

Engine Mechanical - 6.5L

Specifications

Fastener Tightening Specifications

| Application | N-m | Lb Ft | Lb In |
|--|-----|-------|-------|
| Accessory/Engine Lift Bracket Nut and Bolts | 50 | 37 | — |
| Bell Housing Bolts | 40 | 30 | — |
| Camshaft Gear Bolt | 171 | 125 | — |
| Camshaft Thrust Plate Bolts | 23 | 17 | — |
| Connecting Rod Cap Nuts | 65 | 48 | — |
| Coolant Crossover Bolts/Studs | 42 | 31 | — |
| Coolant Drain Plugs | 25 | 18 | — |
| Crankshaft Balancer Bolt | 270 | 200 | — |
| Crankshaft Bolts Inner Bolts | 150 | 110 | — |
| Crankshaft Bolts Outer Bolts | 135 | 100 | — |
| Crankshaft Pulley Bolts | 58 | 43 | — |
| Crankshaft Sensor Bolt | 23 | 17 | — |
| Cylinder Head Bolts (First Pass) | 25 | 20 | — |
| Cylinder Head Bolts (Second Pass) | 75 | 55 | — |
| Cylinder Head Bolts (Final Pass; In Sequence, Plus 90 degrees) | — | — | — |
| Exhaust Manifolds Bolts | 35 | 26 | — |
| Flywheel Bolts | 90 | 65 | — |
| Front Cover Bolts | 45 | 33 | — |
| Fuel Filter Mount Bolts | 42 | 31 | — |
| Fuel Filter Water Drain Valve Stud | 41 | 31 | — |
| Fuel Injection Pump Gear Retaining Bolts | 25 | 20 | — |
| Fuel Injection Pump Nuts | 40 | 30 | — |
| Glow Plugs | 22 | 16 | — |
| Injection Line Fittings | 36 | 28 | — |
| Injection Nozzle | 80 | 59 | — |
| Intake Manifold Bolts/Studs | 42 | 31 | — |
| Oil Fill Neck Nuts | 23 | 17 | — |
| Oil Filter Adapter Bolt | 65 | 47 | — |
| Oil Gallery Plugs | 34 | 25 | — |
| Oil Level Indicator Tube Bracket Bolt | 4 | — | 36 |
| Oil Pan All Except Rear Two Bolts | 10 | — | 89 |
| Rear Two Bolts | 23 | 17 | — |
| Oil Pan Drain Plug | 23 | 17 | — |
| Oil Pump Bolt | 90 | 65 | — |
| Oil Pump Cover Screws | 16 | 12 | — |
| Oil Pump Driver Clamp Bolt | 42 | 31 | — |
| Thermostat Housing Bolts/Studs | 47 | 35 | — |
| Turbocharger Connector Hose Clamps | 6 | — | 50 |
| Turbocharger Exhaust Manifold Mounting Nuts | 58 | 43 | — |
| Turbocharger Long Brace Bolt | 50 | 37 | — |

Fastener Tightening Specifications (cont'd)

| Application | N-m | Lb Ft | Lb In |
|--|-----|-------|-------|
| Turbocharger Long Brace Nut | 34 | 26 | — |
| Turbocharger Oil Feed Hose Fittings | 22 | 17 | — |
| Turbocharger Oil Return Pipe Bolts | 26 | 19 | — |
| Turbocharger Short Brace Bolts | 25 | 18 | — |
| Upper Intake Connector Hose Clamps | 6 | — | 50 |
| Upper Intake Manifold To Intake Manifold Bolts | 23 | 17 | — |
| Valve Lifter Guide Plate Clamp Bolts | 25 | 18 | — |
| Valve Rocker Arm Cover Bolts | 22 | 16 | — |
| Valve Rocker Arm Shaft Bolts | 55 | 40 | — |
| Water Pump Plate to Coolant Pump Bolts | 28 | 20 | — |
| Water Pump Plate to Front Cover Bolts | 28 | 20 | — |
| Water Pump to Front Cover Bolts | 42 | 32 | — |

Engine Mechanical Specifications

| Application | Specification | |
|--------------------------------|---|---|
| | Metric | English |
| General Data | | |
| Type | V8 | |
| Displacement | 6.5L | 396CID |
| Bore | 103 mm | 4.06 in |
| Stroke | 97 mm | 3.82 in |
| Compression Ratio | 21.3:1 | |
| Firing Order | 1-8-7-2-6-5-4-3 | |
| Oil Pressure | 69 kPa @ idle hot 275-310kPa @ 2000RPM | 10 psi @ idle hot 40-45 psi @ 2000 RPM |
| Cylinder Bore | | |
| Diameter | Refer to Service Piston and Bore Specifications | |
| Out-of-Round | 0.02 mm maximum | 0.0008 in maximum |
| Taper | 0.02 mm maximum | 0.0008 in maximum |
| Piston | | |
| Piston Diameter | Refer to Service Piston and Bore Specifications | |
| Piston Bore Clearance 1-6 | 0.094-0.120 mm | 0.0037-0.0047 in |
| Piston Bore Clearance 7 and 8 | 0.107-0.133 mm | 0.0042-0.0052 in |
| Piston Ring Compression | | |
| Top Groove Side Clearance | Keystone Type Ring | |
| Second Groove Side Clearance | 0.039-0.079 mm | 0.0015-0.0052 in |
| Top Ring Gap | 0.26-0.51 mm | 0.010-0.020 in |
| Second Ring Gap | 0.75-1.00 mm | 0.030-0.039 in |
| Piston Ring Oil | | |
| Groove Clearance | 0.040-0.090 mm | 0.0016-0.0035 in |
| Gap | 0.25-0.51 mm | 0.010-0.020 in |
| Piston Pin | | |
| Diameter | 30.9961-31.0039 mm | 1.2212-1.2216 in |
| Piston Pin to Piston Bore | 0.0101-0.153 mm | 0.0004-0.0006 in |

Engine Mechanical Specifications (cont'd)

| Application | Specification | |
|--|--|--------------------------|
| | Metric | English |
| Piston Pin to Connecting Rod Bushing | 0.0081-0.0309 mm | 0.0003-0.0012 in |
| Crankshaft | | |
| Main Journal Diameter | Refer to Crankshaft Bearing Selection Specifications | |
| Main Journal Taper | 0.005-0.083 mm maximum | 0.0018-0.0033 maximum in |
| Main Journal Out -of-Round | 0.005-0.083 mm maximum | 0.0018-0.0033 in maximum |
| Main Bearing Clearance #1, #2, #3, #4 | 0.045-0.083 mm | 0.0018-0.0033 in |
| Main Bearing Clearance #5 | 0.055-0.092 mm | 0.0022-0.0037 in |
| Crankshaft End Play | 0.10-0.25 mm | 0.0039-0.0010 in |
| Rod Bearing Clearance | 0.045-0.100 mm | 0.0018-0.0039 in |
| Rod Side Clearance | 0.17-0.0305 mm | 0.0020-0.0120 in |
| Camshaft | | |
| Journal Diameter #1, #2, #3, #4 | 54.970-55.025 mm | 2.1658-2.1680 in |
| Journal Diameter #5 | 50.970-51.025 mm | 2.0082-2.0104 in |
| Journal Clearance #1, #2, #3, #4 | 0.025-0.118 mm | 0.0010-0.0046 in |
| Journal Clearance #5 | 0.020-0.113 mm | 0.0008-0.0044 in |
| Camshaft End Play | 0.51-0.305 mm | 0.0020-0.0120 in |
| Intake Lobe Lift +/- 0.050mm (0.002 in) | 7.133 mm | 0.281 in |
| Exhaust Lobe Lift +/- 0.050 mm (0.002 in) | 7.133 mm | 0.281 in |
| Valve System | | |
| Valve Lifter | Hydraulic Roller | |
| Valve Rocker Arm Ratio | 1.50:1 | |
| Valve Lash | Not adjustable | |
| Valve Face Angle (Intake and Exhaust) | 45 Degrees | |
| Valve Seat Angle (Intake and Exhaust) | 46 Degrees | |
| Valve Runout (Intake and Exhaust) | 0.5 mm | 0.002 in |
| Seat Width Intake | 0.89-1.53 mm | 0.0351-0.0603 in |
| Seat Width Exhaust | 1.57-2.36 mm | 0.0618-0.0930 in |
| Valve Protrusion (Negative, because the valve is recessed in the head) | -0.86 to -1.22 mm | -0.034 to -0.048 in |
| Stem Clearance Intake | 0.026-0.069 mm | 0.0010-0.0027 in |
| Stem Clearance Exhaust | 0.026-0.069 mm | 0.0010-0.0027 in |
| Valve Spring Pressure (Closed) | 356 N @ 46 mm | 80 lb @ 1.80 in |
| Valve Spring Pressure (Open) | 1025 N @ 35.3 mm | 230 lb 1.40 in |
| Valve Spring Installed Height | 46 mm | 1.80 in |
| Valve Spring Timing Chain Free Play New Chain | 12.7 mm | 0.50 in |
| Valve Spring Timing Chain Free Play Used Chain | 20.3 mm | 0.80 in |

Crankshaft Journals and Connecting Rod Bearings

| Crankshaft Journal Diameter | Connecting Rod Bearings | Rod & Cap Bearings Color Codes | Connecting Rod I.D. |
|--|---|-----------------------------------|--|
| Green 60.913 MM/60.926 mm (2.399 in/2.400 in) | Standard in Rod .026 mm (0.0010 in) U.S. in Cap | .026 mm (0.0010 in) U.S. Green | 64.150 mm/64.124 mm (2.5275 in/2.5265 in) |
| Yellow 60.926 mm/60.939 mm (2.400 in/2.401 in) | Standard in Rod Standard in Cap | Standard (Yellow) | — |

Connecting Rod To Crankshaft Journal Bearing Clearance

| Calculated Clearance | | *Actual Clearance | |
|----------------------|---------------------|-------------------|---------------------|
| 0.035 mm/0.090 mm | 0.0014 in/0.0035 in | 0.045 mm/0.100 mm | 0.0018 in/0.0039 in |

Case, Camshaft and Camshaft Bearings Specifications

| — | #1 | #2 | #3 | #4 | #5 |
|---|--|--|--|--|--|
| Camshaft Journal Diameter O.D. (Diameter Tolerance 0.055 mm) | 55.025 mm/ 54.970 mm (2.168 in/2.166 in) | 55.025 mm/ 50.970 mm (2.010 in/2.008 in) |
| Finished Cam Bearing I.D. (Diameter Tolerance 0.38 mm) | 55.088 mm/ 55.050 mm (2.170 in/2.169 in) | 51.083 mm/ 51.045 mm (2.013 in/2.011 in) |
| Camshaft Bearing Clearance | 0.118 mm/0.025 mm (0.0046 in/0.0010 in) | 0.113 mm/0.020 mm (0.004 in/0.008 in) |
| Cam Bore Diameter (Case) | 59.17 mm/59.12 mm (2.331 in/2.329 in) | 58.92 mm/58.87 mm (2.321 in/2.319 in) | 58.67 mm/58.62 mm (2.312 in/2.310 in) | 58.42 mm/58.37 mm (2.302 in/2.330 in) | 50.42 mm/50.37 mm (1.987 in/1.985 in) |
| Cam Bearing O.D. | 59.30 mm/59.25 mm (2.336 in/2.334 in) | 59.05 mm/59.00 mm (2.327 in/2.325 in) | 58.00 mm/58.75 mm (2.317 in/2.315 in) | 58.55 mm/58.50 mm (2.307 in/2.305 in) | 50.55 mm/50.50 mm (1.992 in/1.990 in) |
| Press Fit (Bearing to Case) | 0.18 mm/0.08 mm (0.007 in/0.003 in) |

Important: In order to cover all the possible service conditions (i.e., the old cam with the large journal diameter matched with the new block with the small bore diameter), the camshaft and the camshaft bearing service specifications are different than production specifications.

Crankshaft Bearing Selection and Specifications

| Crankshaft Journal Diameters | | Cylinder and Case Bearing Bore Diameters | | |
|---|---|---|---|---|
| #1 to 4 | #5 | 79.850 mm (3.1461 in) 79.842 mm (3.1458 in) Stamp 3 | 79.842 mm (3.1458 in) 79.834 mm (3.1455 in) Stamp 2 | 79.842 mm (3.1455 in) 79.826 mm (3.1451 in) Stamp 1 |
| 74.917 mm (2.9517 in) 74.925 mm (2.9520 in) Blue | 74.912 mm (2.9515 in) 74.920 mm (2.9518 in) Blue | 1-0.026 mm (0.0010 in) U.S. IN CASE 1-0.026 mm (0.0010 in) U.S. IN CAP | 1-0.013 mm (0.0005 in) U.S. IN CASE 1-0.026 mm (0.0010 in) U.S. IN CAP | 1-STD IN CASE 1-0.026 mm (0.0010 in) U.S. IN CAP |
| 74.925 mm (2.9520 in) 74.933 mm (2.9524 in) Orange or Red | 74.920 mm (2.9518 in) 74.928 mm (2.9522 in) Orange or Red | 1-0.026 mm (0.0010 in) U.S. IN CAP 1- 0.013 mm (0.0005 in) U.S. IN CAP | 1-0.013 mm (0.0005 in) U.S. IN CASE 1-0.013 mm (0.0005 in) U.S. IN CAP | 1-STD IN CASE 1-0.013 mm (0.0005 in) U.S. IN CAP |
| 74.933 mm (2.9524 in) 74.942 mm (2.9527 in) White | 74.928 mm (2.9522 in) 74.936 mm (2.9525 in) White | 1-0.026 mm (0.0010 in) U.S. IN CASE 1-STD IN CAP | 1- 0.013 mm (0.0005 in) U.S. IN CASE 1-STD IN CAP | 1-STD CASE 1-STD IN CAP |

Production and Service Piston-Cylinder Bore

| Engine Displacement | Piston Grade | Skirt Diameter | Bore Diameter 1 Thru 6 | Bore Diameter 7 and 8 |
|---------------------|------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| 6.5L | Production Std -JT or JT | 102.865-102.883 mm (4.0529-4.0536 in) | 102.972-102.990 mm (4.0571-4.0578 in) | 102.985-103.003 mm (4.0576-4.0583 in) |
| | Production Std -S or ST | 103.008-103.026 mm (4.0585-4.0592 in) | 103.117-103.130 mm (4.0628-4.0633 in) | 103.130-103.143 mm (4.0633-4.0638 in) |
| | Service Std. -JT | 102.865-102.883 mm (4.0529-4.0536 in) | 102.972-102.990 mm (4.0570-4.0578 in) | 102.985-102.003 mm (4.0576-4.0583 in) |
| | Service Hi Limit—GT | 102.904-102.922 mm (4.0544-4.0551 in) | 103.013-103.026 mm (4.0587-4.0592 in) | 103.026-103.039 mm (4.0592-4.0597 in) |
| | Service 0.50 mm OS -0.50 OST | 103.399-103.417 mm (4.0739-4.0746 in) | 103.508-103.512 mm (4.0782-4.0784 in) | 103.521-103.525 mm (4.0787-4.0789 in) |

GM SPO Group Numbers

| Application | GM SPO Group Number |
|----------------------------|---------------------|
| Camshaft Bearing | 0.539 |
| Camshaft Bearing Hole Plug | 0.553 |
| Camshaft Sprocket | 0.736 |
| Camshaft Thrust Plate | 0.533 |
| Camshaft Timing Chain | 0.724 |
| Connecting Rod | 0.603 |
| Connecting Rod Bearing | 0.616 |
| Crankshaft Balancer | 0.659 |
| Crankshaft Front Oil Seal | 0.213 |
| Crankshaft Oil Seal (RR) | 0.137 |
| Crankshaft Position Sensor | 2.383 |
| Crankshaft Sprocket | 0.728 |
| Crankshaft Sprocket Key | 8.960 |

GM SPO Group Numbers (cont'd)

| Application | GM SPO Group Number |
|--------------------------------|---------------------|
| Cylinder Head | 0.269 |
| Cylinder Head Gasket | 0.289 |
| EGR Valve | 3.670 |
| Engine Block Fuel Drain Tube | 3.300 |
| Engine Camshaft | 0.519 |
| Engine Crankshaft | 0.646 |
| Engine Flywheel | 0.666 |
| Engine Frame Side Mount | 0.027 |
| Engine Front Cover | 0.206 |
| Engine Lift Front Bracket | 0.004 |
| Engine Mount Frame Side | 0.024 |
| Exhaust Manifold | 3.601 |
| Exhaust Manifold Heat Shield | 3.602 |
| Exhaust Valve | 0.297 |
| Fuel Injection Pump Drive Gear | 3.306 |
| Fuel Injection Pump Gasket | 3.306 |
| Glowplug | 2.270 |
| Goodwrench Engine | 0.000A |
| Intake Manifold | 3.265 |
| Intake Valve | 0.296 |
| Oil Filler Cap | 1.758 |
| Oil Filler Tube | 1.745 |
| Oil Filter | 1.836 |
| Oil Level Indicator | 1.516 |
| Oil Level Indicator Tube | 1.516 |
| Oil Pan Seal (RR) | 1.429 |
| Oil Pump | 1.652 |
| Oil Pump Drive | 1.639 |
| Oil Pump Drive Shaft | 1.639 |
| Oil Pump Screen | 1.656 |
| Piston | 0.629 |
| Piston Pin Retainer | 0.639 |
| Upper Intake Manifold Gasket | 3.270 |
| Valve Lifter | 0.459 |
| Valve Lifter Guide | 0.439 |
| Valve Push Rod | 0.426 |
| Valve Rocker Arm | 0.333 |
| Valve Rocker Arm Cover | 0.386 |
| Valve Rocker Arm Retainer | 0.333 |
| Valve Rocker Arm Shaft | 0.353 |
| Valve Spring | 0.303 |
| Valve Spring Cap | 0.309 |
| Valve Stem Key | 0.310 |
| Valve Stem Oil Seal | 0.308 |
| Valve Stem Oil Shield | 0.308 |
| Water Jacket Plug | 8.970 |

Diagnostic Information and Procedures

Engine Noise Diagnosis

Intermittent Noise on Idle Only, Disappearing When Engine Speed Is Increased

Possible causes of the intermittent noise include the following conditions:

1. Dirt in the valve lifter. Replace the valve lifter if necessary.
2. A pitted or damaged valve lifter check ball. Replace the valve lifter if necessary.

Noise at Slow Idle or With Hot Oil; Quiet at Higher Engine Speeds or With Cold Oil

High valve lifter leak down rate may cause noise at slow idle or with hot oil. Replace the valve lifter.

Noise at High Vehicle Speeds, Quiet at Low Speeds

Noise at high vehicle speeds may be caused by the following conditions:

1. A high oil level.
An oil level above the FULL mark allows crankshaft counterweights to churn the oil into foam. When foam is pumped into the valve lifters, they will become noisy since a solid column of oil is required for proper operation. Drain the oil to the proper level.
2. A low oil level.
An oil level that is below the ADD mark allows the oil pump to pump air at high speeds, which results in noisy valve lifters.
Add oil as necessary.
3. An oil pan that is bent against the oil pump pickup screen.
4. An oil pump pickup screen that is bent or loose.

Noise Regardless of Engine Speed

1. Incorrect valve adjustment may lead to noise occurring regardless of engine speed. Check valve lash.
2. Excessive valve lash may also cause engine noise.
Check for valve lash by turning the engine so that the piston in that cylinder is on TDC of the firing stroke. If the valve lash is present, the pushrod can be freely moved up and down a certain amount with the valve rocker arm held against the valve.
3. Excessive valve lash may be caused by the following conditions:
 - A worn pushrod upper end ball. Replace the pushrod and the valve rocker arm.
 - A bent pushrod.

- Improper lubrication of the pushrod. Replace the pushrod and the valve rocker arm.
Check the lubrication system feed to the pushrod.
 - A loose or damaged valve rocker arm.
4. If the pushrod and valve rocker are OK, trouble in the valve lifter is indicated. Replace the valve lifter.

Valve Train Noise

The following conditions may cause valve train noise:

1. Low oil pressure.
2. Loose valve rocker arm attachments.
3. Worn valve rocker arm and/or pushrod.
4. Broken valve spring.
5. Sticking valves. Inspect the valves.
6. Worn, dirty or faulty valve lifters.
7. Worn or faulty camshaft. Replace the camshaft.
8. Worn valve guides. Repair as necessary.

Vibrating or Rattling from Exhaust System

Vibration or rattling from the exhaust system may be caused by loose and/or misaligned exhaust components. Align, then tighten the connections. Check for damaged hangers or mounting brackets and clamps.

Exhaust Leakage and/or Noise

Exhaust leakage and/or noise may be caused by the following conditions:

1. Leakage at the exhaust component joints and couplings. Tighten the clamps or couplings to the specified torque.
2. Improperly installed or misalignment of the exhaust system. Align, then tighten the exhaust clamps.
3. A cracked or broken exhaust manifold. Replace the exhaust manifold.
4. A leak between the exhaust manifold or the cylinder head. Tighten the exhaust manifold to the cylinder head nuts and the bolts to specifications.
5. A damaged or worn exhaust seals or packing. Replace as necessary.
6. A burned or rusted out exhaust pipe. Replace the exhaust pipe as necessary.
7. A burned or blown out muffler. Replace the muffler assembly.
8. A broken or loose exhaust clamp and/or bracket. Replace as necessary.

Oil Leak Diagnosis

Diagnostic Procedure

You can easily locate and repair most oil leaks by visually finding the leak and replacing or repairing the necessary parts. Some fluid leaks, however, are difficult to locate or repair. The following procedure can help you locate and repair most leaks.

Finding the Leak

Do the following to locate a leak:

1. Identify the fluid. Determine if the fluid is engine oil, automatic transmission fluid, power steering fluid, or other fluids.
2. Determine where the leak is. When the vehicle reaches normal operating temperature, park the vehicle over a large sheet of paper. After a few minutes, you should be able to find the approximate place of the leak from the drippings on the paper.
3. Visually check around the suspected component. Check for leaks around all gasket mating surfaces. Use a mirror to find leaks that are hard to reach.
4. If you still cannot find the leak, clean the suspected area with a degreaser, steam, or spray solvent. Dry the area. Operate the vehicle for several miles at normal operating temperature, varying the speeds. After operating the vehicle, visually check the suspected component. If you still cannot locate the leak, use the powder method or the black light and dye method.

Powder Method

Perform the powder method as follows:

1. Clean the suspected area.
2. Apply an aerosol-type powder (such as foot powder) to the area.
3. Operate the vehicle normally.
4. Visually inspect the suspected component. You should be able to trace the leak path over the powder surface to the source of the leak.

Black Light and Dye Method

A dye and light kit is available for finding leaks. Refer to the manufacturer's directions when using the kit.

1. Pour the specified amount of dye into the leaking component.
2. Operate the vehicle normally, as directed.
3. Direct the light toward the suspected area. The dyed fluid appears as a yellow path leading to the source of the leak.

Repairing the Leak

Once the leak is identified and traced back to the source, determine the cause of the leak. Repair the leak properly. If you replace a gasket, but the sealing flange is bent, the new gasket will not repair the leak. You also must repair the bent flange. Before attempting to repair a leak, check for the following:

Gasket Leaks

Check for the following conditions:

- High fluid level or high oil pressure
- Plugged crankcase ventilation filter or PCV valve
- Improperly tightened fasteners or dirty/damaged threads
- Warped flanges or sealing surfaces
- Scratches, burrs, or other damage to the sealing surfaces
- Damaged or worn gaskets
- Cracking or porous components
- Improper sealant used or no sealant where required

Seal Leaks

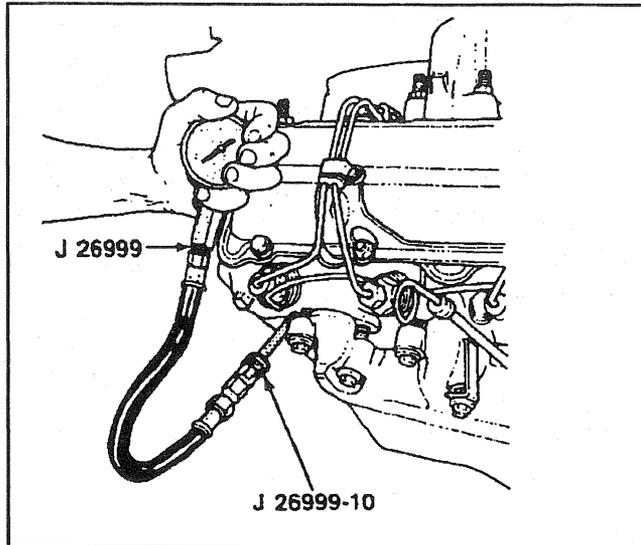
Check for the following conditions:

- High fluid level or high oil pressure
- Plugged crankcase ventilation filter or PCV valve
- Damaged seal bore (scratched, burred, or nicked)
- Damaged or worn seal
- Improper installation
- Cracks in the component
- Shaft surface scratched, nicked, or damaged
- Loose or worn bearing that causes excessive seal wear.

Engine Compression Test (Diesel)

Tools Required

- *J 26999* Compression Gauge
 - *J 26999-10* Compression Gauge Adapter
1. Remove the fuel solenoid fuse.
 2. Disconnect the wires from the glow plugs.
 3. Remove all of the glow plugs.
 4. Screw the *J 26999-10* into the glow plug hole of the cylinder that is being checked. Connect the *J 26999-10* to the *J 26999*.



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5. Make sure that the batteries are fully charged. The engine should be at normal operating temperature.
6. Crank the engine. Allow the engine to turn over six times (six "puffs") per cylinder.

Notice: Do not add oil to any cylinder during a compression test as extensive engine damage may result.

7. Take the compression test at each cylinder and record the readings.
8. The lowest reading cylinder should not be less than 80 percent of the highest reading cylinder. No cylinder should read less than 2625 kPa (380 psi).

Normal: The compression builds up quickly and evenly to the specified compression on each cylinder. The reading should be within the 2625-2760 kPa (380-400 psi) range.

Leaking: The compression is low on the first stroke. The compression builds up on the following strokes but does not reach the normal level.

Cranking Speed Test

Important: Cranking speed is critical for a diesel engine to start, whether the engine is hot or cold. Some tachometers are not accurate at cranking speed. An alternate method of testing cranking speed or determining the accuracy of tachometer is to use a scan tool.

1. Remove the fuel solenoid fuse.
2. Install the digital tachometer to be tested (if desired).

3. Install the scan tool.
4. Crank the engine for 2 or 3 seconds in order to allow the starter to reach full speed.
5. Observe the engine RPM reading on the scan tool.
6. The minimum cranking speed on the 6.5L diesel engine is 100 cold and 180 hot. The actual cranking speed needed will vary depending on the condition of the engine (compression) and nozzles.

Camshaft Gear Timing Test

Important: This procedure is a test for proper camshaft gear timing without removing the engine front cover of the engine.

The following test will not work with the valve rocker arms on the heads because the valve spring pressure causes the valve lifters to bleed down and not give true lobe lift readings. Also, it is important that the crankshaft lobe is rotated only in a clockwise direction so that the timing chain slack does not effect the position of the maximum lobe lift.

Removal Procedure

1. Remove all of the glow plugs.
2. Remove the valve rocker arm cover and the valve rocker arms for the number 1 cylinder.
3. Mount the dial indicator on the exhaust pushrod and zero gauge in order to read the camshaft exhaust lobe lift.

Test Procedure

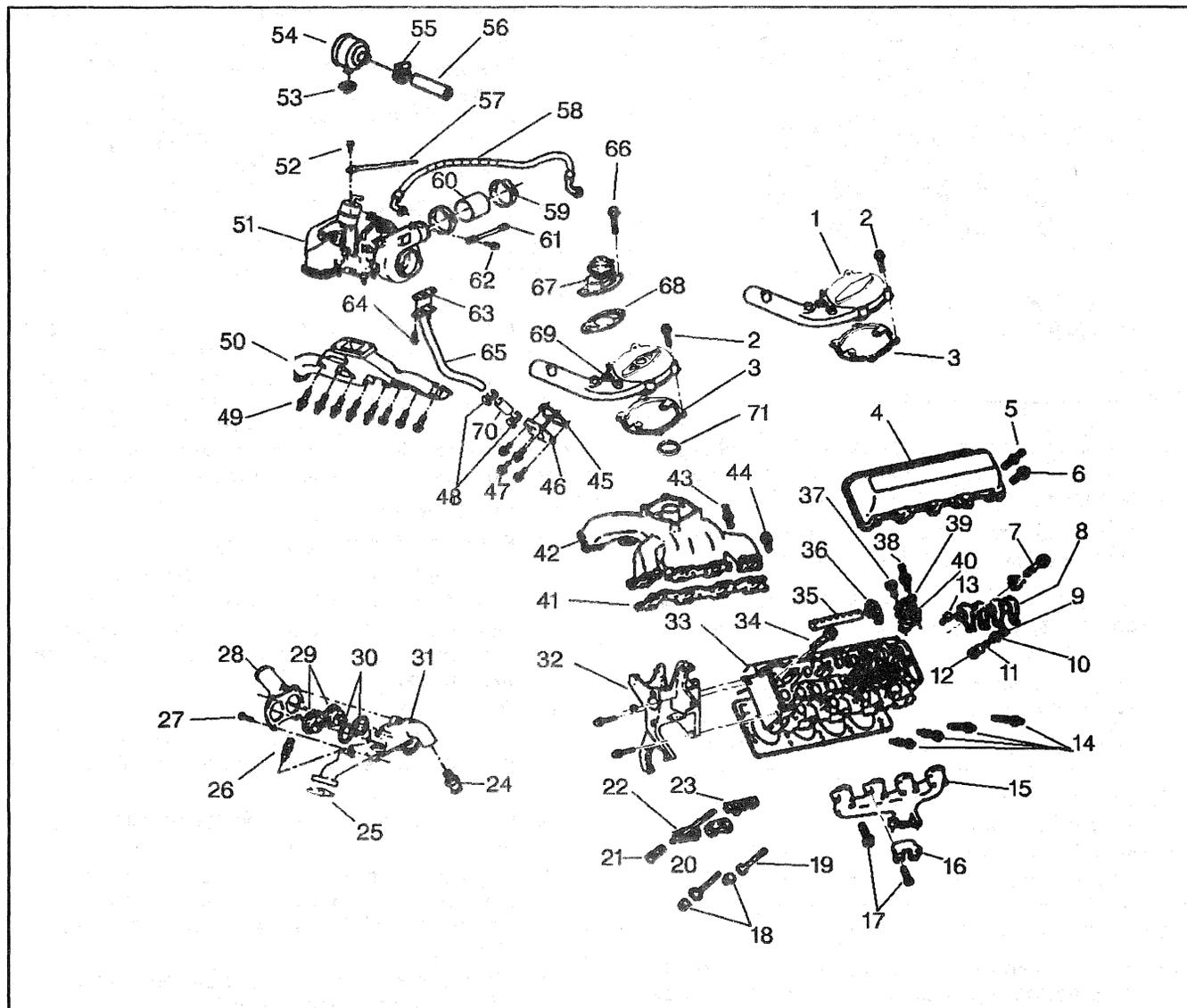
1. Slowly rotate the crankshaft clockwise until the dial indicator shows the maximum exhaust lobe lift.
2. Place a chalk mark on the crankshaft balancer next to the timing tab.
3. Reposition the dial indicator over the intake pushrod and slowly rotate the crankshaft clockwise until the maximum lobe lift is obtained.
4. Place a second chalk mark on the crankshaft balancer next to the timing tab.
5. Measure the distance from each of the chalk marks to the factory timing groove in the crankshaft balancer. If the camshaft gear is properly indexed (positioned) to the crankshaft gear, the distance of each chalk mark to the factory gear timing groove (TDC) will be roughly the same. If the gears are out of position by one tooth or more, the distance from the chalk marks to the (TDC) mark will differ by roughly 50.8 mm (2 in) or more.

Installation Procedure

1. Install the valve rocker arms and the valve rocker arm cover.
2. Install all of the glow plugs.

Visual Identification

Disassembled View



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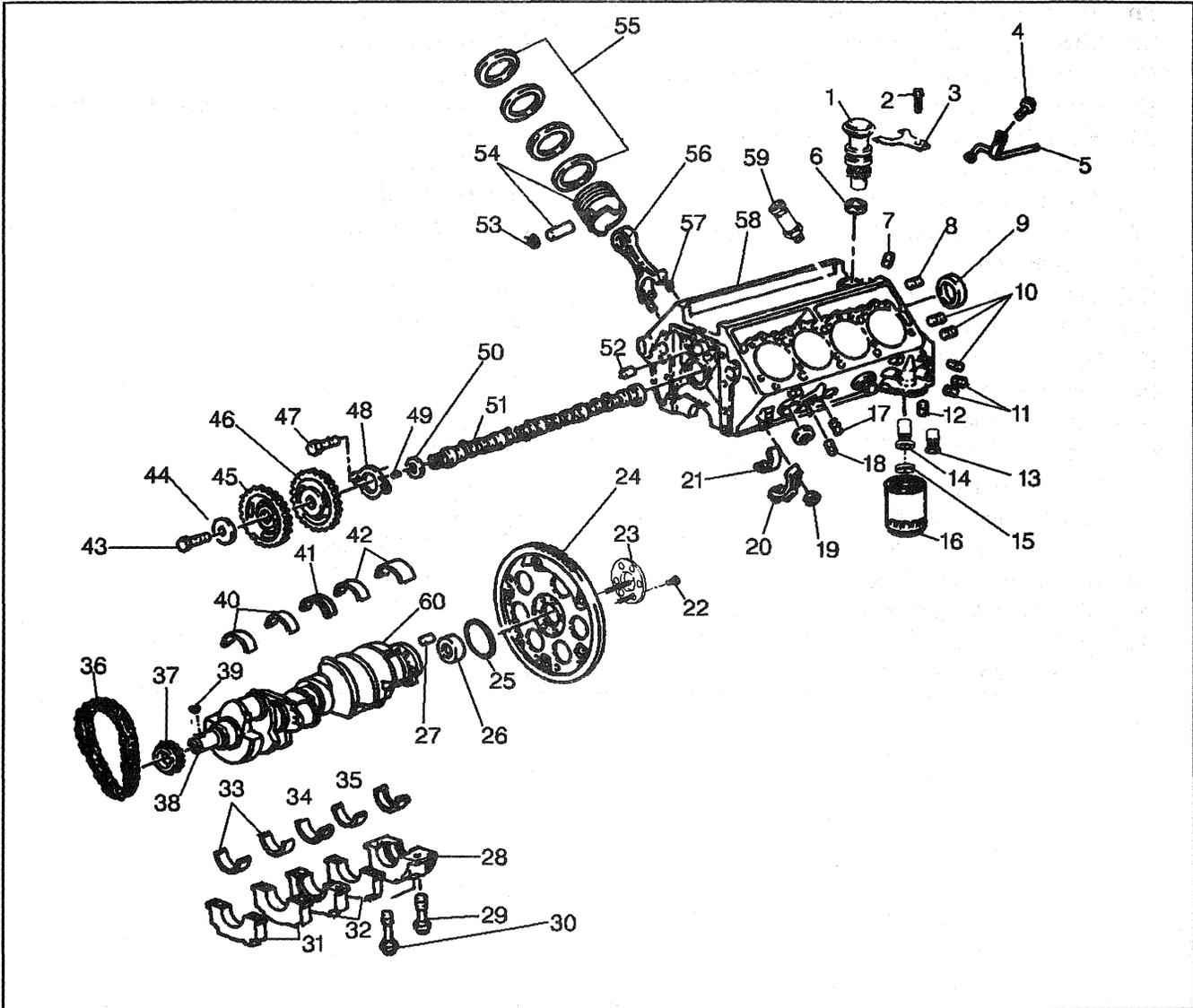
Legend

- | | |
|----------------------------------|---|
| (1) Upper Intake Manifold (L65) | (14) Glow Plugs |
| (2) Upper Intake Manifold Bolts | (15) Exhaust Manifold (LH) |
| (3) Upper Intake Manifold Gasket | (16) Dipstick Tube Shield |
| (4) Rocker Arm Cover (LH) | (17) Exhaust Manifold Bolt |
| (5) Rocker Arm Cover Stud | (18) Prechamber |
| (6) Rocker Arm Cover Bolt | (19) Exhaust Valve |
| (7) Rocker Arm Shaft Bolt | (20) Intake Valve |
| (8) Rocker Arm Shaft Retainer | (21) Valve Lifter |
| (9) Valve Stem Key | (22) Valve Lifter Guide Plate and Pushrod |
| (10) Exhaust Valve Rotator | (23) Valve Lifter Guide Clamp |
| (11) Exhaust Valve Seal | (24) Bypass Hose Fitting (Later Production) |
| (12) Valve Spring | (25) Coolant Crossover Gasket (Later Production) |
| (13) Rocker Arm Retainer | (26) Engine Coolant Temperature (ECT) Sensor (Later Production) |

Engine**Engine Mechanical - 6.5L 6A-267**

-
- | | |
|---|---|
| (27) Thermostat Housing Bolt (Later Production) | (50) Exhaust Manifold (RH) |
| (28) Thermostat Housing (Later Production) | (51) Turbocharger Assembly |
| (29) Thermostat (Later Production) | (52) Long Brace Bolt |
| (30) Thermostat Seal (Dual) (Later Production) | (53) Grommet |
| (31) Coolant Crossover (Later Production) | (54) Crankcase Depression Regulator (CDR) Valve |
| (32) Front Engine Lift Bracket | (55) Clamp |
| (33) Cylinder Head | (56) Hose (CDR) |
| (34) Cylinder Head Bolt | (57) Turbocharger Long Brace |
| (35) Rocker Arm Shaft | (58) Oil Feed Line |
| (36) Rocker Arm | (59) Connector Clamp |
| (37) Cylinder Head Coolant Jacket Cover Plug | (60) Connector Hose |
| (38) Coolant Crossover Stud | (61) Turbocharger Short Brace |
| (39) Cylinder Head Coolant Jacket Cover | (62) Short Brace Bolt |
| (40) Cylinder Head Coolant Jacket Gasket | (63) Oil Return Pipe Gasket |
| (41) Intake Manifold Gasket | (64) Oil Return Pipe Bolt |
| (42) Intake Manifold | (65) Oil Return Pipe |
| (43) Intake Manifold Stud | (66) EGR Valve Bolt (L56) |
| (44) Intake Manifold Bolt | (67) EGR Valve (L56) |
| (45) Oil Return Pipe Adapter Gasket | (68) EGR Valve Gasket (L56) |
| (46) Oil Return Pipe Adapter | (69) Upper Intake Manifold (L56) |
| (47) Oil Return Adapter Bolt | (70) Oil Return Pipe Connector Hose |
| (48) Oil Return Hose Clamp | (71) EGR Tower Gasket (L56) |
| (49) Exhaust Manifold Bolts | |
-

Cylinder Block and Components



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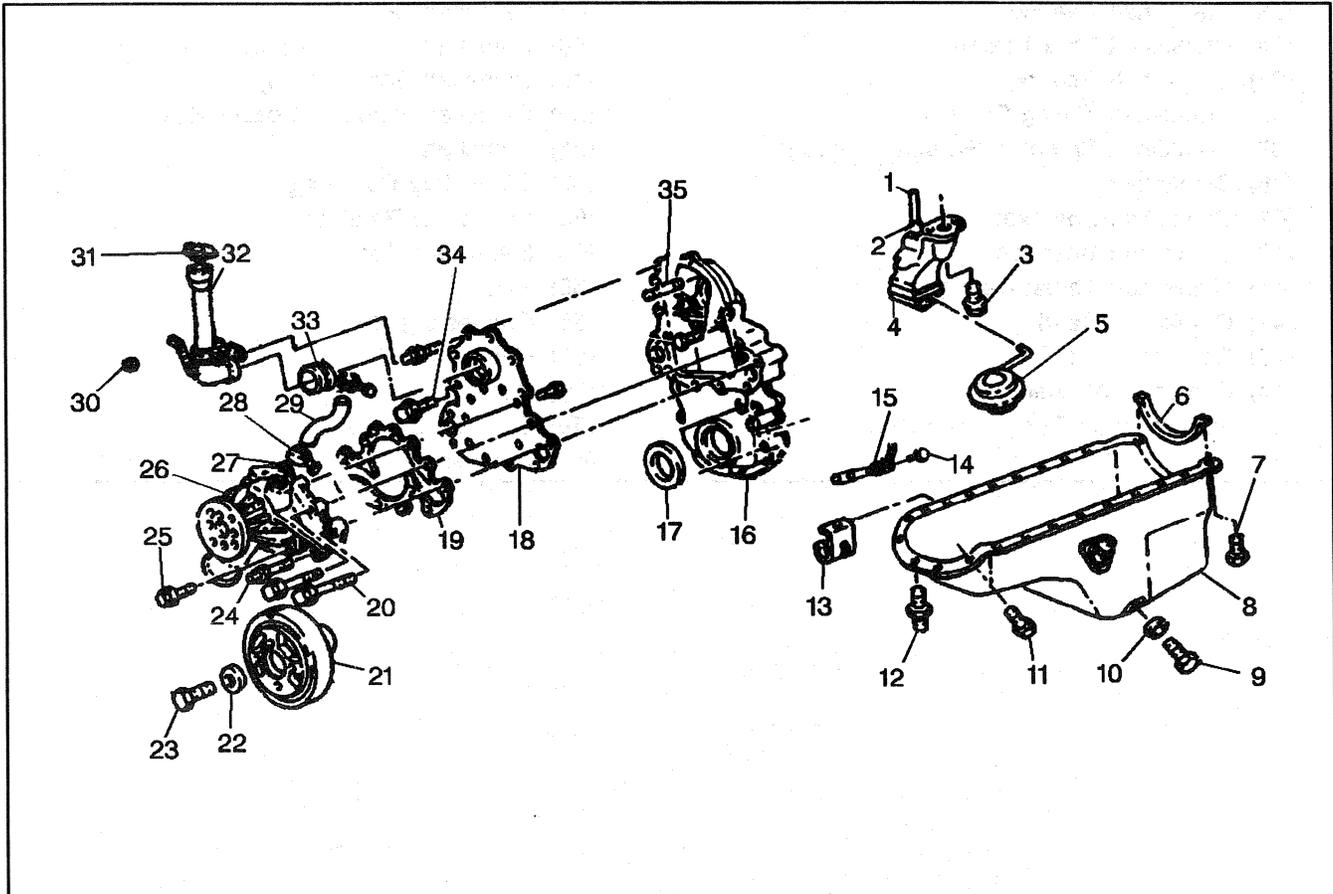
Legend

- | | |
|---------------------------------------|--|
| (1) Oil Pump Drive | (16) Oil Filter |
| (2) Bolt | (17) Oil Gallery Plug |
| (3) Oil Pump Drive Clamp | (18) Plug |
| (4) Bolt | (19) Connecting Rod Nut |
| (5) Fuel Drain Plug | (20) Connecting Rod Bearing Cap |
| (6) Oil Pump Drive Gasket | (21) Connecting Rod Bearing |
| (7) Oil Pressure Sensor Plug | (22) Flywheel Bolt |
| (8) Plug | (23) Retainer |
| (9) Rear Plug Camshaft Bearing | (24) Flywheel |
| (10) Oil Gallery Plug | (25) Crankshaft Rear Oil Seal (One Piece) |
| (11) Oil Cooler Fitting | (26) Clutch Pilot Bearing |
| (12) Main Gallery Hole Plug | (27) Flywheel Dowel Pin |
| (13) Oil Cooler Bypass Valve | (28) Crankshaft Rear Bearing Cap |
| (14) Oil Filter Bypass Valve | (29) Crankshaft Rear Bearing Cap Bolt (Outboard) |
| (15) Oil Cooler Bypass Valve Cup Plug | (30) Crankshaft Bearing Cap Bolt (Inboard) |
| | (31) Crankshaft Bearing Cap |

Engine**Engine Mechanical - 6.5L 6A-269**

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- | | |
|---|------------------------------------|
| (32) Crankshaft Bearing Cap | (46) Camshaft Sprocket |
| (33) Crankshaft Bearings | (47) Camshaft Bolt |
| (34) Crankshaft Thrust Bearing | (48) Camshaft Thrust Bearing |
| (35) Crankshaft Bearings | (49) Camshaft Sprocket Key |
| (36) Crankshaft Timing Chain | (50) Camshaft Sprocket Spacer Ring |
| (37) Crankshaft Sprocket (Reluctor Wheel) | (51) Camshaft |
| (38) Crankshaft | (52) Oil Gallery Hole Plug |
| (39) Crankshaft Sprocket Key | (53) Piston Pin Retainer |
| (40) Crankshaft Bearings | (54) Piston and Pin |
| (41) Crankshaft Thrust Bearings | (55) Rings |
| (42) Crankshaft Bearings | (56) Connecting Rod |
| (43) Camshaft Bolt | (57) Connecting Rod Bolt |
| (44) Camshaft Washer | (58) Block |
| (45) Fuel Injection Pump Drive Gear | (59) Oil Pressure Sensor |
| | (60) Crankshaft |
-

Front Cover, Oil Pan, and Components



67735

Legend

- | | |
|---------------------------------------|-----------------------------------|
| (1) Oil Pump Drive Shaft | (18) Water Pump Backing Plate |
| (2) Oil Pump Drive Shaft | (19) Water Pump Gasket |
| (3) Oil Pump Bolt | (20) Water Pump and Plate Bolt |
| (4) Oil Pump | (21) Torsional Damper |
| (5) Oil Pump Screen | (22) Torsional Damper Bolt Washer |
| (6) Rear Oil Pan Seal | (23) Torsional Damper Bolt |
| (7) Bolt | (24) Water Pump Stud |
| (8) Oil Pan | (25) Water Pump Bolt |
| (9) Oil Pan Drain Plug | (26) Water Pump |
| (10) Oil Pan Drain Plug Gasket | (27) Thermostat Bypass Nipple |
| (11) Oil Pan Bolt | (28) Clamp |
| (12) Oil Pan Stud | (29) Thermostat Bypass Hose |
| (13) Oil Cooler Pipe Clip | (30) Nut |
| (14) Bolt | (31) Oil Filler Cap |
| (15) Crankshaft Position (CKP) Sensor | (32) Oil Fill Tube |
| (16) Front Cover | (33) Oil Filler Grommet |
| (17) Crankshaft Front Oil Seal | (34) Bolt |
| | (35) Fuel Injection Pump Stud |

Repair Instructions

Engine Mounts Inspection

Front Engine Mount

Notice: Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

1. Raise the engine in order to remove the weight from the mount and to place a slight tension on the rubber cushion. Observe both mount while raising the engine.
2. Replace the mount if any of the following conditions exist:
 - Hard rubber surface covered with heat check cracks
 - The rubber cushion separated from the metal plate of the mount
 - The rubber cushion is split through the center
3. If there is movement between a metal plate of the mount and its attaching points, lower the engine and tighten the bolts or nuts attaching the mount to the engine, the frame or the bracket.

Rear Engine Mount

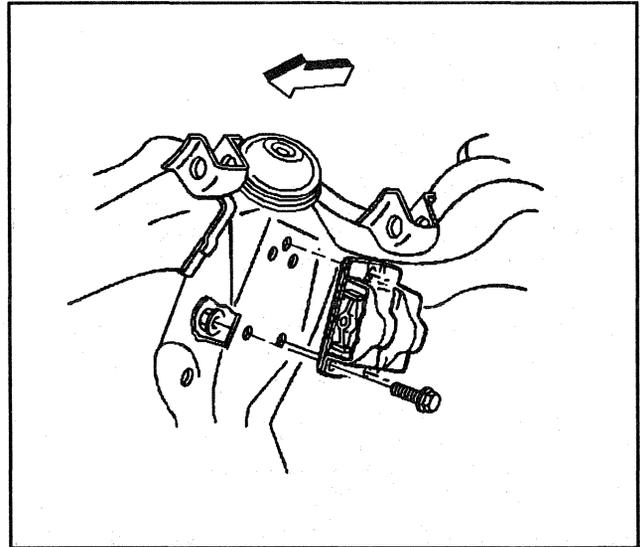
1. Push up and pull down on the transmission tailshaft. Observe the rear engine mount.
2. Replace the mount if either of the following conditions exist:
 - The rubber cushion is separated from the metal plate of the mount
 - The mount is bottomed out (the tailshaft can be moved up but not down).
3. If there is relative movement between a metal plate of mount and its attaching point, tighten the bolts or nuts attaching the mount to the transmission or crossmember.

Engine Mount Replacement (Front)**Removal Procedure**

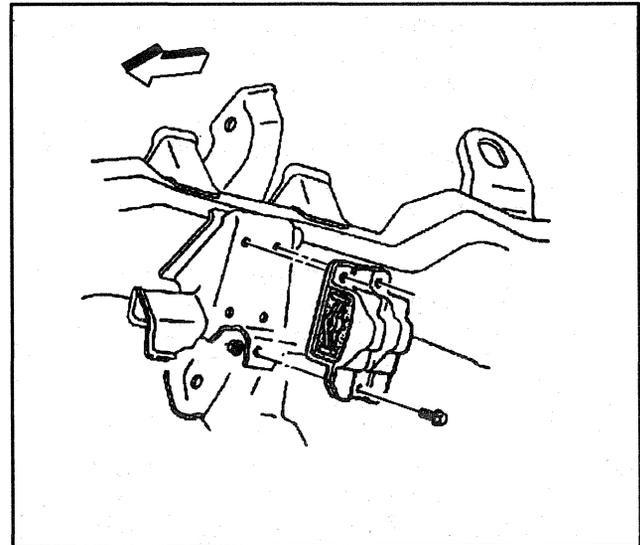
1. Remove the upper shroud.
2. Raise the vehicle.
3. Support the vehicle with safety stands.

Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

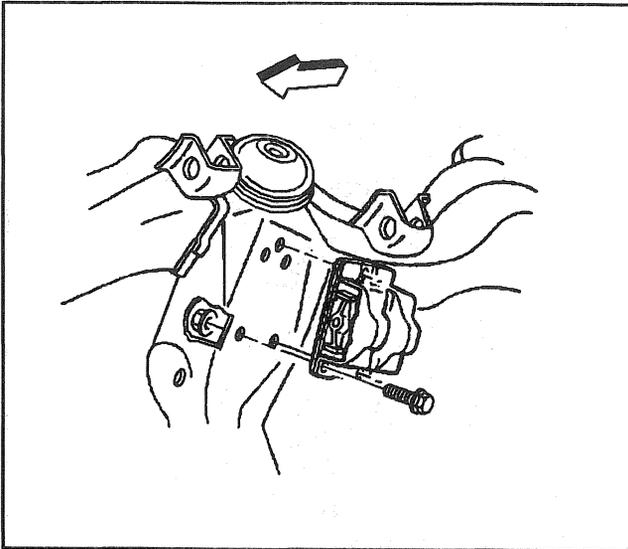
4. Remove the front engine mount through-bolts on both sides.
5. Raise the engine and the block into position.
6. Remove the lower control arm at the pivot point. Refer to Front Suspension and Axle.
7. Remove the front engine mount to frame bolts.
8. Remove the front engine mount.



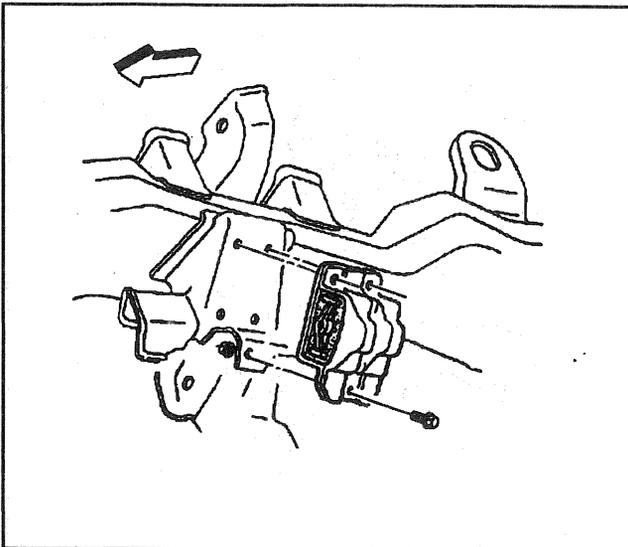
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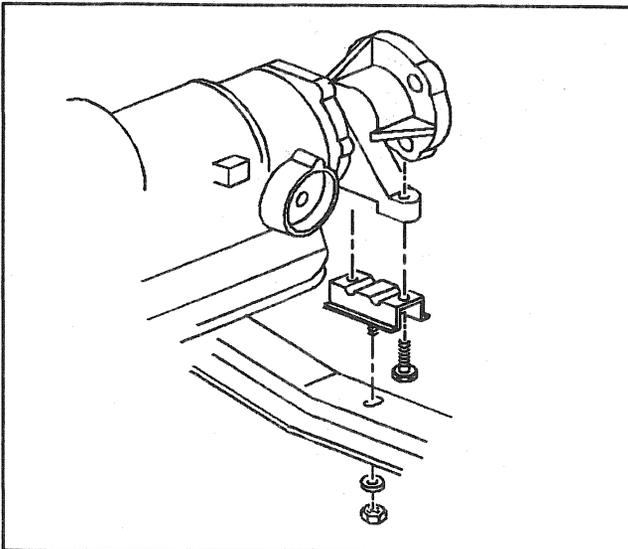
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Installation Procedure

1. Install the front engine mount to the frame.

2. Install the front engine mount to the frame with nuts and bolts.
Tighten
Tighten the nuts to 48 N.m (36 lb ft).
Refer to *Fastener Notice* in General Information.

3. Lower the engine.
4. Install the front engine mount through-bolts.
Tighten
Tighten the through-bolts to 95 N.m (70 lb ft) or the nuts to 70 N.m (50 lb ft).

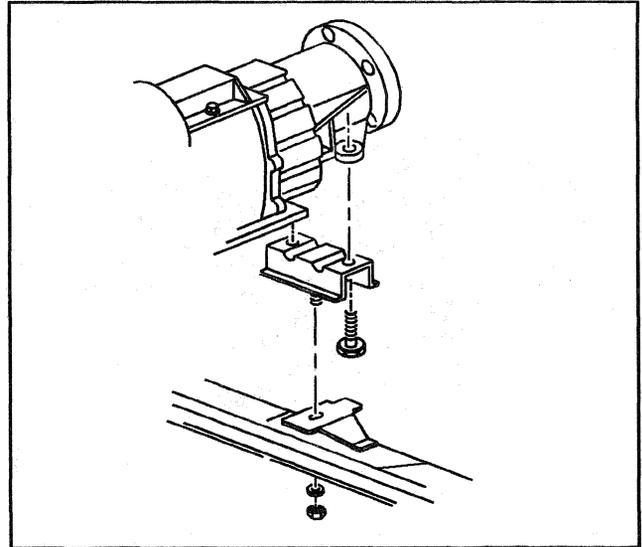
5. Install the lower control arm. Refer to Front Suspension and Axle.
6. Install the upper fan shroud.

Engine Mount Replacement (Rear)

Removal Procedure

1. Disconnect the negative battery cable. Refer to *Battery Disconnect Caution*
Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.
2. Support the rear of the engine in order to relieve the weight on the rear engine mount.
3. Remove the rear engine mount nuts and washers.
4. Raise the rear of the engine in order to allow removal of the rear engine mount.

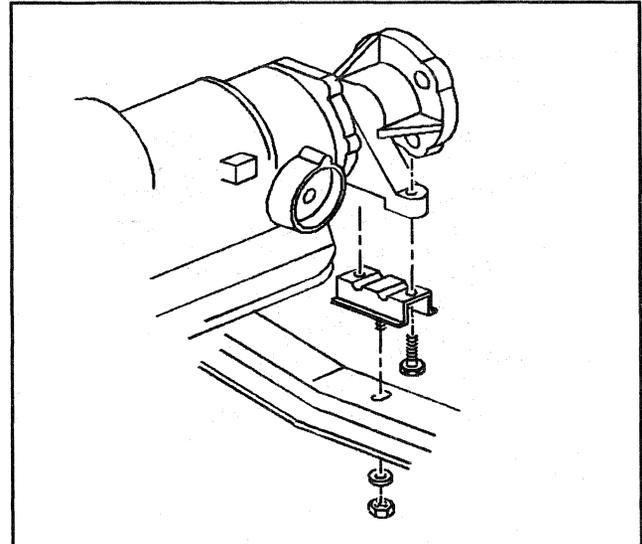
5. Remove the rear engine mount.



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Installation Procedure

1. Install the rear engine mounts.
2. Lower the rear of the engine.



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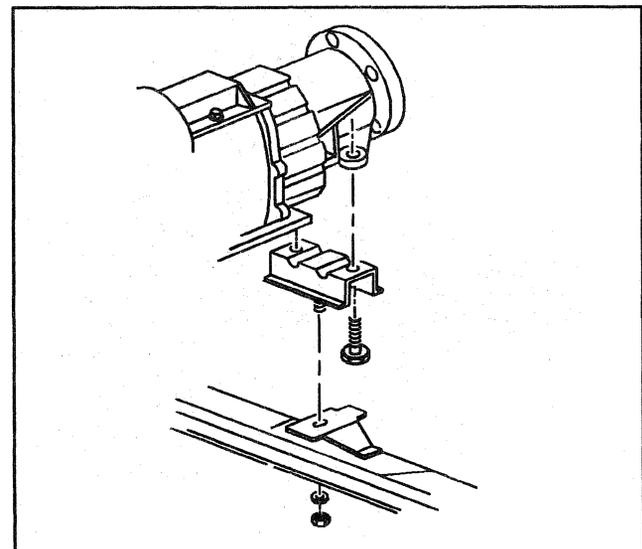
3. Install the rear engine mount bolts and washers.

Tighten

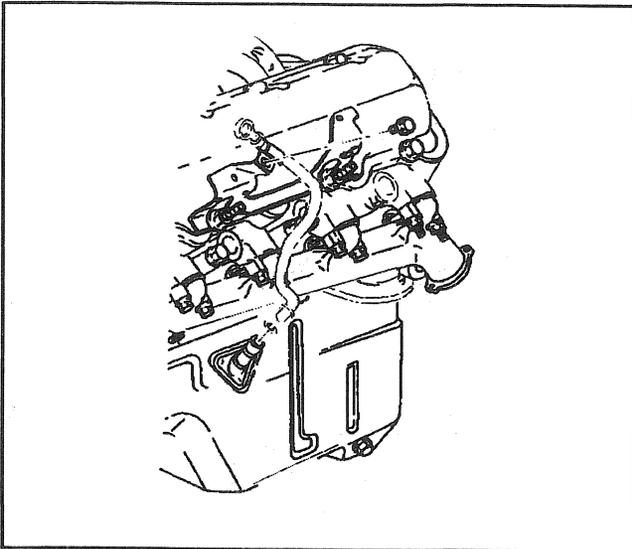
- Tighten the bolt to 47 N·m (35 lb ft).
- Tighten the nut to 47 N·m (35 lb ft).

Refer to *Fastener Notice* in General Information.

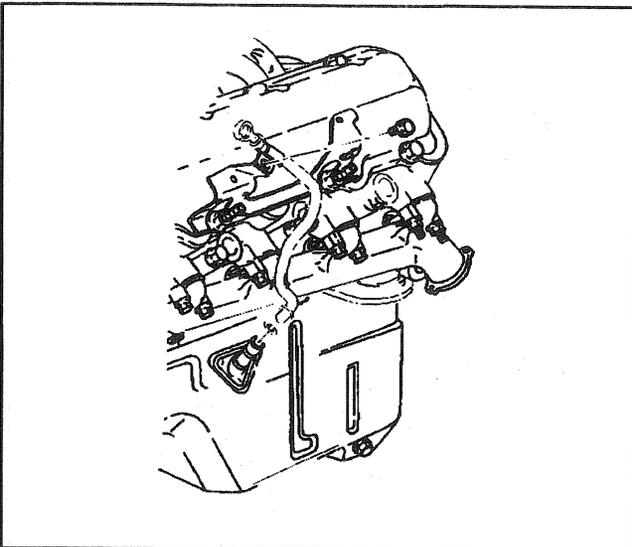
4. Connect the negative battery cable.



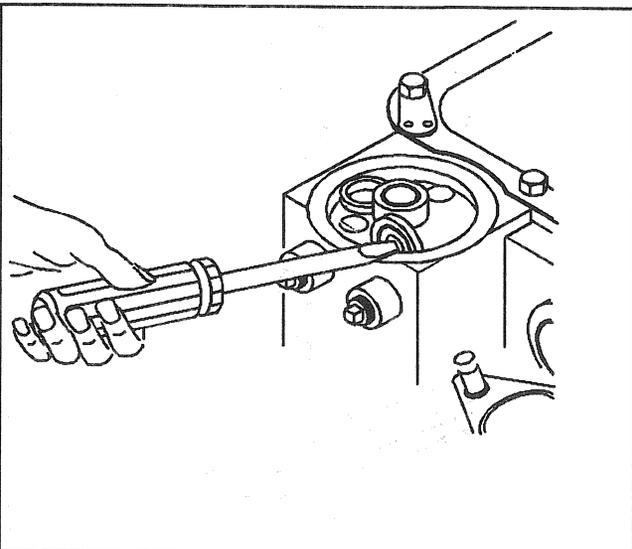
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Oil Level Indicator and Tube Replacement

Removal Procedure

1. Disconnect the negative battery cables. Refer to *Battery Disconnect Caution* in General Information.
2. Remove the oil level indicator tube bracket, nut and washer, at the exhaust manifold.
3. Remove the oil level indicator tube.
4. Remove the o-ring seal from the oil level indicator tube.

Installation Procedure

1. Install the o-ring seal to the oil level indicator tube.
2. Install the oil level indicator tube to the engine.
3. Install the oil level indicator tube nut and washer.

Tighten

Tighten the oil level indicator nut to 4 N.m (35 lb in).

Refer to *Fastener Notice* in General Information.

4. Connect the negative battery cables.

Oil Filter Adapter and Bypass Valve Replacement

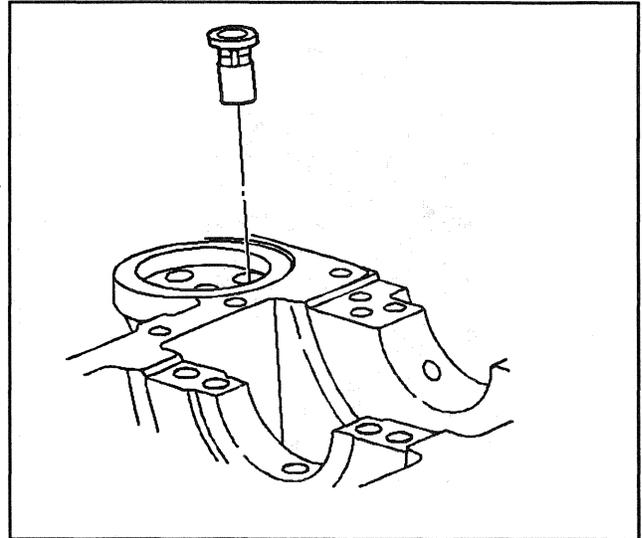
Removal Procedure

1. Raise the vehicle.
2. Remove the oil filter.
3. Remove the oil filter adapter bolt (4WD only).

Important: Do not damage the engine block when removing the bypass valve.
4. Remove the oil cooler bypass valve.
 - Install a 4.8 mm (3/16 in) sheet metal screw into the hole in the cup plug.
 - Using the two heel bars, take out the cup plug.
 - Remove the oil cooler bypass valve. Use a slide hammer.
5. Clean the recess in the block.

