

Engine Mechanical - 3.8L

Specifications

Fastener Tightening Specifications

Application	Specifications	
	Metric	English
Accelerator Control Cable Bracket Bolt	10 N·m	89 lb in
Balance Shaft Gear Bolt	22 + 70° N·m	16 + 70° lb ft
Balance Shaft Retainer Bolt	30 N·m	22 lb ft
Camshaft Position Sensor Bolt	10 N·m	89 lb in
Camshaft Sprocket Bolt	100 + 90° N·m	74 + 90° lb ft
Camshaft Thrust Plate Bolt	15 N·m	11 lb ft
Connecting Rod Cap Bolt	27 + 50° N·m	20 + 50° lb ft
Crankshaft Balancer Bolt	150 + 114° N·m	111 + 114° lb ft
Crankshaft Main Bearing Cap Bolt	40 + 110° N·m	30 + 110° lb ft
Crankshaft Main Bearing Cap Bolt (Side)	15 + 45° N·m	11 + 45° lb ft
Crankshaft Position Sensor Stud	30 N·m	22 lb ft
Crankshaft Rear Oil Seal Housing Bolt	15 + 50° N·m	11 + 50° lb ft
Cylinder Head Bolt	50 + 120° N·m	37 + 120° lb ft
Drive Belt Tensioner Bracket Bolt	50 N·m	37 lb ft
EGR Valve Adapter Nut	50 N·m	37 lb ft
EGR Valve Nut	29 N·m	21 lb ft
EGR Valve Outlet Pipe Bolt/Nut (Except Upper Intake Manifold)	29 N·m	21 lb ft
EGR Valve Wiring Harness Heat Shield Bolt/Nut	10 N·m	89 lb in
Engine Block Coolant Drain Plug	18 N·m	13 lb ft
Engine Coolant Temperature Sensor	25 N·m	18 lb ft
Engine Flywheel Bolt (New)	15 + 50° N·m	11 + 50° lb ft
Engine Front Cover Bolt/Stud	20 + 40° N·m	15 + 40° lb ft
Engine Lift Bracket Bolt/Nut/Stud	30 N·m	22 lb ft
Engine Mount Bracket Bolt	102 N·m	75 lb ft
Engine Mount Nut, Lower	43 N·m	32 lb ft
Engine Mount Nut, Upper	47 N·m	35 lb ft
Engine Mount Strut Bolt	48 N·m	35 lb ft
Engine Mount Strut Bracket Bolt at Engine, Left	50 N·m	37 lb ft
Engine Mount Strut Bracket Bolt at Engine, Right	50 N·m	37 lb ft
Engine Mount Strut Bracket Bolt at Upper Radiator Support	28 N·m	21 lb ft
Engine Mount Strut Nut	48 N·m	35 lb ft
Engine Oil Gallery Plug	30 N·m	22 lb ft
Exhaust Manifold Nut	23 N·m	17 lb ft
Exhaust Manifold Bolt/Stud	23 N·m	17 lb ft
Fuel Injector Rail Assembly Nut	9 N·m	80 lb in
Fuel Injector Rail Stud	25 N·m	18 lb ft
Fuel Injector Sight Shield Bracket Nut	30 N·m	22 lb ft
Generator Brace Bracket Bolt	50 N·m	37 lb ft
Heated Oxygen Sensor	42 N·m	31 lb ft
ICM Bracket Stud	30 N·m	22 lb ft
ICM Assembly Bolt/Nut	50 N·m	37 lb ft
Lower Intake Manifold Bolt	15 N·m	11 lb ft
MAP Sensor Bracket Bolt	30 N·m	22 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specifications	
	Metric	English
MAP Sensor Bolt	3 N·m	27 lb in
Oil Cooler Adapter Connector	50 N·m	37 lb ft
Oil Filter Adapter Bolt	15 N·m + 50°	11 lb ft + 50°
Oil Level Indicator Tube Nut	19 N·m	14 lb ft
Oil Pan Bolt	14 N·m	125 lb in
Oil Pan Drain Plug	30 N·m	22 lb ft
Oil Pump Cover Screw	11 N·m	98 lb in
Oil Pump Screen Bolt	15 N·m	11 lb ft
Power Brake Booster Heat Shield Nut	20 N·m	15 lb ft
Side Main Cap Bolt	15 + 45° N·m	11 + 45° lb ft
Starter Motor Heat Shield Bolt	30 N·m	22 lb ft
Throttle Body Bolt/Nut	10 N·m	89 lb in
Throttle Body Support Bolt	10 N·m	89 lb in
Timing Chain Dampener Bolt	22 N·m	16 lb ft
Upper Intake Manifold Bolt	Refer to Procedure	
Valve Lifter Guide Retainer Bolt	30 N·m	22 lb ft
Valve Rocker Arm Bolt	15 + 90° N·m	11 + 90° lb ft
Valve Rocker Arm Cover Bolt	10 N·m	89 lb in
Water Outlet Bolt	27 N·m	20 lb ft
Water Pump Bolt	15 + 80° N·m	11 + 80° lb ft
Water Pump Pulley Bolt	13 N·m	116 lb in

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
Engine Type	90° V-6	
Displacement	231 cu in	
Liter (VIN)	3.8L (K)	
RPO	L36	
Bore	96.52 mm	3.8 in
Stroke	86.36 mm	3.4 in
Compression Ratio	9.4:1	
Firing Order	1-6-5-4-3-2	
Lubrication System		
Oil Capacity with Oil Filter Change	4.25 L	4.5 qt
Oil Capacity without Oil Filter Change	3.75 L	4 qt
Oil Pressure @ Operating Temperature (1850 RPM) Using 10W-30 Oil	414 kPa	60 psi min
Oil Filter Type	Throw Away Element and Can	
Gear Pocket Depth	11.71-11.75 mm	0.461-0.4625 in
Gear Pocket Diameter	89.10-89.20 mm	3.508-3.512 in
Inner Gear Tip Clearance	0.152 mm	0.006 in
Outer Gear Diameter Clearance	0.203-0.381 mm	0.008-0.015 in
End Clearance	0.025-0.089 mm	0.001-0.0035 in
Valve-to-Bore Clearance	0.038-0.076 mm	0.0015-0.003 in

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Type of Lubrication		
Main Bearings	Pressure	
Connecting Rods	Pressure	
Piston Pins	Splash	
Balance Shaft Bearing - Front	Splash	
Balance Shaft Bushing - Rear	Pressure	
Camshaft Bearings	Pressure	
Timing Chain	Splash	
Cylinder Walls	Splash	
Oil Pump Type	Gerotor	
Oil Pressure Sending Unit	Electrical	
Oil Intake	Stationary	
Oil Filter System	Full Flow	
Cylinder Bore		
Diameter	96.5 mm	3.8 in
Out-Of-Round Maximum	0.0254 mm	0.001 in
Taper	0.0254 mm	0.001 in
Piston		
Used Piston Clearance (41 mm from Top of Piston)	0.050-0.091 mm	0.0020-0.0036 in
New Piston Clearance (41 mm from Top of Piston)	0.010-0.051 mm	0.0004-0.0020 in
Piston Ring Groove Depth		
Top Compression	4.019-4.146 mm	0.158-0.163 in
2nd Compression	4.214-4.341 mm	0.166-0.171 in
Oil Control	3.814-3.941 mm	0.150-0.155 in
Piston Ring End Gap		
Top Compression	0.25-0.46 mm	0.010-0.018 in
2nd Compression	0.58-0.84 mm	0.023-0.033 in
Oil Control	0.254-0.762 mm	0.010-0.030 in
Piston Ring Side Clearance		
Top Compression	0.033-0.079 mm	0.0013-0.0031 in
2nd Compression	0.033-0.079 mm	0.0013-0.0031 in
Oil Control	0.023-0.201 mm	0.0009-0.0079 in
Piston Ring Width		
Top Compression	1.176-1.197 mm	0.0463-0.0471
2nd Compression	1.476-1.497 mm	0.0581-0.0589
Oil Control	1.854-2.007 mm	0.073-0.079
Piston Pin		
Diameter	21.9950-22.0000 mm	0.8659-0.8661 in
Clearance in Piston	0.0020-0.0130 mm	0.00008-0.00051 in
Fit-In-Rod (Clearance)	0.0066-0.0217 mm	0.0003-0.0009 in
Crankshaft		
Main Journal Diameter-All	63.470-63.495 mm	2.4988-2.4998 in
Rod Journal Diameter-All	57.1170-57.1475 mm	2.2487-2.2499 in
Main Journal Taper-Maximum	0.00889 mm	0.00035 in
Rod Journal Taper-Maximum	0.00889 mm	0.00035 in
Main Journal Out-of-Round-Maximum	0.00635 mm	0.00025 in
Rod Journal Out-of-Round-Maximum	0.00508 mm	0.00020 in

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Main Bearing To Journal Clearance 1	0.0178-0.0406 mm	0.0007-0.0016 in
Main Bearing To Journal Clearance 2, 3, and 4	0.0229-0.0457 mm	0.0009-0.0018 in
Rod Bearing Clearance	0.0127-0.0660 mm	0.0005-0.0026 in
Crankshaft End Play	0.076-0.276 mm	0.003-0.011 in
Connecting Rod		
Rod Side Clearance	0.102-0.508 mm	0.004-0.0200 in
Connecting Rod Large End Bore ID	60.295-60.312 mm	2.37378-2.3745 in
Camshaft		
Journal Diameter	47.655-46.858 mm	1.8462-1.8448 in
Bearing Inside Diameter 1 and 4	46.970-46.934 mm	1.8428-1.8492 in
Bearing Inside Diameter 2 and 3	46.977-46.942 mm	1.8481-1.8495 in
Bearing-to-Journal Clearance	0.041-0.119 mm	0.0016-0.0047 in
Intake Maximum Lobe Lift	6.55 mm	0.258 in
Exhaust Maximum Lobe Lift	6.48 mm	0.255 in
Balance Shaft		
End Play	0.0-0.171 mm	0.0-0.0067 in
Rear Journal Diameter	38.085-38.105 mm	1.4994-1.5002 in
Radial Play-Front, Bearing Clearance	0.0-0.026 mm	0.0-0.0010 in
Rear Bearing To Journal Clearance	0.0127-0.109 mm	0.0005-0.0043 in
Drive Gear Lash	0.050-0.125 mm	0.002-0.0049 in
Bearing Bore Diameter-Front	51.973-51.999 mm	2.0462-2.0472 in
Bearing Bore Diameter-Rear, In Block	47.584-47.612 mm	1.8735-1.8745 in
Bearing Inside Diameter-Rear	38.118-38.194 mm	1.5007-1.5037 in
Valve System		
Lifter	Hydraulic	
Rocker Arm Ratio	1.6:1	
Face Angle	45°	
Seat Angle	45°	
Minimum Margin	0.635 mm	0.025 in
Seat Runout-Maximum	0.050 mm	0.002 in
Seat Width-Intake	1.53-2.03 mm	0.060-0.080 in
Seat Width-Exhaust	2.29-2.79 mm	0.090-0.110 in
Stem Height-All	49.15-50.17 mm	1.935-1.975 in
Stem Clearance-All	0.038-0.089 mm	0.0015-0.0032 in
Valve Spring		
Free Length	49.78 mm	1.960 in
Load-Closed	334 N @ 43.69 mm	75 lb @ 1.72 in
Load-Open	1014 N @ 32.4 mm	228 lb @ 1.277 in
Installed Height	42.93-44.45 mm	1.690-1.720 in
Approximate Number of Active Coils	4.48	
Approximate Number of Total Coils	6.60	
Flywheel		
Runout-Maximum	0.38 mm	0.015 in

