



200 ENGINE ASSEMBLY

ENGINE ASSEMBLY



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GENERAL

This section includes step-by-step procedures for complete assembly of the MACK E7 engine. Major components that were overhauled in the BENCH PROCEDURES section of this manual are reinstalled here as assemblies.

CAUTION

Failure to follow the sequence of operations listed may result in damage to components or personal injury.

NOTE

After cleaning the components, properly store them where they will remain clean until needed for assembly.

The purpose of component inspection is to determine which parts can be reused and which parts must be replaced. Use considerable judgment to make this determination.

[211 DB] CYLINDER BLOCK

Special Tools Required

- Camshaft Bushing Installation/Removal Kit J 37713
- Camshaft Bushing Remover/Installer J 21428-01
- Counterbore Tool PT2210
- Counterbore Cutter Plate PT2210-3A
- Hex Key Wrench PT2210-14
- Universal Dial Depth Gauge PT5025
- 3-Inch Stylus Extension PT5025-11

Cleaning and Inspection

The engine should have been thoroughly steam cleaned prior to component removal and the block should be relatively clean. If heavy accumulations of dirt and grease are still present, steam clean the block as thoroughly as possible before attempting to clean with solvents.

WARNING

Cleaning solvent is flammable and toxic to the eyes, skin and respiratory tract. Skin and eye protection is required. Avoid repeated or prolonged contact. Use only in well-ventilated area.

WARNING

Compressed air used for cleaning can create airborne particles that may enter the eyes or irritate the skin. Pressure must not exceed 30 psi (207 kPa). Eye protection is required. Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).

NOTE

Cleaning the cylinder block is important. While cleaning the cylinder block, carefully inspect the areas around the cup plugs and the coolant jacket. If cup plugs or pipe plugs show signs of leaking, they should be replaced.

Cleaning the cylinder block is a good time to inspect it for cracks or other possible defects that may be reason for rejection. Refer to TROUBLESHOOTING section of this manual for information on testing for leaks in the cylinder head and cylinder block. If damage is not found until after the engine is assembled, the engine must be disassembled and rebuilt again.

SOLVENT TANK CLEANING

NOTE

Use a cleaning tank large enough to accommodate the largest component to be cleaned. Fill the tank with a suitable solvent and always use caution while cleaning parts. Parts may be dried with compressed air.

1. Scrape any remaining gasket material from the block.



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2. Using a wire brush or rotary wheel, remove any rust, corrosion or other debris from the block.
3. Clean all other block surfaces with mineral spirits or other suitable solvent.
4. Using due care and caution, clean and dry the block with compressed air.

INSPECTION

NOTE

A complete discussion of the proper methods of precision measuring and inspection is outside the scope of this manual. However, every shop should be equipped with standard gauges such as bore gauges, dial indicators, outside and inside micrometers, thickness gauges and straightedges.

Check the cylinder block for indications of cracking or coolant leakage. If any damage is suspected, use a standard dye penetrant or magnaflux procedure to determine if cracks exist. A cracked engine block must be replaced and never reused.

Refer to Figure 6-1.

Using a straightedge (PT5027 or equivalent) and thickness gauges, check the cylinder head mounting surfaces for flatness. The cylinder block mounting surface, on a service block, should be flat within 0.004 inch (0.102 mm).

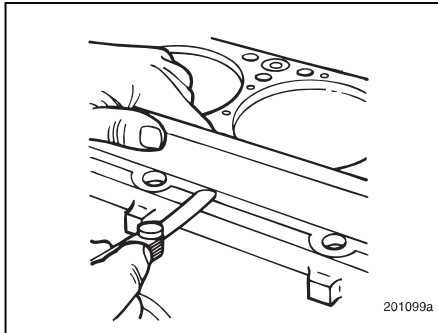


Figure 6-1 — Checking Flatness of Cylinder Block Deck

SERVICE HINT

If the cylinder block is determined to be serviceable after thorough cleaning and inspection, reassemble the engine. Use replacement or original parts, as determined during component inspection.

Cup Plug Replacement

REMOVAL

Refer to Figure 6-2.

1. Using a hammer and punch, drive one edge of the plug inward. The plug should rotate causing the opposite edge to move outward. When the edge moves out far enough, grab it with a pair of pliers and pull it out.

CAUTION

If, after several taps with a hammer, the plug does not rotate and is being driven inward, stop tapping. Drill a hole approximately 1/8 inch (3.2 mm) in diameter in the center of the plug. Insert a sheet-metal screw in the hole. Leave enough of the screw protruding from the plug to allow a pry bar to be inserted under the head of the screw and pry the plug out.

2. Clean the plug hole(s) with a wire brush or wire wheel. After cleaning, visually check the surface for cracks. When satisfied that there are no cracks *anywhere* in the block, replace the plug(s).



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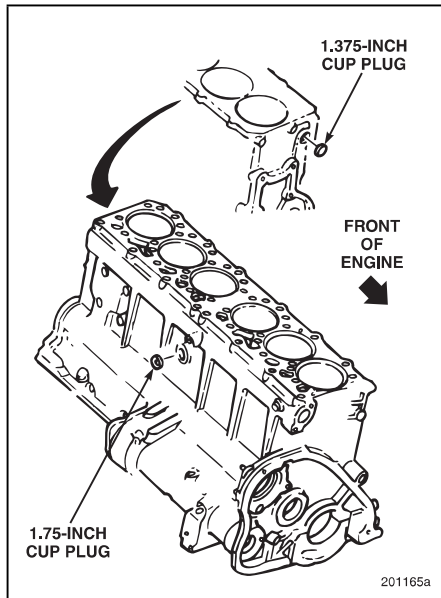


Figure 6-2 — Cylinder Block Cup Plugs

INSTALLATION

1. After cleaning the plug hole, apply a thin coat of Loctite® 277 to both the surface of the hole and the outer edge of the plug.
2. Using a proper driver, align the plug in the hole and drive it inward until the outer lip of the plug is flush with the cylinder block. Refer to Figure 6-3.

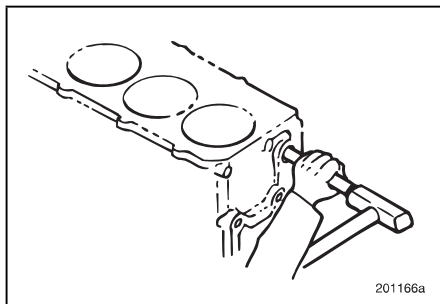


Figure 6-3 — Cylinder Block Cup Plug Installation

Pipe Plug Replacement

NOTE

Any rust around a pipe plug is an indication of a leak and the plug should be replaced.

REMOVAL

1. Using an appropriate wrench, remove the plug.
2. Clean the threads in the block by running a tap into the hole, just far enough to remove any rust on the threads without expanding the diameter of the hole. Use compressed air to remove any chips from the block.

NOTE

It is best to replace a leaking pipe plug. However, if reusing the same plug, clean thoroughly, paying special attention to the threads.

3. Using a wire wheel, clean the threads of the plug. Visually check the thread surfaces for burrs or damage. Then clean and check the remaining surfaces.

NOTE

New plugs already have a sealer applied to the threads. Applying a Teflon sealer to the threads will not adversely affect the precoating.

INSTALLATION

Apply appropriate Teflon thread sealant to the threads and install the plug. Torque to specification. Refer to Torque Chart in the SPECIFICATIONS section of this manual.

NOTE

When checking or assembling engine components, refer to the Fits and Limits Chart and Torque Chart in the SPECIFICATIONS section of this manual for specified dimensions and torque settings.



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[213 CC] Camshaft Bushings

DESCRIPTION

Lubrication oil is pumped into the cylinder block main oil gallery. Oil from the gallery flows to each main bearing bushing bore and then on to the respective camshaft bushing bore, providing lubrication for both the crankshaft and camshaft bushings. Camshaft bushing bores No. 1, 2 and 5 are grooved to supply oil to other components as well. Oil from the No. 1 camshaft bushing bore flows on through a drilled passage to lubricate the front auxiliary driveshaft bushing. Oil from the No. 2 and 5 camshaft bushing bores flows on through vertical drilled passages to lubricate the rocker arm assemblies. Oil from the No. 4 camshaft bushing bore flows through a cast groove in the cylinder block bushing bore to lubricate the fuel injection pump, the rear auxiliary driveshaft bushing, and the air compressor.

INSPECTION

NOTE

During in-chassis overhaul, check the inside diameter of the camshaft bushings. If overhauling out-of-chassis, replace camshaft bushings.

1. Using a telescope gauge or suitable inside micrometer, measure the ID of each camshaft bushing in the cylinder block. Record the dimensions. Refer to Figure 6-4.

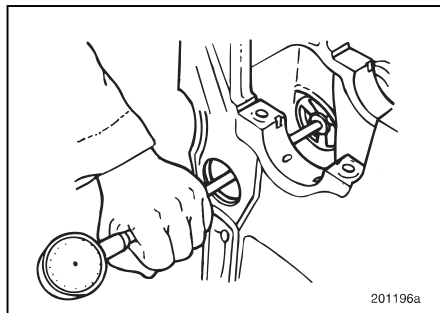


Figure 6-4 — Measuring Camshaft Bushing ID

2. Refer to the Fits and Limits chart for camshaft bushing measurement specifications. Check the recorded dimensions against the specifications.
3. If bore size exceeds tolerance or if there is any evidence of scratching or scoring, replace the bushings.

REMOVAL

Refer to Figure 6-5.

NOTE

Use camshaft bushing remover/installer kit J 37713 (use with J 21428-01 kit) for camshaft bushing removal.

Camshaft bushings are identified in sequence from 1 to 7, starting from the front of the engine.

1. Using camshaft bushing remover/installer kit J 21428-01 (2), with the correct pilot adapter (J 37713 kit) and a hammer (3), remove the No. 1 camshaft bushing (4) from the cylinder block (1).
2. Remove the remaining six bushings in sequence.

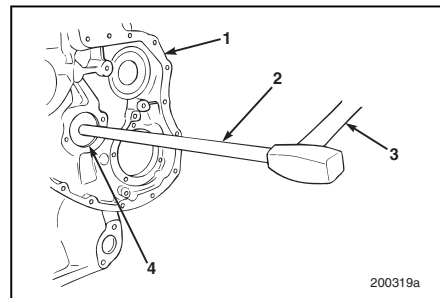


Figure 6-5 — Camshaft Bushing Removal

- | | |
|--|---------------------------|
| 1. Cylinder block | 3. Hammer |
| 2. Camshaft bushing remover/installer (J 21428-01 kit) | 4. No. 1 camshaft bushing |



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INSTALLATION

Refer to Figure 6-6.

Each camshaft bushing is located at set distances from the thrust washer mounting surface to the forward edge of the bushings.

CAUTION

Correct installation of each camshaft bushing is very important. If a bushing is not properly aligned with both its oil supply and oil feed passages in the cylinder block, either the camshaft bushing will fail or the components lubricated by the bushing feed will fail from inadequate lubrication.

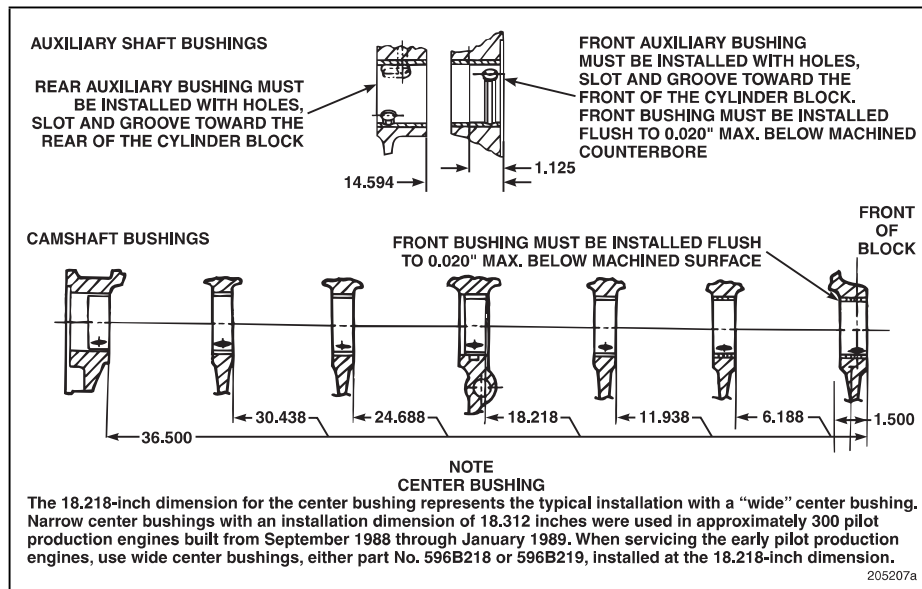


Figure 6-6 — Camshaft and Auxiliary Shaft Bushing Locations



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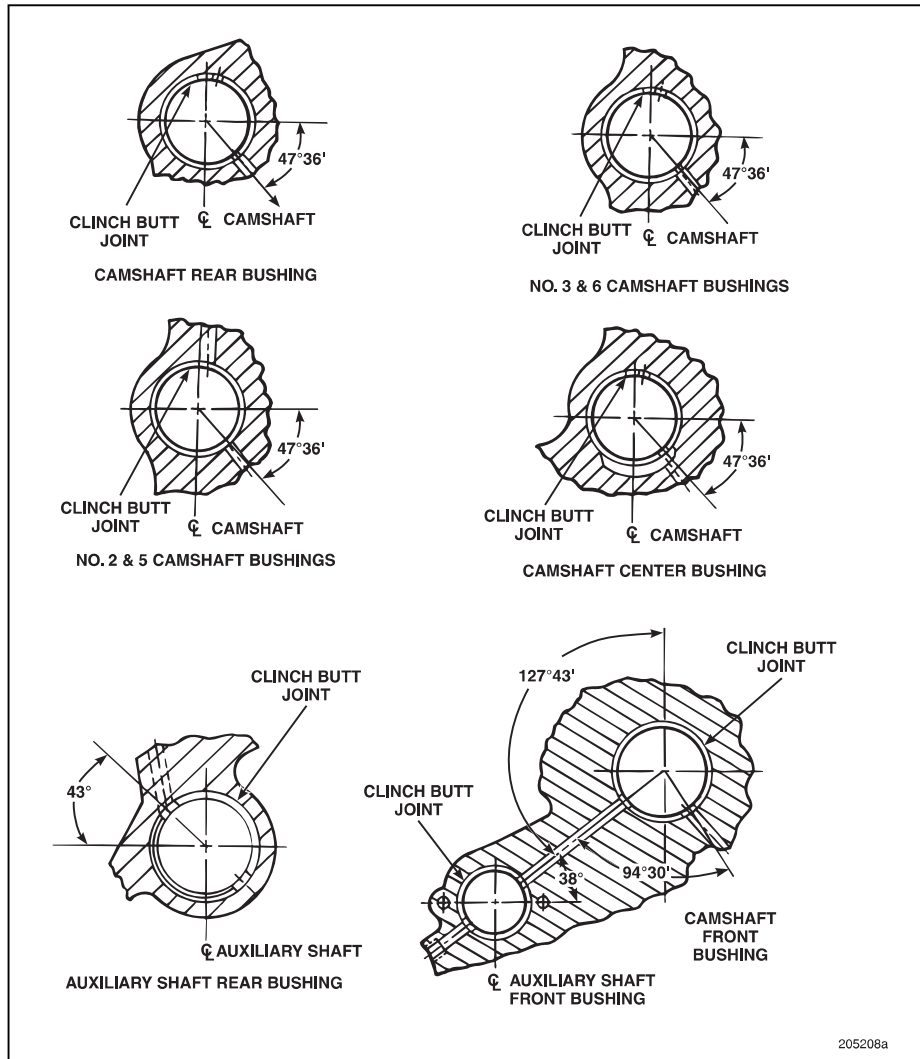


Figure 6-7 — Camshaft and Auxiliary Shaft Bushing Alignment



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Refer to Figure 6-8.

1. Position a replacement bushing (2) against the side of the block at the No. 7 (rear) bushing bore. Align the oil hole in the bushing (1) with the oil passage (7) in the block.
2. Using a dark-colored felt-tip marker, mark the block and the bushing with a line (5) to facilitate correct alignment at installation.
3. Clean the surfaces of the bushing and the bore. Dry both surfaces with compressed air.
4. Using bushing remover/installer J 21428-01 kit (4) and the appropriate pilot adapter J 37713 (3), install the bushing.

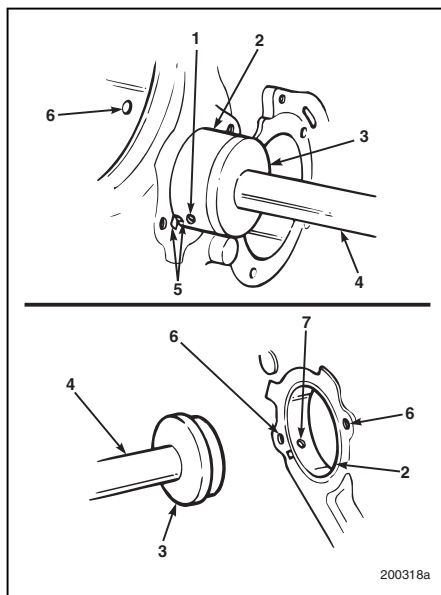


Figure 6-8 — Camshaft Bushing Installation

- | | |
|---|----------------------|
| 1. Bushing oil hole | 5. Alignment mark |
| 2. Bushing | 6. Mounting hole |
| 3. Pilot adapter (J 37713) | 7. Block oil passage |
| 4. Bushing remover/installer J 21428-01 kit | |

5. Check the surface of the bushing for burrs caused by installation.

NOTE

Refer to Fits and Limits chart for correct bushing ID dimensions.

Refer to Figure 6-9.

6. Using an inside micrometer or telescope gauge, measure the ID of the bushing to ensure against an undersize bushing. An undersize bushing may cause the camshaft to seize in the bushing during installation.

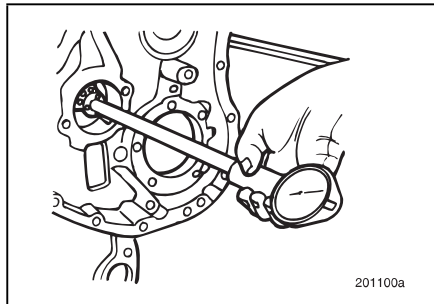


Figure 6-9 — Camshaft Bushing ID Check

7. Repeat steps 1 through 6 for all of the remaining bushings in sequence.



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[212 CB] Auxiliary Driveshaft Bushing Replacement

DESCRIPTION

The front and rear auxiliary driveshaft bushings are identical. Engine lubrication oil passing through the No. 1 camshaft bushing supplies oil to the front auxiliary driveshaft bushing. Oil passing through the No. 4 camshaft bushing supplies oil to the rear auxiliary driveshaft bushing. A groove in the rear auxiliary driveshaft journal, in conjunction with a rifle-drilled hole in the auxiliary driveshaft and a small oil feed tube, supplies lubrication to the air compressor.

INSPECTION

1. Using a telescope gauge or inside micrometer, measure the auxiliary bushing bores. Take two readings, perpendicular to each other, in each bore. Record the readings. Refer to Figure 6-10.
2. Compare readings with the tolerances listed in the Fits and Limits chart in this manual.

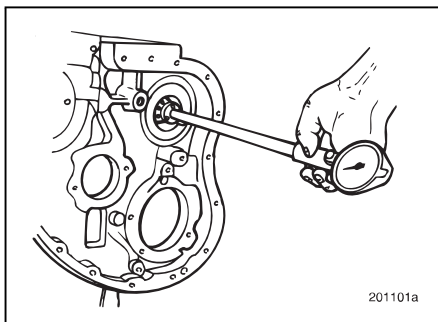


Figure 6-10 — Auxiliary Driveshaft Bushing ID Check

INSTALLATION

CAUTION

Correct installation of auxiliary driveshaft bushings is very important. If bushings are misaligned, lubrication oil will not be allowed to lubricate the auxiliary driveshaft journal. This will also cause the component lubricated through that journal to run without lubrication and prematurely fail.

If the approximately 1.25 inches long (32 mm) oil feed tube, which connects the oil feed hole in the rear of the auxiliary shaft to the oil feed hole in the front of the air compressor crankshaft, is accidentally lost during air compressor or auxiliary shaft service work, the compressor will fail from oil starvation. Also, the loss of oil pressure resulting from the missing tube can cause damage and problems in other components and parts.

Refer to Figure 6-11.

1. Position a replacement bushing (2) against the side of the block at the rear bushing bore. Align the oil hole in the bushing with the hole in the block.
2. Using a dark-colored felt-tip marker, mark the block and the bushing with a line (1) to facilitate correct alignment during installation.
3. Clean the surfaces of the bushing and the bore. Dry both surfaces with compressed air.
4. Using camshaft bushing remover/installer kit J 21428-01 (4) and the appropriate pilot adapter J 37713 (3), install the bushing.



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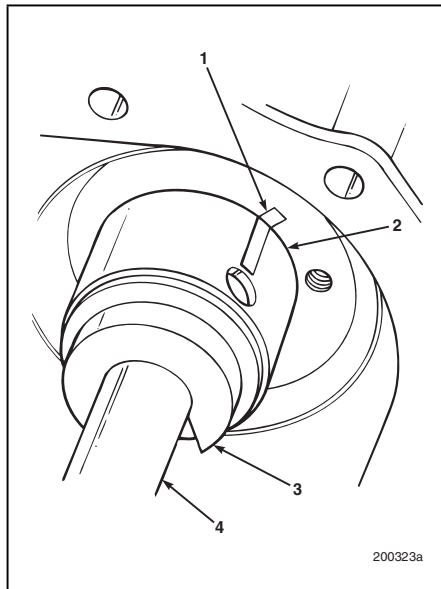


Figure 6-11 — Auxiliary Driveshaft Bushing Alignment

- | | |
|--------------------------|--|
| 1. Alignment mark | 4. Camshaft bushing remover/installer kit J 21428-01 |
| 2. Bushing | |
| 3. Pilot adapter J 37713 | |

5. Check the bushing surface for burrs caused by installation.

NOTE

Refer to the Fits and Limits chart in this manual for correct bushing ID dimensions.

6. Using an inside micrometer or telescope gauge, measure the ID of the bushing to ensure against using an undersize bushing. An undersize bushing may cause the auxiliary driveshaft to seize in the bushing during installation.

CAUTION

The front auxiliary driveshaft bushing must be flush or recessed within 0.020 inch (0.508 mm) of the front of the cylinder block. Incorrect recess will cause misalignment of the oil supply hole, resulting in insufficient lubrication of the journal.

7. Working from the front of the cylinder block, repeat steps 1 through 6 to install front bushing.



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[212 NC] CYLINDER SLEEVE

Description

The cylinder sleeve works with the piston, piston rings, cylinder head, and cylinder head gasket to seal combustion pressure. It transfers combustion heat to engine coolant and guides piston travel during engine operation. Correct extension of sleeve flange above top deck and uniform cylinder block counterbore are essential for satisfactory sleeve life and head gasket seal.

The cylinder sleeves are a wet-dry design, made of centrifugal cast iron. A crevice seal is needed for sealing purposes.

Special Tools Required

- Depth Gauge J 26948
- Dial Bore Gauge J 5347-B
- Cylinder Hone and Glaze Breaker J 5902-01

Installation

Refer to Figure 6-12.

1. Thoroughly clean and dry the prepared cylinder block (6), counterbore ledge (5) and cylinder sleeves (3). Refer to cylinder block cleaning procedures in this section.
2. Install the crevice seal (2) into the cylinder sleeve groove with the pointed face toward the cylinder block (6) (outward). Lubricate with ethylene glycol.
3. If the counterbore ledges (5) have been cut, place the shims (4) on the cylinder block counterbore ledges. If more than one shim is necessary, use the fewest number of shims required to achieve the proper cylinder sleeve flange height. Always place the thickest shim on the bottom.

CAUTION

The crevice seal groove (1) must be clean and free of any oil residue. Under no circumstances should oil contaminate the crevice seal groove or crevice seal. Damage to the seal will result.

NOTE

Applying a Silastic bead is now standard assembly procedure whenever cylinder sleeves are installed.

To prevent partial curing and questionable sealing and bonding, apply Silastic just before installing the sleeves.

4. Apply approximately a 1/8-inch (3.18 mm) bead of RTV silicone (Mack Silastic 342SX32, Dow Corning Silastic RTV732, or General Electric RTV130) around the cylinder block sleeve seat and completely around the cylinder wall. Do not use excessive amounts of RTV.