Installation Procedure

1. Install the oil cooler bypass valve by using a socket to drive the bypass valve into the bore until seated on the shoulder in the bore.
Important: This plug has an orifice hole that prevents an air lock from occurring and blocking oil flow.
2. Install the cup plug for the oil cooler bypass valve.
3. Install the oil filter bypass valve. Use a socket to drive the valve into the bore until the valve seats against the shoulder in the bore.
4. Install the oil filter adapter end bolt (4WD only).
Tighten
Tighten the bolt to 65N.m (47 lb ft).
Refer to *Fastener Notice* in General Information.
5. Install the oil filter.

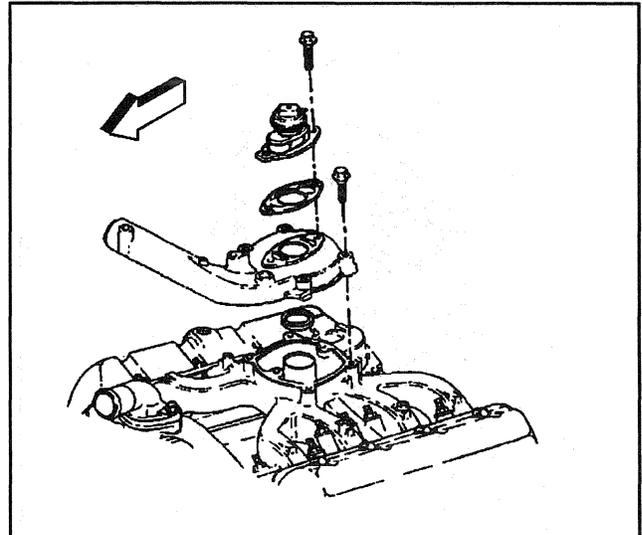


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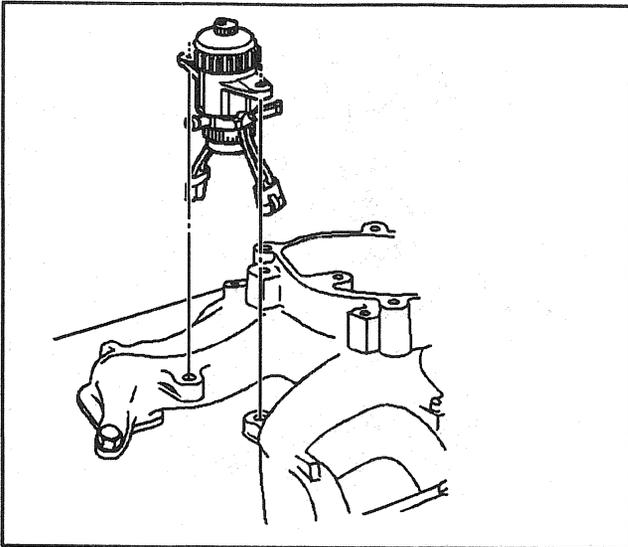
Intake Manifold Replacement**Removal Procedure****Tools Required**

J 39664 Manifold Cover Set

1. Disconnect the negative battery cables. Refer to *Battery Disconnect Caution* in General Information.
2. Remove the fuel filter. Refer to Engine Fuel.
3. Drain the cooling system. Refer to Cooling and Radiator.
4. Remove the thermostat bolts.
5. Remove the fuel line return hose and the clips.
Important: Mark the placement of the studs in order to properly reinstall them.
6. For the L56 remove the EGR/Boost solenoids with the bracket from the intake manifold studs.
7. For the L65 remove the Boost solenoids with the bracket from the intake manifold studs.
8. Remove the heater hose bracket.
9. Remove the vacuum hoses. at the EGR valve (L56 only).
10. Remove the long pencil brace to the turbocharger.
11. Remove the upper radiator hose.



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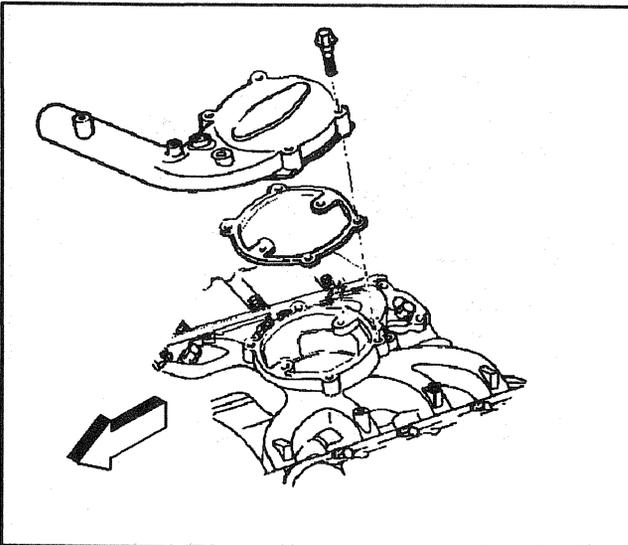
12. Remove the fuel filter assembly and the POE wiring harness bracket to the rear of the lower intake manifold.

Tighten

Tighten the fuel filter mount bolts to 42 N.m (31 lb ft).

Important: In order to loosen the sealer, run a small screw driver (flat blade) between the hose and the upper intake manifold. Do not damage the hose.

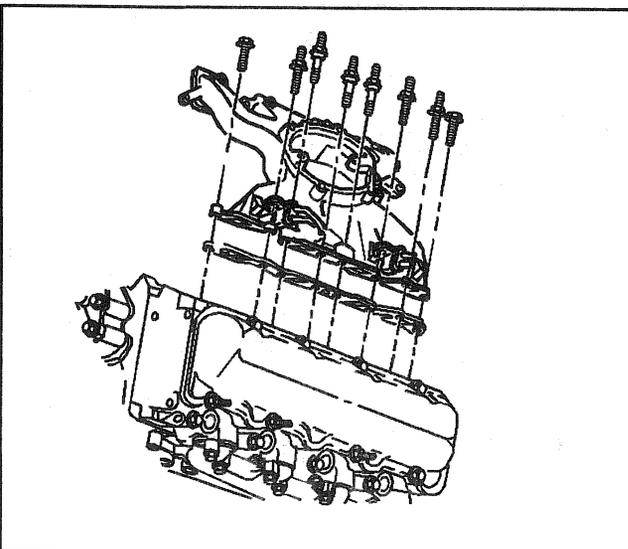
13. Remove the air intake hose from the turbocharger to the upper intake manifold.



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Important: Mark the fuel line clips and brackets in order to insure proper reinstallation.

14. Remove the intake manifold studs and fuel line clips.



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15. Remove the intake manifold and the gasket.

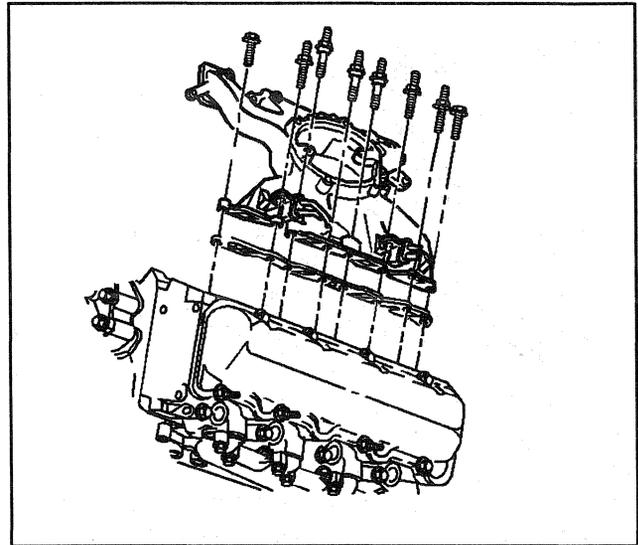
Important: If any further service work is to be done, cover the intake ports with the J 39664.

16. Clean the gasket surfaces on the intake manifold and the cylinder heads.

Installation Procedure

Important: Be sure to use the correct gasket. The gaskets for the L56 models have openings for the EGR, the gaskets for the L65 models do not have openings.

1. Remove the *J 39664* from the intake ports before installing the gaskets.
2. Install the intake manifold with new gaskets.



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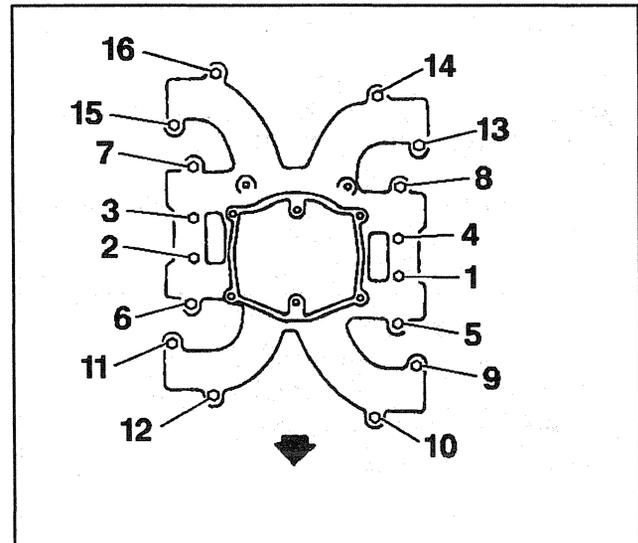
Important:

- There are four bolt/studs, numbers 9, 11, 13 and 15 exposed to the crankcase, and should be sealed with teflon sealer.
 - Apply threadlocker GM P/N 12345493 to the threads of bolts and studs numbers 1 through 8, 10, 12, 14, and 16.
3. Install the intake manifold studs and the fuel line clips.

Tighten

Tighten the intake manifold studs to 42 N·m (31 lb ft).

Refer to *Fastener Notice* in General Information.



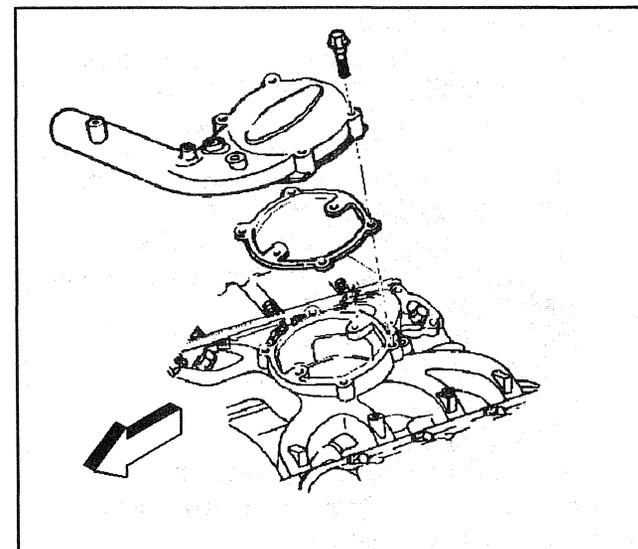
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4. Install the upper intake manifold.
5. For the L56 model, install the EGR tower gasket on the round center portion of the upper intake manifold.
6. Slide the upper intake manifold into the turbocharger outlet hose.
7. Apply the silicone sealant GM P/N 9985943, or equivalent, to the turbocharger outlet before you install the turbocharger outlet onto the upper intake manifold.
8. Install the clamp for the turbocharger connector hose.

Tighten

Tighten the connector hose clamps to 6N·m (50 lb in).

9. Install the fuel line brackets and ground straps.
10. Install the upper radiator hose.
11. Install the long pencil brace to the turbo charger.



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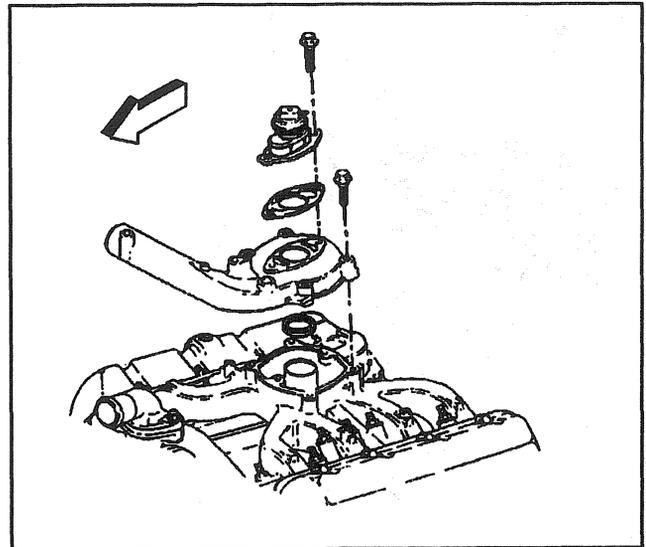
Important: When replacing the upper intake manifold gasket for the L56, always replace the O-ring between the lower and upper intake manifolds. Failure to replace the O-ring will cause a driveability problem.

12. Install the vacuum hoses.
13. Install the heater hose bracket.
14. Install the EGR/Boost solenoids with the bracket to the intake manifold studs.
15. Install the fuel line return hose.
16. Install the fuel filter and the bolts.

Tighten

Tighten the bolts to 42 N.m (31 lb ft).

17. Install the thermostat bolts.
18. Connect the negative battery cables.
19. Refill the engine coolant with the proper quantity and type of coolant. Refer to Cooling and Radiator.



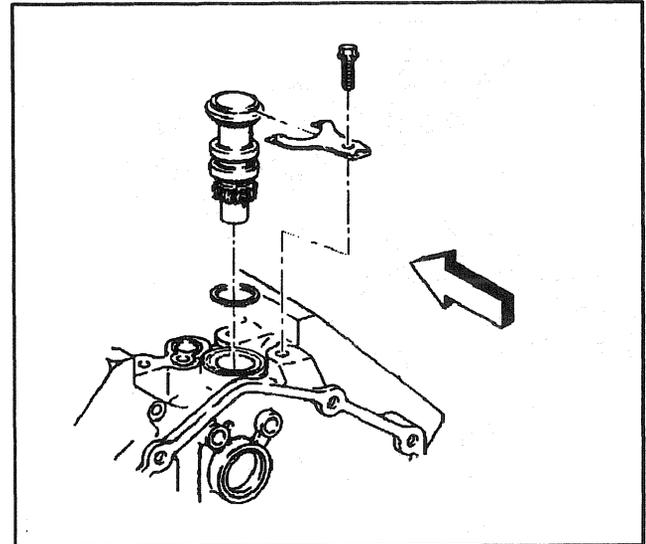
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Oil Pump Drive Replacement

Removal Procedure

Notice: Do not run the engine without the oil pump drive in place. This will cause extensive engine damage.

1. Disconnect the negative battery cables. Refer to *Battery Disconnect Caution* in General Information.
2. Remove the fuel filter from the intake manifold. Refer to Engine Controls.
3. Move the wiring harness aside.
4. Remove the bolt and the clamp.
5. Remove the oil pump drive.
6. Remove the O-ring.



60246

Installation Procedure

1. Install the new O-ring to the oil pump drive. Coat the O-ring with clean engine oil.

Important: Do not force the oil pump drive gear into place. The oil pump drive gear should slide into place with slight resistance. Apply clean engine oil to the new O-ring.
2. Install the oil pump drive to the engine.
 - Index the drive with the camshaft gear and the oil pump drive shaft.
 - Make sure the drive is fully seated.

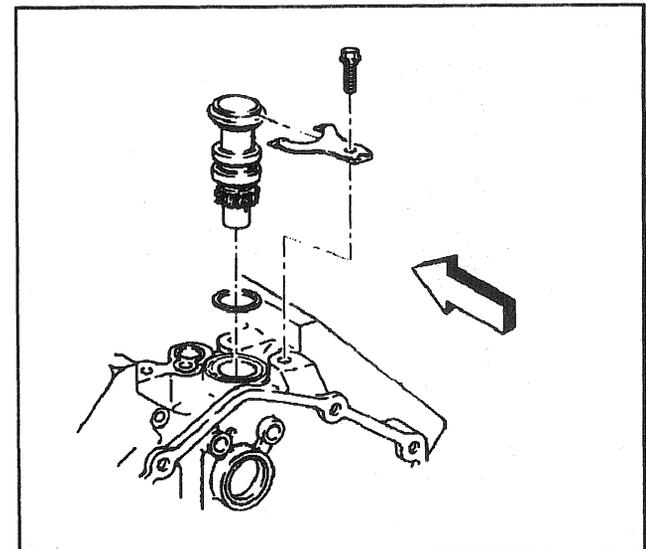
3. Install the clamp.
4. Install the bolt.

Tighten

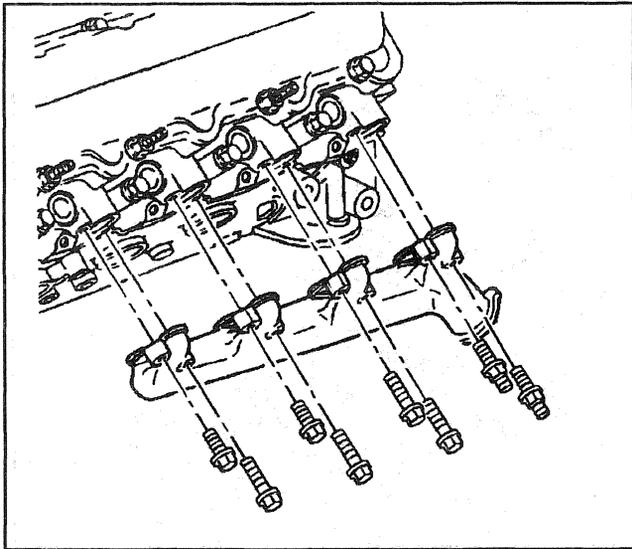
Tighten the bolts to 42 N.m (31 lb ft).

Refer to *Fastener Notice* in General Information.

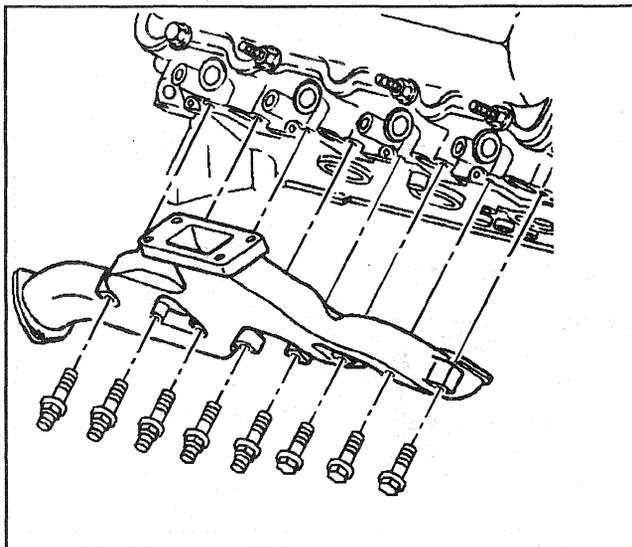
5. Install the wiring harness.
6. Install the fuel filter.
7. Connect the negative battery cables.



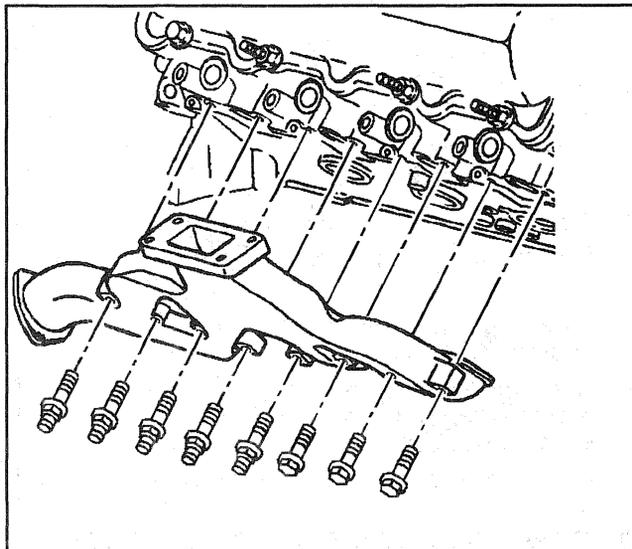
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Exhaust Manifold Replacement (Left Side)

Removal Procedure

1. Disconnect the negative battery cables. Refer to *Battery Disconnect Caution* in General Information.
2. Raise the vehicle.
3. Support the vehicle with safety stands.
4. Remove the glow plugs. Refer to Engine Controls.
5. Remove the exhaust pipe from the exhaust manifold. Refer to Exhaust System.
6. Remove the exhaust manifold bolts.
7. Remove the exhaust manifold from under the vehicle.
8. Clean the sealing surfaces on the exhaust manifold and cylinder head.
9. Clean the threads on the exhaust manifold bolts.

Installation Procedure

1. Install the exhaust manifold from under the vehicle.
2. Install the exhaust manifold bolts.

Tighten

Tighten the bolts to 35 N.m (36 lb ft). Refer to *Fastener Notice* in General Information.

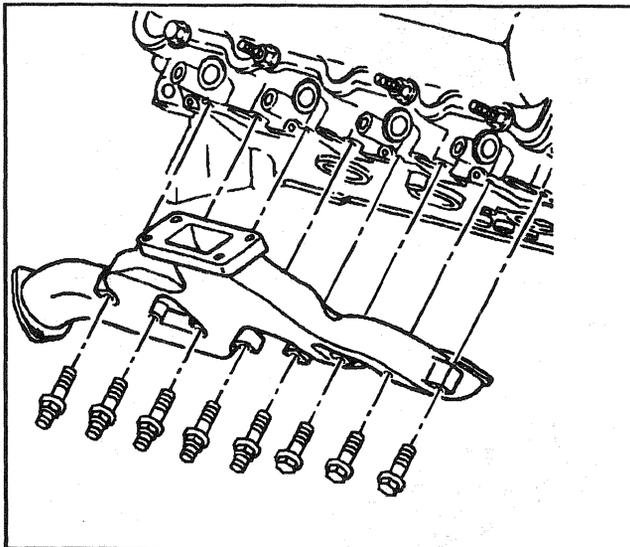
3. Install the exhaust pipe to the exhaust manifold.
4. Lower the vehicle.
5. Install the glow plugs.
6. Connect the negative battery cables.

Exhaust Manifold Replacement (Right Side)

Removal Procedure

1. Disconnect the negative battery cables. Refer to *Battery Disconnect Caution* in General Information.
2. Remove the air cleaner box and intake duct.
3. Raise the vehicle.
4. Support the vehicle with safety stands.
5. Remove the exhaust pipe from the exhaust manifold. Refer to Exhaust System.
6. Remove the glow plug wires. Refer to Engine Controls.
7. Lower the vehicle.
8. Remove the turbocharger assembly. Refer to Turbocharger.

9. Remove the glow plugs and shields. Refer to Engine Controls.
10. Remove the exhaust manifold bolts.
11. Remove the exhaust manifold.
12. Clean the following items:
 - The sealing surfaces on the exhaust manifold and the cylinder head
 - The threads on the exhaust manifold bolts



60245

Installation Procedure

1. Install the exhaust manifold.
Install the exhaust manifold bolts.
Tighten
Tighten the bolts to 35 N.m (26 lb ft).
Refer to *Fastener Notice* in General Information.
2. Install glow plugs and shields.
3. Install the turbocharger assembly.
4. Raise the vehicle.
5. Support the vehicle with safety stands.
6. Install the glow plug wires.
7. Install the exhaust pipe to the exhaust manifold.
8. Lower the vehicle.
9. Install the air cleaner box and intake duct.
10. Connect the negative battery cables.

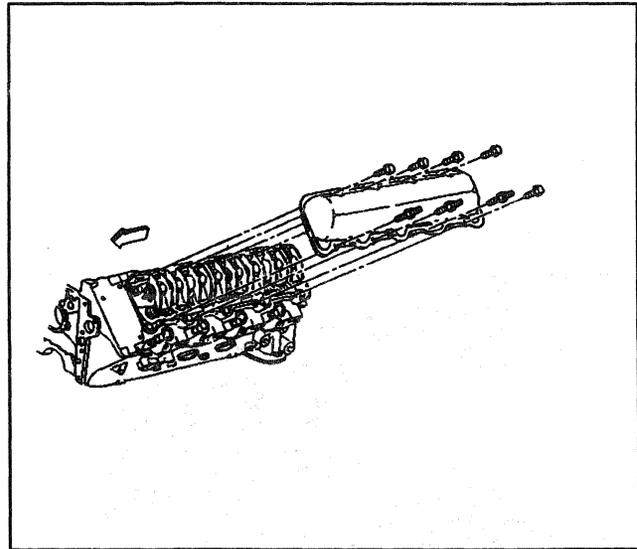
Valve Rocker Arm Cover Replacement

Removal Procedure

1. Remove the intake manifold. Refer to *Intake Manifold Replacement*.
Important: Do not bend the fuel injector lines in order to ease the removal of the valve rocker arm cover. Damage to the fuel injector lines will occur.
Important: Mark the fuel line clips and brackets in order to insure proper installation.
2. Remove the fuel injection lines and clips. Refer to Engine Controls.
3. Remove the CDR valve and hose (right side).
4. Remove the long pencil brace to the turbocharger (right side).
5. Remove the ground strap.
6. Remove the heater hose (right side).
7. Remove the oil level indicator tube and bracket (left side).
Important: Mark the fuel line clips and brackets in order to insure proper installation.
8. Remove the fuel return line clip at the valve rocker arm cover stud.
9. Remove the wiring harness at the rear of the valve rocker arm cover from the clips and move aside.
10. Remove the turbocharger heat shield (right side).

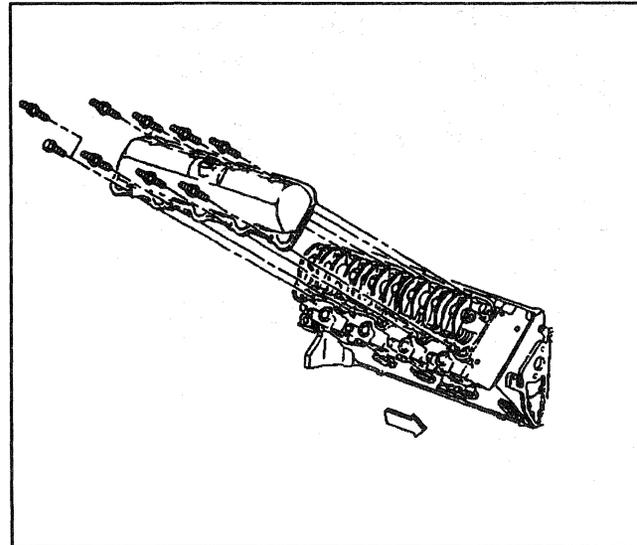
Important: Do not pry on the rocker arm cover. Prying on the rocker arm cover may cause damage to the sealing surfaces.

11. Remove the valve rocker arm cover.
12. Clean the RTV from the valve rocker arm cover and cylinder head. All loose RTV or pieces that will cause installation interference must be removed.
13. Clean the oil and grease from the sealing surfaces on the valve rocker arm cover and cylinder head. Use a suitable solvent.



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14. Inspect the valve rocker arm cover sealing flanges for distortion. Replace as necessary.

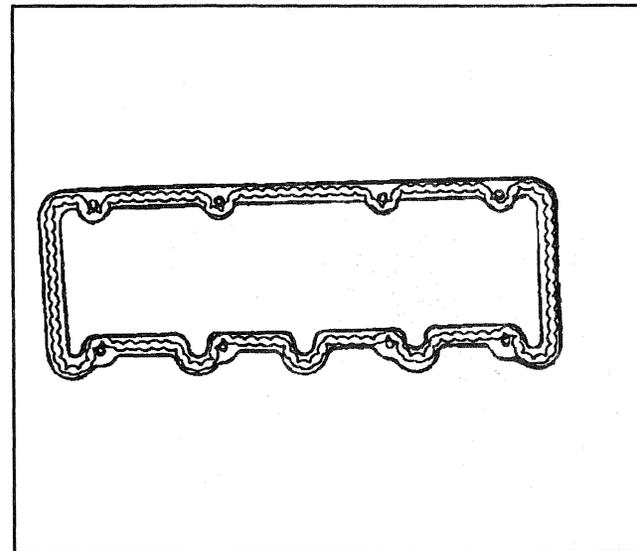


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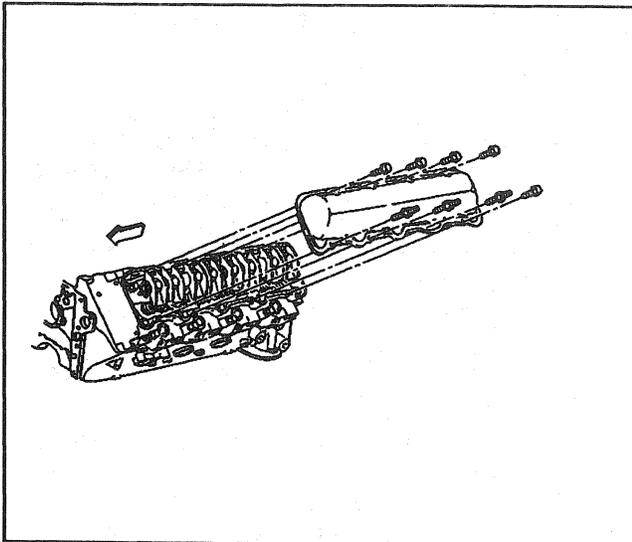
Installation Procedure

Notice: Do not allow the RTV sealant into the valve rocker arm cover bolt holes. This may cause a "valve lock" condition, when the bolts are tightened, damaging the cylinder head casting.

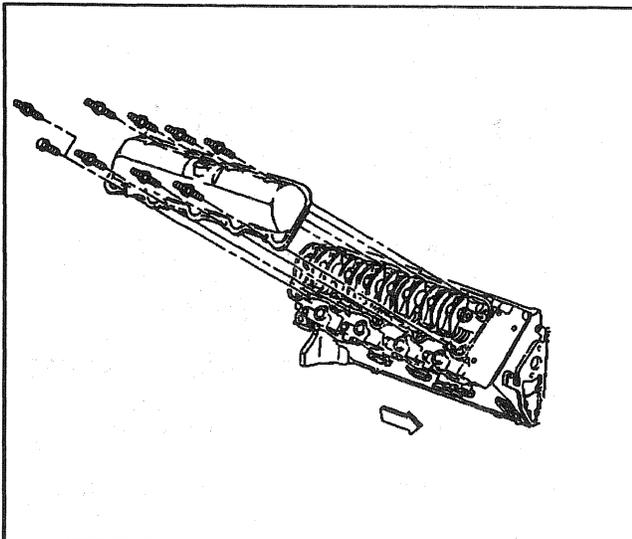
1. Apply a 5 mm (3/16 in) bead of RTV sealant GM P/N 12345739 to the valve rocker arm covers, inboard of the bolt holes. The sealer must be wet to the touch when the bolts are tightened.



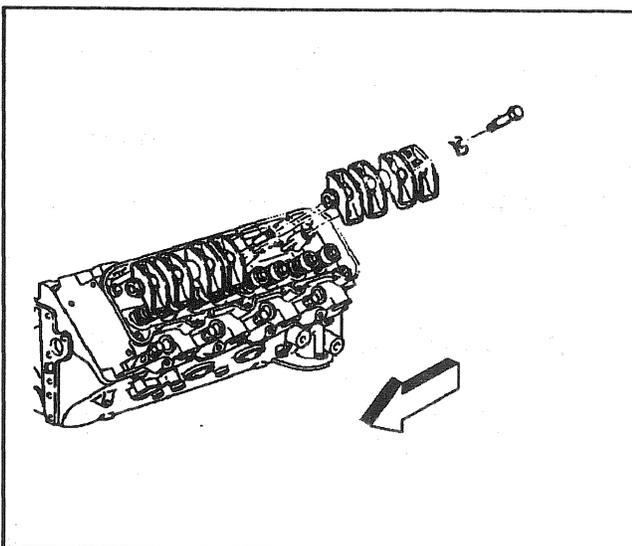
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2. Install the valve rocker arm cover.
Tighten
Tighten the bolts to 22 N.m (16 lb ft).
Refer to *Fastener Notice* in General Information.
3. Install the wiring harness.

4. Install the turbocharger heat shield (right side).
5. Install the fuel return lines.
6. Install the oil level indicator tube and the bracket (left side).
7. Install the heater hose (right side).
8. Install the ground strap.
9. Install the long pencil brace to the turbocharger (right side).
10. Install the CDR valve and hose (right side).
11. Install the fuel injection lines and clips to their original location as marked during removal.
12. Install the intake manifold. Refer to *Intake Manifold Replacement*.

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

Important:

- Rotate the engine until the mark on the crankshaft balancer is at 2 o'clock.
- Rotate the crankshaft counterclockwise 88 mm (3 1/2 in), aligning the crankshaft balancer mark with the first lower water pump bolt, about 12:30.
- This will position the engine so no valves are close to a piston crown.

1. Remove the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Replacement*.

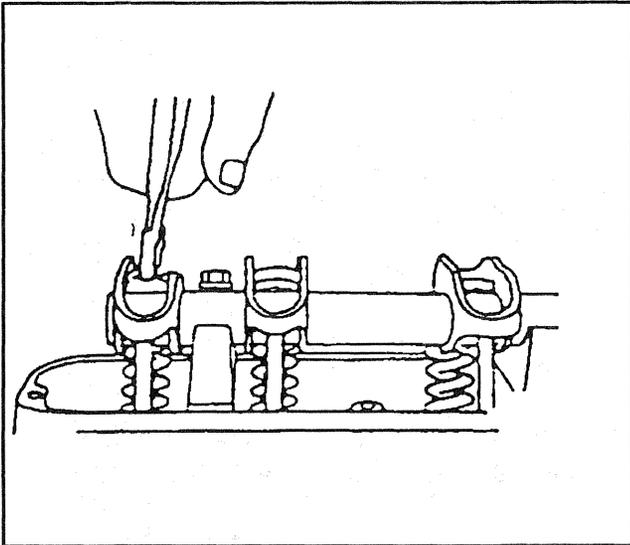
Notice: All valve train components must be reassembled in the exact order and position from which they were removed.

2. Remove the valve rocker arm shaft bolts.

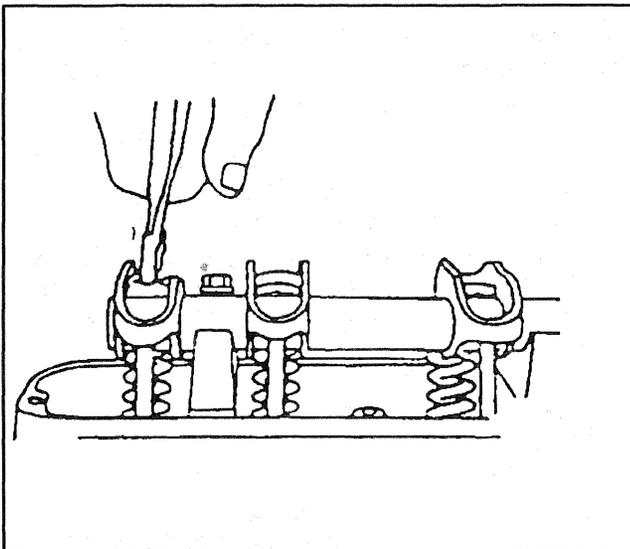
3. Remove the valve rocker arm shaft with the valve rocker arms.
4. Remove the pushrods.

Important: The pushrods must be installed in the original direction as disassembly. This is because the pushrods have a different degree of hardness at each end. A paint stripe identifies the upper end of the pushrod. If the paint stripe is not visible, mark the pushrods on the upper end as they are removed.

5. Remove the valve rocker arms, if required.
6. Insert a screwdriver into the valve rocker arm shaft bore and break off the end of the nylon valve rocker arm retainers.
7. Remove the valve rocker arm retainers with a pair of pliers.
8. Slide the valve rocker arms from the shaft.
9. Inspect each of the following components:
 - Inspect the valve rocker arms and the shafts at their mating surfaces. These surfaces should be smooth and free from scoring or other damage.
 - Inspect the valve rocker arm areas which contact the valve stems and the sockets which contact the pushrods. These areas should be smooth and free of damage and wear.
 - Inspect the pushrods for bending. Roll the pushrod on a flat surface to determine if the pushrod is bent. Replace the pushrod if necessary.
 - Inspect the ends of the pushrods for scoring or roughness.
 - Inspect the valve lifter guides and the retainers.
 - Inspect the oil passages in the pushrods for obstructions. The pushrod oil passages must be clean.



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Installation Procedure

Notice: All valve train components must be reassembled in the exact order and position from which they were removed.

Important: Lubricate the valve rocker arms with clean engine oil before installing.

1. Install the valve rocker arms to the valve rocker arm shaft. One type of valve rocker arm is used at all locations.
2. Install the valve rocker arm retainers.
3. Center the valve rocker arms on the corresponding holes in the valve rocker arm shaft.
4. Install the new retainers. Use a drift of at least 13 mm (1/2 in) in diameter.

Notice: Install the valve pushrods with the marked or painted end up in order to avoid damage or premature wear.

5. Install the pushrods, with the painted or marked end up.

Notice: Improper installation of the valve rocker arm shaft bolts may cause valve rocker arm shaft breakage and piston to valve contact.

Important: Make sure the ball ends of the pushrods seat in the valve rocker arms.

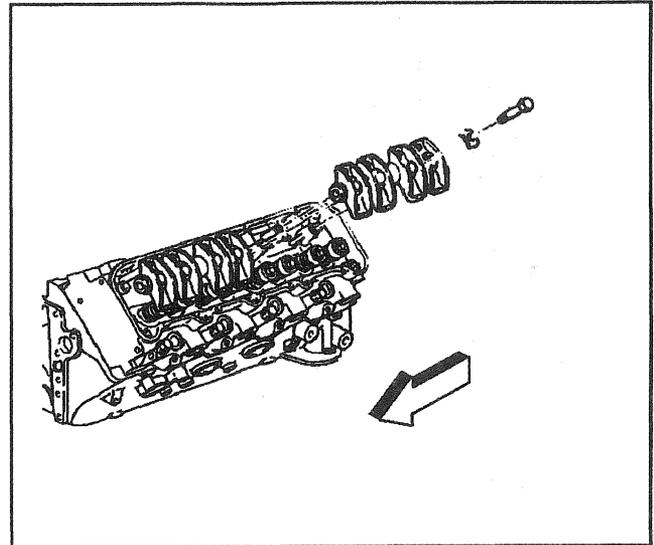
6. Install the valve rocker arm shaft assembly.
7. Install the valve rocker arm shaft bolts.

Tighten

Tighten the bolts alternately to 55 N·m (40 lb ft). Rotate the engine by hand in order to ensure free movement of the valve train.

Refer to *Fastener Notice* in General Information.

8. Install the valve rocker arm cover.



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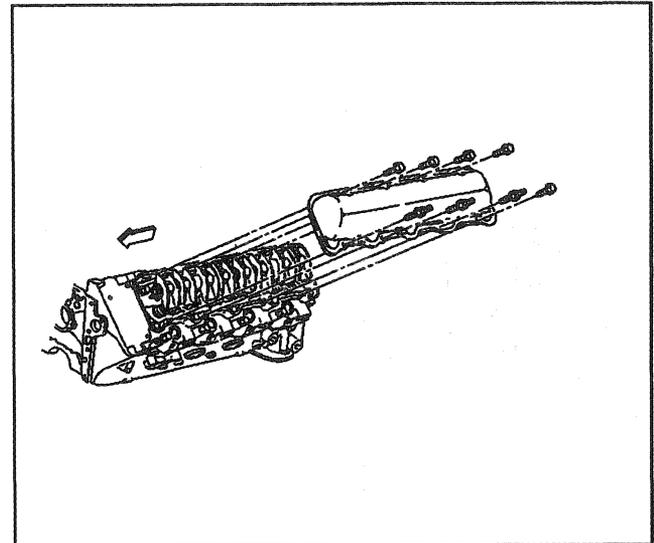
Valve Stem Oil Seal and Valve Spring Replacement

Removal Procedure

Tools Required

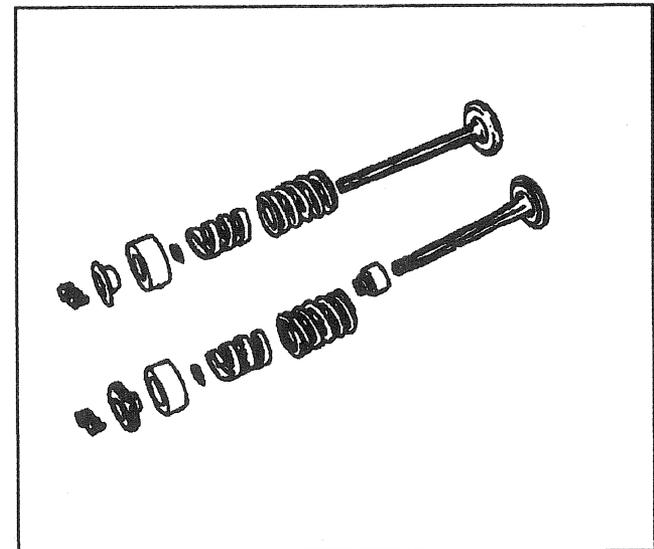
- J 26999-10 Compression Gauge Adapter
- J 26999-30 Compression Gauge Adapter
- J 38606 Valve Spring Compressor

1. Remove the valve rocker arm covers. Refer to *Valve Rocker Arm Cover Replacement*.
2. Remove the valve rocker arm shaft with the valve rocker arms. Mark the assemblies so these can be returned to the original locations. Refer to *Valve Rocker Arm and Push Rod Replacement*.
3. Remove the glow plugs. Refer to Engine Controls.

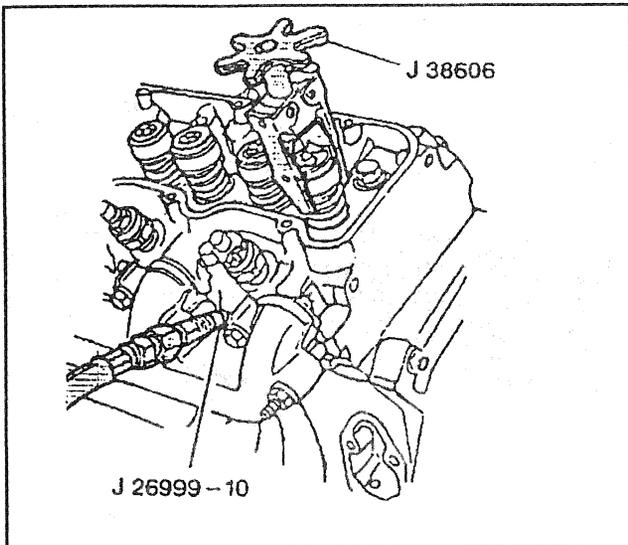


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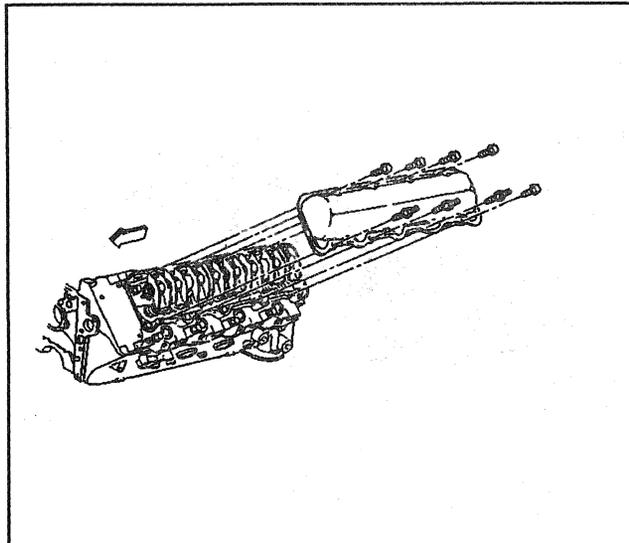
4. Remove the valve keys.
5. Rotate the engine until the piston for the cylinder being serviced is at TDC.
6. Install the J 26999-10 or the J 26999-30 into the glow plug hole.
7. Apply compressed air to hold the valves in place. If the compressed air is released, the valves can drop into the cylinder.



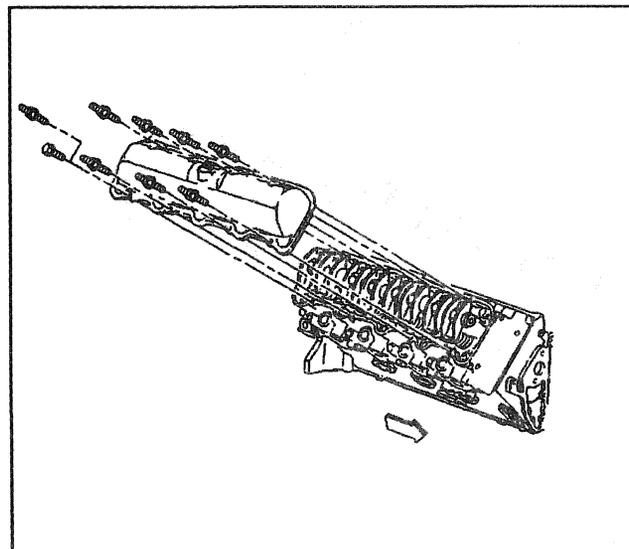
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8. Use the *J 38606* in order to compress the valve spring. If the spring will not compress, tap on the tool lightly with a mallet in order to loosen the cap or rotator from the valve keys.
9. Remove the valve keys.
10. Carefully release the valve spring tension. Remove the *J 38606*.
11. Remove the cap or the rotator, the shield, and the valve spring with the damper.
12. Remove the valve stem oil seals.

Installation Procedure

Notice: Air pressure should remain applied to the cylinder for installation.

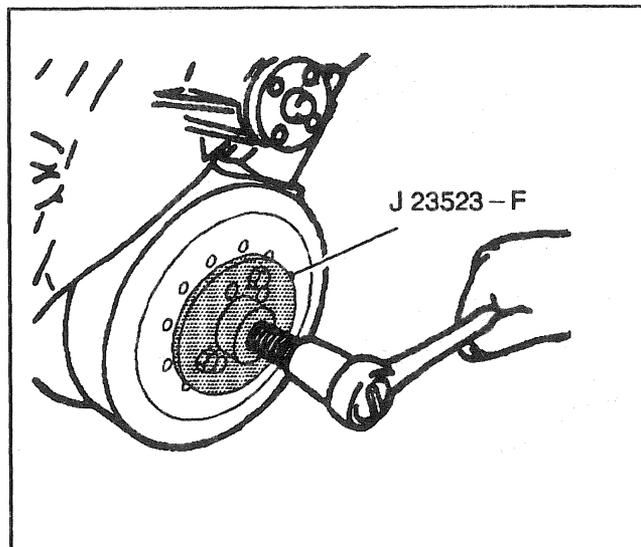
1. Apply a small amount of clean engine oil to the valve stem.
2. Install the new valve stem oil seals.
3. Install the valve spring with the damper, the shield, and the cap or the rotator.
4. Install the valve keys.
 - Install the valve keys. Use grease in order to hold the valve keys in place.
 - Carefully release the valve spring pressure. Make sure the valve keys stay in place.
 - Remove the *J 38606* or the *J 26999-30* and the *J 26999-10*.
5. Install the glow plugs.
6. Install the valve rocker arm shaft with the valve rocker arms.
7. Install the valve rocker arm covers.

Crankshaft Balancer Replacement

Removal Procedure

Tools Required

- J 39046 Crankshaft Balancer Remover
 - J 22102 Seal Installer
1. Disconnect the negative battery cables. Refer to *Battery Disconnect Caution* in General Information.
 2. Remove the accessory drive belt.
 3. Remove the upper radiator upper shroud. Refer to Cooling and Radiator.
 4. Remove the bolts.
 5. Remove the crankshaft pulley.
 6. Remove the crankshaft balancer bolt and washer.
 7. Remove the crankshaft balancer. Use the J 22102.
 8. Remove the engine front cover oil seal. Pry out the oil seal with a screwdriver.



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Installation Procedure

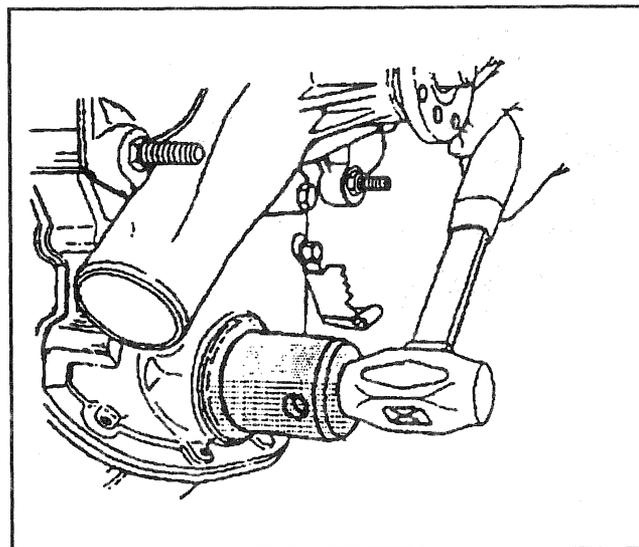
1. Install the new engine front cover oil seal. Use the J 22102.
2. Lubricate the sealing area with engine oil. Apply clean engine oil to the crankshaft.
3. Inspect the crankshaft balancer sealing surface for grooving or roughness. Replace the crankshaft balancer if necessary.
4. Install the crankshaft balancer. Tap into place with a mallet and make sure the balancer is all the way on the crankshaft.
5. Install the crankshaft balancer bolt and washer.

Tighten

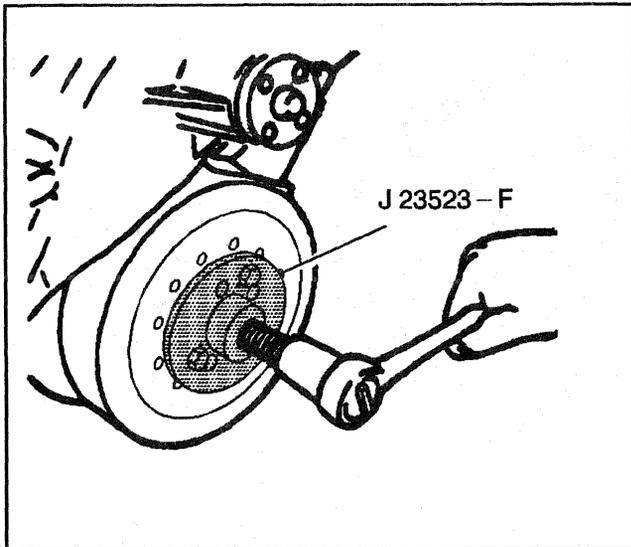
Tighten the bolt to 270 N·m (200 lb ft). Refer to *Fastener Notice* in General Information.
6. Install the crankshaft pulley and bolts.

Tighten

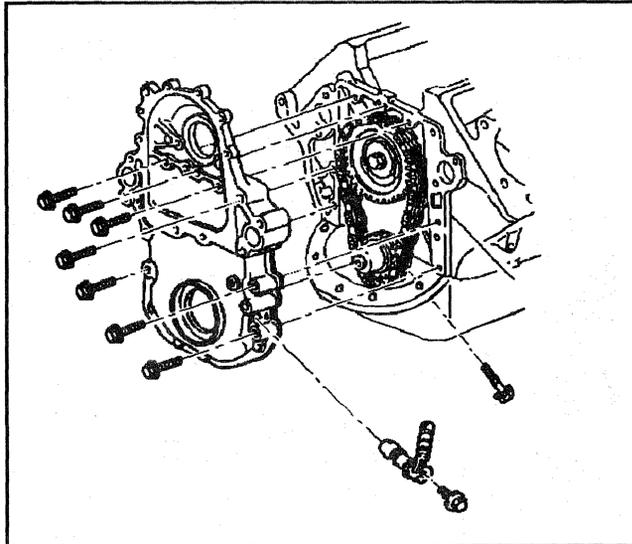
Tighten the bolts to 40 N·m (30 lb ft).
7. Install the accessory drive belt.
8. Connect the negative battery cables.



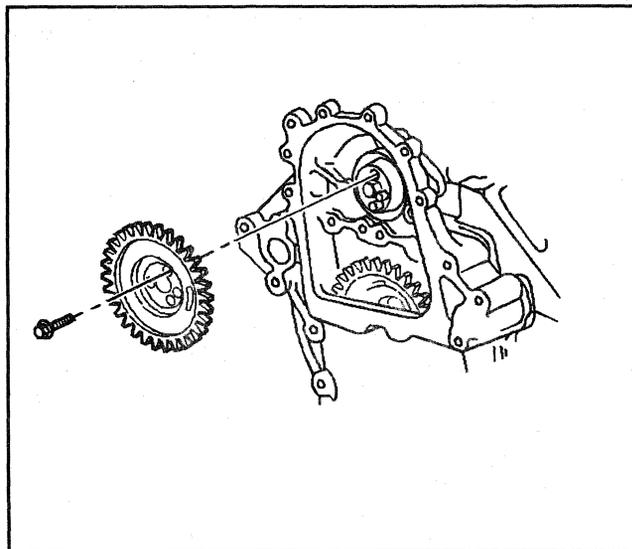
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Engine Front Cover Replacement

Removal Procedure

Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

1. Drain the cooling system.
2. Remove the water pump. Refer to Cooling and Radiator.
3. Rotate the engine until the timing marks are aligned.
4. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
5. Remove the crankshaft position sensor.
6. Remove the engine front cover to oil pan bolts.

Important: Mark the fuel line clips, so that they can be re-installed on the proper stud.
7. Remove the fuel return line clips.

8. Remove the front cover for the fuel injection pump drive gear.
9. Remove the fuel injection pump gear.
10. Remove the fuel injection pump retaining nuts.
11. Remove the engine front cover and bolts.
12. Remove the engine front cover oil seal. Pry the oil seal out with a screwdriver.
13. Clean the RTV from the oil pan sealing surface and the sealing surfaces on the engine front cover.
14. Inspect the engine front cover for cracks or damage to the sealing surfaces.

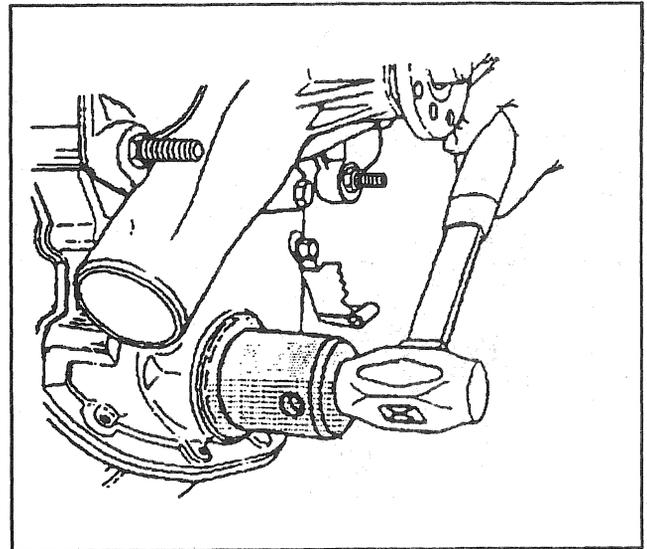
Installation Procedure

1. Install the new engine front cover oil seal to the engine front cover. Use the *J 22102*.
 - Apply a 2 mm (3/32 in) bead of anaerobic sealant GM P/N 1052357 or equivalent to the engine front cover.
 - Apply a 5 mm (3/16 in) bead of RTV sealant to the engine front cover sealing the surface that mates against the oil pan.
2. Install the engine front cover to the engine.
3. Install the attaching bolts and the fuel injection pump studs.

Tighten

Tighten the nuts to 40 N.m (30 lb ft).

Refer to *Fastener Notice* in General Information.



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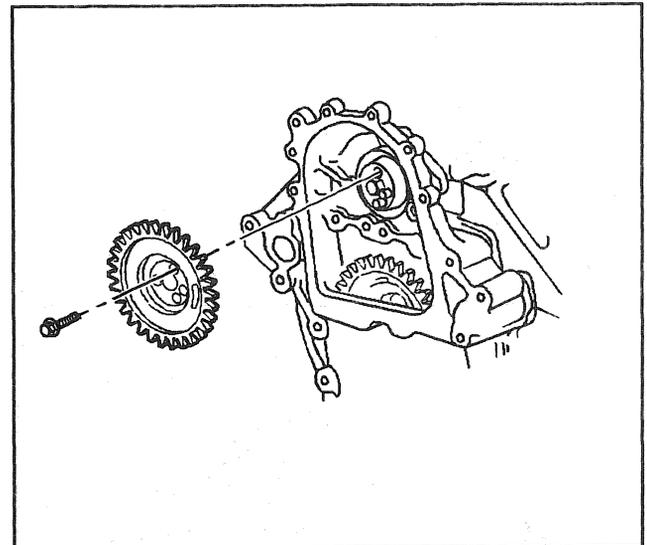
4. Install the fuel injection pump gear.
5. Install the fuel injection pump gear bolts and align the timing marks.

Tighten

Tighten the bolts to 25 N.m (20 lb ft).

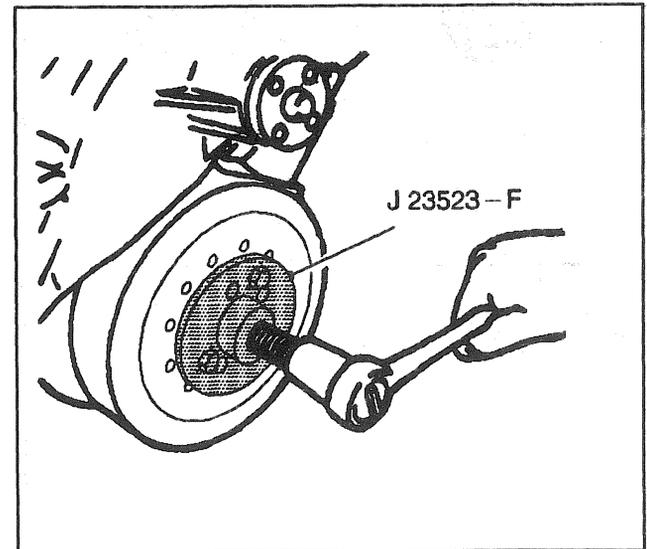
6. Install the front cover fuel injection drive gear.

Important: Check the marks on the fuel line clips made during removal. Ensure that the fuel line clips are re-installed on the proper studs.
7. Install the fuel return line clip.
8. Install the crankshaft position sensor.
9. Install the engine front cover.

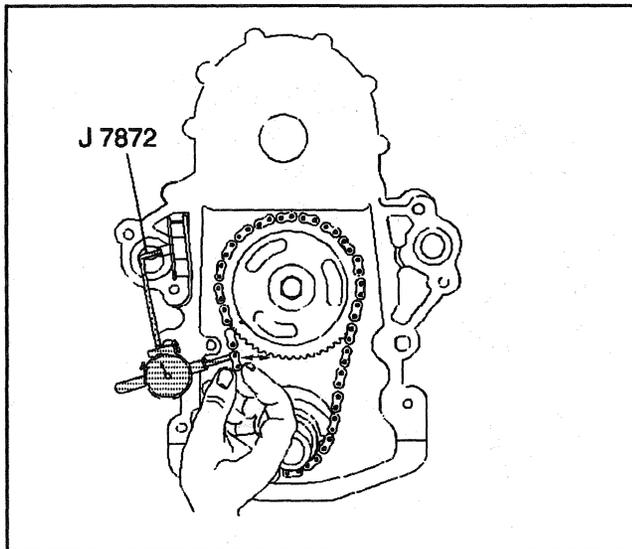


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10. Install the crankshaft balancer.
11. Fill the cooling system with the proper quantity and grade of coolant. Refer to Maintenance and Lubrication.
12. Reset the fuel injection pump timing. Refer to Engine Controls.



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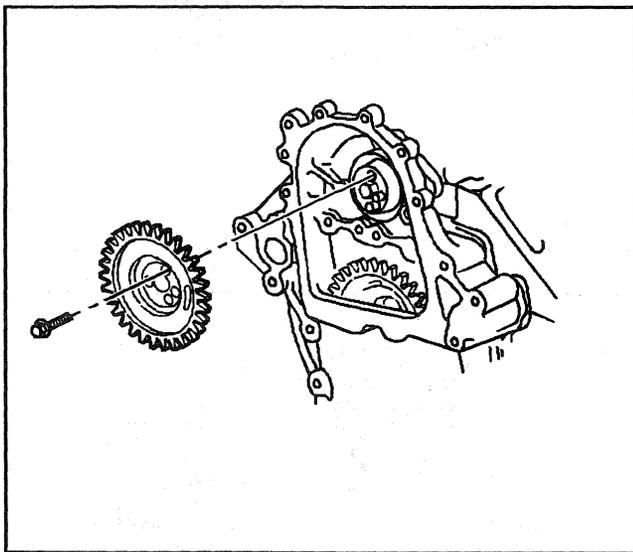
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Timing Chain and Sprockets Replacement

Removal Procedure

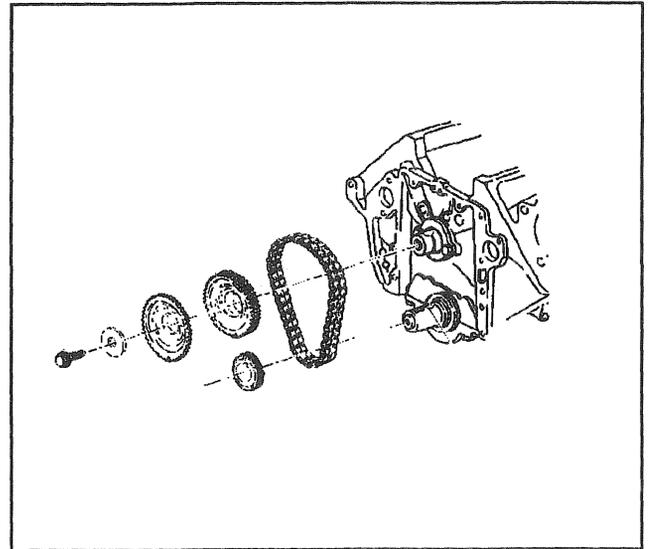
Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

1. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.
2. Measure the timing chain free play in the following way:
 - Mount a dial indicator to the front of the block.
 - Position the dial indicator so that the plunger contacts the timing chain.
 - Pull the chain outward, parallel to the front face of the block, the maximum amount with finger pressure on the inside of the chain.
 - Set the dial indicator to zero.
 - Move the chain inward, parallel to the front face of the block, the maximum amount with finger pressure on the outside of the chain.
 - Note the total indicator travel. With used parts, the deflection must not exceed 20.3 mm (0.8 in). If the deflection exceeds this limit, the sprockets and the timing chain must be inspected for wear and replaced as necessary. With the new parts the deflection must not exceed 12.7 mm (0.5 in).
3. Align the timing marks.