GM SPO Group Numbers

Application	GM SPO Group Number
Automatic Transmission Engine Flywheel	0.666
Camshaft Bearing	0.539
Camshaft Timing Chain	0.724
Connecting Rod	0.603
Connecting Rod Bearing Kit	0.616
Crankshaft Balancer	0.659
Crankshaft Bearing Kit	0.096
Cylinder Head	0.269
Cylinder Head Gasket	N.S.
EGR Valve Gasket	3.680
Engine Block	N.S.
Engine Camshaft	0.519
Engine Cooling Manifold	1.097
Engine Cooling Manifold Gasket	1.097
Engine Cooling Thermostat	1.246
Engine Crankshaft	0.646
Engine Front Cover	0.206
Engine Front Cover Gasket	0.207
Exhaust Manifold	3.601
Exhaust Manifold Gasket	3.270
Intake Manifold	3.265
Intake Manifold Gasket	N.S.
Oil Filter	1.836
Oil Filter Adapter	1.840
Oil Filter Adapter Gasket	1.840
Oil Level Indicator	1.516
Oil Level Indicator Tube	1.516
Oil Pan Kit with Gasket	1.429
Oil Pan Reinforcement	1.426
Oil Pump Screen	1.656
Oil Pump Screen Gasket	1.657
Oil Pump Cover	1.723
Piston with Pin	0.629
Piston with Ring Kit	0.643
Spark Plug	2.270
Throttle Body	3.335
Throttle Body Gasket	3.336
Valve Lifter	0.459
Valve Lifter Guide	0.439
Valve Pushrod	0.426
Valve Rocker Arm Cover	0.386
Valve Rocker Arm Cover Gasket	0.423
Valve Spring	0.303
Water Pump Gasket	1.079
Water Pump Kit	1.069
Water Pump with Gasket	1.069

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number
Accelerator Control Cable Bracket Bolt Threads	Threadlock	12345382
Coolant Temperature Sensor Threads	Sealant	12346004
Crankshaft Position Sensor Bolt/Stud Threads	Threadlock	12345382
Crankshaft Side Main Bolt Threads	Threadlock	12345493
Engine Block Coolant Drain Plug Threads	Sealant	12346004
Engine Block Oil Gallery Plug Threads	Sealant	12346004
Engine Front Cover Bolt Threads	Sealant	12346004
Engine Oil	Oil-10W-30	12345616
Engine Oil Supplement	Lubricant	1052368
Exhaust Manifold Bolt and Stud Threads	Threadlock	12345493
Intake Manifold Bolt Threads (Lower)	Threadlock	12345382
Intake Manifold Coolant Pipe	Sealant	12345493
Intake Manifold to Engine Block Mating Surface	Sealant	12346286
Knock Sensor Threads	Sealant	12346004
Oil Filter Bypass Hole Plug Threads	Sealant	12346004
Oil Pan Bolt Threads	Threadlock	12345382
Oil Pressure Switch Threads	Sealant	12346004
Piston and Piston Pin	Oil-10W-30	12345616
Rear Crankshaft Main Bearing Cap	Sealant	1052942
Valve Lifter and Camshaft Prelube	Lubricant	12345501
Valve Rocker Arm Cover Bolt Threads	Threadlock	12345382
Valve Rocker Arm Bolt Threads	Threadlock	12345493

Diagnostic Information and Procedures

Base Engine Misfire Diagnosis

Checks	Action
Engine performance diagnosis procedures are covered in Engine Controls and should be consulted for diagnosis of any Driveability, Emissions, or Malfunctioning Indicator Lamp (MIL) concerns. The following diagnosis covers common concerns and possible causes. When the proper diagnosis is made, the concern should be corrected by adjustment, repair or replacement as required. Refer to the appropriate section of the service manual for each specific procedure. This diagnostic table will assist in engine misfire diagnosis due to a mechanical concern such as a faulty engine camshaft, worn or damaged bearings or bent valve pushrod. This table will not isolate a crossed fuel injector wire, faulty fuel injector or any other driveability component failure that may cause a misfire. The Powertrain On-Board Diagnostic System checks must be performed first. When using this table to make a Base Engine Misfire diagnosis, begin with the preliminary information below and then proceed to the specific category.	
Preliminary	1. Perform DTC P0300 before proceeding with Base Engine Misfire Diagnosis information. DTC P0300 will assist in determining which cylinder or cylinders are misfiring. 2. Perform a visual inspection of the following: • A loose or improperly installed engine flywheel or crankshaft balancer • Worn, damaged or misaligned accessory drive system components 3. Listen to the engine for any abnormal internal engine noises. 4. Inspect the engine for acceptable oil pressure. 5. Verify if the engine has excessive oil consumption. 6. Verify if the engine has excessive coolant consumption. 7. Perform a compression test on the engine.
Intake Manifold Leaks	An intake manifold that has a vacuum leak may cause a misfire. Inspect for the following: • Improperly installed or damaged vacuum hoses • Faulty or improperly installed lower intake manifold and/or gaskets • Cracked or damaged lower intake manifold • Improperly installed MAP sensor. The sealing grommet of the MAP sensor should not be torn or damaged • Improperly installed throttle body or damaged gasket • Warped intake manifold • Warped or damaged cylinder head sealing surface
Coolant Consumption	Coolant consumption may or may not cause the engine to overheat. Inspect for the following: • External coolant leaks • Faulty cylinder head gasket • Warped cylinder head • Cracked cylinder head • Damaged engine block

Base Engine Misfire Diagnosis (cont'd)

Checks	Action
Oil Consumption	Oil consumption may or may not cause the engine to misfire. 1. Remove the spark plugs and inspect for an oil fouled spark plug. 2. Perform a cylinder compression test. 3. If the compression test indicates worn valves or valve guides, inspect the following: • Worn, brittle, or improperly installed valve stem oil seals • Worn valve guides • Worn valve stems • Worn or burnt valves or valve seats 4. If the compression test indicates worn or damaged piston rings, inspect the following: • Broken or improperly seated piston rings • Excessive piston ring end gap • Excessive cylinder bore wear or taper • Cylinder damage • Piston damage
Abnormal Internal Engine Noises	1. Start the engine and determine if the noise is timed to the engine camshaft speed or the crankshaft speed. 2. Using a timing light, two knocks per flash is the crankshaft speed and one knock per flash is the engine camshaft speed. 3. If the noise is timed to the engine camshaft speed, inspect the following: • Missing or loose valve train components • Worn or loose valve rocker arms • Worn or bent valve pushrods • Faulty valve springs • Bent or burnt valves • Worn engine camshaft lobes • Worn or damaged camshaft timing chain and/or sprockets Important: A slight COLD knock or piston slapping noise could be considered normal if not present after the engine has reached normal operating temperatures. 4. If the knock is timed to the crankshaft speed, inspect the following: • Worn crankshaft or connecting rod bearings • Piston or cylinder damage • Worn piston or piston pin • Faulty connecting rod • Excessive carbon build-up on the top of the piston
No Abnormal Internal Engine Noise	1. Inspect for a worn or improperly installed camshaft timing chain and/or sprockets. 2. Remove the valve rocker arm cover on the side of the engine with the cylinder that is misfiring. 3. Inspect for the following: • Loose valve rocker arm studs • Bent valve push rods • Faulty valve springs • Faulty valve lifters (bleeding down) • Worn or improperly seated valves • Worn engine camshaft lobes

Engine Compression Test

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all the spark plugs.
5. Turn the ignition to the ON position.
6. Depress the accelerator pedal to position the throttle plate wide open.
7. Start with the compression gauge at zero and crank the engine through four compression strokes (four puffs).
8. Check the compression for each cylinder. Record the readings.
9. If a cylinder has low compression, inject approximately 15 ml (one tablespoon) of engine oil into the combustion chamber through the spark plug hole. Recheck the compression and record the reading.
10. The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). ($1\ 035 \times 70\% = 725$) ($150 \times 70\% = 105$).
 - Normal — Compression builds up quickly and evenly to the specified compression for each cylinder.
 - Piston Rings Leaking — Compression is low on the first stroke. Then compression builds up with the following strokes but does not reach normal. Compression improves considerably when you add oil.
 - Valves Leaking — Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
 - If two adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the cylinders.

Engine Noise Diagnosis (Base Engine)

Notice: Some engine noise is characteristic to the design. Compare the sounds in other engines in order to make sure that you are not trying to correct a normal condition.

- There are four steps to diagnosing engine noise. They include:
 - The type of noise
 - Under which operating conditions it exists
 - At what rate in the engine
 - At what location in the engine

- Compare the sounds in other engines to ensure the noise is not a normal condition.
- Remember, engine noise is generally synchronized to either engine speed (caused by the crankshaft, connecting rods or pistons) or one-half engine speed (valve train noise). Try to determine the rate at which the noise is occurring.

