Engine Mechanical - 6.5L

Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accessory/Engine Lift Bracket Nut and Bolts	50 N·m	37 lb ft
Bell Housing Bolts	40 N·m	30 lb ft
Camshaft Gear Bolt	170 N·m	125 lb ft
Camshaft Thrust Plate Bolts	25 N·m	17 lb ft
Connecting Rod Cap Nuts	65 N·m	48 lb ft
Coolant Crossover Bolts/Studs	42 N·m	31 lb ft
Coolant Drain Plugs	25 N·m	18 lb ft
Crankshaft Balancer Bolt	270 N·m	200 lb ft
Crankshaft Bearing Cap Bolts		
(Inner Bolts–12 mm) First Pass	75 N·m	55 lb ft
(Inner Bolts–12 mm) Second Pass	75 N·m	55 lb ft
(Inner Bolts–12 mm) Final Pass	+ 90 Degrees	
(Outer Bolts–12 mm) First Pass	65 N·m	48 lb ft
(Outer Bolts–12 mm) Second Pass	65 N·m	48 lb ft
(Outer Bolts–12 mm) Final Pass	+ 90 Degrees	
(Outer Bolts–10 mm) Single Pass	40 N·m	30 lb ft
Crankshaft Pulley Bolts	50 N·m	37 lb ft
Crankshaft Sensor Bolt	23 N·m	17 lb ft
Cylinder Head Bolts		
First Pass	25 N·m	20 lb ft
Second Pass	75 N·m	55 lb ft
Third Pass	75 N·m	55 lb ft
Final Pass	+ 90 Degrees	
Exhaust Manifolds Bolts	35 N·m	26 lb ft
Flywheel Bolts	90 N·m	65 lb ft
Front Cover Bolts	45 N·m	33 lb ft
Fuel Filter Mount Bolts	42 N·m	31 lb ft
Fuel Filter Water Drain Valve Stud	41 N·m	31 lb ft
Fuel Injection Line Fittings to Fuel Injection Pump	33 N·m	24 lb ft
Fuel Injection Line Fittings to Fuel Injection Nozzles	33 N·m	24 lb ft
Fuel Injection Nozzles	80 N·m	59 lb ft
Fuel Injection Pump Gear Retaining Bolts	25 N·m	20 lb ft
Fuel Injection Pump Nuts	40 N·m	30 lb ft
Glow Plugs	22 N·m	16 lb ft
Intake Manifold Bolts/Studs	42 N·m	31 lb ft
Oil Cooler Line Fittings	57 N·m	42 lb ft
Oil Fill Neck Nuts	23 N·m	17 lb ft
Oil Filter Adapter Bolt	63 N·m	47 lb ft
Oil Gallery Plugs	34 N·m	25 lb ft
Oil Level Indicator Tube Bracket Bolt	4 N·m	35 lb in
Oil Pan (All Except Rear Two Bolts)	10 N·m	89 lb in
Oil Pan (Rear Two Bolts)	23 N·m	17 lb ft
Oil Pan Drain Plug	25 N·m	18 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Oil Pump Bolt	90 N·m	65 lb ft
Oil Pump Cover Screws	16 N·m	12 lb ft
Oil Pump Driver Clamp Bolt	42 N·m	31 lb ft
Thermostat Housing Bolts/Studs	47 N·m	35 lb ft
Turbocharger Connector Hose Clamps	6 N·m	50 lb in
Turbocharger Exhaust Manifold Mounting Nuts	58 N·m	43 lb ft
Turbocharger Long Brace Bolt	50 N·m	37 lb ft
Turbocharger Long Brace Nut	34 N·m	26 lb ft
Turbocharger Oil Feed Line Fittings	28 N·m	21 lb ft
Turbocharger Oil Return Pipe Bolts	26 N·m	19 lb ft
Turbocharger Short Brace Bolts	25 N·m	18 lb ft
Upper Intake Connector Hose Clamps	6 N·m	50 lb in
Upper Intake Manifold To Intake Manifold Bolts	23 N·m	17 lb ft
Valve Lifter Guide Plate Clamp Bolts	27 N·m	20 lb ft
Valve Rocker Arm Cover Bolts	27 N·m	20 lb ft
Valve Rocker Arm Shaft Bolts	55 N·m	40 lb ft
Water Pump Plate to Coolant Pump Bolts	28 N·m	20 lb ft
Water Pump Plate to Front Cover Bolts	28 N·m	20 lb ft
Water Pump to Front Cover Bolts	42 N·m	32 lb ft

Engine Mechanical Specifications (L65)

Application	Specification	
	Metric	English
General Data		
Type	V8	
Displacement	6.5L	396CID
Bore	103 mm	4.0600 cu in
Stroke	97 mm	3.8200 cu in
Compression Ratio	20.2:1	
Cylinder Compression (Sea Level)	2,550 kPa minimum (subtract 55 kPa per 305 m of elevation above sea level)	370 psi minimum (subtract 8 psi per 1,000 ft of elevation above sea level)
Firing Order	1–8–7–2–6–5–4–3	
Cranking RPM (Cold)	100–RPM minimum	
Cranking RPM (Hot)	180–RPM minimum	
Oil Pressure (Mechanical Gage) (Hot)	41 kPa minimum @ IDLE 207–296 kPa minimum @ 2000 RPM	6 psi minimum @ IDLE 30–43 psi minimum @ 2000 RPM
Operating Temperature	88°C	190°F
Crankshaft Bore		
ID	79.8260-79.8500 mm	3.1427-3.1437 in
Out-of-Round	0.0830 mm maximum	0.0033 in maximum
Camshaft Bore		
ID (1)	59.1200-59.1700 mm	2.3290-2.3310 in
ID (2)	58.8700-58.9200 mm	2.3190-2.3210 in
ID (3)	58.6200-58.6700 mm	2.3100v2.3120 in
ID (4)	58.3700-58.4200 mm	2.2980-2.3020 in

Engine Mechanical Specifications (L65) (cont'd)

Application	Specification	
	Metric	English
ID (5)	54.3700-54.4200 mm	2.1406-2.1425 in
Out-of-Round	0.1000 mm maximum	0.0039 in maximum
Cylinder Bore		
Production STD (J) ID (1-6)	102.9720–102.9900 mm	4.0571–4.0578 in
Production STD (J) ID (7-8)	102.9850–103.0030 mm	4.0576–4.0583 in
Production O.S. (S) ID (1-6)	103.1170–103.1300 mm	4.0628–4.0633 in
Production O.S. (S) ID (7-8)	103.1300–103.1430 mm	4.0633–4.0638 in
Service Hi Limit (G) ID (1-6)	103.0130–103.0260 mm	4.0587–4.0592 in
Service Hi Limit (G) ID (7-8)	103.0260–103.0390 mm	4.0592–4.0597 in
Service O.S. (OS) ID (1-6)	103.5080–103.5120 mm	4.0782–4.0784 in
Service O.S. (OS) ID (7-8)	103.5210–103.5250 mm	4.0787–4.0789 in
Piston		
Production STD (J or JT) OD (1-6)	102.8650-102.8830 mm	4.0529-4.0536 in
Production STD (J or JT) OD (7-8)	102.8650-102.8830 mm	4.0529-4.0536 in
Production O.S. (S or ST) OD (1-6)	103.0080-103.0260 mm	4.0585-4.0592 in
Production O.S. (S or ST) OD (7-8)	103.0080-103.0260 mm	4.0585-4.0592 in
Service STD (JT) OD (1-6)	102.8650-102.8830 mm	4.0529-4.0536 in
Service STD (JT) OD (7-8)	102.8650-102.8830 mm	4.0529-4.0536 in
Service Hi Limit (GT) OD (1-6)	102.9040-102.9220 mm	4.0544-4.0551 in
Service Hi Limit (GT) OD (7-8)	102.9040-102.9220 mm	4.0544-4.0551 in
Service OS (0.50 OST) OD (1-6)	103.399-103.417 mm	4.0739-4.0746 in
Service OS (0.50 OST) OD (7-8)	103.399-103.417 mm	4.0739-4.0746 in
Out-of-Round	0.0200 mm maximum	0.0008 in maximum
Taper	0.0200 mm maximum	0.0008 in maximum
Cylinder Bore Clearance (1-6)	0.0890–0.1250 mm	0.0035–0.0049 in
Cylinder Bore Clearance (7-8)	0.1020–0.1380 mm	0.0040–0.0054 in
Cylinder Bore Protrusion	0.0900–0.3100 mm	0.0035–0.0122 in
Pin OD (Green)	30.9961–30.9987 mm	1.2203–1.2204 in
Pin OD (Orange)	30.9987–31.0013 mm	1.2204–1.2205 in
Pin Bore ID (Green)	31.0088-31.0114 mm	1.2208-1.2209 in
Pin Bore ID (Orange)	31.0114-31.0140 mm	1.2209-1.2210 in
Pin Bore Clearance	0.0101–0.153 mm	0.0004–0.0006 in
Piston Ring (Compression)		
Side Clearance (Top Ring)	Keystone-Type Ring	
Side Clearance (Second Ring)	0.0390–0.0790 mm	0.0015–0.0052 in
Gap (Top Ring) (1-6)	0.2500–0.5700 mm	0.0100–0.0220 in
Gap (Top Ring) (7-8)	0.2900–0.6100 mm	0.0120–0.0240 in
Gap (Second Ring) (1-6)	0.7200–1.0300 mm	0.0280–0.0410 in
Gap (Second Ring) (7-8)	0.7600–1.0700 mm	0.0300–0.0430 in
Piston Ring (Oil)		
Side Clearance	0.0400–0.0900 mm	0.0016–0.0035 in

Engine Mechanical Specifications (L65) (cont'd)

Application	Specification	
	Metric	English
Gap	0.2500–0.5100 mm	0.0100–0.0200 in
Connecting Rod		
ID (Crankshaft Rod Journal End)	64.1240-64.1500 mm	2.5265-2.5275 in
ID (Piston Pin End-With Bushing)	31.0120-31.0270 mm	1.2209-1.2215 in
Piston Pin Bushing Clearance	0.0081–0.0309 mm	0.0003–0.0012 in
Crankshaft Journal (Main)		
OD (White) (1-4)	74.9330–74.9420 mm	2.9524–2.9527 in
OD (White) (5)	74.9280–74.9360 mm	2.9522–2.9525 in
OD (Orange or Red) (1-4)	74.9250–74.9330 mm	2.9520–2.9524 in
OD (Orange or Red) (5)	74.9200–74.9280 mm	2.9518–2.9522 in
OD (Blue) (1-4)	74.9170–74.9250 mm	2.9517–2.9520 in
OD (Blue) (5)	74.9120–74.9200 mm	2.9515–2.9518 in
Taper	0.0830 mm maximum	0.0033 in maximum
Out-of-Round	0.0830 mm maximum	0.0033 in maximum
Bearing Clearance (1-4)	0.0450–0.0830 mm	0.0018–0.0033 in
Bearing Clearance (5)	0.0550–0.0920 mm	0.0022–0.0037 in
Crankshaft Journal (Rod)		
OD (Yellow)	60.9260–60.9390 mm	2.4000–2.4010 in
OD (Green)	60.9130–60.9260 mm	2.3990–2.4000 in
Taper	0.0050–0.0830 mm maximum	0.0018–0.0033 in maximum
Out-of-Round	0.0050–0.0830 mm maximum	0.0018–0.0033 in maximum
Bearing Clearance	0.0350–0.0900 mm	0.0014–0.0035 in
Side Clearance	0.1700–0.0305 mm	0.0020–0.0120 in
End Play	0.1000–0.2500 mm	0.0039–0.0010 in
Crankshaft Bearing (Main)–Select Fit: Refer to *Crankshaft and Bearings Installation (L65).*		
White (1)	STD in Case, STD in Cap	STD in Case, STD in Cap
White (2)	0.013 mm U.S. in Case, STD in Cap	0.0005 in U.S. in Case, STD in Cap
White (3)	0.026 mm U.S. in Case, STD in Cap	0.0010 in U.S. in Case, STD in Cap
Orange or Red (1)	STD in Case, 0.013 mm U.S. in Cap	STD in Case, 0.0005 in U.S. in Cap
Orange or Red (2)	0.013 mm U.S. in Case, 0.013 mm U.S. in Cap	0.0005 in U.S. in Case, 0.0005 in U.S. in Cap
Blue (1)	STD in Case, 0.026 mm U.S. in Cap	STD in Case, 0.0010 in U.S. in Cap
Blue (2)	0.013 mm U.S. in Case, 0.026 mm U.S. in Cap	0.0005 in U.S. in Case, 0.0010 in U.S. in Cap
Blue (3)	0.026 mm U.S. in Case, 0.026 mm U.S. in Cap	0.0010 in U.S. in Case, 0.0010 in U.S. in Cap
Crankshaft Bearing (Rod)–Select Fit: Refer to *Crankshaft and Bearings Installation (L65).*		
Yellow	STD in Rod, STD in Cap	STD in Rod, STD in Cap
Green	STD in Rod, 0.026 mm U.S. in Cap	STD in Rod, 0.0010 in U.S. in Cap
Camshaft		
Journal OD (1-4)	54.9700–55.0130 mm	2.1642–2.1659 in

Engine Mechanical Specifications (L65) (cont'd)

Application	Specification	
	Metric	English
Journal OD (5)	50.9760–51.0190 mm	2.0069–2.0086 in
Journal Clearance (1-4)	0.0250–0.1180 mm	0.0010–0.0046 in
Journal Clearance (5)	0.0200–0.1130 mm	0.0008–0.0044 in
Intake Lobe Lift	7.0830-7.1830 mm	0.2790-0.2830 in
Exhaust Lobe Lift	7.0830-7.1830 mm	0.2790-0.2830 in
End Play	0.51–0.305 mm	0.0020–0.0120 in
Timing Chain Deflection (Free Play) (New Chain)	12.7000 mm	0.5000 in
Timing Chain Deflection (Free Play) (Used Chain)	20.3000 mm	0.8000 in
Valve System		
Valve Lifter	Hydraulic Roller	
Valve Rocker Arm Ratio	1.50:1	
Valve Lash	Non-Adjustable	
Valve Face Angle (Intake)	45 degrees	
Valve Face Angle (Exhaust)	45 degrees	
Valve Seat Angle (Intake)	46 degrees	
Valve Seat Angle (Exhaust)	46 degrees	
Valve Runout (Intake)	0.5000 mm	0.0020 in
Valve Runout (Exhaust)	0.5000 mm	0.0020 in
Seat Width (Intake)	0.8900–1.5300 mm	0.0351–0.0603 in
Seat Width (Exhaust)	1.5700–2.3600 mm	0.0618–0.0930 in
Valve Protrusion (Intake) (This is a negative value, as the valve is recessed in the head)	-0.8600 to -1.2200 mm	-0.0340 to -0.0480 in
Valve Protrusion (Exhaust) (This is a negative value, as the valve is recessed in the head)	-0.8600 to -1.2200 mm	-0.0340 to -0.0480 in
Stem Clearance (Intake)	0.0260–0.0690 mm	0.0010–0.0027 in
Stem Clearance (Exhaust)	0.0260–0.0690 mm	0.0010–0.0027 in
Valve Spring Pressure (Closed) (Intake)	356 N·m @ 46	80 lb @ 1.80 in
Valve Spring Pressure (Closed) (Exhaust)	356 N·m @ 46	80 lb @ 1.80 in
Valve Spring Pressure (Open) (Intake)	1025 N·m @ 35.3	230 lb 1.40 in
Valve Spring Pressure (Open) (Exhaust)	1025 N·m @ 35.3	230 lb 1.40 in
Valve Spring Installed Height (Intake)	46 mm	1.8000 in
Valve Spring Installed Height (Exhaust)	46 mm	1.8000 in

Vacuum Pump Specifications

Application	Specification	
	Metric	English
Elevation		
0 m (0 ft) (Sea Level)	-70 kPa (minimum)	21 in (minimum)
1 524 m (5,000 ft)	-60 kPa (minimum)	18 in (minimum)
3 048 m (10,000 ft)	-49 kPa (minimum)	14 in (minimum)
4 572 m (15,000 ft)	-40 kPa (minimum)	12 in (minimum)

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
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

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
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

Sealers, Adhesives, and Lubricants

Application	Type Of Material	GM Part Number
Crankshaft Keyway	RTV Sealant	12346286
Cylinder Head Bolts	Pipe Sealant with Teflon®	12346004
Front Engine Cover	RTV Sealant	12346286
Lower Intake Manifold Bolts	Loctite® 242	12345382
Oil Filter Adapter Pipe Plugs	Pipe Sealant with Teflon®	12346004
Oil Pan	RTV Sealant	12346286
Rear Camshaft Plug	Loctite® 272	12345493
Upper Intake Manifold Bolts	Loctite® 272	12345493
Valve Rocker Arm Cover	RTV Sealant	12346286

Diagnostic Information and Procedures

Engine Cranking Speed Test

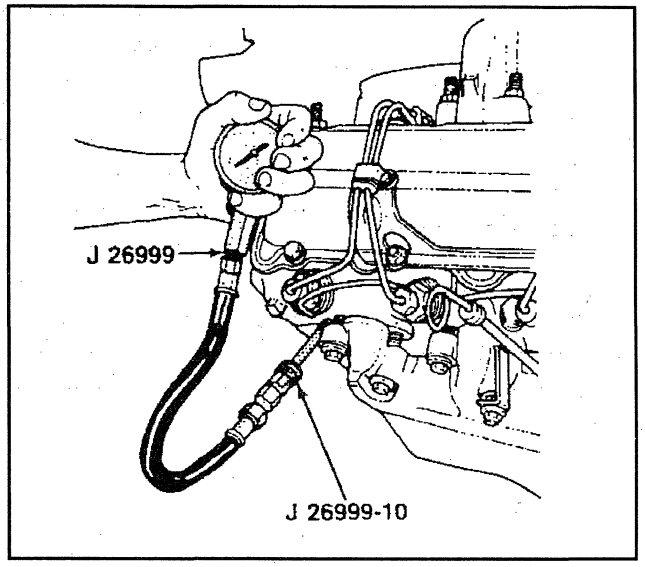
Important:

- 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. The primary method of testing cranking speed or determining the accuracy of a tachometer is to use a scan tool.
- Ensure that the vehicle's batteries are in good condition, and fully charged, prior to performing this test.

1. Remove the fuel solenoid fuse.
2. Install the scan tool.
3. Crank the engine for 2 to 4 seconds. This will allow the starter to reach it's maximum performance.
4. Observe the engine RPM reading on the scan tool.
   - The minimum cold cranking speed required for the 6.5L diesel engine is 100 RPM.
   - The minimum hot cranking speed required for the 6.5L diesel engine is 180 RPM.
   - The actual cranking speed needed for starting will vary depending on the condition of the engine mechanical components (compression), and the condition of the fuel system components (fuel injection pump operating pressure, and fuel injection nozzles cracking pressure and spray pattern).
5. Observe the engine RPM reading on the tachometer (if desired).

Engine Vacuum Pump Test

1. Operate the engine until it reaches normal operating temperature.
2. Disconnect the engine vacuum harness from the vacuum pump inlet pipe.
3. Connect the J 23951 Manometer (or any standard vacuum gage) to the vacuum pump inlet pipe.
4. Operate the engine at an idle for 30 seconds. If the engine operates for longer than 30 seconds, or if the engine does not operate at an idle, vent the manometer and repeat this step.
5. While operating the engine, observe the manometer reading. Refer to Engine Mechanical Specifications.
6. If the vacuum pump fails to meet the minimum specifications, replace the vacuum pump and retest.



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Engine Compression Test (C/K)

Tools Required

- *J 26999* Compression Gauge
- *J 26999-10* Compression Gauge Adapter
- *J 26999-30* Compression Gauge Adapter
- *J 41515-A* Glow Plug Socket

1. Ensure that the vehicle's batteries are in good condition, and fully charged. Refer to *Battery Load Test* in Engine Electrical.
2. Operate the vehicle until the engine is at normal operating temperature.
3. Check the engine cranking speed. The minimum cranking speed specification must be met to obtain valid test results. Refer to *Engine Cranking Speed Test*.
4. Remove the fuel solenoid driver fuse.
5. Using the *J 41515-A* Glow Plug Socket, remove all eight glow plugs. All eight glow plugs must be removed from the engine during each cylinder test to obtain valid test results.

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

6. Install the *J 26999-10* Compression Gauge Adapter, or the *J 26999-30* Compression Gauge Adapter, as appropriate, in the glow plug hole for the cylinder that is being checked.
7. Connect the *J 26999* Compression Gauge to the Compression Gauge Adapter.
8. Using the vehicle's starter motor, rotate (crank) the engine for ten compression strokes (puffs) for the cylinder being tested. If the engine rotates for more than ten compression strokes, re-test the cylinder.
   - Normal: The compression builds up quickly and evenly to the minimum specified compression.
   - Leaking: The compression is low on the first compression stroke. The compression builds up on the following compression strokes but does not reach the minimum specified compression.
9. Record the compression reading.
10. Disconnect the Compression Gauge from the Compression Gauge Adapter.
11. Remove the Compression Gauge Adapter.
12. Repeat steps 5 through 11 for all remaining cylinders. All eight cylinders must be tested to obtain valid test results.
13. Check the compression readings. Refer to *Engine Mechanical Specifications (L65)*.
14. If one or more cylinders fails to meet the minimum specified compression, repair or replace damaged or malfunctioning components and retest.
15. Using the *J 41515-A* Glow Plug Socket, install all eight glow plugs.
16. Install the fuel solenoid driver fuse.

Engine Noise Diagnosis

Engine Knock Noise (Fuel Knock)

Problem	Action
DEFINITION: A stuck fuel injection nozzle can cause a knocking noise similar to a damaged piston, rod, or rod bearing.	
Leaking Fuel Injection Nozzle.	• Use the cylinder balance diagnostic procedure to help locate the cylinder that is the source of the noise. • Exchange the fuel injection nozzle for one in an adjacent cylinder to see if the condition persists. • If the condition follows the fuel injection nozzle to the adjacent cylinder, and disappears from the original cylinder, the fuel injection nozzle is at fault. Exchange or replace the fuel injection nozzle. • If the condition does not change, or you still cannot locate the cylinder that is the source of the noise, diagnose the engine for mechanical damage.

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

Problem	Action
DEFINITION: Contaminated or insufficient oil supply can cause intermittant noise from valve train components.	
Dirt in the Valve lifter.	Replace all damaged components.
Pitting on the valve lifter check ball.	Replace all damaged components.

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

Problem	Action
DEFINITION: Possible causes of the intermittent noise include the following conditions:	
High Valve Lifter leak Down Rate	Repair or replace all damaged components.

Noise at High Vehicle Speeds, Quiet at Low Vehicle Speeds

Problem	Action
DEFINITION: Possible causes of the intermittent noise include the following conditions:	
High engine 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, as a solid column of oil is required for proper operation. Drain engine oil to the proper level.
Low engine 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. Fill engine oil to the proper level.
Oil pan bent against the oil pump pickup tube or screen.	Repair or replace all damaged components.
Oil pump pickup tube or screen bent or loose.	Repair or replace all damaged components.

Noise Regardless of Engine Speed

Problem	Action
DEFINITION: Possible causes of the noise include the following conditions:	
Excessive Valve Lash.	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 correct, the pushrod can be moved up and down a small amount with the valve rocker arm held against the valve.
Worn Pushrod Upper End Ball.	Repair or replace all damaged components.
Bent Pushrod.	Repair or replace all damaged components.
Improper Lubrication of the Pushrod.	Repair or replace all damaged components.
Loose or Damaged Valve Rocker Arm.	Repair or replace all damaged components.
Damaged or Failed Lifter.	Repair or replace all damaged components.

Valve Train Noise

Problem	Action
DEFINITION: The following conditions may cause valve train noise:	
Low Oil Pressure.	Repair or replace all damaged components.
Loose Valve Rocker Arm Attachments.	Repair or replace all damaged components.
Worn Valve Rocker Arm and/or Pushrod.	Repair or replace all damaged components.
Broken Valve Spring.	Repair or replace all damaged components.
Sticking Valve.	Repair or replace all damaged components.
Worn, Dirty or Faulty Valve Lifter.	Repair or replace all damaged components.
Worn or Faulty Camshaft.	Repair or replace all damaged components.
Worn Valve Guide.	Repair or replace all damaged components.

Vibrating or Rattling from Exhaust System

Problem	Action
DEFINITION: Vibration or rattling from the exhaust system may be caused by loose and/or misaligned exhaust components.	
Vibration or Rattle Noise.	Align and tighten all connections. Repair or replace all damaged components.

Exhaust Leakage and/or Noise

Problem	Action
DEFINITION: Possible causes of the noise include the following conditions:	
Leakage at One or More of the Exhaust System Joints and/or Couplings.	Repair or replace all damaged components.
Improperly Installed or Misaligned Exhaust System.	Repair or replace all damaged components.
Cracked or Broken Exhaust Manifold.	Repair or replace all damaged components.
Leak Between the Exhaust Manifold and the Cylinder head.	Repair or replace all damaged components.
Burned, Blown or Rusted Out Exhaust Pipe or Muffler.	Repair or replace all damaged components.

Valve Train Diagnosis

A light tapping at one-half engine speed, or any varying frequency, can indicate a valve train problem.

These tapping noises increase with engine speed.

Before attempting to judge the valve train noises thoroughly warm up the engine. By doing this you will bring all engine components to a normal state of expansion. Also, run the engine at various speeds and listen for engine noise with the hood closed while sitting in the driver's seat. The causes of the valve train noise include the following conditions:

- Incorrectly adjusted valve lash
- Low oil pressure
- Loose valve rocker arm attachments
- Worn valve rocker arm and/or pushrod
- Broken valve spring
- Sticking valves
- Lifters worn, dirty or faulty
- Camshaft lobes worn
- Worn valve guides
- Worn or damaged valve keys
- Bent pushrods

Oil Pressure Diagnosis and Testing

Step	Action	Value(s)	Yes	No
DEFINITION: Low or no engine oil pressure indicates a potentially serious condition with all of the engine mechanical components. Once the cause of the low or no oil pressure condition has been identified, repair all collateral damage to the engine mechanical components as well as the initial cause of the condition.				
1	Check engine oil level. Use only the GM service parts brand and recommended grade of engine oil specified for the vehicle. Is the engine oil level between ADD and FULL on the oil level indicator?	—	*Go to Step 2*	—
2	1. Operate vehicle until engine reaches normal operating temperature. Refer to Engine Mechanical Specifications. 2. Park vehicle on a level surface. 3. Wait (15 minutes). 4. Check engine oil level. Use only the GM service parts brand and recommended grade of engine oil specified for the vehicle. Is the engine oil level between ADD and FULL on the oil level indicator?	—	*Go to Step 3*	—
3	Operate the engine and measure the engine oil pressure with the vehicle gauge or light. Refer to Engine Mechanical Specifications. Is engine oil pressure within specification?	—	System OK	*Go to Step 4*
4	1. Remove the oil pressure sender or engine block oil gallery plug. 2. Install a mechanical oil pressure gauge. 3. Operate the engine and measure the engine oil pressure with the mechanical oil pressure gauge. Refer to Engine Mechanical Specifications. Is engine oil pressure within specification?	—	System OK	*Go to Step 5*
5	Change the engine oil and filter. • Use only the GM service parts brand and recommended grade of engine oil specified for the vehicle. • Use only the GM service parts brand and recommended type of engine oil filter specified for the vehicle. Operate the engine and measure the engine oil pressure with the mechanical oil pressure gauge. Refer to Engine Mechanical Specifications. Is engine oil pressure within specification?	—	System OK	*Go to Step 6*

Oil Pressure Diagnosis and Testing (cont'd)

Step	Action	Value(s)	Yes	No
6	1. Inspect the engine for mechanical damage. Special interest should be shown to the following areas: • Twisted oil cooler lines. • Malfunctioning oil bypass valve • Oil pump worn or dirty • Oil pump-to-engine block bolts loose • Oil pump screen loose, plugged, or damaged • Oil pump screen O-ring seal missing or damaged • Malfunctioning oil pump pressure regulator valve • Excessive bearing clearance • Cracked, porous or restricted oil galleries • Oil gallery plugs missing or incorrectly installed • Damaged or missing oil spray cooling nozzles • Broken valve lifters 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	—	*Go to Step 7*	*Go to Step 1*
7	Repair or replace all damaged or modified components. Is the repair complete?	—	*Go to Step 1*	—

Oil Leak Diagnosis

Step	Action	Value(s)	Yes	No
DEFINITION: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.				
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait (15 minutes). 4. Check for drippings. Are drippings present?	—	Go to *Step 2*	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 3*
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 4*
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait (15 minutes). 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 5*

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 6*
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 7*
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 8*
8	Use *J 28428-E*, Dye and Light Kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	Go to *Step 9*
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to *Step 10*	System OK

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	—	Go to *Step 11*	System OK
11	Repair or replace all damaged or modified components. Does the engine stll leak oil?	—	Go to *Step 1*	—

Drive Belt Diagnosis

Definitions

The following are symptomatic noises of the drive belt system:

Chirping

The following items are indications of chirping:

- A high pitched noise that is usually heard once per revolution of a pulley or a belt.
- It is most common on cold, damp mornings.
- Verify this condition by squirting water onto the belt. The noise will momentarily stop.

Squeal

The following items are indications of squeal:

- A loud screeching noise that is caused by a slipping belt (this is unusual for a belt with multiple ribs).
- The noise occurs when a heavy load is applied to the belt, such as an air conditioning compressor engagement, snapping the throttle, or slipping on a seized pulley.

Whine

A high pitched continuous noise that may be caused by a failed bearing.

Faint Cycle Rumbling

A low frequency noise heard once per revolution of the drive belt.

Pilling

The following items are indications of pilling:

- The random accumulation of rubber dust in the bottom of the multi-ribbed belt grooves.
- A small amount of pilling is normal.
- Operation of the drive belt system will not be effected unless the buildup exceeds one third (1/3) of the belt groove depth.

Multiple-ribbed type drive belts wear evenly with their pulleys. Unusual wear indicates a correction is needed. The following diagnostic tables will aid in diagnosing drive belt system conditions.

Drive Belt Diagnosis

Step	Action	Value(s)	Yes	No
DEFINITION: A high pitched noise ususally heard once per revolution of a pulley or belt. It is usually heard at idle and is most common on cold damp mornings. Squirting water on a chirping belt will usually cause the noise to momentarily go away.				
1	Check for misalignment of the pulleys. Are any of the pulleys misaligned?	—	*Go to Step 2*	*Go to Step 3*
2	Replace any misaligned pulleys. Is the chirp still present?	—	*Go to Step 3*	System OK
3	Check for bent or cracked brackets. Are there any bent or cracked brackets?	—	*Go to Step 4*	*Go to Step 5*

Drive Belt Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
4	Replace any bent or cracked brackets. Is the chirp still present?	—	*Go to Step 5*	System OK
5	Check for any loose or missing fasteners. Are there any loose or missing fasteners?	—	*Go to Step 6*	*Go to Step 7*
6	Tighten any loose fasteners and properly install any missing fasteners. Refer to *Fastener Notice.* Is the chirp still present?	—	*Go to Step 7*	System OK
7	Check for a bent pulley flange. Is the pulley flange bent?	—	*Go to Step 8*	*Go to Step 9*
8	Replace the pulley flange. Is the chirp still present?	—	*Go to Step 9*	System OK
9	Check for severe pilling, exceeding 1/3 of the belt groove depth. Is there severe pilling?	—	*Go to Step 10*	—
10	Replace the accessory drive belt. Refer to *Drive Belt Replacement (6.5L Drive Belt).* Is the chirp still present?	—	—	System OK

Drive Belt Squeal

Step	Action	Value(s)	Yes	No
1	Check for a misaligned pulley. Is there a pulley misaligned?	—	*Go to Step 3*	*Go to Step 2*
2	Check for incorrect belt length, refer to *Drive Belt Tensioner Diagnosis.* Is the belt length correct?	—	*Go to Step 4*	*Go to Step 3*
3	Repair or install new parts as necessary. Is the repair complete?	—	System OK	—
4	Check for a malfunctioning drive belt tensioner, refer to *Drive Belt Tensioner Diagnosis.* Is the tensioner malfunctioning?	—	*Go to Step 3*	*Go to Step 5*
5	Check for correct pulley size. Are the pulleys the correct size?	—	*Go to Step 6*	*Go to Step 3*
6	Check for siezed bearings. Is there a siezed bearing?	—	*Go to Step 3*	System OK

Drive Belt Whine

Step	Action	Value	Yes	No
1	Check for a worn accessory component bearing. Is a bearing making the noise?	—	*Go to Step 2*	System OK
2	Install new parts as necessary Is the repair complete?	—	System OK	—

Drive Belt Rumbling

Step	Action	Value(s)	Yes	No
1	Check for severe pilling. Is there severe pilling of more than 1/3 of the rib depth?	—	*Go to Step 2*	System OK
2	Clean the drive belt pulleys. Are the drive belt pulleys clean?	—	*Go to Step 3*	*Go to Step 2*
3	Install a new accessory drive belt. Is the repair complete?	—	System OK	—

Drive Belt Vibration

Step	Action	Value(s)	Yes	No
1	Check for loose or missing fasteners. Are there loose or missing fasteners?	—	*Go to Step 2*	*Go to Step 3*
2	Re-tighten or replace as necessary. Is the repair complete?	—	System OK	—
3	Check for damaged fan blades. Are there damaged fan blades?	—	*Go to Step 4*	*Go to Step 5*
4	Replace as necessary. Refer to Fan Blade Replacement in Engine Cooling. Is the replacement complete?	—	System OK	—
5	Check for a bent fan clutch or coolant pump shaft. Is the fan clutch or coolant pump shaft bent?	—	*Go to Step 6*	*Go to Step 7*
6	Replace as necessary. Refer to Water Pump Replacement in Engine Cooling. Is the repair complete?	—	System OK	—
7	Check for bent or cracked brackets. Are there bent or cracked brackets?	—	*Go to Step 8*	System OK
8	Replace the brackets as necessary. Is the repair complete?	—	System OK	—

Drive Belt Falls Off

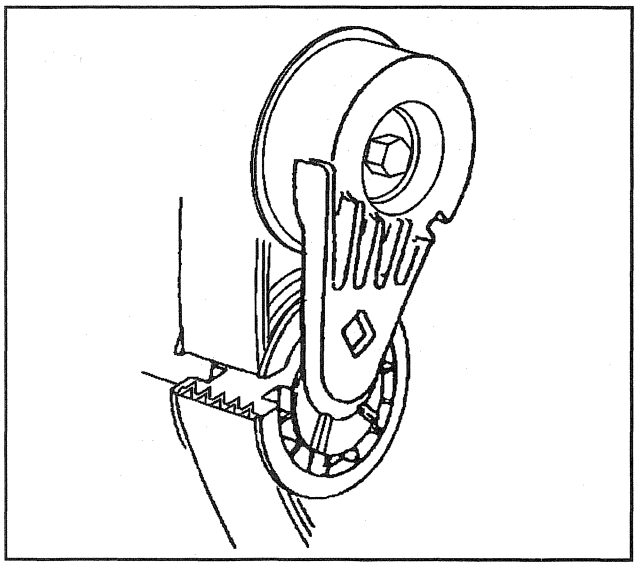
Step	Action	Value(s)	Yes	No
1	Check for a misaligned or a bent pulley. Are the pulleys misaligned?	—	*Go to Step 2*	*Go to Step 3*
2	Replace any misaligned or bent pulleys. Does the drive belt continue to fall off?	—	*Go to Step 3*	System OK
3	Check for a bent or a cracked bracket. Are any of the brackets bent or cracked?	—	*Go to Step 4*	*Go to Step 5*
4	Replace the damaged brackets. Does the drive belt continue to fall off?	—	*Go to Step 5*	System OK
5	Check for loose or missing fasteners. Are there any loose or missing fasteners?	—	*Go to Step 6*	*Go to Step 7*
6	Replace any missing fasteners and tighten to specifications. Refer to *Fastener Notice*. Does the drive belt continue to fall off?	—	*Go to Step 7*	System OK
7	Check for a misaligned power steering pump pulley. Is the power steering pump pulley misaligned?	—	*Go to Step 8*	*Go to Step 9*
8	Realign or replace the power steering pump pulley. Refer to Power Steering Pump Replacement in Power Steering. Does the drive belt continue to fall off?	—	*Go to Step 9*	System OK
9	Check for a damaged drive belt. Is the drive belt damaged?	—	*Go to Step 10*	*Go to Step 11*
10	Replace the drive belt. Refer to *Drive Belt Replacement (6.5L Drive Belt)*. Does the drive belt continue to fall off?	—	*Go to Step 11*	System OK
11	Check for a malfunctioning drive belt tensioner. Is the drive belt tensioner malfunctioning?	—	*Go to Step 12*	*Go to Step 13*
12	Replace the drive belt tensioner. Does the drive belt continue to fall off?	—	*Go to Step 13*	System OK
13	Check for worn idler or tensioner pulley bearings. Are the idler or tensioner pulley bearings worn?	—	*Go to Step 14*	—
14	Replace the worn bearings. Does the drive belt continue to fall off?	—	—	System OK

Drive Belt Diagnosis

Step	Action	Value(s)	Yes	No
1	Check to see if the ribs in the drive belt do not match the grooves in the pulley. Do the ribs in the drive belt match the grooves in the pulley?	—	—	*Go to Step 2*
2	Replace the drive belt. Is there still excessive wear in either outside groove of the drive belt?	—	—	System OK

General Instructions

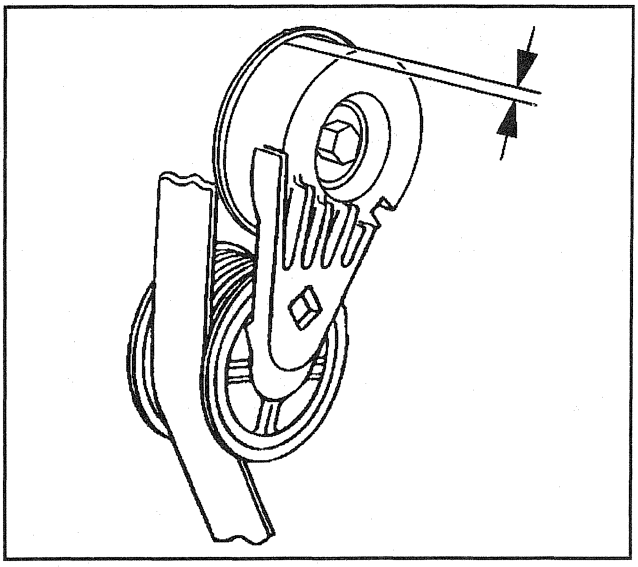
The following graphics illustrate the correct way to route the drive belt over the pulleys, and some examples of incorrect belt placement.



172992

1. Observe the drive belt correctly installed on the pulley.

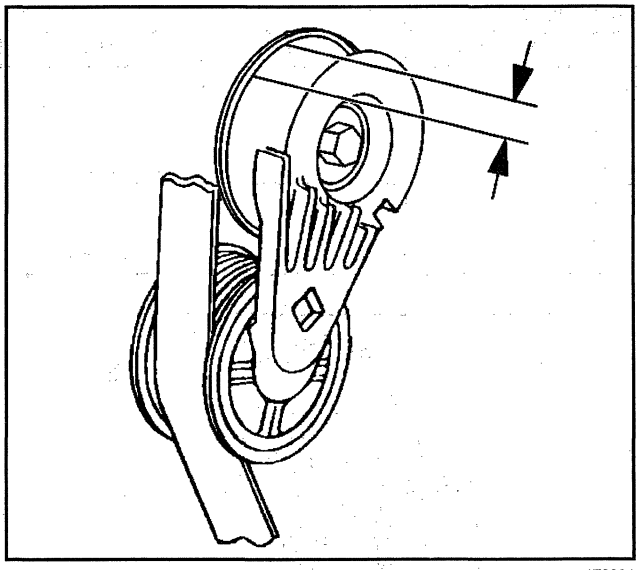
   Each groove on the drive belt rests inside a matching groove in the pulley.



172989

2. When installing a new drive belt, observe the indicator on the tensioner.

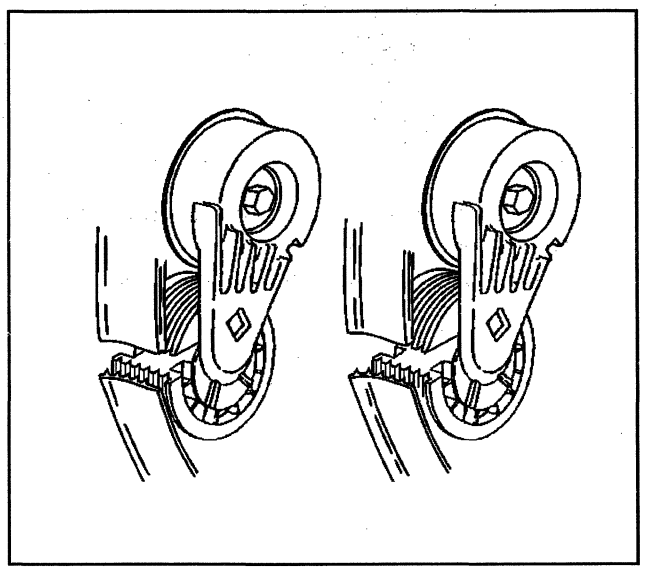
   A new drive belt should fall inside this range.



172991

3. When installing a used drive belt, observe the indicator on the tensioner.

   A used drive belt should fall inside this range.



172993

4. Observe these incorrectly installed drive belts:

   Avoid mis-positioning the belt by one or more grooves.

Drive Belt Tensioner Diagnosis

Inspection Procedure

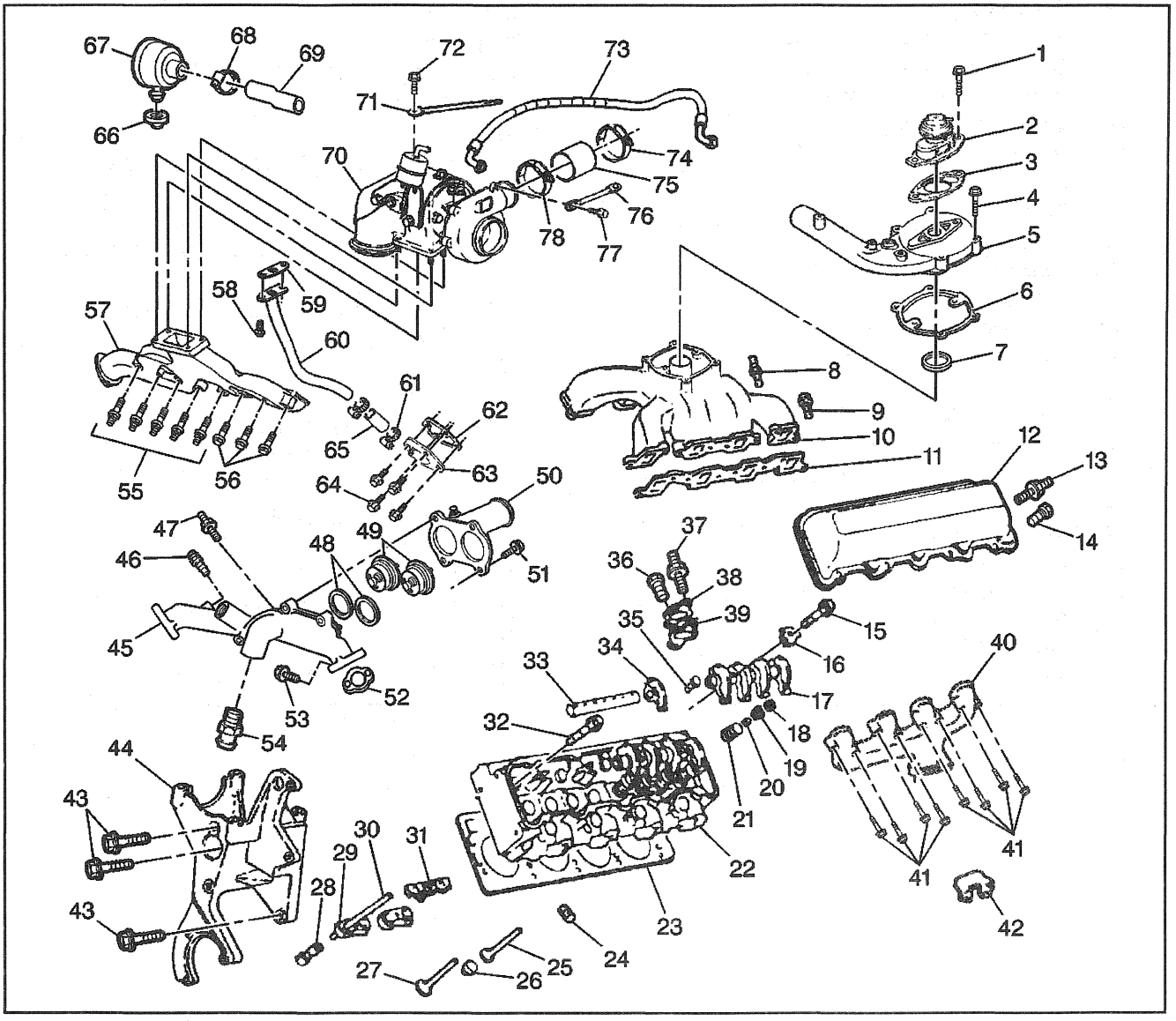
Notice: Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

1. Remove the drive belts. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
2. Position a hex-head socket on the belt tensioner pulley bolt head.
3. Move the drive belt tensioner through it's full travel.
   - The movement should feel smooth.
   - There should be no binding.
   - The tensioner should return freely.
4. If any binding is observed, replace the tensioner. Refer to *Drive Belt Tensioner Replacement*.
5. Install the drive belt. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.

Visual Identification

Disassembled Views (L56, L65)

Cylinder Head and Components



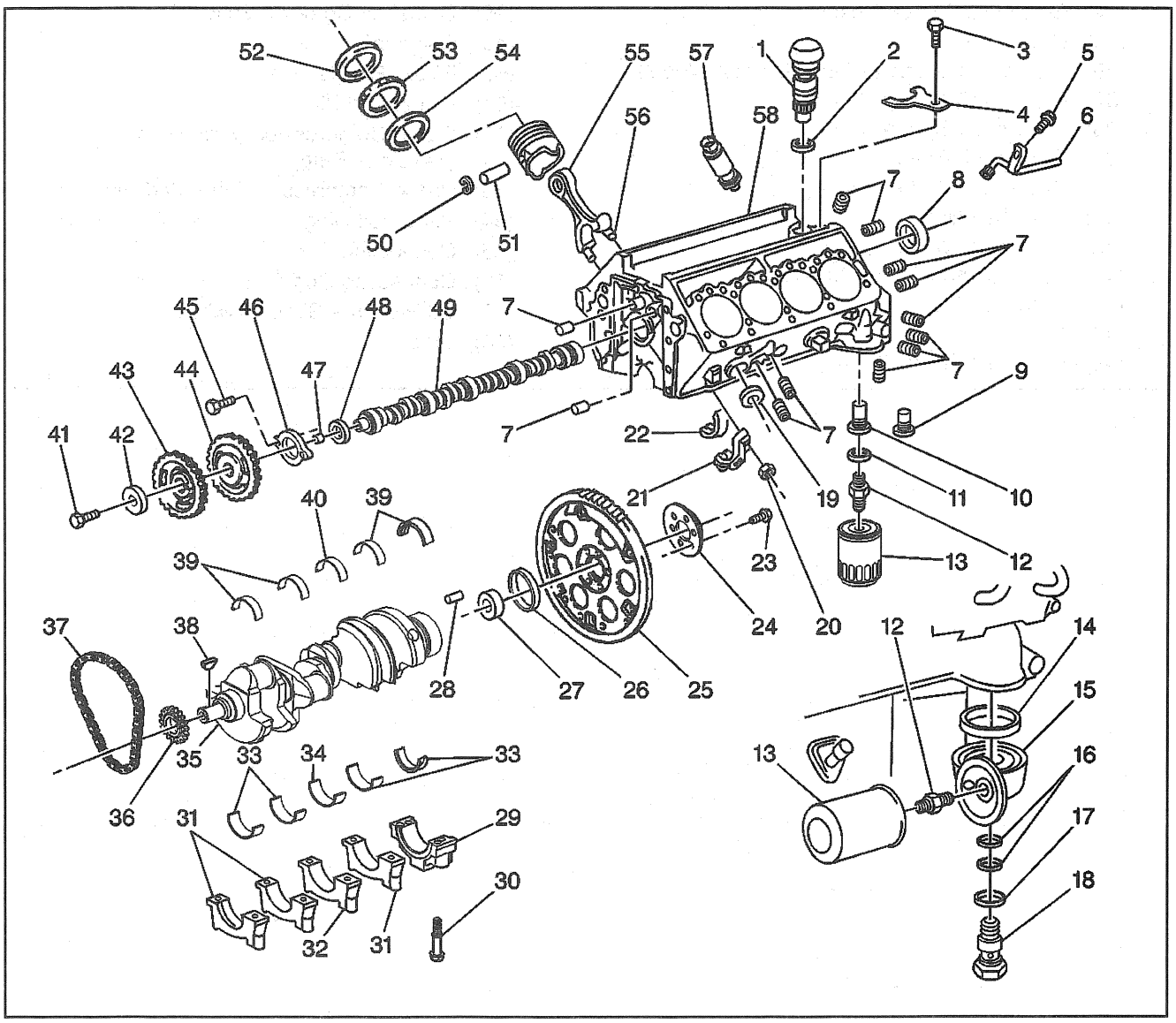
74101

Legend

(1) Upper Intake Manifold Bolt
(2) Exhaust Gas Recirculation (EGR) Valve (If Equipped)
(3) EGR Gasket (If Equipped)
(4) Upper Intake Manifold Bolt
(5) Upper Intake Manifold
(6) Gasket
(7) EGR Gasket (If Equipped)
(8) Stud
(9) Bolt
(10) Lower Intake Manifold
(11) Bolt
(12) Valve Rocker Arm Cover
(13) Stud
(14) Bolt
(15) Valve Rocker Arm Shaft Bolt
(16) Valve Rocker Arm Shaft Retainer
(17) Valve Rocker Arm Shaft Assembly
(18) Valve Stem Key
(19) Exhaust Valve Rotator
(20) Exhaust Valve Seal
(21) Valve Spring
(22) Cylinder Head
(23) Cylinder Head Gasket
(24) Coolant Jacket Plug
(25) Exhaust Valve

(26) Cylinder Head Pre-Combustion Chamber
(27) Intake Valve
(28) Valve Lifter
(29) Valve Lifter Guide Plate
(30) Push Rod
(31) Valve Lifter Guide Plate Clamp
(32) Cylinder Head Bolt
(33) Valve Rocker Arm Shaft
(34) Valve Rocker Arm
(35) Valve Rocker Arm Retainer
(36) Bolt
(37) Stud
(38) Coolant Jacket Cover
(39) Gasket
(40) Exhaust Manifold (Right)
(41) Exhaust Manifold Bolt
(42) Oil Level Indicator Tube Heat Shield
(43) Bolt
(44) Accessory Mounting/Lift Bracket
(45) Thermostat Housing (Lower)
(46) Engine Coolant Temprature (ECT) Sensor
(47) Stud
(48) Thermostat Seal
(49) Thermostat
(50) Thermostat Housing (Upper)
(51) Bolt
(52) Gasket
(53) Bolt
(54) Coolant Bypass Hose Nipple
(55) Exhaust Manifold Studs
(56) Exhaust Manifold Bolts
(57) Exhaust Manifold (Right)
(58) Bolt
(59) Gasket
(60) Turbocharger Oil Return Pipe
(61) Clamp
(62) Gasket
(63) Turbocharger Oil Return Pipe Adapter
(64) Bolt
(65) Hose
(66) Valve Rocker Arm Cover to CDR Valve Grommet
(67) Crankcase Depression Regulator (CDR) Valve
(68) Clamp
(69) Hose
(70) Turbocharger Assembly
(71) Turbocharger Brace (Long)
(72) Bolt
(73) Turbocharger Oil Feed Line
(74) Clamp
(75) Hose
(76) Turbocharger Brace (Short)
(77) Bolt
(78) Clamp

Cylinder Block and Components



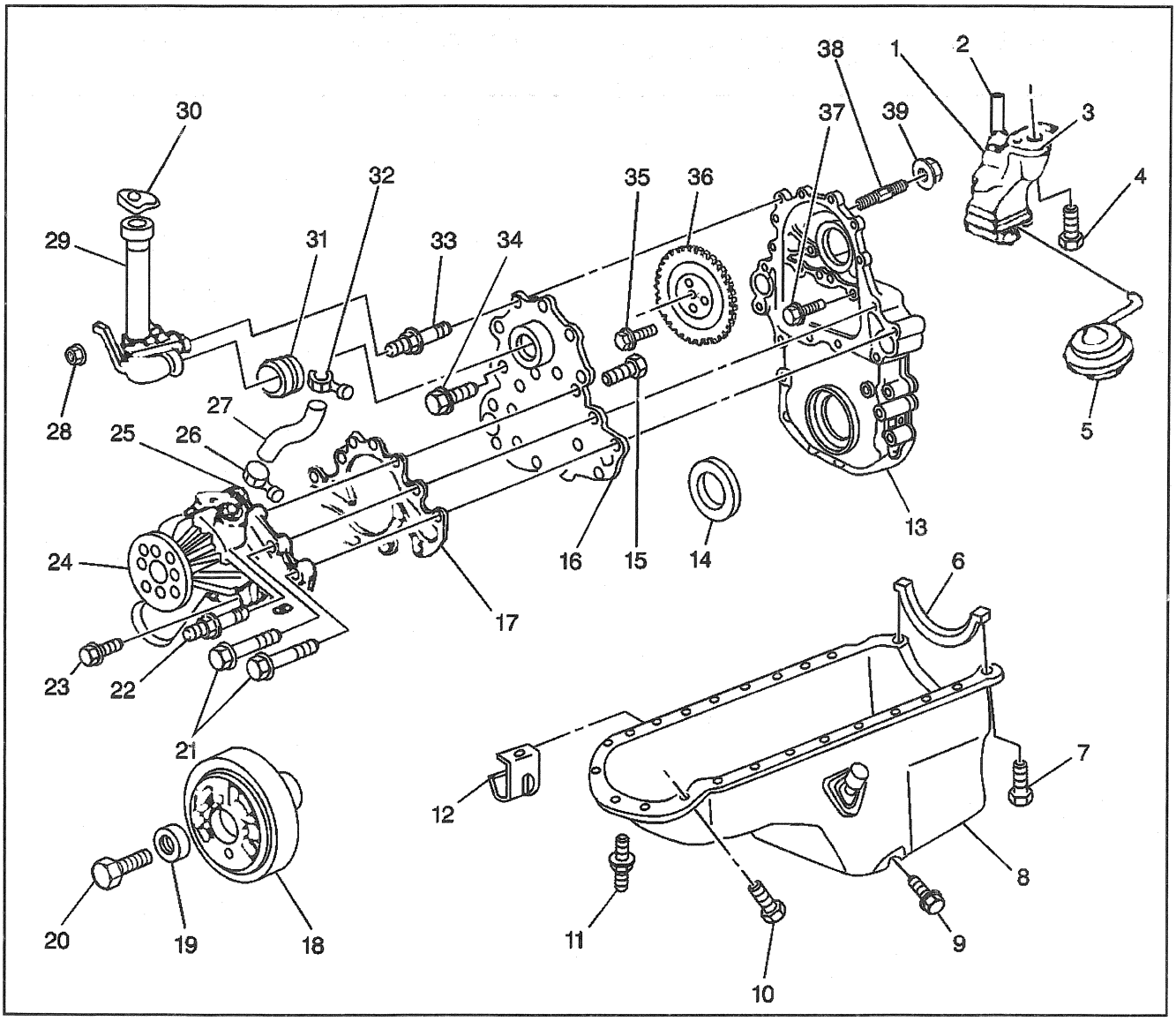
67734

Legend

(1) Oil Pump Drive
(2) Oil Pump Drive Gasket
(3) Bolt
(4) Oil Pump Drive Clamp
(5) Bolt
(6) Fuel Drain Tube (If Equipped)
(7) Oil Gallery Plug
(8) Camshaft Plug
(9) Oil Cooler Bypass Valve
(10) Oil Filter Bypass Valve
(11) Cup Plug
(12) Oil Filter Attachment Fitting
(13) Oil Filter
(14) Gasket
(15) Oil Filter Adapter (If Equipped)
(16) Oil Filter Adapter Seal (If Equipped)
(17) Oil Filter Adapter Gasket (If Equipped)
(18) Oil Filter Adapter Bolt (If Equipped)
(19) Coolant Jacket Plug
(20) Connecting Rod Nut
(21) Connecting Rod Bearing Cap
(22) Connecting Rod Bearing
(23) Flywheel Bolt
(24) Retainer (If Equipped)
(25) Flywheel
(26) Crankshaft Rear Oil Seal (One Piece)
(27) Clutch Pilot Bearing (If Equipped)
(28) Flywheel Dowel Pin
(29) Crankshaft Rear Bearing Cap
(30) Crankshaft Bearing Cap Bolt
(31) Crankshaft Bearing Cap
(32) Crankshaft Thrust Bearing Cap

(33) Crankshaft Bearing
(34) Crankshaft Thrust Bearing
(35) Crankshaft
(36) Crankshaft Sprocket (and Reluctor Wheel)
(37) Crankshaft Timing Chain
(38) Crankshaft Sprocket Key
(39) Crankshaft Bearing
(40) Crankshaft Thrust Bearing
(41) Camshaft Bolt
(42) Camshaft Washer
(43) Fuel Injection Pump Drive Gear
(44) Camshaft Sprocket
(45) Bolt
(46) Camshaft Thrust Bearing
(47) Camshaft Sprocket Key
(48) Camshaft Sprocket Spacer Ring
(49) Camshaft
(50) Piston Pin Retainer
(51) Piston and Pin
(52) Piston Compression (Fire) Ring (Keystone Ring)
(53) Piston Compression Ring (2nd Ring)
(54) Piston Oil Ring
(55) Connecting Rod
(56) Connecting Rod Bolt
(57) Oil Pressure Sensor Switch
(58) Block

Front Cover, Oil Pan, and Components



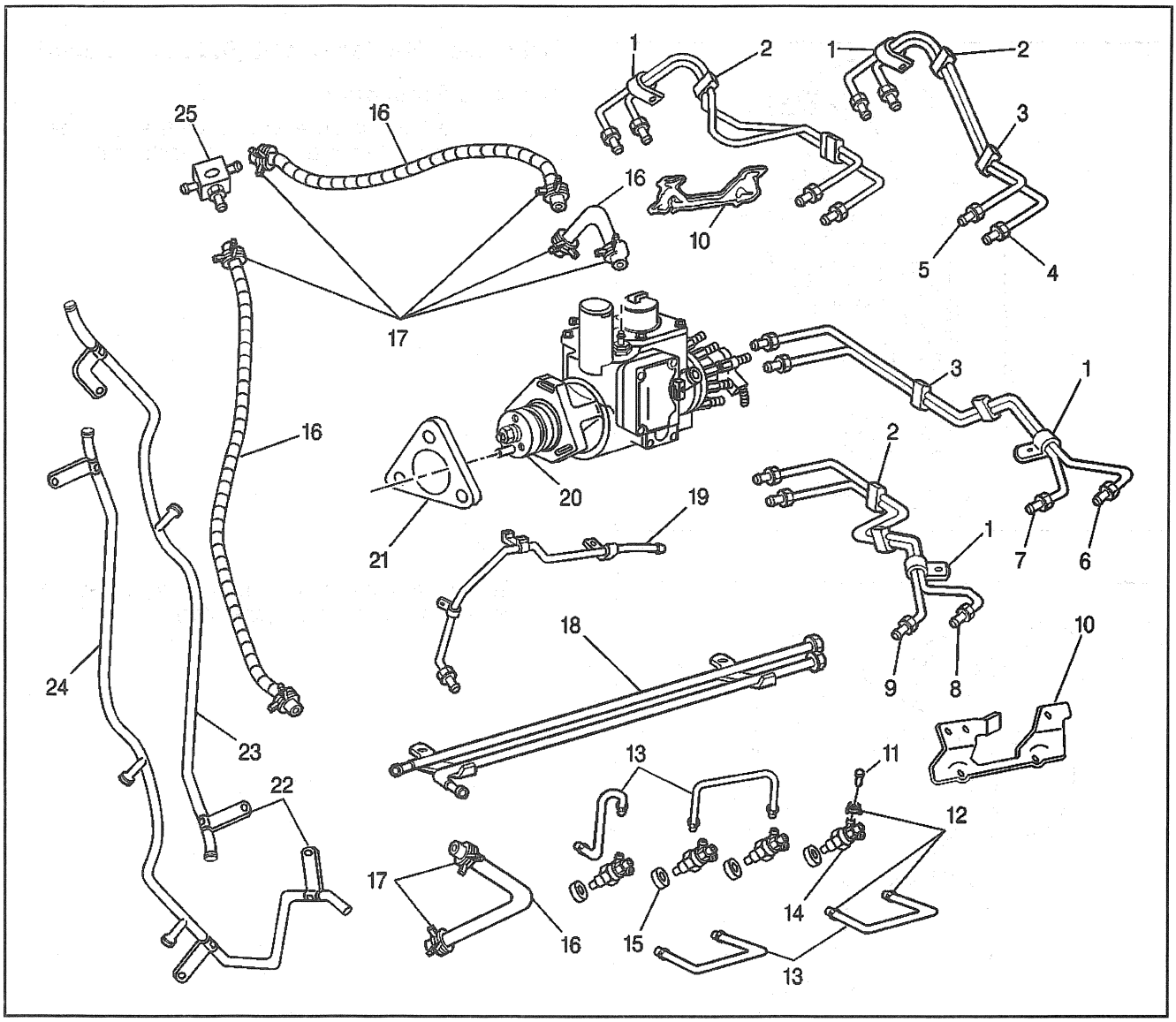
67735

Legend

(1) Oil Pump
(2) Oil Pump Drive Shaft
(3) Oil Pump Pressure Relief Spring
(4) Oil Pump Bolt
(5) Oil Pump Pick Up Tube and Screen
(6) Rear Oil Pan Seal
(7) Bolt
(8) Oil Pan
(9) Oil Pan Drain Plug
(10) Bolt
(11) Stud
(12) Oil Cooler Pipe Clip
(13) Front Cover
(14) Crankshaft Front Oil Seal
(15) Bolt
(16) Water Pump Backing Plate
(17) Gasket
(18) Torsional Damper
(19) Torsional Damper Washer
(20) Torsional Damper Bolt
(21) Water Pump and Backing Plate Bolt
(22) Water Pump and Backing Plate Stud
(23) Bolt
(24) Water Pump
(25) Coolant Bypass Nipple
(26) Clamp
(27) Hose
(28) Clamp
(29) Oil Fill Tube
(30) Oil Filler Cap
(31) Oil Fill Tube Grommet
(32) Clamp

(33) Stud
(34) Bolt
(35) Fuel Injection Pump Driven Gear Bolt
(36) Fuel Injection Pump Driven Gear
(37) Bolt
(38) Fuel Injection Pump Mounting Stud
(39) Fuel Injection Pump Retaining Nut

Fuel Systems Components



67731

Legend

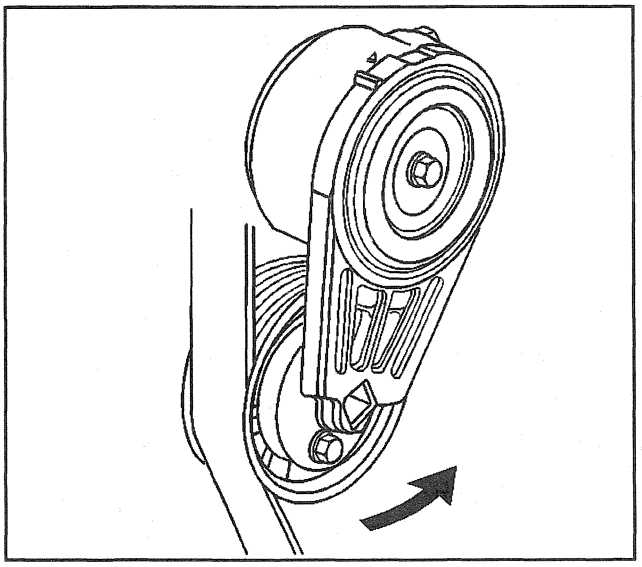
(1) Fuel Injection Pipe Clamp
(2) Fuel Injection Pipe One Piece Clip
(3) Fuel Injection Pipe Clamp
(4) Fuel Injection Pipe
(5) Fuel Injection Pipe
(6) Fuel Injection Pipe
(7) Fuel Injection Pipe
(8) Fuel Injection Pipe
(9) Fuel Injection Pipe
(10) Fuel Injection Pipe Bracket
(11) Fuel Injection Nozzle Cap
(12) Clamp
(13) Hose
(14) Fuel Injection Nozzle
(15) Gasket
(16) Hose
(17) Clamp
(18) Fuel Drain Back Pipe (If Equipped)
(19) Fuel Drain Back Pipe (If Equipped)
(20) Fuel Injection Pump
(21) Gasket
(22) Fuel Drain Back Pipe Clip
(23) Fuel Drain Back Pipe (If Equipped)
(24) Fuel Drain Back Pipe (If Equipped)
(25) Schreader Valve (Fuel-Water Separator)

Repair Instructions

Drive Belt Replacement (6.5L Drive Belt)

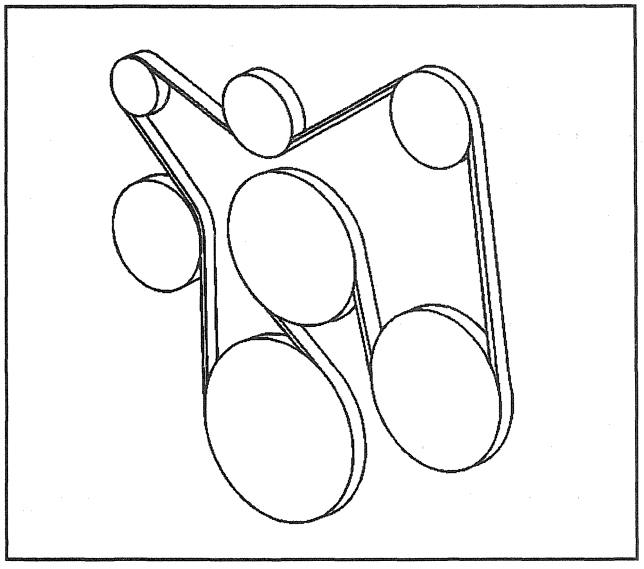
Removal Procedure

1. Install a 3/8 inch drive wrench on the tensioner arm and rotate the arm counterclockwise.



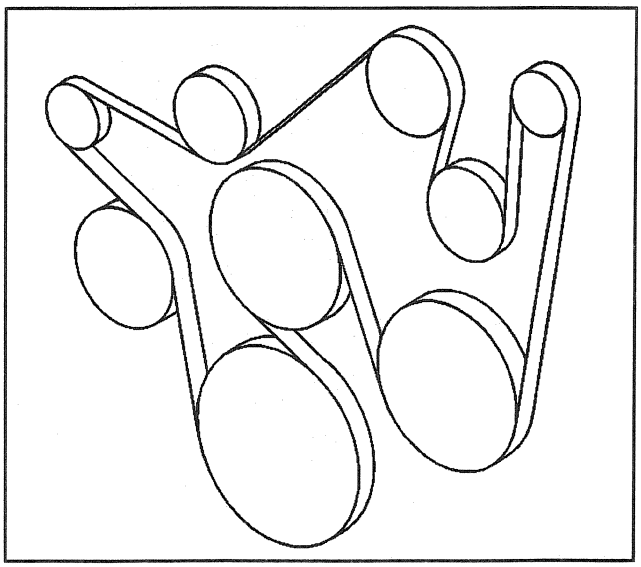
374176

2. Remove the drive belt from the drive pulleys (if equipped with a single generator).



240478

3. Remove the drive belt from the drive pulleys (if equipped with dual generators).
4. Slowly release the tension on the tensioner arm.



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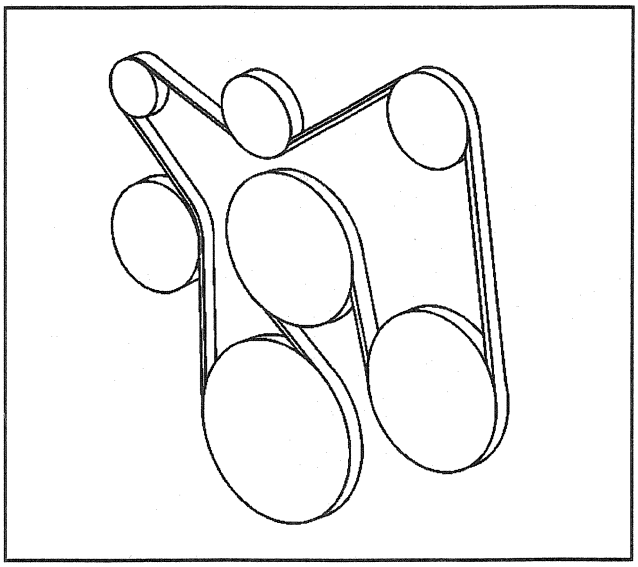
Installation Procedure

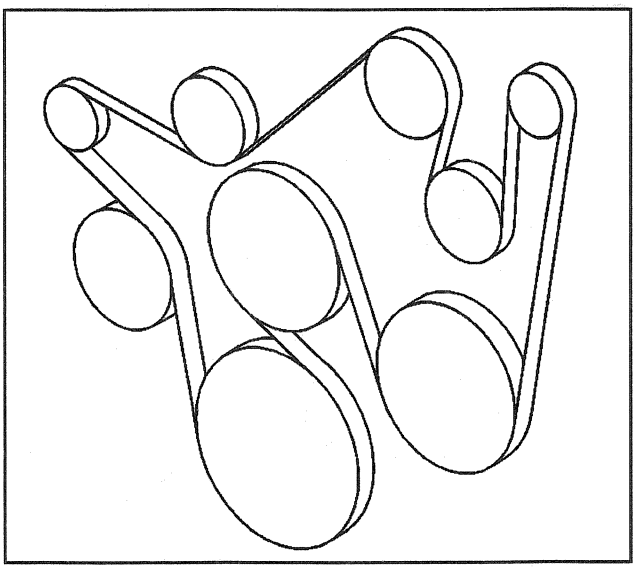
Important: Refer to the Underhood Label for the proper drive belt routing graphic.

1. Install the belt over all the pulleys except the tensioner arm (if equipped a with single generator).

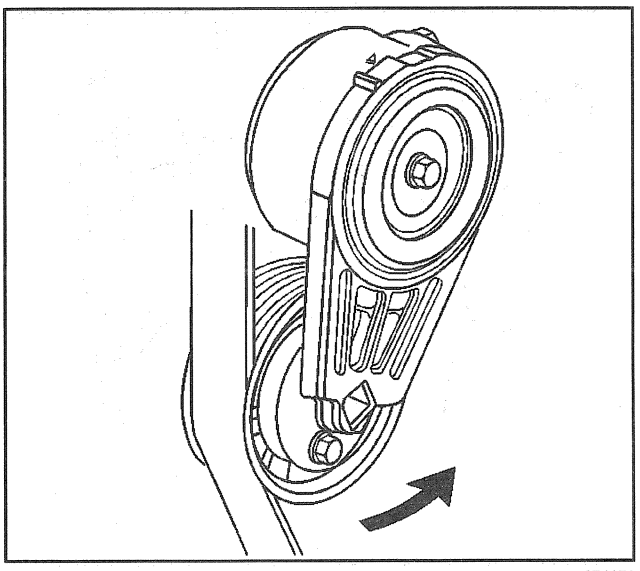


240478

2. Install the drive belt over all the pulleys except the tensioner arm (if equipped a with dual generators).

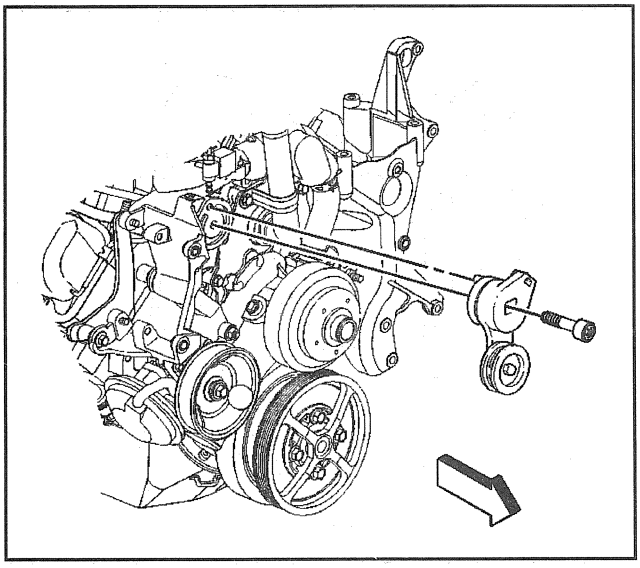


279365



374176

3. Install a 3/8 inch drive wrench on the tensioner arm and rotate the arm counterclockwise.
4. Slowly release the tension on the tensioner arm.
5. Confirm that the drive is properly seated in all the pulleys and is properly routed before starting the vehicle.

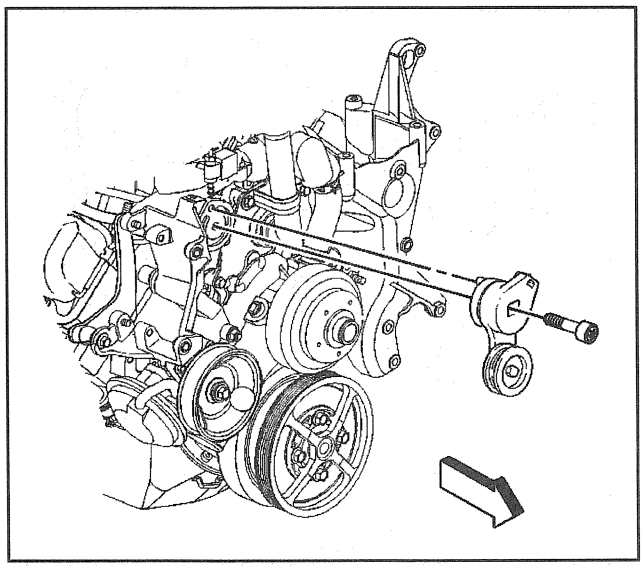


520123

Drive Belt Tensioner Replacement

Removal Procedure

1. Remove the drive belt from the drive pulleys. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
2. Remove the mounting bolt for the tensioner.
3. Remove the tensioner from the accessory bracket.



520123

Installation Procedure

1. Install the drive belt tensioner assembly.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the mounting bolt.

   Tighten

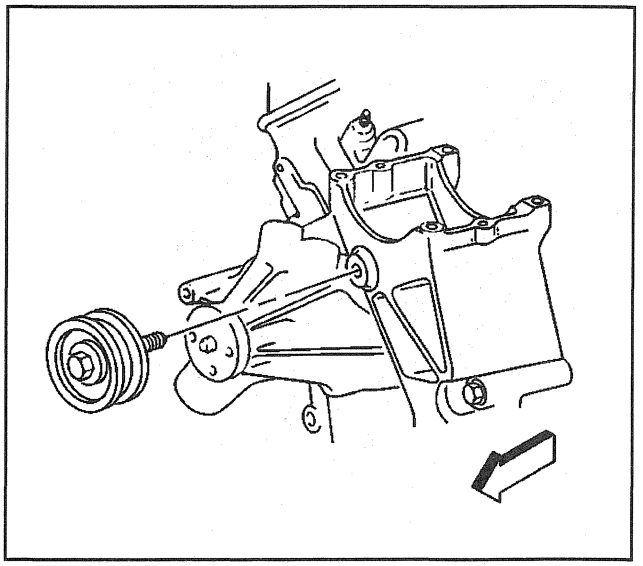
   Tighten the tensioner assembly bolt to 50 N·m (37 lb ft).

3. Install the drive belt on the drive pulleys. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.

Drive Belt Idler Pulley Replacement

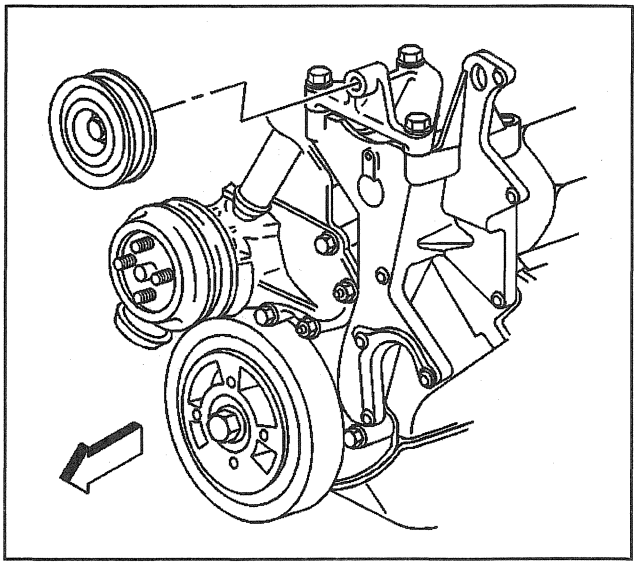
Removal Procedure

1. Remove the upper radiator shroud from the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.
2. Remove the drive belt from the vehicle. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.



188927

3. Remove the air conditioning idler pulley (for those vehicles not equipped with A/C).
4. Remove the drive belt idler pulley and bolt.



391682

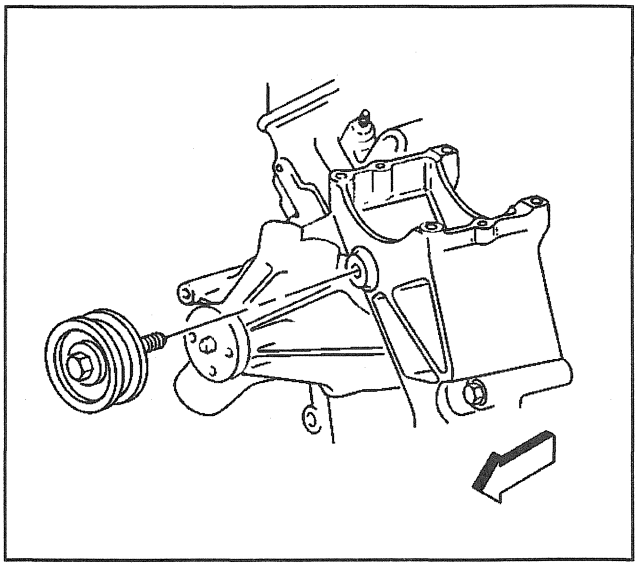
Installation Procedure

Notice: Refer to *Fastener Notice* in Cautions and Notices.

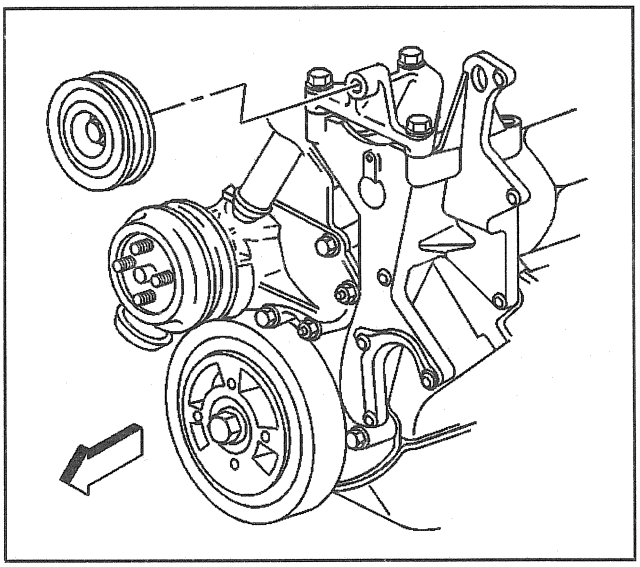
1. Install the drive belt idler pulley to the mounting bracket.

   Tighten

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



188927



391682

2. Install the A/C idler pulley (for those vehicles not equipped with A/C).

   Tighten

   Tighten the bolts to 83N·m (61 lb ft).
3. Install the drive belt to the vehicle. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
4. Install the upper radiator shroud to the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.

Engine Mount 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.

Engine Mount Replacement (Front)

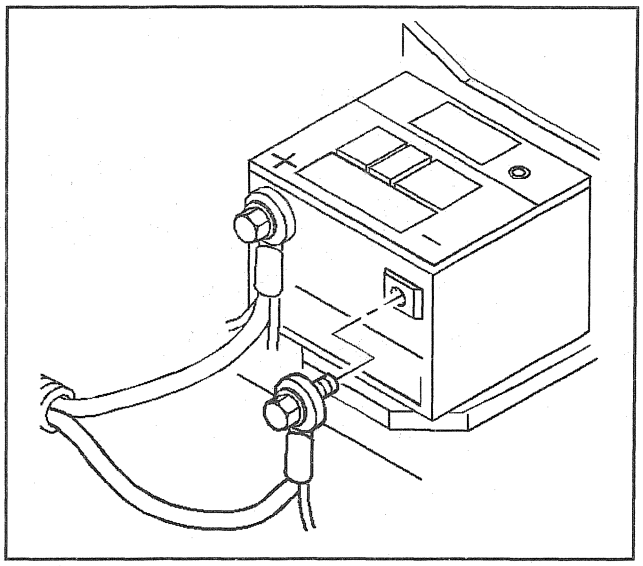
Removal Procedure

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the battery negative cable from the battery.
2. Inspect the engine mounts. Refer to *Engine Mount Inspection.*

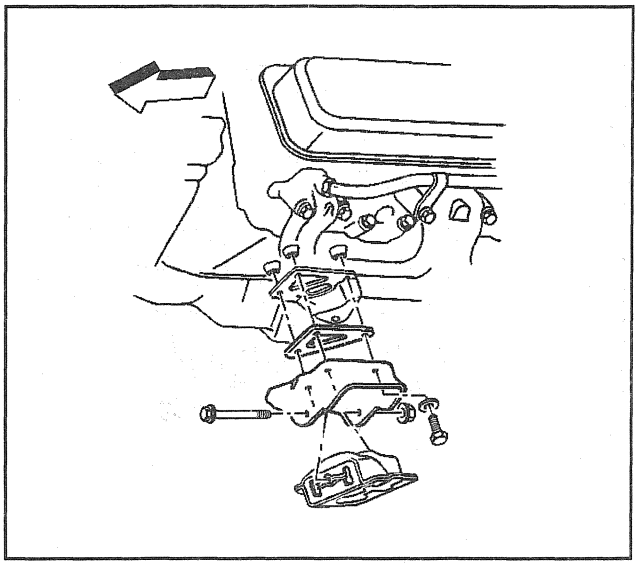
Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This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

3. Support the engine with a suitable jack. Do not load the engine mounts.



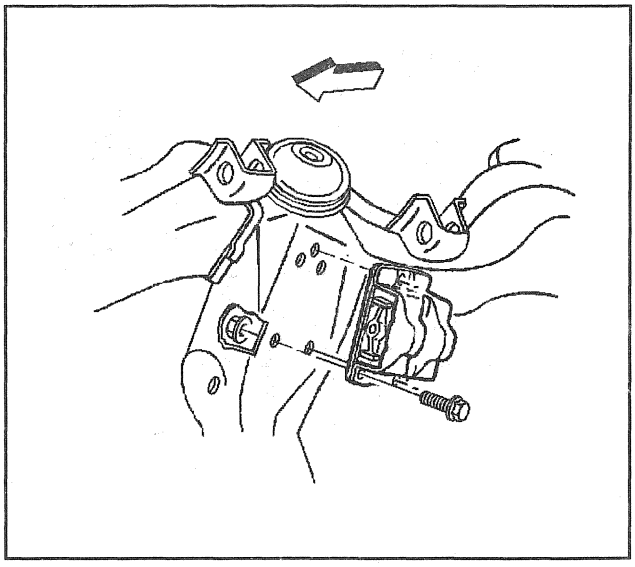
38205

4. Remove the engine mount through bolt and the nut.
5. Raise the engine only enough to permit removal of the engine mount.