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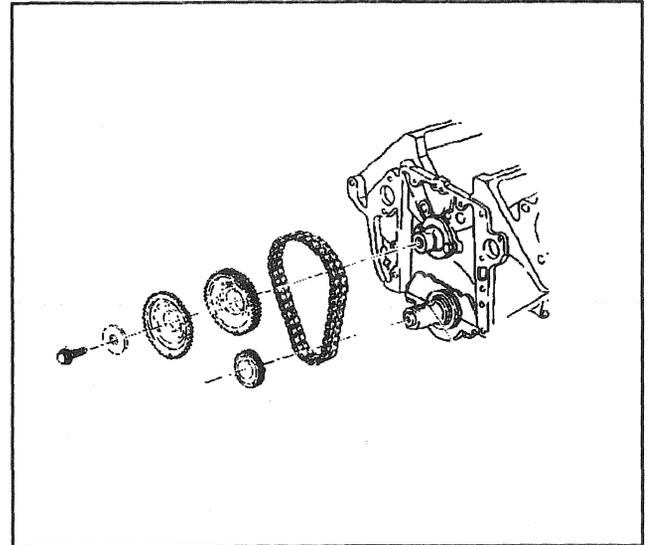
4. Remove the camshaft sprocket with the timing chain.
5. Remove the camshaft sprocket.



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Installation Procedure

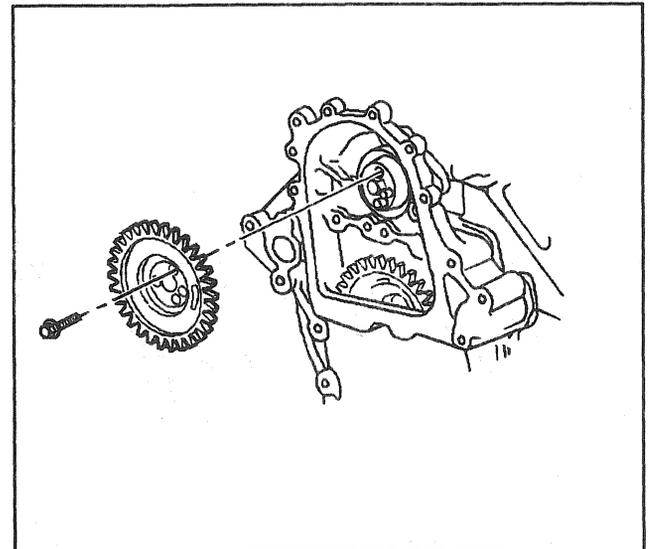
1. Install the crankshaft sprocket.
Important: Align the timing marks.
2. Install the camshaft sprocket with the timing chain.
Tighten
Tighten the bolt to 171 N·m (125 lb ft).
Refer to *Fastener Notice* in General Information.



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Important: Align the timing marks.

3. Install the fuel injection pump gear and bolts.
Tighten
Tighten the bolt to 23 N·m (20 lb ft).
4. Install the front cover for the fuel injection pump drive gear.
5. Install the bolts to the front cover for the fuel injection pump drive gear.
6. Adjust the fuel injection pump timing. Refer to Engine Controls.



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Camshaft Replacement

Removal Procedure

Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

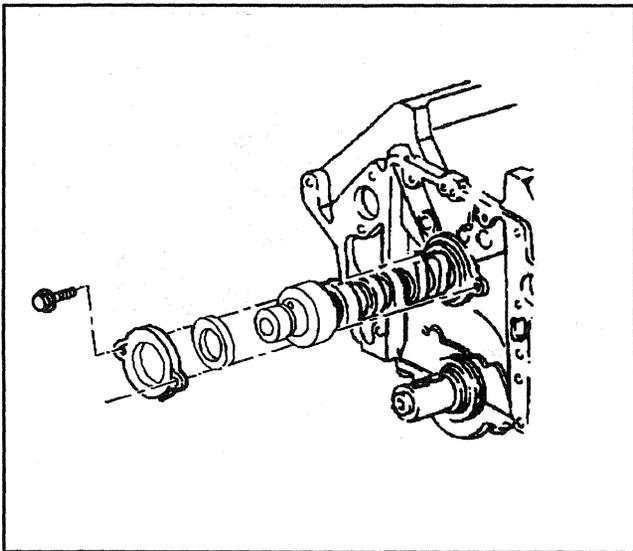
1. Disconnect the negative battery cable. Refer to *Battery Disconnect Caution* in General Information.
2. Evacuate the air conditioning system. Refer to HVAC.
3. With the aid of an assistant, remove the radiator and air conditioning condenser as an assembly.
4. Remove the grille and parking lamp assembly. Refer to Sheet Metal and Fiberglass.
5. Remove the hood latch and brace assembly. Refer to Sheet Metal and Fiberglass.
6. Remove the cylinder head assembly. Refer to *Cylinder Head Replacement*.
7. Remove the oil pump drive. Refer to *Oil Pump Replacement*.
8. Remove the valve lifters. Refer to *Valve Lifter Replacement*.
9. Remove the timing chain. Refer to *Timing Chain and Sprockets Replacement*.
10. Remove the camshaft sprocket.

Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

11. Remove the front engine mount through bolts and raise the engine block in position.
12. Remove the bolts and the thrust bearing.

Important: Pull the camshaft bolt from the block carefully to avoid damage to the camshaft bearings.

13. Remove the camshaft.
14. Remove the spacer if necessary.
15. Clean, inspect, and repair or replace the camshaft and related components. Refer to *Camshaft Clean and Inspect (Unit Repair)*.



Installation Procedure

Important: When a new camshaft is installed, replace the following items:

- The valve lifters
 - The engine oil
 - The oil filter
1. Install the spacer with the chamfer toward the camshaft.
 2. Install the camshaft.
 - Coat the camshaft lobes with camshaft and valve Prelube GM P/N 1052365 or equivalent.
 - Lubricate the camshaft bearing journals with clean engine oil.
 - Insert the camshaft carefully into the block to avoid damage to the camshaft bearings.
 3. Install the thrust plate and the spacer.

Tighten

Tighten the bolts to 23 N.m (17 lb ft).

Refer to *Fastener Notice* in General Information.

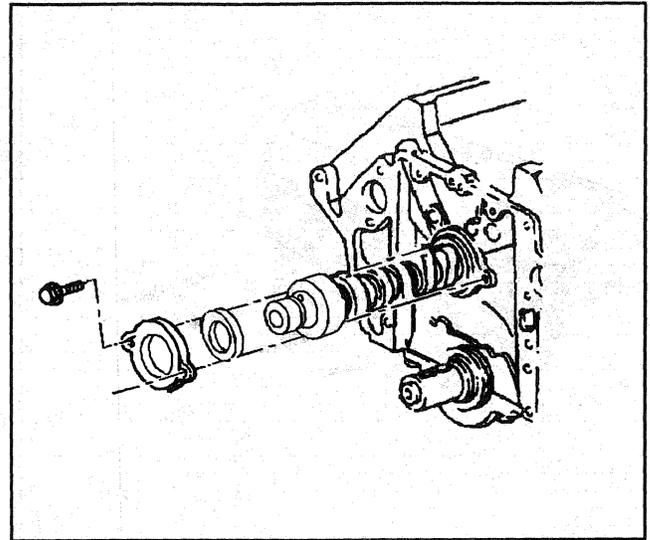
4. Lower the engine.
5. Install the engine mount through-bolts and nuts.

Tighten

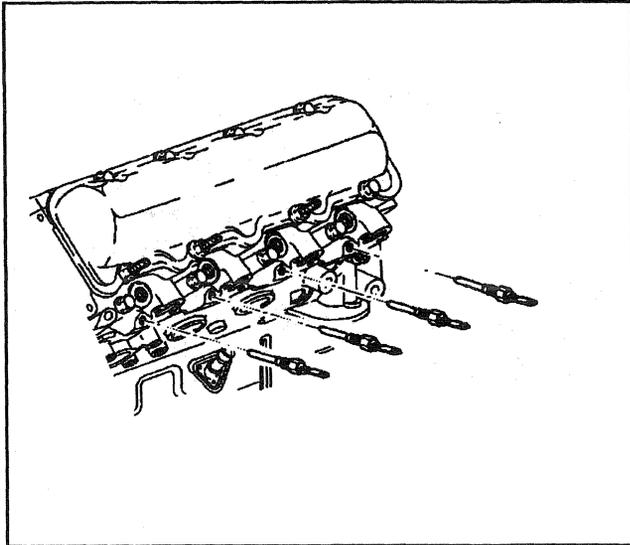
Tighten the bolts to 95 N.m (70 lb ft) or the nuts to 70 N.m (50 lb ft).

Important: Align the timing marks.

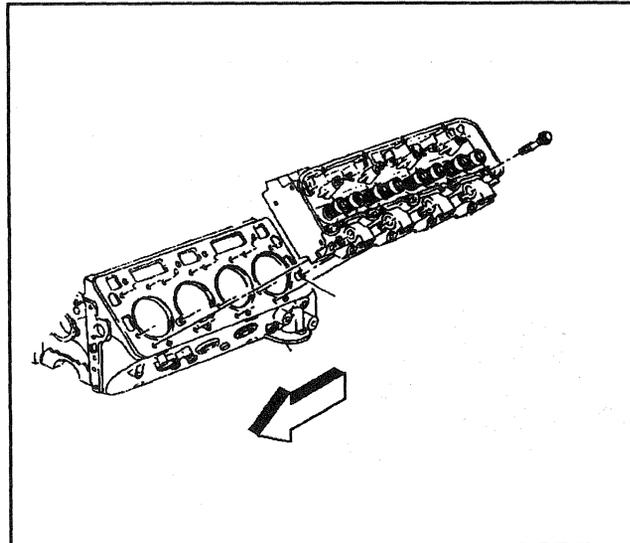
6. Install the camshaft sprocket.
7. Install the timing chain. Refer to *Timing Chain and Sprockets Replacement*.
8. Install the valve lifters. Refer to *Valve Lifter Replacement*.
9. Install the oil pump drive gear. Refer to *Oil Pump Drive Replacement*.
10. Install the cylinder head assembly. Refer to *Cylinder Head Replacement*.
11. Install the radiator and A/C condenser as an assembly. Refer to Heating, Ventilation, and Air Conditioning.
12. Install the hood latch assembly. Refer to Sheet Metal and Fiberglass.
13. Install the front grille and parking lamp assembly. Refer to Sheet Metal and Fiberglass.
14. Charge the A/C system. Refer to Heating, Ventilation, and Air Conditioning.
15. Connect the negative battery cable. Refer to Engine Electrical.



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Cylinder Head Replacement

Removal Procedure

Tools Required

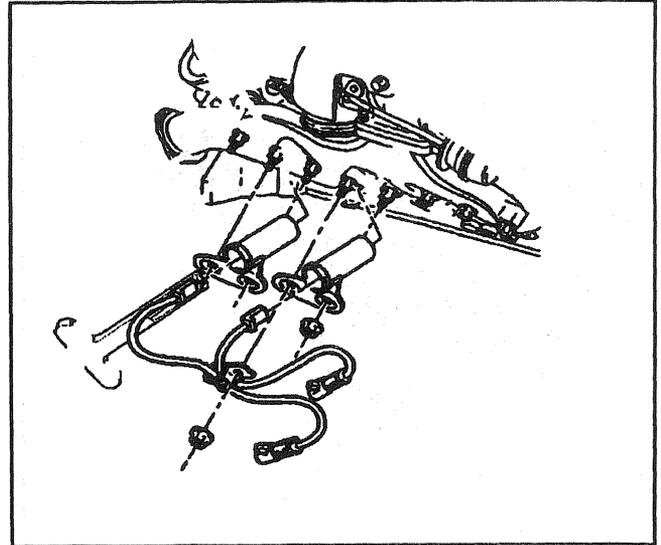
J 39083 Glow Plug Connector Tool

1. Remove the intake manifold. Refer to *Intake Manifold Replacement*.
2. Disconnect the fuel injection lines. Refer to Diesel Fuel Injection.
3. Remove the valve rocker arm covers. Refer to *Valve Rocker Arm Cover Replacement*.
4. Drain the cooling system.
5. Raise the vehicle.
6. Support the vehicle with safety stands.
7. Remove the exhaust pipe from the exhaust manifold. Refer to Exhaust System.
8. Lower the vehicle.
9. Remove the components as follows for the left cylinder head:
 - The air conditioning compressor and the bracket. Refer to Heating, Ventilation, and Air Conditioning.
 - The power steering pump with the bracket. Refer to Power Steering Gear and Pump.
 - The glow plug relay
 - The oil level indicator tube
 - The upper radiator hose
 - The wiring harness
10. Remove the following components for the right cylinder head:
 - The ground strap
 - The generator and the rear bracket
 - The vacuum pump and the bracket
 - The turbocharger assembly. Refer to Turbocharger.
 - The wire harness at the clips and move aside
11. Disconnect the wire from the coolant sensor at the cylinder head.

12. Remove the glow plug wires. Use the *J 39083* in order to disconnect the glow plug connectors from the glow plugs on the right hand cylinder head. The connector cannot be reached with the hand. Do not pull on the glow plug harness wire.

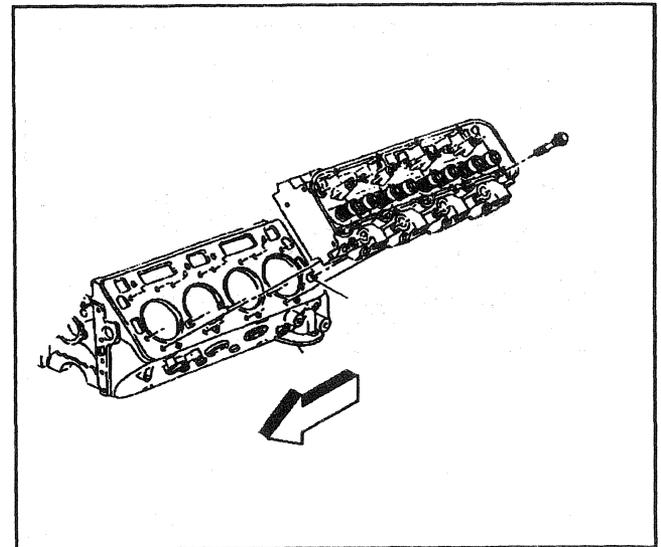
Important: The valve rocker arm assemblies and the pushrods must be marked for proper assembly.

13. Remove the valve rocker arm assemblies and the pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
14. Remove the water pump bypass and the heater hoses.
15. Remove the coolant crossover pipe/thermostat housing assembly.
16. Remove the exhaust manifold. Refer to *Exhaust Manifold Replacement*.
17. Remove the cylinder head bolts. The rear bolt in the left cylinder head may have to remain in the head during removal.

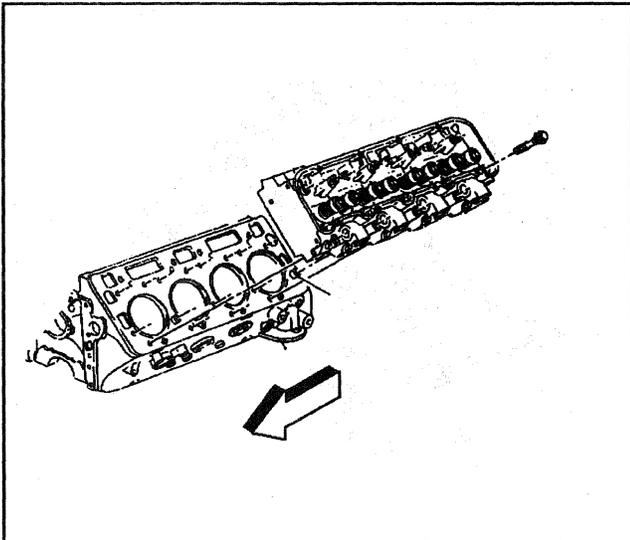


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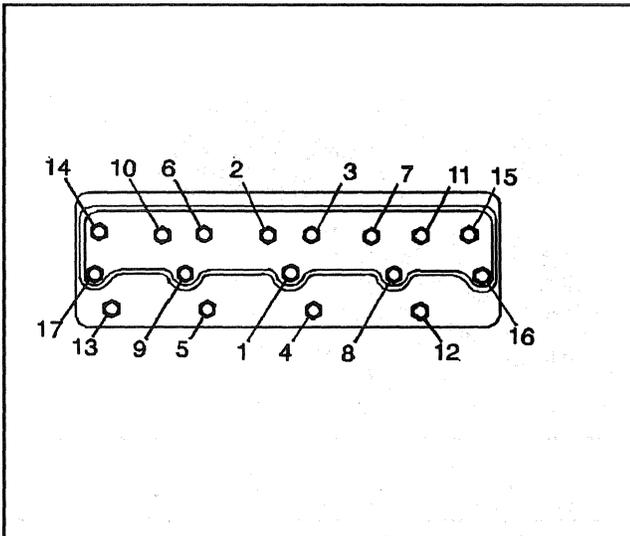
18. Remove the cylinder head.
19. Clean the following parts:
 - The carbon deposits from the combustion chambers
 - Clean all traces of the old head gasket from the cylinder head and block. The use of a motorized wire brush is not recommended.
 - The cylinder head bolt threads using a wire brush
 - The metal chips and dirt from the threads in the block
20. Inspect the following components:
 - The cylinder head for cracks between the intake and exhaust ports. Use the magnaflux or dye method if available.
 - The sealing surfaces of the block and cylinder head for nicks, heavy scratches or other damage
 - The block for missing or damaged dowel pins or dowel pins in the wrong location
21. Measure the following items:
 - The cylinder head warpage.
 - The pre-chamber installed depth.



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Installation Procedure

Important:

- The block gasket surfaces must be clean.
- Do not use a sealer on the head gasket. The head gasket is manufactured with the proper amount of sealant "printed" on its surface. Additional sealer may cause leakage or malfunction. In addition, some sealers may attack the sealant already on the head gasket.

Important: The cylinder head gasket material is soft. Handle the cylinder head gasket with care and make sure that the sealing surfaces are not damaged.

1. Install the head gasket to the block over the dowel pins.

Connect the rear cylinder head bolt to the cylinder head (left cylinder head). Due to the clearances, the bolt must be installed at this time.

2. Install the cylinder head. Make sure the gasket surfaces are clean. Guide the head carefully in place over the dowel pins.
3. Install the cylinder head bolts.
 - Check the cylinder head bolts for stretching.
 - Make sure the bolt threads are clean.
 - Apply sealant GM P/N 9985283 or equivalent to the bolt threads and under the bolt heads.

4. Tighten the cylinder heads in the following 3 passes:

Tighten

- Tighten the bolts to 25 N·m (20 lb ft).
- Tighten the bolts to 75 N·m (55 lb ft).
- In sequence, tighten all the bolts an additional 90–100 degrees (1/4 + turn).

Refer to *Fastener Notice* in General Information.

5. Install the exhaust manifold to the cylinder head.

Tighten

- 5.1. Tighten the exhaust manifold bolts to 35 N·m (26 lb ft).
- 5.2. Tighten the exhaust manifold nuts and mounting studs to 35 N·m (26 lb ft).

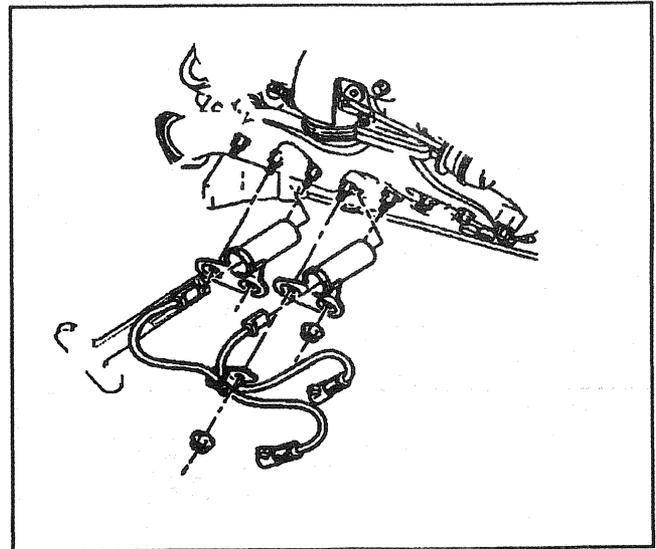
6. Install the coolant crossover pipe/thermostat assembly. Use new gaskets.

Tighten

Tighten bolts to 42 N·m (31 lb ft).

7. Install the water pump bypass and heater hoses.
8. Install the pushrods and the valve rocker arm assemblies, in their original locations.

9. Install the glow plug wires. Use the *J 39083* in order to connect the glow plug connectors to the glow plugs.
10. Connect the wire to the coolant sensor at the cylinder head.
11. Install the components as follows for the right cylinder head:
 - The turbocharger assembly
 - The ground strap
 - The generator and rear bracket
 - The vacuum pump and bracket
 - The wiring harness at the clips and move aside
12. Install the components as follows for the left cylinder head:
 - The air conditioning compressor and bracket
 - The power steering pump with bracket
 - The glow plug relay
 - The oil level indicator tube
 - The upper radiator hose
 - The wiring harness
13. Raise the vehicle.
14. Support the vehicle with safety stands.
15. Install the exhaust pipe to the exhaust manifold. Refer to Exhaust Systems.
16. Lower the vehicle.
17. Install the valve rocker arm covers.
18. Install the fuel injection lines.
19. Install the intake manifold.
20. Fill the cooling system with the proper quantity and grade of coolant.
21. Change the engine oil and the filter. Refer to Maintenance and Lubrication.

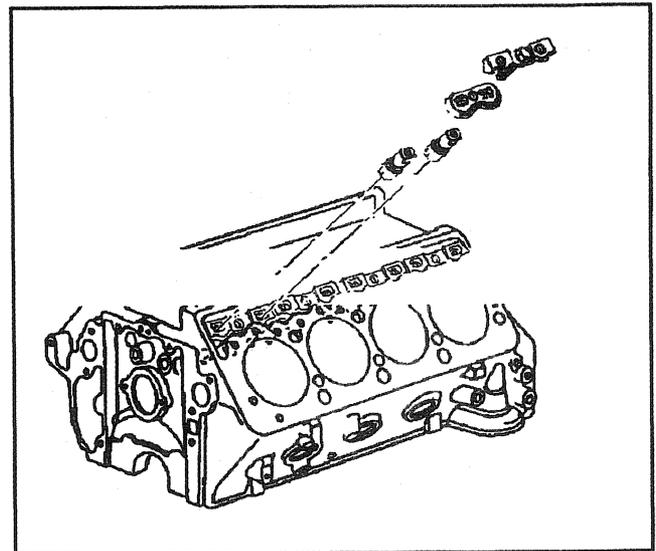


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Valve Lifter Replacement

Removal Procedure

1. Remove the cylinder head. Refer to *Cylinder Head Replacement*.
2. Remove the clamp.
3. Remove the plates.
4. Remove the valve lifters.
 - Place the valve lifters in an organizer rack.
 - The valve lifters must be installed in the same bores from which they were removed.
5. Inspect each of the following components:
 - Inspect the valve lifter body for scuffing and scoring. Replace if necessary.
 - Inspect the roller for looseness and excessive play.
 - Check for missing or broken needle bearings. Replace if necessary.

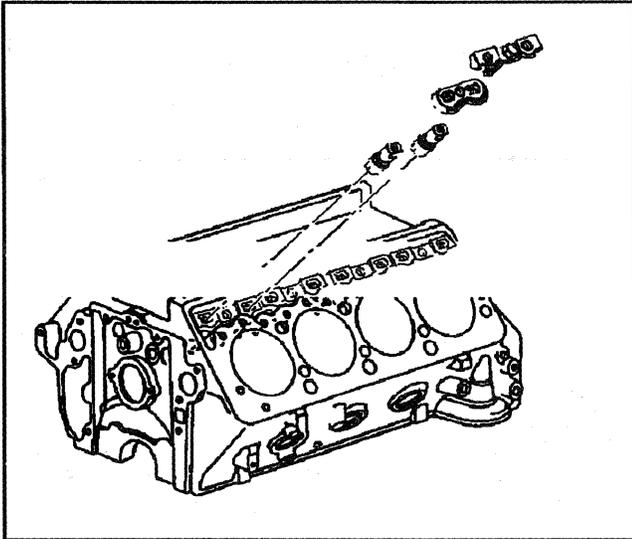


60255

- Inspect the roller surface for pits and roughness. If present, the mating camshaft lobe should also be checked. If the lobe is pitted or rough, replace the camshaft and valve lifters.

Important

Some engines will have both standard and 0.010 inch oversize valve lifters. The oversize valve lifter will have a "10" etched on the side. The block will be stamped "O.S." on the cast pad adjacent to the valve lifter bore and on the top rail of the cylinder case above the valve lifter bore.



60255

Installation Procedure

Notice: Prime the new valve lifters before installation. The valve lifters may be damaged if the valve lifters are dry when the engine is started.

1. Connect the valve lifters to the engine.

Important:

- Prime the new valve lifters before installation by working the valve lifter plunger while submerged in clean engine oil.
- Coat the valve lifter roller and bearings with lubricant GM P/N 1052365 or equivalent.
- The valve lifters must be installed in their original locations.

2. Install the plates.

Important: The straight edge of the guide plates and clamps face away from the cylinder.

3. Install the clamps.

Tighten

Tighten the clamp bolt to 26 N.m (18 lb ft).

Refer to *Fastener Notice* in General Information.

Important: After all the clamps are installed, turn the crankshaft by hand two full revolutions, to ensure free movement of the valve lifters in the plate. If the engine will not turn over by hand, one or more of the valve lifters may be binding in the plate.

4. Install the cylinder head. Refer to *Cylinder Head Replacement*.
5. Install the valve rocker arm covers. Refer to *Valve Rocker Arm Cover Replacement*.
6. Refill the engine coolant with the proper type and quantity. Refer to *Cooling and Radiator*.
7. Change the oil filter and oil.

Oil Pan Replacement

Removal Procedure

1. Disconnect the negative battery cables. Refer to *Battery Disconnect Caution* in General Information.
2. Remove the oil level indicator.
3. Raise the vehicle.
4. Support the vehicle with safety stands.
5. Drain the engine oil.
6. Remove the flywheel cover.
7. Remove the oil cooler line clip.
8. Remove the front propeller shaft (if equipped). Refer to Propeller Shaft.
9. Roll the front axle (if equipped).
10. Remove the oil pan bolts.
11. Remove the oil pan.
12. Remove the oil pan rear oil seal.
13. Clean the old RTV from the oil pan and the block.
14. Clean all the oil and grease from the gasket surfaces.

Installation Procedure

1. Apply a 2 mm (1/16 in) bead of RTV sealant GM P/N 12345739 or equivalent to the oil pan rear seal at the inside corners where the seal meets the rear main bearing cap on the block.
2. Install the oil pan rear seal to the rear main bearing cap before the sealer starts to dry.
3. Install the oil pan rear oil seal.
4. Install the oil pan to the engine.
5. Install the oil pan bolts.

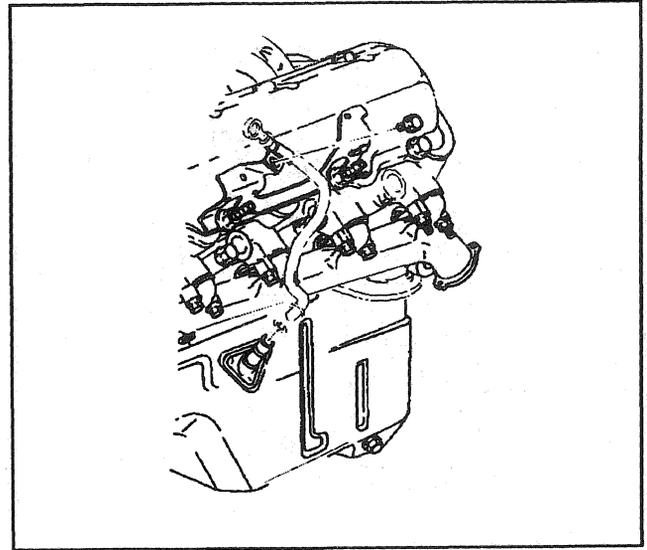
Tighten

- Tighten all except the rear two bolts to 10 N·m (89 lb in).
- Tighten the rear two bolts to 23 N·m (17 lb ft).

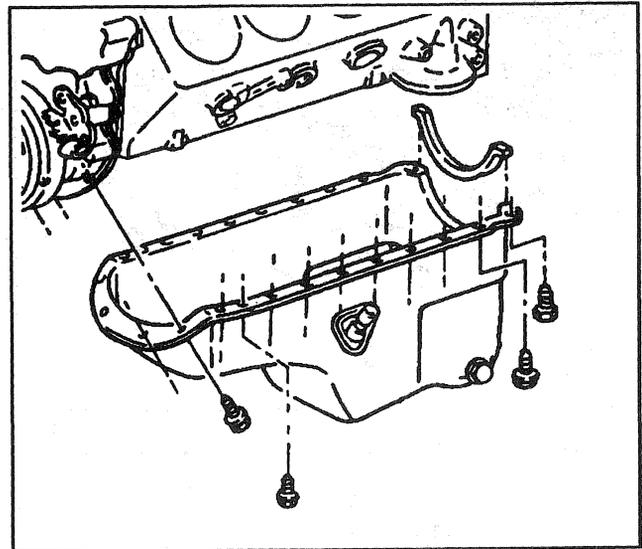
Refer to *Fastener Notice* in General Information.

Important: If the oil cooler lines were disconnected from the quick connector or block, replace the fastener clip when reconnecting.

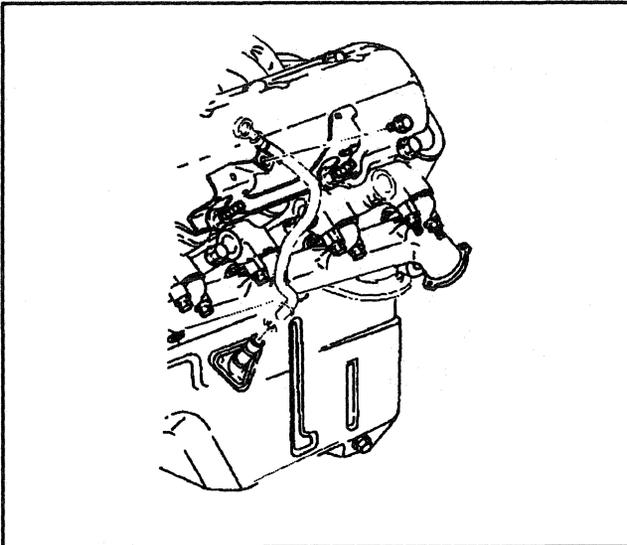
6. Install the oil cooler line clip.



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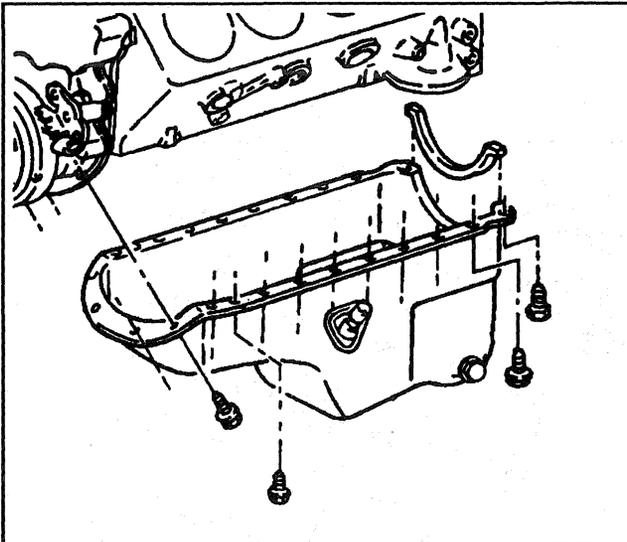
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7. Install the oil level indicator tube.
8. Install the oil level indicator tube bolt.

Tighten

Tighten the oil level indicator tube bolt to 4 N·m (35 lb in).

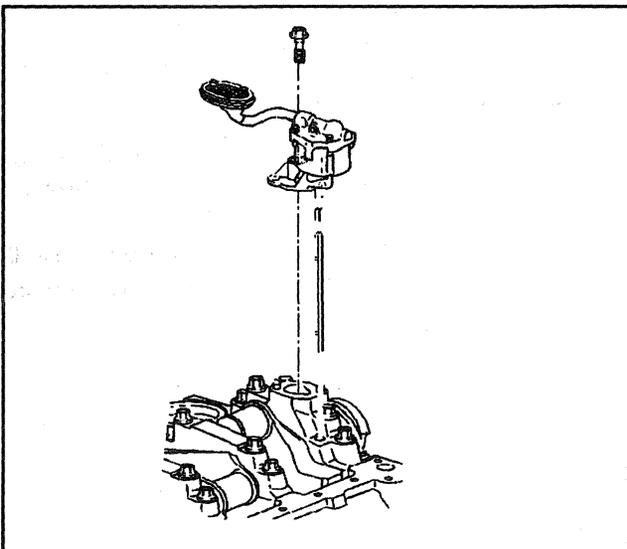
9. Install the flywheel cover.
10. Reposition the front axle (if equipped).
11. Install the front propeller shaft (if equipped). Refer to Propeller Shaft.
12. Lower the vehicle.
13. Apply proper quantity and grade of engine oil. Refer to Maintenance and Lubrication.
14. Connect the negative battery cables. Refer to *Battery Disconnect Caution* in General Information.



60264

Oil Pump Replacement**Removal Procedure**

1. Remove the oil pan. Refer to *Oil Pan Replacement*.
2. Remove the oil pump from the crankshaft rear main bearing cap.
3. Remove the oil pump and the hex drive.
4. Inspect the following parts:
 - The oil pump pick up tube and screen for damage
 - The oil pump hex drive retainer for cracks



60265

Installation Procedure

1. Install the oil pump and the extension shaft to the engine.
2. Align the extension shaft hex with the drive hex on the oil pump drive. The oil pump should push easily into place.
3. Install the oil pump and the bolt to the crankshaft rear bearing cap.

Tighten

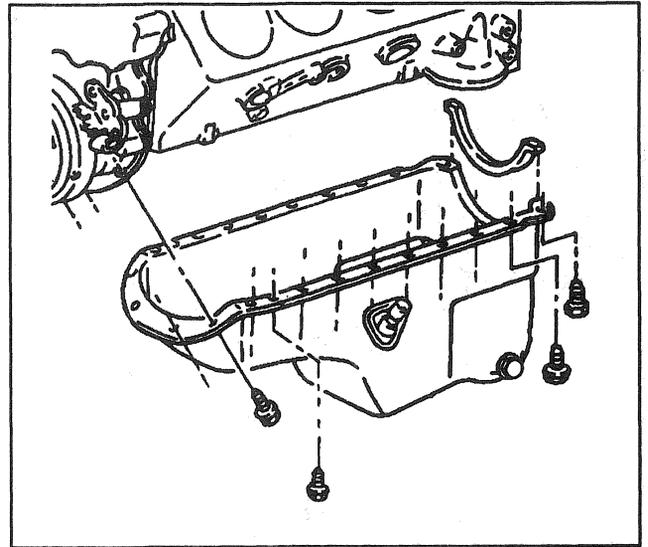
Tighten the bolt to 90 N·m (65 lb ft).

Refer to *Fastener Notice* in General Information.

4. Install the oil pan.

Tighten

- Tighten all the oil pan bolts, except the rear two bolts, to 10 N.m (89 lb in).
- Tighten the rear two oil pan bolts to 23 N.m (17 lb ft).



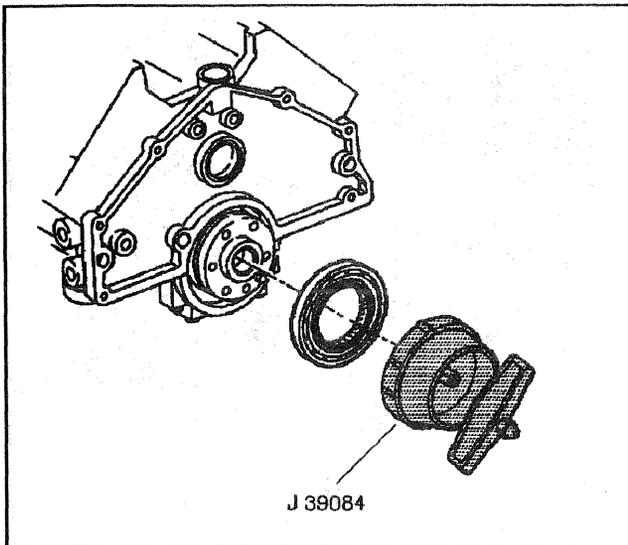
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Rear Crankshaft Oil Seal Replacement**Removal Procedure****Tools Required***J 39084* Rear Crankshaft Oil Seal Installer

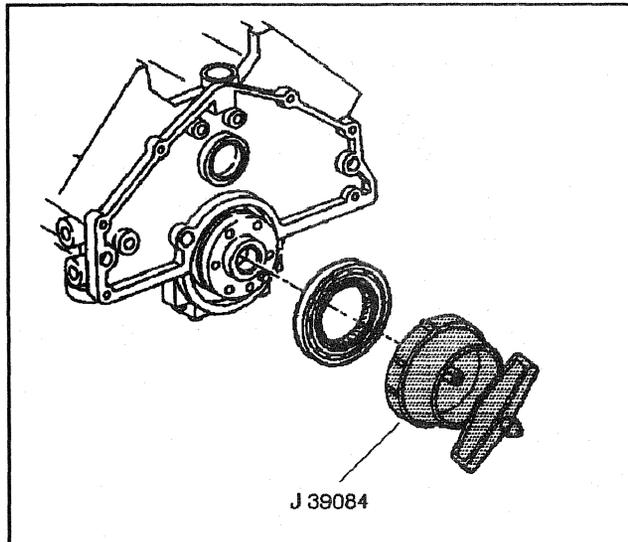
Important: Before a new seal is installed, the CDR and the crankcase ventilation system should be thoroughly inspected and the crankcase pressure should also be checked. Refer to Engine Controls.

Remove the transfer case (if equipped). Refer to Transfer Case.

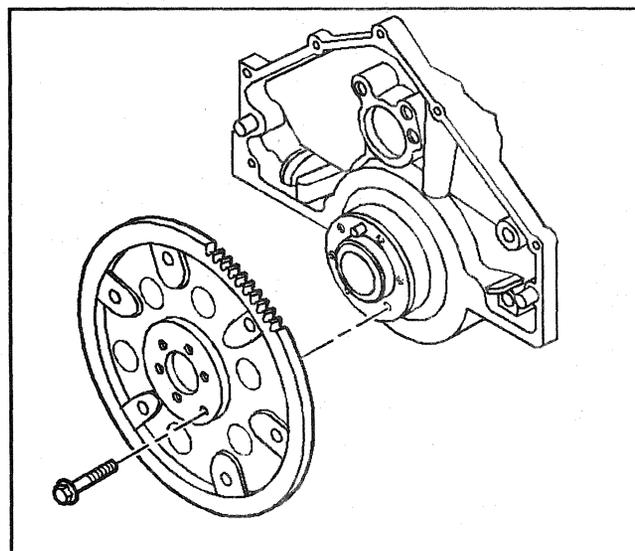
- 1.
2. Remove the transmission. Refer to Transmission.
3. Remove the flywheel.
4. Remove the oil seal. Do not reuse the old seal.
5. Clean the oil seal bore in the block thoroughly before installing a new oil seal.
6. Inspect the rear portion of the crankshaft where the oil seal makes contact for the following conditions:
 - Wear due to the rubbing action of the oil seal
 - Dirt build up



60280



60280



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Important:

- The crankshaft surface must be clean and smooth in order to prevent damaging the seal lip when a new oil seal is installed.
 - Because of the rear crankshaft wear or grooving, the service seal will be positioned flush with the rear block face. The position of the new oil seal will be controlled by the *J 39084*. Positioning the oil seal in a new location provides a new surface for the oil seal to ride on.
7. Inspect the rear portion of the crankshaft where the oil seal makes contact for wear due to the rubbing action of the oil seal or dirt buildup. Correct as necessary.

Installation Procedure

Important: Coat the crankshaft surface with clean engine oil, and lightly coat the sealing area of the new oil seal with engine oil before installing the new oil seal. Do not scratch or nick the sealing edge of the oil seal.

1. Install the oil seal, with the spring cavity towards the engine, onto the crankshaft.
2. Using the *J 39084*, drive the seal in until the tool bottoms against the block and the crankshaft rear main bearing cap.
3. Install the flywheel.
4. Install the transmission. Refer to Transmission.
5. Install the transfer case (if equipped). Refer to Transfer Case.

Engine Flywheel Replacement (Automatic)

Removal Procedure

1. Remove the transmission. Refer to *Transmission Replacement* in Automatic Transmission.
2. Remove the flywheel bolts.
3. Remove the flywheel.

Installation Procedure

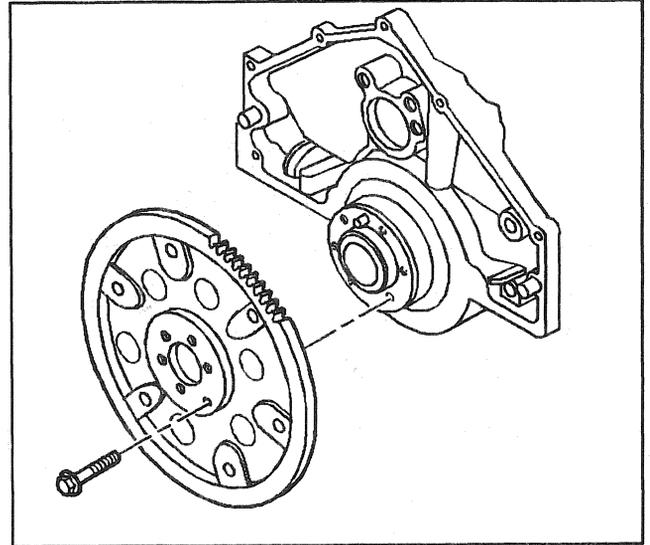
1. Install the flywheel.
2. Install the flywheel bolts.

Tighten

Tighten the bolts to 90 N·m (65 lb ft).

Refer to *Fastener Notice* in General Information.

3. Install the transmission. Refer to *Transmission Replacement* in Automatic Transmission.



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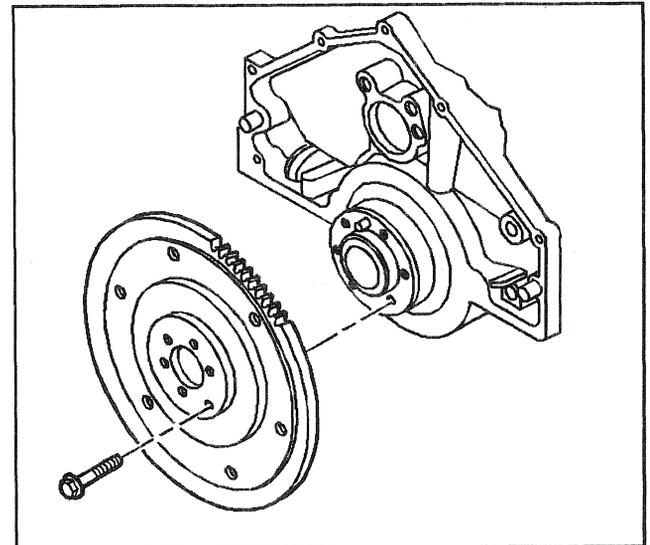
Engine Flywheel Replacement (Manual)

Removal Procedure

1. Remove the transmission. Refer to *Transmission Replacement*.
2. Remove the clutch if equipped. Refer to *Clutch Replacement* in Clutch.
3. Remove the flywheel bolts.

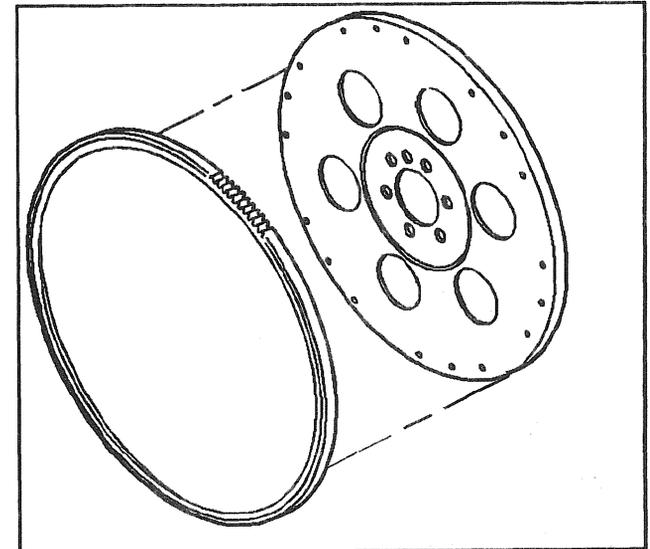
Important: Do not machine the flywheel. Replace if necessary.

4. Remove the flywheel.

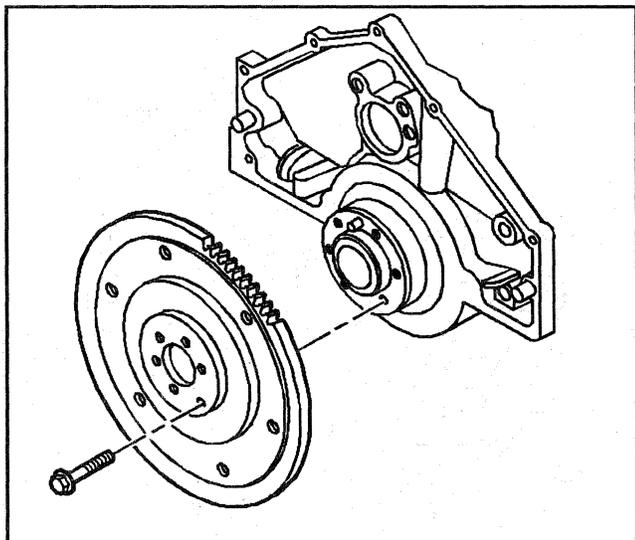


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5. Remove the flywheel ring gear.
 - Use a torch to heat around the entire circumference of the ring gear, then drive the gear off the flywheel.
 - Do not heat the flywheel gear to red hot. This may cause the metal structure to change.



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Installation Procedure

1. Install the flywheel ring gear.
 - Uniformly heat the gear to a temperature that will expand the gear. The temperature should not exceed 204 °C (400 °F).
 - Install the gear, as soon as it had been heated, onto the flywheel.
2. Install the flywheel.
3. Install the flywheel bolts.

Tighten

Tighten the bolts to 90 N.m (65 lb ft).

Refer to *Fastener Notice* in General Information.

4. Install the clutch (if equipped). Refer to Clutch Replacement in Clutch.
5. Install the transmission. Refer to *Transmission Replacement* Transmission Replacement.

Engine Replacement

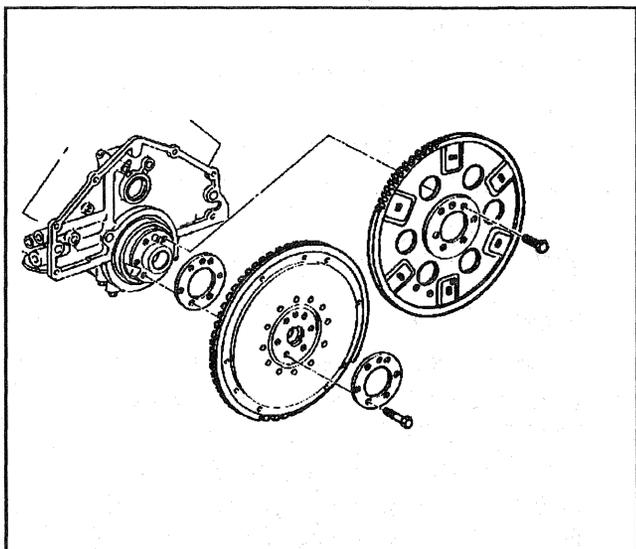
Removal Procedure

Tools Required

- J 39664 Manifold Cover Set
- J 41427 Universal Lift Bracket

1. Remove the hood.
2. Disconnect the negative battery cables. Refer to *Battery Disconnect Caution* in General Information.
3. Evacuate the air conditioning (A/C) system. Refer to HVAC.
4. Drain the cooling system. Refer to Cooling and Radiator.
5. Remove the air cleaner assembly and the intake duct.
6. Cover the mouth of the intake manifold with the J 39664.
7. Remove the generator wires and clips. Refer to Engine Electrical.
8. Remove the wiring at the fuel injector pump.
9. Remove the wiring from the valve rocker arm clips, including the glow plug relay, and the temperature solenoid.
10. For the L56, remove the EGR/Boost solenoid. Move the harness aside.
11. For the L65 remove the Boost solenoid. Move the harness aside.
12. Remove the ground strap.
13. Remove the engine cooling fan. Refer to Cooling and Radiator.
14. Remove the power steering pump and reservoir.
15. Remove the heater hose at the engine.

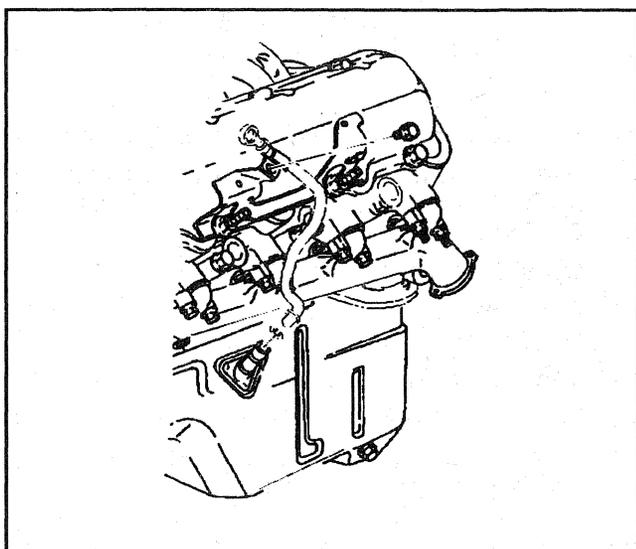
16. With the aid of an assistant, remove the radiator and A/C condenser as an assembly. Refer to Cooling and Radiator.
 - Support the transmission with a jack.
Notice: Damage may result from the use of an improper bolt when attaching J36857 into the cylinder head.
 - Install the *J 41427* to the right rear cylinder head.
 17. Raise the vehicle.
 18. Support the vehicle with safety stands.
 19. Remove the flywheel inspection cover.
 20. Remove the flywheel to torque converter bolts (automatic transmission).
 21. Remove the exhaust pipes at the exhaust manifolds. Refer to Exhaust Systems.
 22. Remove the front propeller shaft (if equipped). Refer to Propeller Shaft.
 23. Remove the starter. Refer to Engine Electrical.
 24. Remove the bellhousing bolts.
 25. Remove the front engine mount through-bolts.
 26. Remove the block heater wire (if equipped).
 27. Remove the wiring harness.
 28. Remove the transmission cooler lines. Refer to Transmission and Clutch.
 29. Remove the front battery cable clamp at the oil pan.
 30. Remove the fuel return lines at the engine.
 31. Remove the oil cooler lines at the engine. Refer to Cooling and Radiator.
 - Any time the oil cooler lines are disconnected from the quick connectors or the block, the retaining clip needs to be replaced.
 - Lower the vehicle.
 32. Remove the attaching bolt. Use GM P/N 23503910 or equivalent.
Tighten
Tighten the lift bracket bolt to 55 N·m (40 lb ft). Refer to *Fastener Notice* in General Information.
 33. Remove the lifting device and chain to the *J 41427* and accessory bracket eyelet.
 34. Remove the engine.
- ### Installation Procedure
1. Install the engine.
 2. Remove the lifting device and chain to the *J 41427* and accessory bracket eyelet.
 3. Remove the attaching bolt.
Important: Any time the oil cooler lines are disconnected from the quick connectors or the block, the retaining clip needs to be replaced.
 4. Install the oil cooler lines at the engine. Refer to Cooling and Radiator.
 5. Install the bellhousing bolts.
 6. Install the engine mount through-bolts.
 7. Install the fuel return lines at the engine.
 8. Install the front battery cable clamp at the oil pan.
 9. Install the transmission cooler lines. Refer to Transmission and Clutch.
 10. Install the wiring harness.
 11. Install the block heater wire (if equipped).
 12. Install the flywheel to torque converter bolts (automatic transmission).
 13. Install the starter. Refer to Engine Electrical.
 14. Install the front propeller shaft (if equipped). Refer to Propeller Shaft.
 15. Install the exhaust pipes at the exhaust manifolds. Refer to Exhaust Systems.
 16. Install the flywheel inspection cover.
 17. Lower the vehicle.
 18. Install the power steering pump and reservoir.
 19. With the aid of an assistant, install the radiator and A/C condenser as an assembly. Refer to Cooling and Radiator.
 20. Install the heater hose at the engine.
 21. Install the engine cooling fan. Refer to Cooling and Radiator.
 22. Install the ground strap.
 23. Install the EGR/Boost solenoid.
 24. Install the wiring to the valve rocker arm clips, including the glow plug relay, and the temperature solenoid.
 25. Install the wiring to the fuel injector pump.
 26. Install the generator wires and clips. Refer to Engine Electrical.
 27. Remove the cover from the mouth of the intake manifold with the *J 39664*.
 28. Install the air cleaner box and the intake duct.
 29. Refill the cooling system with the proper quantity and type of coolant. Refer to Cooling and Radiator.
 30. Charge the air conditioning (A/C) system. Refer to HVAC.
 31. Connect the negative battery cables.
 32. Install the hood.



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Engine Flywheel Removal

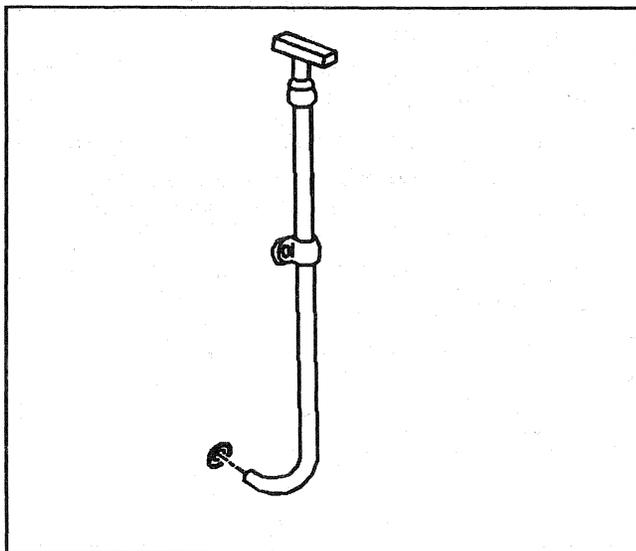
1. Remove the flywheel bolts.
2. Remove the outer retainer (if equipped).
3. Remove the flywheel.
4. Remove the inner retainer (if equipped).



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Oil Level Indicator and Tube Removal

1. Remove the oil level indicator.
2. Remove the oil level indicator tube bracket bolt.
3. Remove the oil level indicator tube. Pull the tube outward.

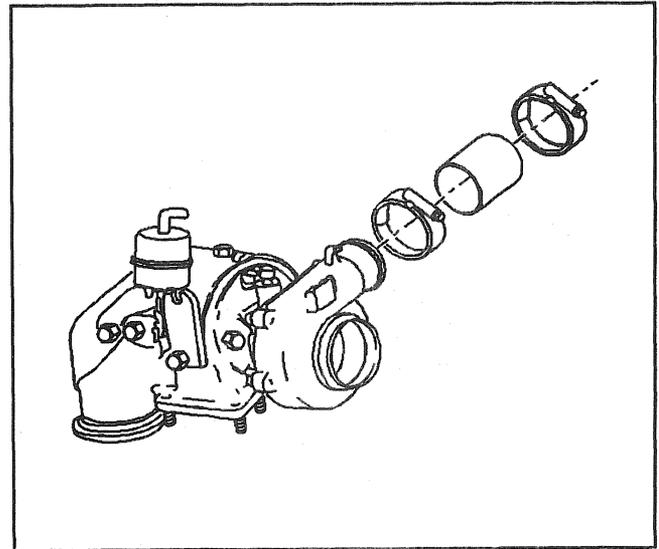


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4. Remove the o-ring seal from the oil level indicator tube.

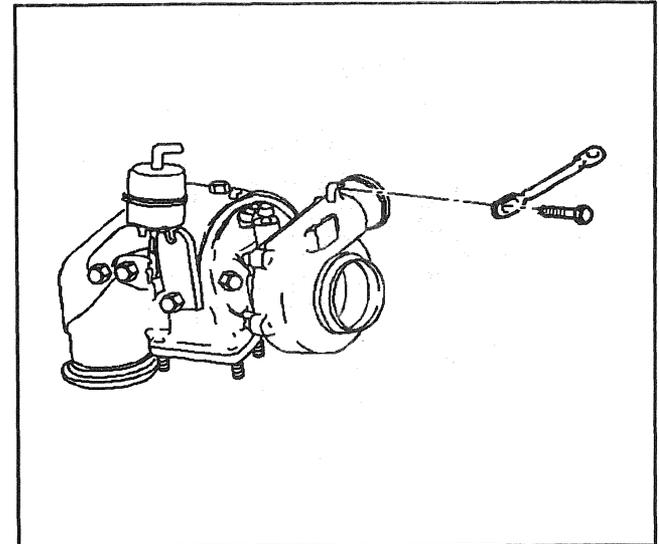
Intake Manifold Removal (Upper)

1. Remove the clamp at turbocharger connection hose.
2. In order to loosen the sealer, run a small flatblade screwdriver between the hose and the upper intake manifold.



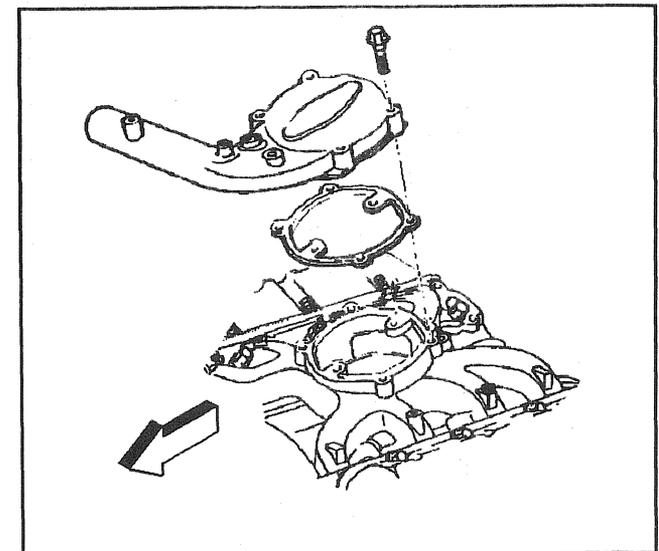
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3. Remove the turbocharger short brace bolt and the turbocharger short brace.
4. Remove the six upper intake manifold bolts.
5. For the L56 model, remove the two center bolts which fasten the EGR valve.

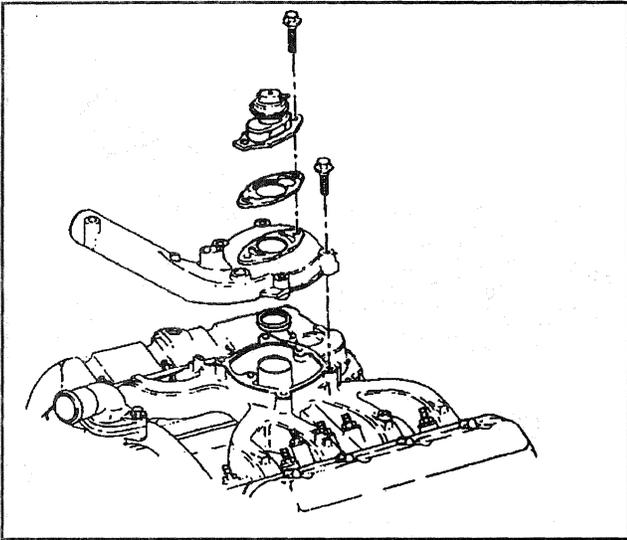


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6. Remove the upper intake manifold and gasket.

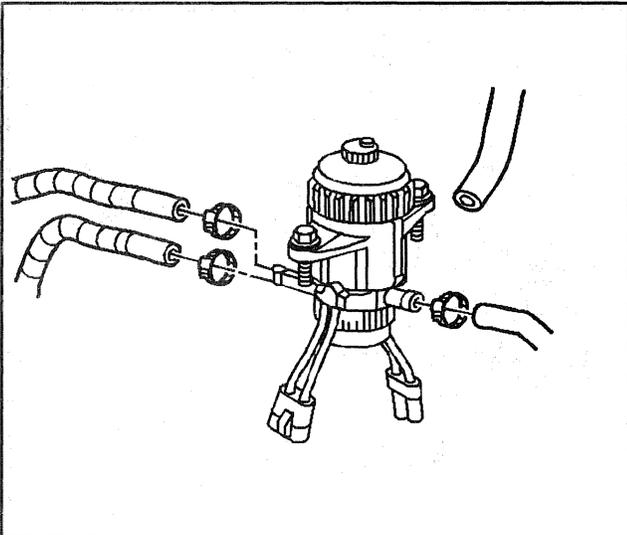


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7. For the L56 model, remove the EGR tower gasket on the round center portion of the intake manifold.
8. Cover the turbocharger intake housing to keep out foreign material.