Main Bearing Noise

- Damaged or worn main bearing noise is revealed by dull thuds or knocks which happen on every engine revolution. This noise is loudest when the engine is under heavy load.
- Excessive crankshaft end play is indicated by an intermittent rap or knock sharper than a worn main bearing.
- The following are causes of main bearing noise:
 - Low oil pump pressure
 - Thin, diluted, or dirty oil and/or filter
 - Excessive main bearing clearance
 - Excessive crankshaft end play
 - Out-of-round crankshaft journals
 - Loose crankshaft pulley
 - Loose flywheel or torque converter
 - Loose main bearing cap
 - Belt pilling

Connecting Rod Bearing Noise

A damaged or worn connecting rod bearing will produce a knock under all speeds. During the early stages of wear, connecting rod noise may be confused with piston slap or loose piston pins. Connecting rod knock noise increases in volume with engine speed and is at its loudest on deceleration.

The following are causes of connecting rod bearing noise:

- Excessive bearing clearance
- Worn crankshaft connecting rod journal
- Thin, diluted, or dirty oil and/or filter
- Low oil pressure
- Crankshaft connecting rod journals out-of-round
- Misaligned connecting rod
- Connecting rod bolts not properly torqued
- The wrong bearing inserts or misaligned bearing half

Timing Gear or Chain and Sprocket Noise

Engines designed with timing gears, or those equipped with a timing chain and sprockets, can produce different noise. The most common noise is a high frequency, light-knocking sound. This sound will generally be the same in intensity whether the engine is idling, operating at high speeds, or under load.

The following are causes of timing gear or chain and sprocket noise:

- Worn timing chain and/or gears
- Misaligned gears
- Excessive backlash
- A damaged tooth
- Gear or sprocket loose on the shaft
- Too much end play in the camshaft or crankshaft

Loose or improperly seated camshaft timing gears are usually loudest when warm. They are speed sensitive only. They are not load sensitive.

Cam gear noise will usually be evident at a warm idle in neutral and sounds much like a loose timing chain.

Piston Noise

Piston pin, piston, and connecting rod noise are hard to separate. A loose piston pin, for example, causes a sharp double knock usually heard when the engine is idling, or during sudden acceleration then deceleration of the engine. A piston pin that has been improperly fitted will emit a light ticking noise that is more noticeable with no load on the engine. Excessive piston-to-cylinder bore clearance will cause a piston slap noise. The noise is similar to a metallic knock, as if the piston were slapping the cylinder wall during its stroke. As with most engine noise, understanding the cause of the noise will help you imagine what the noise sounds like. An indication of piston slap is a decrease in noise as the engine warms up. When the engine is cold, the piston-to-bore clearance is greater and piston slap will be louder. The following are causes of piston noise:

- Worn or loose piston pin or bushing
- Improper pin fit
- Excessive piston-to-cylinder bore clearance
- Lack of lubrication
- Carbon deposits on top of the piston striking the cylinder head
- Worn or broken piston ring land
- Broken or cracked piston
- Misaligned connecting rods
- Worn or damaged rings
- Excessive ring land clearance
- Insufficient ring-end gap clearance
- Piston 180 degrees out of position
- Incorrect skirt profiles

Rattle (Balance Shaft)

Balance shaft rattle sounds like a tinny, chattery rattle or a knocking noise that seems to come from the top rear of the engine. This noise is most pronounced when the engine is hot, and is not affected by engine load. An example would be dirt lodged in the root between two gear teeth. Each time the root between two balance shaft gear teeth meshes with a cam gear tooth, the balance shaft is momentarily forced upward. This pivots the shaft through the front bearing, causing a downward force on the rear bearing that eventually wears the rear bearing, causing a rattle. The following are other factors that contribute to balance shaft bearing rattle:

- A tight link on the timing chain
- Damaged, broken, or dirty teeth on the balance shaft gears
- A worn timing chain tensioner
- Misaligned rear balance shaft bushing

Flywheel Noise

Notice: Converter bolts that are too long may dimple the torque converter clutch apply surface and cause a shudder condition.

A loose or cracked flywheel will produce an irregular thud or click. To test for a loose or cracked flywheel, operate the vehicle at approximately 32 km/h (20 mph) and shut off the engine. If a thud is heard, the flywheel may be loose or damaged. This type of thud is loudest on deceleration. Loose torque converter-to-flywheel or flywheel-to-crankshaft bolts will resemble a bearing knock. This condition produces several raps during quick acceleration on a free-running engine. Depending on the idle smoothness, when the transaxle is in gear, the noise may or may not appear. Check the torque converter-to-flywheel and the flywheel-to-crankshaft bolts before attempting to investigate any bearing-related knock.

Knocks Cold and Continues for 2 to 3 Minutes

Cold engine knock usually disappears when the specific cylinder secondary ignition circuit is grounded out. Cold engine piston knock which disappears in 1.5 minutes should be considered acceptable.

- Engine flywheel contacting the transmission converter cover — reposition the transmission converter cover.
- Loose or broken crankshaft balancer or the drive pulleys — tighten or replace the crankshaft balancer or the drive pulleys as necessary.
- Excessive piston-to-bore clearance — replace the piston.
- Bent connecting rod — replace the connecting rod.

Knocks at Idle Hot

- Inspect the drive belt for wear. Check the tension and/or replace as necessary.
- Inspect the A/C compressor or generator bearing. Replace or repair as necessary.
- Inspect the valve train. Replace the parts as necessary.
- Inspect for improper oil viscosity. Install the proper viscosity oil for the expected temperature. Refer to Maintenance and Lubrication for the engine oil specifications.
- Inspect for excessive piston pin clearance. Replace the piston and the pin as necessary.
- Inspect the connecting rod alignment. Check and replace the connecting rods as necessary.
- Inspect for insufficient piston-to-bore clearance. Hone the bore and fit the new piston.
- Inspect the crankshaft balancer for looseness. Tighten and/or replace the worn parts.
- Ensure that the piston pin is not offset to the wrong side. Properly install the piston.
- Ensure that the camshaft drive gear backlash is not excessive. The knock will also be heard on a cold engine.

Knocks on Start-Up but Only Lasts a Few Seconds

The following conditions may produce engine knocks on initial start-up, but only last a few seconds:

- Improper oil viscosity
 - Install the proper oil viscosity for the expected temperatures.
 - Refer to Maintenance and Lubrication.
- Lifter bleed down — clean, test, and replace the lifter as necessary.
 - When the engine is off, some valves will be open. Spring pressure against the lifters will tend to bleed the lifter down. Repair the lifter only if the problem is consistent.
 - Engines operated for only short periods between start-ups may have lifter noise that lasts for a few seconds. This is a normal condition.
- Excessive crankshaft end play — replace the crankshaft thrust bearing.
- Excessive front main bearing clearance — replace the worn parts.
- Timing chain tensioner malfunction — clean, inspect and, replace the timing chain tensioner, if required.

Heavy Knock Hot in Heavy Load Condition

- Broken crankshaft balancer or pulley hub — replace the parts as necessary.
- Loose torque converter bolts — tighten the bolts.
- The drive belt is too tight or nicked — replace the drive belt as necessary.
- The exhaust system is grounded — reposition the exhaust system components as necessary.

- The flywheel is cracked — replace the flywheel.
- Excessive crankshaft main bearing clearance — replace the crankshaft main bearings as necessary.
- Excessive connecting rod bearing clearance — replace the connecting rod bearings as necessary.

Light Knock Hot in Light Load Condition

Light knock hot may be caused by one or more of the following conditions:

- Loose torque converter bolts — tighten the torque converter bolts.
- Leak at the exhaust manifold — tighten the bolts and replace the exhaust manifold gasket if necessary.
- Excessive connecting rod bearing clearance — replace the connecting rod bearings as necessary.
- Detonation or spark knock, refer to Engine Controls.

Engine Noise Diagnosis (Valve Train)

A light tapping at one-half engine speed, or any varying frequency, can indicate a valve train problem. These tapping noises increase with the engine speed. Warm up the engine before attempting to judge the valve train noise. This will bring all of the engine components to a normal state of expansion. Run the engine at various speeds and listen for engine noise with the hood closed.

Caution: The following procedure is not recommended on engines with stainless steel exhaust manifolds because manifold temperature will exceed the flash point of the oil causing a fire with possible personal injury.

If the valve mechanism is abnormally noisy, remove the valve rocker arm covers and use a stethoscope to determine which valve train components are causing the noise. The causes of the valve noise include the following conditions:

- Broken or weak valve springs
- Sticking or warped valves
- Bent push rods
- Dirty, stuck, or worn valve lifters
- Damaged or improperly machined camshaft lobes
- Insufficient or poor oil supply to the valve train (low oil pressure)
- Excessive valve stem-to-guide clearance
- Worn valve guides
- Worn push rods
- Worn valve rocker arms
- Broken valve rocker arm bolt
- Loose or worn valve rocker arm attachments
- Missing or improperly positioned lifter guides (roller lifter engines)

Momentary Noise on Engine Startup

Step	Action	Value(s)	Yes	No
DEFINITION: Momentary noise when the engine is started, usually cold				
1	This condition is normal. Oil drains from the valve lifters which hold the valves open when the engine is not running. The valve lifter needs a few seconds to fill with oil after you start the engine. Does the noise continue after a few seconds?	—	Repair as required	No correction is needed

Intermittent Noise on Idle Only

Step	Action	Value(s)	Yes	No
DEFINITION: Intermittent noise on idle that disappears when engine speed increases				
1	1. Disassemble the valve lifters. 2. Check the valve lifters for any dirt. Check the valve lifters for a pitted or damaged check ball. Are the valve lifters dirty or damaged?	—	Replace the valve lifter	System OK

Noise at Idle

Step	Action	Value(s)	Yes	No
DEFINITION: Noise at idle or with hot oil that quiets at higher engine speeds or with cold oil				
1	Inspect the lifter for a high leakdown rate. Does the lifter have a high leakdown rate?	—	Replace the faulty lifter	No correction is needed

Noise at High Vehicle Speeds

Step	Action	Value(s)	Yes	No
DEFINITION: Noise at high RPM only				
1	Check for a high engine oil level. An oil level above the FULL mark allows the crankshaft counterweights to churn the oil into a foam. When the foam is pumped into the lifters, the lifters become noisy since a solid column of oil ensures the proper operation. Is the oil level too high?	—	Drain the oil to the proper level	Go to Step 2
2	Check for a low engine oil level. An oil level below the ADD mark allows the oil pump to pump air at high speeds. This causes noisy valve lifters. Is the oil level too low?	—	Add oil as required	Go to Step 3
3	Check the oil pan. Is the oil pan bent against the oil pump pickup?	—	Repair as required	Go to Step 4
4	Check the oil pump screen. Is the oil pump screen bent or loose?	—	Repair as required	System OK