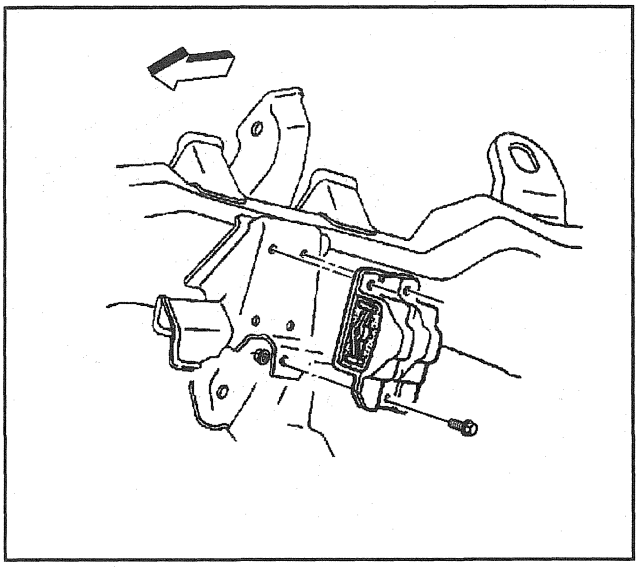


66191

6. If servicing a C-model truck, remove the engine mount assembly bolts, nuts, and washers.
7. Remove the engine mount assembly.

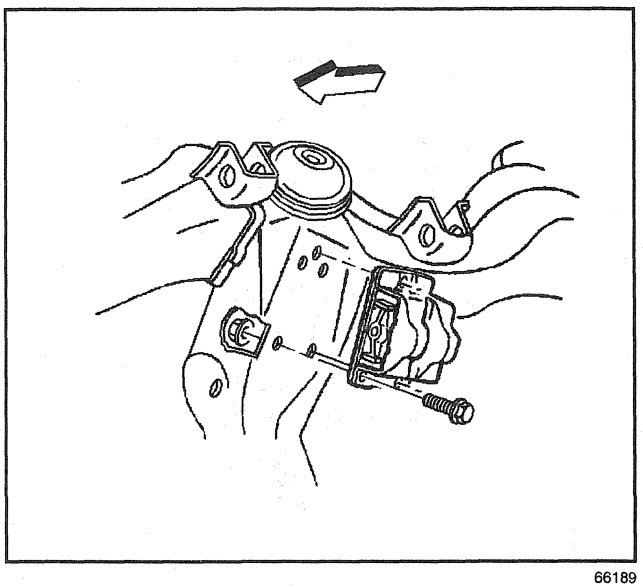


66189



66190

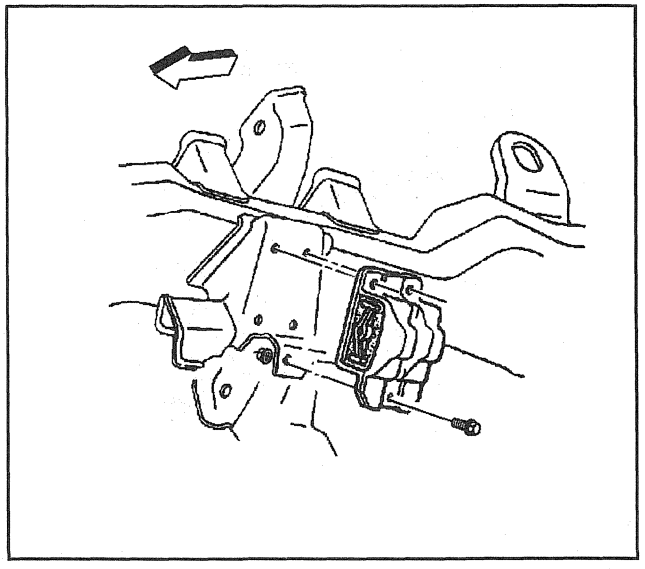
8. If servicing a K-model truck, remove the engine mount assembly bolts, nuts, and washers.
9. Remove the engine mount assembly.



66189

Installation Procedure

1. If servicing a C-model truck, install the engine mount assembly.



66190

2. If servicing a K-model truck, install the engine mount assembly.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the engine mount assembly bolts, nuts, and washers.

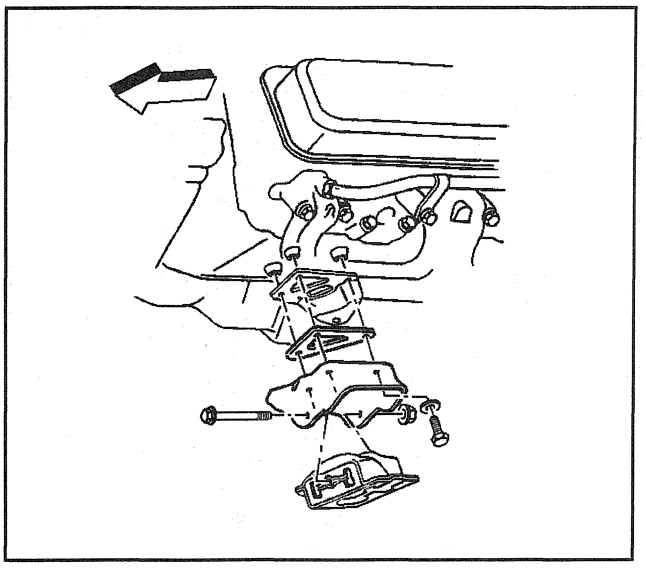
   Tighten

   - Tighten the bolts to 59 N·m (44 lb ft).
   - Tighten the nuts to 45 N·m (33 lb ft).

4. Lower the engine until the engine mount through bolt can be inserted.
5. Install the engine mount through bolt and the nut.

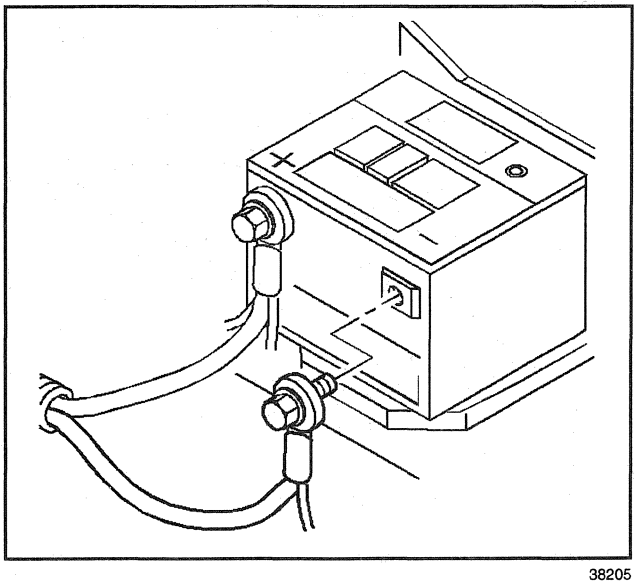
   Tighten

   Tighten the through bolt nut to 68 N·m (50 lb ft).



66191

6. Connect the battery negative cable.



38205

Engine Mount Replacement (Rear)

Removal Procedure

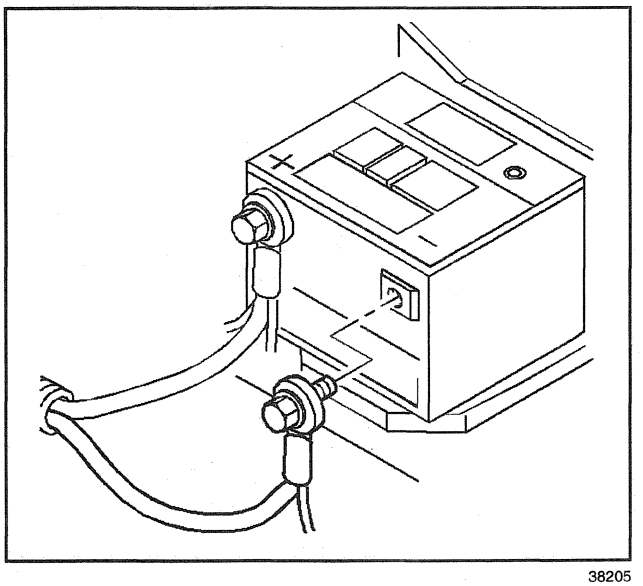
C-Models (Automatic Transmissions)

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

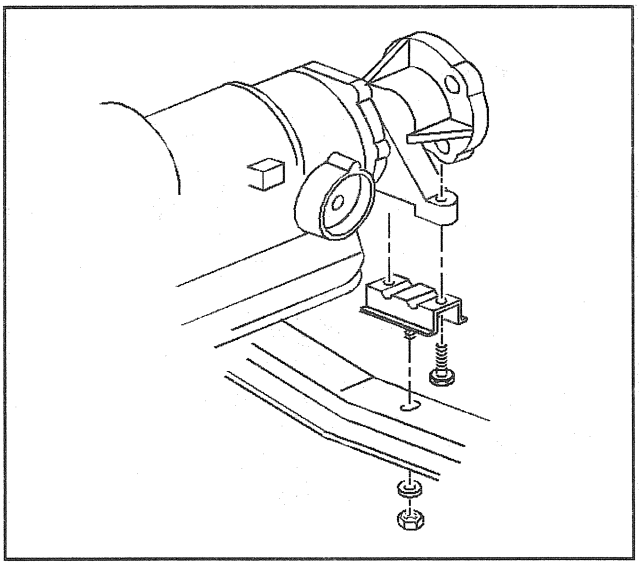
1. Disconnect the battery negative cable from the battery.
2. Inspect the engine mounts. Refer to *Engine Mount Inspection.*

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.

3. Support the rear of the engine to relieve the weight on the rear mounts.

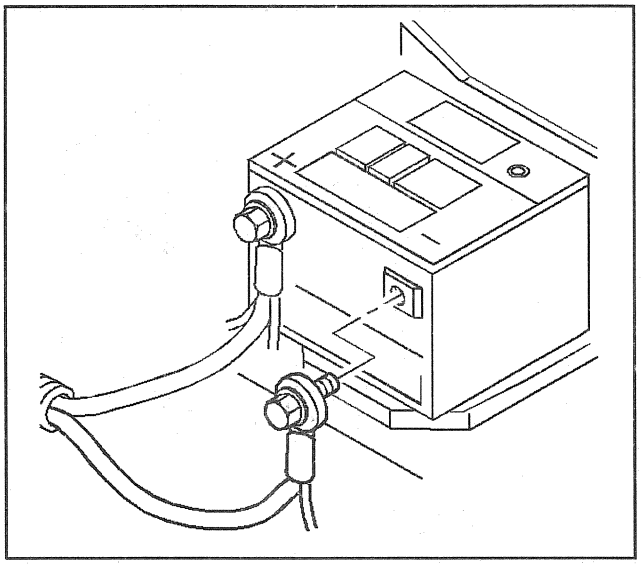


38205



66075

4. Remove the bolts and washers from the rear engine mount.
5. Raise the rear of the engine only enough to permit removal of the engine mount.
6. Remove the engine mount.



38205

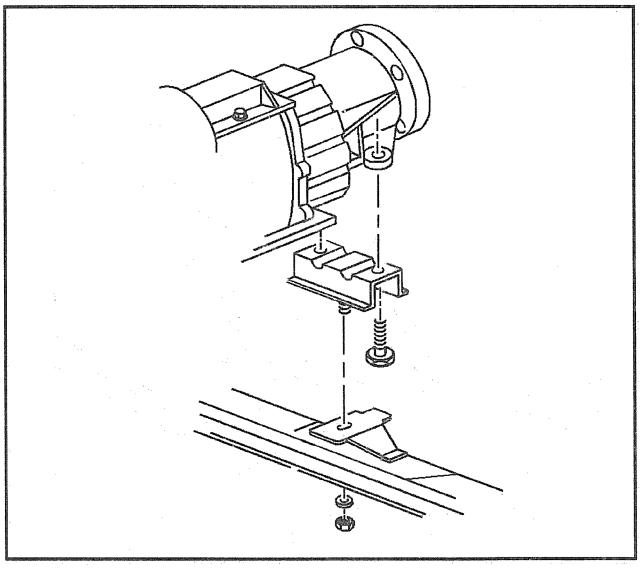
C-Models (Manual Transmission)

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the battery negative cable from the battery.

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 to relieve the weight on the rear mounts.



66095

3. Remove the bolts and washers from the rear engine mount.
4. Remove the rear transmission bolts and washers.
5. Raise the rear of the engine only enough to permit removal of the mount.
6. Remove the mount.

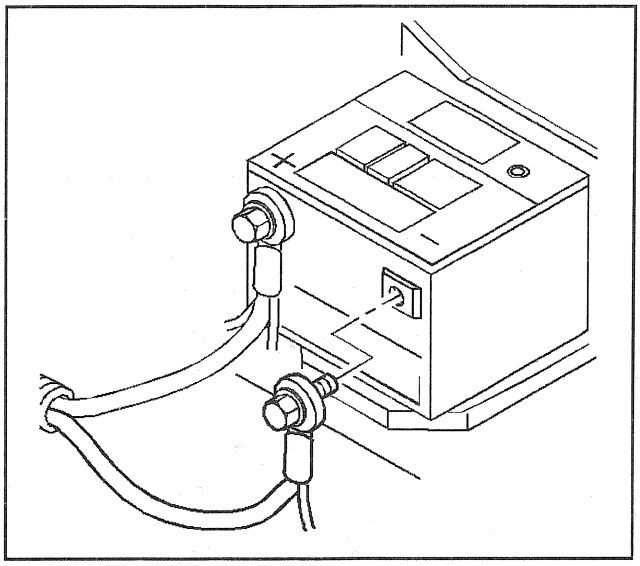
4WD or 2WD with 15,000 GVW Models (Automatic Transmission)

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the battery negative cable from the battery.

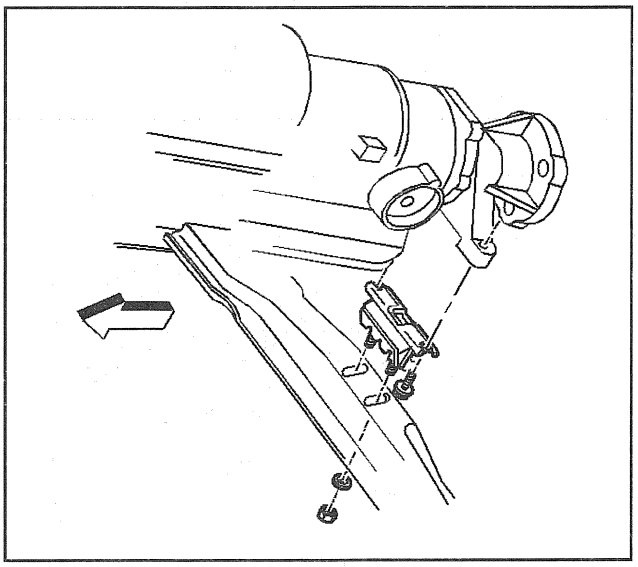
Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This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

2. Support the rear of the engine to relieve the weight on the rear mounts.



38205

3. Remove the bolts and washers from the rear engine mount.
4. Raise the rear of the engine only enough to permit removal of the mount.
5. Remove the mount.



66454

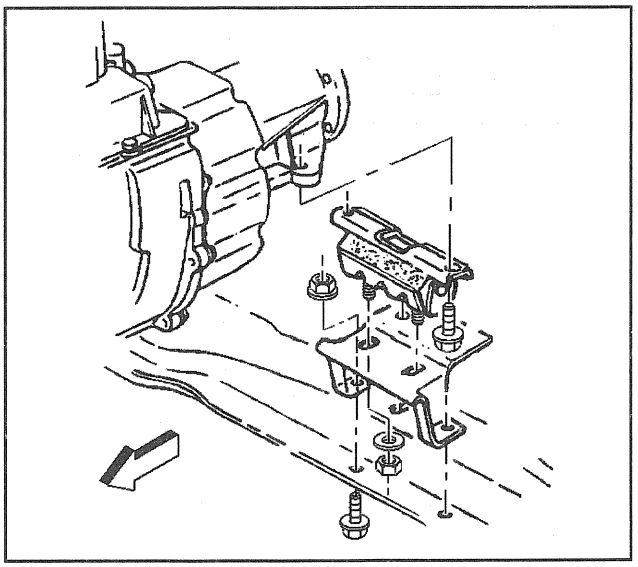
4WD or 2WD with 15,000 GVW Models (Manual Transmission)

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the battery negative cable from the battery.

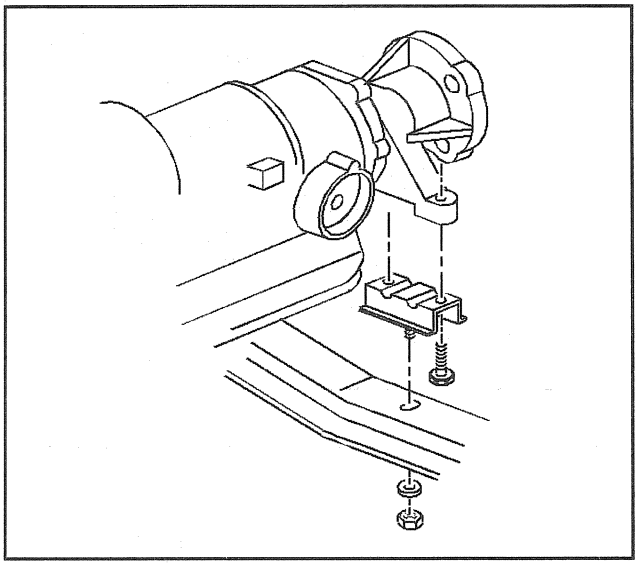
Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This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

2. Support the rear of the engine to relieve the weight on the rear mounts.



66192

3. Remove the bolts and washers from the rear engine mount.
4. Raise the rear of the engine only enough to permit removal of the mount.
5. Remove the mount.



66075

Installation Procedure

C-Models (Automatic Transmissions)

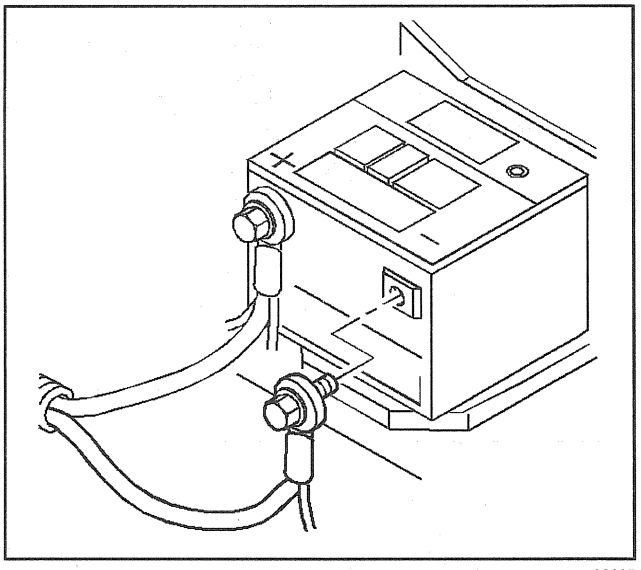
1. Install the mount.
2. Lower the rear of the engine.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the engine mount bolts and washers to the rear engine mount.

   Tighten

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



38205

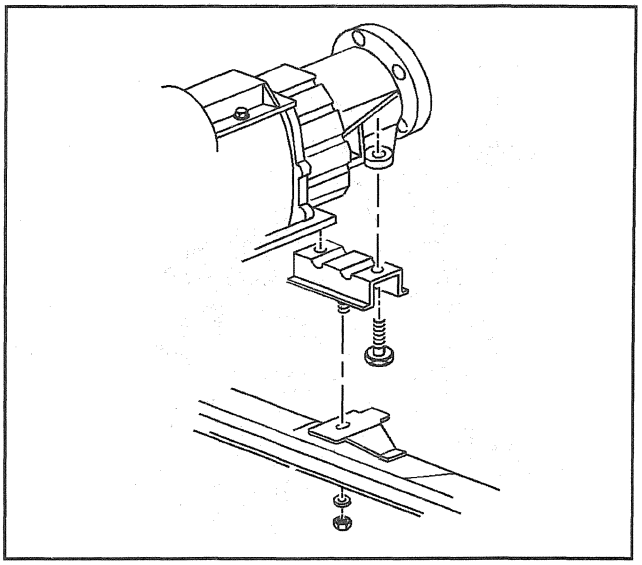
4. Connect the negative battery cable.

C-Models (Manual Transmissions)

1. Install the mount.
2. Lower the rear of the engine.
3. Install the engine mount bolts and washers to the rear engine mount.

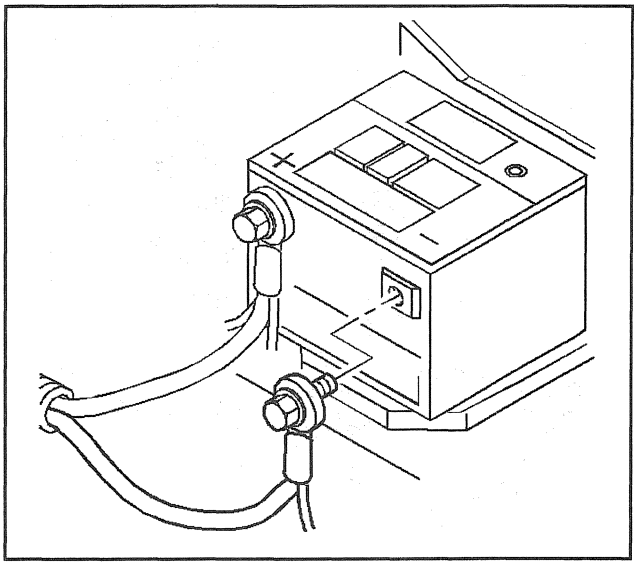
   Tighten

   Tighten the bolts to 47 N·m (35 lb ft).
4. Install the mount to the crossmember nuts and washers.



66095

5. Connect the negative battery cable.



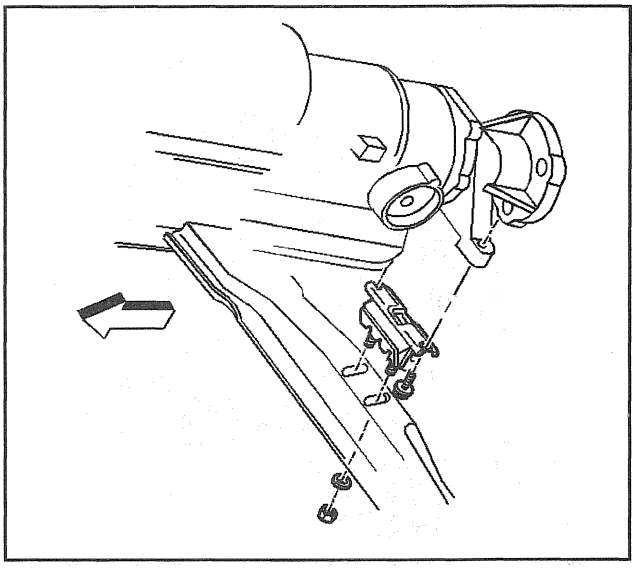
38205

4WD or 2WD with 15,000 GVW Models (Automatic Transmission)

1. Install the mount.
2. Lower the rear of the engine.
3. Install the engine mount bolts and washers to the rear engine mount.

   Tighten

   Tighten the bolts to 47 N·m (35 lb ft).
4. Connect the negative battery cable.



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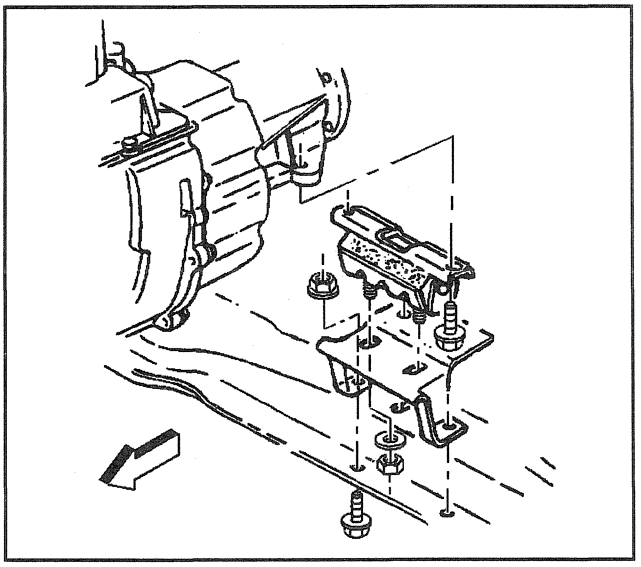


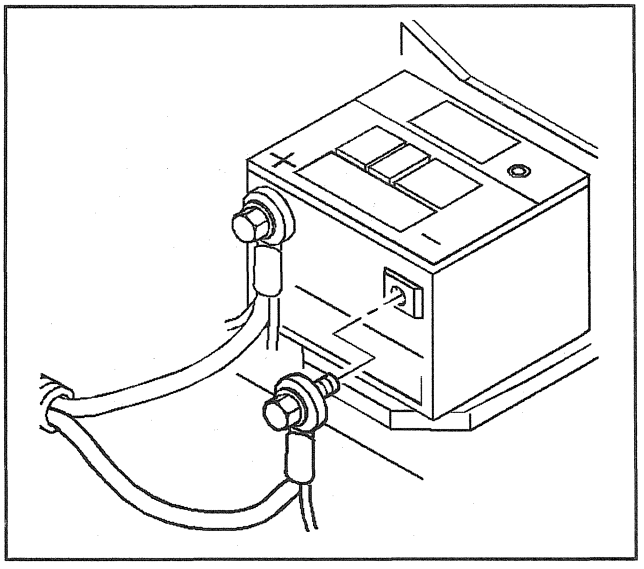
66192

4WD or 2WD with 15,000 GVW Models (Manual Transmission)

1. Install the mount.
2. Lower the rear of the engine.
3. Install the engine mount bolts and washers to the rear engine mount.

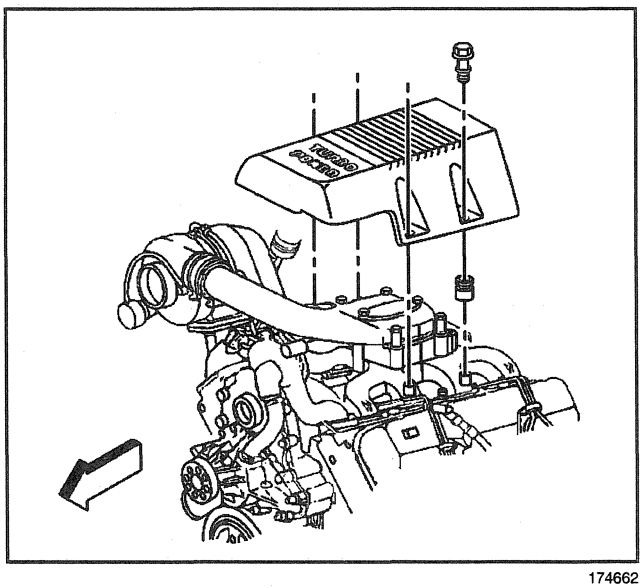
   Tighten

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



38205

4. Connect the negative battery cable.



174662

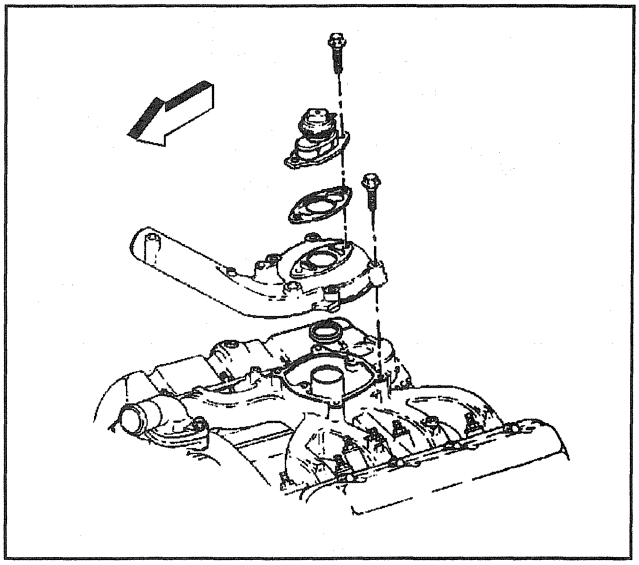
Intake Manifold Replacement (Upper)

Removal Procedure

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Remove the upper intake manifold cover.
3. Remove the air intake duct from the upper intake manifold.
4. Loosen the clamps on the hose between the turbocharger and the upper intake manifold. Refer to *Turbocharger*.

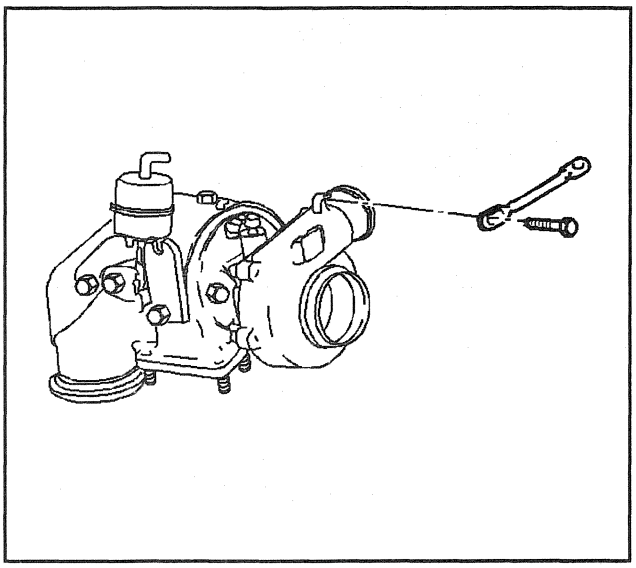
Important: In order to loosen the sealer, run a small screw driver (flat blade) between the hose and the upper intake manifold. Use caution as not to damage the hose.

5. Loosen the hose connecting the upper intake manifold and the turbocharger.
6. Slide the hose connecting the upper intake manifold and the turbocharger on to the upper intake manifold.
7. Remove the EGR Valve (L 56 only) from the upper intake manifold. Refer to *EGR Valve Replacement* in Engine Controls-6.5L.

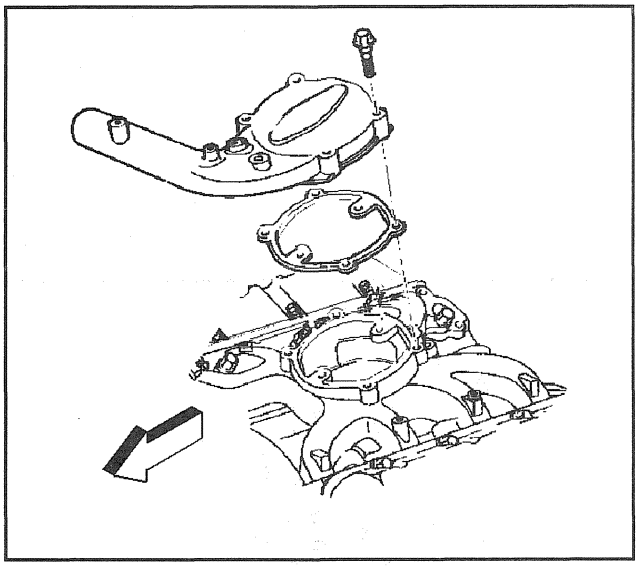


69759

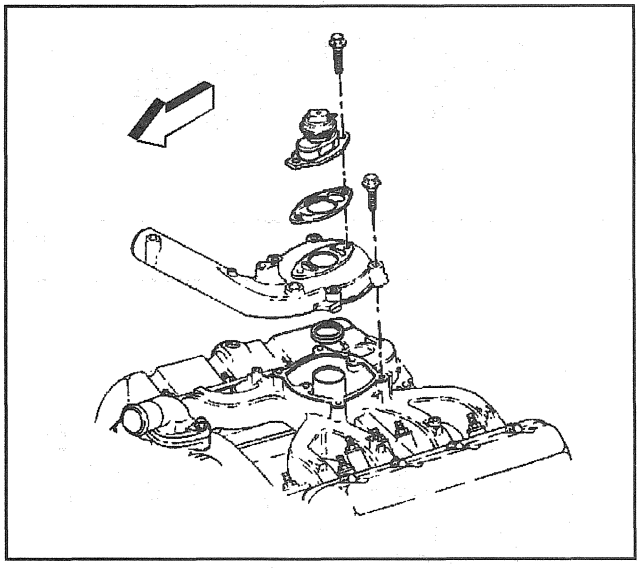
8. Remove the brace (long for the L 65 and short for the L 56) from the turbocharger to the upper intake manifold.



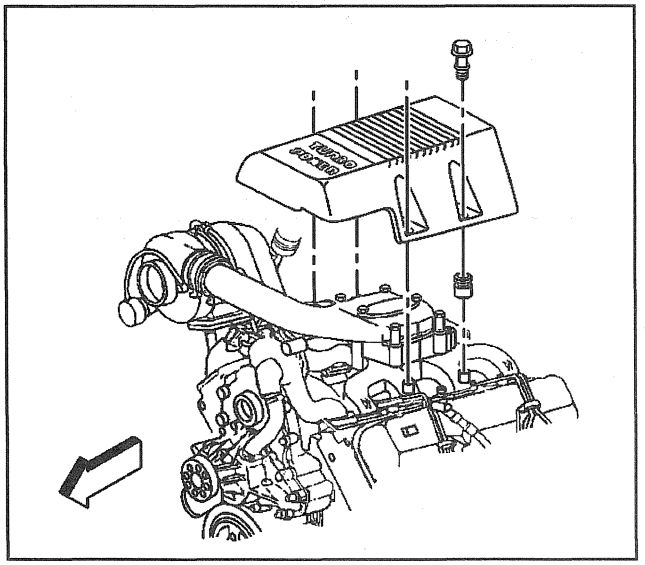
59747



60235



69759



174662

9. Remove the upper intake manifold bolts from the lower intake manifold (L 65 shown).
10. Remove the upper intake manifold and the gasket from the lower intake manifold.

Installation Procedure

Important: When replacing the upper intake manifold gasket for the L 56, always replace the O-ring between the upper and lower intake manifolds. Failure to replace this O-ring will cause a driveability problem.

1. Install the upper intake manifold to the lower intake manifold.

Notice: Refer to *Fastener Notice* in Caution and Notices.

2. Install the mounting bolts.

   Tighten

   Tighten the bolts to 42N·m (31 lb ft).
3. Install the EGR valve (L 56) to the upper intake manifold. Refer to *EGR Valve Replacement* in Engine Controls-6.5L.
4. Install the air intake duct to the upper intake manifold.
5. Install the upper intake manifold cover.

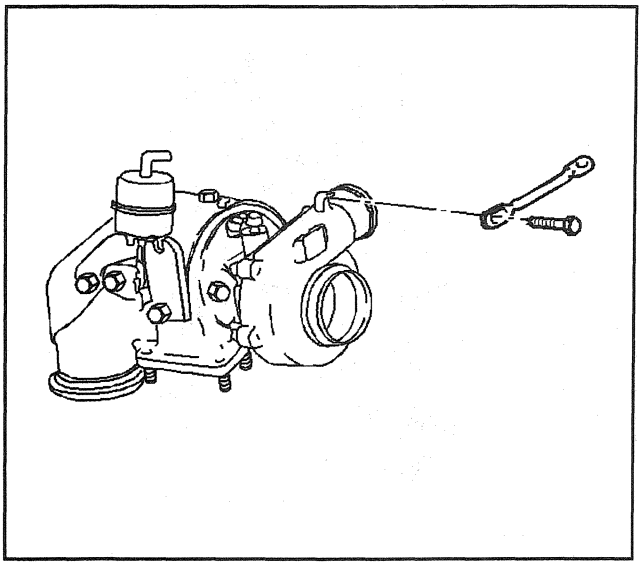
   Tighten

   Tighten the bolts to 12N·m (106 lb in).

Important: Apply a small amount of silicone sealant on the openings of the hose before installing it on the turbocharger and the upper intake manifold.

6. Slide the hose connecting from the upper intake manifold on to the turbocharger.
7. Tighten the clamps on the hose between the turbocharger and the upper intake manifold. Refer to *Turbocharger*.

8. Install the brace (long for the L 65 and short for the L 56) from the turbocharger to the upper intake manifold.
9. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.

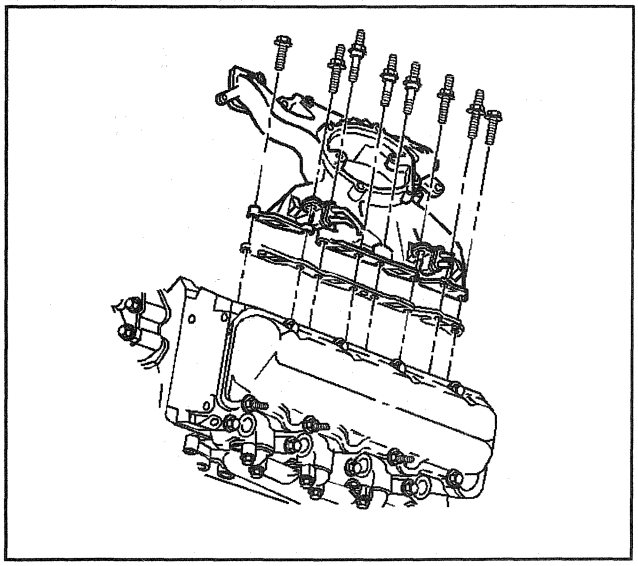


59747

Intake Manifold Replacement (Lower)

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the upper intake manifold from the lower intake manifold. Refer to *Intake Manifold Replacement (Upper)*.
3. Remove the fuel filter from the lower intake manifold. Refer to *Fuel Manager/Filter Replacement* in Engine Control-6.5L.
4. Remove the EGR/Boost solenoids (L 56 only) with the bracket from the intake manifold studs. Refer to *EGR Solenoid Replacement*.
5. Remove the Boost solenoids (L 65 only) with brackets from the Intake Manifold studs. Refer to *Boost Sensor Replacement*.
6. Remove the lower intake manifold stud/bolts from the engine block.
7. Remove the lower intake manifold and the gasket from the engine block.
8. Clean and check the sealing surfaces of the engine block.



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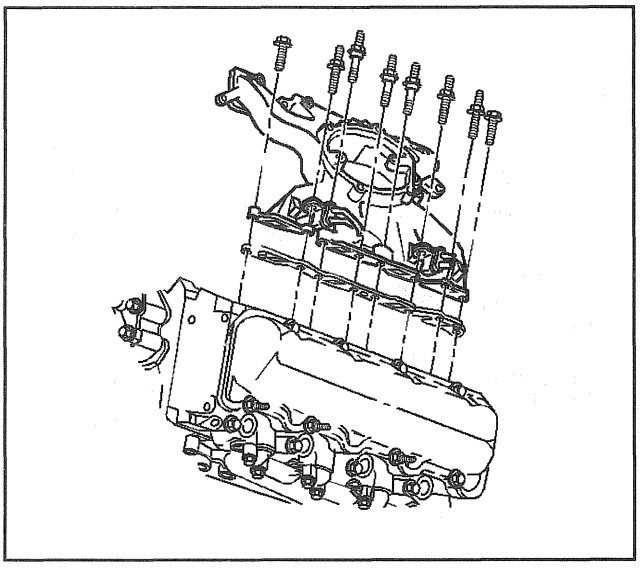

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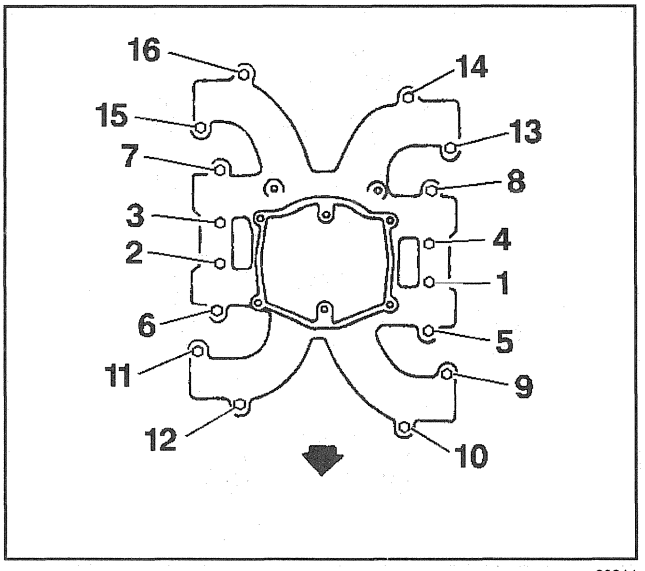


60311

Installation Procedure

Important: Be sure to use the correct gasket. The gasket for the L 56 models have openings for the EGR Valve, the gaskets for the L 65 models do not have openings.

1. Install the lower intake manifold gasket to the cylinder head.
2. Install the lower intake manifold to the cylinder head.

Important: There are four stud/bolts, 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 and 10, 12, 14, and 16.

Notice: Refer to *Fastener Notice* Cautions and Notices.

3. Install the lower intake manifold bolts to the cylinder head.

   Tighten

   Tighten the bolts to 42 N·m (31 lb ft).
4. Install the EGR/Boost solenoids (L 56 only) with the bracket to the intake manifold studs. Refer to *EGR Solenoid Replacement* in Engine Controls-6.5L.

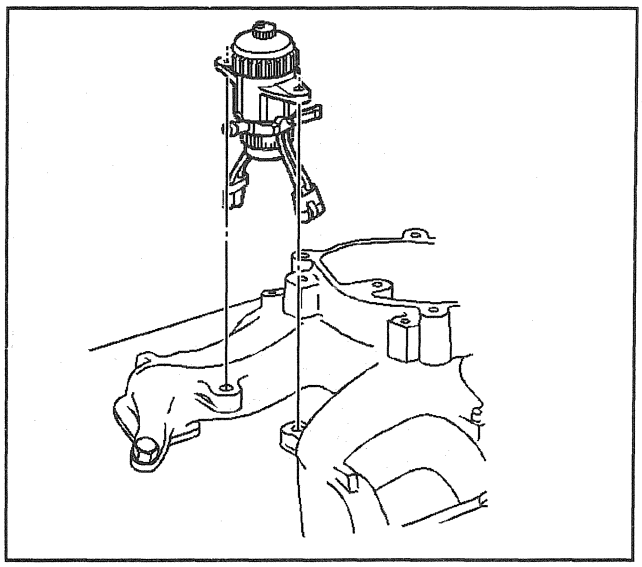
   Install the Boost solenoids (L 65 only) with brackets to the intake manifold studs. Refer to *Boost Sensor Replacement* in Engine Controls-6.5L.
5. Install the fuel filter to the lower intake manifold. Refer to *Fuel Manager/Filter Replacement* in Engine Controls 6.5L.
6. Install the upper intake manifold (L 56 shown) to the lower intake. Refer to *Intake Manifold Replacement (Upper).*
7. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.

Oil Pump Drive Replacement

Removal Procedure

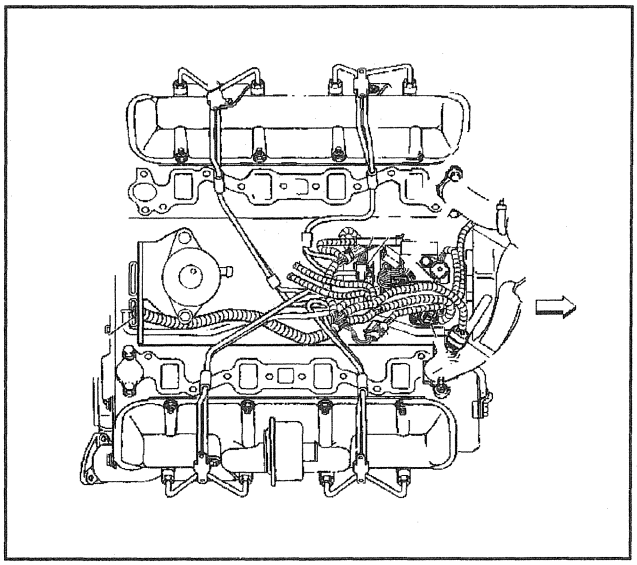
Notice: Do not run the engine without the oil pump drive in place. This will cause extensive engine damage.

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Replacement* in Engine Electrical.
2. Remove the upper intake manifold cover.
3. Remove the fuel filter from the lower intake manifold and lay to the side secure out of the way.



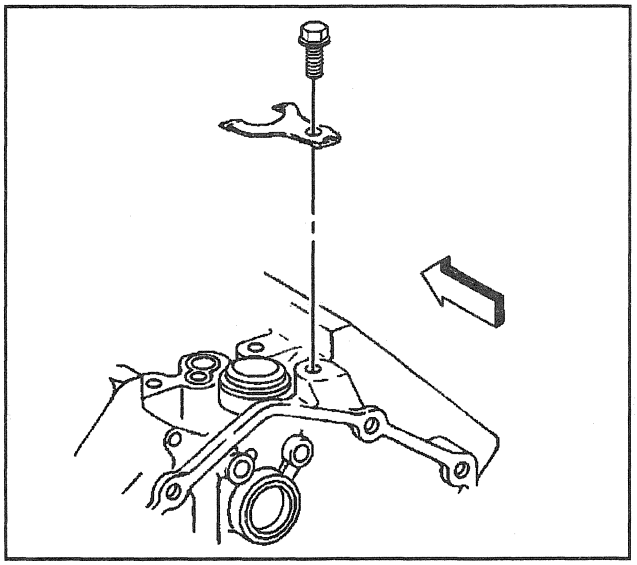
59759

4. Tie the engine wiring harness extension harness assembly out of the way.

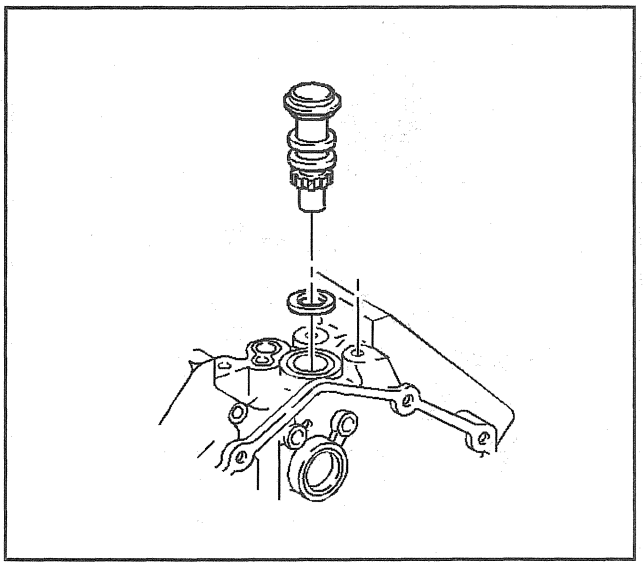


64989

5. Remove the retaining clamp and bolt from the oil pump drive gear.

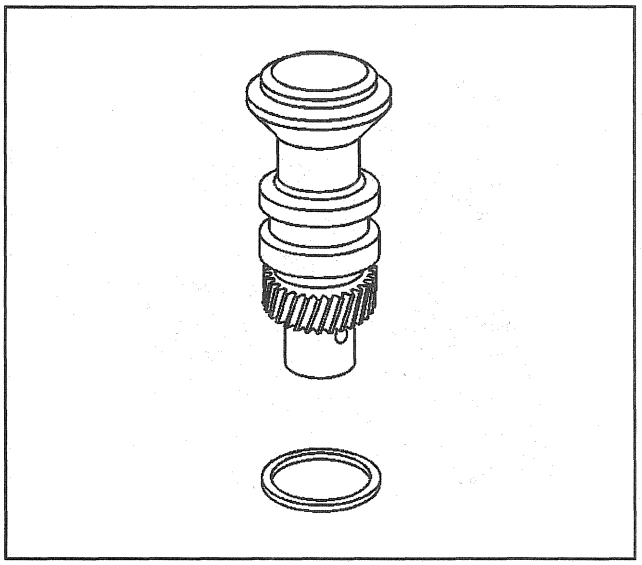


358441



59768

6. Remove the oil pump drive gear from the engine block.
7. Remove the oil pump drive gear O-ring.



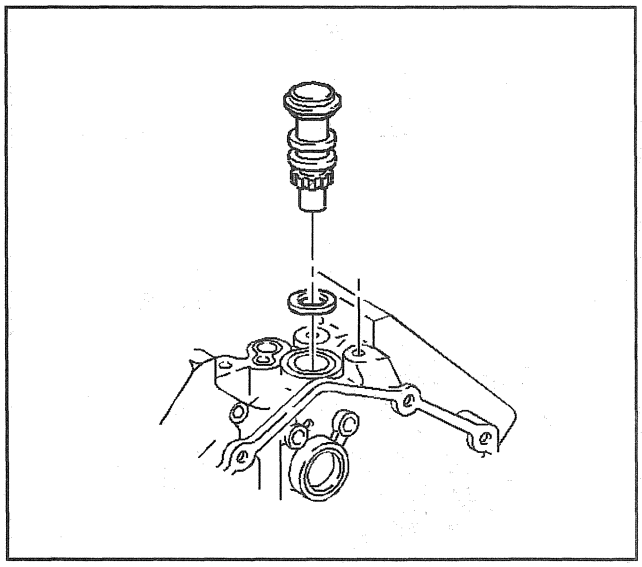
358444

Installation Procedure

Important: When replacing the oil pump drive gear, always use a new O-ring.

1. Coat the new O-ring with clean engine oil before install it on the oil pump drive gear.
2. Install the O-ring on the oil pump drive gear.

Important: Do not force the oil pump drive gear into place. The oil pump drive gear should slide into place with slight resistance. Clean the bore and apply a small amount of clean engine oil before installing the oil pump drive gear.

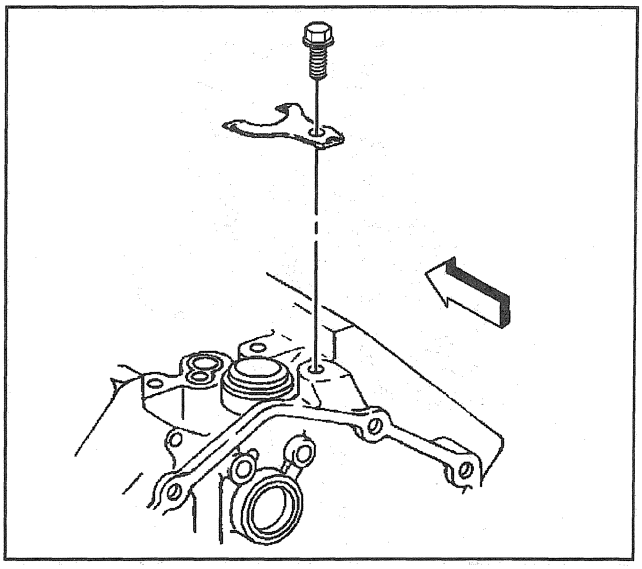


59768

3. Install the oil pump drive gear into the engine block.
   - Index the drive with the camshaft gear.
   - Make sure the oil pump drive gear is fully seated before installing the retaining clamp and bolt.

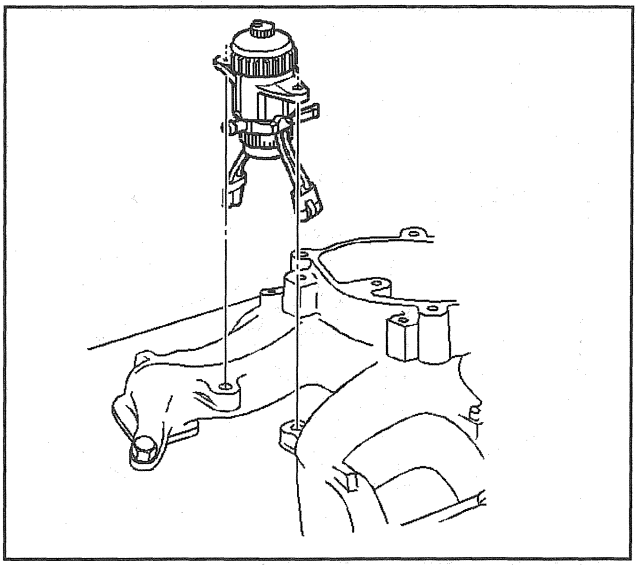
Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the retaining clamp bolt to the engine block.
   Tighten
   Tighten the bolt to 42 N·m(31 lb ft).
5. Untie the engine wiring harness extension harness assembly and reposition.



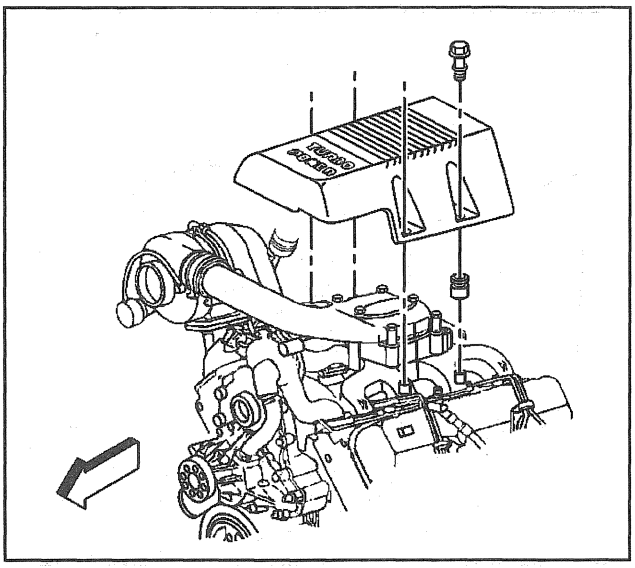
358441

6. Repostion the fuel filter on the lower intake manifold.

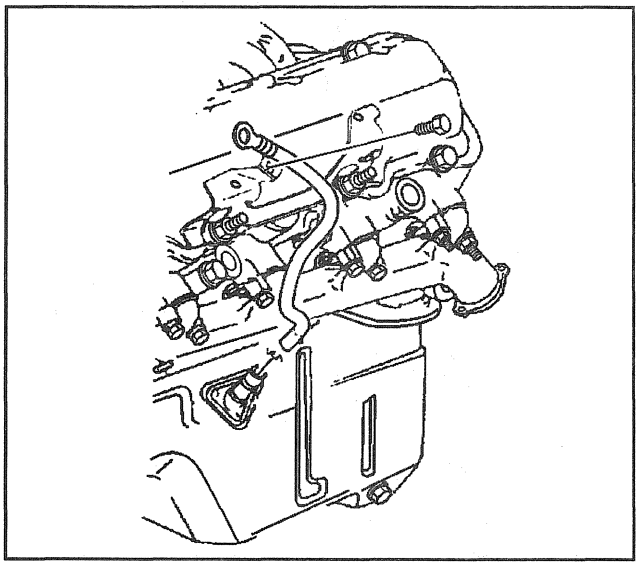


59759

7. Install the upper intake manifold cover from the engine.
8. Connect the battery negative cables to the batteries. Refer to *Battery Replacement* in Engine Electrical.



174662



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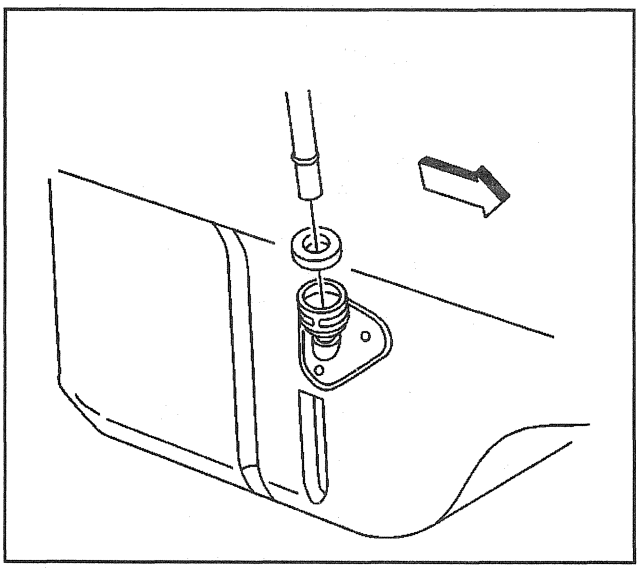
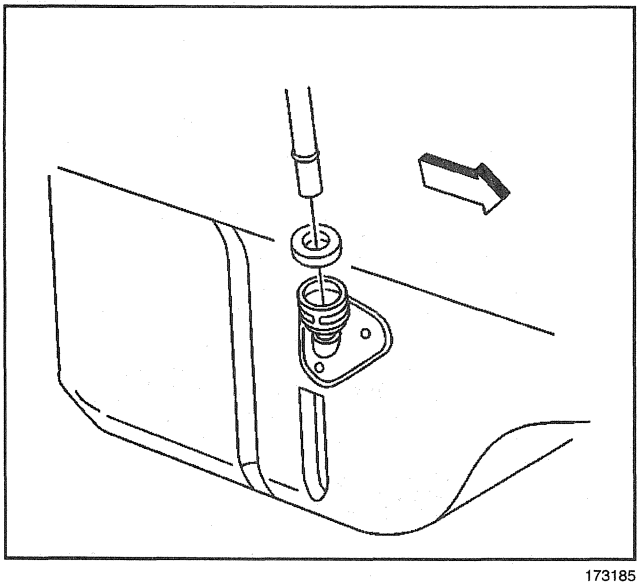


173185



173185

Oil Level Indicator and Tube Replacement

Removal Procedure

1. Remove the oil level indicator from the tube.
2. Remove the oil level indicator tube mounting bolt.
3. Remove the oil level indicator tube from the engine block.
4. Remove the O-ring from the oil level indicator tube.

Installation Procedure

Important: Always replace existing O-ring when installing the oil level indicator tube.

1. Apply a small amount of clean engine oil on the end of the oil level indicator tube.
2. Install the O-ring on the oil level indicator tube.

3. Install the oil level indicator tube to the engine.

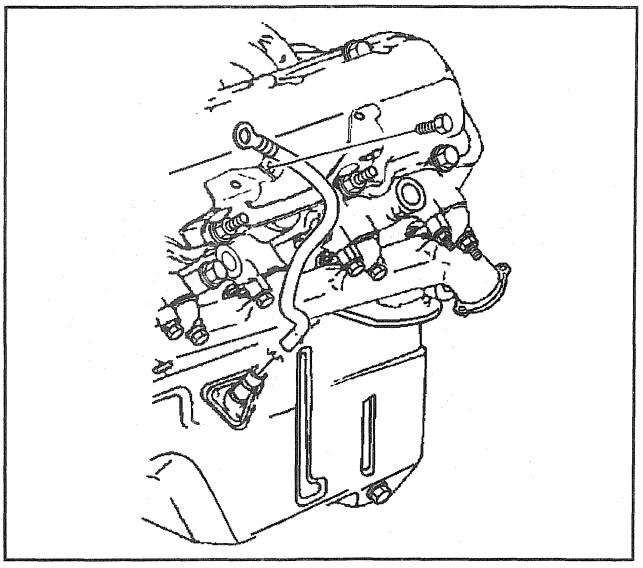
Notice: Refer to *Fastener Notice* in Caution and Notices.

4. Install the mounting bolt to the retaining bracket.

   Tighten

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

5. Install the oil level indicator in the oil level indicator tube.

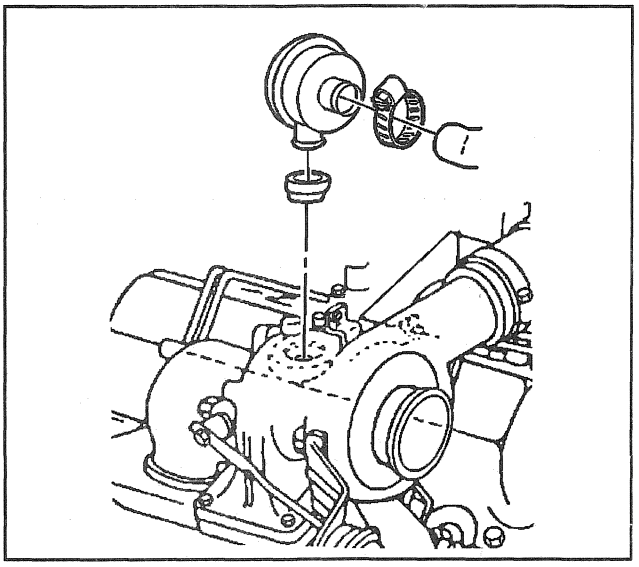


60238

Valve Rocker Arm Cover Replacement

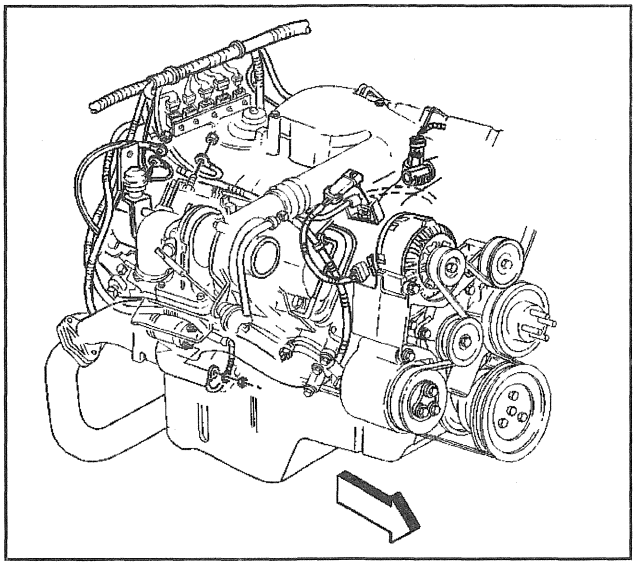
Removal Procedure

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Remove the CDR valve from the valve rocker arm cover.
3. Remove the upper intake manifold from the lower intake manifold. Refer to *Intake Manifold Replacement (Upper)*.

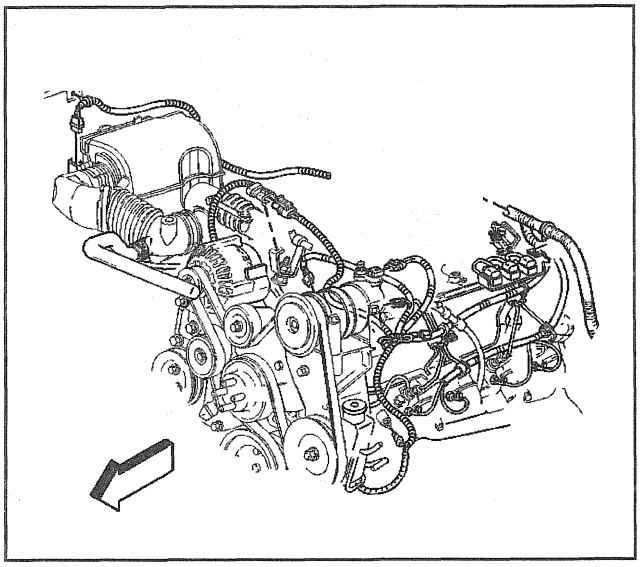


332410

4. Remove the wiring harness from the right side of the engine assembly.

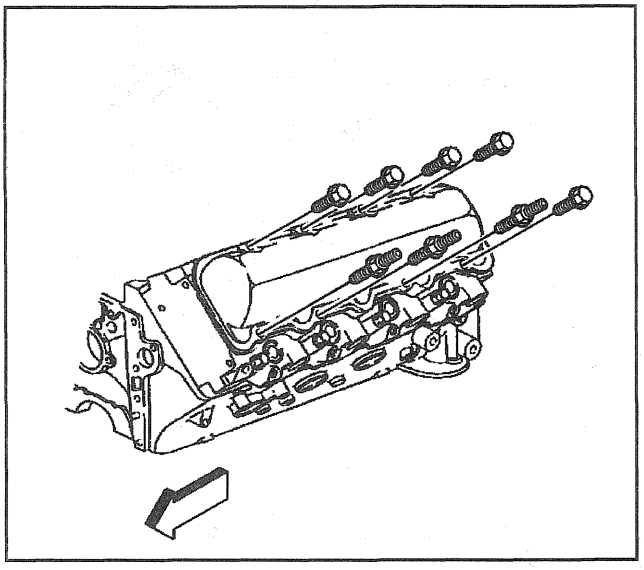


309340



309349

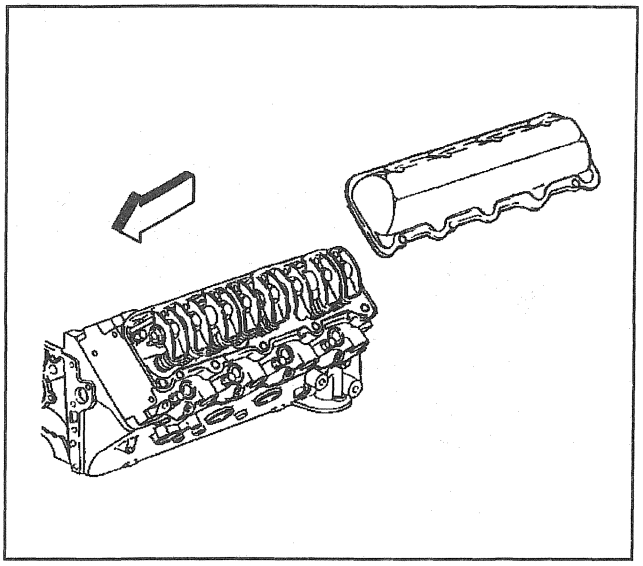
5. Remove the wiring harness from the left side of the engine assembly.
6. Remove the lower intake manifold from the engine assembly. Refer to *Intake Manifold Replacement (Lower)*.
7. Remove the turbocharger if replacing the right valve rocker arm cover. Refer to *Turbocharger*.
8. Remove the oil level indicator and tube if replacing the left valve rocker arm cover. Refer to *Oil Level Indicator and Tube Replacement*.
9. Remove the heater hoses from engine assembly.
   - For the vehicles with auxiliary heat (front), refer to *Heater Hoses Replacement - Auxiliary (Suburban- Front)* in HVAC.
   - For the vehicles with auxiliary heat (rear), refer to *Heater Hoses Replacement - Auxiliary (Diesel- Rear)* in HVAC.
   - For the vehicles with without auxiliary heat (inlet), refer to *Heater Hoses Replacement (Inlet Hose- Diesel)* in HVAC.
   - For the vehicles with auxiliary heat (outlet), refer to *Heater Hoses Replacement (Outlet Hose- Diesel)* in HVAC.
10. Remove the fuel injection lines from the fuel injectors. Refer to *Injection Line(s) Replacement* in Engine Controls-6.5L.
11. Remove the valve rocker arm cover bolts from the cylinder head.



358437

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.

12. Remove the valve rocker arm cover from the cylinder head.
13. Remove all oil and grease from the sealing surfaces.

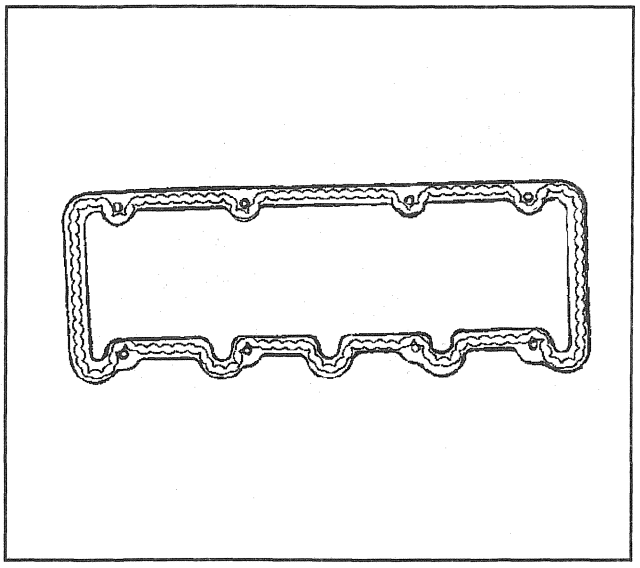


358435

Installation Procedure

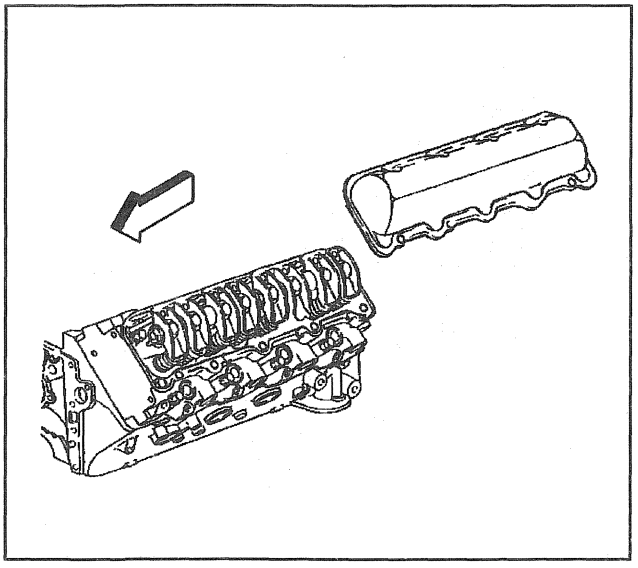
Notice: Do not allow the RTV sealant into the valve rocker arm cover bolt holes. This may cause a "valve lock" condition, when the bolts are tightened, damaging the cylinder head casting.

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

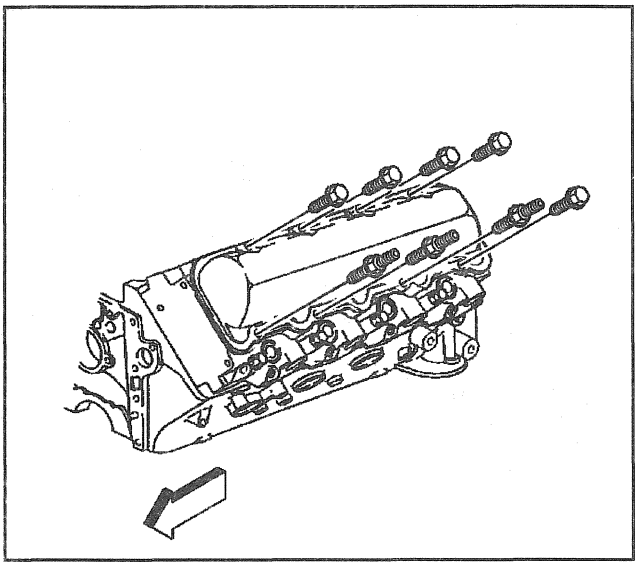


60277

2. Install the valve rocker arm cover to the cylinder head.



358435



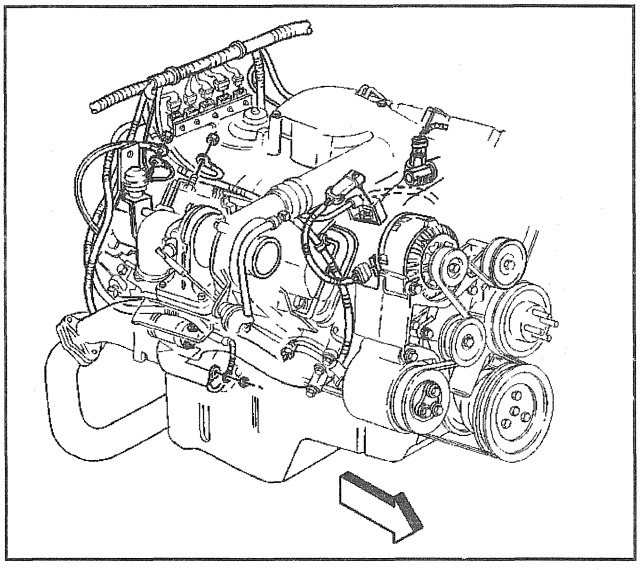
358437

Notice: Refer to *Fastener Notice* in Caution and Notices.

3. Install the valve rocker arm cover bolts to the cylinder head.

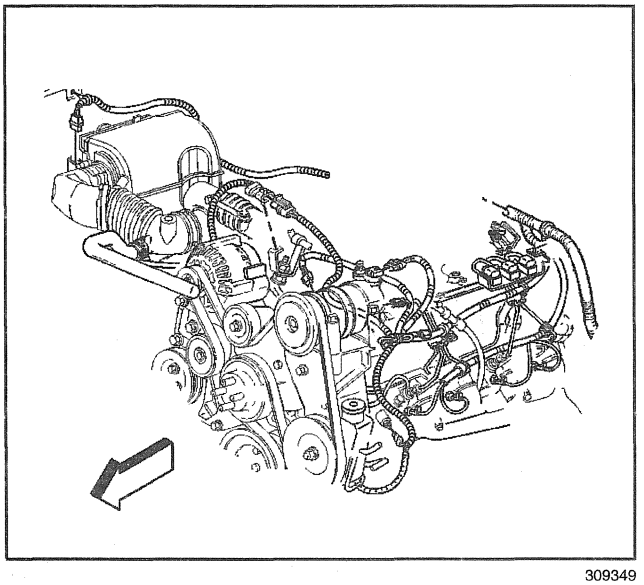
   Tighten

   Tighten the bolts to 22 N·m (16 lb ft).
4. Install the fuel injection lines to the fuel injection pump and fuel injectors. Refer to *Injection Line(s) Replacement* in Engine Controls—6.5L.
5. Remove the lower intake manifold from the engine assembly. Refer to *Intake Manifold Replacement (Lower)*.
6. Install the upper intake manifold to the lower intake manifold. Refer to *Intake Manifold Replacement (Upper)*.



309340

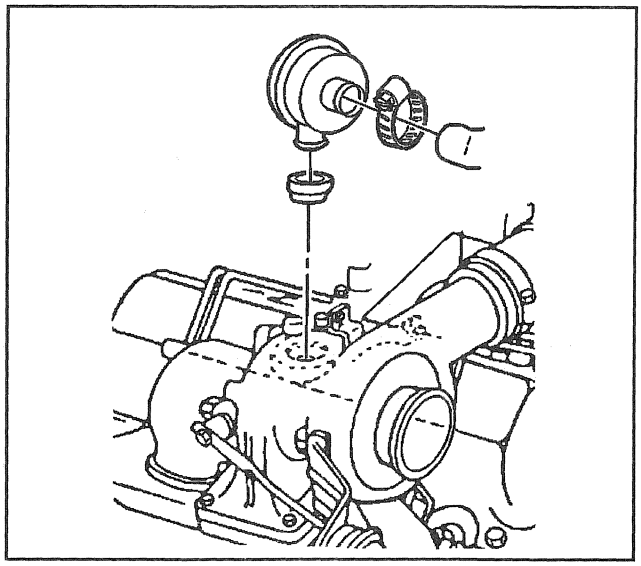
7. Install the wiring harness to the right side of the engine assembly.



309349

8. Install the wiring harness to the left side of the engine assembly.

9. Install the CDR valve to the valve rocker arm cover.
10. Install the heater hoses on the engine assembly.
    - For the vehicles with auxiliary heat (front), refer to *Heater Hoses Replacement - Auxiliary (Suburban- Front)* in HVAC.
    - For the vehicles with auxiliary heat (rear), refer to *Heater Hoses Replacement - Auxiliary (Diesel- Rear)* in HVAC.
    - For the vehicles with without auxiliary heat (inlet), refer to *Heater Hoses Replacement (Inlet Hose- Diesel)* in HVAC.
    - For the vehicles with auxiliary heat (outlet), refer to *Heater Hoses Replacement (Outlet Hose- Diesel)* in HVAC.
11. Install the oil level indicator and tube on the engine assembly if removed. Refer to *Oil Level Indicator and Tube Replacement*.
12. Install the turbocharger on the exhaust manifold if removed. Refer to *Turbocharger*.
13. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.



332410

Valve Rocker Arm, Shaft, and Push Rod Replacement

Removal Procedure

Important: Rotate the engine until the mark on the crankshaft balancer is at the 2 o'clock position.

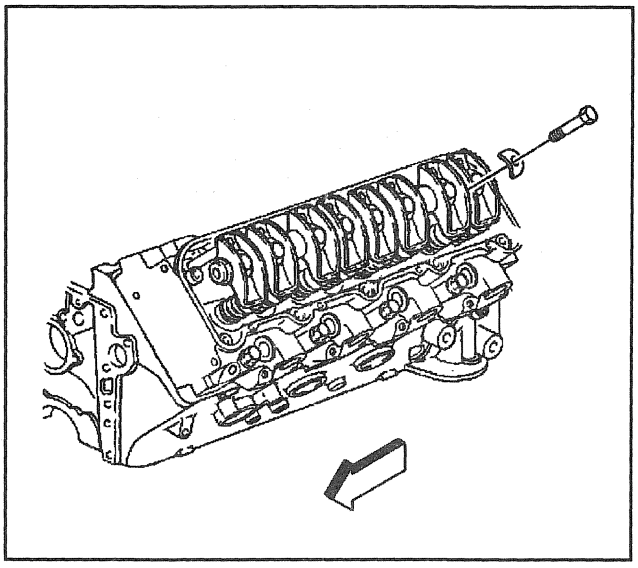
Rotate the crankshaft counter clock wise 88 mm (3 1/2 inch), aligning the crankshaft balancer mark with the first lower water pump bolt, about 12:30.

This will position the engine so that no valves are close to the piston crown.

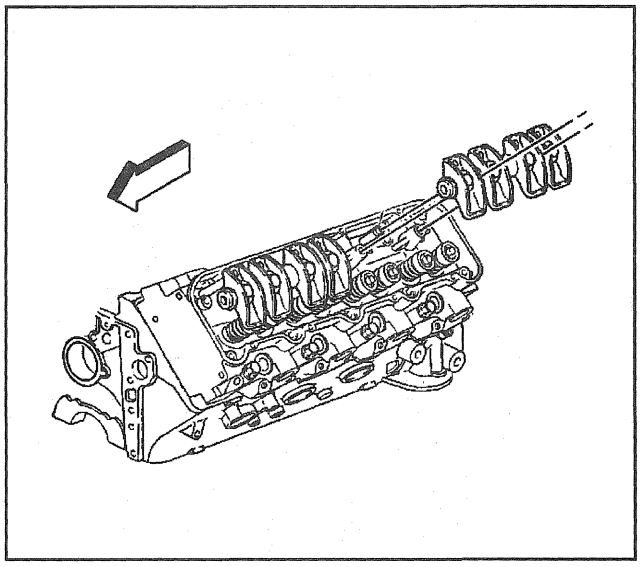
1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable*.
2. Remove the upper intake manifold from the lower intake manifold. Refer to *Intake Manifold Replacement (Upper)*.
3. Remove the lower intake manifold from the cylinder heads. Refer to *Intake Manifold Replacement (Lower)*.
4. Remove the valve rocker arm cover from the cylinder head. 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.

5. Remove the valve rocker arm shaft bolts from the cylinder head.

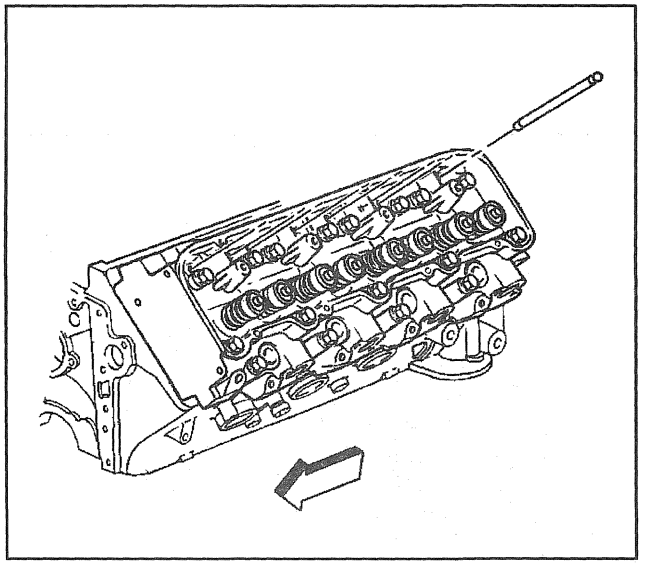


358427



358429

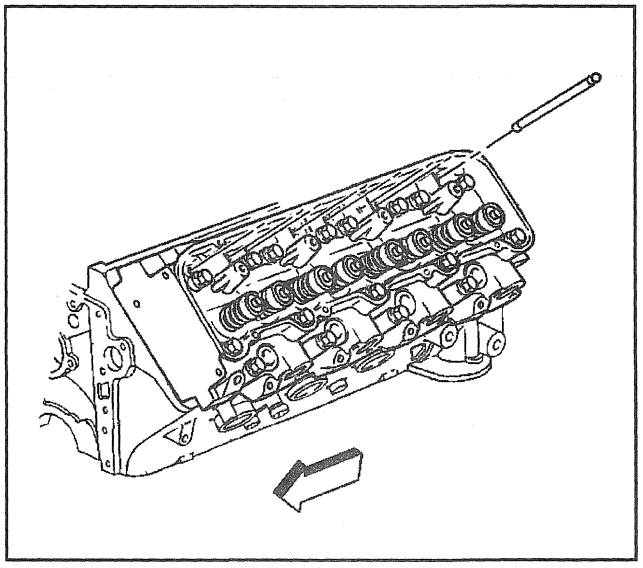
6. Remove the valve rocker arm shaft with the valve rocker arm.



172998

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

7. Remove the push rods from the engine block.
8. Remove the valve rocker arms from the cylinder head.
9. Insert a screwdriver into the valve rocker arm shaft bore and break off the end of the nylon valve rocker arm retainers.
10. Remove the valve rocker arm retainers with a pair of pliers.
11. Slide the valve rocker arms from the rocker arm shaft.



172998

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.

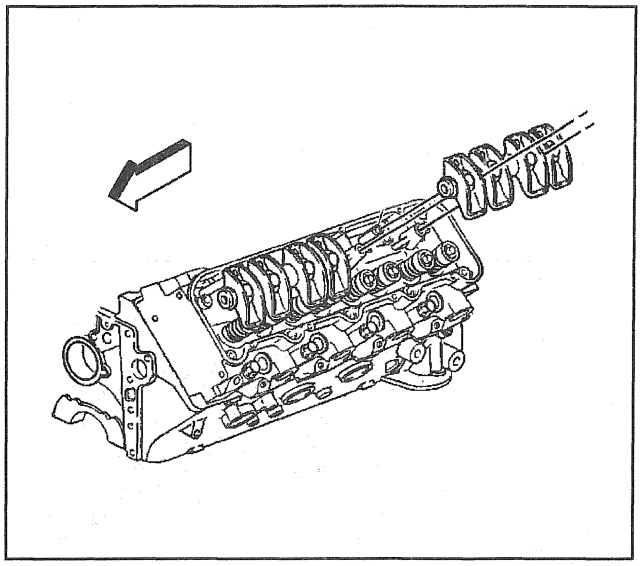
Notice: Install the valve pushrods with the copper-colored, painted, or marked end up in order to avoid damage or premature wear.

