new copper sleeve. Reclean if necessary.

18. Using the chip vacuum, remove all debris from the copper sleeve bore.

SERVICE HINT

Do not attempt to blow away debris using compressed air. Doing so can result in eye injury.

19. Remove the injector bore sealing tool from the cylinder head. Using the chip vacuum, remove any remaining debris.

Copper Sleeve Installation

1. Ensure the piston is at the lowest position in the cylinder. If not, use the flywheel turning tool to place the piston at its lowest position.

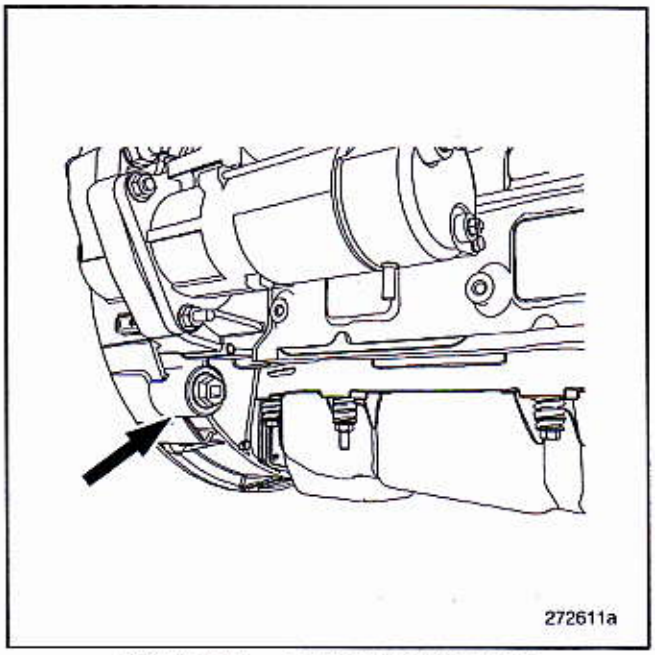


Figure 415 — Flywheel Turning Tool

NOTE

This is to ensure that the copper sleeve installation tool does not damage the piston due to tool length.

2. Before installing the copper sleeve, inspect it to ensure that it is the correct part.

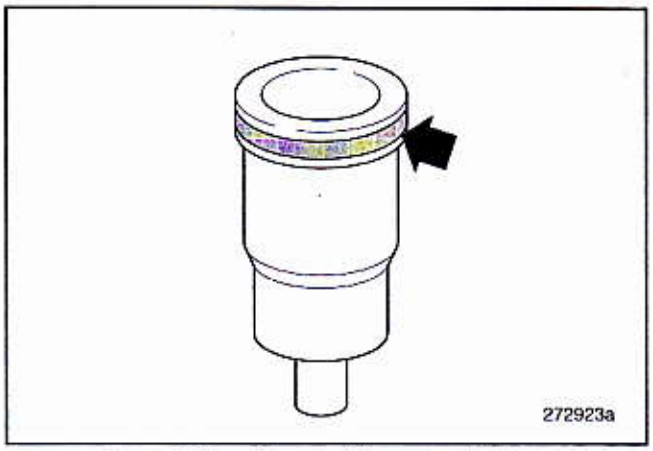


Figure 416 — Copper Sleeve and O-Ring

3. Lubricate a **new** copper sleeve O-ring with coolant. Install the O-ring on the copper sleeve and lubricate again with coolant. Always use a **new** O-ring.
4. Place the **new** copper sleeve on the installation tool.

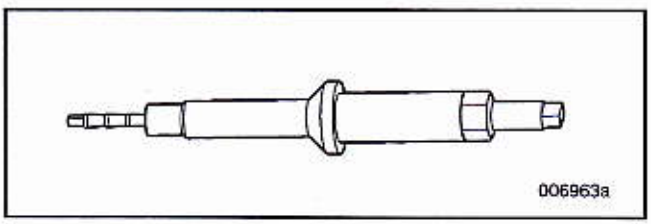


Figure 417 — Installation Tool Identification

⚠ CAUTION

Before installing the sleeve on the installation tool, inspect the tool to ensure that it is the correct tool. The correct tool is identified by a bottom surface that has a machined circular recess. Use of a tool with a perfectly flat bottom may result in damage to the copper sleeve.

5. Using calipers, measure the swedging bit to make sure that the proper swedging tool is used. Measurement should read approximately 7.8 mm. Also, verify that the length of the swedging bit is 108 mm.

⚠ CAUTION

Failure to use the proper bit can result in the bit breaking off into the cylinder head.

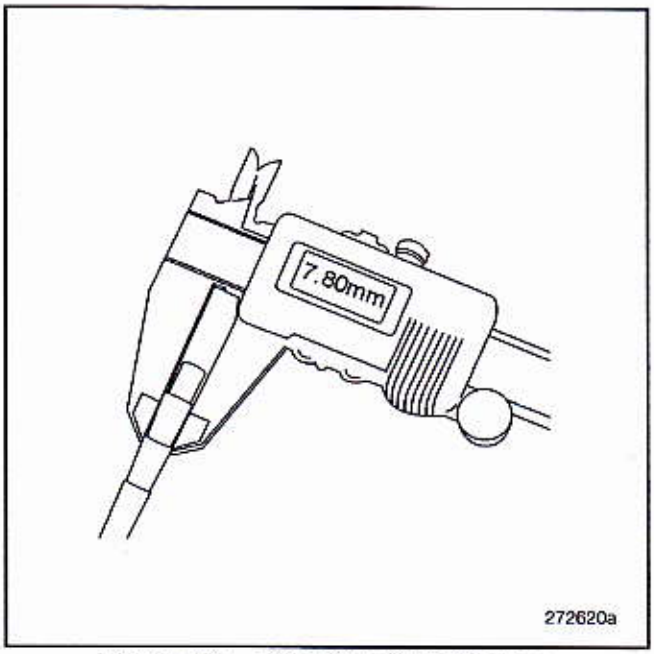


Figure 418 — Swedging Bit Verification

6. Thread the swedging bit completely into the flaring tool until it stops (finger tight).

NOTE

Swedging bit can be ordered as a spare part if the bit is worn or broken.

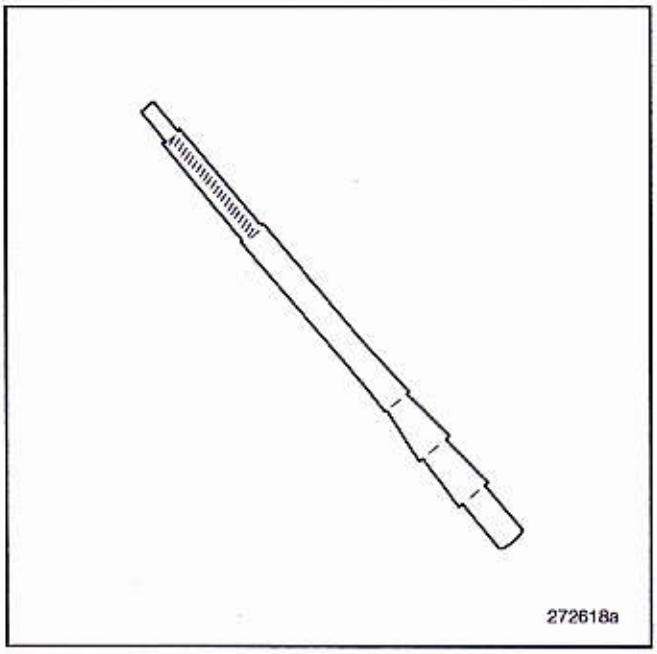


Figure 419 — Swedging Bit

7. Loosen the swedging bit 180 degrees before installing the tool in the cylinder head.

⚠ CAUTION

Failure to loosen the swedging bit can result in the bit being twisted or broken.

8. Lubricate the swedging bit and the threads on the tool with oil.

9. Carefully place the sleeve installation tool (with new copper sleeve attached) into the unit injector bore of the cylinder head. Carefully move the copper sleeve downward into the injector bore so that the swedging bit is guided into the injector tip bore in the cylinder head. Push downward on the installation tool using hand force to move the copper sleeve downward until it bottoms out on the injector sleeve seat in the bottom of the injector bore. Use the unit injector hold down and bolt to hold the tool in position. To ensure that the copper sleeve is bottomed in the cylinder head, tighten the unit injector hold down bolt to specification.

NOTE

Remove any oil from the injector hold down bolt holes to avoid hydraulic lock for this step and when the injector is installed.

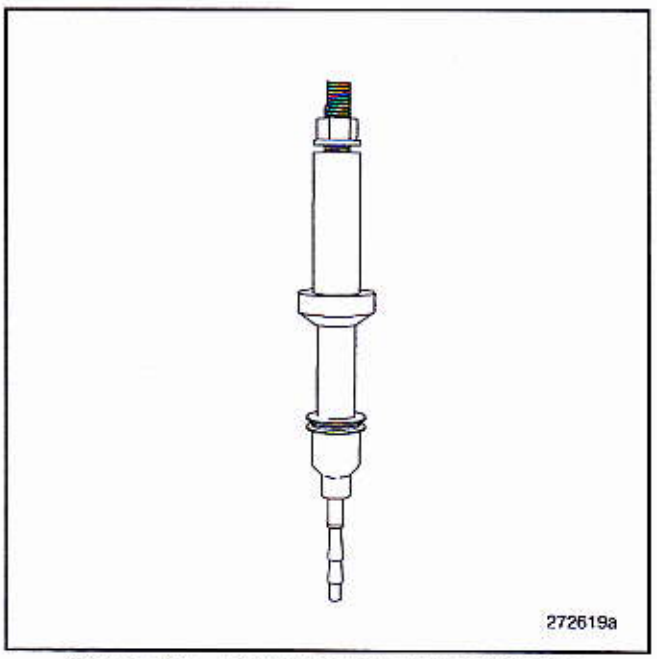


Figure 420 — Copper Sleeve Installation Tool

10. Flare the copper sleeve by turning the nut (1) clockwise while holding the spindle until the swedging bit has been pulled completely through the copper sleeve.

⚠ CAUTION

Failure to hold the spindle can result in a twisted or broken swedging bit.

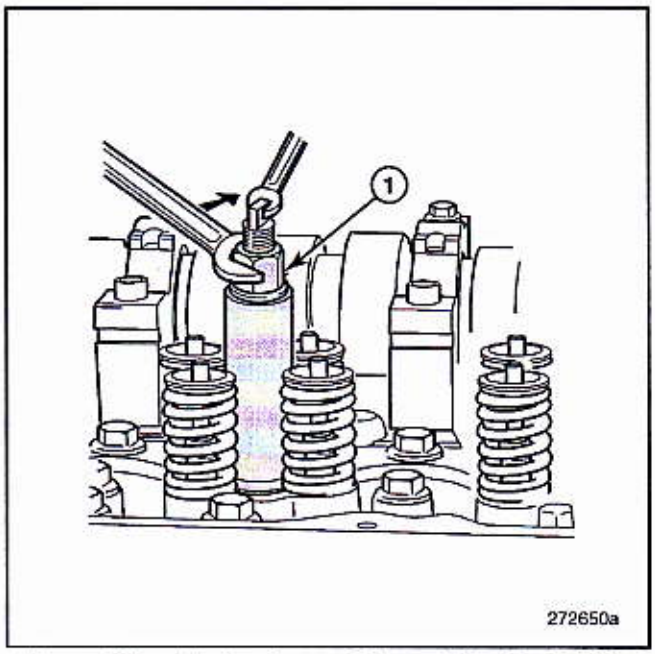


Figure 421 — Flaring Copper Sleeve Using Installation Tool

11. Remove the sleeve installation tool from the injector bore.

NOTE

If the injector is not being installed immediately, install the protective plug into the injector bore to protect it from debris.

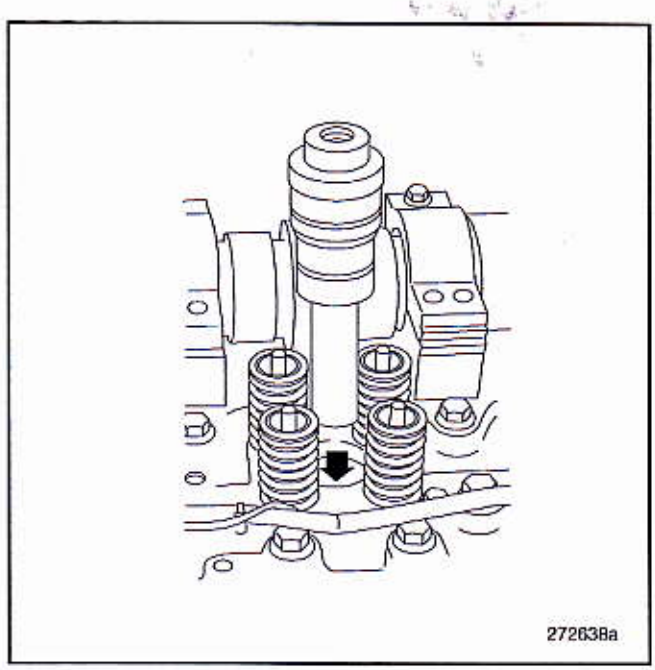


Figure 422 — Unit Injector Bore Protective Plug

Final Steps

Install the following components which were removed for access to the injector copper sleeves (see ENGINE REASSEMBLY for procedures):

- Unit Injector(s)
- Rocker Arm Shaft
- Cylinder Head Cover

UNIT INJECTOR CLEANING

Preliminary Steps

Remove the following components from the engine (see ENGINE DISASSEMBLY for procedures):

- Cylinder Head Cover
- Rocker Arm Shaft Assembly
- Unit Injectors

Install the sealing plug, 9998251, into the unit injector bore of the cylinder head to prevent dirt and debris from entering the bore.

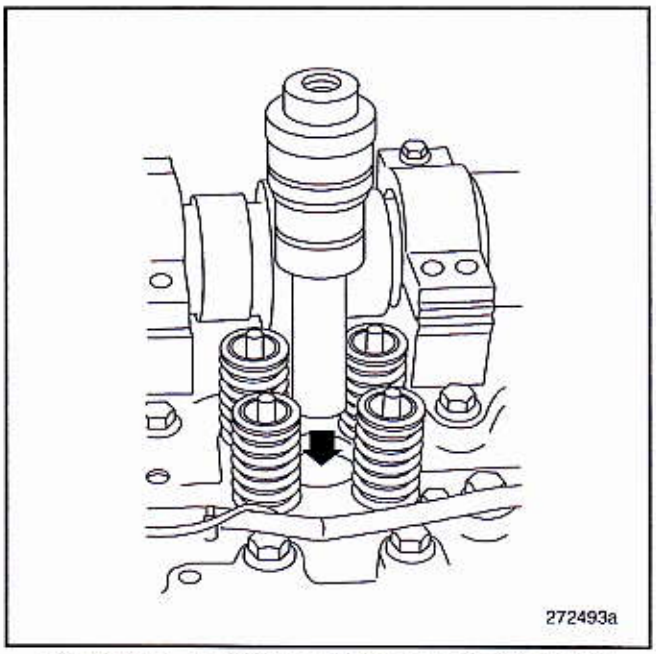


Figure 423 — Installing Injector Bore Sealing Plug, 9998251

Cleaning and Inspection

NOTE

Since the unit injectors operate at very high fuel injection pressures, the nozzle tip spray holes and the immediate area around the spray holes remain clean and free of carbon deposits. This leaves the cap nut seat surface as the only surface which requires a thorough cleaning.

Clean the injector **cap nut surface** as follows:

1. Remove the two O-rings from the injector and discard the O-rings.
2. Cover the O-ring grooves and the complete area between the grooves with tape or equivalent to prevent contaminants from getting into the injector.
3. Cover the opening for the electrical connection.
4. Slide a short section of 6 mm (0.25 inch) ID hose over the injector nozzle tip until it covers approximately half the nozzle tip length. This is necessary to protect the nozzle spray holes from damage when cleaning the cap nut seat surface.

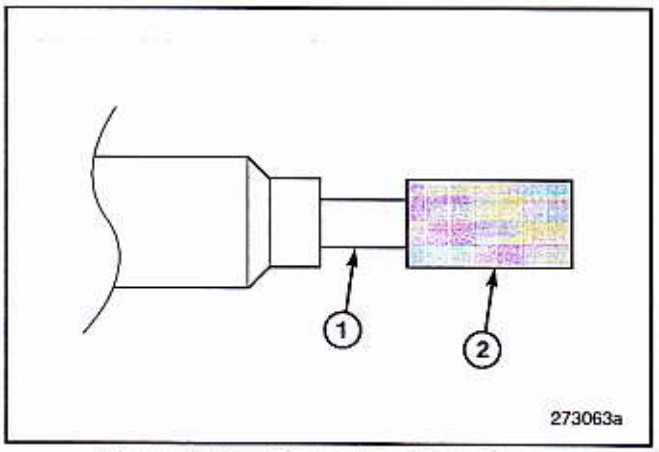


Figure 424 — Injector Nozzle Tip Cover

1. Injector Cap Nut Seat Surface	2. Hose (covering Nozzle Tip)

5. With the unit injector nozzle tip spray holes protected, carefully clean the cap nut seat surface of hard carbon deposits using a wire wheel. Apply only light nominal pressure to hold the wire wheel against the injector surface for short periods of time.

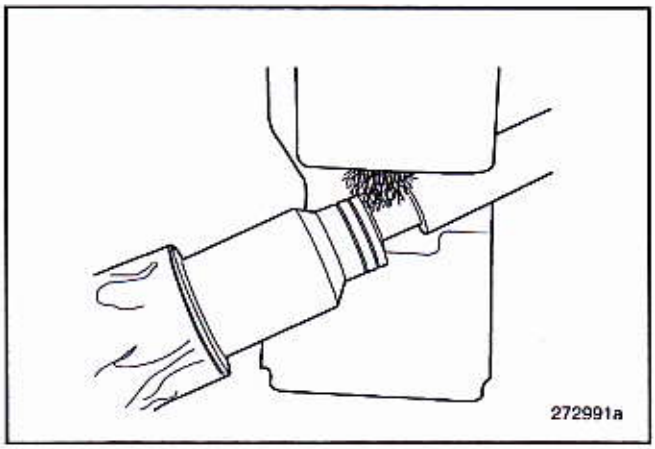


Figure 425 — Cleaning Injector Cap Nut Seat Surface

⚠ CAUTION

The carbon will be very hard and difficult to remove. Avoid the tendency to use excessive pressure in holding the wire wheel against the injector cap nut surface. Excessive force can damage the cap nut surface, making the injector unacceptable for reuse.

6. Clean any remaining carbon using hand tools such as a hand scraper or medium grit emery cloth.
7. After cleaning, inspect the injector nozzle cap nut seat surface for pitting or related damage. If there is pitting or other damage, replace the injector.

NOTE

Pitting on surfaces other than the cap nut seat does not affect the function of the unit injector and is acceptable.

8. Install **new** O-rings in the grooves on the injector.
9. Lubricate the injector O-rings with clean engine oil.

Final Steps

Install the following components on the engine (see ENGINE REASSEMBLY for procedures):

- Unit Injectors
- Rocker Arm Shaft Assembly
- Cylinder Head Cover

VALVE STEM HEIGHT MEASUREMENT PROCEDURE [213 FB]

On engines exhibiting poor performance, smoke (at times) and a noticeable engine miss (with the symptoms getting worse as the engine gets hotter), may be an indication of valve seat recession. A decrease in clearance (valve lash) between the valve rocker and valve yoke (bridge) can be measured at the valves to determine if seat recession is occurring. If valve seat recession is suspected, the following procedure can be used to measure valve stem height. To perform this measurement, a valve stem height measurement gauge (tool No. 85112461) and a depth micrometer are required.

NOTE

For detailed information on rocker arm shaft removal and installation procedures, refer to the applicable section of this service manual.

1. Remove components as necessary to gain access to the cylinder head (valve) cover.
2. Remove the cylinder head cover and rocker arm shaft assembly.

⚠ CAUTION

On engines equipped with an engine brake, use suitable tie straps or mechanics wire to retain the pistons in the rocker arms. The match between the pistons and rocker arms must be maintained. Failure to secure the engine brake pistons before removing the rocker shaft assembly, allows the pistons to drop from the bore of the rocker arms. If a piston drops out, it might not be noticed, or it may be difficult to push the piston fully back into the bore of the rocker arm. Also, pistons are a match-fit to the rocker arm, and so inadvertent mix-up of components must be avoided. Assembling the rocker arm shaft to the engine, or operating an engine with the engine brake pistons not fully retracted (or missing), results in breakage of valve train components and significant engine damage.

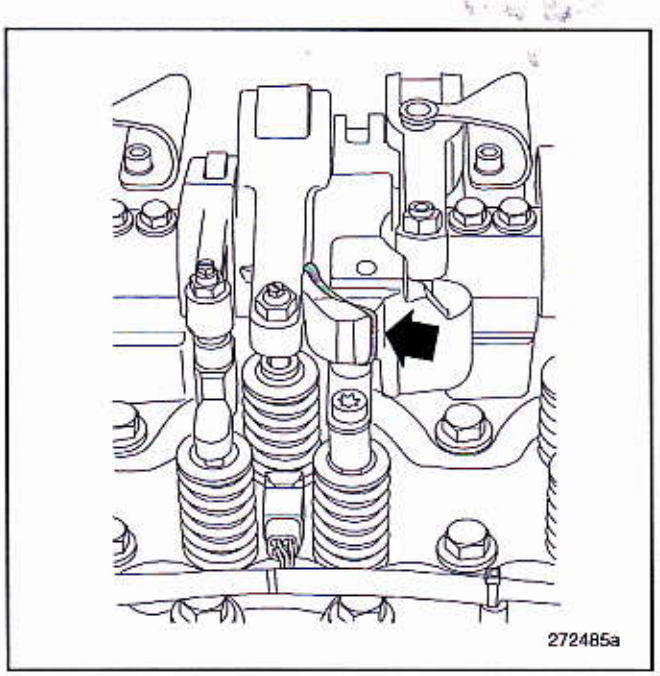


Figure 426 — Engine Brake Piston Retained

3. Remove the valve yokes (bridges).

NOTE

The valve yokes must be installed on the same set of valves that they were removed from. Before removing the valve yokes, mark them to identify their location and orientation. An incorrectly installed valve yoke causes severe engine damage due to a dropped valve. For proper valve yoke removal and installation, refer to the appropriate sections in this service manual.

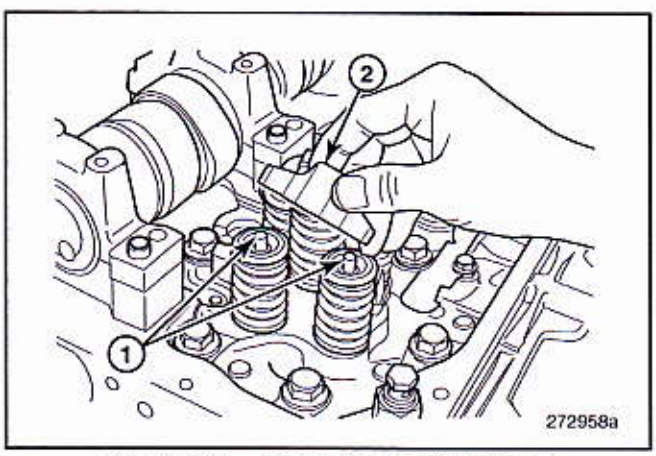


Figure 427 — Removing the Valve Yoke

1. Inlet Valve Stem Tips	2. Inlet Valve Yoke

4. Remove the screws securing the unit injector harness tie bar to the cylinder head. Slide the tie bar outward to provide sufficient clearance for the valve stem height measurement gauge to be installed over the valve springs. Do not disconnect the harness connectors from the unit injectors or cut the tie straps that secure the harness to the tie bar.