Noise at Idle, Louder at High Engine Speed

Step	Action	Value(s)	Yes	No
DEFINITION: Noise at idle that gets louder as the engine speed increases, up to 1500 RPM				
1	This noise is not connected with lifter malfunction. The noise becomes noticeable at 10 to 15 mph LOW range, or 30 to 35 mph DRIVE range. The noise is described as a ticking sound. At idle, the sound may be entirely gone or appear as a light ticking noise in one or more of the valves. This noise is caused by one or more of the following: • A badly worn or scuffed valve tip and rocker arm pad • Excessive valve stem-to-guide clearance • Excessive valve seat runout • An off-square valve spring • Excessive valve face runout Are any components damaged or worn excessively?	—	Repair as necessary	Go to Step 2
2	The noise may be an off-square valve spring. Eliminate this noise by rotating the valve spring and the valve. 1. Crank the engine until the noisy valve is off its seat. 2. Rotate the spring. This will also rotate the valve. 3. Repeat until the valve is quiet. 4. If correction is obtained, check for an off-square valve spring. Is the valve spring off-square more than 1.6 mm (1/16 in)?	—	Replace the valve spring	System OK

Noise at any Engine Speed

Step	Action	Value(s)	Yes	No
DEFINITION: Noise at all engine RPM				
1	Check for excessive valve lash. To check for valve lash, turn the engine so the piston in the cylinder is on TDC of the firing stroke. If valve lash is present, the push rod moves freely up and down with the valve rocker arm held against the valve. Is the valve lash excessive?	—	Repair as required	Go to Step 2
2	Check for a worn push rod upper end ball. Is the push rod upper end ball worn?	—	Replace the push rod and valve rocker arm	Go to Step 3
3	Check for a bent push rod. Is the push rod bent?	—	Replace the push rod	Go to Step 4
4	Check the lubrication system feed to the push rod and for a properly lubricated push rod. Are the push rod and feed system properly lubricated?	—	Go to Step 5	Replace the push rod and valve rocker arm
5	Check for a loose or damaged valve rocker arm. Is the valve rocker arm loose or damaged?	—	Replace the valve rocker arm	Go to Step 6
6	If the push rod or the valve rocker arm does not need to be replaced, this indicates trouble in the valve lifter or the camshaft. Is the camshaft worn or damaged?	—	Replace the camshaft and valve lifters	Replace the valve lifters as necessary

Oil Consumption Diagnosis

An engine that has excessive oil consumption uses 0.9L (1 qt) of oil, or more, within 2,000 mi (3 200 km). The following list indicates the conditions and corrections of excessive oil consumption:

- An improperly read oil level indicator (dipstick)
 - Inspect the oil level while the vehicle is parked on a level surface.
 - Allow adequate drain-down time.
- Improper oil viscosity
 - Use the recommended SAE viscosity for prevailing temperatures.
 - Refer to Maintenance and Lubrication for the proper oil viscosity specifications.
- Continuous high-speed driving
- Severe hauling, such as a trailer. This causes decreased oil mileage.
- A malfunctioning crankcase ventilation system
- External oil leaks
 - Tighten the bolts, as needed.
 - Replace the gaskets and seals, as needed.
- Worn or omitted valve guides and/or valve stem seals
 - Ream the guides.
 - Install oversized service valves and/or new valve stem seals.
- Broken or worn piston rings
- Improperly installed or unseated piston rings
- Improperly installed or improperly fitted piston
- Plugged cylinder head gasket oil drain holes
- Damaged intake gaskets

Oil Pressure Diagnosis and Testing

Low or No Oil Pressure

The following can cause low or no oil pressure:

- Low oil level — fill to the full mark on the oil level indicator.
- Slow idle speed
- Incorrect or malfunctioning oil pressure switch — replace the oil pressure switch.
- Incorrect or malfunctioning oil pressure gauge — replace the oil pressure gauge.
- Improper oil viscosity or diluted oil
 - Install oil of proper viscosity for expected temperature.
 - Install new oil if it is diluted.
- The oil pump is worn or dirty — clean or replace the oil pump.
- The oil filter is plugged — replace the oil filter.
- The oil pickup screen is loose or plugged — replace the oil pickup screen.
- A hole in the oil pickup tube — replace the oil pickup tube.

- Excessive bearing clearance — replace the bearings.
- Cracked, porous, or plugged oil galleries — repair or replace the engine block.
- The gallery plugs are missing or improperly installed — install or repair as necessary.
- The pressure regulator valve is stuck.
 - Check the pressure regulator valve for sticking in the bore.
 - Check the bore for scoring and burrs.
- The camshaft is worn or poorly machined — replace the camshaft.
- Worn valve guides — repair as needed.

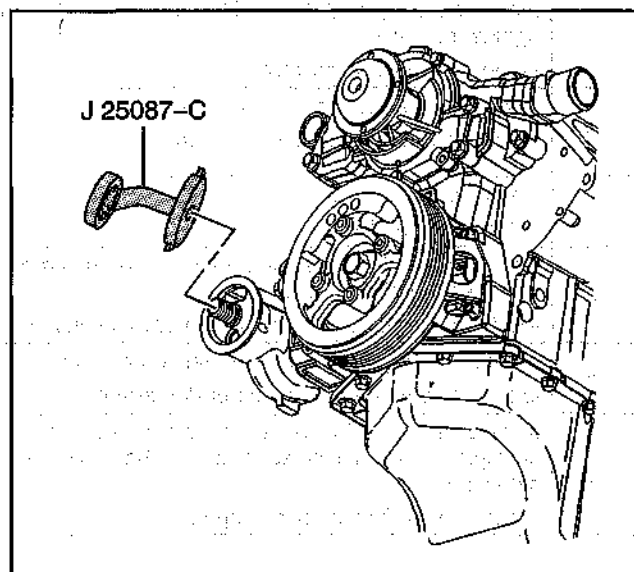
Oil Pressure Testing

Tools Required

J 25087-C Oil Pressure Test Kit

If the vehicle has low oil pressure perform the following tests.

1. Check the oil level.
2. Raise the vehicle and remove the oil filter.
3. Assemble the plunger valve in the large hole of J 25087-C base and the hose in the small hole of J 25087-C base. Connect the gauge to the end of the hose.
4. Insert the flat side of the rubber plug in the bypass valve without depressing the bypass valve itself.
5. Install J 25087-C on the filter mounting pad.



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6. Start the engine and check the overall oil pressure, the oil pressure switch, and for noisy lifters. The engine should be at operating temperature before checking the oil pressure. The oil pressure should be approximately 414kPa (60 psi) at 1850 rpm using 10W30 engine oil.

7. If adequate oil pressure is indicated, check the oil pressure switch.
8. If a low reading is indicated, press the valve on the tester base to isolate the oil pump and/or its components from the lubricating system. An

adequate reading at this time indicates a good pump and the previous low pressure was due to worn bearings, etc. A low reading while pressing the valve would indicate a faulty pump.

Oil Leak Diagnosis

Step	Action	Value(s)	Yes	No
Important: 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
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

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
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 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
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 still leak oil?	—	Go to Step 1	System OK

Cylinder Leakage Test

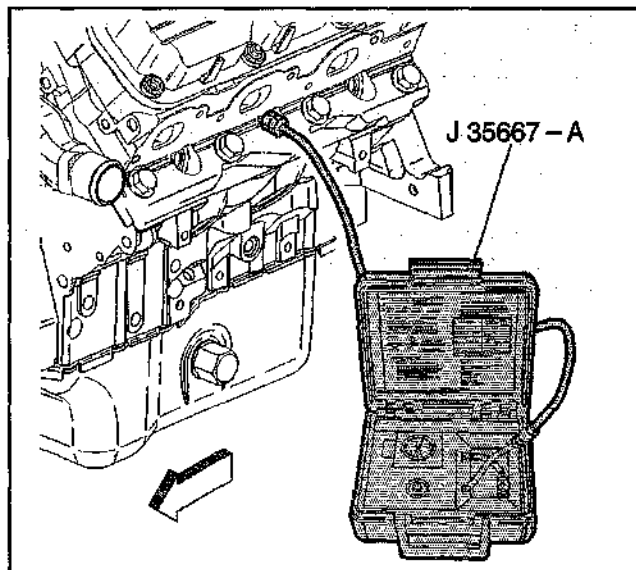
Tools Required

J 35667-A Cylinder Leakdown Tester

With the use of air pressure, a cylinder leakage test will aid in the diagnosis. The cylinder leakage test may be used in conjunction with the engine compression test, to isolate the cause of leaking cylinders.

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

1. Remove the battery ground (negative) cable.
2. Remove the spark plugs. Refer to Ignition System.
3. Install the J 35667-A.



4. Measure each cylinder on the compression stroke, with both valves closed.

Important: It may be necessary to hold the crankshaft balancer bolt, to prevent piston movement.

5. Apply air pressure, using the J 35667-A. Refer to the manufacturer's instructions.
6. Record the cylinder leakage readings for each cylinder.

Important:

- Normal cylinder leakage is from 12 to 18 percent.
 - Make a note of any cylinder with more leakage than the other cylinders.
 - Any cylinder with 30 percent leakage or more requires service.
7. Inspect the four primary areas, to properly diagnose a leaking cylinder.
 8. If air is heard from the intake or exhaust system, perform the following procedure:
 - Remove the valve rocker arm cover of the suspect cylinder head.
 - Ensure that both valves are closed.
 - Inspect the cylinder head for a broken valve spring.

- Remove the suspect cylinder head and inspect. Refer to *Cylinder Head Clean and Inspect*.
9. If air is heard from the crankcase system at the crankcase (oil filler tube), perform the following procedure:
 - Remove the piston from the suspect cylinder.
 - Inspect the piston and connecting rod assembly. Refer to *Piston, Connecting Rod, and Bearings Clean and Inspect*.
 - Inspect the engine block. Refer to *Engine Block Clean and Inspect*.
 10. If bubbles are found in the radiator, perform the following procedure:
 - Remove both cylinder heads and inspect. Refer to *Cylinder Head Clean and Inspect*.
 - Inspect the engine block. Refer to *Engine Block Clean and Inspect*.
 11. Remove the J 35667-A.
 12. Install the spark plugs. Refer to Ignition System.
 13. Install the battery ground (negative) cable. Refer to Battery.