1. Install the push rod, with the painted or marked end up to the engine block.

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

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

6. Install the valve rocker arm shaft assembly to the cylinder head.



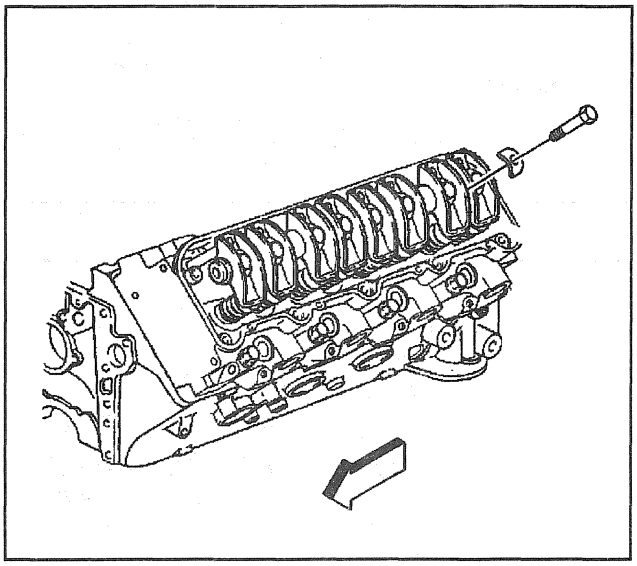
358429

Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. Install the valve rocker arm shaft bolts to the cylinder head.

   Tighten

   Tighten the bolts to 55 N·m (40 lb ft).
8. Install the valve rocker arm cover to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement*.
9. Install the lower intake manifold to the cylinder heads. Refr to *Intake Manifold Replacement (Lower)*.
10. Install the upper intakew manifold to the lower intake manifold. Refer to *Intake Manifold Replacement (Upper)*.
11. Connect the battery negative cable to the battery. Refer to *Battery Cable* in Engine Electrical.

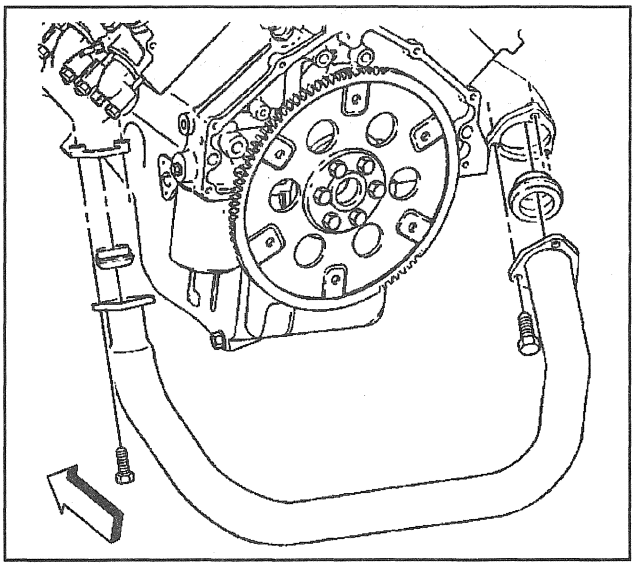


358427

Exhaust Manifold Replacement (Right)

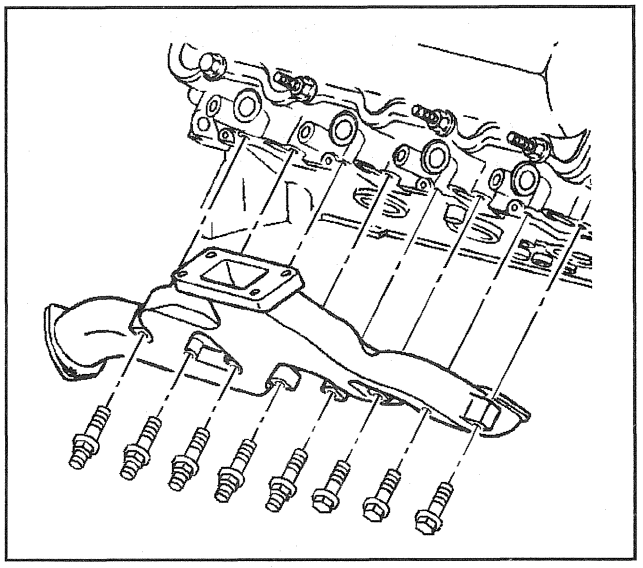
Removal Procedure

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Remove the air cleaner assembly from the vehicle. Refer to *Air Cleaner Assembly Replacement* in Engine Controls-6.5L.
3. Remove the turbocharger assembly from the exhaust manifold. Refer to *Turbocharger*.
4. Raise the vehicle and support the vehicle with safety stands.
5. Remove the starter from the vehicle. Refer to *Starter Motor Replacement (Diesel Engines)* in Engine Electrical.
6. Remove the inspection cover from the transmission.



210390

7. Remove the exhaust crossover pipe bolts from the exhaust manifold.
8. Remove the safety stands and partially lower the vehicle.
9. Remove the glow plugs from the cylinder head. Refer to *Glow Plug Replacement - Right Side* in Engine Controls-6.5L.
10. Remove the inner wheel housing splash shield.
11. Remove the exhaust manifold bolts (all but the front and rear) and bolts from the cylinder head.
12. Completely lower the vehicle.
13. Remove the remaining bolts exhaust manifold.
14. Remove the exhaust manifold from the cylinder head.
15. Clean the threads on the exhaust manifold bolts.



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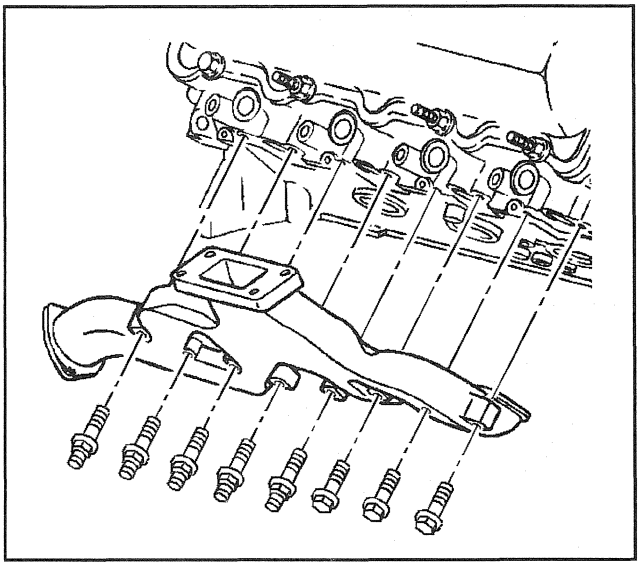


60245

Installation Procedure

1. Install the exhaust manifold to the cylinder head.
2. Install a bolt to the front and rear of the exhaust manifold.
3. Raise the vehicle and support with safety stands.

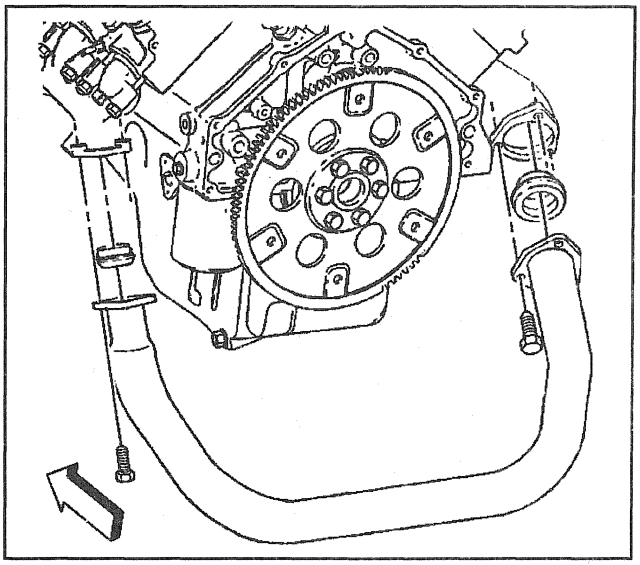
Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the exhaust manifold bolts.

   Tighten

   Tighten the bolts and stud/nuts to 35 N·m (26 lb ft).
5. Install the inspection cover to the transmission.
6. Install the starter to the engine block. Refer to *Starter Motor Replacement (Diesel Engines)* in Engine Electrical.

7. Install the exhaust crossover pipe to the exhaust manifold.
8. Remove the safety stands and partially lower the vehicle.
9. Install the glow plugs in the cylinder head. Refer to *Glow Plug Replacement - Right Side* in Engine Controls-6.5L.
10. Lower the vehicle completely.
11. Install the turbocharger to the exhaust manifold. Refer to *Turbocharger*.
12. Install the air cleaner assembly to the vehicle. Refer to *Air Cleaner Assembly Replacement* in Engine Controls—6.5L.
13. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.



210390

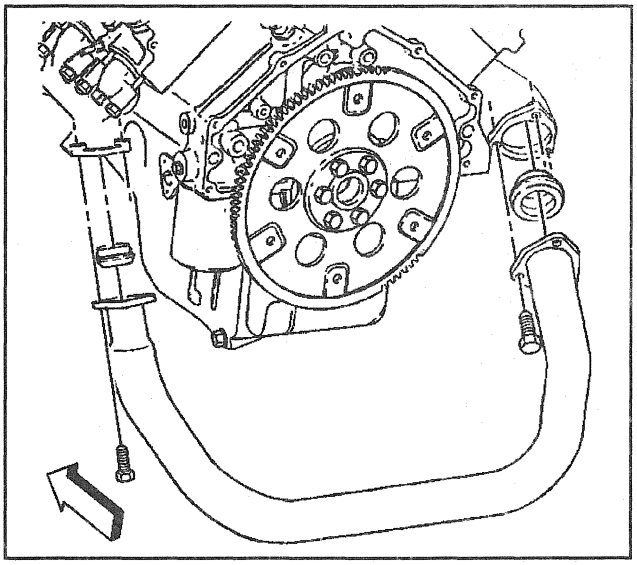
Exhaust Manifold Replacement (Left)

Removal Procdure

Important: The exhaust crossover pipe does not have to be removed from the vehicle to perform this service procedure.

1. Remove the exhaust crossover pipe bolts from the exhaust manifolds left exhaust manifold.

   Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Loosen the exhaust crossover pipe bolts at the right exhaust manifold.
3. Secure the exhaust crossover pipe out of the way.
4. Partially raise the vehicle and remove the splash shield from the wheel housing.
5. Remove the glow plugs from the cylinder head. Refer to *Glow Plug Replacement - Left Side* in Engine Controls-6.5L.
6. Completely raise the vehicle.
7. Remove the exhaust manifold from underneath the vehicle.
8. Clean the threads on the exhaust manifold bolts and stud/nuts.



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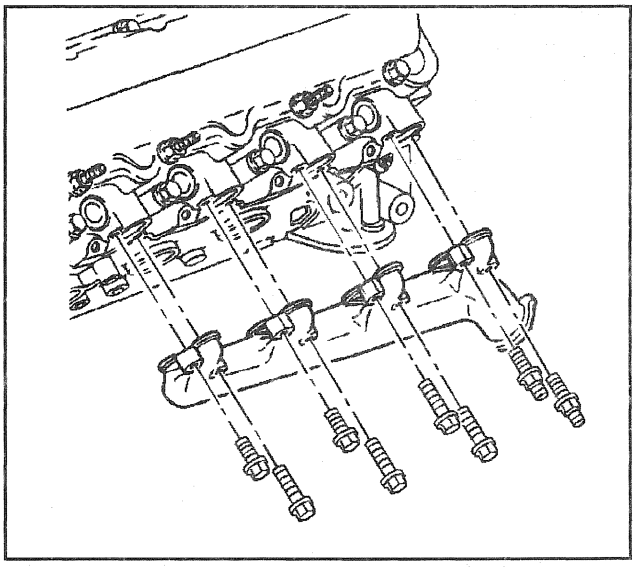

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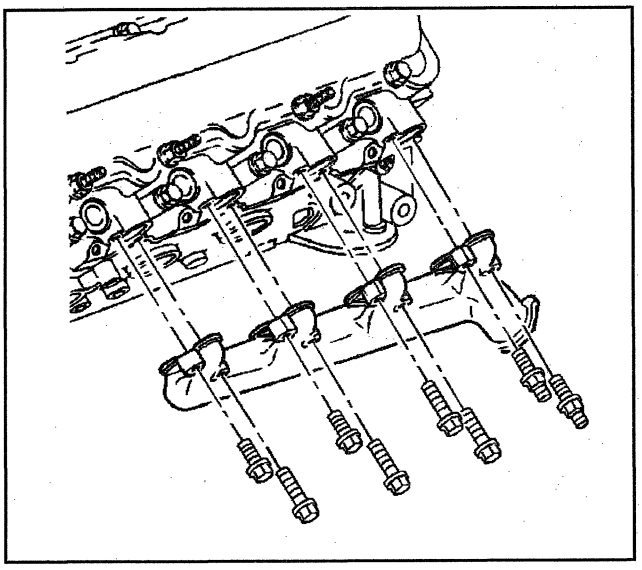


60243

Installation Procedure

1. Install the exhaust manifold from underneath the vehicle.

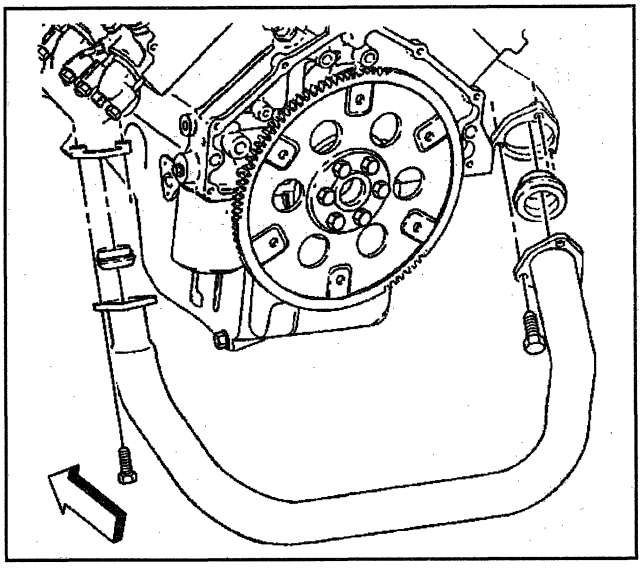
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the exhaust manifold bolts and stud/nuts.

   Tighten

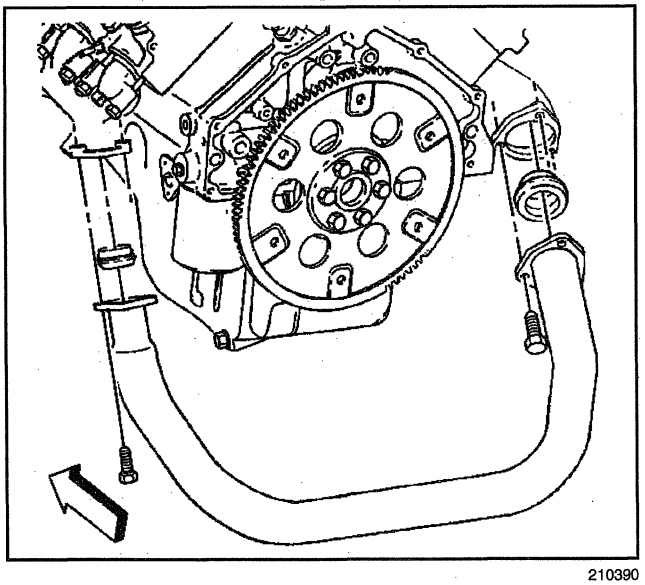
   Tighten the bolts and stud/nuts to 35 N·m (26 lb ft).

3. Partially lower the vehicle.
4. Install the glow plugs in the cylinder heads. Refer to *Glow Plug Replacement - Left Side* in Engine Controls-6.5L.



210390

5. Install the exhaust crossover pipe to the exhaust manifold.
6. Install the splash shield to the inner wheel housing.
7. Completely lower the vehicle.
8. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.



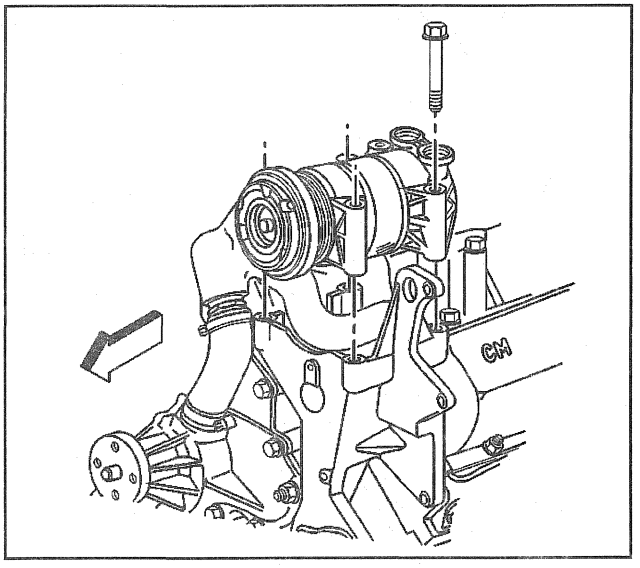
210390

Cylinder Head Replacement

Removal Procedure

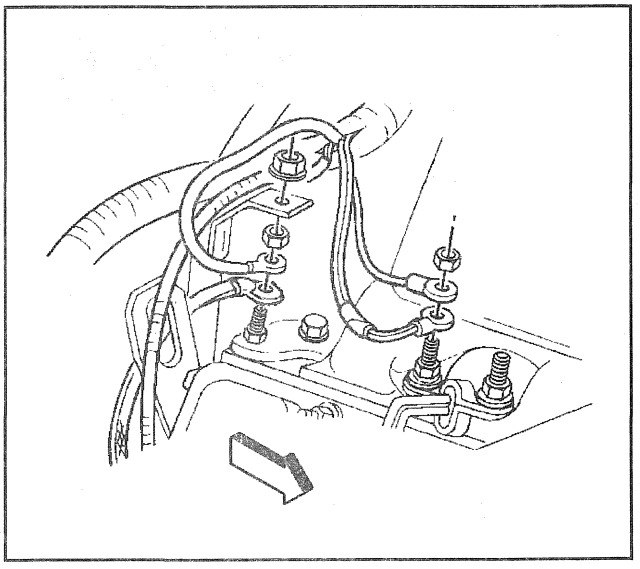
1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Remove the upper intake manifold from the lower intake manifold. Refer to *Intake Manifold Replacement (Upper).*
4. Remove the lower intake manifold from the cylinder heads. Refer to *Intake Manifold Replacement (Lower).*
5. Remove the radiator hoses from them engine block.
6. Remove the thermostat housing crossover from the cylinder heads. Refer to *Thermostat Housing Crossover Replacement* in Engine Cooling.

7. Raise the vehicle and support with safety stands.
8. Remove the exhaust crossover pipe from the exhaust manifolds.
9. Lower the vehicle.
10. Remove the exhaust manifold (s) from the cylinder head (s) from the engine block.
    - If removing the left cylinder head, refer to *Exhaust Manifold Replacement (Left).*
    - If removing the right cylinder head, refer to *Exhaust Manifold Replacement (Right).*
11. Remove the air conditioning compressor and mounting bracket and secure to the side.
12. Remove the vacuum pump if necessary. Refer to *Vacuum Pump Replacement.*
13. Remove the generator and bracket form the engine assembly. Refer to *Generator Replacement (Diesel Engines)* in Engine Electrical.



317717

14. Remove the ground strap from the cylinder head.
15. Remove the valve rocker arm, shaft, and push rods from the cylinder head. Refer to *Valve Rocker Arm, Shaft, and Push Rod Replacement.*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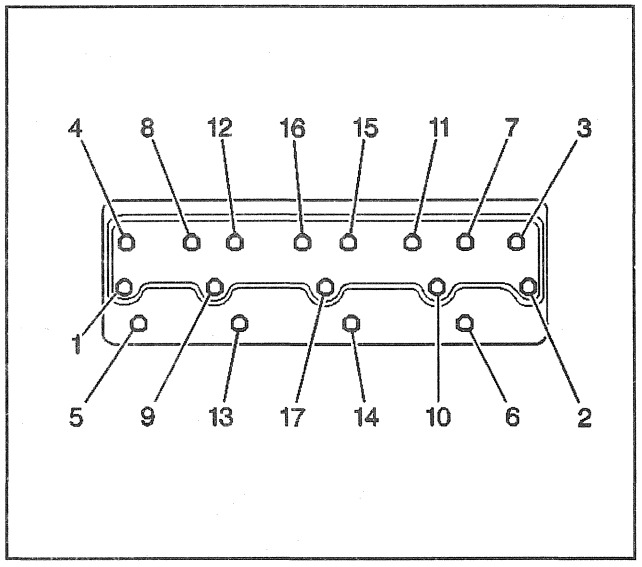

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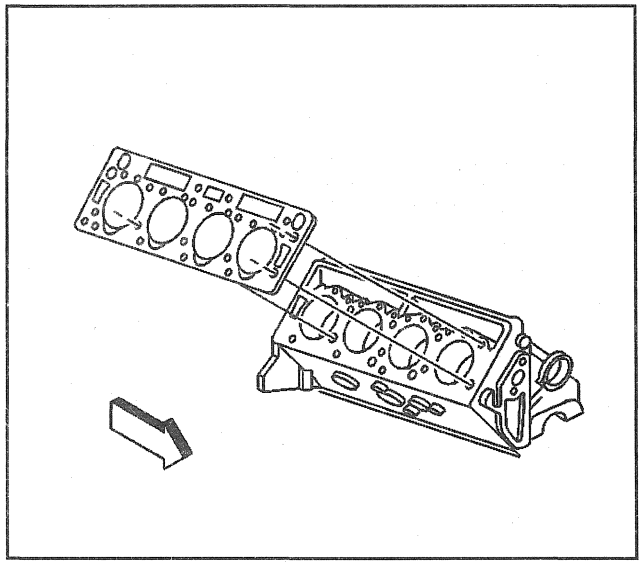
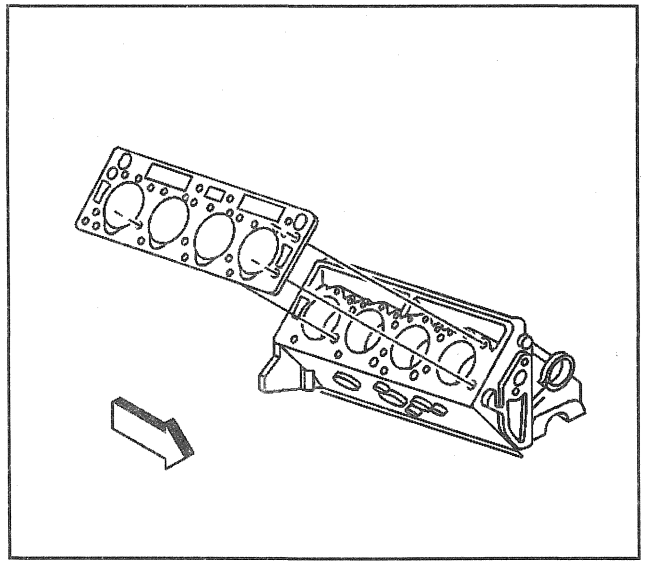
16. Remove the cylinder head bolts (in sequence) from the cylinder head.



311338

17. Remove the cylinder head from the engine block.
18. Remove the cylinder head gasket from the engine block.
19. Disassemble the cylinder head (if necessary). Refer to *Cylinder Head Disassemble*.



311338

Installation Procedure

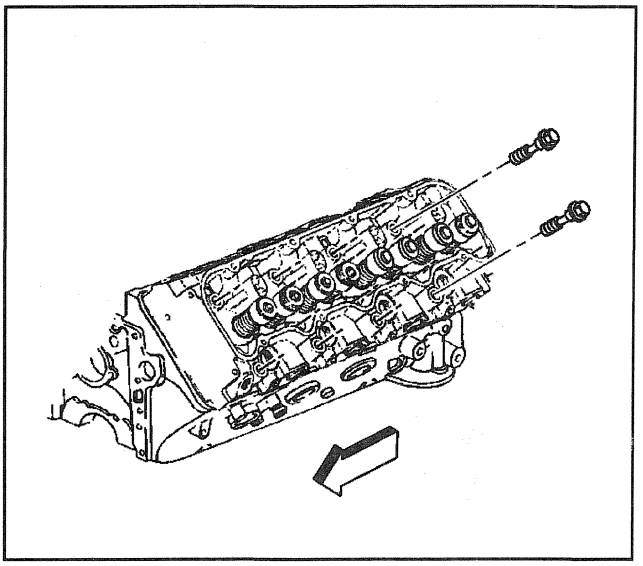
Important: The engine block surfaces must be clean. Do not use a sealer on the cylinder head gaskets. The cylinder head gaskets are manufactured with the proper amount of sealant "Printed" on its surface. Additional sealer may cause leakage or a malfunction. In addition, some sealers may attack the sealant already on the cylinder 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. Assemble the cylinder head (if necessary). Refer to *Cylinder Head Assemble*.

Important: Connect the rear cylinder head bolt to the cylinder head (left cylinder head only) with a rubber band. Due to the clearances, the bolt must be installed at this time.

2. Install the cylinder head bolts in the cylinder head.



362141

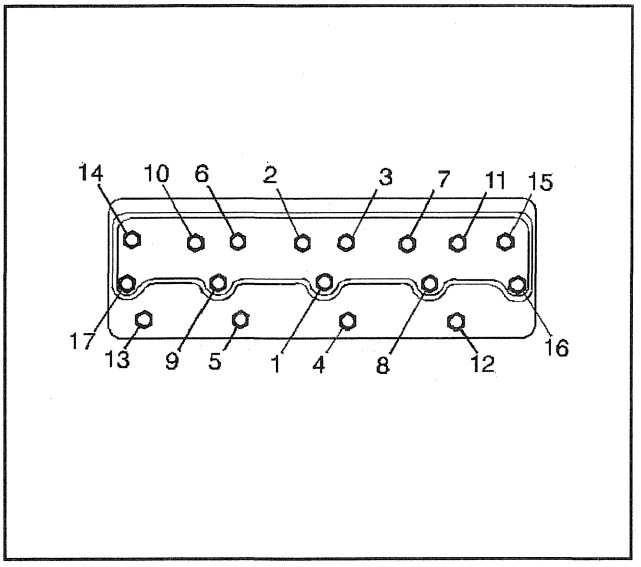
Notice: Refer to *Fastener Notice* in Caution and Notices.

3. Install the cylinder head bolts and tighten in sequence.

   Tighten

   3.1. Tighten the bolts in four passes.
   3.2. Tighten the bolts to 25 N·m (20 lb ft).
   3.3. Tighten the bolts to 75 N·m (55 lb ft).
   3.4. Tighten the bolts to 75 N·m (55 lb ft).
   3.5. In sequence, tighten all bolts an additional 90 to 100 degrees (1/4 + turn).

4. Install the push rods, valve rocker arm, and the shafts to the cylinder head. Refer to *Valve Rocker Arm, Shaft, and Push Rod Replacement*.
5. Install the thermostat housing crossover to the cylinder heads. Refer to *Thermostat Housing Crossover Replacement* in Engine Cooling.
6. Install the generator and mounting bracket to the cylinder head. Refer to *Generator Replacement (Diesel Engines)* in Engine Electrical.
7. Install the vacuum pump if necessary. Refer to *Vacuum Pump Replacement*.



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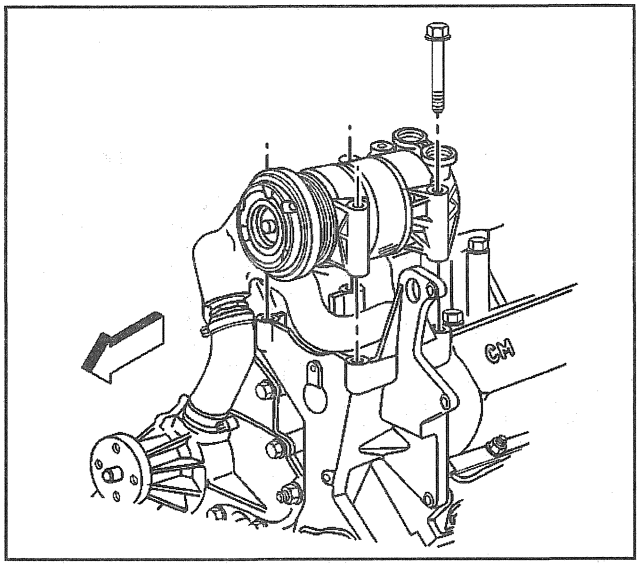
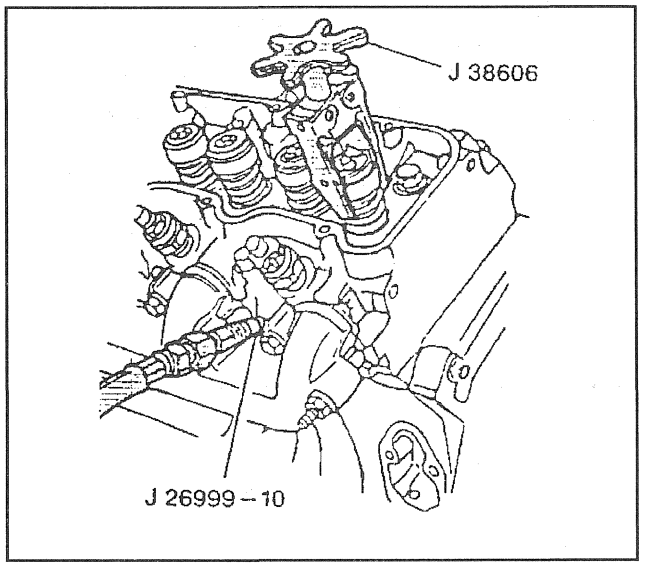


317717

8. Install the air conditioning compressor and mounting bracket.
9. Install the exhaust manifold (s) to the cylinder head (s).
   - If installing the left cylinder head, refer to *Exhaust Manifold Replacement (Left)*.
   - If installing the right cylinder head, refer to *Exhaust Manifold Replacement (Right)*.
10. Raise the vehicle.
11. Install the exhaust crossover pipe to the exhaust manifolds.
12. Lower the vehicle.
13. Install the lower intake manifold to the engine block. Refer to *Intake Manifold Replacement (Lower)*.
14. Install the upper intake manifold lower intake manifold. Refer to *Intake Manifold Replacement (Upper)*.
15. Install the radiator hoses on the engine block.
16. Refill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
17. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.



66613

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. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Remove the valve rocker arm covers from the cylinder head. Refer to *Valve Rocker Arm Cover Replacement*.
3. Remove the valve rocker arm and pushrod from the engine block. Refer to *Valve Rocker Arm, Shaft, and Push Rod Replacement*.
4. Remove the glow plugs from the cylinder head.
   - If servicing the left cylinder head, refer to *Glow Plug Replacement - Left Side* in Engine Controls-6.5L.
   - If servicing the right cylinder head, refer to *Glow Plug Replacement - Right Side* in Engine Controls-6.5L.

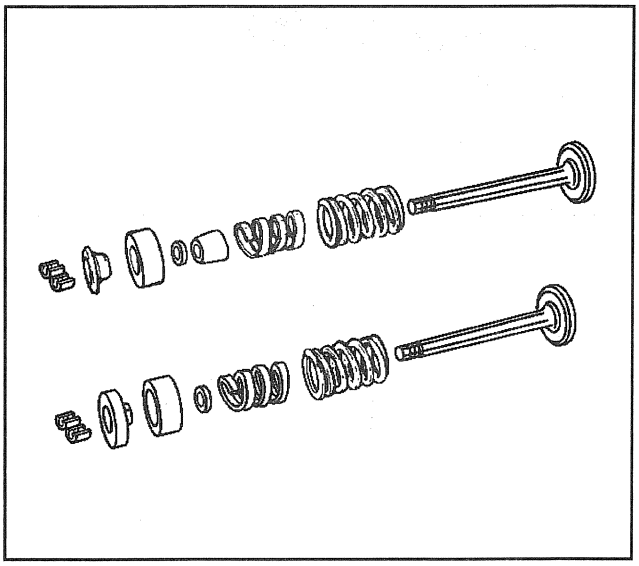
Important: Rotate the engine until the in the cylinder being serviced is at the bottom of the stroke. This will ensure that the cylinder will not move when compressed air is applied to that cylinder.

5. Use the *J 26999-10* left side of the engine and *J 26999-30* for the right side of the engine when applying the compressed air to the cylinder being serviced.

Important: Make sure that the compressed air is not released, until the repair the is completed. The valve will drop into the cylinder and damage could occur.

Apply compressed air into the cylinder being serviced.

6. Tap lightly on the valve spring cap or rotator to loosen the valve keys.
7. Use the *J 38606* in order to compress the valve spring.
8. Compress the valve spring.
9. Remove the valve keys from the retainers from the cylinder head.
10. Carefully release the valve spring tension and remove the *J 38606*.
11. Remove the valve stem oil seals from the valve guides.



60271

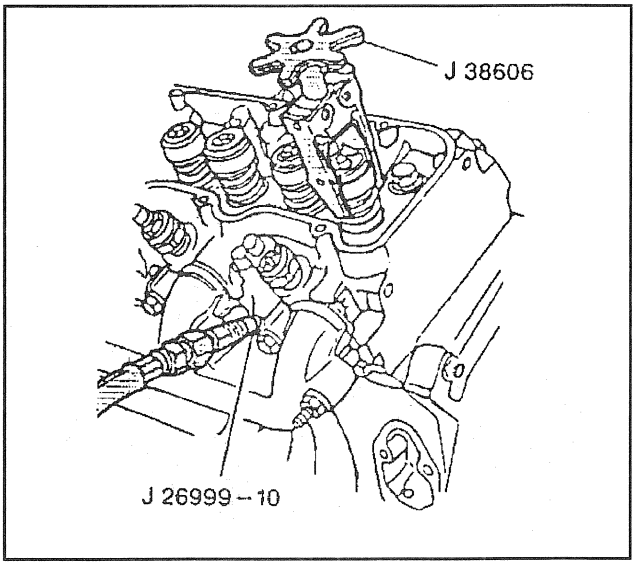
Installation Procedure

Tools Required

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

Important: The air pressure should remain applied to the cylinder being serviced until after the repair has been completed.

1. Apply a small amount of clean engine oil to the valve stem and to the new valve stem oil seal.
2. Install the valve stem oil seal to the valve stem.
3. Install the valve spring, cap, rotator and shield.
4. Use the *J 38606* to compress the valve spring.



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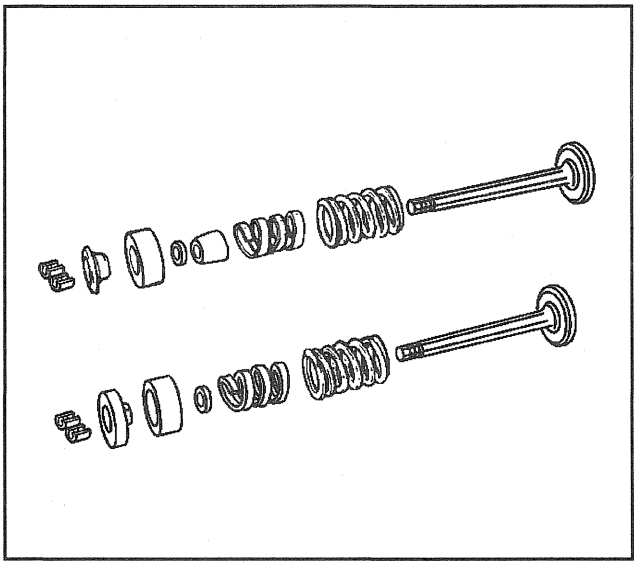
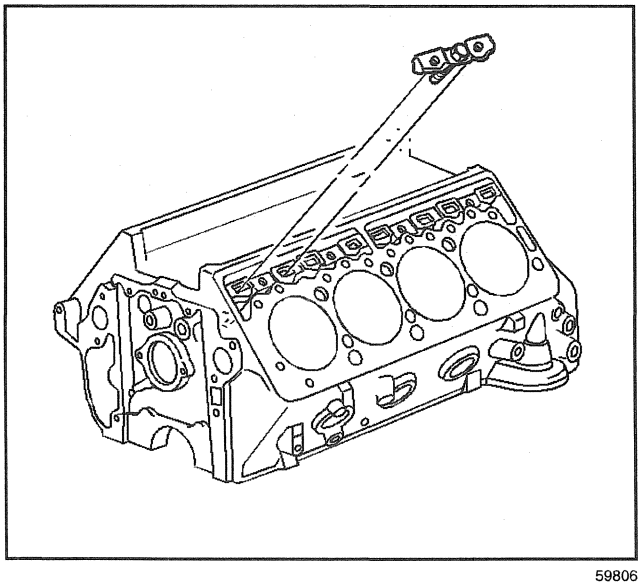


60271

5. Install valve spring assembly to the cylinder head.
6. Install the valve keys in the retainer.
   - Apply a small amount of grease on the valve stem end. This will help to hold the valve keys in place.
   - Carefully release the valve spring pressure. Make sure the valve key are properly seated in the cap.
   - Remove the *J 38606* from the valve spring.
7. Slowly release the compressed air from the cylinder being serviced.
8. Remove the *J 26999-10* when working on the left side of the engine and *J 26999-30* for the right side of the engine.
9. Install the glow plug to the cylinder head.
   - If servicing the left cylinder head, refer to *Glow Plug Replacement - Left Side* in Engine Controls-6.5L.
   - If servicing the right cylinder head, refer to *Glow Plug Replacement - Right Side* in Engine Controls-6.5L.

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

10. Install the valve rocker arm and pushrod to the cylinder head. Refer to *Valve Rocker Arm, Shaft, and Push Rod Replacement.*
11. Install the valve rocker arm covers to the cylinder head. Refer to *Valve Rocker Arm Cover Replacement.*
12. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.



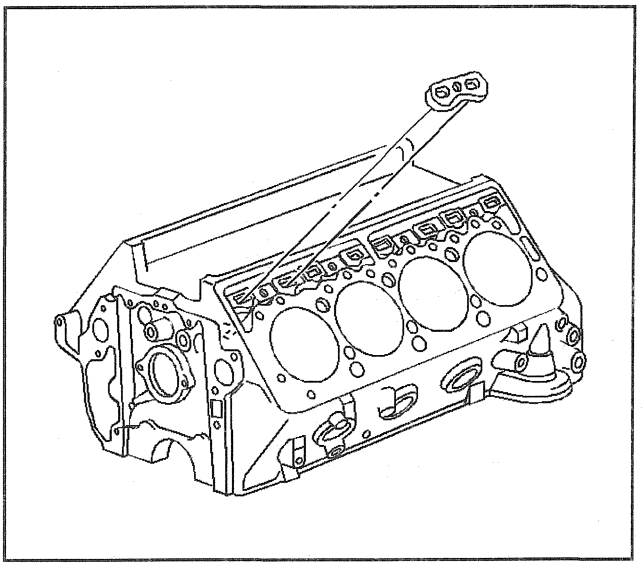
59806

Valve Lifter Replacement

Removal Procedure

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Remove the upper intake manifold from the lower intake manifold. Refer to *Intake Manifold Replacement (Upper).*
3. Remove the lower intake manifold from the cylinder heads. Refer to *Intake Manifold Replacement (Lower).*
4. Remove the valve rocker arm, shaft and push rod from the cylinder head. Refer to *Valve Rocker Arm, Shaft, and Push Rod Replacement.*
5. Remove the cylinder head from the engine block. Refer to *Cylinder Head Replacement.*
6. Remove the valve lifter retainer and bolt from the engine block

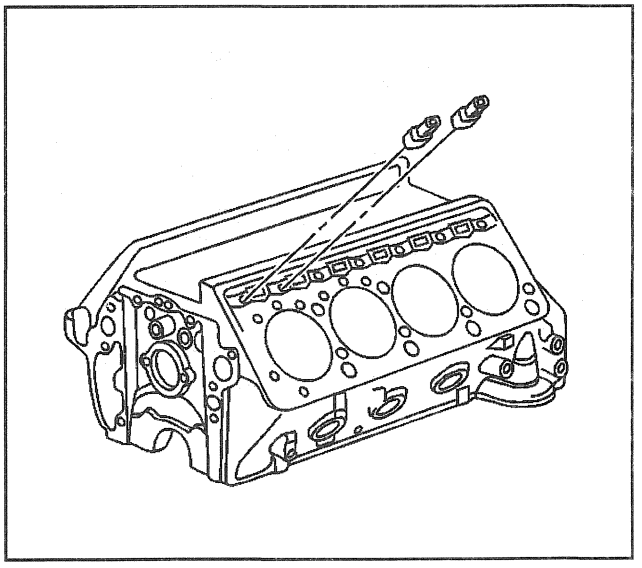
7. Remove the valve lifter guide from the engine block.



59809

8. Remove the valve lifters from the engine block.
9. Place the valve lifters, valve lifter guides, and retainer and bolt in a organizer rack

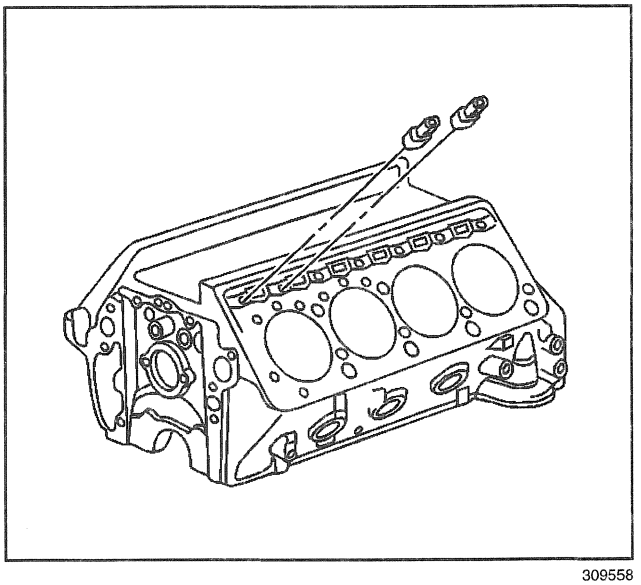
Important: Some engines will have both standard and 0.010 inch oversize valve lifters. The oversize valve lifter will have a "10" etched on the cast pad adjacent to the valve lifter bore and on the top rail of the cylinder case above the valve lifter.



309558

Installation Procedure

1. Apply a small amount of GM P/N 1052365 lubricant to the valve lifter roller bearings.
2. Install the new valve lifters to the engine block.



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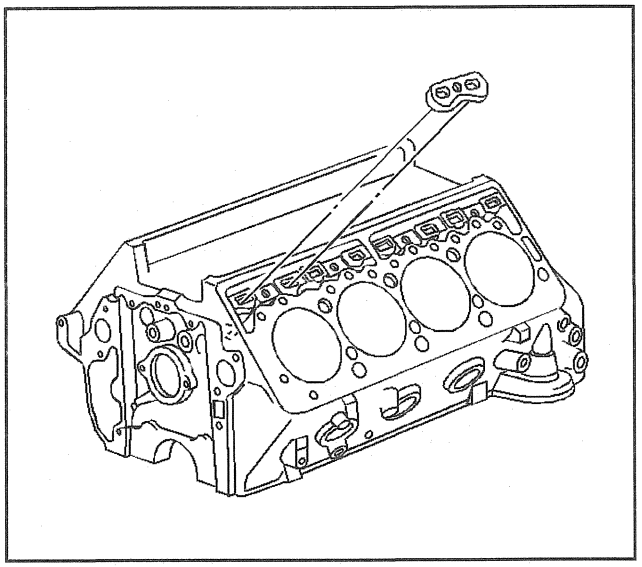
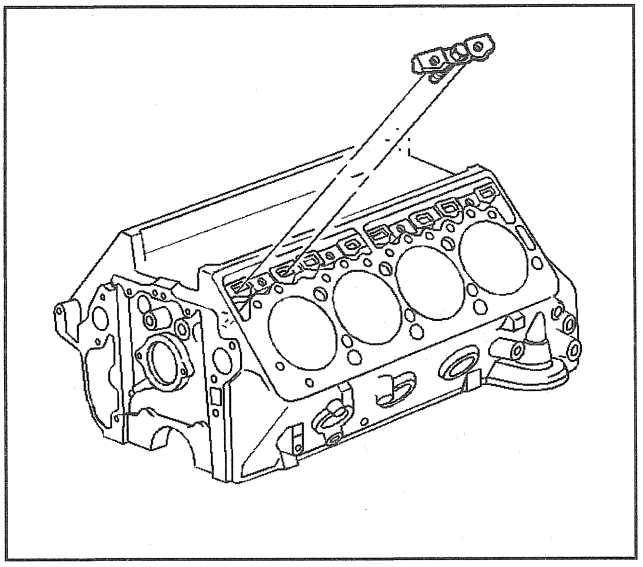


59809

3. Install the valve lifter guide to the engine block.



59806

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

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the valve lifter retainer and bolt to the engine block.

   Tighten

   Tighten the bolts to 26 N·m (18 lb ft).
5. Install the valve rocker arm, shaft, and push rod to the cylinder head. Refer to *Valve Rocker Arm, Shaft, and Push Rod Replacement.*
6. Install the cylinder head assembly to the engine block. Refer to *Cylinder Head Replacement.*
7. Install the lower intake manifold to the engine block. Refer to *Intake Manifold Replacement (Lower).*
8. Install the upper intake manifold to the engine block. Refer to *Intake Manifold Replacement (Upper).*
9. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.

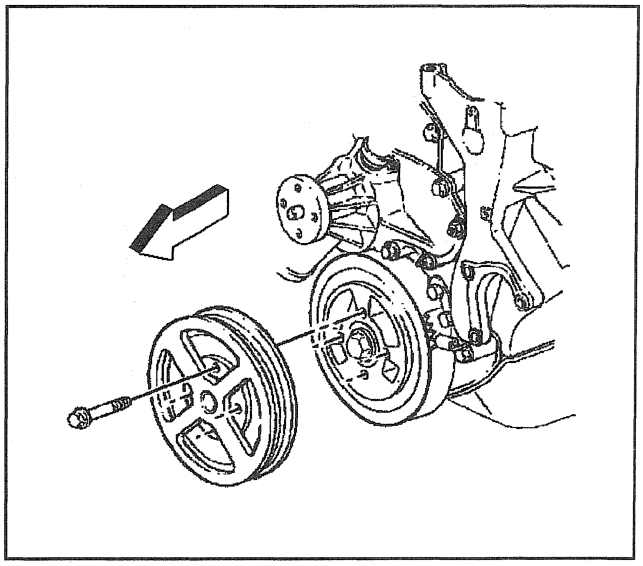
Crankshaft Balancer Replacement

Removal Procedure

Tools Required

J 23523-F Crankshaft Balancer Remover

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Remove the upper fan shroud from the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.
3. Remove drive belt from the vehicle. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
4. Raise the vehicle and support with safety stands.
5. Remove the lower fan shroud from the radiator. Refer to *Fan Shroud Replacement (Lower)* in Engine Cooling.
6. Remove the crankshaft pulley from the crankshaft.



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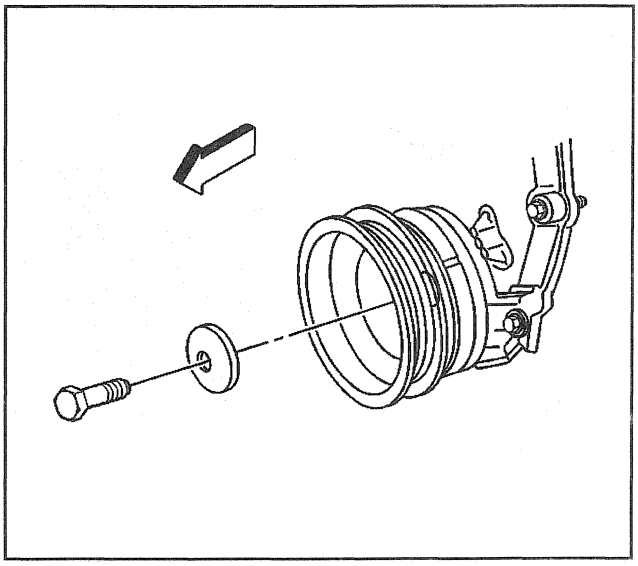
7. Remove the crankshaft balancer bolt and washer from the crankshaft.



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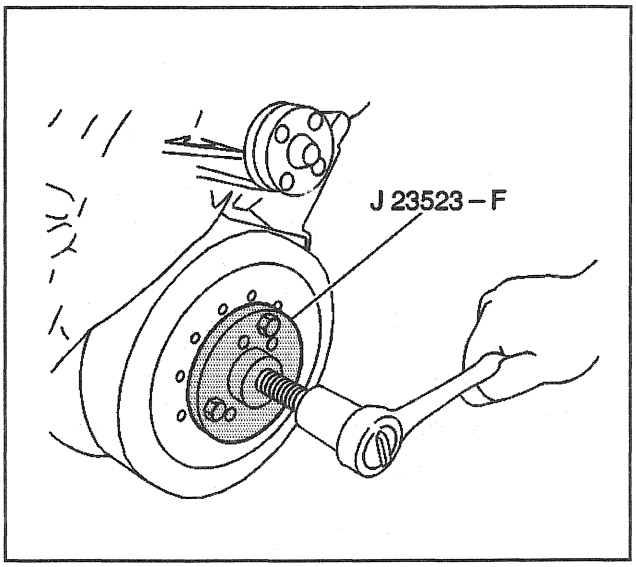
8. Use the *J 23523-F* to remove the crankshaft balancer from the crankshaft.
9. Remove the *J 23523-F* from the crankshaft balancer.



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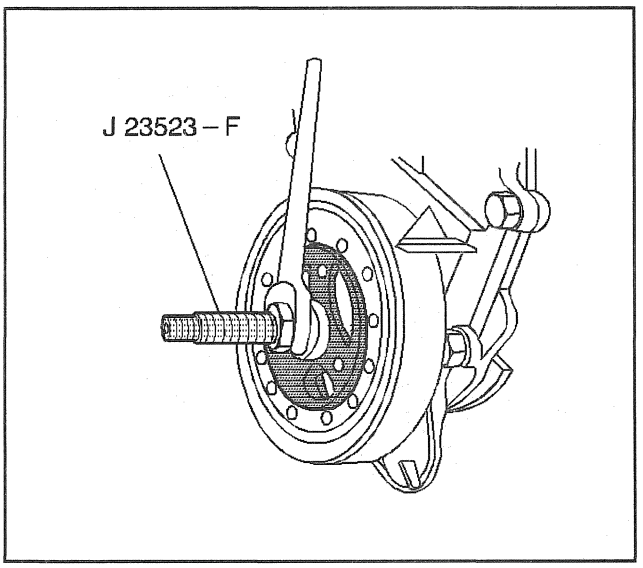


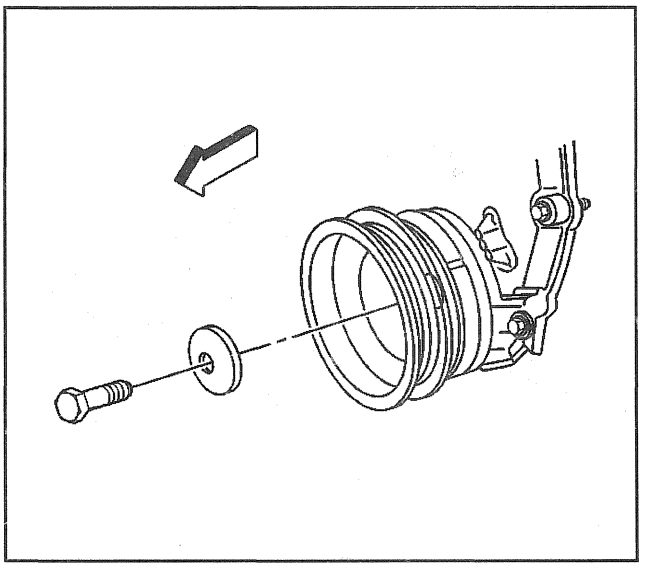
66720

Installation Procedure

Tools Required

J 23523-F Crankshaft Balancer Remover

1. Apply a small amount of clean engine oil the crankshaft balancer.
2. Lightly tap the crankshaft balancer into the crankshaft.
3. Install the *J 23523-F* to the crankshaft balancer.
4. Install the crankshaft balancer to the crankshaft.
5. Remove the *J 23523-F* from the crankshaft balancer.



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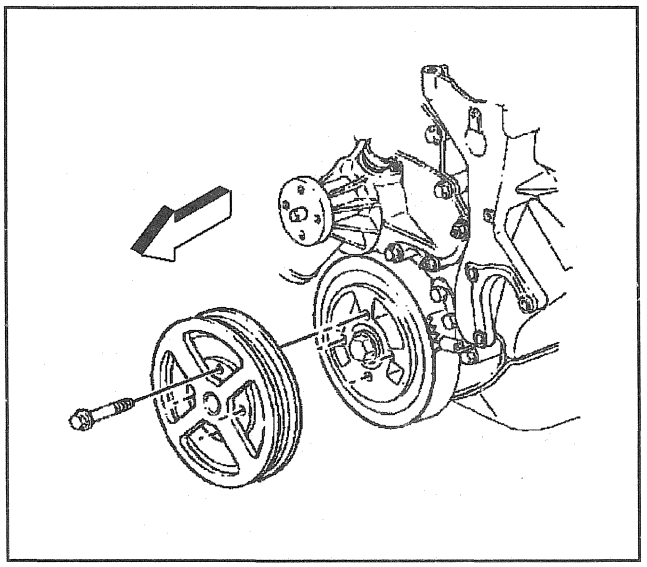
Important: When installing the crankshaft balancer bolt and washer, make sure take the curved part of the washer is pointed away from the engine.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

6. Install the crankshaft balancer bolt and washer to the crankshaft.

   Tighten

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



70257

7. Install the crankshaft pulley to the crankshaft.
8. Install the crankshaft pulley bolts.

   Tighten

   Tighten the bolts to 40 N·m (30 lb ft).
9. Install the lower fan shroud to the radiator. Refer to *Fan Shroud Replacement (Lower)*.
10. Lower the vehicle.
11. Install the drive belt in the vehicle. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
12. Install the upper fan shroud to the radiator. Refer to *Fan Shroud Replacement (Upper)*.
13. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.

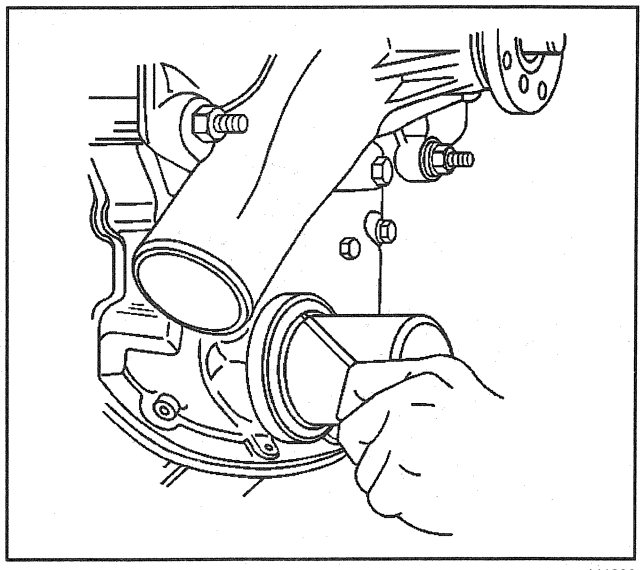
Crankshaft Front Oil Seal Replacement

Removal Procedure

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical
2. Remove the upper fan shroud from the radiator. Refer to *Fan Shroud Replacement (Upper)*.
3. Remove the drive belt from the pulleys. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
4. Raise the vehicle.
5. Remove the lower fan shroud from the radiator. Refer to *Fan Shroud Replacement (Lower)*.
6. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement*.

Important: Use care as not to damage the engine front cover, or the crankshaft when removing this seal.

7. Remove the crankshaft front cover oil seal from the engine front cover.



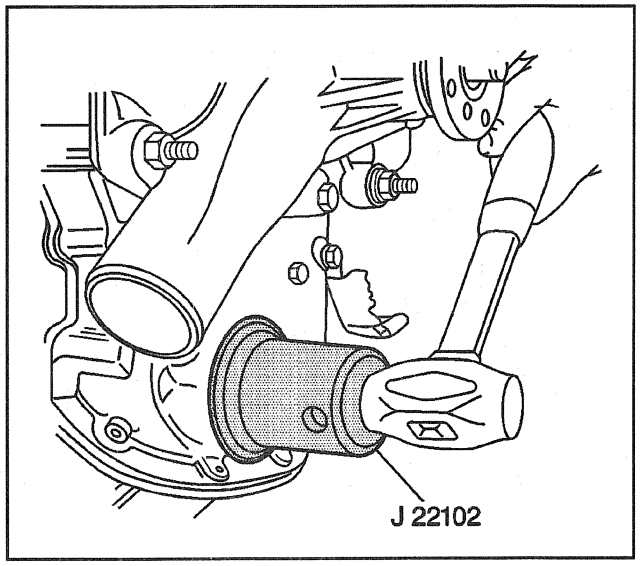
441296

Installation Procedure

Tools Required

J 22102 Seal installer

1. Apply a small amount of clean engine oil to the sealing surface of the crankshaft balancer.
2. Apply a small amount of clean engine oil to the inner sealing surface of the oil seal.
3. Use the *Install New Engine Front Cover Oil Seal 6.5L* to install the crankshaft front cover oil seal.
4. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement*.
5. Install the lower fan shroud to the radiator. Refer to *Fan Shroud Replacement (Lower)*.
6. Lower the vehicle.
7. Install the upper fan shroud to the radiator. Refer to *Fan Shroud Replacement (Upper)*
8. Install the drive belt to the pulleys. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
9. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.



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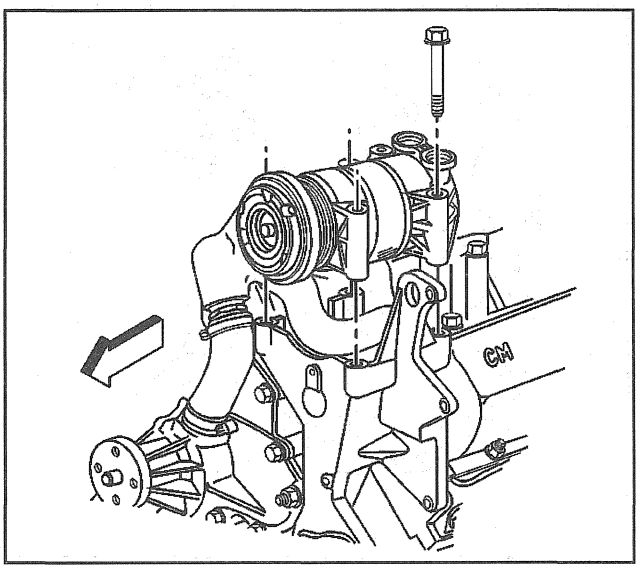

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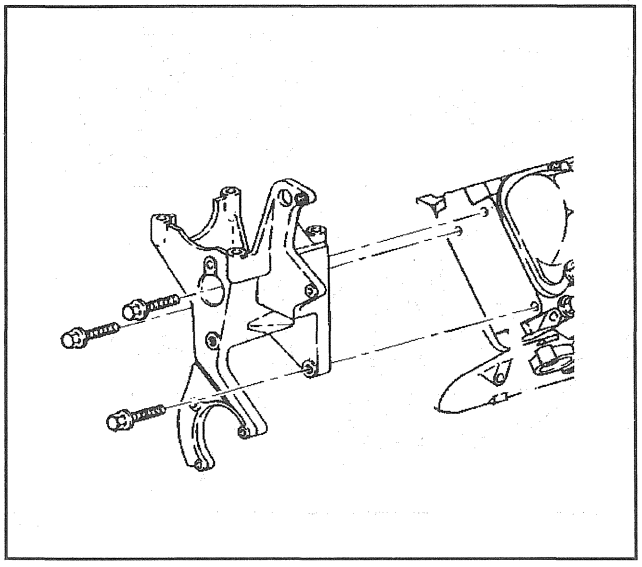

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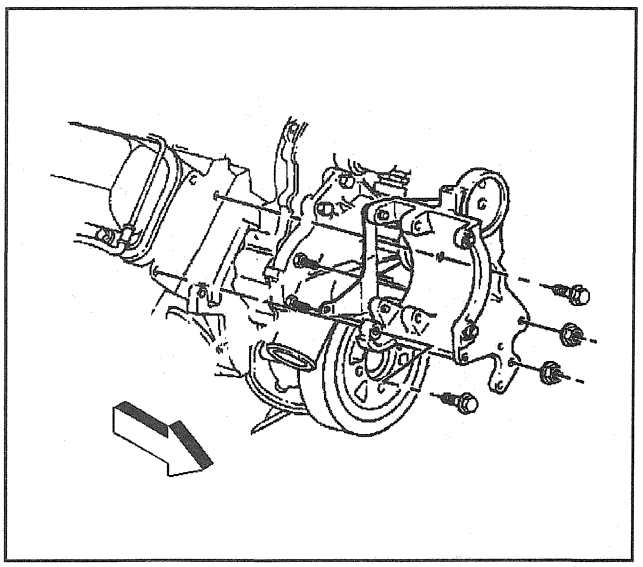
Engine Front Cover Replacement

Removal Procedure

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Remove the upper fan shroud from the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.
4. Remove the drive belt from the pulleys. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
5. Raise the vehicle.
6. Remove the lower fan shroud from the radiator. Refer to *Fan Shroud Replacement (Lower)* in Engine Cooling.
7. Remove the A/C compressor from the mounting bracket and reposition to the side.
8. Remove the power steering pump from the mounting bracket. Refer to *Power Steering Pump Replacement (6.5L)* in Power Steering.
9. Remove the left mounting bracket from the engine block.
10. Remove the generator from the mounting bracket. Refer to *Generator Replacement (Diesel Engines)* in Engine Electrical.
11. Remove the vacuum pump from the mounting bracket. Refer to *Vacuum Pump Replacement*.

12. Remove the right mounting bracket from the engine block.
13. Remove the water pump from the engine front cover. Refer to *Water Pump Replacement (Diesel Engines)* in Engine Cooling.
14. Remove the crankshaft balancer from the crankshaft. Refer to *Crankshaft Balancer Replacement*.
15. Remove the crankshaft position sensor from the engine front cover. Refer to *Crankshaft Position Sensor Replacement* in Engine Controls-6.5L.



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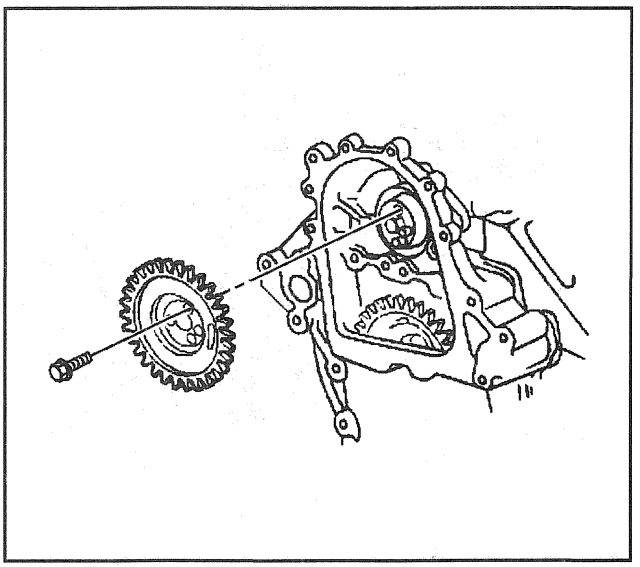
16. Remove the fuel injection drive gear from the camshaft.
17. Remove the fuel injection pump mounting bolts. Refer to *Fuel Injection Pump Replacement* in Engine Controls-6.5L

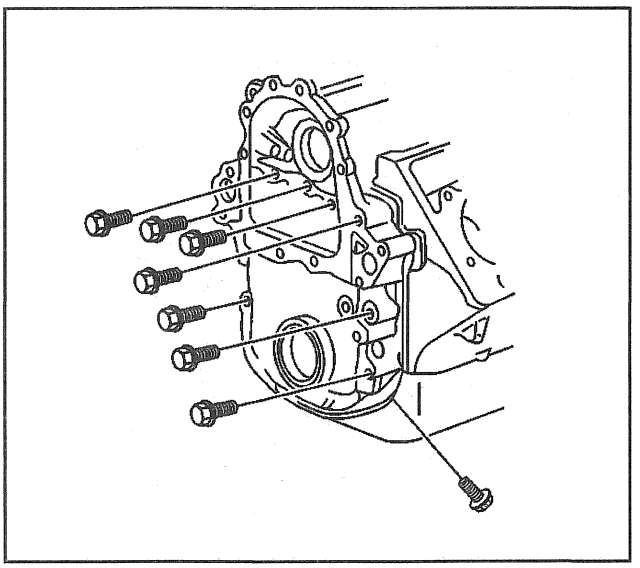


346972

18. Remove the bolts from the engine front cover and the oil pan.

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

19. Remove the fuel line clips from the studs.



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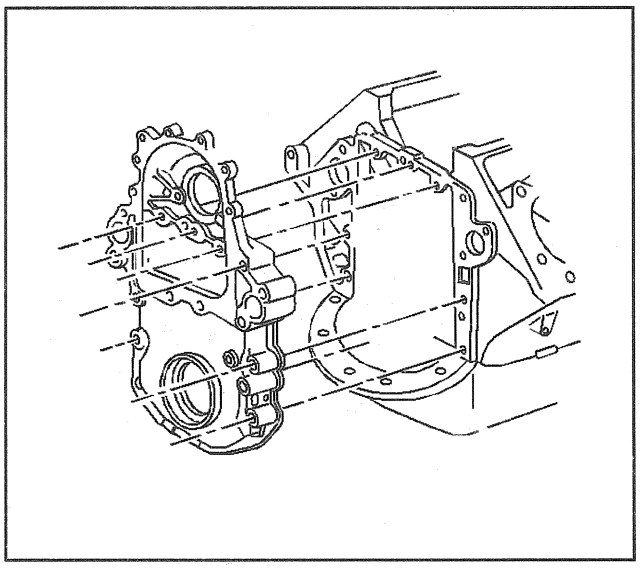

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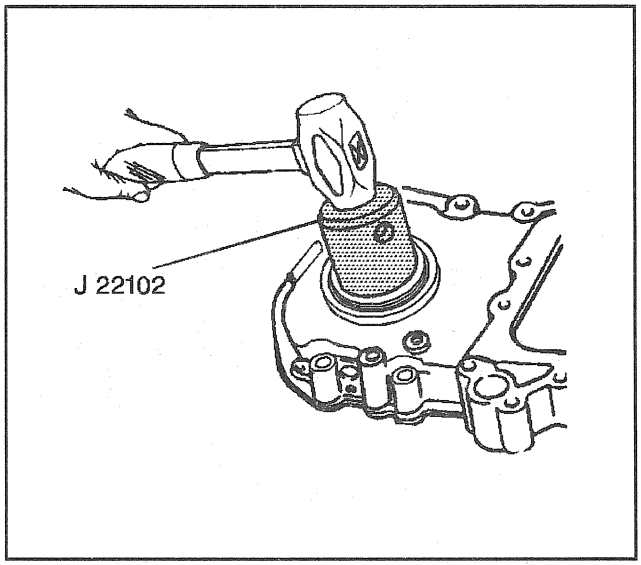
20. Remove the engine front cover from the engine block.



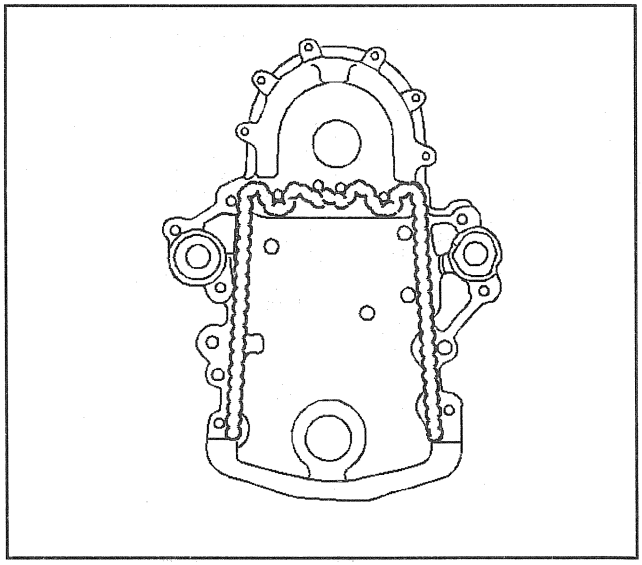
60269

Installation Procedure

Tools Required

J 22102 Seal Installer

1. Use the *J 22102* to install a new crankshaft front cover oil seal.



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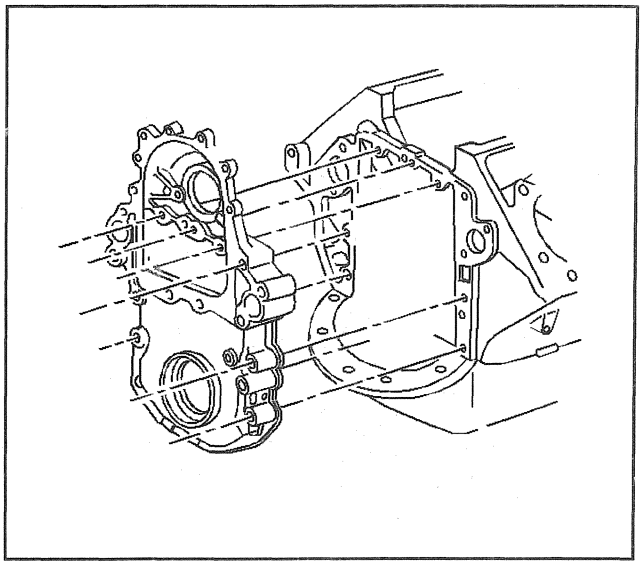
2. Apply a 2 mm (3/32 inch) bead of anaerobic sealant GM P/N 1052357 to the engine front cover.
3. Apply a 5 mm (3/16 inch) bead of RTV sealant GM P/N 12345739 to the engine front cover sealing surface that mates with oil pan.

4. Install the engine front cover to the engine block



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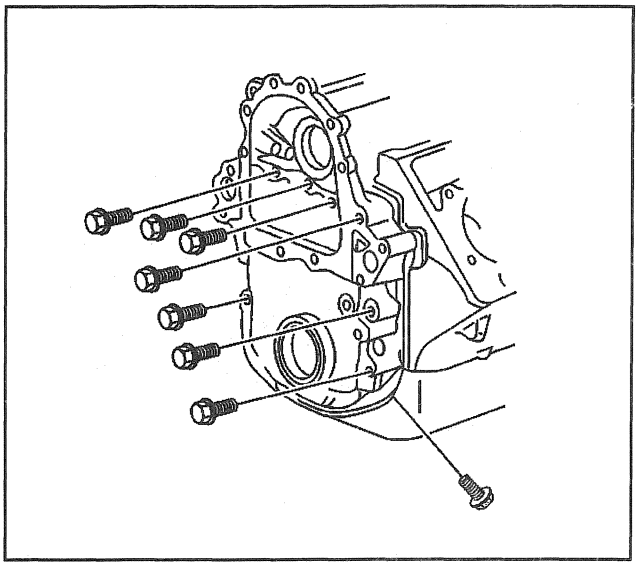
Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the engine front cover mounting bolts

   Tighten

   tighten the engine front cover mounting bolts to 40 N·m (30 lb ft).



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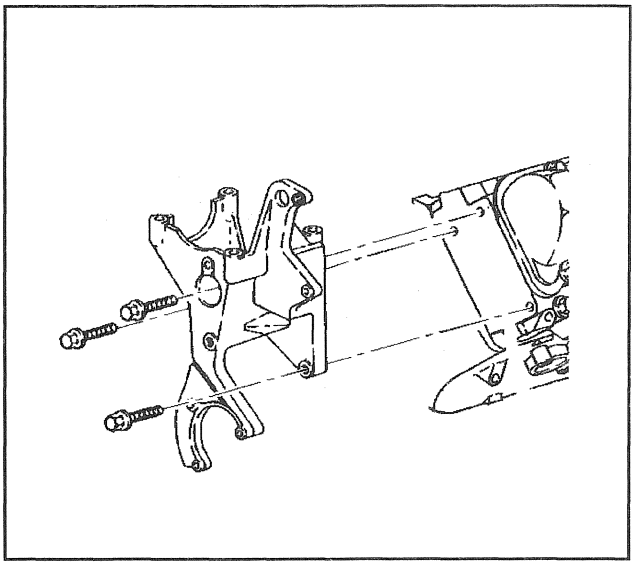
6. Install the left mounting bracket to the engine front cover.
7. Install the power steering pump to the mounting bracket. Refer to *Power Steering Pump Replacement (6.5L)* in Power Steering.



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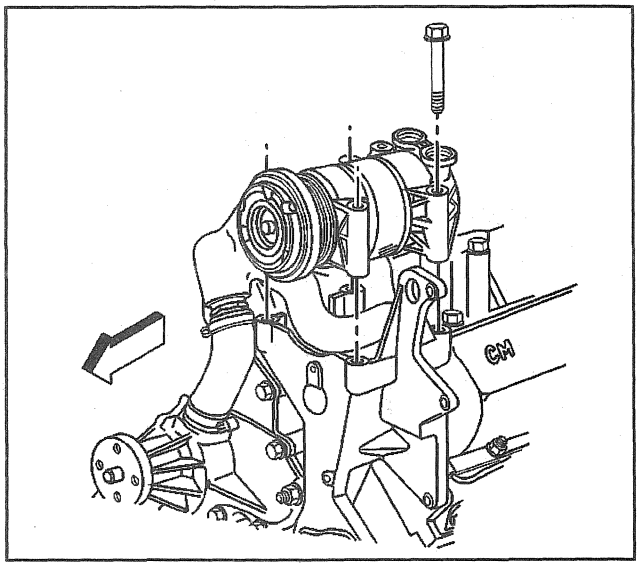

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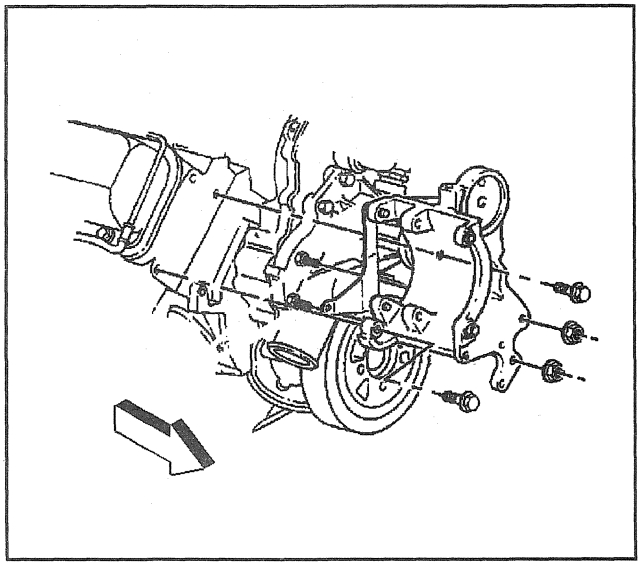
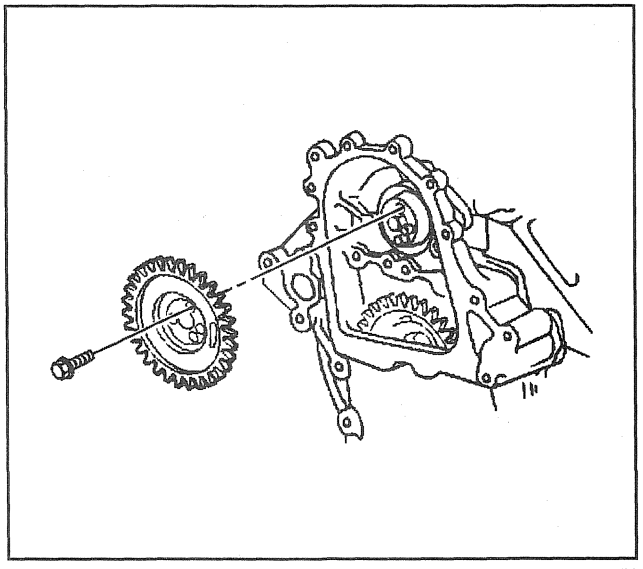
8. Install the A/C compressor to the mounting bracket and reposition to the side.



105622

9. Install the right mounting bracket to the engine front cover.
10. Install the generator to the mounting bracket. Refer to *Generator Replacement (Diesel Engines)* in Engine Electrical.
11. Install the vacuum pump to the mounting bracket. Refer to *Vacuum Pump Replacement*.
12. Install the fuel injection pump mounting bolts. Refer to *Fuel Injection Pump Replacement* in Engine Controls-6.5L.
13. Install the water pump to the engine block. Refer to *Water Pump Replacement (Diesel Engines)* in Engine Cooling.

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.



346972

14. Install the fuel pump drive gear to the camshaft and align the timing marks.

    Tighten

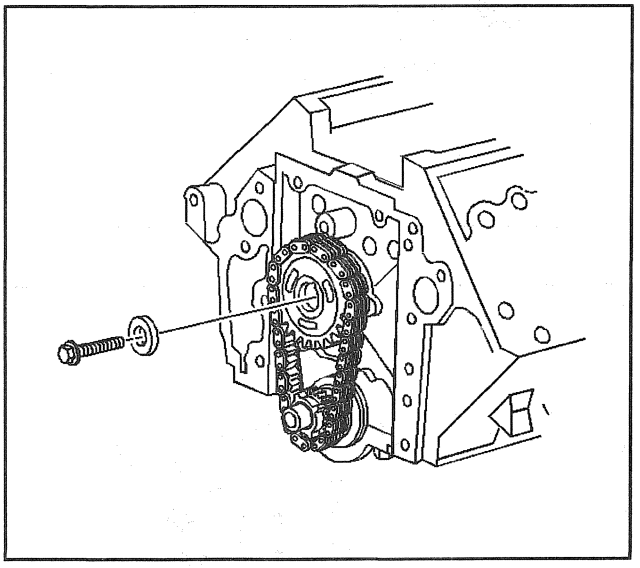
    Tighten the bolts to 25 N·m (20 lb ft).
15. Install the fuel return line clips.
16. Install the crankshaft position sensor to the engine front cover. Refer to *Crankshaft Position Sensor Replacement* in Engine Controls-6.5L.
17. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement*.
18. Install the lower fan shrouds to the radiator. Refer to Radiator Replacement in Engine Cooling.
19. Lower the vehicle.
20. Install the drive belt on the pulleys. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
21. Install the upper fan shroud to the radiator. Refer to *Fan Shroud Replacement (Upper)*

22. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical
23. Refill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
24. Reset the fuel injection pump timing. Refer to *Injection Timing Adjustment* in Engine Controls-6.5L.
25. Perform the TDC offset timing procedure. Refer to *TDC Offset Adjustment* in Engine Controls-6.5L.

Timing Chain and Sprockets Replacement

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Rotate the engine to TDC.
4. Remove the upper fan shroud from the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.
5. Remove the drive belt from the pulleys. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
6. Remove the lower fan shroud from the radiator. Refer to *Fan Shroud Replacement (Lower)* in Engine Cooling.
7. Remove the crankshaft balancer from the engine. Refer to *Crankshaft Balancer Replacement*.
8. Remove the water pump from the engine block. Refer to *Water Pump Replacement (Diesel Engines)* in Engine Cooling.
9. Remove the engine front cover from the engine block. Refer to *Engine Front Cover Replacement*.
10. Remove the bolt from the timing chain sprocket to the camshaft.
11. Remove the fuel injection pump drive gear from the camshaft.



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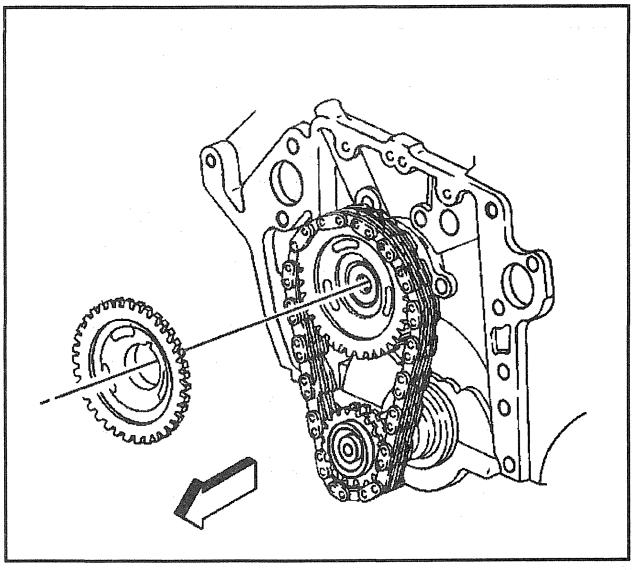

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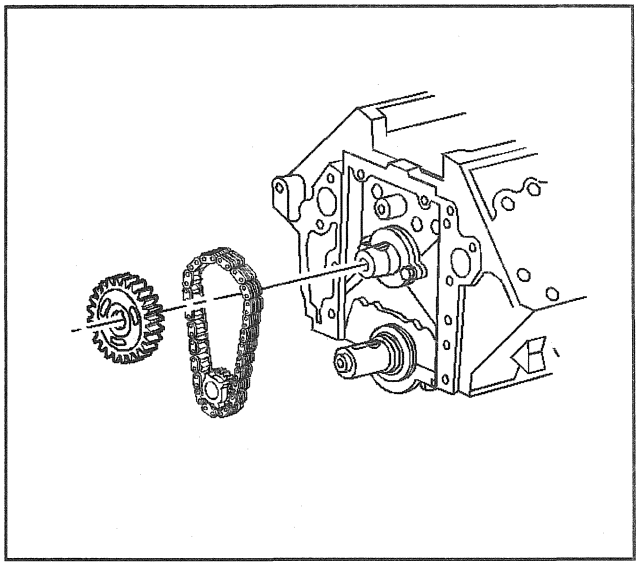

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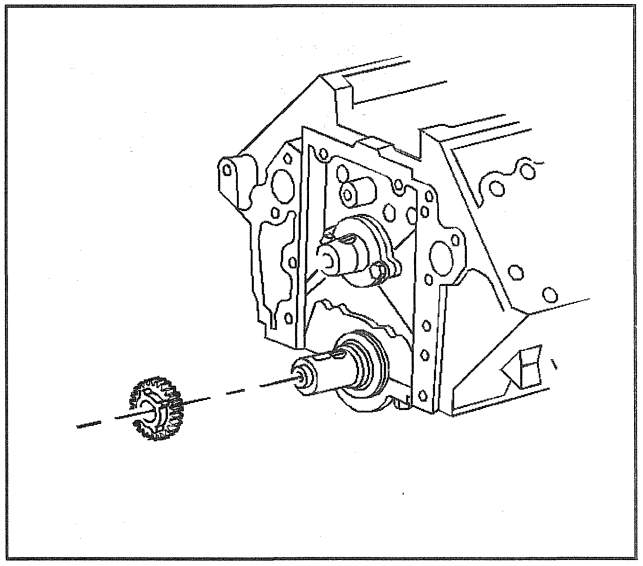
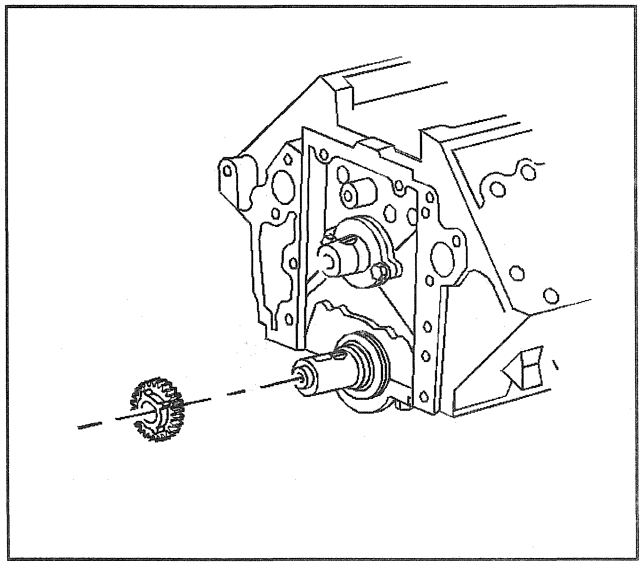
12. Remove the timing chain and sprocket from the camshaft.