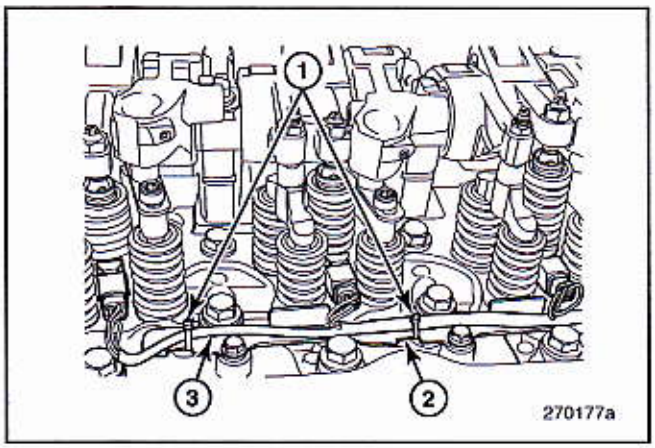


Figure 428 — Move Harness Tie Bar Outward

1. Tie Straps 2. Tie Bar Notch	3. Wiring Harness

5. Set the depth micrometer to 8.10 mm (0.319 inch) to measure stem protrusion.

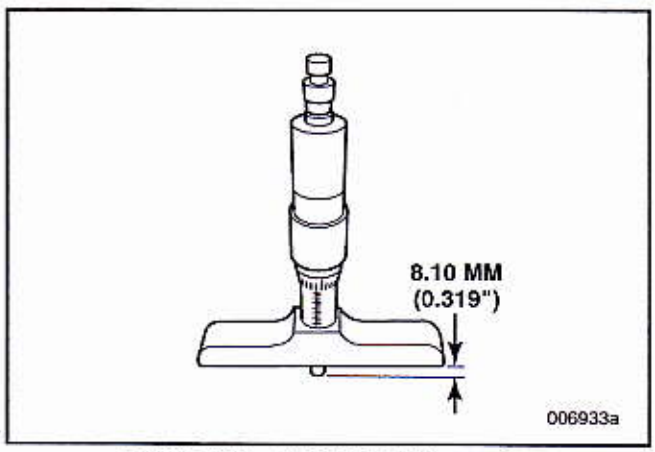


Figure 429 — Set Depth Micrometer

6. Place the valve stem height measurement gauge (tool No. 85112461) over the valve spring of the valve to be measured. Make sure the tool is fully seated on a clean surface.

NOTE

Make sure there are no particles of any kind between the bottom of the valve stem height measurement gauge and the cylinder head surface. Particles between the gauge and the cylinder head surface results in an inaccurate measurement.

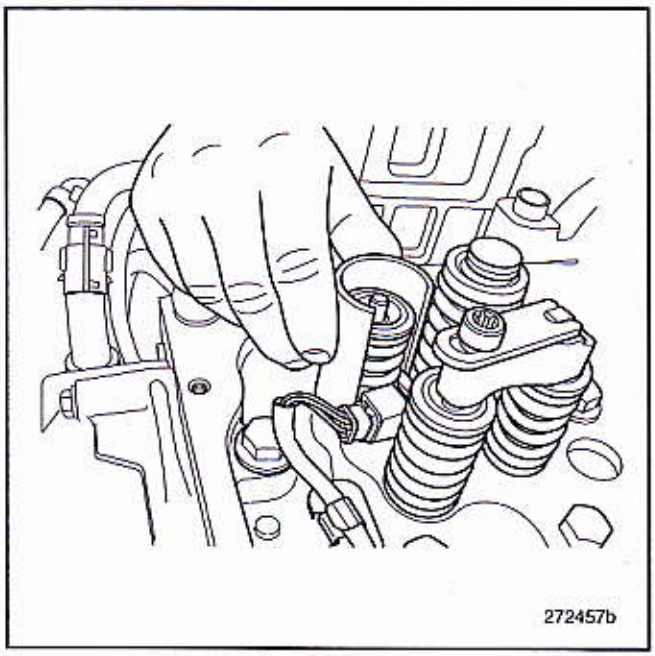


Figure 430 — Place Measurement Gauge over Valve Spring

7. Place the depth micrometer on top of the valve stem height measurement gauge and note if there is clearance between the end of the micrometer spindle and the tip of the valve stem.

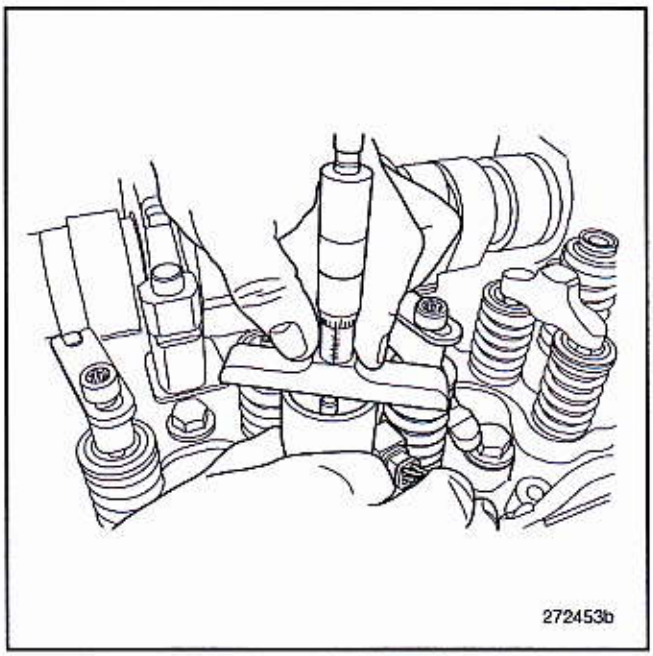


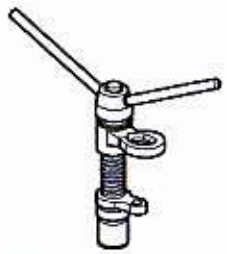
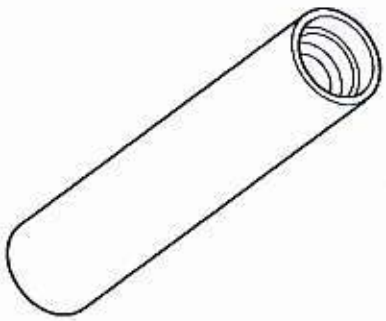
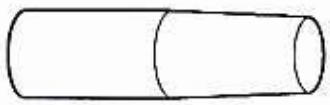
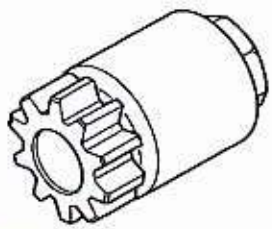
Figure 431 — Measuring Valve Stem Height

- If there is clearance between the tip of the valve stem and the tip of the depth micrometer spindle, valve height is within specification. Measure the next valve stem height using the same method.
- If valve stem height is less than 8.10 mm (0.319 inch), as indicated by the tip of the depth micrometer spindle contacting the tip of the valve stem, the valve seat is recessed. Replacement of the cylinder head is necessary.

8. Position the unit injector harness tie bar to the cylinder head, install the screws and tighten according to specification.
9. Install the valve yokes to their original location.
10. Install the rocker arm shaft assembly and remove the retainers securing the engine brake pistons. Adjust valve lash as necessary.
11. Install the cylinder head cover.
12. Install the components that were removed to gain access to the cylinder head cover.

VALVE STEM SEAL REPLACEMENT [213 MV]

Special Tools

Tool No.	Description	Image
9990210	Valve Spring Compressor (Essential)	 006782a
85112460	Valve Stem Seal Installation Tool	 006966a
88800011	Valve Stem Seal Protection Tool (Essential)	 006773a
88800014	Flywheel Turning Tool (Essential)	 271485a

Preliminary Steps

The following components need to be removed for access to the valve stem seals (see ENGINE DISASSEMBLY for procedures):

- Cylinder Head Cover
- Rocker Arm Shaft Assembly
- Unit Injectors

Seal Removal

NOTE

When replacing the valve stem seals, the pistons must be at TDC when the valves are released so that the valves do not drop into the cylinder.

1. Using the flywheel turning tool, 88800014, rotate the crankshaft so that the pistons are at TDC for the appropriate pair of cylinders where stem seals are being replaced.

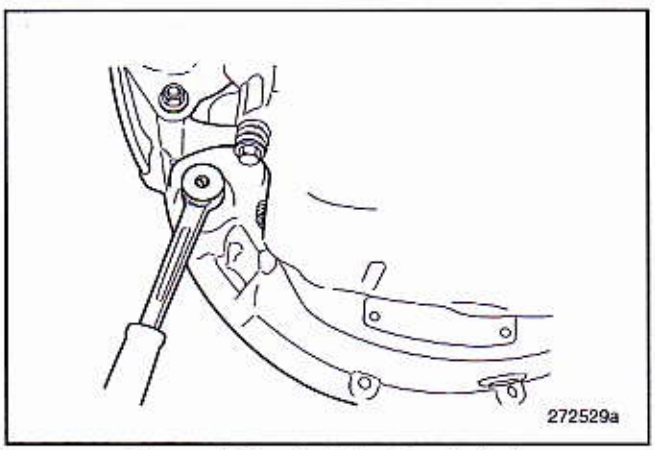


Figure 432 — Rotating Crankshaft

2. Using the valve spring compressor tool, 9990210, press down on the springs (one at a time) and remove the valve retainers and springs for the cylinder.

⚠ WARNING

Use protective goggles or eye injury could occur.

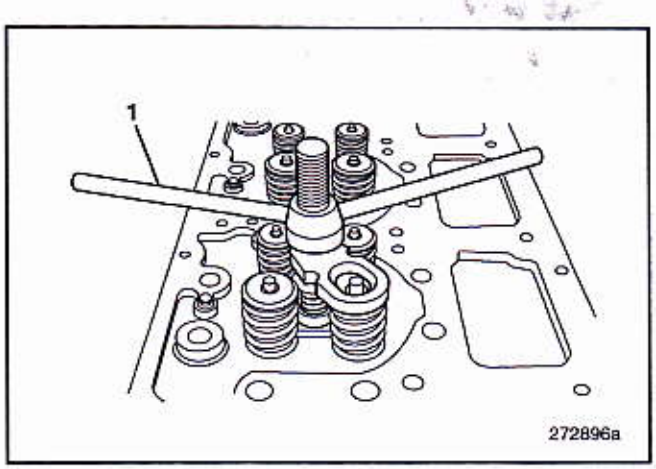


Figure 433 — Compressing Valve Springs

1. Valve Spring Compressor 9990210

3. Remove and discard the valve stem seals.
4. Using a clean cloth, thoroughly clean all engine oil off the valve stem and valve guide.

Seal Installation

1. Apply a thin film of clean engine oil to the outside diameter of the valve seal guide tool and to the sealing lips of the **new** valve stem seal to avoid damage to the seal as it is installed.

NOTE

Do NOT apply oil to the inner surfaces of the seal that contact the valve guide. These surfaces must be dry.

2. Place the seal guide tool, 88800011, in position on the valve stem.
3. Place a **new** valve stem seal in position over the guide tool and onto the valve stem.
4. Using the appropriate end of the seal installation tool, 85112460, seat the valve stem seal on the valve guide by gently tapping the installation tool with a light plastic or rubber mallet. When the seal is fully seated, a normal "spring-back" of the seal will occur, leaving a maximum gap of approximately 0.5 mm (0.02 inch) between the bottom of the seal and the shoulder surface on the valve guide.

⚠ CAUTION

Use only gentle taps with the hammer when seating the seal to avoid damage to the seal casing as well as the top rubber portion of the seal.

NOTE

Seal installation tool, 85112460, is designed for use on MP7, MP8 and MP10 engines. Use the appropriate end of the tool for the engine being serviced.

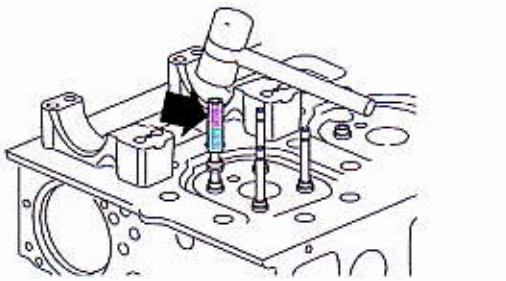


Figure 434 — Seating the Valve Stem Seal

5. Using the valve spring compressor, 9990210, install the valve spring and valve retainers. Carefully tap on the valve stem with a plastic or rubber hammer to ensure that the valve keepers are positioned correctly.

⚠ WARNING

Use protective goggles or eye injury could occur.

6. Move the valve spring compressor to the next cylinder of the cylinder pair and repeat the procedure. Rotate the crankshaft so that the pistons are at TDC for the next cylinder pair and repeat the procedure. Continue on and repeat the procedure for the final cylinder pair.

Final Steps

Install the following components which were removed for access to the valve stem seals (see ENGINE REASSEMBLY for procedures):

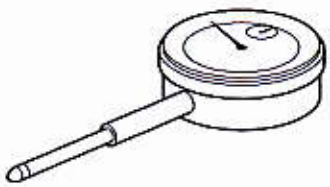
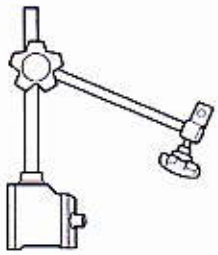
- Unit Injectors
- Rocker Arm Shaft Assembly
- Cylinder Head Cover

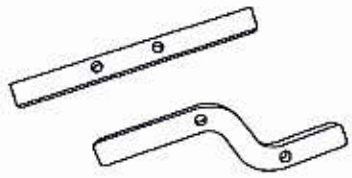
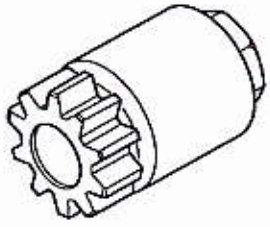
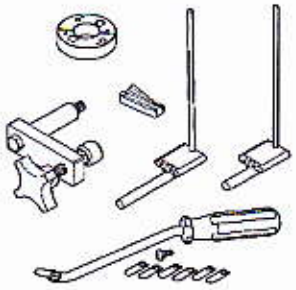
MP8 EURO 3 ENGINE SETUP AND ADJUSTMENT [200 EA]

NOTE

Due to the Engine Electronic Control Unit (EECU) self-learning capability, it is necessary to reset learned EECU parameters after servicing some engine-related components. This allows the EECU to learn the new component's behavior. After servicing is complete, perform the "Learned Data Reset" located in VCADS.

Special Tools

Tool No.	Description	Image
9989876	Dial Indicator (Available)	 006899a
9999696	Magnetic Base (Available)	 006900a
85111377	Feeler Gauge Set	006844a

Tool No.	Description	Image
85111422 (A, B)	Timing Gear Cover Alignment Tool	 006924a
85111493	Angled Extension (Available)	006898a
88800014	Flywheel Turning Tool	 271485a
J 44514-B	Engine Timing Kit (Essential)	 006889a

Valve and Unit Injector Adjustment [213 NB, 222 KG]

GENERAL INFORMATION

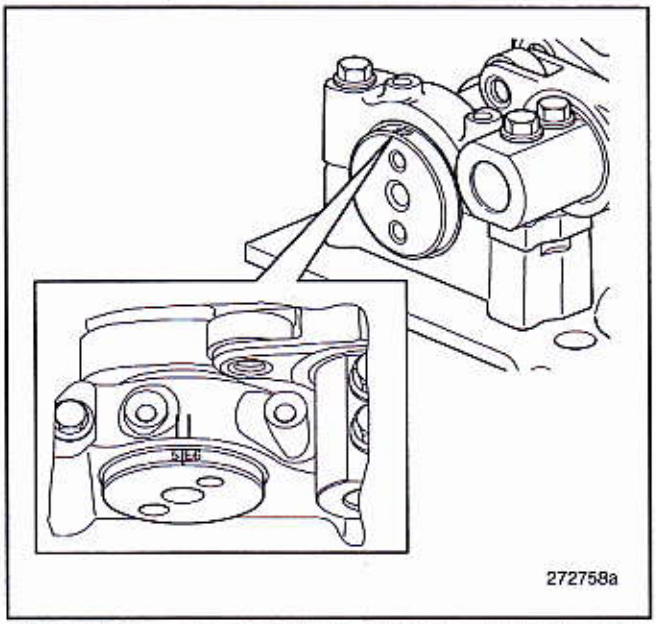


Figure 435 — Camshaft Timing Marks — Front Bearing Cap (4 Rocker Shown)

Timing marks for basic camshaft timing and adjustment of the valves and unit injectors are located at the front of the camshaft just forward of the No. 1 front bearing journal. Two lines at the top of the front bearing cap mark the alignment point for positioning of the camshaft and making the adjustments.

The top dead center (TDC) mark is used for basic camshaft timing. The TDC mark must be between the two lines on the front camshaft bearing cap when the flywheel is at 0° (top dead center for cylinder No. 1).

The engine must be cold, 60°C (140°F) or less, before making these adjustments.

Camshaft markings for setting of valves and unit injectors:

- **Without PowerLeash™**: Markings 1–6 apply to adjustment of inlet valves, exhaust valves and injectors.
- **With PowerLeash™**: Markings 1–6 apply to adjustment of inlet valves and injectors. Markings E1–E6/V1–V6 apply to adjustment of exhaust valves.

NOTE

— **4 Rocker** — Marked as E1–E6.

— **3 Rocker** — Marked as V1–V6.

INLET VALVE ADJUSTMENT

⚠ WARNING

Apply the parking brake before barring the engine over. Remove the EMS power supply fuse to avoid starting the engine unintentionally. Make sure that the transmission is not in gear.

With the engine cold, 60°C (140°F) or less, check and adjust the valves and injector as required for each cylinder before moving to the next. Follow this sequence of cylinders when adjusting clearances: 5, 3, 6, 2, 4 and 1.

1. Using the flywheel turning tool, 88800014, bar the engine over manually to the appropriate camshaft marking for adjustment of the inlet valves and injector for that cylinder.
2. Using a feeler gauge, check the clearance between the rocker arm adjusting screw and the valve yoke (bridge) of the inlet valves. Refer to Figure 436.

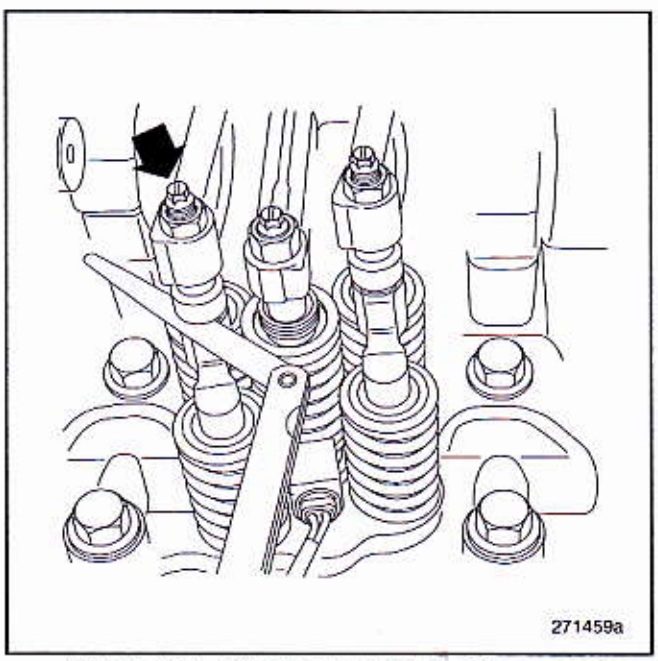


Figure 436 — Checking Inlet Valve Clearance

3. If the clearance is not within specification, loosen the locknut and adjust the clearance as required.
4. Hold the adjusting screw to prevent it from turning and tighten the locknut to specification.
5. Recheck the clearance after tightening the locknut.
6. Mark the rocker arm when adjustment is complete.

UNIT INJECTOR ADJUSTMENT

The unit injector adjustment is done with the engine and camshaft in the same position as for the inlet valve adjustment on each cylinder.

1. Loosen the injector rocker arm adjusting screw jam nut and turn the adjusting screw out (counterclockwise) to relieve the preload.
2. Turn the adjusting screw in (clockwise) until it firmly contacts the injector. Do not compress the spring.
3. Turn the adjusting screw in a further 240° (four flats on the hex head).

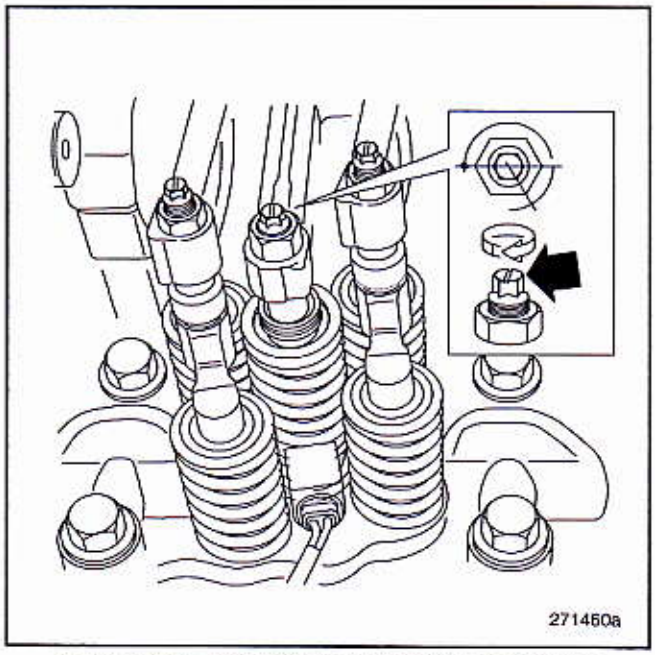


Figure 437 — Adjusting Unit Injector Clearance

4. Hold the adjusting screw to prevent it from turning further and, using a torque wrench, tighten the jam nut to specification.
5. Mark the rocker arm when adjustment is complete.

EXHAUST VALVE ADJUSTMENT (WITHOUT POWERLEASH™)

1. At the current camshaft setting used for the inlet valves, adjust the exhaust valves following the same procedure described for adjustment of the inlet valves. However, the valve clearance specification is different.

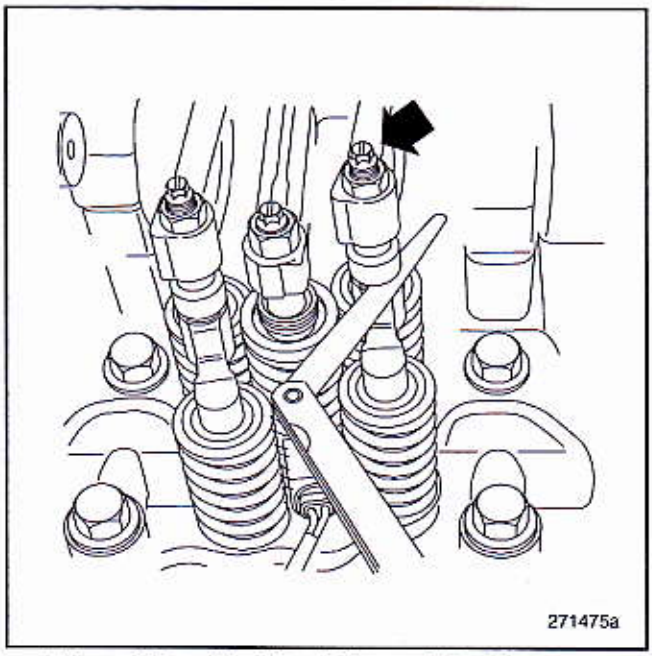


Figure 438 — Checking Exhaust Valve Clearance

2. Mark the rocker arm when adjustment is complete.
3. Using the flywheel turning tool, bar the engine over manually to the appropriate marking for the next cylinder. Adjust the inlet valves, unit injector and exhaust valves at that cylinder.

EXHAUST VALVE ADJUSTMENT (WITH 3-ROCKER POWERLEASH™)

NOTE

The numbers on the camshaft preceded by a **V** are used to adjust the exhaust valves when the engine is equipped with PowerLeash™.

1. Using the flywheel turning tool, 88800014, bar the engine over so that the appropriate **V** number marking for the respective exhaust valve is between the lines on the camshaft bearing cap.
2. Press down on the rocker arm as shown in Figure 439. If the rocker arm "springs," the brake piston spring should be pulled outward at the same time as the rocker arm is pressed down to make and ensure contact with the valve stem. Use a strong wire with a hooked end to catch and compress the spring. When the piston spring is loosened from its seat, the residual oil film retaining the spring is punctured, allowing the adjustment setting to be more accurate.