CAUTION

The cylinder block counterbore ledges and the cylinder sleeve must be kept clean and free of any oil residue to ensure that the Silastic bead seals and bonds properly.

5. Position the cylinder sleeve (3) in the cylinder bore until it contacts the crevice seal (2).
6. Placing the palms of the hands on the upper end of the cylinder sleeve 180 degrees apart, push downward with a quick, even pressure. Using a large plastic-faced hammer, tap the sleeve close to the inside diameter. Tap alternately from one side to the other, gradually working around the entire circumference of the sleeve.



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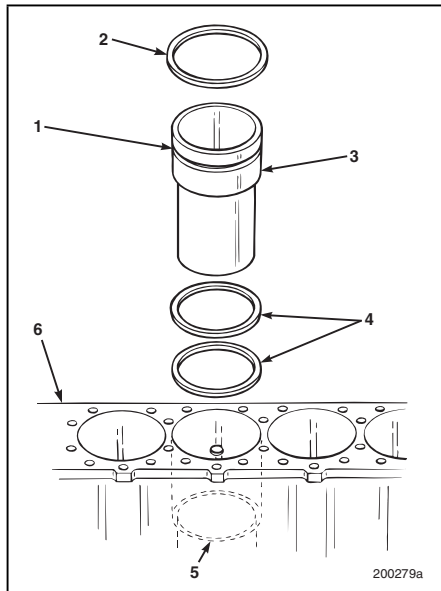


Figure 6-12 — Sleeve Installation

- | | |
|------------------------|------------------------|
| 1. Crevice seal groove | 4. Shims (as required) |
| 2. Crevice seal | 5. Counterbore ledge |
| 3. Sleeve | 6. Cylinder block |

NOTE

Clean any RTV from around the bottom of the cylinder sleeve and the block which may have been pressed between the block and sleeve during installation.

- After the cylinder sleeve is fully seated, use depth gauge J 26948 or equivalent to check flange height above the deck dimensions. The specified flange height above-deck dimension is 0.022–0.027 inch (0.559–0.686 mm). The measurement should be taken in the channel between the sleeve top lip (fire dam) and the coining bead. Refer to the TROUBLESHOOTING section, Figures 9-1 and 9-2.

NOTE

The height of the cylinder sleeves above the cylinder block deck (under the same cylinder head) can vary as long as all are within the 0.022–0.027 inch specification.



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Refer to Figure 6-13.

8. Using dial bore gauge J 5347-B or equivalent, check the cylinder sleeve for out-of-round and taper limit. Take readings in two directions, 90 degrees apart, at each of three levels.

Cylinder sleeve ID maximum: 4.877 inches (123.876 mm).

Cylinder sleeve ID minimum: 4.875 inches (123.825 mm), cylinder sleeve ID may be minimum 4.872 inches (123.749 mm) due to close-in from press fit.

HONING THE CYLINDER SLEEVE BORE

CAUTION

Engines produced since mid-year 1992 have finer, more precisely finished cylinder sleeves. Because of the finer finish, honing is NOT recommended. Particles from the honing process which become wedged in the pattern are impossible to completely remove and can cause further damage.

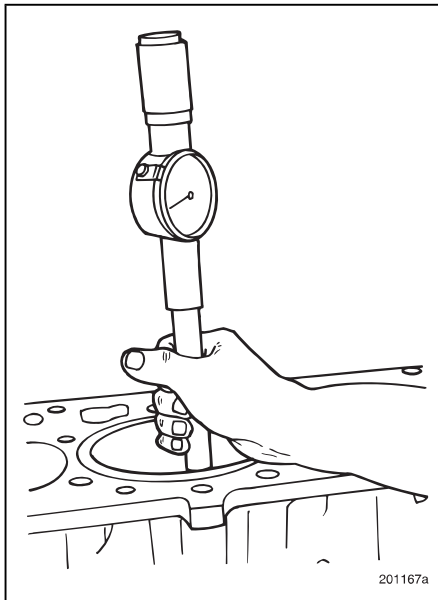


Figure 6-13 — Checking Cylinder Sleeve for Out-of-Round or Taper



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[219 RV] PISTON COOLING SPRAY NOZZLE

Description

Refer to Figure 6-14.

The piston cooling system consists of an oil pump, oil passages drilled in the cylinder block, and an oil spray-nozzle assembly for each piston. The piston cooling nozzles are attached to the main oil gallery. Oil is discharged through the nozzles and into the underside of each piston. This spray provides additional piston cooling. The oil returns, by gravity, to the crankcase oil pan. Inside the crankcase at each cylinder is a drilled oil passage from the main oil gallery and one threaded hole for the retaining screw.

Beginning with 1991 E7 engine production, piston cooling nozzle hardware and nozzle spray positioning tool changes have been made. The two-piece piston design uses two types of cooling. A unique splash and forced piston cooling system first appeared on the 1991 E7 engine. Precise targeting of the piston cooling spray provides adequate cooling to the piston crown and fills the four oil reservoirs located in the top of the piston skirt.

The piston cooling nozzle bracket is thicker on the piston cooling nozzles beginning on 1991 E7 production engines. Also, "310" is etched on the pre-1991 piston cooling nozzle, and "316" began in 1991 E7 production. These parts are not interchangeable with 1989/1990 production.

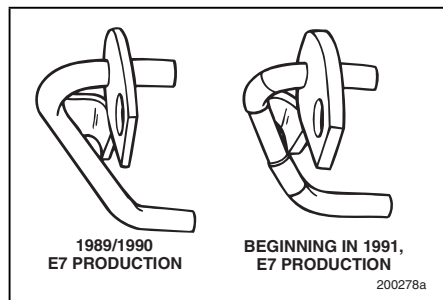


Figure 6-14 — Spray Nozzle Comparison

Special Tools Required

- Piston Cooling Nozzle Spray Position Set J 37721-A (for 1989/1990 production)
- Two-Piece Piston Cooling Nozzle Aimer J 39045 (for 1991 and later production)

Installation

Refer to Figure 6-15.

1. Using a liberal amount of lubricant, install elastomer sleeve (7) on locator tube (6).
2. Install a retaining screw (4) in the spray nozzle bracket (3).
3. Position spray nozzle locator tube (6) in cylinder block oil passage (2) and torque retaining screw to 15 lb-ft (20 N·m) using torque wrench J 24406 or equivalent.

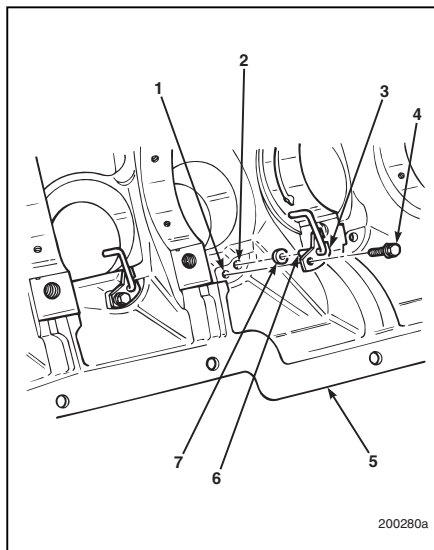


Figure 6-15 — Spray Nozzle Installation

- | | |
|-------------------------|---------------------|
| 1. Threaded hole | 5. Cylinder block |
| 2. Oil passage | 6. Locator tube |
| 3. Spray nozzle bracket | 7. Elastomer sleeve |
| 4. Retaining screw | |



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Piston Cooling Nozzle Spray Positioning

Refer to Figure 6-16.

The piston cooling oil spray location on the underside of the piston is important; it ensures adequate heat dissipation from the piston and makes certain that the crankshaft counterweights of the connecting rods do not strike the nozzles.

CAUTION

Always replace a badly deformed spray nozzle. Do not attempt to realign it. Precise targeting is necessary to adequately cool the piston crown.

SERVICE HINT

For ease of installation and to reduce the amount of crankshaft rotation needed to facilitate access to the spray nozzles, install the spray nozzles in the following order: cylinders 1 and 6, 5 and 2, 3 and 4.

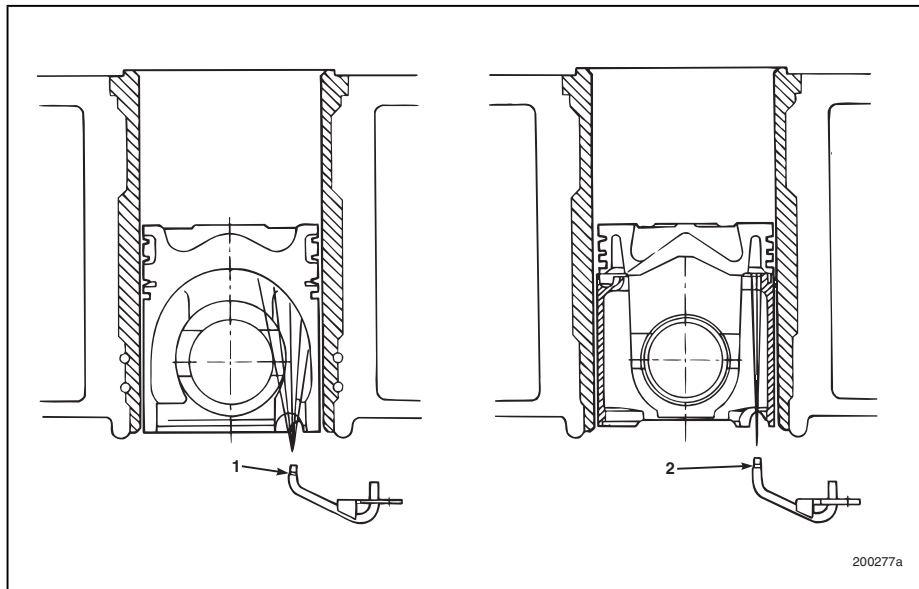


Figure 6-16 — Spray Nozzle Patterns

1. Old pattern (pre-1991)

2. New pattern (1991 and later)



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Refer to Figure 6-17.

1. Using piston cooling nozzle spray position set J 37721-A (pre-1991) or J 39045 (1991 and later), check the direction of the spray from the nozzles.
2. Position rod (6) in end of spray nozzle (7).
3. Place the applicable plastic target (1) on the cylinder block (2) over the cylinder to be tested.
4. Install a cylinder head bolt through the target alignment hole (3) and into the cylinder block capscrow hole (4) to align the target.
5. The rod (6) should now be aligned in the target area (5). If rod is at edge of target area, two methods may be tried to center the rod into the target area.
 - a. Preferred — Loosen nozzle set screw. A slight adjustment can then be made to center the rod within the target area. Following adjustment, retorque set screw to 15 lb-ft (20 N·m).
 - b. Alternate (pre-1991 only) — It is permissible to bend the hooked end of the nozzle tube **only slightly** to bring the rod fully within 1/8 inch of the target area. If more than 1/8 inch out of target area, replace nozzle.

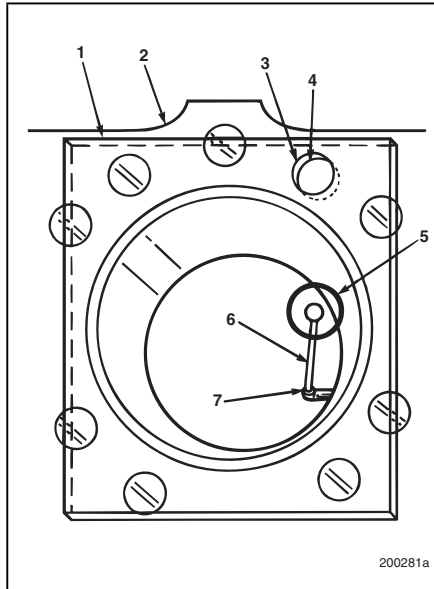


Figure 6-17 — Spray Nozzle Targeting

- | | |
|------------------------|-----------------|
| 1. Plastic target | 5. Target area |
| 2. Cylinder block | 6. Rod |
| 3. Alignment hole | 7. Spray nozzle |
| 4. Cylinder block hole | |



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[211 HA] CYLINDER BLOCK DOWEL PINS

Description

The diamond locating dowel pins used to install the front timing gear cover, flywheel and flywheel housing, have been replaced in production by blade-style locating dowel pins. The diamond pins were dual-diameter type pins with a smaller diameter at the round end that goes into the cylinder block. The blade-style pins are the same diameter at the round end and the blade end. There are no changes in the size of the hole in the front timing cover. However, the cylinder block has a larger hole to accept the blade-style dowel pins. The cylinder block timing gear cover old pin number is 183GC221 and the new number, starting with serial number 2T (August 1992), is 183GC238.

Use a dowel size and type that is appropriate for the block being used. (Service old with old and new with new.) Install the blade-style dowel with the blade in a vertical direction (pointing up and down).

Special Tools Required

- Flywheel Housing Diamond Dowel Aligner J 37711
- Flywheel Housing/Timing Cover Locating Pin Driver J 37712

Removal

If it is necessary to remove the timing cover or flywheel housing locating dowel pins, do so as follows:

1. Securely clamp the pin with a pair of vise-grip pliers.
2. While exerting an outward force, rotate pin back and forth until the pin works free from the hole.

Installation

Two precision-made dowel pins are used to locate the flywheel housing to the cylinder block. One dowel is round, the other is a diamond shape or blade type, as described earlier, depending on the production date.

NOTE

The dowels used for timing gear cover installation are similar except for the size. The smaller dowels are used for the timing cover. The larger dowels are used for the flywheel housing.

ROUND DOWEL PIN INSTALLATION

Refer to Figure 6-18.

1. Insert round dowel pin (2) into the flywheel housing/timing cover locating pin driver J 37712 (1). The pin must be positioned in the driver with tapered end of the dowel facing outward.
2. Position exposed end of dowel into the left dowel pin hole (4) in cylinder block (3).
3. Using a hammer, drive the pin into the block until the driver contacts the cylinder block. When the driver has made contact with the block, the dowel pin will be at the correct dimension above the block.

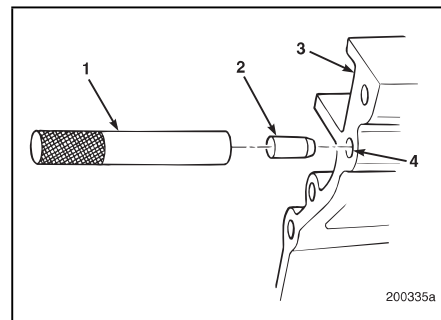


Figure 6-18 — Round Dowel Pin Installation

- | | |
|------------------------|-------------------|
| 1. Locating pin driver | 3. Cylinder block |
| 2. Round dowel pin | 4. Dowel pin hole |



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DIAMOND-SHAPED DOWEL PIN INSTALLATION

Refer to Figure 6-19.

1. Position the two alignment studs (3) in the threaded holes (2) nearest the right dowel location hole (6) in the cylinder block (1).
2. Position the diamond-shaped dowel pin (5) in the diamond dowel aligner J 37711 (4).
3. Position the diamond dowel aligner with the pin in position on the two alignment studs (3).
4. Using a hammer, drive the dowel pin into the hole until it bottoms out in the block.
5. Remove the diamond dowel aligner and the two alignment studs. The dowel pin will be at the correct height above the block.

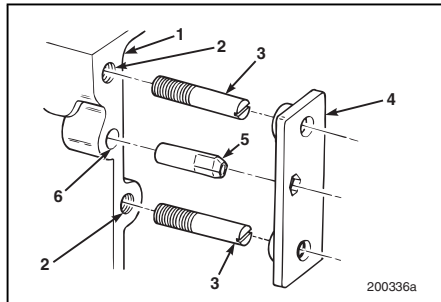


Figure 6-19 — Diamond-Shaped Dowel Pin Installation

- | | |
|--------------------------|-----------------------------|
| 1. Cylinder block | 5. Diamond-shaped dowel pin |
| 2. Threaded holes | 6. Dowel location hole |
| 3. Alignment studs | |
| 4. Diamond dowel aligner | |

BLADE-TYPE DOWEL PIN INSTALLATION

1. Position the round end of the blade-type dowel pin into the dowel pin hole in the cylinder block. The blade end must be aligned vertically with the block.
2. Using a hammer, drive the dowel pin into the block until the shoulder of the pin is flush with the cylinder block surface.



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[212 HP] CRANKSHAFT

Installation

1. Clean the crankshaft and crankcase area.
2. Thoroughly clean each main bearing bore and the back of each bearing insert before installation. The inserts must be installed dry.

CAUTION

The hole in the insert should line up with the drilled hole in the block or the bearing will fail due to lack of lubrication. The upper bearing insert is stamped on the back with the word UPPER.

3. Place the upper half of the bearing insert in the block bore, making sure that the locating tab fits into the notch provided.
4. Repeat above step to install the remaining upper inserts. Refer to Figure 6-20 for the part number and location of each bearing insert.

CAUTION

A bearing insert installed at the wrong location can cause engine failure.

5. Apply a light coat of clean engine oil on the insert surfaces and on the crankshaft main bearing journals.

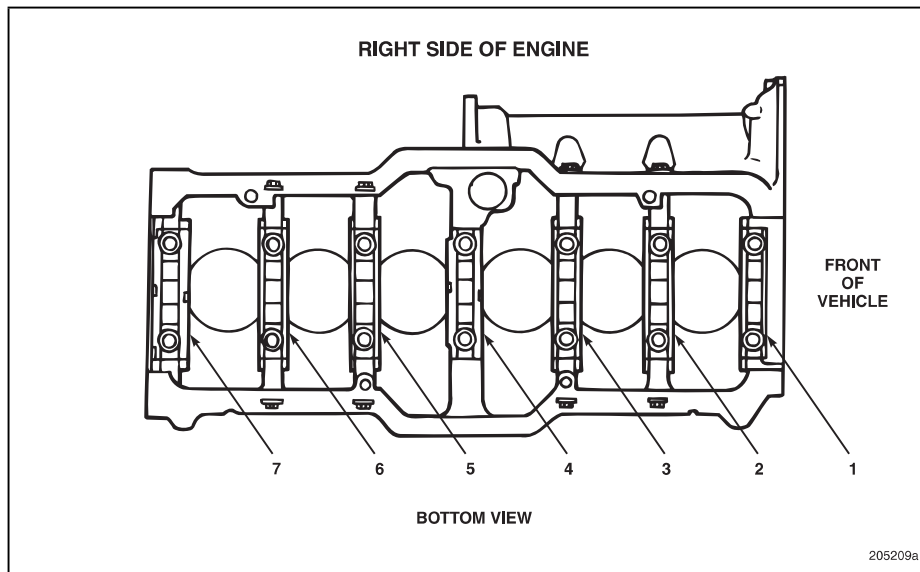


Figure 6-20 — Main Bearing Insert Part Numbers and Locations

- | | |
|---|---|
| 1. Upper insert — 646B348; Lower insert — 646B343 | 5. Upper insert — 646B345; Lower insert — 646B343 |
| 2. Upper insert — 646B345; Lower insert — 646B343 | 6. Upper insert — 646B345; Lower insert — 646B343 |
| 3. Upper insert — 646B345; Lower insert — 646B343 | 7. Upper insert — 646B350; Lower insert — 646B344 |
| 4. Upper insert — 646B349; Lower insert — 646B344 | |



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WARNING

Due to the considerable weight of the crankshaft, extreme care must be observed during installation. No nicks, scratches, burrs, or any other kinds of distress are acceptable on the main bearing and/or crankshaft journals and fillets.

6. Using a suitable lifting device, position the crankshaft in the crankcase.

[212 HH] MAIN BEARING CAP

NOTE

Unfinished main bearing caps are available for servicing of E7 engines. These are undersize bore bearing caps for service rebore:

- Cap, Intermediate and Front Main Bearing (Semi-Finished), No. 223GB2131M
- Cap, Rear and Center Main Bearing (Semi-Finished), No. 223GB2132

Special Tool Required

- Magnetic Base Indicator Tool J 7872

Installation

1. Clean bore in bearing cap and back of the lower bearing inserts.
2. Install bearing insert in bearing cap bore. The inserts must be installed dry.

NOTE

The lower bearing inserts do not have a hole or a notch. They are stamped with the word LOWER.

CAUTION

Do not mix caps or inserts. The caps are numbered from 1 through 7, front to rear.

3. Lubricate threads of the bearing capscrews with clean engine oil and place bearing capscrews in the bearing cap holes.
4. Position cap in the correct location and start the screws in the threads.
5. Using a plastic-faced mallet, tap bearing cap down until it contacts the machined mounting surface.
6. Tighten the screws until they contact the bearing cap. At this time, tighten them only to finger tight.
7. Repeat above steps for remaining main bearing caps, except the center main bearing cap. Torque bearing cap capscrews to 210 lb-ft (285 N·m) using torque wrench J 24407 or equivalent.

NOTE

Use standard thickness thrust washers initially.

Refer to Figure 6-21.

8. Place upper thrust washer sections in position at the center bearing. The steel side of the thrust washer goes toward the block, the bronze side goes toward the crankshaft (this applies to upper and lower thrust washer sections).

NOTE

Beginning with October 1996 production, new-style thrust washers were introduced. These thrust washers are steel backed with an aluminum facing material on the side that goes against the crankshaft. As with the previous bronze-style thrust washers, the aluminum-faced thrust washers have oil reservoir grooves cut into the aluminum surface as well as tip face reliefs. The aluminum thrust washers can easily be installed incorrectly because of the similarity of color between the steel backing and aluminum face. When installing aluminum-faced thrust washers, make sure the oil reservoir grooves and tip relief cuts are facing against the crankshaft.



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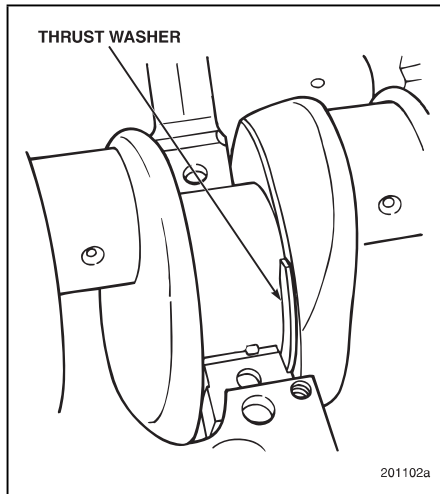


Figure 6-21 — Crankshaft Thrust Washer Installation

9. Position the lower section thrust washers on the center bearing cap (bronze/aluminum faces crankshaft) and install the cap. Torque capscrews to 210 lb-ft (285 N·m) using torque wrench J 24407 or equivalent.
10. Install magnetic base indicator tool J 7872, or equivalent, on the block with the plunger against a crankshaft counterweight to check for crankshaft end play.
11. Using a suitable pry bar, move crankshaft either forward or rearward until it stops. Tap end of the crankshaft with a plastic-faced hammer to seat the thrust washer.
12. Using pry bar, move crankshaft in the opposite direction. Tap end of the crankshaft with a plastic-faced hammer to seat the other thrust washer.
13. Set dial on the indicator to zero.
14. Using pry bar, move crankshaft in the opposite direction and read the dial indicator. Refer to the Fits and Limits chart for specifications.
15. If end play is out of specification, remove thrust washers and install standard or oversize thrust washers, as required, to bring the end play into specification.

CAUTION

The thickness of the thrust washers used in the bearing cap must match the thickness of the thrust washers in the block. Be sure to put the bearing surface of the thrust washer against the crankshaft when installing thrust washers.

16. Install the center main bearing cap, with bearing insert and the correct thrust washer sections in place, and torque the bearing capscrews to specification.
17. Recheck end play to make sure thrust washers have been installed correctly and end play is within specification. Rotate crankshaft to make sure there is no binding.

CHECKING RUNNING CLEARANCE

CAUTION

When using the Plastigage method of checking running clearance, do not turn the crankshaft. Doing so will destroy the Plastigage.

NOTE

If checking the main bearing clearance with engine in the upright position (such as in the chassis), the weight of the crankshaft must be removed from the lower half of the bearing being checked. To do this, place cardboard under the crankshaft journal in the main caps adjacent to journal to be checked and tighten the adjacent caps until the journal to be checked seats against the upper bearing. Do not fully torque screws. Capscrews on bearing being checked should be torqued to specification after Plastigage strip has been positioned on the bearing shell. Support crankshaft at No. 1, 4 and 7 main journals, while checking No. 2, 3, 5 and 6 bearings. Support crankshaft at No. 3 and 5 while checking No. 1, 4 and 7 bearings.



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Refer to Figure 6-22.