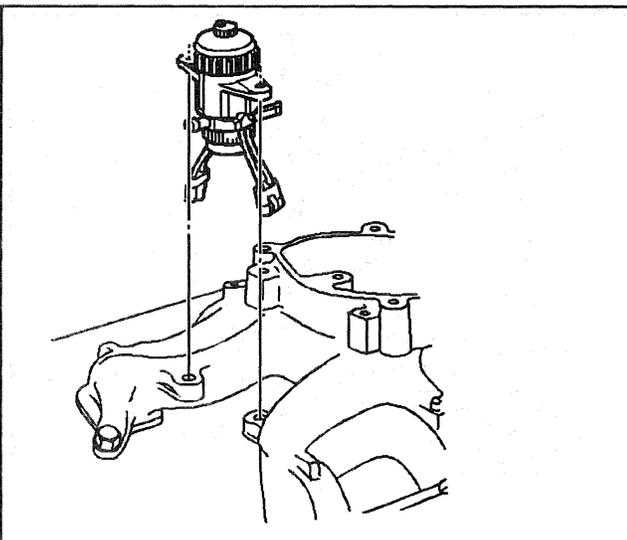
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Intake Manifold Removal (Lower)

Tools Required

J 39664 Manifold Cover Set

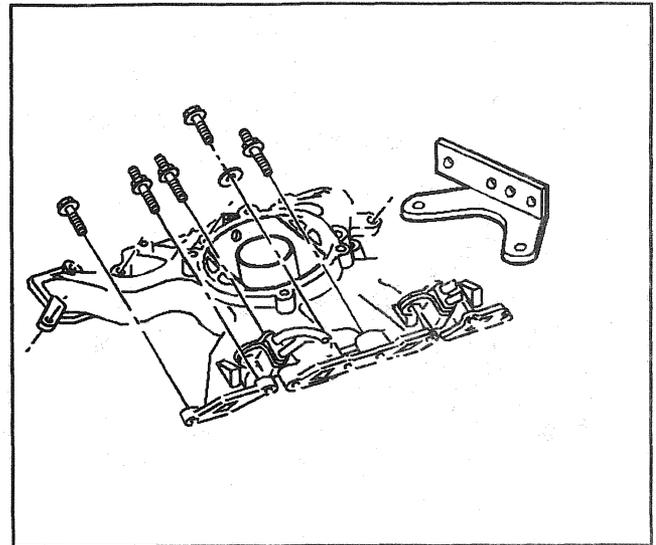
1. Remove the hoses and the clamps from the fuel filter assembly.



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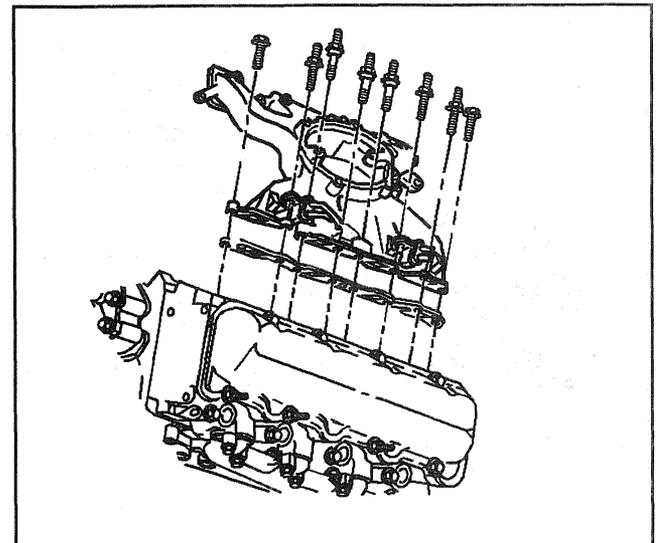
2. Remove the fuel filter assembly bolts.
3. Remove the fuel filter assembly.

4. Remove the intake manifold bolts and the engine wiring harness brackets.



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5. Remove the intake manifold.
6. Remove the gaskets.
7. Install the *J 39664* to the intake ports.



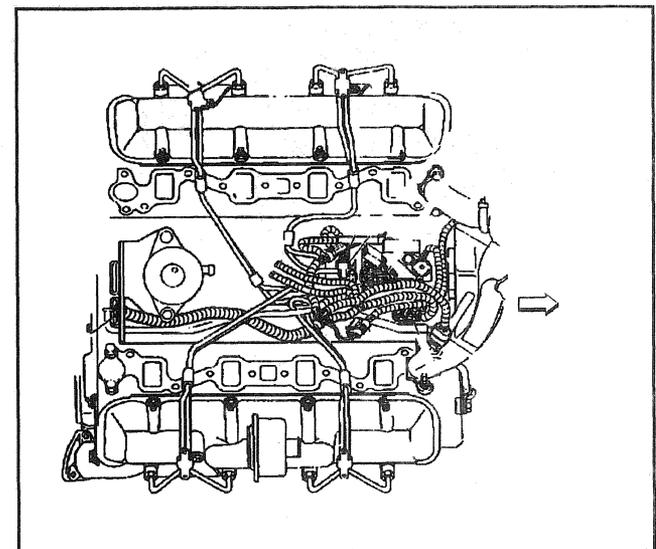
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POE Wiring Harness Removal

Tools Required

J 39083 Glow Plug Connector Tool

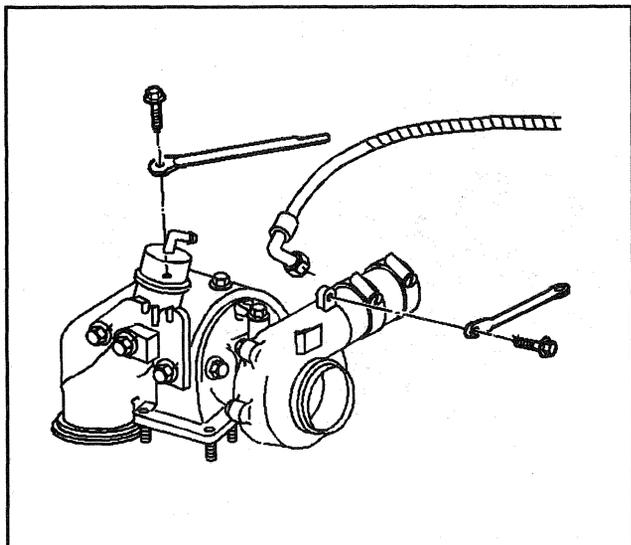
1. Unplug or disconnect all wiring harness connectors from devices or attaching points.
2. Remove the harness.



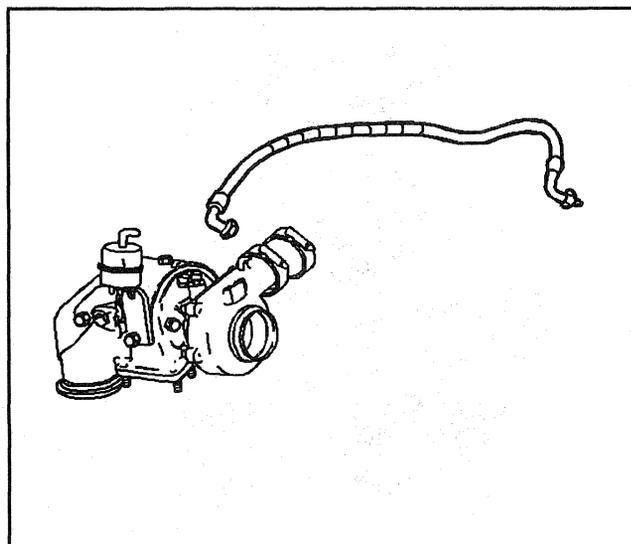
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Turbocharger Removal

1. Remove the CDR (Crankcase Depression Regulator) assembly from the left valve rocker arm cover.
2. Remove the long turbocharger assembly brace.

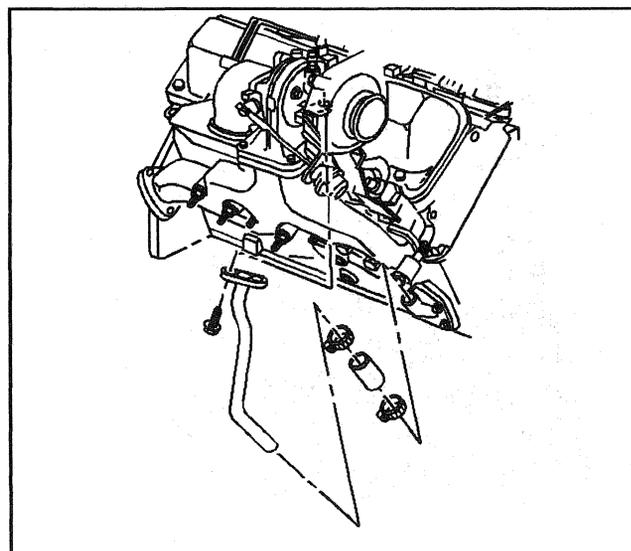


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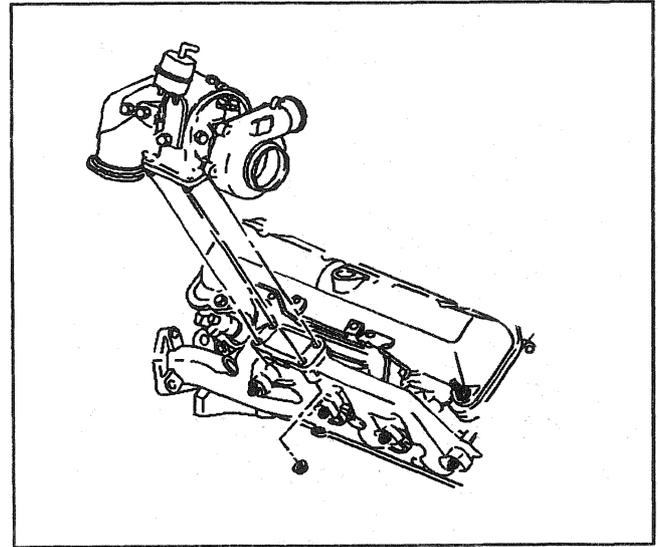
3. Remove the oil feed hose at the turbocharger assembly.



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4. Remove the bolts from the oil return pipe.
5. Remove the hose clamps and the hose from the oil return pipe.

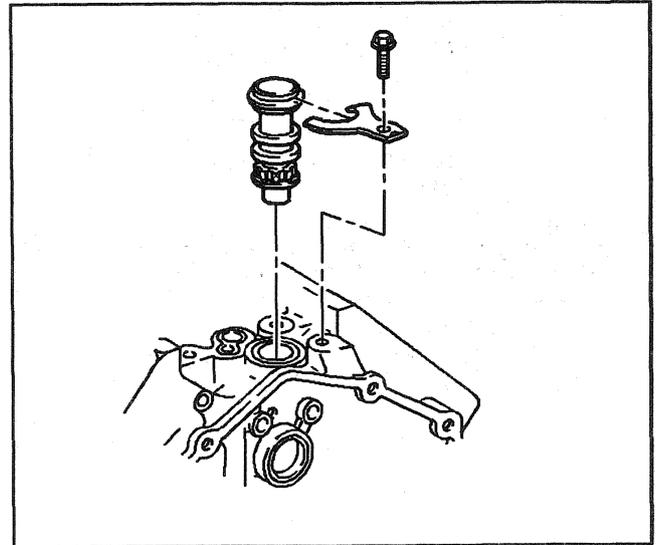
6. Remove the turbocharger assembly flange nuts.
7. Remove the turbocharger assembly from the exhaust manifold.



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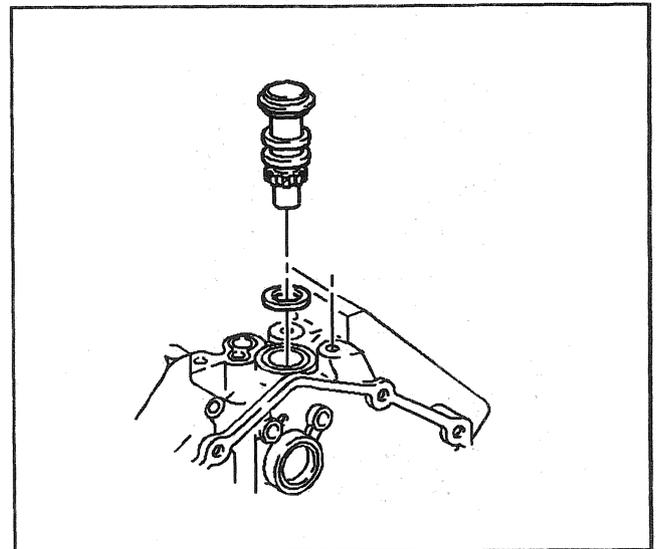
Oil Pump Drive Removal

1. Remove the hold down clamp and the bolt.

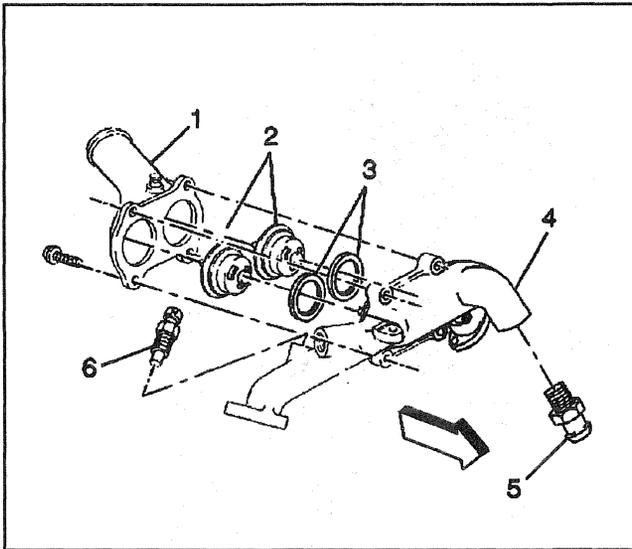


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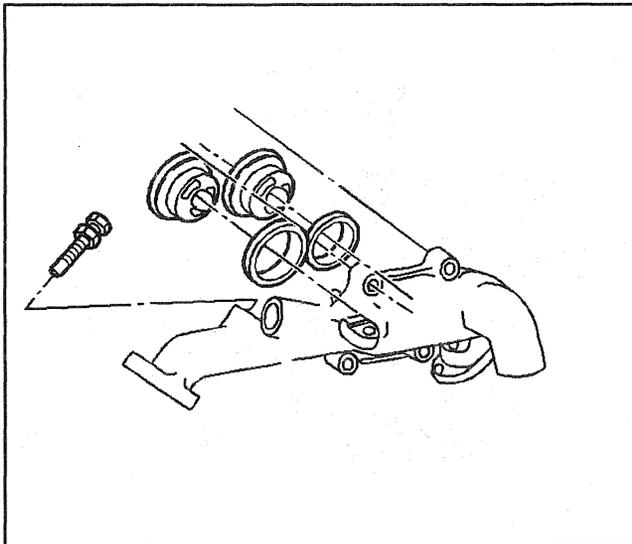
2. Remove the oil pump drive, by pulling the oil pump drive outwards.
3. Remove the gasket.



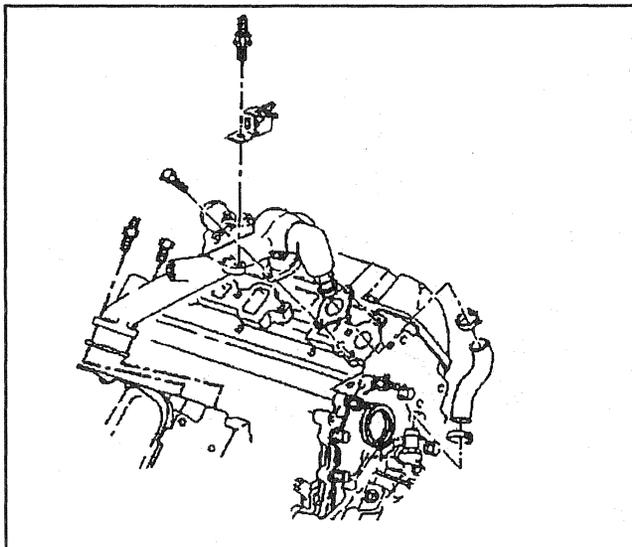
59768



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Thermostat Housing/Thermostat Removal

1. Remove the bolts from the thermostat housing.
2. Remove the thermostat housing.

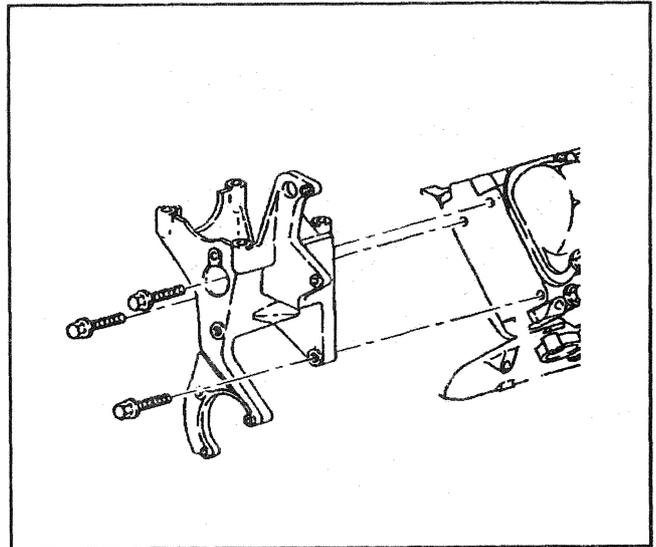
3. Remove the thermostats with the seals.

Coolant Crossover Removal

1. Remove the nut holding the fuel air bleed (shreader) valve.
2. Remove the engine coolant temperature (ECT) sensor.
3. Remove the clamps from the bypass hose.
4. Remove the bolts from the coolant crossover.
5. Remove the coolant crossover.
6. Remove the bypass hose.
7. Remove the gaskets.

Accessory/Engine Lift Brackets Removal

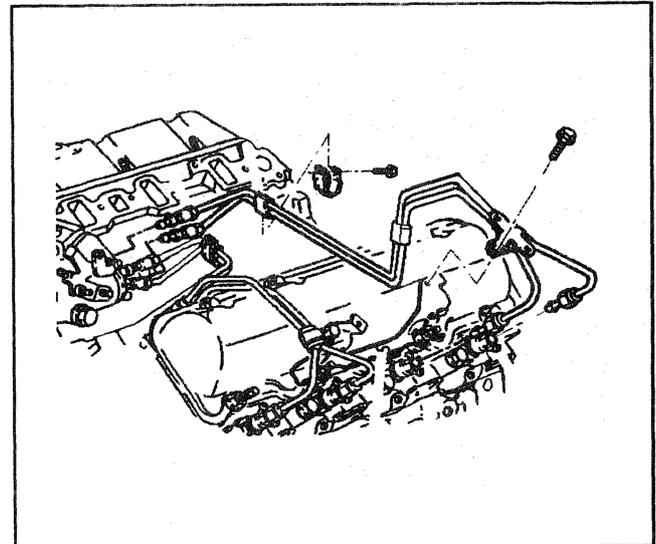
1. Remove the three bolts.
2. Remove the lift bracket.



59794

Fuel Injection Line Removal

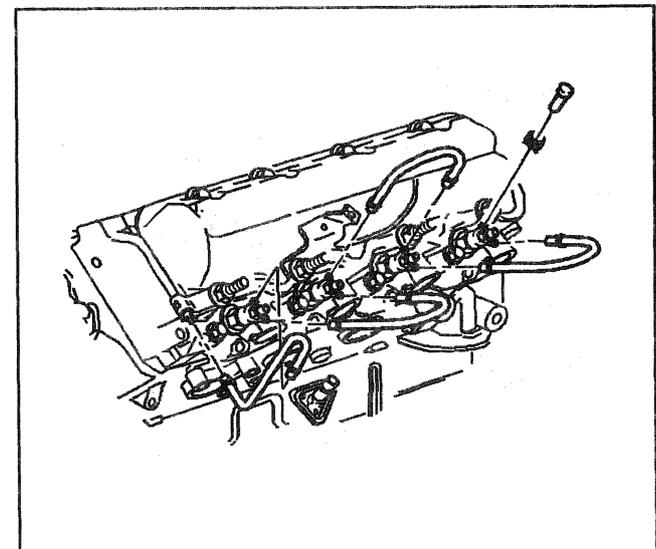
1. Remove the injection line clips at the brackets.
2. Remove the injection lines at the nozzles using a 22 mm (0.87 in) open end wrench to hold the nozzle body while opening the injection line. Wear safety glasses in order to protect against fuel spray.
 - Cap the lines and the nozzles immediately.
 - Do not bend the injection lines.
3. Remove the injection lines at the pump.
 - Cap the lines and the pump fittings immediately.
 - Tag the lines for installation.
4. Remove the injection line brackets.



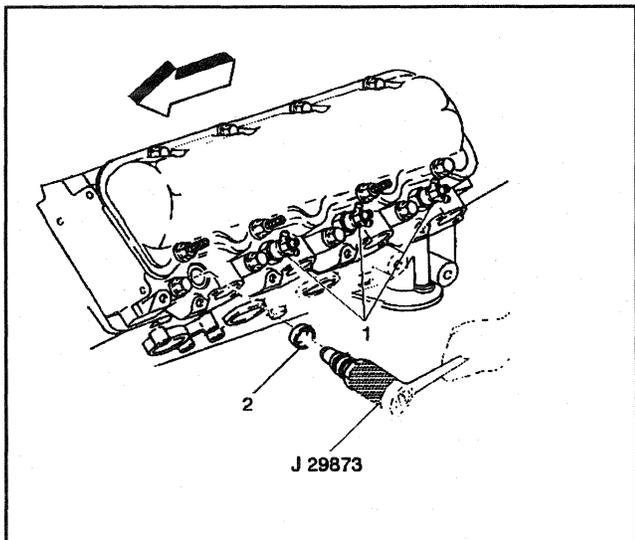
66573

Fuel Inlet and Return Line Removal

1. Remove the clamps from the return hoses at the injection nozzles.
2. Remove the fuel return hoses at the injection nozzles.
3. Remove the fuel return crossover line brackets at the front of both valve rocker arm covers.
4. Remove the clamps and the fuel inlet hose from the fuel injection pump.
5. Remove the clamps and the fuel return hose from the fuel injection pump.
6. Remove the fuel return crossover lines.



59763



60452

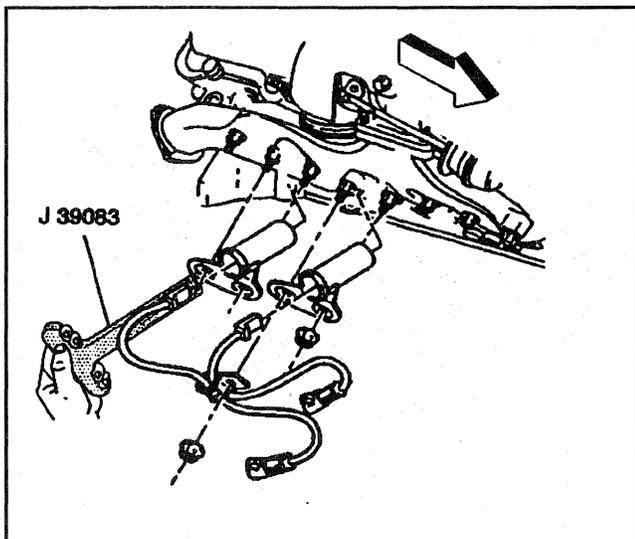
Fuel Injection Nozzle Removal

Tools Required

J 29873 Nozzle Socket

Notice: In order to remove or install an injection nozzle, use the *J 29873* Nozzle Socket on the 30-mm portion of the nozzle. Failure to use the 30-mm hex portion will result in damage to the injection nozzle

1. Remove the injection nozzle using the *J 29873*. Store the nozzles in a clean place.
2. Remove the gaskets.



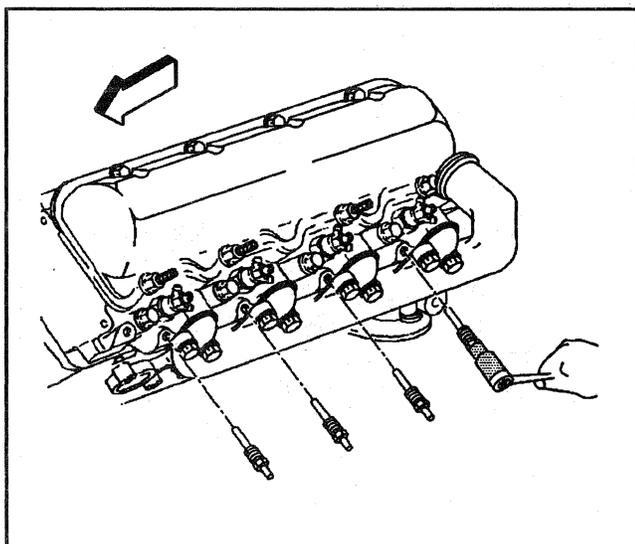
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Glow Plug Removal

Tools Required

- *J 41515-A* Glow Plug Socket
- *J 39083* Glow Plug Connector Tool

1. Use the *J 39083* in order to remove the jumper wires for cylinders number 4 and number 6.
 - 1.1. Hook the end of *J 39083* to the terminal connector body.
 - 1.2. Pull the *J 39083* in order to remove the jumper wire.
2. Remove the following components:
 - The nuts
 - The heat shields

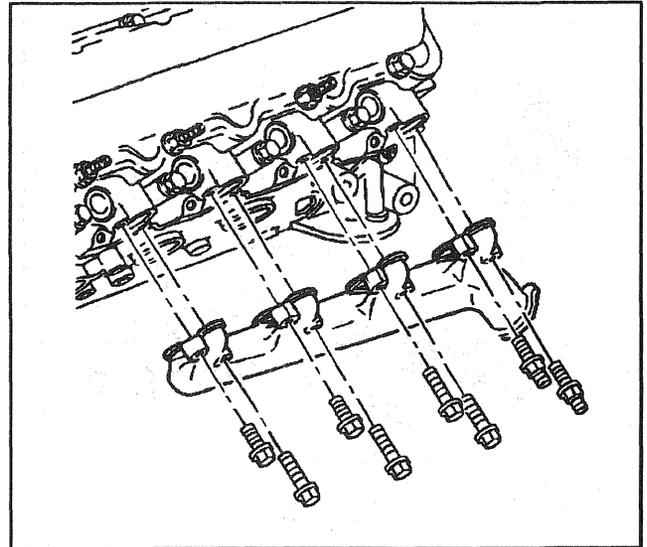


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3. Use the *J 41515-A* in order to remove the glow plugs.

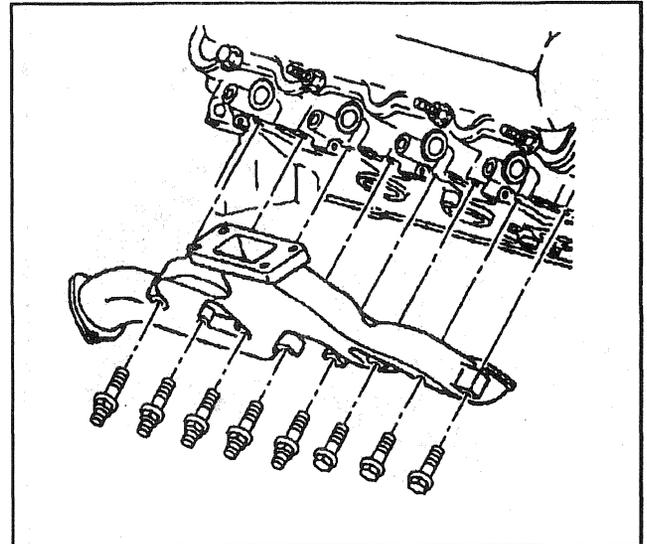
Exhaust Manifold Removal

1. Remove the left side exhaust manifold bolts.
2. Remove the left side exhaust manifold.



60243

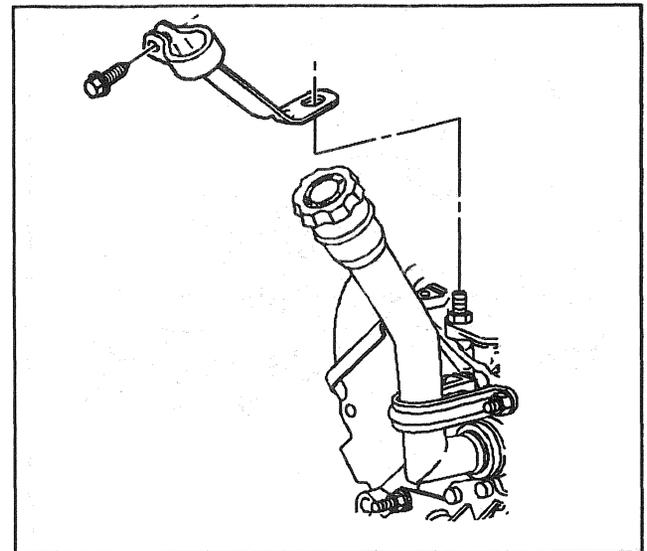
3. Remove the right side exhaust manifold bolts.
4. Remove the right side exhaust manifold.



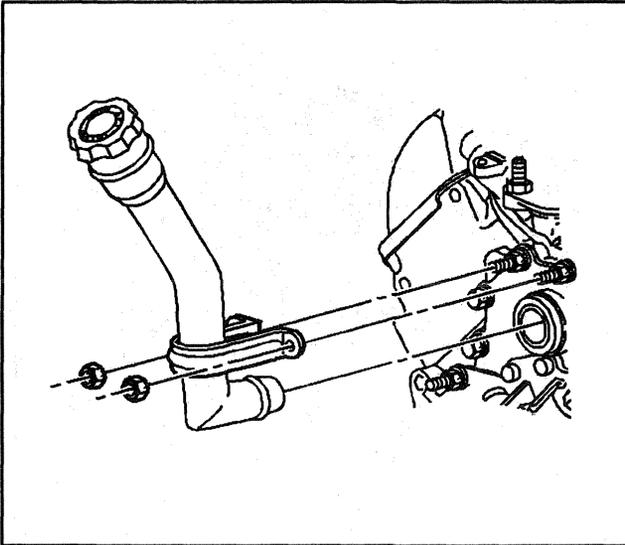
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Oil Fill Neck Removal

1. Remove the nut holding the bracket to the thermostat housing.

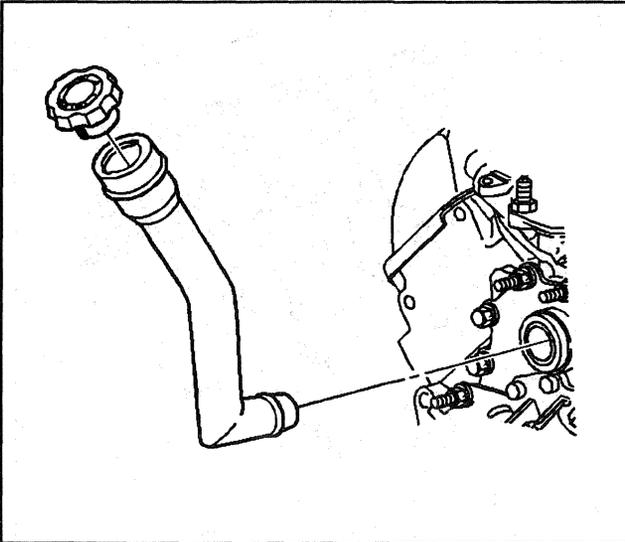


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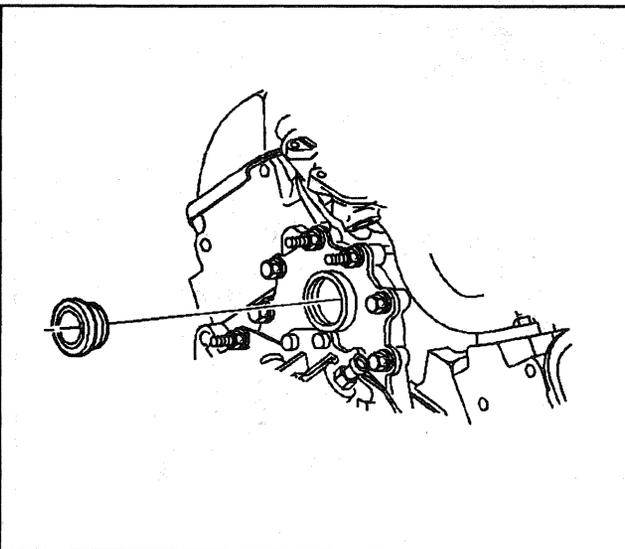
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2. Remove the nuts from the oil fill neck bracket to the front of the engine.



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3. Remove the oil fill neck.



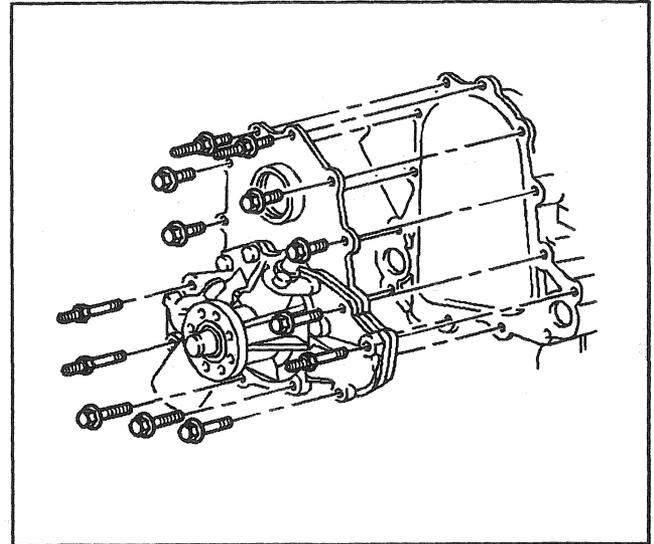
59776

4. Remove the seal.

Water Pump Removal

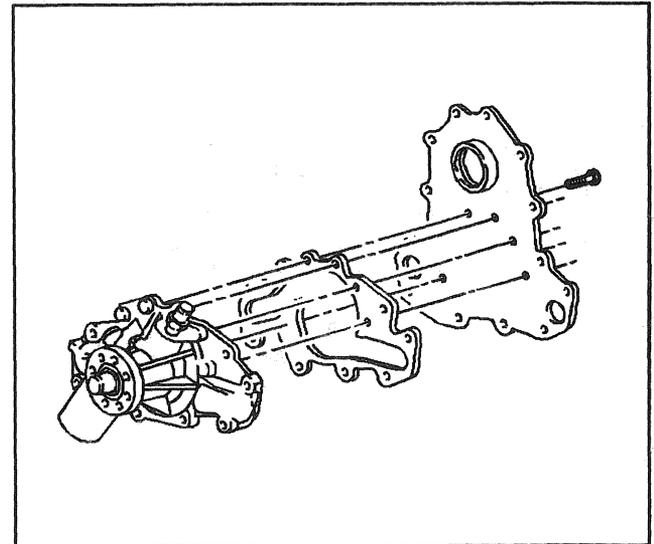
Important: The water pump bolts to the backing plate from the back. Remove the water pump and the backing plate together.

1. Remove the bolts and the stud nuts which hold the water pump and the water pump backing plate to the front crankcase cover.
2. Remove the water pump backing plate and the water pump together.



59826

3. Remove the bolts which hold the water pump to the water pump backing plate.
4. Remove the water pump.
5. Remove the gasket.

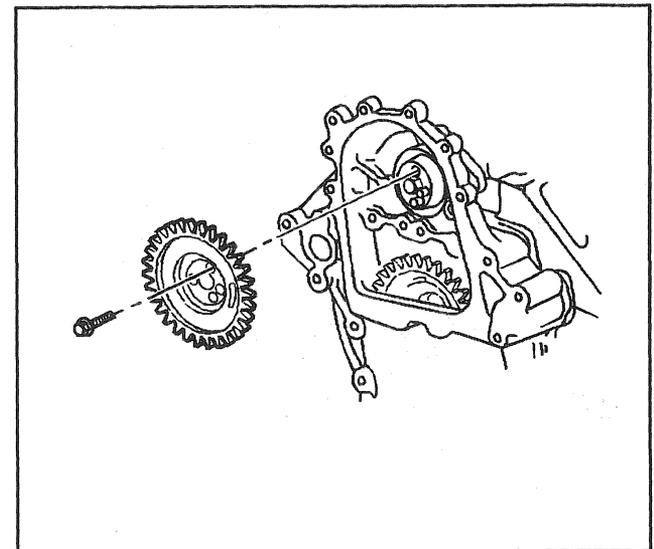


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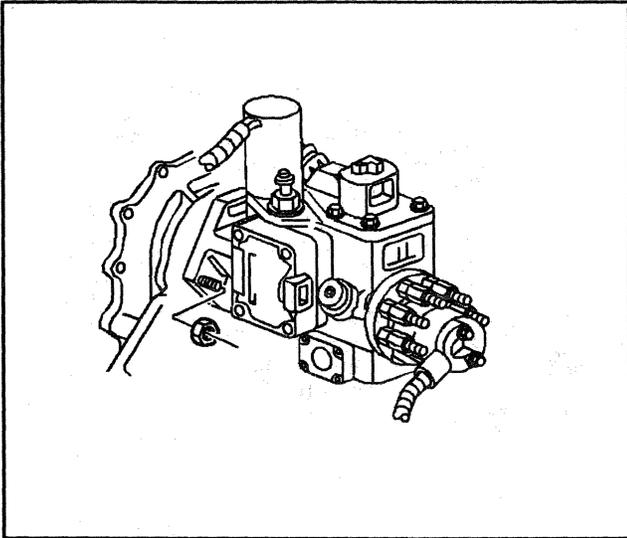
Fuel Injection Pump Removal

Notice: The fuel injection pump is an electronically controlled device. Handle carefully in order to prevent damage to internal and external components.

1. Remove the three bolts from the fuel injection pump timing gear.
2. Remove the fuel injection pump timing gear.

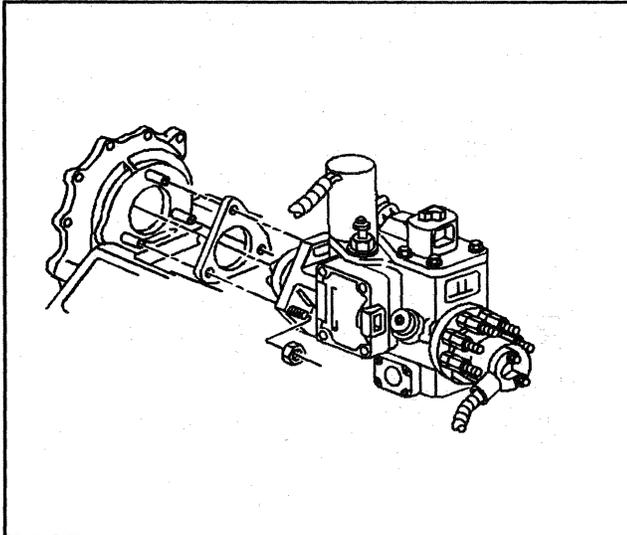


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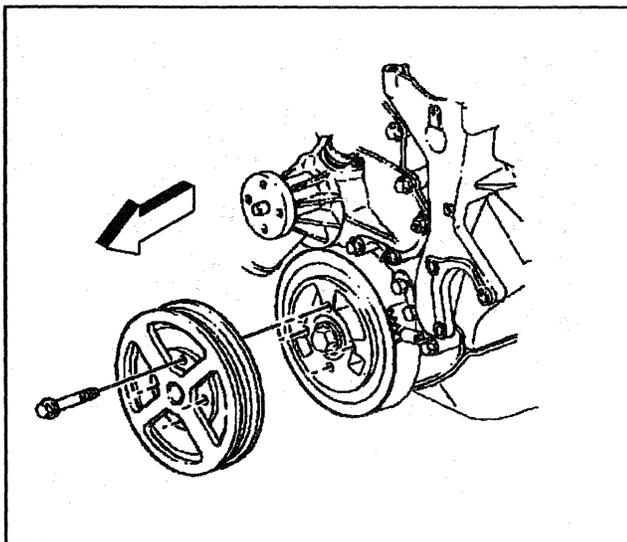
3. Remove the three fuel injection pump mounting nuts.



59855

Notice: Never rotate the engine with the starter, the starter location engine rotation fixture, or with the wrench from the front of the engine with the fuel injection pump removed. The loose fuel pump drive gear could become lodged in the front cover and cause gear tooth distress and shear the camshaft drive gear. Align the camshaft gear timing marks before installing the fuel injection pump drive gear.

4. Remove the fuel injection pump.
5. Remove the fuel injection pump gasket.



70257

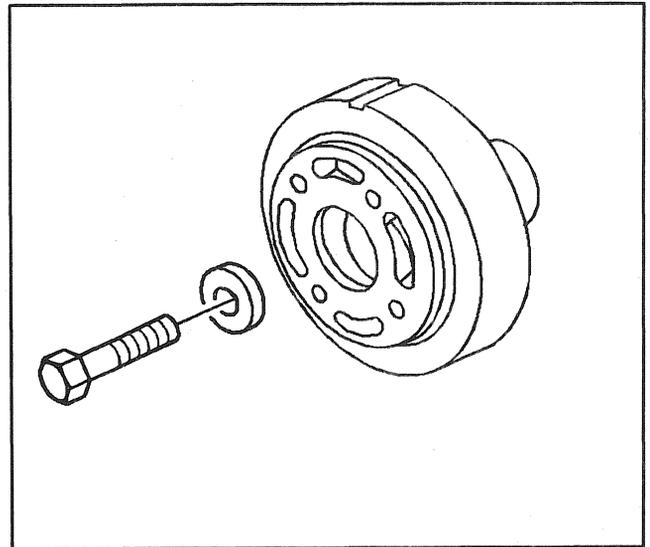
Crankshaft Balancer Removal

Tools Required

J 39046 Crankshaft Balancer Remover

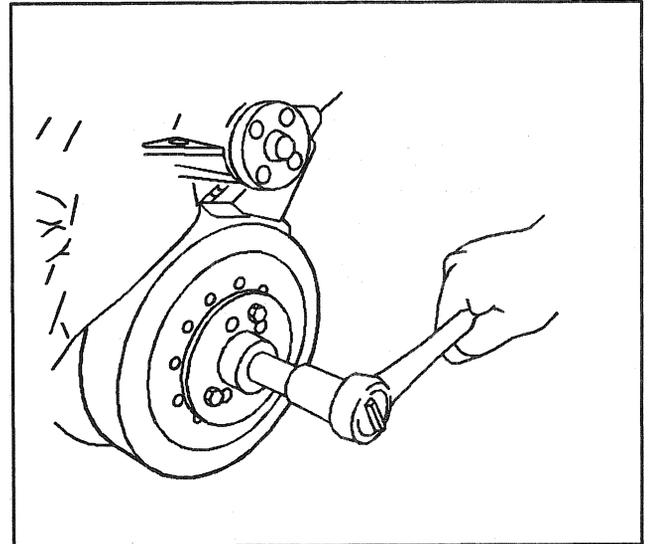
1. Remove the bolt for the front crankshaft pulley.
2. Remove the front crankshaft pulley.

3. Remove the bolt and washer for the crankshaft balancer.



59837

4. Remove the crankshaft balancer using the J 39046.

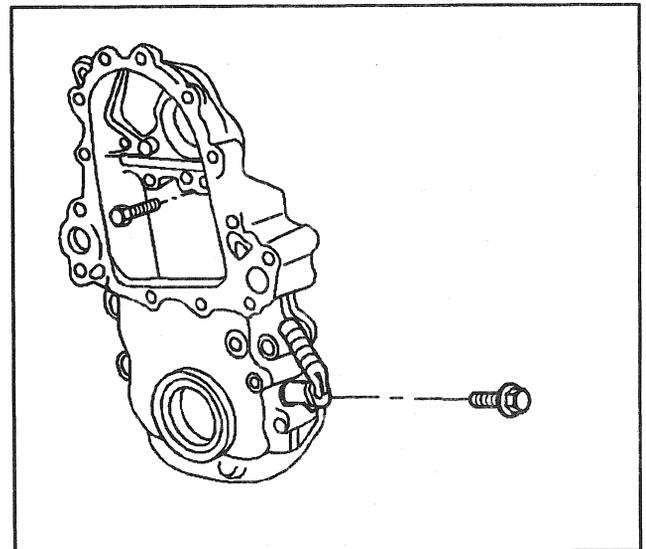


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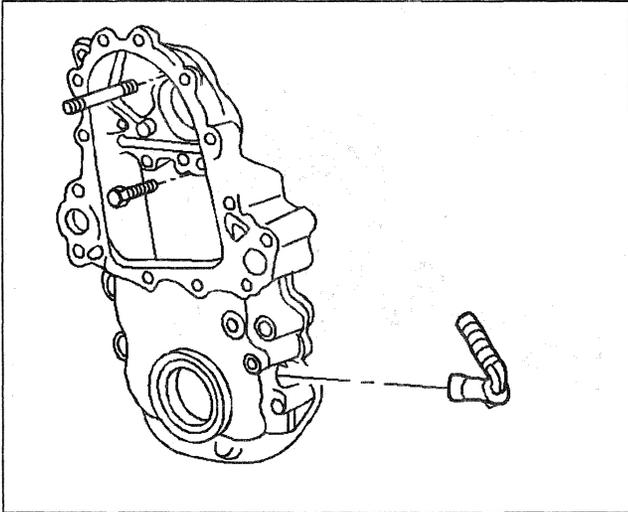
Engine Front Cover Removal

Important: In order to prevent damage, take care when removing the crankshaft position sensor. Prying up the mounting bracket may break the bracket loose from the sensor. If the mounting bracket separates from the sensor, replace the crankshaft position sensor.

1. Remove the bolt in the crankshaft position sensor mounting bracket.

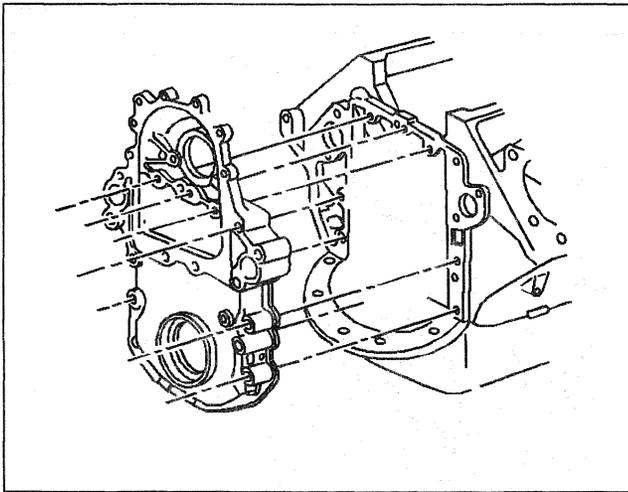


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2. Twist and pull the crankshaft position sensor straight out from the front cover.

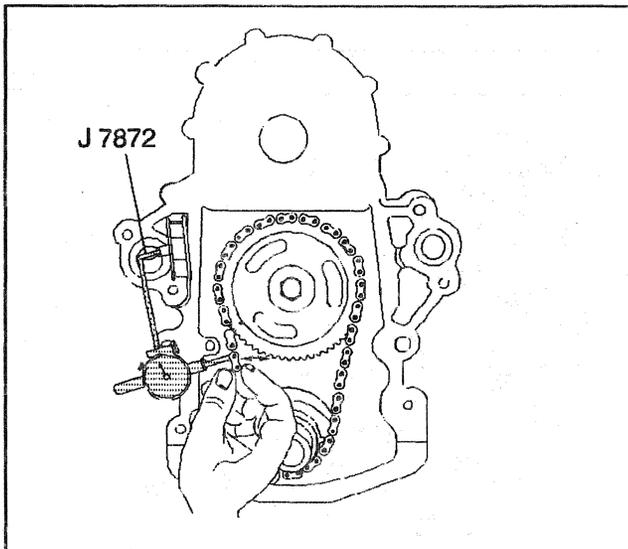


59864

3. Remove the oil pan to front cover bolts.
4. Remove the front cover to block bolts.
5. Remove the front cover.

Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

6. Remove the front crankshaft seal using a large screwdriver. Do not reuse the seal.



60261

Timing Chain Wear Check

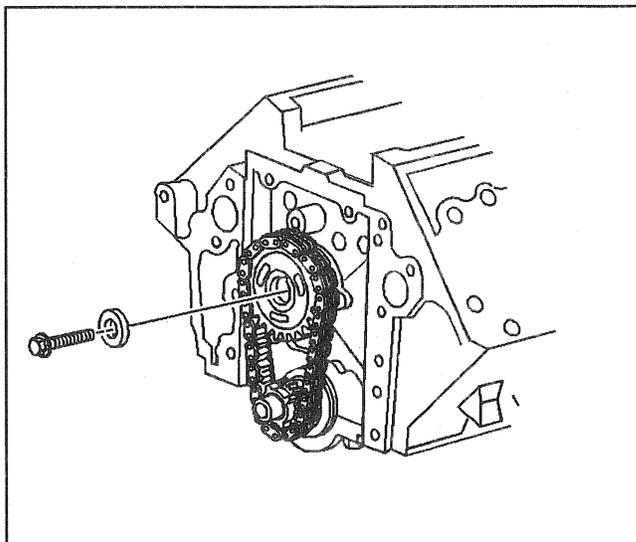
Tools Required

J 7872 Magnetic Base Dial Indicator

1. Mount the J 7872 to the front of the block.
2. Position the dial indicator so that the plunger contacts the timing chain between the two sprockets.
3. Pull the chain outward, parallel to the front face of the block, to the maximum amount, with finger pressure on the inside of the chain.
4. Set the J 7872 to zero.
5. Move the chain inward, parallel to the front face of the block, to the maximum amount with finger pressure on the outside of the chain.
6. Note the total indicator travel.
 - With used parts, the deflection must not exceed 20.3 mm (0.80 in).
 - If the deflection exceeds this limit, inspect the sprockets and the timing chain for wear and replace the worn parts.
 - With new parts, the deflection must not exceed 12.7 mm (0.50 in).

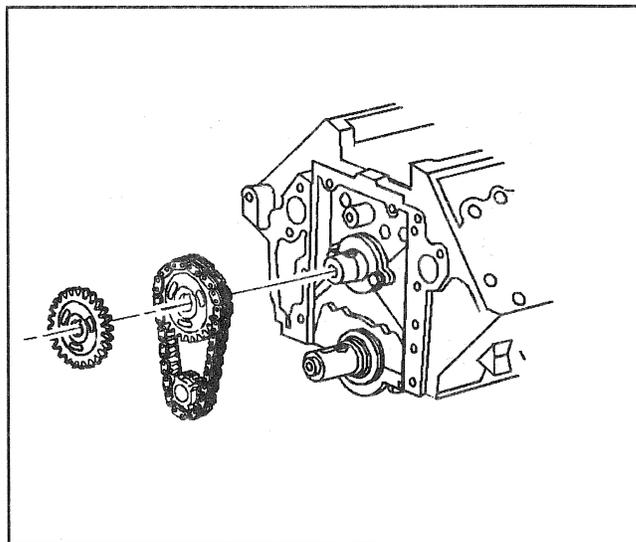
Timing Chain and Camshaft Sprocket Removal

1. Remove the camshaft sprocket bolt and the washer.



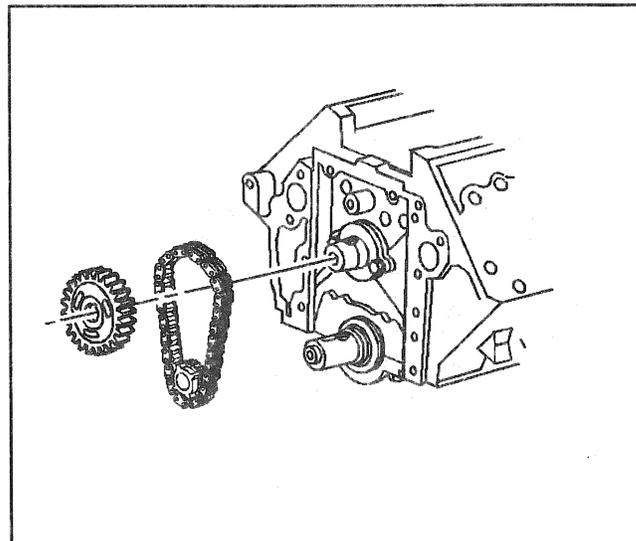
59872

2. Remove the injection pump camshaft gear.

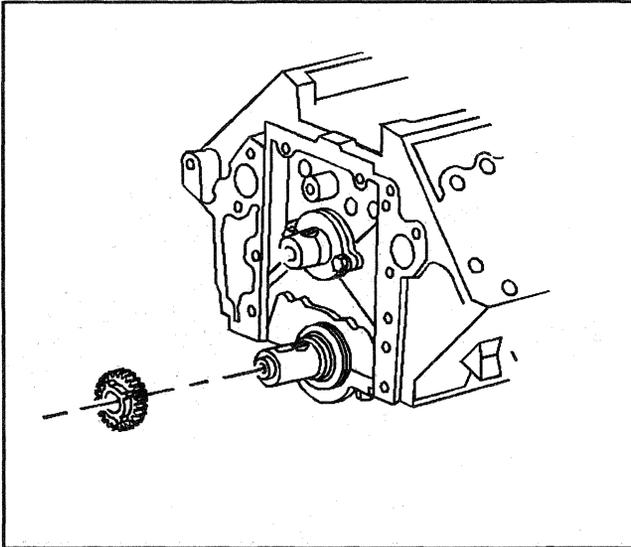


59874

3. Remove the camshaft sprocket with the timing chain.

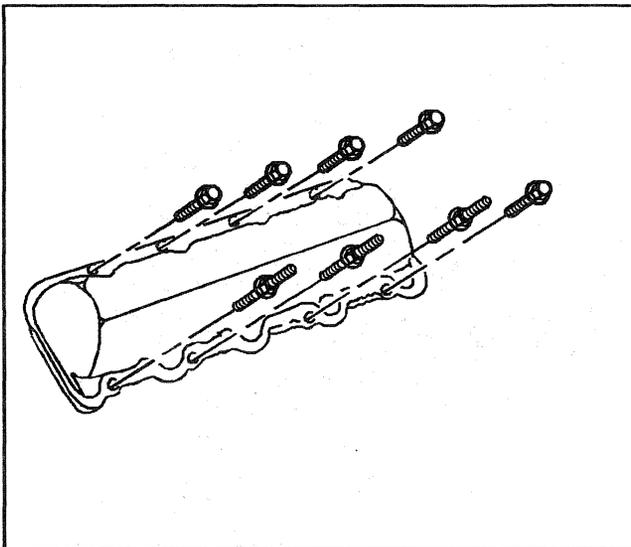


59876



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4. Remove the crankshaft sprocket. Do not damage the square bosses of the crankshaft sprocket during removal.
5. Remove the keyways from the camshaft and the crankshaft.



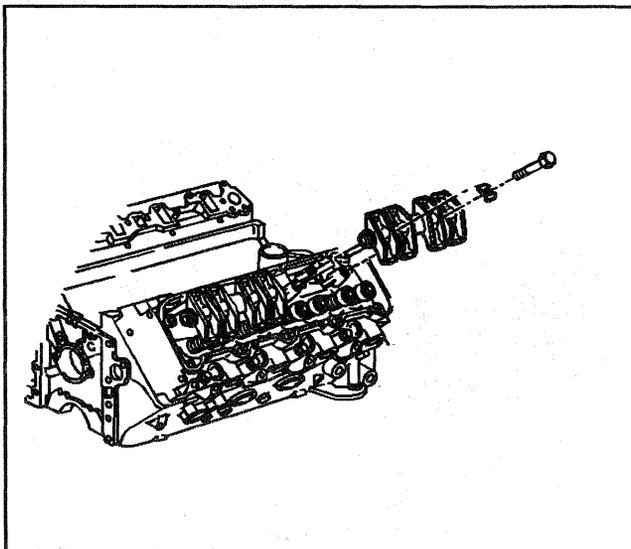
59831

Valve Rocker Arm Cover Removal

1. Remove the valve rocker arm cover bolts and stud/nuts.

Notice: Prying on the valve rocker arm cover may cause damage to the sealing surfaces. Use a block of wood against the side of the valve rocker arm cover and strike with a hammer in a sideways direction to shear the RTV sealant.

2. Remove the valve rocker arm covers.



59797

Valve Rocker Arm and Push Rod Removal

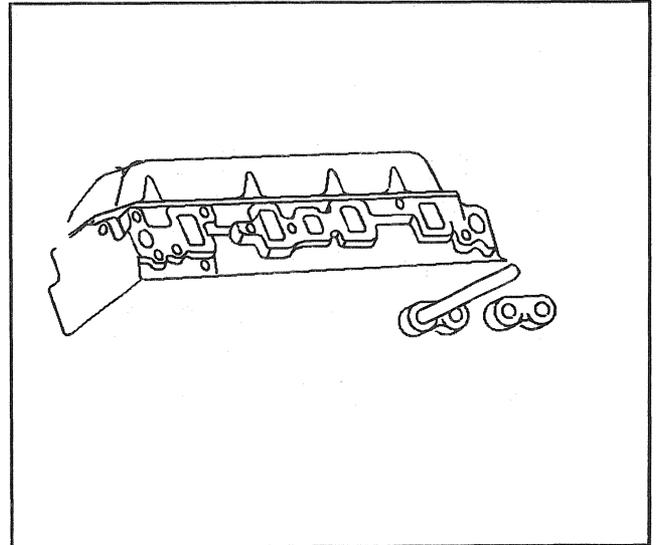
1. Remove the bolts from the valve rocker arm shaft assemblies.

Important: Mark the valve rocker arm assemblies, in order to return each assembly to the original location.

2. Remove the valve rocker arm shaft assemblies.

Important: Install the valve pushrods in the original position and in the same direction at assembly. Each end of the valve pushrods have a different degree of hardness. The upper end of the valve pushrod is copper colored. A paint stripe also identifies the upper end of the valve pushrod.

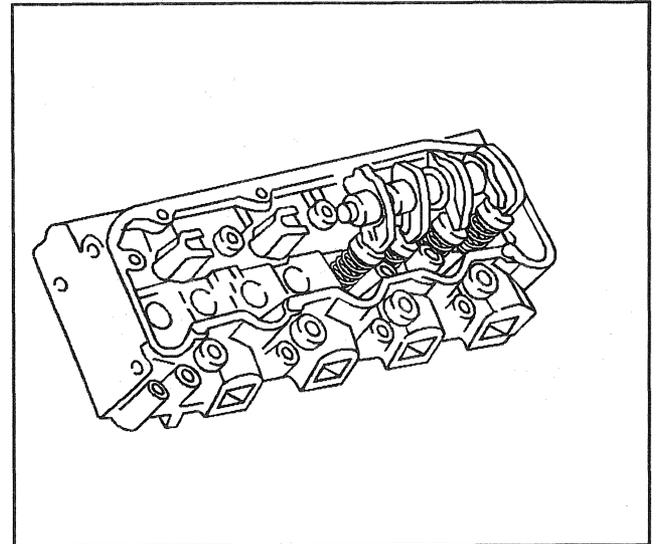
3. Remove the valve pushrods.



59800

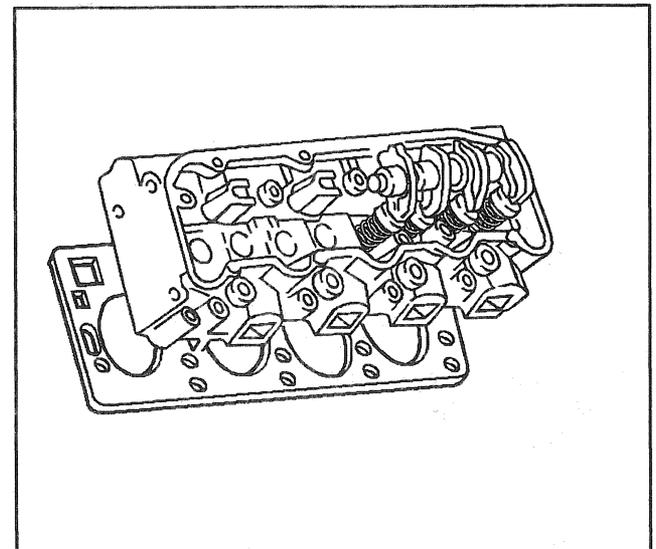
Cylinder Head Removal

1. Remove the cylinder head bolts.
2. Remove the cylinder heads.

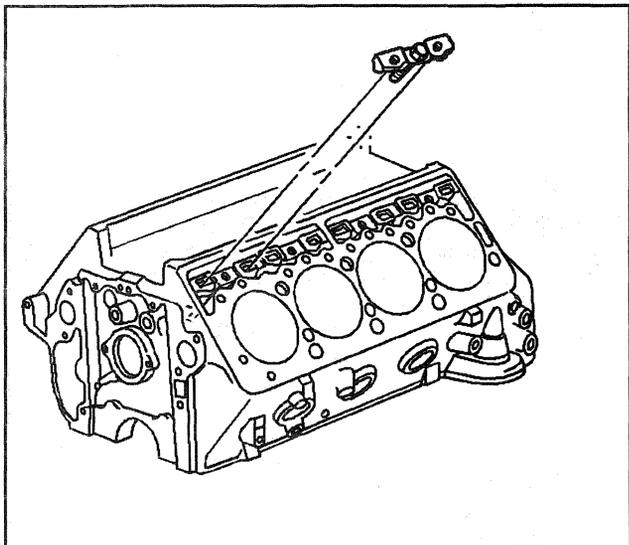


59802

3. Remove the cylinder head gaskets.



59803

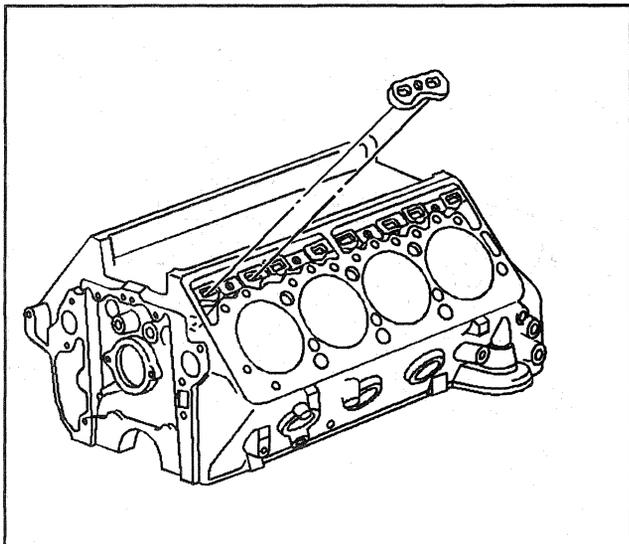


59806

Valve Lifter Removal

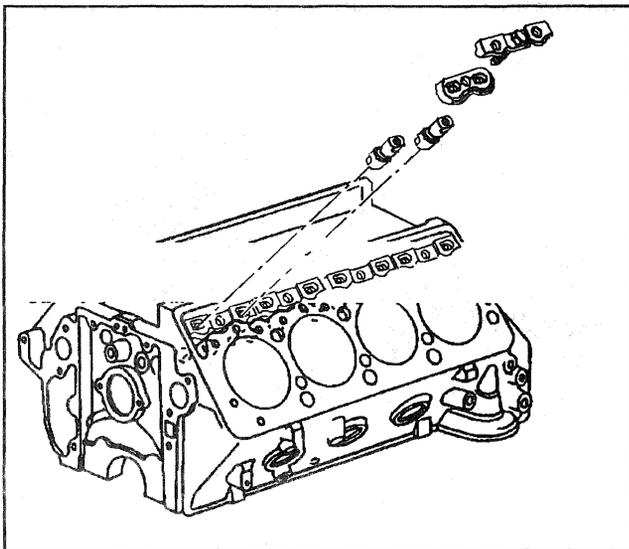
Important: When removing the valve lifters, place the lifters in an organizer rack. The lifters must be installed in the same bore from which these were removed.