Symptoms - Drive Belt

Important: Review the drive belt system operation in order to familiarize yourself with the system functions. Refer to *Drive Belt System Description*.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the drive belts.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Inspect the drive belt for excessive wear, shredding, or missing sections.
- Inspect the drive belt for contamination of excessive dirt, oil, coolant or other substances that may affect the drive belt operation.

Intermittent

- Drive belt symptoms may be from intermittent failure of an accessory drive component.
- Drive belt symptoms may occur from changes in load of the accessory drive components.
- Ambient temperatures, moisture, or engine operating temperature can affect the drive belt operation.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- *Drive Belt Chirping Diagnosis*
- *Drive Belt Squeal Diagnosis*
- *Drive Belt Whine Diagnosis*
- *Drive Belt Rumbling Diagnosis*
- *Drive Belt Vibration Diagnosis*
- *Drive Belt Falls Off Diagnosis*
- *Drive Belt Excessive Wear Diagnosis*

Drive Belt Chirping Diagnosis

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt or the pulleys. It may be necessary to spray a small amount of water on the drive belt in order to duplicate the customer's concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.

A loose or improper installation of a body component, a suspension component, or other item(s) on the vehicle may cause the chirping noise.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
3. The noise may be an internal engine noise. Remove the drive belt and operate the engine for a brief period, this will verify if the chirping noise is related to the drive belt. With the drive belt(s) removed the water pump may not operate and the engine may overheat. Also DTCs may set when the engine is operated with the drive belt removed.
4. Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it may be strings in the drive belt grooves from the accumulation of rubber dust.
6. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley may be bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that accessory drive component for the proper installation procedure for that pulley.
10. Inspection of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
12. Inspecting the pulleys for being bent should include inspecting for dents or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
14. Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp startup conditions and will subside once the vehicle reaches normal operating temperature.			
1	Did you review the Symptoms - Drive Belt diagnostic information and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to Step 3	Go to Diagnostic Aids.
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to Engine Noise Diagnosis (Base Engine)	Go to Step 4
4	Inspect for severe belt pilling exceeding 1/3 of the belt groove depth. Does the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Were the drive belt pulleys cleaned?	Go to Step 15	Go to Step 6
6	Inspect for a misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace and/or repair any misaligned pulleys. Were the misaligned pulleys repaired and/or replaced?	Go to Step 15	Go to Step 8
8	Inspect for bent and/or cracked brackets. Were there any bent and/or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent and/or cracked brackets. Refer to <i>Drive Belt Tensioner Replacement</i> . Were the bent and/or cracked brackets replaced?	Go to Step 15	Go to Step 10
10	Inspect for improper, missing and/or loose fasteners. Were there any improper, missing and/or loose fasteners?	Go to Step 11	Go to Step 12
11	Replace any improper and/or missing fasteners. Tighten any loose fasteners. Refer to <i>Fastener Tightening Specifications</i> . Did you complete the repair?	Go to Step 15	Go to Step 12
12	Inspect for a bent pulley. Was a bent pulley found?	Go to Step 13	Go to Step 14
13	Replace the bent pulley. Was the bent pulley replaced?	Go to Step 15	Go to Step 14
14	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Was the drive belt replaced?	Go to Step 15	Go to Diagnostic Aids
15	Run the engine in order to verify the repair. Does the drive belt still chirp?	Go to Step 3	System OK

Drive Belt Squeal Diagnosis

Diagnostic Aids

A loose or improper installation of a body component, a suspension component, or other items on the vehicle may cause the squeal noise.

If the noise is intermittent, verify that the accessory drive components are not the cause, by varying their loads making sure they are operating to their maximum capacity. An overcharged A/C system, a power steering system restriction, or incorrect fluid, or a failing generator are suggested items to inspect.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
3. The noise may be an internal engine noise. Remove the drive belt and operate the engine for a brief period, this will verify that the squeal noise is the drive belt or an accessory drive component. With the drive belt removed the water pump may not operate and the engine may overheat. Also DTCs may set when the engine is operated with the drive belt removed.
4. This test is to verify that an accessory drive component does not have a seized bearing. With the drive belt removed test the bearings in the accessory drive components for smooth operation.

Test the accessory drive components with the engine operating by varying the load on the components to verify that the components operate properly.

5. This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a belt squeal noise.
6. This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from operating properly. Also if an incorrect length drive belt were installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.
7. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley is bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
8. This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt (this is unusual for a drive belt with multiple ribs) • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.			
1	Did you review the Symptoms - Drive Belt diagnostic information and perform the necessary inspections?	Go to Step 2	Go to <i>Symptoms - Drive Belt</i> .
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the squeal noise still exist?	Go to <i>Engine Noise Diagnosis (Base Engine)</i>	Go to Step 4
4	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to Step 9	Go to Step 5
5	Inspect the drive belt tensioner for proper operation. Refer to <i>Drive Belt Tensioner Diagnosis</i> . Did you find and correct the condition?	Go to Step 9	Go to Step 6
6	Check for the correct drive belt length. Refer to <i>Drive Belt Replacement</i> . Did you find and correct the condition?	Go to Step 9	Go to Step 7
7	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 9	Go to Step 8
8	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 9	Go to Diagnostic Aids
9	Run the engine in order to verify the repair. Does the drive belt still squeal?	Go to Step 3	System OK

Drive Belt Whine Diagnosis

Diagnostic Aids

The drive belt will not cause the whine noise.

If the whine noise is intermittent, verify the accessory drive components are not the cause, by varying their loads making sure they are operating to their maximum capacity. An overcharged A/C system, a power steering system restriction or incorrect fluid, or a failing generator are suggested items to inspect.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

- This test is to verify that the noise is being caused by the drive belt or the accessory drive components. With the drive belt removed the

water pump may not operate and the engine may overheat. Also DTCs may set when the engine is operated with the drive belt removed.

- The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belt may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the proper inspection and replacement procedure.

Drive Belt Whine Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices.			
DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.			
1	Did you review the Symptoms - Drive Belt diagnostic information and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt
2	Verify that there is a whine noise. Does the engine make the whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the whine noise still exist?	Go to Engine Noise Diagnosis (Base Engine)	Go to Step 4
4	Inspect for a failed accessory drive component bearing. Did you find and repair the condition?	Go to Step 5	Go to Diagnostic Aids
5	Run the engine in order to verify the repair. Does the drive belt still whine?	Go to Step 3	System OK

Drive Belt Rumbling Diagnosis

Diagnostic Aids

Vibration when the engine is operating may cause a body component or another part of the vehicle to produce rumbling noise.

The drive belt may have a condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

If replacing the drive belt, and completing the diagnostic table, the noise is only heard when the drive belt is installed, there may be an accessory drive component failure. Varying the load on the accessory drive components may aid in identifying which accessory drive component is causing the rumbling noise.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

- This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.
- This test is to verify that the drive belt is causing the rumbling noise. The rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. With the drive belt removed the water pump may not be operate and the engine may overheat. Also DTCs may set when the engine is operated with the drive belt removed.
- Inspect the drive belt to ensure that the drive belt is not the cause of the noise. Small cracks across the ribs of the drive belt will not cause the rumbling noise. Belt separation is identified by the plys of the drive belt separating, this may be seen at the edge of the belt or felt as a lump in the belt.
- Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: - A low pitch tapping, knocking, or thumping noise heard at or just above idle. - Heard once per revolution of the drive belt or a pulley. - Rumbling may be caused from: - Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove - The separation of the drive belt - A damaged drive belt			
1	Did you review the Symptoms - Drive Belt diagnostic information and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to Engine Noise Diagnosis (Base Engine)	Go to Step 4
4	Inspect the drive belt for damage, separation, or sections of missing ribs. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt. Refer to <i>Drive Belt Replacement</i> Did you complete the repair?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Refer to <i>Drive Belt Replacement</i> Did you complete the replacement?	Go to Step 8	—
8	Run the engine in order to verify the repair. Does the drive belt still rumble?	Go to Diagnostic Aids	System OK

Drive Belt Vibration Diagnosis

Diagnostic Aids

The accessory drive components may have an affect on engine vibration. An overcharged A/C system, a power steering system restriction, or incorrect fluid, or an extra load placed on the generator are some systems that should be inspected. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom such as the exhaust system, or the drivetrain.
3. This test is to verify that the drive belt or accessory drive components may be causing the vibration. With the drive belt removed the water pump may not operate and the engine may overheat. Also DTCs may set when the engine is operated with the drive belt removed.
4. The drive belt may cause a vibration. With the drive belt removed inspect the condition of the drive belt.
6. Inspection of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
8. This step should only be performed if the cooling fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smooth operation. Inspect for a bent fan shaft or bent mounting flange.
9. This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known good water pump.
10. Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Symptoms - Drive Belt diagnostic information and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to Engine Related Vibration in Vibration and Diagnosis	Go to Step 4
4	Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions?	Go to Step 5	Go to Step 6
5	Install a new drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the replacement?	Go to Step 11	—
6	Inspect for improper, missing or loose fasteners. Did you find any of these conditions?	Go to Step 7	Go to Step 8
7	Tighten any loose fasteners. Refer to <i>Fastener Tightening Specifications</i> . Replace improper or missing fasteners. Did you complete the repair?	Go to Step 11	—
8	Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Refer to <i>Cooling Fan Motor Replacement - Electric</i> in Engine Cooling. Did you find and correct the condition?	Go to Step 11	Go to Step 9
9	Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to <i>Water Pump Replacement (3.8 L)</i> in Engine Cooling. Did you find and correct the condition?	Go to Step 11	Go to Step 10
10	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 11	Go to Diagnostic Aids
11	Run the engine in order to verify the repair. Does the drive belt still vibrate?	Go to Step 3	System OK

Drive Belt Falls Off Diagnosis

Diagnostic Aids

If the drive belt repeatedly falls off the drive belt pulleys, this may be caused by pulley misalignment.

An extra load that is quickly applied on released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify that the accessory drive components operate properly.