59879

13. Remove the sprocket from the crankshaft.



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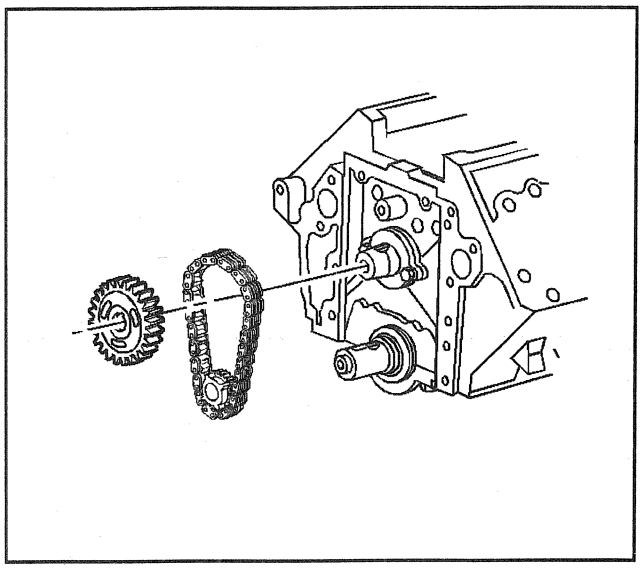
Installation Procedure

1. Install the crankshaft sprocket on the crankshaft.

Important: Make sure the timing marks are aligned.

2. Install the camshaft sprocket with the timing chain to the engine block.



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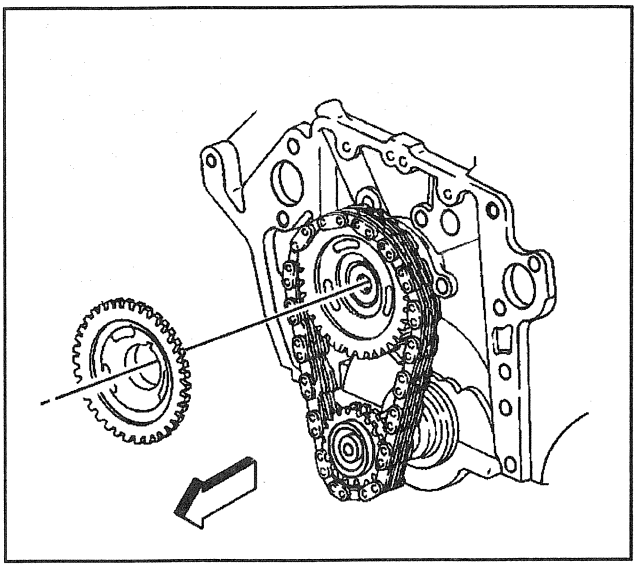
3. Install the fuel injection pump drive gear to the camshaft.



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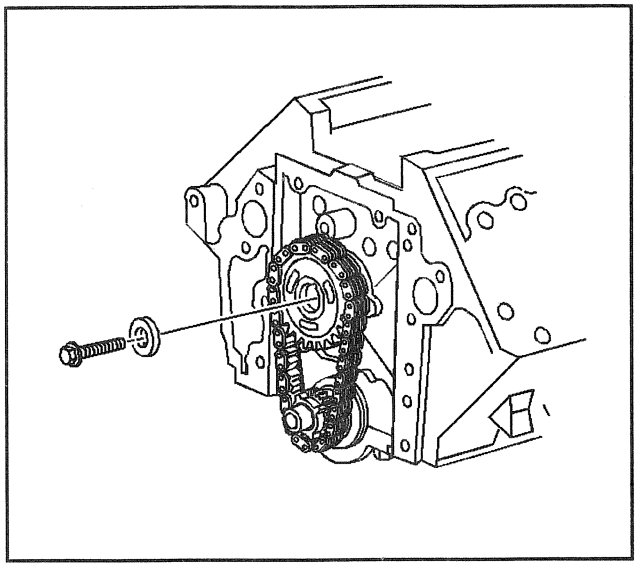
Notice: Refer to *Fastener Notice* in Caution and Notices.

4. Install the bolts from the timing chain sprocket to the camshaft.

   Tighten

   Tighten the bolts to 25 N·m (20 lb ft).
5. Install the engine front cover to the engine block. Refer to *Engine Front Cover Replacement.*
6. Install the water pump to the engine block. Refer to *Water Pump Replacement (Diesel Engines)* in Engine Cooling.
7. Install the crankshaft balancer to the crankshaft. Refer to *Crankshaft Balancer Replacement.*
8. Install the lower fan shroud to the radiator. Refer to *Fan Shroud Replacement (Lower)* in Engine Cooling



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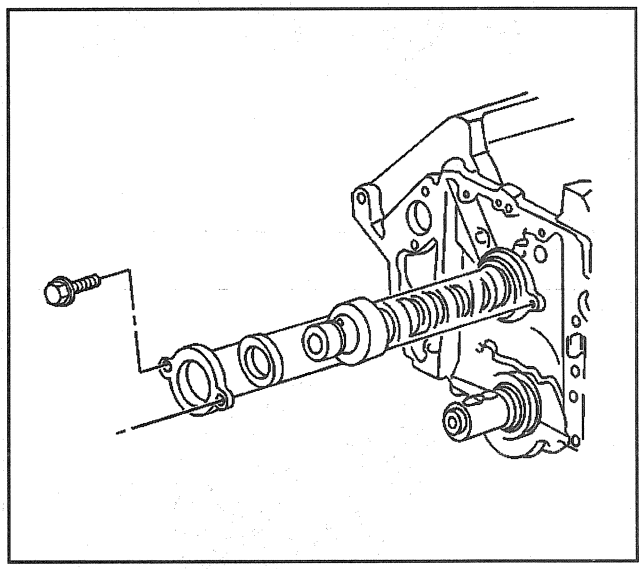
9. Install the drive belt on the vehicle. Refer to *Drive Belt Replacement (6.5L Drive Belt)*.
10. Install the upper fan shroud to the radiator. Refer to *Fan Shroud Replacement (Upper)* in Engine Cooling.
11. Refill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
12. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.



60263

Camshaft Replacement

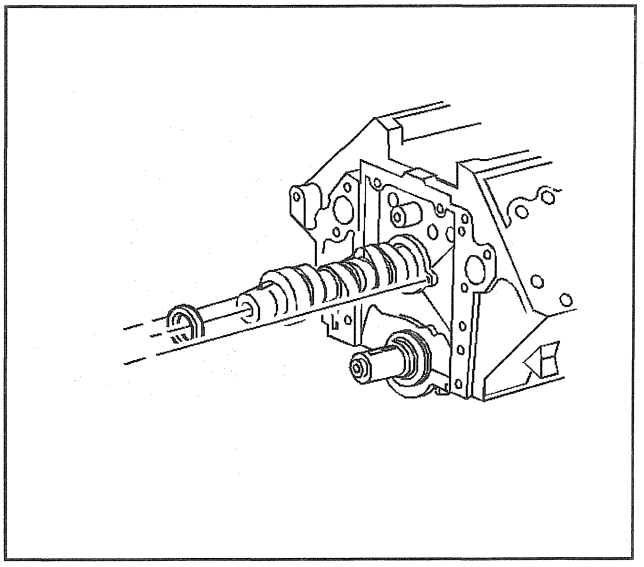
Removal Procedure

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 battery negative cables from the batteries. Refer to *Battery Cable* in Engine Cooling.
2. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Recover the A/C refrigerant from the A/C system. Refer to *Refrigerant Recovery and Recharging* in HVAC.
4. Remove the front grille and parking lamp assembly.
   - If the vehicle has a standard grille, refer to *Grille Replacement (All Models)* in Body and Accessories.
   - If the vehicle has a C H/D option, refer to *Grille Replacement (C3500HD Only)* in Body and Accessories.
5. Remove the air conditioning condenser. Refer to *Condenser Replacement* in HVAC.
6. Remove the radiator from the vehicle. Refer to *Radiator Replacement* in Engine Cooling.
7. Remove the cylinder head assembly from the engine block. Refer to *Cylinder Head Replacement*.
8. Remove the oil pump drive from the engine block. Refer to *Oil Pump Drive Replacement*.
9. Remove the valve lifters from the engine block. Refer to *Valve Lifter Replacement*.
10. Remove the timing chain from the engine block. Refer to *Timing Chain and Sprockets Replacement*.
11. Remove the camshaft thrust plate and bolts from the engine block.

12. Remove the camshaft spacer from the engine block.

Important: When removing the camshaft from the engine block, use caution as not to damage the camshaft bearing.



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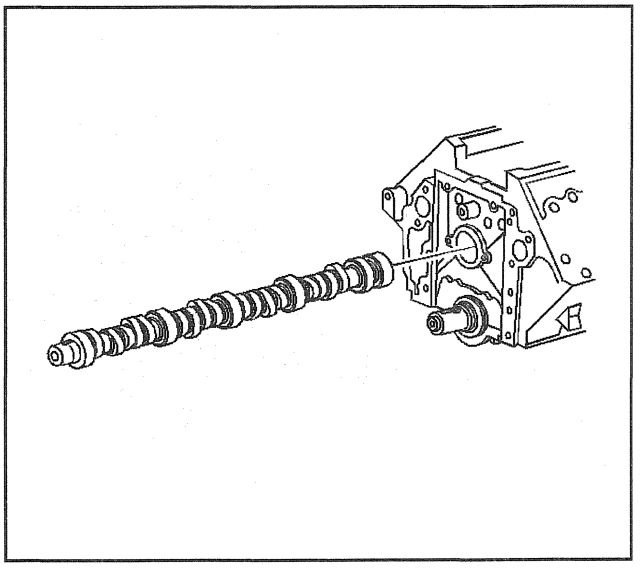
13. Remove the camshaft assembly from the engine block.
14. Replace the wood drift key if it is damaged.



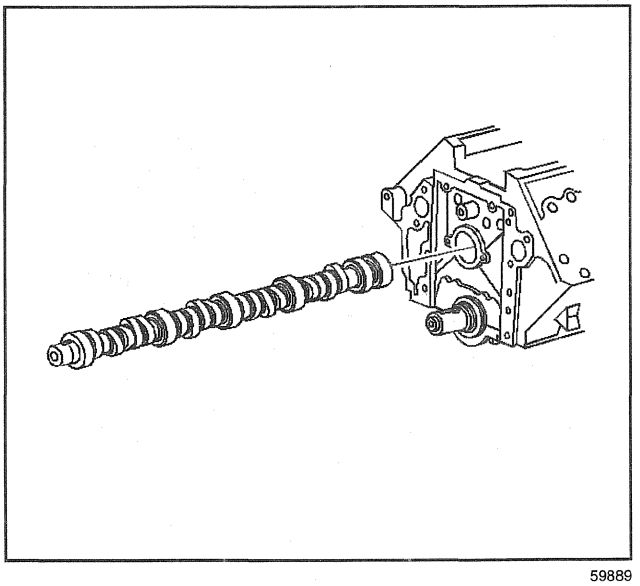
59889

Installation Procedure

Important: When a new camshaft is being installed, new valve lifters, engine oil and oil filter must be replacement at the same time.

Important: When installing the camshaft assembly into the engine block, use caution as not to damage the camshaft bearing during installation.

1. Install the camshaft assembly to the engine block.
   - Coat the camshaft lobes with camshaft and valve Prelube GM P/N 1052365.
   - Lubricate the camshaft bearing journals with clean engine oil.



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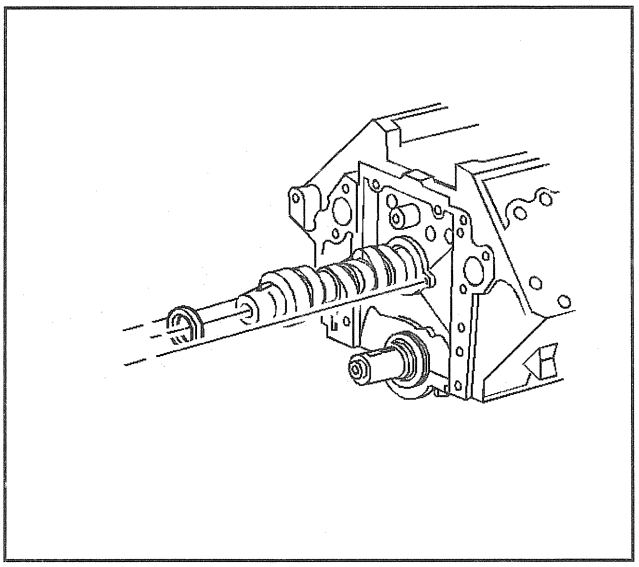

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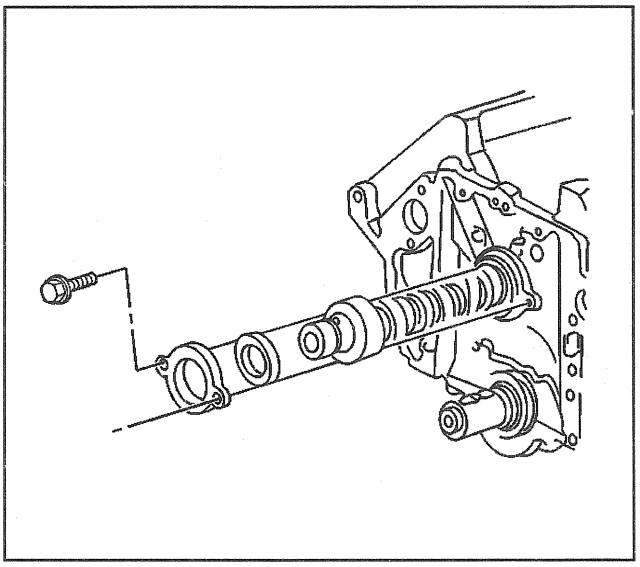
2. Install the spacer to the camshaft.



60263

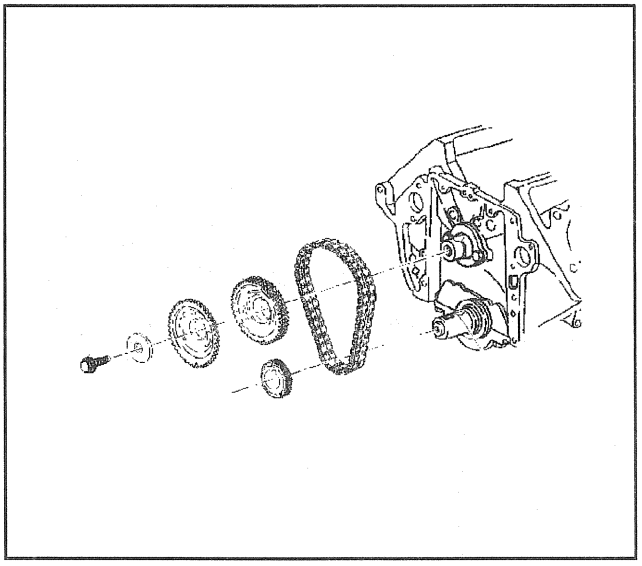
3. Install the camshaft thrust plate to the engine block.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the thrust plate retaining bolts.

   Tighten

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



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5. Install the timing chain and sprockets to the camshaft. Refer to *Timing Chain and Sprockets Replacement.*
6. Install the valve lifters to the engine block. Refer to *Valve Lifter Replacement.*
7. Install the cylinder head assembly to the engine block. Refer to *Cylinder Head Replacement.*
8. Install the oil pump drive to the engine block. Refer to *Oil Pump Drive Replacement.*
9. Install the radiator to the vehicle. Refer to *Radiator Replacement* in Engine Cooling.
10. Install the air conditioning condenser in the vehicle. Refer Air *Condenser Replacement* in HVAC.

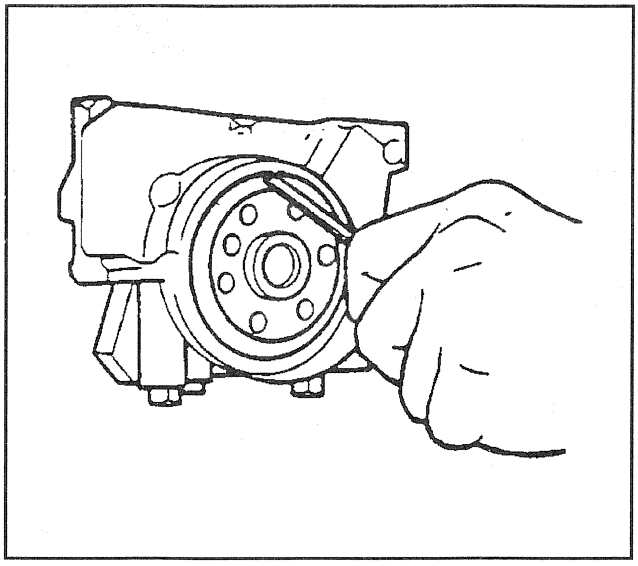
11. Install the front grille and parking lamp assembly.
    - If the vehicle has a standard grille, refer to *Grille Replacement (All Models)* in Body and Accessories.
    - If the vehicle has a C H/D option, refer to *Grille Replacement (C3500HD Only)* in Body and Accessories.
12. Refill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
13. Recharge the A/C system. Refer to *Refrigerant Recovery and Recharging* in HVAC.
14. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.
15. Perform the TDC off set timing procedure. Refer to *TDC Offset Adjustment* in Engine Controls-6.5L.

Crankshaft Rear Oil Seal Replacement

Removal Procedure

Important: Before a new crankshaft rear oil seal is installed, the CDR and crankshaft ventilation system should be thoroughly inspect and crankshaft pressure should also be checked. Refer to Engine Controls for proper inspection procedures.

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Remove the transfer case from the vehicle if equipped.
    - For the vehicle equipped with Selectable Four Wheel Drive, refer to *Transfer Case Replacement (Selectable Four Wheel Drive)* in Driveline Axle.
    - For vehicles equipped with Auto Four Wheel Drive 2 Speed, refer to *Transfer Case Replacement (Auto Four Wheel Drive)* in Driveline Axle.
    - For vehicles equipped with Manual Four Wheel Drive, refer to *Transfer Case Replacement (Manual Four Wheel Drive)* in Driveline Axle.
3. Remove the transmission from the vehicle.
    - For the 4L 80–E automatic transmission, refer to *Transmission Replacement* in Transmission/Transaxle.
    - For the NV 4500 RWD manual transmission, refer to *Transmission Replacement (NV4500 RWD)* in Transmission/Transaxle.
    - For the NV 4500 4WD manual transmission, refer to *Transmission Replacement (NV4500 4WD)* in Transmission/Transaxle.
4. Remove the clutch assembly if equipped. Refer to *Clutch Assembly Replacement* in Transmission/Transaxle.
5. Remove the flywheel from the crankshaft. Refer to *Engine Flywheel Replacement.*



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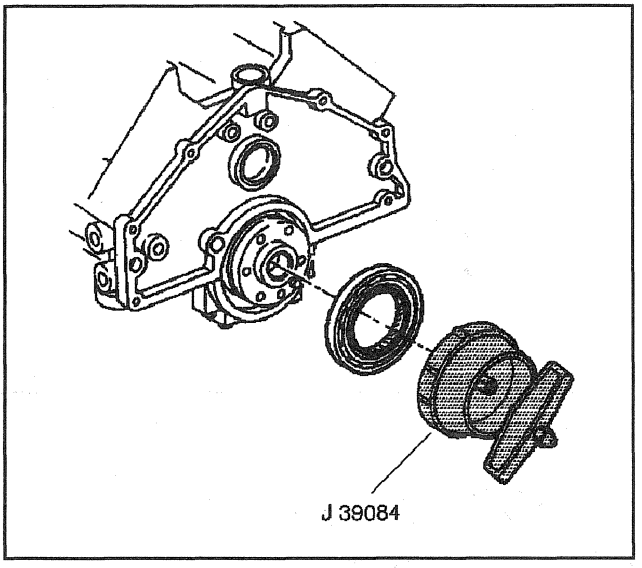


60280

Important: Use caution as not to damage the sealing area of the crankshaft when removing the crankshaft rear oil seal.

6. Remove the crankshaft rear oil seal from the engine block.

Installation Procedure

Tools Required

J 39084 Crankshaft Oil Seal Installer

Important: The crankshaft sealing surface must be clean and smooth in order to prevent damaging the crankshaft rear oil seal lip when a new seal is installed.

Because of the crankshaft rear oil seal wear or grooving, the service crankshaft rear oil will be positioned flush with the rear cylinder block surface. The position of the new crankshaft rear oil seal will be controlled by the tool. Positioning the crankshaft rear oil in a new location provides a new surface for the crankshaft rear oil seal to ride on.

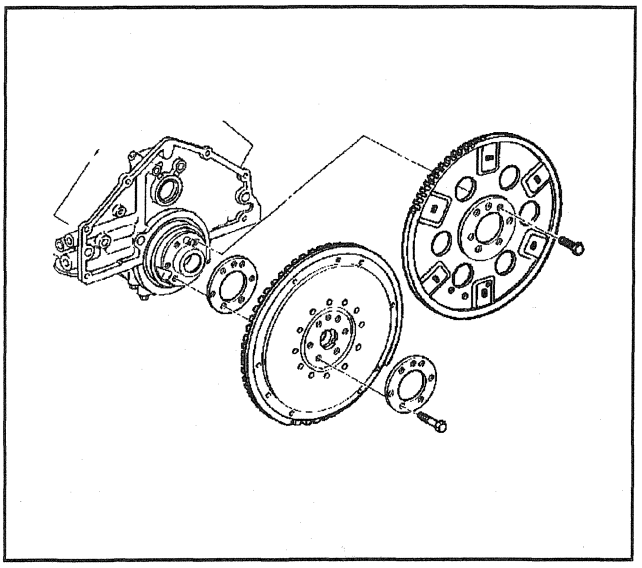
Important: Use care as not to cause the spring in the crankshaft rear oil seal to unseat itself.

1. Apply a small amount of clean engine oil to the lips of the crankshaft rear oil seal before installing.
2. Use the *J 39084* to install the crankshaft rear oil seal.
3. Install the flywheel to the crankshaft. Refer to *Engine Flywheel Replacement.*
4. Install the clutch assembly to the flywheel. Refer to *Clutch Assembly Replacement* in Transmission/Transaxle.
5. Install the transmission to the vehicle.
   - For the 4L 80–E automatic transmission, refer to *Transmission Replacement* in Transmission/Transaxle.
   - For the NV 4500 RWD manual transmission, refer to *Transmission Replacement (NV4500 RWD)* in Transmission/Transaxle.
   - For the NV 4500 4WD manual transmission, refer to *Transmission Replacement (NV4500 4WD)* in Transmission/Transaxle.
6. Install the transfer case to the transmission.
   - For the vehicle equipped with Selectable Four Wheel Drive, refer to *Transfer Case Replacement (Selectable Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Auto Four Wheel Drive 2 Speed, refer to *Transfer Case Replacement (Auto Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Manual Four Wheel Drive, refer to *Transfer Case Replacement (Manual Four Wheel Drive)* in Driveline Axle.
7. Lower the vehicle.
8. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.

Engine Flywheel Replacement

Removal Procedure

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Refer to transfer case if equipped.
   - For vehicles equipped with Selectable Four Wheel Drive, refer to *Transfer Case Replacement (Selectable Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Auto Four Wheel Drive 2 Speed, refer to *Transfer Case Replacement (Auto Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Manual Four Wheel Drive, refer to *Transfer Case Replacement (Manual Four Wheel Drive)* in Driveline Axle.
3. Remove the transmission from the vehicle.
   - For vehicles equipped with the 4L 80–E transmission, refer to *Transmission Replacement* in Transmission Transaxle.
   - For vehicles equipped with the NV 4500 RWD transmission, refer to *Transmission Replacement (NV4500 RWD)* in Transmission Transaxle.
   - For the vehicles equipped with the NV 4500 4WD transmission, refer to *Transmission Replacement (NV4500 4WD)* in Transmission Transaxle.
4. Remove the clutch assembly from the crankshaft (if equipped). Refer to *Clutch Assembly Replacement* in Transmission Transaxle.
5. Remove the flywheel from the crankshaft.



64987

Installation Procedure

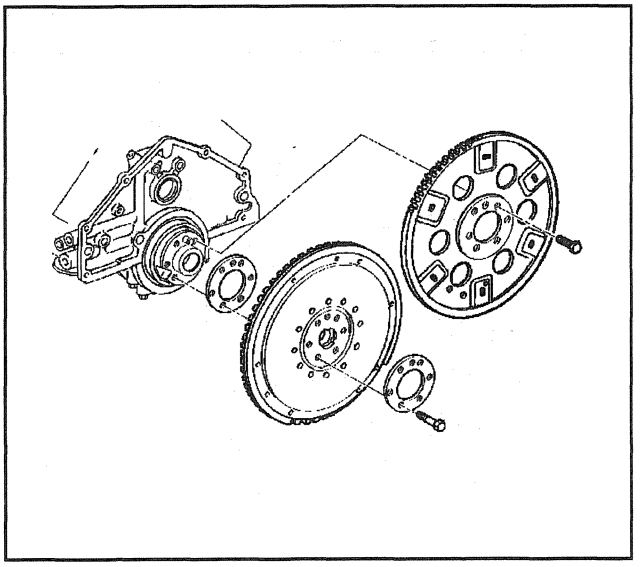
1. Install the flywheel to the crankshaft

Notice: Refer to *Fastener Notice* in Caution and Notices.

2. Install the flywheel mounting bolts.

   Tighten

   Tighten the bolts to 90 N·m (65 lb ft).
3. Install the clutch assembly to the flywheel (if removed). Refer to *Clutch Assembly Replacement* in Transmission Transaxle.
4. Install the transmission in the vehicle.
   - For vehicles equipped with the 4L 80–E transmission, refer to *Transmission Replacement* in Transmission Transaxle.
   - For vehicles equipped with the NV 4500 RWD transmission, refer to *Transmission Replacement (NV4500 RWD)* in Transmission Transaxle.
   - For the vehicles equipped with the NV 4500 4WD transmission, refer to *Transmission Replacement (NV4500 4WD)* in Transmission Transaxle.



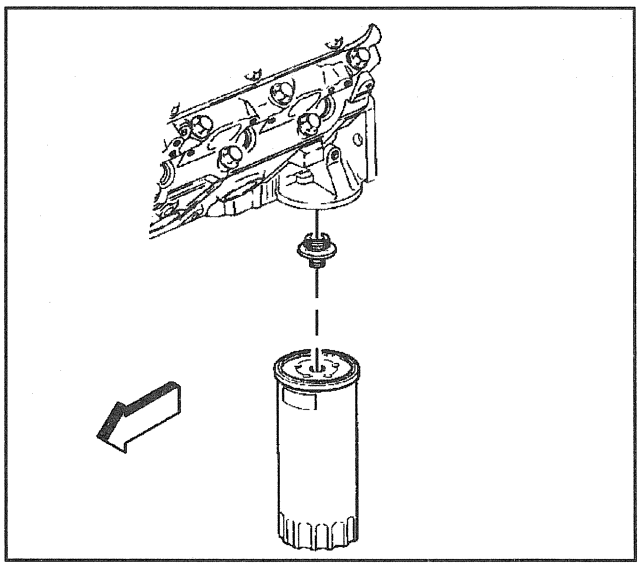
64987

5. Install the transfer case in the vehicle.
   - For vehicles equipped with Selectable Four Wheel Drive, refer to *Transfer Case Replacement (Selectable Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Auto Four Wheel Drive 2 Speed, refer to *Transfer Case Replacement (Auto Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Manual Four Wheel Drive, refer to *Transfer Case Replacement (Manual Four Wheel Drive)* in Driveline Axle.
6. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.

Oil Filter Adapter and Valve Assembly Replacement

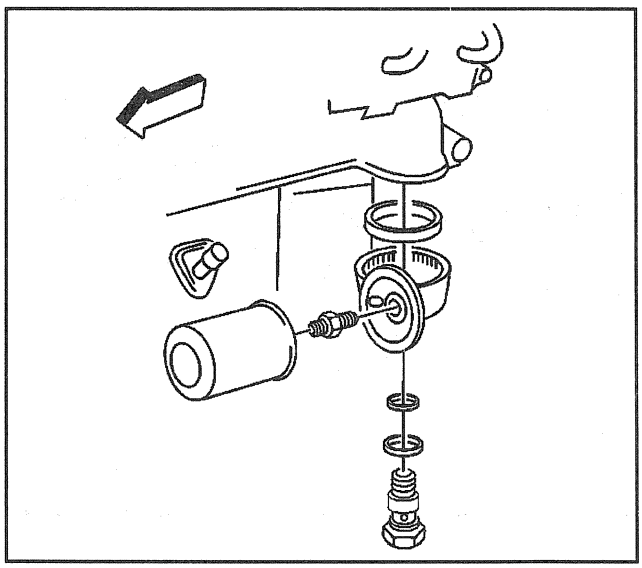
Removal Procedure

1. Raise the vehicle.
2. Remove the oil filter from the oil filter adapter (2 WD only).



181988

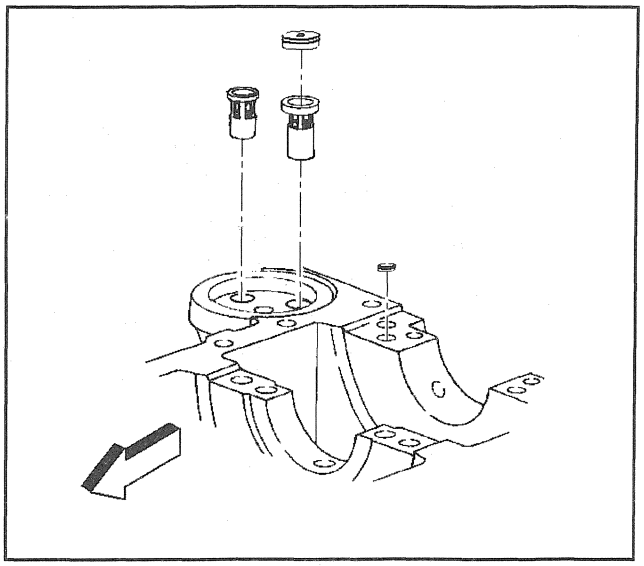
3. Remove the oil filter adapter bolt from the engine block (4 WD only).



188406

Important: Do not damage the engine block when removing the bypass valve.

4. Remove the oil cooler bypass valve.
   4.1. Install a 4.8 mm (3/16 inch) sheet metal screw into the hole in the cup plug.
   4.2. Using the two small pry bars, take out the cup plug.
   4.3. Use a slide hammer to remove the oil cooler bypass valve from the engine block.
5. Clean the recess of the engine block.



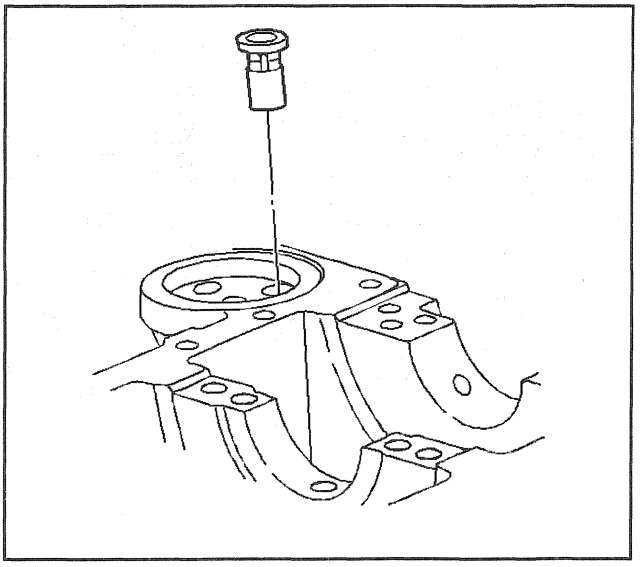
66576

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.

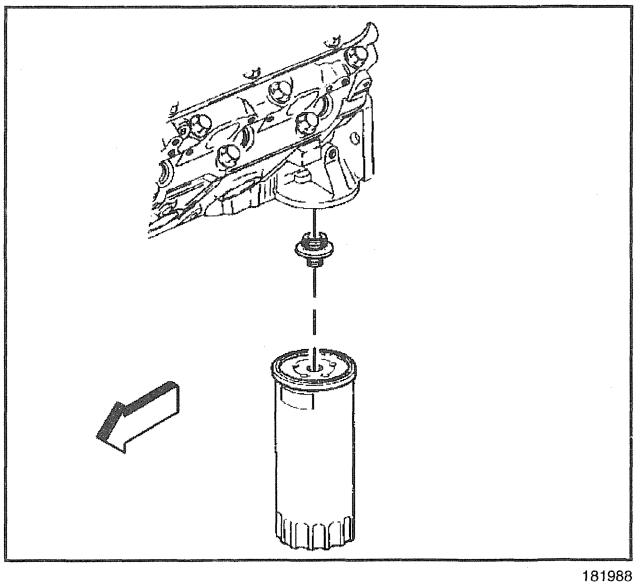
Important: This plug has an orifice hole that prevents an air lock from occurring and blocking the oil flow.

2. Install the cup plug for the oil cooler bypass valve.
3. Install the oil filter bypass valve into the engine block.
4. Use a socket to drive the valve into the bore until the valve seats against the shoulder inside the bore.



59939

5. Install the oil filter adapter into the engine block (2 WD only).



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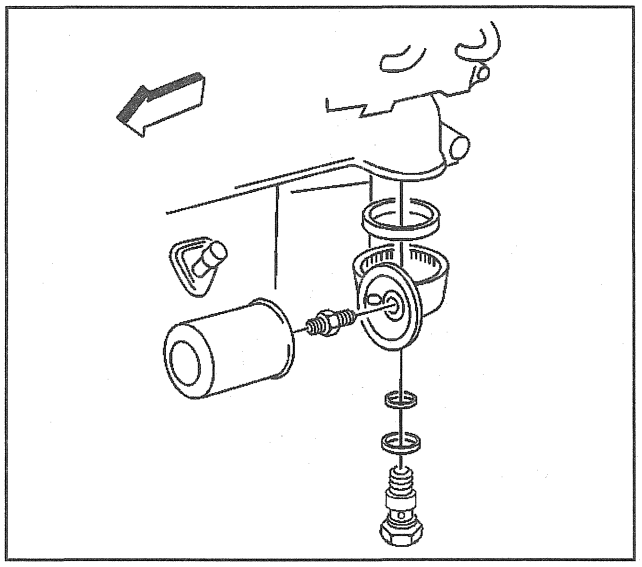


188406

Notice: Refer to *Fastener Notice* in Caution and Notices.

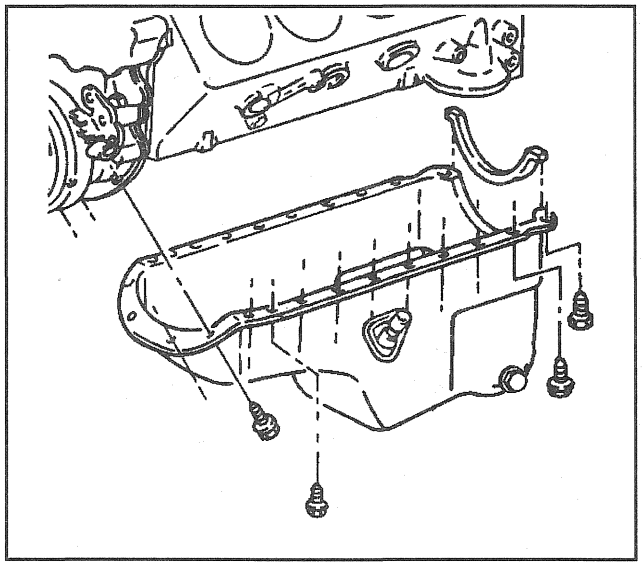
6. Install the oil filter adapter to the engine block (4 WD only).

   Tighten

   Tighten the bolt to 65 N·m (47 lb ft).

Important: After installing the oil filter to the adapter (4 WD only), it will be necessary to recheck the torque setting on the oil filter adapter.

7. Install the oil filter to the oil filter adapter.
8. Lower the vehicle.



60264

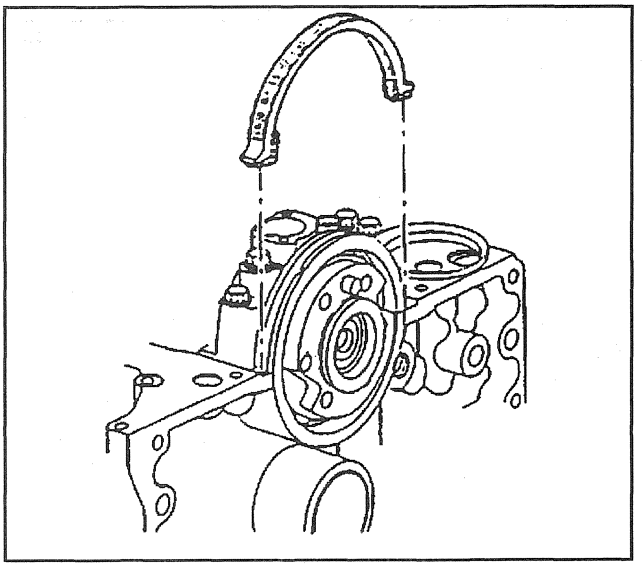
Oil Pan Replacement

Removal Procedure

Important: Do not raise the engine block by the crankshaft balancer to perform this service procedure. Damage to the crankshaft balancer or the crankshaft may occur.

1. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
2. Remove the oil level indicator and tube from the engine. Refer to *Oil Level Indicator and Tube Replacement.*
3. Raise the vehicle.
4. Support the vehicle with safety stands.
5. Drain the engine oil.
6. Remove the flywheel from the crankshaft. Refer to *Engine Flywheel Replacement.*
7. Remove the transfer case from the vehicle if equipped.
   - For the vehicle equipped with Selectable Four Wheel Drive, refer to *Transfer Case Replacement (Selectable Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Auto Four Wheel Drive 2 Speed, refer to *Transfer Case Replacement (Auto Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Manual Four Wheel Drive, refer to *Transfer Case Replacement (Manual Four Wheel Drive)* in Driveline Axle.

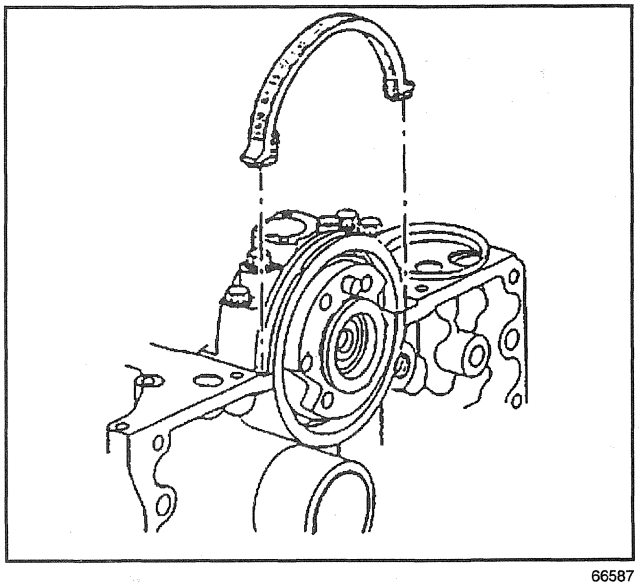
8. Remove the transmission from the vehicle.
   - For the 4L 80–E automatic transmission, refer to *Transmission Replacement* in Transmission/Transaxle.
   - For the NV 4500 RWD manual transmission, refer to *Transmission Replacement (NV4500 RWD)* in Transmission/Transaxle.
   - For the NV 4500 4WD manual transmission, refer to *Transmission Replacement (NV4500 4WD)* in Transmission/Transaxle.
9. Remove the clutch assembly if equipped. Refer to *Clutch Assembly Replacement* in Transmission/Transaxle.
10. Remove the flywheel from the crankshaft. Refer to *Engine Flywheel Replacement*.
11. Remove the oil pan bolts from the oil pan.
12. Remove the oil pan from the engine block.
13. Remove the rear seal on the from the oil pan.
14. Clean the old RTV sealant from the oil pan and engine block.



66587

Installation Procedure

1. Apply a 2 mm (1/16 inch) bead of RTV sealant GM P/N 12345739 to the oil pan rear seal at the inside corners where the seal meets the rear crankshaft bearing cap on the engine block.
2. Install the oil pan rear seal to the rear crankshaft bearing cap before the sealer starts to dry.



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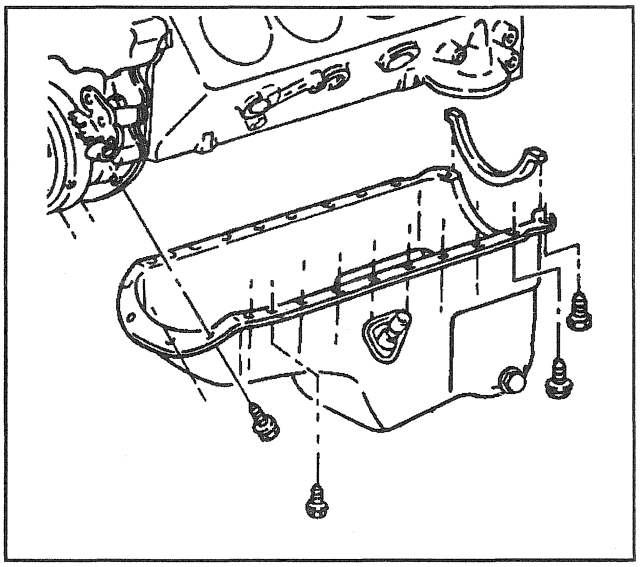


60264

3. Install the oil pan to the engine block.

Notice: Refer to *Fastener Notice* in Caution and Notices.

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

   Tighten

   4.1. Tighten the bolts in the following order:

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

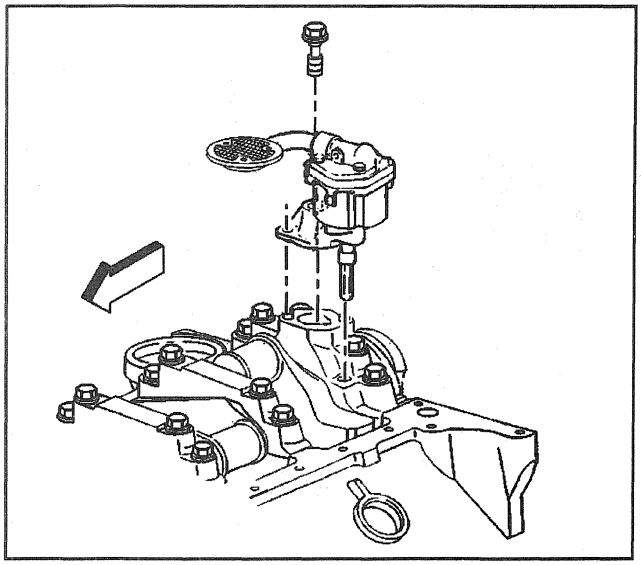
   4.3. Tighten all the other bolts to 10 N·m (89 lb in).

5. Install the clutch assembly to the flywheel (if removed). Refer to *Clutch Assembly Replacement* in Transmission/Transaxle.
6. Install the transmission in the vehicle.
   - For the 4L 80–E automatic transmission, refer to *Transmission Replacement* in Transmission/Transaxle.
   - For the NV 4500 RWD manual transmission, refer to *Transmission Replacement (NV4500 RWD)* in Transmission/Transaxle.
   - For the NV 4500 4WD manual transmission, refer to *Transmission Replacement (NV4500 4WD)* in Transmission/Transaxle.
7. Install the transfer case in the vehicle if equipped.
   - For the vehicle equipped with Selectable Four Wheel Drive, refer to *Transfer Case Replacement (Selectable Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Auto Four Wheel Drive 2 Speed, refer to *Transfer Case Replacement (Auto Four Wheel Drive)* in Driveline Axle.
   - For vehicles equipped with Manual Four Wheel Drive, refer to *Transfer Case Replacement (Manual Four Wheel Drive)* in Driveline Axle.
8. Lower the vehicle.
9. Install the oil level indictor and tube to the engine block. Refer to *Oil Level Indicator and Tube Replacement.*
10. Fill the crankcase with engine oil. Refer to *Engine Oil and Oil Filter Replacement.*
11. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.

Oil Pump Replacement

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to *Battery Cable* in Engine Electrical.
2. Raise the vehicle.
3. Remove the oil pan from the engine block. Refer to *Oil Pan Replacement*.
4. Remove the oil pump bolt mounting bolts.
5. Remove the oil pump assembly from the crankshaft rear bearing cap.



173012

Installation Procedure

Important: When installing the oil pump assembly to the engine block, always replace the retainer between the oil pump and the drive shaft.

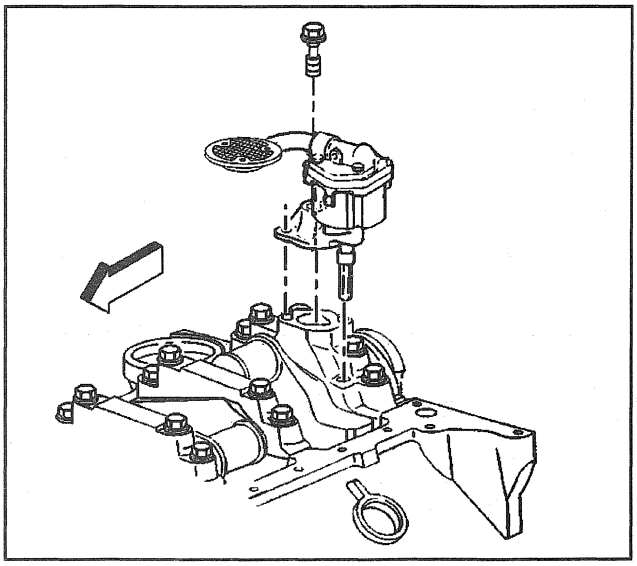
1. Prime the oil pump assembly.
   1.1. Submerge the oil pump in a clean container with clean motor oil.
   1.2. Rotate the oil pump hex drive by hand until the oil begins to flow from the oil pump assembly.
   1.3. Clean excess motor oil from the outside of the oil pump.
2. Align the extension shaft with the drive shaft to the oil pump drive gear. The oil pump should slide easily into place, do not force the oil pump into place.
3. Install the oil pump and the extension shaft to the engine block
4. Install the oil pump assembly to the crankshaft rear bearing cap.

Notice: Refer to *Fastener Notice* in Caution and Notices.

5. Install the oil pump mounting bolts to the rear crankshaft main bearing cap.

   Tighten

   Tighten the mounting bolts to 90 N·m (65 lb ft)
6. Install the oil pan to the engine block. Refer to *Oil Pan Replacement*.
7. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.



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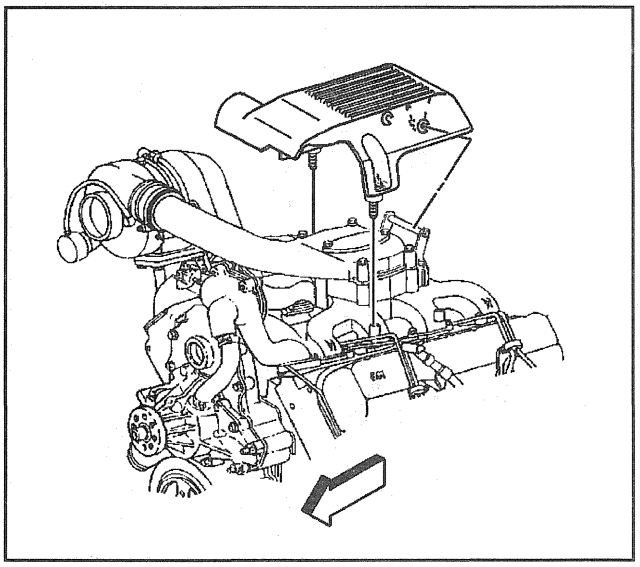
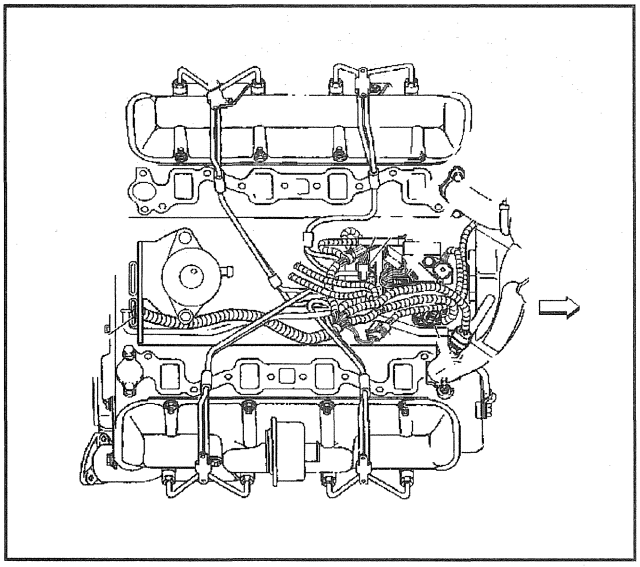


358421

Engine Replacement

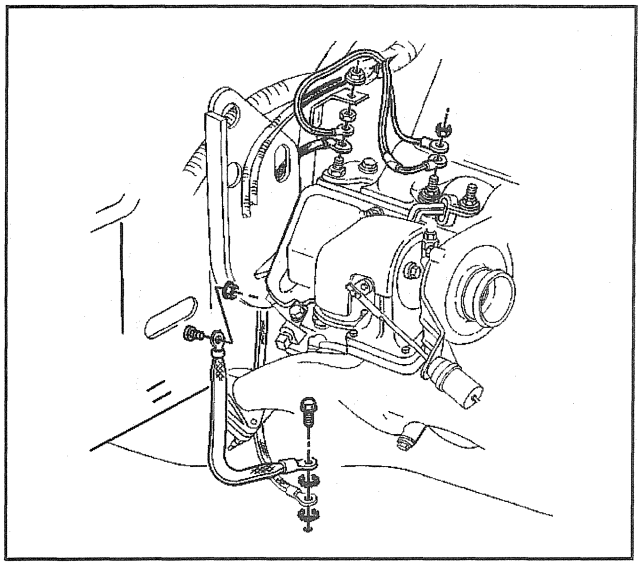
Removal Procedure

1. Remove the upper intake manifold cover.
2. Remove the hood. Refer to *Hood Replacement* in Body and Accessories.
3. Disconnect the battery negative cables from the batteries. Refer to *Battery Cable* in Engine Electrical.
4. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
5. Remove the radiator assembly from the vehicle. Refer to *Radiator Replacement* in Engine Cooling.
6. Remove the air conditioning condenser from the vehicle. Refer to *Condenser Replacement* in HVAC.
7. Remove the air conditioning compressor from the vehicle. Refer to *Compressor Replacement (Diesel)* in HVAC.
8. Relocate the A/C lines and secure out of the way.
9. Remove the generator from the mounting bracket. Refer to *Generator Replacement (Diesel Engines)* in Engine Electrical.
10. Remove the power steering lines pump from the power steering pump. Refer to *Power Steering Hoses Replacement* in Power Steering.
11. Disconnect the fuel line from the fuel filter. Refer to *Fuel Manager/Filter Replacement*.
12. Disconnect the engine wiring harness assembly from the engine block.
13. Disconnect the electrical connector for the engine wiring harness extension harness assembly for the fuel injection pump at the cowl.



64989

14. Remove the ground straps from the right rear cylinder head and body.
15. Remove the heater hoses from the heater core.
    - For the heater inlet hose, refer to *Heater Hoses Replacement (Inlet Hose- Diesel)* in HVAC.
    - For the heater outlet hose, refer to *Heater Hoses Replacement (Outlet Hose- Diesel)* in HVAC.



345208

16. Install the engine lift bracket to the rear of the right cylinder head.

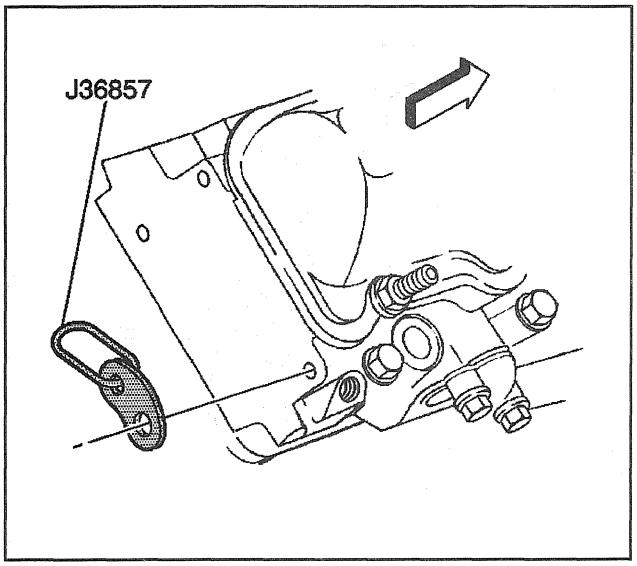
Notice: Refer to *Damage May Result From The Use Of An Improper Bolt When...* in Cautions and Notices.

Notice: Refer to *Fastener Notice* in Caution and Notices.

17. Install *J 36857* along with GM P/N 94282217 bolt and GM P/N 15650963 washer to the right rear cylinder head.

    Tighten

    Tighten the lift bracket bolt to 40 N·m (30 lb ft).
18. Raise the vehicle and support the vehicle with safety stands.



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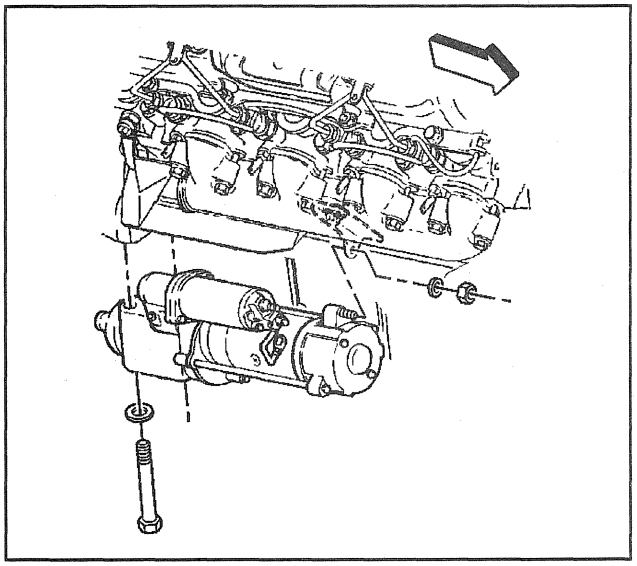
19. Remove the starter from the engine block. Refer to *Starter Motor Replacement (Diesel Engines)* in Engine Electrical.



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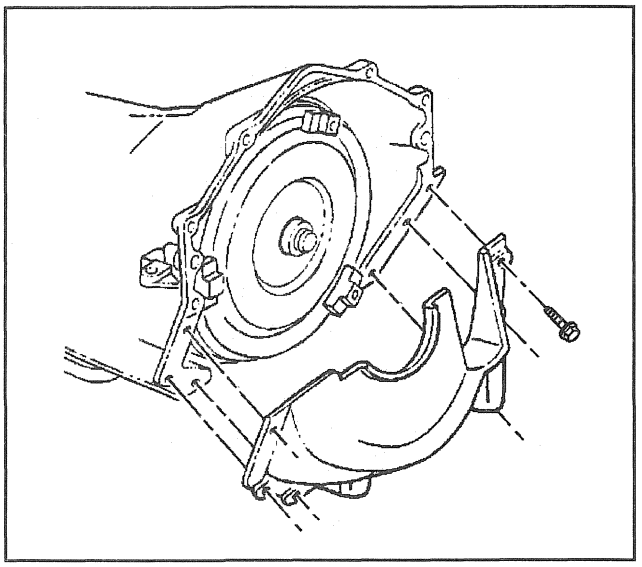
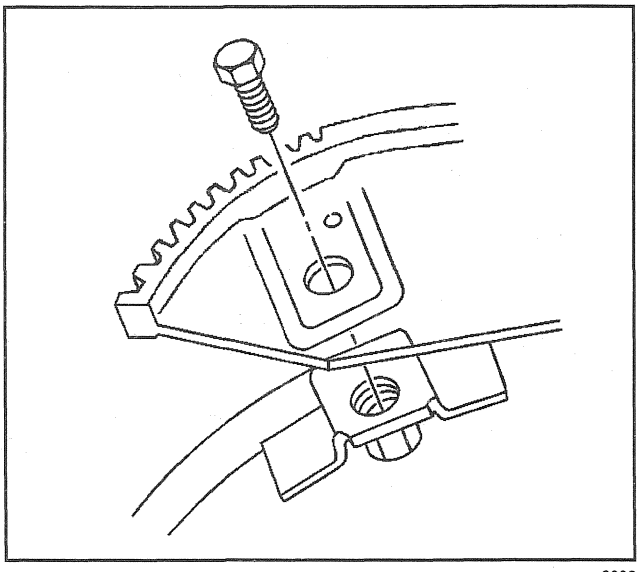


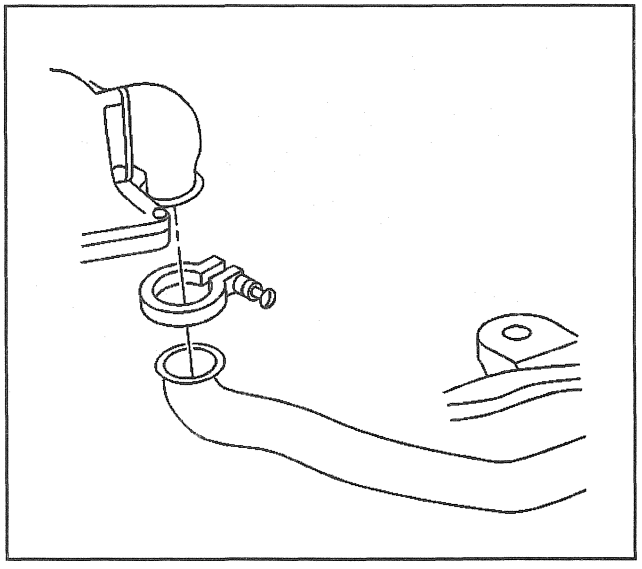
32688

20. Remove the flywheel inspection cover from the transmission.
    - For the 4L80–E automatic transmission, refer to *Transmission Replacement* in Transmission/Transaxle.
    - For the NV 4500 (two wheel drive) manual transmission, refer to *Transmission Replacement (NV4500 RWD)* in Transmission/Transaxle.
    - For the NV 4500 (four wheel drive) manual transmission, refer to *Transmission Replacement (NV4500 4WD)* in Transmission/Transaxle.



9096

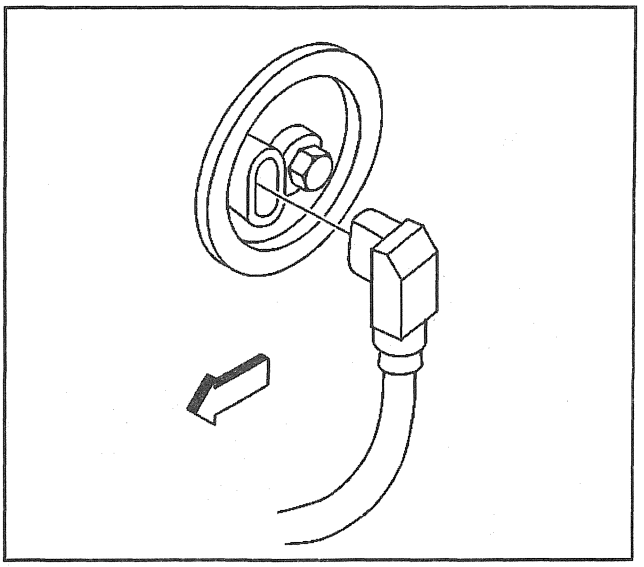
21. Remove the bolts from the torque converter.



177088

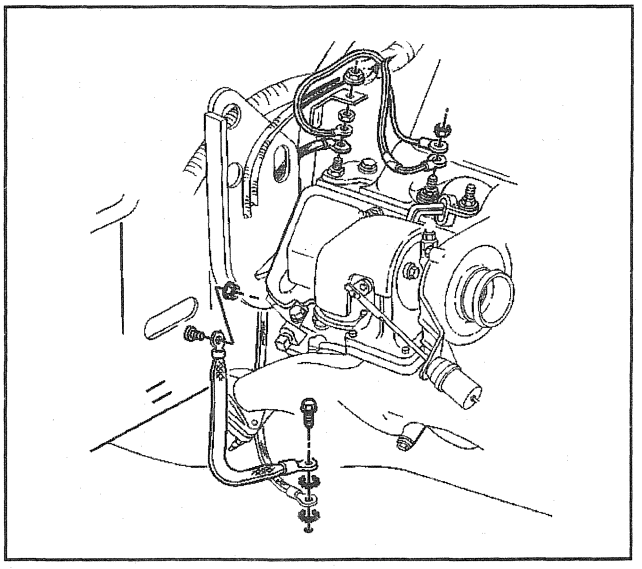
22. Remove the exhaust pipe from the turbocharger.

23. Remove block heater electrical connection.



317722

24. Remove the battery ground from the right rear cylinder head and the body.
25. Disconnect the oil cooler lines from the engine block if equipped. Refer to *Engine Oil Cooler Line Replacement*.
26. Remove the transmission cooler lines from the retaining brackets. Refer to *Oil Cooler Line Replacement* in Transmission/Transaxle.
27. Remove the oil filter and adapter for four wheel drive models only. Refer to *Oil Filter Adapter and Valve Assembly Replacement*.
28. Remove the front propeller shaft four wheel drive models only. Refer to *Propeller Shaft Replacement (Front Axle - All Except NP8)*.

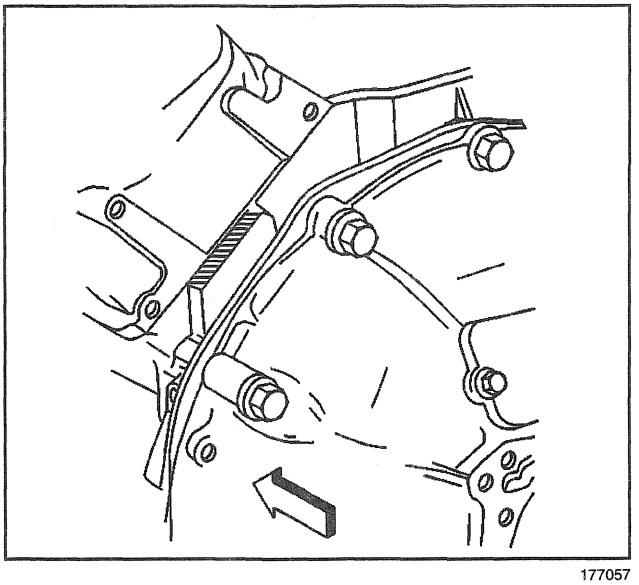


345208

29. Remove the bellhousing bolts from the engine block.
30. Remove the safety stands and lower the vehicle.
31. Support the transmission assembly with a suitable support.
32. Attach a suitable lifting devise from the lifting bracket to the A/C mounting bracket.
33. Raise the engine enough to remove the engine mount through bolt.
34. Remove the engine mount though bolt. Refer to *Engine Mount Replacement (Front)*.
35. Remove the engine from the vehicle.

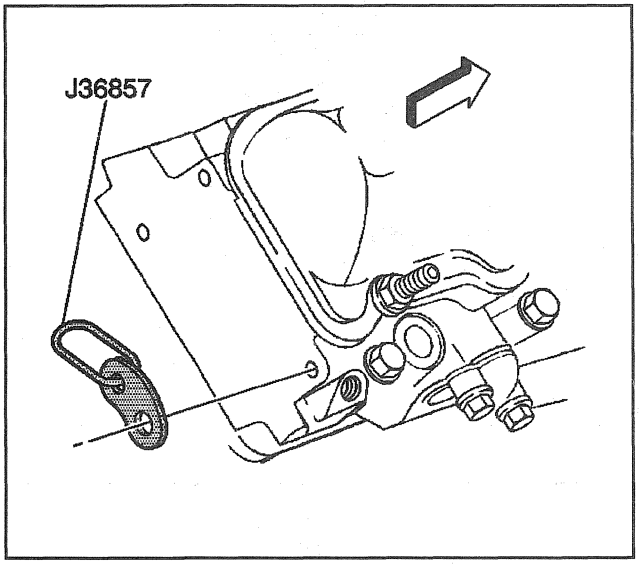
Important: It maybe necessary to remove the clutch assembly (if equipped) and the flywheel before installing the engine assembly on a suitable engine stand.

36. Remove the clutch assembly (if equipped) from the flywheel.

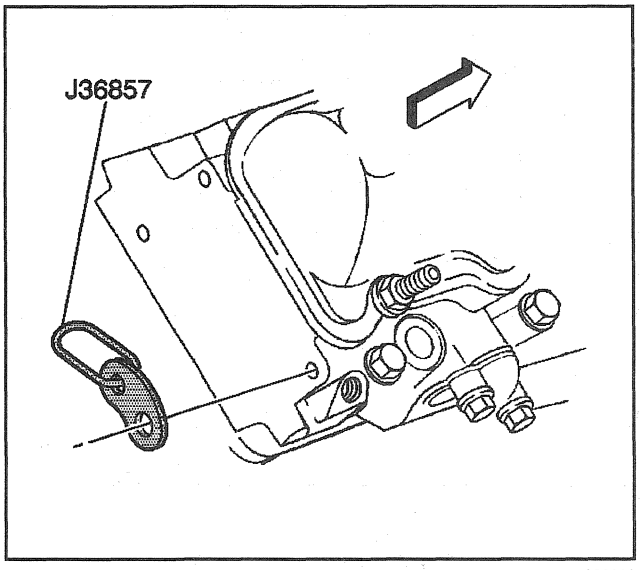


177057

37. Remove the flywheel from the engine assembly.
38. Install the engine assembly to a suitable engine stand.
39. Remove the lifting devise from the engine.
40. Remove the *J 36857* from the right rear cylinder head.



222260



222260

Installation Procedure

Notice: Refer to *Damage May Result From The Use Of An Improper Bolt When...* in Cautions and Notices.

1. Install *J 36857* along with GM P/N 94282217 bolt and GM P/N 15650963 washer to the right rear cylinder head.

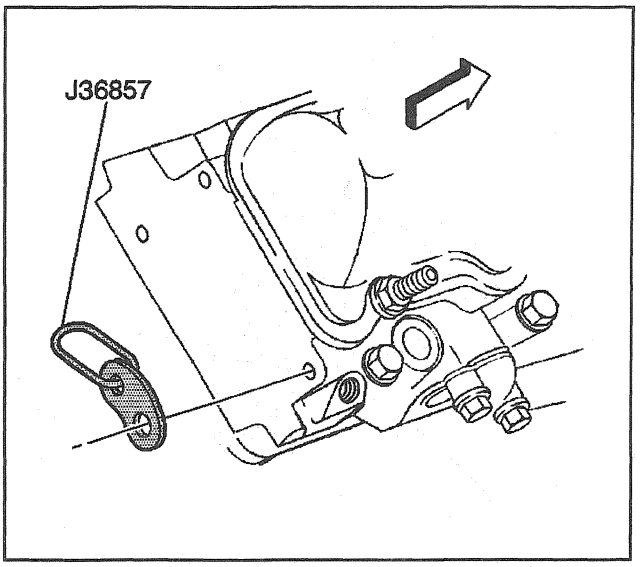
Notice: Refer to *Fastener Notice* in Caution and Notices.

Tighten

Tighten the lift bracket bolt to 40 N·m (30 lb ft).

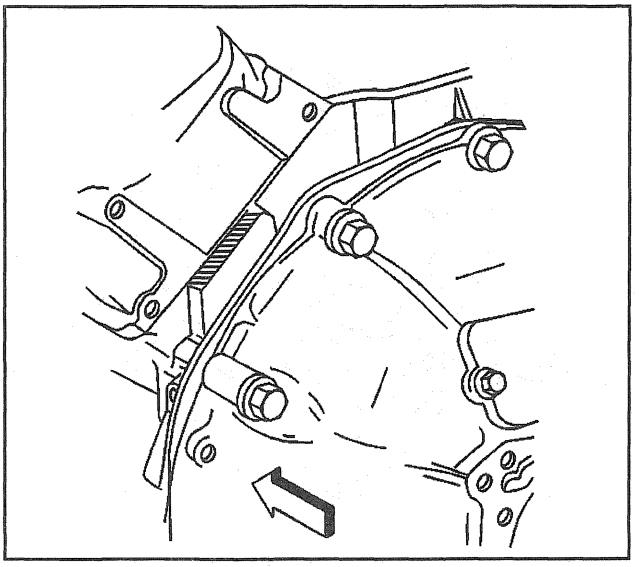
2. Attach a suitable lifting devise to the engine assembly.
3. Remove the engine assembly from the engine stand.
4. Install the flywheel on the engine assembly.
5. Install the clutch assembly (if equipped) to the flywheel.
6. Install the engine assembly into the vehicle.
7. Install the engine mount through bolt. Refer to *Engine Mount Replacement (Front).*
8. Remove the lifting devise from the engine assembly.

9. Remove the engine lift bracket and the bolt and washer, GM P/N 94282217 and GM P/N 15650963 from the cylinder head.

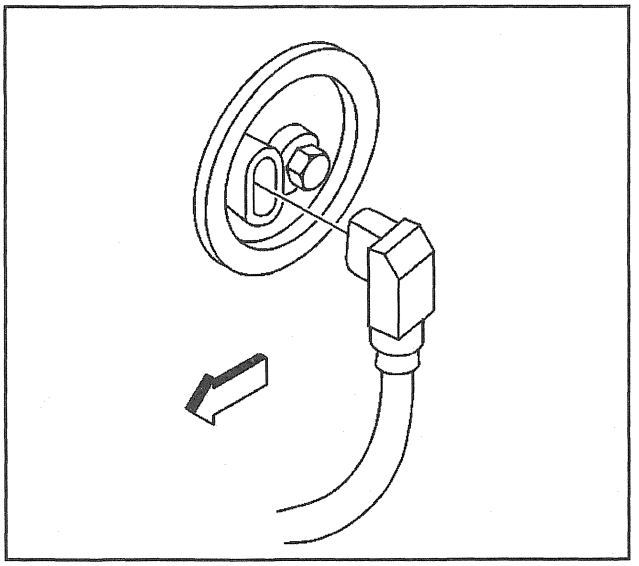


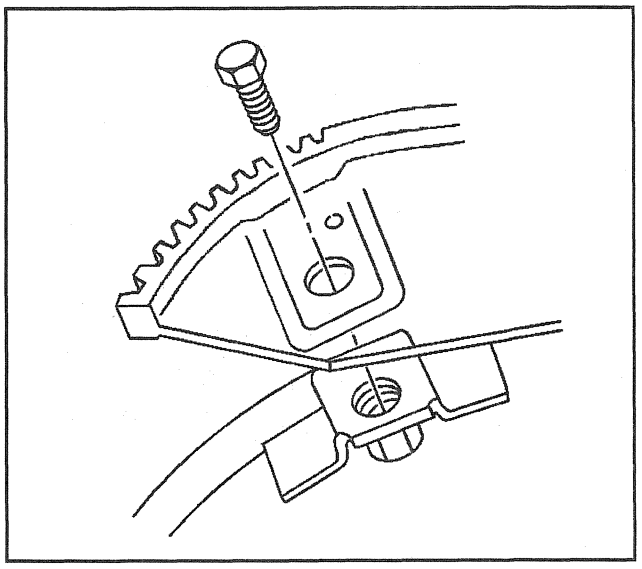
222260

10. Install bolts from the bellhousing to the engine block.
11. Remove the support for the transmission.
12. Raise the vehicle and support the vehicle with safety stands.


177057

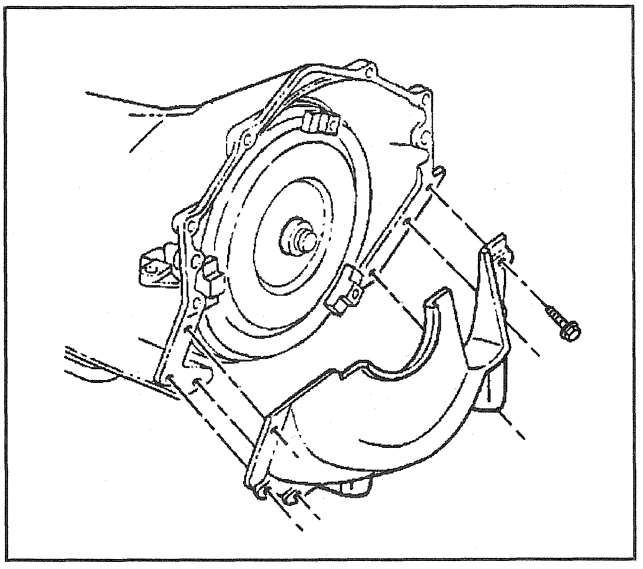
13. Reconnect the electrical connector for the block heater.


317722



9096

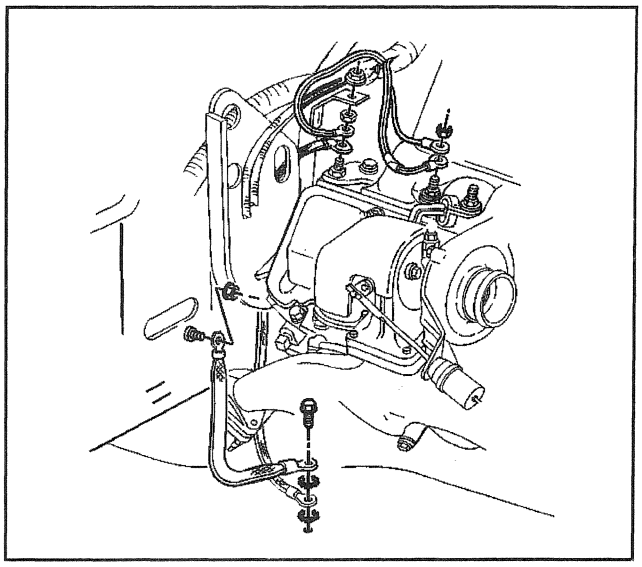
14. Install the bolts into the torque convertor.



32688

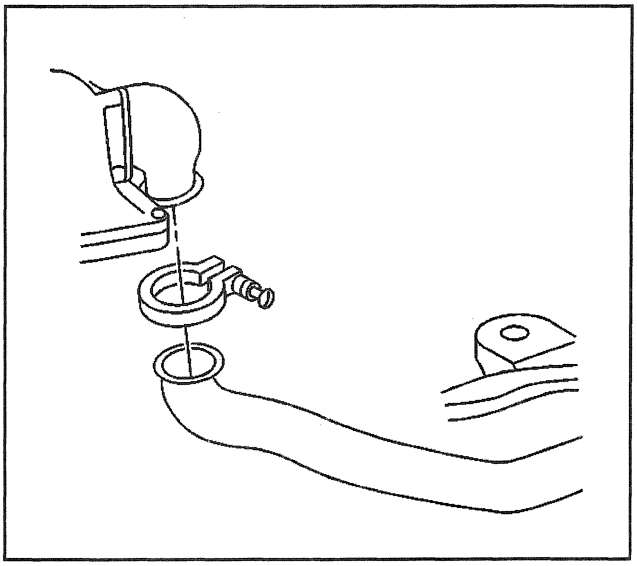
15. Install the flywheel inspection cover to the transmission. Refer to Automatic Transmission Replacement in Transmission/Transaxle.
    - For the 4L80–E automatic transmission, refer to *Transmission Replacement* in Transmission/Transaxle.
    - For the NV 4500 (two wheel drive) manual transmission, refer to *Transmission Replacement (NV4500 RWD)* in Transmission/Transaxle.
    - For the NV 4500 (four wheel drive) manual transmission, refer to *Transmission Replacement (NV4500 4WD)* in Transmission/Transaxle.
16. Install the starter on the engine assembly. Refer to *Starter Motor Replacement (Diesel Engines)* in Engine Electrical.
17. Install the oil filter and adapter (four wheel drive vehicles only). Refer to *Oil Filter Adapter and Valve Assembly Replacement.*
18. Connect the oil cooler lines to the engine block. Refer to *Engine Oil Cooler Line Replacement.*
19. Install the transmission cooler lines to the retaining brackets. Refer to *Oil Cooler Line Replacement* in Transmission/Transaxle.
20. Install the front propeller shaft (4 wheel drive vehicles only). Refer to *Propeller Shaft Replacement (Front Axle - All Except NP8).*

21. Install the ground strap from the body to engine and the rear of the right cylinder head.
22. Install the battery grounds straps on front of the engine assembly.



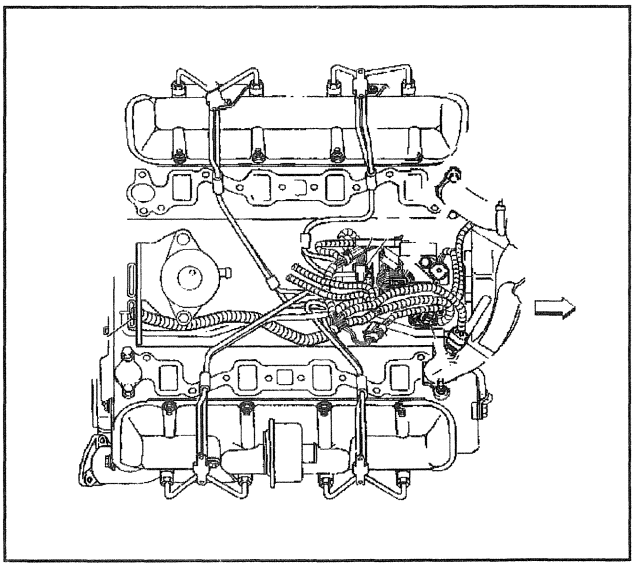
345208

23. Install the exhaust pipe to the turbocharger.
24. Lower the vehicle.
25. Install the generator to the mounting bracket. Refer to *Generator Replacement (Diesel Engines)* in Engine Electrical.
26. Install the air conditioning compressor to the mounting bracket. Refer to *Compressor Replacement (Diesel)* in HVAC.
27. Install the power steering hoses to the power steering pump. Refer to *Power Steering Hoses Replacement* in Power Steering.
28. Install the heater hoses to the heater core.
    - For the heater inlet hose, refer to *Heater Hoses Replacement (Inlet Hose- Diesel)* in HVAC.
    - For the heater outlet hose, refer to *Heater Hoses Replacement (Outlet Hose- Diesel)* in HVAC.

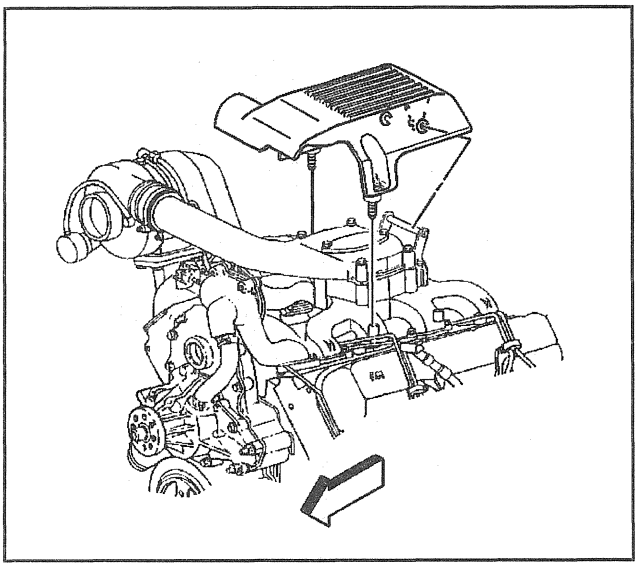


177088

29. Reconnect the engine wiring harness extension harness assembly at the cowl.
30. Reconnect the fuel lines to the fuel filter. Refer to *Fuel Manager/Filter Replacement* in Engine Controls-6.5L.

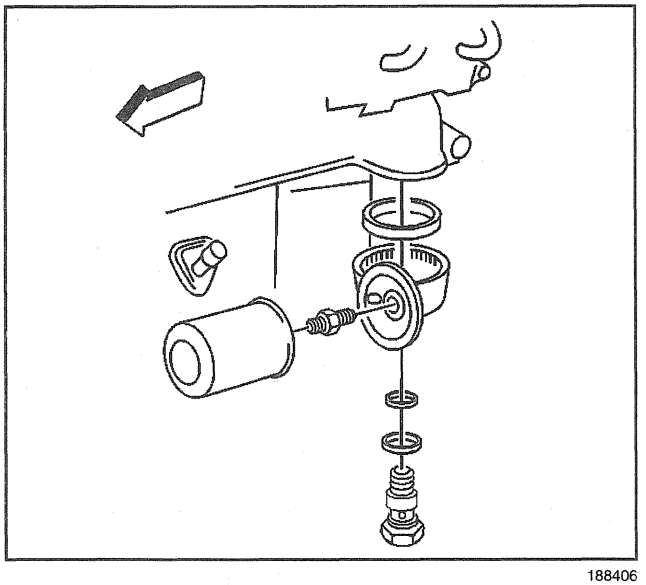


64989



358421

31. Install the upper intake manifold cover. Refer to *Intake Manifold Replacement (Upper)*.
32. Connect the battery negative cables to the batteries. Refer to *Battery Cable* in Engine Electrical.
33. Refill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
34. Install the hood to the vehicle. Refer to *Hood Replacement* in Body and Accessories.
35. Install the radiator assembly in the vehicle. Refer to *Radiator Replacement* in Engine Cooling.
36. Install the air conditioning condenser in the vehicle. Refer to *Condenser Replacement* in HVAC.
37. Install the A/C lines on the A/C compressor.
38. Recharge the A/C system. Refer to *Refrigerant Recovery and Recharging* in HVAC.
39. Reset the fuel injection pump timing. Refer to *Injection Timing Adjustment* in Engine Controls-6.5L.
40. Perform the TDC offset timing procedure. Refer to *TDC Offset Adjustment* in Engine Controls-6.5L.