1. Remove the bolts and the valve lifter retaining clamps.



59809

2. Remove the valve lifter guide plates.

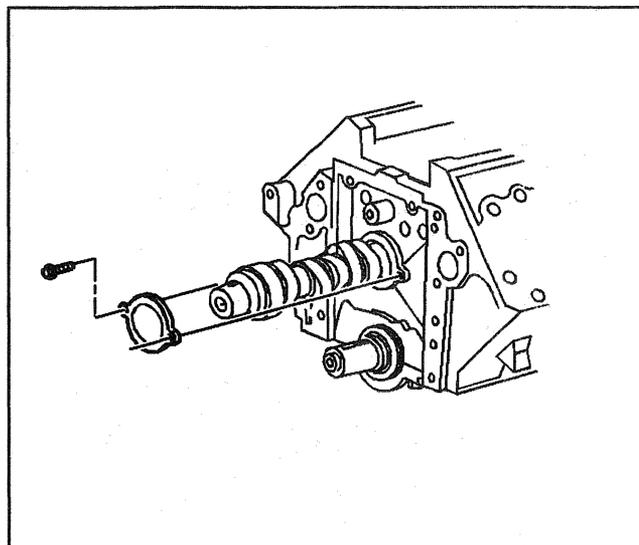


66589

3. Remove the valve lifters.

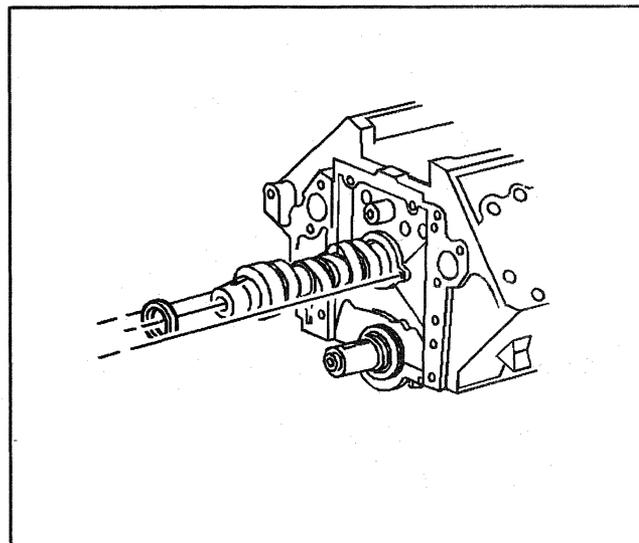
Camshaft Removal

1. Remove the bolts.
2. Remove the camshaft thrust bearing.



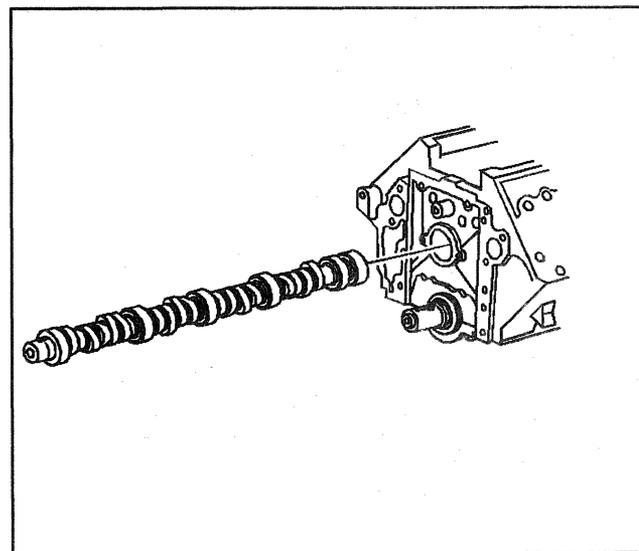
59885

3. Remove the camshaft sprocket spacer.

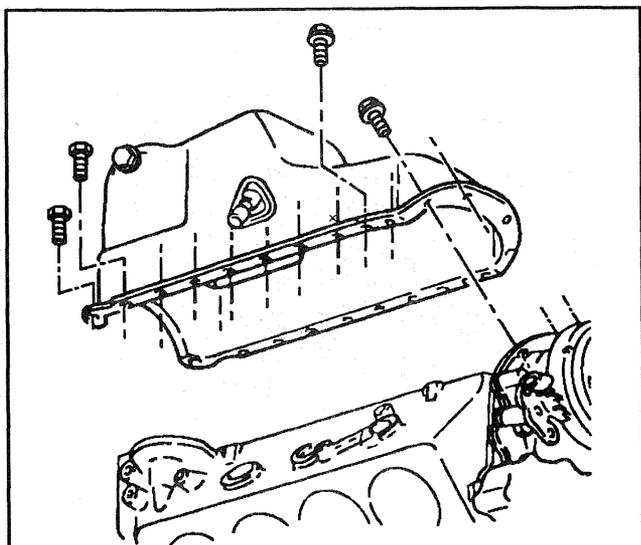


59887

4. Remove the camshaft. Pull the camshaft from the block carefully to avoid damage to the camshaft bearings.



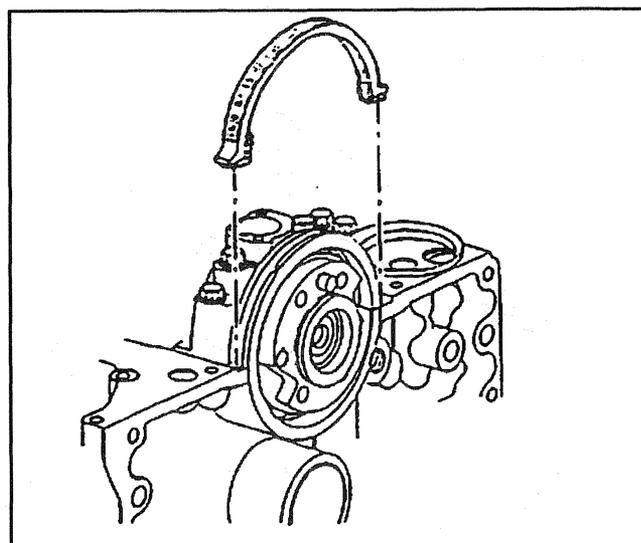
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65010

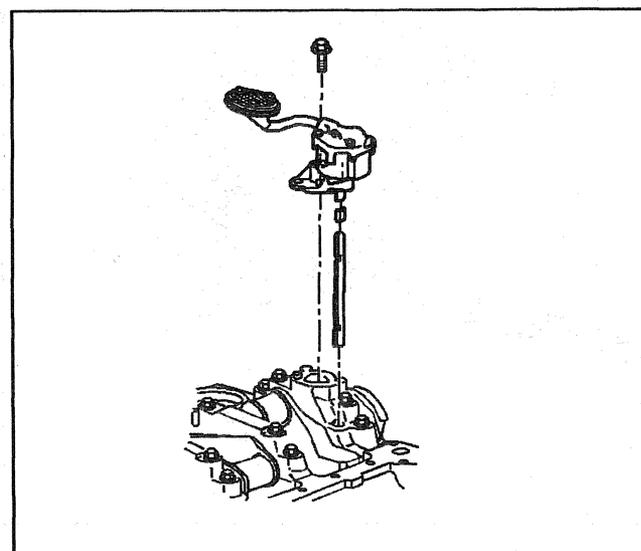
Oil Pan Removal

1. Remove the oil pan bolts.
2. Remove the oil pan.



66587

3. Remove the oil pan rear seal.



59893

Oil Pump Removal

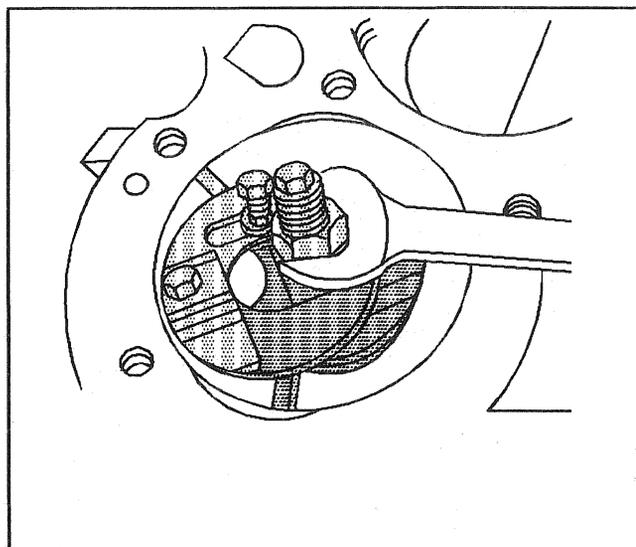
1. Remove the oil pump bolts.
2. Remove the oil pump and drive shaft assembly.

Piston, Connecting Rod, and Bearing Removal

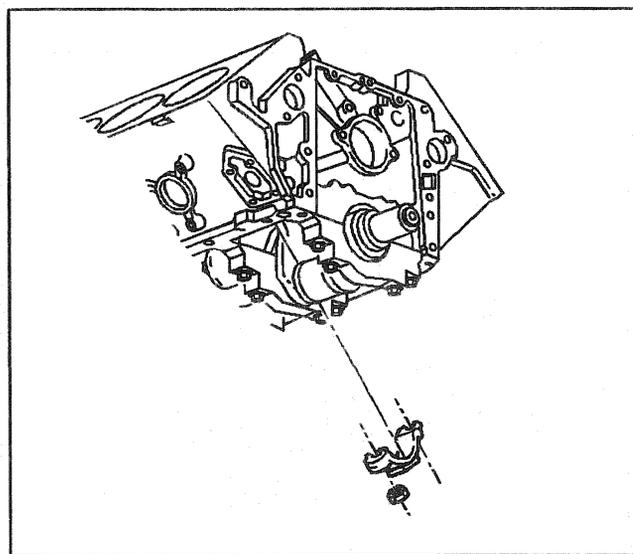
Tools Required

J 24270 Ridge Reamer

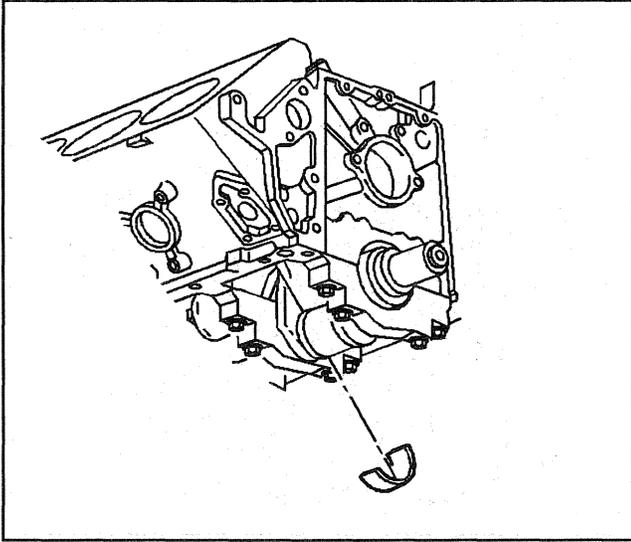
1. Use the *J 24270* in order to remove the ridge or the deposits from the upper end of the cylinder bores.
 - 1.1. Turn the crankshaft until the piston is at the bottom of the stroke.
 - 1.2. Place a cloth on top of the piston.
 - 1.3. Perform the cutting operation with the *J 24270*.
 - 1.4. Turn the crankshaft until the piston is at the top dead center (TDC).
 - 1.5. Remove the cloth and the cuttings.
 - 1.6. Repeat this procedure for each cylinder.
2. Before removing the pistons and the rods, check the pistons and the rods for cylinder identification numbers.
3. If the pistons are not numbered, use a metal number stamp in order to mark the piston, the rod and the cap using the following procedure:
 - Mark the cylinder number, on the bottom of the front section of the piston boss, of each piston.
 - Mark the cylinder number on the bearing tang slot side of both the rod and the cap.
 - Mark the components from the front to the rear, with the engine in an upright position and viewed from the front.
 - The left bank is numbered 1-3-5-7, while the right bank is number 2-4-6-8.
 - Be sure to mark both, the rod and the cap with the correct cylinder number.
 - Keep the connecting rod and cap together as mating parts.
4. Remove the connecting rod nuts.
5. Remove the connecting rod cap.



11497

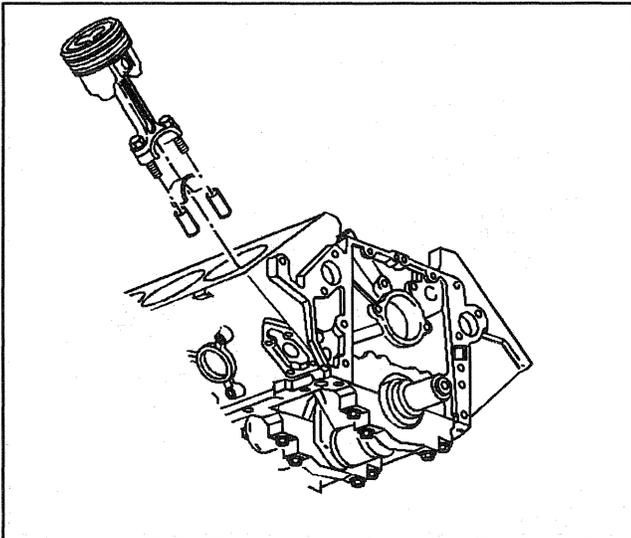


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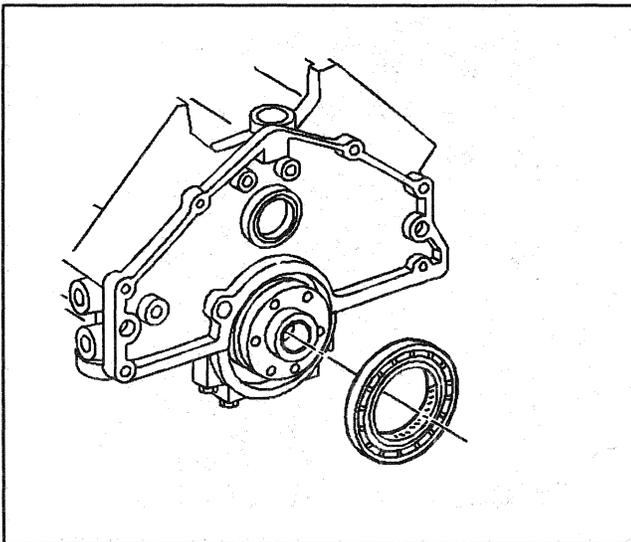
59899

6. Remove the bearing inserts from the connecting rod.



59901

7. Attach two short pieces of 10 mm (3/8 in) hose to the connecting rod bolts, in order to protect the crankshaft journal during removal.
8. Push the connecting rod and the piston out of the bore.
9. After removal, assemble the connecting rod, the cap and the bearings. If reusing the bearing inserts, keep the inserts in the rods and cap from which they were removed.



59909

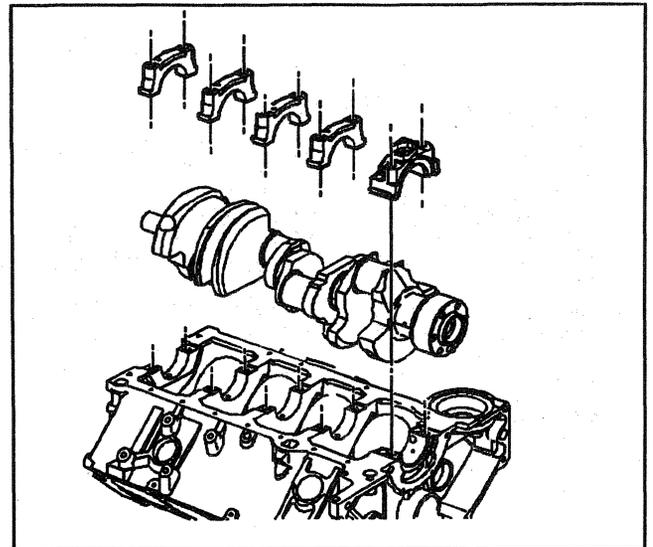
Rear Crankshaft Oil Seal Removal

Remove the rear oil seal using a small screw driver. Do not reuse the old seal.

Crankshaft, Bearings, and Bearing Cap Removal

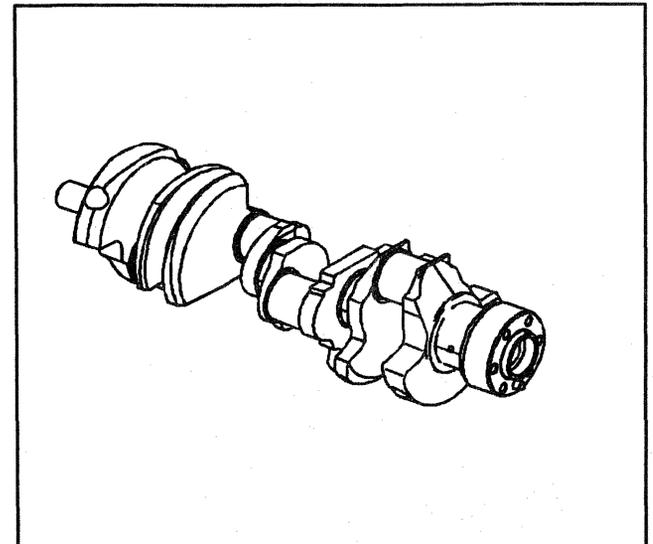
Important: Check the crankshaft bearing caps for location markings. Mark the caps, if necessary. Return the crankshaft bearing caps to their original locations during assembly.

1. Remove the crankshaft bearing cap bolts.
2. Remove the crankshaft bearing caps.



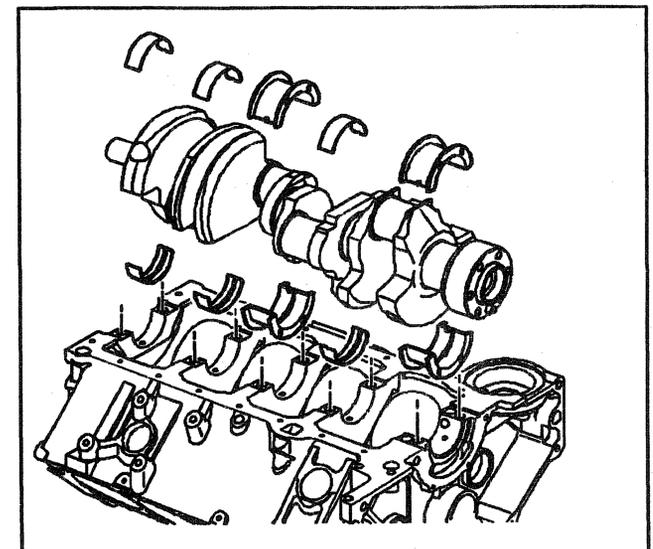
59912

3. Remove the crankshaft by lifting the crankshaft straight up, in order to avoid damage to the crankshaft journals and the thrust flange surfaces.

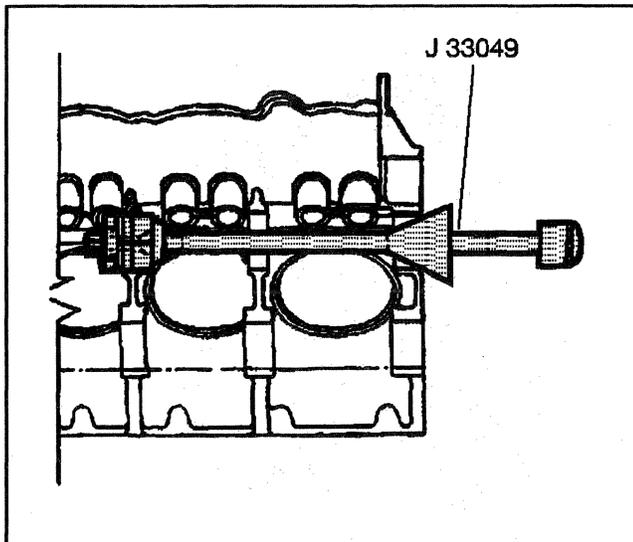


59918

4. Remove the crankshaft bearing inserts. If reusing the bearing inserts, place them in a rack in order to return the bearing inserts to the original location during assembly.



59916



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Cylinder Block Disassemble

Tools Required

J 33049 Universal Camshaft Bearing Remover and Installer Set

1. Remove the camshaft bearings using the following procedure:

- 1.1. Remove the rear camshaft plug.

Important: The rear camshaft bearing must be removed from the front of the block and the front camshaft bearing must be removed from the rear of the block. This allows the tool to remain centered.

- 1.2. Insert the driving bar of the *J 33049* with the correct expanding driver into the camshaft bearing (collet 4 for camshaft bearings one through four, and collet 3 for camshaft bearing five).

- 1.3. Turn the *J 33049* until the collet has tightened in the bearing.

- 1.4. Push the guide cone against the block and into the first bearing bore in order to center the tool.

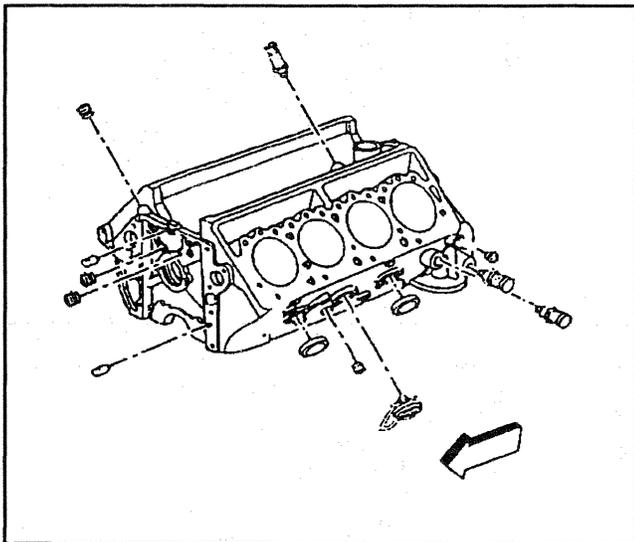
- 1.5. Drive the bearing from the block.

- 1.6. Repeat this procedure in order to remove the remaining camshaft bearings.

2. Remove the block drain plugs.

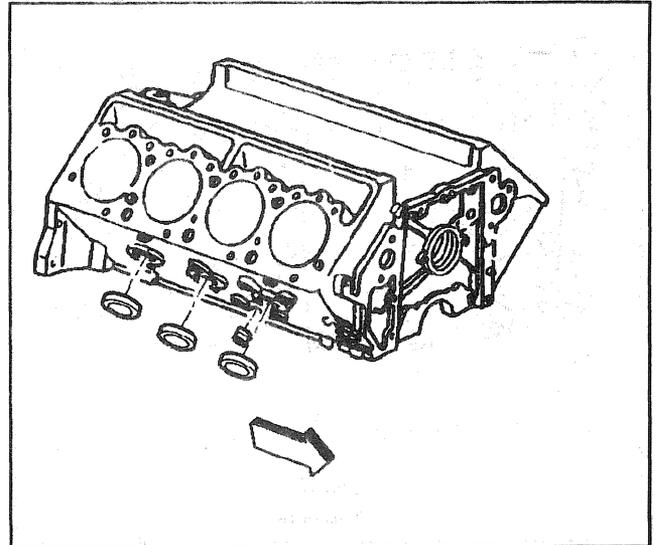
3. Remove the cup plugs and the block heater.

4. Remove the engine oil pressure sensor switch.



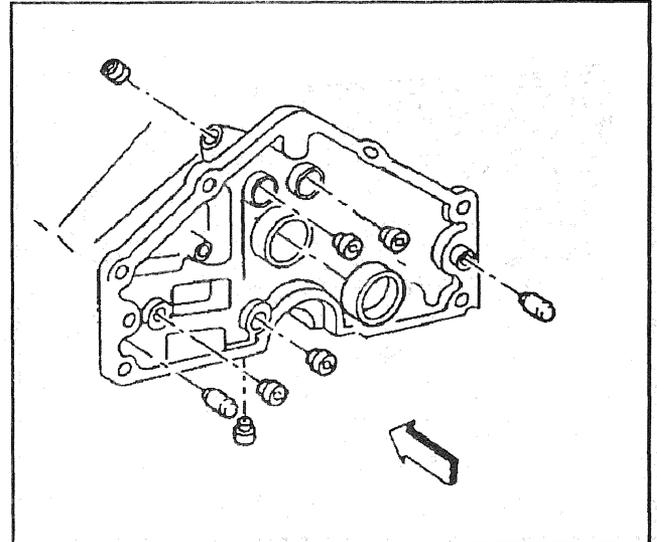
65012

5. Remove the side oil gallery plugs.



65013

6. Remove the rear oil gallery plugs. An oil gallery plug is located inside the rear main bearing cap land.

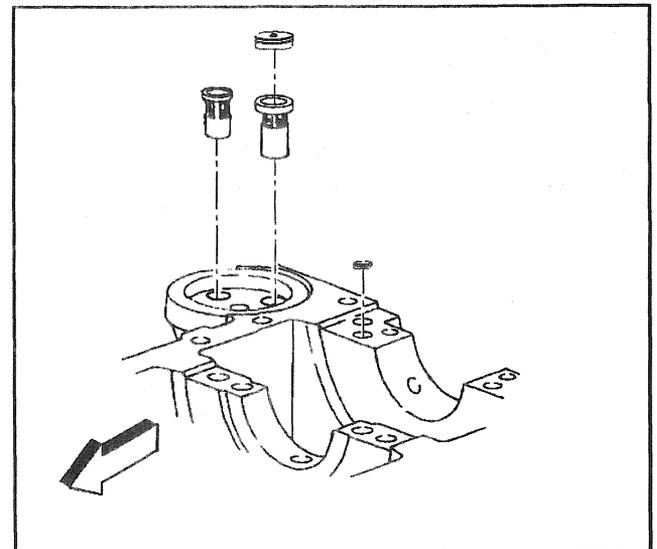


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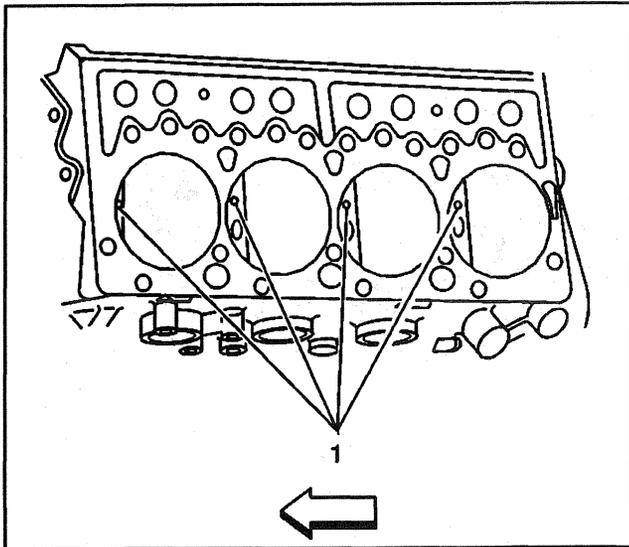
7. Pry out the oil filter bypass valve using a screwdriver.

8. Remove the oil cooler bypass valve using the following procedure:

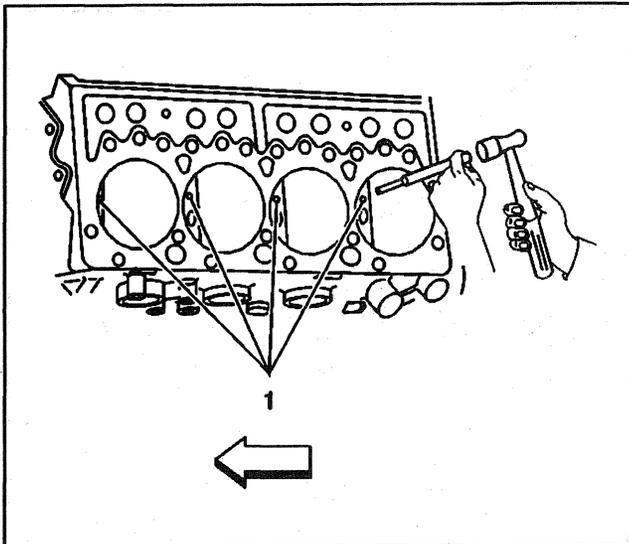
- 8.1. Install a sheet metal screw into the hole in the cup plug.
- 8.2. Using side cutters or pliers, pry out the cup plug.
- 8.3. Pry out the oil cooler bypass valve using a screwdriver.



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Important:

- The piston oil nozzles are made of aluminum and are pressed fit into the block. Certain cleaning solutions can damage the nozzles.
- Do not damage the nozzle bore.
- Do not damage the cylinder bore or deck surface.

9. Remove the piston oil nozzles.

10. Using a brass drift, drive the piston oil nozzles out of the block.

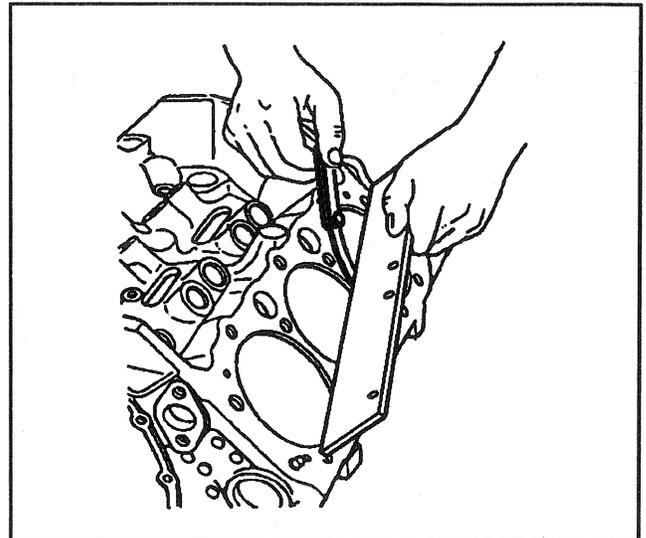
Cylinder Block Clean and Inspect

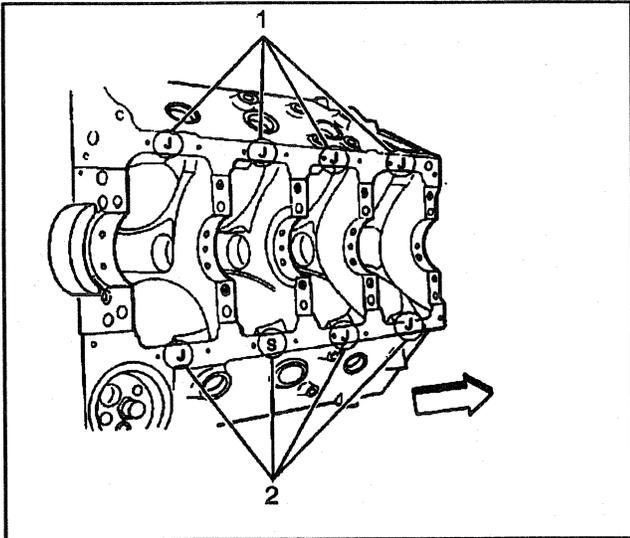
You will need a solvent tank large enough to hold the large engine parts, along with various bristle brushes and a gasket scraper. Whenever you are using cleaning solvents for cleaning parts, follow the manufacturer's recommendations. If necessary, wear protective clothing. A source of compressed air will be helpful in the cleaning operations. Wear safety glasses throughout the cleaning, inspection, and repair process.

The inspection procedure requires precision measuring tools. These include micrometers, cylinder bore gauge, feeler gauges, dial indicator set, etc. Perform the inspection work with the proper method and tools. Using parts worn beyond the acceptable limits will decrease the performance of the rebuilt engine.

1. Clean the block in the cleaning solvent.
2. Clean the block gasket surfaces.
3. Clean the cylinder bores.

4. Clean the oil galleries and passages.
5. Clean the scale deposits from the coolant passages.
6. Inspect the valve lifter bores for deep scratches and varnish deposits.
7. Inspect the block for cracks. Use the Magnaflux Spot check dye method, or the equivalent.
 - Inspect the cylinder walls.
 - Inspect the coolant jackets.
 - Inspect the crankshaft bearing webs.
8. Inspect the crankshaft bearing bores and caps. All crankshaft bearing bores' inside diameters should be round and uniform at all the bearing supports.
9. Inspect the area where the crankshaft bearing inserts contact the crankshaft bearing bore. This area must be free of burrs and scratches.
10. Inspect the engine mount bosses.
11. Inspect the cylinder head gasket mating surfaces for pitting.
12. Inspect the engine block to cylinder head gasket surface area for warping. Use a straight edge and feeler gauge. Replace the block if it is warped more than 0.15 mm (0.006 in) longitudinally or more than 0.08 mm (0.003 in) transversely.
13. Inspect the camshaft bearings. Replace the camshaft bearings if any of the following conditions exist:
 - Scratches
 - Pits
 - Loose fit in their bores
14. Inspect the camshaft bearings' inside diameter using an inside micrometer. Refer to *Engine Mechanical Specifications*. If the bearings are worn beyond specification, replace the bearings.





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Cylinder Boring and Honing

Tools Required

J 8087 Cylinder Bore Gauge

1. Determine if any cylinders will require honing.
2. In order to identify fine vertical scratches, use a finger nail in order to feel the scratches. You should not be able to feel a fine vertical scratch. Fine vertical scratches will not by themselves cause excessive oil consumption. Therefore, honing in order to remove fine vertical scratches is not necessary.
3. If the bore has polished areas through the hone marks but is serviceable, break the polished surface lightly with a finish hone and install new rings.
4. Prepare the cylinder bores for reuse by cleaning them with a hot water and detergent wash. Apply clean engine oil to the bore after cleaning.

Important: There is only one production standard piston grade size. When using production standard grade size pistons in all eight cylinder bores, a J is metal stamped in a single place on the cylinder block oil pan rail.

A 0.13 mm oversize production piston is available for in a plant rework of cylinders that do not meet the production standard specification. An S metal stamped on the pan rail next to any reworked cylinder identifies that cylinder as production oversize. A J will also be metal stamped in a single place on the oil pan rail to represent that all remaining cylinders are production standard.

All service oversize pistons are of the same weight as the production pistons. Using service oversized pistons will not affect engine balance.

5. Before the honing or reboring operation is started, measure all new pistons.
6. Select the smallest piston for the first fitting. The slight variation usually found between pistons in a set may provide for correction in case the first cylinder is bored too large. Refer to *Engine Mechanical Specifications*.
7. Before using any type of boring bar, file the top of the cylinder block in order to remove any dirt or burrs. If not checked, the boring bar may be tilted which would result in the rebored cylinder wall not being at right angles to the crankshaft.

Important: Carefully follow the instructions furnished by the manufacture of the equipment being used.

8. When reboring cylinders, all crankshaft bearing caps must be in place and tightened to the proper torque in order to avoid distortion of the bores in the final assembly. Refer to *Engine Mechanical Specifications*.
9. When taking the final cut with a boring bar, leave 0.03 mm (0.001 in) on the diameter for finish honing in order to give the required position to the cylinder clearance specifications.

Perform the honing or boring operation carefully so that the specified clearance between pistons, rings, and the cylinder bores is maintained. Refer to *Engine Mechanical Specifications*.

10. When honing the cylinders, follow the hone manufacturer's recommendations for use, cleaning, and lubrication during honing. Use only clean, sharp stones of the proper grade for the amount of material to be removed. Dull, dirty stones cut unevenly and generate excessive heat. When using coarse or medium grade stones, use care to leave sufficient metal so that all stone marks may be removed with the fine stones used for finishing to provide proper clearance. Refer to *Engine Mechanical Specifications*.
11. Occasionally, during the honing operation, thoroughly clean the cylinder bore and check the piston selected for the individual cylinder for correct fit.
12. When honing to eliminate taper in the cylinder, make full strokes of the hone in the cylinder. Check the measurement at the top, the middle, and the bottom of the bore repeatedly. Refer to *Engine Mechanical Specifications*.
13. Handle the pistons with care. Do not attempt to force them through the cylinder until the cylinder has been honed to the correct size. The piston can be easily distorted through careless handling.
14. When finish honing a cylinder bore to fit a piston, move the hone up and down at a sufficient speed in order to obtain very fine uniform surface finish marks in a cross-hatch pattern at the specified angle (45–65 degrees).
15. The finish marks should meet the following requirements:
 - Clean but not sharp
 - Free from imbedded particles
 - Free from torn or folded metal

Important: Measure the block and the piston at normal room temperature.

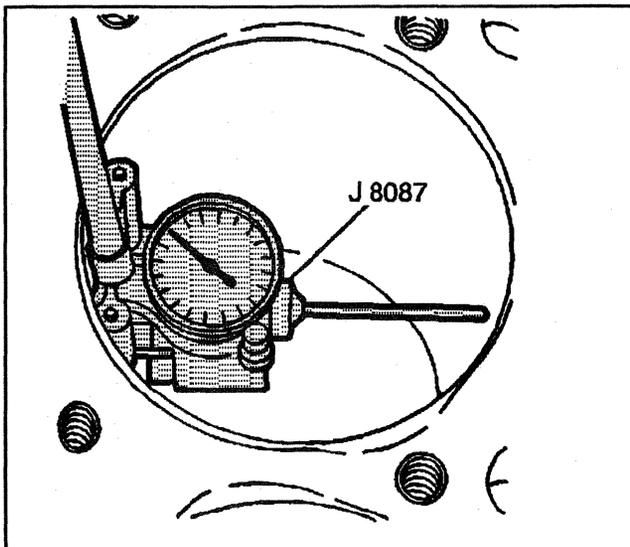
16. Determine the finish hone cylinder measurement by adding the average of the clearance specification to the measurement of the piston. Refer to *Engine Mechanical Specifications*.

Important: True up refinished cylinder bores to have less than the specified out-of-round or taper.

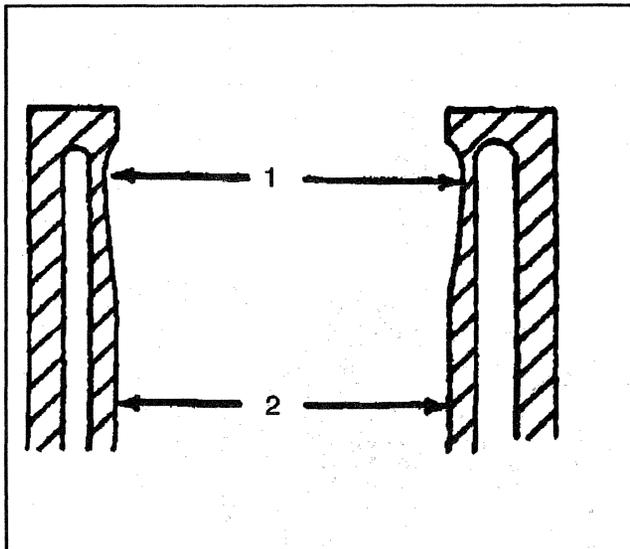
17. Final hone each bore in order to remove all stone or cutter marks and to provide a smooth surface.

Important: If any of the abrasive material is allowed to remain in the cylinder bores, it will wear the new rings, cylinder bores, and bearings lubricated by the contaminated oil.

18. After final honing and before the piston is checked for fit, clean the bores with hot water and detergent. Scrub with a stiff bristle brush. Rinse thoroughly with hot water.
19. After washing, brush clean the dry bore with a power-driven fiber brush.
20. Permanently mark the piston for the cylinder to which it has been fitted.
21. Apply clean engine oil to each bore in order to prevent rusting.
22. The following are the surface roughness specifications for cylinder bores:
 - RA (Minimum) = 0.40 Micro-meter (16 Micro-inch)
 - RA (Maximum) = 0.90 Micro-meter (32 Micro-inch)
23. Inspect the cylinder bores for scoring and other damage.
24. If one or more cylinder bores are rough, scored or worn beyond limits, smooth or true up such bores in order to fit new pistons.
25. No attempt should be made to cut down oversize pistons to fit cylinder bores as this will destroy the surface treatment and affect the weight. Use the smallest possible oversize pistons. Hone the cylinder bores to size for the proper clearances.



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26. Check the cylinders for out-of-round and taper using the following procedure:
 - 26.1. Refer to *Engine Mechanical Specifications* for cylinder bore tolerances.
 - 26.2. Depress the plunger on the tool 7 mm (0.03 in) or until the tool enters the cylinder bore.
 - 26.3. Center the gauge in the cylinder and turn the dial to 0.
 - 26.4. Carefully work the gauge up and down the cylinder in order to determine taper. Turn the gauge to different points around the cylinder wall in order to determine the out-of-round condition. Measure the bore both parallel to and at right angles to the engine centerline. Measure at the top, middle, and the bottom of the bore. Note the readings.
 - 26.5. Recondition the cylinder bore as necessary. If the bore out-of-roundness and taper measurements exceed 0.02 mm (0.0008 in), it will be necessary to rebores and hone such bores and fit new pistons and rings.

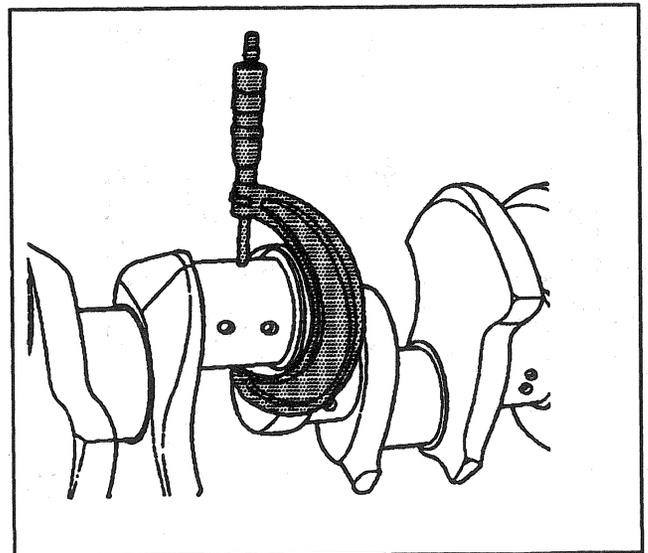
Crankshaft and Bearings Clean and Inspect

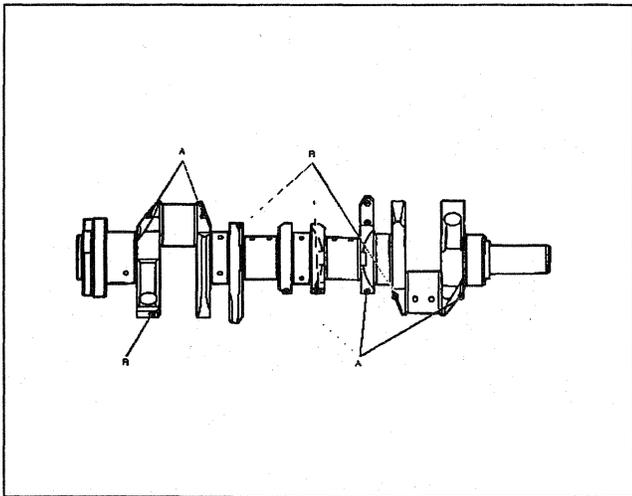
Tools Required

J 7872 Magnetic Base Dial Indicator

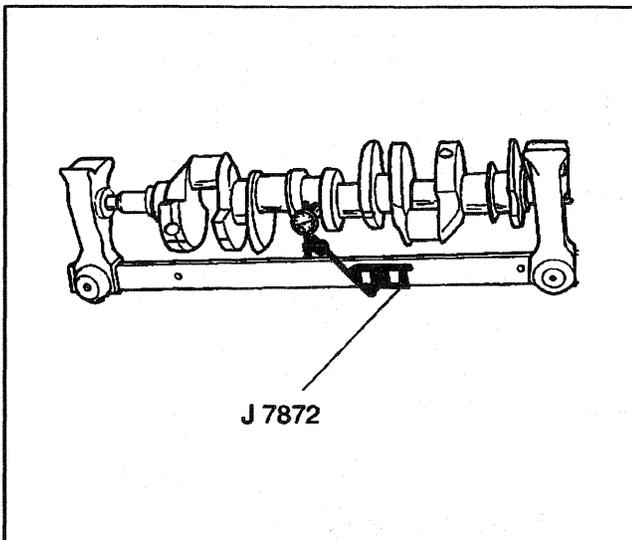
Caution: *Wear safety glasses to avoid injury when using compressed air or any cleaning solvent. Bodily injury may occur if fumes are inhaled or if skin is exposed to chemicals.*

1. Clean the crankshaft with clean solvent using the following procedure:
 - Do not scratch the bearing journals.
 - Blow all of the sludge from the oil passages with compressed air.
 - Remove the clutch pilot bearing located in the end of the crankshaft (manual transmission only).
2. Wipe the crankshaft bearing inserts free of oil with a soft cloth.
3. Inspect the crankshaft for cracks using the Magniflux Spot-check dye method or the equivalent.
4. Inspect the crankshaft bearing journals and thrust surfaces for the following conditions:
 - Scoring
 - Nicks
 - Damage caused by lack of lubrication
5. Inspect the crankshaft bearing inserts and thrust surfaces for the following conditions:
 - Scoring
 - Nicks
 - Damage caused by lack of lubrication
 - The lower bearing inserts (except the front bearing) will show greater wear and the most distress from fatigue. If the lower insert is worn or damaged, replace both the upper and the lower inserts as a set.
6. Measure the crankshaft journal diameter with a micrometer in several places, approximately 90 degrees apart. Average the measurements. Refer to *Engine Mechanical Specifications*.

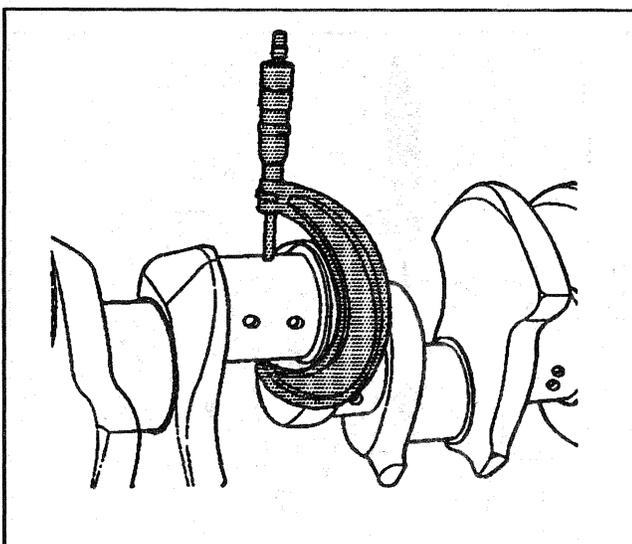




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7. The connecting rod and the crankshaft bearing journal sizes are color coded with paint markings. Main bearing journal markings are blue, orange/red, or white. Rod bearing journal markings are yellow or green.

8. Compute taper. Refer to *Engine Mechanical Specifications*. Replace the crankshaft if the measurement exceeds specifications.
9. Measure the crankshaft runout using the following procedure:
 - 9.1. Mount the crankshaft in V-blocks at crankshaft journals one and five.
 - 9.2. Use the *J 7872* to measure crankshaft runout. Replace the crankshaft bearings and the crankshaft if the runout exceeds 0.01 mm (0.0004 in).

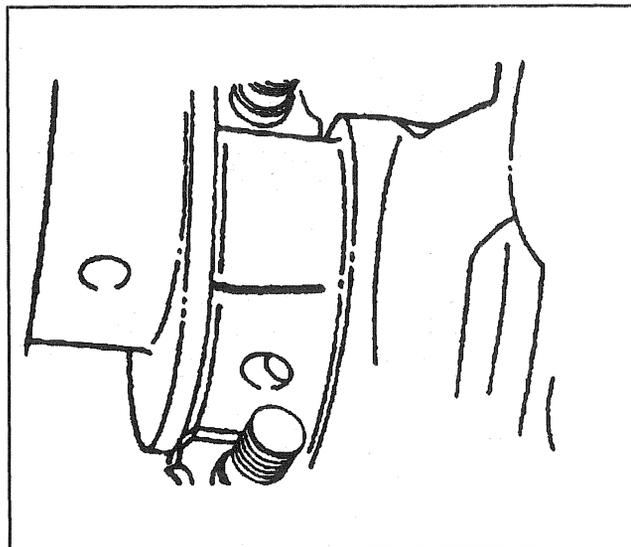
Measurement Procedure

Notice: The crankshaft bearing and the connecting rod journals are machined with deep, rolled fillets for strength. Grinding the crankshaft may disturb the fillets and weaken the crankshaft. Replace the crankshaft if it is damaged.

Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

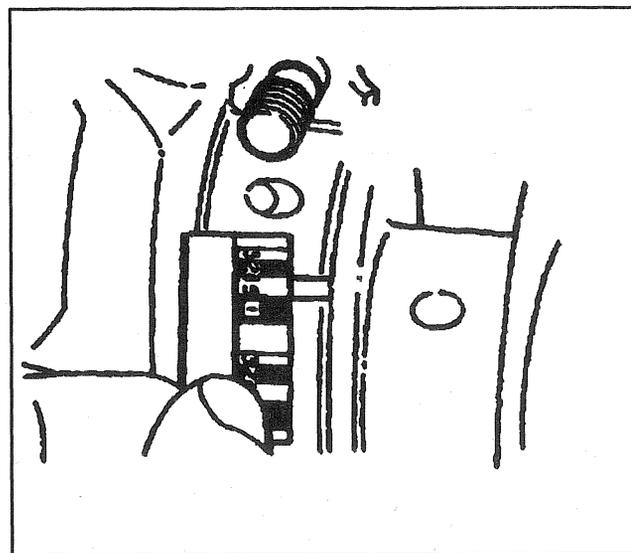
1. Measure clearances using either the micrometer method or the plastic gauging method.
2. In order to measure clearances with the micrometer method, use the following procedure:
3. Install the crankshaft bearings into the crankshaft caps and engine block.
4. Install the crankshaft caps and bolts. Refer to *Engine Mechanical Specifications*.
5. Measure the bearing inside diameter (I.D.) using an inside micrometer.

6. Measure the inside diameter with and inside micrometer. Place the micrometer at 90 degrees to the split line of the crankshaft bearing.
7. Subtract the journal diameter from the bearing inside diameter in order to obtain the bearing clearance.
8. Clearances for crankshaft bearing numbers one, two, three, and four are 0.045–0.083 mm (0.0018–0.0033 in).
9. Clearances for crankshaft bearing number five are 0.055–0.093 mm (0.0022–0.0037 in).
10. If bearing clearances exceeds specifications, install new crankshaft bearings.
11. In order to measure clearances with the plastic gauging method, use the following procedure:
12. Install all lower crankshaft bearings and the crankshaft into the block.
13. Place the gauging plastic across each crankshaft journal.
14. Install all upper crankshaft bearings and bearing caps into the block. Torque all bolts. Refer to *Engine Mechanical Specifications*. The gauging plastic may adhere to either the crankshaft bearing or the crankshaft journal.
15. Carefully remove all bearing caps and the upper crankshaft bearings.



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16. Without removing the gauging plastic, measure the gauging plastic compressed width at the widest point. Use the graduated scale on the edge of the gauging plastic envelope .
17. Clearances for crankshaft bearing numbers one, two, three, and four are 0.045–0.083 mm (0.0018–0.0033 in).
18. Clearances for crankshaft bearing number five are 0.055–0.093 mm (0.0022–0.0037 in).
19. If the flattened gauging plastic tapers toward the middle or ends, there is a difference in clearance indicating taper, out-of-round, low spot, or other irregularity of the bearing or journal. Replace the crankshaft if the journal taper or out-of-round exceeds 0.025 mm (0.001 in).
20. If the bearing clearance is not within specifications, replace the bearing. Always replace both upper and lower bearing inserts as a set.
21. If a bearing is being fitted to an out-of-round journal, be sure to fit to the maximum diameter of the journal. If the bearing is fitted to the minimum diameter, interference between the bearing and the journal will result in rapid bearing failure.



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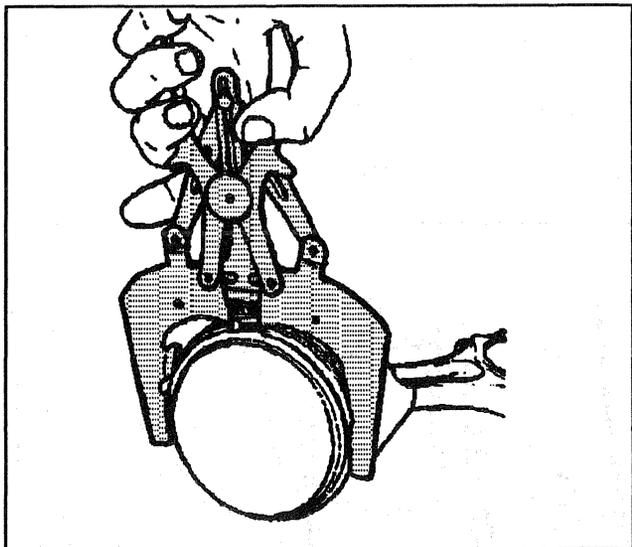
- 22. A standard or undersize bearing combination may result in the proper clearance. If the proper bearing clearance cannot be achieved using standard or undersize bearings, replace the crankshaft.
- 23. Remove the flattened gauging plastic.

Piston and Connecting Rod Disassemble

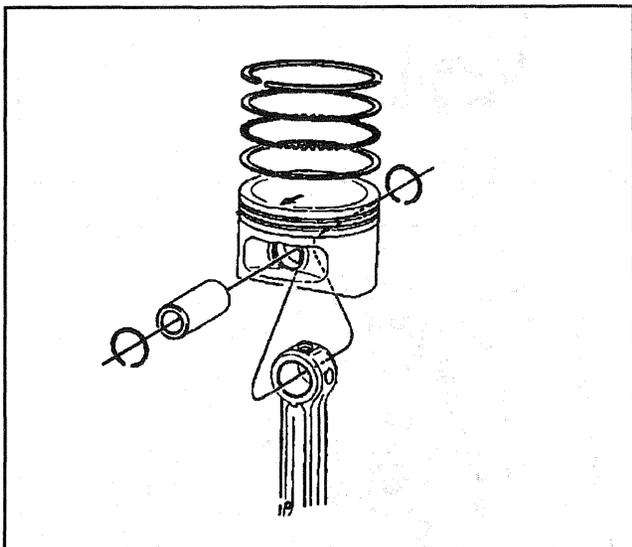
Production standard 6.5L pistons are available in one grade size, identified by a J (naturally aspirated) or JT (turbocharged) ink or metal stamped on the top or bottom of the piston. Also available is a production oversize piston grade sizes for in-plant rework. Identified by an S (naturally aspirated) or ST (turbocharged) ink or metal stamped on the top or bottom of the piston.

Mark the piston according to its cylinder position during removal. This is to ensure installation of the piston in its original cylinder during assembly. This step is necessary when removing the pistons from the connecting rods.

- 1. Remove the piston rings. Discard rings if worn or damaged.
- 2. Remove the connecting rod bearings. If the bearings are to be reused, place them in a rack so that they may be reinstalled with the original connecting rod and cap.
- 3. Pry out the pin retainer with a small screwdriver or a scribe with a rounded end.
- 4. Remove the piston pin. The pin is a full-floating style and should slide from the piston.
- 5. Remove the piston from the connecting rod.



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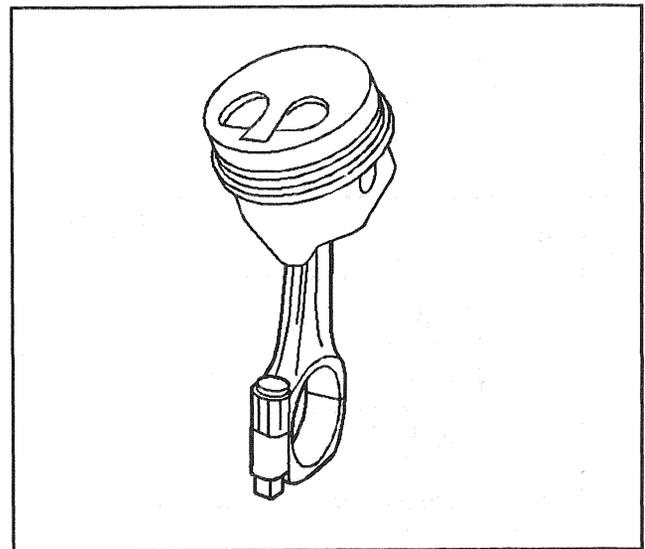
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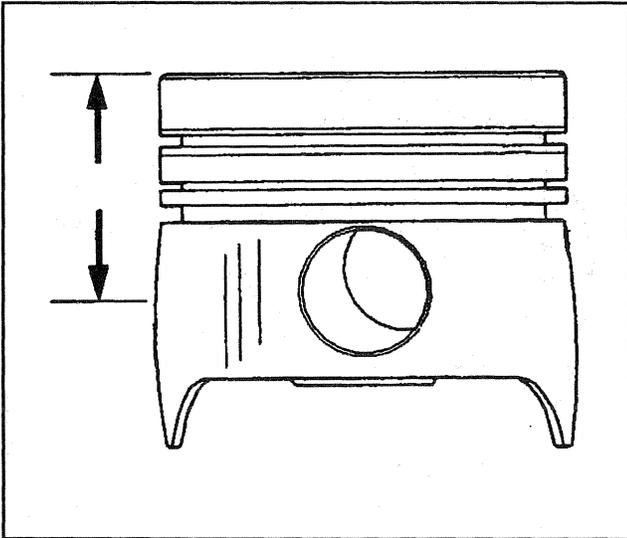
Piston and Connecting Rod Clean and Inspect

Piston Inspection

Important:

- Do not use a wire brush or glass bead blasting.
 - Use a cleaning solution that will dissolve the carbon deposits.
 - Remove the carbon in the ring grooves with a ring groove cleaner.
1. Clean the piston, by removing all of the varnish and the carbon deposits.
 2. Inspect the piston for the following conditions:
 - Cracking or wear of the ring lands
 - Burrs or nicks of the ring grooves
 - Cracking of the skirts or pin bosses
 - Cracking of the piston dome (Use Magnaflux Spot-check dye method or the equivalent.)
 - Scuffing or deep scratches of the piston skirt
 - Scuffing of the piston bore
 - Wear of the piston pin retaining ring or the grooves
 3. Inspect the connecting rod for the following conditions:
 - Cracks or nicks on the connecting rod (Use Magnaflux Spot-check dye method or the equivalent.)
 - Scuffing or scratching of the piston pin bushing
 - Nicks or scoring of the bearing bore
 - Bent or twisted rods
 4. The connecting rod is not serviceable for the following repairs:
 - Straightening
 - Bushing replacement
 - Connecting rod bearing bore enlargement





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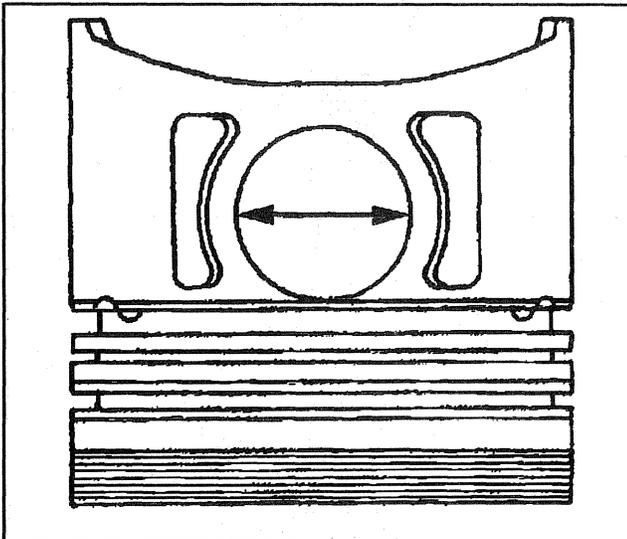
Piston Measurement

The piston skirts are barrel-shaped so the piston diameter must be measured at a specific gauge point.

1. The piston gauge is 65.33 mm (2.575 in) from the top of the piston.
2. Refer to *Piston and Connecting Rod Clean and Inspect* Piston and Connecting Rod Clean and Inspect (Pin to Piston Clearance) for procedures on how to measure pistons.

Measuring Piston Pin To Piston Pin Bushing

1. Clean the piston pin and bushing. The parts must be free of oil and dirt. Refer to *Piston and Connecting Rod Clean and Inspect* Piston and Connecting Rod Clean and Inspect (Pin to Piston Clearance) in order to measure piston pin to piston clearance.
2. Measure the piston pin to bushing following these steps:
 - Measure the piston pin diameter.
 - Measure the piston pin bushing inside diameter. Use an inside micrometer.
 - Subtract the piston pin diameter from the piston pin bushing inside diameter. If the clearance is excessive, try a new piston pin. If the clearance is excessive with a new piston pin, the connecting rod must be replaced. Replacement bushings are not available. Piston pins are available only with new pistons.



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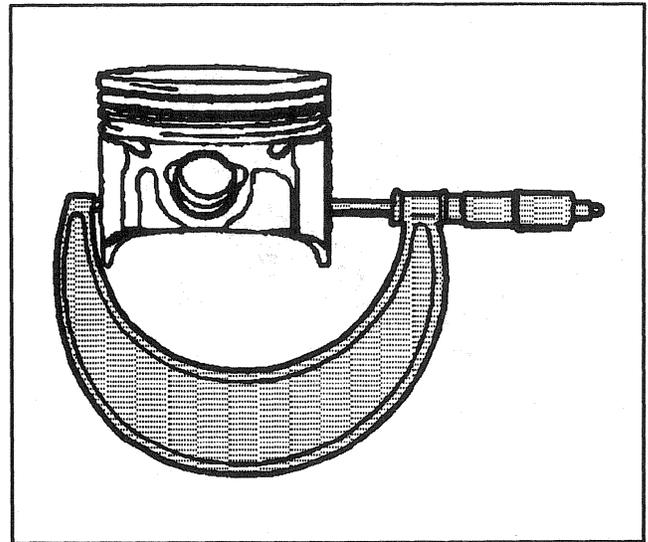
Measuring Piston Pin To Piston Clearance

1. Measure the piston pin diameter.
2. Measure the piston pin to piston clearance.
 - Measure the piston pin hole diameter.
 - Subtract the piston pin diameter from the piston pin hole diameter to obtain the clearance.
 - Replace the piston and piston pin if the clearance exceeds specifications. The piston and the piston pin are a matched set and not available separately.