If the drive belt is the incorrect length, the drive belt tensioner may not maintain the proper tension on the drive belt.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

2. This inspection is to verify the condition of the drive belt. Damage may have occurred to the drive belt when the drive belt fell off the pulley. The drive belt may have been damaged in which case caused the drive belt to fall off the pulley. Inspect the drive belt for cuts, tears, sections of ribs missing, or damaged belt plies.
4. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory

drive component pulley, or the pulley being bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.

5. Inspect the pulleys for dents, bends or other damage. Damage to the pulleys that would prevent the drive belt from seating properly in the pulley grooves. Damage would also prevent proper alignment of the drive belt pulley, when the smooth surface of the drive belt is required to drive the pulley.
6. Accessory drive component brackets that are bent or cracked will let the drive belt fall off.
7. Inspection of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed. Missing, loose, or the incorrect fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Symptoms - Drive Belt diagnostic information and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt
2	Inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to <i>Drive Belt Replacement</i> . Does the drive belt continue to fall off?	Go to Step 4	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, missing or loose fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	Tighten any loose fasteners. Refer to <i>Fastener Tightening Specifications</i> . Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to <i>Drive Belt Tensioner Diagnosis</i> . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to <i>Drive Belt Tensioner Replacement</i> . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to Step 12	Go to Diagnostic Aids
12	Run the engine in order to verify the repair. Does the drive belt still fall off?	—	System OK

Drive Belt Excessive Wear Diagnosis

Diagnostic Aids

Excessive wear on a drive belt is usually caused by an incorrect installation or the wrong drive belt for the application.

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will probably cause the drive belt to make a noise or to fall off the pulley (s).

Excessive misalignment of the drive belt pulleys will cause excessive wear and may also make the drive belt fall off the pulley.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

- The inspection is to verify the drive belt(s) is correctly installed over all of the drive belt pulleys. Wear on the drive belt may be caused by mis-positioning the drive belt by one groove on a pulley.

- The installation of a drive belt that is too wide or too narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.
- This inspection is to verify the drive belt is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices.			
DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the Symptoms - Drive Belt diagnostic information and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt
2	Inspect the drive belt(s) for the proper installation. Refer to <i>Drive Belt Replacement</i> . Did you find this condition?	Go to Step 5	Go to Step 3
3	Inspect for the proper drive belt. Did you find this condition?	Go to Step 5	Go to Step 4
4	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to Step 6	Go to Diagnostic Aids
5	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the replacement?	Go to Step 6	—
6	Run the engine in order to verify the repair. Is there still excessive drive belt wear?	—	System OK

Drive Belt Tensioner Diagnosis

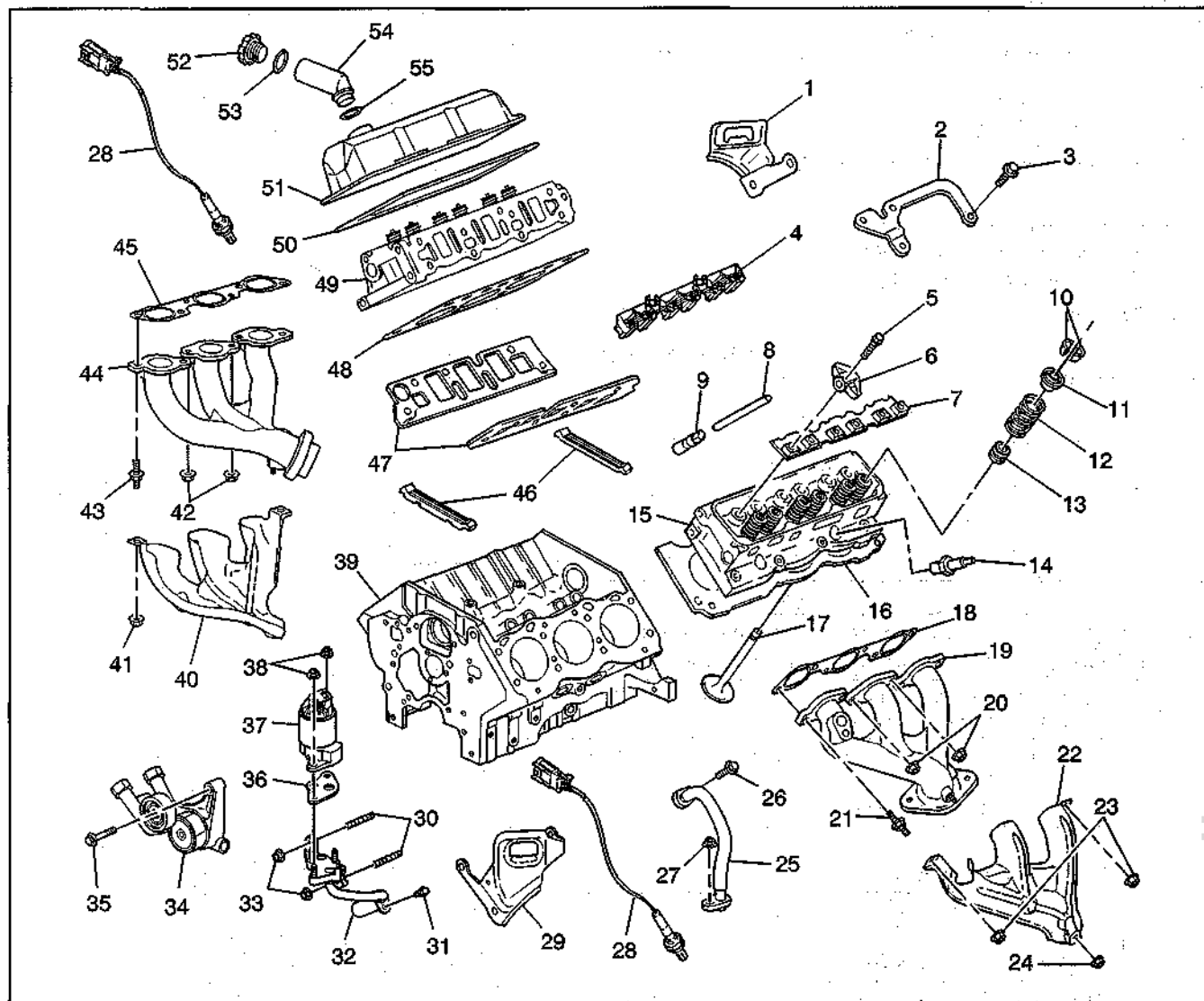
Important: When the engine is operating, the belt tensioner arm will move. Do not replace the belt tensioner because of movement in the belt tensioner arm.

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

- Remove the drive belt. Refer to *Drive Belt Replacement*.
- Position a hex-head socket on the drive belt tensioner arm and rotate the arm counterclockwise.
- Move the drive belt tensioner through its full travel.
 - The movement should feel smooth
 - There should be no binding.
 - The tensioner should return freely.
- If any binding is observed, replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.
- Install the drive belt. Refer to *Drive Belt Replacement*.