1. Use Plastigage to check the main bearing clearance. Check each bearing, one at a time, by placing a piece of Plastigage on the journal and tightening the cap in place. The bearing clearance is determined by measuring the width of the crushed Plastigage with the supplied gauge.
2. Place a section of Plastigage (2) on the journal to be checked and assemble main bearing cap (1) to cylinder block.
3. Apply a light coat of oil on threads of the bearing cap capscrews and secure cap.
4. Torque capscrews to 210 lb-ft (285 N·m) using torque wrench J 24407 or equivalent. The Plastigage strip will be crushed between the bearing insert (3) and the crankshaft journal (4).

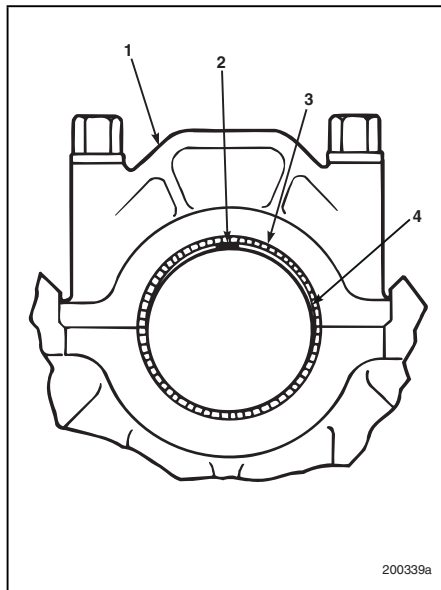


Figure 6-22 — Checking Running Clearance with Plastigage

- | | |
|---------------------|-----------------------|
| 1. Main bearing cap | 3. Bearing insert |
| 2. Plastigage | 4. Crankshaft journal |

5. Remove capscrews and cap, and check the bearing running clearance.
6. Check width of the Plastigage using a Plastigage width chart. After measuring width, remove Plastigage from bearing.
7. If clearance is not within specification, correct as required. Be sure to use the correct size bearing.
8. If clearance is less than specified, also check behind bearing for dirt, chips or burrs which would prevent the bearing from seating properly.
9. Reposition cap on journal. Lubricate capscrews with clean EO-L specification engine oil. Lubricate and install the bearing cap buttress capscrews as required, and leave finger tight. Install the bearing cap capscrews and torque to 210 lb-ft (285 N·m) using torque wrench J 24407 or equivalent.

Refer to Figure 6-23.

NOTE

There are two buttress capscrew dimensions:

- LH side 2, 3, 5, 6; RH side 5, 6 (6 each) are 80 mm long (1)
- RH side FRT 2 and 3, engine bulkhead (2 each) are 110 mm long (2)



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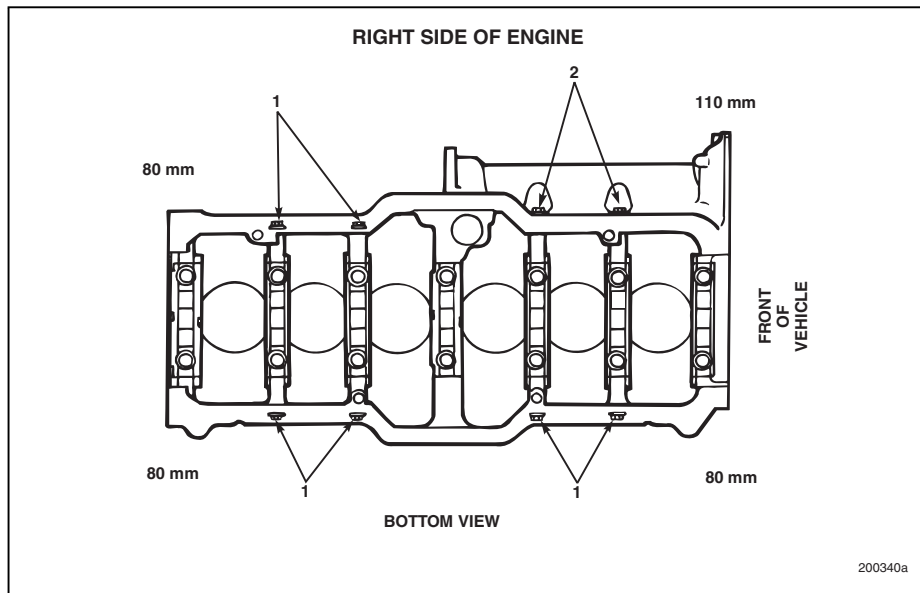


Figure 6-23 — Buttress Capscrew Locations

1. 80-mm buttress capscrews

2. 110-mm buttress capscrews

After obtaining proper main bearing clearance:

1. Check torque of main bearing capscrews: 210 lb-ft (285 N·m) using torque wrench J 24407 or equivalent.
2. Torque the buttress capscrews to 90 lb-ft (122 N·m) using torque wrench J 24407 or equivalent.

The piston design incorporates two compression ring grooves and one oil control ring groove. A plasma-faced keystone type ring is used in the top location. A tapered chrome rectangular-type ring is used in the second ring groove. The oil control ring is located in the third or lower ring groove, nearest the piston pin bore. The new piston rings are designed to further improve oil and particulate control.

[212 NP & 212 LP] PISTONS AND CONNECTING RODS

Description

Since 1991, all E7 engines have used a two-piece piston. To ensure a continued high level of piston durability, the piston crown is made of forged steel and the piston skirt is made of cast aluminum. The piston pin bore pedestal and skirt are stamped FRONT and must face the front of the engine. These production parts are not interchangeable with 1989/1990 production.

Special Tools Required

- Piston Ring Compressor J 23442 or Piston Ring Compressor PT7070-A



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Installation

Refer to Figure 6-24.

1. Rotate crankshaft so that the journals for the No. 1 and No. 6 cylinders are at bottom dead center.
2. Place piston, marked No. 1, on a clean, flat surface. Rest the piston and rod assembly on the piston crown with the rod upward.
3. Apply a light coat of clean engine oil to piston and rings.
4. Apply a light coat of clean engine oil to inside surface of the piston ring compressor J 23442 or PT7070-A.
5. Install ring compression tool by slipping it over the rod and down over the piston skirt with tapered end downward.

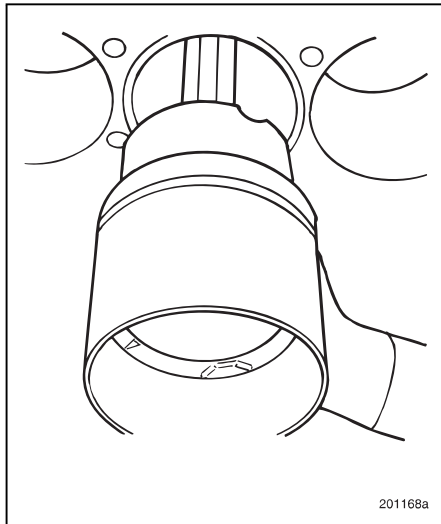


Figure 6-24 — Piston and Connecting Rod Installation

6. Carefully slide tool downward while guiding rings into the ring grooves.
7. Continue sliding tool downward until it contacts the surface on which the piston crown is resting.

NOTE

MACK E7 6-cylinder engines use a special type of connecting rod bearing. Each bearing half has a different thickness. The upper (rod) bearing half is thicker than the lower (cap) half. This design increases the load-carrying capacity of the upper bearing and provides longer bearing life.

CAUTION

The hole in the upper connecting rod bearing must be aligned with the oil passage in the connecting rod. Otherwise, damage to the bearing, rod and crankshaft journal will result.

8. Position an upper (rod) bearing into the connecting rod. Align tab in the bearing with notch in the rod. Be sure that the hole in the bearing aligns with the oil passage in the rod.
9. Apply a light coat of clean engine oil to bearing surface.
10. Apply a light coat of clean engine oil to inside surface of the No. 1 cylinder sleeve.
11. With the ring compression tool in place, position piston and rod assembly into the No. 1 cylinder. The arrow and word FRONT on both the piston crown and the connecting rod must be facing the front of the engine.

CAUTION

Apply downward pressure to the ring compression tool, keeping it in contact with the cylinder sleeve, until the top ring has passed into the cylinder sleeve. Otherwise, damage to the rings may result.

12. Make sure connecting rod aligns with journal and, using a hammer handle, carefully push piston into cylinder until piston crown is below the surface of the sleeve.



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CAUTION

Do not force the piston. This indicates an incorrectly aligned ring. Remove piston, correct the problem, and reinstall.

Before pushing piston all the way down in the sleeve, check to see if piston cooling nozzle is aligned with the nozzle clearance notch provided in the lower end of the piston skirt. If it is not aligned, damage to piston or spray nozzle may result.

13. Align rod with the journal and continue pushing piston into sleeve while guiding rod end (to clear piston cooling nozzle), until rod is in position on the crankshaft journal.
14. Ensure that the correct mate to the upper rod bearing and alignment sleeves, if applicable, are positioned in the rod cap. Perform a running clearance check at this connecting rod journal before installing the next piston in Step 15.

CAUTION

Perform running clearance check after installing each piston. Damage to engine may result if clearance is not within specification.

15. After performing running clearance check, repeat above installation procedures to install the No. 6 piston.
16. Rotate crankshaft so that the journals for the No. 2 and No. 5 cylinders are at bottom dead center. Follow above installation procedures to install the No. 2 and No. 5 pistons. Repeat procedures to install the No. 3 and No. 4 pistons.

CHECKING RUNNING CLEARANCE

1. Place a section of Plastigage on the cap bearing and assemble cap to rod.
2. Apply a light coat of oil on threads of the rod cap capscrews and secure cap.
3. Torque capscrews to 150 lb-ft (203 N·m) using torque wrench J 24407 or equivalent.
4. Remove capscrews and cap, and check the bearing running clearance.
5. Using a Plastigage width chart, measure width of the Plastigage and remove it from bearing.
6. If clearance is not within specification, correct as required. Make sure to use the correct size bearing.
7. If clearance is less than specified, also check behind bearing for dirt, chips or burrs which would prevent the bearing from seating properly.
8. Reposition cap on journal. Lubricate new capscrews with clean engine oil, install the capscrews and torque to 150 lb-ft (203 N·m) using torque wrench J 24407 or equivalent.

CAUTION

If cap and rod are not properly aligned, bearing and rod damage may result.



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Refer to Figure 6-25.

9. Check rod side clearance by installing a thickness gauge between rod and side of journal at the entire parting line area.

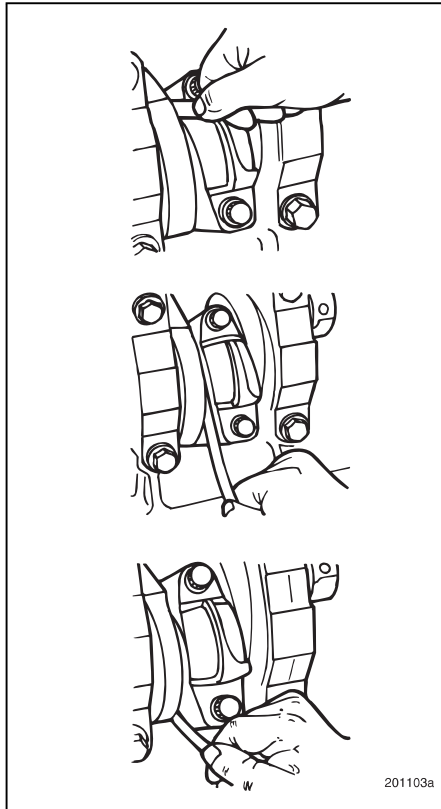


Figure 6-25 — Connecting Rod Side Clearance Check

10. The clearance must be within specification shown in the Fits and Limits chart. If not, recheck for proper cap and rod alignment.

[211 HD] FLYWHEEL HOUSING

Description

Beginning in 1991, flywheel and flywheel housings for E7 engines equipped with standard transmissions incorporate engine timing and engine turnover features. In addition, new procedures and tools were introduced and must be used to ensure optimum performance, engine durability and emission compliance.

Inspection

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

CAUTION

Before installing flywheel housing, examine crankshaft flange for any cracks, surface damage or presence of foreign particles. This type of damage could ruin the sealing capabilities of the new seal and lead to oil leakage.

Dowel Pins

The diamond locating dowel pins, used to install the front timing gear cover, flywheel, and flywheel housing, have been replaced in production by blade-style locating dowel pins. The diamond pins were dual-diameter type pins with a smaller diameter at the round end that goes into the cylinder block. The blade-style pins are the same diameter at the round end and the blade end. There are no changes in the size of the hole in the flywheel housing. However, the cylinder block has a larger hole to accept the blade-style dowel pins. The old cylinder block flywheel housing pin number is 183GC219 and the new number, starting with serial No. 2T (August 1992), is 183GC237.

Use a dowel size and type that is appropriate for the block being used. (Service old with old and new with new.) Install the blade-style dowel with the blade in a vertical direction (pointing up and down).



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Capscrews (Flywheel Housing)

A variety of lengths of flywheel housing-to-cylinder block capscrews are used. Also, different sized flat washers are used depending upon whether a ductile iron or aluminum flywheel housing is being installed. The following illustrations show where the different length capscrews should be installed in various flywheel housings.

Refer to Figure 6-26.

NOTE

On flywheel housing-to-cylinder block capscrew, No. 429GC23M, the dash suffix denotes the length of the capscrew.

- -M3 is 3 inches long, -M2 is 2-9/16 inches long, -M5 is 2-3/8 inches long, -M is 2 inches long, and -M4 is 1-3/4 inches long.

Flat washers:

- 271AM5008, approximately 3/16-inch thick. Use with ductile iron flywheel housing.
- 711GC1100P7, approximately 5/16-inch thick. Use with aluminum flywheel housing.
- 35AX1489, used with newer standardized aluminum flywheel housing.

NOTE

For standardization purposes, the E7 E-Tech™ flywheel housing castings are now being used on the E7 engine. Production phase-in began mid-October 1996. Along with the new flywheel housing, a standardization of the flywheel housing mounting hardware also took place. For all new-style housings used on the E7 engine, use the following mounting hardware:

- Two upper external mounting location capscrews — M3 (3 inches long).
- Six internal mounting location capscrews — M (2 inches long).
- Eight washers used with aluminum housing — Part No. 35AX1489.
- Eight washers used with ductile iron housing — Part No. 271AM5008.

CAUTION

Service replacement flywheel housings will be the standardized flywheel housing. If an existing, older E7 flywheel housing is replaced with the newer standardized housing, the six (429GC23M) two-inch capscrews must be used at the internal mounting locations. If the older, various-length mounting bolts are used to mount the new-style housing, thread engagement is insufficient for some of the shorter bolts, and the longer bolts bottom in the cylinder block mounting holes, causing damage to the threads. The new appropriate mounting hardware comes with the new-style flywheel housing supplied by the MACK Truck Parts System.



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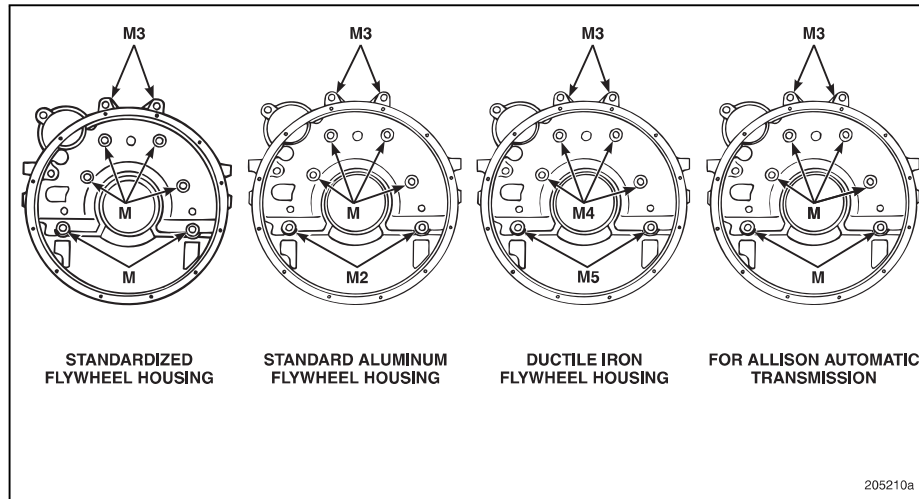


Figure 6-26 — Flywheel Housing Bolts



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Installation

1. Remove the rear crankshaft oil seal from the flywheel housing by drilling two 3-mm holes 180 degrees apart into the outer edge of the seal. Remove the seal with a slide hammer fitted with a No. 10 sheet-metal screw. Thread it into each of the holes alternately and work the seal free.
2. Using standard shop cleaning procedures for aluminum, clean the seal mounting surface.
3. Insert the two dowel pins in the cylinder block if they were removed. Refer to Figure 6-27.

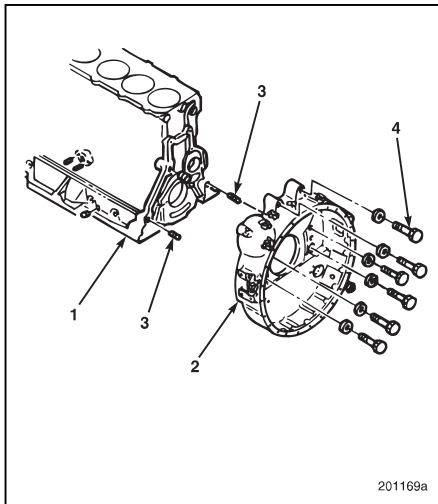


Figure 6-27 — Flywheel Housing Installation

- | | |
|---------------------|--------------|
| 1. Cylinder block | 3. Dowel pin |
| 2. Flywheel housing | 4. Capscrews |

NOTE

The flywheel housing dowels maintain the alignment of the flywheel housing on the engine. This is necessary to center the transmission with respect to the engine flywheel and crankshaft.

4. Apply an even coat of Silastic (approximately a 1/16-inch [2 mm] bead) to the flywheel housing mounting surface of the cylinder block. Refer to Figure 6-28.

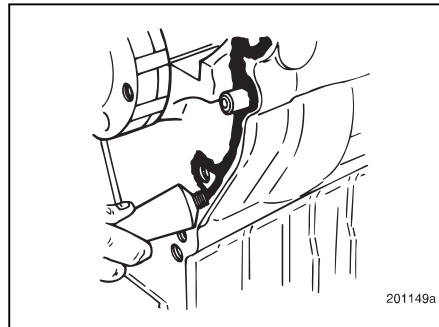


Figure 6-28 — Applying Sealant

5. Align the flywheel housing on the dowels and position it flush against the cylinder block surface. Refer to Figure 6-29.

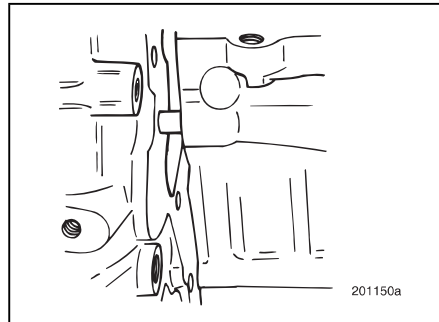


Figure 6-29 — Positioning Flywheel Housing



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6. Install the exposed flywheel mounting capscrews and tighten them finger tight.
7. Torque all flywheel housing capscrews to 170 lb-ft (231 N·m) using torque wrench J 24407 or equivalent. Refer to Figure 6-30.

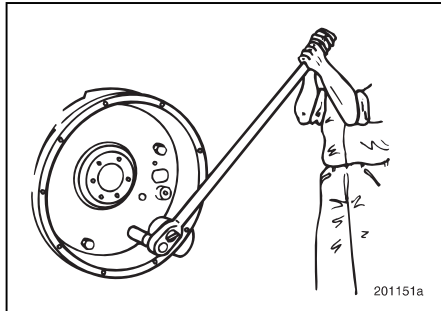


Figure 6-30 — Torquing Flywheel Housing Capscrews

Runout

With the machined dowel method of installation, flywheel housing runout is well within the old service specification of 0.010 inch (0.254 mm) Total Indicated Runout (TIR), when checked with an alignment bar through the cylinder block main bearing bores. However, when checking flywheel runout using a dial indicator on the crankshaft rear flange or the flywheel, results may exceed 0.010 inch (0.254 mm) due to factors such as crankshaft movement within the bearing clearances and other variables.

Flywheel housing runout specifications are as follows:

- Runout checked with an alignment bar installed through the cylinder block main bearing bores: 0.010 inch (0.254 mm) TIR maximum. Refer to Figure 6-31.
- Runout checked with a dial indicator mounted on the crankshaft rear flange or flywheel: 0.020 inch (0.508 mm) TIR maximum. This way, the runout may appear to be excessive due to crankshaft movement within bearings and other variables. Refer to Figure 6-32.

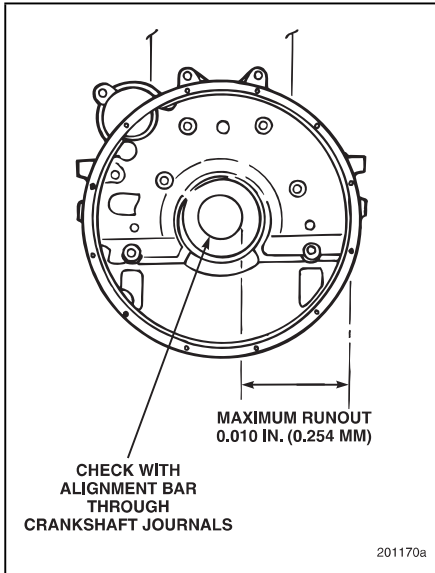


Figure 6-31 — Flywheel Housing Runout Check with Alignment Bar

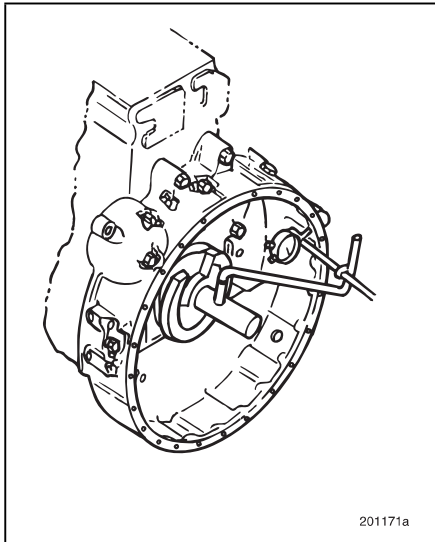


Figure 6-32 — Flywheel Housing Runout Check with Dial Indicator (PT5035) and Z adapter (PT5035-1)



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[212 JH] CRANKSHAFT WEAR RING

When the service oil seal is to be replaced and the crankshaft flange is worn, the crankshaft can be salvaged by installing a crankshaft wear ring. An oil seal with a larger inside diameter is used with this wear ring.

Special Tools Required

- Crankshaft Rear Seal Installer J 37716-A
- Wear Ring Installer J 38880
- Universal Driver Handle J 8092

Removal

CAUTION

A limited number of crankshafts were manufactured with a repair sleeve installed on the flange. The repair sleeve is usually not noticeable and is finish ground to standard flange size. If the repair sleeve is damaged or becomes loose, the crankshaft must be replaced.

Special care must be taken not to damage the crankshaft flange during wear-ring removal.

Refer to Figure 6-33.

1. The wear ring can be removed by carefully applying heat, using a ball-peen hammer to expand the diameter, or by using a chisel to split the wear ring. Use extreme care not to damage the crankshaft flange.

CAUTION

Place chisel face squarely on wear ring. Use careful blows to cut wear ring only and not damage crankshaft flange. The wear ring will become loose enough to remove without cutting it completely through. The goal is to carefully remove the wear ring in this manner and not cut, nick, or damage the crankshaft flange.

2. Thoroughly clean the flange area of the crankshaft. Check for nicks or scratches and repair any damaged areas with crocus cloth as necessary.

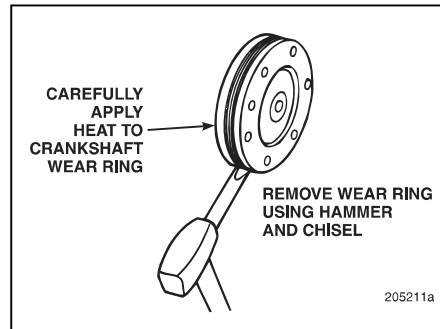


Figure 6-33 — Crankshaft Wear Ring Removal

Installation

Refer to Figure 6-34.

CAUTION

On some wear rings it may be difficult to determine the direction of the arrow on the inside diameter. In this case, ensure proper installation by installing the wear ring with the chamfer on the inside diameter toward the engine. The chamfer on the outside diameter of the wear ring must face away from the engine.