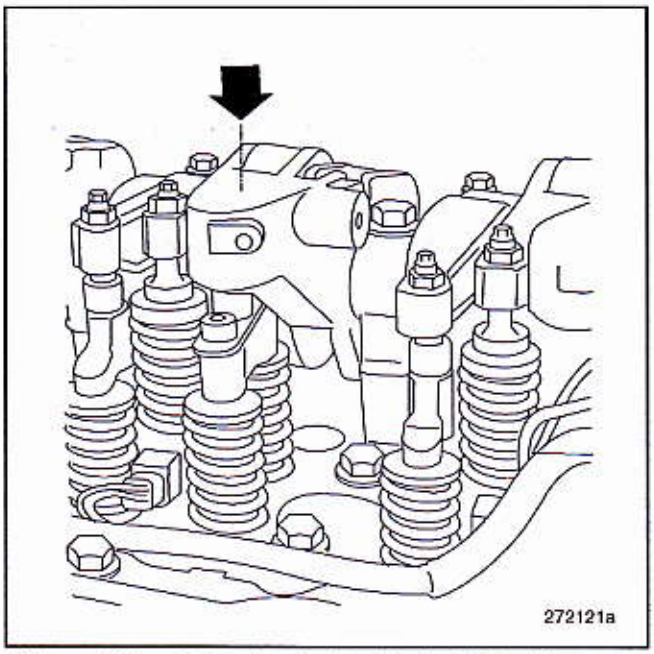


Figure 439 — Releasing Engine Brake Piston Pressure

3. Measure the clearance between the rocker arm piston and the shim on top of the yoke (bridge) as shown in Figure 440.

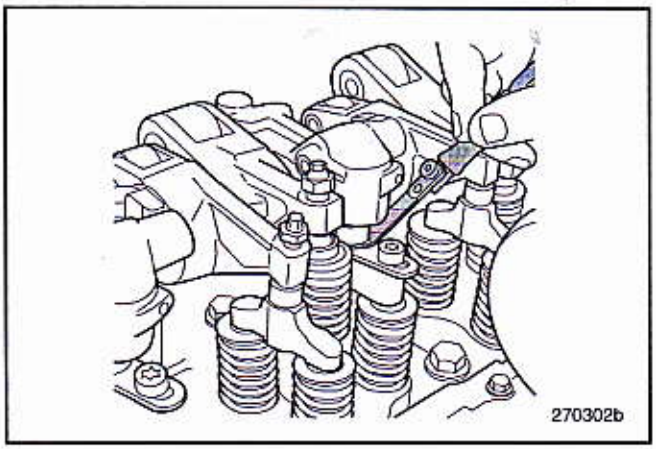


Figure 440 — Measuring Exhaust Valve Clearance

4. If clearance is not within specification, adjust the clearance as required, using shims (Figure 441) placed on top of the valve yoke (bridge).
   a. Remove the shim retaining screw and remove the shim(s).
   b. Determine the thickness of the shim(s) required to match the measured clearance.
   c. Make sure that the valve yoke and shim(s) are clean. Place the shim(s) in position on the valve yoke.

NOTE

DO NOT use more than two shims. Shims are available in 0.05 mm (0.002 inch) increments with the thickness marked on the surface. If two shims are required to take up the clearance, the shims should be of nearly equal thickness.

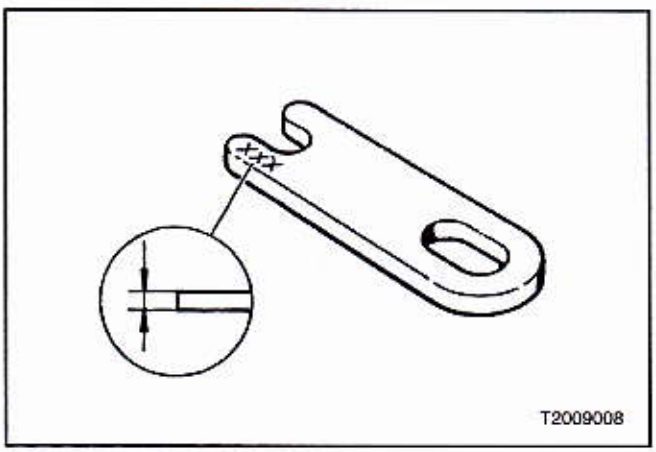


Figure 441 — Engine Compression Brake Adjustment Shim

5. With the required shim(s) in place, install the retainer screw securing the shim(s) to the valve yoke and tighten to specification. Hold the yoke securely while tightening the retaining screw.
6. Recheck the clearance between the exhaust valve rocker arm and the valve yoke.

SERVICE HINT

Mark the respective rocker arm as each valve adjustment is completed.

EXHAUST VALVE ADJUSTMENT (WITH 4-ROCKER POWERLEASH™)

NOTE

The numbers on the camshaft preceded by an ***E*** are used to adjust the exhaust valves when the engine is equipped with PowerLeash™.

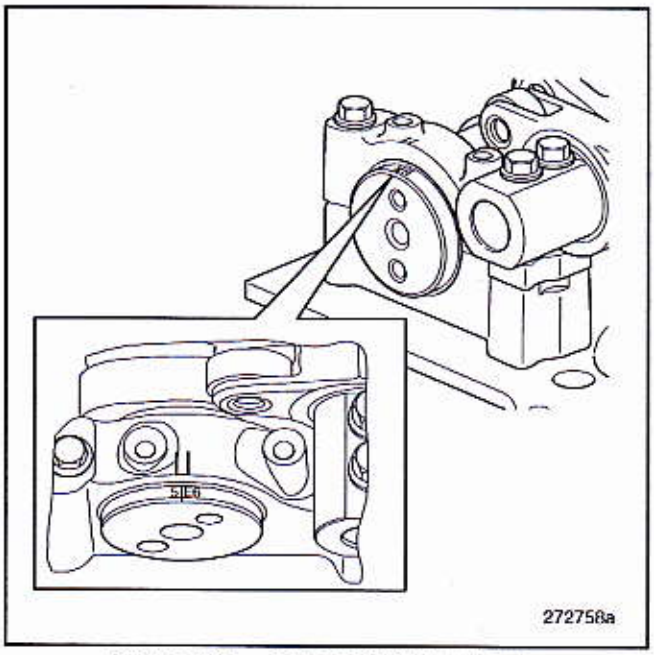


Figure 442 — Camshaft Timing Marks

Engines equipped with the PowerLeash™ engine brake have two rocker arms working in combination to control the exhaust valves. They are the **exhaust rocker arm** and the **brake rocker arm** which are adjusted separately as described in the following procedure.

1. Loosen the screws holding the plate springs to release the spring tension against the engine brake rocker arms.

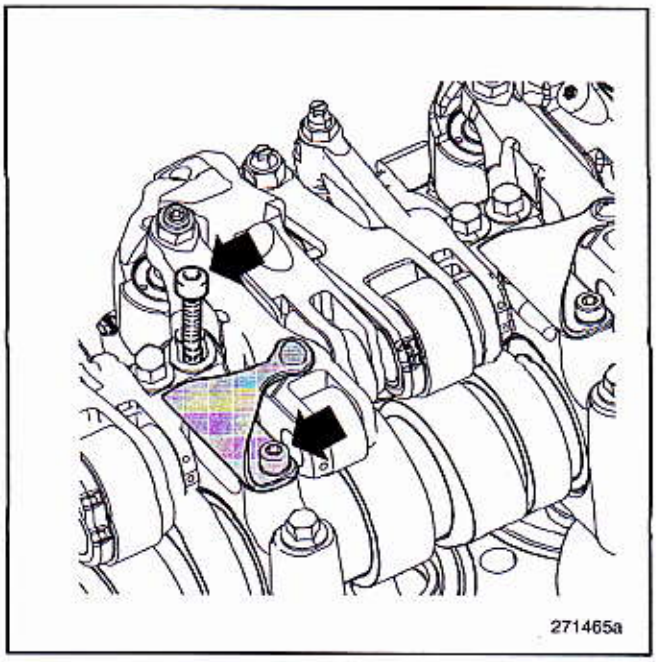


Figure 443 — Plate Spring Attaching Screws

2. Using the flywheel turning tool, 88800014, bar the engine over so that the appropriate ***E*** number marking is between the lines on the front camshaft bearing cap.
3. Measure the clearance between the exhaust rocker arm piston and the shim on top of the valve yoke (bridge) as shown in Figure 444.

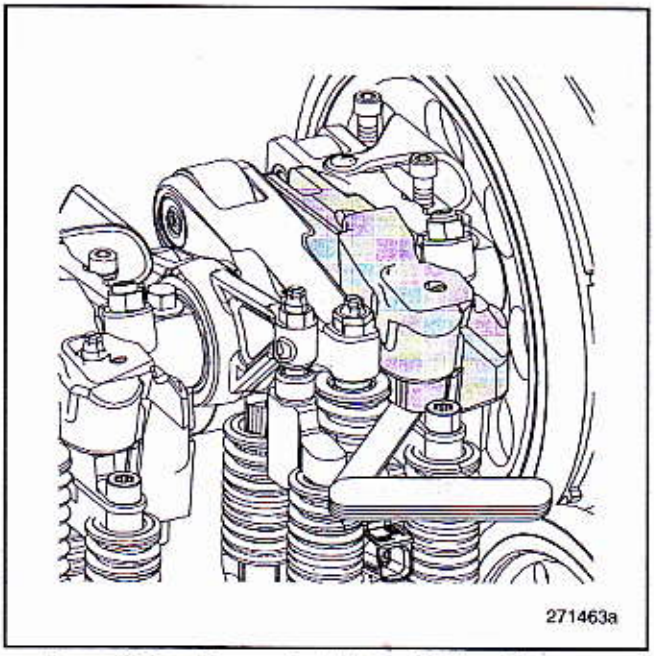


Figure 444 — Measuring Exhaust Valve Clearance

4. If clearance is not within specification, adjust the clearance as follows, using shims (Figure 441) placed on top of the valve yoke (bridge).

Adjusting Exhaust Rocker Arm Clearance

a. Remove the shim retaining screw and remove the shim(s).

b. Determine the thickness of the shim(s) required to provide the specified clearance.

c. Make sure that the valve yoke and shim(s) are clean. Place the shim(s) in position on the valve yoke and install the retaining screw. Tighten the screw to specification.

NOTE

DO NOT use more than two shims. Shims are available in 0.05 mm (0.002 inch) increments with the thickness marked on the surface. If two shims are required to take up the clearance, the shims should be of nearly equal thickness.

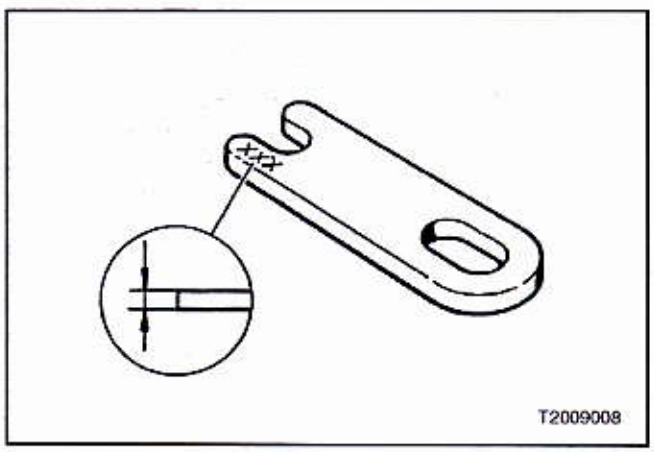


Figure 445 — Engine Compression Brake Adjustment Shim

5. Leave the feeler gauge in place between the exhaust rocker arm piston and the valve yoke shim and adjust the brake rocker arm clearance.

Adjusting Brake Rocker Arm Clearance

a. Loosen the locknut **A** on the brake rocker arm adjusting screw.

b. Using the dial indicator with angled extension and base (9989876, 85111493 and 9999696), place the tip of the dial gauge on the yoke as close as possible to the rocker arm yoke pad. Zero the gauge.

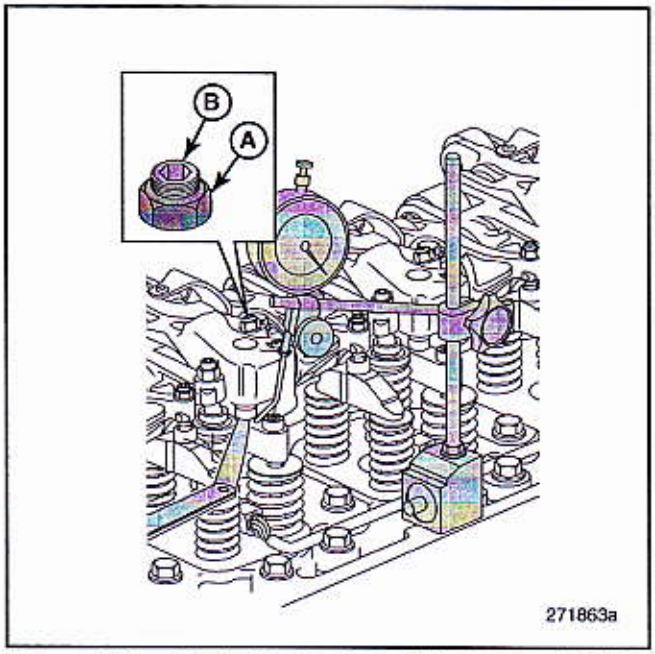


Figure 446 — Brake Rocker Arm Adjustment with Dial Indicator

A. Locknut	B. Adjusting Screw

c. Tighten the rocker arm adjusting screw **B** until the dial shows that the yoke has been pushed downward to specification.

d. Loosen the rocker arm adjusting screw according to specification.

e. Hold the adjusting screw to prevent it from turning further and, using a torque wrench, tighten the locknut to specification.

6. Remove the dial indicator and the feeler gauge.

7. Using a feeler gauge, check the clearance between the brake rocker arm roller and the cam lobe. If the clearance is incorrect, repeat the brake rocker arm clearance adjustment.

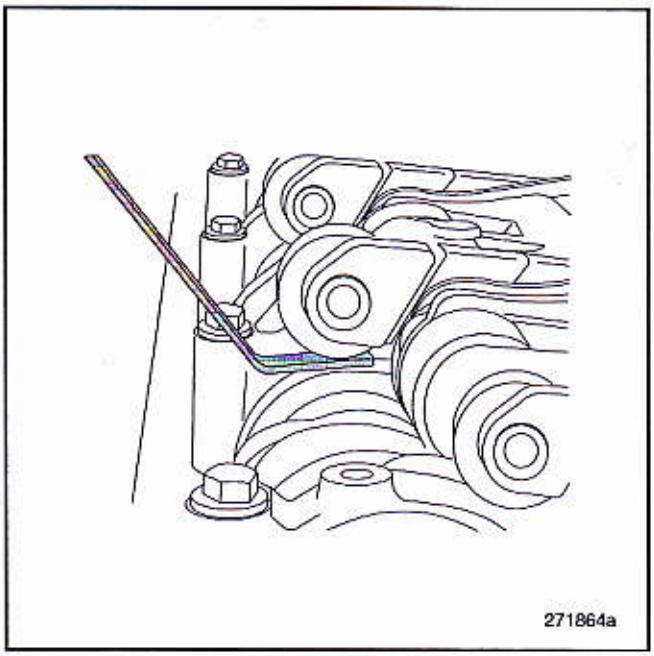


Figure 447 — Checking Brake Rocker Arm Roller to Cam Lobe Clearance

8. Mark the respective rocker arm as each valve adjustment is completed.

CONTINUATION OF ADJUSTMENTS

Continue the procedure by barring the engine to the appropriate timing marks and adjusting the valves and unit injectors at each of the remaining cylinders. Follow the steps described above to adjust the inlet and exhaust valves, and unit injector at each cylinder.

For engines equipped with the 4-rocker PowerLeash™ engine brake, tighten the plate spring attaching screws to specification after the valve and unit injector adjustments have been completed.

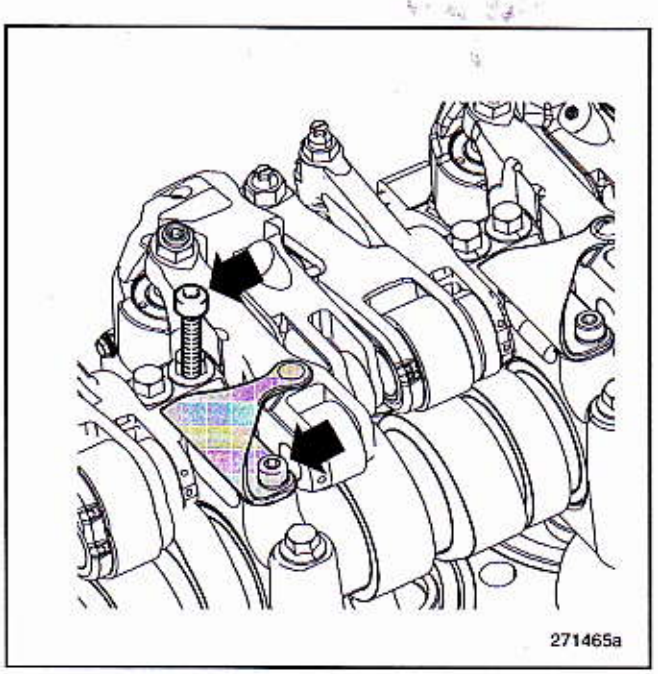


Figure 448 — Plate Spring Attaching Screws

OPERATIONAL CHECK

After the valve and unit injector adjustments have been completed, check engine operation as follows:

1. Using the flywheel turning tool, bar the engine over manually two complete revolutions to ensure that no piston-to-valve contact occurs. If contact does occur, readjust the valves as needed BEFORE starting the engine.
2. Start the engine and bring it up to normal operating temperature.
3. Once normal operating temperature is attained, let the engine idle for an additional five minutes. During this time, the electronic engine management system (EMS) will perform its own cylinder balancing, resulting in smooth engine idling.

NOTE

DO NOT use any form of power consuming equipment, such as PTO or air conditioning, when cylinder balancing is being carried out.

Checking and Adjusting Timing Gear Backlash

(Camshaft Gear to Idler Gear)

⚠ WARNING

Apply the parking brake before barring the engine over. Remove the EMS power supply fuse to avoid starting the engine unintentionally. Make sure that the transmission is not in gear.

1. Remove the 16 retaining screws and springs and remove the valve cover from the cylinder head.
2. Disconnect the wiring harness leads at the unit injectors and camshaft sensor connector. Pull the harness out through the cover.
3. Remove the compressor coolant lines.
4. Loosen and remove the capscrews securing the timing gear cover to the cylinder head.
5. Remove the timing gear cover from the engine. Use care when removing the cover to avoid the rubber seals falling into the flywheel housing. Remove the rubber seals from the cover and discard.

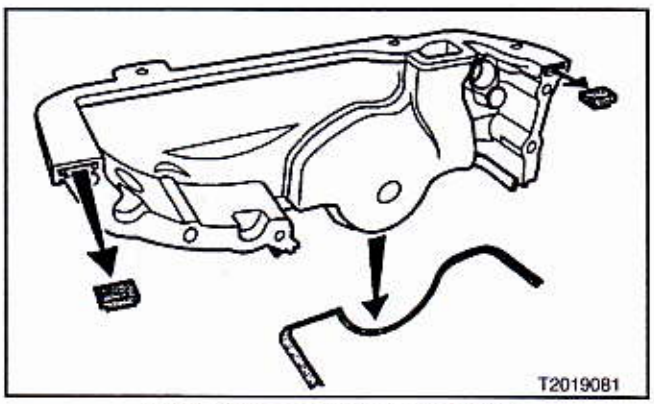


Figure 449 — Timing Gear Cover

6. Using the flywheel turning tool, bar the engine over manually so that the camshaft is positioned at top dead center (TDC) by aligning the TDC mark on the camshaft with the timing marks on the No. 1 camshaft bearing cap.

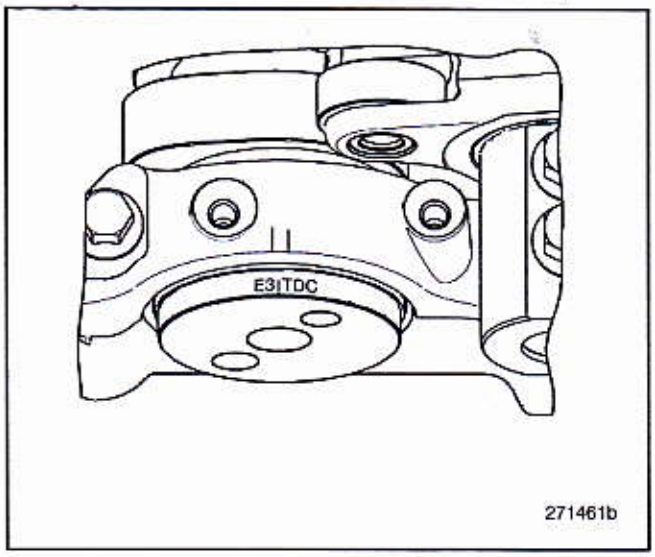


Figure 450 — Camshaft Positioning

7. Loosen and remove the six screws securing the vibration damper and gear to the camshaft. Remove the damper from the camshaft, but DO NOT remove the camshaft gear.
8. Install the gauge plate tool, J 44514-1A.

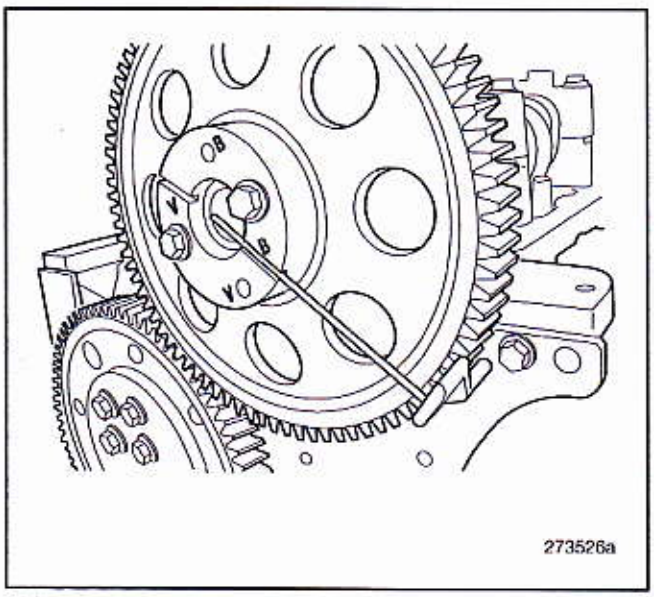


Figure 451 — Camshaft Gear Timing Marks Alignment

9. Insert the alignment tool in the hole in the timing gear plate to engage the camshaft gear teeth with the rod of the tool in the slot of the clamp tool. Rotate the camshaft until this occurs.

10. Tighten the bolts to specification. With the camshaft set at TDC, the double timing marks on the gear should be aligned with the marking hole in the gear plate.
11. Install the clamp assembly tool, J 44514-5.
12. Install a dial gauge against a tooth on the camshaft gear (Figure 452). With the idler gear locked in position, rotate the camshaft gear back and forth to measure backlash. The backlash reading should be within specification.

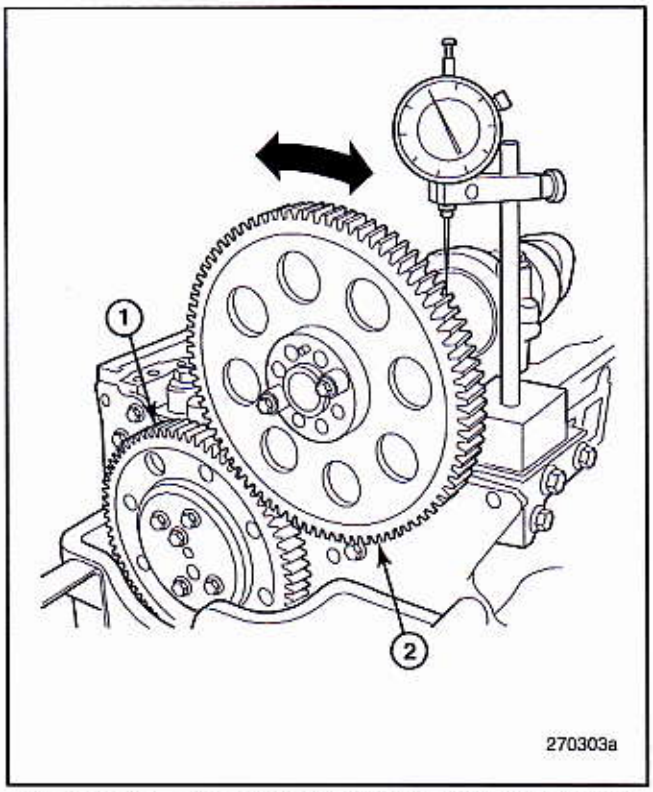


Figure 452 — Camshaft Gear Backlash Measurement

1. Idler Gear	2. Camshaft Gear

13. If the backlash measurement is out of specification, adjust the gear flank clearance as follows:
    a. Loosen the clamp assembly tool.
    b. Loosen the camshaft idler gear hub screws. Loosening the hub screws will allow the idler gear to be moved slightly in/out from the camshaft gear.
    c. Insert a 0.1 mm (0.004 inch) thickness gauge on the pressure side of the idler and camshaft gear teeth (Figure 453).
    d. While holding the idler gear in against the thickness gauge and camshaft gear, tighten, but DO NOT torque, the idler gear hub screws.
    e. Tighten the clamp assembly tool.
    f. Recheck the backlash. With the specified backlash attained, replace each adjustable idler gear hub screw with **new** and tighten the screws to specification.