Disassembled Views

Cylinder Head and Components



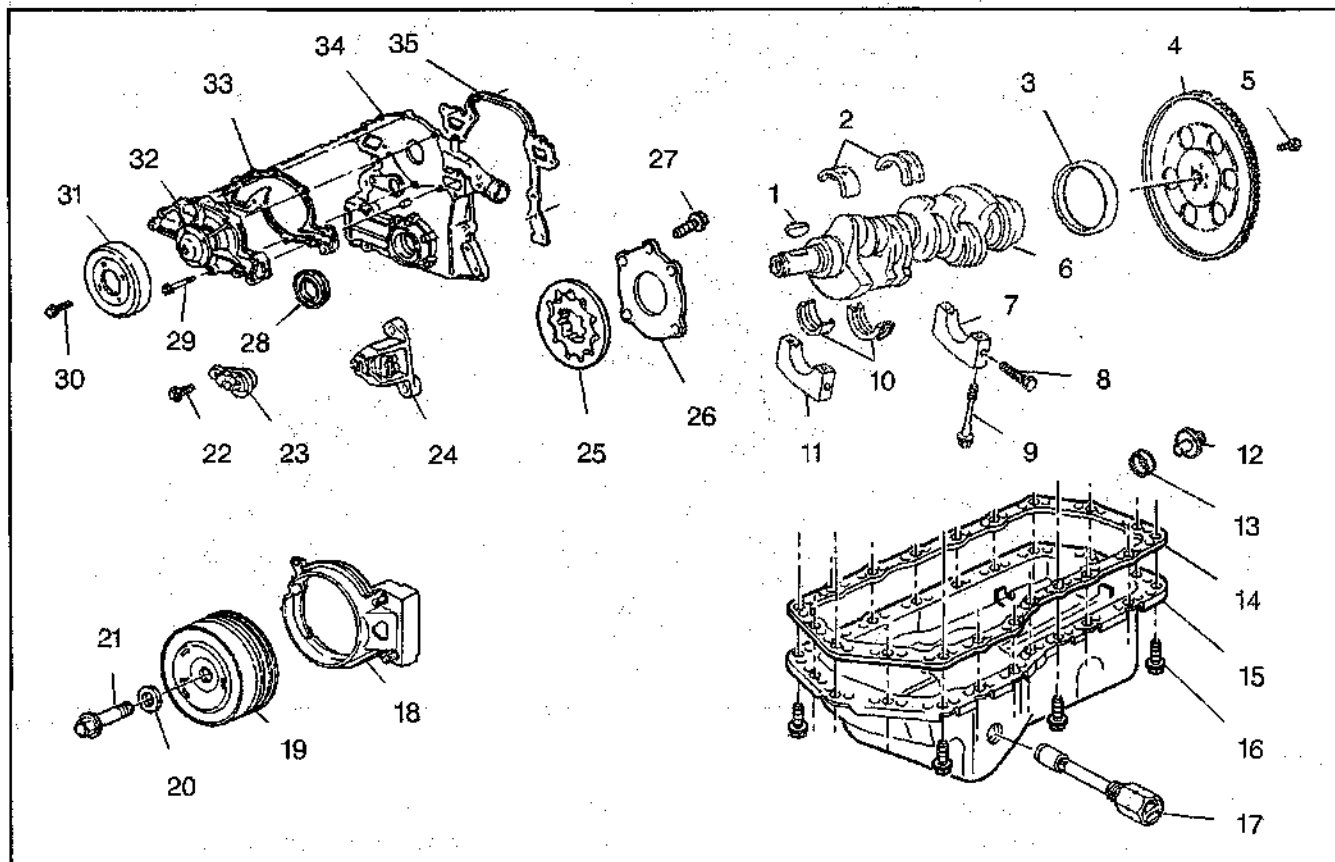
589348

Legend

- | | |
|-------------------------------|---------------------------------------|
| (1) Engine Lift Rear Bracket | (17) Intake Valve |
| (2) Generator Brace Bracket | (18) Exhaust Manifold Gasket (Left) |
| (3) Generator Brace Bolt | (19) Exhaust Manifold (Left) |
| (4) Valve Lifter Guide | (20) Exhaust Manifold Nut |
| (5) Valve Rocker Arm Bolts | (21) Exhaust Manifold Stud |
| (6) Valve Rocker Arm | (22) Exhaust Manifold Heat Shield |
| (7) Valve Rocker Arm Retainer | (23) Exhaust Manifold Heat Shield Nut |
| (8) Pushrod | (24) Exhaust Manifold Heat Shield Nut |
| (9) Valve Lifter | (25) EGR Valve Outlet Pipe |
| (10) Valve Stem Keys | (26) EGR Valve Outlet Pipe Bolt |
| (11) Valve Stem Cap | (27) EGR Valve Outlet Pipe Nut |
| (12) Valve Stem Spring | (28) Heated Oxygen Sensor |
| (13) Valve Seal | (29) Engine Lift Front Bracket |
| (14) Spark Plug | (30) EGR Valve Adapter Studs |
| (15) Cylinder Head | (31) EGR Valve Adapter Bolt |
| (16) Cylinder Head Gasket | (32) EGR Valve Adapter |

- | | |
|---------------------------------------|--------------------------------------|
| (33) EGR Valve Adapter Nuts | (45) Exhaust Manifold Gasket (Right) |
| (34) Drive Belt Tensioner | (46) Intake Manifold Seal |
| (35) Drive Belt Tensioner Bolt | (47) Lower Intake Manifold Gasket |
| (36) EGR Valve Gasket | (48) Cylinder Head Gasket |
| (37) EGR Valve | (49) Cylinder Head |
| (38) EGR Valve Nuts | (50) Valve Rocker Arm Cover Gasket |
| (39) Engine Block | (51) Valve Rocker Arm Cover |
| (40) Exhaust Manifold Heat Shield | (52) Oil Fill Cap |
| (41) Exhaust Manifold Heat Shield Nut | (53) Oil Fill Cap Seal |
| (42) Exhaust Manifold Nut | (54) Oil Fill Tube |
| (43) Exhaust Manifold Stud | (55) Oil Fill Tube Seal |
| (44) Exhaust Manifold (Right) | |

Crankshaft and Components



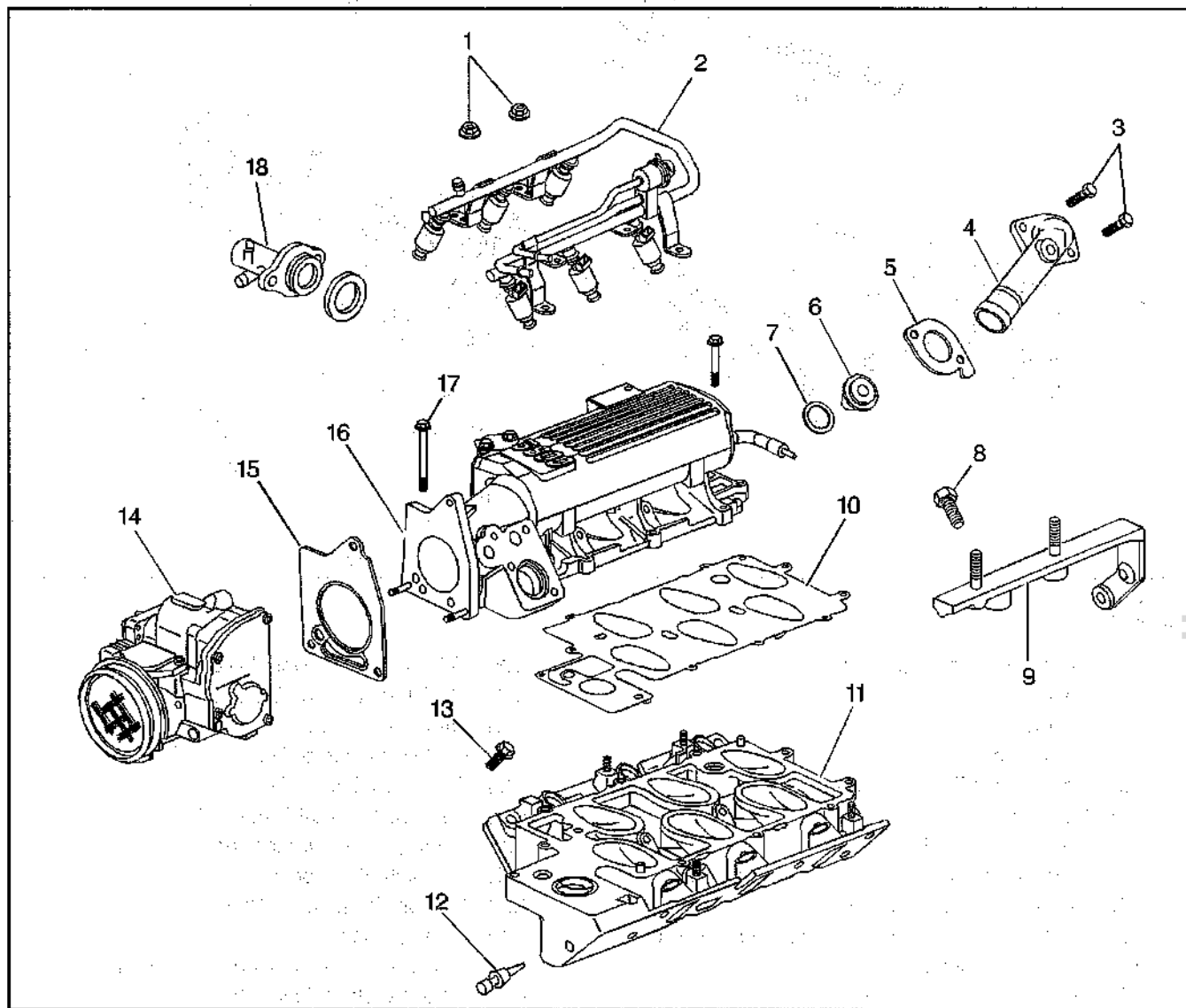
42447

Legend

- | | |
|--------------------------------------|--|
| (1) Crankshaft Balancer Key | (13) Oil Pan Drain Plug Gasket |
| (2) Crankshaft Upper Bearing | (14) Oil Pan Gasket |
| (3) Crankshaft Rear Oil Seal | (15) Engine Oil Pan |
| (4) Engine Flywheel | (16) Oil Pan Bolt |
| (5) Flywheel Bolt | (17) Engine Oil Level Sensor |
| (6) Engine Crankshaft | (18) Crankshaft Position Sensor Shield |
| (7) Crankshaft Main Bearing Cap | (19) Crankshaft Balancer |
| (8) Side Main Bearing Bolt | (20) Crankshaft Balancer Washer |
| (9) Crankshaft Main Bearing Cap Bolt | (21) Crankshaft Balancer Bolt |
| (10) Crankshaft Lower Bearing | (22) Camshaft Position Sensor Bolt |
| (11) Crankshaft Main Bearing Cap | (23) Camshaft Position Sensor |
| (12) Oil Pan Drain Plug | (24) Crankshaft Position Sensor |

- | | |
|--------------------------------|--------------------------------|
| (25) Oil Pump Gear Set | (31) Water Pump Pulley |
| (26) Oil Pump Cover | (32) Water Pump |
| (27) Oil Pump Cover Bolt | (33) Water Pump Gasket |
| (28) Crankshaft Front Oil Seal | (34) Engine Front Cover |
| (29) Water Pump Bolt | (35) Engine Front Cover Gasket |
| (30) Water Pump Pulley Bolt | |