NOTE

The crankshaft wear ring is shrink fit on the crankshaft flange. Use wear ring installer J 38880 and universal driver handle J 8092 to install the ring to the proper depth.

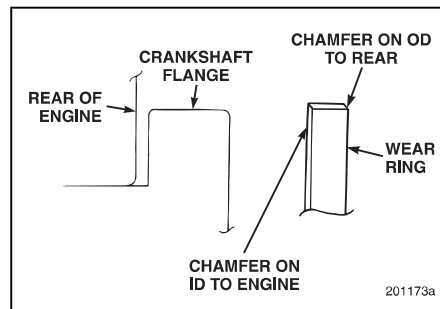


Figure 6-34 — Proper Crankshaft Wear Ring Installation



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1. Position wear ring in the spring clips of the wear ring installer J 38880 with the arrow pointing away from the installer tool.

CAUTION

Do not heat the wear ring with a torch. This type of heat source will not heat the ring evenly.

2. Heat the wear ring and wear ring installer together in a temperature-controlled oven or on a hotplate, with the wear ring on the bottom and installed in the spring clips of the installer. Work as close as possible to the engine to avoid heat loss after heating ring. Heat to 400°F (205°C). Do not install the driver handle at this time. This allows the wear ring to maintain sufficient heat until it is fully installed on the crankshaft flange.
3. Thoroughly clean and dry the crankshaft oil seal mounting flange.
4. After the wear ring is sufficiently heated, use heat-resistant gloves to install the universal driver handle J 8092 into the threaded hole in the center of the installation tool.
5. Remove the wear ring and installation tool from the oven or hot plate and immediately position the wear ring and installation tool over the crankshaft flange until the installation tool is fully seated against the end of the flange. As the wear ring cools, it will shrink fit onto the crankshaft flange. Refer to Figure 6-35.
6. Allow the wear ring to cool completely. Then remove the installation tool.

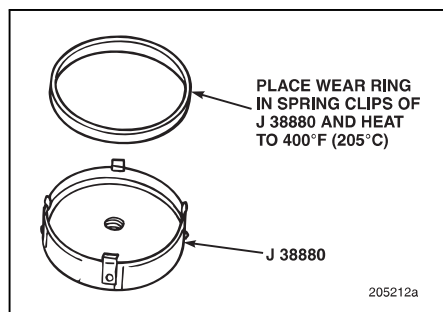


Figure 6-35 — Crankshaft Wear Ring Installation

Wear Ring with Double-Lip Teflon Seal (Automatic Transmission)

The oversize inside diameter lip seal and wear ring are shipped as an assembly, with the seal installed on the wear ring. Do not remove the seal from the wear ring prior to installation. The wet clutch wear ring and seal installer J 35529 is required for installation. This tool presses both the wear ring and the oil seal onto the crankshaft flange.

SPECIAL TOOL REQUIRED

- Wear Ring and Seal Installer J 35529

INSTALLATION

Refer to Figure 6-36.

1. Remove existing wear ring from crankshaft before installing new wear ring.
2. Thoroughly clean and dry the crankshaft flange.
3. Apply a thin, even layer of Loctite 609 to the circumference of the crankshaft flange.

NOTE

Do not lubricate the lips of a Teflon seal before installation. Teflon seals function most effectively when installed dry.

4. The lip of one side of the seal is yellow. Install the oil seal with the yellow lip toward the transmission. Position the oil seal and wear ring assembly onto the recessed side of the installation tool adapter plate with the yellow lip facing away from the direction of installation (toward the transmission).
5. Using the three guide pins, attach the oil seal installation tool adapter plate to the crankshaft flange.
6. Install the press cup over the guide pins, then install the press cup driver hex nut.



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7. Tighten the hex nut until a positive stop is felt. At that point, the oil seal and wear ring are properly installed on the crankshaft flange.
8. Remove the installation tool.

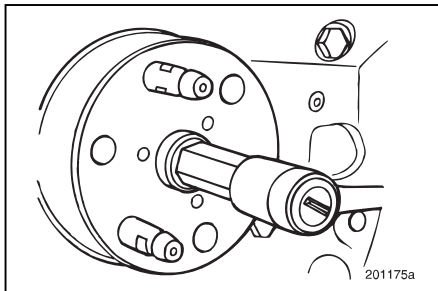


Figure 6-36 — Crankshaft Wear Ring (with Double-Lip Teflon Seal) Installation Using J 35529

[212 JH] CRANKSHAFT REAR OIL SEAL

In November 1992, MACK introduced Teflon oil seals into E7 production. E7 engines with dry flywheel housings (standard transmission) use single-lip seals. Replacement seals are available in Viton or Teflon. Viton seals are available with an oversized inside diameter and the wear ring is installed in the seal. E7 engines with wet flywheel housings (automatic transmission) use double-lip seals, which are available in Teflon only.

Installation

Standard-size Teflon seals are shipped on a plastic installation sleeve. Do not remove the sleeve from the seal before installation. The installation sleeve provides a smooth surface for the seal as it moves from the tool to the crankshaft flange.

Crankshaft design allows the single-lip seal to be installed at the production depth of 0.344 inch $\pm$ 0.005 inch (8.74 mm $\pm$ 0.127 mm), or a service depth of 0.250 inch $\pm$ 0.005 inch (6.35 mm $\pm$ 0.127 mm) from the outer edge of the crankshaft flange.

The double-lip seal must be installed to a depth of 0.250 inch $\pm$ 0.005 inch (6.35 mm $\pm$ 0.127 mm) only. This is the only installation depth specified for a double-lip seal.

Special handling precautions must be taken while installing Teflon seals. Do not lubricate the lips of a Teflon seal before installation. Teflon seals function most effectively when installed dry.

1. Thoroughly clean the surface of the crankshaft flange.
2. Position the oil seal (2) and installation sleeve (3) onto the recessed side of the J 37716-B oil seal installation tool adapter plate (1). The single-lip seal must be installed with the lip toward the engine. Refer to Figure 6-37.

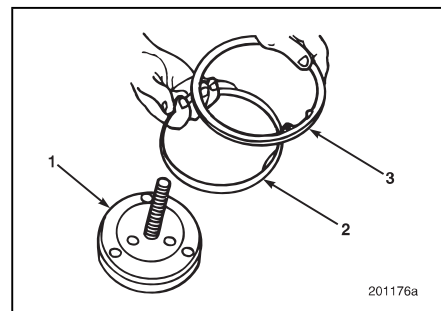


Figure 6-37 — Crankshaft Rear Oil Seal Installation

- | | |
|--------------|------------------------|
| 1. J 37716-B | 3. Installation sleeve |
| 2. Oil seal | |

3. Using the three guide pins, attach the adapter plate to the crankshaft flange. Refer to Figure 6-38.

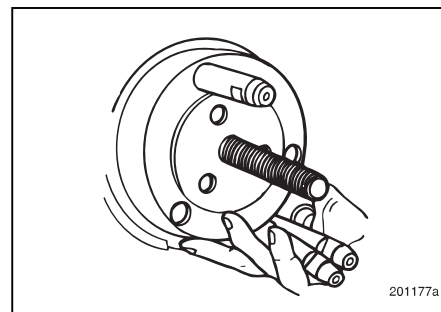


Figure 6-38 — Adapter Plate J 37716-B Installation



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4. Determine the seal and wear ring installation depth:
 - New seal on new crankshaft — Install to initial production depth of 0.339–0.349 inch (8.611–8.865 mm).
 - New seal on service crankshaft — Install to service depth of 0.245–0.255 inch (6.223–6.477 mm).
 - Wear ring installation depth — 0.15–0.220 inch (5.461–5.588 mm).
 - Service oil seal installation depth with new wear ring — 0.339–0.349 inch (8.611–8.865 mm).
 - Service oil seal installation depth with used wear ring — 0.245–0.255 inch (6.223–6.477 mm).
5. The two installation depths are stamped above two of the guide pin bores of the installation tool press plate. To install the seal to the desired depth, position the press plate so that the guide pins go through the bore stamped with the desired depth.
6. Install the press plate driver hex nut and continue tightening until a positive stop is felt. At this point, the seal is installed to the proper depth.
7. Remove the installation tool.

Refer to Figure 6-39.

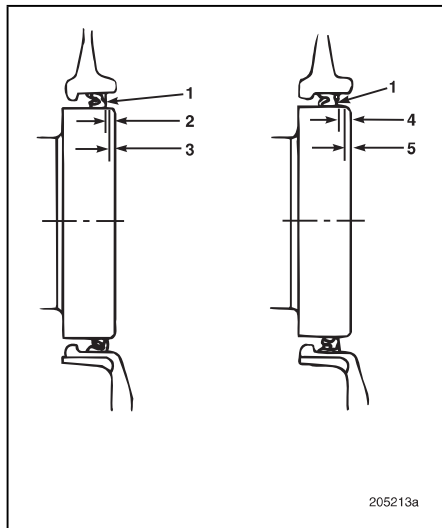


Figure 6-39 — Crankshaft Rear Oil Seal

- | | |
|--|---|
| 1. Crankshaft rear oil seal | 4. Service oil seal installation depth with wear ring |
| 2. Production installation depth | 5. Wear ring installation depth |
| 3. Service oil seal installation depth | |



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[212 VC] FLYWHEEL (E7 ENGINE WITHOUT POINTER ON TIMING COVER)

Description

The flywheel has a stamped timing scale of TDC to 45 degrees of engine travel for setting and checking injection pump to engine timing. It also has three stamped locations, 120 degrees apart, for valve settings.

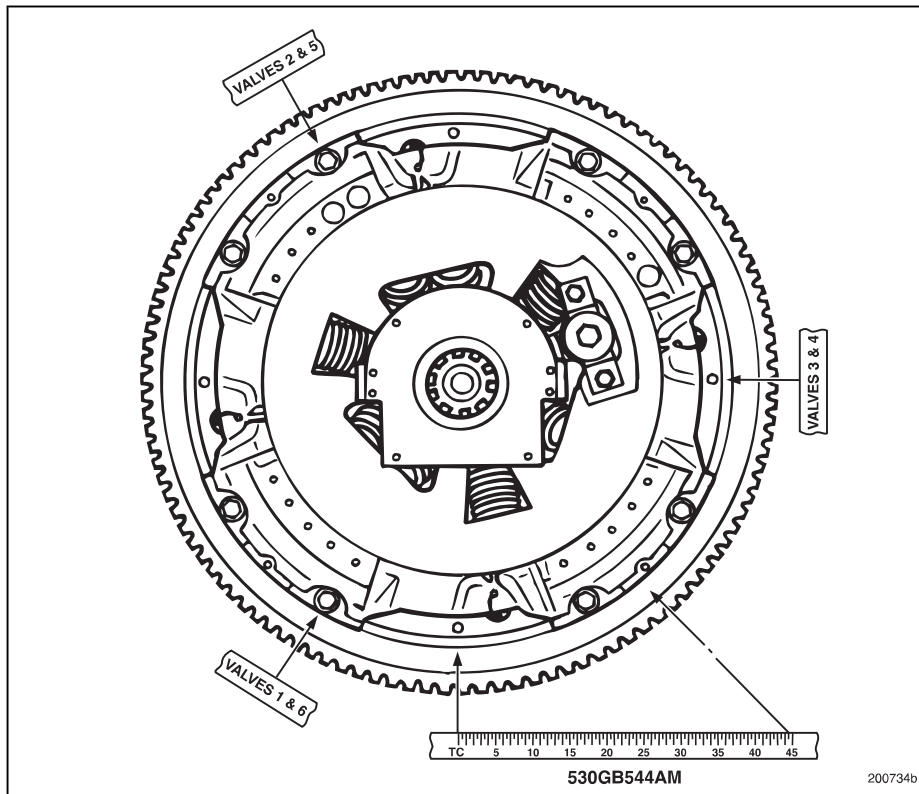


Figure 6-40 — Flywheel Markings



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Installation

CAUTION

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

SERVICE HINT

When installing the flywheel, insert two alignment studs into the flywheel mounting holes to aid in installation.

Refer to Figure 6-41.

1. Position the flywheel on the rear of the crankshaft at the flywheel mounting surface.
2. Install flywheel mounting capscrews in the exposed mounting holes. At this time, tighten the capscrews finger tight only.
3. Remove the two alignment studs and insert the remaining mounting capscrews.

CAUTION

Do not torque capscrews adjacent to each other in sequence as uneven flywheel alignment may result. Alternately torque capscrews on opposite sides of the flywheel.

4. Torque the capscrews to 185 lb-ft (251 N·m), alternating from opposite sides to apply even pressure to the flywheel (use torque wrench J 24407 or equivalent).

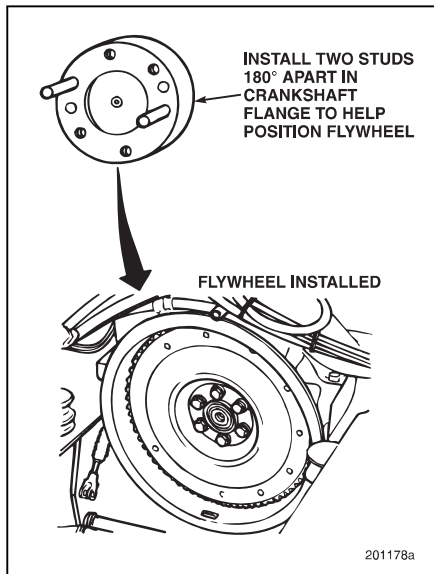


Figure 6-41 — Flywheel Installation



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[213 CH] CAMSHAFT

Description

Refer to Figure 6-42.

The E7 camshaft design uses large journals to decrease bearing loading and to allow for larger, more durable cam lobes. In addition, the profile of the exhaust lobes has been changed (with part No. 5205) to increase the duration of exhaust valve opening. Both the camshaft driven gear and the fuel injection pump driving gear are pressed onto the shaft.

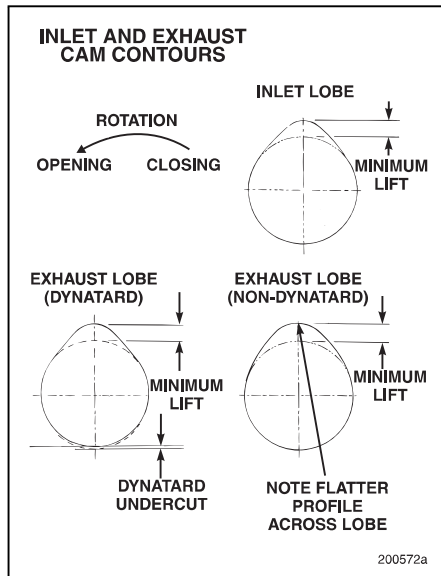


Figure 6-42 — Camshaft Contours

MINIMUM ACCEPTABLE CAM LOBE LIFT		
Camshaft Part No.	Exhaust Lobe	Intake Lobe
454GC583, 454GC583A	0.300 inch (7.62 mm)	0.300 (7.62 mm)
454GC5142	0.300 inch (7.62 mm)	0.270 inch (6.86 mm)
454GC5205	0.300 inch (7.62 mm)	0.280 inch (7.112 mm)

Special Tools Required

- Tappet Holders J 37720-B
- Camshaft Removal/Installation Tool J 41461

Inspection

1. Thoroughly clean the camshaft.
2. Inspect the camshaft cam lobes. Replace the camshaft if cam lobes show evidence of cracking, pitting or scoring.

NOTE

To provide increased duration for the exhaust valve opening, the exhaust lobe profile for cam part No. 5205 is flatter across the nose portion compared to traditional MACK cams. Do not misinterpret this flatter profile design as an improperly machined or worn lobe. The 5205 cams can be identified by the 3 grooves in the shaft between the No. 11 and No. 12 lobes. Refer to Figure 6-43.

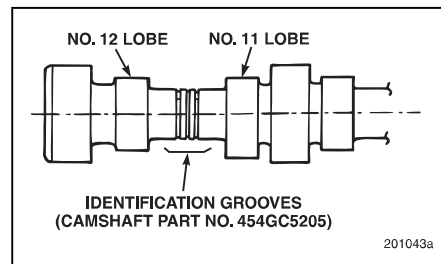


Figure 6-43 — Camshaft Identification, Part No. 454GC5205

3. Inspect the journals. Replace the camshaft if the journals are scored or worn.
4. Use standard magnaflux inspection procedures to detect cracks.



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Installation (Engine in Stand)

1. With the cylinder block in the stand, rotate the stand so that the crankcase is upward (engine inverted).
2. Rotate the crankshaft so that the drive gear timing mark is aligned with the camshaft opening. Refer to Figure 6-44.

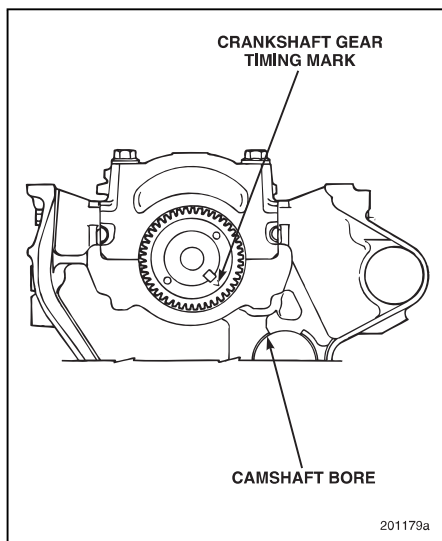


Figure 6-44 — Crankshaft Drive Gear Alignment

NOTE

Arrange valve lifters so that they can be identified and reinstalled into the same hole from which they came.

3. Clean the valve lifters, lubricate by dipping the shaft of the valve lifter in clean engine oil, and insert into the valve lifter holes in the block.

NOTE

Visually check the camshaft to be sure that the two camshaft gears and the captured thrust washer are in place on the shaft.

4. Lubricate the camshaft journals and the camshaft bearing surfaces with clean engine oil.

Refer to Figure 6-45.

5. Carefully insert the camshaft into the block using installation guide tool J 41461. Align the timing marks on the camshaft with the timing mark on the main crankshaft drive gear.

NOTE

The use of the installation tool will make it easy to slide the camshaft into the block while protecting the cam and bushings from damage.

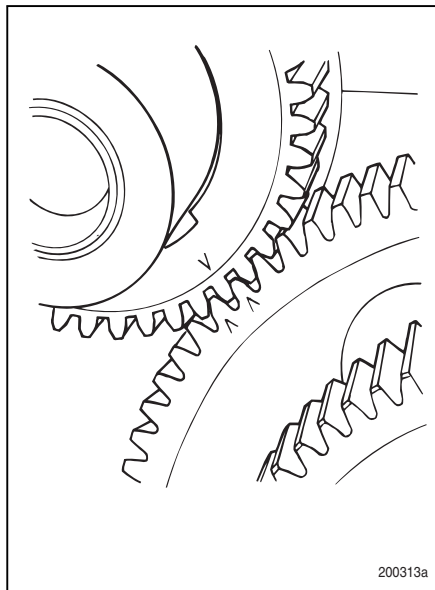


Figure 6-45 — Alignment of Timing Marks

6. Secure the camshaft captured thrust washer to the block using the two patch-lock 12-point capscrews and hardened washers. Torque to 15 lb-ft (20 N•m) using torque wrench J 24406 or equivalent.



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Installation (Engine in Chassis)

NOTE

In order to use the valve lifter tool to hold the valve lifters in position, the cylinder heads must be installed on the engine.

Arrange valve lifters so that they can be identified and reinstalled into the same hole from which they came.

1. Rotate the crankshaft so that the drive gear timing mark on the drive gear is aligned with the camshaft opening. Refer back to Figure 6-44.
2. Clean the valve lifters. Lubricate valve lifters by dipping the shaft in clean engine oil.

CAUTION

With the engine in the chassis, the valve lifters must be held in the UP position, using tappet holders J 37720-B.

3. Insert the valve lifter into the valve lifter holes provided in the block. As the lifter is installed, it must be held in position by inserting a tappet holder into the opening through the top of the cylinder block. The tappet holder must be positioned so that the magnetic head of the tool holds the lifter in position. Check to see if the tool has captured the valve lifter by drawing upward on the tool. A resistance will be felt that cannot be felt if the magnet has contacted something other than a valve lifter.
4. Secure the lifter in the UP position with grommets provided in the tappet holder. The holding tool shafts of two adjacent valve lifters can be prevented from dropping by wrapping a rubber band around the two shafts. This draws the shafts together and holds them in position. Refer to Figure 6-46.

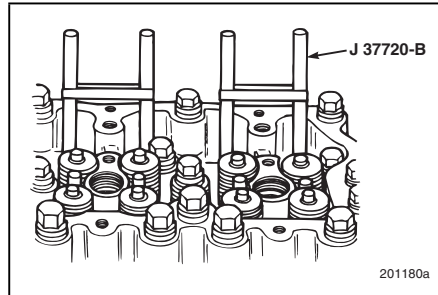


Figure 6-46 — Tappet Holder Tool

5. Perform steps 3 and 4 on each of the remaining valve lifters.

CAUTION

Visually check the camshaft to be sure that the two camshaft gears and the captured thrust washer are in place on the shaft.

Refer to Figure 6-47.

6. Insert camshaft removal/installation tool J 41461 (3) into position on the rear segment of the camshaft (1) by snapping the clip (2) into position.

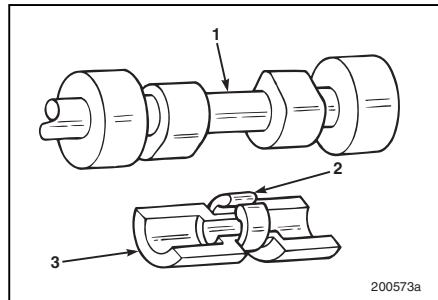


Figure 6-47 — Camshaft Removal/Installation Tool

- | | |
|-----------------------------|---|
| 1. Rear segment of camshaft | 3. Camshaft installation/removal tool J 41461 |
| 2. Tool retaining clip | |



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7. Lubricate camshaft journals and camshaft bearing surfaces (in cylinder block) with clean engine oil.

NOTE

Do not rotate camshaft with the installation tool in position on the shaft. The tool must remain on the bottom of the shaft (6 o'clock position) or it will not function properly.

8. Carefully insert camshaft into the block with the camshaft installation tool in place. Align timing marks on the camshaft with timing mark on the main crankshaft drive gear. Refer back to Figure 6-45.

NOTE

The use of the installation tool will make it easy to slide the camshaft into the block while protecting the cam and bushings from damage.

Refer to Figure 6-48.

9. Secure camshaft captured thrust washer to the block using the two patch-lock 12-point capscrows (3) and hardened washers. Torque to 15 lb-ft (20 N•m) using torque wrench J 24406 or equivalent.

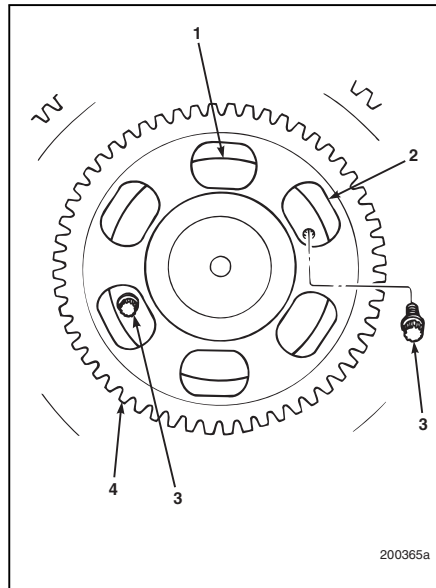


Figure 6-48 — Camshaft Installation

1. Thrust washer	3. Capscrow, 12-point
2. Openings	4. Camshaft drive gear

10. Remove the camshaft removal/installation tool.



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[212 CV] AUXILIARY DRIVESHAFT

CAUTION

Current production engines (effective February 27, 1992, serial No. 2E1233) feature an improved "fast ratio" auxiliary driveshaft assembly and oil pump assembly. This arrangement increases operating oil pressure by approximately 25% and creates a change in the oil pump speed. Do not mix ratios. Refer to Oil Pump assembly procedures in this section for part number information.

Inspection

1. Using standard shop procedures, thoroughly clean auxiliary driveshaft.
2. Inspect auxiliary driveshaft journals, gear teeth and splines for evidence of cracks, pitting, scoring or severe wear. Replace auxiliary driveshaft if any of these conditions exist.
3. Use magnaflux (PT7190 or equivalent) inspection procedures to detect cracks.