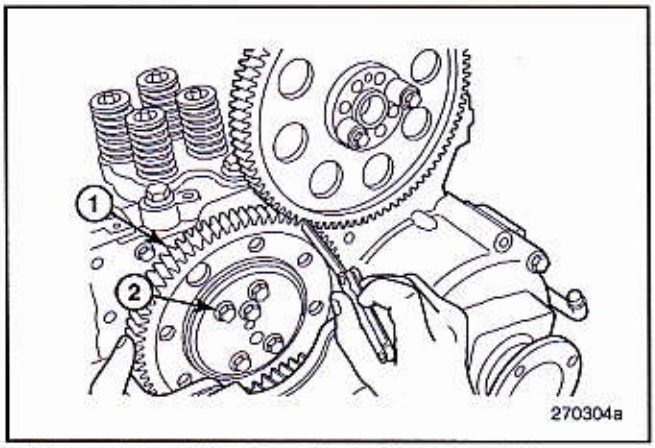


Figure 453 — Idler Gear Flank Clearance Adjustment

1. Idler Gear	2. Hub Screws

14. Remove the gauge plate tool securing the camshaft gear. Use care to ensure that the gear remains in place and properly aligned on the camshaft.
15. Reinstall the vibration damper on the gear and camshaft. Install the six **new** mounting screws and tighten to specification.
16. Apply a 2 mm (5/64 inch) bead of MACK-approved sealant on the timing gear cover mounting surface and install **new** rubber seals (Figure 454).

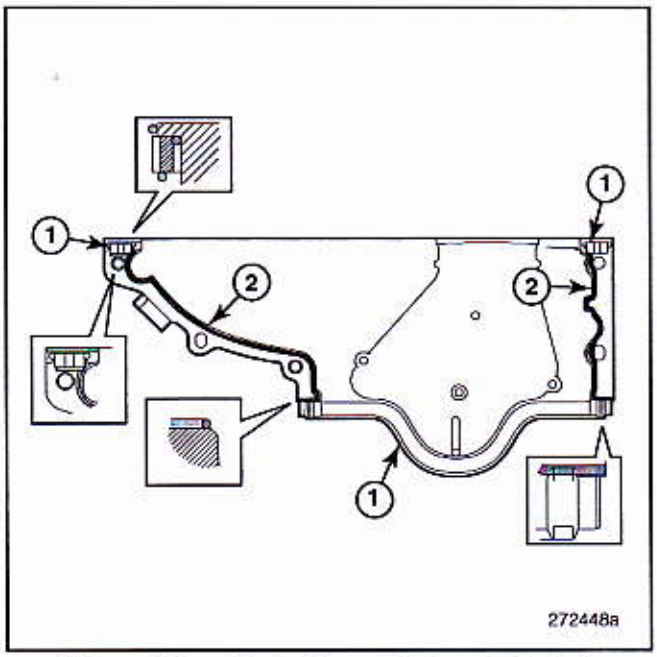


Figure 454 — Timing Cover Seals and Sealant Application

1. Rubber Seals	2. Sealant

17. Place the timing gear cover in position on the engine. Install two capscrews (item 1 in Figure 455) and hand tighten.

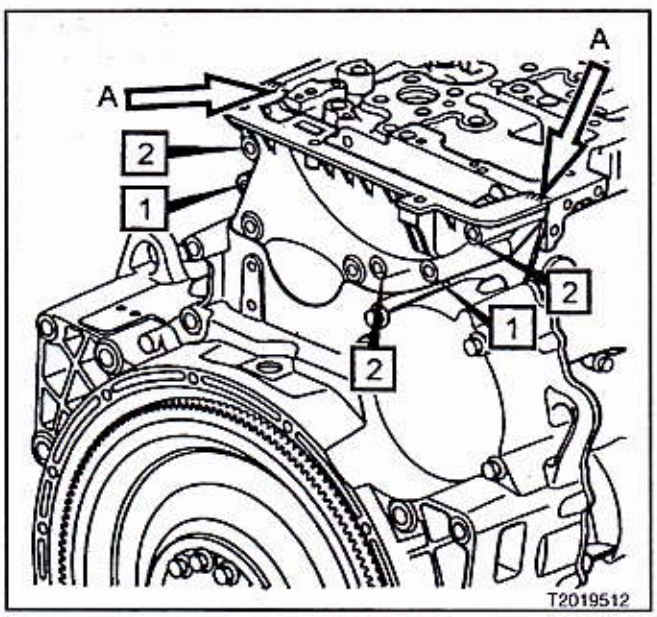


Figure 455 — Timing Gear Cover Installation

18. Using alignment tools, 85111422A and 85111422B, ensure that the upper and lower seals are properly seated and that the upper surface of the cover is flush with the top of the cylinder head (points A in Figure 455).
19. Install the three remaining capscrews (item 2 in Figure 455) and tighten to specification.
20. Reconnect the wiring harness leads at the unit injectors and camshaft sensor connector.
21. Apply an even 2 mm (5/64 inch) bead of sealant at the joint lines (point A) between the cylinder head and the timing cover.
22. Install the valve cover and the 16 retaining screws and springs. Tighten the screws to specification.

ENGINE FINAL PREPARATION AND OPERATIONAL CHECK

After Engine Overhaul Procedures

Filter Element Installation

All filters and coolant conditioners must meet MACK specifications.

1. Install a **new** air filter in the air filter housing.
2. Using a torque wrench, tighten the attaching screw to specification.
3. Lubricate the gaskets.
4. Using a filter wrench, tighten the filters to specification.
5. Attach the filters to the valve housing.
6. Using a filter wrench, tighten the filters to specification.

Engine Lubrication System

An oil film coats rotating parts and bearings of an overhauled engine, but this may not provide sufficient lubrication when the engine is started for the first time. Following is the recommended procedure for providing adequate lubrication.

⚠ CAUTION

Do not mix brands or types of lubricants. Chemical additives may be incompatible and may contribute to the formation of sludge, acid and hardening.

Failure to heed this caution may result in severe engine damage.

SERVICE HINT

Usually there are various points on the engine where a pressure line may be opened, but if no other is apparent, use the oil pressure sensor port.

PRIMING THE LUBRICATION SYSTEM

1. Fill the engine crankcase with the specified quantity of the specified engine oil.
2. Using a pressure prelubricator filled with the specified oil, prime the engine lubrication system for a minimum of five minutes.
3. Check the crankcase oil level.
4. If necessary, add oil to reach the FULL mark on the dipstick.

NOTE

Do NOT overfill.

Oil Pressure

Engine Speed/RPM	Temperature	Pressure
600	90–110°C (195–230°F)	>250 kPa (36 psi)
>1100	90–110°C (195–230°F)	300–550 kPa (44–80 psi)
>1100	Cold Engine	650 kPa (95 psi)

Rocker Shaft Engine Brake	Engine Speed/RPM	Oil Pressure
Inactive	—	80–120 kPa (12–17 psi)
Active	900–2300	220 kPa (32 psi)

Turbocharger

⚠ CAUTION

It is necessary to perform the system pre-lubrication procedure anytime the vehicle has not been operated for a period exceeding 30 days to avoid damage to the turbocharger. During this extended period, all oil will have drained away from the bearing and shaft surfaces.

1. Remove and flush the turbocharger oil supply line with a suitable, clean, non-flammable solvent.

SERVICE HINT

Allow solvent to run through the line to flush any debris, then blow the line dry with clean compressed air.

⚠ CAUTION

A turbocharger failure can result in debris contaminating the turbocharger oil supply line. It is EXTREMELY IMPORTANT to remove, flush and thoroughly clean the line prior to starting the engine. Failure to heed this caution may result in severe component and engine damage.

2. Reinstall the oil supply line.
3. Prime the lubrication system following the procedure described earlier in this section.
4. Following engine overhaul, use the diagnostic computer to calibrate the variable geometry turbocharger.

Cooling System

1. Check the cooling system. Make sure all plugs and coolant drain quick disconnects are installed and are tight.
2. Make sure the thermostat is installed.
3. Install a **new** coolant filter.
4. Fill the system with the recommended coolant.

NOTE

Make sure that all air is purged from the cooling system.

Fuel System

⚠ DANGER

Before working on or inspecting a vehicle, set the parking brake, place the transmission in neutral and block the wheels. Failure to heed this warning can result in unexpected vehicle movement and cause severe personal injury or death.

⚠ DANGER

To avoid potential fire hazard, do not service any part of the fuel system while smoking or in the presence of flames, sparks or hot surfaces, or when working on an operating engine. Failure to heed this warning can result in fire which can produce severe personal injury or death.

⚠ DANGER

Wear adequate protective clothing (face shield, heavy gloves, apron, etc.) when working on a hot engine to guard against burns from direct contact with hot fuel. Failure to heed this warning can result in severe personal injury or death.

⚠ WARNING

Do not work near the fan with the engine running. The engine fan can become active at any time without warning. Failure to heed this warning can result in severe personal injury.

⚠ WARNING

Before turning the ignition on, make sure no one is near the fan. Failure to heed this warning can result in severe personal injury.

1. Check the fuel system to make sure that all connections are tight.
2. Start the engine and run it at idle for approximately 5 minutes to remove air trapped in the fuel system.

PRIMING THE FUEL SYSTEM

Using the hand priming pump is usually only necessary when the fuel system has air in it, or when replacing filters. If hand priming is needed, use the following procedure.

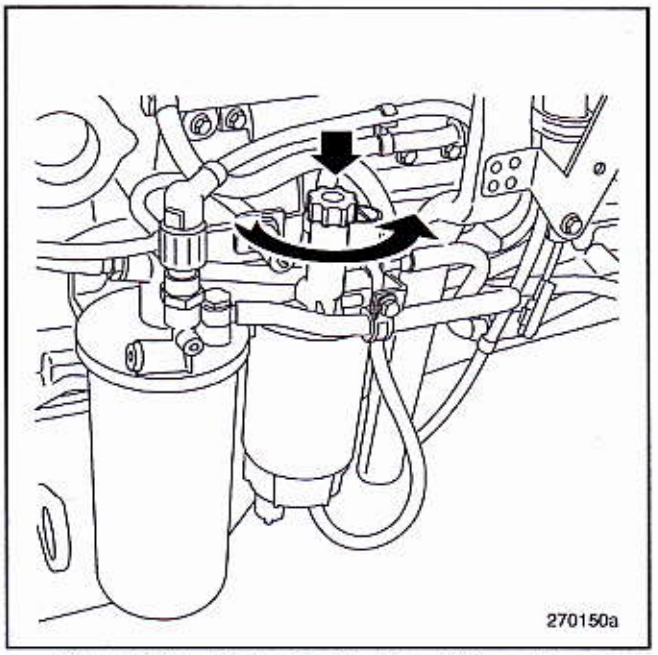


Figure 456 — Unlocking the Hand Primer Pump

1. Unlock the hand primer pump by pushing the handle in and turning it counterclockwise.
2. Pump the hand primer until the force of pumping increases.

NOTE

When the fuel system is completely empty, 200 or more strokes may be needed to prime the system properly.

NOTE

There are NO bleed nipples to be opened in order to prime the fuel system.

3. Lock the pump by pushing the handle into the housing, turning it clockwise and releasing it.
4. Start the engine and run it at an increased idle for approximately 5 minutes to remove air trapped in the fuel system.
5. Check the fuel system to make sure that all connections are tight.

NOTE

If the engine does not start following this procedure, contact your local MACK Truck dealer.

NOTE

Do not crank the engine continuously for more than 30 seconds without allowing the starter to cool for 2 minutes between cranks.

Some starters are equipped with starter protection. If the starter temperature is too high, starter engagement is inhibited to prevent starter damage. Wait until the starter has cooled to crank the engine.

⚠ CAUTION

The only acceptable method of priming the fuel system is the hand primer pump. Applying air pressure to the fuel tank or using an auxiliary pump to prime the fuel system is PROHIBITED. These priming techniques may cause fuel to leak past the supply pump seal into the crankcase. Failure to heed this caution may result in severe engine damage.

⚠ WARNING

After running for 5 minutes, the engine, all its components and fluids will be hot. Contact with hot components and fluids can cause severe burns. Failure to heed this warning can result in severe personal injury.

Engine Operational Check

1. Remove all tools from the engine compartment.
2. Connect the battery cables (negative cable last).
3. Clear the work area of debris and personnel.

NOTE

The following step is important to proper break-in for all new parts at initial startup of the engine.

4. Start the engine and immediately increase the speed to 1200–1600 rpm. During the break-in period, check for leaks and monitor gauges for satisfactory oil pressure, etc.
5. Operate the engine within the 1200–1600 rpm range for 15 minutes.

NOTE

DO NOT allow the engine to drop to idle speed until the 15 minute break-in period at 1200–1600 rpm has been completed.

6. Shut down the engine.
7. Check the fluid levels and fill to capacity before restarting the engine.
8. Refer to *Rebuilt Engine Run-In Procedures* for inspections to be sure of proper engine operation before releasing the vehicle for service.

REBUILT ENGINE RUN-IN PROCEDURES

General

The durability and service life of a rebuilt engine is directly related to its initial run-in following overhaul. After a complete overhaul or any major repair job involving installation of piston rings, pistons, cylinder liners or bearings, the engine must be run-in prior to release for service.

Run-in procedures vary depending on method used (i.e., engine dynamometer, chassis dynamometer or highway run-in). Regardless of method, however, always prepare the engine properly before starting it for the first time.

Run-In Check

NOTE

Install any additional instrumentation needed for the run-in method selected.

The operator should be familiar with the correct, established procedure for checking chassis power *before* using the chassis dynamometer method for run-in. Refer to applicable chassis dynamometer operating procedures.

The operator must be observant throughout the entire run-in procedure in order to detect any problems.

Constantly monitor the instrument display of engine functions and support systems and record all readings.

If the engine develops any of the following abnormal characteristics during run-in, shut it down immediately.

Discover and correct problems before continuing the run-in procedure.

Always investigate the following conditions:

- Unusual noises, such as knocking, scraping, etc.
- A significant drop in engine oil pressure
- A significant rise in coolant temperature, exceeding 116°C (240°F)
- A significant rise in oil temperature that exceeds 116°C (240°F)
- An exhaust temperature that exceeds maximum acceptable limits for the engine involved, as measured by a pyrometer (if applicable)
- Any oil, coolant, fuel or air inlet system leaks

MP8 EURO 3 ENGINE MECHANICAL SPECIFICATIONS

Material and Dimensional Data

GENERAL DATA, WEIGHTS AND DIMENSIONS

Item	Specification
Engine Type	In-line, direct injection, diesel
Number of Cylinders	6
Displacement	12.8 L
Bore and Stroke	131 x 158 mm (5.16 x 6.22 in.)
Compression Ratio	18.1:1
Emissions Level	Euro 3
Fuel System	Electronic Unit Injector
Valve Actuation	Single Overhead Cam, 4 valves per cylinder
Aspiration	Turbocharger
Power Cylinder	Wet sleeve; one-piece steel pistons
Electronic Controls	Electronic Management System (EMS)
Peak Power Ratings	254–324 kW (346–440 hp)
Peak Torque Ratings	1800–2200 N•m (1328–1623 lb-ft)
Weight, Dry	1145 kg (2524 lb.)
Firing Order	1–5–3–6–2–4
Length Overall	1359 mm (53.5 in.)
Width Overall	813 mm (32.0 in.)
Height Overall	1171 mm (46.1 in.)

COMPONENT FEATURES AND MATERIALS

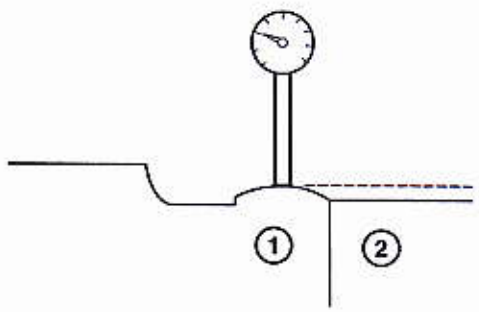
Item	Description
Air Compressor	Flange mounted, oil lubricated, coolant cooled
Camshaft	Induction hardened, gear driven
Coolant Conditioner	Spin-on type, disposable
Coolant Pump	Centrifugal rotor impeller, belt driven
Connecting Rods	Forged steel, cracked cap design
Crankshaft	Drop forged steel, induction hardened, seven main bearings
Cylinder Block	In-line six cylinder; wet, replaceable cylinder sleeves; cast iron, machined with bearing caps, stiffener plate added at bottom, timing gear train mounting plate added at rear
Cylinder Head	One-piece cast iron alloy; supports overhead camshaft, four valve system, unit injectors; replaceable cast iron valve guides with oil seals; replaceable steel valve seats; copper unit injector sleeves; integral fuel passages; integral thermostat housing
Cylinder Head (Valve) Cover	Plastic, 20 spring tension attaching screws
Cylinder Head — Valve Springs	Double springs on exhaust valves, single on inlet

Item	Description
Cylinder Head — Valve Guides	Cast iron, replaceable; with oil seals
Cylinder Head Gasket	One-piece steel stamping; elastomer seals added; one-time bosses to aid head installation
Cylinder Head Bolts	M16 (38)
Cylinder Liner	Wet; replaceable; with EDPM rubber and Viton seals
Fasteners and Threads	Metric
Flywheel Housing	Die-cast aluminum
Fuel Filters	Two: primary and pre-filter with water separator
Fuel Injection	Individually programmed unit injectors (6): EMS module controlled; common fuel gallery in head; constant supply pressure; over-pressure return
Fuel Supply Pump	Gear type pump integral with power steering pump; crankshaft idler gear driven
Lubrication System	Crankshaft gear driven lubrication pump; system integrated within block and head; serves camshaft, rocker arm shaft, pistons, crankshaft, air compressor; three filters, 1 bypass and 2 full-flow; lubricant level and temperature sensor in oil pan
Main Bearing Caps	Nodular iron; machined with block; No. 7 mounts lubrication pump; 1–3, 5 and 6 numbered for consistent reassembly; cast and drilled for consistent reassembly; thrust washers at No. 4 main bearing journal
Manifold — Exhaust	Three-piece, six port
Pistons	Steel; one-piece; 3 ring grooves
Piston Rings — Compression	2: 1 trapezoidal cross section, 1 rectangular cross section
Piston Ring — Oil	1 garter spring type; scraping
Oil Filters	2 full flow; 1 bypass Filter capacity, 2 full flow: • 4.0–4.5 L (4.2–4.8 qts.)
Oil Pan	Plastic or steel; 22 spring-tension screws Sump capacity: • 25 L (26.4 qts.) minimum • 30 L (31.7 qts.) maximum
Thermostat, Coolant	Piston-type; 82°C (180°F)
Thermostat Housing	Integrated in head
Timing Gear Cover	Die-cast aluminum, elastomer seals
Turbocharger	Exhaust gas driven, radial flow, engine oil lubricated
Valve Rocker Arms	Roller followers
Valve Seat Inserts	Pressed in head, replaceable
Vibration Damper, Crankshaft	Internal fluid-filled ring

FITS AND LIMITS

The specifications as listed are for new parts and, therefore, maximum wear must be established by good judgment, experience and sound shop practice.

Tolerances Are Shown Low to High	Standard Size or Fit	
Component	**Metric**	**English**
CAMSHAFT		
Camshaft Journal Diameter	70 mm	2.75 in.
Inlet Valve Lobe Nominal Lift	13.1 mm	0.516 in.
Exhaust Valve Lobe Nominal Lift (EPG)	12.3 mm	0.484 in.
Exhaust Valve Lobe Nominal Lift (3-Rocker)	13.1 mm	0.516 in.
Exhaust Valve Lobe Nominal Lift (4-Rocker)	12.3 mm	0.484 in.
Camshaft End Play	0.24 mm max.	0.0094 in. max.
CONNECTING ROD		
Length between Centers	267.5 mm	10.5 in.
CRANKSHAFT		
Crankpin Journal OD (Inspection only: not for machining)	99 mm	3.9 in.
Main Journal OD (Inspection only: not for machining)	108 mm	4.25 in.
CYLINDER BLOCK		
Main Bearing Bore in Block	113 mm	4.449 in.
Cylinder Sleeve Flange Bead to Block Deck (Top of Bead to Block Deck)	0.15–0.21 mm	0.0059–0.0083 in.



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1. Cylinder Liner	2. Cylinder Block

Tolerances Are Shown Low to High	Standard Size or Fit	
Component	Metric	English
CYLINDER HEAD		
⚠ CAUTION *Do **NOT** machine the cylinder head. This will change the extension of the injector/valves and upset injector timing.* *Do **NOT** grind copper injector sleeves.*		
Overall Height	135 mm	5.315 in.
Valve Guide Height Above Cylinder Head Spring Face — Inlet	24.5 mm	0.965 in.
Valve Guide Height Above Cylinder Head Spring Face — Exhaust	24.5 mm	0.965 in.
Valve Seat Insert (Inlet)	45 mm	1.77 in.
Valve Seat Insert (Exhaust)	43 mm	1.69 in.
Valve Seat Height (Inlet)	7.55 mm	0.2972 in.
Valve Seat Height (Exhaust)	7.5 mm	0.2953 in.
Valve Seat Counterbore Depth (Inlet)	11.8 mm	0.4646 in.
Valve Seat Counterbore Depth (Exhaust)	11.2 mm	0.4409 in.
INJECTORS		
Preload	240° (4 flats on the hex head)	
PISTON		
Wrist Pin Diameter	58 mm	2.2835 in.
Wrist Pin Length	76 mm	2.9921 in.
PISTON RINGS		
Compression Ring End Gap — Upper: Wear Tolerance	0.9 mm max.	0.0354 in. max.
Compression Ring End Gap — Lower: Wear Tolerance	1.3 mm max.	0.0512 in. max.
Oil Control Ring End Gap — Wear Tolerance	1.0 mm max.	0.0394 in.
OIL PUMP		
Crankshaft Gear to Oil Pump Gear Backlash	0.1–0.4 mm	0.004–0.016 in.
TIMING GEARS		
Adjustable Idler Gear to Camshaft Gear Backlash	0.05–0.15 mm	0.0020–0.0059 in.
VALVES		
Head Diameter (Inlet Valve)	42 mm	1.654 in.
Head Diameter (Exhaust Valve)	40 mm	1.575 in.
Inlet Rocker Arm Clearance (cold engine)	0.2 ±0.05 mm	0.008 ±0.002 in.

Tolerances Are Shown Low to High	Standard Size or Fit	
Component	**Metric**	**English**
Exhaust Rocker Arm Clearance (cold engine)		
— without PowerLeash™	0.8 ±0.05 mm	0.031 ±0.002 in.
— with PowerLeash™ 3-Rocker	1.6 ±0.05 mm	0.063 ±0.002 in.
— with PowerLeash™ 4-Rocker	0.8 ±0.05 mm	0.031 ±0.002 in.
Brake Rocker Arm Clearance, PowerLeash™ 4-Rocker (cold engine) **Note:** After setting exhaust arm clearance		
— Brake rocker press down using adjusting screw	0.25 ±0.05 mm	0.010 ±0.002 in.
— Brake rocker adjusting screw loosening	720° counterclockwise	—
— Clearance check (camshaft to brake rocker arm roller)	3.8 ±0.1 mm	0.150 ±0.004 in.
Valve Face to Cylinder Head Deck (Inlet)	1.0 mm min. 1.6 mm max.	0.0394 in. min. 0.0630 in. max.
Valve Face to Cylinder Head Deck (Exhaust)	1.35 mm min. 2.0 mm max.	0.0531 in. min. 0.0787 in. max.
Note: Replacing valve seats requires replacing valves.		
VALVE SEAT ANGLE		
Inlet Valve Head	24.5°	
Exhaust Valve Head	39.5°	
Inlet Valve Seat	25.0°	
Exhaust Valve Seat	40.0°	
VALVE SPRINGS		
Outer Spring:		
Free Length (approximate)	73.8 mm	2.91 in.
Inner Spring:		
Free Length (approximate)	70.5 mm	2.78 in.

Exhaust Pressure Governor

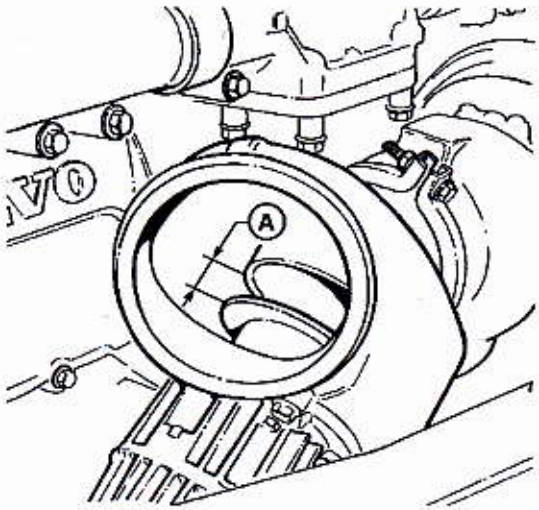

Figure 457 — Exhaust Pressure Governor

Stroke, shutter (A)	29 mm min.	1.14 in. min.

Engine Component Torque Specifications (Critical Fasteners)

NOTE

All components are to be clean and free from foreign material or corrosion. Assemblies are to be made using suitable tools and procedures so that no permanent damage will occur as a result of the assembly.

Threads, washers, under head of screw and washer face of nuts should be lubricated with clean engine oil unless otherwise specified.

The following listed fasteners require the use of a calibrated manual torque wrench. If an adapter is required in combination with a torque wrench, a correction factor **must be** applied to the torque wrench readings in order to obtain accurate fastener torque values.