Piston Selection

To determine the piston to cylinder bore clearance perform the following measurements:

1. Measure the cylinder bore. If the bore is serviceable, note the lowest bore diameter measurement. Then compare this measurement to the piston measurement.
2. Measure the piston. Compare the piston measurement to the piston-to-cylinder-bore specifications found at the end of this section. Subtract the piston diameter from the lowest bore diameter to determine piston-to-bore-clearance.
3. If the used piston is not acceptable, determine if a new piston will fit the cylinder bore using the above measurement procedures.



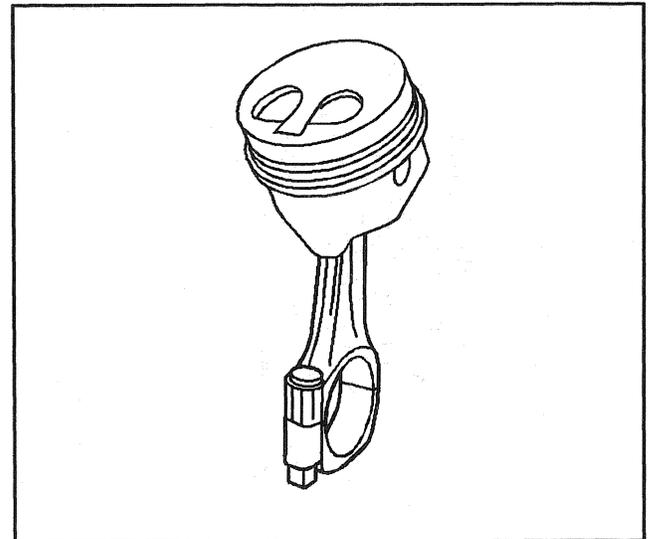
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Piston and Connecting Rod Assemble

Tools Required

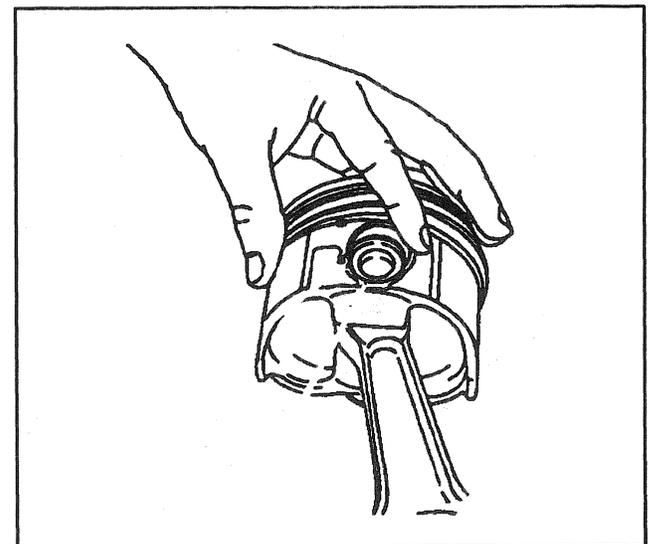
J 39507 Piston Retaining Ring Installer

1. Install the piston to the connecting rod.
 - Install the piston with the piston crown indent on the same side as the connecting rod bearing tang slots.
 - When installing the piston in the cylinder, the piston crown indent on the top of the piston must be towards the outside of the cylinder.

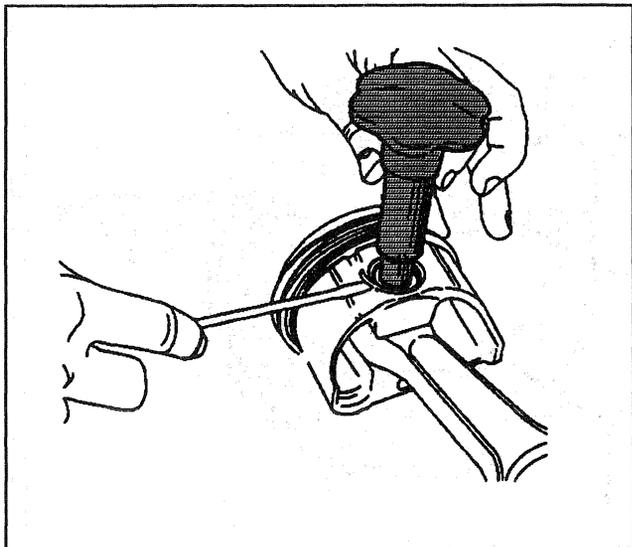


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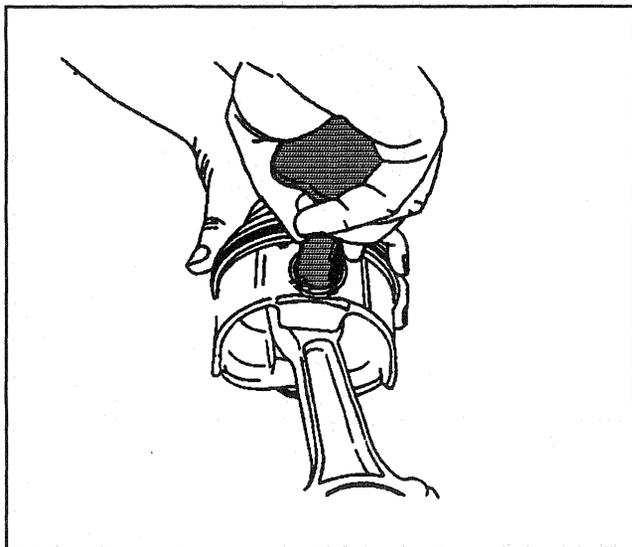
2. Install the piston pin by applying engine oil to the pin and pushing it into place.
3. Install the retaining rings, using the *J 39507*.
4. Align the open end of the retaining ring toward the bottom of the piston.



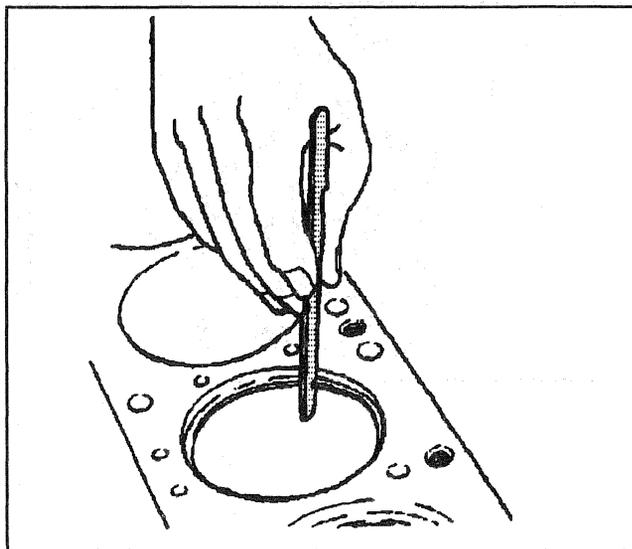
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5. Use a small screwdriver and start one end of the ring in the groove.
6. Install the *J 39507* through the ring and into the piston pin.

7. Press down on the ring with the pin on the tool.
8. Turn the tool-to-seat ring in the groove.
9. Inspect the retaining rings for proper assembly.
 - Visually inspect the retaining ring in order to ensure that it is seated in the ring groove.
 - The opening in an installed retaining ring should face downward, toward the crankshaft.

10. Measure the piston ring end gap.
11. Measure all rings in their respective cylinders.

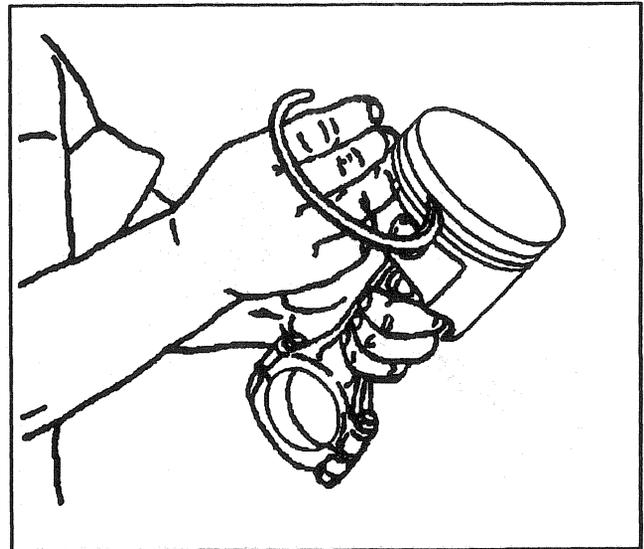
12. Measure for ring clearance, using a feeler gauge.
13. Inspect the ring fit using the following procedure:
 - 13.1. Fit each second compression ring to the piston on which it is going to be used.
 - 13.2. Slip the outer surface of the second compression ring into the respective piston ring groove in order to make sure the ring does not bind. If the ring groove causes binding, dress the groove with a fine cut file. Replace distorted rings.
14. The oil ring is a two-piece ring, consisting of an expander and a scraper ring.
 - 14.1. Install the oil expansion ring in the oil ring groove.
 - 14.2. Install the oil ring over the oil expansion ring.

Important:

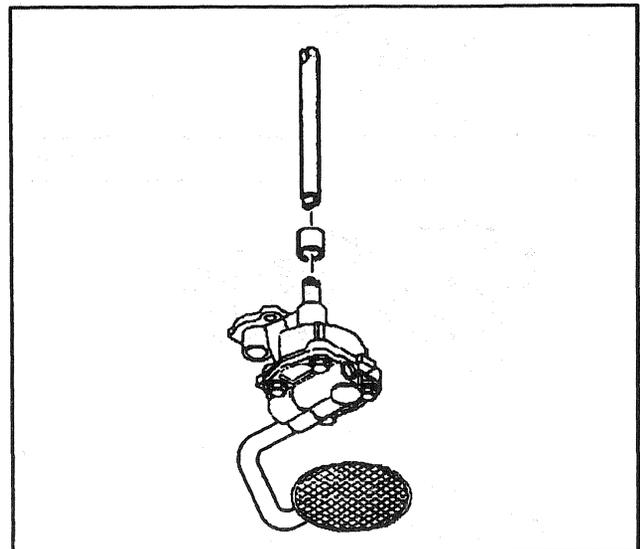
- When installing the compression rings, ensure that the marked side is facing the top of the piston.
 - The top compression ring is a keystone style ring.
 - While assembling the rings onto the piston, rotate the rings to check for binding.
 - If binding occurs, inspect the ring grooves for dirt or damage, such as nicks caused by improper installation.
15. Install the second compression ring.
 16. Install the top compression ring.

Oil Pump Disassemble

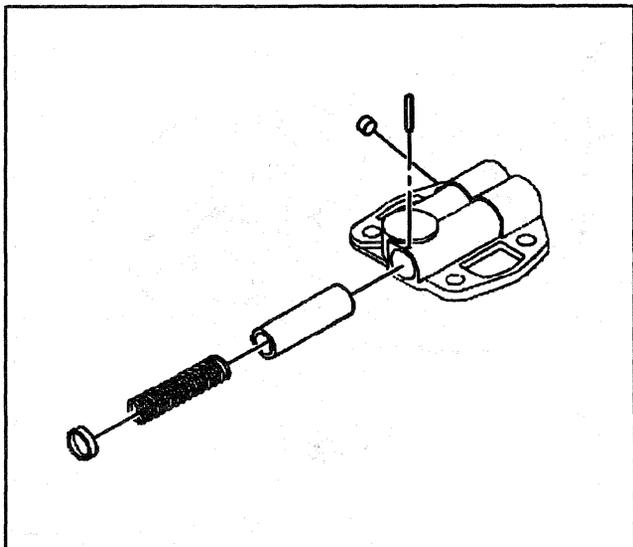
1. Remove the oil pump drive shaft retainer.
2. Remove the oil pump drive shaft.



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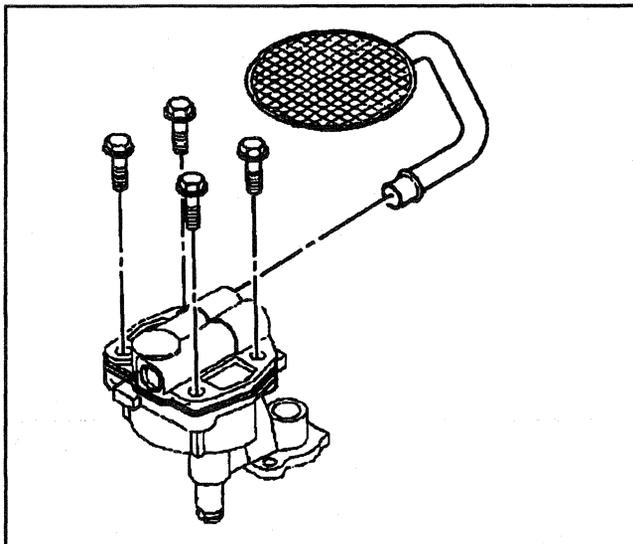


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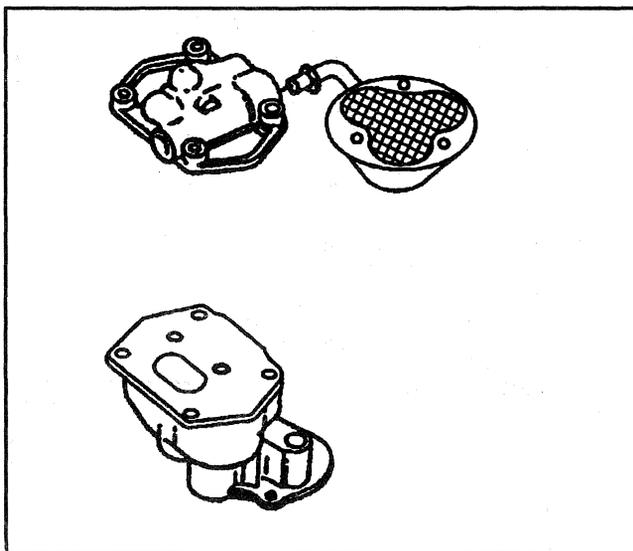
3. Remove the roll pin.
4. Remove the pressure regulator valve.
5. Remove the spring.



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Important: If the pick-up tube and screen is not damaged, do not remove it. A new pick-up tube and screen assembly will be required for reassemble. The tube is press-fit into the cover and is hard to remove without damaging it.

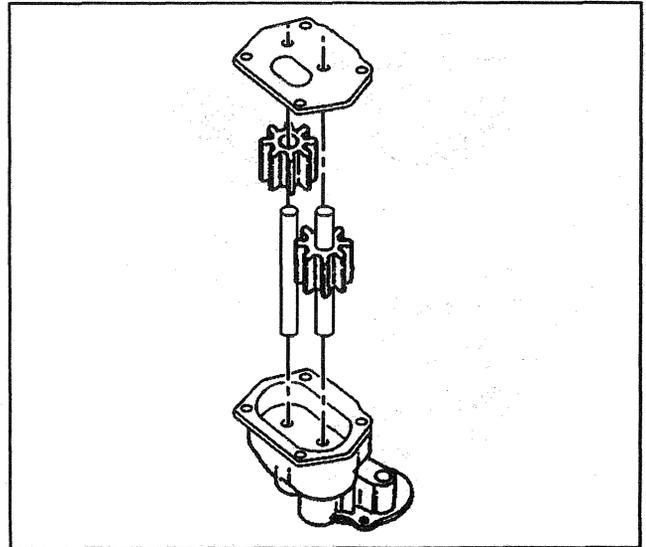
6. Remove the pick-up tube and screen assembly if necessary.
7. Remove the oil pump cover bolts.



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8. Remove the oil pump cover.
9. Remove the spacer plate.

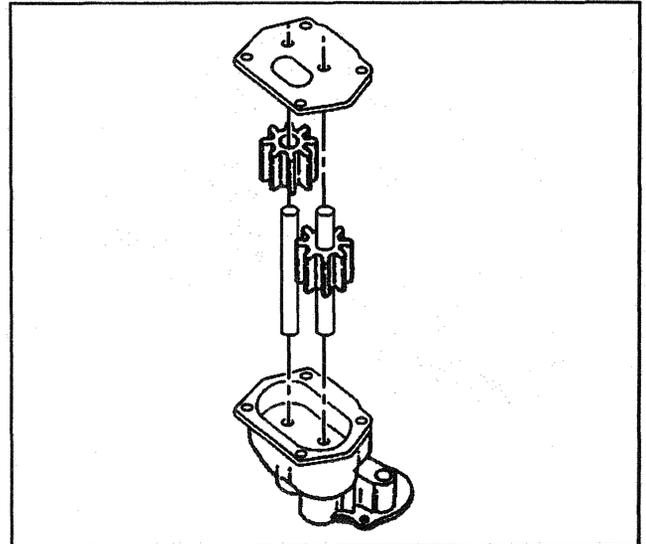
10. Mark the gear teeth in order to install the pump gears with the same gear teeth index.
11. Remove the drive gear.
12. Remove the shaft.
13. Remove the driven gear.
14. Remove the idler shaft.



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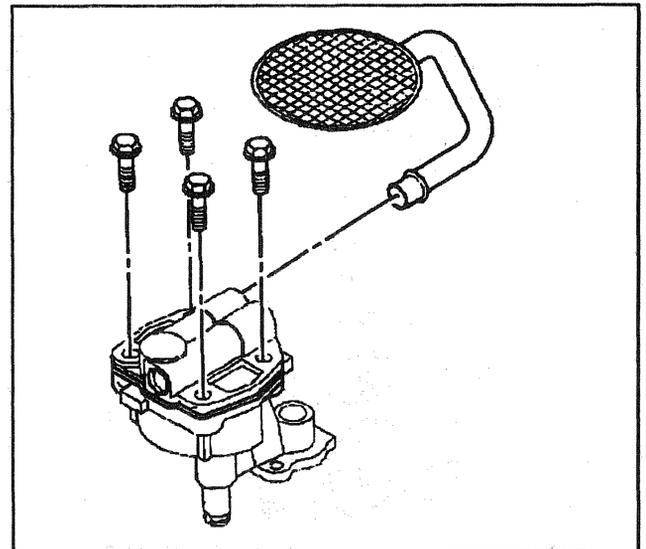
Oil Pump Assemble

1. Install the driven gear.
2. Install the idler shaft.
3. Install the drive gear with the shaft. Align the marks made during disassembly.
4. Install the spacer plate.

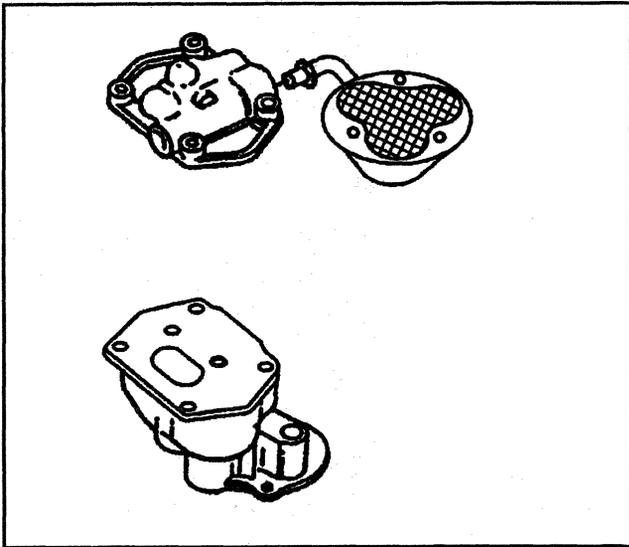


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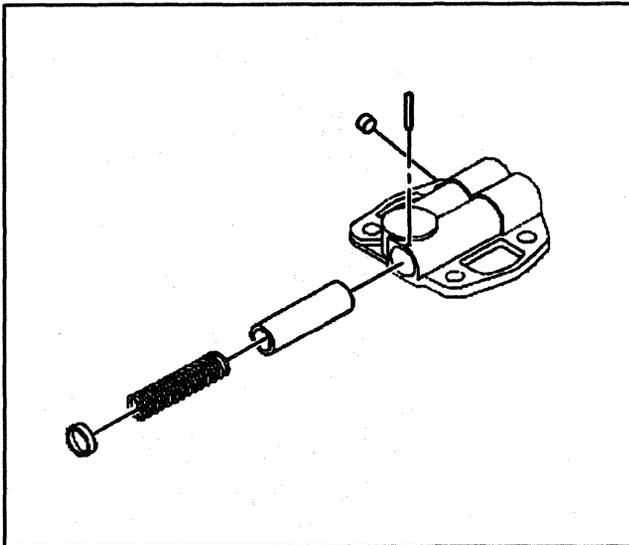
5. Install the oil pump cover.



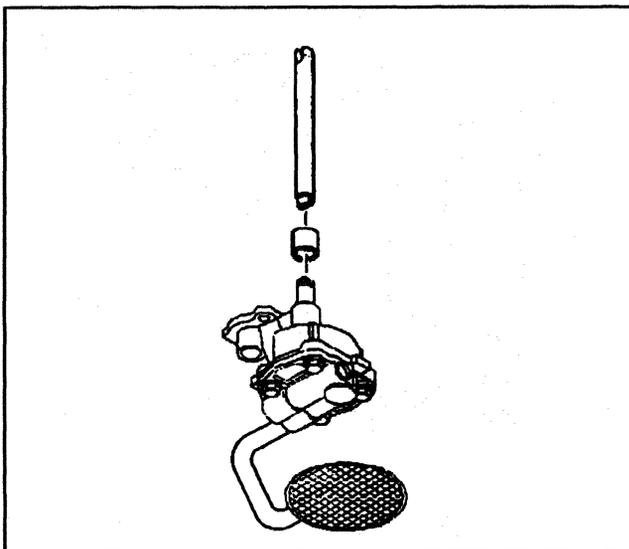
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6. Install the oil pump cover screws.

Tighten

Tighten the bolts to 16 N·m (12 lb ft).

Refer to *Fastener Notice* in General Information.

7. Install the pressure regulator valve.

8. Install the spring.

9. Install the roll pin.

10. Install the pick-up tube and screen assembly if necessary. Align the tube in the same location as removed from.

11. Prime the oil pump by filling the cavity with clean engine oil.

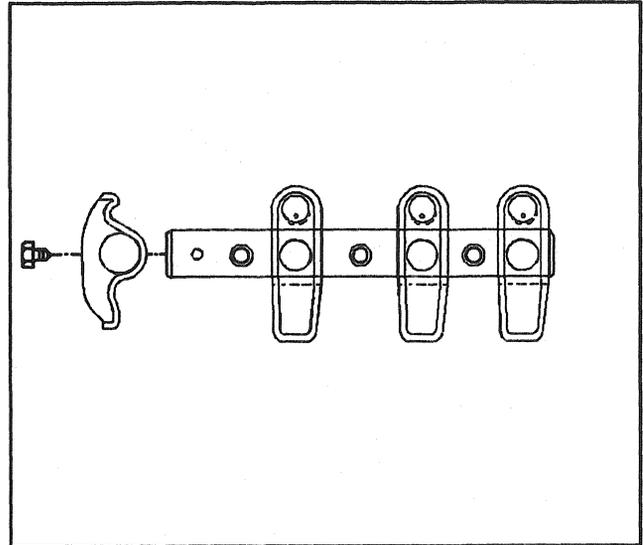
12. Inspect the oil pump.

- Turn the drive shaft by hand and check for smooth rotation.
- If the oil pump does not rotate smoothly, check for proper assembly.
- If necessary replace the oil pump assembly.

Valve Train Components Disassemble

Important: Store all reusable components in an exact order in order to return them to the original locations during assembly.

1. Remove the valve rocker arm retainers.
 - 1.1. Insert a screwdriver into the valve rocker arm shaft bore and break off the end of the retainers.
 - 1.2. Pull the valve rocker arm retainers out with pliers.
2. Remove the valve rocker arms from the valve rocker arm shaft.
3. Mark the valve rocker arms and return the valve rocker arms to the original location during assembly.

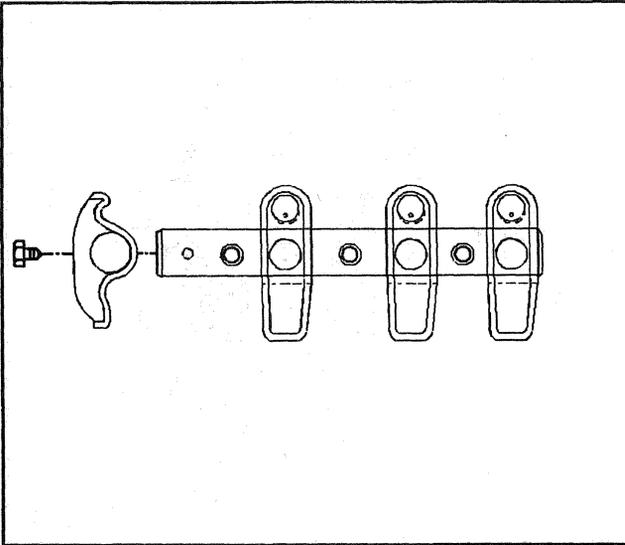


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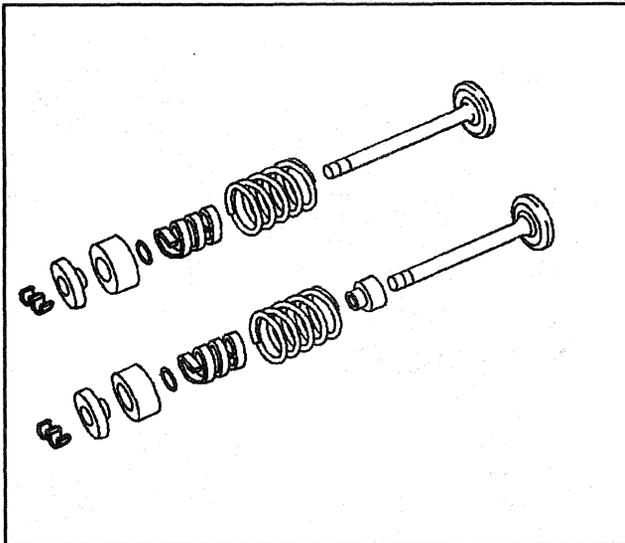
Valve Train Components Clean and Inspect

1. Clean the parts in solvent.
 - Wear protective safety glasses and gloves.
 - Blow-dry the parts with compressed air.
 - Make sure the oil passages in the valve pushrods are clear.
2. Inspect the valve rocker arms and shafts at the mating surfaces, in order to ensure that they are smooth and without scoring damage.
3. Inspect the valve rocker arm areas which contact the valve stems and the sockets which contact the valve pushrods. These areas should be smooth and without damage or wear.
4. Determine if the valve pushrods are bent by rolling the pushrod on a flat surface.
5. Replace the pushrod if the pushrod is bent.
6. Inspect the ends of the valve pushrods for scoring or roughness.
7. Inspect the valve lifter guide plates and clamps for damage.
8. Replace any damaged parts.

Important: Some engines may have both standard and 0.010 inch oversize valve lifters. The oversize lifter will have a 10 etched on the side. Stamped on the cast pad next to the lifter bore and on the top rail of the cylinder case above the lifter bore will be the letters OS.
9. Inspect the valve lifter rollers for fatigue or pitting. Replace the valve lifter as an assembly.



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Valve Train Components Assemble

Important: Lubricate the valve rocker arms with engine oil before installing.

Install valve rocker arms to their original locations.

1. Install the valve rocker arms to the valve rocker arm shaft.
2. Install new valve rocker arm retainers using the following procedure:
 - 2.1. Center the valve rocker arms on the corresponding holes in the valve rocker arm shaft.
 - 2.2. Install the retainers with a drift of at least 13 mm (1/2 in) diameter.

Cylinder Head Disassemble

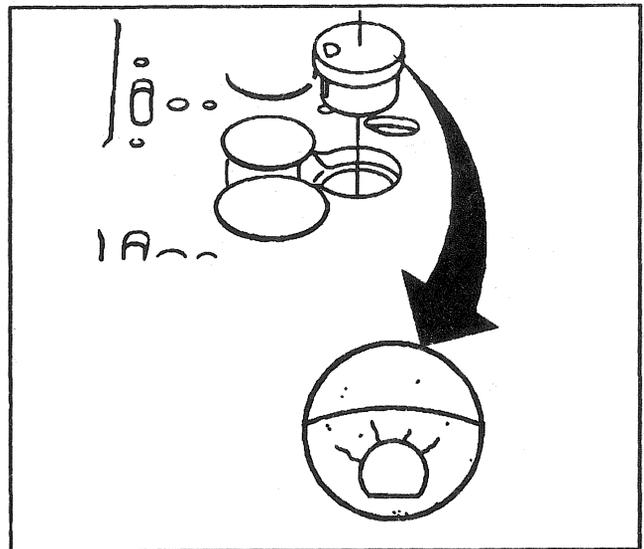
Tools Required

J 8062 Valve Spring Compressor

This engine uses a 39 mm (1.53 in) stellite faced exhaust valve and an intake valve that is 46 mm (1.81 in). Intake and exhaust valves with oversize stems are available in 0.09 mm (0.03 in) and 0.39 mm (0.153 in) oversize.

1. Remove the valve keys using the following procedure:
 - 1.1. Compress the valve springs with the *J 8062*.
 - 1.2. Remove the valve keys.
 - 1.3. Remove the *J 8062*.
2. Remove the following components:
 - The caps from the intake valves
 - The rotators from the exhaust valves
 - The shields
 - The o-rings
 - The valve springs with the dampers and the shims
3. Remove the exhaust valve seals.
4. Remove the valves.
5. Place the valves in a rack and return the valves to the original positions during assembly.

6. Drive out the prechambers with a small nylon or brass drift inserted through the injection nozzle hole. The prechambers use high temperature super alloy materials. Replace the prechambers with the correct part number for this series of engine.

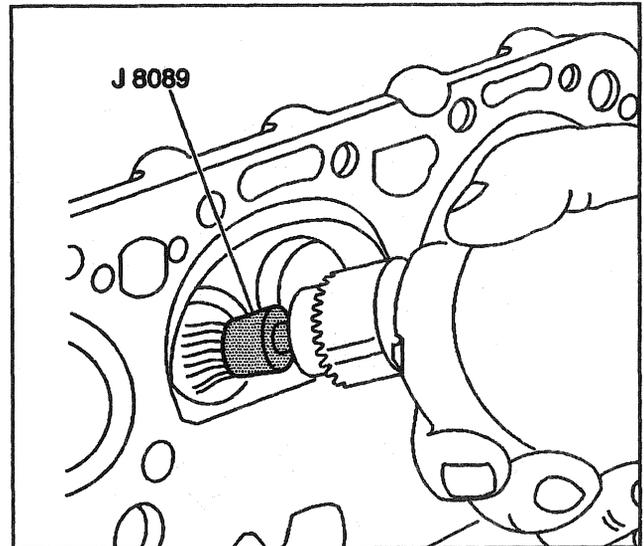


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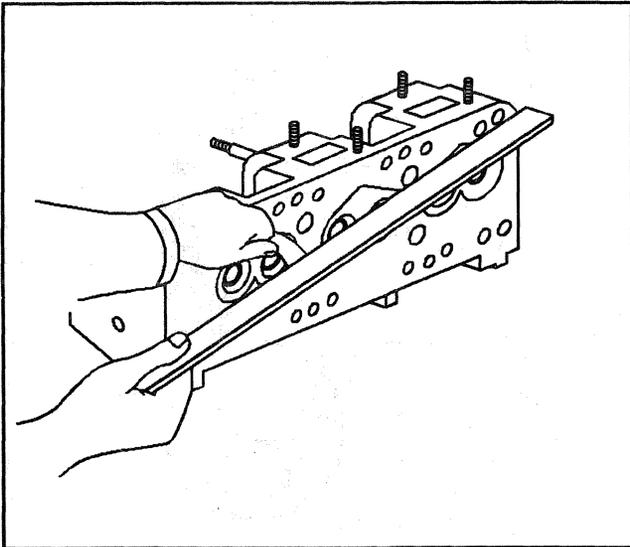
Cylinder Head Clean and Inspect

Tools Required

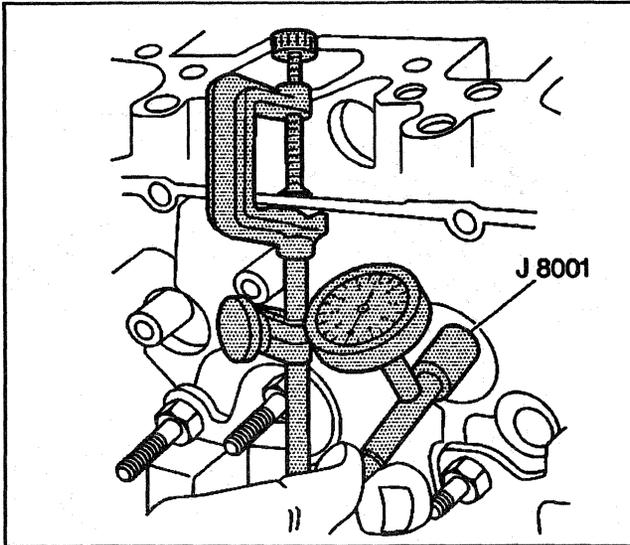
- J 7872 Magnetic Base Dial Indicator
 - J 8089 Wire Brush
 - J 9666 Valve Spring Tester
1. Clean the carbon from the combustion chambers, using the J 8089.
 2. Clean the valve stems and heads on a wire wheel.
 3. Clean the carbon and old gasket from the cylinder head gasket surface.
 4. Clean the valve guides using a valve guide cleaner.
 5. Inspect the cylinder head for the following conditions:
 - Cracks in the exhaust ports
 - Cracks in the combustion chambers
 - External cracks to the coolant chamber
 - Gasket surfaces should be free of damage
 6. Inspect the valves for the following conditions:
 - Burning
 - Pitting
 - Warpage
 7. Grind or replace the valves as needed.
 8. Check the valve stems for scoring or excessive wear. Stems must not be bent.
 9. Inspect the valve seats for pitting or other damage. Grind or reface as needed.
 10. Inspect the exhaust valve rotators. The rotators should rotate smoothly without binding.



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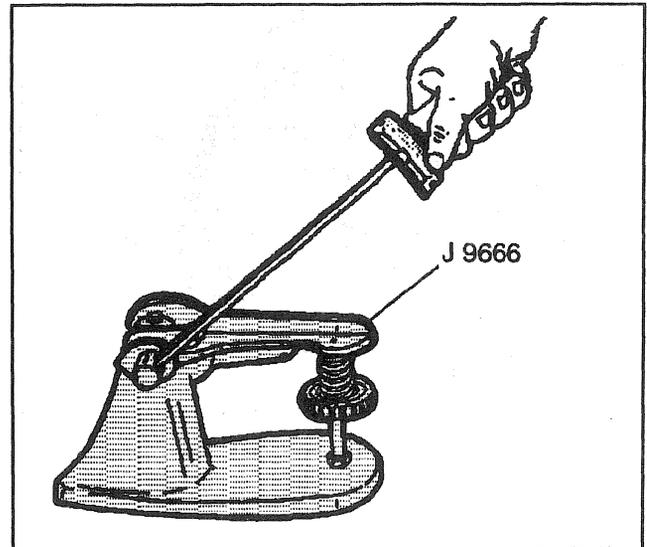
11. Inspect the cylinder head for warpage. When the warpage is greater than 0.15 mm (0.006 in) longitudinally, or 0.08 mm (0.003 in) transversely, replace the cylinder head.
12. Inspect the prechambers for cracks.
 - Replace any prechambers with facial cracks longer than 5 mm (0.20 in).
 - Service prechambers are available in standard and 0.25 mm (0.010 in) oversize.

Notice: Resurfacing the cylinder head is not recommended due to the extremely close valve to piston clearances.
13. Cylinder head thickness (valve rocker arm cover gasket rail to head gasket surface) must be at least 97.87 mm (3.853 in).

Notice: Excessive oil consumption and component damage may result from excessive valve stem to guide bore clearance. Insufficient clearance may cause noisy and sticky functioning of the valve and disturb the smoothness of the engine.

14. Measure the valve stem to guide bore clearance using the following procedure:
 - 14.1. Attach the J 7872 on one side of the cylinder head valve rocker arm cover gasket rail.
 - 14.2. Zero in the dial indicator.
 - 14.3. Observe the dial indicator movement while moving the valve from side to side (crosswise to the head). The dial indicator measurement must be taken just above the valve guide bore.
 - 14.4. Drop the valve head about 1.6 mm (0.063 in) off the valve seat.
 - 14.5. Move the stem of the valve from side to side using light pressure to obtain a clearance reading. If the clearance exceeds specifications, it will be necessary to ream the valve guide bores for oversize valves.

15. Measure the valve spring tension using the following procedure:
 - 15.1. Using the J 9666, compress the valve springs to the specified tension.
 - 15.2. Check the valve spring height. Valve springs should be replaced if not within specification. Refer to *Engine Mechanical Specifications*.
16. The cylinder head bolts were installed with a thread locker. Use a power wire brush to clean the entire head bolt.
17. Replace the head bolt if any of the following conditions exist:
 - Pitting or pulling of the threads
 - Pitting of the shaft
 - Excessive corrosion or stripping of the head



4960

Valve Guide Reaming/Valve and Seat Grinding

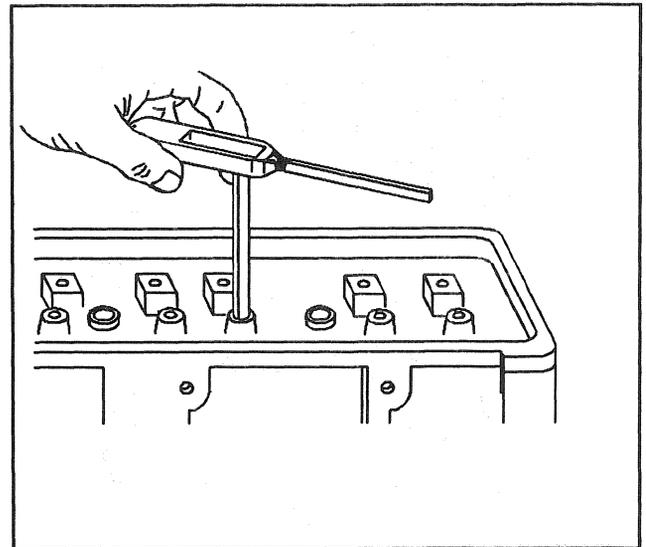
1. Ream the valve guides for oversize valves if the clearance exceeds the specifications.
2. Ream the valve guide bores for the oversize valves as necessary.
3. Reconditioning the valve seats is very important.

Recondition valve seat after reaming the valve guide bores or installing the new valve guides.

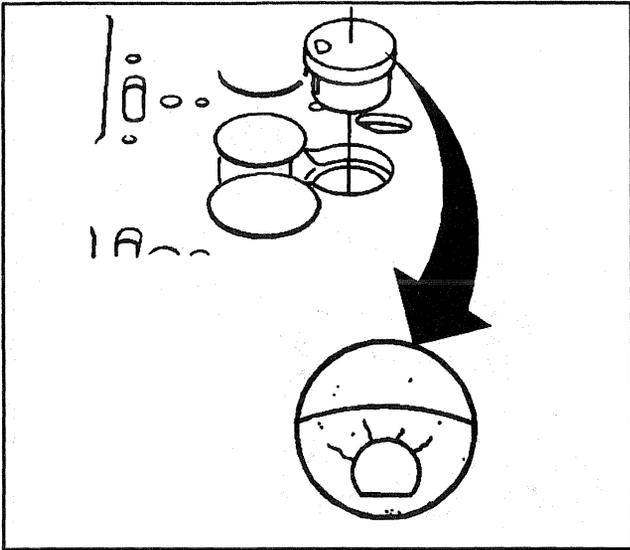
- The valves must seat perfectly for the engine to deliver optimum power and performance.
- Cooling the valve heads is another important factor. Good contact between each valve and its seat in the cylinder head is necessary to ensure that the heat in the valve head is properly carried away.
- Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the guide.

The valve seats should be concentric to within 0.05 mm (0.031 in) total indicator reading.

- Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the head and the stem. Replace the valve if the stem is warped, or if the stem shows signs of excessive wear. Replace the valve if the edge of the head is less than 0.79 mm (0.031 in) thick after grinding.
- Several different types of equipment are available for reconditioning valves and valve seats. Use the manufacturers recommendations of equipment to attain the proper results.



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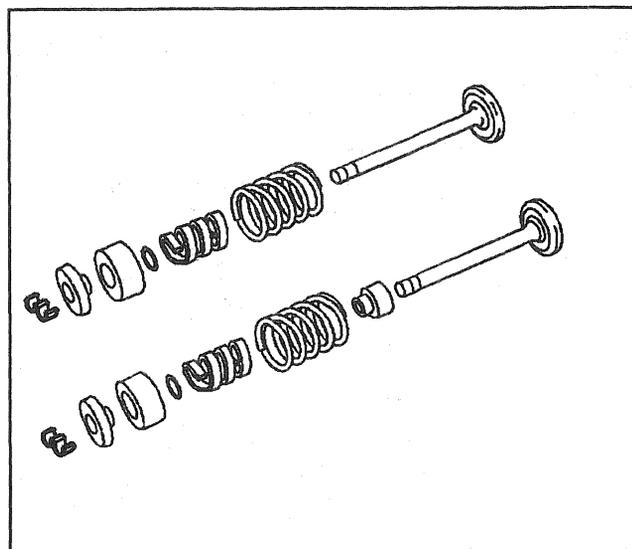


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Cylinder Head Assemble

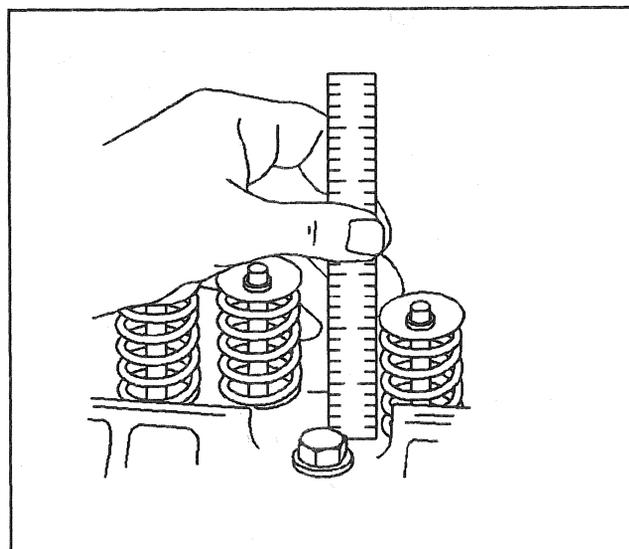
1. Install the prechambers (if removed) using the following procedure:
 - 1.1. Align the locating notches. The prechamber will fit correctly in only one position.
 - 1.2. Tap the prechamber into place. Use a 32 mm (1.25 in) socket.
2. Measure the valve protrusion of each valve using the following procedure: (Valve protrusion is the distance the valve extends past or recesses into the head surface.)
 - 2.1. With the plunger resting on the surface of the cylinder head, set the gauge to zero.
 - 2.2. Move the plunger over each valve and note the reading on the gauge.
 - If the valve is recessed too far, the valve pushrod can bottom out in the lifter and hold the valve open. When the valves are left open, the spring seat tension and compression are lost.
 - Maximum protrusion is negative 0.86 mm (negative 0.034 in) to negative 1.22 mm (negative 0.048 in) for both intake and exhaust valves. The valves are recessed.
3. Measure the prechamber installed depth.
4. The prechamber should be flush to a maximum of 0.05 mm (0.002 in) protrusion.
 - Make the measurement at two or more points on the prechamber where the prechamber seats on the head gasket shield and sealing ring.
 - Measure the difference between the flat of the prechamber and the flat surface of the cylinder head.
 - The prechamber must not protrude out of the cylinder head more than 0.05 mm (0.002 in).
 - Do not recess the prechamber into the cylinder head.

5. Lubricate the valve stems with engine oil.
6. Insert the valves into the proper ports.
7. Install the shims, if required.
8. Install the exhaust valve seals.
 - Install the valve seals over the valve stems.
 - Seat the valve seals against the heads.
9. Install new valve springs with dampers.
10. Install the shields.
11. Install the intake valve caps.
12. Install the exhaust valve rotators.
13. Install the o-ring seals and the valve keys using the following procedure:
 - 13.1. Compress the valve spring using the *J 8062* in order to clearly see the lower valve stem groove.
 - 13.2. Push a new O-ring seal, so that it is flat, on the valve stem's lower groove.
 - 13.3. Apply a small amount of grease to the area of the upper valve stem groove.
 - 13.4. Assemble the two valve keys using the grease to hold the keys in place. Ensure that the keys seat properly in the groove.
 - 13.5. Release the valve spring, ensuring that the key stays in place.
 - 13.6. Repeat this procedure for each of the remaining valves.



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14. Measure the valve spring installed height of each valve spring using the following procedure:
 - 14.1. Using a narrow thin scale, measure the valve installed height from the spring seat in the cylinder head to the top of the valve spring cap. A cutaway scale may be helpful.
 - 14.2. If the measurement exceeds specifications, install valve spring seat shims between the spring and the cylinder head in order to obtain the desired measurement. NEVER shim the spring so as to give an installed height under the specified amount. Refer to *Engine Mechanical Specifications*.
 - 14.3. If the valve spring measurements exceed specifications, inspect for the following conditions:
 - Proper assembly
 - Excessive wear at the valve keys
 - Worn retainers
 - Worn valve key area on the valves



35203

Thermostat and Coolant Crossover Clean and Inspect

1. Inspect the coolant outlet and the coolant crossover for cracks.
2. Check the thermostat using the following procedure:
 - 2.1. Suspend the thermostat and a thermometer in the water with the thermometer located close to the thermostat.
 - 2.2. The thermostat must be completely submerged.
 - 2.3. The coolant must be thoroughly agitated while heating. Do not let the thermostat or the thermometer touch the sides or bottom of the container.
 - 2.4. Apply heat to the coolant.
 - 2.5. Record both the temperature at which the thermostat begins to open and the temperature at which the thermostat is fully open.
 - 2.6. The thermostat should begin to open at 1.6°C (4°F) above the stamped temperature located on the thermostat.
 - 2.7. The thermostat should be fully open at approximately 13°C (24°F) above the stamped temperature located on the thermostat.
 - 2.8. Do not attempt to repair the thermostat.
 - 2.9. If the thermostat does not function properly, replace the thermostat with a new unit that has been checked using this procedure.

Fuel System Components Clean and Inspect

1. Clean the fuel system components with clean solvent.

Notice: Contamination of foreign material in the fuel system can cause poor engine operation and cause severe engine damage.
2. When handling fuel system components, follow these guidelines:
 - Keep all of the openings on the fuel injection pump capped at all times.
 - Do not allow any cleaning solvents to enter the fuel injection pump during cleaning.
 - Keep the injection nozzle openings capped at all times.
 - Clean the exterior of the nozzles only in cleaning solvent. Do not use a wire brush.
 - Blow out the inside of all fuel lines with compressed air after cleaning the fuel lines in solvent. Wear protective safety glasses.

3. Inspect the injection lines for kinks or damaged fittings. Replace any damaged lines.
4. Inspect the entire length of the injection line for wear from rubbing or where holding brackets or retaining clips were located.
5. Inspect the holding brackets for cracking.
6. Inspect the retaining clips and insulators for damage.

Glow Plugs Clean and Inspect

Important: Replace the glow plug if the injector nozzle failed, even if the glow plug checks out as being good.

1. Inspect the glow plugs for stripped threads and visible damage.
2. Replace the glow plugs if the tips are cracked, bulged, or broken.

Intake Manifold Clean and Inspect

1. Remove the MAP sensor from the intake manifold.
2. Remove the IAT sensor from the intake manifold.
3. Clean the old pieces of gasket from the gasket surfaces.
4. Clean the soot deposits from the intake manifold.
5. Inspect the manifold for the following conditions:
 - Cracks
 - Broken flanges
 - Gasket surface damage

Exhaust Manifold Clean and Inspect

1. Clean the sealing surfaces.
2. Clean the soot deposits from the exhaust manifold.
3. Inspect the manifolds for the following conditions:
 - Cracks
 - Broken flanges
 - Sealing surface damage

Oil Pan and Rocker Arm Covers Clean and Inspect

1. Clean the parts in solvent, removing all sludge and varnish.
2. Clean the old sealer from the sealing surfaces.
3. Inspect for the following conditions:
 - Bent or damaged sealing flanges
 - Deterioration of the rubber grommets or parts on the valve rocker arm cover
 - Damage to the oil pan caused by rocks
 - Loose fit of the oil pan baffle
 - Stripped oil pan drain plug opening threads

Water Pump Inspect

Important: The water pump used with the serpentine belt system rotates counterclockwise (CCW). Replace the pump only with the proper part number or engine overheating may occur, causing damage to the engine.

Important:

- Do not immerse the pump in solvent.
 - The solvent will dissolve the permanently lubricated bearings' lubricant supply and cause premature bearing failure.
1. Clean the old gasket off of the gasket surfaces on the water pump and the water pump plate.
 2. Replace the water pump if the following conditions exist:
 - Roughness or excessive end play in the pump shaft; If the pump has been dry for a while it may be difficult to turn the shaft on the first try. If the pump does not turn smoothly after a few attempts, replace the water pump.
 - Coolant leakage at the drain hole
 - Damage to the water pump plate

Fuel Injection Pump Clean and Inspect

Notice: The fuel injection pump is an electronically controlled device. Handle carefully in order to prevent damage to internal and external components.

1. Inspect the fuel injection pump body for damage.
2. Inspect the mounting flange for damage.
3. Inspect the fuel injection pump for evidence of fuel leakage.
4. Inspect the injection line fittings for stripping.
5. Inspect the electrical connectors for damage or corrosion.

Crankshaft Balancer Clean and Inspect

1. Inspect the oil seal contact area on the crankshaft balancer shaft for grooving and roughness. Replace if necessary.
2. Always replace the crankshaft balancer if the crankshaft breaks.

Engine Front Cover Clean and Inspect

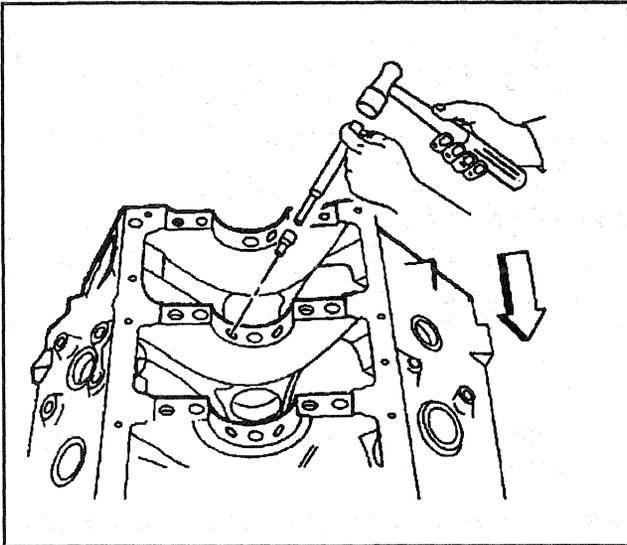
Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

1. Clean the old sealer from the sealing surfaces.
2. Inspect the front cover for cracks and damage to the sealing surfaces.

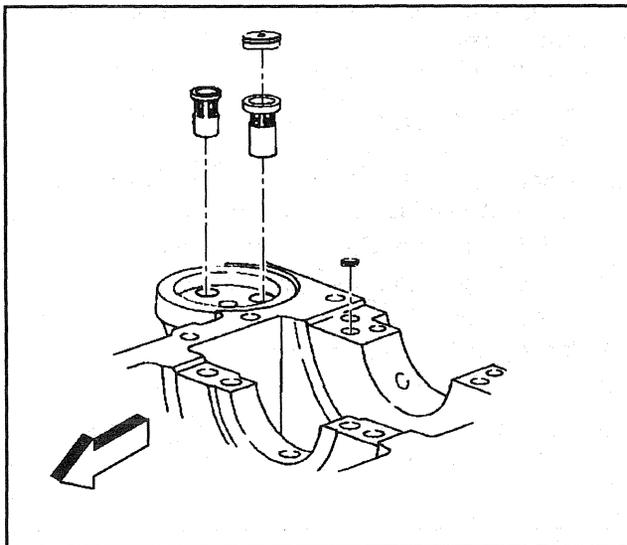
Timing Chain, Sprockets, and Gear Inspect

Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

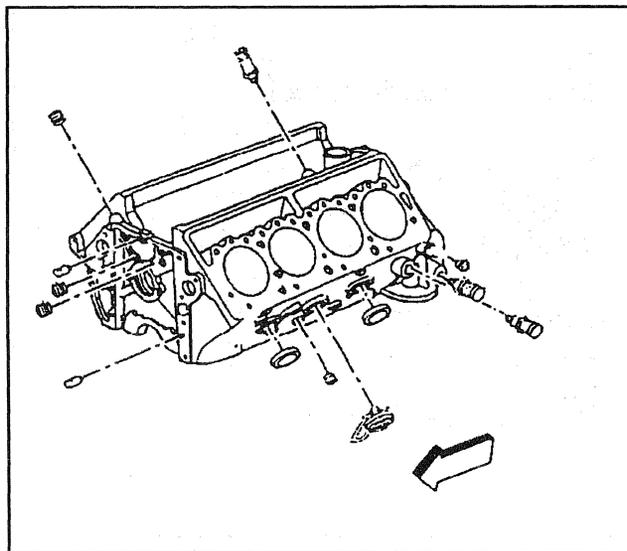
1. Inspect the sprockets for chipped teeth and wear.
2. Inspect the reluctor wheel four square bosses for nicks or dings.
 - Handle the reluctor wheel carefully.
 - Damage to the machined bosses will directly effect engine timing.
3. Inspect the timing chain for damage and wear.
4. Replace worn sprockets and chains.
5. Inspect the timing gears on the fuel injection pump for broken teeth and wear.



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Cylinder Block Assemble

Important: Excessive force can crush the nozzle. Do not damage the nozzle bore. Do not damage the crankshaft bearing bore.

1. Install the piston nozzles.
 - Using a 9/32 inch brass punch drive pin, gently tap the piston nozzles in their bores.
 - Ensure the piston nozzles seat fully.

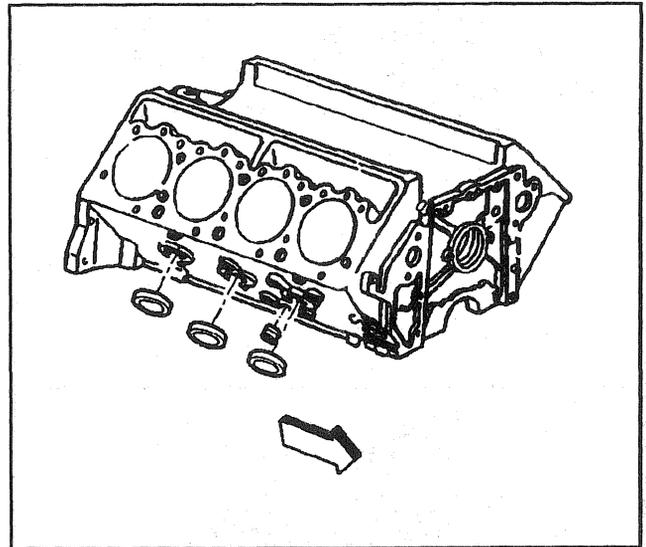
2. Install the oil cooler bypass valve using a socket the same size as the outside diameter of the valve. Drive the valve into the bore until the valve seats on the shoulder in the bore.

Important: The cup plug has an orifice hole that prevents an air lock from occurring and blocking the oil flow.

3. Install the cup plug for the oil cooler bypass valve.
4. Install the oil filter bypass valve using a socket the same size as the outside diameter of the valve. Drive the valve into the bore until the valve seats on the shoulder in the bore.

5. Install the front camshaft oil gallery plugs.
 - Do not use sealer. The pre-applied sealer is reusable.
 - Tighten the plugs until they are completely seated.

6. Install the side oil gallery plugs.



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7. Install the remaining oil gallery plugs. An oil gallery plug is located inside the rear main bearing cap land. On threaded plugs, use GM P/N 12346004 or the equivalent.

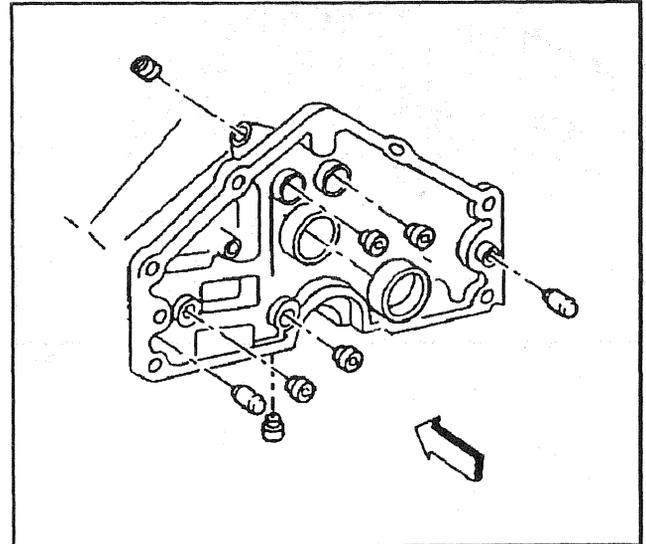
Tighten

Tighten oil gallery plugs to 34 N.m (25 lb ft).
Refer to *Fastener Notice* in General Information.

8. Install the engine oil pressure sensor switch.
9. Install the cup plugs and the block heater. Use GM P/N 12345382 or the equivalent on the cup plugs.
10. Install the coolant drain plugs.

Tighten

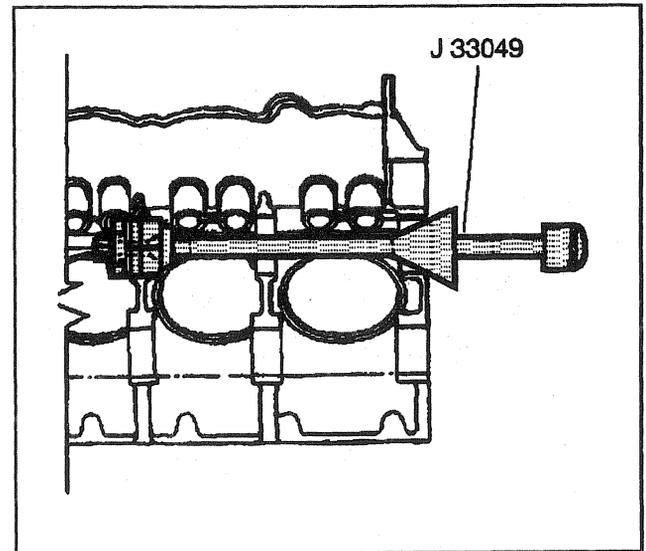
Tighten the coolant drain plugs to 25 N.m (18 lb ft).



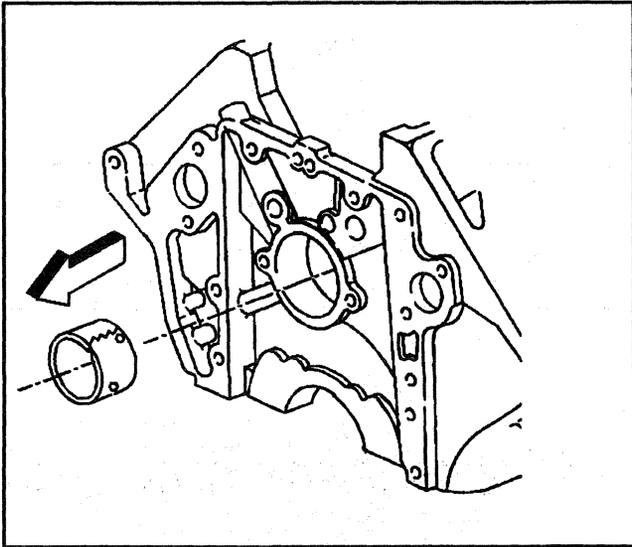
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Important:

- All bearing locations are viewed from the front of the block, with the block in an upright position. The camshaft bearing bores vary in size. On the back of the camshaft bearing is the bore location number from one through five. Be sure to fit the correct camshaft bearing into the correct bore.
- The outer camshaft bearings must be installed first. These bearings serve as guides for the tool.
- The rear camshaft bearing must be installed from the front of the block and the front camshaft bearing must be installed from the rear of the block. This allows the tool to remain centered.
- There is one oil hole in the rear camshaft bearing. Using the seam in the 11 o'clock position as a reference point, the oil hole must be in the 1 o'clock position. Be sure that the oil hole in the camshaft bearing lines up with the oil hole in the block.



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11. Install the rear camshaft bearing using the *J 33049*.
 - 11.1. Insert the driving bar with the correct expanding driver into the camshaft bearing (collet 4 for camshaft bearing one).
 - 11.2. Turn the tool until the collet has tightened in the bearing.
 - 11.3. Push the guide cone against the block and into the fifth bearing bore to center the tool.
 - 11.4. Drive the bearing into the block.

Important: There are two oil holes in the front camshaft bearing. Using the seam in the 12 o'clock position, and the notch facing the front of the block as reference points, one oil hole will be in the 1 o'clock position and the other oil hole will be in the 4:30 position. Be sure that both oil holes in the camshaft bearing line up with the oil holes in the block.

12. Install the front camshaft bearing using the *J 33049*.
 - 12.1. Insert the driving bar with the correct expanding driver into the camshaft bearing (collet 3 for camshaft bearing five).
 - 12.2. Turn the tool until the collet has tightened in the bearing.
 - 12.3. Push the guide cone against the block and into the first bearing bore to center the tool.
 - 12.4. Drive the bearing into the block.

Important: There is one oil hole in the center camshaft bearings. Using the seam in the 11 o'clock position as a reference point, the oil hole must be in the 1 o'clock position. Be sure that the oil hole in the camshaft bearing lines up with the oil hole in the block.

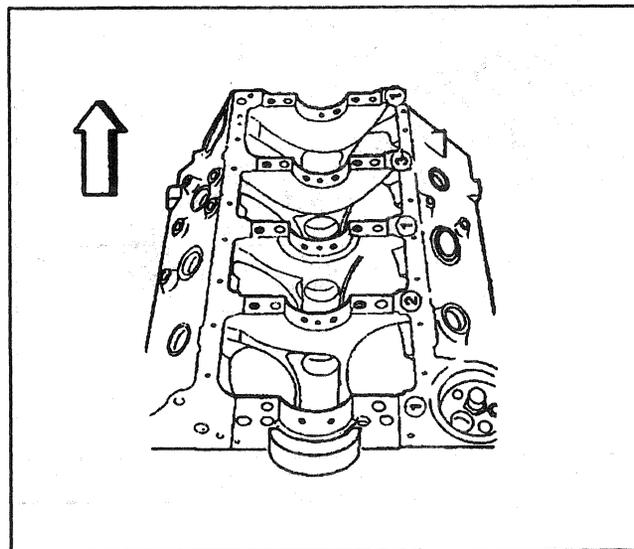
13. Install the inner camshaft bearings using the *J 33049*.
 - 13.1. Insert the driving bar with the correct expanding driver into the camshaft bearing (collet 4 for camshaft bearings two through four).
 - 13.2. Turn the tool until the collet has tightened in the bearing.
 - 13.3. Push the guide cone against the block and into the first bearing bore to center the tool.
 - 13.4. Drive the bearing into the block.
 - 13.5. Repeat this procedure in order to install the remaining camshaft bearings.
14. Install a new rear camshaft plug.
 - 14.1. Use sealer GM P/N 12345382 or equivalent on the camshaft plug.
 - 14.2. Install the plug flush or to a maximum of 0.80 mm (0.03 in) deep.