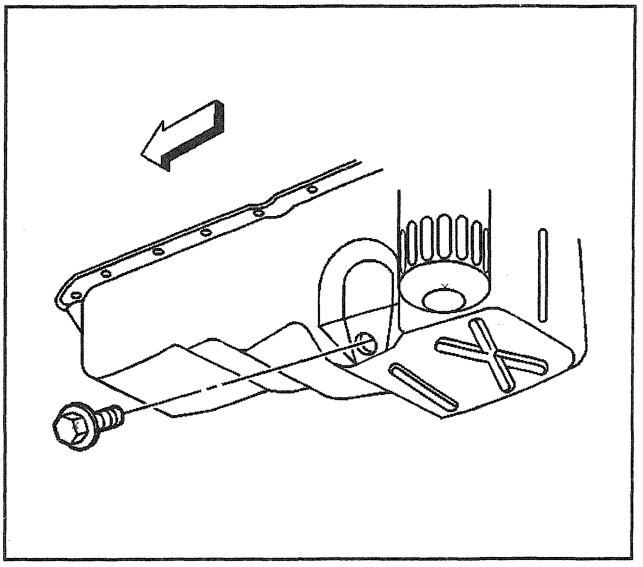
188406

Engine Oil and Oil Filter Replacement

Removal Procedure

1. Raise the vehicle.
2. Remove the oil filter from the engine block.

3. Remove the drain plug from the oil pan.



182850

Installation Procedure

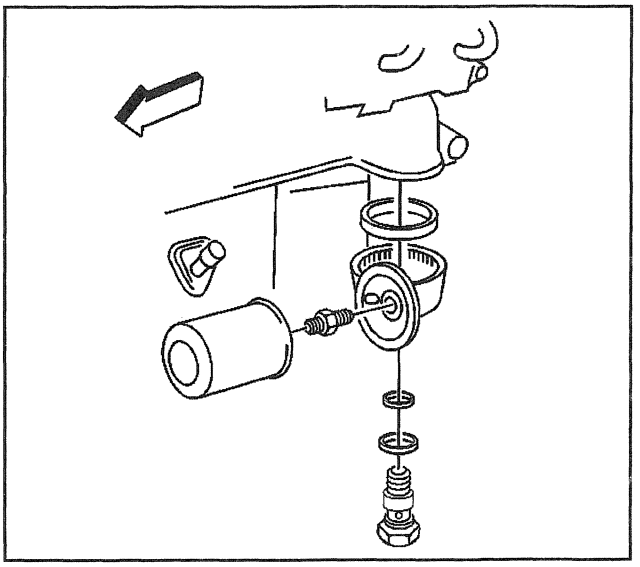
Important: When serving a vehicle equipped with four wheel drive and a 6.5L turbocharger diesel engine, retighten the oil filter adapter bolt to 65 N·m (47 lb ft) after installing a new oil filter.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the oil filter to the engine block.

   Tighten

   Tighten the oil filter to 40 N·m (30 lb ft).



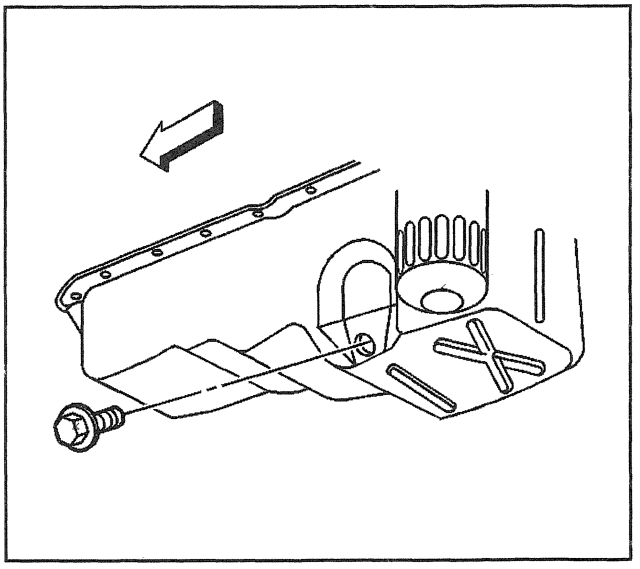
188406

2. Install the drain plug to the oil pan.

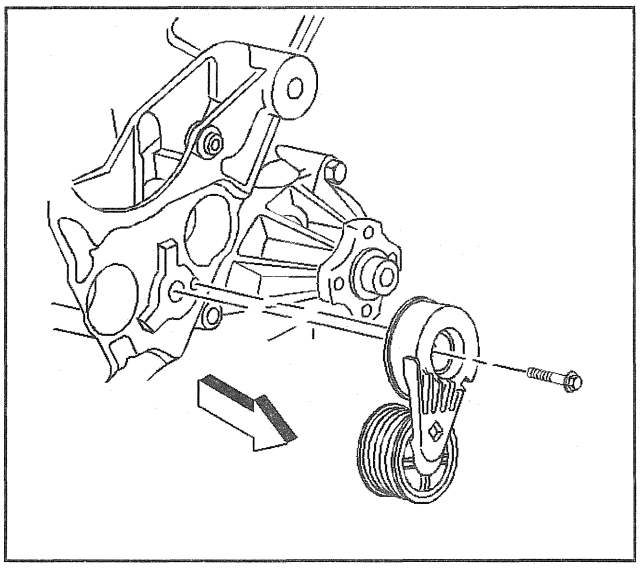
   Tighten

   Tighten the drain plug to 40 N·m (30 lb ft).
3. Lower the vehicle.
4. Fill the crankcase with engine oil.

Important: When performing an oil filter and oil change on a 6.5L diesel engine, use only 8 quarts of oil. This will bring the oil level between ADD and FULL, which is normal. Start the vehicle and wait until the engine reaches normal operating temperature. Shut the vehicle off and wait a minimum of 15 minutes before checking the oil level. It should read Full or very close to "Full". Do not check the oil level when the engine is cold, a false reading will occur.



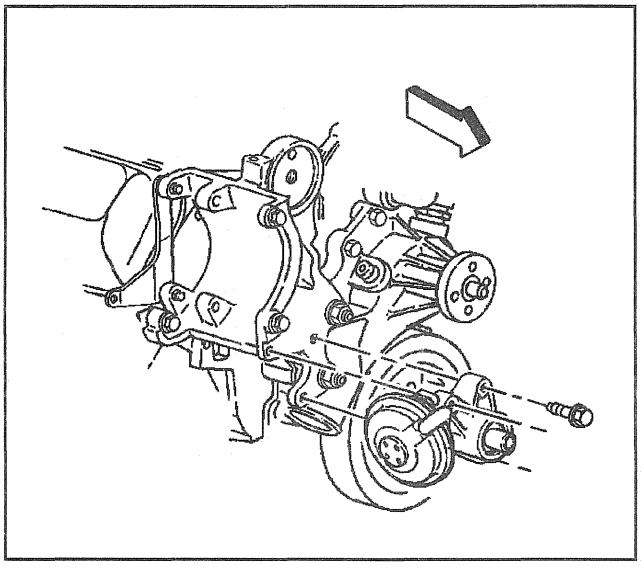
182850



43854

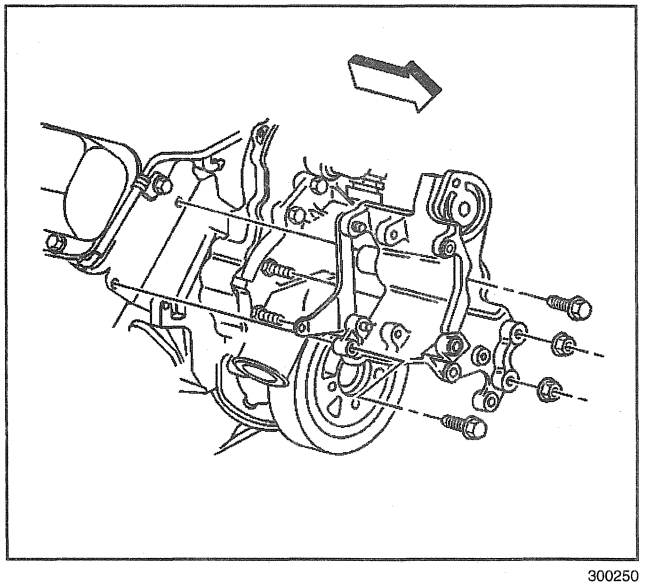
Accessory Removal

1. Remove the drive belt tensioner retaining bolt.
2. Remove the drive belt tensioner.



177149

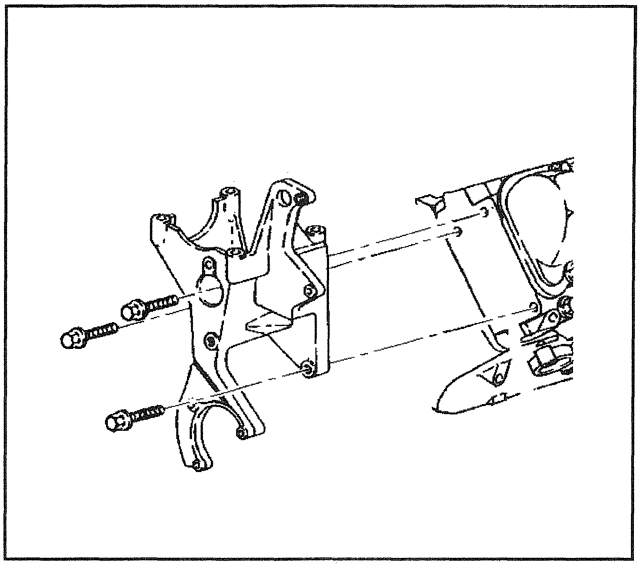
3. Remove the vacuum pump retaining bolts.
4. Remove the vacuum pump.



300250

5. Remove the right accessory bracket retaining bolts.
6. Remove the right accessory bracket retaining nuts.
7. Remove the right accessory bracket.

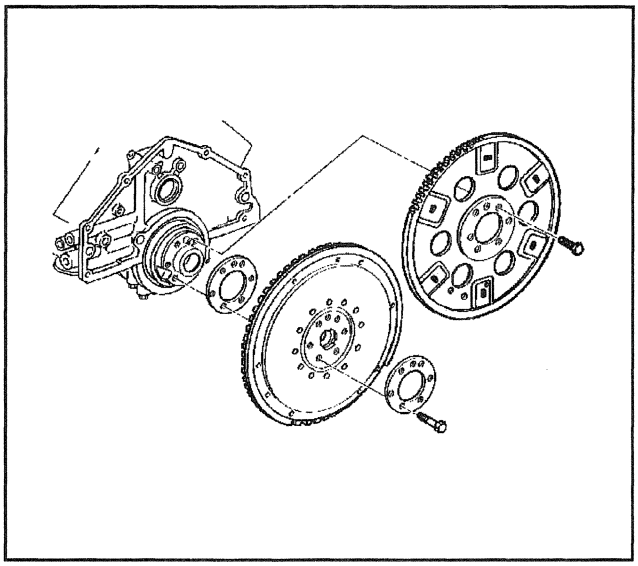
8. Remove the left accessory/lift bracket retaining bolts.
9. Remove the left accessory/lift bracket retaining nut (if equipped).
10. Remove the left accessory/lift bracket.



59794

Engine Flywheel Removal

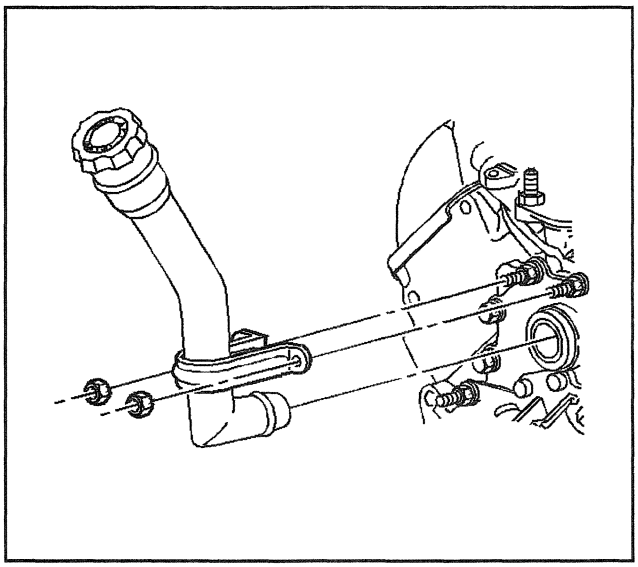
1. Remove the flywheel retaining bolts.
2. Remove the outer retainer (if equipped).
3. Remove the flywheel.
4. Remove the inner retainer (if equipped).



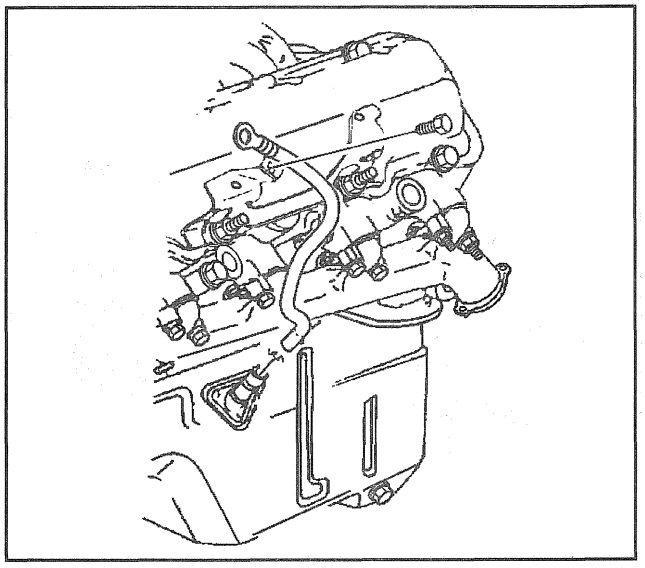
64987

Oil Fill Tube Removal

1. Remove the oil fill tube retaining nuts.
2. Remove the oil fill tube.



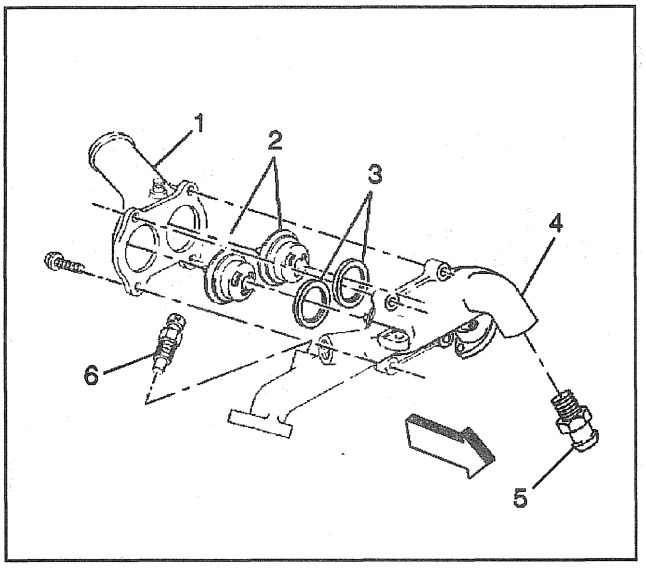
59772



60238

Oil Level Indicator and Tube Removal

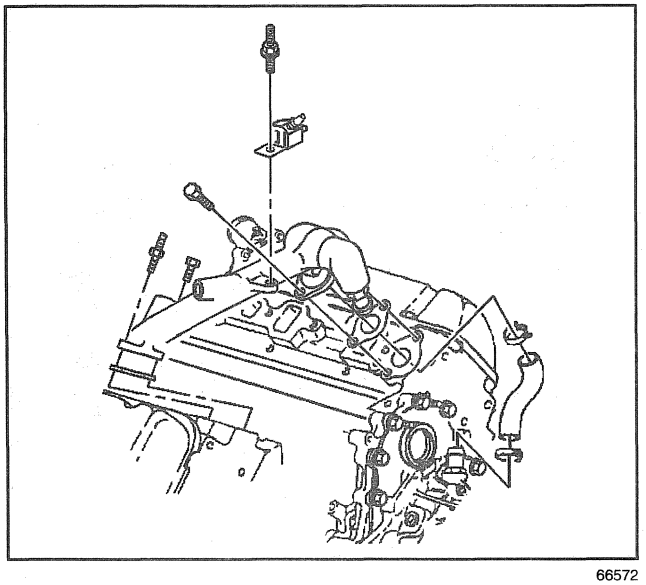
1. Remove the oil level indicator.
2. Remove the oil level indicator tube retaining bolt.
3. Remove the oil level indicator tube.
4. Remove the O-ring seal.



64991

Thermostat Removal

1. Remove the air bleed valve.
2. Remove the water outlet retaining bolts.
3. Remove the water outlet (1).
4. Remove the thermostats (2) with the seals (3).
5. Remove the thermostat seals (3) from the thermostats (2).
6. Remove the heater flow control valve.
7. Remove the engine coolant temperature (ECT) sensor (6).

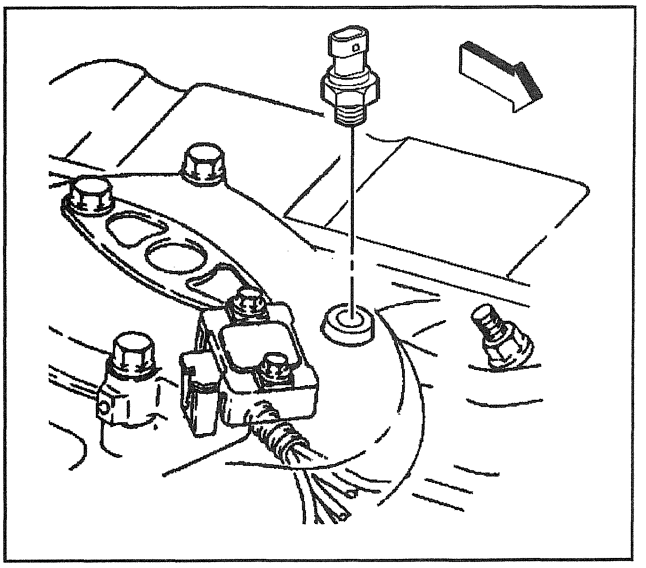


66572

8. Remove the fuel bleed valve retaining nut.
9. Remove the fuel bleed valve.
10. Remove the fuel bleed valve mounting bolt.
11. Loosen the thermostat bypass hose retaining clamps.
12. Remove the thermostat housing retaining bolts.
13. Remove the thermostat housing.
14. Remove the thermostat bypass hose.
15. Remove the thermostat bypass hose retaining clamps.
16. Remove the thermostat bypass hose fitting.
17. Remove the gaskets.

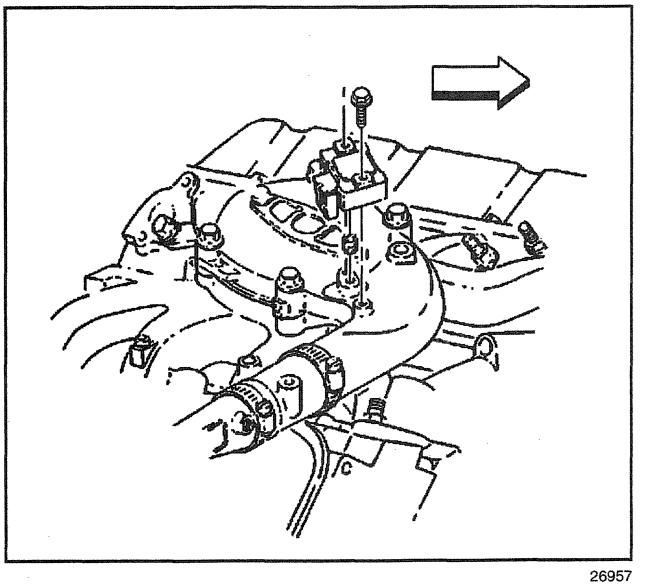
Intake Manifold Removal (Upper-L56)

1. Disconnect the Intake Air Temperature (IAT) sensor electrical connector.
2. Remove the IAT sensor.



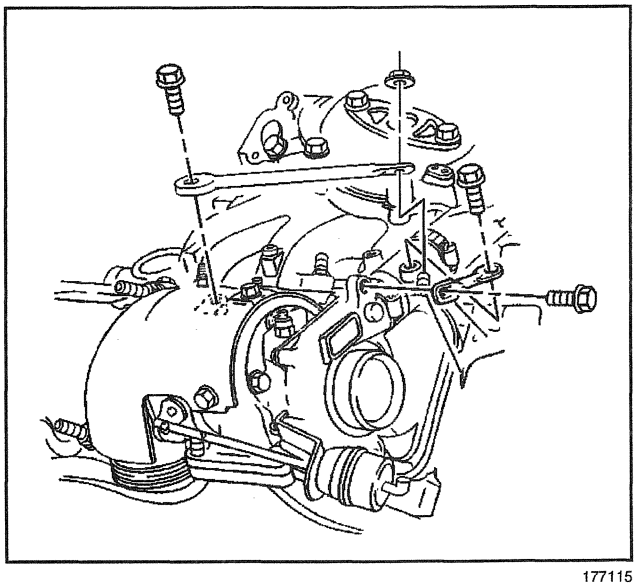
73425

3. Disconnect the Manifold Absolute Pressure (MAP) sensor electrical connector.
4. Remove the MAP sensor retaining bolts.
5. Remove the MAP sensor.
6. Remove the gasket.

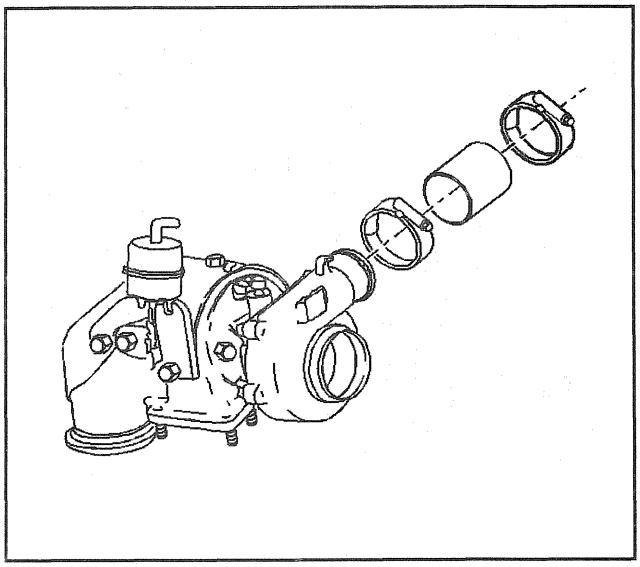


26957

7. Remove the turbocharger short brace retaining bolts.
8. Remove the turbocharger short brace.
9. Remove the turbocharger long brace retaining bolt.
10. Remove the turbocharger long brace retaining nut.
11. Remove the turbocharger long brace.

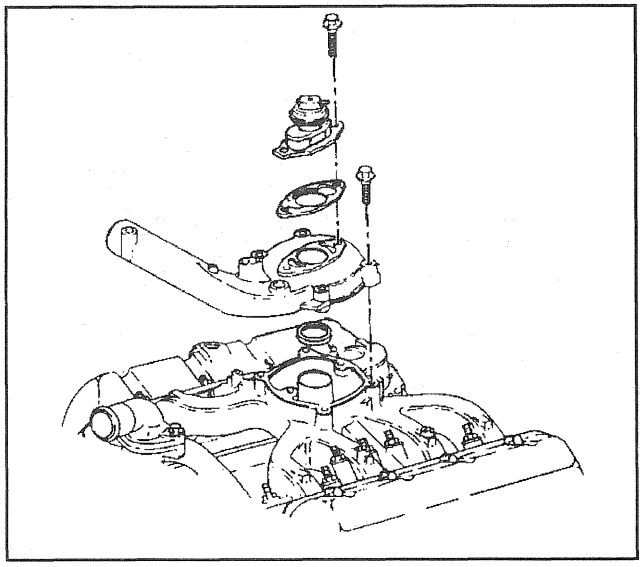


177115



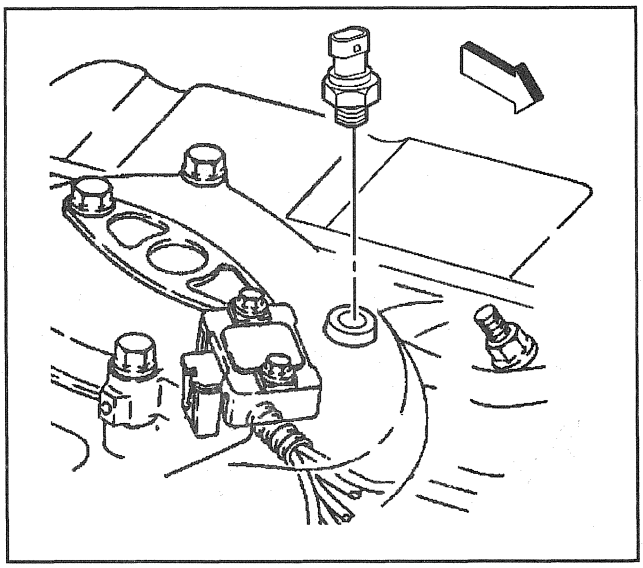
59746

12. Loosen the turbocharger connection hose clamps.
13. Loosen the turbocharger connection hose.
    13.1. Insert a small flat screwdriver blade between the turbocharger connection hose and the turbocharger and slide the screwdriver blade along the surface of the turbocharger until the hose twists freely.
    13.2. Insert a small flat screwdriver blade between the turbocharger connection hose and the upper intake manifold and slide the screwdriver blade along the surface of the upper intake manifold until the hose twists freely.



59748

14. Remove the upper intake manifold retaining bolts.
15. Remove the EGR valve.
16. Remove the gasket.
17. Remove the upper intake manifold.
18. Remove the gaskets. The EGR tower gasket is located on the round center portion of the intake manifold.

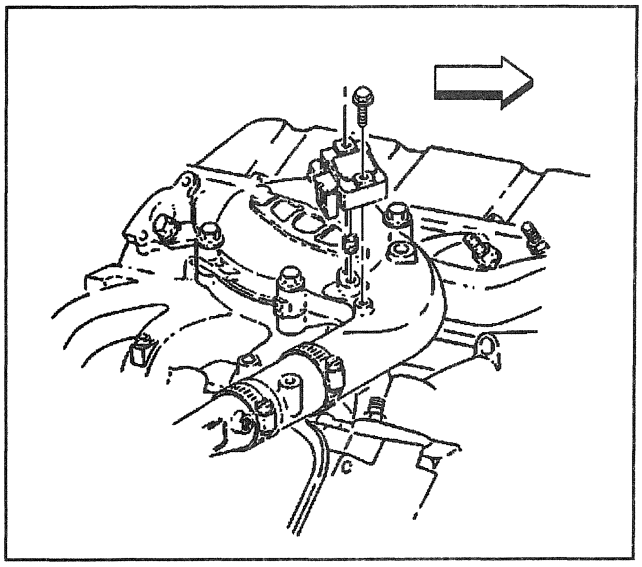


73425

Intake Manifold Removal (L65)

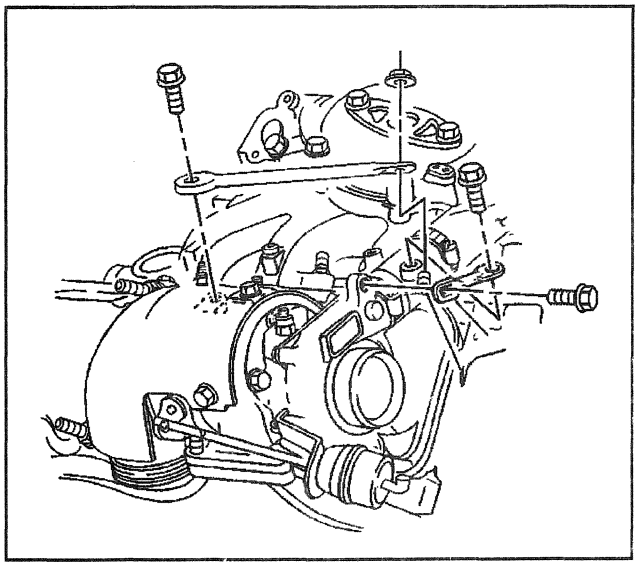
1. Disconnect the Intake Air Temperature (IAT) sensor electrical connector.
2. Remove the IAT sensor.

3. Disconnect the Manifold Absolute Pressure (MAP) sensor electrical connector.
4. Remove the MAP sensor retaining bolts.
5. Remove the MAP sensor.
6. Remove the gasket.



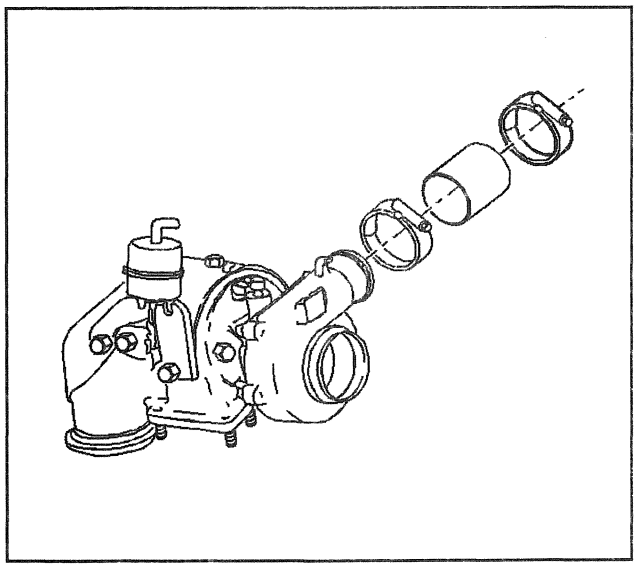
26957

7. Remove the turbocharger short brace retaining bolts.
8. Remove the turbocharger short brace.
9. Remove the turbocharger long brace retaining bolt.
10. Remove the turbocharger long brace retaining nut.
11. Remove the turbocharger long brace.

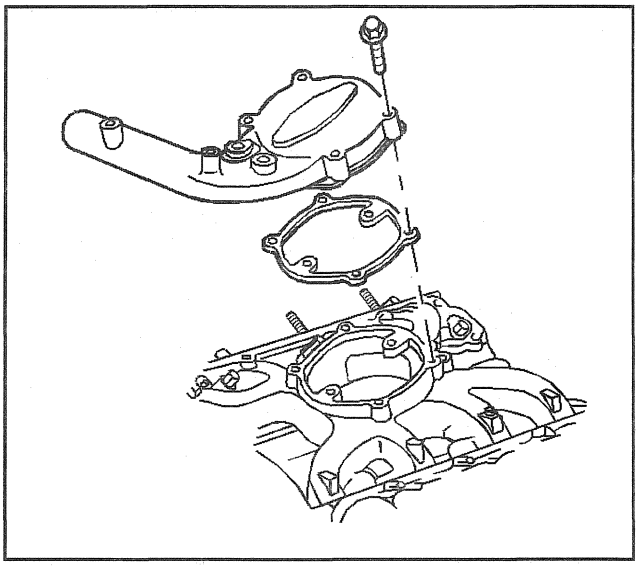


177115

12. Loosen the turbocharger connection hose clamps.
13. Loosen the turbocharger connection hose.
    - 13.1. Insert a small flat screwdriver blade between the turbocharger connection hose and the turbocharger and slide the screwdriver blade along the surface of the turbocharger until the hose twists freely.
    - 13.2. Insert a small flat screwdriver blade between the turbocharger connection hose and the upper intake manifold and slide the screwdriver blade along the surface of the upper intake manifold until the hose twists freely.

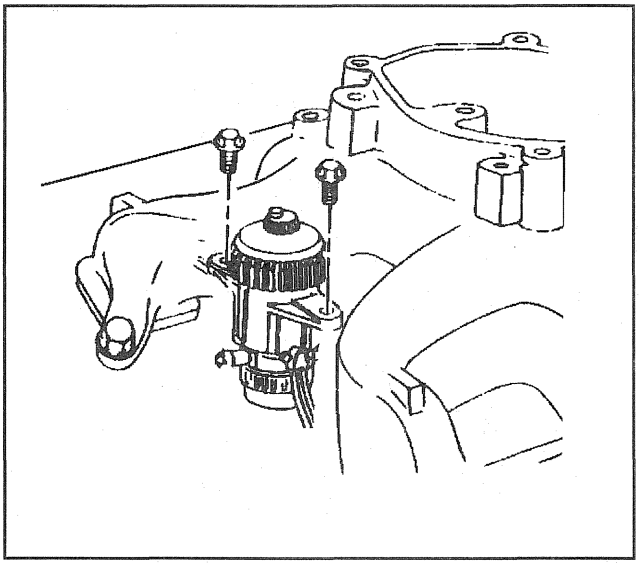


59746



59749

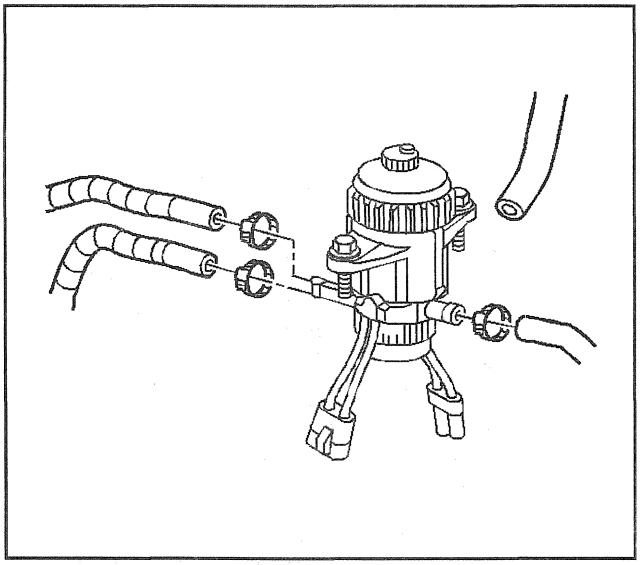
14. Remove the upper intake manifold retaining bolts.
15. Remove the upper intake manifold.
16. Remove the gasket.
17. Remove the intake manifold.



55513

Intake Manifold Removal (L57, L65)

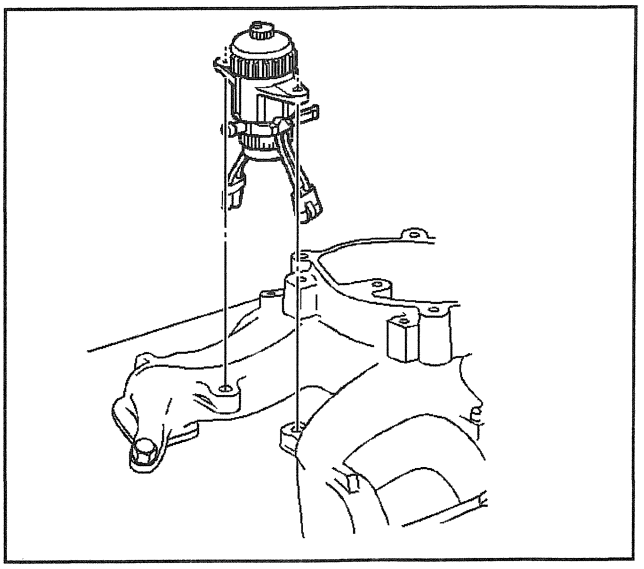
1. Remove the fuel manager/filter assembly retaining bolts.



59758

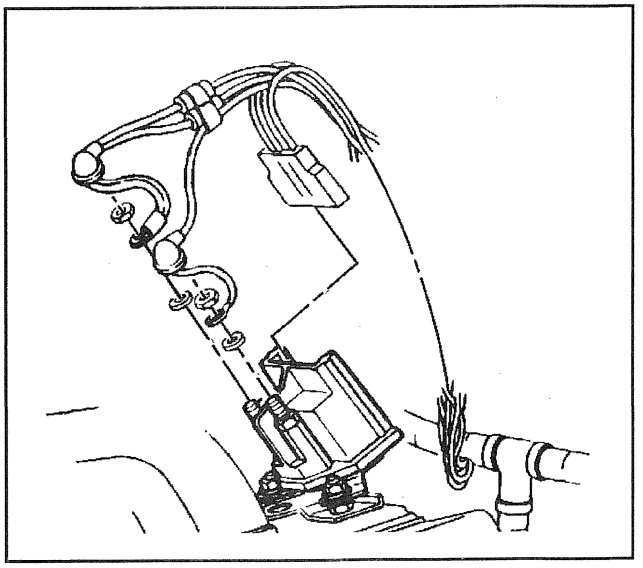
2. Loosen the fuel hose clamps at the fuel filter assembly.
3. Remove the fuel hoses from the fuel filter assembly.
4. Disconnect the fuel manager/filter electrical connector.

5. Remove the fuel filter assembly.



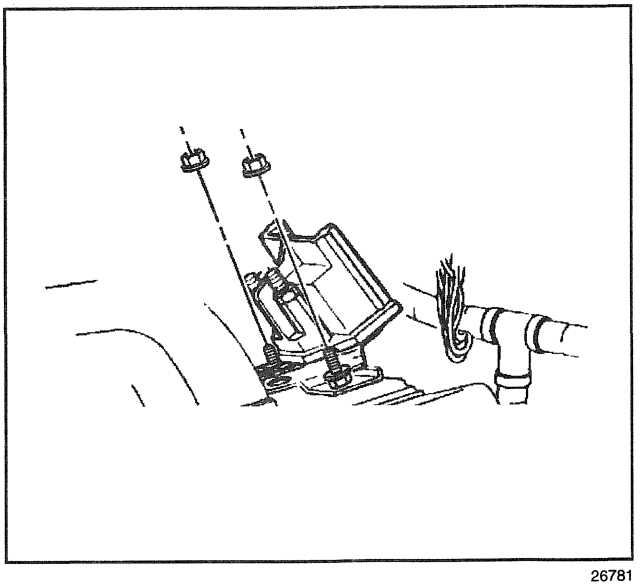
59759

6. Disconnect the glow plug relay electrical connectors.

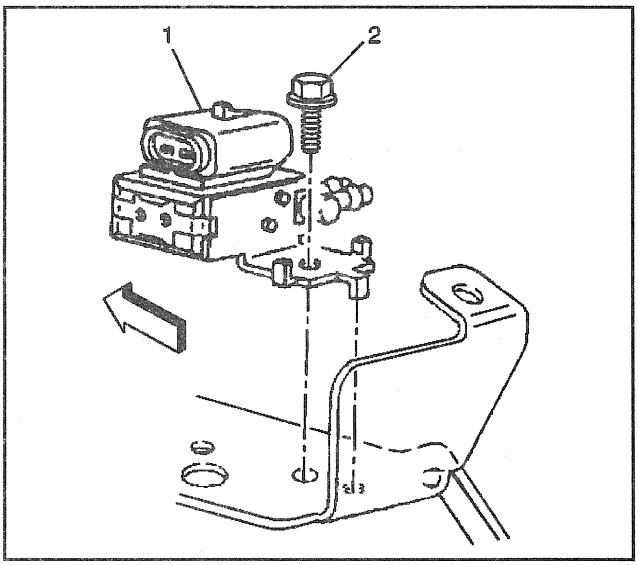


26780

7. Remove the glow plug relay retaining nuts.
8. Remove the glow plug relay.

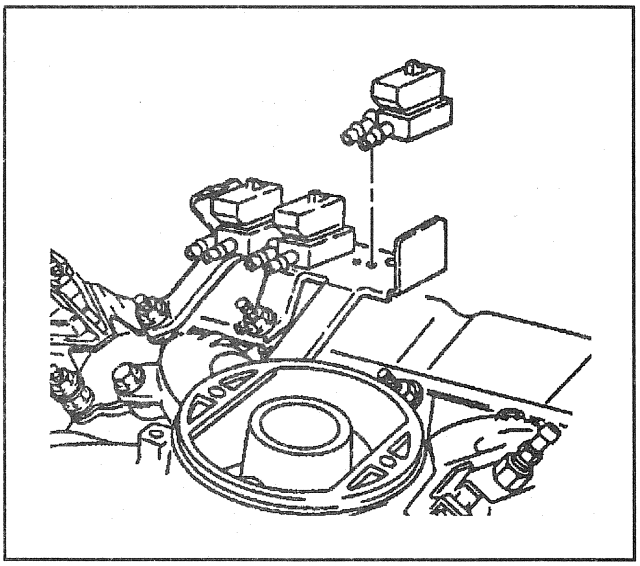


26781



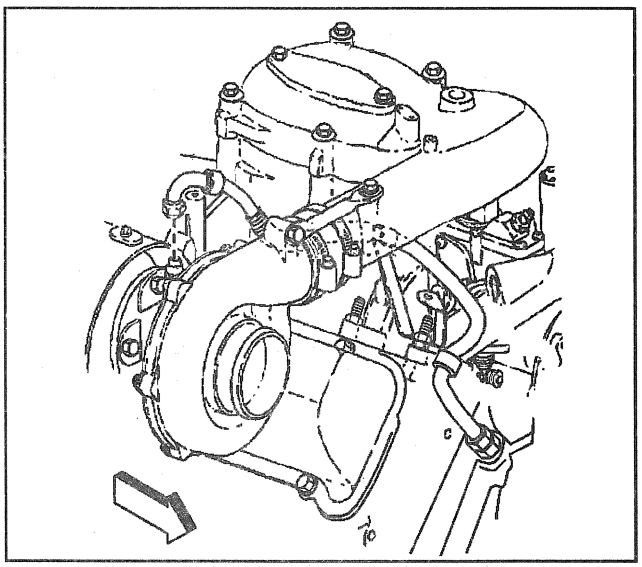
25300

9. Disconnect the vacuum harness hose connectors.
10. Remove the vacuum harness.
11. Remove the vacuum solenoid retaining bolt(s) (2).
12. Remove the vacuum solenoid(s) (1).



26958

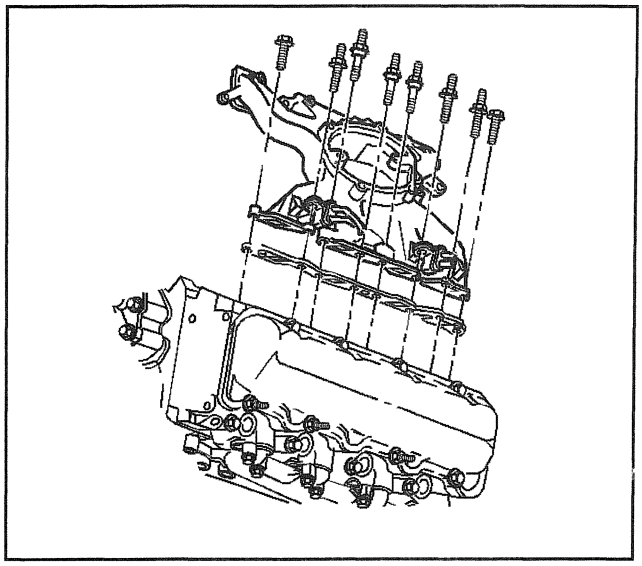
13. Remove the vacuum solenoid mounting bracket retaining nuts.
14. Remove the vacuum solenoid mounting bracket.



177108

15. Remove the turbocharger oil feed line mounting bracket retaining nut.
16. Remove the turbocharger oil feed line mounting bracket. Gently pull the bracket from the turbocharger oil feed line at a 45 degree angle to separate.

17. Remove the intake manifold bolts.
18. Remove the intake manifold.
19. Remove the gaskets.



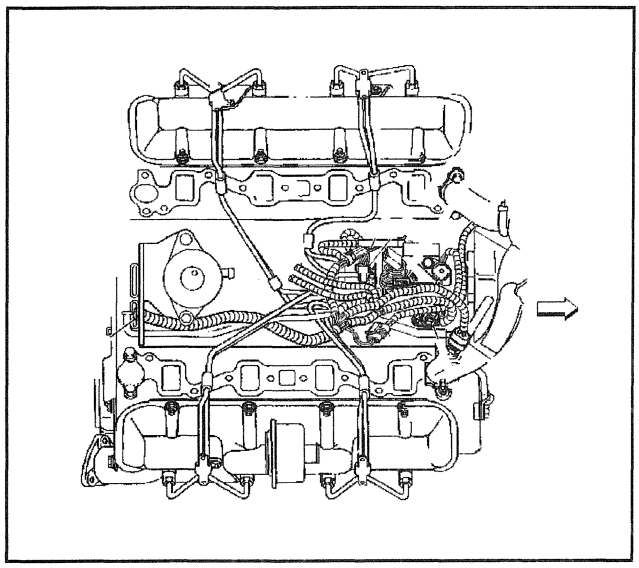
59835

Engine Wiring Harness Assembly Removal

Tools Required

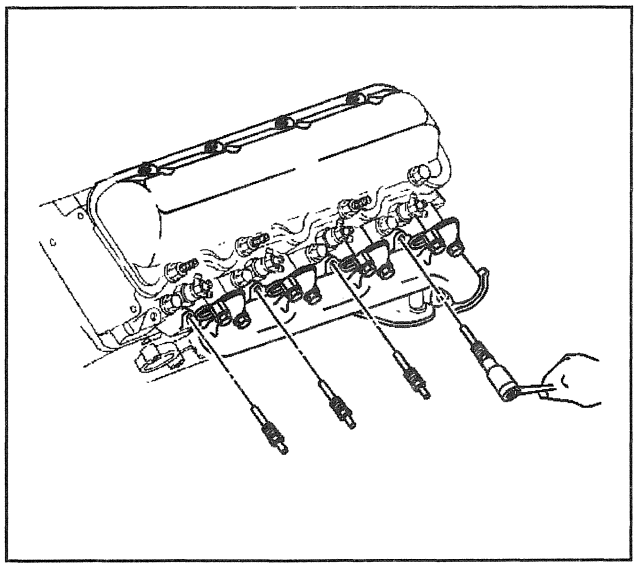
- *J 41515-A* Glow Plug Socket
- *J 41712* Oil Pressure Sending Unit Socket

1. Disconnect all engine wiring harness connectors.
2. Disconnect the engine wiring harness from all attachment points.
3. Remove the engine wiring harness.

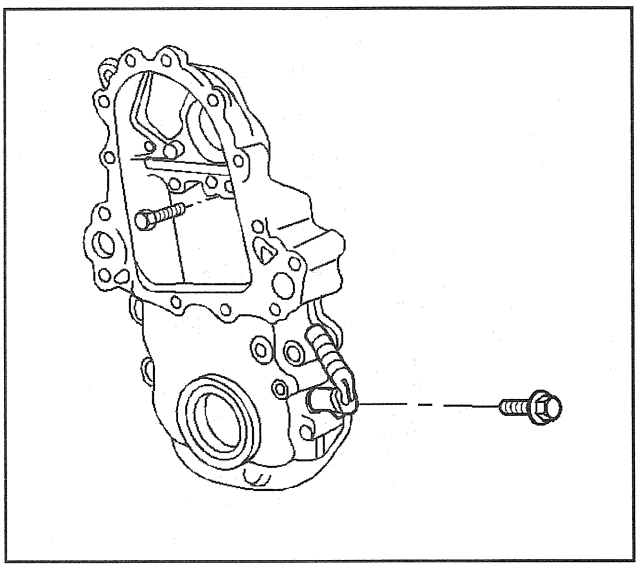


64989

4. Using the *J 41515-A* Glow Plug Socket, remove the glow plugs.

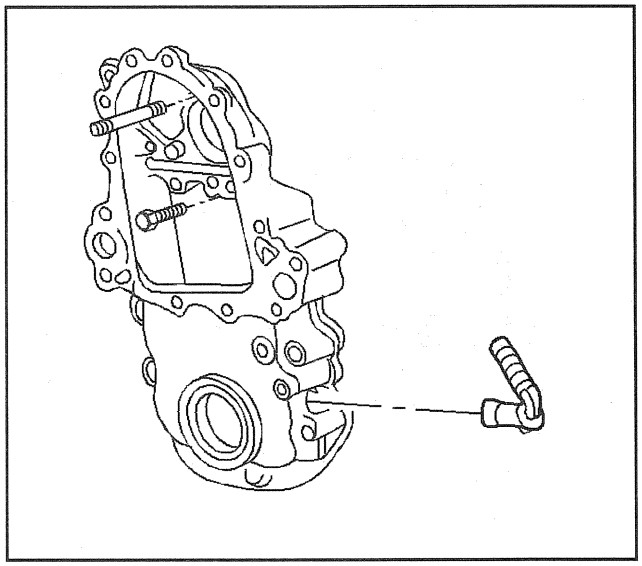


65040



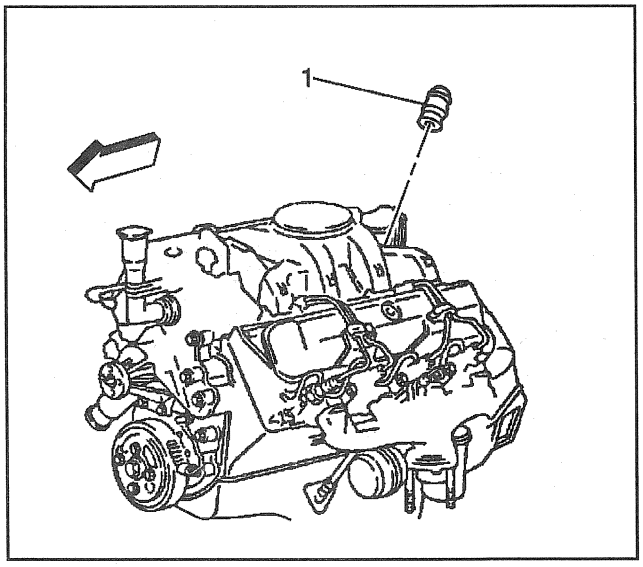
59857

5. Remove the crankshaft position sensor mounting bolt (if equipped).



59862

6. Remove the crankshaft position sensor (if equipped). Twist and pull the crankshaft position sensor straight out from the front cover (if equipped).



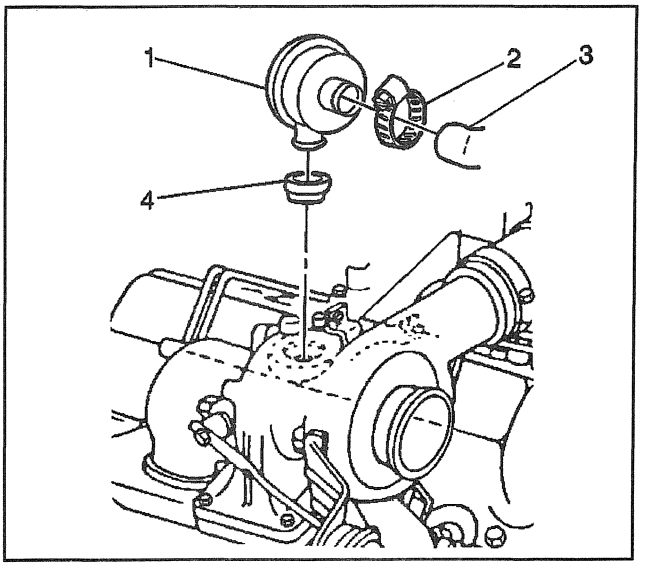
27615

7. Using the *J 41712* Oil Pressure Sending Unit Socket, remove the oil pressure sending unit (1).

Turbocharger Removal

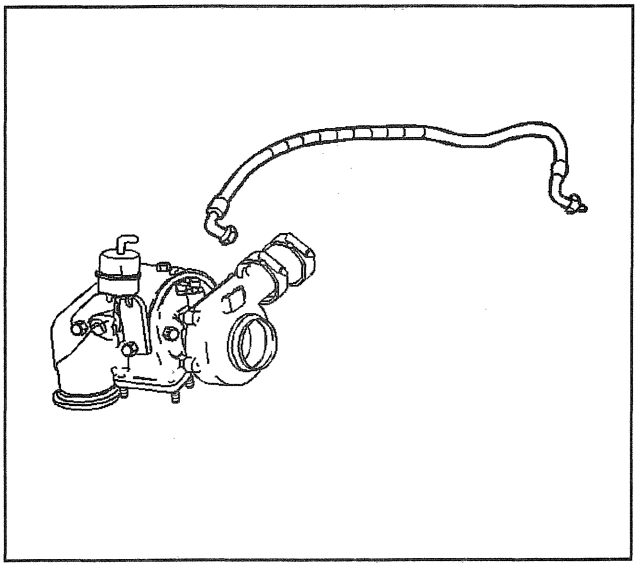
1. Loosen the Crankcase Depression Regulator (CDR) valve vent hose clamp at the CDR valve.
2. Remove the CDR valve vent hose (3) from the CDR valve (1).
3. Remove the CDR valve vent hose clamp (2) from the CDR valve vent hose (3).
4. Remove the CDR valve from the valve rocker arm cover (4).

   Pull upwards while twisting/rocking CDR valve.

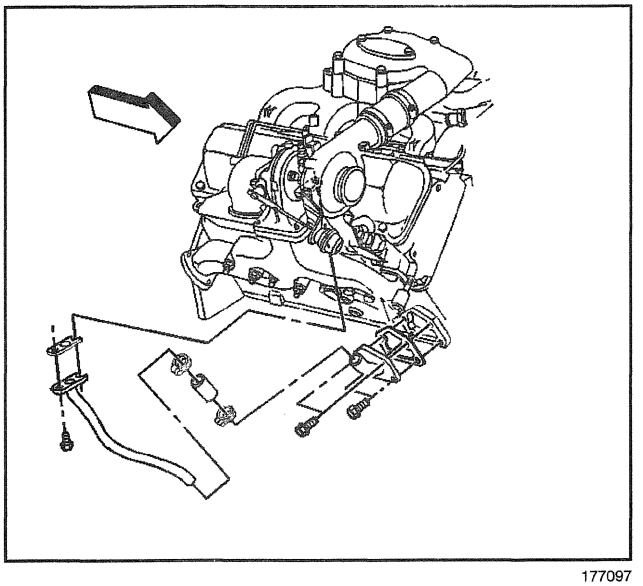


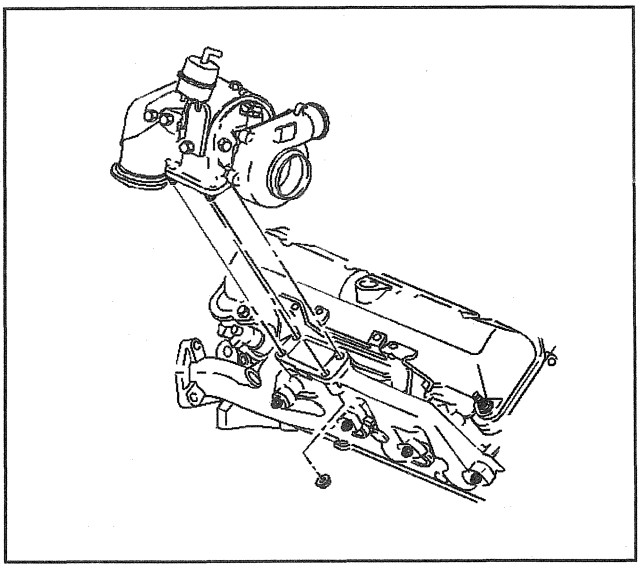
25616

5. Remove the turbocharger oil feed hose.


59754

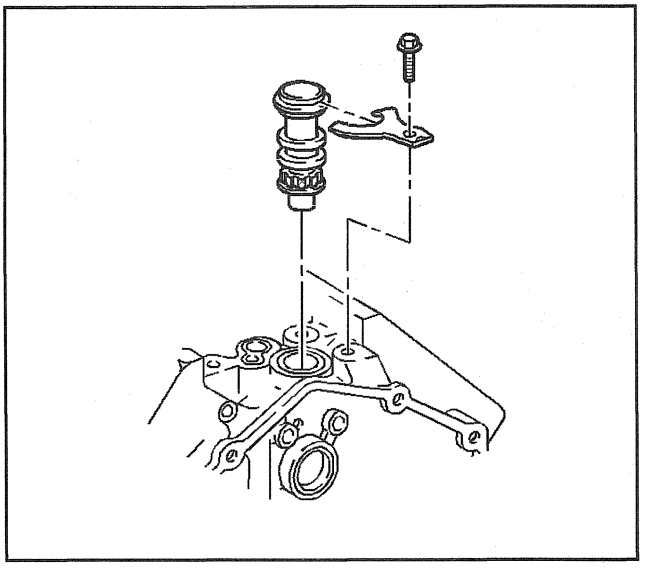
6. Remove the turbocharger upper oil return pipe retaining bolts.


177097



59756

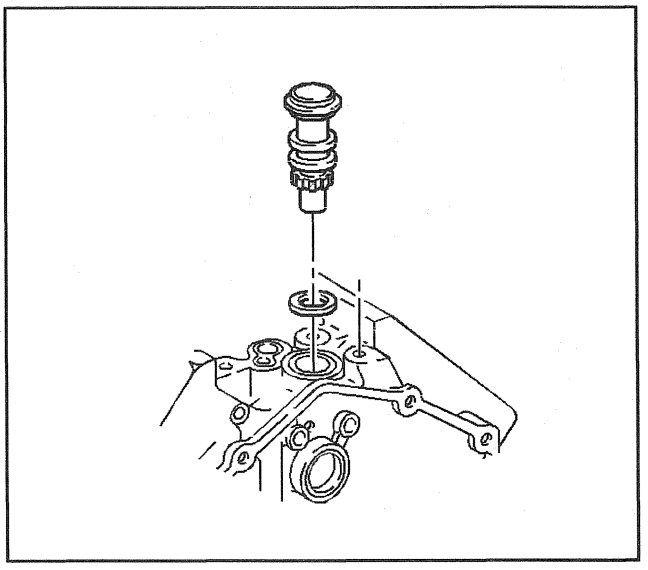
7. Remove the turbocharger assembly retaining nuts.
8. Remove the turbocharger assembly from the exhaust manifold.



59765

Oil Pump Drive Removal

1. Remove the oil pump drive clamp retaining bolt.
2. Remove the oil pump drive clamp.

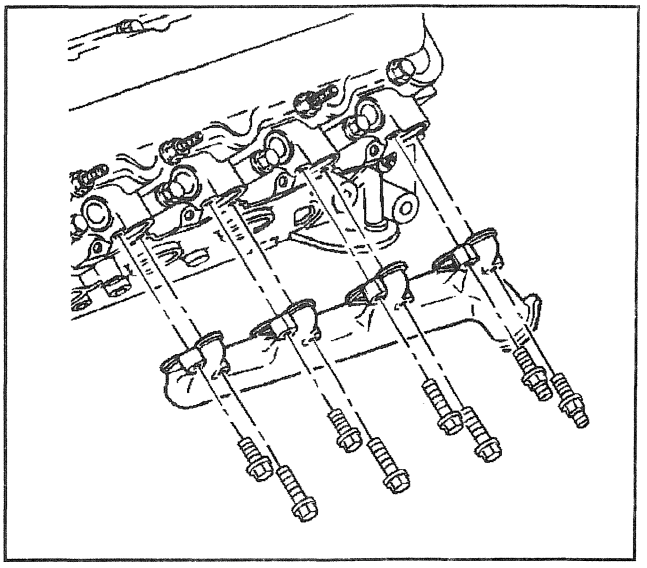


59768

3. Remove the oil pump drive.
4. Remove the gasket.

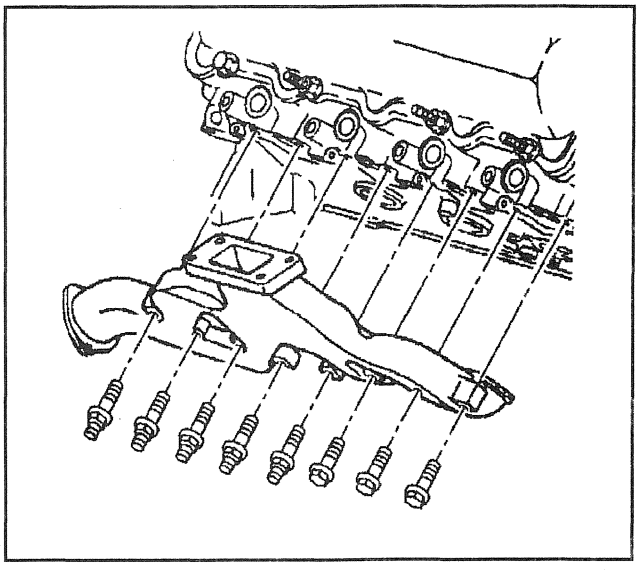
Exhaust Manifold Removal (L65)

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.



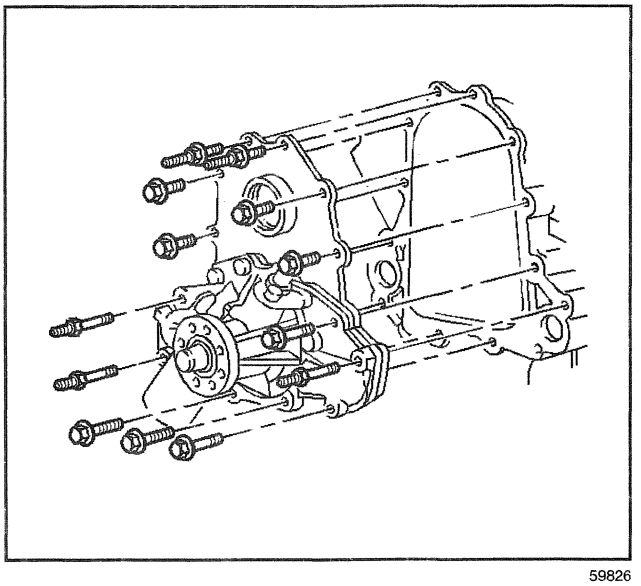
66575

Water Pump Removal

1. Remove the thermostat bypass fitting.

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

2. Remove the water pump and water pump plate retaining bolts.
3. Remove the water pump and the water pump plate.



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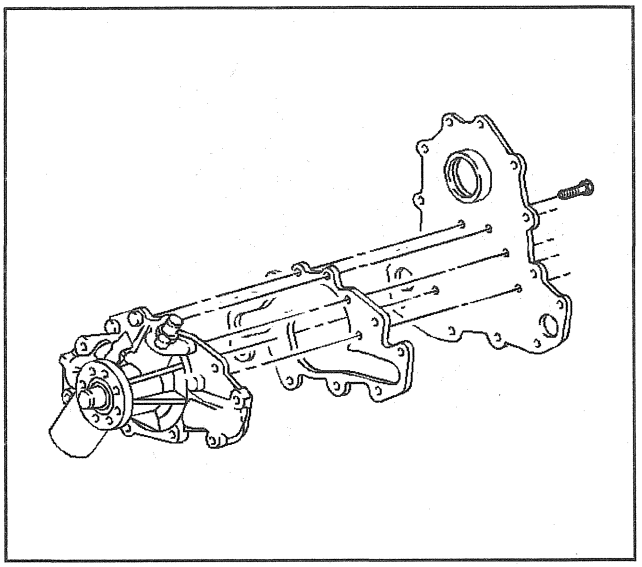
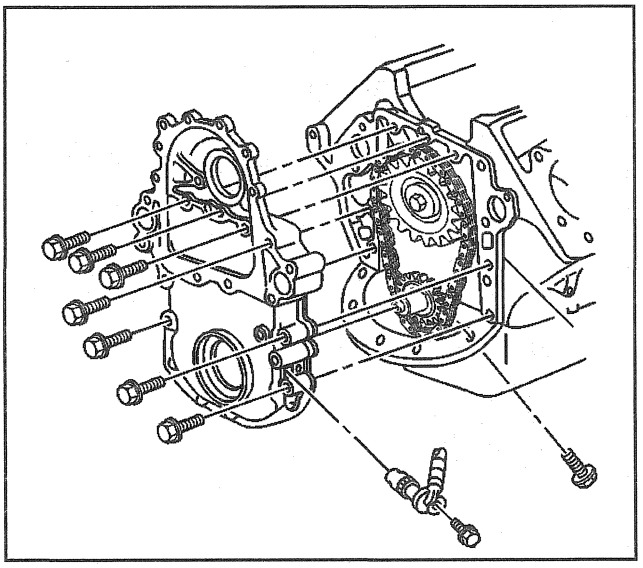


59828

4. Remove the water pump retaining bolts.
5. Remove the water pump.
6. Remove the gasket.



59842

Fuel Injection Pump Removal

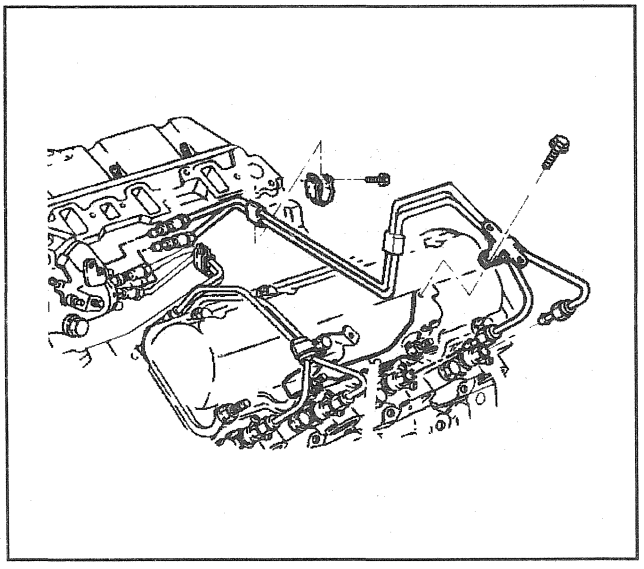
Tools Required

- *J 29873* Nozzle Socket
- *J 29698-B* Fuel Line Wrench, 3/4 inch

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

Important: Align timing marks at Top Dead Center (TDC) prior to removing the fuel injection pump driven gear bolts.

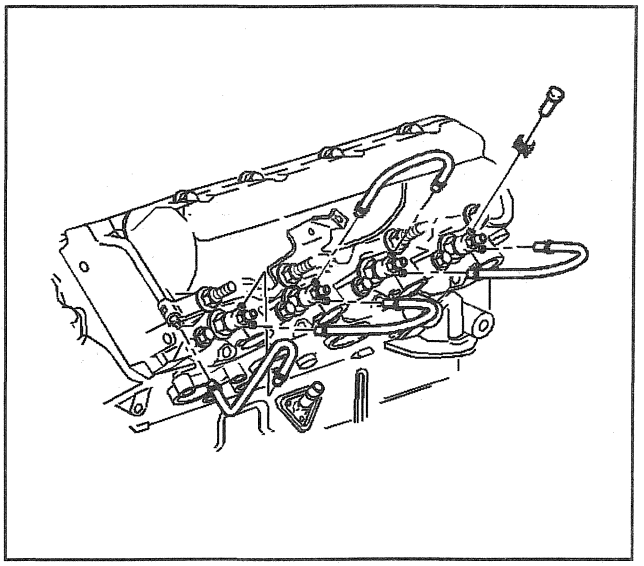
1. Remove the fuel injection pump driven gear retaining bolts.
2. Remove the fuel injection pump driven gear.



66573

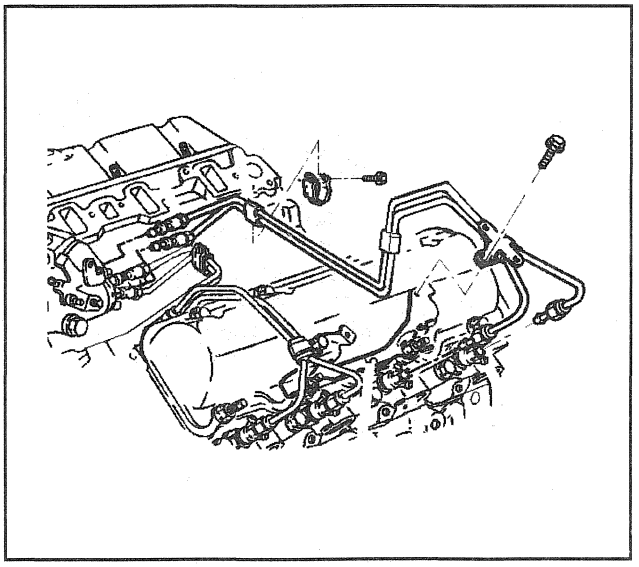
3. Loosen the fuel injection pump fuel return hose clamps.
4. Remove the fuel injection pump fuel return hose.
5. Remove the fuel injection pump fuel feed pipe clips at the brackets.
6. Remove the fuel injection pump fuel feed pipe brackets.

7. Loosen the fuel injection nozzle to fuel return pipe fuel return hose clamps.
8. Remove the fuel injection nozzle to fuel return pipe fuel return hoses.
9. Remove the fuel return pipe retaining nuts.
10. Remove the fuel return pipe.
11. Using the *J 29698-B* remove fuel injection pump fuel injection fuel feed pipe fittings.
    - Do not bend the fuel injection fuel feed pipes.
    - Cap the fuel feed pipe fittings and the fuel injection pump fittings immediately.



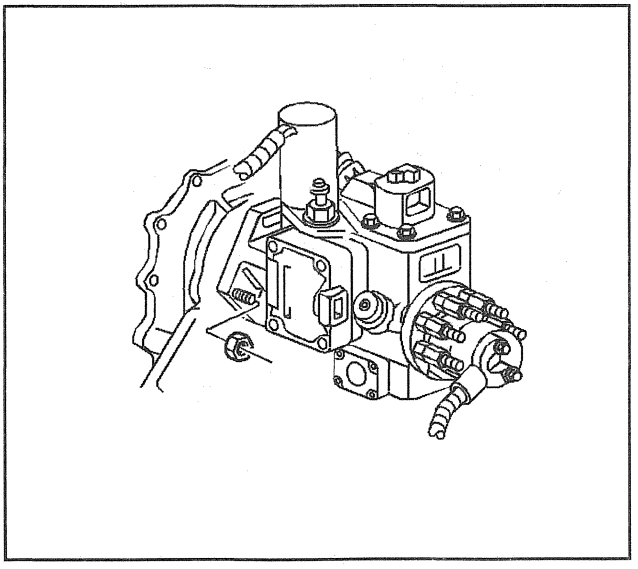
59763

12. Using the *J 29698-B* remove fuel nozzle fuel injection fuel feed pipe fittings.
    - Wear safety glasses to protect against fuel spray.
    - Use a 30 mm wrench to hold the fuel injection nozzle.
    - Do not bend the fuel injection fuel feed pipes.
    - Cap the fuel feed pipe fittings and the fuel injection nozzle fittings immediately.

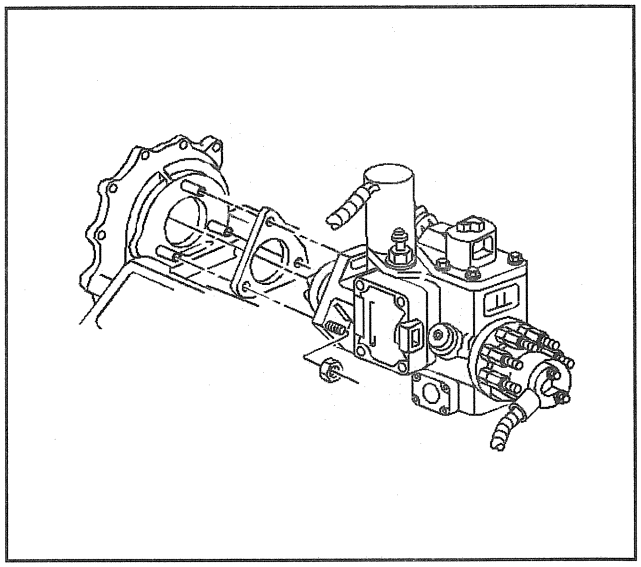


66573

13. Remove the three fuel injection pump mounting nuts.



59851

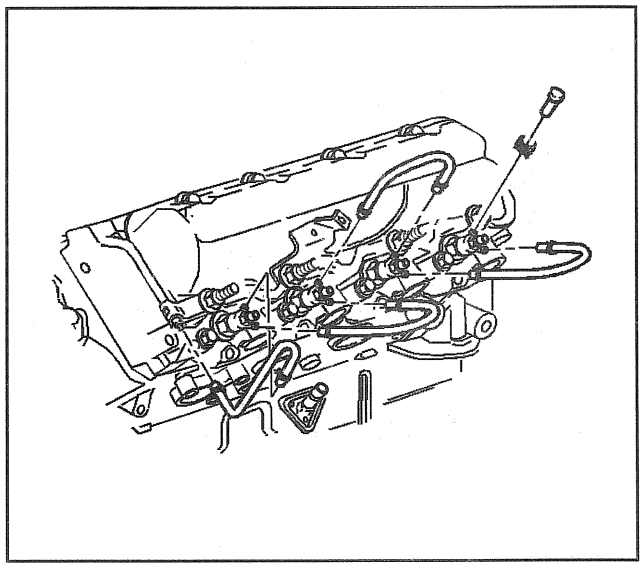


59855

14. Loosen the fuel injection pump fuel feed hose clamps.
15. Remove the fuel injection pump fuel feed hose.

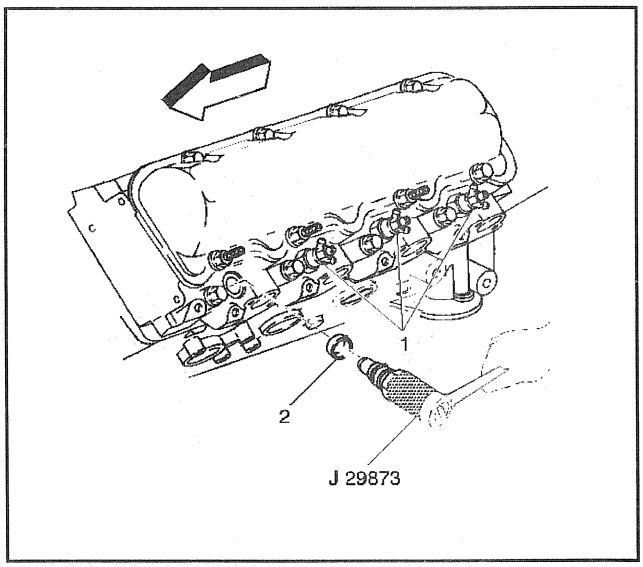
Important: Never rotate the engine with the starter, the starter location engine rotation fixture, or with the wrench from the front of the engine with the fuel injection pump removed. The loose fuel pump drive gear could become lodged in the front cover and cause gear tooth distress and shear the camshaft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

16. Remove the fuel injection pump.
17. Remove the gasket.



59763

18. Loosen the fuel injection nozzle fuel return hose clamps.
19. Remove the fuel injection nozzle fuel return hoses.



60452

Important: Mark the fuel injection nozzles, in order to return each fuel injection nozzle to it's original location during installation.

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

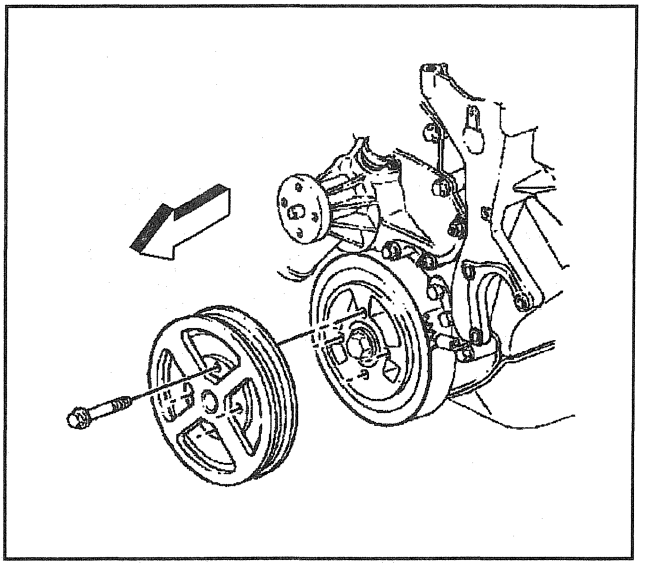
20. Using the *J 29873* remove the fuel injection nozzles (1).
    - Cap the fuel injection nozzle fittings immediately.
    - Store the fuel injection nozzles in a clean place.
21. Remove the gaskets (2).

Crankshaft Balancer Removal

Tools Required

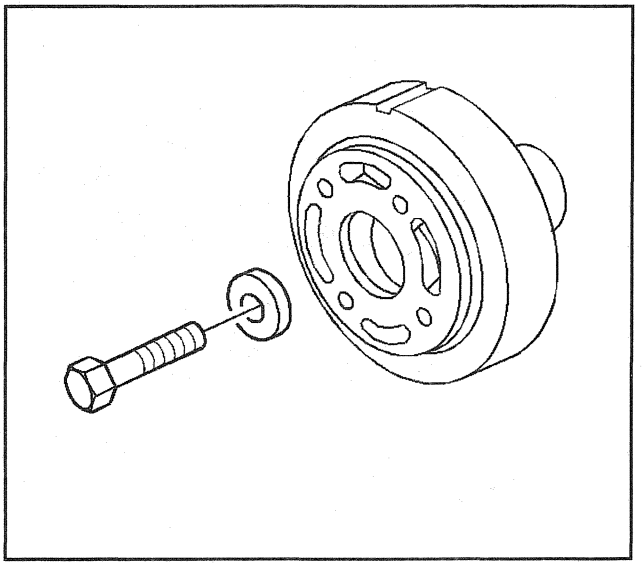
J 39046 Crankshaft Balancer Remover

1. Remove the crankshaft pulley retaining bolts.
2. Remove the crankshaft pulley.



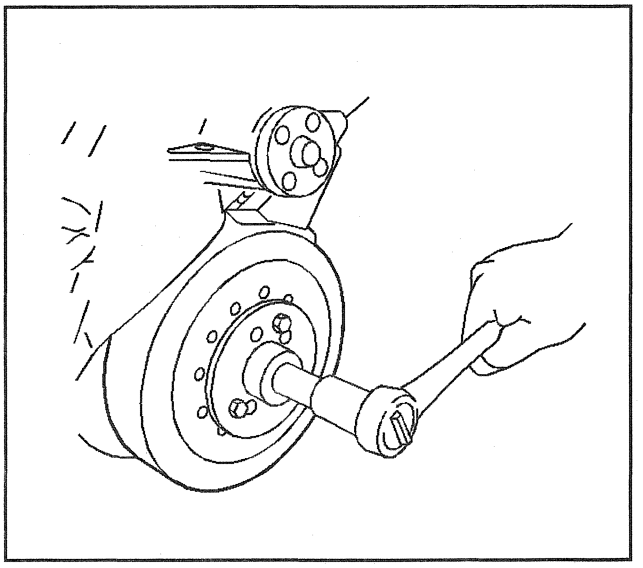
70257

3. Remove the crankshaft balancer retaining bolt and washer.



59837

4. Using the *J 39046* remove the crankshaft balancer.



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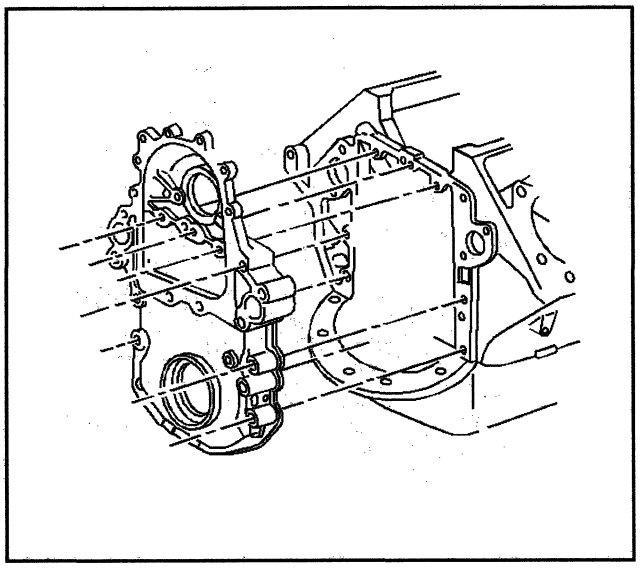


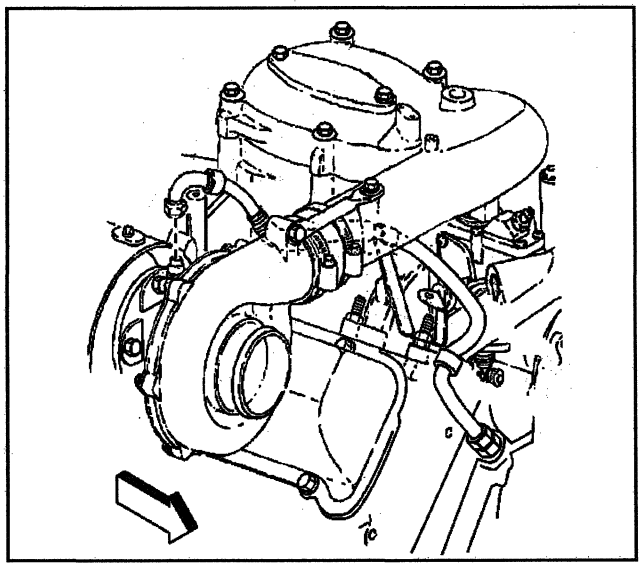
59864

Engine Front Cover Removal

1. Remove the oil pan to front cover retaining bolts.
2. Remove the front cover to block retaining bolts.

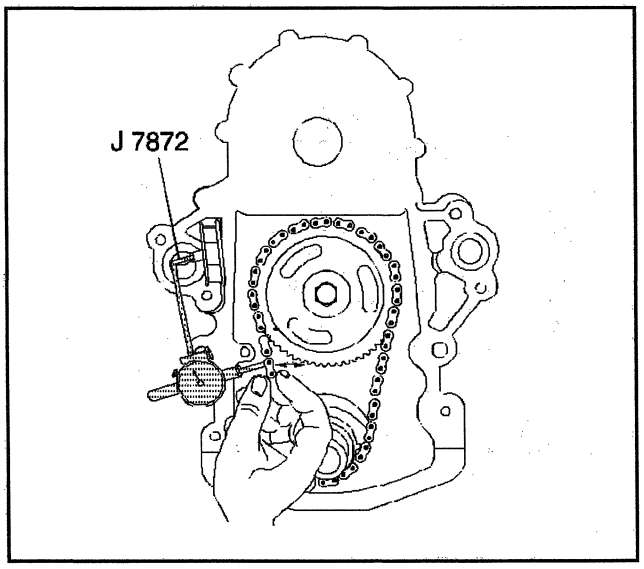
Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

3. Remove the front cover.



177108

4. Remove the turbocharger oil feed line.
5. Remove the turbocharger oil feed line fitting.



60261

Timing Chain Wear Check

Tools Required

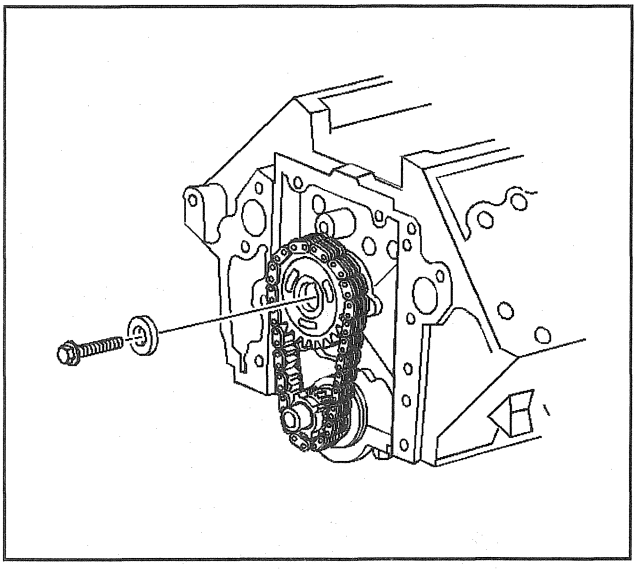
J 7872 Magnetic Base Dial Indicator

1. Attach the *J 7872* to the front of the engine cylinder block.
   - Position the magnetic base dial indicator to allow the plunger to contact the timing chain.
   - The magnetic base dial indicator plunger should contact the timing chain centered between the two sprockets.
2. Using finger pressure on the inside radius of the timing chain, push the timing chain outward (parallel to the front face of the block) to the maximum deflection.
3. Set the *J 7872* to zero.