Fasteners noted by an asterisk (*) require retorque after engine run-in.

FASTENER REUSE

⚠ CAUTION

Repeated tightening of fasteners and threaded components reduces their capacity to function adequately. The following table describes the various items and the limits of their reusability. Failure to conform to these limits may result in severe component damage.

Fasteners	Examples	Reusable Limit	Reuse Recommendations
Highly loaded screws (Phosphating plus oil)	Cylinder head Cylinder block Injector yoke Camshaft bearing housing Transmission (except adjustable idler gear) Flywheel	5 times	Apply engine oil on threads and under screw head. Mark bolt head with an indentation. Dry mounting for new screws (delivered with oil pre-applied and anti-rust treatment for spare parts). If a part is replaced, e.g., cylinder head, also replace the screws.
	Connecting rods	5 times	Apply clean engine oil.
	Adjustable idler gear	Do not reuse	
Special screws (specific shape)	Oil pan and valve cover	No limit	No limit if no cracks, corrosion or damage to the flat surfaces.
Flange head screws	Exhaust manifold	5 times	If exhaust manifold is replaced, also replace the screws.
Stainless steel fasteners and spacers	Turbocharger	5 times	If turbocharger or the exhaust manifold is replaced, also replace the fasteners and spacers and apply anti-seize.
Prevailing torque feature screws (Dri-Loc Plastic or Tuflock)	Piston cooling jets	Do not reuse	
Standard screws	Property class 8.8 Property class 10.9 Property class 12.9	No limit	No limit if no cracks, corrosion or damage to the flat surfaces.

Fasteners	Examples	Reusable Limit	Reuse Recommendations
V-nipples with taper thread	With locking fluid pre-applied	Do not reuse	Before fitting the new nipple, clean the hole with a nipple tap and apply sealant on the nipple thread, or use a new, coated nipple.
Taper plugs or nipples	With sealer fluid pre-applied	Do not reuse	Before fitting the new nipple, clean the hole with a nipple tap and apply sealant on the nipple thread, or use a new, coated nipple.

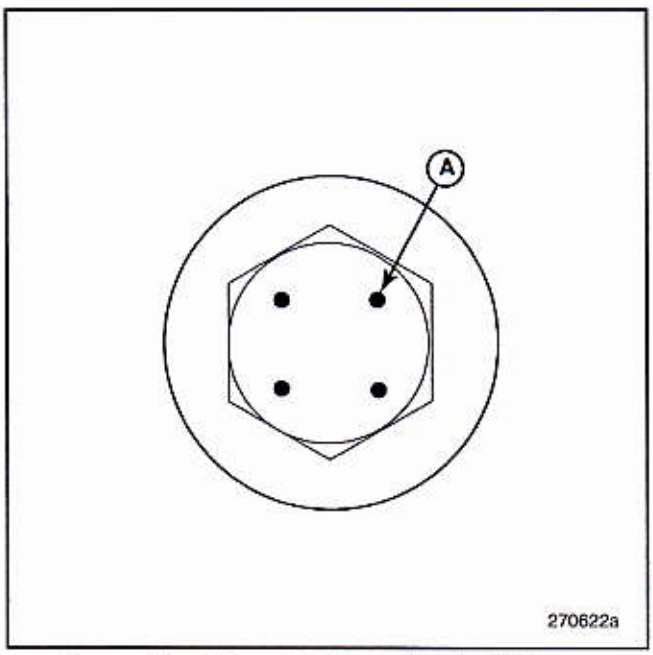

Figure 458 — Usage Marks on Head of Fastener

Bolts and screws that have limited reusability specified in the table above must be marked with a punch **(A)** each time they are installed in service. Bolts and screws with four punch marks when removed have been tightened five times and must be discarded.

⚠ CAUTION

Do not reuse timing gear mounting plate bolts.

Do not reuse timing gear mounting bolts.

SENSORS AND WIRING HARNESS

⚠ CAUTION

Overtorquing a sensor or sensor mounting screw can result in sensor breakage or thread damage.

Sensors	
Camshaft Position (timing gear cover)	8 ±2 N•m (6 ±1 lb-ft)
Charge Air Pressure/Temperature (inlet manifold)	3.3 N•m (29 lb-in)
Coolant Level (surge tank)	Plug-in
Coolant Temperature (front, right side cylinder head)	22 ±3 N•m (16 ±2 lb-ft)
Crankcase Pressure (block, front of air compressor)	30 ±5 N•m (22 ±3 lb-ft)
Flywheel Position/Speed (top of flywheel housing)	8 ±2 N•m (6 ±1 lb-ft)
Fuel Pressure (fuel filter housing)	25 ±3 N•m (18.5 ±2 lb-ft)
Humidity (fresh air pipe)	27 ±3 N•m (20 ±2 lb-ft)
Oil Level/Temperature (inside sump)	Standard Torque
Oil Pressure (block, front of air compressor)	30 ±5 N•m (22 ±4 lb-ft)
Wiring Harness	
Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)

MP8 ENGINE COMPONENTS — TOP OF ENGINE

Valve (Cylinder Head) Cover

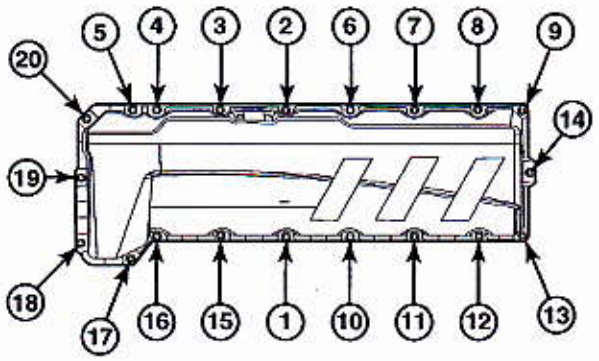

Figure 459 — Valve Cover Torque Sequence

Install two alignment pins and bushings in the head before assembling the valve cover.	
Tighten screws in the order indicated to . . .	24 ±4 N•m (18 ±3 lb-ft)

Camshaft Bearing Caps and Rocker Arm Shaft Assembly

The rocker arm shaft assembly is installed on top of the camshaft bearing caps (inboard side) using the long screws, numbers 8 through 21. The rocker arm shaft and camshaft bearing cap retaining screws are tightened to specification as listed below in the table.

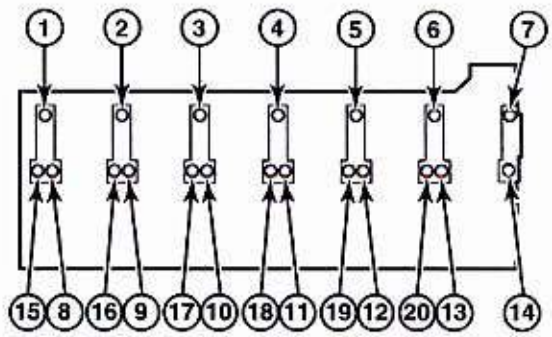

Figure 460 — Camshaft Cap Torque Sequence Screw Numbers

Preliminary steps: • Discard screws with four punch marks when removed and replace with **new** screws. • If not already loose, loosen screws 1–7 before proceeding with the tightening sequence.	
Step 1. Screws 1–7	25 ±3 N•m (18 ±2 lb-ft)
Step 2. Screws 8–14	60 ±5 N•m (44 ±4 lb-ft)
In step 2, tighten the screws progressively beginning with screw No. 11.	
In steps 3–7, tighten the screws progressively from the center to the outer ends.	
Step 3. Screws 1–7, angle tighten	90 ±5°
Step 4. Screws 15–20	25 ±3 N•m (18 ±2 lb-ft)
Step 5. Screws 15–20, angle tighten	120 ±5°
Step 6. Screws 8–13	Loosen completely
Step 7. Screws 8–13	25 ±3 N•m (18 ±2 lb-ft)
Step 8. Screws 8–14, angle tighten	120 ±5°

Cylinder Head

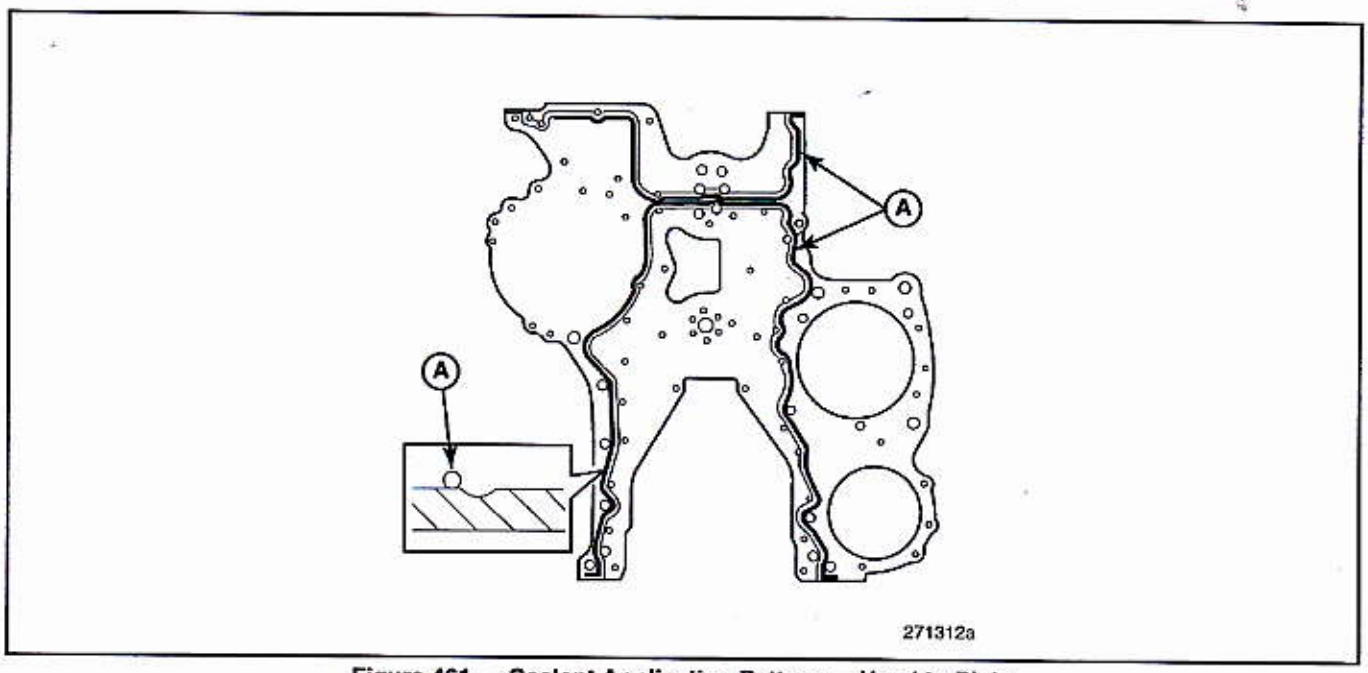

Figure 461 — Sealant Application Pattern — Head to Plate

Remove all old sealant before attempting to apply new sealant.
Apply a 2 mm (0.079 inch) bead of sealant to the timing gear plate following the pattern shown.
Attach the head to the timing gear plate within 20 minutes of applying the sealant.

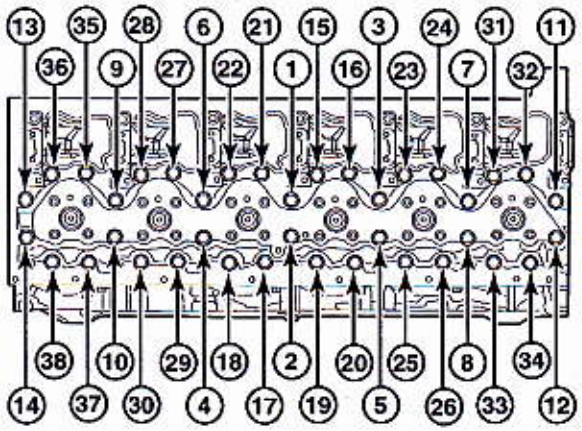

Figure 462 — Torque Sequence Screw Numbers — Head to Block

Discard screws with four marks when removed and substitute new screws. Tighten the screws in the order indicated by the numbers in the graphic.	
Step 1.	100 ±5 N•m (74 ±4 lb-ft)
Step 2. Verify	100 ±5 N•m (74 ±4 lb-ft)
Step 3. Angle tighten	120° ±5°
Step 4. Angle tighten	90° ±5°

Additional Top of Engine Components

Cylinder Head Plugs	
Plug, M10 x 1.00	25 ±3 N•m (18 ±2 lb-ft)
Plug, M10 x 1.00, coated	10 ±2 N•m (7.5 ±1.5 lb-ft)
Plug, M14 x 1.50, coated	30 ±3 N•m (22 ±2 lb-ft)
Plug, M16 x 1.50	50 ±3 N•m (37 ±2 lb-ft)
Cylinder Head Connectors	
Right side, coated	10 N•m (7.5 lb-ft)
Rocker Arm Components	
Locknut, Valve Adjustment (Inlet and Exhaust without Engine Brake)	38 ±4 N•m (28 ±3 lb-ft)
Locknut, Valve Adjustment (Exhaust with Engine Brake)	52 ±4 N•m (38 ±3 lb-ft)
Locknuts, Injector Adjustment	52 ±4 N•m (38 ±3 lb-ft)
Retainer Screw, Shim (Exhaust Yoke)	38 ±4 N•m (28 ±3 lb-ft)
Engine Brake	
Attaching Screws, Solenoid Valve See *Engine Brake Valve* under **Rocker Arm Components**.	24 ±4 N•m (18 ±3 lb-ft)
Engine Brake Plate Spring (PowerLeash™, 4-Rocker)	25 ±3 N•m (18 ±2 lb-ft)
Injector Retainers	
If the copper injector sleeve is new, injector yoke screws must be tightened in five steps. Step 3 requires loosening after steps 1 and 2. If the copper injector sleeve is reused, only steps 4 and 5 below apply.	
Step 1.	20 +5/–0 N•m (15 +4/–0 lb-ft)
Step 2. Angle tighten	180° ±5°
Step 3. Loosen the screws until the torque is 10–15 N•m (7–11 lb-ft).	
Step 4.	20 +5/–0 N•m (15 +4/–0 lb-ft)
Step 5. Angle tighten • With raised-bead design copper sleeve (no injector gasket) • With flat-bottom design copper sleeve and injector gasket	 60° ±5° 90° ±5°

MP8 ENGINE COMPONENTS — FRONT OF ENGINE

Crankshaft Damper

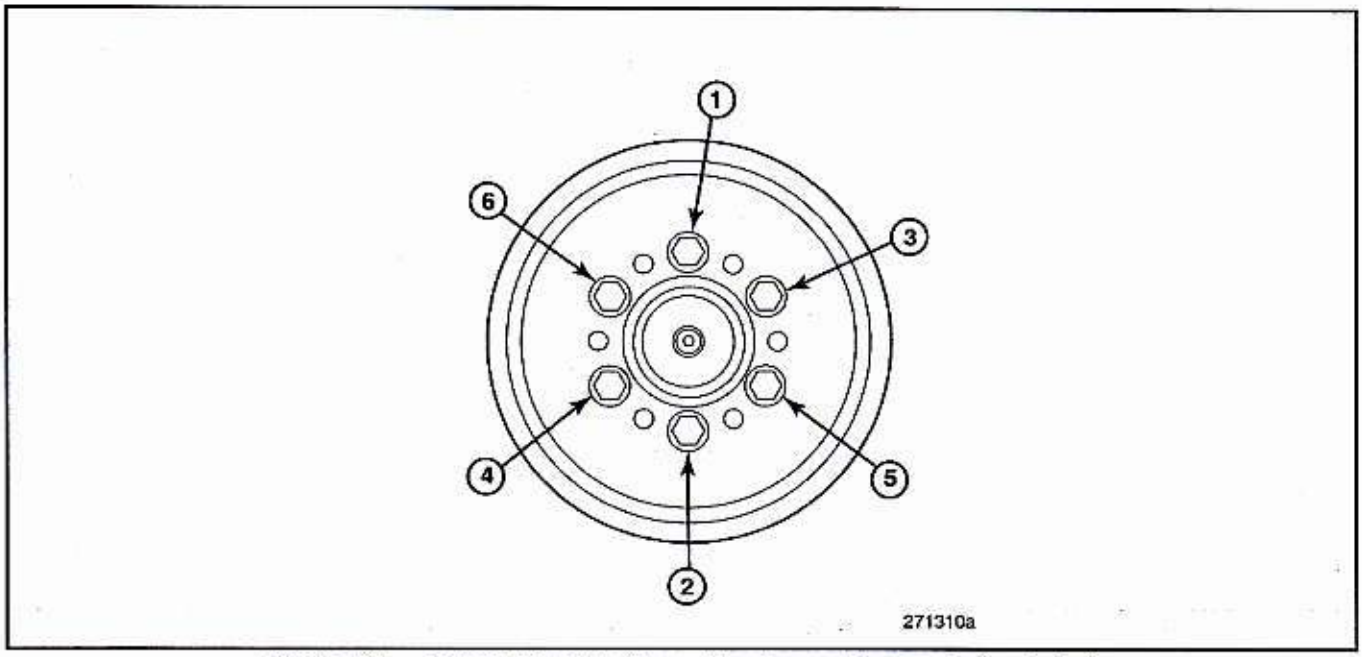

Figure 463 — Torque Sequence Screw Numbers — Damper to Crankshaft

Do **NOT** reuse screws. Use **new** screws in service and tighten in the order indicated.	
Step 1.	35 ±5 N•m (26 ±4 lb-ft)
Step 2.	90 ±10 N•m (66 ±7 lb-ft)

Crankshaft Front Seal Cover

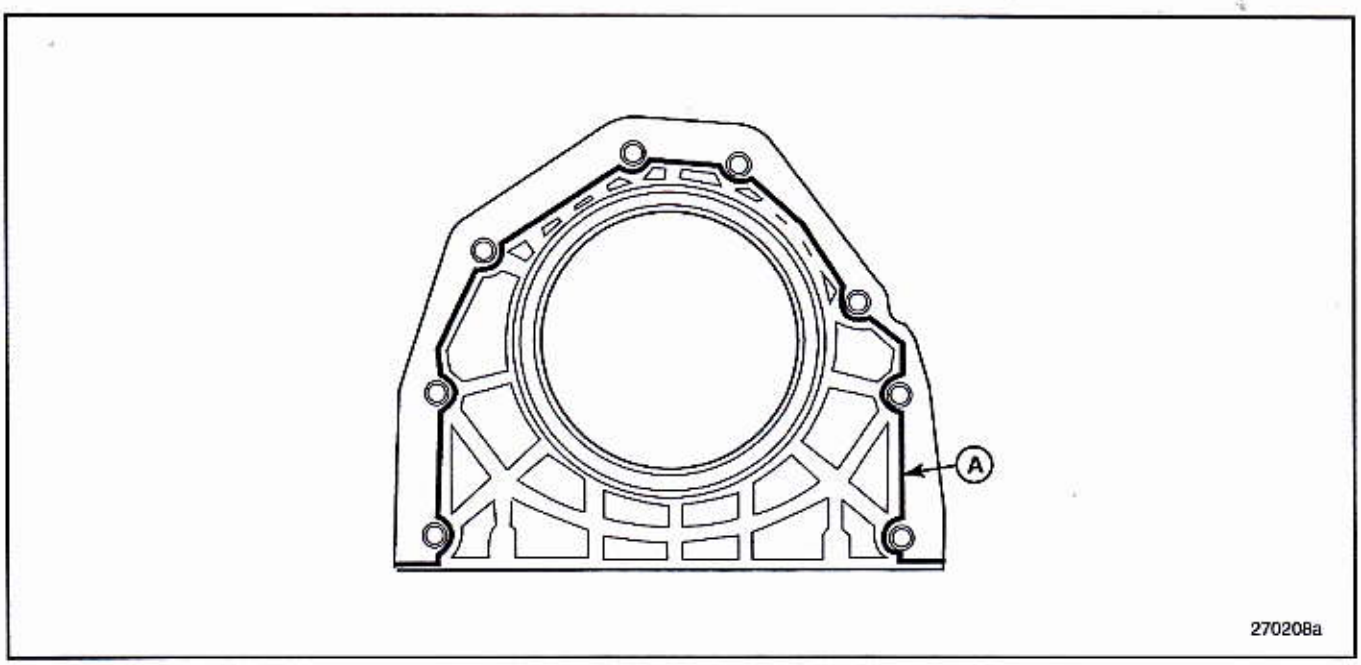

Figure 464 — Sealant Application Pattern — Cover to Block

Remove all old sealant before attempting to apply new sealant. Apply a 2 mm (5/64 inch) bead of 3092340 sealant to the seal cover following the pattern (A) shown. Attach the cover to the cylinder block within 20 minutes of applying the sealant.

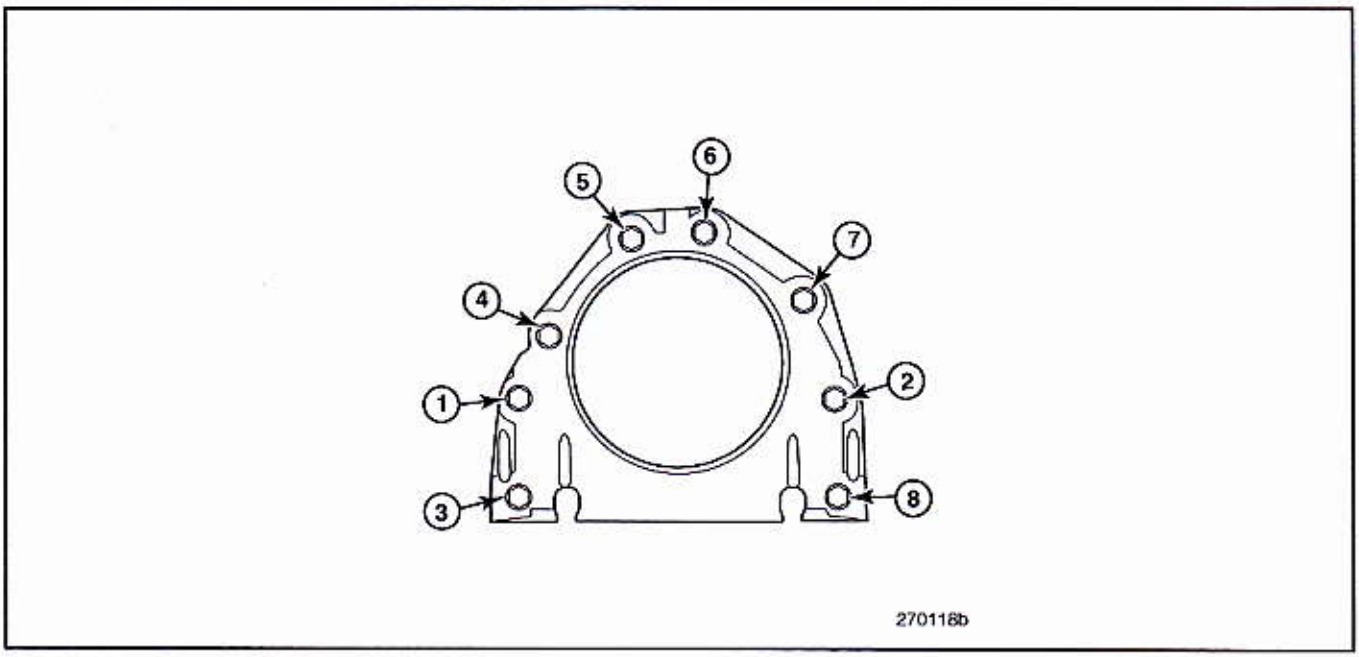

Figure 465 — Torque Sequence Screw Numbers — Cover to Block

Tighten screws in the order indicated according to the following torque specifications.	
Step 1. Secure cover with screws 1 and 2	Hand tighten
Step 2. Screws 1–8	24 ±4 N•m (18 ±3 lb-ft)