Installation

- Fast Ratio, 1.5:1, part No. 453GC381M (18 teeth)
- Standard Ratio, 1.3:1, part No. 453GC379AM (17 teeth)

Refer to Figure 6-49.

CAUTION

Purchase the auxiliary driveshaft as an assembly only. Do not try to dismantle or rework as it may result in damage to the engine.

It is possible to assemble an auxiliary driveshaft with a fast ratio oil pump drive gear (5) and a standard ratio oil pump drive. Do not mix a 1.5 fast ratio assembly with a 1.3 standard ratio assembly. Damage to the engine will result.

1. Lubricate front auxiliary driveshaft journal (2), rear auxiliary driveshaft journal (4) and shaft bearings (in cylinder block) with clean engine oil.
2. Install shaft (3) into the rear of auxiliary driveshaft housing. Take care when aligning shaft through rear bearing (1).

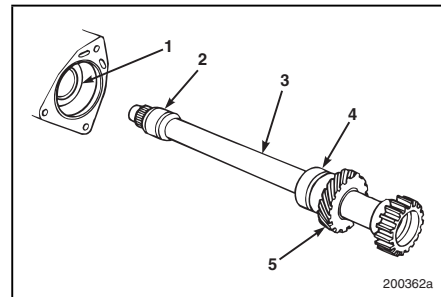


Figure 6-49 — Auxiliary Driveshaft Installation

- | | |
|---------------------------------------|--------------------------------------|
| 1. Rear bearing | 4. Auxiliary driveshaft rear journal |
| 2. Auxiliary driveshaft front journal | 5. Oil pump drive gear |
| 3. Shaft | |



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Refer to Figure 6-50.

3. Install thrust washer (4) and secure it in position with the patch-lock capscrews (3) and hardened washers.
4. Torque the thrust washer retaining patch-lock capscrews to 15 lb-ft (20 N·m) using torque wrench J 24406 or equivalent.
5. Install auxiliary driveshaft gear (2) on shaft splines (5).

NOTE

The auxiliary driveshaft and nut threads must be clean and dry before assembly. Clean the threads thoroughly with Brakleen® or electrical contact cleaner. Apply Loctite® 271 or 277 to the threads and install the nut.

6. Install auxiliary driveshaft nut (1) and torque to 300 lb-ft (407 N·m) using torque wrench J 23775-01 or equivalent.

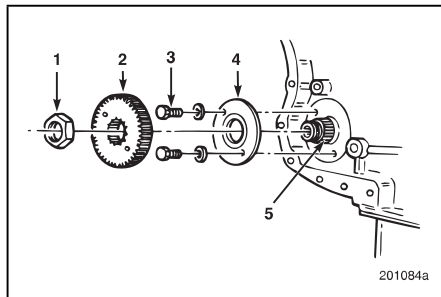


Figure 6-50 — Auxiliary Driveshaft Gear Installation

- | | |
|------------------------------|------------------|
| 1. Nut | 4. Thrust washer |
| 2. Auxiliary driveshaft gear | 5. Shaft splines |
| 3. Capscrew | |

[219 MU] OIL PUMP

Description

The oil pump is a gear-type pump. As the pump rotates, a vacuum forms on the inlet side, drawing oil from the crankcase through the oil pump inlet pipe, and into the pump gear compartment. Oil then passes through the regulating valve. Regulated pressure then forces oil through the discharge port into a drilled passage in the cylinder block, which leads to the oil filter and cooler. The oil is then distributed to all main parts of the engine. If the oil filter is excessively contaminated, the filter bypass valve will open, allowing the unfiltered, contaminated oil to continue through the engine.

Oil fed to the main bearings also travels through the connecting rods into the piston wrist pins to lubricate the pistons and cylinder sleeve surfaces. Oil jets below the pistons, also fed by the oil pump, spray the bottom of the pistons with the pressurized oil to assist in removing some of the heat from the pistons produced by combustion. Oil is then returned, by gravity, to the crankcase.

CAUTION

Do not mix standard-ratio oil pumps with fast-ratio pumps. Damage to the engine will result.

Current fast-ratio oil pumps:

- Part No. 315GC459AM, with rear sump
- Drive gear, No. 683GB284 (12 teeth)

Former standard-ratio oil pumps:

- Part No. 315GC460M, with rear sump
- Drive gear, part No. 683GB287 (13 teeth)

NOTE

Make sure the oil pump is in satisfactory condition as described in the BENCH PROCEDURES section of this manual.



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Installation

Refer to Figure 6-51.

1. Position the oil pump (1) on the cylinder block (3).
2. Secure the pump in position using the mounting capscrews (2). Torque the mounting capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.

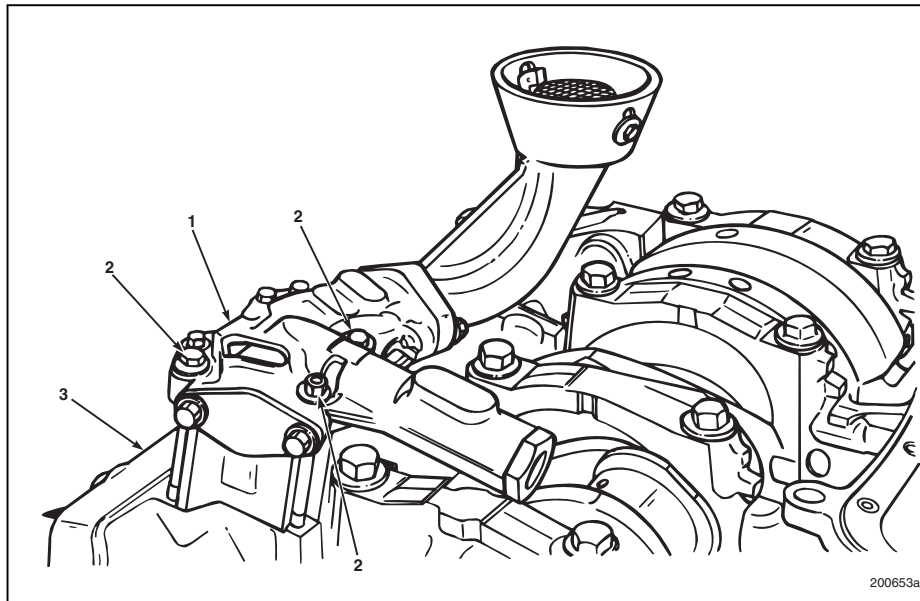


Figure 6-51 — Oil Pump Installation

1. Lubrication oil pump
2. Mounting capscrews

3. Cylinder block



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CAUTION

Apply Loctite® 271 to all capscrews used to assemble the oil pump.

3. If the pump was disassembled and is now securely mounted in position, torque all capscrews on the pump as follows:
 - Plate, 15 lb-ft (20 N•m)
 - Sump, 35 lb-ft (47 N•m)
 - Relief valve cap, 80 lb-ft (108 N•m)
 - Housing cover, 15 lb-ft (20 N•m)

CAUTION

After the auxiliary driveshaft has been installed, check the backlash between the auxiliary driveshaft gear and the oil pump drive gear.

4. Check the oil pump drive gear to oil pump driven gear backlash, 0.0072–0.0138 inch (0.1829–0.3505 mm), using a thickness gauge between the auxiliary driveshaft gear and the oil pump drive gear.

[211 RP] TIMING GEAR COVER

With the crankshaft, camshaft and auxiliary driveshaft in place, install the timing gear cover. Remove the injection pump cover from the timing cover to allow access to the injection pump drive gear during injection pump installation.

NOTE

For all E7 engines that do not use the front timing boss, a new timing gear cover (No. 333GB5123M2) is available without the timing boss. The new timing gear cover has a reduced possibility of cracking. For E7 engines requiring front timing, the old timing gear cover (No. 333GB5123M) is still available.

1. Apply a light coat of Silastic to the timing-cover mounting surface.
2. Position the timing cover on the cylinder-block mounting surface.

NOTE

Some mounting capscrews cannot be installed until the injection pump is installed.

3. Secure the timing cover to the cylinder block using the mounting capscrews. Torque the capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
4. Position the front pedestal mount on the timing cover and secure with the mounting hardware. Torque the pedestal mounting capscrews to 70 lb-ft (95 N•m) using torque wrench J 24407 or equivalent.



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[211 SB] TIMING GEAR COVER SEAL

Special Tool Required

- Crankshaft Front Seal Installer J 37715-A

Installation

Refer to Figure 6-52.

1. To install the lip-type seal, use crankshaft front seal installer J 37715-A. Position the seal on the tool, with the solid portion of the seal outward (toward the tool).
2. Position the tool over hub and into the seal opening.

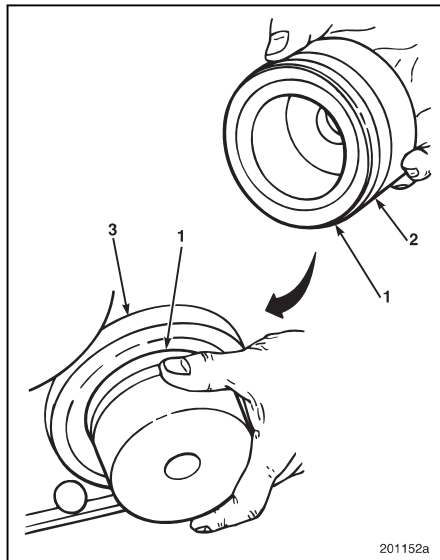


Figure 6-52 — Timing Gear Cover Seal Installation

- | | |
|-----------------------------|----------------------|
| 1. Timing gear cover seal | 3. Timing gear cover |
| 2. Seal installer J 37715-A | |

3. Insert the hub capscrew into the hole in the seal installation tool and draw the seal in until the tool bottoms out on the face of the crankshaft.
4. Remove the tool and check the seal to make sure it has been evenly installed.

[221 GP] FUEL INJECTION PUMP INSTALLATION

Refer to SETUP AND ADJUSTMENTS section under Fuel Injection Fixed-Timing Procedures for pump installation procedure.

[212 RH] CRANKSHAFT HUB

Inspection

Inspect the crankshaft hub for scoring and condition of flange, threaded holes and keyway.

CAUTION

Replace the hub if the seal shows signs of wear. Mack Trucks, Inc. does not recommend the use of a service sleeve to repair the crankshaft hub when there is hub damage. When there is damage to the hub, replace it.

Installation

Refer to Figure 6-53.

1. Insert hub key in keyway of the crankshaft.
2. Using a suitable grease-type lubricant, coat the working surface of the seal in preparation for crankshaft hub installation.

NOTE

Teflon-type seals do not require greasing the seal working surface of the crankshaft hub.

3. Heat hub to approximately 250°F (121°C) prior to installation.
4. Using heat-resistant gloves, align keyway in the hub with key in the shaft.

NOTE

When engine has flywheel timing, the crankshaft hub will not have a keyway slot.

5. In a quick, even motion, push the hub onto the crankshaft.
6. Install hub washer and capscrew. Tighten capscrew to 330 lb-ft (447 N·m) using torque wrench J 23775-01 or equivalent.



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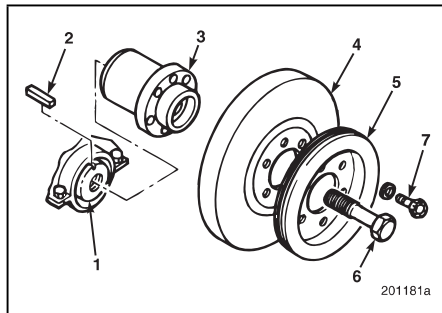


Figure 6-53 — Crankshaft Hub/Vibration Damper

- | | |
|---------------------|----------------------------|
| 1. Crankshaft | 5. Pulley |
| 2. Key | 6. Hub capscrew |
| 3. Crankshaft hub | 7. Damper/puller capscrews |
| 4. Vibration damper | |

[212 RB] VIBRATION DAMPER

Description

The vibration damper is mounted to the front of the engine crankshaft hub and secured with six capscrews. The viscous-type vibration damper consists of a flywheel (inertia mass) enclosed in a fluid-tight housing. The vibration damper flywheel and the housing are separated by a thin layer of viscous fluid that is not affected by temperature changes. Any movement of the inertia mass is resisted by the friction of the fluid, which tends to dampen excessive torsional vibrations in the crankshaft.

The vibration damper must be removed whenever the crankshaft front seal, timing gear cover or crankshaft are removed.

CAUTION

When removing or handling the vibration damper, be careful not to damage the housing. Any dents in the damper outer case may render the vibration damper ineffective. An ineffective vibration damper may result in crankshaft cracks. The vibration damper cannot be repaired.

Inspection

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

Installation

1. Position the vibration damper and drive pulley on the crankshaft hub.
2. Secure with six mounting capscrews. Torque screws to 45 lb-ft (61 N·m).

[211 NB] OIL PAN

Description (Isolating Oil Pan Gasket on E7 Engines)

Reducing oil pan vibration is an important step in reducing engine noise and ensuring oil pan integrity, especially at the high power levels of today's engines. For this reason, the isolating oil pan gasket arrangement introduced early in 1994 will gradually be phased into all engine and chassis models.

Most noticeable among the changes in this arrangement are the use of a 1/4-inch (6.35 mm) thick rubber gasket and the elimination of the reinforcement strip on the pan rail and the belly bands on the oil pan. The thicker, more conformable isolating gasket will substantially improve sealing, especially over a long period of time.

Serviceability is also improved. When the oil pan is removed, unlike the fiber gasket, it is not necessary to scrape the gasket from the cylinder block and the oil pan. In fact, the new gasket, in most cases, can be reused.



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Other changes include the use of new shouldered oil pan bolts which bottom on the cylinder block rather than the oil pan, and rubber isolators installed between the heads of the pan bolts and the oil pan. Together, these isolators and the isolating gasket eliminate metal-to-metal contact between the bolts and the oil pan, significantly

reducing the amount of engine vibration transmitted to the pan.

The illustration below, Figure 6-54, shows both the fiber oil pan gasket arrangement and the new isolating gasket arrangement.

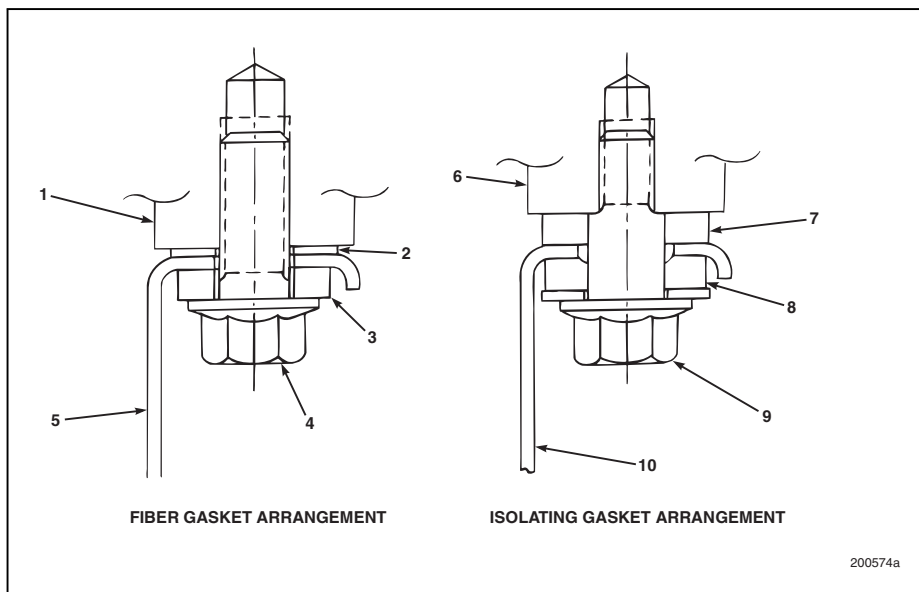


Figure 6-54 — Oil Pan Gasket Arrangements

1. Old cylinder block
2. Fiber gasket
3. Steel reinforcement strip
4. Flange head screw
5. Oil pan

6. New cylinder block
7. New thicker gasket
8. Isolator
9. New flanged bolt
10. Isolator oil pan



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With the new isolating oil pan gasket arrangement, the mounting holes tapped into the cylinder block, timing gear cover, and flywheel housing are now 8 mm rather than 10 mm. The illustration below, Figure 6-55, shows the newer production arrangement.

NOTE

The fiber oil pan gasket can be used on engines with either 8-mm or 10-mm tapped mounting holes. The isolating oil pan gasket may only be used on cylinder blocks with 8-mm tapped holes.

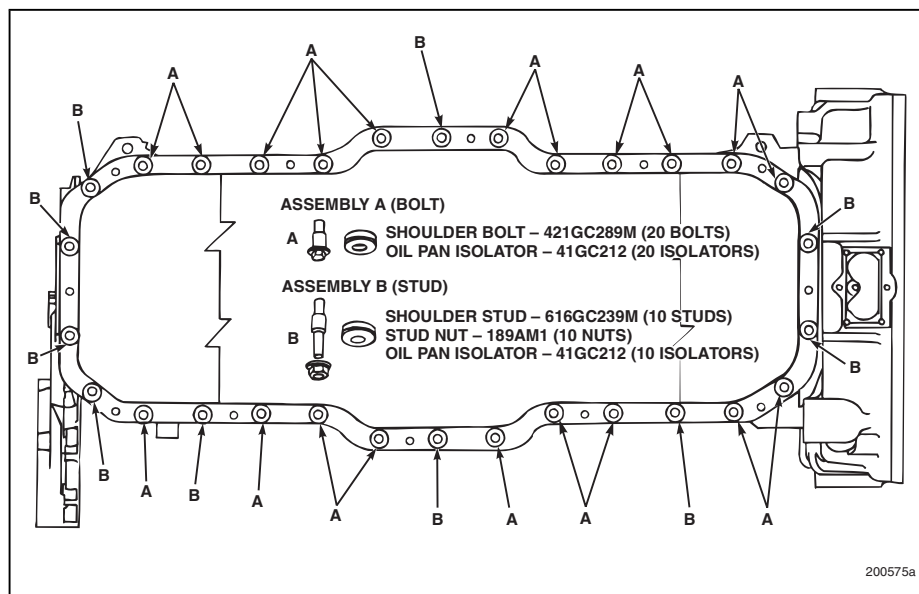


Figure 6-55 — Oil Pan Stud Identification



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The isolating oil pan gasket contains 12 integral locating/retaining cones which lock into holes drilled through the oil pan rails, and two large rectangular tabs located directly across from each other on the inner perimeter of the gasket. The cones keep the gasket properly located during oil pan installation, and the rectangular tabs serve as a starting point for locating the gasket on the oil pan rail.

CAUTION

When servicing an E7 engine with an isolating oil pan arrangement, avoid using an engine stand that supports the engine on the oil pan rail while the oil pan is still installed. Damage to the oil pan, pan gasket or the isolators may result. If this type of stand must be used and the oil pan is to remain installed, support the engine on the pads provided at each corner of the cylinder block as shown in Figure 6-56.

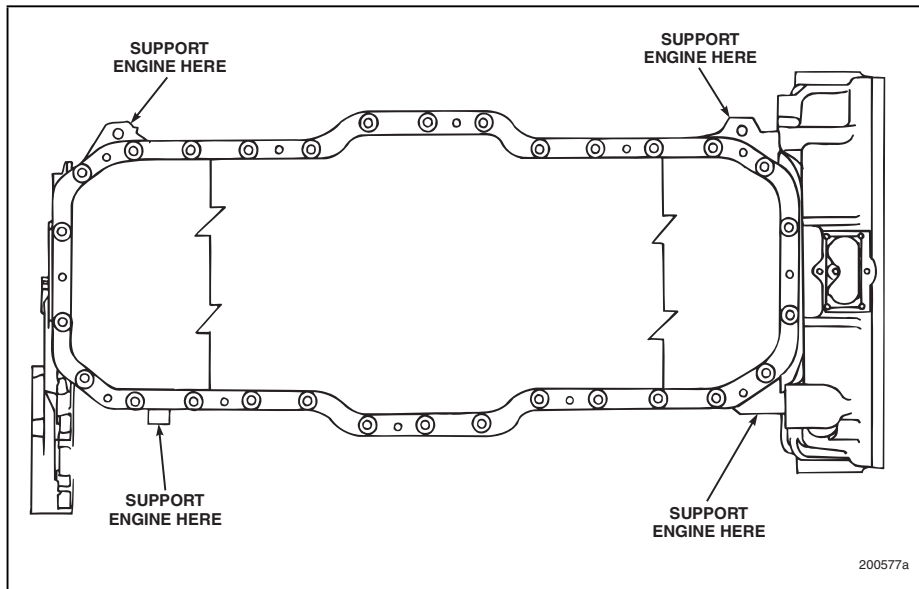


Figure 6-56 — Oil Pan Support Locations



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Oil Pan Installation

1. Clean any oil from the cylinder block mounting surface and the oil pan rail. The oil pan must be installed dry.

CAUTION

Oil on the surface of the gasket or the rails of the cylinder block and oil pan during oil pan installation can cause the gasket to bulge out between any two bolts, particularly those at the mid-section corners. This condition may not occur immediately, but can do so at any time after installation. To avoid this occurrence, wipe any oil from the inner walls of the cylinder block crankcase and then clean the rails of the cylinder block and oil pan with a solvent such as lacquer thinner. Dry the cleaned surfaces completely.

2. Position the isolating oil pan gasket on the oil pan rails with ribbed side facing up.
3. Beginning at the center of the pan at one of the rectangular tabs, align rubber locating cones with corresponding holes in the oil pan rails.
4. In one motion, firmly press upper portion of the gasket with one hand while carefully pulling the rubber cone through the hole with the other hand until seated. Continue this procedure for the remaining locating cones.
5. After all cones have been installed, recheck to ensure they are all properly seated.

NOTE

During removal of the isolating oil pan from the engine, the studs may have backed out while loosening the stud nuts. Be sure they are fully seated prior to installing oil pan.

6. When installing oil pan onto the engine, center the pan before tightening fasteners so that the edges of the metal isolator washers do not touch the pan. Refer to Figure 6-57.

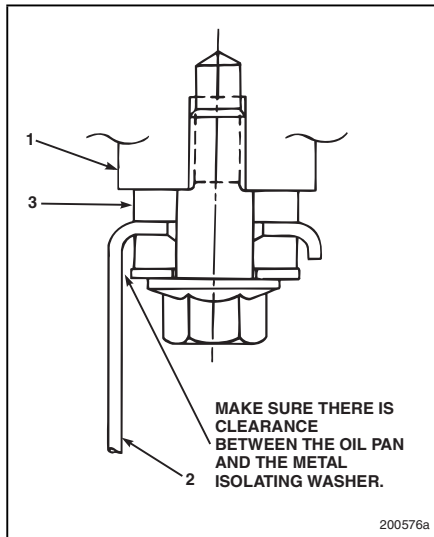


Figure 6-57 — Checking Clearance

- | | |
|-------------------|------------------|
| 1. Cylinder block | 3. Rubber gasket |
| 2. Oil pan | |

OIL PAN INSTALLATION WITH NEW E7 CYLINDER BLOCKS

Part numbers for E7 cylinder blocks with 8-mm tapped holes in the pan mounting rail are listed below. These are the service replacements for cylinder blocks with 10-mm tapped holes in the cylinder block oil pan rail.

- Cylinder Block Assembly No. 239GB5517M
- Cylinder Block Service Assembly No. 239GB5494C

With the introduction of these cylinder blocks, blocks with the 10-mm tapped holes in the cylinder block oil pan rail are no longer available.

NOTE

The isolating oil pan gasket arrangement can only be used with cylinder blocks, timing gear covers and flywheel housings that have 8-mm tapped holes in the oil pan rail.



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OIL PAN INSTALLATION WITH NEW E7 TIMING GEAR COVER AND FLYWHEEL HOUSING

A new timing gear cover with 8-mm holes for oil pan mounting was introduced with the 1994 certified E7-427 and E7-454 engines. This timing cover is used in conjunction with the isolating oil pan arrangement, but is also the service replacement for timing covers with 10-mm tapped holes for oil pan mounting. The new style timing gear cover part No. is 333GB285AM.

New flywheel housings with 8-mm tapped holes for oil pan mounting were also introduced on engines with the isolating oil pan gasket. As with the timing gear cover, the new housings are service replacements for flywheel housings with 10-mm tapped holes for oil pan mounting.

Two types of 8-mm studs will be supplied with all new timing gear covers and flywheel housing service assemblies. One type of stud is used if the engine has a fiber oil pan gasket, and the other type is used for engines with the isolating oil pan gasket.