4. Using finger pressure on the outside radius of the timing chain, push the timing chain inward (parallel to the front face of the block) to the maximum deflection.
5. Note the deflection of the timing chain (total travel of the magnetic base dial indicator plunger).
   - For used parts, the deflection must not exceed 20.3 mm (0.80 in).
   - For new parts, the deflection must not exceed 12.7 mm (0.50 in).
6. If the deflection exceeds the limit, replace the worn parts. Refer to *Timing Chain and Sprockets Clean and Inspect.*

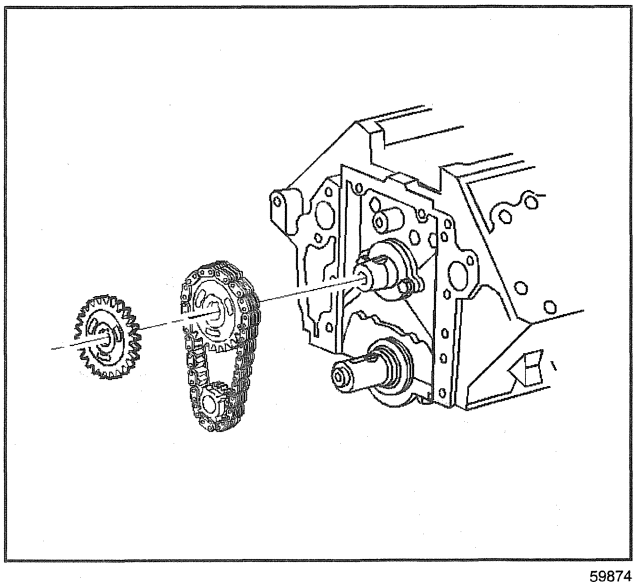
Timing Chain and Camshaft Sprocket Removal

1. Remove the camshaft sprocket retaining bolt and washer.

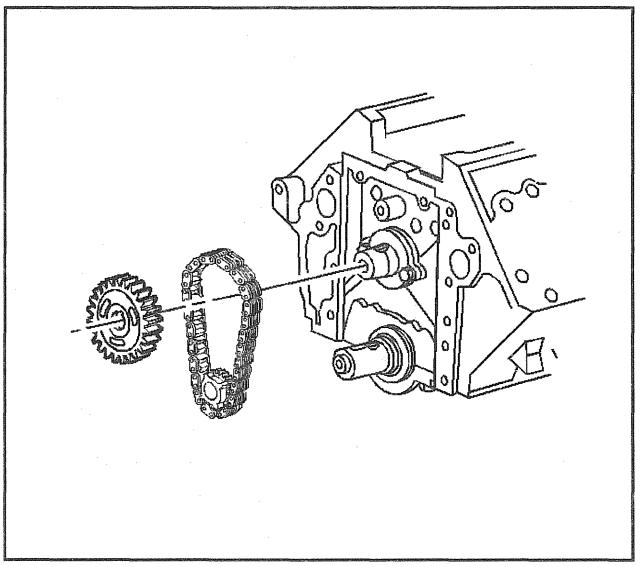


59872

2. Remove the fuel injection pump drive gear.



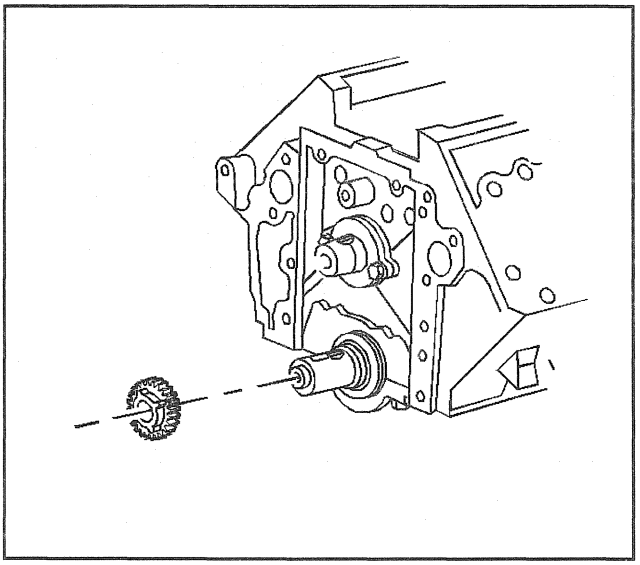
59874



59876

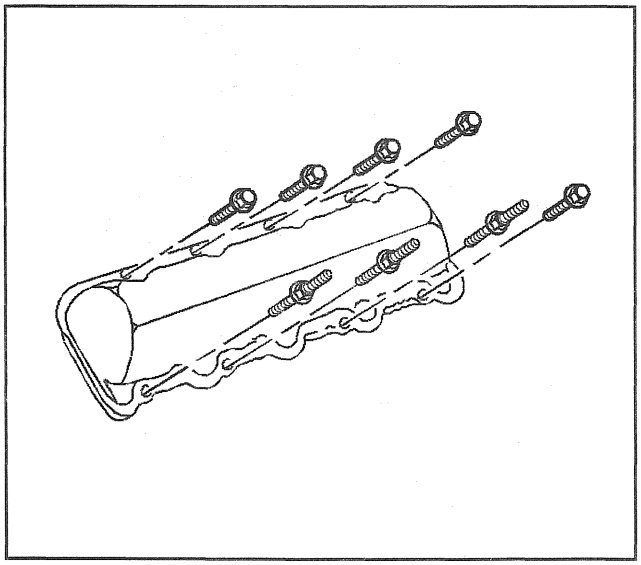
Important: Do not damage the square bosses of the crankshaft sprocket during removal.

3. Remove the timing chain, camshaft sprocket and crankshaft sprocket assembly.



59879

4. Remove the fuel injection pump drive gear woodruff key.
5. Remove the camshaft sprocket woodruff key.
6. Remove the crankshaft sprocket woodruff key.



59831

Valve Rocker Arm Cover Removal

1. Remove the fuel injection fuel feed pipe bracket retaining nuts.
2. Remove the fuel injection fuel feed pipe brackets.
3. Remove the valve rocker arm cover retaining bolts.

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.

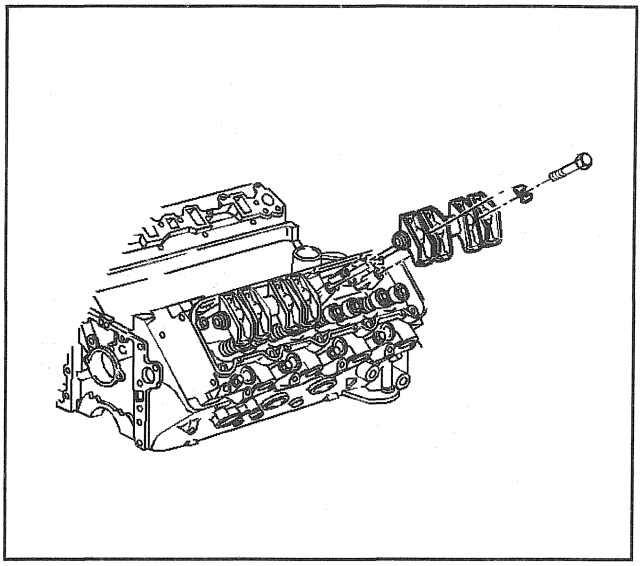
4. Remove the valve rocker arm covers.

Valve Rocker Arm, Shaft, and Push Rod Removal

1. Remove the valve rocker arm shaft assembly retaining bolts.

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

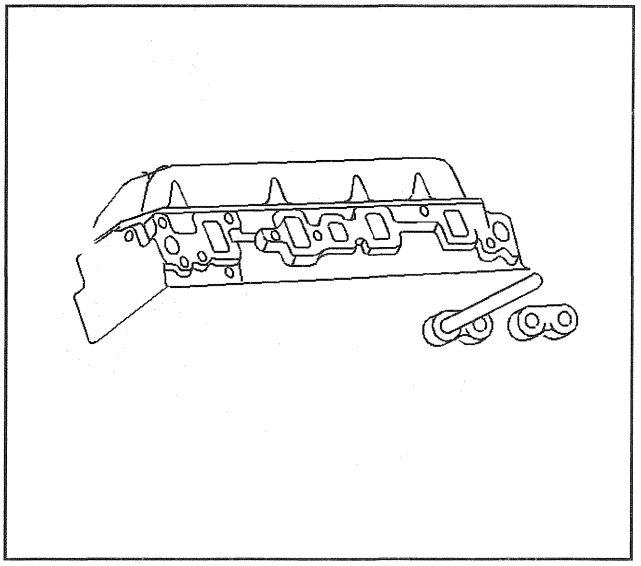
2. Remove the valve rocker arm shaft assemblies.



59797

Important: Mark the valve pushrods, in order to return each valve pushrod to it's original location and direction during installation. Each end of the valve pushrods has 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.

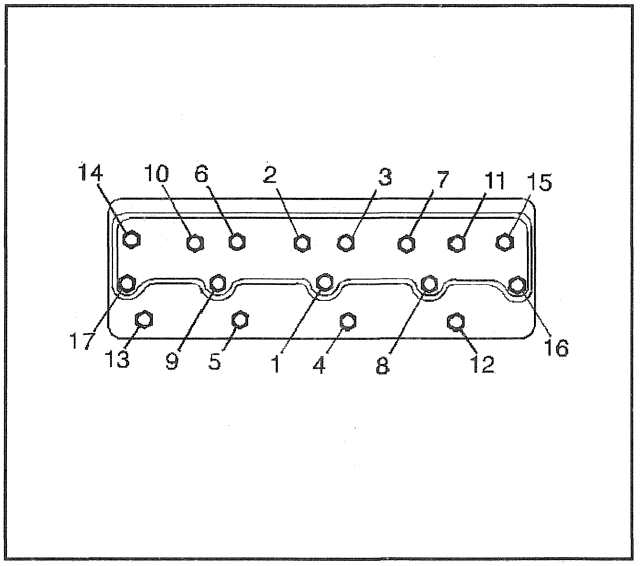
3. Remove the valve pushrods.



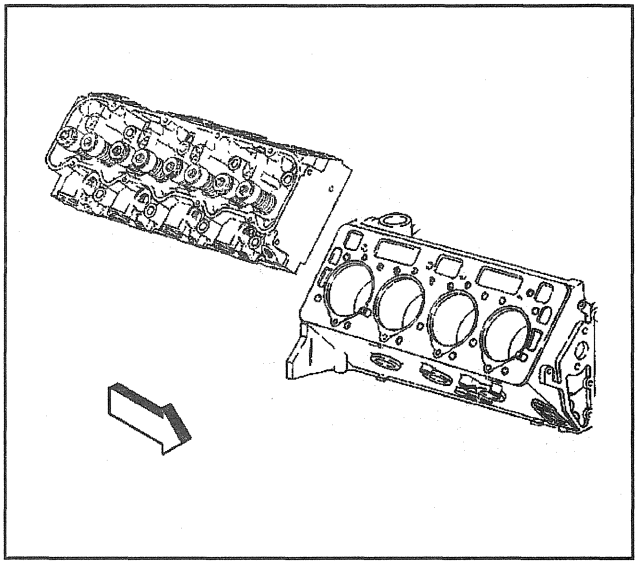
59800

Cylinder Head Removal

1. Remove the cylinder head retaining bolts (1–17).

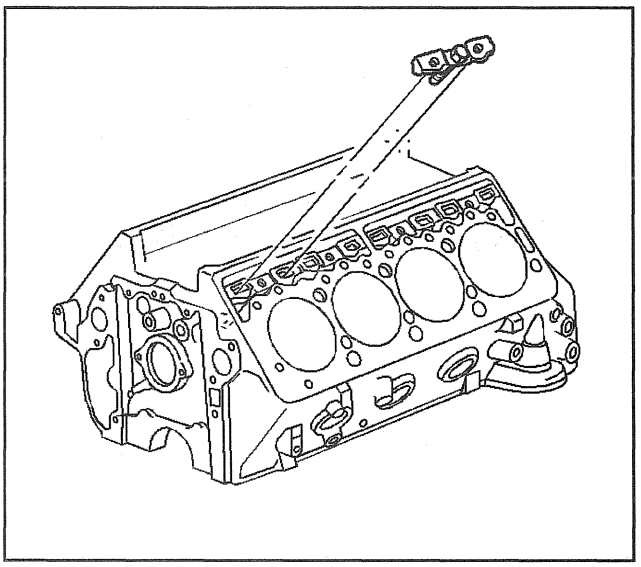


60278



525110

2. Remove the cylinder heads.
3. Remove the gaskets.

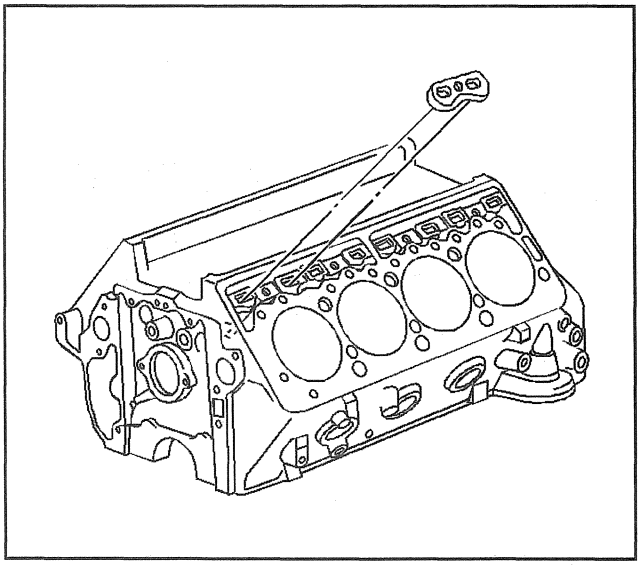


59806

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 they were removed.

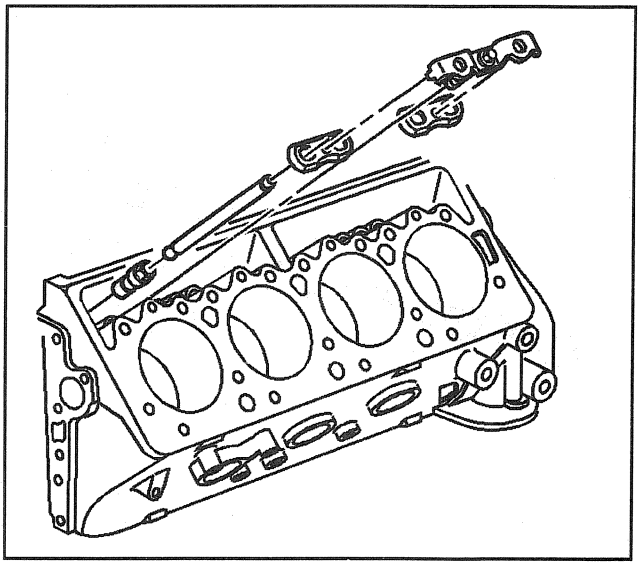
1. Remove the valve lifter retaining clamp retaining bolts.
2. Remove the valve lifter retaining clamps.



59809

3. Remove the valve lifter guide plates.

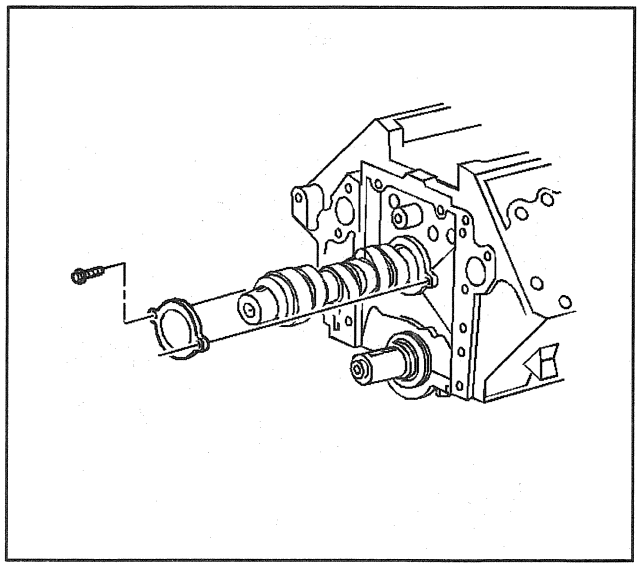
4. Remove the valve lifters.



549753

Camshaft Removal

1. Remove the camshaft thrust plate retaining bolts.
2. Remove the camshaft thrust plate.



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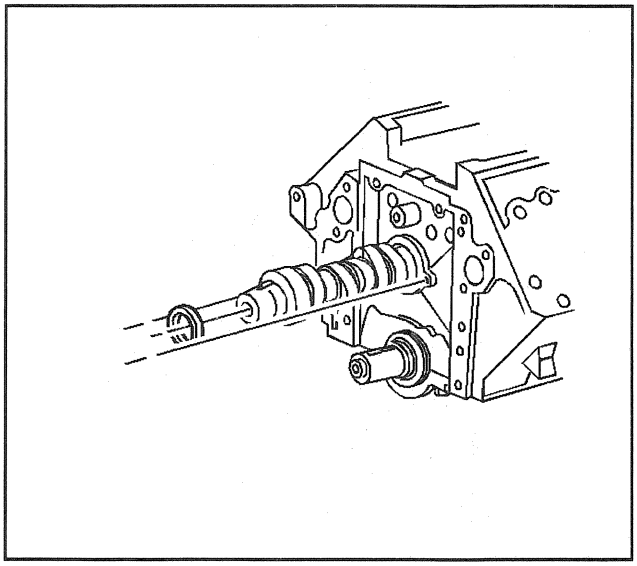
3. Remove the camshaft thrust plate spacer.



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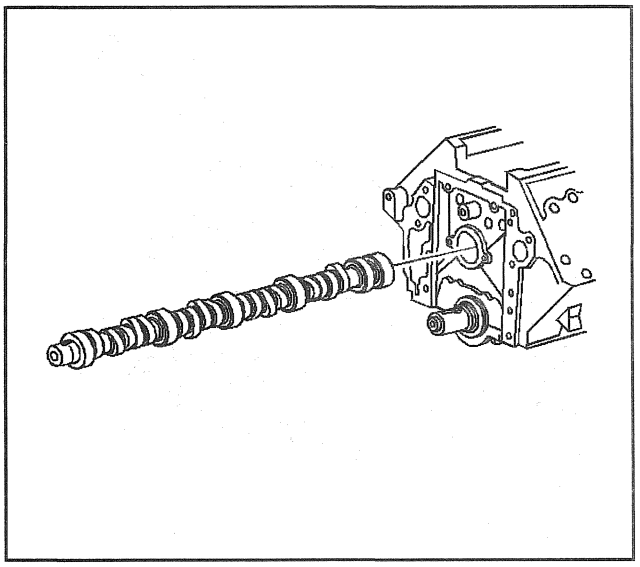

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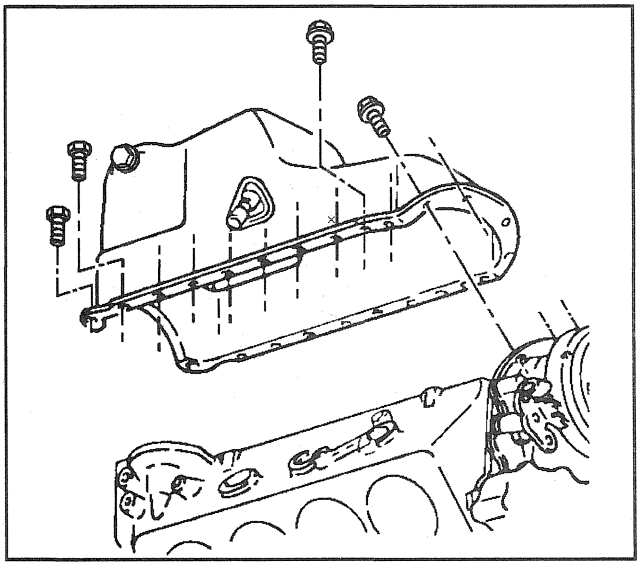
Important: Pull the camshaft from the engine cylinder block carefully to avoid damage to the camshaft bearings.

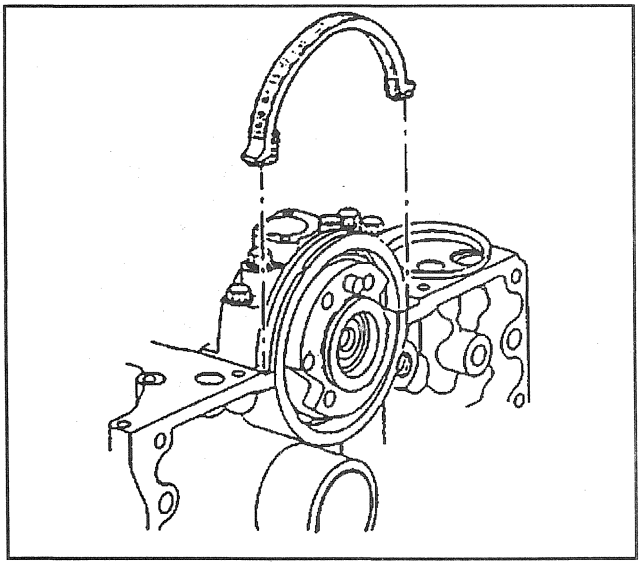
4. Remove the camshaft.



65010

Oil Pan Removal

1. Remove the transmission oil cooler line retaining clip retaining nuts.
2. Remove the transmission oil cooler line retaining clip.
3. Remove the oil pan retaining bolts.
4. Remove the oil pan.



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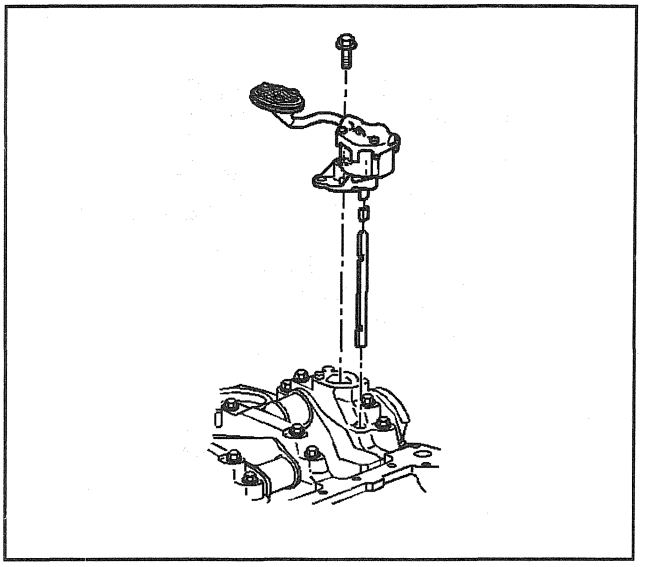
5. Remove the seal.

Oil Pump Removal

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



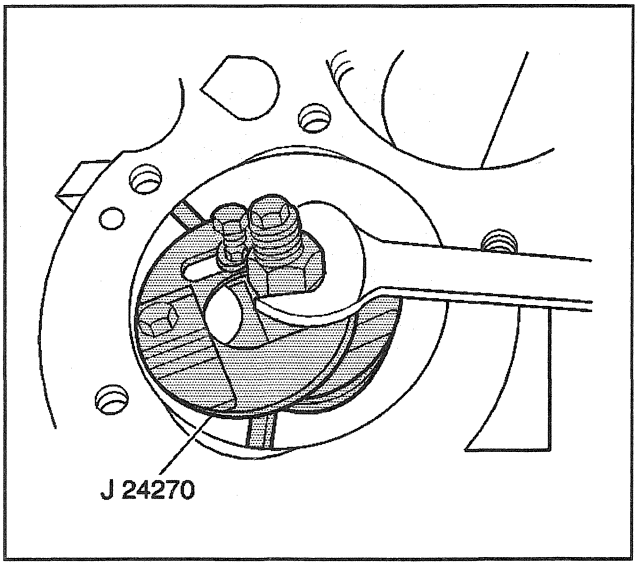
59893

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.



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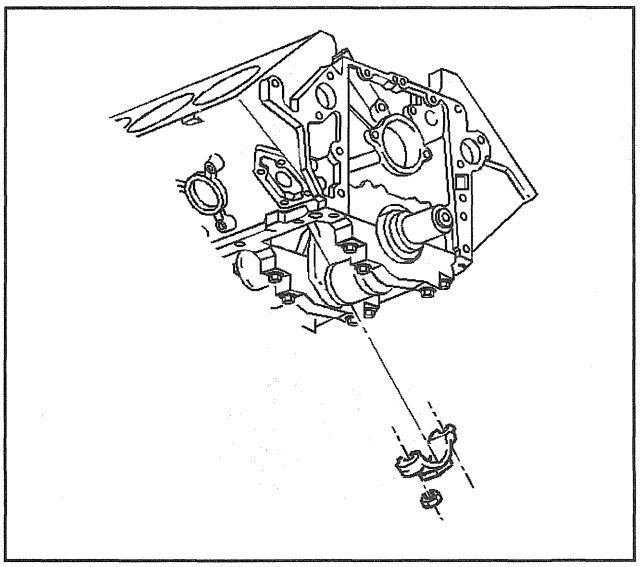

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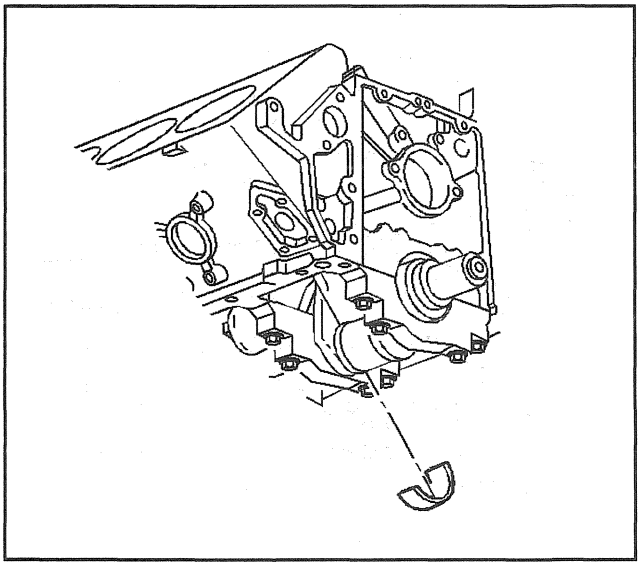
4. Remove the connecting rod nuts.
5. Remove the connecting rod cap.



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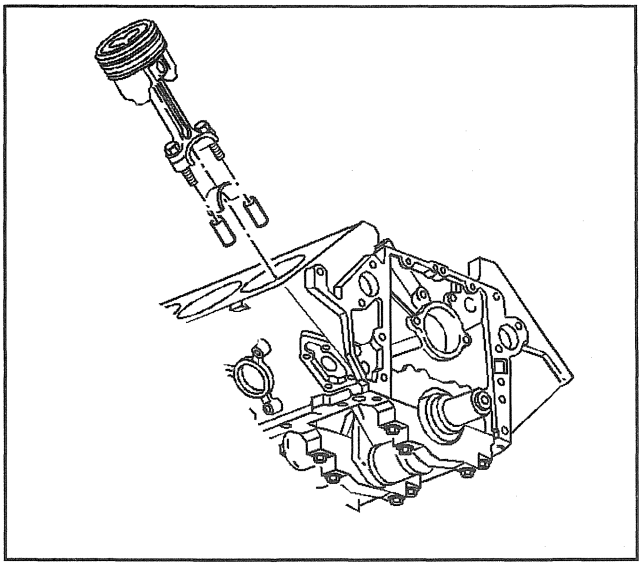
6. Remove the bearing inserts from the connecting rod.



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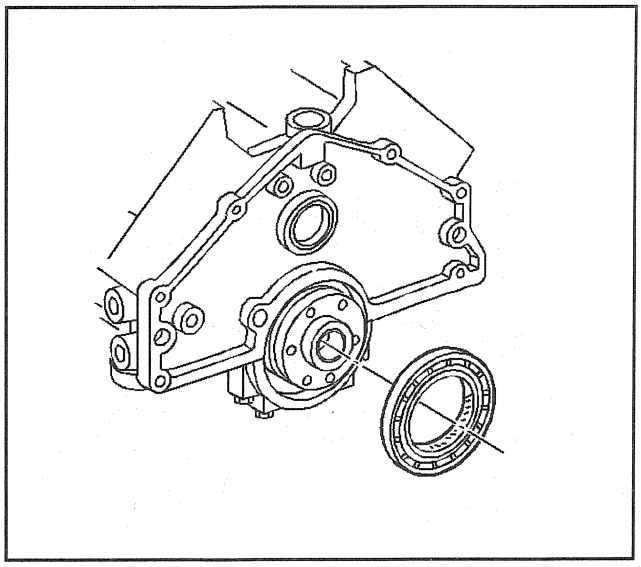
7. Attach two short pieces of 10 mm (3/8 in) hose to the connecting rod bolts, in order to protect the crankshaft journal during removal.
8. Push the connecting rod and the piston out of the bore.
9. After removal, assemble the connecting rod, the cap and the bearings. If reusing the bearing inserts,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

Crankshaft Rear Oil Seal Removal

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

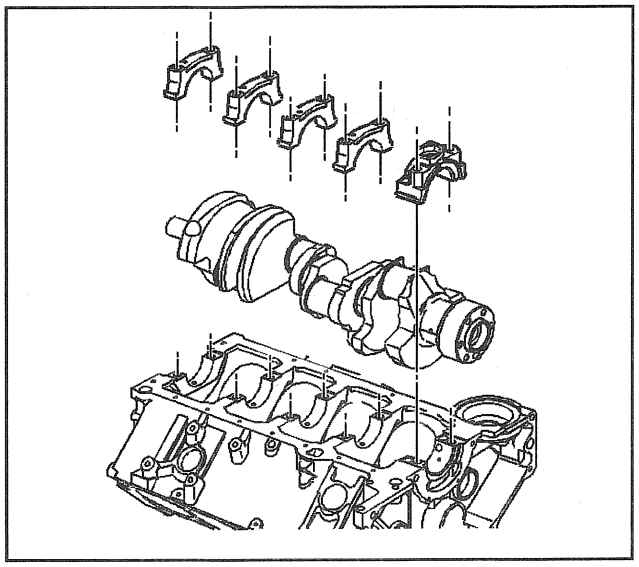


59909

Crankshaft and Bearings 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.



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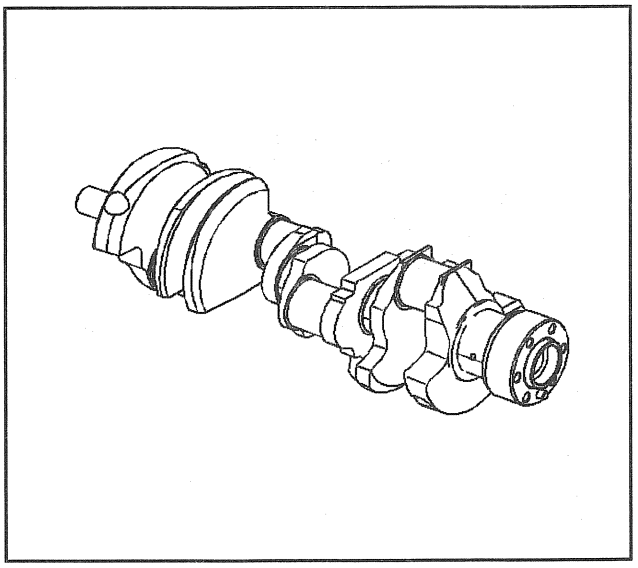
3. Remove the crankshaft by lifting the crankshaft straight up, in order to avoid damage to the crankshaft journals and the thrust flange surfaces.



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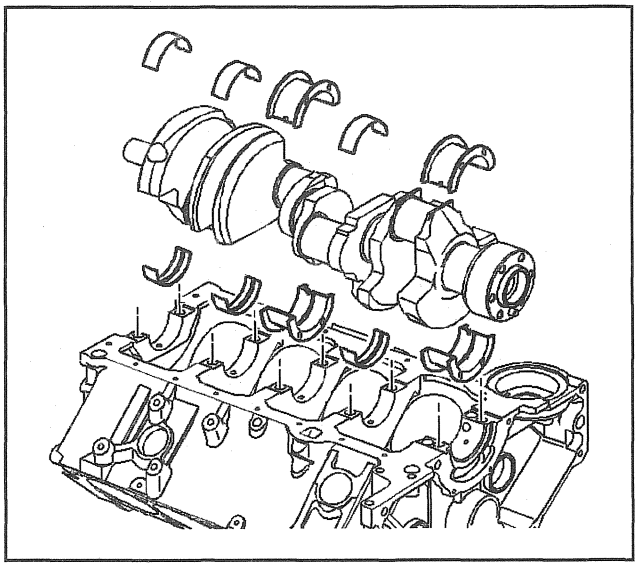

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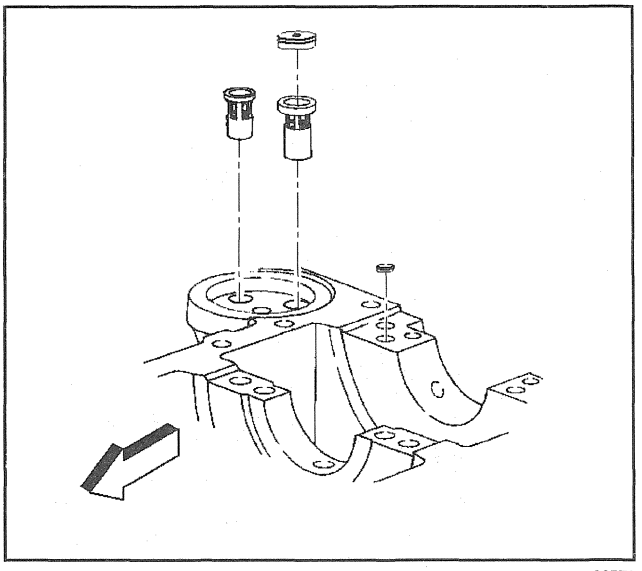
4. Remove the crankshaft bearing inserts. If reusing the bearing inserts, place them in a rack in order to return the bearing inserts to the original location during assembly.



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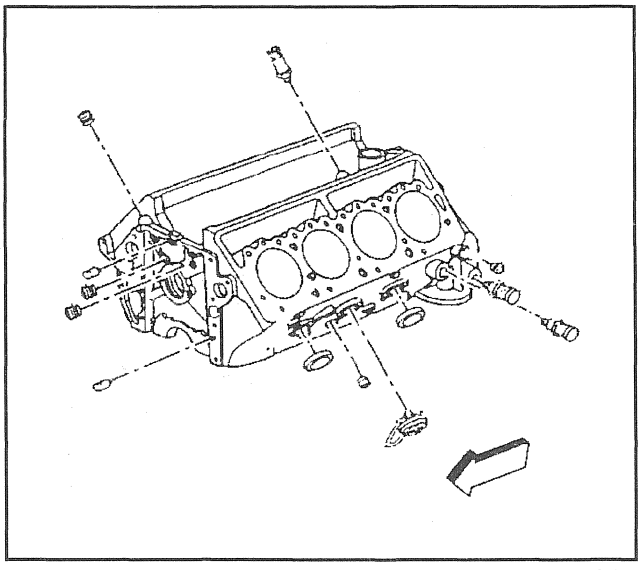
Oil Filter Adapter Removal

1. Pry out the oil filter bypass valve using a screwdriver.
2. Remove the oil cooler bypass valve using the following procedure:
   2.1. Install a sheet metal screw into the hole in the cup plug.
   2.2. Using side cutters or pliers, pry out the cup plug.
   2.3. Pry out the oil cooler bypass valve using a screwdriver.

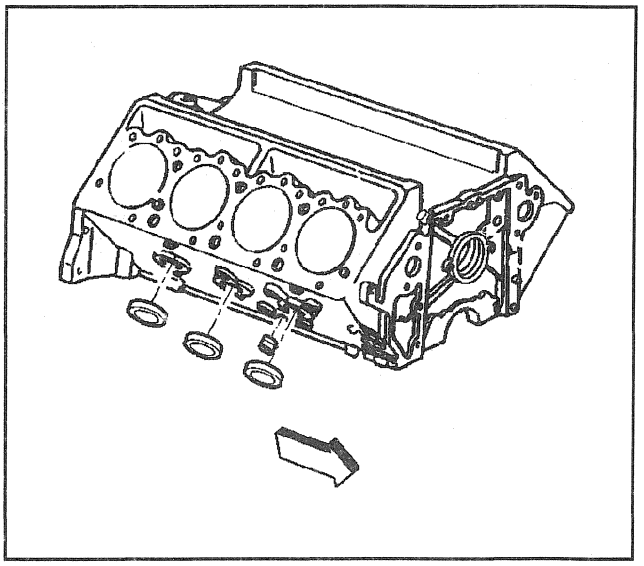


65012

Engine Block Plug Removal

1. Remove the engine oil pressure sensor switch.
2. Remove the engine oil cooler line fittings.
3. Remove the block drain plugs.
4. Remove the cup plugs and the block heater.

5. Remove the side oil gallery plugs.



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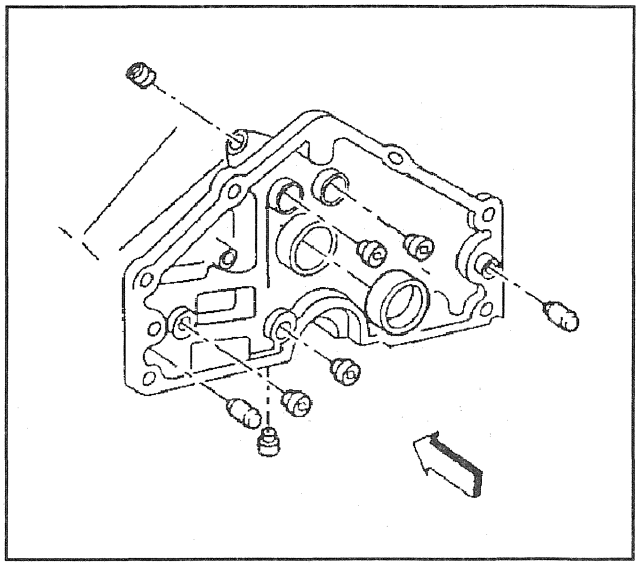
6. Remove the rear oil gallery plugs. An oil gallery plug is located inside the rear main bearing cap land.



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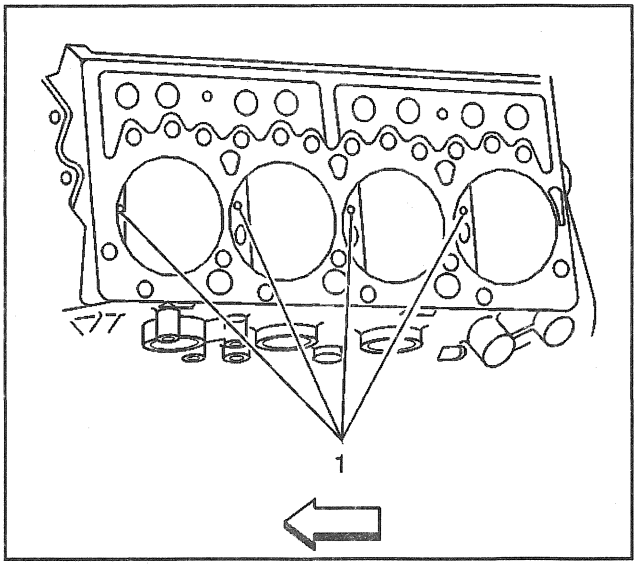
Piston Oil Cooling Nozzle Removal

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.

1. Remove the piston oil nozzles (1). Discard the used piston oil nozzles.



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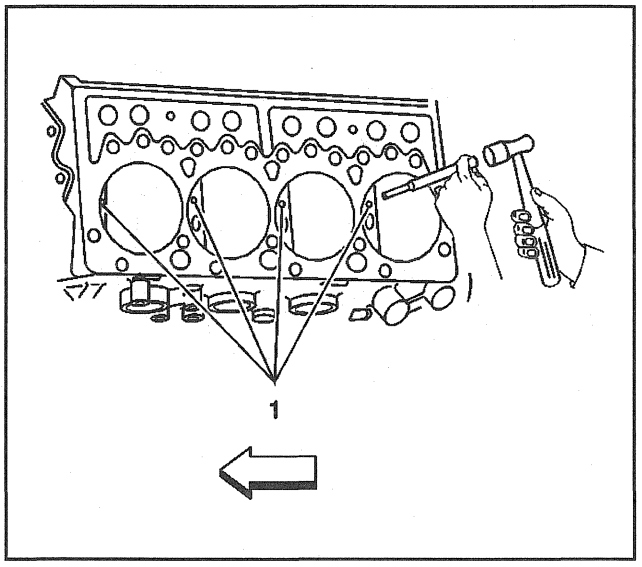

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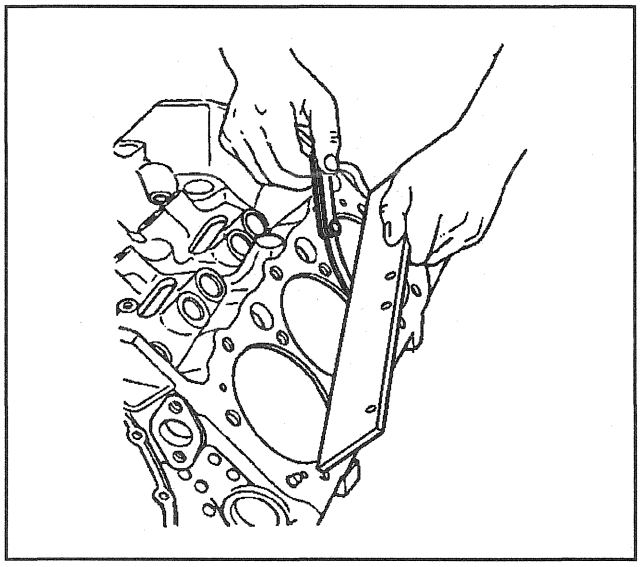
2. Using a brass drift, drive the piston oil nozzles (1) out of the block. Do not reuse the nozzles.



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Engine 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.

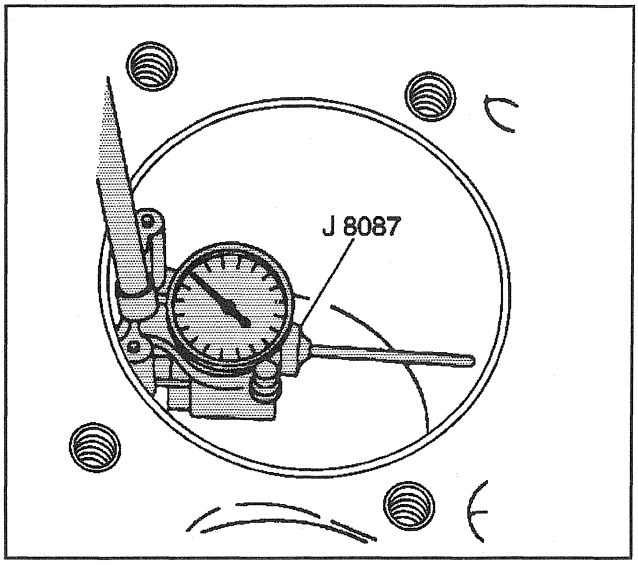
11. Inspect the cylinder head gasket mating surfaces for pitting.
12. Inspect the engine block to cylinder head gasket surface area for warping. Use a straight edge and feeler gauge. Replace the block if it is warped more than 0.15 mm (0.006 in) longitudinally or more than 0.08 mm (0.003 in) transversely.
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 (L65)*. If the bearings are worn beyond specification, replace the bearings.

Cylinder Boring and Honing

Tools Required

J 8087 Cylinder Bore Gauge

1. Clean the cylinder bores with a hot water and detergent wash.
2. Using a suitable measuring device, measure the diameter of the cylinder bore. Refer to *Engine Mechanical Specifications (L65)*.
3. Record the measurements.
4. Using the *J 8087* Cylinder Bore Gauge, measure the taper and out-of-round of the cylinder bore. Refer to tool manufacturer's instructions for proper tool operation. Refer to *Engine Mechanical Specifications (L65)*.
5. Record the measurements.
6. Using a finger nail, check the cylinder bore for fine vertical scratches.
    - You should not be able to feel a fine vertical scratch.
    - Fine vertical scratches will not cause excessive oil consumption.
    - Honing to remove fine vertical scratches is not necessary.
7. Visually check the cylinder bore for smooth, shiny, polished areas through the hone marks. If present, hone the cylinder lightly with a finish hone.
8. Repeat steps two through seven for the remaining cylinders.



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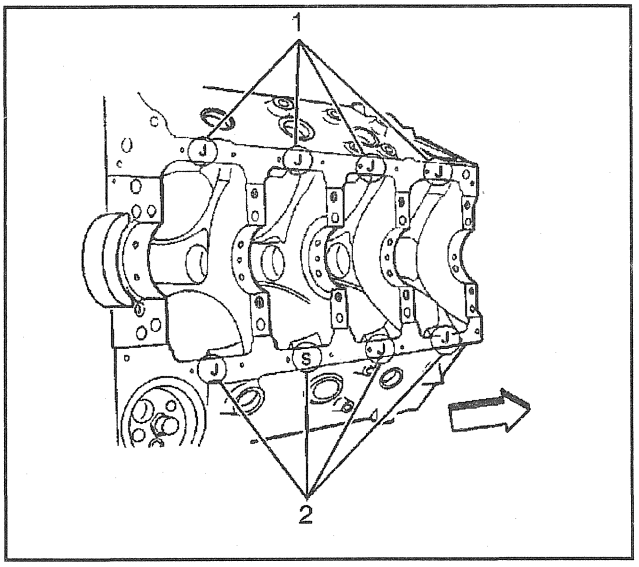

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Important: There is only one production standard piston grade size. When using production standard grade size pistons in all eight cylinder bores, a J is metal stamped in a single place on the cylinder block oil pan rail.

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.

9. Review the recorded measurements to determine the condition of the cylinders. Refer to *Engine Mechanical Specifications (L65)*.
10. Hone the cylinders, as required. Hone only those cylinders that require it.
    - Follow the tool manufacturer's instructions for use.
    - 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, leave sufficient metal to allow all stone marks to be removed with the fine stones used during the finishing process.
    - The surface roughness specifications for cylinder bores are:
      - RA (Minimum) = 0.40 Micro-meter (16 Micro-inch)
      - RA (Maximum) = 0.90 Micro-meter (32 Micro-inch)
    - All crankshaft bearing caps must be in place and tightened to the proper torque in order to avoid distortion of the bores. Refer to *Engine Mechanical Specifications (L65)*.
    - Ensure that the specified clearance between pistons, rings, and the cylinder bores is maintained. Refer to *Engine Mechanical Specifications (L65)*.
11. Make full strokes of the hone in the cylinder bore.
12. 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). The finish marks should be:
    - Smooth but not sharp
    - Free from imbedded particles
    - Free from torn or folded metal
13. Check the measurement at the top, the middle, and the bottom of the cylinder bore regularly.

Important: Any abrasive material remaining in the cylinder bores will cause premature wear to the piston rings, cylinder bores, and bearing surfaces.

14. Clean the cylinder bores with a hot water and detergent wash.
15. Clean the dry cylinder bores with a power-driven fiber brush.
16. Apply a light coating of clean engine oil to the cylinder bores.

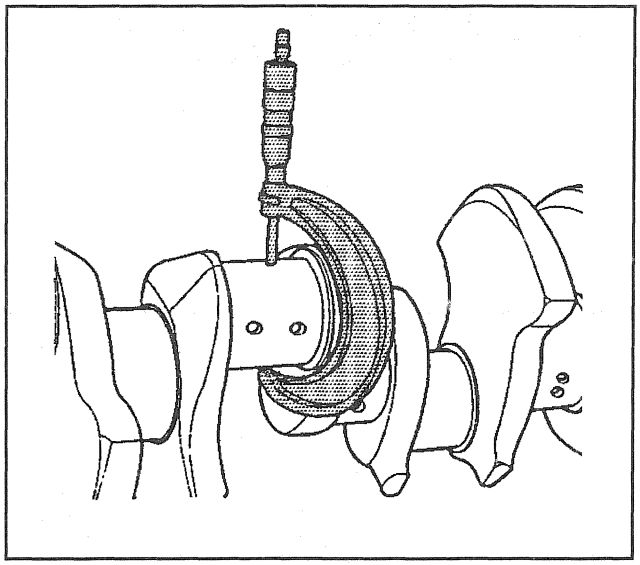
Crankshaft and Bearings Clean and Inspect

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. Using a soft cloth and clean solvent, clean the crankshaft. Do not scratch the crankshaft bearing journals.
2. Using compressed air, clean the crankshaft oil passages.
3. Using a soft cloth and clean solvent, clean the crankshaft bearing inserts. Do not scratch the crankshaft bearing inserts.
4. Inspect the crankshaft for cracks using the Magnaflux Spot-check dye method or the equivalent.
5. Inspect the crankshaft bearing journals and thrust surfaces for the following conditions:
   - Scoring
   - Nicks
   - Damage caused by lack of lubrication
6. Inspect the crankshaft bearing inserts and thrust surfaces for the following conditions:
   - Scoring
   - Nicks
   - Damage caused by lack of lubrication
7. Using a suitable measuring device, measure the crankshaft journal diameter and taper in several places, approximately 90 degrees apart. Refer to *Engine Mechanical Specifications (L65)*.
   - The connecting rod and the crankshaft journal sizes are color coded with paint markings.
   - Crankshaft journal markings are blue, orange/red, or white.
   - Connecting rod journal markings are yellow or green.
8. Record the measurements.



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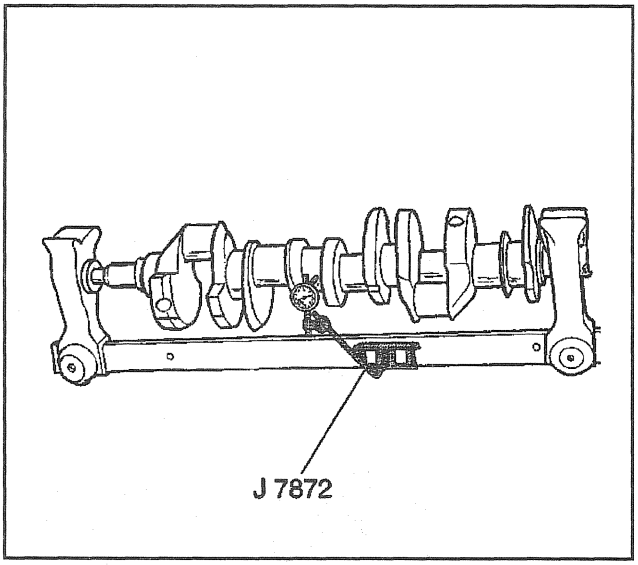

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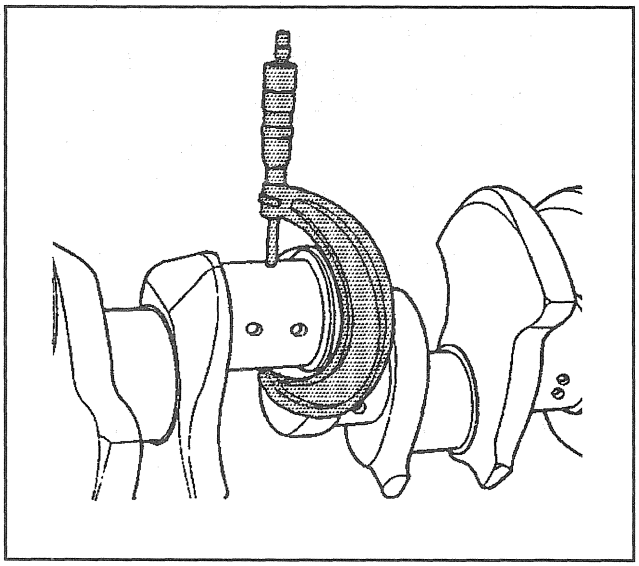
9. Mount the crankshaft in V-blocks at crankshaft journals one and five.
10. Using the *J 7872* Magnetic Base Dial Indicator, measure crankshaft journal runout at crankshaft journal three. *Engine Mechanical Specifications (L65).*
11. Record the measurements.



35207

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.

Notice: Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

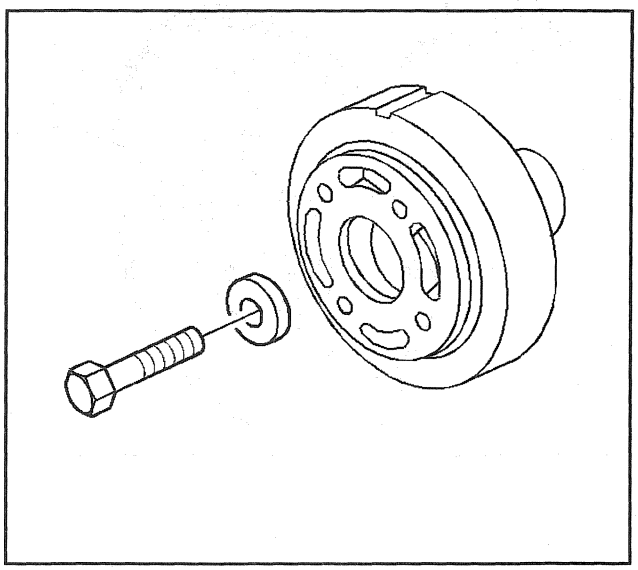
1. Measure the crankshaft bearing clearance.
    1.1. Install the crankshaft bearings into the crankshaft caps and engine block.
    1.2. Install the crankshaft caps and bolts.
    1.3. Tighten crankshaft bolts. Refer to *Engine Mechanical Specifications (L65).*
    1.4. Using a suitable measuring device, measure the bearing inside diameter (I.D.), in several places, approximately 90 degrees apart. Refer to *Engine Mechanical Specifications (L65).*
    1.5. Record the measurements.
    1.6. Subtract the journal diameter from the bearing inside diameter in order to obtain the bearing clearance *Engine Mechanical Specifications (L65).*

2. Replace damaged/worn crankshaft bearings as required.
   - If the bearing clearance is not within specifications, replace the bearing. Always replace both upper and lower bearing inserts as a set.
   - 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.
   - 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.
   - The connecting rod and the crankshaft journal sizes are color coded with paint markings.
   - Crankshaft journal markings are blue, orange/red, or white.
   - Connecting rod journal markings are yellow or green.

Crankshaft Balancer Clean and Inspect

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

1. Using clean solvent, clean the crankshaft balancer.
2. Using compressed air, dry the crankshaft balancer.
3. Inspect the oil seal contact area on the crankshaft balancer shaft for grooving and roughness. Replace if necessary.
4. Always replace the crankshaft balancer if the crankshaft breaks.



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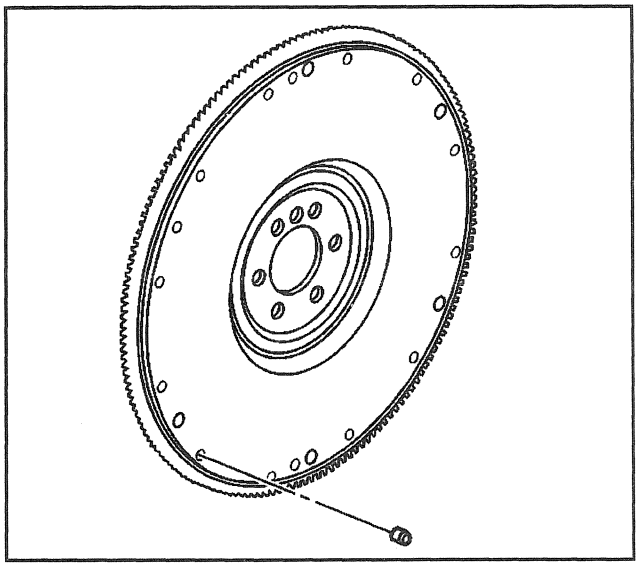

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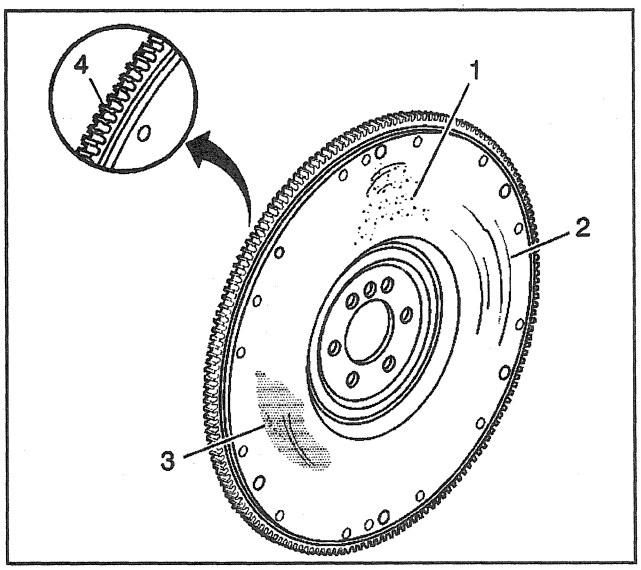
Engine Flywheel Clean and Inspect

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

1. Using clean solvent, clean the flywheel.
2. Using compressed air, dry the flywheel.
3. Inspect the flywheel for loose or improperly installed balance weights (manual transmission only). A properly installed balance weight should be installed until flush with, or below, the face of the flywheel.



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4. Inspect the flywheel for the following:
   - Pitted surface (manual transmission only) (1).
   - Scoring or grooves (manual transmission only) (2).
   - Rust or other surface damage (manual transmission only).
   - Stress cracks around the flywheel-to-crankshaft bolt hole locations.
   - Loose or improperly positioned ring gear. The ring gear has an interference fit onto the flywheel and should be positioned completely against the flange of the flywheel (manual transmission only).

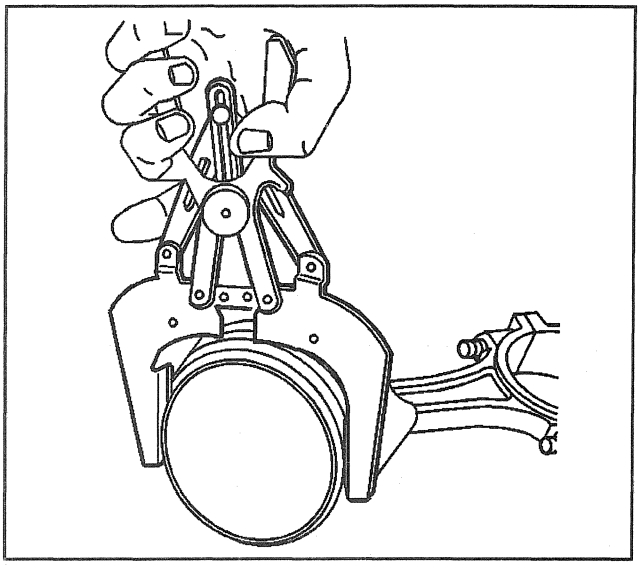
Important: Do not attempt to repair the welded areas that retain the ring gear to the flywheel plate. Install a new flywheel.

- Welded areas that retain the ring gear onto the flywheel for cracking (automatic transmission only).
- Damaged ring gear teeth (4).

Piston and Connecting Rod Disassemble

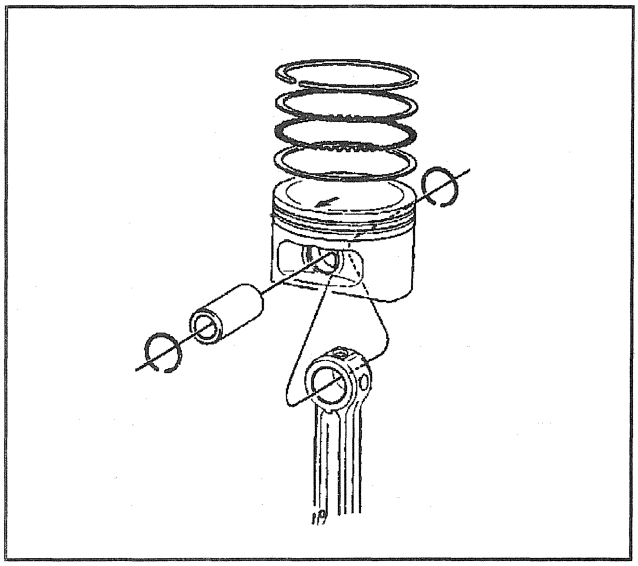
Production standard 6.5L pistons are available in one grade size, identified by a J (naturally aspirated) or JT (turbocharged) ink or metal stamped on the top or bottom of the piston. Also available is a production oversize piston grade sizes for in-plant rework. Identified by an S (naturally aspirated)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

1. Remove the piston rings.



4977

2. Remove the connecting rod bearing inserts.
3. Using a scribe with a hooked, rounded end, pry out the piston pin retainers.
4. Remove the piston pin. The pin is a full-floating style and should slide from the piston. If the piston pin is to be reused, place it in a rack so that it may be reinstalled with the original connecting rod and cap.
5. Remove the piston from the connecting rod.



66577

Piston, Connecting Rod and Bearings Clean/Inspect (Piston Inspection)

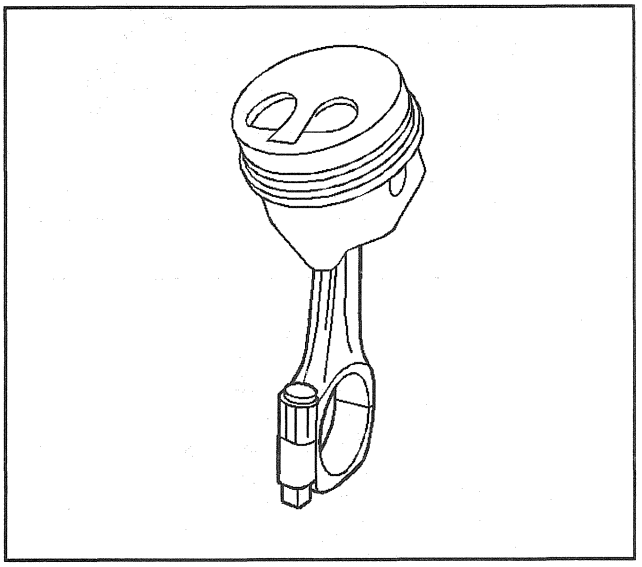
Clean/Inspect

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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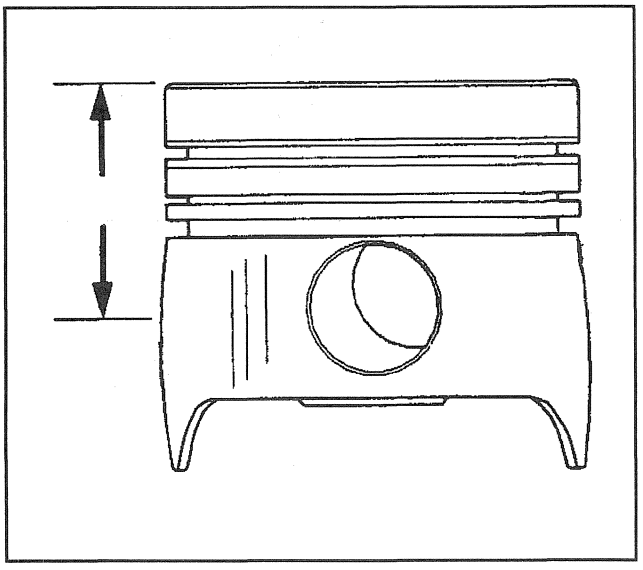


70102

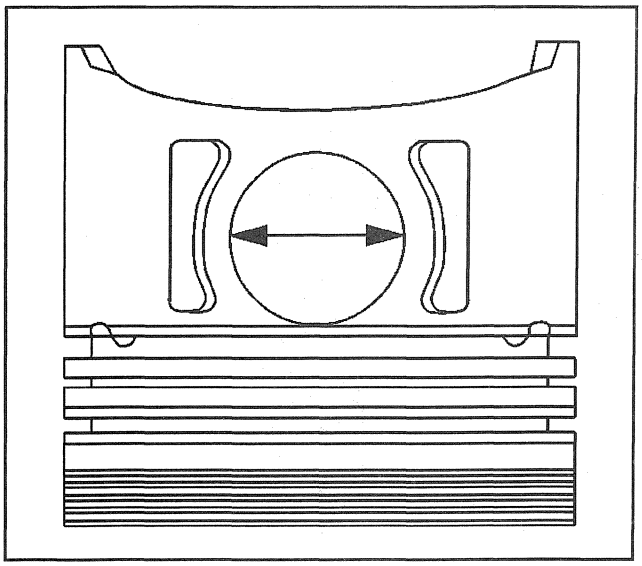
Piston Measurement

The piston skirts are barrel-shaped. To accurately determine the piston diameter, the piston must be measured at a specific gauge point.

The piston gauge point is 65.33 mm (2.575 in) from the top of the piston.

Measuring Piston Pin To Piston Pin Bushing Clearance

1. Measure the piston pin to piston pin bushing.
2. Measure the piston pin diameter.
3. Measure the piston pin bushing inside diameter. Use an inside micrometer.
4. Substract the piston pin diameter from the piston pin bushing inside diameter to obtain the clearance.
5. If the clearance is excessive, replace the piston and piston pin. Piston pins are available only with new pistons.
6. If the clearance is excessive with a new piston and piston pin, replace the connecting rod. Piston pin bushings are available only with new connecting rods.



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Measuring Piston Pin To Piston Clearance

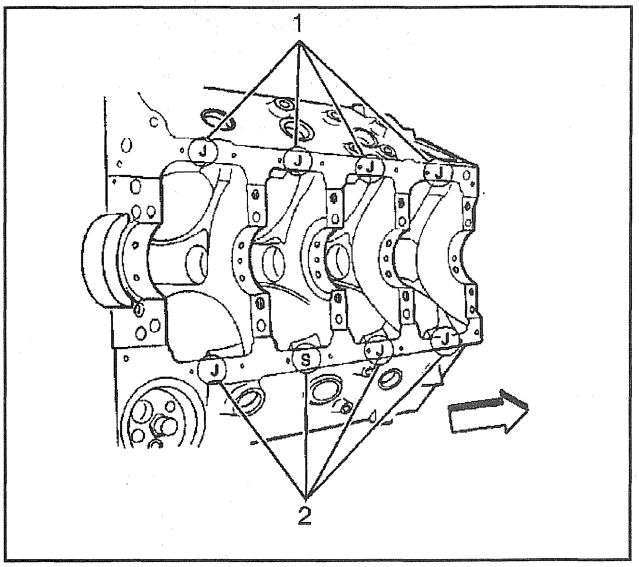
1. Measure the piston pin diameter.
2. Measure the piston pin hole inside diameter. Use an inside micrometer.
3. Substract the piston pin diameter from the piston pin hole diameter to obtain the clearance.
4. If the clearance is excessive, replace the piston and piston pin. Piston pins are available only with new pistons.

Piston Selection

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 (1).

A 0.13 mm (0.005 in) 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 (2) 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 the same weight as production pistons. Using service oversize pistons will not affect engine balance.



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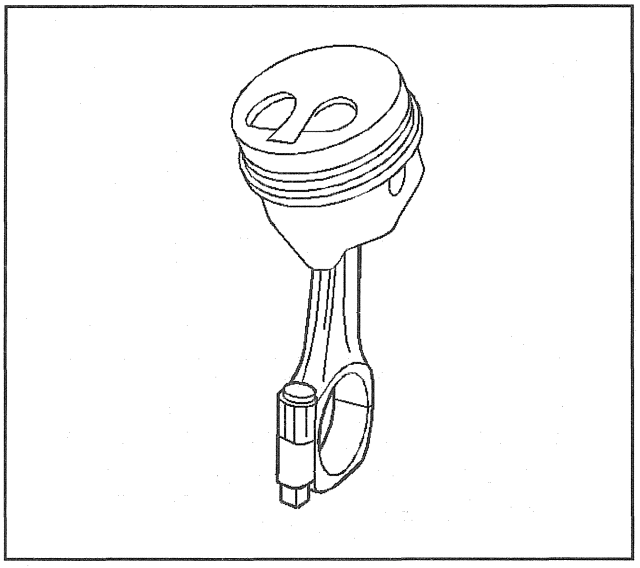


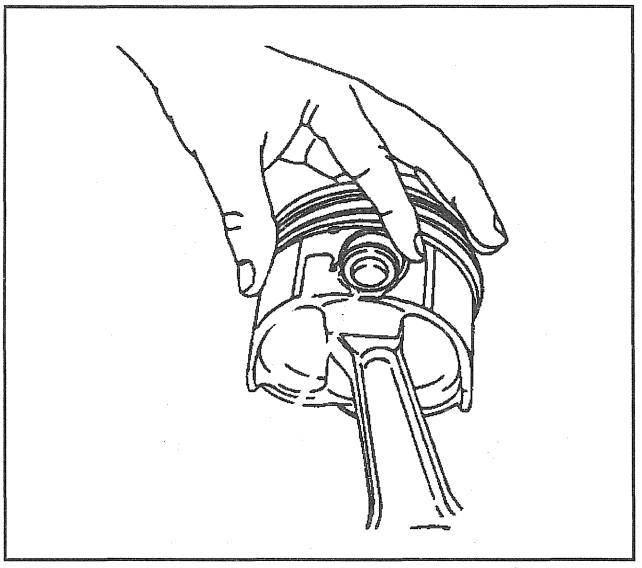
59946

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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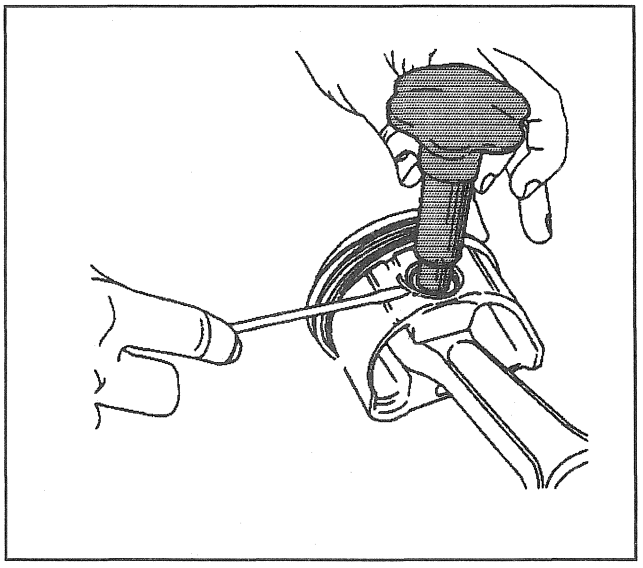
2. Apply engine oil to the surface of the piston pin.
3. Install the piston pin to the piston and the connecting rod.

Important: Piston, piston pin, and connecting rod assembly must be stable (held firmly with no lateral movement) during piston pin retaining ring installation.

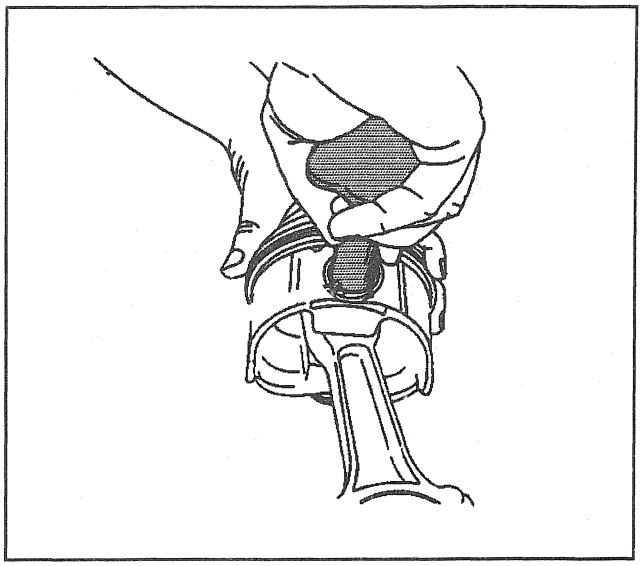
4. Install the piston pin retaining rings, using the *J 39507*.
5. Align the open end of the retaining ring toward the bottom of the piston.



66581

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

8. Press down on the ring with the pin on the tool.
9. Turn the tool-to-seat ring in the groove.
10. 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.



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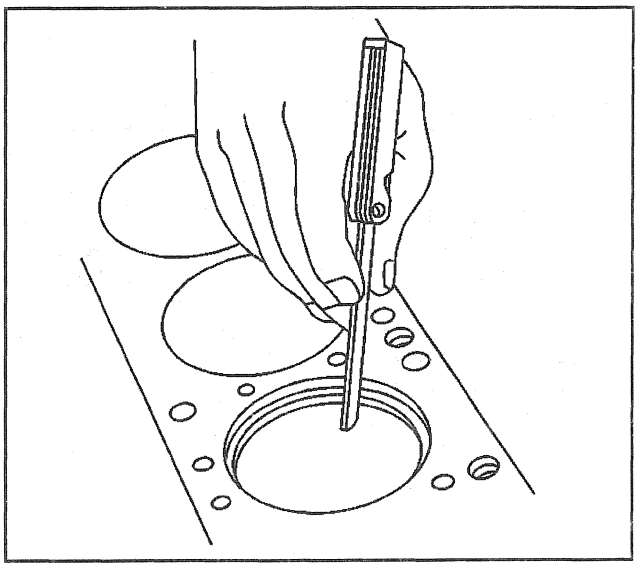
11. Measure the piston ring end gap.
12. Measure all rings in their respective cylinders.



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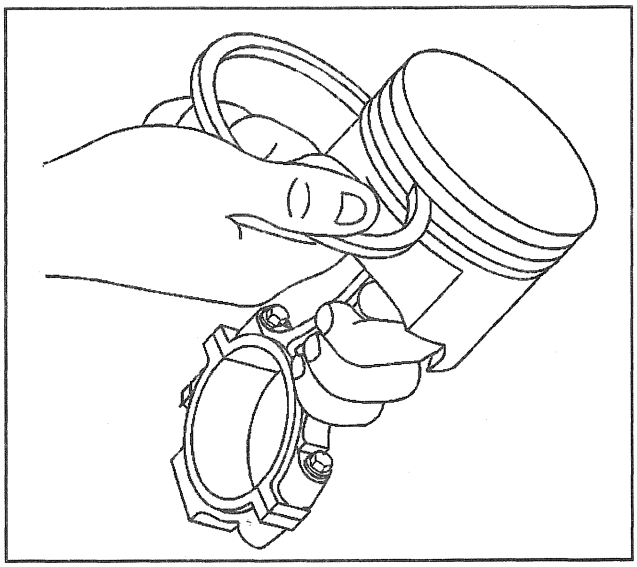
13. Measure for ring clearance, using a feeler gauge.
14. Inspect the ring fit using the following procedure:
    14.1. Fit each second compression ring to the piston on which it is going to be used.
    14.2. Slip the outer surface of the second compression ring into the respective piston ring groove 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.



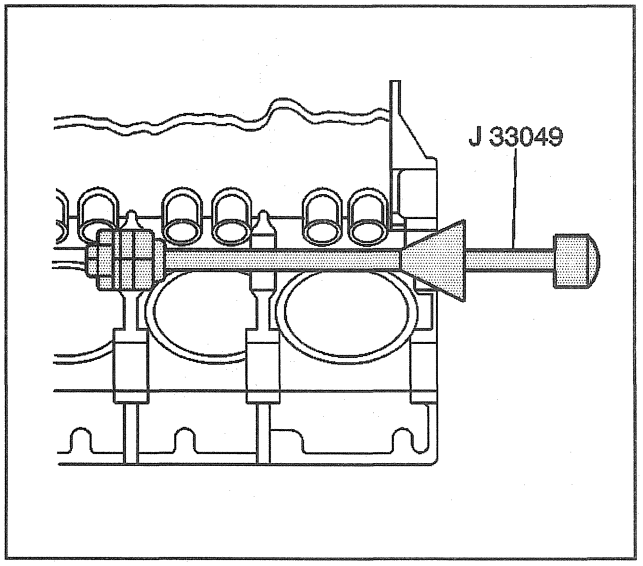
4969

15. The oil ring is a two-piece ring, consisting of an expander and a scraper ring.
    15.1. Install the oil expansion ring in the oil ring groove.
    15.2. 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.

16. Install the second compression ring.
17. Install the top compression ring.



4985

Camshaft Bearing Removal

Tools Required

J 33049 Universal Camshaft Bearing Remover and Installer Set

1. Remove the rear camshaft plug.

Important: Cam bearings are numbered one through five, from front to rear. The number one cam bearing being the largest and the number five cam bearing being the smallest. In order to allow the tool to remain centered, it is recommended that the number five (Rear) cam bearing be removed with the tool installed through the front of the block and the number one bearing (Front) be removed with the tool installed from the rear. This will allow the guide cone of the tool surface to center itself on the block.

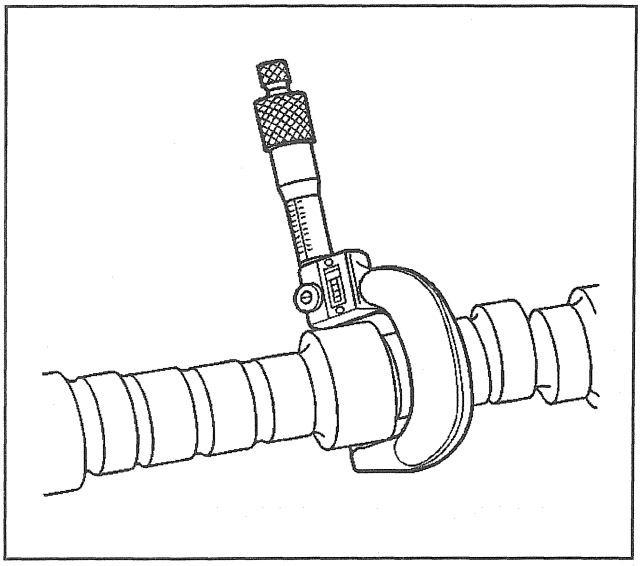
2. Insert the driving bar of the *J 33049* with the correct expanding driver into the camshaft bearing (collet 4 for camshaft bearings one through four, and collet 3 for camshaft bearing five).
3. Turn the *J 33049* until the collet has tightened in the bearing.
4. Push the guide cone against the block and into the first bearing bore in order to center the tool.
5. Drive the bearing from the block.
6. Repeat this procedure in order to remove the remaining camshaft bearings.

Camshaft and Bearings Clean and Inspect

Tools Required

J 7872 Magnetic Base Indicator Set

1. Measure the camshaft journals with a micrometer.
2. If journals are more than 0.025 mm (0.0010 in) out-of-round, replace the camshaft.



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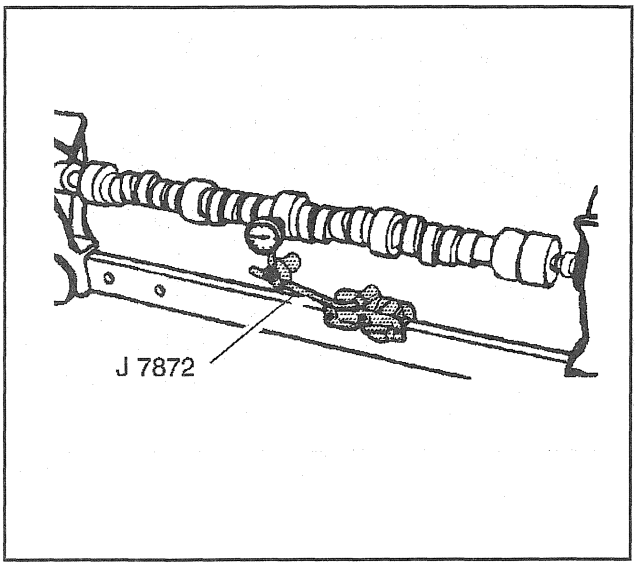
3. Measure camshaft runout using tool J 7872. Mount the camshaft in V-blocks between centers.
4. If runout exceeds 0.065 mm (0.0026 in), camshaft is excessively bent and should be replaced.



35211

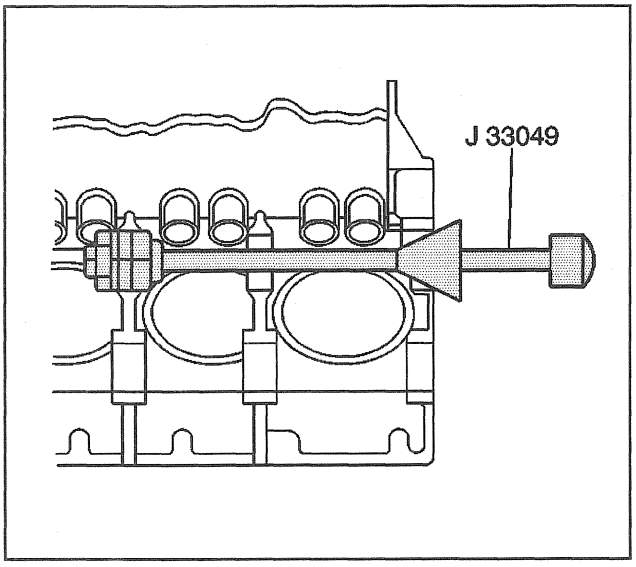
Camshaft Bearing Installation

Tools Required

J 33049 Camshaft Bearing Remover/Installer Set

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.



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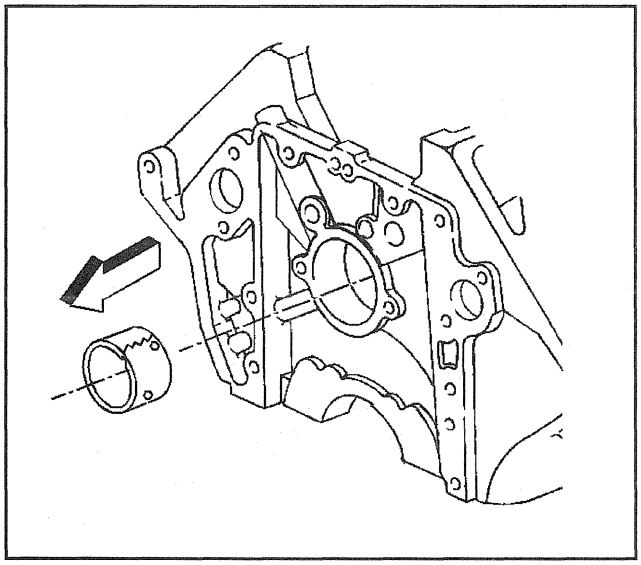
- There is one oil hole in the rear camshaft bearing. Using the seam in the 11 o'clock position as a reference point, the oil hole must be in the 1 o'clock position. Be sure that the oil hole in the camshaft bearing lines up with the oil groove in the block.

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



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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 grooves in the block.

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

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

Timing Chain and Sprockets Clean and Inspect

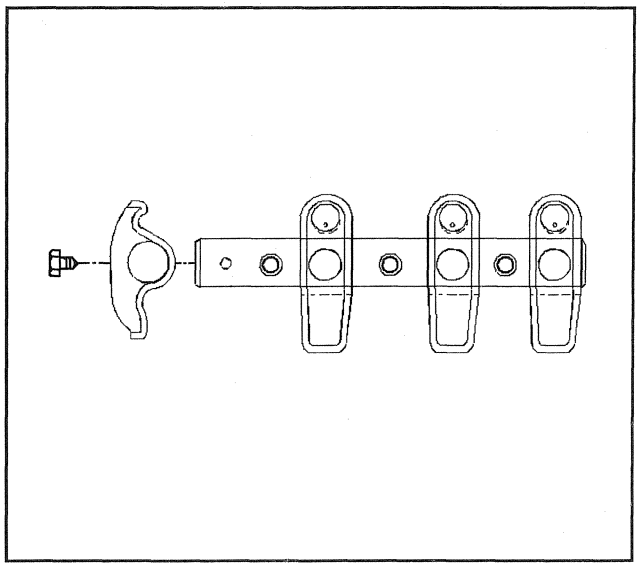
Notice: Perform TDC Offset Recovery procedure if the timing chain, timing gears, engine front cover, crankshaft position sensor, crankshaft or other components affecting the timing are replaced.