Front Engine Support

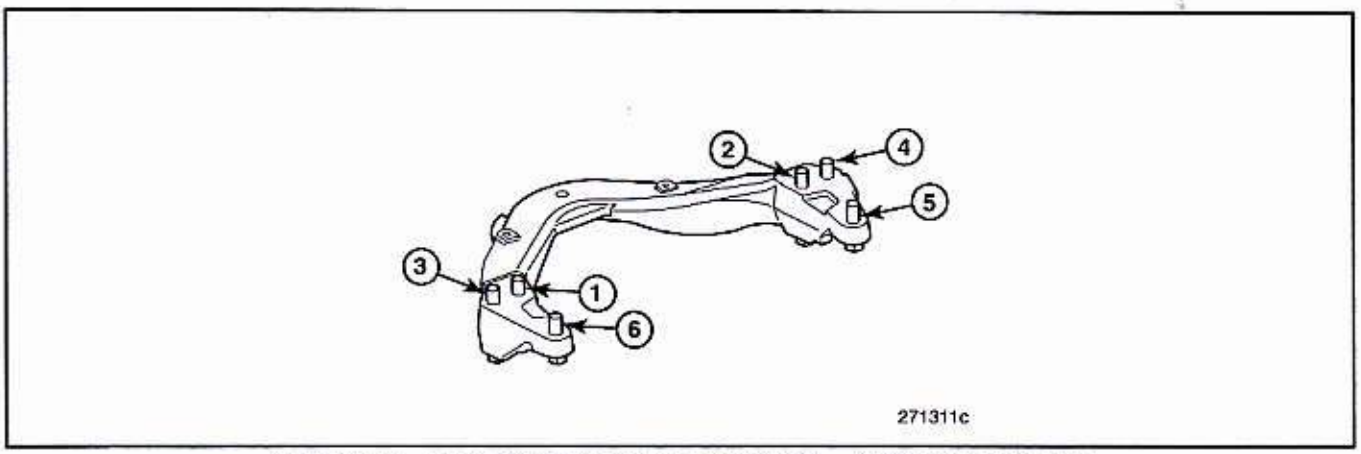

Figure 466 — Torque Sequence Screw Numbers — Support to Brackets

Step 1. Tighten in order: 1, 2, 3, 4, 5 and 6	275 ±45 N•m (203 ±33 lb-ft)
Step 2. Verify in the same order	275 ±45 N•m (203 ±33 lb-ft)

Front Engine Support Mounting Brackets

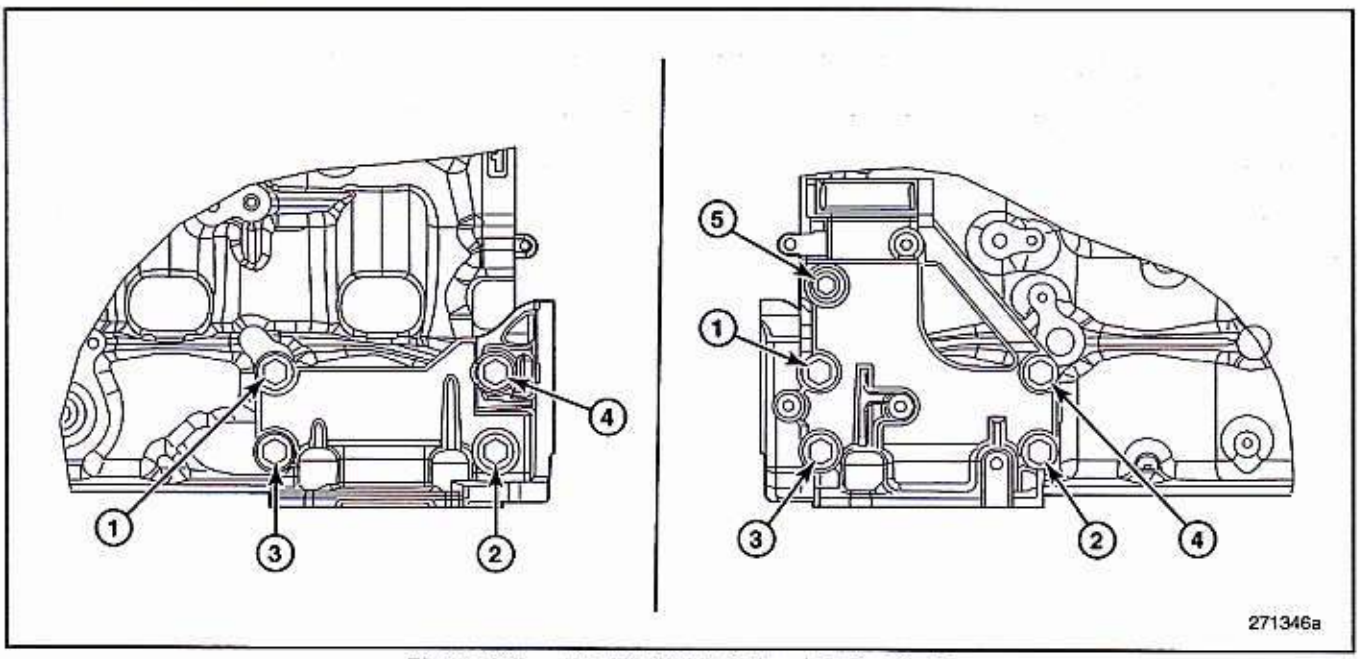

Figure 467 — Engine Support Brackets to Block

Sequence	Torque	Angle Tighten
Step 1. Screw No. 1	80 ±15 N•m (59 ±11 lb-ft)	—
Step 2. Screws No. 2, 3 and 4	105 ±15 N•m (77 ±11 lb-ft)	60 ±5°
Step 3. Screw No. 1	105 ±15 N•m (77 ±11 lb-ft)	60 ±5°
Step 4. Screw No. 5	Standard screw torque	—

Additional Front of Engine Components

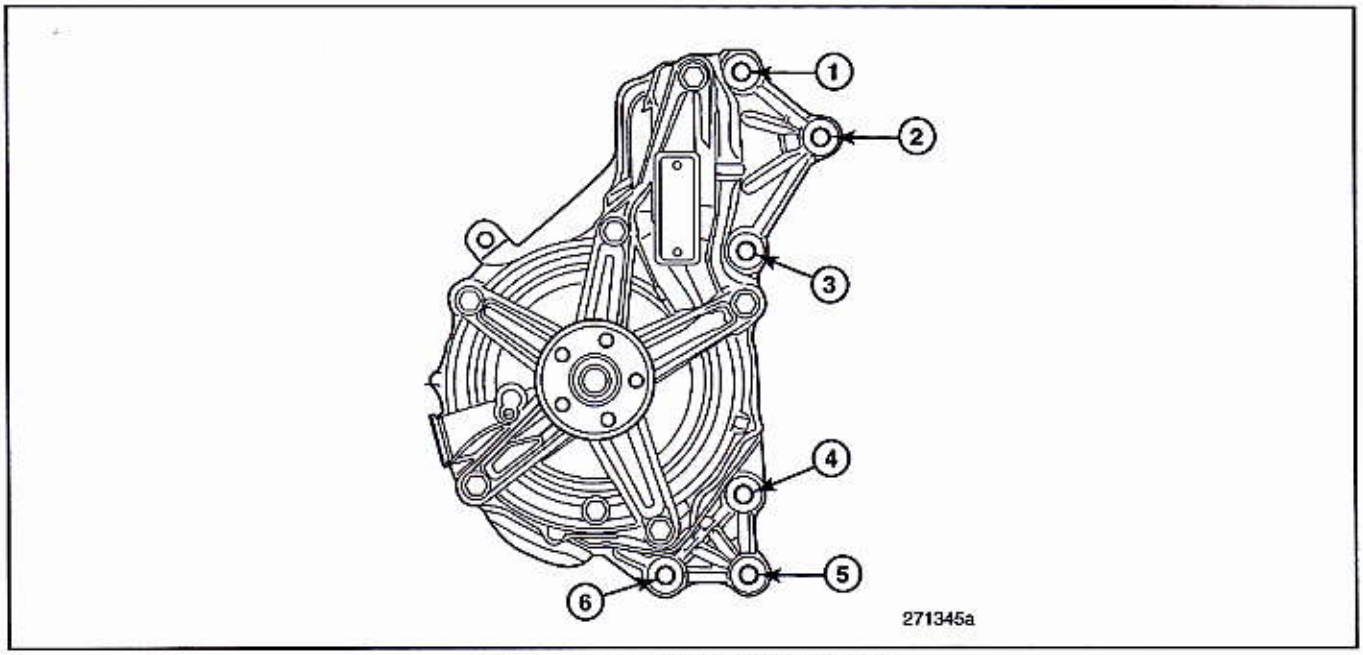

Figure 468 — Coolant Pump Housing

Coolant Pump Housing	
Step 1. Tighten all 6 screws in the following sequence: 2, 5, 6, 4, 3, 1.	48 ±8 N•m (35 ±6 lb-ft)
Step 2. Retighten screws 2 and 5.	48 ±8 N•m (35 ±6 lb-ft)
Viscous Fan Drive	
Attaching Nuts, Drive to Hub	24 ±4 N•m (18 ±3 lb-ft)
Attaching Nuts, Hub to Cylinder Head and Block	48 ±8 N•m (35 ±6 lb-ft)

MP8 ENGINE COMPONENTS — REAR OF ENGINE

Timing Gear Train Plate

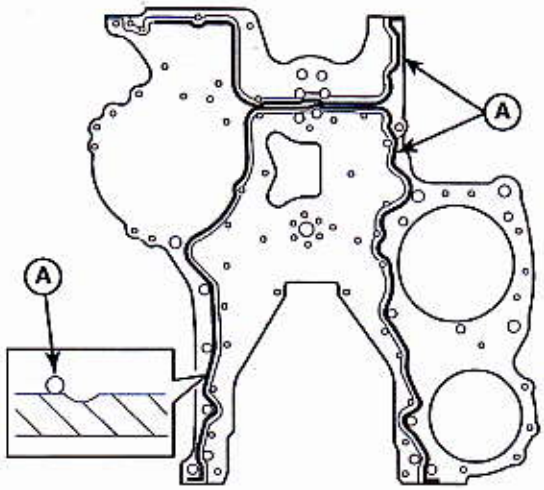

Figure 469 — Sealant Application Patterns — Head and Block to Plate

Remove all old sealant before attempting to apply new sealant. Apply a 2 mm (0.079 inch) bead of sealant to the timing gear plate next to the groove following the patterns shown. Attach the timing gear plate to the head and block within 20 minutes of applying the sealant.

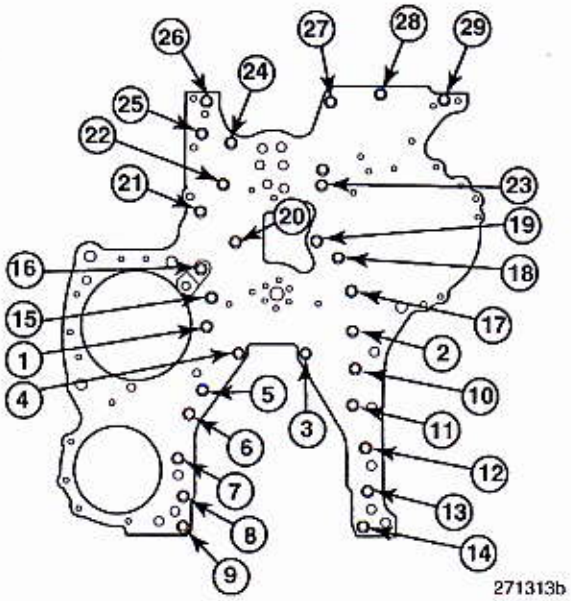

Figure 470 — Torque Sequence — Plate to Cylinder Block and Cylinder Head

Do not reuse mounting plate screws. Do NOT apply sealant to new, coated screws.	
Tighten screws in the order indicated.	28 ±4 N•m (21 ±3 lb-ft)

Timing Gears

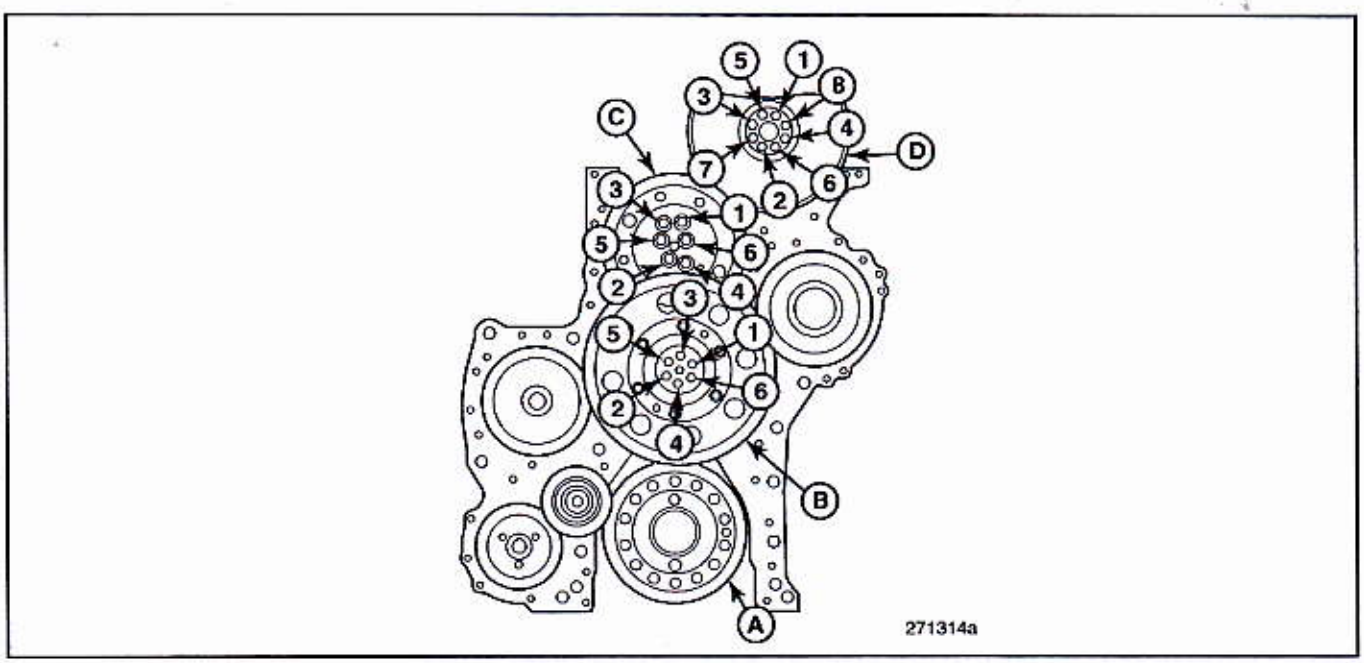

Figure 471 — Torque Sequence Screw Numbers — Gear Mounting

Component	Torque	Plus Angle Tighten
Loosen any screws used to pull the cylinder head into position before beginning this sequence. Tighten screws in the order indicated on each gear.		
(A) Crankshaft Gear (2 screws)	24 ±4 N•m (18 ±3 lb-ft)	
(B) Intermediate Gear Hub (6 screws)	25 ±3 N•m (18 ±2 lb-ft)	110° ±5°
(C) Intermediate Adjustable Gear Hub (5 screws)	35 ±4 N•m (26 ±3 lb-ft)	120° ±5°
(D) Camshaft Gear and Damper (6 screws)	45 ±5 N•m (33 ±4 lb-ft)	90° ±5°

Timing Gear Cover

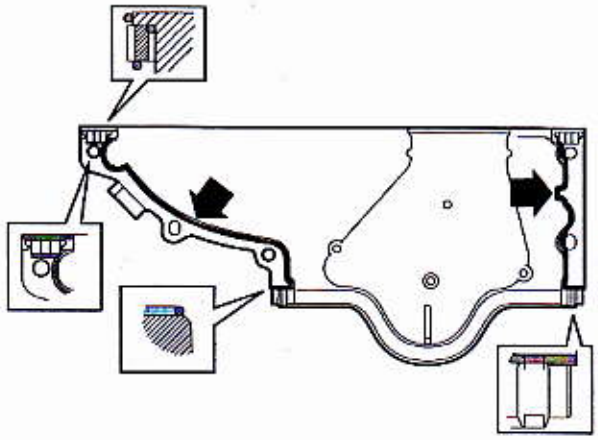

Figure 472 — Sealant Application Pattern — Cover to Plate

Remove all old sealant before attempting to apply new sealant. Apply a 2 mm (0.079 inch) bead of sealant to the timing gear cover following the pattern shown. Attach the cover to the timing gear plate within 20 minutes of applying the sealant.

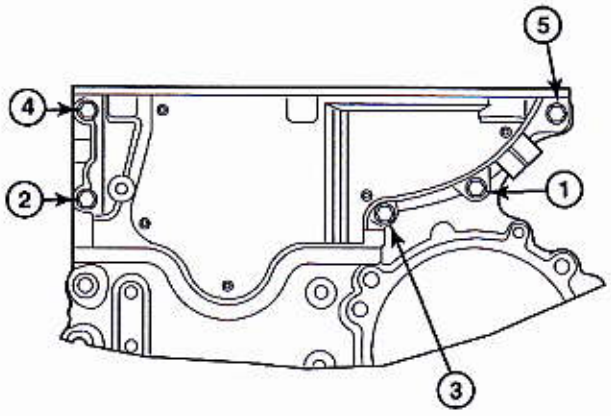

Figure 473 — Torque Sequence Screw Numbers — Cover to Plate

Step 1. Align cover to cylinder head so that sealing surfaces are flush and install screws 1 and 2. Hand tighten screws 1 and 2 to hold alignment.	
Step 2. Tighten screws in the order indicated.	24 ±4 N•m (18 ±3 lb-ft)

Flywheel

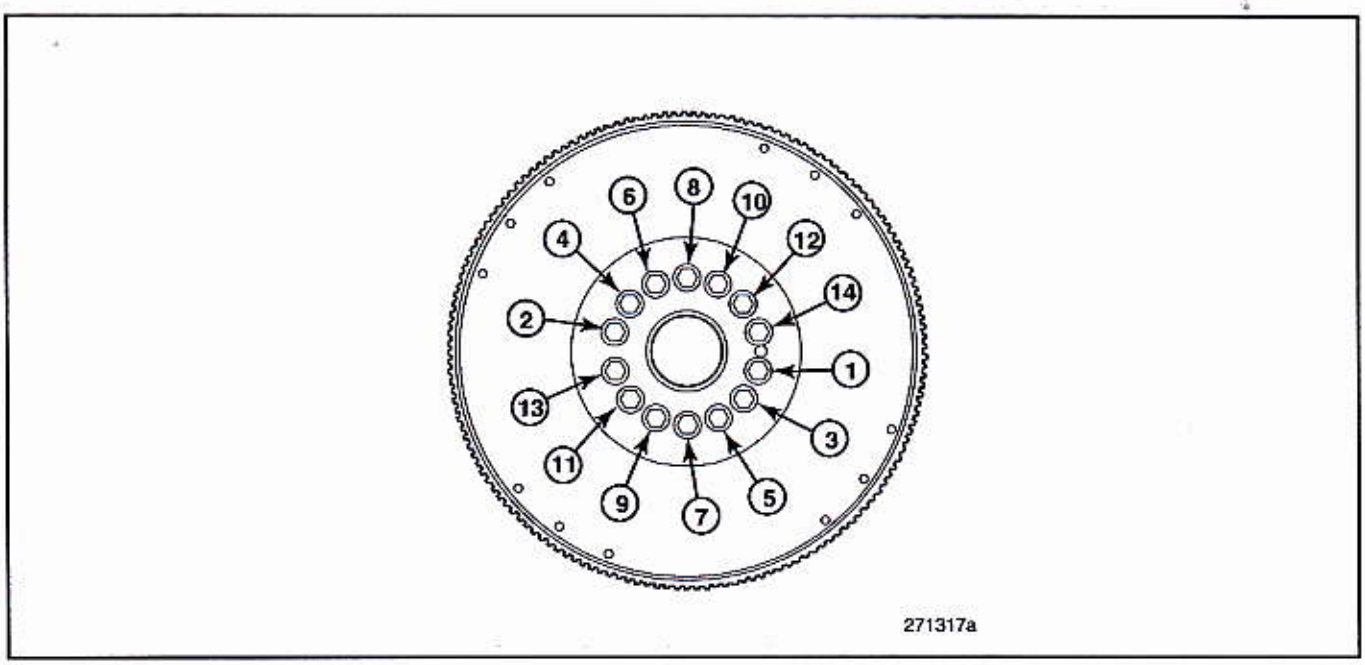

Figure 474 — Torque Sequence Numbers — Flywheel to Crankshaft

Mark the head of each screw after installation. Discard screws with four marks when removed and substitute **new** screws. Lubricate the threads and under the heads of screws to be reused. Do NOT lubricate new screws that are coated.	
Step 1. Tighten screws in the order indicated.	60 ±5 N•m (44 ±4 lb-ft)
Step 2. In the order indicated: angle tighten.	120° ±10°

Flywheel Housing

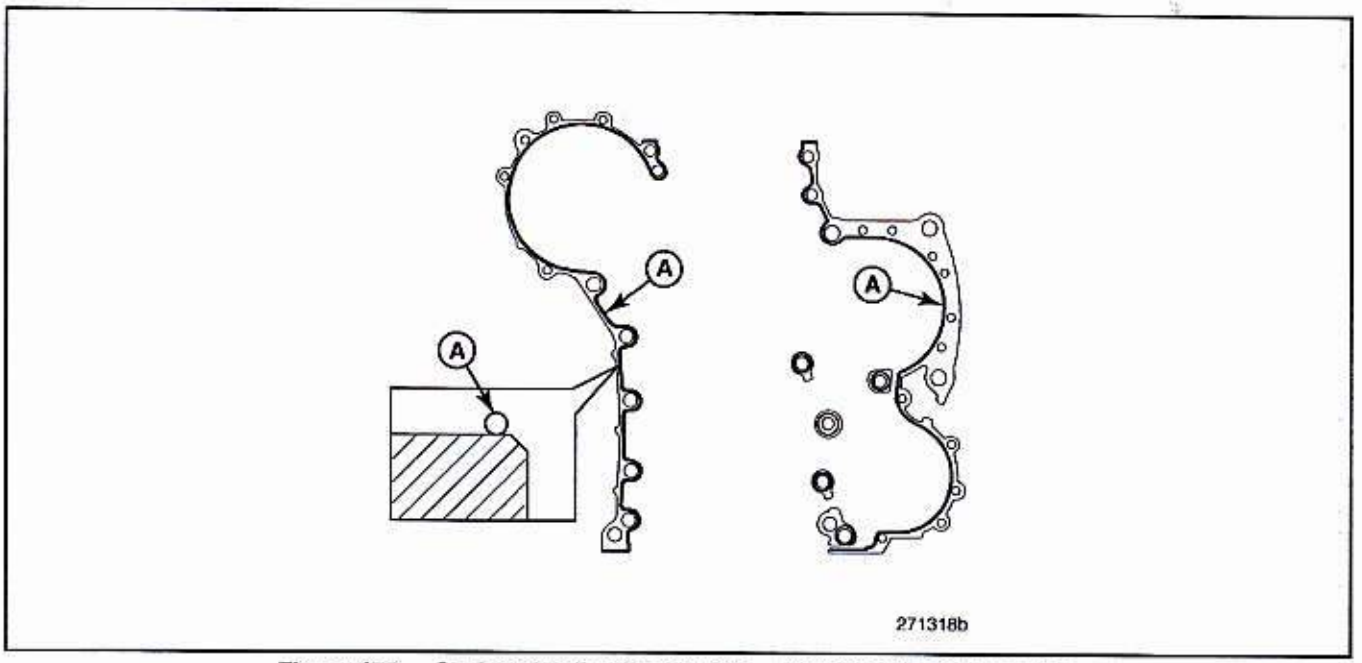

Figure 475 — Sealant Application Pattern — Flywheel Housing to Plate

Remove all old sealant before attempting to apply new sealant.
Apply a 2 mm (5/64 inch) bead of 3092340 sealant to the flywheel housing following the pattern shown.
Attach the housing to the timing gear mounting plate within 20 minutes of applying the sealant.