NOTE

When replacing a timing gear cover or a flywheel housing on an engine equipped with an isolating oil pan gasket, first remove the oil pan to prevent damaging the rubber isolating oil pan gasket.

To prevent damaging the threads in the aluminum timing gear cover and the aluminum flywheel housing, be sure to use the designated studs rather than capscrews.

- When servicing an old engine with 10-mm tapped holes in the oil pan mounting rail with a new cylinder block with 8-mm holes, reinstall the old oil pan and a new fiber oil pan gasket with 26 new 8-mm fasteners, No. 421GC293M, at the cylinder block and four 10-mm fasteners, No. 66AM4, at the timing gear cover and flywheel housing. Lubricate and torque fasteners No. 421GC293 to 24 lb-ft (33 N·m) using torque wrench J 24406 or equivalent.

- When servicing any engine with the fiber oil pan gasket (8-mm or 10-mm tapped holes in the cylinder block oil pan rail) and installing a new timing gear cover and/or a new flywheel housing, use the two standard studs, No. 107AM5019M, and two flange-head nuts, No. 191AM2, to attach the oil pan to the flywheel housing and/or the timing gear cover. Lubricate and torque stud nuts to 15 lb-ft (20 N·m) using torque wrench J 24406 or equivalent.
- When servicing any engine with the isolating oil pan gasket (8-mm tapped holes in the cylinder block oil pan rail), and installing a new timing gear cover and/or flywheel housing, use the two shouldered studs, No. 616GC239M, with two flange-head nuts, No. 189AM1, with which the engine was originally built. Lubricate and torque shoulder bolts to 15 lb-ft (20 N·m) using torque wrench J 24406 or equivalent.

[213 EV] CYLINDER HEADS

Description

Each cylinder head is a one-piece casting covering three cylinders and securely held to the top of the cylinder block by special-head bolts. The inlet and exhaust valves, fuel injection nozzles and the engine compression brake housing assemblies (if equipped) are located in the cylinder heads. Valve seat inserts and valve guides are replaceable.

Cast-iron sleeves pass through the coolant cavity of the cylinder head at the center of each cylinder. The fuel injection nozzle holder assemblies are installed in these sleeves. The sleeve design and installation provides effective cooling for the fuel injection nozzles, valves and cylinder head. This sleeve also provides a sealed passage for the nozzle return-to-tank fuel, which passes from the nozzle sleeve chamber into a drilled fuel return passage in the cylinder head and back to the fuel tank.

The air inlet, coolant and exhaust manifolds are secured to the cylinder heads. The fuel inlet lines also enter the engine at the cylinder heads.



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Installation

Ensure that the cylinder heads are in acceptable condition. Refer to the cylinder head inspection procedures in the BENCH PROCEDURES section in this manual.

NOTE

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

Refer to Figure 6-58.

1. Place the head gaskets in position on the locating pins in the cylinder block deck.

2. Place a fire ring carefully in position on top of each cylinder sleeve.

CAUTION

Check that the design of the fire ring used is the correct match for the cylinder sleeves installed. Refer to the TROUBLESHOOTING section for Proper Fire Ring/Cylinder Top Combinations.

3. Position the completely assembled cylinder heads on the cylinder block. Locate the heads into the guide pins in the cylinder block.

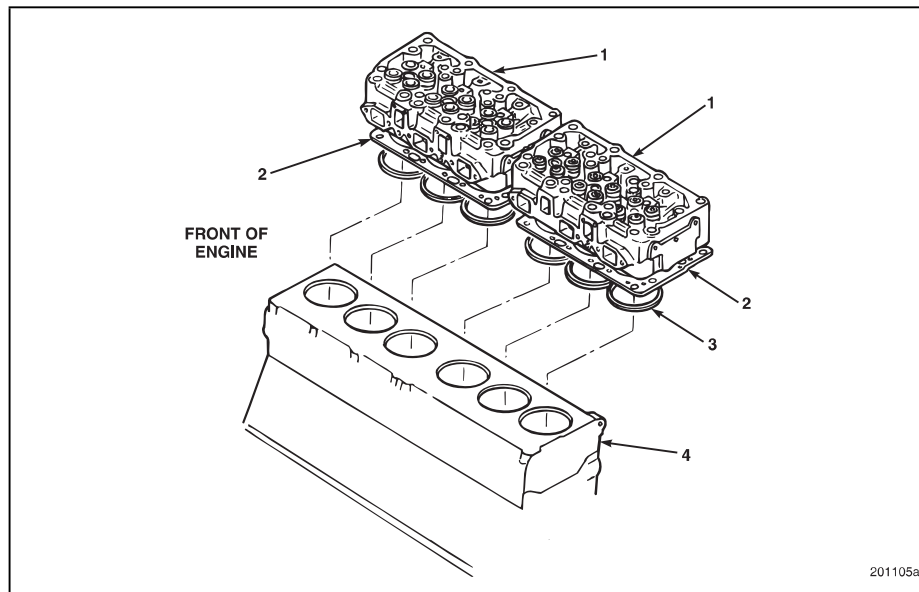


Figure 6-58 — Cylinder Head Gasket and Fire Ring Positioning

1. Cylinder head
2. Gasket

3. Fire ring
4. Cylinder block



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NOTE

Several of the head mounting capscrews have threaded holes drilled in the heads for bracket-mounting purposes. The drilled capscrews must be located in the correct positions for proper bracket installation.

There are two cylinder-head capscrew lengths: 198.0 mm and 225.0 mm.

4. Check the condition of the capscrews, lubricate the capscrew heads (underside), threads and washers with clean engine oil, and insert the capscrews in the mounting holes. Tighten all cylinder head capscrews finger tight.

NOTE

Do not install painted capscrews at locations that are under the valve cover.

Refer to Figure 6-59.

5. Check the alignment of the cylinder heads by placing a straightedge against the exhaust manifold mounting surfaces. Using a feeler gauge, measure any gaps between the straightedge and manifold mounting surfaces. The heads should be in alignment within 0.005 inch (0.127 mm). If not, reposition the heads to achieve the specified alignment.

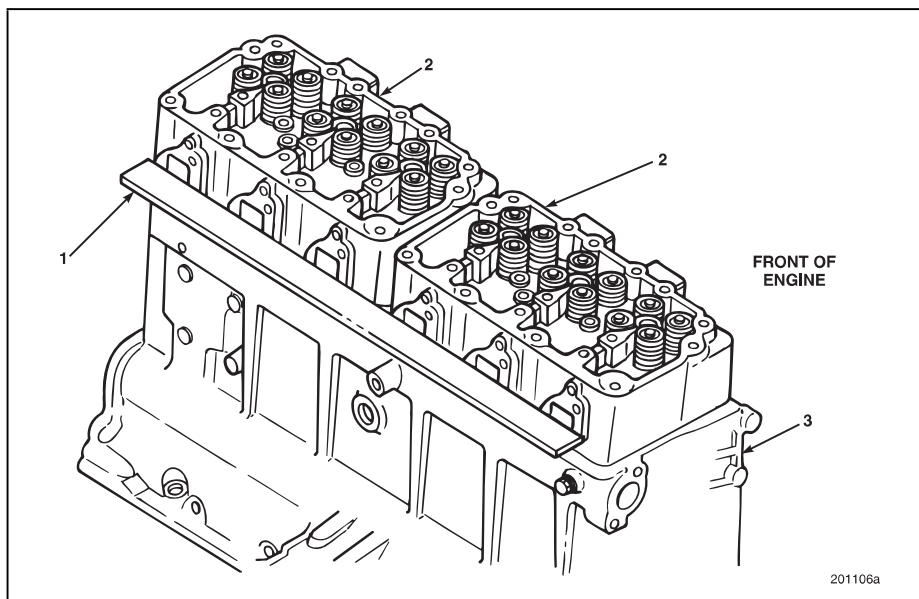


Figure 6-59 — Cylinder Head Alignment

1. Straightedge
2. Cylinder head

3. Cylinder block



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Refer to Figure 6-60.

6. Torque all head mounting capscrews in three stages to the specified torque.
 - a. Torque all head mounting capscrews in sequence to 50 lb-ft (68 N·m) using torque wrench J 24407 or equivalent.
 - b. Torque all head mounting capscrews in sequence to 125 lb-ft (170 N·m) using torque wrench J 24407 or equivalent.
 - c. Torque all head mounting capscrews in sequence to final torque value of 205 lb-ft (278 N·m) using torque wrench J 24407 or equivalent.
7. Perform the engine run-in procedure, bringing temperatures up to the normal operating range.
8. After completing the run-in procedure, retorque the cylinder head capscrews in sequence, breaking each loose one at a time and then bringing it up to the specified torque.

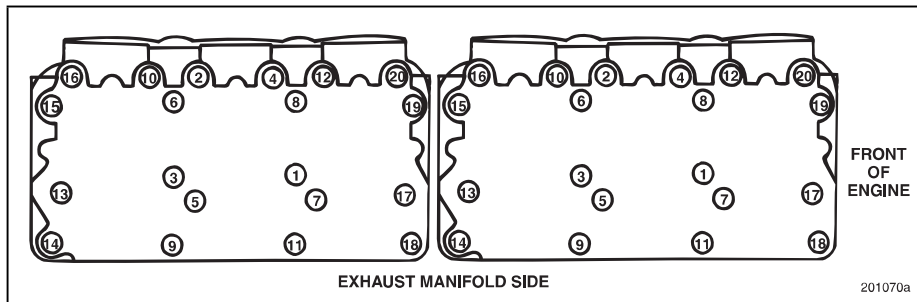


Figure 6-60 — Head Bolt Torque Sequence Chart



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[222 KG] NOZZLE HOLDER ASSEMBLY

Description

Each cylinder has a nozzle to ensure proper delivery of fuel that is metered and timed by the injection pump. The nozzle is positioned at the lower end of the nozzle holder.

The nozzle holder is positioned vertically in the cylinder head and centered in the cylinder between the four valves. The nozzle fuel inlet tube is inserted through the side of the cylinder head and the tapered end of the inlet tube seals the area between the tube and the nozzle holder. The tube is secured in position with a sleeve nut.

Special Tool Required

- Injection Nozzle Puller J 37093

Installation

1. Insert a nozzle holder gasket in the bottom of the nozzle holder hole. Refer to Figure 6-61. Make sure the washer-type gasket is lying flat in the bottom of the nozzle holder bore.

NOTE

An alternate method of installing the washer-type gasket is to hold it in place on the bottom of the nozzle with a small dab of grease instead of placing the washer in the hole.

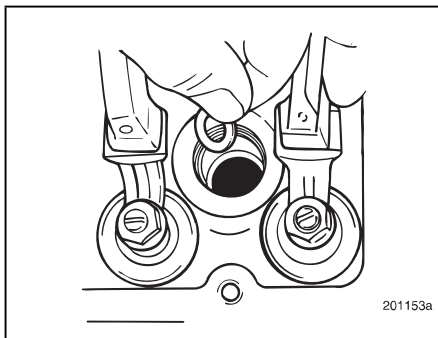


Figure 6-61 — Nozzle Holder Gasket Installation

2. Lubricate the nozzle holder surface and install O-ring on the nozzle holder.
3. Thread injection nozzle puller J 37093 into the top of nozzle holder. Refer to Figure 6-62.

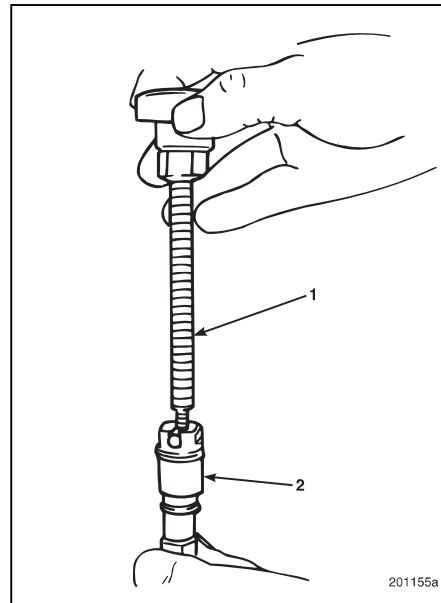


Figure 6-62 — Puller Application

1. Nozzle holder puller J 37093

2. Nozzle holder



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4. Insert nozzle holder in the nozzle holder hole. Be sure to align the locator ball in the nozzle holder with the socket in the cylinder head to ensure inlet tube alignment. Refer to Figure 6-63.

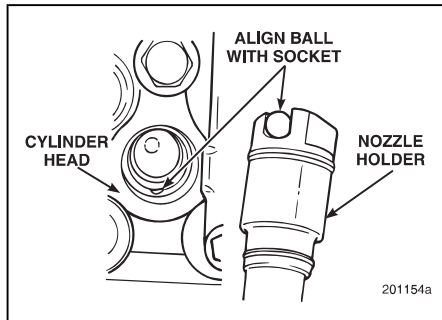


Figure 6-63 — Nozzle Holder Alignment

5. After making sure that the nozzle holder ball is properly aligned with the alignment socket in the cylinder head, push downward on the handle of the installation tool driving the nozzle holder into position. Refer to Figure 6-64.

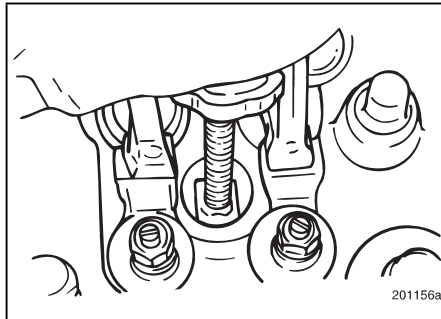


Figure 6-64 — Nozzle Holder Installation

6. Remove the tool from the nozzle holder and insert the gauge block on the end of the tool handle.
7. Insert the gauge block into the nozzle holder hole. The gauge block should be flush with the top of the cylinder head surface. Refer to Figure 6-65.
 - If the gauge block is below level, it may indicate that the gasket was omitted.

- If the gauge block is too high, it may indicate that there are two gaskets installed under the nozzle holder, or the nozzle holder has not been fully inserted.
- If a gauge block is not available, measure the distance from the top of the cylinder head to the top of the nozzle holder. The nominal measurement should be 0.564 inch (14.326 mm).

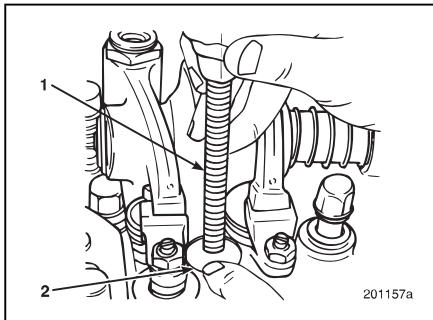


Figure 6-65 — Nozzle Holder Installation Check

- | | |
|------------------------------------|----------------|
| 1. Nozzle holder puller
J 37093 | 2. Gauge block |
|------------------------------------|----------------|

8. Lubricate the threads of the retaining plug and install in position. Torque to 45 lb-ft (61 N•m) using torque wrench J 24407 or equivalent. Refer to Figure 6-66.

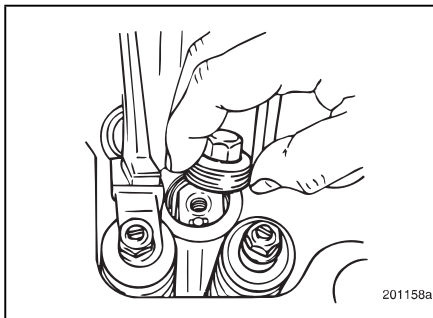


Figure 6-66 — Retaining Plug Installation



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[213 LH] VALVE LIFTER PUSH RODS

Inspection

Check the push rods. Replace any push rods that have loose ends, are bent, or show signs of excessive wear.

Identification

Refer to Figure 6-67.

The current E7 valve lifter has no hole in the center of the stem. In conjunction with this change, the E7 inlet and exhaust (nonbrake engine) push rods have a 0.060-inch (1.524 mm) maximum flat or dimple on the ball end. The push rod part number is etched or roll-stamped on the push rod.

The non-current push rod should be used only with the non-current lifter. If the non-current push rod with the wide flat or dimple is used in the current valve lifter which has no center hole, it may create an undesirable wear pattern in the lifter socket.

Mixing current and non-current valve lifters is permissible when using the correct lifter/push rod combination.

- Current push rod can be used with either valve lifter.
- Do not use non-current valve lifter to service current valve lifter.

Only Dynatard exhaust push rods are not affected and can be used with current and non-current valve lifters. Dynatard intake push rods still need to be updated to current push rods when using current valve lifters.

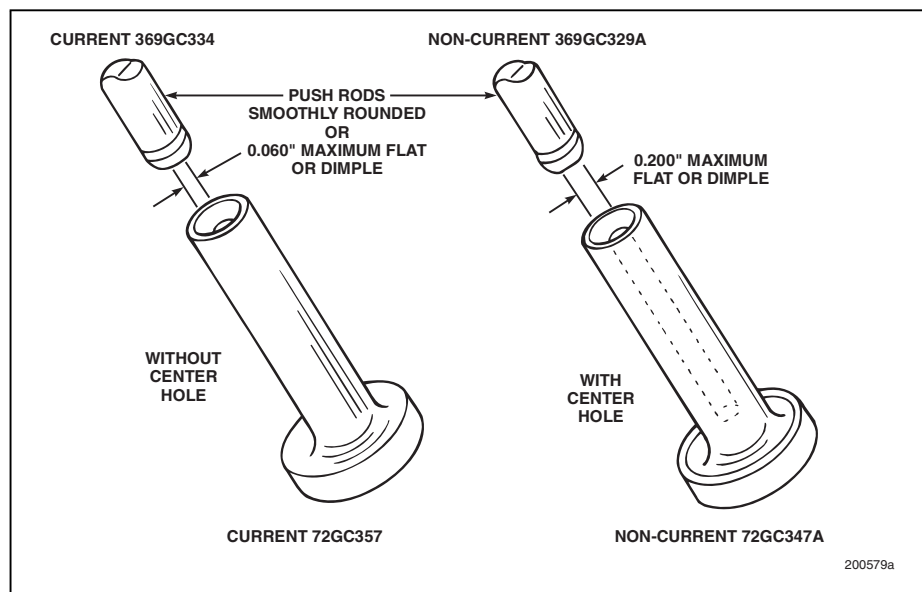


Figure 6-67 — Valve Lifter/Push Rod Identification



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All E7 production engines starting with serial No. 2X0000 and above, feature valve lifters with no hole as well as inlet and nonbrake push rods with 0.060 inch (1.524 mm) maximum flat or dimple on the push rod ball end.

Installation

NOTE

Used push rods have established wear patterns. Push rods being returned to service should be installed in the same position from which they were removed.

1. Apply lubricating oil to spherical end of the push rod and insert it into the lifter opening. Ensure that it has engaged the lifter by lifting it slightly. If the lifter has been properly contacted, some resistance will be felt in the rod as the lifter is raised.
2. Repeat step 1 until all 12 push rods are in position.

[213 NV] VALVE YOKES

Description

There are two exhaust valves and two inlet valves for each cylinder. Each rocker arm, in conjunction with the valve yoke, operates both valves together, in a set (exhaust or inlet), per cylinder.

Installation

NOTE

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

Refer to Figure 6-68.

1. Lubricate the yoke guide pins (5) with clean engine oil.

CAUTION

If the engine is equipped with a Jake Brake, the exhaust valve yokes will have a larger rocker arm contact surface. The yokes with the larger surface must be installed on pins corresponding with the Jake Brake actuators.

2. Place the valve yokes (2) on the yoke guide pins (5) from which they were removed. Slightly rock the yokes from side to side to be sure they are seated on the valve stems (4).

NOTE

Engines equipped with Jake Brake: Effective January 1994 (engine serial No. 401269), the E7 Jake Brake yoke was manufactured with metric threads utilizing the Spiralock™ thread form. Refer to Section 7, SETUP AND ADJUSTMENTS, under Valve Yoke, Valve Lash and Slave Piston Adjustments (with Jake Brake) for details regarding correct method to loosen the yoke adjusting screw.

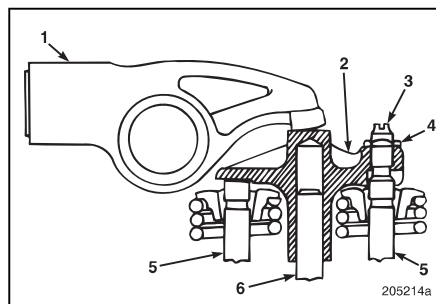


Figure 6-68 — Valve Yoke

- | | |
|-------------------------|-------------------|
| 1. Rocker arm | 4. Jam nut |
| 2. Valve yoke | 5. Valve stem |
| 3. Yoke adjusting screw | 6. Yoke guide pin |



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[213 LP] ROCKER ARMS

Description

The valve rockers pivot on a shaft supported by three brackets per cylinder head. Two capscrews secure each bracket to the cylinder head. The rocker arms are operated by a camshaft through valve lifters and push rods extending through the cylinder heads. A coil spring returns each valve to the closed position, holding the rocker arm in contact with the push rod.

Installation (Non-Brake and Dynatard Equipped Engines)

Refer to Figure 6-69.

1. Position the rocker arm assemblies on the cylinder heads.
2. Ensure that the ball end of the rocker arm adjusters are in position in the push rod cups.

CAUTION

Make sure that adjusting screws are retracted upward in the rocker arms. If extended far below rocker arm, the push rods can be bent when tightening the rocker arm assembly brackets.

3. Lubricate the threads of the rocker arm mounting capscrews with clean engine oil. Install the capscrews and torque to 40 lb-ft (54 N·m) using torque wrench J 24407 or equivalent.
4. Adjust valve and engine brake slave piston lash settings as applicable. Refer to the SETUP AND ADJUSTMENTS section in this manual for correct specification.

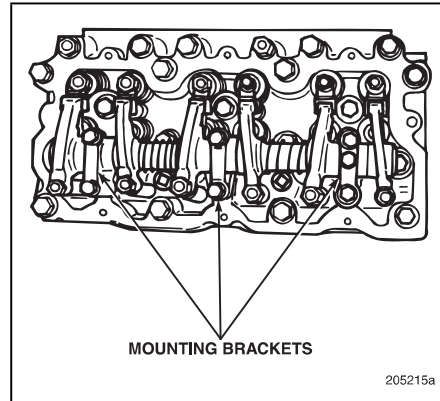


Figure 6-69 — Valve Rocker Arm Installation

Installation (Jake Brake-Equipped Engines)

CAUTION

Use only Jacobs exhaust rocker arm adjusting screws for Jacobs engine brake installation. Using a MACK or any other type of screw will result in severe screw wear and engine damage.

Jacobs exhaust rocker screws have hex heads. MACK screws have a screwdriver slot.

Refer to Figure 6-70.

Verify that Jacobs exhaust rocker arm adjusting screws are installed in the exhaust rocker arms.

Turn the screws all the way into the rocker arms from the underside. Install the MACK locknuts.

1. Install the rocker arm assemblies. Apply clean engine oil to the MACK hold-down capscrews. Install one capscrew with a washer in each bracket next to the push rods. Each rocker assembly has three brackets.



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2. Check that all push rods are in their sockets and rocker adjusting screws are backed out to prevent piston damage or bent rods.
3. Start at the center and tighten each bracket hold-down screw in two steps:
 - Torque to 20 lb-ft (27 N•m).
 - Retorque to 40 lb-ft (54 N•m).
4. Lubricate and install O-rings in the groove in the Jacobs oil supply screws. Install the screws into the rocker brackets and tighten to 5 lb-ft (7 N•m).

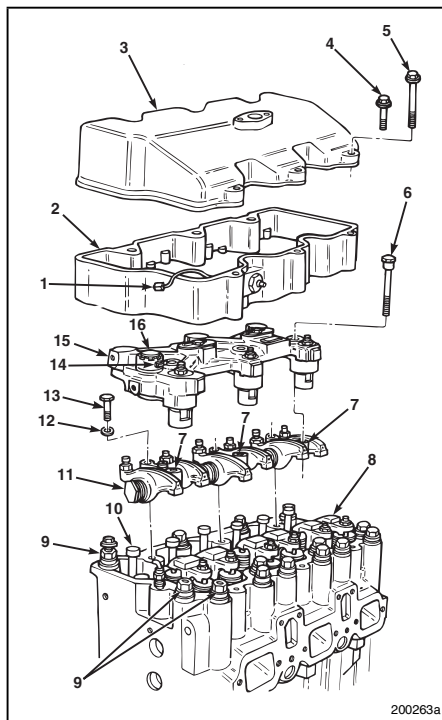


Figure 6-70 — Valve Rocker Arm Installation
(with Jake Brake)

1. Wire connector	9. Head bolt with threaded hole
2. Riser	10. Push rod
3. Valve cover	11. Rocker arm assembly
4. Short cap screw	12. Washer
5. Long cap screw	13. Cap screw
6. Actuator cap screw	14. Connector
7. Rocker arm shaft bracket	15. Actuator assembly
8. Valve yoke	16. Actuator solenoid

Brake Housing Installation

Refer back to Figure 6-70.