1. 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.

Valve Rocker Arm and Shaft Disassemble

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

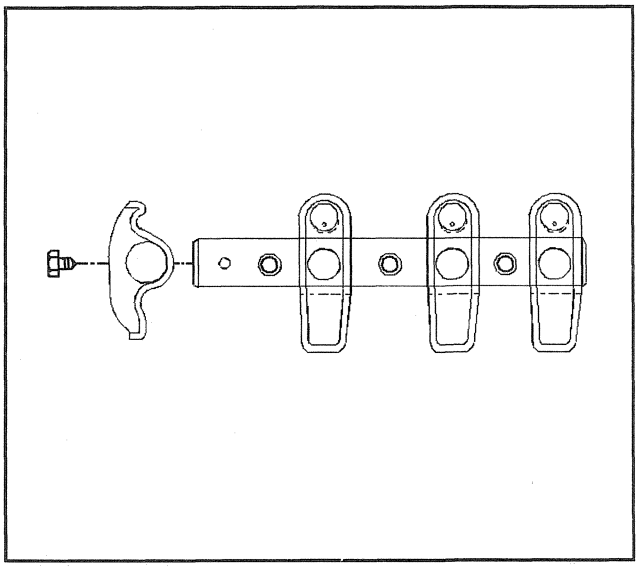
1. Remove the valve rocker arm retainers.
   1.1. Insert a screwdriver into the valve rocker arm shaft bore and break off the end of the retainers.
   1.2. Pull the valve rocker arm retainers out with pliers.
2. Remove the valve rocker arms from the valve rocker arm shaft.
3. Mark the valve rocker arms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



60456

Valve Rocker Arm and Shaft Clean and Inspect

1. Clean the parts i solvent.
   - Wear protective safety glasses and gloves.
   - Blow-dry the parts with compressed air.
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. Make sure the oil passages in the valve pushrods are clear.
8. Replace any damaged parts.



60456

Valve Rocker Arm and Shaft Assemble

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

Install valve rocker arms to their original locations.

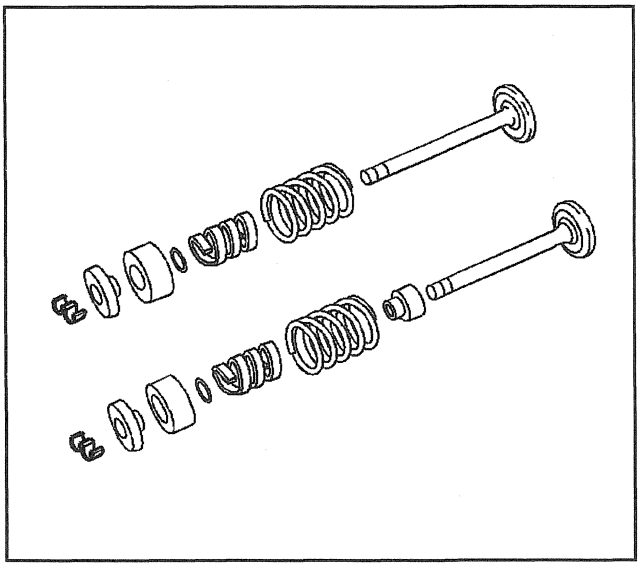
1. Install the valve rocker arms to the valve rocker arm shaft.
2. Install new valve rocker arm retainers using the following procedure:
   2.1. Center the valve rocker arms on the corresponding holes in the valve rocker arm shaft.
   2.2. Install the retainers with a drift of at least 13 mm (1/2 in)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

Valve Lifters and Guides Clean and Inspect

1. Clean the parts in solvent.
   - Wear protective safety glasses and gloves.
   - Blow-dry the parts with compressed air.
2. Inspect the valve lifter guide plates and clamps for damage.

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.

3. Inspect the valve lifter rollers for fatigue or pitting. Replace the valve lifter as an assembly.
4. Replace any damaged parts.



59973

Cylinder Head Disassemble

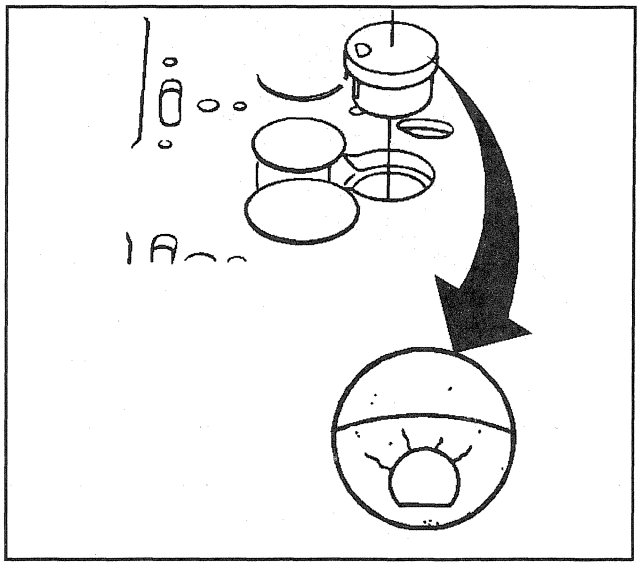
Tools Required

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.

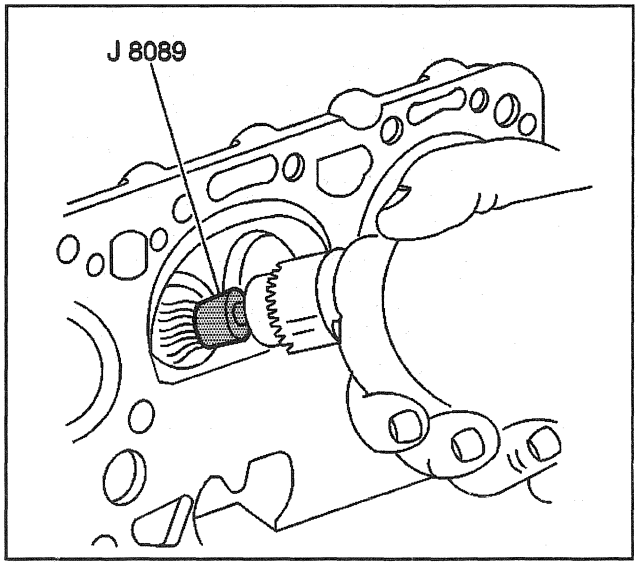

66585

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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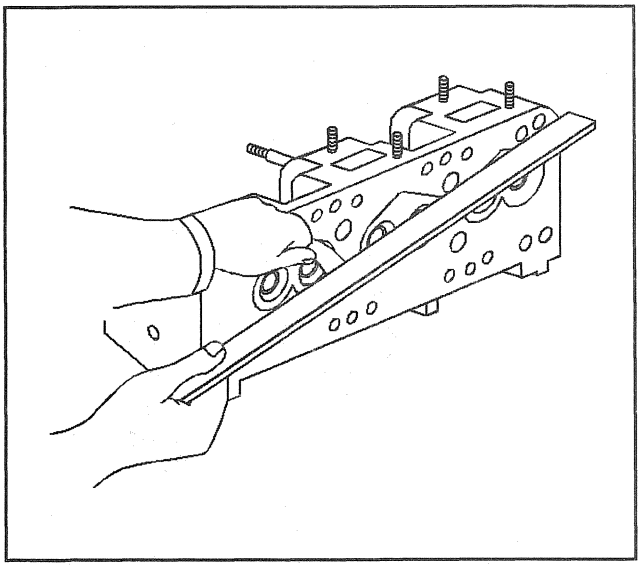

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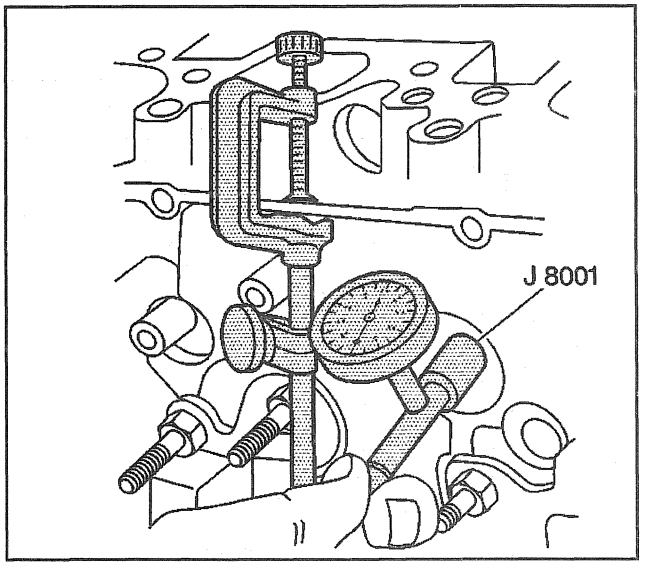
11. Inspect the cylinder head for warpage. When the warpage is greater than 0.15 mm (0.006 in) longitudinally, or 0.08 mm (0.003 in) transversely, replace the cylinder head.
12. Inspect the prechambers for cracks.
    - Replace any prechambers with facial cracks longer than 5 mm (0.20 in).
    - Service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

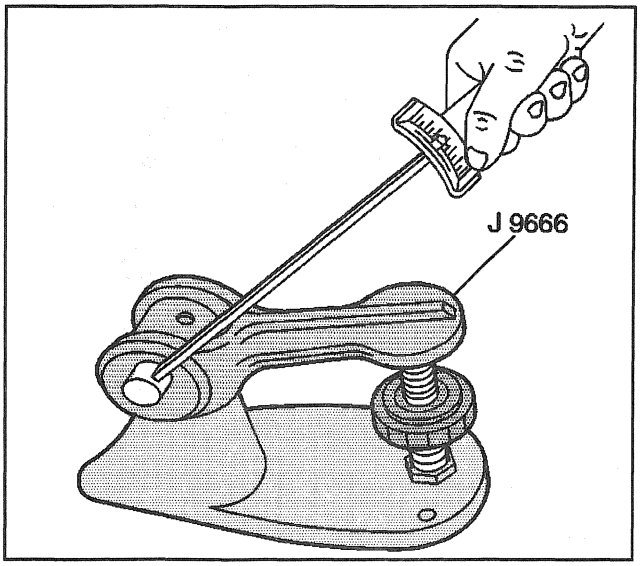


4959

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.

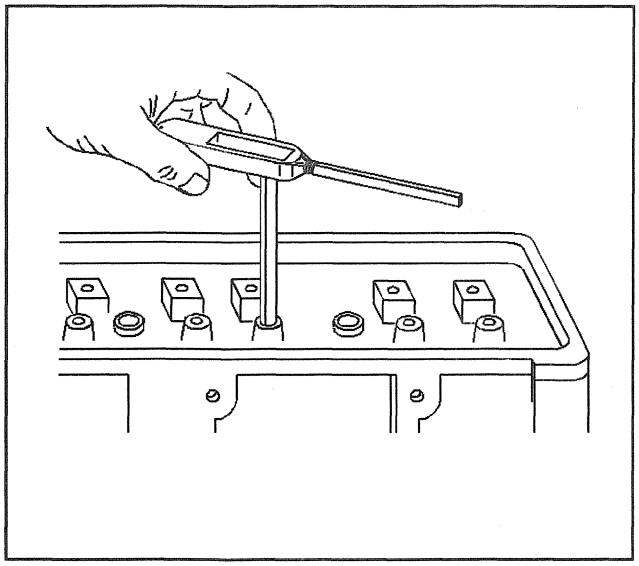
15. Measure the valve spring tension using the following procedure:
    15.1. Using the *J 9666*, compress the valve springs to the specified tension.
    15.2. Check the valve spring height. Valve springs should be replaced if not within specification. Refer to *Engine Mechanical Specifications (L65).*
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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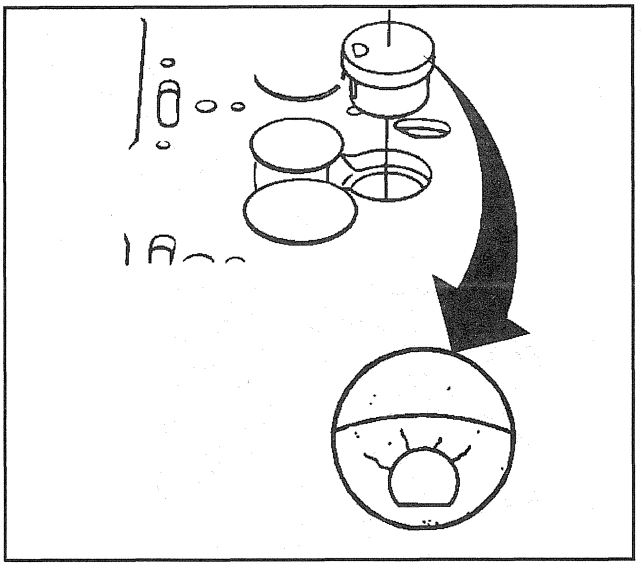
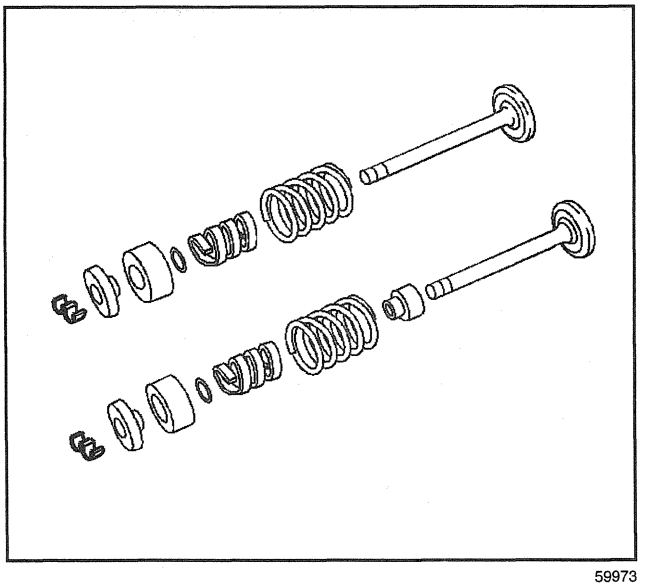


66585

Cylinder Head Assemble

1. Install the prechambers.
   1.1. Align the locating notch. The prechamber will fit correctly in only one position.
   1.2. Using a 32 mm (1.25 in) socket, tap the prechamber into place.
2. Measure the valve protrusion for all valves (Valve protrusion is the distance the valve extends past, or is recessed into, the cylinder 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 deep, the valve pushrod can bottom out in the lifter and hold the valve open. When the valves are left open, the valve spring seat tension and cylinder 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.
   - Measure 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 surface 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).
   - The prechamber must not recess into the cylinder head.
5. Lubricate the valve stems with engine oil.
6. Install the valves.
7. Install the valve spring shims (if required).
8. Install the exhaust valve stem seals.
   - Install the valve stem seals over the valve stems.
   - Seat the valve stem seals against the valve guides.
9. Install the valve springs.
10. Install the valve spring dampers.
11. Install the valve spring shields.
12. Install the intake valve spring caps.
13. Install the exhaust valve spring rotators.



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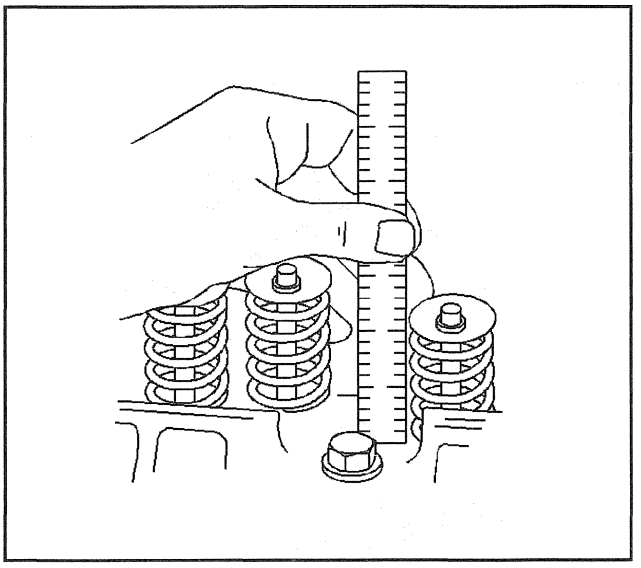
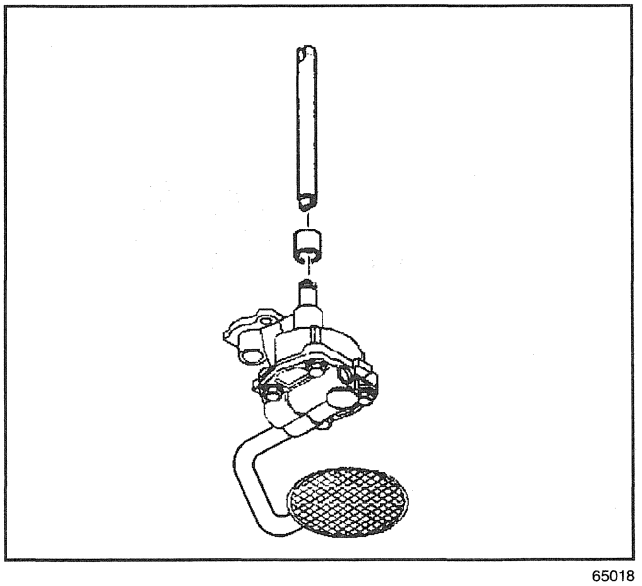
14. Install the valve stem O-ring seals and valve stem keys.
    14.1. Compress the valve spring using the *J 8062* Valve Spring Compressor.
    14.2. Install a new O-ring seal on the valve stem's lower groove.
    14.3. Apply a small amount of grease to the upper valve stem groove.
    14.4. Assemble the two valve keys to the upper valve stem groove. Ensure that the keys seat properly in the groove.
    14.5. Release the valve spring compressor, ensuring that the key stays in place.
    14.6. Repeat this procedure for each remaining valve.
15. Measure the valve spring installed height of each valve spring.
    15.1. 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. Refer to *Engine Mechanical Specifications (L65)*.
    15.2. 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

    15.3. Install or remove valve spring seat shims between the spring and the cylinder head to obtain the desired measurement. NEVER shim the spring to give an installed height less than the specified amount.


35203

Oil Pump Disassemble

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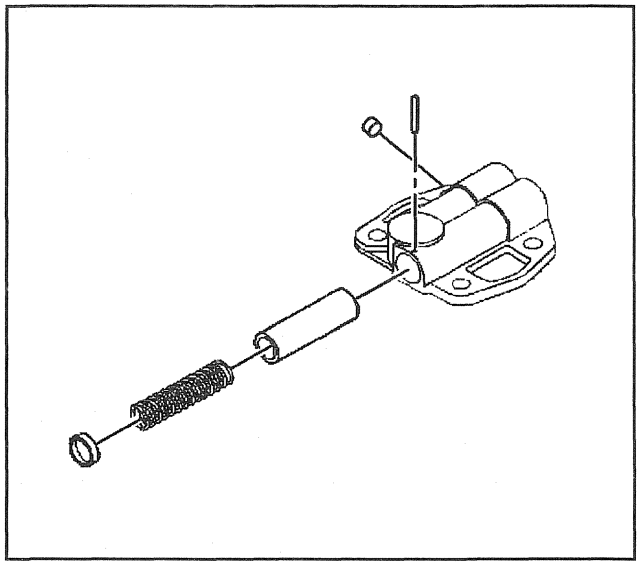
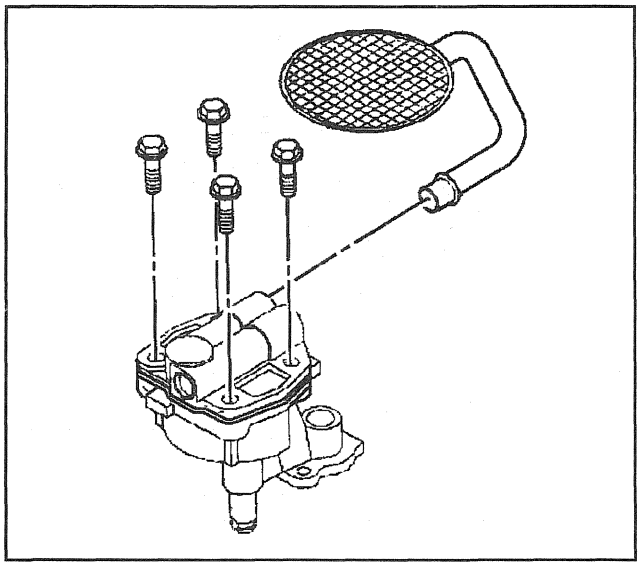


65020

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



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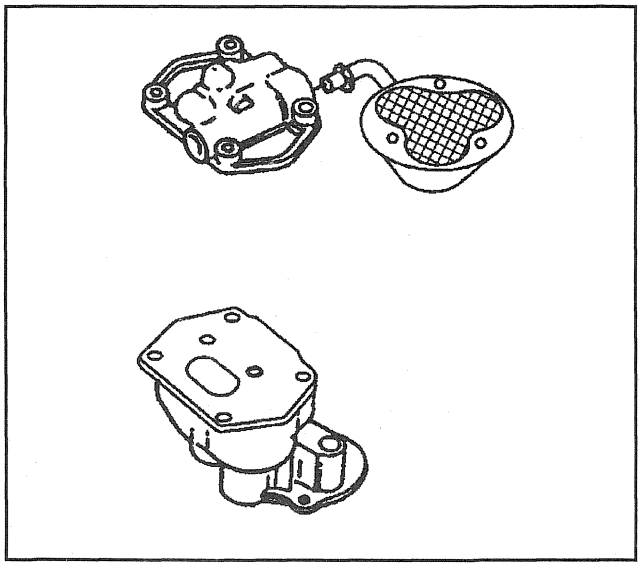
Important: If the pick-up tube and screen is not damaged, do not remove it. A new pick-up tube and screen assembly will be required for reassemble. The tube is press-fit into the cover and is hard to remove without damaging it.

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



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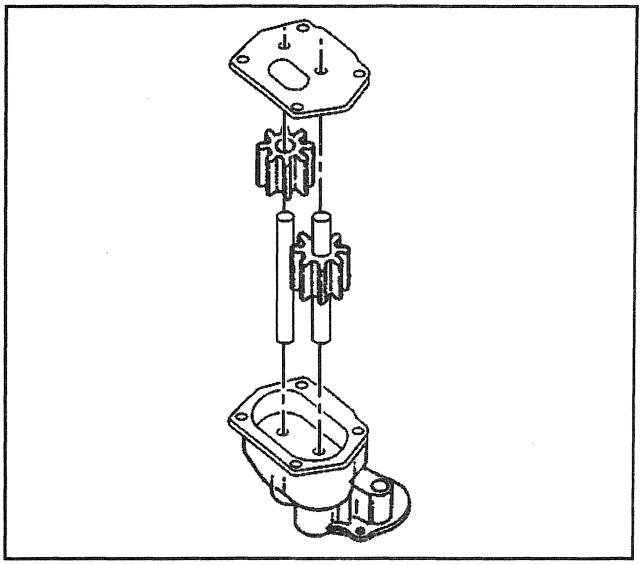
8. Remove the oil pump cover.
9. Remove the spacer plate.

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.



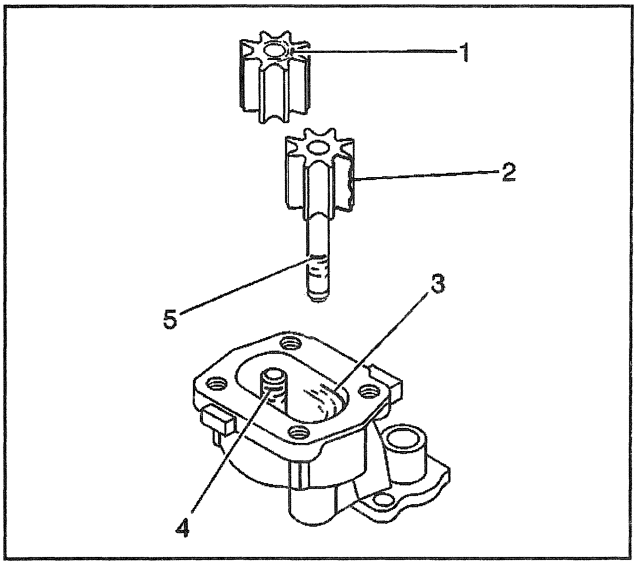
65023

Oil Pump Clean and Inspect

1. Clean the oil pump components in solvent.

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

2. Dry the components with compressed air.
3. Inspect the oil pump for the following:
   - Scoring, damage or casting imperfections to the housing (3)
   - Damage gears (chipping, galling, or wear) (2)
   - Scoring on the top of the gears (1)
   - Damaged or scored gear shaft (5)
   - Damaged bolt threads
   - Worn driveshaft housing bore
   - Damaged or sticking pressure relief valve (minor imperfections may be removed with a fine oil stone).
   - Collapsed or broken pressure relief valve spring
4. If the oil pump is to be reused, install a NEW pressure relief valve spring.
5. During oil pump installation, install a NEW oil pump driveshaft retainer.



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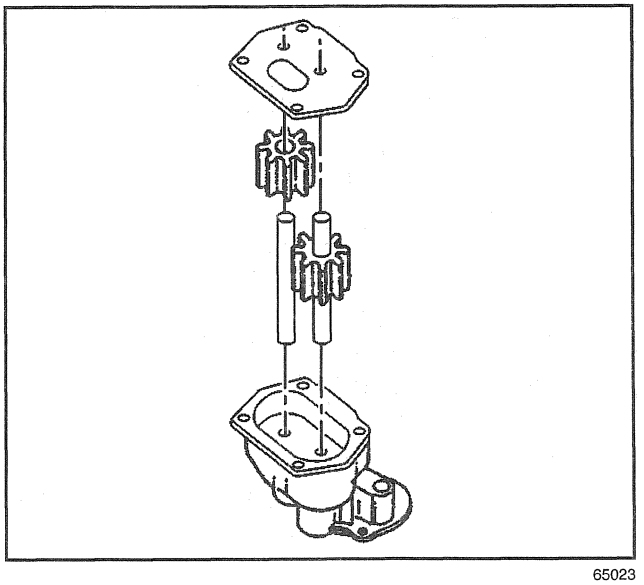

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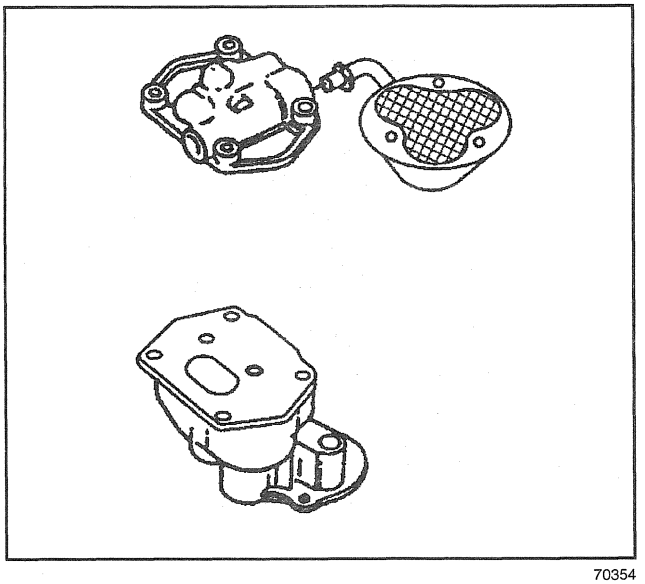
Oil Pump Assemble

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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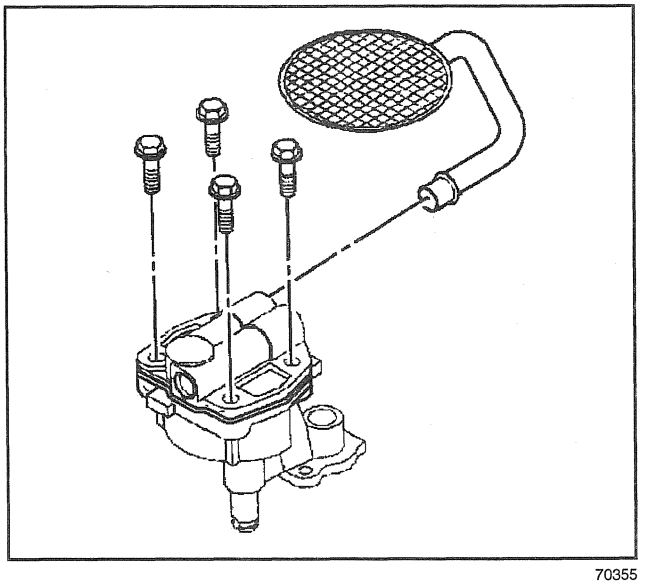
5. Install the oil pump cover.



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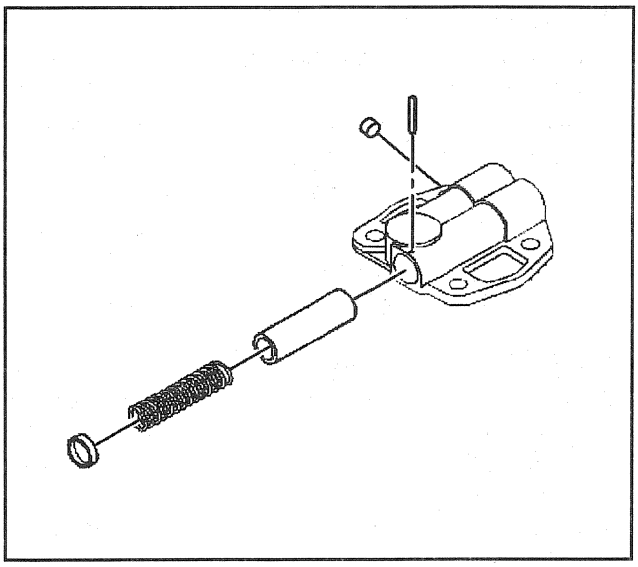
Notice: Refer to *Fastener Notice* in Cautions and Notices.

6. Install the oil pump cover screws.

   Tighten

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

7. Install the pressure regulator valve.
8. Install the spring.
9. Install the roll pin.



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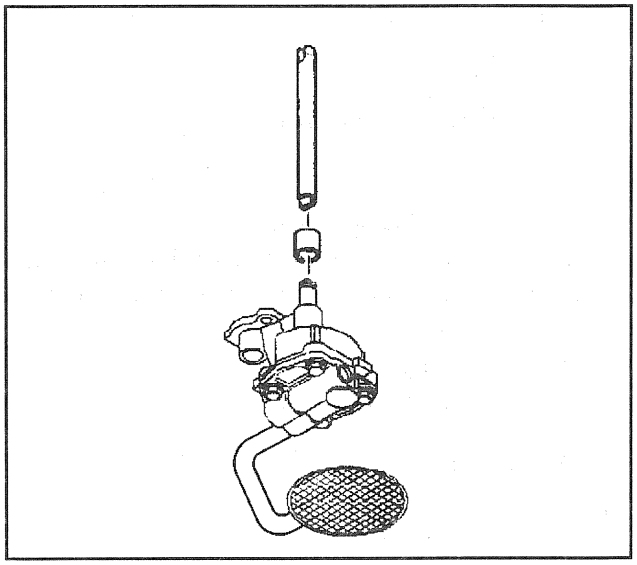
10. Install the pick-up tube and screen assemble if necessary. Align the tube in the same location as removed from.
11. Prime the oil pump by filling the cavity with clean engine oil.
12. Inspect the oil pump.
    - Turn the drive shaft by hand and check for smooth rotation.
    - If the oil pump does not rotate smoothly, check for proper assembly.
    - If necessary replace the oil pump assembly.



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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.

Valve Rocker Arm Cover 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

Oil Pan 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
   - Damage to the oil pan caused by rocks
   - Loose fit of the oil pan baffle
   - Stripped oil pan drain plug opening threads

Intake Manifold Clean and Inspect

1. Remove the MAP sensor from the intake manifold (if equipped).
2. Remove the IAT sensor from the intake manifold (if equipped).
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

Water Pump Clean and 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.
- Do not immerse the water pump in solvent. Solvent will dissolve the lubricant supply for the permanently lubricated bearings, causing premature bearing failure.

1. Clean the old gasket off of the gasket surfaces on the water pump and the water pump backing plate.
2. Replace the water pump if the following conditions exist:
   - Excessive end play in the pump shaft (0.20 mm/0.008 in end play is normal).
   - Pump drive shaft will not rotate smoothly (binding or roughness).
     - 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 water pump drain hole.
   - Damage to the water pump sealing surface.
   - Damage to the water pump pulley.
3. Replace the water pump backing plate if the following condition exists:
   - Damage to the water pump backing plate sealing surface.
   - Damage to the oil fill tube seal flange.

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. 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 fuel injection nozzle openings capped at all times.
2. Clean the fuel injection pump and components with clean solvent.
3. Clean the exterior of the fuel injection nozzles only in clean solvent. Do not use a wire brush.
4. Clean the fuel injection lines in clean solvent.
5. Using compressed air, dry the fuel injection nozzles. Wear protective safety glasses.
6. Using compressed air, dry the inside of the fuel injection lines. Wear protective safety glasses.
7. Inspect the fuel injection pump for the following:
   - Damage to the body.
   - Damage to the mounting flange.
   - Damage to the injection line fittings.
   - Damage to the electrical connectors.
   - Evidence of fuel leakage.
8. Inspect the fuel injection lines for the following:
   - Cracking, kinks, or wear marks from rubbing.
   - Damage to the injection line fittings.
   - Damage to the mounting brackets, retaining clips, and insulators.
9. Inspect the fuel injection nozzle injection line fittings for damage.

Important: Replace the glow plug if the matching fuel injection nozzle fails testing, even if the glow plug checks out as being good.

10. Test the fuel injection nozzles for proper operation. Refer to Fuel System.
11. Inspect the glow plugs for damage, stripped threads, and tips that are cracked, bulged, or broken.
12. Test the glow plugs for proper operation. Refer to Engine Controls.

Service Prior to Assembly

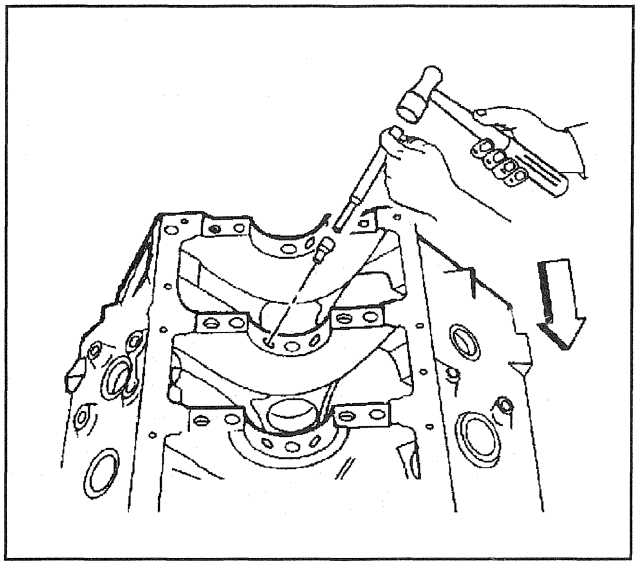
- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

Piston Oil Cooling Nozzle Installation

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

Using a brass drive pin, install the piston oil nozzles.

- Use a brass drive pin that has the same OD as the piston oil nozzles.
- Gently tap the piston oil nozzles into their bores.
- Ensure the piston oil nozzles are fully seated in their bores.



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Engine Block Plug Installation

Notice: Refer to *Fastener Notice* in Cautions and Notices.

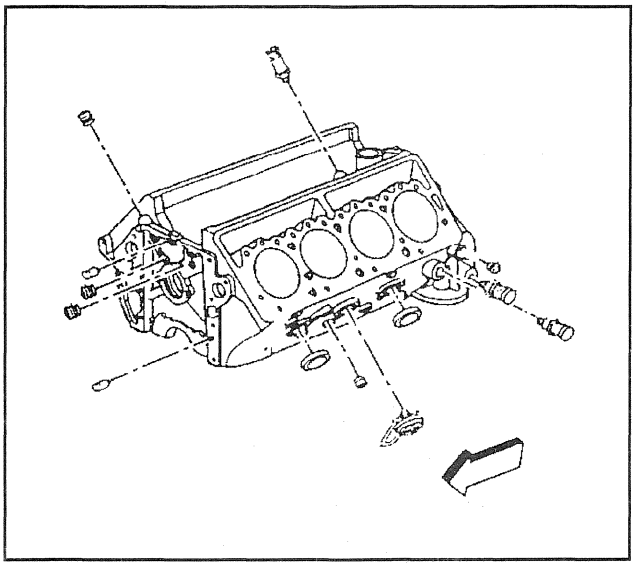
1. Install the front camshaft oil gallery plugs. Use GM part number 12345493, or the equivalent, on the threads.

   Tighten

   Tighten the plugs until they are completely seated.
2. Install the oil cooler line fittings. Use GM P/N 12346004, or the equivalent, on the threads.

   Tighten

   Tighten oil cooler line fittings to 57 N·m (43 lb ft).



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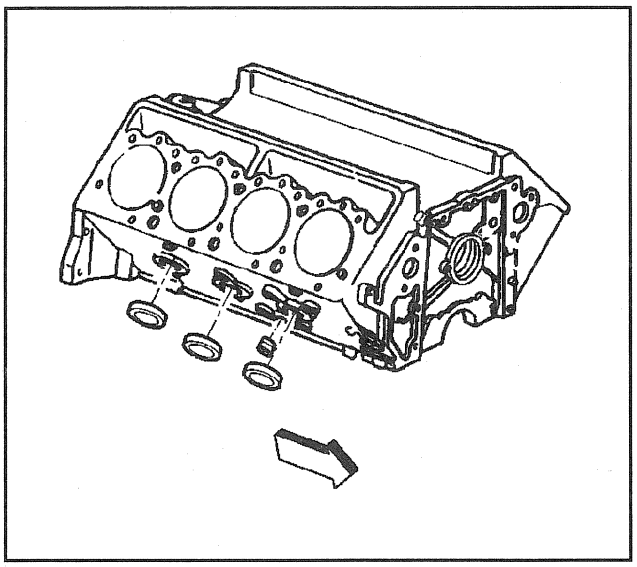

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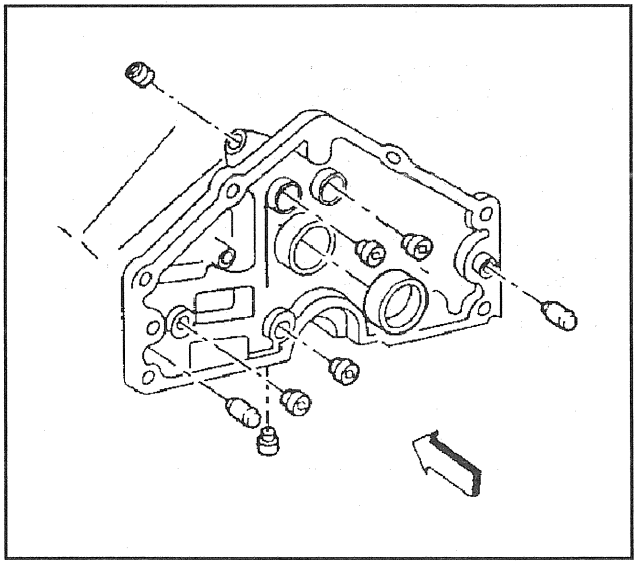
3. Install the side oil gallery plugs.

   Tighten

   Tighten oil gallery plugs to 34 N·m (25 lb ft).



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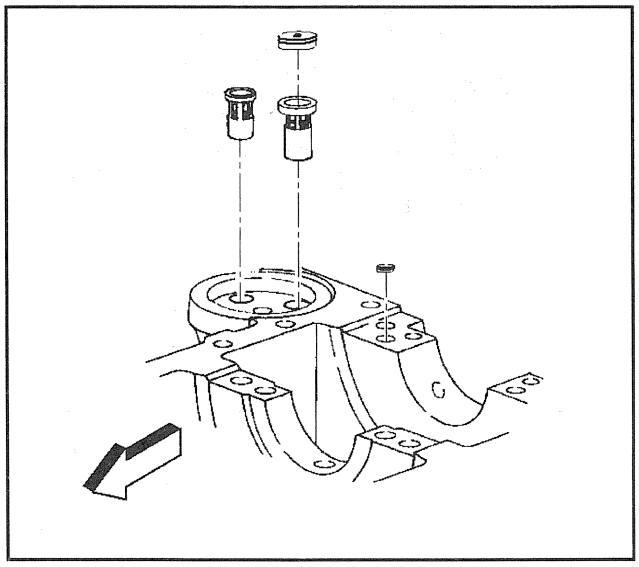
4. Install the remaining oil gallery plugs. An oil gallery plug is located inside the rear main bearing cap land. Use GM P/N 12346004, or the equivalent, on the threads.

   Tighten

   Tighten oil gallery plugs to 34 N·m (25 lb ft).
5. Install the engine oil pressure sensor switch.
6. Install the cup plugs and the block heater. Use GM P/N 12345493, or the equivalent, on the cup plugs.
7. Install the coolant drain plugs.

   Tighten

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



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Oil Filter Adapter Installation

1. 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.

2. Install the cup plug for the oil cooler bypass valve.
3. 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.

Crankshaft and Bearings Installation (L65)

Component Description

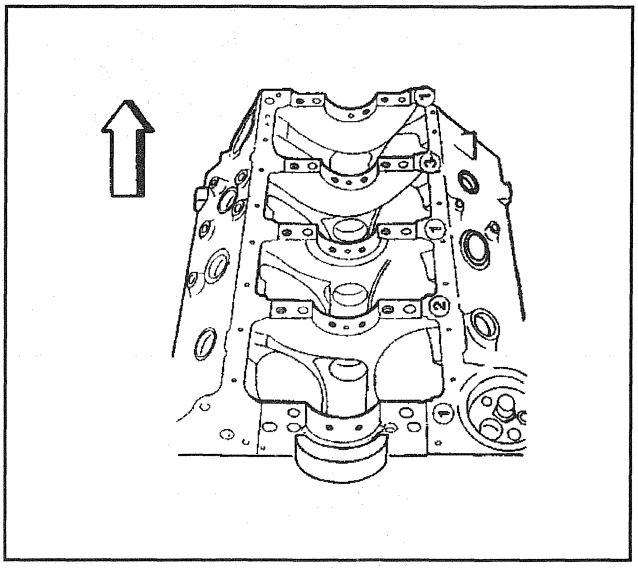
There are five crankshaft bearings numbered 1 through 5, as viewed from the front of the engine. There is an arrow on each bearing cap that points toward the front of the engine. The center crankshaft bearing, number three, is the thrust bearing.

The upper crankshaft bearing inserts all have an oil groove and a oil gallery hole from the block in the center of the groove. The upper crankshaft bearing inserts also have additional holes in the oil groove at 10 o'clock and 2 o'clock to provide oil to the oil spray nozzles. The oil spray nozzles are mounted in the crankshaft bearing bulk heads. The lower bearing inserts do not have an oil groove or holes.

During initial assembly, the crankshaft bearings are select-fitted to each of the five crankshaft bearing bores. The total diameter size range of crankshaft bearing bores 1 through 5 is 79.826–79.850 mm (3.145–3.146 in). This range divides into three sizes, represented by the size numbers 1, 2 or 3. The proper size number is then stamped on the pan rail at the corresponding crankshaft bearing bulk head.

The crankshaft is color-marked in red/orange, blue or white, near each crankshaft bearing journal. Cross-referencing the size 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) undersized for select fitting, in order to attain proper crankshaft bearing clearance.
- Undersized 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).



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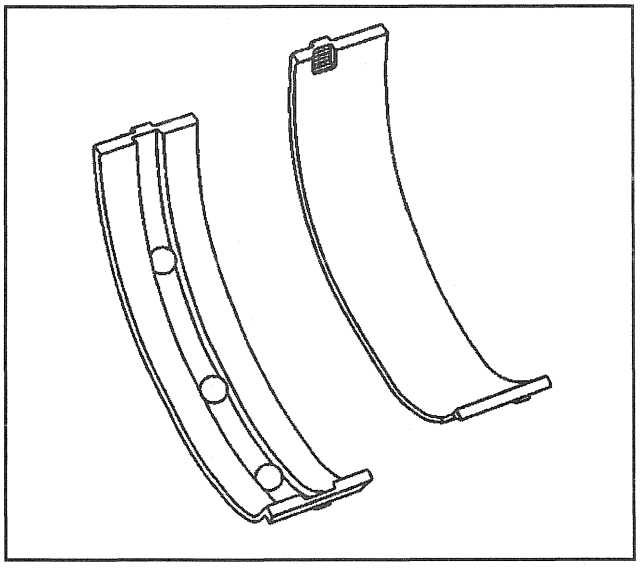

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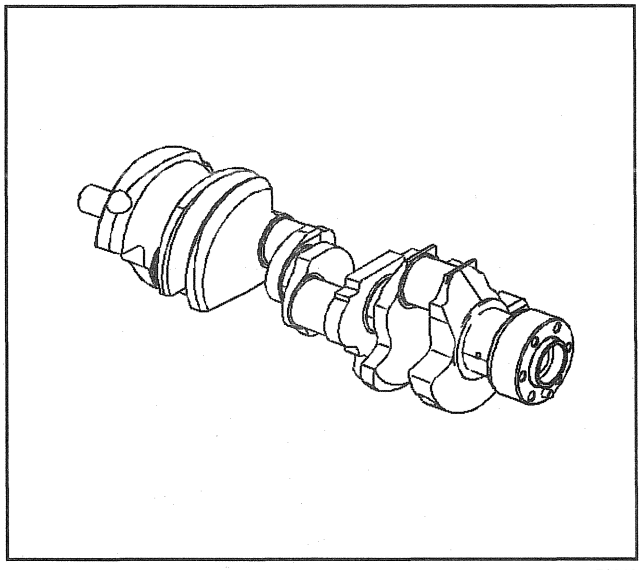
Important: The upper crankshaft bearing inserts must have holes for the piston oil nozzles, or damage to the engine could result. All engines were assembled with three-hole upper crankshaft bearing inserts in positions 1, 2, 3 and 4, and with a two-hole upper crankshaft bearing insert in position and 5. Replace the upper crankshaft bearing inserts with the same type as originally installed.

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 bearing inner surfaces.



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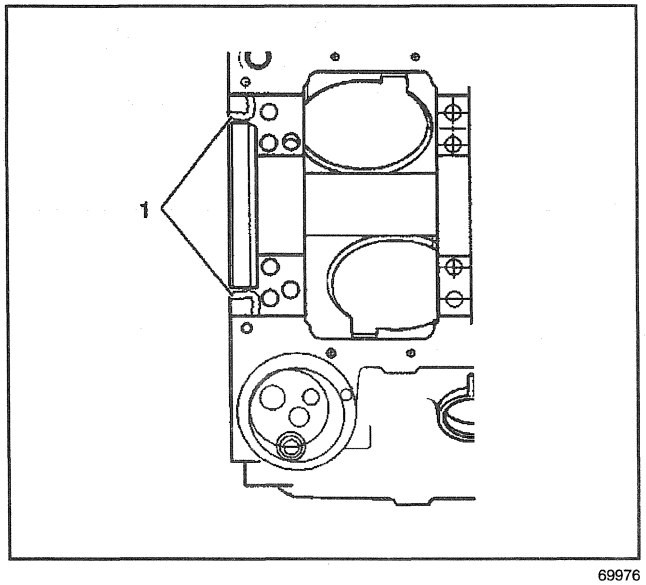
4. Install the crankshaft.



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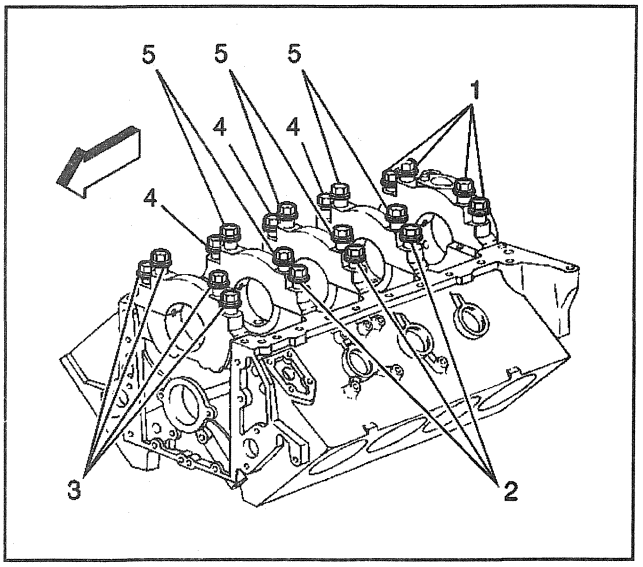
5. Apply a 1/8 inch bead of gasket maker (1), GM P/N 1052942, or equivalent, on each side of the rear crankshaft bearing cap area.

Important: Crankshaft bearing cap bolt sizes are as follows:

- All inner crankshaft bearing cap bolts on crankshaft bearing caps 1, 2, 3, 4, and 5 are 12 mm (101 mm long) bolts.
- All outer crankshaft bearing cap bolts on crankshaft bearing caps 1 and 5 are 12 mm (68 mm long) bolts.
- All outer crankshaft bearing cap bolts on crankshaft bearing caps 2, 3, and 4 are 10 mm (68 mm long) bolts.

6. Apply engine oil to the crankshaft bearing cap bolt threads.



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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.

7. Install the number 1, 2, 4, and 5 crankshaft bearing caps and bearing by tapping into place with a brass or leather mallet.
8. Apply engine oil to the crankshaft bearing cap bolt threads.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

9. Install the crankshaft bearing cap inner 12 mm bolts.

   Tighten

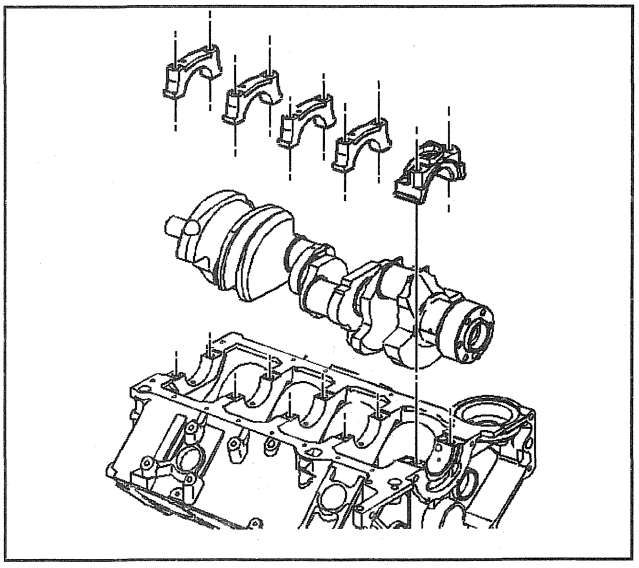
   Tighten the inner 12 mm bolts to 75 N·m (55 lb ft).
10. Install the number three crankshaft bearing cap and the bearing (thrust bearing) by tapping into place with a brass or leather mallet.
11. Install the crankshaft bearing cap inner 12 mm bolts.

    Tighten

    Tighten the inner 12 mm bolts to 14 N·m (10 lb ft).
12. Tap the end of the crankshaft first rearward then forward with a lead hammer to line up the crankshaft bearing and the crankshaft thrust surfaces.

    Tighten

    Tighten the inner 12 mm bolts to 75 N·m (55 lb ft).
13. Measure the crankshaft end play 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).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14. Tighten all crankshaft bearing cap bolts in the following sequence:

    Tighten

    14.1. Retighten the inner 12 mm bolts to 75 N·m (55 lb ft).

    14.2. Tighten the inner 12 mm bolts an additional 90 degrees.

    14.3. Tighten the outer 12 mm bolts (crankshaft bearing caps 1 and 5) to 65 N·m (48 lb ft).

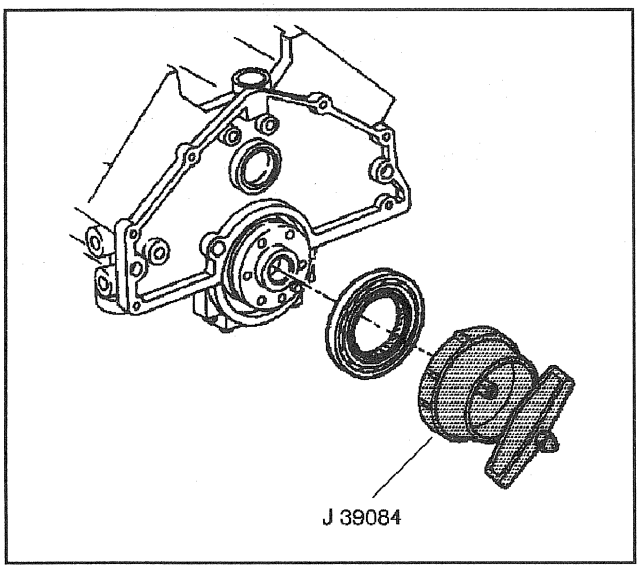
    14.4. Retighten the outer 12 mm bolts (crankshaft bearing caps 1 and 5) to 65 N·m (48 lb ft).

    14.5. Tighten the outer 12 mm bolts an additional 90 degrees.

    14.6. Tighten the outer 10 mm bolts (crankshaft bearing caps 2, 3, and 4) to 40 N·m (30 lb ft).

    DO NOT tighten the outer 10 mm bolts (crankshaft bearing caps 2, 3, and 4) an additional 90 degrees.

15. Inspect the crankshaft for binding.
16. 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.
17. Burrs on the crankshaft bearing cap, foreign matter between the insert and the block or the crankshaft bearing cap, or a faulty insert could cause a lack of clearance at the bearing.



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Crankshaft Rear Oil Seal Installation

Tools Required

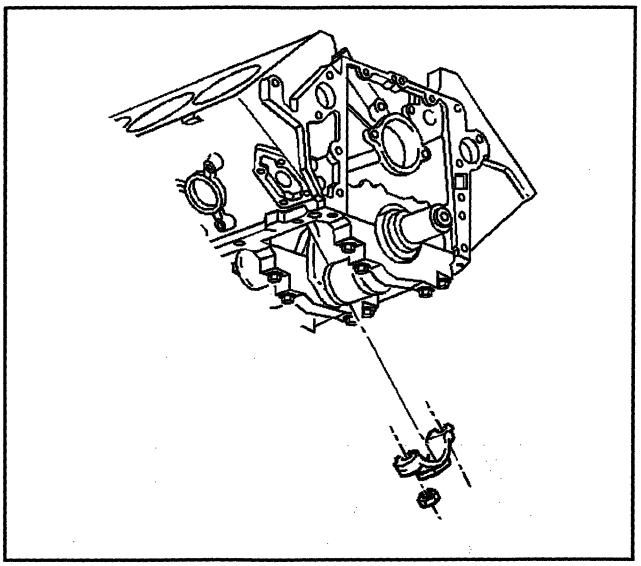
J 39084 Rear Crankshaft Oil Seal Installer

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.

Piston, Connecting Rod, and Bearing Installation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Tools Required

J 8037 Ring Compressor

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) undersized, with green color for identification.

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) undersized insert, which will decrease the clearance by 0.013 mm (0.0005 in), rather than using a full standard bearing.

Important:

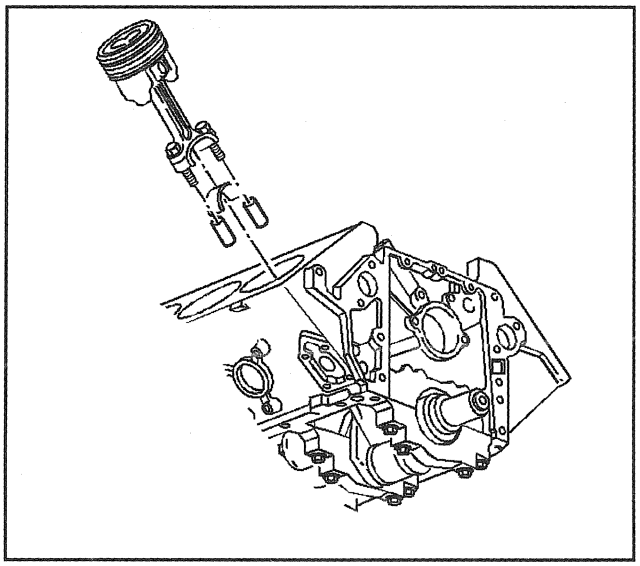
- When using selective fit rod bearings, always use the standard bearing in the connecting rod, and use the undersized bearing in the end of the rod cap.
- Note that the color-coding for selective fit rod bearings is different from the color-coding for the crankshaft bearings.
- Connecting rod bearings are available in 0.026 mm (0.0010 in) undersized 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.

Important:

- Make sure that the cylinder walls are clean.
- Lightly lubricate the cylinder walls with engine oil.
- Make sure that the pistons install in their matching cylinder.
  - Install used pistons in the cylinders from which they were removed.
  - Install new pistons in their fitted cylinders.

1. Remove the connecting rod cap from the piston and connecting rod assembly.
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*.
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.



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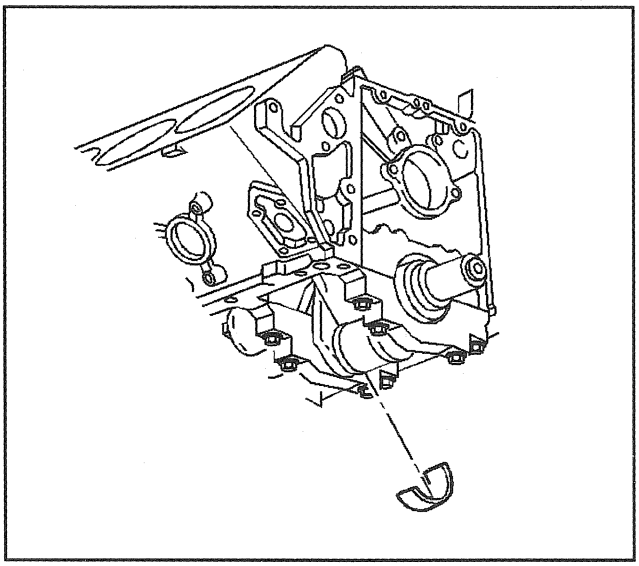

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Important: Each connecting rod and bearing cap should be marked, beginning at the front of the engine. Cylinders 1, 3, 5, and 7 are the left bank and 2, 4, 6, and 8 are the right bank. The numbers on the connecting rod and bearing cap must be on the 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.

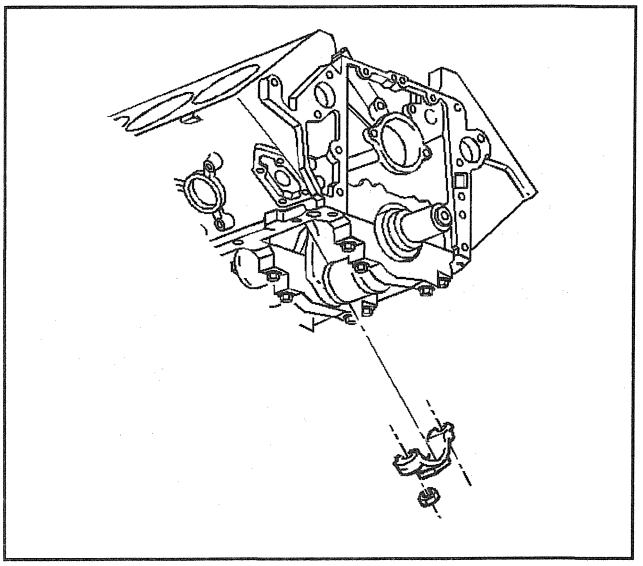
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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).

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

Oil Pump Installation

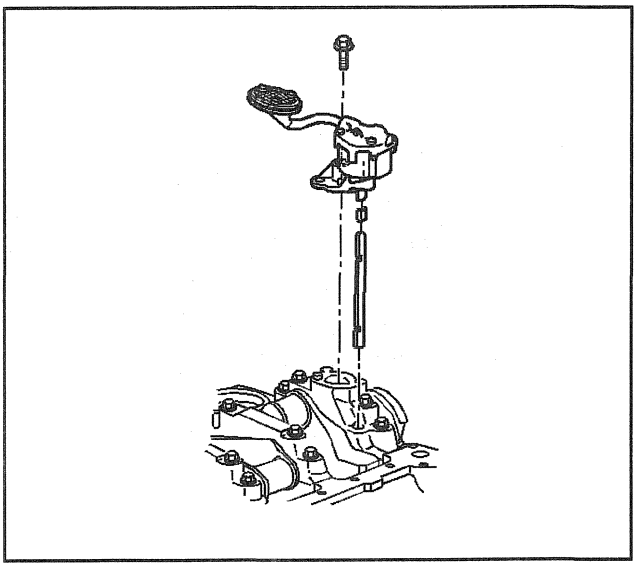
1. Install the oil pump with the driveshaft.

Notice: Refer to *Fastener Notice* in Cautions And Notices.

2. Install the oil pump bolts.

   Tighten

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



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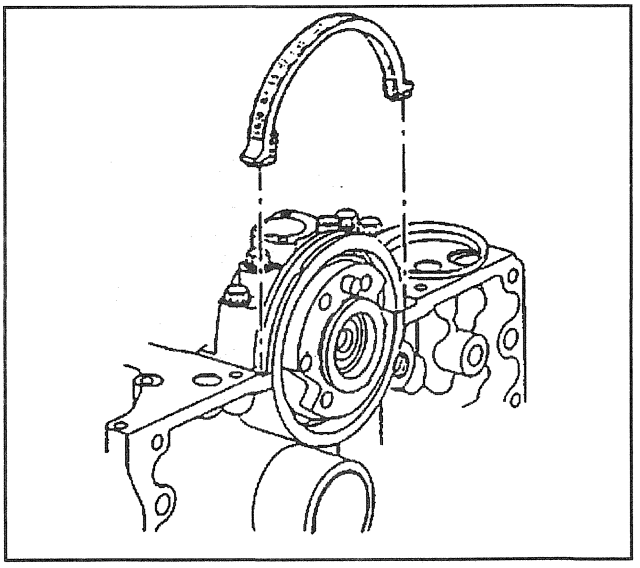
Oil Pan Installation

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.



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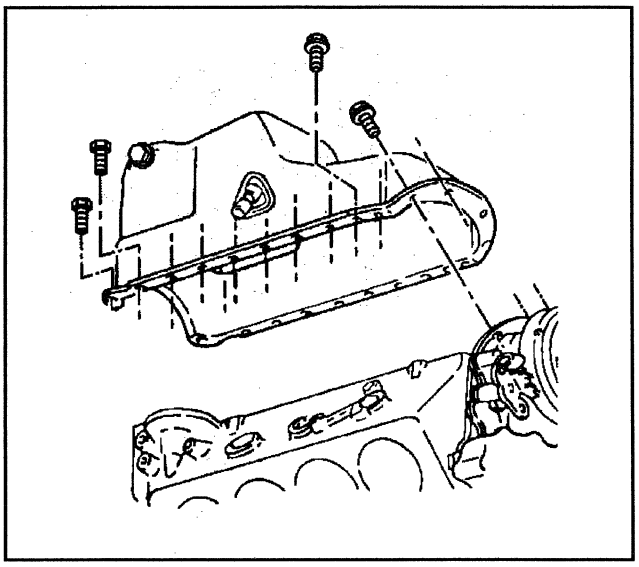

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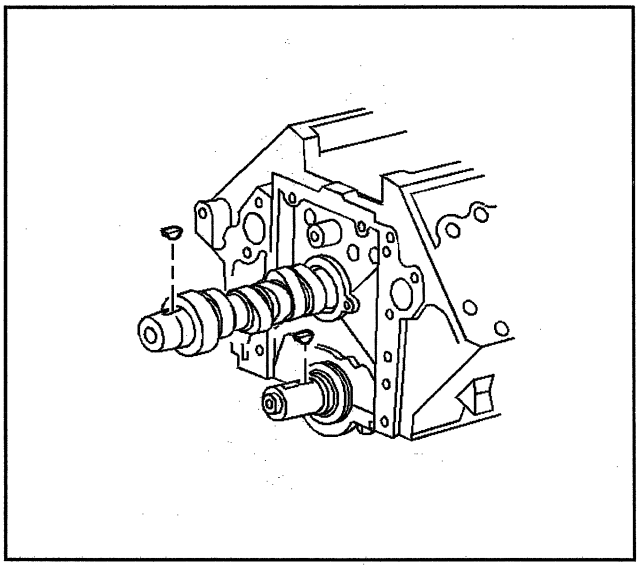
4. Install the oil pan to the engine.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

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).

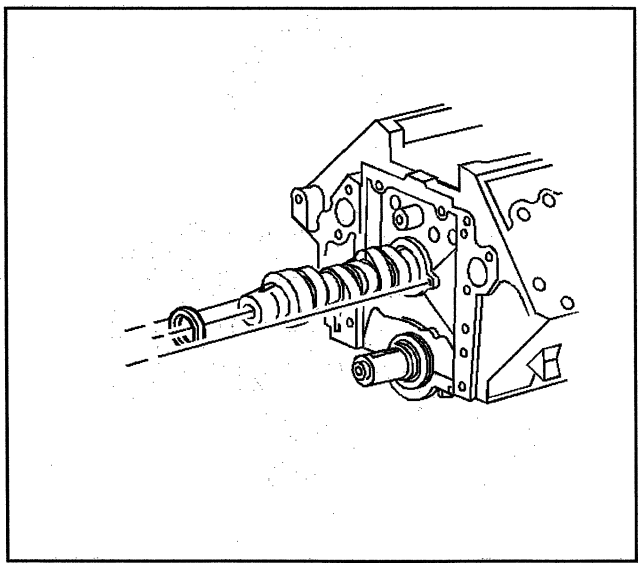


59881

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.

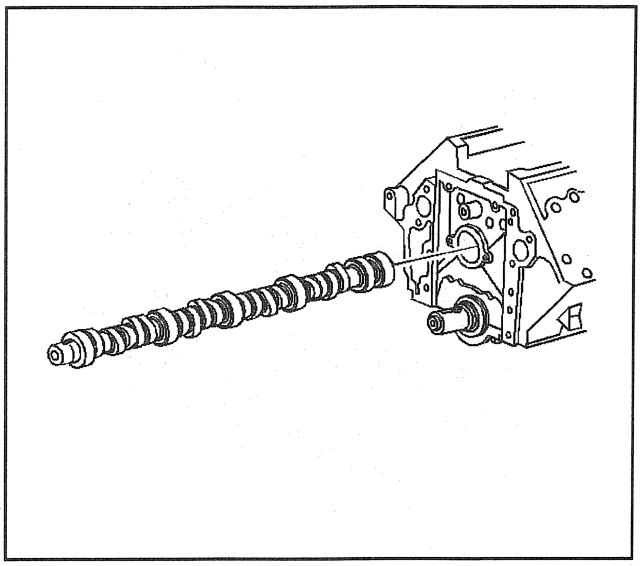
3. Install the camshaft.
   3.1. Coat the camshaft lobes with MOLYKOTE, or the equivalent.
   3.2. Lubricate the camshaft bearing journals with engine oil.
   3.3. Carefully insert the camshaft into the block, in order to avoid damage to the camshaft bearings.
4. Install the thrust bearing.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the thrust bearing bolts.

   Tighten

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



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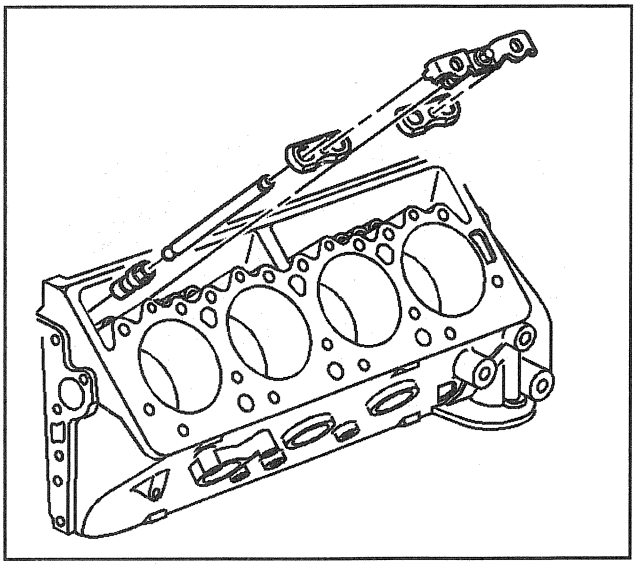
Valve Lifter Installation

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.



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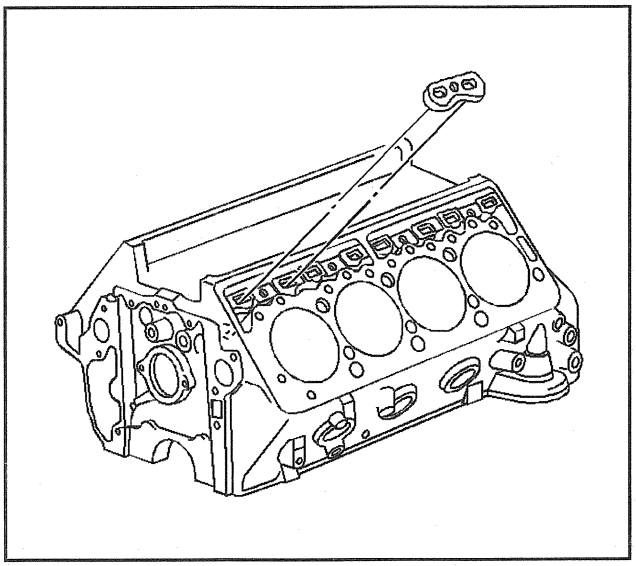
Important: Ensure that the straight edge of the guide plates and the clamps face away from the cylinders.

2. Install the guide plates.



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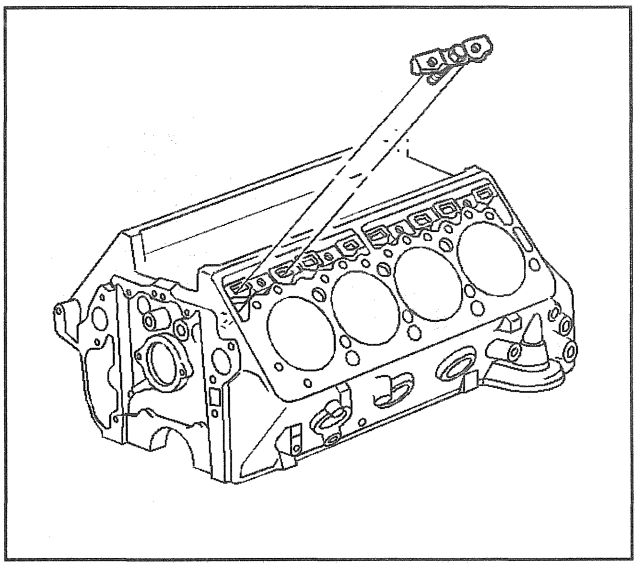


59806

Notice: Refer to *Fastener Notice* in Cautions and Notices.

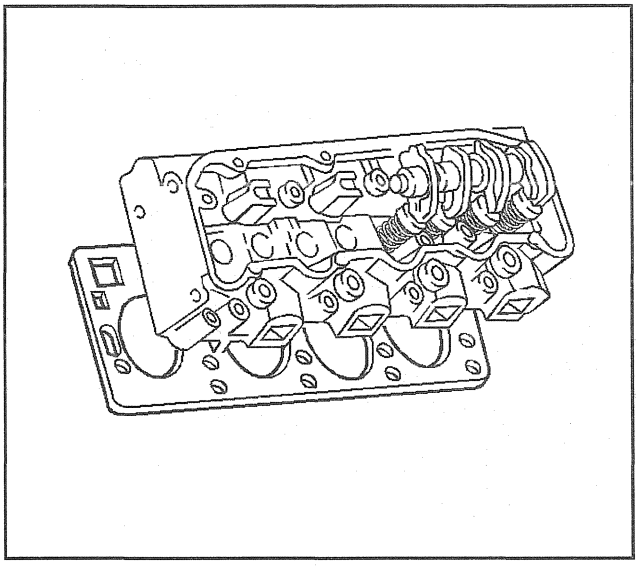
3. Install the clamps.

   Tighten

   Tighten the clamp bolts to 27 N·m (20 lb ft).

Important: If the engine will not turn over by hand, one or more of the lifters may be binding in the guide plates.

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.



59803

Cylinder Head Installation

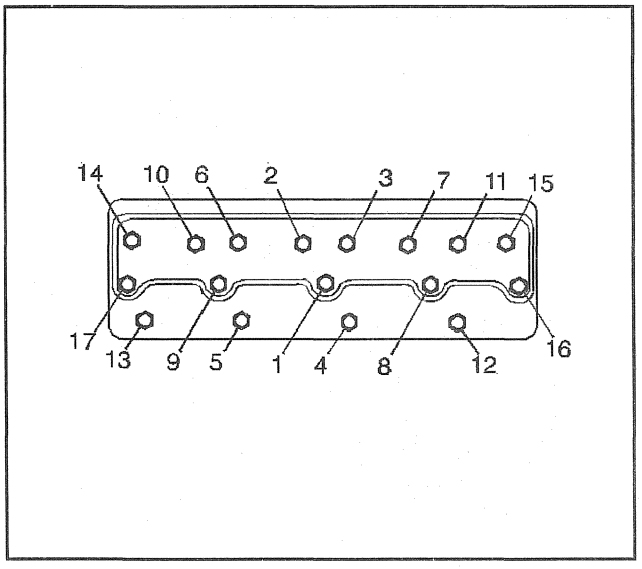
Tools Required

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 is made 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 cylinder head gaskets to the block, over the cylinder head dowel pins.
2. Install the cylinder heads to the block, over the cylinder head gaskets and the cylinder head dowel pins.



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3. Apply the thread sealant GM P/N 12345382, or equivalent, to the bolt threads and under the bolt heads.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the cylinder head bolts using the installation and tightening sequence (1-17).

   Tighten

   - In sequence (1-17), tighten all of the cylinder head bolts to 25 N·m (20 lb ft).
   - In sequence (1-17), tighten all of the bolts to 75 N·m (55 lb ft).
   - In sequence (1-17), retighten all of the bolts to 75 N·m (55 lb ft).
   - In sequence (1-17), tighten all of the bolts an additional 90 degrees–100 degrees (1/4 plus turn).

Valve Rocker Arm, Shaft, and Push Rod Installation

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

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

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

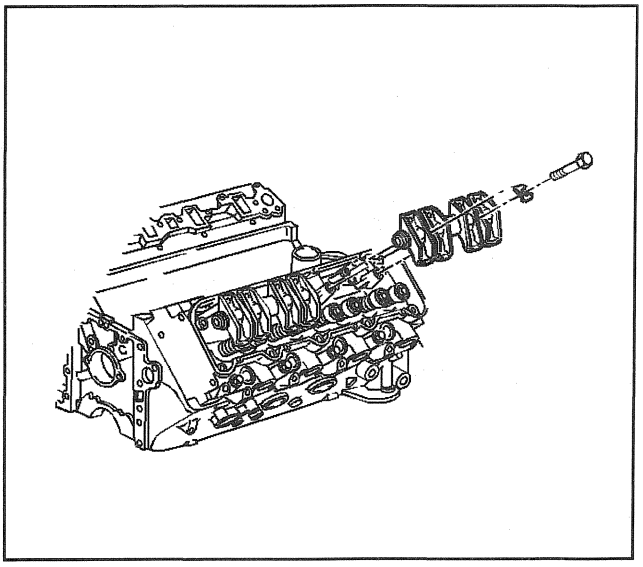
Notice: Improper installation of the valve rocker arm shaft bolts may cause valve rocker arm shaft breakage and piston to valve contact.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

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



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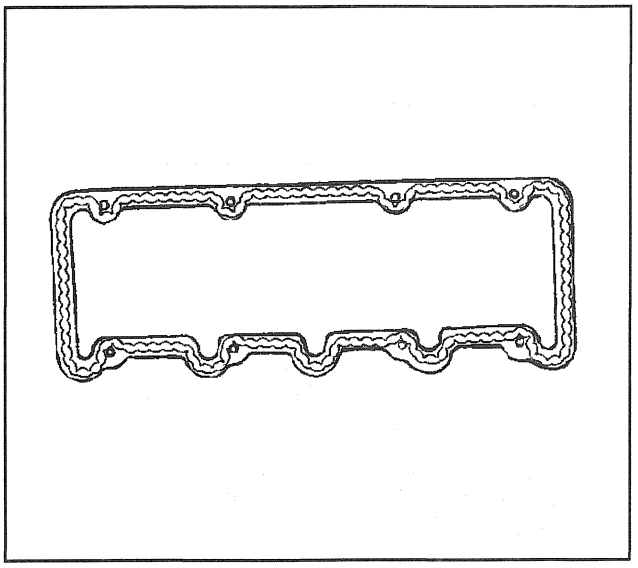
Valve Rocker Arm Cover Installation

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 12346286 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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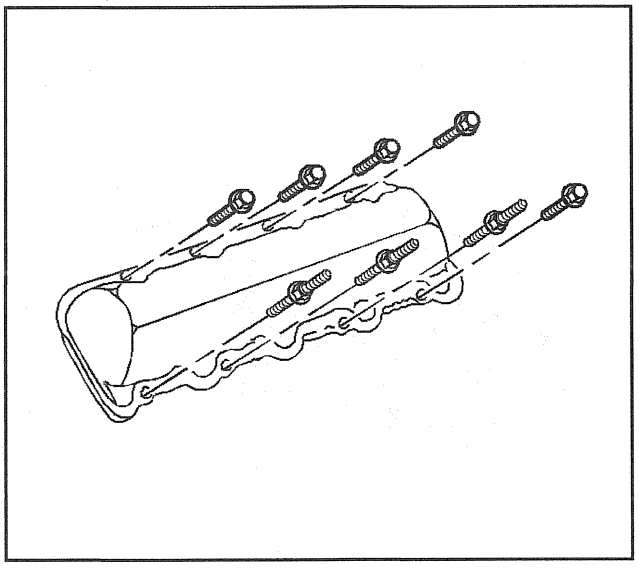

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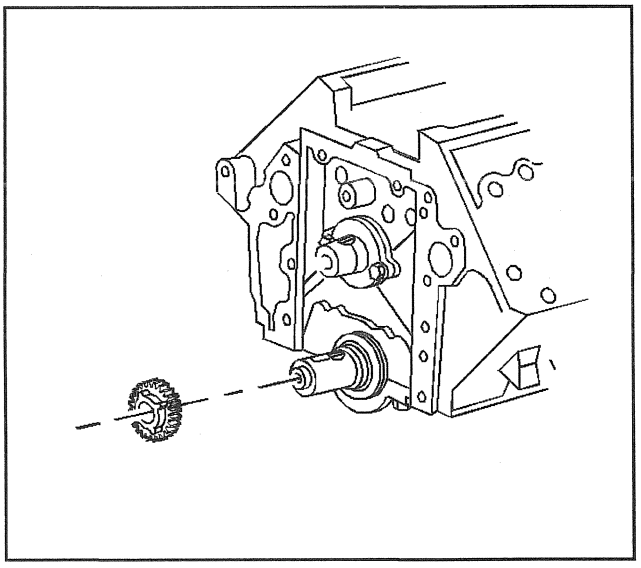
3. Install the valve rocker arm cover.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the valve rocker arm cover bolts.

   Tighten

   Tighten the valve rocker arm cover bolts to 27 N·m (20 lb ft).



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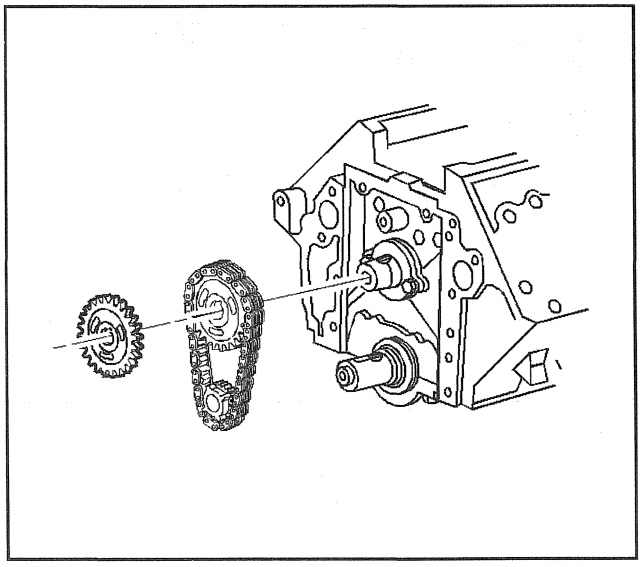
Timing Chain and Sprockets Installation

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.

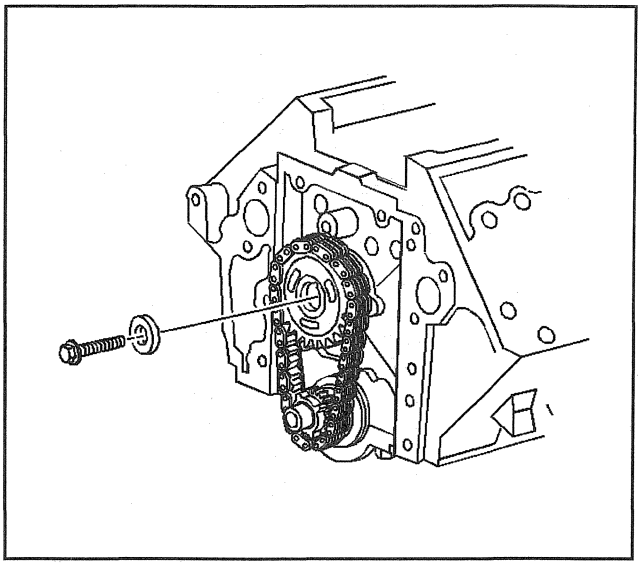


59874

4. Install the fuel injection pump camshaft gear.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the washer and the bolt.
   Tighten
   Tighten the bolt to 170 N·m (125 lb ft).



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Engine Front Cover Installation

Tools Required

J 22102 Seal Installer

Important: Replacing either of the following will affect timing:

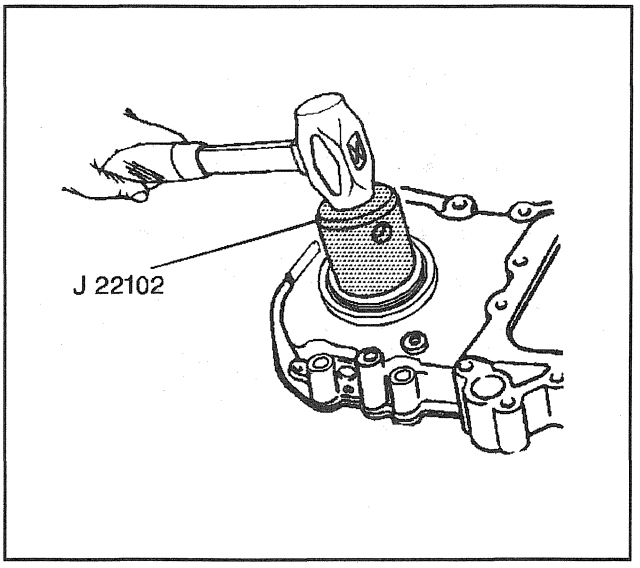
- The timing chain
- The timing gears
- The front cover
- The Crankshaft Position (CKP) sensor
- The crankshaft

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.