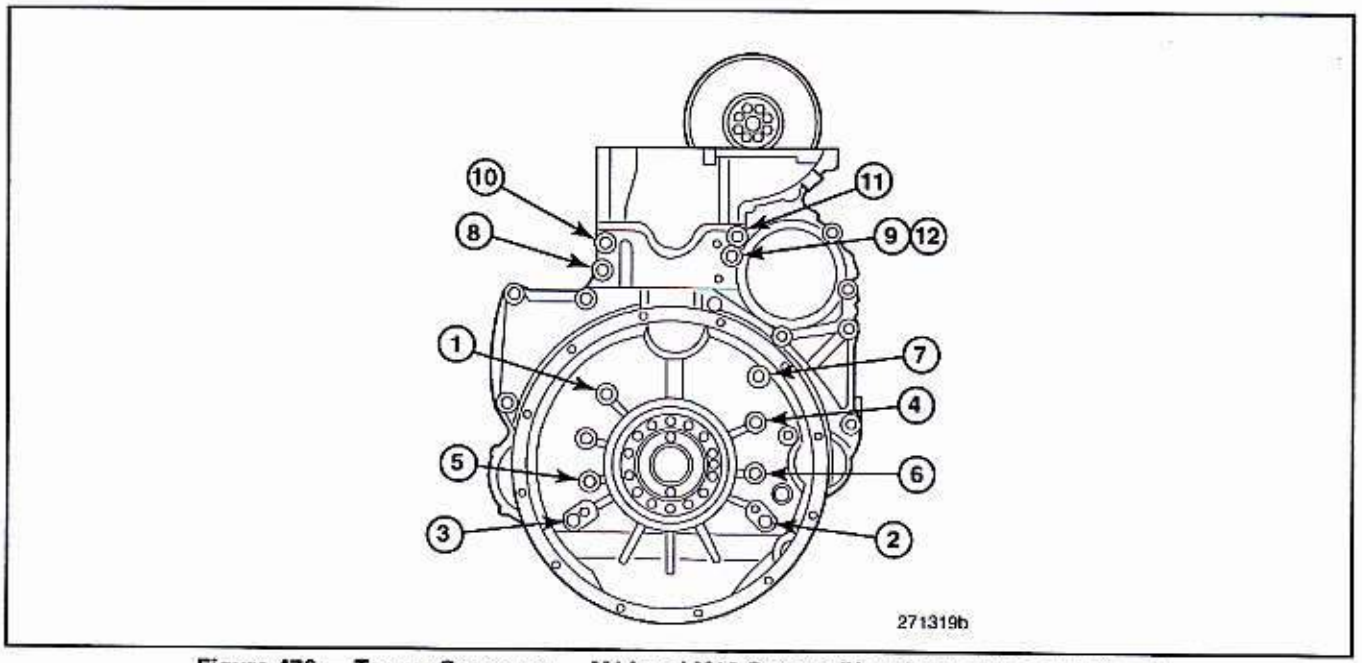

Figure 476 — Torque Sequence — M14 and M10 Screws (Housing to Plate and Block)

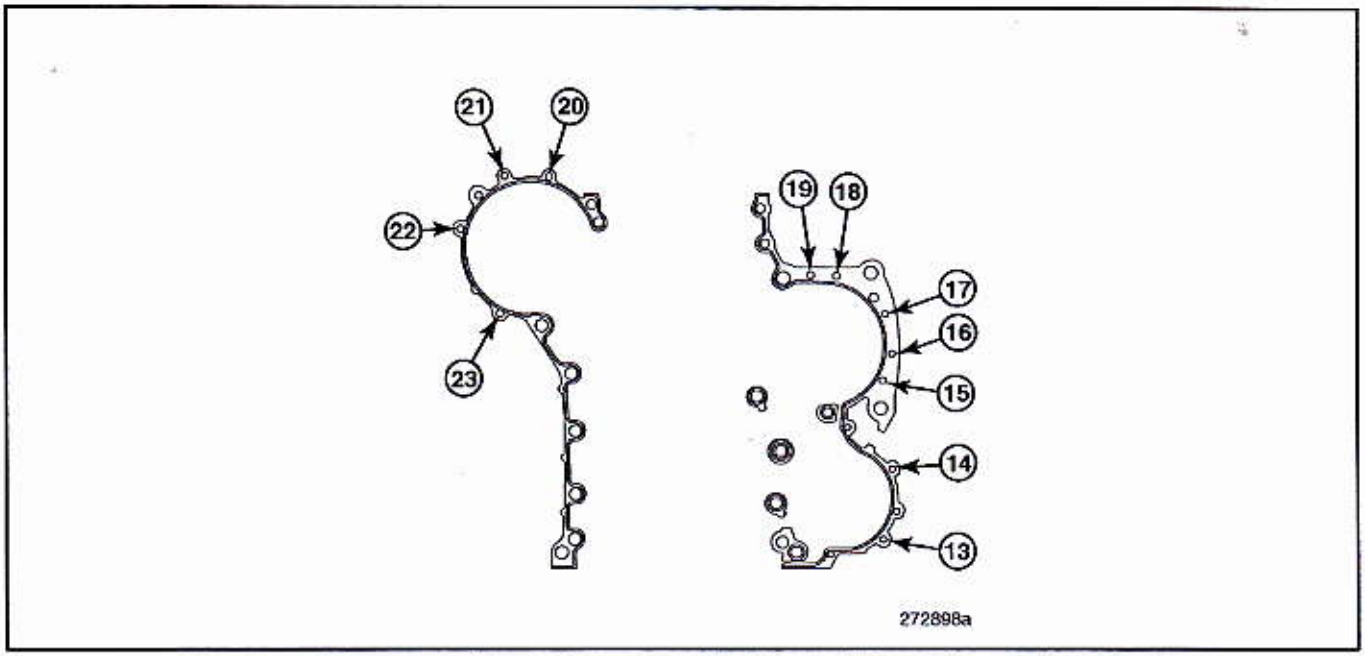

Figure 477 — Torque Sequence — M8 Screws (Plate to Housing)

Tighten the screws in the order indicated according to the following torque values.	
Step 1. M14, M10 and M8 screws	24 ±4 N•m (18 ±3 lb-ft)
Step 2. M14 screws, 1–8	140 ±20 N•m (103 ±15 lb-ft)
Step 3. M10 screws, 9–12	48 ±8 N•m (35 ±6 lb-ft)
Step 4. M8 screws, 13–23 (front of timing gear plate-to-flywheel housing)	24 ±4 N•m (18 ±3 lb-ft)

Additional Rear of Engine Components

Attaching Screws, Rear Engine Support Bracket to Flywheel Housing	300 ±45 N•m (221 ±33 lb-ft)

MP8 ENGINE COMPONENTS — BOTTOM OF ENGINE

Oil Pan

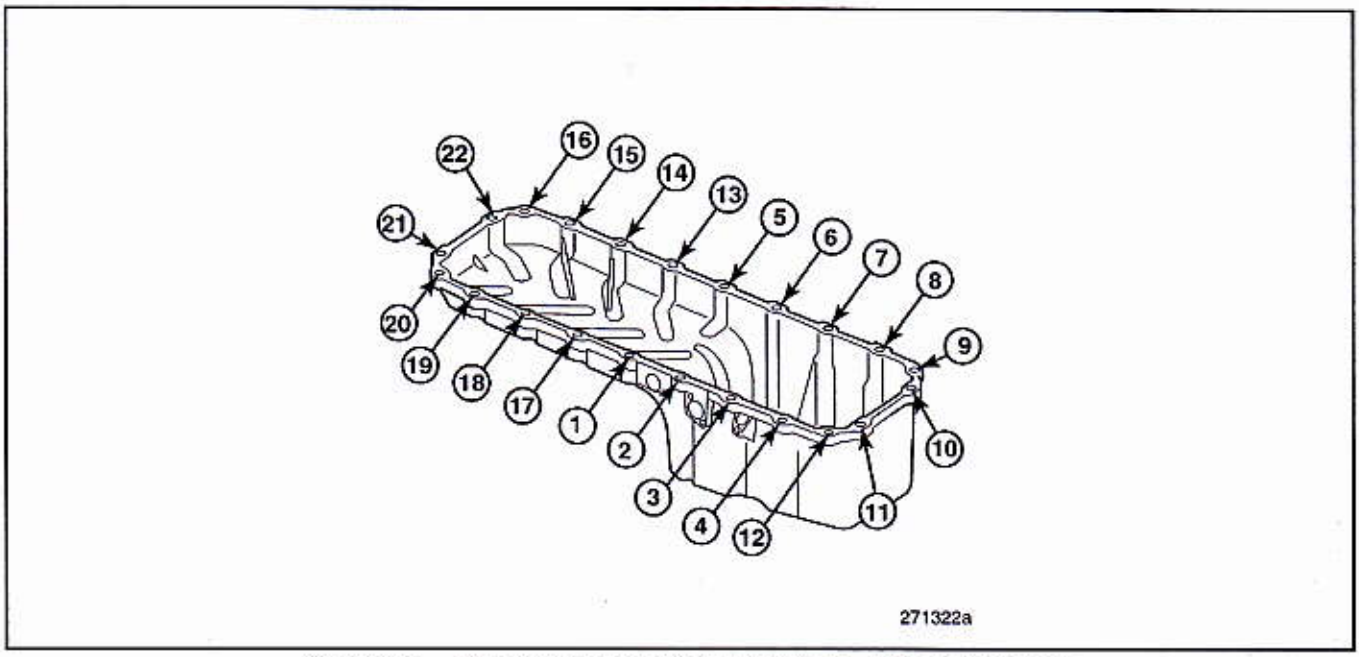

Figure 478 — Torque Sequence Screw Numbers — Oil Pan to Block

Tighten screws in the order indicated to . . .	24 ±4 N•m (18 ±3 lb-ft)

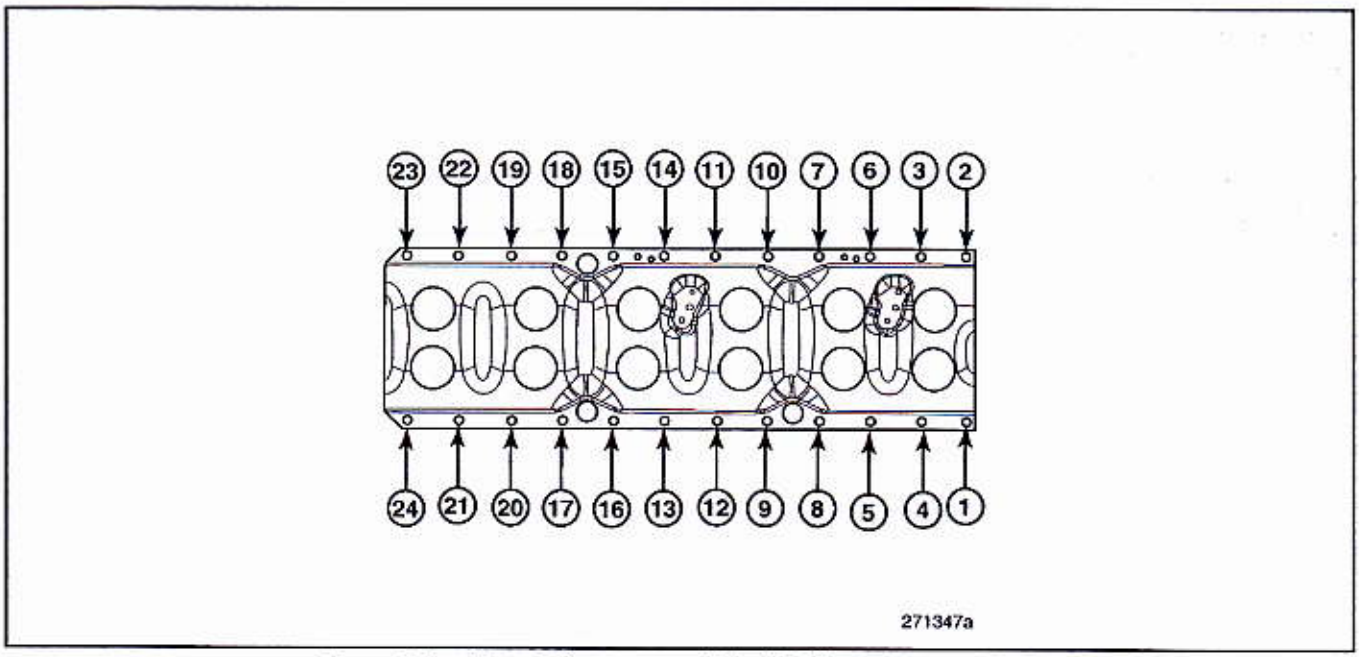

Figure 479 — Torque Sequence — Block Stiffener Plate to Block

Do NOT reuse stiffener plate attaching screws. Always use **new** screws in service. Tighten the screws in the order indicated according to the following torque specifications.	
Step 1. All screws	45 ±5 N•m (33 ±4 lb-ft)
Step 2. Angle tighten	60 ±5°

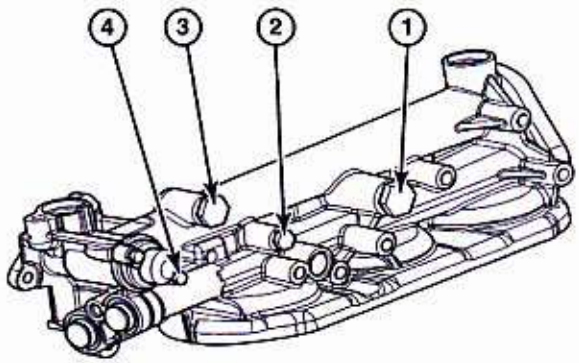

Figure 480 — Oil Filter Support Assembly

Filter Support Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)
Oil Filter	25 +5/–0 N•m (18 +3.5/–0 lb-ft)
1. Plug	55 ±5 N•m (40 ±4 lb-ft)
2. Plug	12 ±2 N•m (9 ±1.5 lb-ft)
3. Plug	55 ±5 N•m (40 ±4 lb-ft)
4. M6 Screws	10 ±2 N•m (7 ±1.5 lb-ft)

Additional Bottom of Engine Components

Lube Valve Housing	
Attaching Screws (4)	Hand start all, then tighten to 48 ±8 N•m (35 ±6 lb-ft).
Crankshaft Bearing Caps	
Discard screws with four marks when removed and substitute new screws.	
Attaching Screws Step 1.	150 ±20 N•m (111 ±15 lb-ft)
Step 2. Angle tighten	120° ±5°
Connecting Rod Bearing Caps	
Discard screws with four marks when removed and substitute new screws. Tighten screws in a cross pattern.	
Attaching Screws Step 1.	20 ±3 N•m (15 ±2 lb-ft)
Step 2.	60 ±3 N•m (44 ±2 lb-ft)
Step 3. Angle tighten	90 ±5°
Oil Pan Drain Plug	60 ±10 N•m (44 ±7 lb-ft)
Oil Pump Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)
Nozzle Attaching Screws, Piston Cooling Do not reuse.	24 ±4 N•m (18 ±3 lb-ft)

MP8 ENGINE COMPONENTS — RIGHT SIDE

Exhaust Manifold

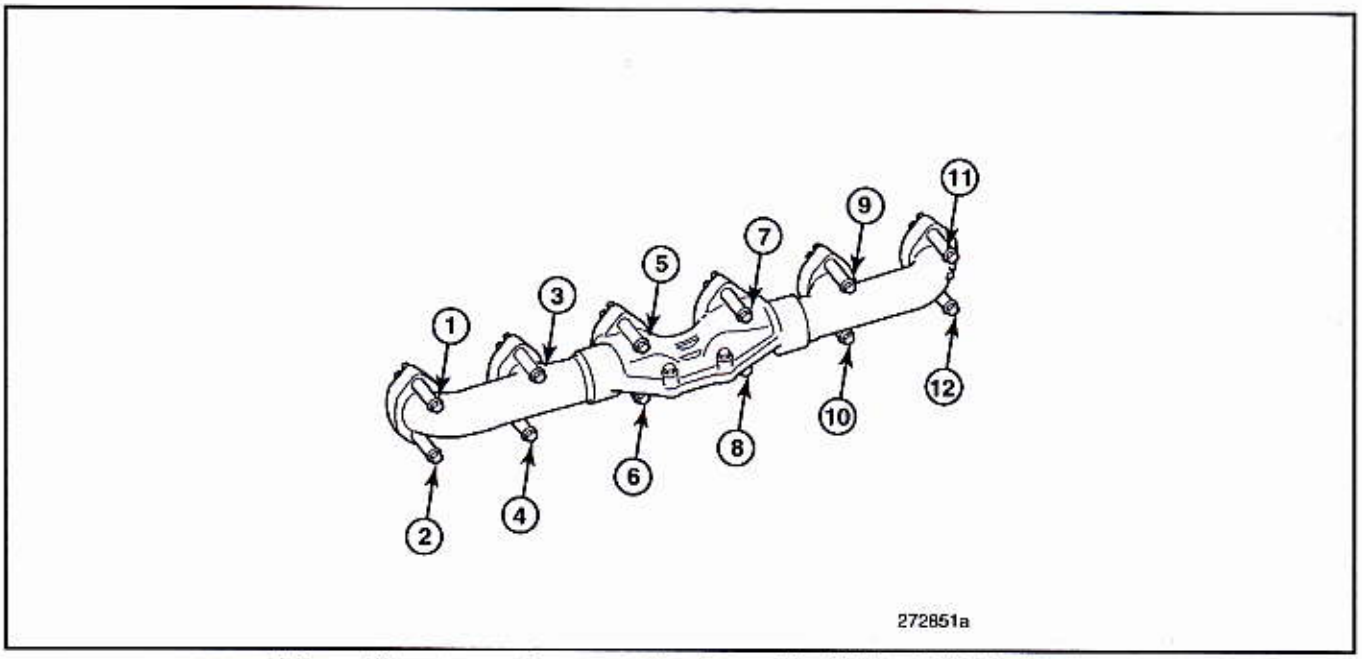

Figure 481 — Torque Sequence Numbers — Manifold to Cylinder Head

Use anti-seize compound on contact surfaces of nuts, bolts and screws when reassembling exhaust system components.	
Step 1. All screws	5 ±1.5 N•m (3.5 ±1 lb-ft)
Step 2. Screws 1, 4, 5, 8, 9 and 12	10 ±1.5 N•m (7.5 ±1 lb-ft)
Step 3. Screws 3, 2, 7, 6, 11, 10, 1, 4, 5, 8, 9 and 12	48 ±8 N•m (35 ±6 lb-ft)

Oil Cooler Cooling Duct Cover

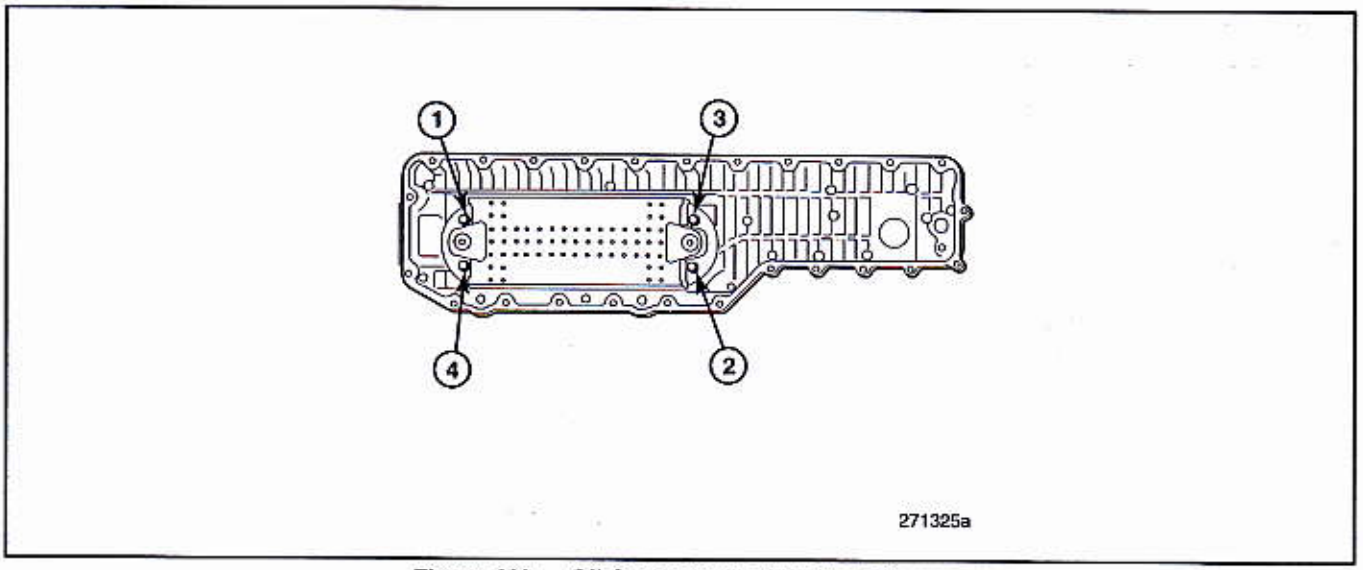

Figure 482 — Oil Cooler to Cooling Duct Cover

Step 1. Screws 1, 2, 3 and 4	5 ±1 N•m (44 ±9 lb-in)
Step 2. Screws 1, 2, 3, 4 and 1	27 ±4 N•m (20 ±3 lb-ft)

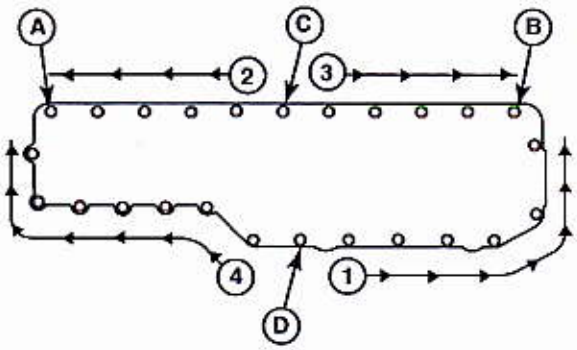

Figure 483 — Torque Sequence Numbers — Cooling Duct Cover to Block

Place the cover in position on the cylinder block and loosely install screw **A**. Press the cover against the coolant pump housing using the assembly tool 88800022 and loosely install screw **B**. Check that the duct cover is properly positioned and install the screws following the step sequence listed below.	
Step 1. Screws C and D	24 ±4 N•m (18 ±3 lb-ft)
Step 2. Starting at the center and moving outward — all screws in sequence 1, followed by sequences 2 (including A), 3 (including B) and 4.	24 ±4 N•m (18 ±3 lb-ft)
Step 3. Verify screws C and D.	24 ±4 N•m (18 ±3 lb-ft)

Turbocharger

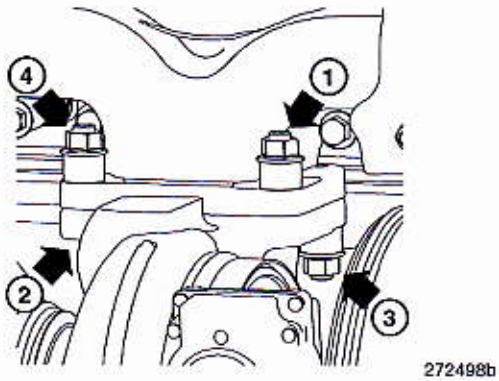

Figure 484 — Torque Sequence — Turbocharger Mounting Fasteners

Fasteners, Turbocharger to Exhaust Manifold (use anti-seize compound at reassembly)	
Step 1.	20 ±4 N•m (15 ±3 lb-ft)
Step 2.	48 ±8 N•m (35 ±6 lb-ft)

Turbocharger Lubrication Fittings

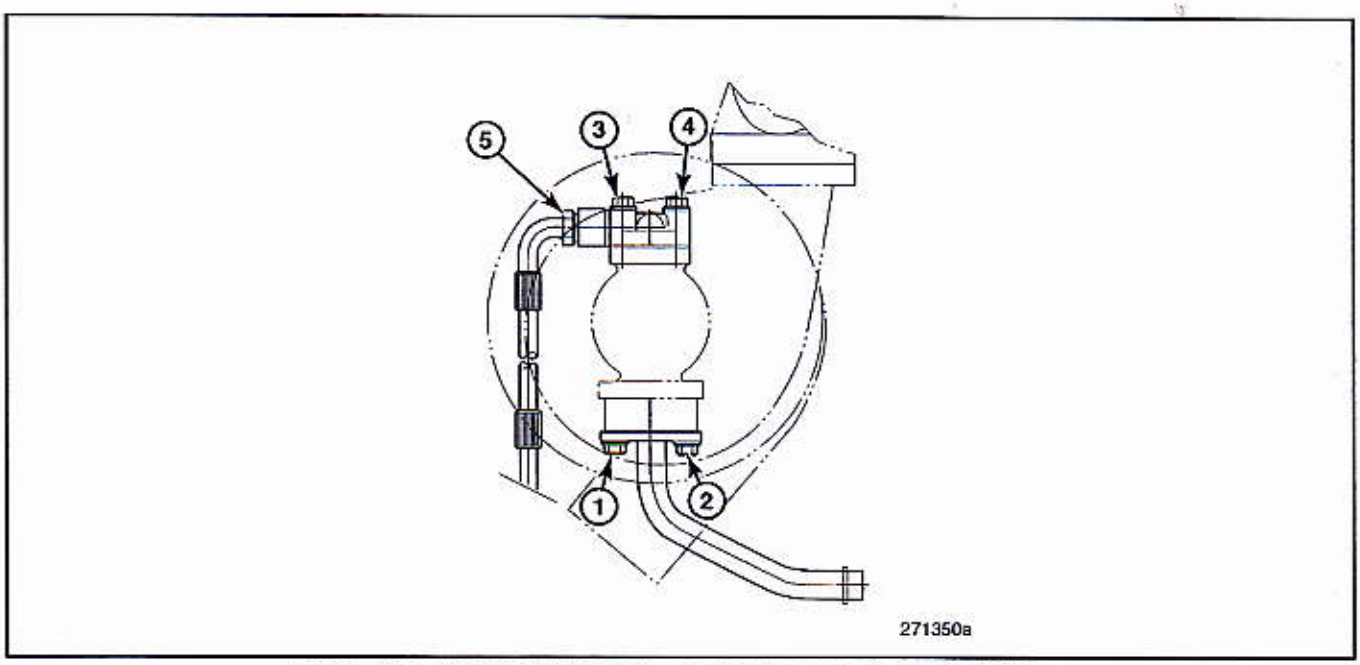

Figure 485 — Torque Sequence — Turbocharger Lubrication Fittings

Step 1. Screws 1 and 3	12 N•m (9 lb-ft)
Step 2. Screws 2, 4, 1 and 3	24 ±2.4 N•m (18 ±1.8 lb-ft)
Connector 5	30 ±5 N•m (22 ±4 lb-ft)