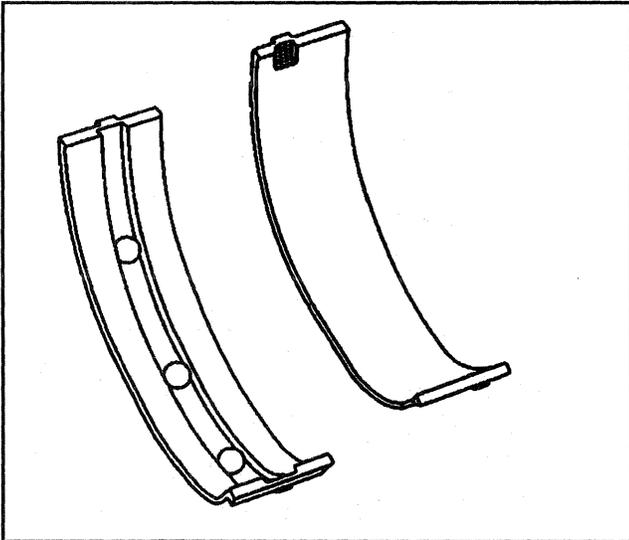
Crankshaft, Bearings, and Bearing Cap Installation

There are five crankshaft bearings, numbered one through five, from the front of the engine. There is an arrow on the bearing cap that points toward the front of the engine. The center, number three bearing is the thrust bearing. The upper bearing halves have an oil groove. The lower bearing halves do not have an oil groove.

During factory assembly, the crankshaft bearings are select-fitted to each of the five crankshaft bearing bores. The proper size code is stamped on the pan rail at the corresponding crankshaft bearing bulk head. The total diameter size range of crankshaft bearing bores one through five is 79.826–79.850 mm (3.145–3.146 in). This range divides into three sizes, represented by the numbers 1, 2 or 3 stamped on the pan rail. The crankshaft is color-marked in red/orange, blue or white, near the crankshaft bearing journal. Cross-referencing the number on the pan rail with the color on the crankshaft indicates the proper bearing selection.

- Crankshaft bearings are available in standard 0.013 mm (0.0005 in) and 0.026 mm (0.0010 in) undersizes for select fitting, in order to attain proper crankshaft bearing clearance.
- Undersize refers to the crankshaft diameter.
- For service purposes, bearing size combinations provide the following clearances:
 - Crankshaft bearing numbers 1, 2, 3 and 4: 0.045–0.083 mm (0.0018–0.0033 in).
 - Crankshaft bearing number 5: 0.055–0.093 mm (0.0022–0.0037 in).

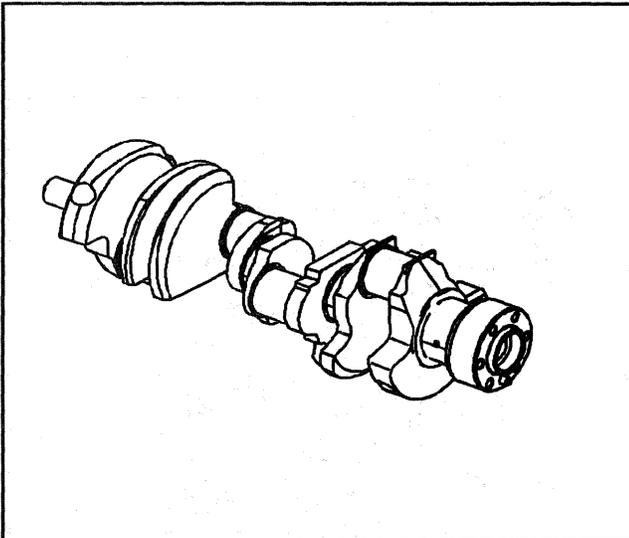




70356

Important: The upper crankshaft bearings must have the holes for the piston oil nozzles.

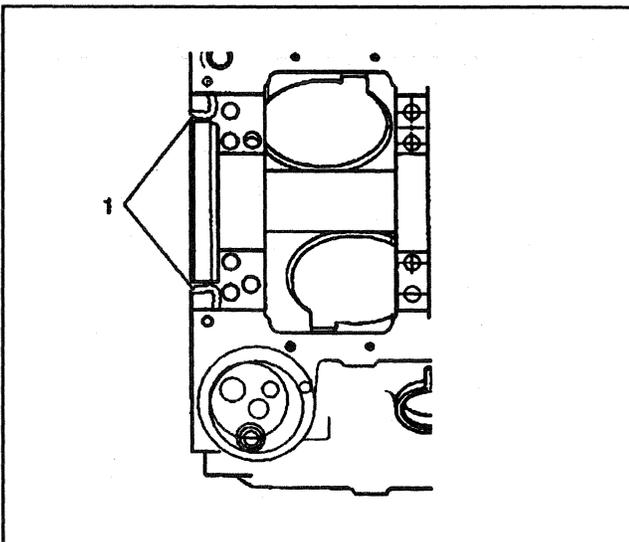
1. Install the upper crankshaft bearing inserts to the block.
2. Install the lower crankshaft bearing inserts to the crankshaft bearing caps.
3. Apply engine oil to the crankshaft bearings.



59918

Notice: The crankshaft bearing caps are to be tapped into place with a brass or leather mallet before the attaching bolts are installed. Do not use the attaching bolts to pull the crankshaft bearing caps into their seats, as this may damage the bearing cap and/or block.

4. Install the crankshaft.



69976

5. Apply a 1/8 inch bead of gasket maker, GM P/N 1052942 or equivalent, on the block, on each side of the rear crankshaft bearing cap area.

6. Apply engine oil to the crankshaft bearing cap bolt threads.
7. Tap the rear crankshaft bearing cap into place with a brass or leather mallet. Then install the bolts. Tighten the bolts in the following sequence:

Tighten

- 7.1. Tighten the inner bolts to 150 N.m (110 lb ft).
- 7.2. Tighten the outer bolts to 135 N.m (100 lb ft).

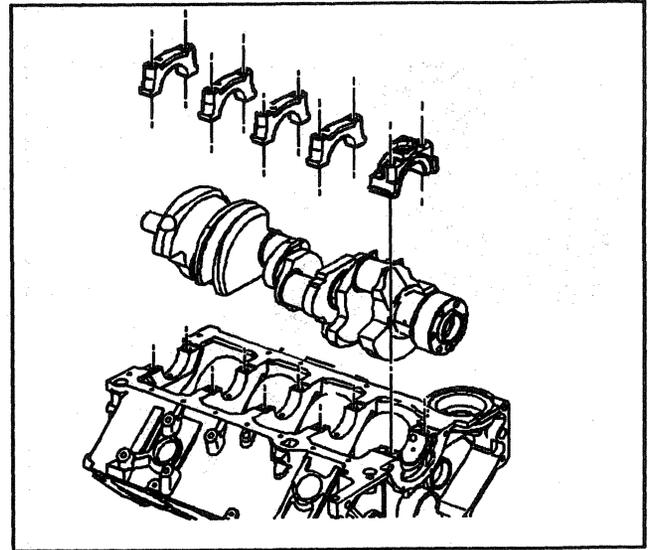
Refer to *Fastener Notice* in General Information.

8. Install the main bearing cap and bearing for numbers 1, 2, and 4.
9. Apply engine oil to the crankshaft bearing cap bolt threads.
10. Tap the crankshaft bearing cap into place with a brass or leather mallet. Then install the bolts. Tighten the bolts in the following sequence:

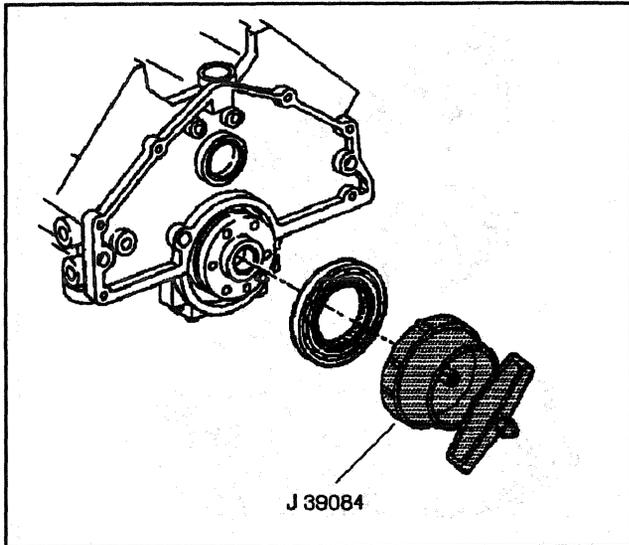
Tighten

- 10.1. Tighten the inner bolts to 150 N.m (110 lb ft).
- 10.2. Tighten the outer bolts to 135 N.m (100 lb ft).
- 10.3. Retighten all the bolts in the same sequence and the above torque.

11. Retighten all the bolts in the same sequence and the above torque.
12. Install the main bearing cap and the bearing for number three, the thrust bearing.
13. Apply engine oil to the crankshaft bearing cap bolt threads.
14. Tap the crankshaft bearing cap into place with a brass or leather mallet. Then install the bolts.
15. Tighten the bolts temporarily to 14 N.m (10 lb ft).
16. Measure the crankshaft end play in the following ways:
 - Tap the end of the crankshaft first rearward then forward with a lead hammer. This will line up the crankshaft bearing and the crankshaft thrust surfaces.
 - Tighten the center crankshaft bearing cap bolts to the same torque specifications and sequence as the other bearing crankshaft caps.
 - With the crankshaft forced forward, measure at the front end of the number three crankshaft bearing with a feeler gauge. The proper clearance is 0.10–0.25 mm (0.004–0.0010 in).
17. Inspect the crankshaft for binding.
18. Try turning the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the crankshaft bearing cap bolts, one pair at a time, until the tight bearing is located.
19. Burrs on the bearing cap, foreign matter between the insert and the block or the bearing cap, or a faulty insert could cause a lack of clearance at the bearing.



59912



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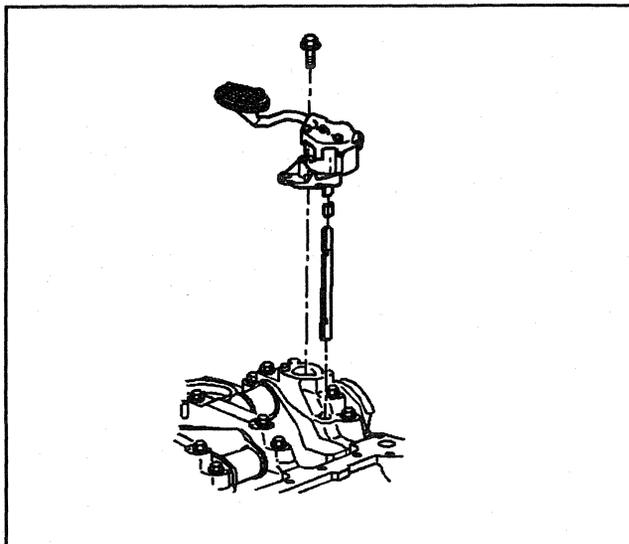
Rear Crankshaft Oil Seal Installation

Tools Required

J 39084 Rear Crankshaft Oil Seal Installer

Important:

- Coat the crankshaft surface with engine oil.
 - Lightly coat the lip of the new oil seal with engine oil or grease before installing the new oil seal.
 - Do not scratch or nick the sealing edge of the oil seal.
1. Install the oil seal, with the spring cavity facing the engine, onto the crankshaft.
 2. Using the J 39084, drive the seal into the crankshaft until the tool bottoms against the block and the rear crankshaft bearing cap.



59893

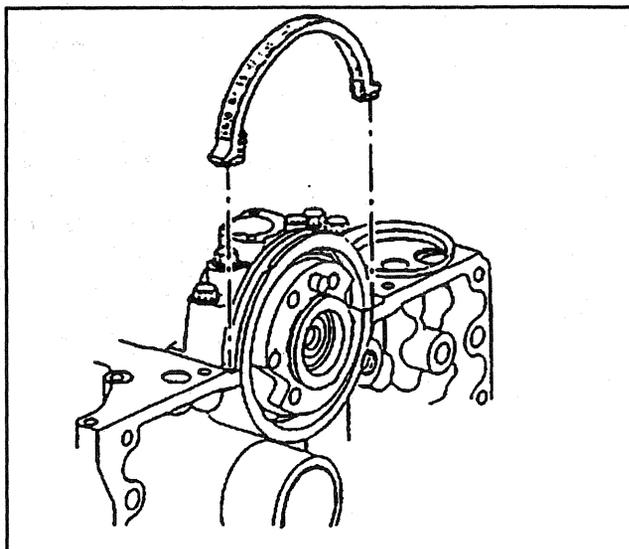
Oil Pump Installation

1. Install the oil pump with the driveshaft.
2. Install the oil pump bolts.

Tighten

Tighten the oil pump bolts to 90 N.m (65 lb ft).

Refer to *Fastener Notice* in General Information.



66587

Oil Pan Installation

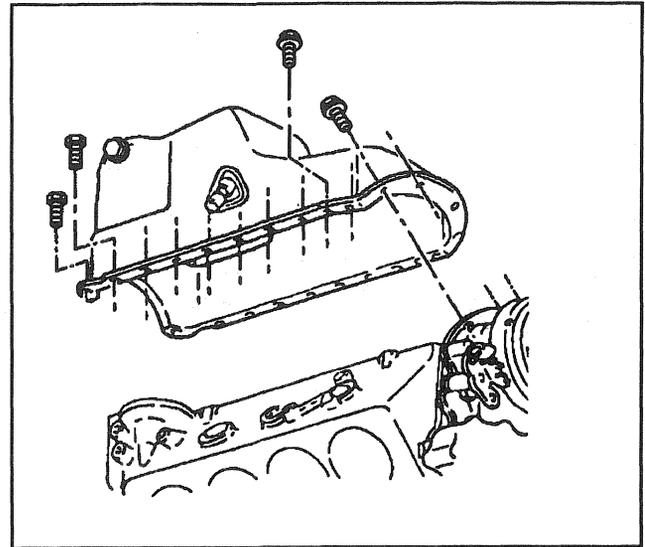
1. Apply a 2 mm (1/16 in) bead of RTV sealant GM P/N 12345739 to the oil pan rear seal at the inside corners where the seal meets the rear main bearing cap on the block.
2. Install the oil pan rear seal to the rear main bearing cap before the sealer starts to dry.
3. Apply a 5 mm (3/16 in) bead of RTV sealant GM P/N 12345739 to the oil pan sealing surface, inboard of the bolt holes. Install the pan before the sealer starts to dry.

4. Install the oil pan to the engine.
5. Install the oil pan bolts.

Tighten

- Tighten all except the rear two bolts to 10 N·m (89 lb in).
- Tighten the rear two bolts to 23 N·m (17 lb ft).

Refer to *Fastener Notice* in General Information.

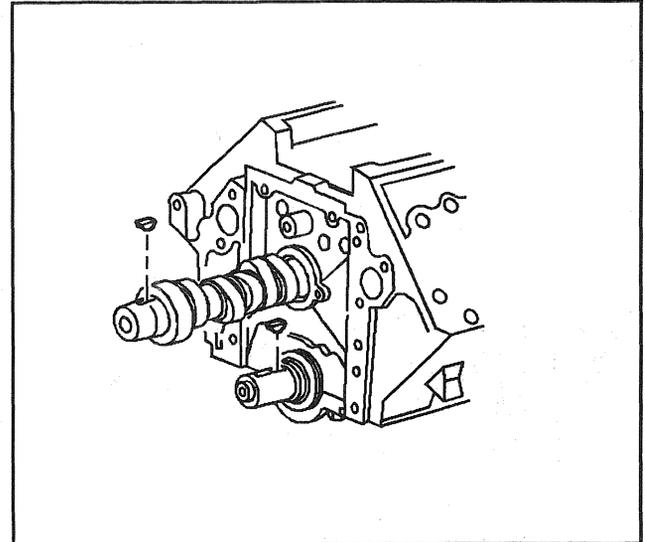


59742

Camshaft Installation

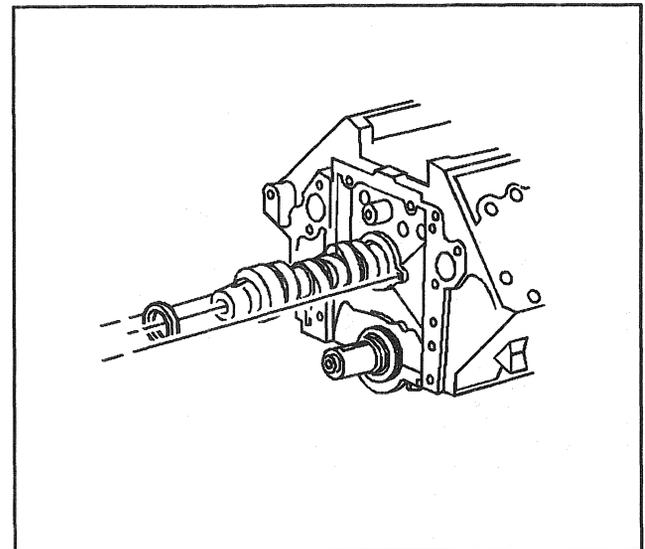
Important: Replace the valve lifters when a new camshaft is installed.

1. Install the camshaft sprocket key.

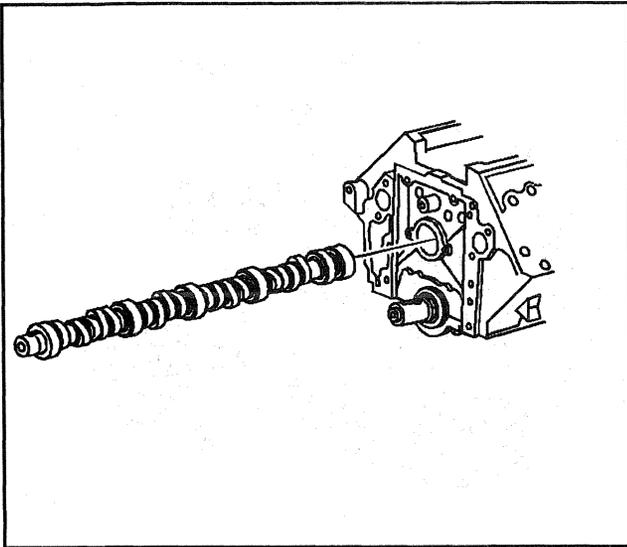


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2. Install the camshaft sprocket spacer, with the ID chamfer facing the camshaft.



59887



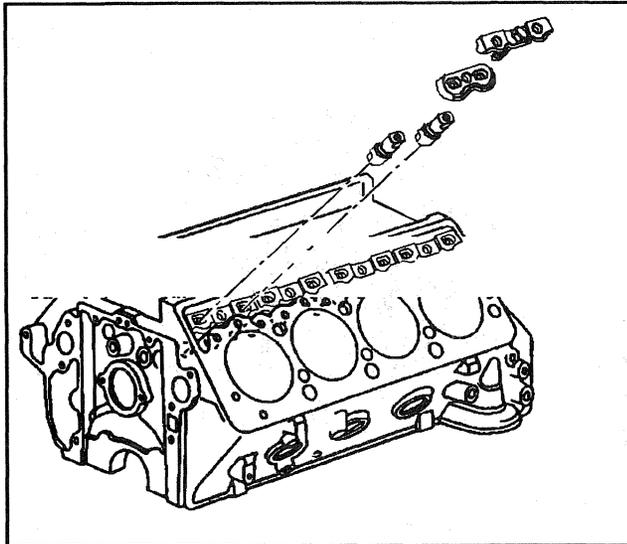
59889

3. Install the camshaft.
 - Coat the camshaft lobes with MOLYKOTE, or the equivalent.
 - Lubricate the camshaft bearing journals with engine oil.
 - Carefully insert the camshaft into the block, in order to avoid damage to the camshaft bearings.
4. Install the thrust bearing.
5. Install the thrust bearing bolts.

Tighten

Tighten the bolts to 23 N·m (17 lb ft).

Refer to *Fastener Notice* in General Information.



66589

Valve Lifter Installation

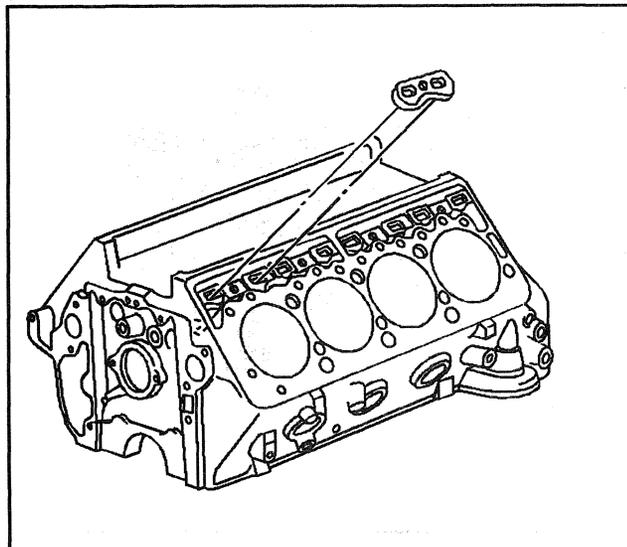
Notice: Prime the new valve lifters before installation. The valve lifters may be damaged if the valve lifters are dry when the engine is started.

Important: Replace the lifters when you install a new camshaft. Some engines will have both standard and 0.25 mm (0.010 in) oversize valve lifters. The oversize lifter will have the number 10 etched on the side. The block will be stamped OS on the cast pad adjacent to the lifter bore and on the top rail of the cylinder case above the lifter bore.

1. Install the valve lifters to the engine.
 - Prime the new valve lifters before installation, by working the lifter plunger while submerged in clean kerosene or diesel fuel.
 - Coat the lifter roller and the bearings with lubricant GM P/N 1052367, or equivalent.
 - Install the lifters in their original location.

Important: Ensure that the straight edge of the guide plates and the clamps face away from the cylinders.

2. Install the guide plates.



59809

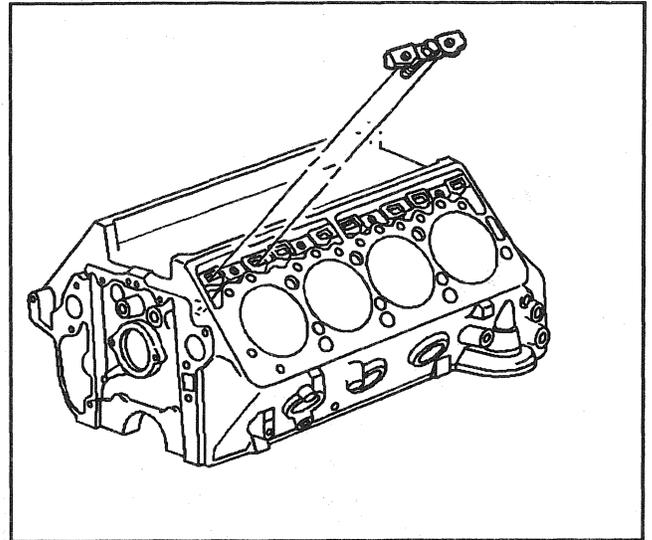
3. Install the clamps.

Tighten

Tighten the clamp bolts to 25 N.m (18 lb ft).

Refer to *Fastener Notice* in General Information.

4. After installing the clamps, turn the crankshaft by hand 720 degrees (two full turns), in order to ensure the free-movement of the lifters in the guide plates.
5. If the engine will not turn over by hand, one or more of the lifters may be binding in the guide plates.



59806

Connecting Rod and Piston Installation

The connecting rod bearings are precision insert connecting rod bearings, and do not require shims for adjustment. Do not file the rods or the rod caps. If the engine has excessive clearances, install a new bearing. Service bearings are available in standards size, with yellow color for identification, and 0.026 mm (0.001 in) undersize, with green color for identification.

Important:

- When using selective fit rod bearings, always use the standard bearing in the connecting rod, and use the undersize bearing in the end of the rod cap.
- Note that the color-coding for selective fit rod bearings is different from the color-coding for the crankshaft bearings.
- Connecting rod bearings are available in 0.026 mm (0.0010 in) undersize for select fitting.
- The L56 engines may have both, standard and 0.08 mm (0.0010 in) oversize connecting rod bearings. The oversize connecting rod cap's lower end is stamped with OS.

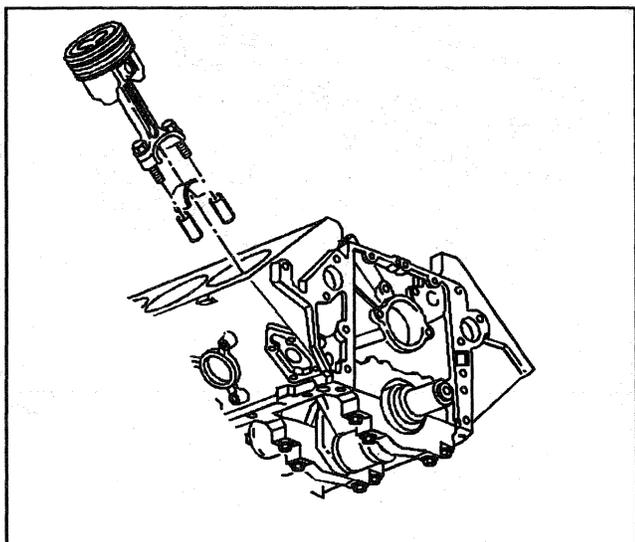
Selective fitting of the rod and the crankshaft is necessary in order to obtain close tolerances. For example, use one-half of a 0.026 mm (0.0010 in) undersize insert, which will decrease the clearance by 0.013 mm (0.0005 in), rather than using a full standard bearing.

Tools Required

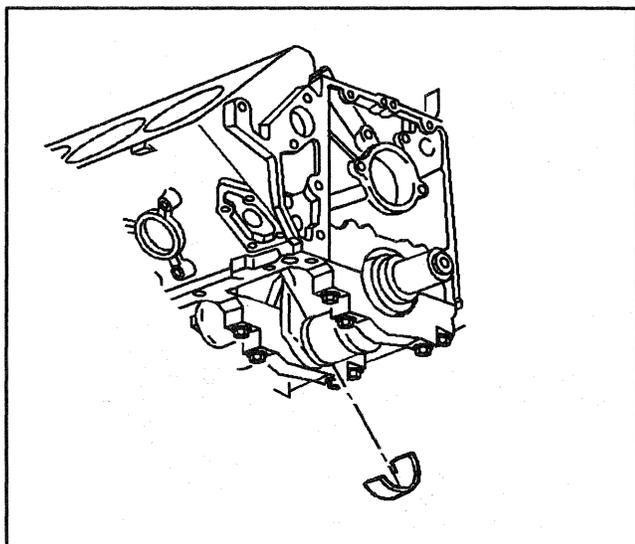
J 8037 Universal Piston Ring Compressor

Important:

- Make sure that the cylinder walls are clean.
- Lightly lubricate the cylinder wall with engine oil.
- Make sure that the piston installs in the matching cylinder.



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- Install new pistons in the fitted cylinders.
 - Install used pistons in the cylinders from which they were removed.
1. Remove the connecting rod cap.
 2. Install two 10 mm (3/8 in) hose onto the connecting rod studs.
 3. Locate the piston ring end gaps, with the piston viewed with the swirl indent up, in the following way:
 - 3.1. The oil ring expander gap at 45 degrees left of the swirl indent
 - 3.2. The oil control ring gaps at 180 degrees opposite of the oil expander ring
 - 3.3. The second compression ring gap at the piston top and under the swirl indent
 - 3.4. The first compression ring 180 degrees opposite of the second ring. Lubricate the piston and rings with engine oil.
 4. Without disturbing the ring end gap location, install the *J 8037* over the piston.
 5. Install the piston so that the depression in the piston crown is toward the outside of the engine.
 6. Tap the piston down into the bore using light blows with a hammer handle, while guiding the connecting rod to the journal from beneath the engine.
 7. Hold the ring compressor against the block until all rings have entered the cylinder bore.
 8. Remove the hoses from the connecting rod bolts.

Important: Each connecting rod and bearing cap should be marked, beginning at the front of the engine. Cylinders 1, 3, 5, and 7 are the left bank and 2, 4, 6, and 8 are the right bank. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is transposed from one block or cylinder to another, new connecting rod bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.

9. Apply engine oil to the connecting rod bearings.

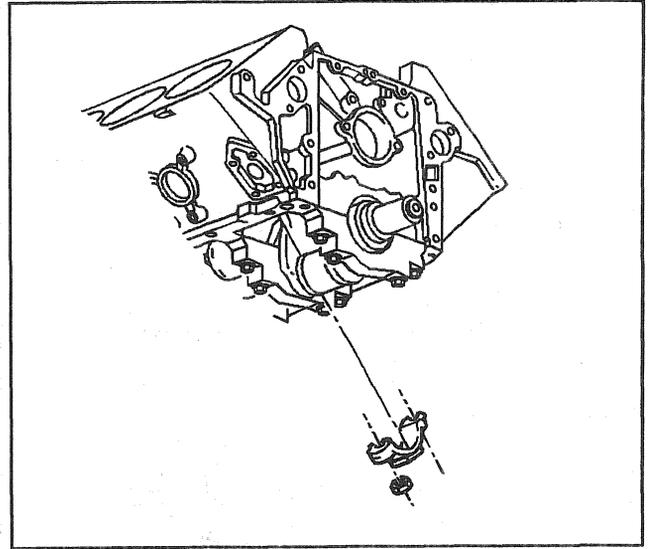
10. Install the connecting rod cap and the nuts, with the bearing.

Tighten

Tighten the connecting rod cap nuts to 65 N.m (48 lb ft).

Refer to *Fastener Notice* in General Information.

11. Measure the connecting rod side clearance.
 - Use a feeler gauge between the connecting rod and the crankshaft.
 - The correct clearance is 0.17–0.63 mm (0.007–0.025 in).



59895

Cylinder Head Installation

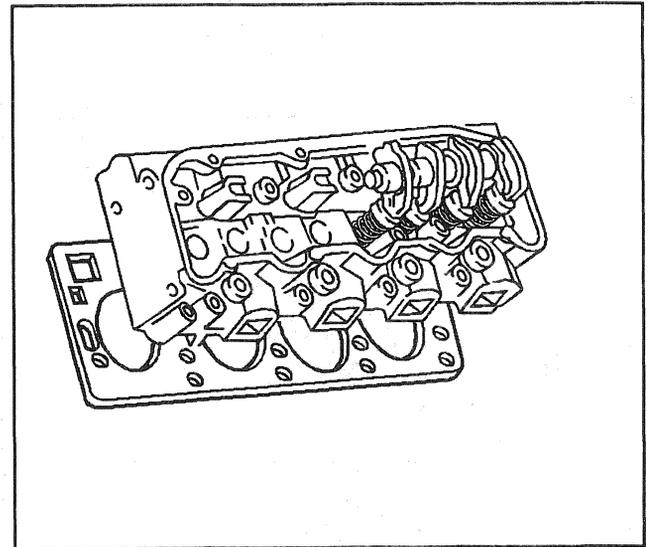
Tools Required

J 39664 Manifold Cover Set

Important:

- Make sure that the block gasket surfaces are clean.
- The head gasket material is soft. Handle the gasket with care. Make sure the gasket surface is not creased or dented.
- Do not use a sealer on the head gasket. The head gasket manufactures with sealant on the gasket surface. Additional sealer may cause leakage or malfunction. In addition, some sealers may attack the initial sealant on the gasket.

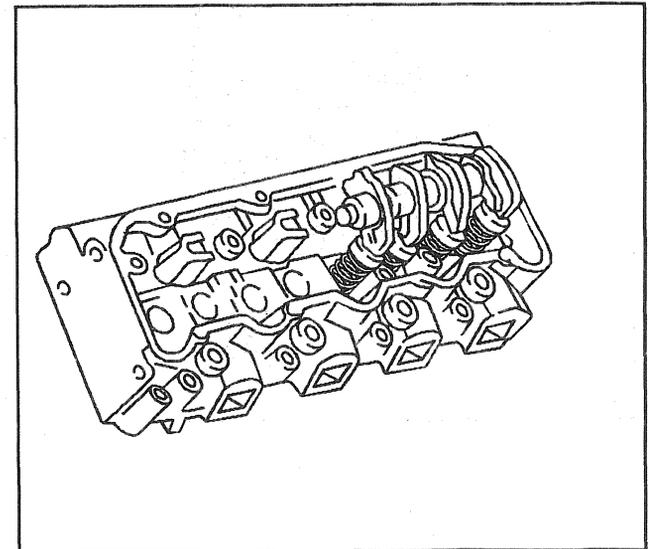
1. Install the head gasket to the block, over the dowel pins.



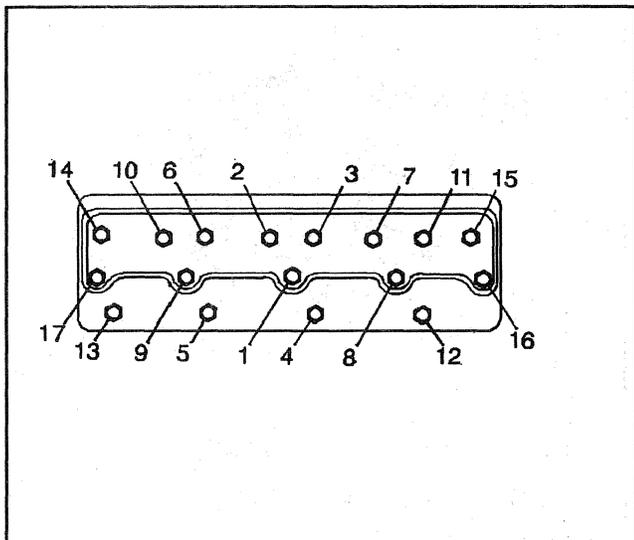
59803

2. Install the cylinder head.

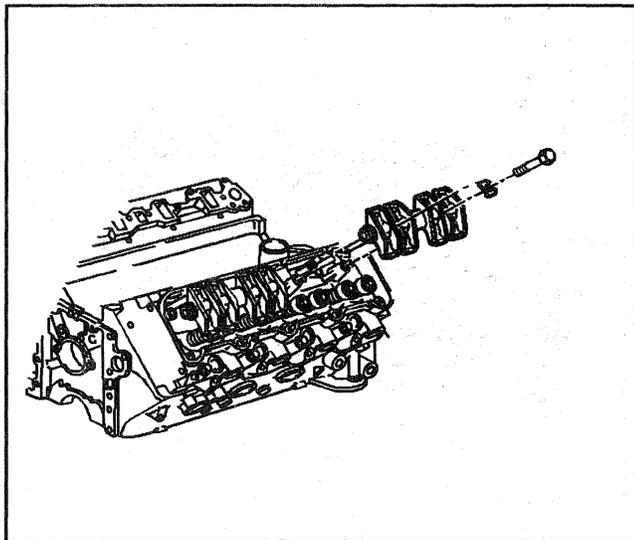
- Make sure that the gasket surfaces are clean.
- Carefully guide the head into place, over the cylinder head dowel pins.



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3. Install the cylinder head bolts.
 - Make sure that the bolt threads are clean.
 - Apply the thread sealant GM P/N 12345382, or equivalent, to the bolt threads and under the bolt heads.

Tighten

- 3.2.1. Tighten all of the cylinder head bolts to 25 N.m (20 lb ft).
- 3.2.2. In sequence, tighten all of the bolts to 75 N.m (55 lb ft).
- 3.2.3. In sequence, tighten all of the bolts and additional 90–100 degrees (1/4 plus turn).

Refer to *Fastener Notice* in General Information.

4. Install the *J 39664* to the intake ports.

Valve Rocker Arm and Push Rod Installation

Notice: Install the valve pushrods with the copper-colored, painted, or marked end up in order to avoid damage or premature wear.

Important: Ensure that the ball ends of the valve pushrods seat in the valve rocker arms.

1. Install the valve pushrods with the copper-colored, painted or marked end upwards.
2. Install the valve rocker arm shaft assembly.

Notice: Improper installation of the valve rocker arm shaft bolts may cause valve rocker arm shaft breakage and piston to valve contact.

3. Install the bolts.
 - 3.1. Rotate the crankshaft, until the mark on the crankshaft balancer is at the 2 o'clock position.
 - 3.2. Rotate the crankshaft counterclockwise 88 mm (3 1/2 in), aligning the crankshaft balancer mark with the first lower water pump bolt, at approximately the 12:30 position.
 - 3.3. This procedure will position the engine so that no valves are close to a piston crown.
 - 3.4. Finger-tighten the bolts.

Tighten

Alternately tighten the bolts to 55 N.m (40 lb ft).

Refer to *Fastener Notice* in General Information.

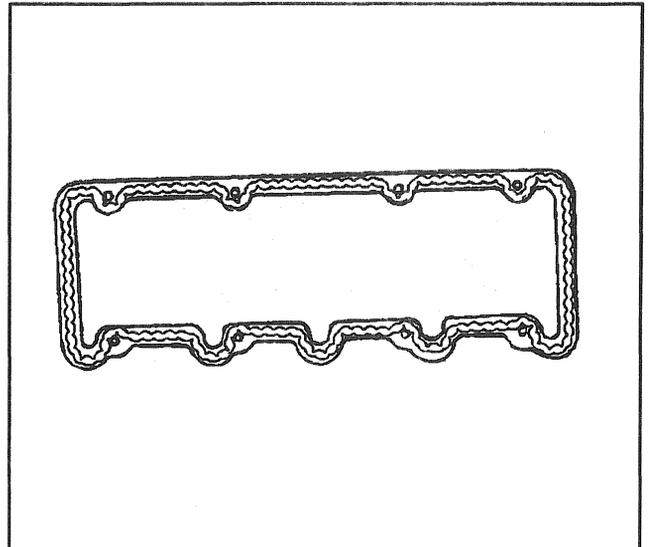
4. Rotate the crankshaft in order to make sure that there is free-movement of the valve train.

Valve Rocker Arm Cover Installation

1. Clean the sealing surfaces on the cylinder head and the valve rocker arm cover, so that the surfaces are free from oil and foreign material.

Notice: Do not allow the RTV sealant into the valve rocker arm cover bolt holes. This may cause a "hydraulic lock" condition, when the bolts are tightened, damaging the cylinder head casting.

2. Apply a 5 mm (3/16 in) bead of RTV sealant GM P/N 12345739 to the valve rocker arm covers, inboard of the bolt holes. The sealer must be wet to the touch, when the bolts are tightened.



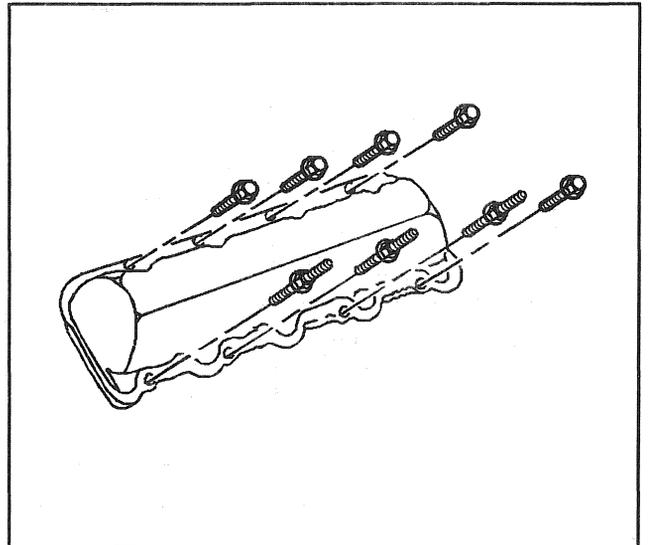
66617

3. Install the valve rocker arm cover.
4. Install the valve rocker arm cover bolts.

Tighten

Tighten the valve rocker arm cover bolts to 22 N.m (16 lb ft).

Refer to *Fastener Notice* in General Information.



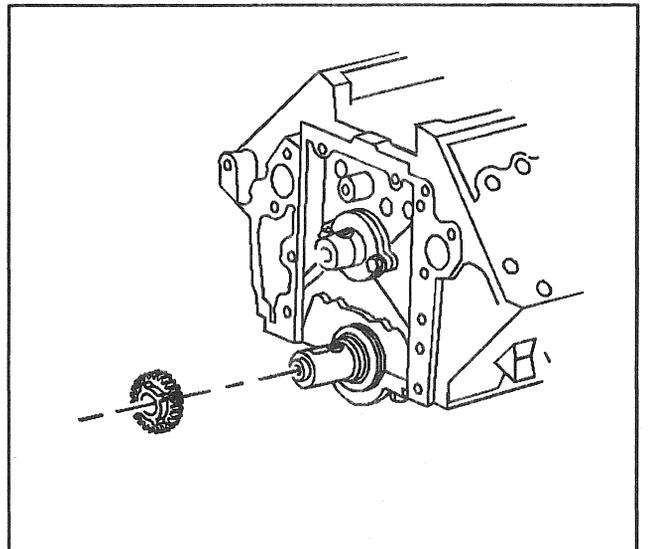
59831

Timing Chain and Camshaft Sprocket Installation

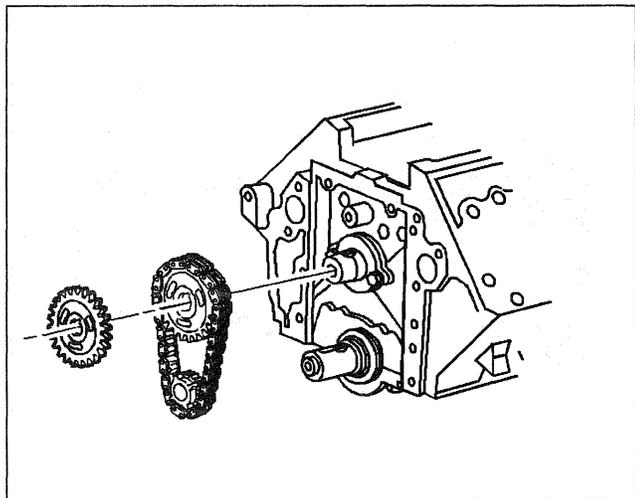
1. Install the keyway in the crankshaft.

Important:

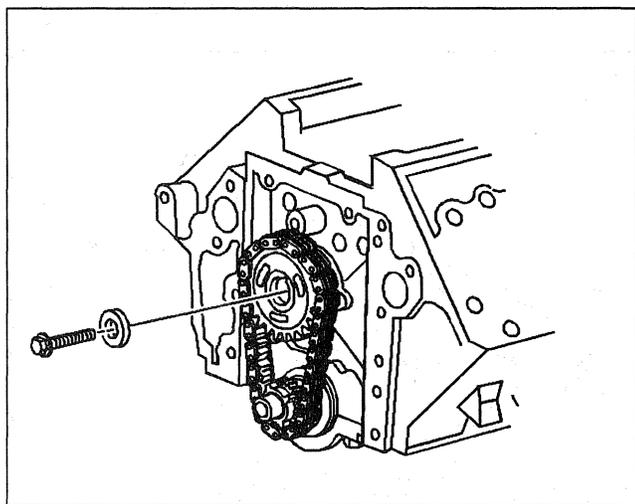
- Do not damage the reluctor wheel square bosses.
 - Align the timing marks.
2. Install the crankshaft sprocket with the reluctor wheel square bosses facing the front.
 3. Install the camshaft sprocket with the timing chain with the mark on the sprocket facing the front.



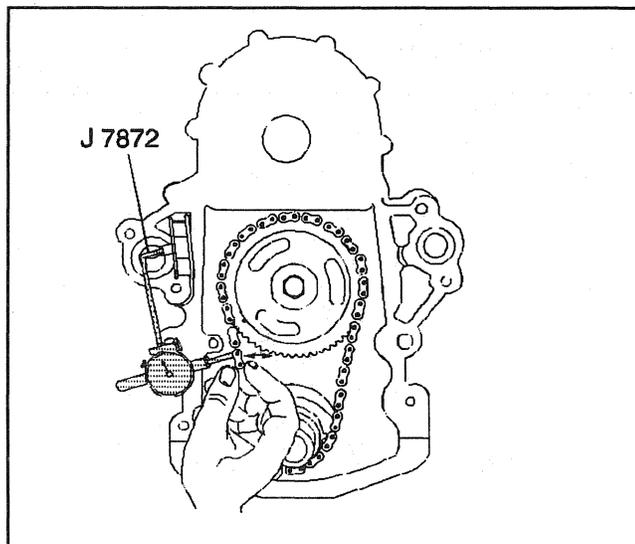
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59872



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4. Install the fuel injection pump camshaft gear.

5. Install the washer and the bolt.

Tighten

Tighten the bolt to 170 N.m (125 lb ft).

Refer to *Fastener Notice* in General Information.

Timing Chain Wear Check**Tools Required**

J 7872 Magnetic Base Dial Indicator

1. Mount the *J 7872* to the front of the block.
2. Position the dial indicator so that the plunger contacts the timing chain between the two sprockets.
3. Pull the chain outward, parallel to the front face of the block, to the maximum amount, with finger pressure on the inside of the chain.
4. Set the *J 7872* to zero.
5. Move the chain inward, parallel to the front face of the block, to the maximum amount with finger pressure on the outside of the chain.
6. Note the total indicator travel.
 - With used parts, the deflection must not exceed 20.3 mm (0.80 in).
 - If the deflection exceeds this limit, inspect the sprockets and the timing chain for wear and replace the worn parts.
 - With new parts, the deflection must not exceed 12.7 mm (0.50 in).

Engine Front Cover Installation

Tools Required

J 22102 Seal Installer

Important: Replacing either of the following will affect timing:

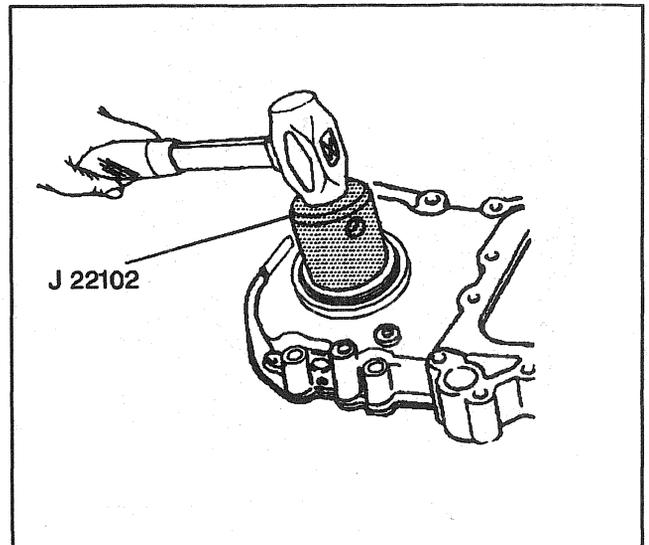
- The timing chain
- The timing gears
- The front cover
- The Crankshaft Position (CKP) sensor
- The crankshaft

It will then be necessary to reprogram TDC Offset (Recovery) into the PCM. Refer to Engine Controls.

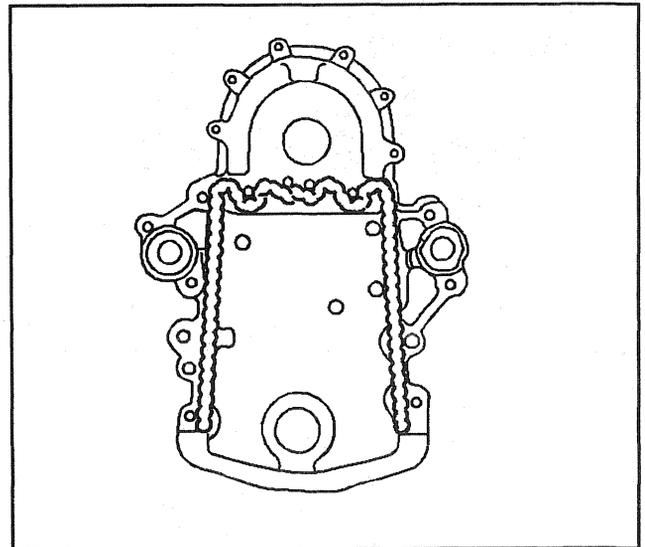
1. Clean the front cover and the block sealing surfaces, in order to ensure that they are free from oil.

Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

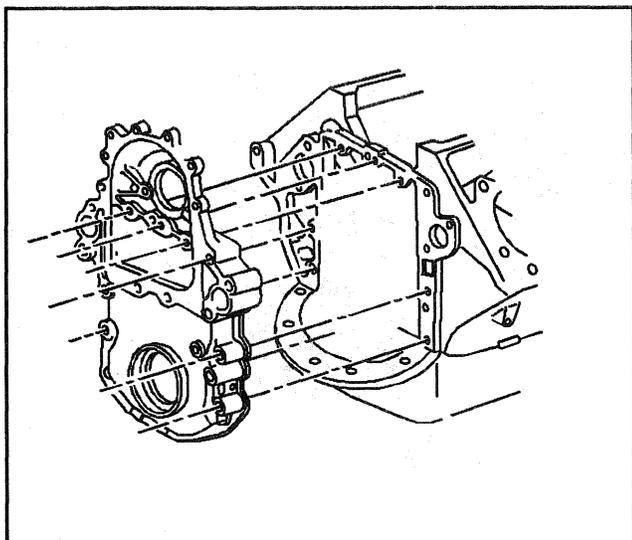
2. Install the front crankshaft oil seal using the J 22102 with the open end of the seal facing the inside cover.
3. Coat the seal lips with grease.
4. Apply a 2 mm (3/32 in) bead of anaerobic sealant GM P/N 1052357, or the equivalent, to the front cover sealing area.



60269



59866



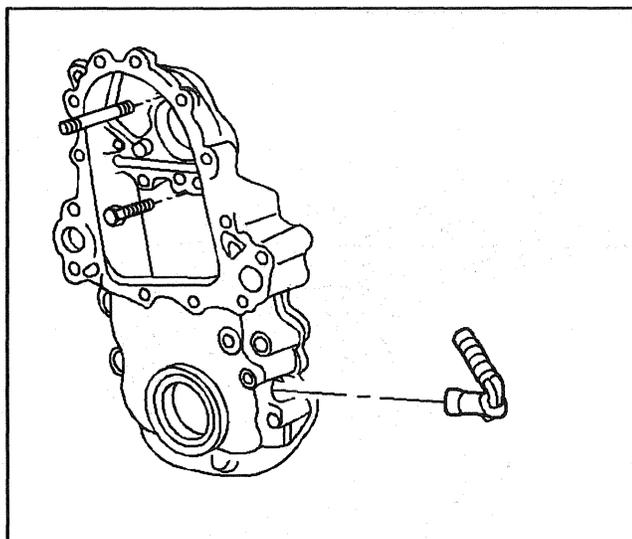
59864

5. Install the front cover to the engine.
6. Install the front cover bolts.

Tighten

Tighten the front cover bolts to 45 N·m (33 lb ft).

Refer to *Fastener Notice* in General Information.

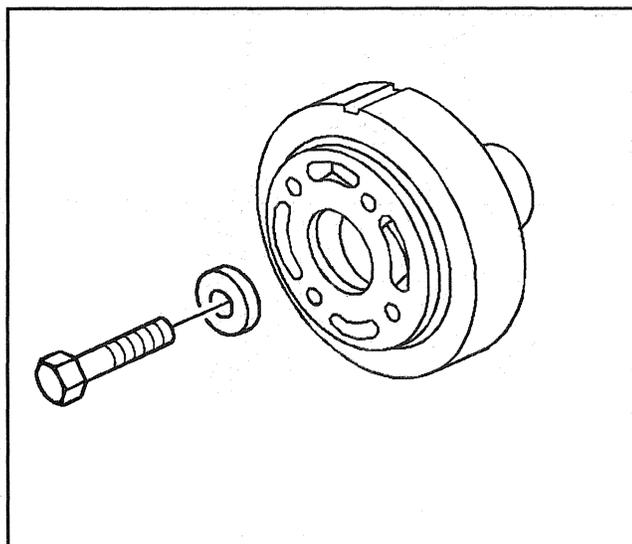


59862

7. Install the crankshaft position sensor with a new o-ring seal.

Tighten

Tighten the retaining bolt to 25 N·m (17 lb ft).



59837

Crankshaft Balancer Installation

Important: Before installing the crankshaft balancer, check the oil seal contact area for grooving and roughness. Replace the crankshaft balancer if necessary.

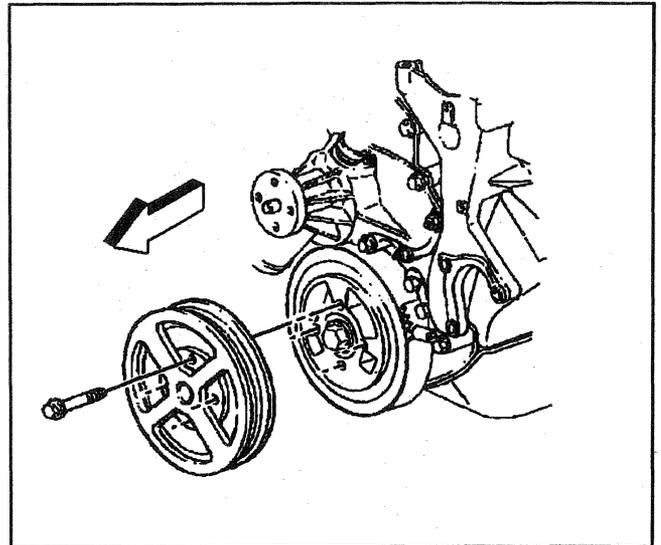
1. Tap the crankshaft balancer into place with a mallet.
2. Make sure that the key is in place.
3. Make sure that the crankshaft balancer is completely installed on the crankshaft.
4. Install the bolt and the washer.

Tighten

Tighten the bolt to 270 N·m (200 lb ft).

Refer to *Fastener Notice* in General Information.

5. Install the crankshaft pulley and bolts.
Tighten
 Tighten the crankshaft pulley bolts to 58 N.m (43 lb ft).

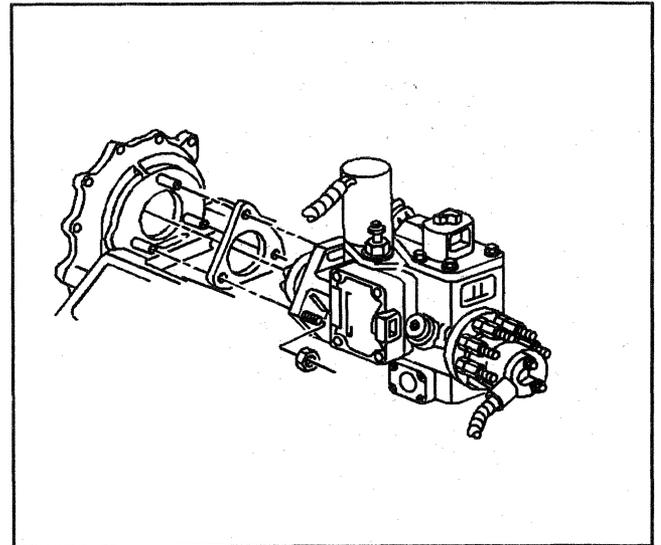


70257

Fuel Injection Pump Installation

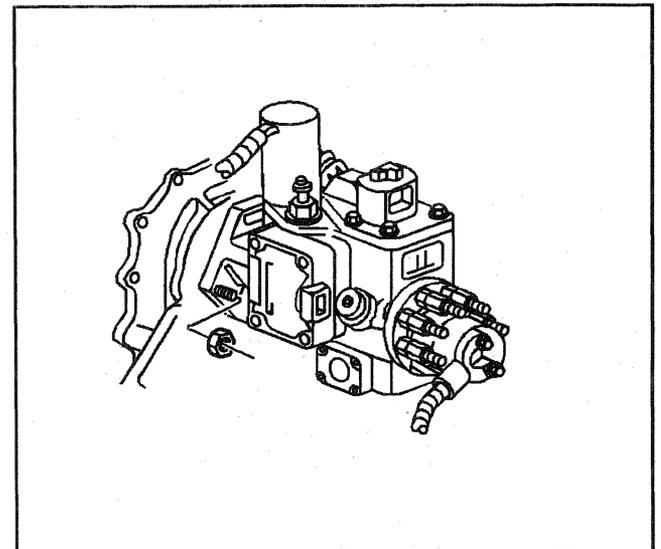
Notice: Never rotate the engine with the starter, the starter location engine rotation fixture, or with the wrench from the front of the engine with the fuel injection pump removed. The loose fuel pump drive gear could become lodged in the front cover and cause gear tooth distress and shear the camshaft drive gear. Align the camshaft gear timing marks before installing the fuel injection pump drive gear.

1. Install the gasket to the front cover.
2. Install the fuel injection pump.
3. Install the electronic fuel injection pump with the ESO straight up.

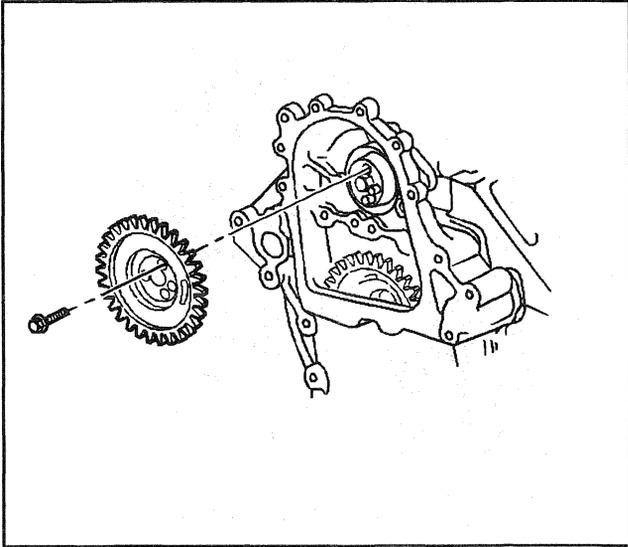


59855

4. Install the pump mount nuts.
Tighten
 Tighten the nuts to 40 N.m (30 lb ft).
 Refer to *Fastener Notice* in General Information.



59851



59842

5. Install the fuel injection pump gear. Align the slot in the fuel injection pump gear with the locating pin on the fuel injection pump hub.

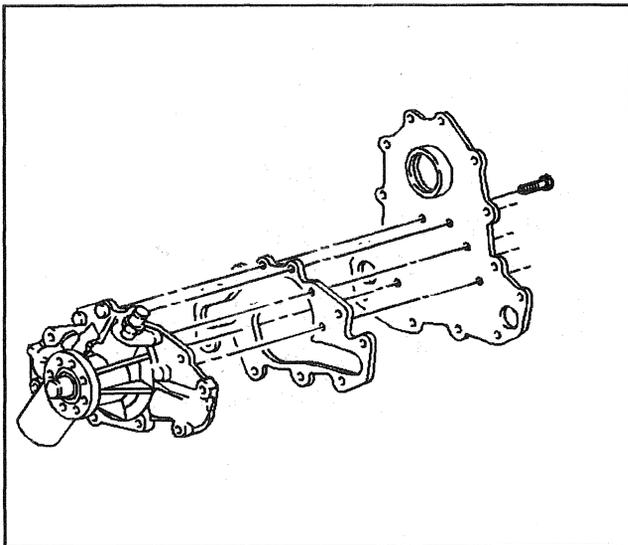
Important: Align the timing marks. Be certain the mark on the fuel injection pump gear is aligned with the mark on the camshaft gear. For the proper timing of the fuel injection pump, the cam gear timing mark must be in the 12 o'clock position. Rotate the crankshaft to bring the cam gear timing mark up to the 12 o'clock position.

6. Install the fuel injection pump gear retaining bolts.

Tighten

Tighten the bolts to 25 N·m (20 lb ft).

7. Install the wires and hoses at the fuel injection pump.



59828

Water Pump Installation

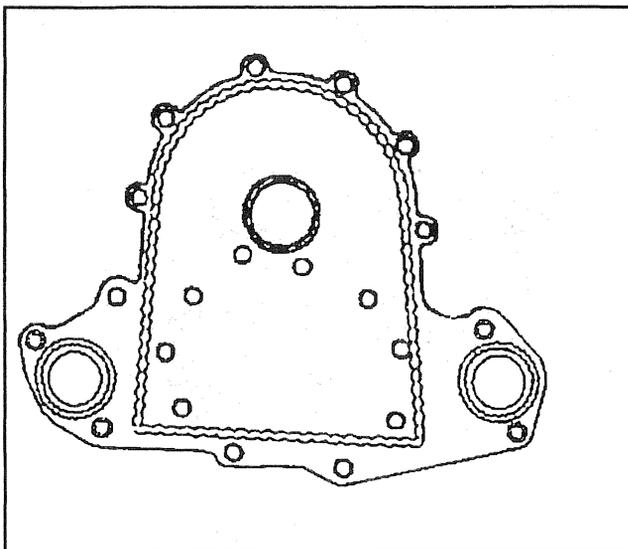
1. Clean the sealing surfaces on the water pump plate and the block.
2. Install the water pump and the gasket to the water pump plate.
3. Install the bolts.

Apply high temperature thread adhesive GM P/N 12345493, or equivalent, to the bolt threads.

Tighten

Tighten the bolts to 28 N·m (20 lb ft).

Refer to *Fastener Notice* in General Information.



66579

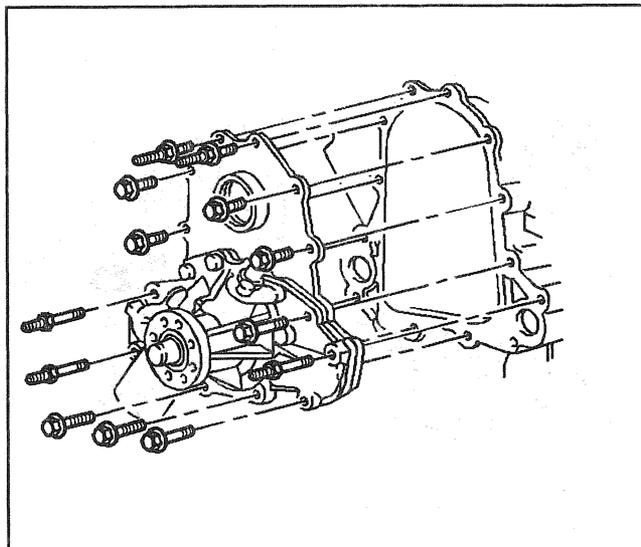
4. Apply a bead of anaerobic sealer GM P/N 1052942 or the equivalent to the water pump plate.