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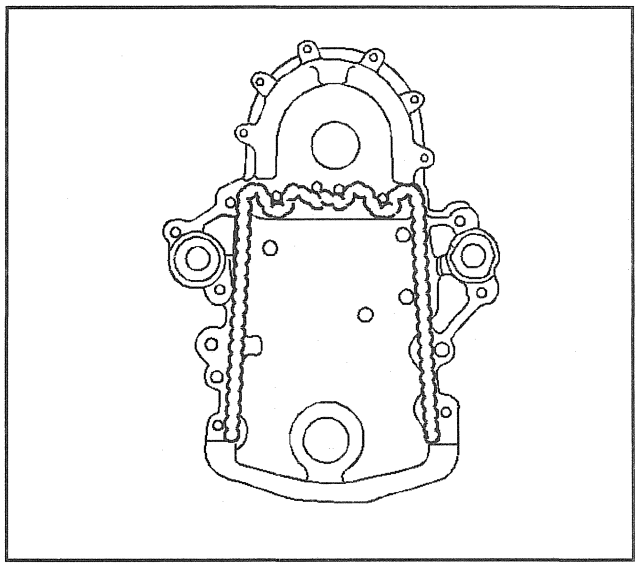

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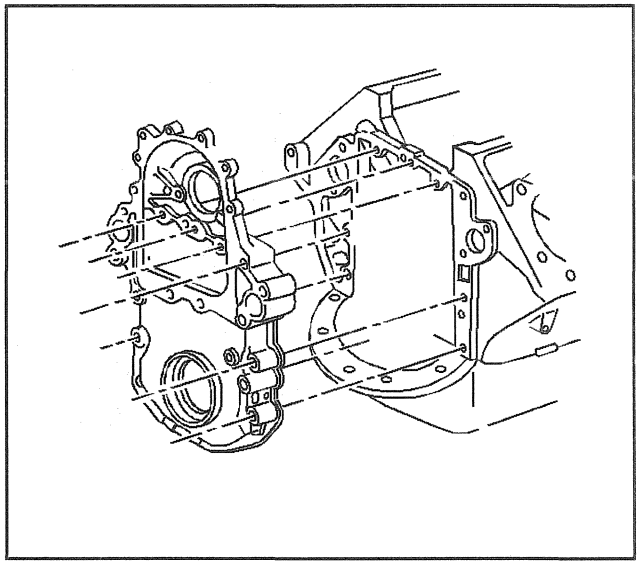
4. Apply a 2 mm (3/32 in) bead of anaerobic sealant GM P/N 1052357, or the equivalent, to the front cover sealing area.



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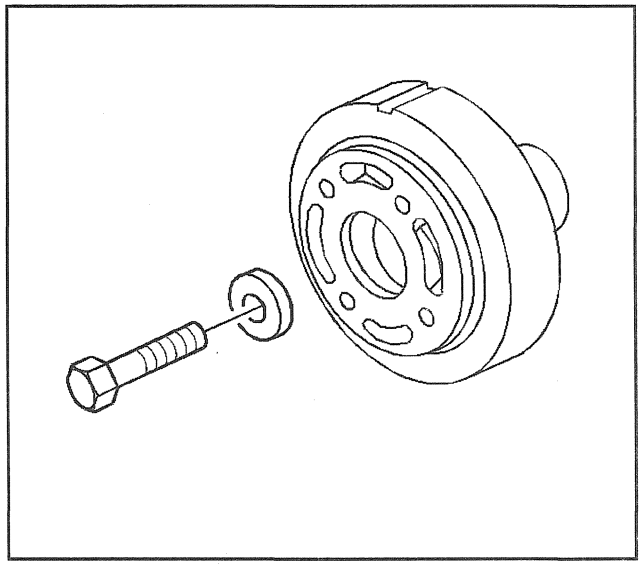
5. Install the front cover to the engine.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

6. Install the front cover bolts.

   Tighten

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

Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the bolt and the washer.

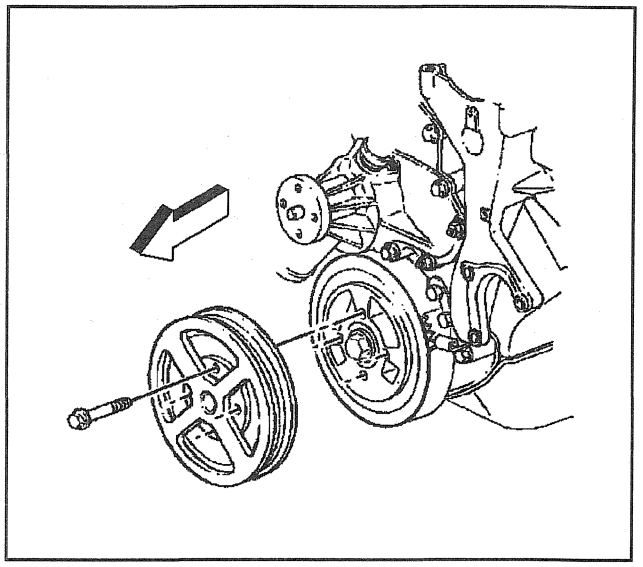
   Tighten

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

5. Install the crankshaft pulley and bolts.

   Tighten

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



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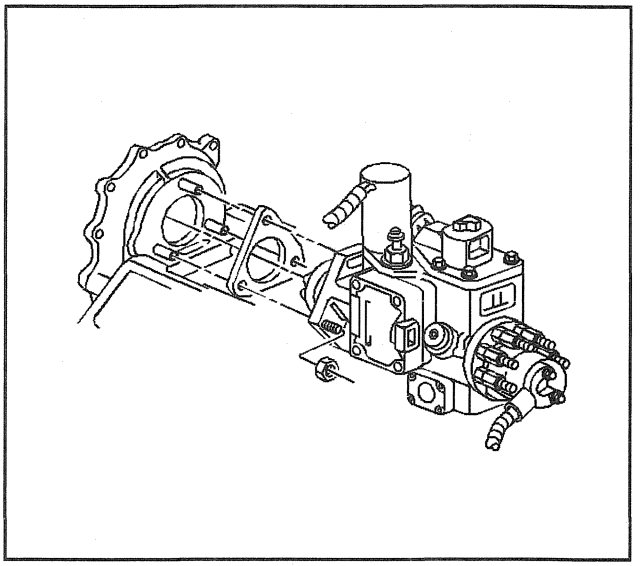
Fuel Injection Pump Installation

Tools Required

J 29873 Nozzle Socket

Important: 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 fuel injection pump and gasket with the ESO solenoid pointed straight up.



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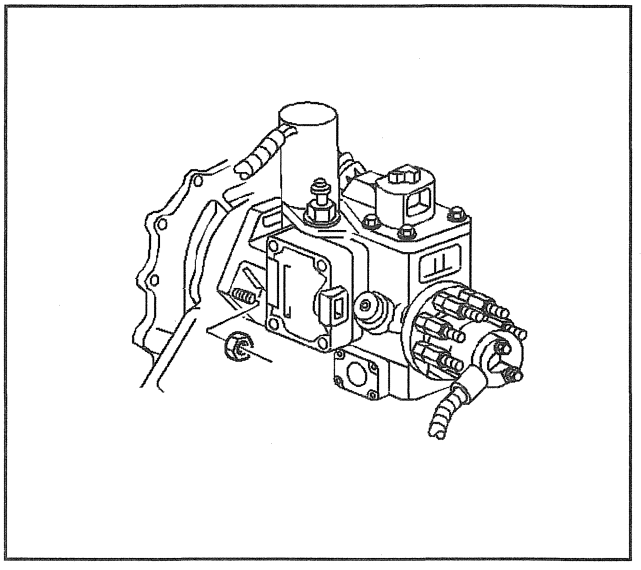
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the fuel injection pump nuts.

   Tighten

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



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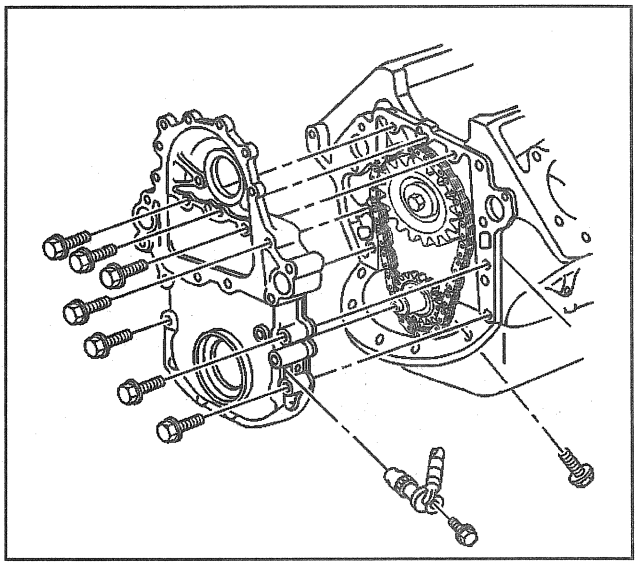


59842

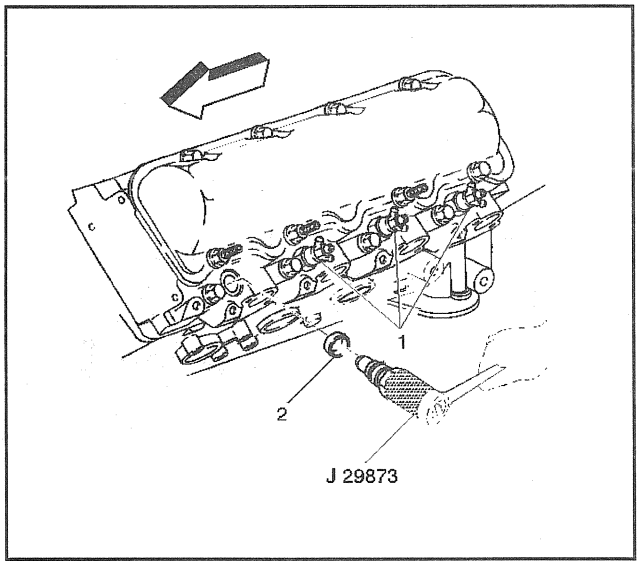
3. Install the fuel injection pump gear. Align the slot in the fuel injection pump gear with the locating pin on the fuel injection pump hub.

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.

4. Install the fuel injection pump gear retaining bolts.

   Tighten

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



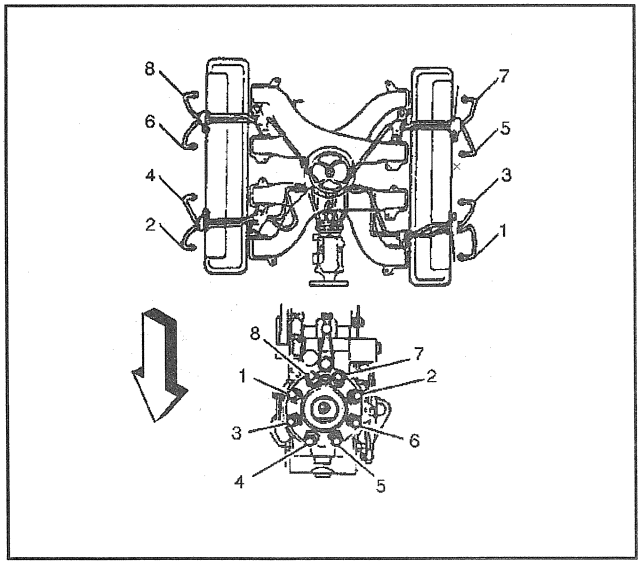
60452

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

5. Apply a thin coating of GM P/N 14001899, or equivalent, to the threads of the injection nozzle.
6. Install the injection nozzle and gasket, using the *J 29873*.

   Tighten

   Tighten the nozzle to 80 N·m (59 lb ft).



70019

7. Install the injection line brackets.

Important:

- Uncap the injection lines before assembly.
- Install the injection lines in the correct position.
- Do not bend the injection lines.

8. Install the injection lines to the pump.

Important:

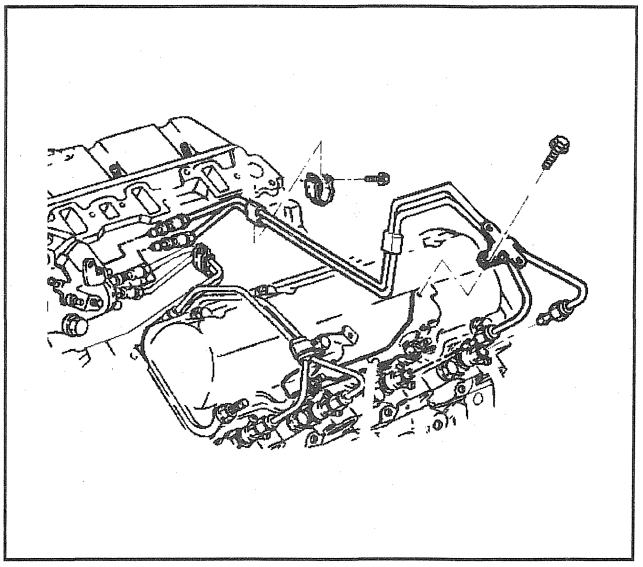
- Uncap the injection lines before assembly.
- Install the injection lines in the correct position.
- Do not bend the injection lines.

9. Install the injection lines to the nozzles.

   Tighten

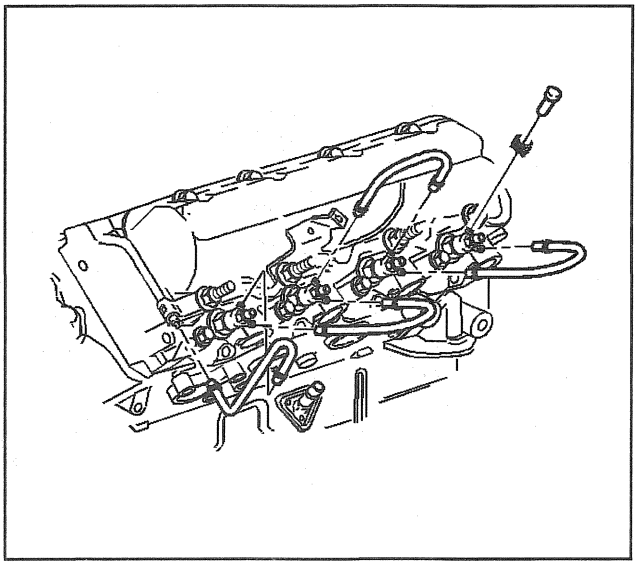
   Tighten the injection line fittings to 36 N·m (28 lb ft).

10. Install the injection line clips to the brackets.



66573

11. Install the fuel inlet line to the fuel injection pump.
12. Install the fuel return hose to the fuel injection pump.
13. Install the fuel return line brackets on the front left and the front right side rocker covers.
14. Install the fuel return hoses at the injector nozzles.
15. Install the clamps.



59763

Water Pump Installation

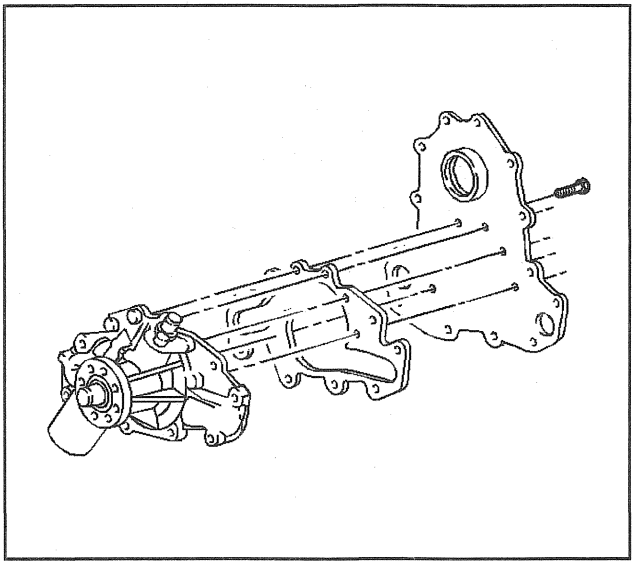
1. Clean the sealing surfaces on the water pump plate and the block.
2. Install the water pump and the gasket to the water pump plate.
3. Apply high temperature thread adhesive GM P/N 12345493, or equivalent, to the bolt threads.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

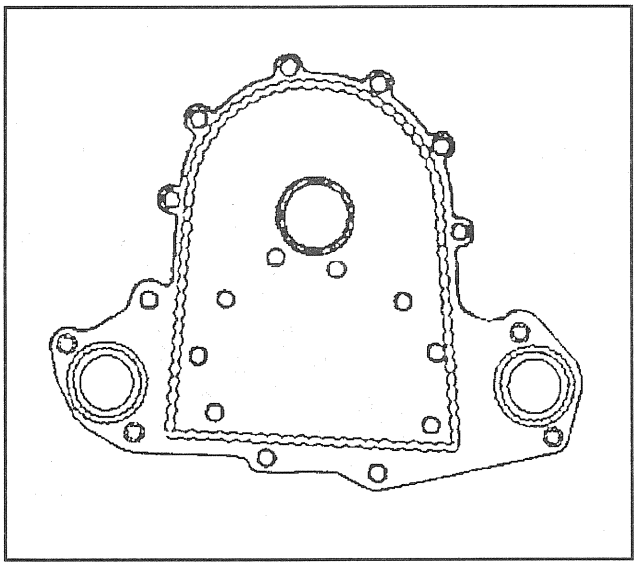
4. Install the bolts.

   Tighten

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

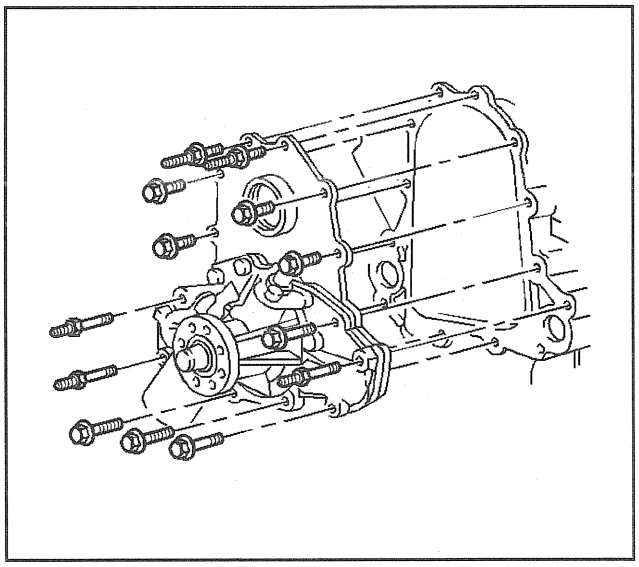


59828



66579

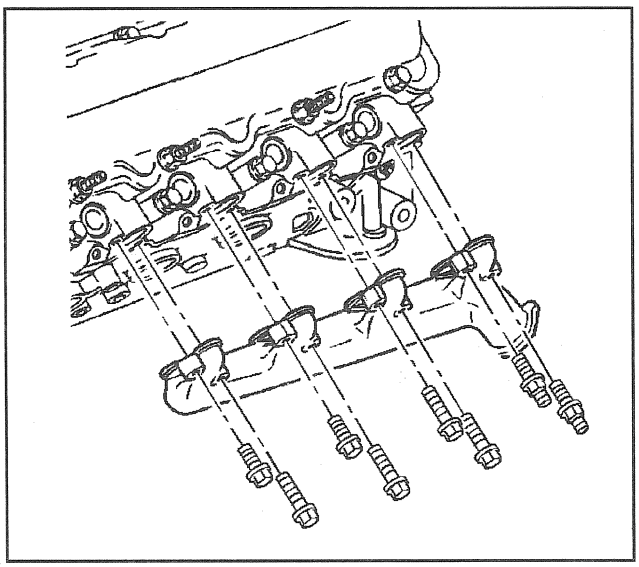
5. Apply a bead of anaerobic sealer GM P/N 1052942 or the equivalent to the water pump plate.



59826

6. 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.
7. 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).



60243

Exhaust Manifold Installation (L65)

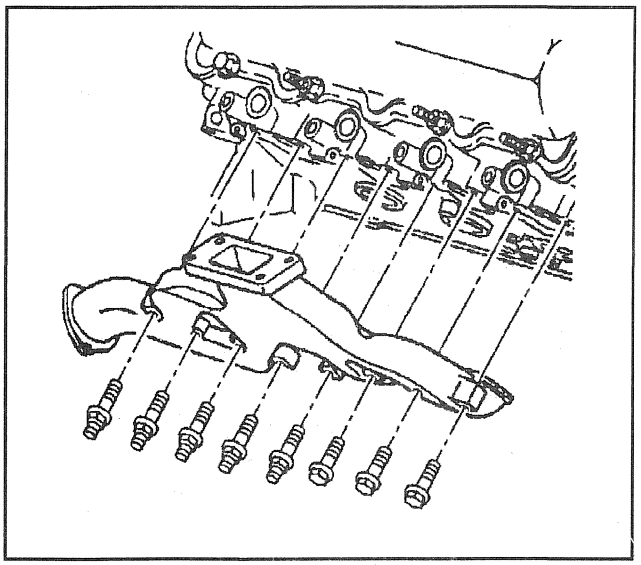
Notice: Refer to *Fastener Notice* in Cautions And Notices.

1. Install the left exhaust manifold and the bolts.

   Tighten

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

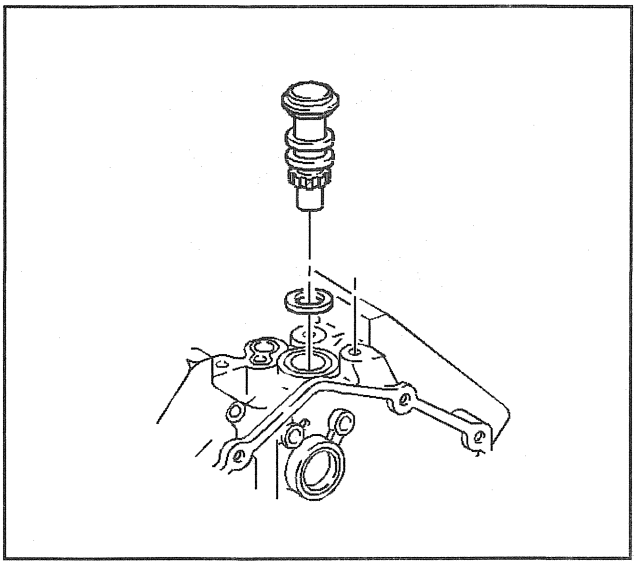
2. Install the right exhaust manifold and the bolts.
   Tighten
   Tighten the bolts to 35 N·m (26 lb ft).



66575

Oil Pump Drive Installation

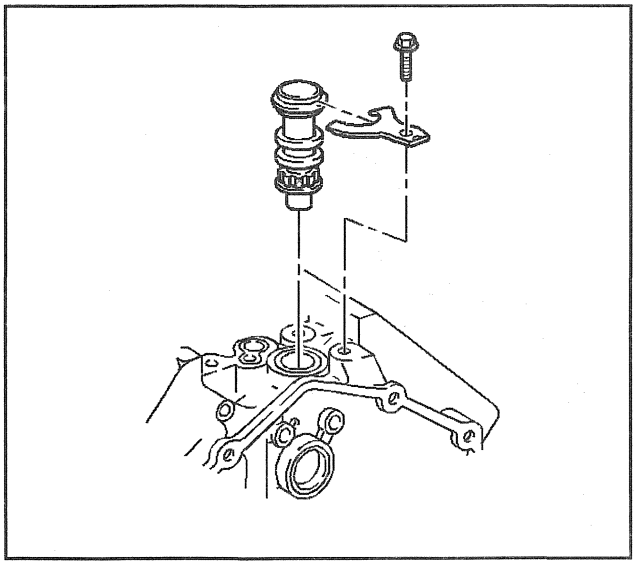
1. Install the new gasket to the oil pump drive.
2. Install the oil pump drive to the engine.
   - Index the drive with the camshaft gear and the oil pump drive shaft.
   - Make sure the drive seats fully.



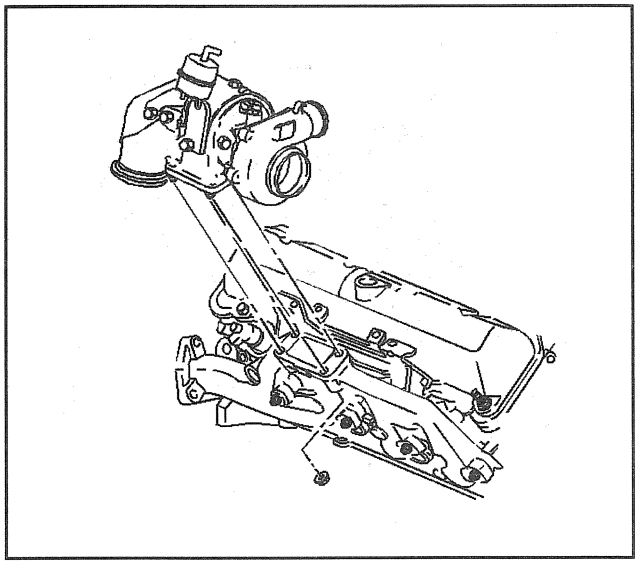
59768

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the clamp and the bolt.
   Tighten
   Tighten the bolt to 42 N·m (31 lb ft).



59765



59756

Turbocharger Installation

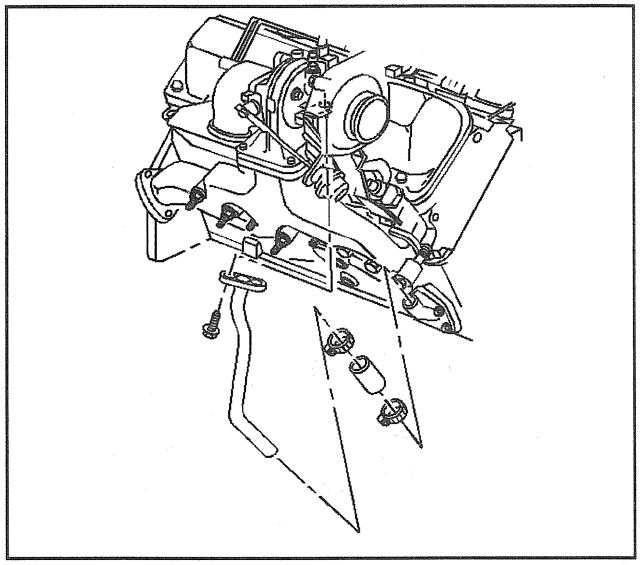
1. Install the turbocharger on the exhaust manifold and the studs.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the nuts to the exhaust manifold.

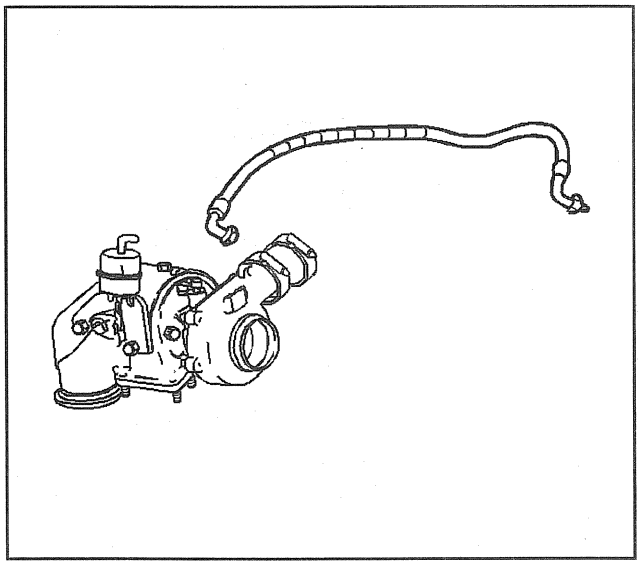
   Tighten

   Tighten the exhaust manifold mounting nuts to 58 N·m (43 lb ft).



59755

3. Install the gasket on the oil return pipe.



59754

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 28 N·m (21 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.

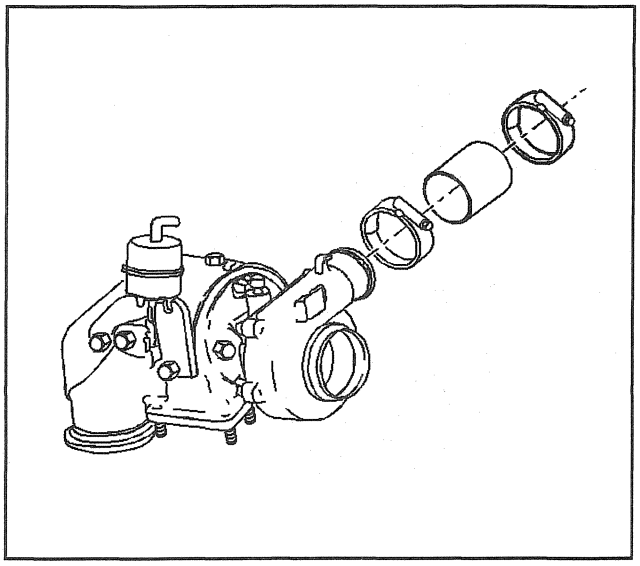
   Tighten

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

8. Install the long and the short turbocharger braces.

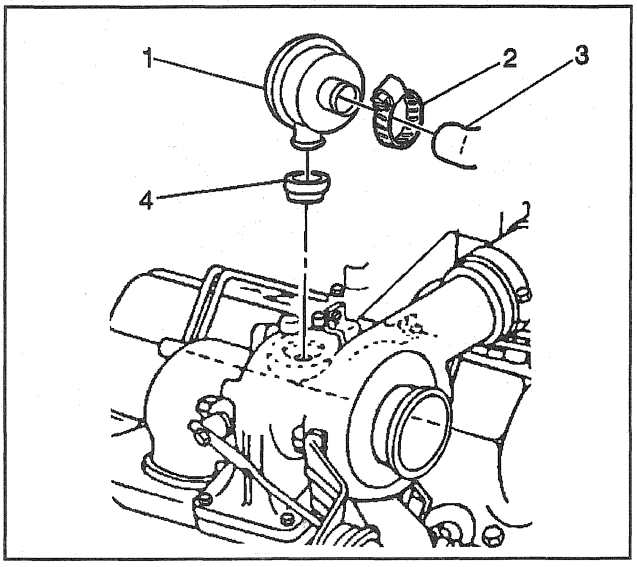
   Tighten

   - 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).



59746

9. Install the grommet (4) in the valve rocker arm cover.
10. Install the CDR (Crankcase Depression Regulator) assembly (1) in the valve rocker arm cover.



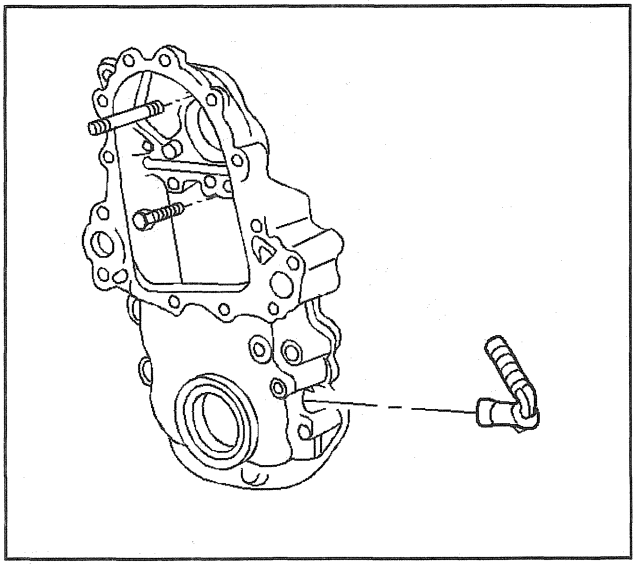
25616

Engine Wiring Harness Assembly Installation

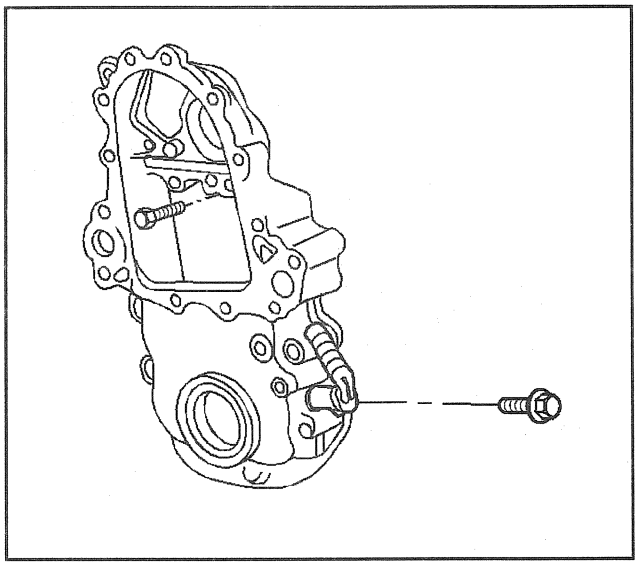
Tools Required

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

1. Install the crankshaft position sensor in the front cover (if equipped).



59862



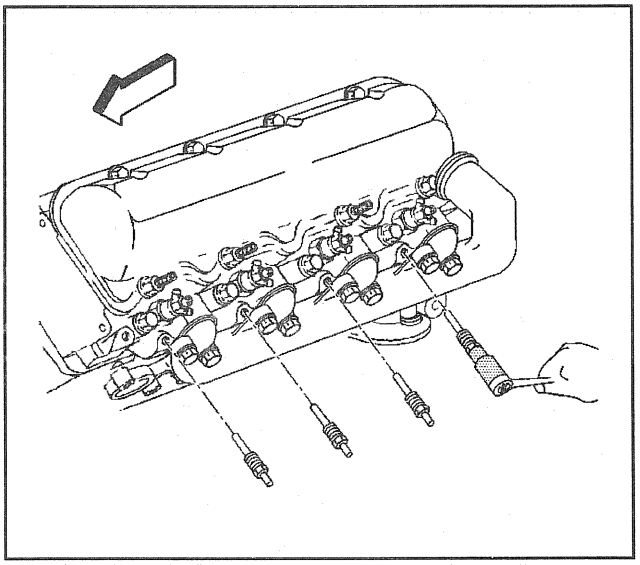
59857

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the crankshaft position sensor bolt (if equipped).

   Tighten

   Tighten the crankshaft position sensor bolt to 23 N·m (17 lb ft) (if equipped).

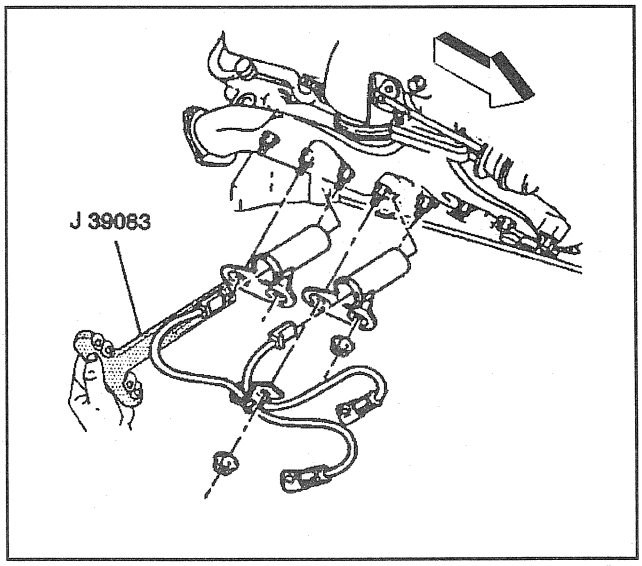


65002

3. Install the glow plugs using the *J 41515-A*

   Tighten

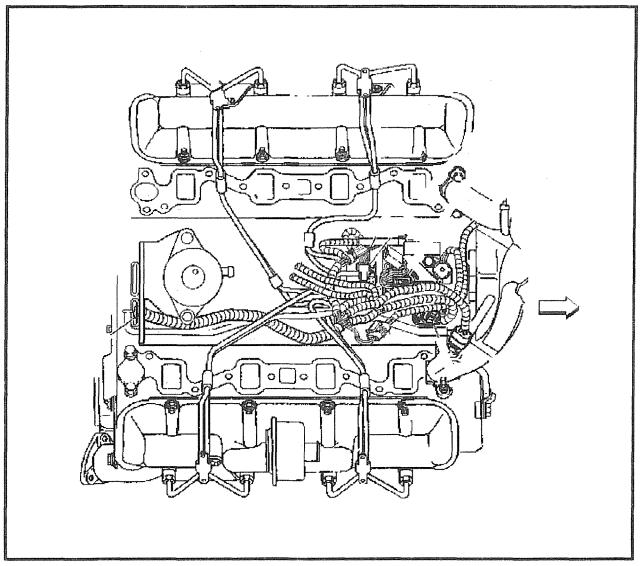
   Tighten the glow plugs to 22 N·m (16 lb ft).



70255

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

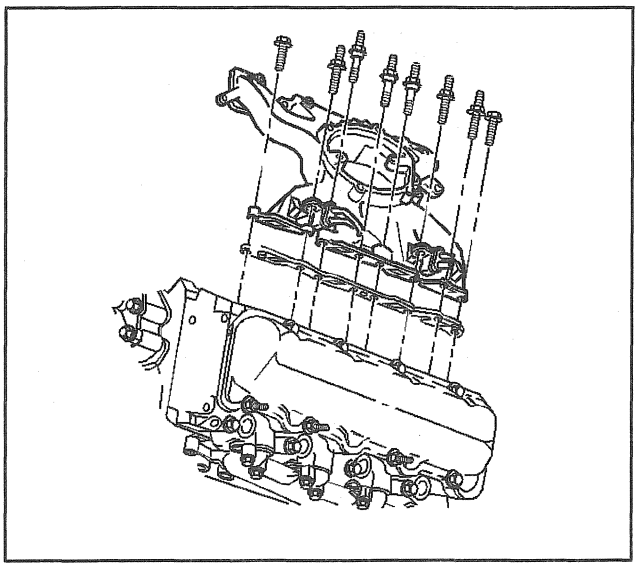
6. Place the harness in the engine valley.
7. Plug in or connect all the wiring harness connectors to devices or attachment points.



64989

Intake Manifold Installation (L57, L65)

1. Install the intake manifold and gaskets.



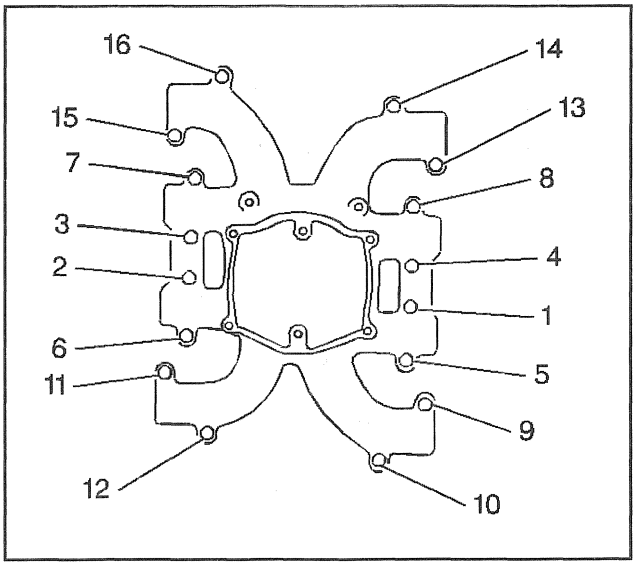
59835

Notice: Refer to *Fastener Notice* in Cautions and Notices.

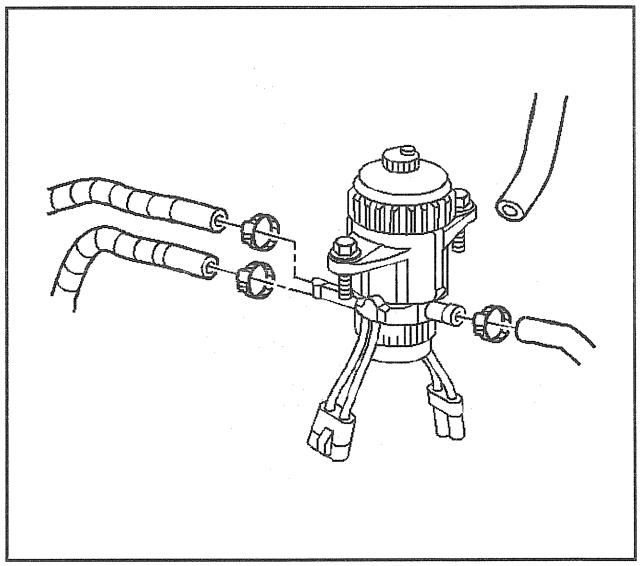
2. Install the intake manifold bolts/studs and fuel line clips.
   - Use teflon sealer to seal the four bolts, numbers 9, 11, 13, and 15 that are exposed to the crankcase.
   - Apply threadlocker GM P/N 12345493 to the threads of the bolts and the studs that are not numbered 9, 11, 13, or 15.

     Tighten

     Tighten the intake manifold bolts/studs, in sequence, to 42 N·m (31 lb ft).

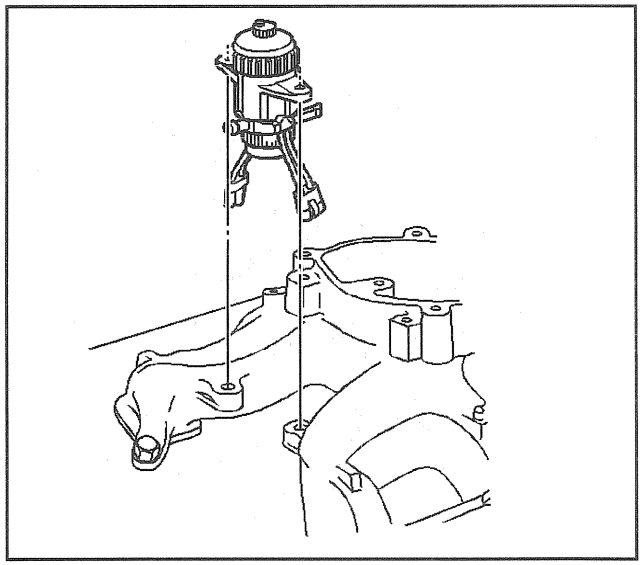


59761



59758

3. Install the hoses and the clamps to the fuel filter assembly.



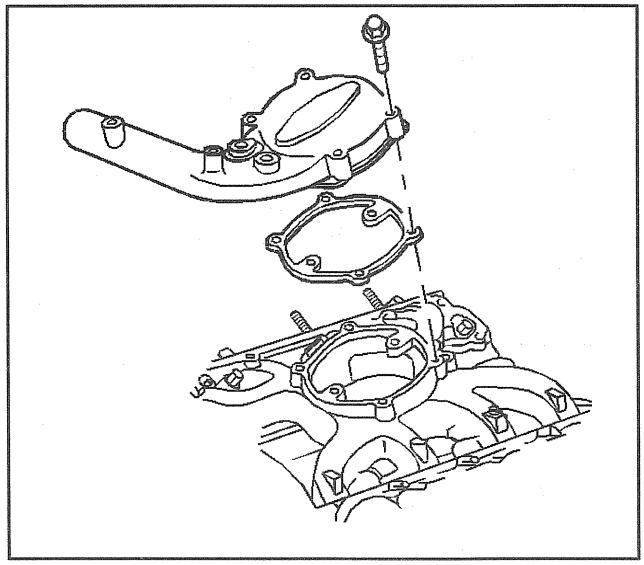
59759

4. Install the fuel filter assembly and the engine wiring harness bracket.

   Tighten

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

5. If equipped, install the upper intake manifold. Refer to *Intake Manifold Installation (Upper-L65)*



59749

Intake Manifold Installation (Upper-L65)

1. Apply the silicone sealant GM P/N 9985943, or equivalent to the turbocharger outlet.
2. Install the intake manifold gasket.
3. Slide the intake into the turbocharger outlet hose.
4. Install the intake manifold.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the intake manifold bolts.

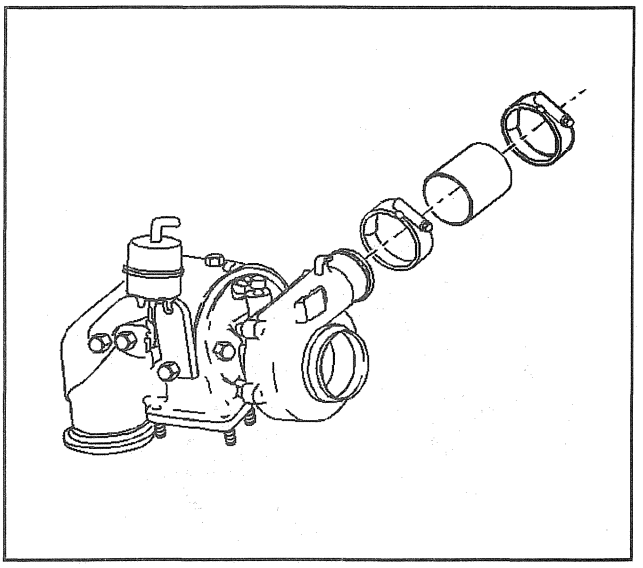
   Tighten

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

6. Install the clamp for the turbocharger connector hose.

   Tighten

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



59746

Intake Manifold Installation (Upper-L56)

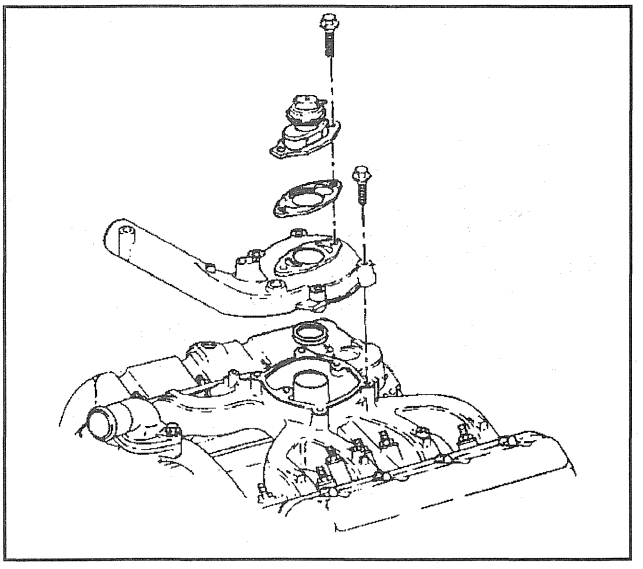
1. Apply the silicone sealant GM P/N 9985943, or equivalent to the turbocharger outlet.
2. Install the EGR tower gasket on the round center portion of the intake manifold.
3. Install the intake manifold gasket.
4. Slide the intake into the turbocharger outlet hose.
5. Install the intake manifold.
6. Install the EGR gasket and valve.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

7. Install the intake manifold bolts.

   Tighten

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

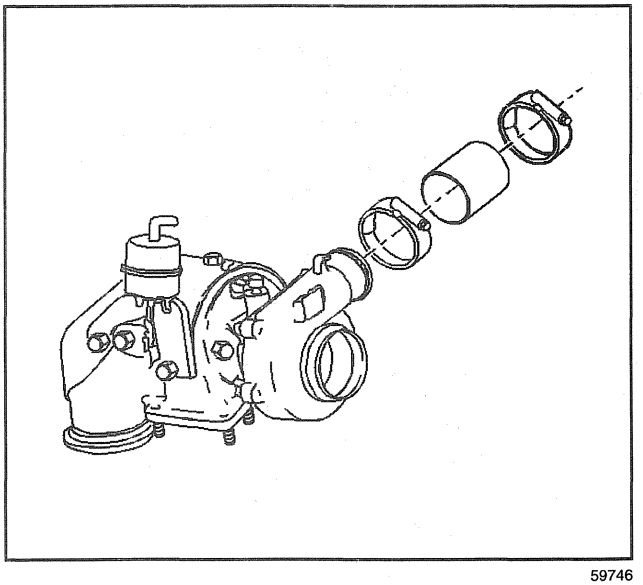


59748

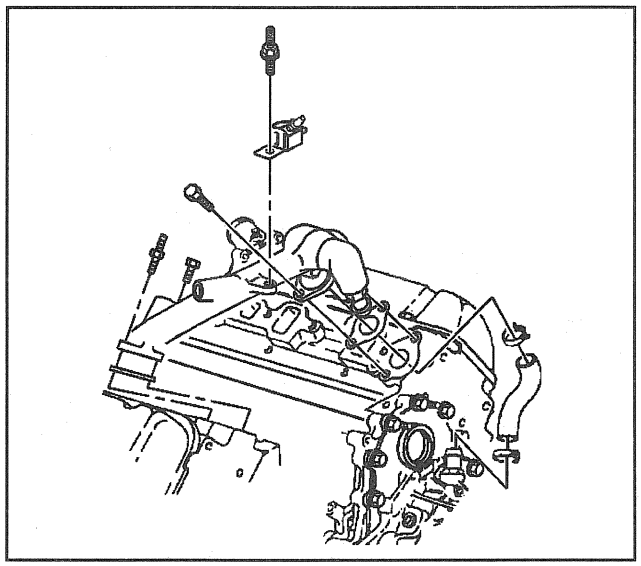
8. Install the clamp for the turbocharger connector hose.

   Tighten

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



59746



66572

Thermostat Installation (L56, L65, L65-CMT)

1. Install the thermostat bypass connector.
2. Install the thermostat bypass hose and clamps.
3. Install the thermostat housing and gaskets.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

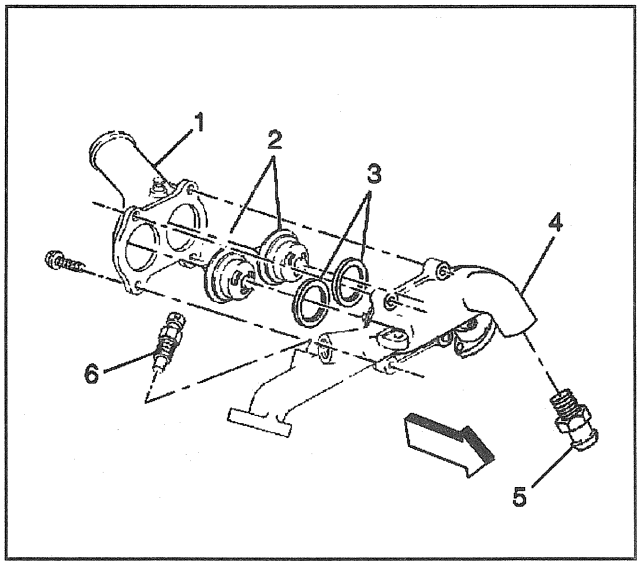
4. Install the bolts and stud/nut.

   Tighten

   Tighten the bolts and the stud/nut to 42 N·m (31 lb ft).
5. Install the engine coolant temperature (ECT) sensor.
6. Install the fuel bleed valve and nut.

   Tighten

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

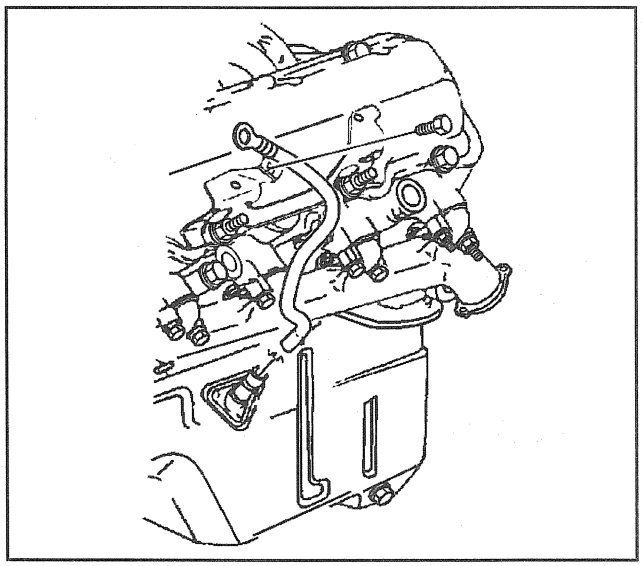


64991

7. 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 water outlet.
8. Install the thermostats in the thermostat housing.
9. Install the water outlet.
10. Install the bolts/studs.

    Tighten

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



60238

Oil Level Indicator and Tube Installation

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

   Install the oil level indicator tube to the engine.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

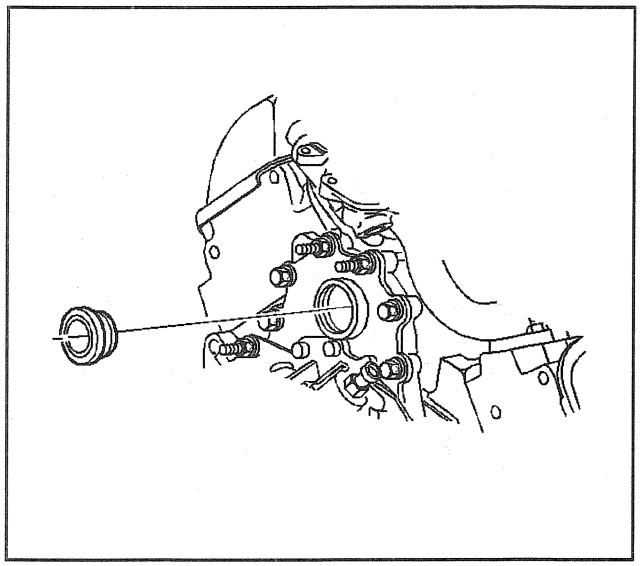
2. Install the oil level indicator tube bracket bolt.

   Tighten

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

Oil Fill Tube Installation

1. Install the oil fill tube grommet to the front cover.



59776

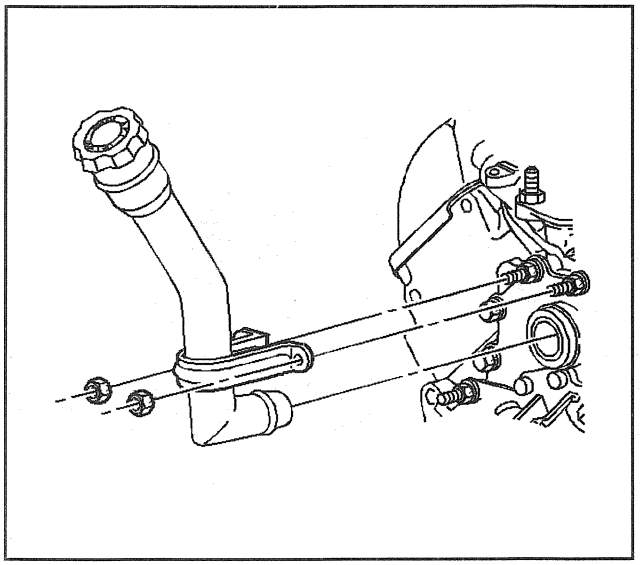
2. Install the oil fill tube to the front cover.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the oil fill tube retaining nuts to the front cover.

   Tighten

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



59772

Engine Flywheel Installation

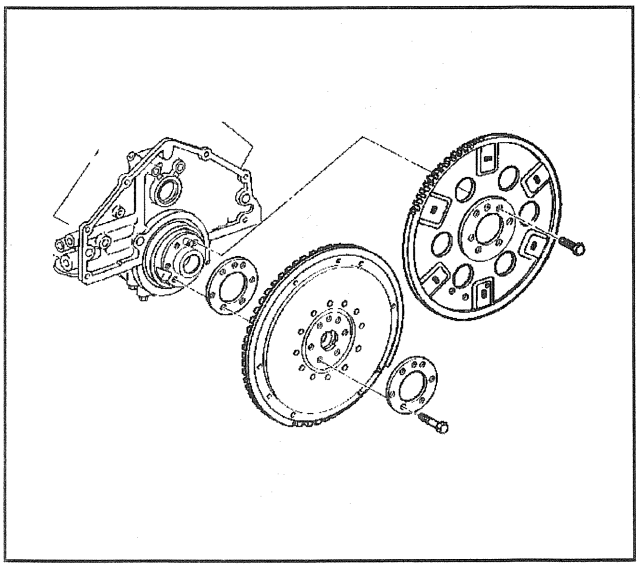
1. Install the inner retainer (if equipped).
2. Install the flywheel.
3. Install the outer retainer (if equipped).

Notice: Refer to *Fastener Notice* in Cautions and Notices.

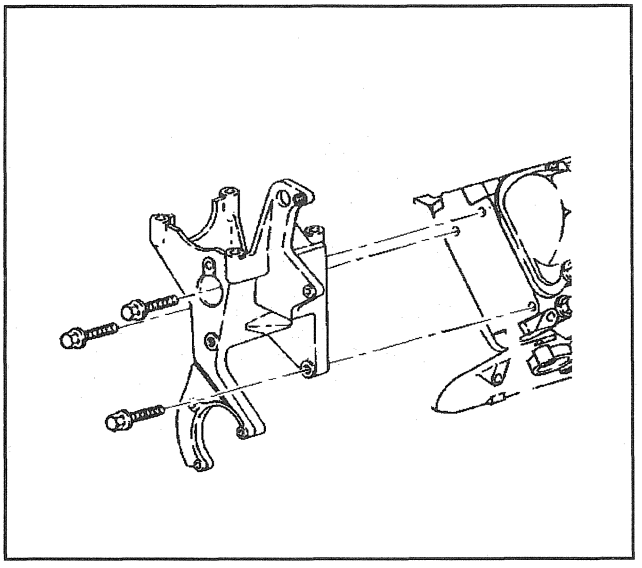
4. Install the flywheel bolts.

   Tighten

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



64987



59794

Accessory Installation

1. Install the left accessory/lift bracket.

Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the left accessory/lift bracket retaining bolts.

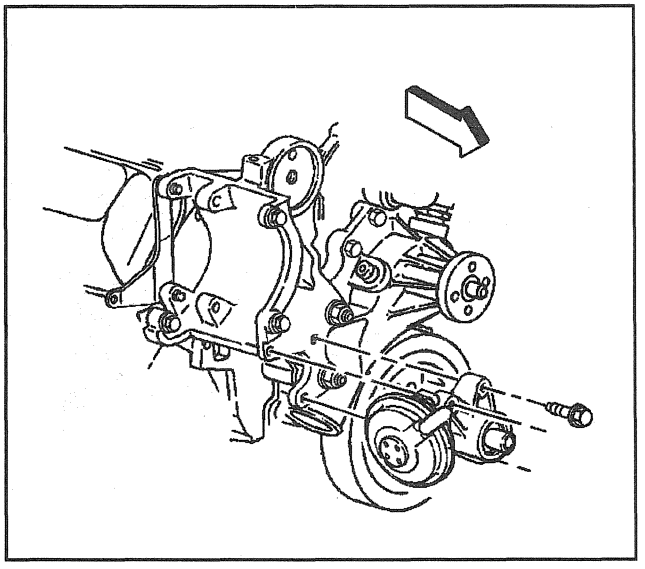
   Tighten

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

3. Install the left accessory/lift bracket retaining nut (if equipped).

   Tighten

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



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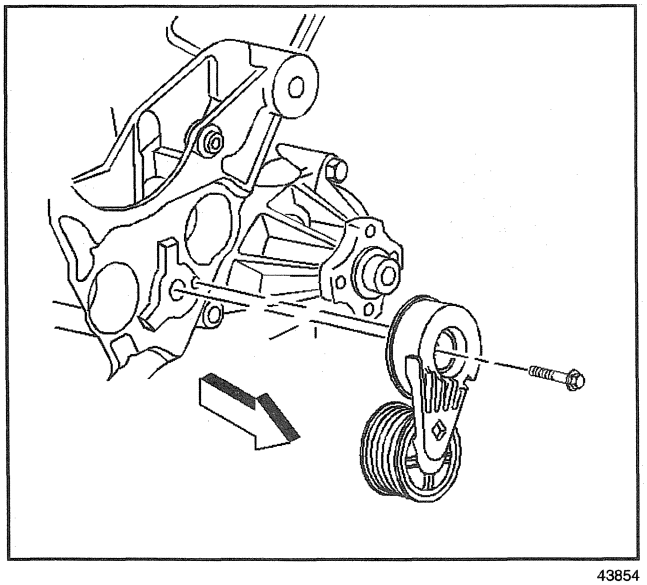
4. Install the vacuum pump.
5. Install the vacuum pump retaining bolts.

   Tighten

   Tighten the bolts to 25 N·m (19 lb ft).



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6. Install the drive belt tensioner.
7. Install the drive belt tensioner retaining bolt.

   Tighten

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

Engine Set-Up and Testing

After overhaul, the engine must be tested before it is installed in the vehicle. If a suitable test stand is not available, the following procedure can be used after the engine is installed in the vehicle.

1. Lubricate the oil filter rubber seal with clean engine oil.
2. Install the oil filter.
3. Fill the crankcase with the proper quantity and grade of oil.
4. Fill the coolant system with the proper coolant. Refer to Engine Cooling.
   - Whenever the cooling system is serviced or drained for service procedures, two cooling system sealing pellets, GM P/N 3634621 or equivalent, must be added to the cooling system.
   - Cooling system sealing pellets must be crushed prior to installation. The cooling system sealing pellets must be added to the radiator or the pressurized coolant reservoir.
   - Do not place the cooling system sealing pellets into a non-pressurized coolant recovery reservoir. On these systems, the pellets must be added to the radiator.
   - The sealant pellets may leave a film on the sides of the pressurized and non-pressurized coolant recovery reservoirs. This film is normal.
5. Bar the engine over several times. Feel for any evidence that any of the parts are binding.
6. Start and idle the engine. Listen for unusual noises.
7. Operate the engine at about 1,000 RPM until the engine is at operating temperature.
8. Listen for improperly adjusted valves or sticking valves, and other unusual noises.
9. Check for oil and coolant leaks while the engine is running.
10. Adjust timing. Refer to Engine Controls.

Description and Operation

Engine Component Description

Cylinder Block

The engine block is made of cast iron and it has eight cylinders arranged in a V shape, with four cylinders in each bank. The engine block is a one piece casting with the cylinders encircled by coolant jackets.

Cylinder Head

The cylinder heads are made of cast iron. They have parent metal intake and exhaust valve guides, and parent metal intake and exhaust valve seats. The intake and exhaust valve seats are induction hardened for durability. Pre-combustion chambers manufactured from NIMONIC-80 (a high strength, heat resistant alloy) are located with each set of intake/exhaust valves. Glow plugs are located between each set of intake/exhaust valves, in the side of the cylinder head, protruding in to the pre-combustion chamber.

Camshaft

A steel camshaft is supported by five bearings pressed into the engine block. The camshaft sprocket is mounted to the front of the camshaft and is driven by the crankshaft sprocket through a timing chain. Motion from the camshaft is transmitted to the valves by hydraulic roller-type hydraulic valve lifters, valve pushrods, shaft-mounted rocker arms. The valve guides are integral to the cylinder head. A spiral drive gear machined into the camshaft near the rear journal operates the oil pump drive assembly.

Crankshaft

The crankshaft is made of cast nodular iron, with fillet ground main bearing journals. The crankshaft is supported by five precision fit crankshaft bearings, retained by the crankshaft bearing caps. The crankshaft bearing caps are machined with the engine block for proper alignment and clearance. The crankshaft bearing caps are retained by four bolts each. The number three crankshaft bearing at the center of the engine block is the thrust bearing. The four connecting rod journals (two rods per journal) are spaced 90 degrees apart. The crankshaft position sensor reluctor ring has four lugs used for crankshaft timing, and is integral to the crankshaft sprocket.

Pistons and Connecting Rods

The pistons are cast aluminum alloy that use two compression rings and one oil control ring assembly. The piston pins are full floating in the pistons and in the connecting rods, with spring steel retainers at each end of the piston pin bore. The connecting rods are forged steel and have precision insert type crankpin bearings.

Valve Train

The valve train is a shaft-mounted rocker arm type. Motion is transmitted from the camshaft through hydraulic roller-type valve lifters, and tubular valve pushrods, to the valve rocker arms. The valve rocker arm pivots on a shaft in order to open the valve. The hydraulic roller-type valve lifters keep all parts of the valve train in constant contact. Each valve lifter act as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment. The valve rocker arms are located and retained by nylon retainers press fit to the valve rocker arm shaft, and by the valve rocker arm shaft retaining bolts. The valve rocker arm shaft retaining bolts are installed into the cylinder head.

Intake Manifold

The intake manifold is a two-piece design. Both the upper and lower portions are made of cast aluminum. A linear exhaust gas recirculation (EGR) port is cast into the upper and lower intake manifold for exhaust gas recirculation mixture (L56 only). The EGR valve bolts into the upper intake manifold (L56 only). A Manifold Absolute Pressure (MAP) sensor is mounted at the front of the upper intake manifold and sealed by an O-ring seal.

Exhaust Manifold

The two exhaust manifolds are constructed of cast iron. The exhaust manifolds direct exhaust gases from the combustion chambers to the turbocharger.

Turbocharger

The turbocharger is used to increase the amount of air that enters the engine's cylinders. The increase of air allows a proportional increase of fuel that is injected into the cylinders. The results are:

- Increased power output.
- More complete combustion of the fuel.
- Cooling of the cylinder heads, the pistons, the valves, and the exhaust gas. This cooling effect helps extend engine life.

Engine exhaust gas is directed to the turbine housing. The turbine housing acts as a nozzle to direct the exhaust gas flow to the turbine wheel blades, where heat energy and pressure from the exhaust gas drives the turbine wheel. The turbine wheel is attached to the shaft assembly along with the compressor wheel, which rotates at the same speed as the turbine wheel. Clean air from the air cleaner, and crankcase vapors from the Crankcase Depression Regulator (CDR) Valve, are drawn into the compressor housing. The air is compressed by the compressor wheel blades and delivered to the engine upper intake manifold. The inside of the turbocharger compressor housing, the compressor wheel, and the inside of the intake manifold can be very oily (wet) due to the crankcase vapors — THIS IS NORMAL.

A vacuum–operated wastegate regulator valve in the turbocharger exhaust housing regulates the flow of exhaust gasses, and the amount of boost delivered to the engine by the turbocharger. The wastegate regulator valve is controlled by the PCM, which monitors turbocharger boost pressure, engine RPM, vehicle load and power requirements. Vacuum is applied to the regulator valve to close the wastegate as increased boost is required. Vacuum is removed from the regulator valve to open the wastegate when increased boost is no longer required.

Vacuum Pump

The belt driven vacuum pump provides vacuum for the operation of the turbocharger wastegate and the Exhaust Gas Recirculation (EGR) valve (L56 only). The vacuum pump does not require periodic maintenance, and is serviced by replacement.

New Product Information

The purpose of New Product Information is to highlight or indicate important product changes from the previous model year.

Changes may include one or more of the following items:

- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisons
- New special tools required
- A component comparison from the previous year

Torque Values and/or Fastener Tightening Strategies

- Cylinder head bolt torque has been changed. Refer to *Fastener Tightening Specifications.*
- Crankshaft bearing cap bolt torque has been changed. Refer to *Fastener Tightening Specifications.*
- Valve lifter guide plate torque has been changed. Refer to *Fastener Tightening Specifications.*
- Valve rocker arm cover torque has been changed. Refer to *Fastener Tightening Specifications.*
- Turbocharger oil feed hose fitting torque has been changed. Refer to *Fastener Tightening Specifications.*

Changed Engine Specifciations

- Piston bore clearance and ring gaps have been changed. Refer to Engine Mechanical Specifications.
- Case, camshaft, camshaft journal, and camshaft bearing diameters have been changed. Refer to Engine Mechanical Specifications.

Disassembly and Assembly Procedure Revisions

- Cylinder head bolt torquing sequence has been changed.

  Refer to *Cylinder Head Installation.*
- Crankshaft bearing cap bolt torquing sequence has been changed. Refer to Crankshaft and Bearings Installation.

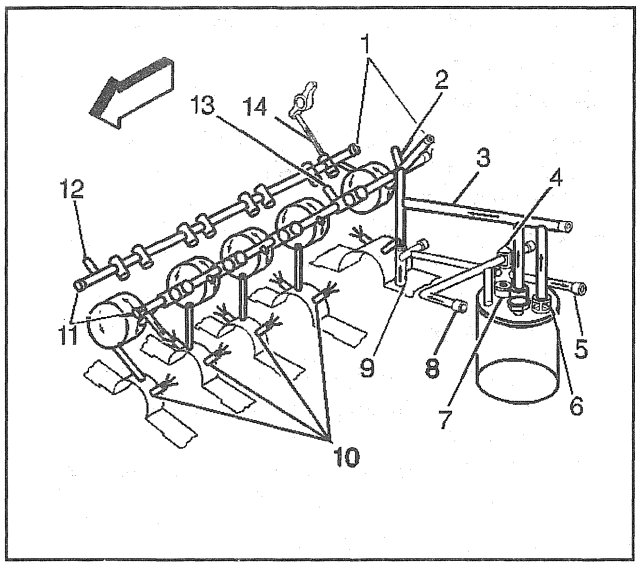
A Component Comparison from the Previous Year

- The number one compression (fire) ring material has been changed to moly carbide to increase durability.
- The intermediate (2, 3, and 4) crankshaft bearing cap outer bolts have been changed to 10mm. The outer (1 and 5) crankshaft bearing cap outer bolts and all of the crankshaft bearing cap inner bolts remain 12mm.
- The oil level indicator has been changed to commonize it with other GM products.

Engine Identification

The 6.5L V-8 diesel engine identification is located at the top left rear of the engine block.

Lubrication



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Legend

(1) Threaded Oil Gallery Plug
(2) Center Mount Turbocharger Oil Feed
(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
(13) To Oil Pressure Sensor
(14) Push Rod Oil Passage To Valve Train

A gear-type oil pump with an enclosed pressure regulator pressurizes the lubrication oil distribution system. The oil pump uses a 552 kPa (80 psi) pressure regulator spring. Bronze bushings in the oil pump drive/driven gears, and a steel base plate, support the oil pump drive/driven gear shafts. The oil pump is driven by the oil pump drive, which, in turn, is driven by the camshaft. The oil pump draws unpressurized oil through a pickup screen and pipe that are submerged in oil inside the oil pan. The oil flows from the oil pump to an oil cooler, located by the radiator, that cools the oil. The oil cooler is protected from high operating pressure (normally seen only during cold ambient temperature conditions) by the oil cooler bypass valve. The oil cooler bypass valve is located in the engine block oil gallery to oil cooler passage (behind the oil filter or oil filter adapter assembly). The oil flows from the oil cooler or from the oil cooler bypass valve to a full-flow oil filter. The engine is protected from operating without lubrication (due to a clogged filter) by the oil filter bypass valve. The oil filter bypass valve is located in the engine block oil gallery to oil filter passage (behind the oil filter or oil filter adapter assembly).

The oil flows from the oil filter or the oil filter 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. 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.

Thread Repair

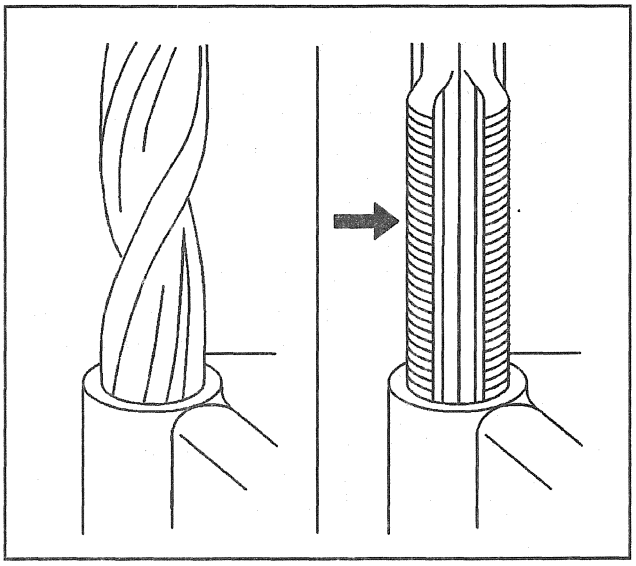
Tools Required

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.



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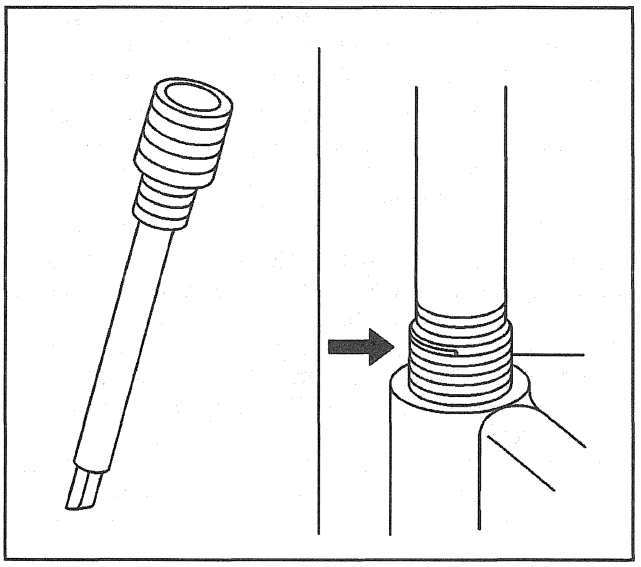
1. Determine the size, the pitch, and the depth of the damaged thread. If necessary, adjust the stop collars on the cutting tool and tap to the required depth.
2. Drill out the damaged thread. Clean out any chips.
3. Tap the hole. Lubricate the tap with light engine oil. Clean the thread.



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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.

Cleanliness and Care

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly.

  Refer to *Separating Parts*.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Replacing Engine Gaskets

Gasket Reuse and Applying Sealants

Tools Required

J 28410 Gasket Remover

- Do not reuse any gasket unless 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.

Separating Components

- 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.

Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the *J 28410* or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - 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.

Assembling Components

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

Use of RTV and Anaerobic Sealer

The following 2 types of sealer are commonly used in engines:

- The RTV sealer
- The anaerobic gasket eliminator sealer

Follow the service procedure instructions. Use the correct sealer in the proper place in order to prevent oil leaks. Do not interchange the 2 types of sealers. Use the sealer recommended in the service procedure.

Applying RTV Sealer

- Do not use the room temperature vulcanizing (RTV) sealant in areas where extreme temperatures are expected. These areas include the following locations:
  - The exhaust manifold
  - The head gasket
  - The other surfaces where gasket eliminator is specified
- Use a rubber mallet in order to separate the components sealed with RTV sealant. Bump the part sideways in order to shear the RTV sealer. Perform the bumping at the bends or the reinforced areas in order to prevent distortion of the components. The RTV sealant is weaker in shear (lateral) strength than in tensile (vertical) strength.

Important: Do not use any other method or technique in order to remove the gasket material from a component.

- Do not use the following items in order to clean the gasket surfaces:
  - Abrasive pads
  - Sand Paper
  - Power tools

These methods of cleaning may damage the part.

Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may cause internal engine damage.

- Remove all of the gasket material from the component using a plastic or a wood scraper. Use Loctite® brand gasket remover P/N 4MA or the equivalent. Follow all of the safety recommendations and the directions that are on the container.

Important: Do not allow the sealer to enter the blind threaded holes. The sealer may cause the following conditions:

  - Prevent you from properly seating the bolt
  - Cause damage when you tighten the bolt

- Apply the RTV sealant to a clean surface. Use a bead size as specified in the procedure. Apply the bead to the inside of any bolt holes.
- Assemble the components while the RTV sealant is still wet (within 3 minutes). Do not wait for the RTV sealant to skin over.

Important: Do not overtighten the bolts.

- Tighten the bolts to specifications.

Applying Anaerobic Sealer

The anaerobic gasket eliminator hardens in the absence of air. This type of sealer is used where 2 rigid parts (such as castings) are assembled together. When 2 rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.

Important: Do not use any other method or technique in order to remove the gasket material from a component.

Do not use the following items in order to clean the gasket surfaces:

- Abrasive pads
- Sand paper
- Power tools

These methods of cleaning may damage the part.

Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may cause internal engine damage.

- Remove all of the gasket material from the component using a plastic or a wood scraper. Use Loctite® brand gasket remover P/N 4MA or the equivalent. Follow all of the safety recommendations and the directions that are on the container.
- Apply a continuous bead of the gasket eliminator to 1 flange. Clean and dry any surfaces that you will reseal.

Important: Anaerobic sealed joints that are partially torqued and allowed to cure more than 5 minutes may result in incorrect shimming and sealing of the joint.

- Do not allow the sealer to enter the blind threaded holes. The sealer may cause the following conditions:
  - Prevent you from properly seating the bolt
  - Cause damage when you tighten the bolt
- Spread the sealer evenly in order to get a uniform coating on the sealing surface.
- Tighten the bolts to the specifications.
- Remove the excess sealer from the outside of the joint.

Separating Parts

Important: Many internal engine components will develop specific wear patterns on their friction surfaces.

When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure reinstallation to their original location and position.

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to the crankshaft journal
- Connecting rod to the bearing cap

  A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.
- Crankshaft main and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, guides, pushrods, pivot supports and rocker arms
- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

Tools and Equipment

Use a clean, well lit work area. Other necessary equipment includes the following items:

- Suitable parts cleaning tank
- Compressed air supply
- Trays — to keep parts and fasteners organized
- Adequate set of hand tools.

Use an approved engine repair stand in order to prevent personal injury or damage to engine components.

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

Inspection of certain critical components require precision measuring tools. Torque wrenches are necessary in order to correctly tighten various fasteners. Those fasteners will be called out within this section.

Special Tools and Equipment

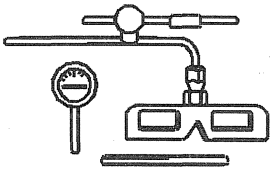
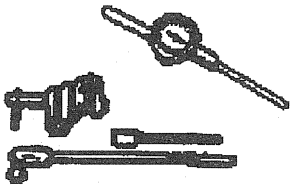
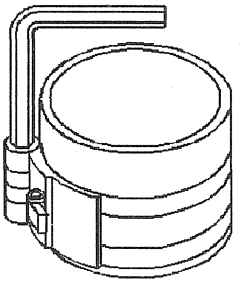
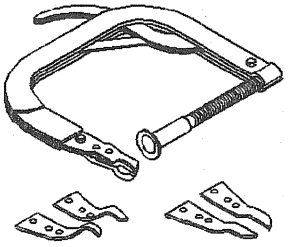
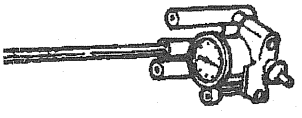
Illustration	Tool Number/ Description
 35463	J 7872 Magnetic Base Dial Indicator
 4996	J 8001 Dial Indicator
 3403	J 8037 Ring Compressor
 3414	J 8062 Valve Spring Compressor
 4990	J 8087 Cylinder Bore Gauge

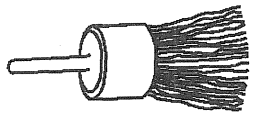
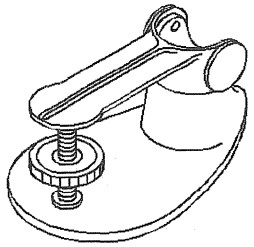
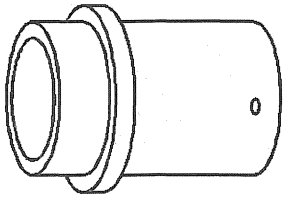
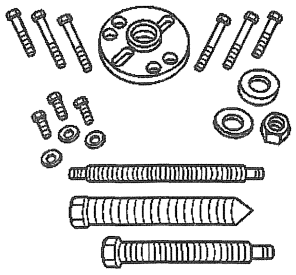
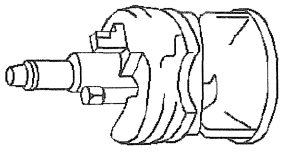
Illustration	Tool Number/ Description
 4994	J 8089 Wire Brush
 5112	J 9666 Valve Spring Tester
 60198	J 22102 Front Crankshaft Seal Installer
 66168	J 23523-F Crankshaft Balancer Remover and Installer
 3412	J 24270 Ridge Reamer

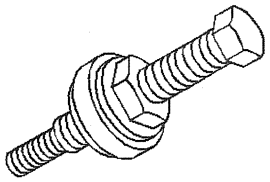
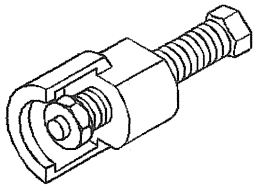
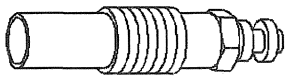
Illustration	Tool Number/ Description
 676	J 25033-B Power Steering Pump Pulley Installer
 675	J 25034-B Power Steering Pump Pulley Remover
 67301	J 26999 Compression Gauge
 66108	J 26999-10 Compression Gauge Adapter
 66109	J 26999-30 Compression Gauge Adapter

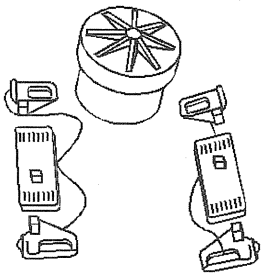
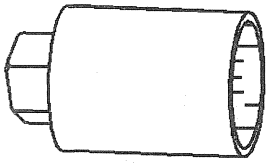
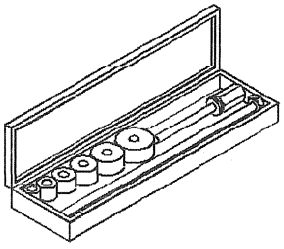
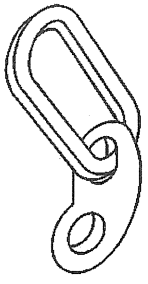
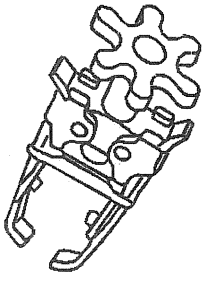
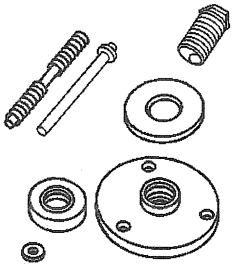
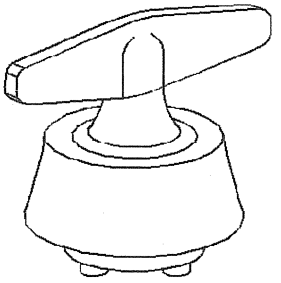
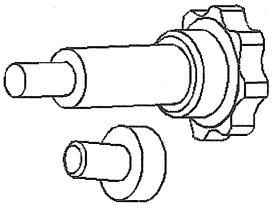
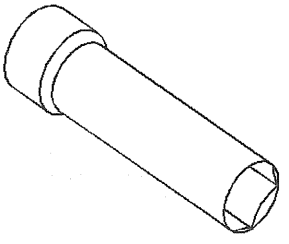
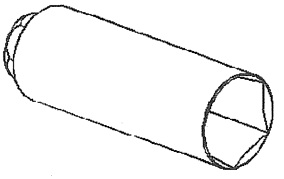
Illustration	Tool Number/ Description
 60215	J 29664 Manifold Cover Set
 60216	J 29873 Nozzle Socket
 5118	J 33049 Universal Camshaft Bearing Removal /Installer Set
 68653	J 36857 Universal Lift Bracket
 49850	J 38606 Valve Spring Compressor

Illustration	Tool Number/ Description
 3398	J 39046 Crankshaft Balancer Remover/Installer
 57458	J 39084 Rear Main Seal Installer
 60212	J 39507 Piston Pin Retainer Ring Installer
 66593	J 41515-A Glow Plug Socket
 67136	J 41712 Oil Pressure Sending Unit Socket