Oil Pressure Safety Valve

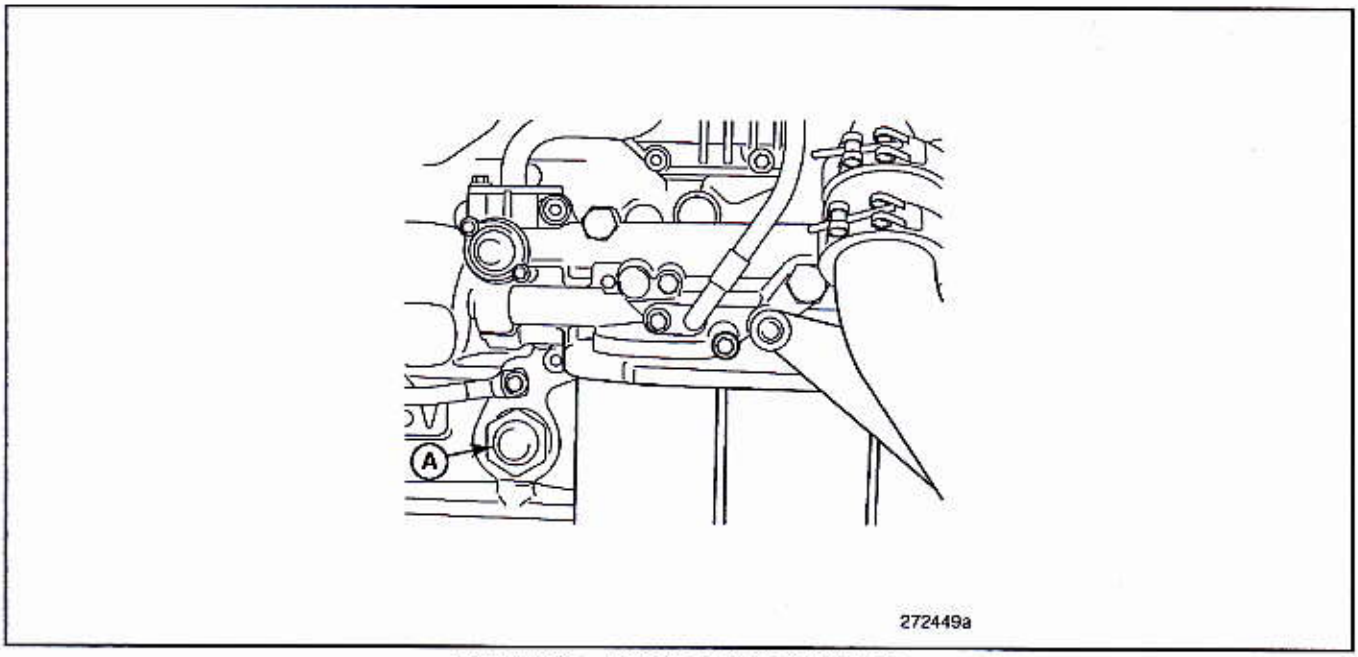

Figure 486 — Oil Pressure Safety Valve

Screws **A**	50 ±5 N•m (37 ±3 lb-ft)

Starter

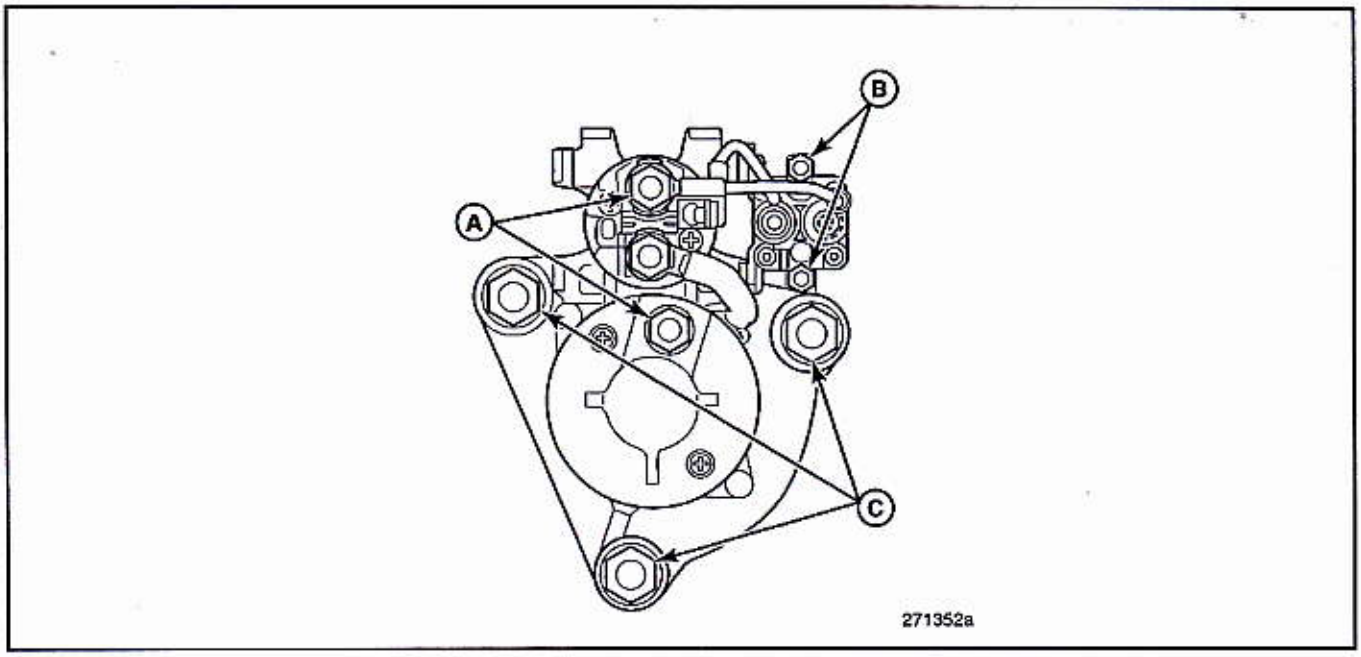

Figure 487 — Starter Attaching Studs

Attaching Studs	24 ±4 N•m (18 ±3 lb-ft)
Screws **A**	18 ±2 N•m (13 ±1.5 lb-ft)
Screws **B**	3 ±0.5 N•m (27 ±4.4 **lb-in**)
Screws **C**	60 ±6 N•m (44 ±4 lb-ft)

Additional Right-Side Engine Components

Oil Filter	
Bracket Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)
Oil Cooler Cooling Duct Cover	
Plug, Oil Cooler Cooling Duct Cover	55 ±8 N•m (40 ±6 lb-ft)
Water Drain Connector	40 ±4 N•m (30 ±3 lb-ft)
Fitting, 90° Elbow	30 ±5 N•m (22 ±4 lb-ft)

MP8 ENGINE COMPONENTS — LEFT SIDE

Inlet Manifold

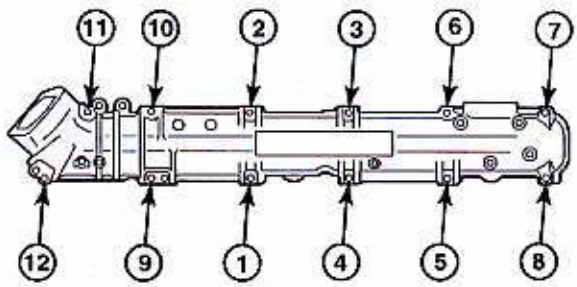

Figure 488 — Torque Sequence — Manifold to Cylinder Head

Tighten screws in the order indicated.	24 ±4 N•m (18 ±3 lb-ft)

Inlet Air Heater

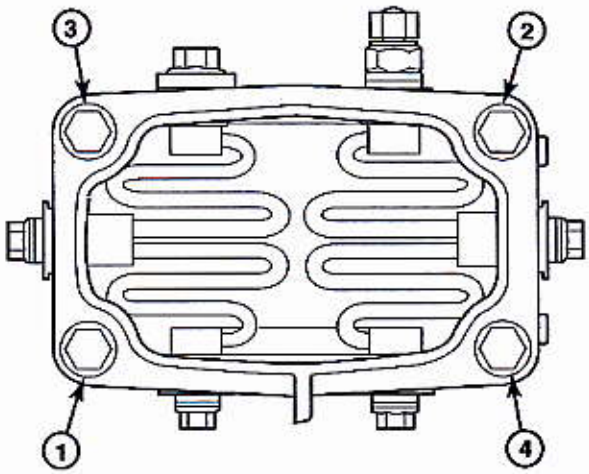

Figure 489 — Torque Sequence Screw Numbers — Inlet Air Heater

Tighten screws in the order indicated.	
Step 1.	10 ±2 N•m (7 ±1.5 lb-ft)
Step 2.	24 ±3 N•m (18 ±2 lb-ft)

Low Pressure Fuel Circuit

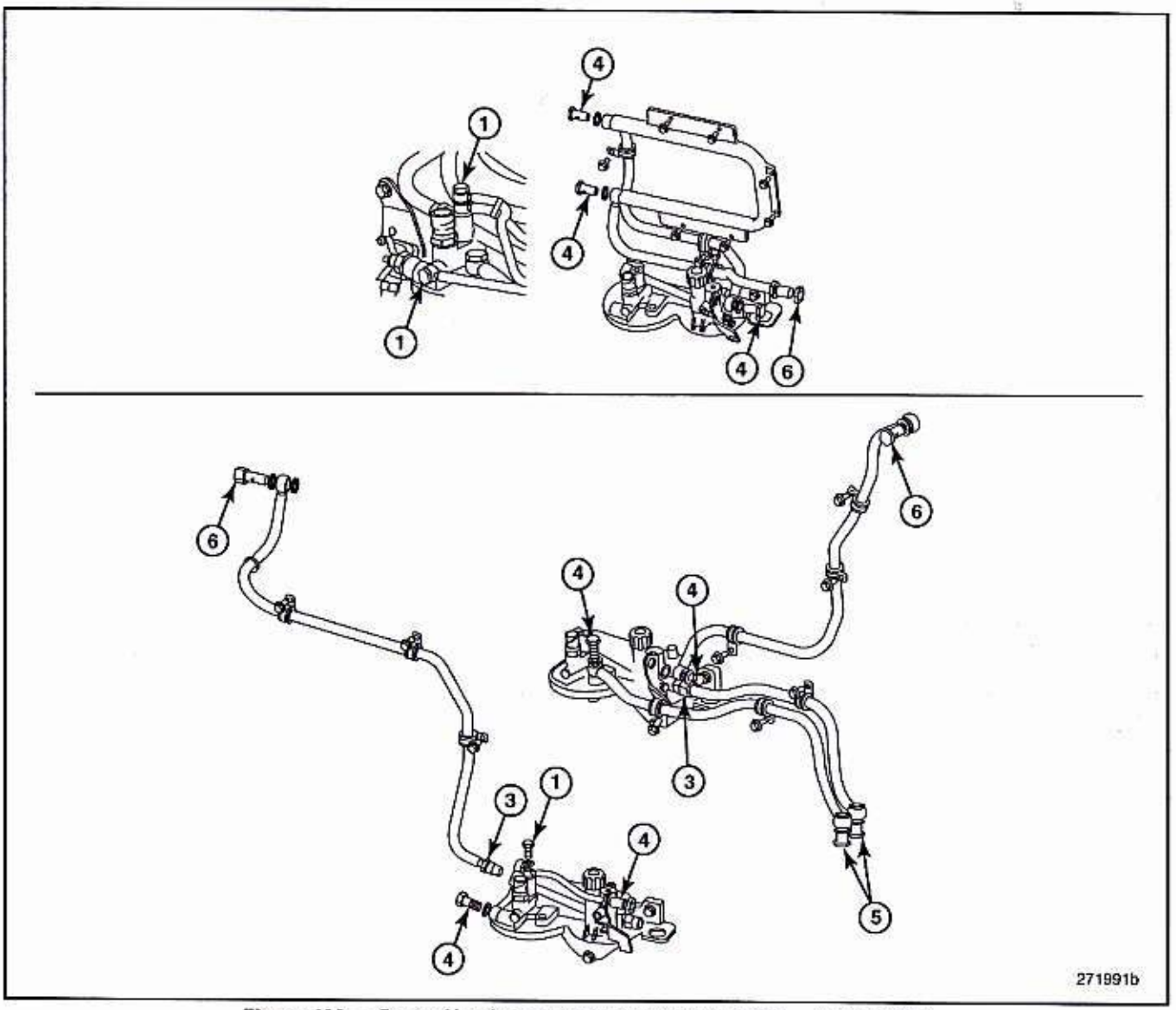

Figure 490 — Screw Number Identification for Torquing — Fuel Circuit

Filter Bracket Attaching Screws, M8 x 1.25	24 ±4 N•m (18 ±3 lb-ft)
No. 1	18 ±3 N•m (13 ±2 lb-ft)
No. 3	30 ±4 N•m (22 ±3 lb-ft)
No. 4	35 ±5 N•m (26 ±4 lb-ft)
No. 5	40 ±5 N•m (29.5 ±4 lb-ft)
No. 6	48 ±5 N•m (35 ±4 lb-ft)

Fuel Filter Support

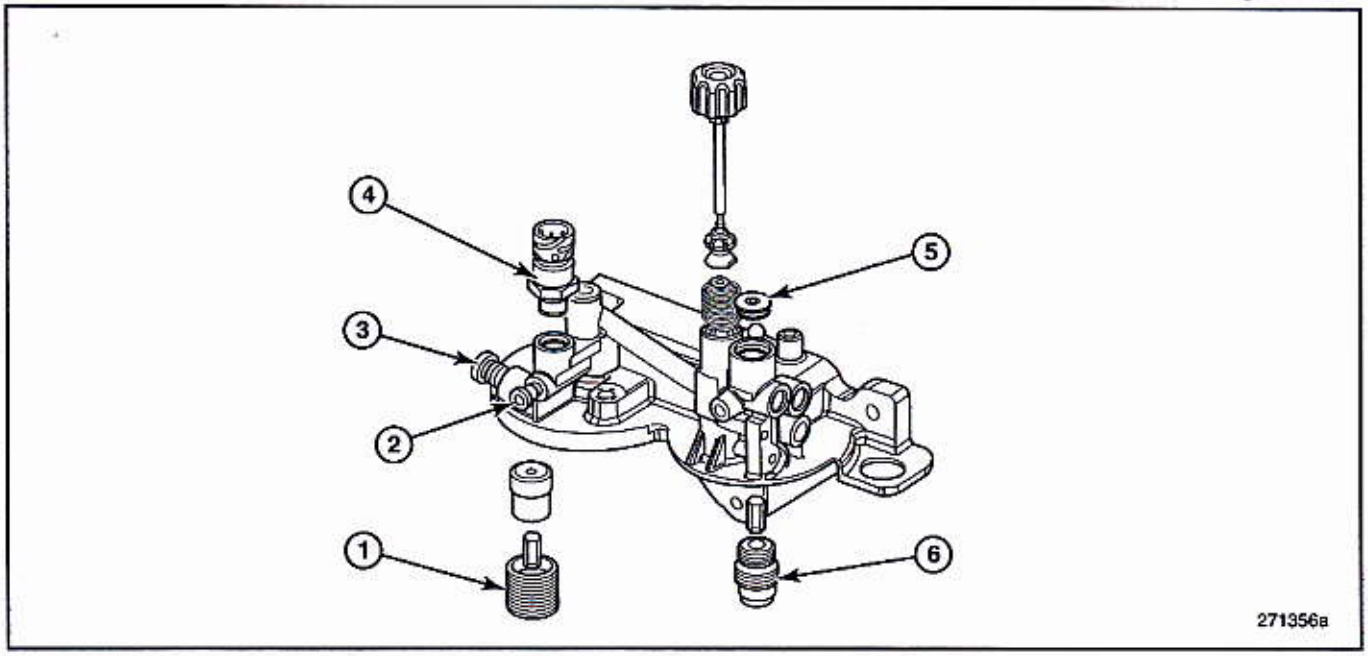

Figure 491 — Fuel Filter Support — Plugs and Valves

Tighten the plugs and valves according to the following specifications.	
No. 1, 40 ±5 N•m (30 ±4 lb-ft)	No. 4, 30 ±5 N•m (22 ±4 lb-ft)
No. 2, 10 ±1.5 N•m (7 ±1 lb-ft)	No. 5, 2 ±0.5 N•m (18 ±4 lb-in) (Note lb-in)
No. 3, 25 ±1.5 N•m (18 ±1 lb-ft)	No. 6, 40 ±1.5 N•m (30 ±1 lb-ft)

Tandem Pump (Fuel and Power Steering)

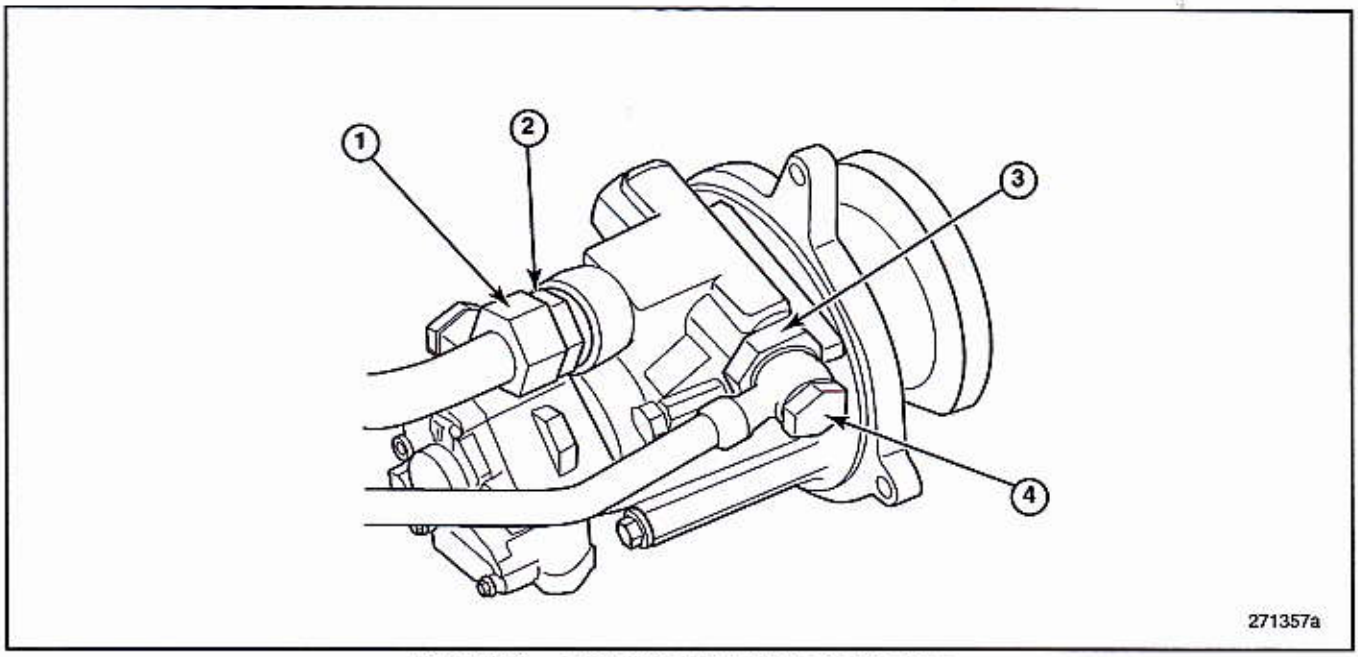

Figure 492 — Power Steering Pump Connectors

Tighten the connectors according to the following specifications.	
No. 1, 80 ±16 N•m (59 ±12 lb-ft)	No. 3, 70 ±10 N•m (52 ±7 lb-ft)
No. 2, 60 ±12 N•m (44 ±9 lb-ft)	No. 4, 37 ±7 N•m (27 ±5 lb-ft)

Additional Left-Side Engine Components

Alternator	
Mounting Bracket Attaching Screws, M10	48 ±8 N•m (35 ±6 lb-ft)
Pad Mount Attaching Screws, M12	85 ±15 N•m (63 ±11 lb-ft)
Attaching Screws, Tension Idler Roller	48 ±8 N•m (35 ±6 lb-ft)
Pulley Nut	101 ±6.5 N•m (75 ±5 lb-ft)
Inlet Manifold	
Plug, Inlet Manifold	20 ±3 N•m (15 ±2 lb-ft)
Air Compressor, Brake System	
Gear Attaching Nut	200 +50/–0 N•m (147 +37/–0 lb-ft)
Compressor Attaching Nuts	85 ±15 N•m (63 ±11 lb-ft)
Grease Connector	25 ±4 N•m (18 ±3 lb-ft)
Attaching Studs	24 ±4 N•m (18 ±3 lb-ft)
Fuel Pump	
Attaching Screws (to Power Steering Pump)	8 +2/–0 N•m (6 +1/–0 lb-ft)
Banjo Bolts	40 ±5 N•m (30 ±4 lb-ft)
Power Steering Pump	
Gear Attaching Nut	100 ±10 N•m (74 ±7 lb-ft)
Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)
Refrigerant Compressor, Air Conditioning	
M8 Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)

Standard Bolt and Nut Torque Values

The torque values in the table below conform to standard STD 5511,15.

	N•m (lb-ft)	
Screw/Bolt (Nut) Metric Size	Grade 8.8	Grade 10.9
M6 x 1.00	10 ±1.5 (7 ±1)	12 ±2 (9 ±1.5)
M8 x 1.25	24 ±4 (18 ±3)	30 ±5 (22 ±4)
M10 x 1.50	48 ±8 (35 ±6)	60 ±10 (44 ±7)
M12 x 1.75	85 ±15 (63 ±11)	105 ±20 (77 ±15)
M14 x 2.00	140 ±25 (103 ±18)	175 ±30 (129 ±22)
M16 x 2.00	190 ±35 (140 ±26)	275 ±45 (203 ±33)
M18 x 2.50	290 ±45 (214 ±33)	360 ±55 (265 ±40)
M20 x 2.50	430 ±70 (317 ±52)	540 ±90 (398 ±66)
M22 x 2.50	580 ±90 (428 ±66)	730 ±120 (528 ±88)
M24 x 3.00	740 ±120 (546 ±88)	900 ±140 (664 ±103)

ENGINE GASKETS, LUBRICANTS AND SEALANTS

Gasket and Seal Reuse

Some gaskets and seals must be discarded if removed during service. The following table describes the components and their limits.

Components	Examples	Reusable Limit	Reuse Recommendations
Gaskets (steel)	Cylinder head	Do not reuse	Discard the old gasket and substitute new if the head is removed.
Gaskets (hot)	Exhaust manifold Turbocharger	Do not reuse	Discard old gaskets and substitute new if associated components are removed.
Rubber gaskets (special)	Sealing strip (coolant duct cover, valve cover, oil pan, upper timing gear cover and inlet manifold)	No limit if no damage and no leaks	Remove old silicone from the T joints. Clean the surfaces. Apply fresh silicone.
Rubber gaskets (standard)	O-rings and sealing rings	Do not reuse	
Bonded seals, steel/rubber gasket	Nipples, hollow screws and oil filter housing	No limit if no damage and no leaks	
Valve seals	Valve stems	No limit if no damage and no leaks	Discard old seals and substitute new if the gasket is removed.
Crankshaft seals		Do not reuse	Discard old seals and substitute new if removed. Do **not** apply oil on the inside or outside diameters of the seal during assembly. **SEALS MUST BE DRY MOUNTED.**
Sealant agent	Sealing between: Timing Gear Plate and Cylinder Block Flywheel Housing and Timing Gear Plate Timing Gear Cover and Gear Plate	Do not reuse	Remove the old sealant. Clean the surfaces. Apply fresh sealant. **Important**: Remove the old silicone from the T joints and apply fresh.

Lubricants and Sealants

Use only the following recommended sealing compounds and lubricants.

NOTE

All genuine MACK cylinder head gaskets are precoated and do not require any type of sealing compound. Before installing **new** gaskets, degrease both gasket sealing surfaces to avoid leaks.

Location	Sealant or Lubricant
Crankshaft front seal cover	Part No. 342SX33 (or Dow Corning® 832)
Cup plugs/threaded plugs	Loctite® 277 or equivalent/Teflon® thread sealer
Cylinder sleeve seats	Part No. 342SX33 (or Dow Corning® 832)
Engine parts, fasteners (sides and threads), and washers	Clean engine oil
Injector sleeve copper seals	Clean coolant
Oil filter sealing gaskets (full-flow filters)	Clean engine oil
O-rings	Use the type of fluid that the O-ring contacts in use.
Sensors with O-ring seals	Assemble dry
Valve stems and guides	SAE 15-40 clean engine oil

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