1. Lubricate the oil supply screw O-rings with clean engine oil.
2. Place the engine brake housing in position on the rocker arm shaft brackets. Be sure the housing marked FRONT is over cylinders 1, 2 and 3, and the housing marked REAR is over cylinders 4, 5 and 6. Position the housings so that the oil supply bores are located over the oil supply screws. Carefully push the housings down until the O-rings enter the bores and the housings rest flat against the rocker-arm shaft brackets.
3. Lubricate all six Jacobs hold-down capscrews with clean engine oil and install them through the housings and into the rocker shaft brackets.
4. Start with the center capscrew on each housing and tighten them to 20 lb-ft (27 N•m). Retorque each, starting with the center capscrew, to 45 lb-ft (61 N•m) using torque wrench J 24407 or equivalent.
5. Check for interference between rocker arm and slave piston by manually moving each rocker arm with the valves closed. Be sure to check all cylinders. If binding occurs, loosen the capscrews and reposition the housing.
6. Connect wiring to Jake actuator solenoid.
7. Adjust yoke, valve and Jake brake slave piston lash as needed. Refer to the SETUP AND ADJUSTMENTS section in this manual for correct specifications and procedures.



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[213 JB] VALVE COVER

Description

Valve cover mounting capscrews have undergone a manufacturing change. The existing mounting capscrews require two different sockets for cover installation. The new capscrews require only one socket. Note the capscrews used on your engine and replace with the same capscrews, if required.

Cylinder head cover (No. 337GB494M2) used on E7, CH 4 x 2 models with Jake Brake and air conditioning, contacts the air-conditioning expansion valve (mounted on the cab fire wall) during articulation. To eliminate this engine/cab interference condition, a new rear cylinder head cover (No. 337GB4108M) is available.

NOTE

The valve cover (and riser, if equipped with Jake Brake, Figure 6-73) requires a strip-type seal valve cover gasket, 51 inches (130 cm) in length.

Sealing compounds are not necessary.

Installation

Refer to Figure 6-71.

NOTE

Installation procedures for riser and valve cover seal are identical.

1. Install a seal strip (2) in the seal grooves (3) of the risers.
 - a. Thoroughly clean the gasket contact surface.
 - b. Install one end of riser gasket into seal groove (inboard side) approximately 1/4 inch (6.4 mm) from the end of the groove.
 - c. Guide the seal strip into the groove around the circumference of the riser. Complete installation and overlap at the starting point approximately 1/4 inch (6.4 mm) from the end of the groove.

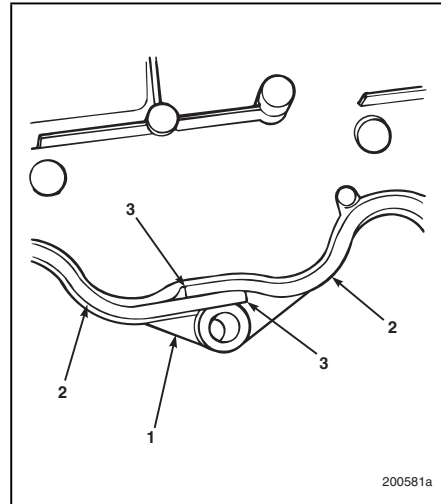


Figure 6-71 — Gasket Installation

- | | |
|----------------|----------------|
| 1. Valve cover | 3. Seal groove |
| 2. Seal strip | |

Refer to Figure 6-72.

2. Position the riser (4) on the cylinder heads.
3. Connect the actuator wire to the actuator (3).
4. Install a seal strip in the valve cover seal groove of the valve covers.
 - a. Thoroughly clean the gasket contact surface.
 - b. Install one end of valve cover gasket into seal groove (inboard side) approximately 1/4 inch (6.4 mm) from the end of the groove.
 - c. Guide the seal strip into the groove around the circumference of the valve cover. Complete installation and overlap at the starting point approximately 1/4 inch (6.4 mm) from the end of the groove.
5. Position valve covers (1) on the cylinder heads or on the risers (4), if equipped.



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6. Lubricate threads of the capscrews (2) and secure the valve covers with the lubricated capscrews. Torque capscrews to 16 lb-ft (22 N·m).

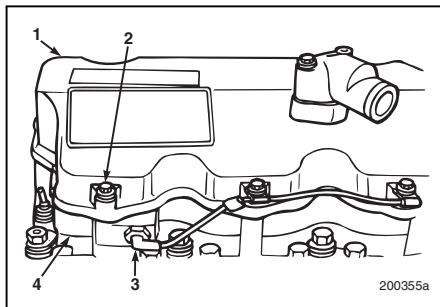


Figure 6-72 — Valve Cover Installation

- | | |
|----------------|-------------|
| 1. Valve cover | 3. Actuator |
| 2. Capscrew | 4. Riser |

[214 EG] EXHAUST MANIFOLD

Description

In March 1995, a new exhaust manifold with a thicker mounting flange was introduced into production on all E7 engines. The mounting flange on this new "low-boss" exhaust is 3/4 inch (19.1 mm) thick, compared to the 1/2-inch (12.7 mm) thick mounting flange on the previous exhaust manifolds. The new manifolds use mounting studs which are 60 mm (approximately 2-3/8 inches) long, and copper-plated flanged nuts without a locking feature.

E7 engines use a new-style exhaust manifold gasket without the stainless steel insert around the exhaust port opening as on previous gaskets. Engines with the older style exhaust manifolds must continue using the previously used "armored" exhaust manifold gasket.

NOTE

If replacing an existing manifold (on engines manufactured before March 1995) with a low-boss exhaust manifold and reusing the long studs (103 mm long), each stud requires a spacer.

When installing a low-boss exhaust manifold on a pre-1992-1/2 E7 V-MAC engine with injection line brackets fastened to the exhaust manifold, spacer and 113 mm studs are required.

The new manifold fastener arrangements do not require washers or lockplates. When installing new fasteners on an engine that uses washers and lockplates, discard those parts and replace both with the new fasteners.

Installation

Refer to Figure 6-73.

1. Install the 12 studs in position on the cylinder head.
2. Position six manifold gaskets on the studs.

NOTE

Exhaust manifold nuts must be installed dry (no lubrication).

3. Position the exhaust manifold on the mounting studs and secure with nuts. Torque the nuts to:
 - 55 lb-ft (75 N·m) for 10 mm nuts
 - 65 lb-ft (88 N·m) for 12 mm nuts



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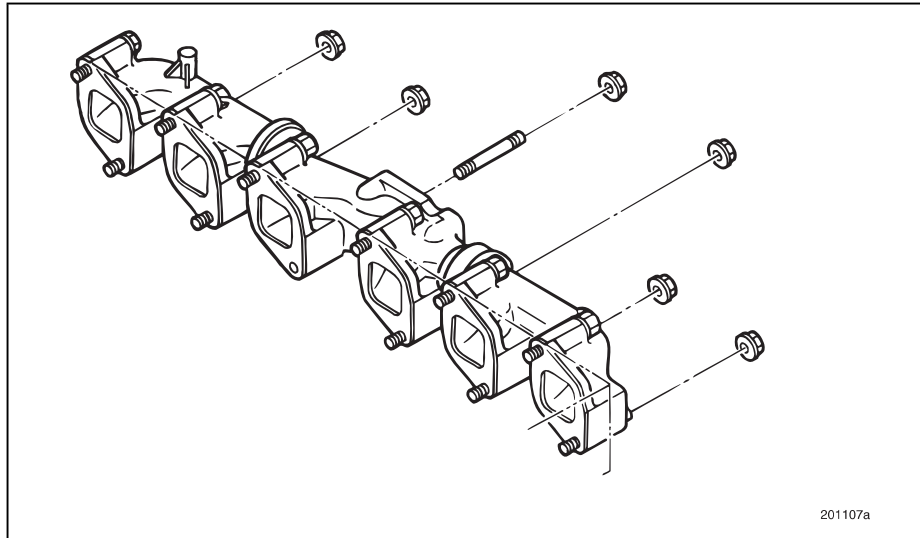


Figure 6-73 — Typical Exhaust Manifold Installation



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[215 NK] COOLANT MANIFOLD

Inspection

Check the coolant manifold sections for restrictions, cracks and flange wear. The manifold cannot be repaired. Replace if any signs of damage are present.

Installation

Refer to Figure 6-74.

1. Ensure that the front coolant manifold section (1) is clean. Position a coolant/air inlet manifold gasket on the mounting surface.
2. Lubricate threads of the capscrews (5) with clean engine oil and secure front coolant manifold section with the mounting capscrews.
3. Place couple (2) in position on the couple mounting flange. Place two clamps (3) over the couple.
4. Insert the rear manifold section (4) in the couple.
5. Place a gasket between the mounting surfaces of the rear manifold section and the cylinder head.
6. Lubricate threads of the mounting capscrews (5) and secure the rear manifold section with the mounting capscrews.
7. Torque all mounting capscrews to 25 lb-ft (34 N·m) using torque wrench J 24406 or equivalent.
8. Ensure that the couple is properly installed and secure it in position with the clamps. Tighten the clamps to 38 lb-in (4.3 N·m).

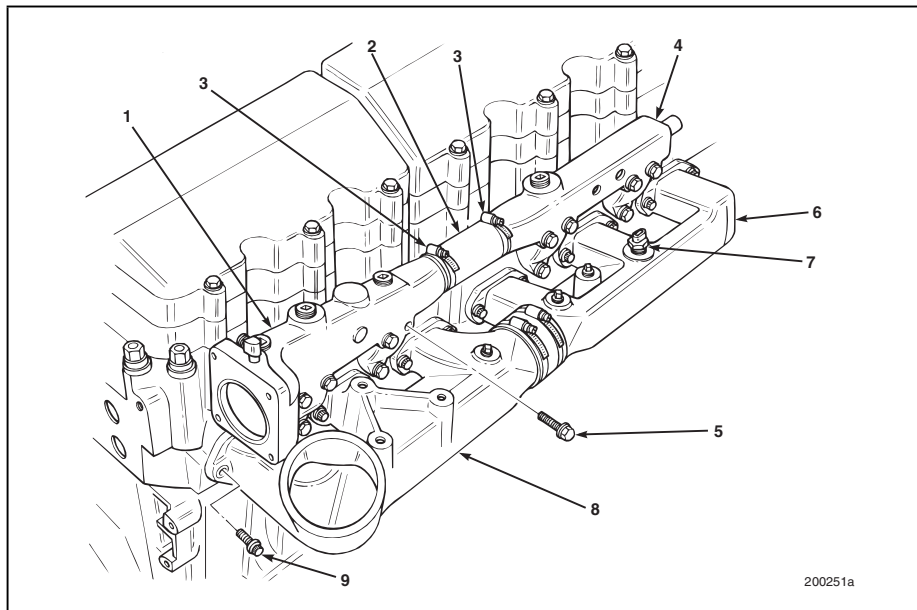


Figure 6-74 — Coolant and Air Inlet Manifold Installation

- | | |
|------------------------------------|--|
| 1. Coolant manifold, front section | 6. Air inlet manifold, rear section |
| 2. Couple | 7. Inlet air temperature sensor (sending unit) |
| 3. Clamp | 8. Air inlet manifold, front section |
| 4. Coolant manifold, rear section | 9. Capscrew, 12-point |
| 5. Capscrew | |



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[261 CK] AIR COMPRESSOR

Installation

Refer to Figure 6-75.

1. Install a new gasket on the air compressor mounting flange.
2. Check to ensure that the lubrication oil supply tube (2) is in place and position the air compressor (1) on the mounting flange.
3. Install the three mounting capscrews (5) and torque to 70 lb-ft (95 N·m) using torque wrench J 24407 or equivalent.
4. Reconnect the coolant lines to the air compressor cylinder head.

CAUTION

If the oil supply tube is lost, the air compressor will fail from lack of oil.

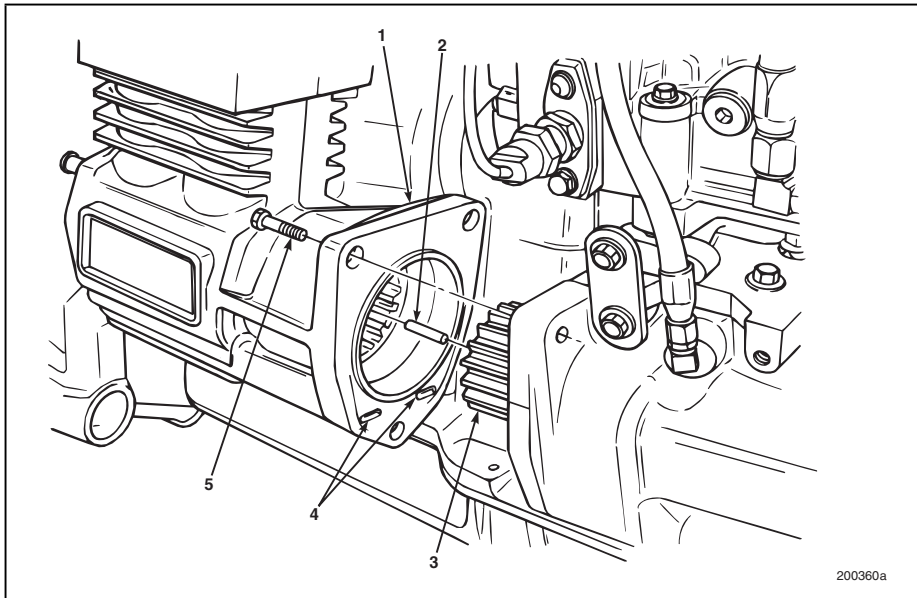


Figure 6-75 — Air Compressor Installation

- | | |
|-------------------------|-----------------------|
| 1. Air compressor | 4. Oil drain openings |
| 2. Oil supply | 5. Capscrew |
| 3. Auxiliary driveshaft | |



200 ENGINE ASSEMBLY

[221 CD] ECONOVANCE

Installation

Refer to Figure 6-76.

1. Lubricate with clean engine oil and then install O-ring in groove on front of Econovance assembly (5).
2. Position the Econovance assembly (5) on the mounting surface of the engine front flange. You may have to rotate the Econovance shaft to clear the camshaft gear.
3. Install the four capscrews (4) securing the assembly to the front flange. Torque to 40 lb-ft (54 N·m) using torque wrench J 24407 or equivalent. Check for binding.
4. Slide the drive coupling (3) into the splines (6) of the shaft (pre-1992 style shown).
5. Install the fuel injection pump adapter (2) and gasket (not shown) on the Econovance housing (5). Torque the mounting capscrews (1) to 40 lb-ft (54 N·m).

NOTE

For installation of the fuel injection pump drive gear, refer to Injection Pump Fixed-Timing procedure found in the SETUP AND ADJUSTMENTS section.

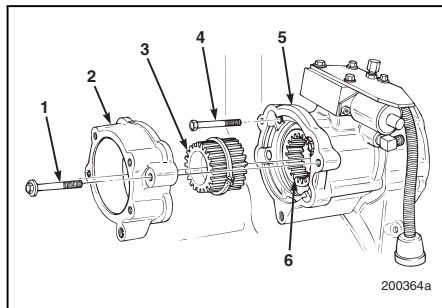


Figure 6-76 — Econovance Housing Installation (Pre-1992 Style Shown)

- | | |
|---------------------------|---------------|
| 1. Mounting capscrew | 4. Capscrew |
| 2. Injection pump adapter | 5. Econovance |
| 3. Drive coupling | 6. Splines |

[221 GP] FUEL INJECTION PUMP

Installation

This procedure is described and illustrated with pump-to-Econovance adapter installed on pump.

To install the fuel injection pump:

1. Install two J 39732 alignment dowels in the Econovance housing. Install a new injection pump adapter housing to Econovance pump adapter housing to Econovance gasket over the alignment dowels.

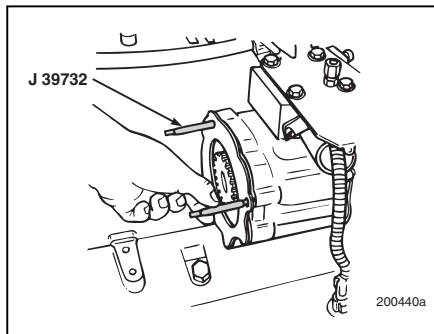


Figure 6-77 — Installing Alignment Dowels

NOTE

Install the outer coupling on the Econovance mating gear prior to fuel injection pump installation. This will prevent the outer coupling from dropping off if installed on the pump prior to installation.



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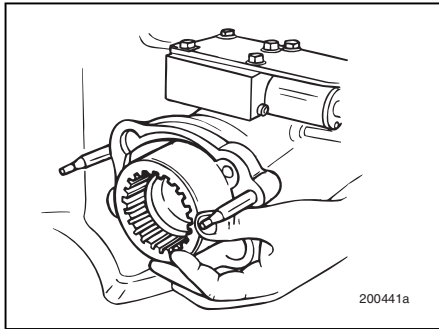


Figure 6-78 — Installing Outer Coupling

2. Loosen the three injection pump rear support bracket-to-cylinder block capscrews. Then hand tighten the capscrews until snug, and loosen 1/4 turn. The lower support bracket should move freely from side to side.

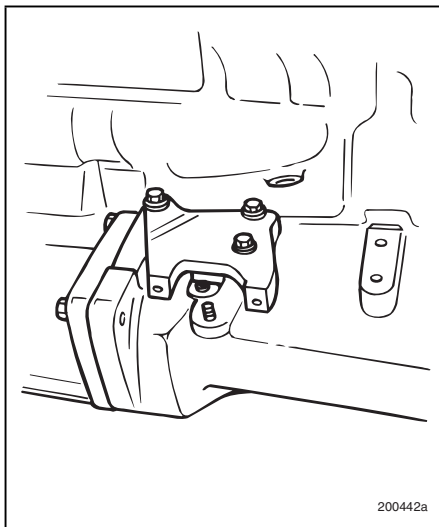


Figure 6-79 — Lower Support Bracket Adjustment

3. Loosen the two upper support bracket-to-fuel injection pump capscrews.

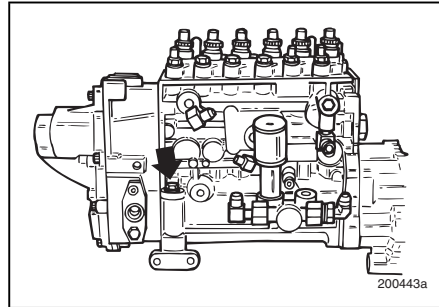


Figure 6-80 — Outer Upper Support Capscrew

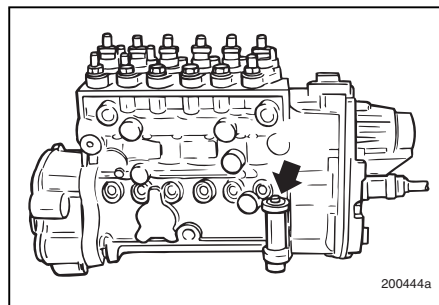


Figure 6-81 — Inner Upper Support Capscrew

4. Align and slide the fuel injection pump and adapter over the two alignment dowels.

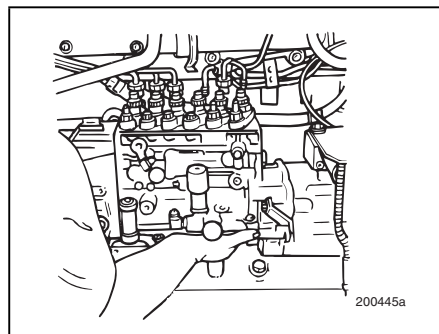


Figure 6-82 — Aligning Pump Over Dowels



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5. With the fuel injection pump positioned over the alignment dowels, in one motion, lift the rear of the pump and slightly rotate the Econovance hub. Slide the pump forward into position.

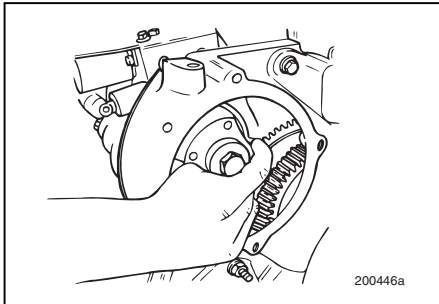


Figure 6-83 — Rotating Hub

6. To secure fuel injection pump, install the lower pump adapter mounting capscrew and then remove the alignment dowels.

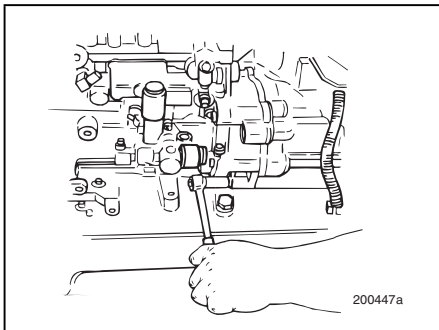


Figure 6-84 — Securing Fuel Injection Pump

7. Install and torque the remaining fuel injection pump adapter mounting capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
8. Install and torque the two link-to-support capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.

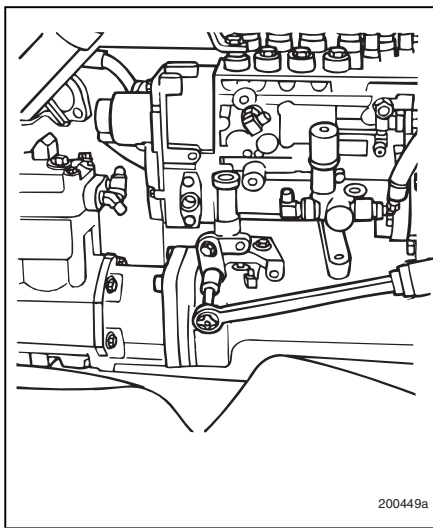


Figure 6-85 — Torquing Link Capscrews



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9. Torque the three lower support bracket-to-cylinder block capscrews to 40 lb-ft (54 N·m) using torque wrench J 24407 or equivalent.

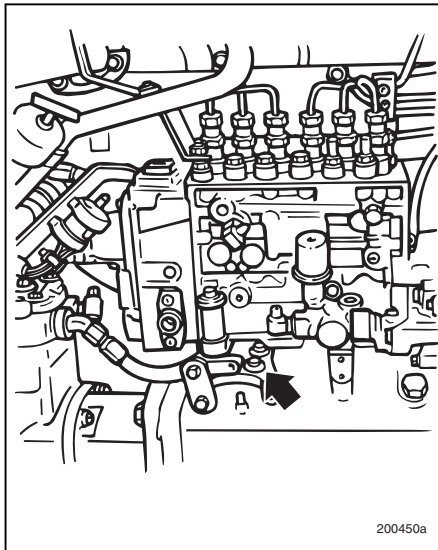


Figure 6-86 — Support Bracket-to-Cylinder Block Capscrews

10. Torque the two upper support bracket-to-fuel injection pump capscrews to 15 lb-ft (20 N·m) using torque wrench J 24407 or equivalent. Loosen and then retorque the capscrews to 40 lb-ft (54 N·m).

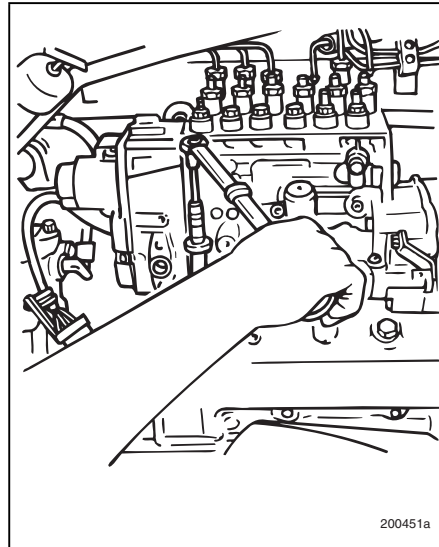


Figure 6-87 — Torquing Upper Support Bracket-to-Fuel Injection Pump Capscrews

11. Loosen the two link-to-support capscrews at least two full turns. Then retorque link-to-support capscrews to specification.