5. Install the water pump plate to the engine.
 - The sealer must be wet to the touch when installing the plate.
 - Apply the sealant GM P/N 12346004, or equivalent, to the threads of the bolts and studs.

6. Install the bolts and studs.

Tighten

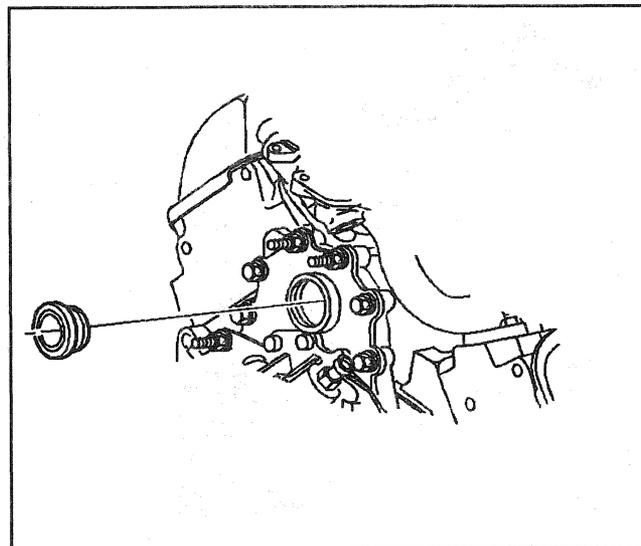
- Tighten the water pump to the front cover bolts to 42 N.m (32 lb ft).
- Tighten the water pump plate to front cover bolts to 28 N.m (20 lb ft).



59826

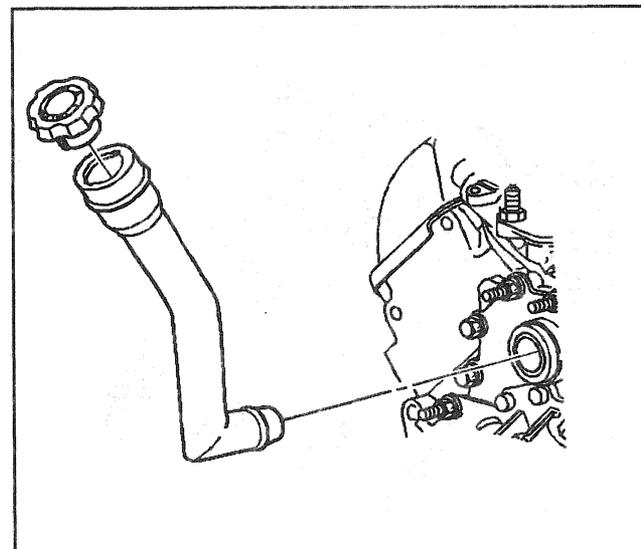
Oil Fill Neck Installation

1. Install the seal.

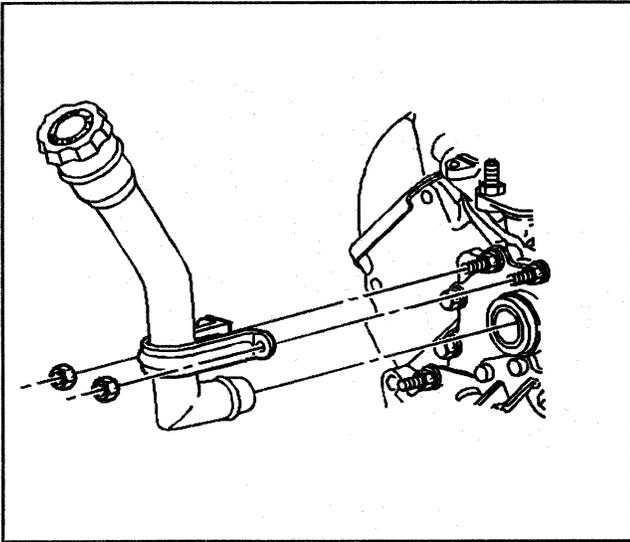


59776

2. Install the oil fill neck.

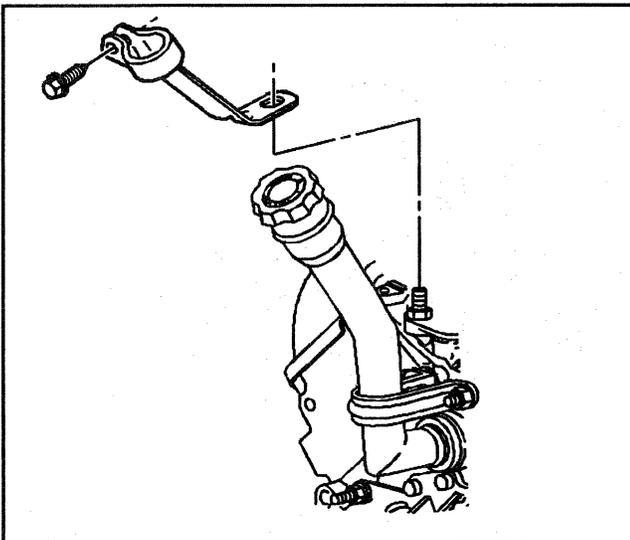


59773



59772

3. Install the holding bracket to the front cover.

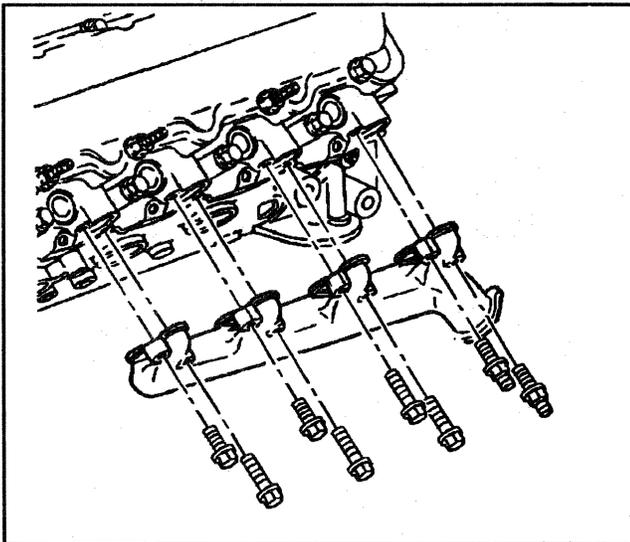


59769

4. Install the holding bracket to the thermostat housing.

Tighten

Tighten the nuts to 23 N.m (17 lb ft).

Refer to *Fastener Notice* in General Information.

60243

Exhaust Manifold Installation

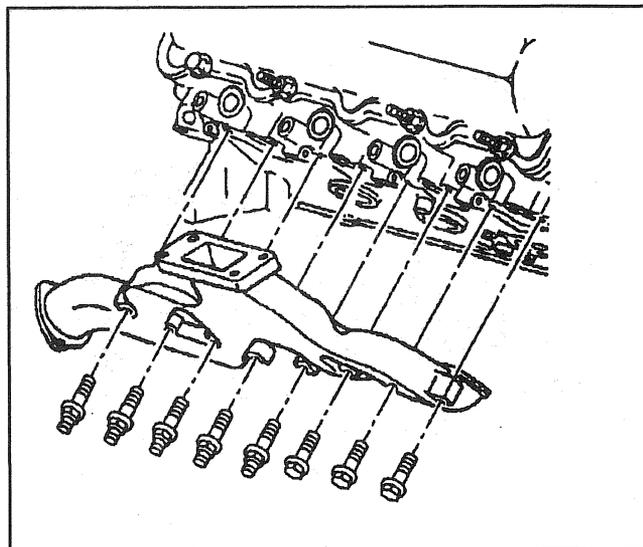
1. Install the left exhaust manifold and the bolts.

Tighten

Tighten the bolts to 35 N.m (26 lb ft).

Refer to *Fastener Notice* in General Information.

2. Install the right exhaust manifold and the bolts.
Tighten
 Tighten the bolts to 35 N-m (26 lb ft).
 Refer to *Fastener Notice* in General Information.



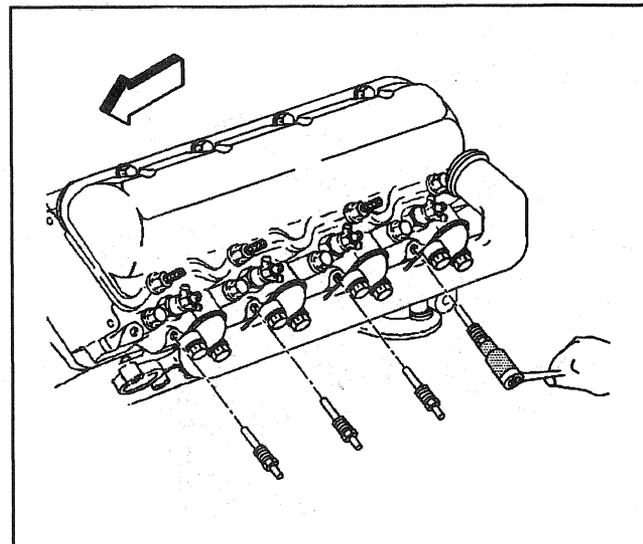
66575

Glow Plug Installation

Tools Required

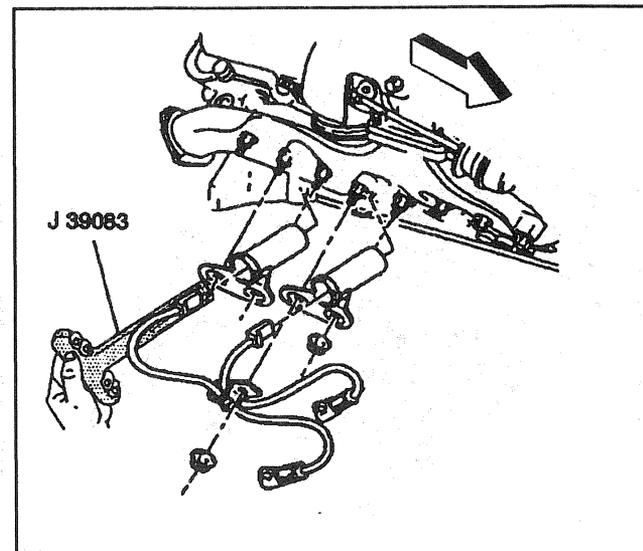
- J 41515-A Glow Plug Socket
- J 39083 Glow Plug Connector Tool

1. Install the glow plugs using the J 41515-A.
Tighten
 Tighten the glow plugs to 22 N-m (16 lb ft).
 Refer to *Fastener Notice* in General Information.

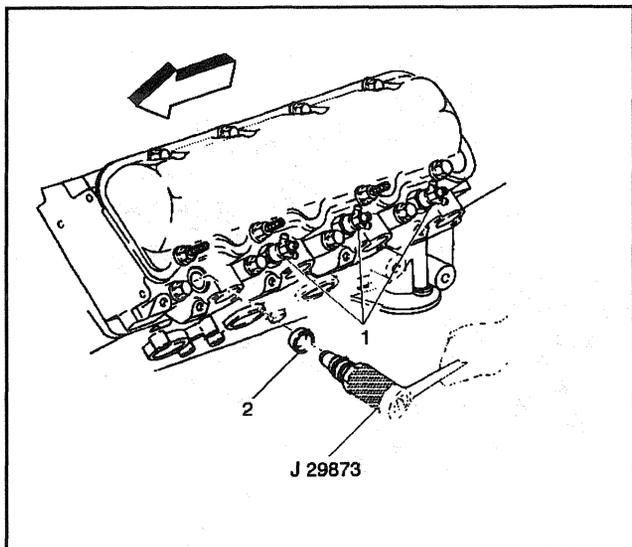


65002

2. Install the heat shields on cylinders number 4 and 6.
3. Using J 39083 install the jumper wires to cylinders 4 and 6.



70255



60452

Fuel Injection Nozzle Installation

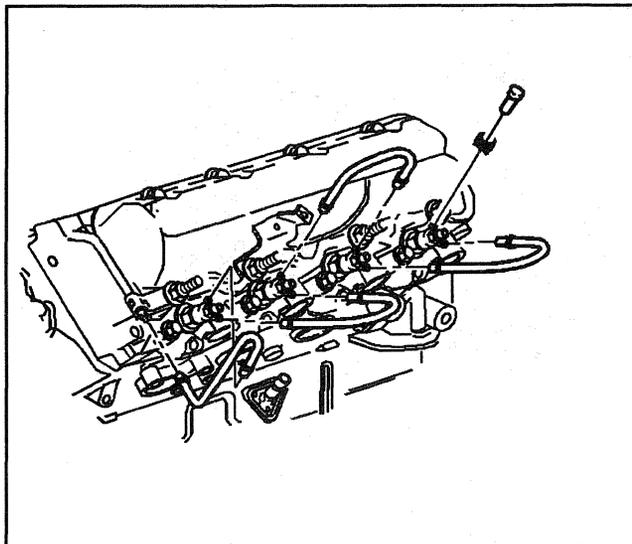
Tools Required
 J 29873 Nozzle Socket

Notice: In order to remove or install an injection nozzle, use the J 29873 Nozzle Socket on the 30-mm portion of the nozzle. Failure to use the 30-mm hex portion will result in damage to the injection nozzle

1. Apply a thin coating of GM P/N 14001899, or equivalent, to the threads of the injection nozzle.
2. Install the injection nozzle with the gasket, using the J 29873.

Tighten

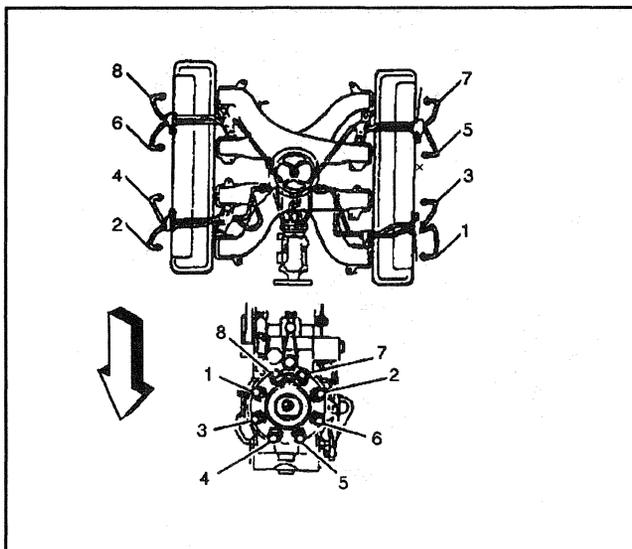
Tighten the nozzle to 80 N.m (59 lb ft).
 Refer to *Fastener Notice* in General Information.



59763

Fuel Inlet and Return Line Installation

1. Install the fuel inlet line to the fuel injection pump.
2. Install the fuel return hose to the fuel injection pump.
3. Install the fuel return line brackets on the front left and the front right side rocker covers.
4. Install the fuel return hoses at the injector nozzles.
5. Install the clamps.



70019

Fuel Injection Line Installation

1. Install the injection line brackets.
Important: Install the lines in the correct position.
2. Install the injection lines to the pump.
3. Do not bend the injection lines.

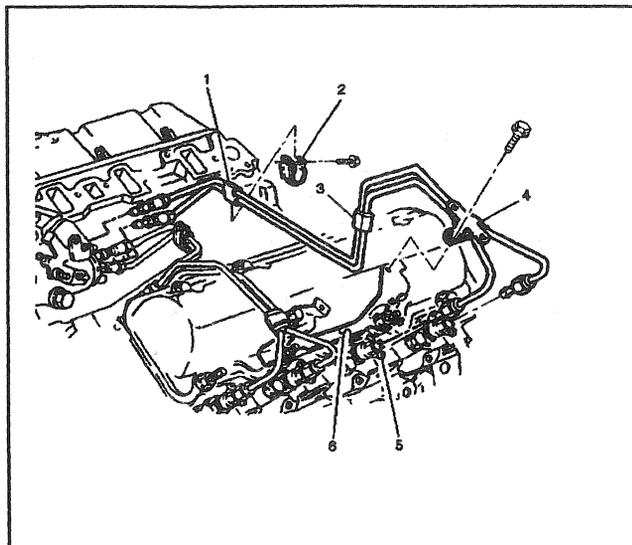
4. Install the injection lines to the nozzles.
 - Uncap the lines before assembly.
 - Do not bend the injection lines.

Tighten

Tighten the injection line fittings to 36 N·m (28 lb ft).

Refer to *Fastener Notice* in General Information.

5. Install the injection line clips to the brackets.



70020

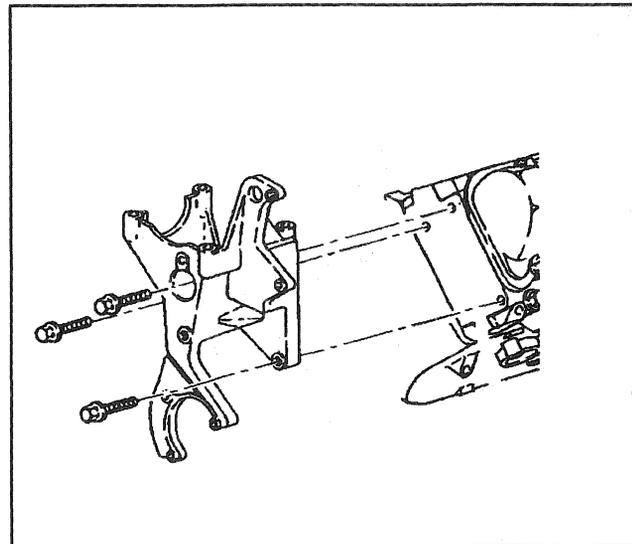
Accessory/Engine Lift Brackets Installation

1. Install the bracket assembly.
2. Install the bolts.

Tighten

Tighten the bolts to 50 N·m (37 lb ft).

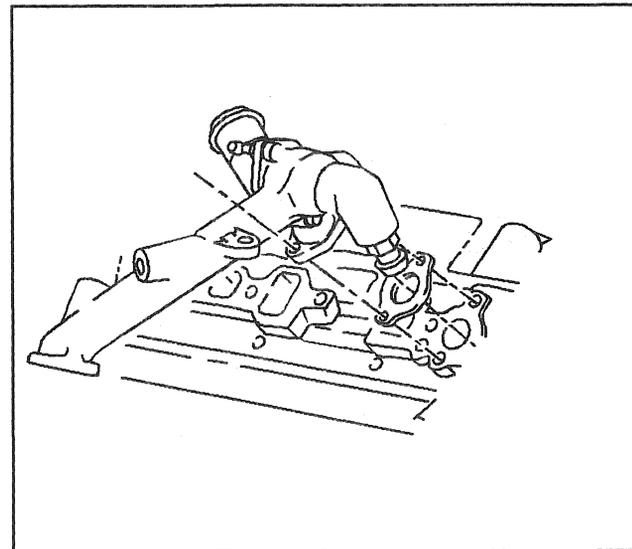
Refer to *Fastener Notice* in General Information.



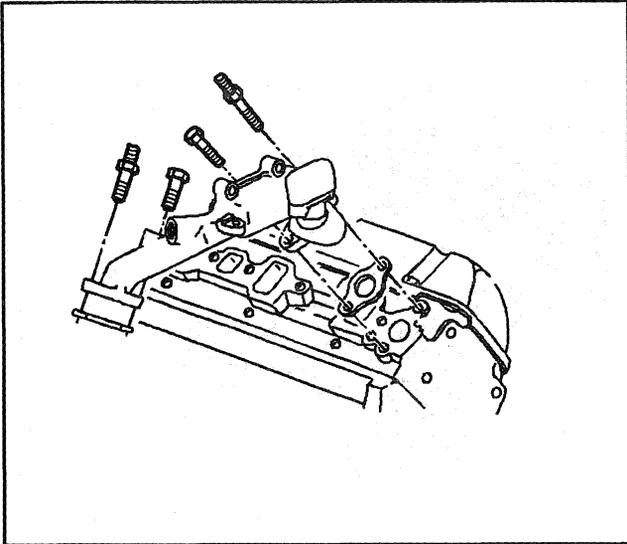
59794

Coolant Crossover Installation

1. Install the gaskets to the heads.
2. Install the coolant crossover.



59788



59777

3. Install the bolts and stud/nut.

Tighten

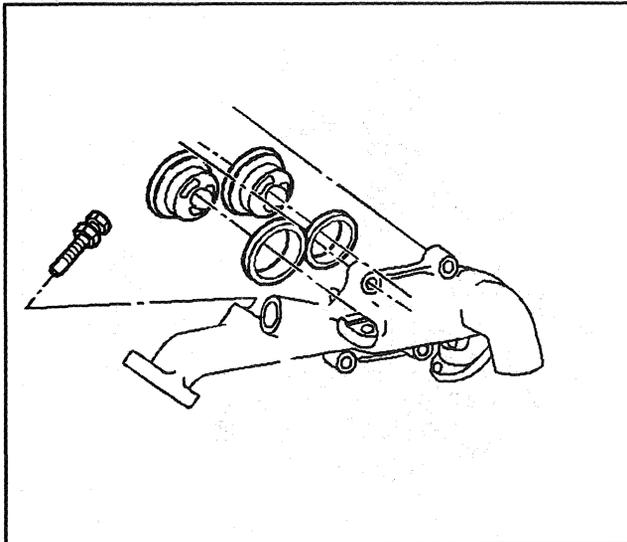
Tighten the bolts and the stud/nut to 42 N·m (31 lb ft).

Refer to *Fastener Notice* in General Information.

4. Install the bypass hose and the clamps.
5. Install the engine coolant temperature (ECT) sensor.
6. Install the fuel air bleed (shreader) valve and the nut.

Tighten

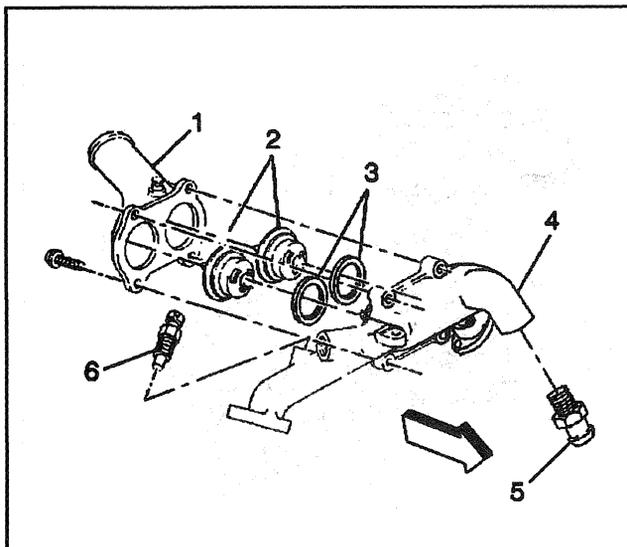
Tighten the stud/nut and the nut to 41 N·m (31 lb ft).



59782

Thermostat Housing/Thermostat Installation

1. Install the seals onto the thermostats.
 - The seals have a split, inner edge, which install over the flange on the thermostats.
 - The seals have a bead on the surface that faces the thermostat housing.
2. Install the thermostats in the coolant crossover.



64991

3. Install the thermostat housing.
4. Install the bolts/studs.

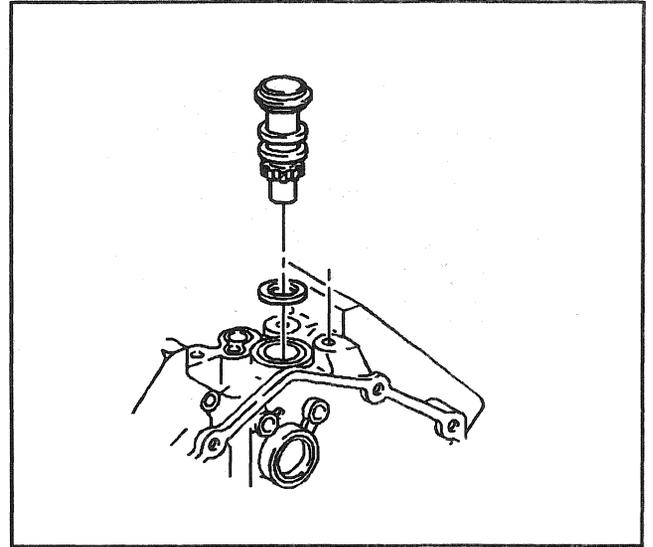
Tighten

Tighten the bolts/studs to 47 N·m (35 lb ft).

Refer to *Fastener Notice* in General Information.

Oil Pump Drive Installation

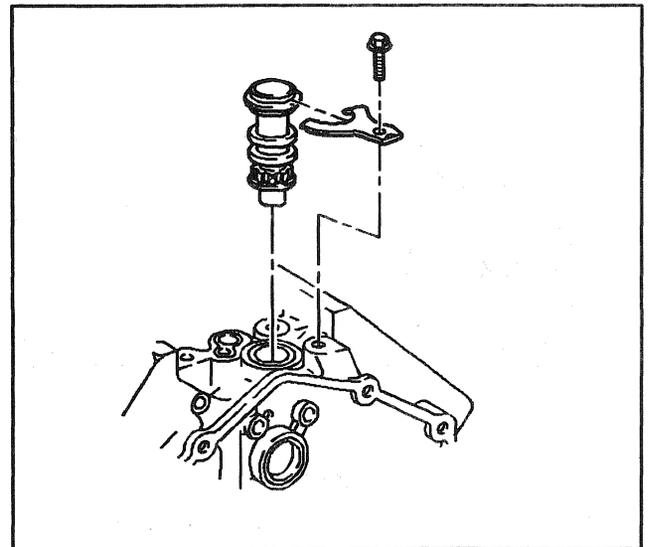
1. Install the new gasket to the oil pump drive.
2. Install the oil pump drive to the engine.
 - Index the drive with the camshaft gear and the oil pump drive shaft.
 - Make sure the drive seats fully.



59768

3. Install the clamp and the bolt.

Tighten
Tighten the bolt to 42 N·m (31 lb ft).
Refer to *Fastener Notice* in General Information.

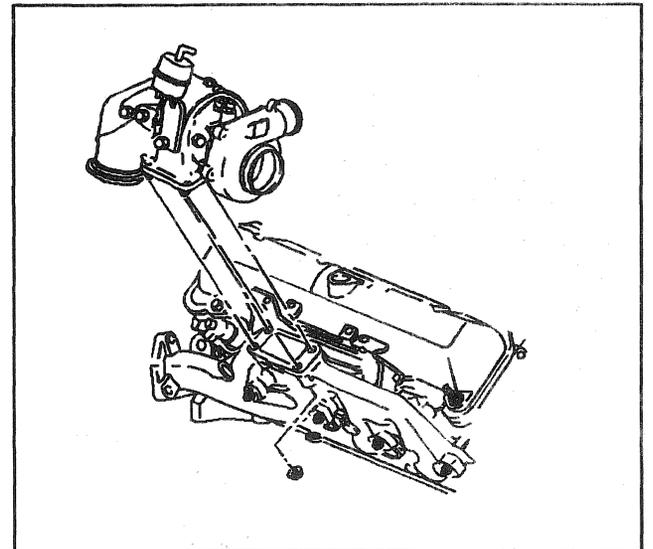


59765

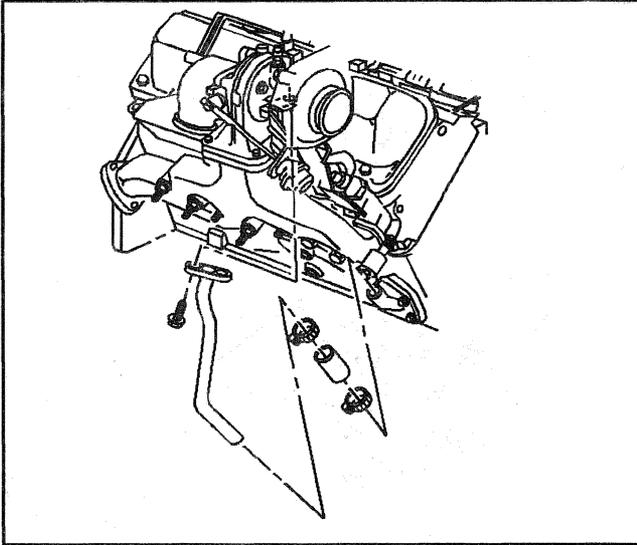
Turbocharger Installation

1. Install the turbocharger on the exhaust manifold and the studs.
2. Install the nuts to the exhaust manifold.

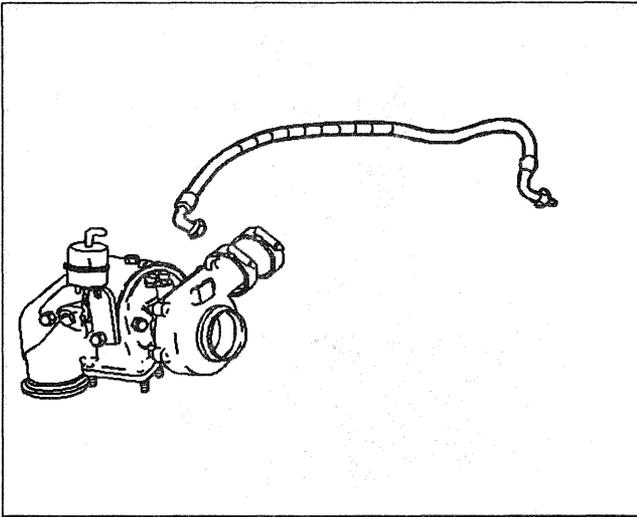
Tighten
Tighten the exhaust manifold mounting nuts to 58 N·m(43 lb ft).
Refer to *Fastener Notice* in General Information.



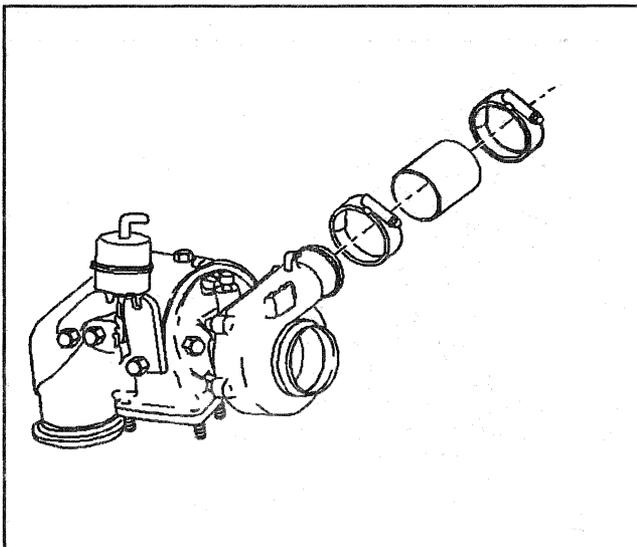
59756



59755



59754



59746

3. Install the gasket on the oil return pipe.

4. Install the oil return pipe to the bottom of the turbocharger.

Tighten

Tighten the oil return pipe bolts to 26 N.m (19 lb ft).

Important: Fill the oil feed hole at the top of the turbocharger with a small amount of the engine oil while rotating the compressor wheel by hand. This action will lubricate the turbocharger shaft bearings.

5. Install the oil feed hose at the turbocharger and the block.

Tighten

Tighten the oil feed hose fittings to 22 N.m (17 lb ft).

6. Install the oil return pipe with the hose and the clamps at the block.

Important: Apply the silicone sealant GM P/N 9985943 or the equivalent to the turbocharger outlet hose before installing onto turbocharger.

7. Install the outlet hose and the clamp on the turbocharger.

Tighten

Tighten the connector hose clamps to 6 N.m (50 lb in).

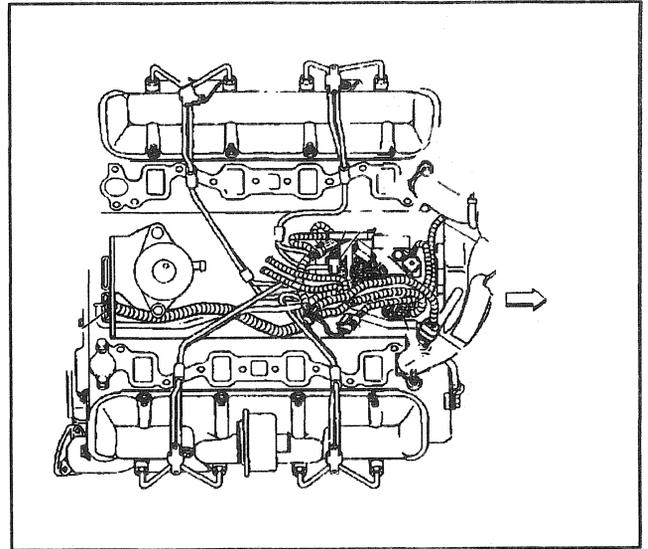
8. Install the long and the short turbocharger braces.

Tighten

- Tighten the long turbocharger brace nut to 34 N.m (26 lb ft).
- Tighten the long turbocharger brace bolt to 50 N.m (37 lb ft).
- Tighten the short turbocharger brace bolts to 25 N.m (19 lb ft).

POE Wiring Harness Installation

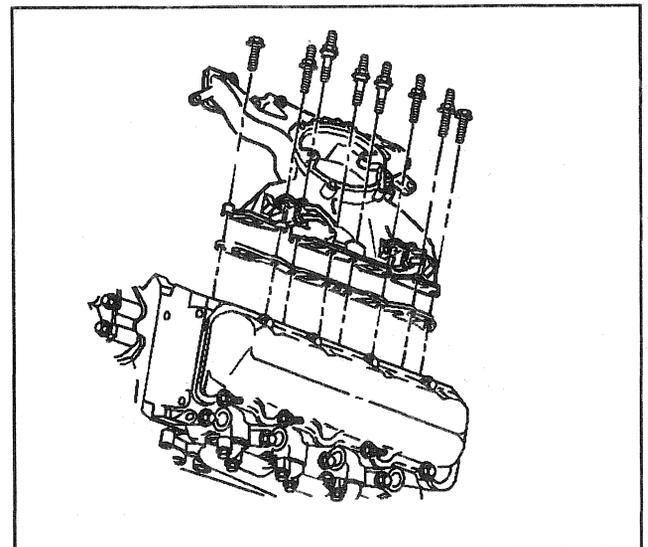
1. Place the harness in the engine valley.
2. Plug in or connect all the wiring harness connectors to devices or attachment points.



64989

Intake Manifold Installation

1. Install the new gaskets.
 - The gaskets for the L56 engine have openings for the EGR.
 - The gaskets for the L65 engine have no openings for the EGR.
2. Install the lower intake manifold.



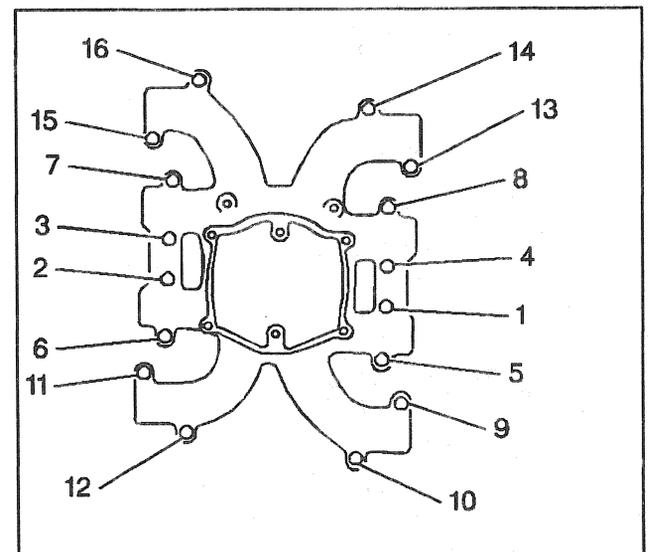
59835

3. Install the lower intake manifold bolts/studs and fuel line clips.
 - Use teflon sealer to seal the four bolts, numbers 9, 11, 13, and 15 that are exposed to the crankcase.
 - Apply threadlocker GM P/N 12345493 to the threads of the bolts and the studs that are not numbered 9, 11, 13, or 15.

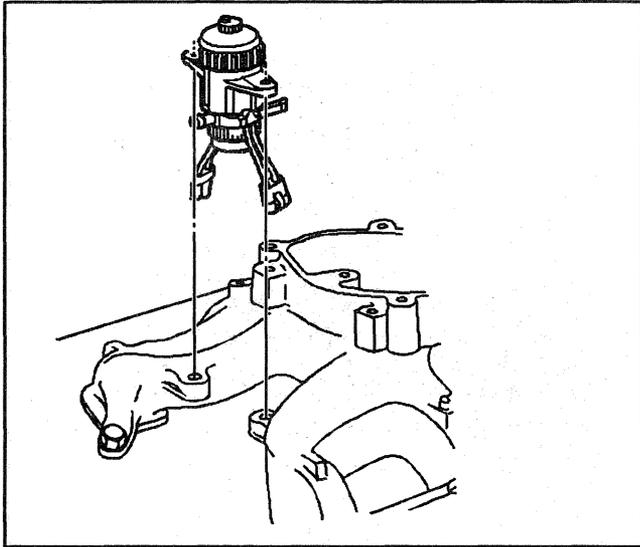
Tighten

- Tighten the lower intake manifold bolts/studs in order of the tightening sequence.
- Tighten the lower intake manifold bolts/studs to 42 N.m (31 lb ft).

Refer to *Fastener Notice* in General Information.



59761

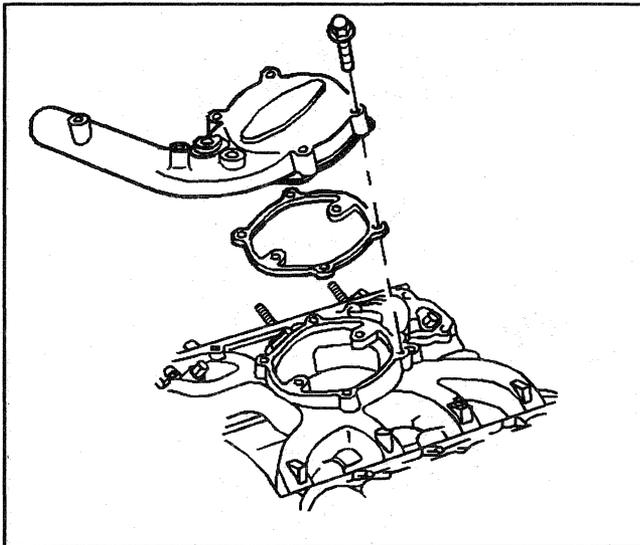


59759

4. Install the fuel filter assembly and the POE wiring harness bracket to the rear of the lower intake manifold.

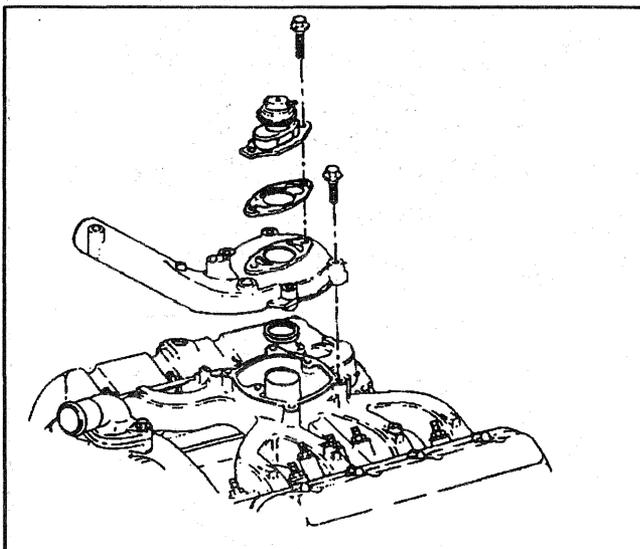
Tighten

Tighten the fuel filter mount bolts to 42 N·m (31 lb ft).



59749

5. For the L56 model, install the EGR tower gasket on the round center portion of the upper intake manifold.



59748

6. Install the upper intake gasket.
7. Install the upper intake manifold to the lower intake manifold.
8. Slide the upper intake into the turbocharger outlet hose.
9. Apply the silicone sealant GM P/N 9985943, or equivalent to the turbocharger outlet before you install the turbocharger outlet onto the upper intake manifold.
10. For the L56 model, install the EGR gasket and valve.
11. Install the mounting bolts.

Tighten

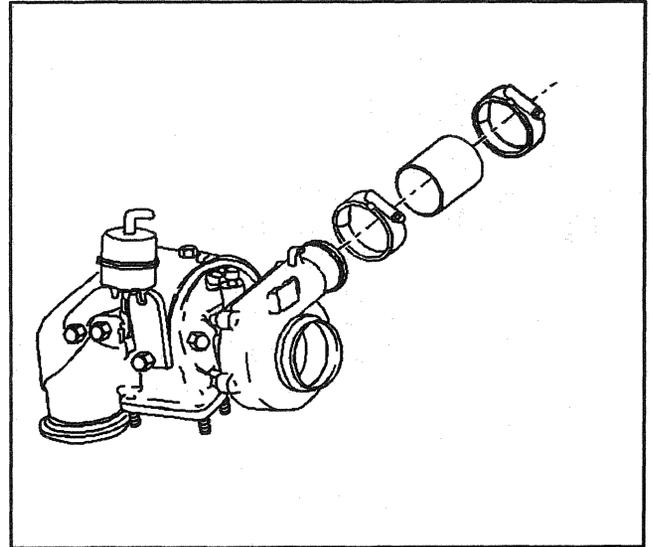
Tighten the nut and the bolts to 23 N·m (17 lb ft).

Refer to *Fastener Notice* in General Information.

12. Install the clamp for the turbocharger connector hose.

Tighten

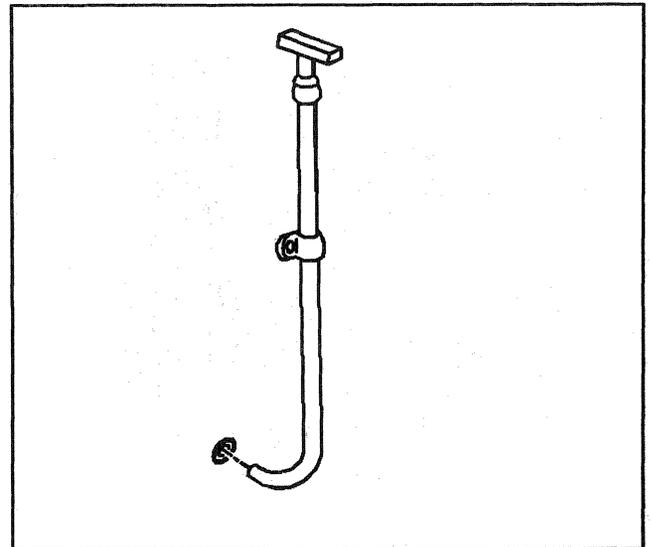
Tighten the connector hose clamps to 6 N.m (50 lb in).



59746

Oil Level Indicator and Tube Installation

1. Install a new o-ring seal to the oil level indicator tube.



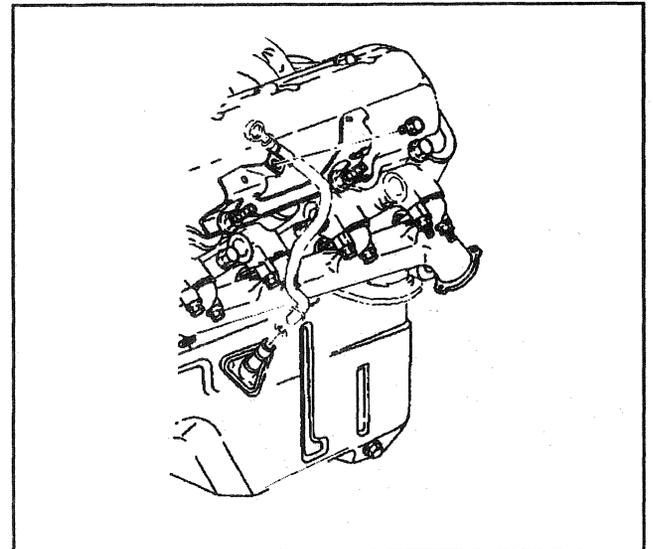
59751

2. Install the oil level indicator tube to the engine.
3. Install the oil level indicator tube bracket bolt.

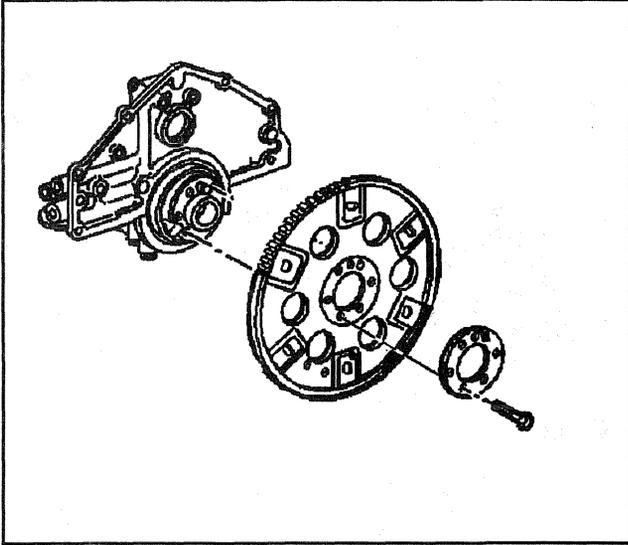
Tighten

Tighten the bolt to 4 N.m (35 lb in).

Refer to *Fastener Notice* in General Information.



60238



69008

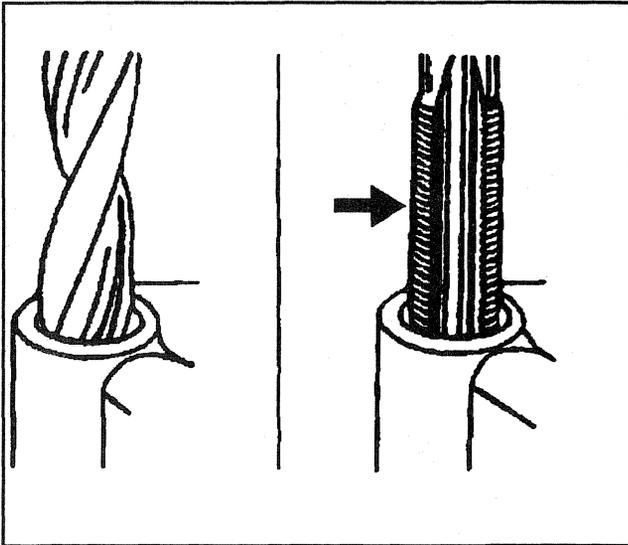
Engine Flywheel Installation

1. Install the flywheel.
2. Install the flywheel bolt.

Tighten

Tighten the bolts to 90 N·m (65 lb ft).

Refer to *Fastener Notice* in General Information.



4962

Thread Repair

Repair Procedure

Tools Required

General purpose thread repair kits. These kits are available commercially.

Caution: Wear safety glasses in order to avoid eye damage.

Important: Refer to the kit manufacturer's instructions regarding the size of the drill and tap to use.

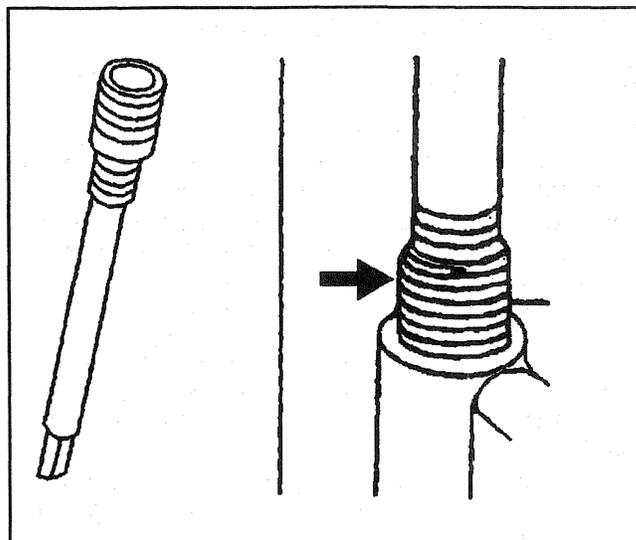
Avoid any buildup of chips. Back out the tap every few turns and remove the chips.

1. Determine the size, the pitch, and the depth of the damaged thread. If necessary, adjust the stop collars on the cutting tool and tap to the required depth.
2. Drill out the damaged threads. Clean out any chips.
3. Lubricate the tap with light engine oil. Tap the hole. Clean the threads.

4. Thread the thread insert onto the mandrel of the installer. Engage the tang of the insert onto the end of the mandrel.

Important: The insert should be flush to one turn below the surface.

5. Lubricate the insert with light engine oil (except when installing in aluminum) and install the insert.
6. If the tang of the insert does not break off when backing out the installer, break the tang off with a drift.



Description and Operation

Engine Component Description (General)

Engine Components

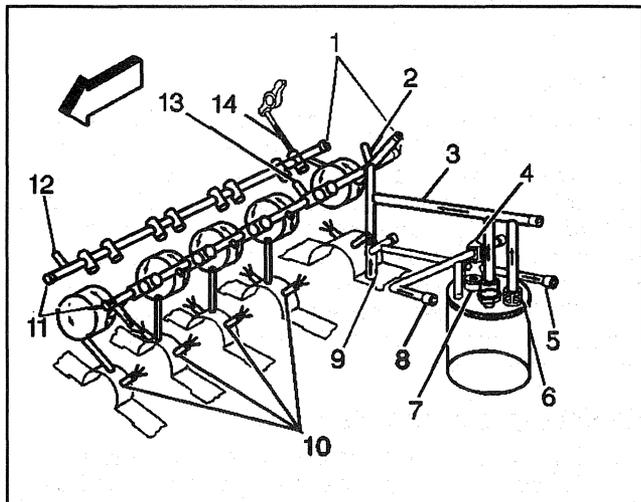
The 6.5L diesel engine is a 90 degree V8 engine with indirect-type combustion chambers.

The crankshaft is supported by five precision insert main bearings with the crankshaft thrust taken at the number three (center) main bearing.

The chain-driven camshaft is supported by five plain-type bearing. Motion from the camshaft is transmitted to the overhead valves by roller-type hydraulic lifters, pushrods, and shaft-mounted rocker arms. The valve guides are integral to the cylinder head.

The connecting rods are forged steel with precision insert-type crankshaft bearings. The piston pins are retained by snap rings.

Engine Component Description (Engine Oil Distribution)



64985

Legend

- (1) Threaded Oil Gallery Plug
- (2) Center Mount Turbocharger Oil Feed (L65-CMT)
- (3) Clean Oil to Engine
- (4) Oil Cooler Bypass Valve
- (5) To Oil Cooler
- (6) Oil Filter Bypass Valve
- (7) Cup Plug With 0.06 inch Hole
- (8) From Oil Cooler
- (9) From Oil Pump
- (10) Piston Oil Nozzle Galleries
- (11) Main Oil Galleries
- (12) Side Mount Turbocharger Oil Feed (L56, L57, L65)
- (13) To Oil Pressure Sensor
- (14) Push Rod Oil Passage To Valve Train

A gear-type oil pump pressurizes the oil with an enclosed pressure regulator. The oil pump uses a 552 kPa (80 psi) pressure regulator spring. Bronze bushings in the gears, and a plate support the gear shafts. An oil pump drive operates the oil pump. The oil pump drive is driven by the camshaft.

The oil pump draws unpressurized oil through a pickup screen and pipe and pressurizes the oil distribution system. The pickup screen and the pipe are submerged in oil inside the oil pan. The oil flows from the oil pump to an oil cooler that cools the oil. The oil cooler is located by the radiator. The oil cooler bypass valve protects the oil cooler from high pressures during cold ambient temperatures start up. The oil flows from the oil cooler or from the bypass valve to a full-flow oil filter. The oil cooler bypass valve is located in the engine block oil gallery to oil cooler passage. The oil filter bypass valve protects the engine from operating without lubrication. The oil filter bypass valve is located in the engine block above the oil filter.

The oil flows from the oil filter or the bypass valve to the main oil galleries. An oil pressure sensor is located on the left main oil gallery. The oil flows from the main oil galleries to the camshaft bearing bores. The channel in the camshaft bearing bores supplies the oil to the camshaft bearings and to the main bearing oil galleries. Oil flows from the channel in the upper main bearing shells to the holes for the piston oil spray nozzles. The piston oil spray nozzles are press-fit into the block. The piston oil spray nozzles spray oil to the underside of the pistons. This oil spray cools the pistons. The oil flows from the upper main bearing shells to the crankshaft oil galleries. The crankshaft oil galleries supply oil to the connecting rod bearings. The oil flows from the main oil galleries to the valve lifters. Oil flows from the valve lifters through hollow valve pushrods, to the valve rocker arms. The oil then flows from the main oil galleries to the turbocharger. Oil from the turbocharger drains back to the crankcase through a gallery in the block.

Tools and Equipment

- All work should be done in a clean well lit area.
- Other necessary items include:
 - A parts cleaning tank.
 - A compressed air supply
 - Trays to keep parts and tools organized
 - An adequate set of hand tools

An approved engine stand will help prevent personal injury or damage to engine components.

Special tools are illustrated throughout this section and are listed at the end under Special Tools. These tools or their equivalents are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these tools will also prevent damage to engine components.

Some precision measuring tools are necessary for inspection of critical components. Torque wrenches are necessary for the correct assembly of the engine.

Use of RTV and Anaerobic Sealer

Two types of sealer are commonly used in engines. These are RTV sealer and anaerobic gasket eliminator sealer. Follow the service procedure instructions carefully. The correct sealer must be used in the proper place and order to prevent oil leaks. Do not interchange the two types of sealers. Use the sealer recommended in the service procedure.

Applying RTV Sealer

1. Do not use Room Temperature Vulcanizing (RTV) sealant in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.
2. Use a rubber mallet to separate components sealed with RTV. Bump the part sideways to shear the RTV sealer. Bumping should be done at bends or reinforced areas to prevent distortion of components. RTV is weaker in shear (lateral) strength than in tensile (vertical) strength.
3. Remove all gasket material from the part using a plastic or wood scraper. Use Loctite® brand Gasket Remover P/N 4MA or equivalent. Follow all safety recommendations and directions that are on the container. Do not use any other method or technique to remove gasket material from a part. Do not use abrasive pads, sand paper or power tools to clean gasket surfaces. These methods of cleaning can damage the part. Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and has been known to cause internal engine damage.
4. Apply RTV to a clean surface. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from seating properly or cause damage when the bolt is tightened.
5. Assemble components while RTV is still wet (within 3 minutes). Do not wait for RTV to skin over.
6. Tighten bolts to specifications. Do not overtighten.

Applying Anaerobic Sealer

1. Anaerobic gasket eliminator hardens in the absence of air. This type sealer is used where two rigid parts (such as castings) are assembled together. When two rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
2. Remove all gasket material from the part using a plastic or wood scraper. Use Loctite® brand Gasket Remover P/N 4MA or equivalent. Follow all safety recommendations and directions that are on the container. Do not use any other method or technique to remove gasket material from a part. Do not use abrasive pads, sand

paper or power tools to clean gasket surfaces. These methods of cleaning can damage the part. Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and has been known to cause internal engine damage.

3. Apply a continuous bead of gasket eliminator to one flange. Surfaces to be resealed must be clean and dry.

Important: Anaerobic sealed joints that are partially torqued and allowed to cure more than five minutes may result in incorrect shimming and sealing of the joint.

Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from seating properly or cause damage when the bolt is tightened.

4. Spread the sealer evenly with your finger to get a uniform coating on the sealing surface.
5. Tighten bolts to specifications. Do not overtighten.
6. Remove the excess sealer from the outside of the joint.

Separating Parts

In addition to its sealing capabilities, RTV sealants can form an adhesive bond between parts that can make them difficult to remove or separate. RTV is weakest in shear strength and parts therefore should be bumped sideways if possible rather than using prying tools to remove them. This technique will prevent part damage when the bonding strength of the RTV is stronger than the part itself. Any bumping should be done at bends or reinforced areas to prevent part distortion.

Replacing Engine Gaskets

1. Do not reuse any gasket unless otherwise specified. Gaskets that can be reused will be identified in the service procedure. Do not apply sealant to any gasket or sealing surface unless called out in the service information.
2. Use a rubber mallet to separate components. Bump the part sideways to loosen the components. Bumping should be done at bends or reinforced areas to prevent distortion of parts.
3. Remove all gasket and sealing material from the part using a plastic or wood scraper. Care must be used to avoid gouging or scraping sealing surfaces. Do not use any other method or technique to remove gasket material from a part. Do not use abrasive pads, sand paper or power tools to clean gasket surfaces. These methods of cleaning can damage the part. Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and has been known to cause internal engine damage.
4. When assembling components, use only the sealant specified in the service procedure.

Sealing surfaces should be clean and free of debris or oil. When applying sealant to a component, apply a bead size as specified in the service procedure. Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from seating properly or cause damage when the bolt is tightened.

5. Tighten bolts to specifications. Do not overtighten.

Installation Precautions

General Information on Engine Service

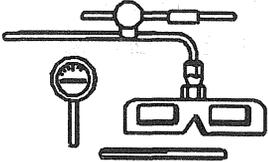
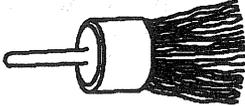
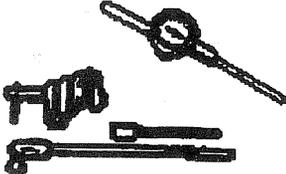
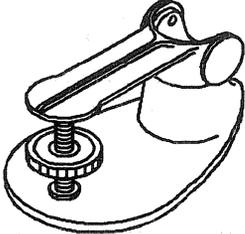
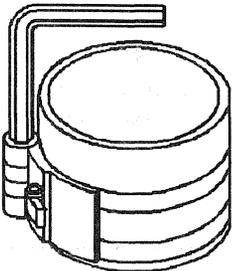
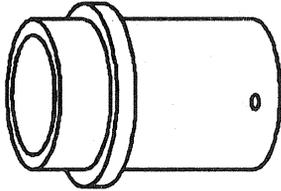
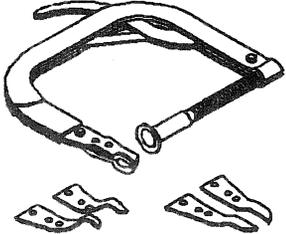
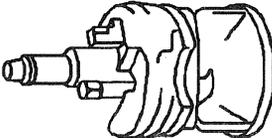
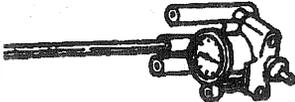
Caution: *Before removing or installing any electrical unit, or when a tool or equipment could easily come in contact with "live" or "hot all the times" exposed electrical terminals, disconnect the negative battery cable to help prevent personal injury and/or damage to the vehicle or components. Unless instructed otherwise, the ignition switch must be in the OFF or LOCK position.*

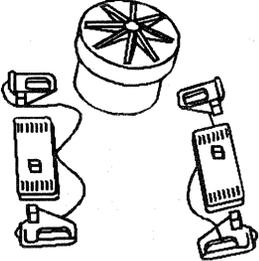
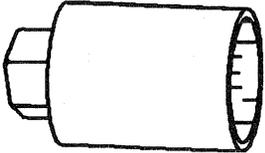
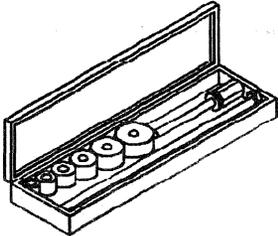
Notice: The following information on engine service should be noted carefully, as it is important in preventing damage and contributing to reliable engine performance.

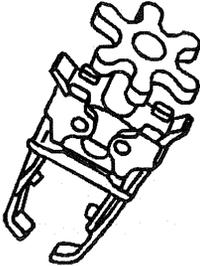
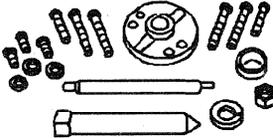
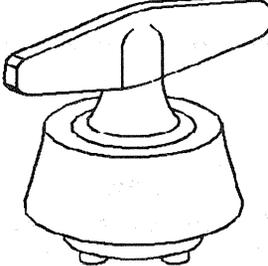
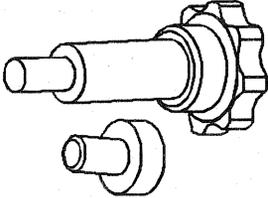
When raising or supporting the engine for any reason, do not use a jack under the oil pan. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen resulting in a damaged oil pickup unit.

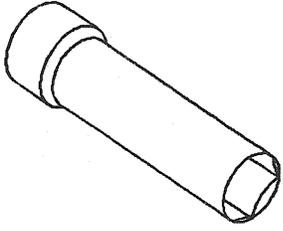
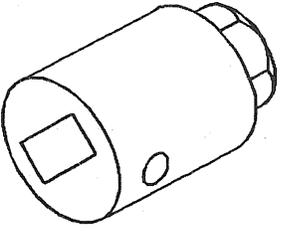
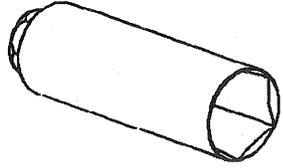
Anytime the port fuel injection assembly or air cleaner is removed, the intake opening should be covered. This will protect against the accidental entrance of foreign material which should follow the intake passage into the cylinder and cause extensive damage when the engine is started.

Special Tools and Equipment

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|  | <p>J 7872 Magnetic Base Dial Indicator</p> |  | <p>J 8089 Wire Brush</p> |
|  | <p>J 8001 Dial Indicator</p> |  | <p>J 9666 Valve Spring Tester</p> |
|  | <p>J 8037 Ring Compressor</p> |  | <p>J 22102 Front Crankshaft Seal Installer</p> |
|  | <p>J 8062 Valve Spring Compressor</p> |  | <p>J 24270 Ridge Reamer</p> |
|  | <p>J 8087 Cylinder Bore Gauge</p> |  | <p>J 26999 Compression Gauge</p> |

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|  | <p>J 26999-10 Compression Gauge Adapter</p> |
|  | <p>J 26999-30 Compression Gauge Adapter</p> |
|  | <p>J 29664 Manifold Cover Set</p> |
|  | <p>J 29873 Nozzle Socket</p> |
|  | <p>J 33049 Universal Camshaft Bearing Removal /Installer Set</p> |

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|  | <p>J 36857 Universal Lift Bracket</p> |
|  | <p>J 38606 Valve Spring Compressor</p> |
|  | <p>J 39046 Crankshaft Balancer Remover/Installer</p> |
|  | <p>J 39084 Rear Main Seal Installer</p> |
|  | <p>J 39507 Piston Pin Retainer Ring Installer</p> |

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|  | <p>J 41515-A Glow Plug Socket</p> |
|  | <p>J 41710 Oil Pressure Regulator Valve Socket</p> |
|  | <p>J 41712 Oil Pressure Sending Unit Socket</p> |

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