NOTE

Refer to Section 7, SETUP AND ADJUSTMENTS, Fuel Injection Fixed-Timing procedure, for steps to be used in setting fuel injection pump-to-engine timing.



200 ENGINE ASSEMBLY

[222 KD] FUEL NOZZLE INLET TUBE ASSEMBLY

Installation

Refer to Figure 6-88.

1. Install the fuel nozzle inlet tube assemblies (1) into the front and rear cylinder heads. Lubricate the nozzle inlet tube clamping screw threads before installing.
2. Install the tube assemblies until light contact is made with the nozzle holders. Lightly tighten the clamping screws and then lightly tighten the fuel inlet tube sleeve nuts (1).
3. Connect the injection pump end of the fuel tubes to the appropriate fuel injection pump outlet ports and lightly tighten the sleeve nuts (6).
4. Install and lightly tighten the fuel inlet tube insulators and clamp plate and brackets (3).

NOTE

These tube insulators and clamp plates and brackets are required to prevent cavitation erosion and vibration failure of the tubes.

5. Tighten all fuel inlet tube assembly clamping screws to 35 lb-ft (48 N•m) torque using torque wrench J 24407 or equivalent.

NOTE

An open-ended "crow's foot" adapter is required with the torque wrench for installation of nozzle fuel inlet tube assemblies. Avoid twisting the lines when tightening the sleeve nuts.

6. While holding the fuel inlet tube assembly clamping screws, tighten the tube sleeve nuts (1) at the cylinder heads to 25 lb-ft (34 N•m) torque using torque wrench J 24407 or equivalent.
7. Tighten all fuel inlet tube sleeve nuts (6) located at the fuel injection pump outlet ports to 25 lb-ft (34 N•m) torque using torque wrench J 24407 or equivalent.
8. Tighten all fuel inlet tube insulators and clamp plates and brackets.



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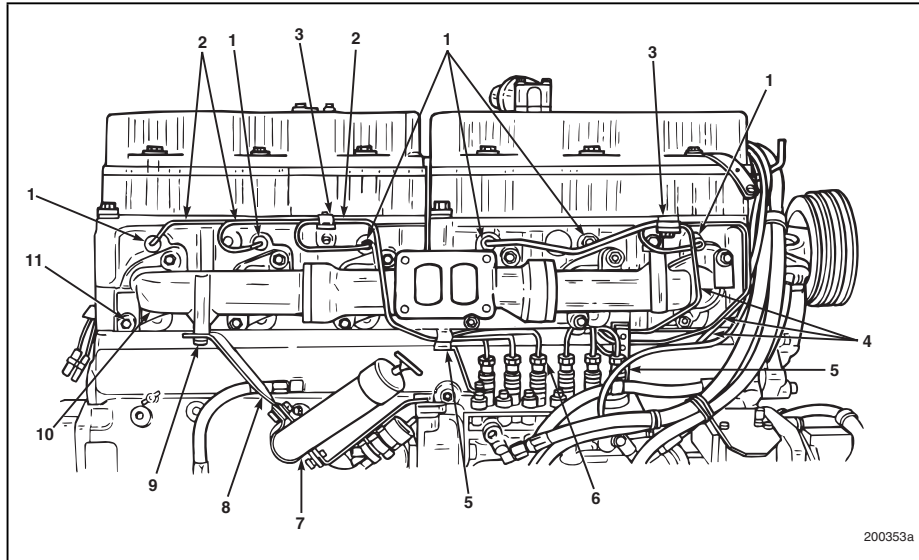


Figure 6-88 — Fuel Nozzle Inlet Tube Assembly Installation

- | | |
|--|---------------------------------|
| 1. Nozzle fuel inlet tube and sleeve nut | 7. Oil filler feed tube |
| 2. Rear fuel inlet tube assembly | 8. Oil filler feed tube bracket |
| 3. Bracket/insulator (tube clamp) | 9. Capscrew |
| 4. Front fuel inlet tube assembly | 10. Exhaust manifold |
| 5. Bracket/insulator (tube clamp) | 11. Capscrew |
| 6. Sleeve nut | |



200 ENGINE ASSEMBLY

[214 SC] TURBOCHARGER

Installation (Includes Pre-Lubing Procedures)

Refer to Figure 6-89.

1. Inspect the intake and exhaust systems leading to and from the turbocharger to ensure absence of foreign material, including burrs and loose lining fragments.

NOTE

A thorough inspection is required as even small particles can cause severe rotor damage if inducted during high-speed operation.

2. Use new and approved gaskets at the various air, oil and exhaust connections to the turbocharger. Avoid the use of sealing or jointing compounds at all flanged connections.
3. Use a high-temperature, anti-seize compound (such as Fel Pro C5A) on all threaded fasteners connected to the turbocharger.
4. Position the turbocharger (1) over the mounting studs on the exhaust manifold.
5. Install the four mounting nuts (6) and torque to 40 lb-ft (54 N·m) using torque wrench J 24406 or equivalent.
6. Fill the oil inlet port to overflowing with clean engine oil before connecting the oil feed hose to the turbocharger.
7. Install the lubrication feed hose (2).
8. If the clamp plates or V-bands are loosened for angular orientation of the compressor cover or turbine housing, be certain that the mating flanges are tightly seated and that the fasteners are snug but will still allow cover orientation.

Complete the orientation of the cover and housing before making any rigid connections to the compressor inlet or to the turbine outlet. Torque the clamp plate capscrews (used on Schwitzer model S300 turbocharger only) to 140 lb-in (16 N·m), if equipped, and V-band

retaining nuts to 90 lb-in (10 N·m) using torque wrench J 5853-C or equivalent. Then make certain that all ducting aligns closely with the turbocharger. This minimizes the external stresses acting on the unit.

9. Before connecting the drain hose, crank the engine without firing until a steady stream of oil flows from the drain port.
10. Install the lubrication drain tube (4) and torque the capscrews (3) to 15 lb-ft (20 N·m) using torque wrench J 24406 or equivalent.
11. Install the clamp (5) securing the lubrication drain tube to the oil fill tube.
12. Operate the engine at low idle for at least three minutes after completing the installation of the turbocharger.

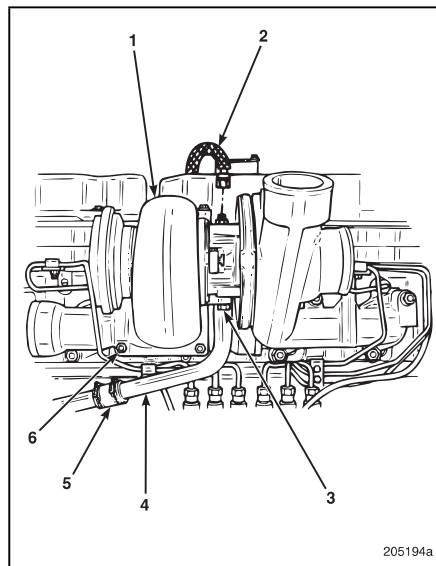


Figure 6-89 — Turbocharger Installation

1. Turbocharger	4. Lubrication drain tube
2. Lubrication feed hose	5. Clamp
3. Capscrew	6. Mounting nut



200 ENGINE ASSEMBLY

[215 NU, NG & LD] THERMOSTAT, THERMOSTAT HOUSING, THERMOSTAT SEAL AND COOLANT CONDITIONER

Refer to Figure 6-90.

1. When replacing a seal for any reason, examine the surface of the thermostat sleeve, the bore area and the seal to prevent premature failure of the new seal. A sealing lip that has been turned back, cut or otherwise damaged will leak and must be replaced. The lip faces the front of the engine.
2. Remove any surface nicks, burrs, sharp edges and tool marks from the thermostat sleeve and housing bore area using crocus cloth.
3. Check to see that replacement seals are free from any contaminants such as chips, grit, dust, or any other debris that would prevent the seal from properly seating in the thermostat housing.
4. Press the seal into the housing bore with smooth, uniform pressure using seal installation tool J 26637-A and driver handle J 8092.

NOTE

Tool J 26637-A is designed to regulate thermostat seal installation depth. The shoulder on the tool bottoms on the thermostat bore of the housing to prevent the seal from being installed too far.

NOTE

Wherever possible, an arbor press should be used to apply assembly pressure. Do not apply hammer blows or uneven pressure directly to seal surfaces. Precautions should be taken against cocking of seal throughout the installation operation. Make sure the seal is not cocked when installed.

5. Position thermostat (7) in the housing (5) with jiggle pin or caged ball up.
6. Install a gasket (8) on the housing mounting surface.
7. Position housing assembly on the coolant manifold (9) mounting surface.
8. Secure in position with two lower mounting capscrews (13).
9. Position a check valve assembly (3) in the coolant conditioner head assembly (2). The ball end of the check valve must be inserted first.
10. Position an O-ring (4) in the O-ring recess of the head assembly.
11. Install head assembly (2) on the thermostat housing (5) and secure with capscrews (1).
12. Torque capscrews to 25 lb-ft (34 N·m) using torque wrench J 24406 or equivalent.
13. Apply a light film of oil on the face of the coolant conditioner filter gasket seal.
14. Install the coolant conditioner filter element (14). Turn the coolant conditioner filter one full turn after gasket contacts base. Use tool J 24783 to tighten.



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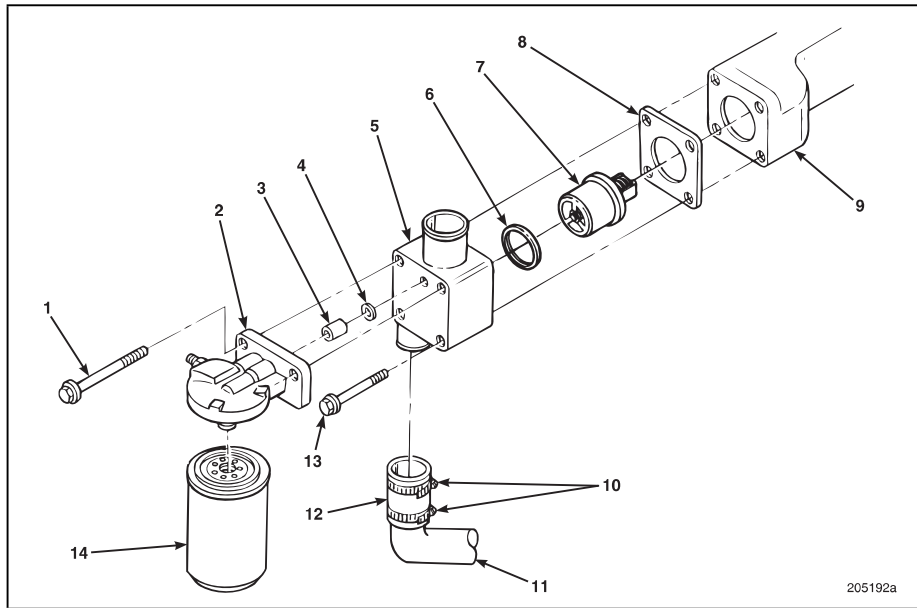


Figure 6-90 — Thermostat Housing Installation

- | | |
|--------------------------------------|--|
| 1. Capscrew | 8. Gasket |
| 2. Coolant conditioner head assembly | 9. Coolant manifold |
| 3. Check valve | 10. Clamps |
| 4. O-ring | 11. Oil cooler supply tube |
| 5. Thermostat housing | 12. Coupling (hose) |
| 6. Thermostat seal | 13. Capscrew |
| 7. Thermostat | 14. Coolant conditioner filter element |



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[214 HD] AIR INLET MANIFOLD

Refer back to Figure 6-74.

1. Place the front air inlet manifold section (8) into position on the cylinder head and insert the 12-point capscrews (9) and washers.
2. Torque capscrews to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
3. Place the coupling on the rear of the front air inlet section (8). Assemble two clamps on the coupling and install the rear air inlet section (6).
4. Insert the 12-point capscrews and torque to 40 lb-ft (54 N•m) using torque wrench J 24407 or equivalent.
5. Tighten the clamps on the coupling and torque to 38 lb-in (4.3 N•m).

[231 PB] FUEL FILTER ADAPTER ASSEMBLY

Installation

Refer to Figure 6-91.

1. Install fuel filter adapter (1) to the air inlet assembly (7).
2. Install the three capscrews (4) and torque to 35 lb-ft (48 N•m).
3. Install the three fuel lines to fittings (2, 3 and 5) and torque to 25 lb-ft (34 N•m).

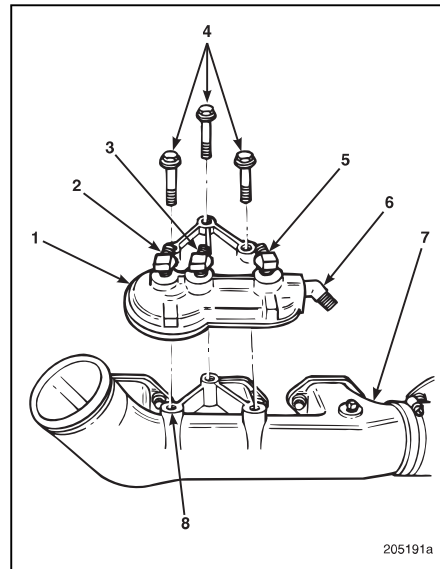


Figure 6-91 — Fuel Filter Adapter Assembly Installation

1. Fuel filter adapter assembly	4. Capscrews
2. Secondary filter fitting (out)	5. Primary filter fitting (out)
3. Secondary filter fitting (in)	6. Primary filter fitting (in)
	7. Air inlet manifold
	8. Mounting flange



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[215 SW] WATER PUMP

Installation

Refer to Figure 6-92.

CAUTION

Water pump-to-housing mounting capscrews should not be lubricated before installation. Instead, apply thread sealing compound to all water pump-to-water pump housing capscrews. Also apply thread sealing compound to water pump housing (pump outlet) to block capscrews.

1. Position a gasket on the water pump mounting flange.
2. Secure pump with three mounting capscrews (3).
3. Position refrigerant compressor support bracket, if required, on the front of the cylinder head. (Insert spacer if refrigerant compressor support bracket and fan ring arrangement are not used.) Secure bracket with mounting hardware.

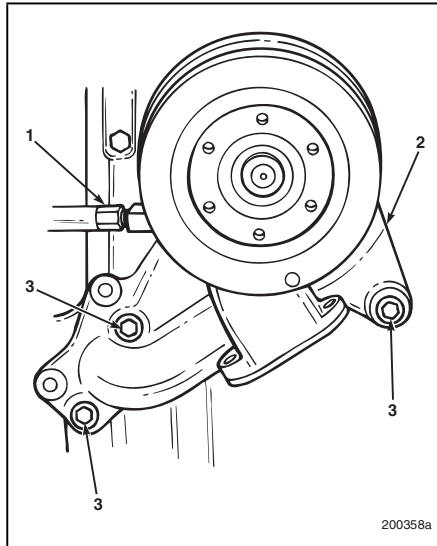


Figure 6-92 — Water Pump Installation

- | | |
|------------------------|-------------|
| 1. Air compressor line | 3. Capscrew |
| 2. Water pump | |



200 ENGINE ASSEMBLY

[215 DW & 219 EP] OIL COOLER AND OIL FILTER HEAD

Assembling a New Oil Filter Adapter

The oil filter head does not come as a complete assembly, so the fittings, nipples, spuds, etc., must be installed before installing the filter head onto the engine. Perform the following procedures before installing the threaded spuds into the filter head.

Refer to Figure 6-93.

1. Apply a continuous bead of Loctite 609 around the circumference of the spud, between the second and fifth threads from the upper end.
2. Screw the spuds into the filter adapter until they protrude 0.703 inch (17.856 mm) when measured from the bottom of the spud to the sealing surface of the oil filter head assembly. To ensure that spuds are secure in the adapter housing, they may be "staked" by using a small punch to make a small indentation between the threads of the spud and the adapter.
3. Apply a continuous bead of Loctite 609 around the circumference of the fitting between the second and fifth threads of the upper end of the Centri-Max™ fitting. Install the fitting and torque to 135–165 lb-ft (183–224 N·m) using torque wrench J 24407 or equivalent. Do not stake the Centri-Max™ fitting.

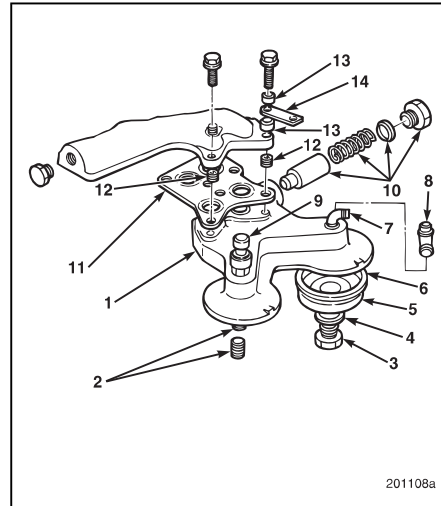


Figure 6-93 — Oil Filter Adapter Assembly

1. Adapter housing	8. Vent hose fitting
2. Filter adapter fitting	9. Oil pressure sensor
3. Filter adapter fitting (Centri-Max™)	10. Oil filter bypass valve plunger assembly
4. Pilot ring washer	11. Adapter gasket
5. Pilot ring	12. Insert
6. Gasket	13. Spacer
7. Gauge connector elbow	14. Wiring harness bracket

SERVICE HINT

The oil cooler and oil filter head assembly can be installed separately, but assembling them together on a bench is easier and reduces the possibility of damaging O-ring seals.



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Installation

Refer to Figure 6-94.

1. Lubricate the oil cooler supply tube (5) with Vaseline® or equivalent.
2. Position coupling (4) over the lubricated tube.
3. Place two clamps (3) over the coupling.
4. Place a gasket on the oil supply mounting flange (11).
5. Position the oil cooler and oil filter head assembly on the engine. Slide the coupling (4) over the thermostat housing flange. Lubricate threads of the capscrews (10) and insert into the mounting flange. Do not tighten at this time.
6. Place a gasket on the water pump mounting flange (2).
7. Lubricate threads of capscrews (1) and insert the two mounting capscrews to secure flange (2) to the water pump. Torque capscrews to 40 lb-ft (54 N·m) using torque wrench J 24407 or equivalent.
8. Tighten oil supply housing capscrews (10). Torque to 40 lb-ft (54 N·m) using torque wrench J 24407 or equivalent.
9. Tighten clamps (3). Torque to 38 lb-in (4.3 N·m).
10. Connect Centri-Max™ filter breather hose (6) to the breather hose fitting (7). (For MR chassis Jake Brake applications, install the Centri-Max™ breather filter.)
11. Connect oil hose (8) to the fitting (9).
12. Coat the threads of the oil sending unit (12) with sealing compound and install in the oil filter head assembly (13).



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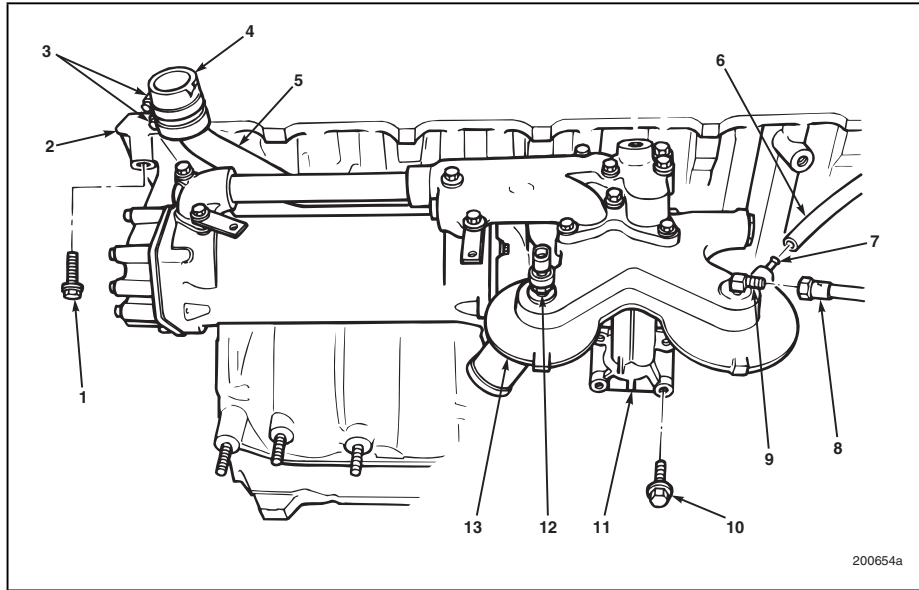


Figure 6-94 — Oil Cooler and Oil Filter Head Installation

- | | |
|---|--------------------------------|
| 1. Capscrew | 8. Oil hose |
| 2. Water pump mounting flange | 9. Fitting |
| 3. Clamps | 10. Capscrew |
| 4. Coupling | 11. Oil supply mounting flange |
| 5. Oil cooler supply tube (water bypass tube) | 12. Sending unit |
| 6. Centri-Max™ filter breather hose | 13. Oil filter head assembly |
| 7. Breather hose fitting (MR chassis with Jake Brake use breather assembly) | |



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[271 CB] ALTERNATOR

Installation

Refer to Figure 6-95.

1. Install the alternator plate (5) and mounting hardware (4).
2. Position the alternator (7) on the plate and install capscrews (3), washers and mounting nuts (6).
3. Connect the electrical wires as tagged during disassembly.
4. Install drive belt(s) (1).
5. Adjust drive belt tension to specification as described in the following Fan Belt(s) Adjustment procedure.

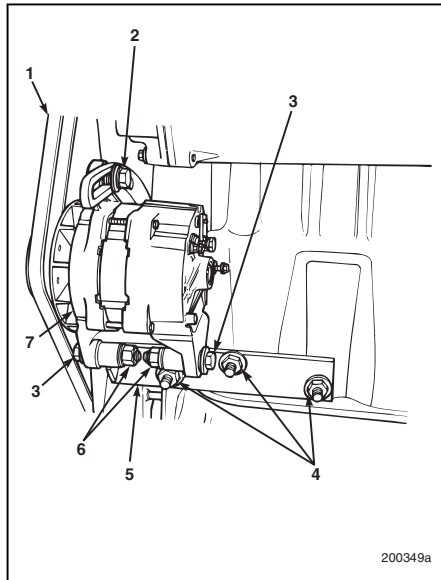


Figure 6-95 — Alternator Installation

- | | |
|-----------------------|---------------------|
| 1. Drive belt | 5. Alternator plate |
| 2. Adjusting capscrew | 6. Mounting nuts |
| 3. Capscrew | 7. Alternator |
| 4. Mounting hardware | |

Fan Belt(s)

ADJUSTMENT

1. For consistent measurements, use belt tension gauge tool BT3373-F to check the belt tension.
2. Check tension at the center of the longest span, and chalk-mark the point checked.
3. When installing new belt(s), initially adjust the tension to give a gauge reading of 130–150 lbs. (578–667 N). Chalk-mark the point checked. Run the engine for approximately 5–10 minutes. Allow the belt(s) to cool and recheck at the chalk mark. If the tension is less than 100 lbs. (445 N), readjust the tension to approximately 110–120 lbs. (489–534 N).
4. After adjusting belt tension, tighten alternator mounting bolts as follows:
 - a. Tighten upper alternator adjusting capscrew (2) to 60–70 lb-ft (81–95 N·m) using torque wrench J 24407 or equivalent.
 - b. Tighten lower alternator mounting fasteners (3 and 6) to 60–70 lb-ft (81–95 N·m) using torque wrench J 24407 or equivalent.

NOTE

With other belt types and configurations, refer to the current Maintenance and Lubrication Manual, TS494, for belt tensioning specifications.



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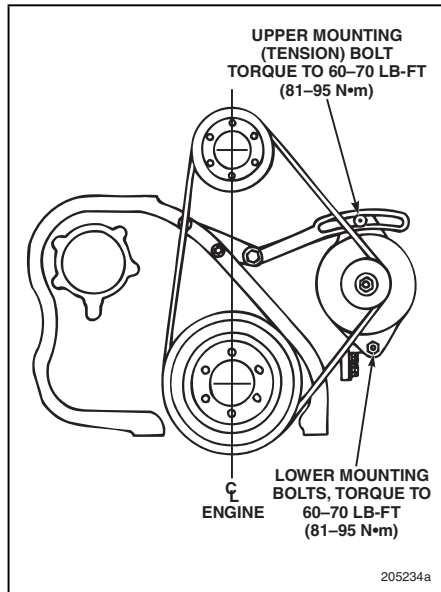


Figure 6-96 — Engine Belt Arrangement



NOTES