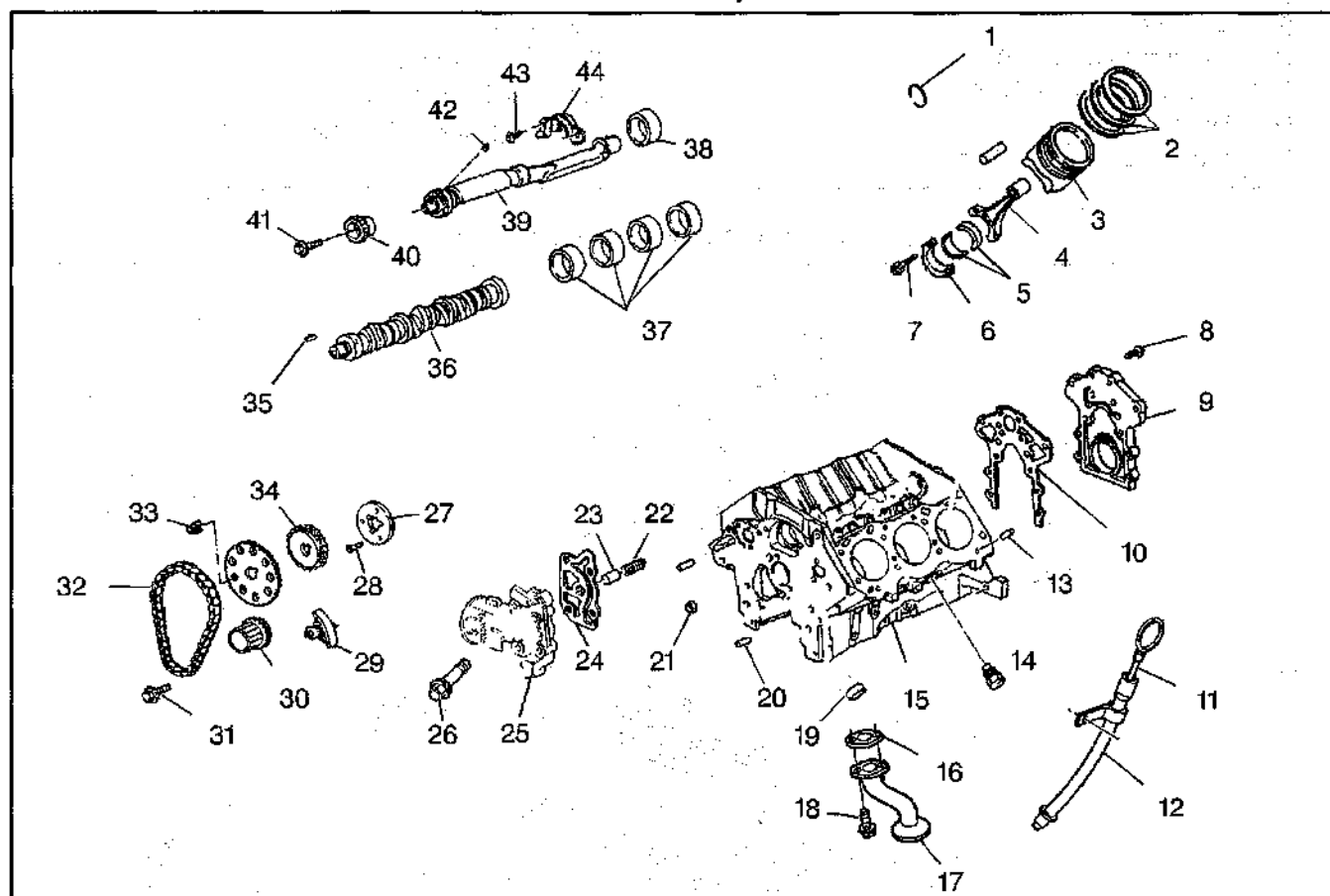
Intake Manifolds and Components



Legend

- | | |
|-----------------------------|-----------------------------------|
| (1) Fuel Injector Rail Nuts | (10) Upper Intake Manifold Gasket |
| (2) Fuel Injector Rail | (11) Lower Intake Manifold |
| (3) Water Outlet Bolts | (12) Coolant Temperature Sensor |
| (4) Water Outlet | (13) Lower Intake Manifold Bolt |
| (5) Water Outlet Gasket | (14) Throttle Body |
| (6) Thermostat | (15) Throttle Body Gasket |
| (7) Thermostat Gasket | (16) Upper Intake Manifold |
| (8) ICM Bracket Bolt | (17) Upper Intake Manifold Bolt |
| (9) ICM Bracket | (18) Vacuum Source Manifold |

Piston and Components



42456

Legend

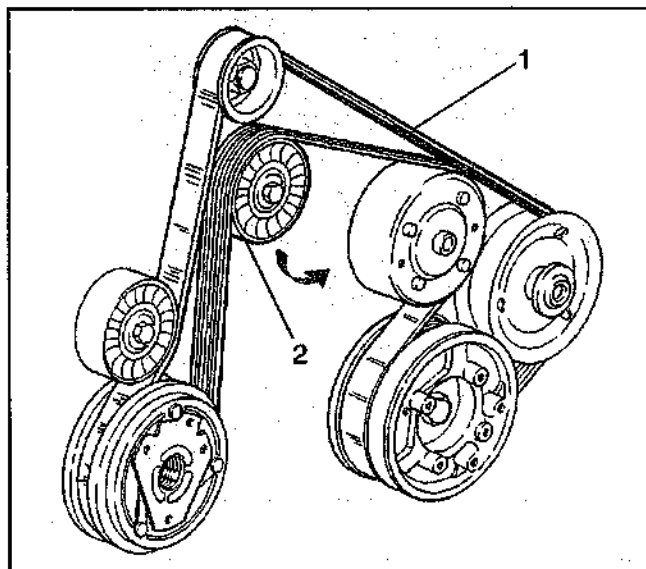
- | | |
|--|--------------------------------------|
| (1) Piston Pin Retainer Clip | (23) Oil Pressure Relief Valve |
| (2) Piston Rings | (24) Oil Filter Adapter Gasket |
| (3) Piston | (25) Oil Filter Adapter |
| (4) Connecting Rod | (26) Oil Filter Adapter Bolt |
| (5) Connecting Rod Bearings | (27) Camshaft Thrust Plate |
| (6) Connecting Rod Cap | (28) Camshaft Thrust Plate Bolt |
| (7) Connecting Rod Cap Bolt | (29) Timing Chain Dampener |
| (8) Crankshaft Rear Oil Seal Housing Bolt | (30) Crankshaft Sprocket |
| (9) Crankshaft Rear Oil Seal Housing | (31) Camshaft Sprocket Bolt |
| (10) Crankshaft Rear Oil Seal Housing Gasket | (32) Timing Chain |
| (11) Oil Level Indicator | (33) Camshaft Position Sensor Magnet |
| (12) Oil Level Indicator Tube | (34) Balance Shaft Drive Gear |
| (13) Cylinder Head Location Hole Pin | (35) Camshaft Key |
| (14) ESC Knock Sensor | (36) Camshaft |
| (15) Engine Block | (37) Camshaft Bearings |
| (16) Oil Pump Screen Gasket | (38) Balance Shaft Bushing |
| (17) Oil Pump Screen | (39) Balance Shaft |
| (18) Oil Pump Screen Bolt | (40) Balance Shaft Gear |
| (19) Engine Block Core Hole Plug | (41) Balance Shaft Gear Bolt |
| (20) Engine Front Cover Pin | (42) Balance Shaft Gear Pin |
| (21) Engine Block Oil Gallery Plug | (43) Balance Shaft Retainer Bolt |
| (22) Oil Pressure Relief Valve Spring | (44) Balance Shaft Retainer |

Repair Instructions

Drive Belt Replacement

Removal Procedure

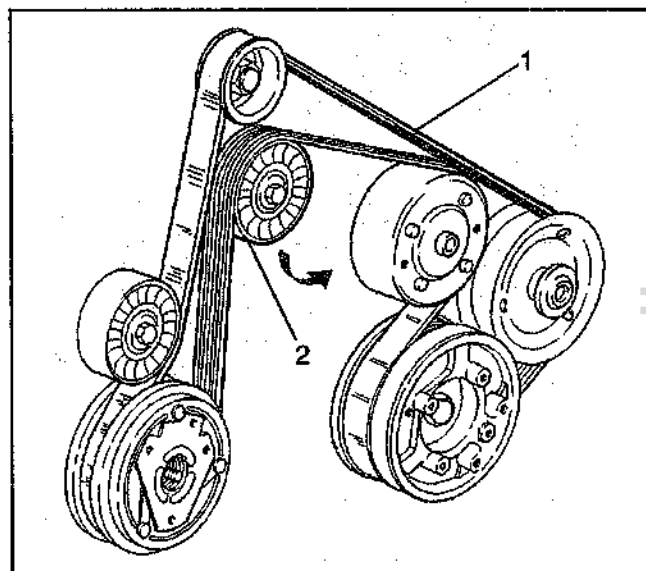
1. Position a hex-head socket on the belt tensioner pulley bolt.
2. Rotate the drive belt tensioner (2) clockwise to relieve the tension on the drive belt (1).
3. Remove the drive belt (1) from the tensioner (2) and pulleys.
4. Clean and inspect the belt surfaces of all the pulleys.



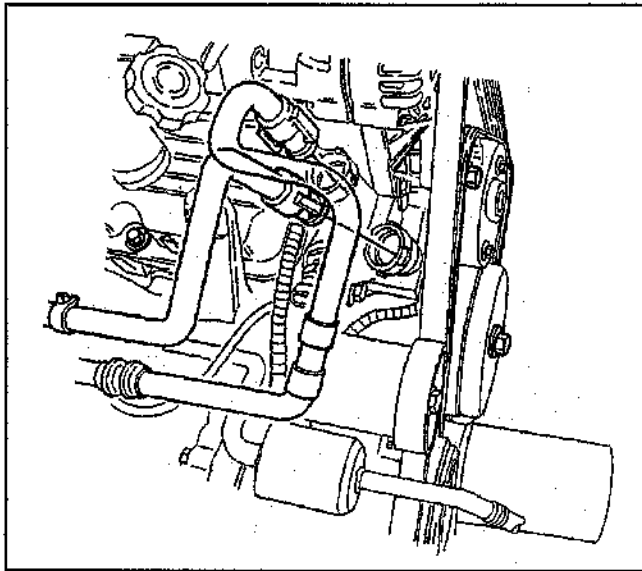
41363

Installation Procedure

1. Route the drive belt (1) around the pulleys.
2. Position a hex-head socket on the belt tensioner pulley bolt.
3. Rotate the drive belt tensioner (2) clockwise to relieve the tension.
4. Install the drive belt (1) onto the drive belt tensioner (2).
5. Inspect the drive belt (1) to ensure that the belt is properly aligned into the grooves of the pulleys.



41363

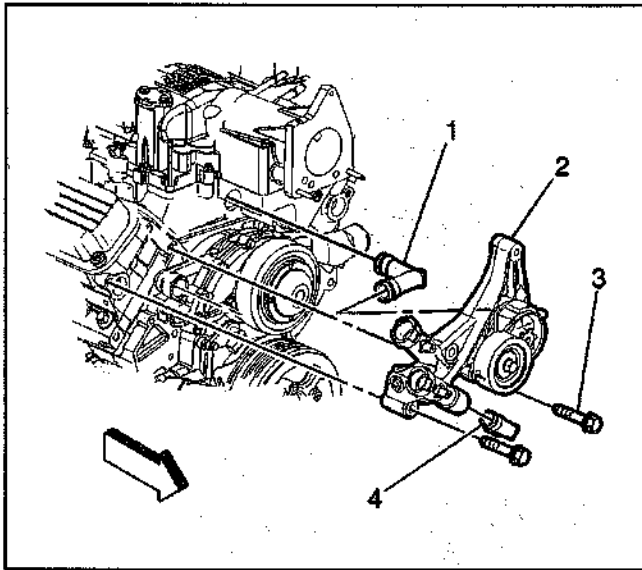


282933

Drive Belt Tensioner Replacement

Removal Procedure

1. Drain the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.
2. Remove the drive belt. Refer to *Drive Belt Replacement*.
3. Remove the generator. Refer to *Generator Replacement (3.8 L)* in Engine Electrical.
4. Remove the heater hoses from the drive belt tensioner.

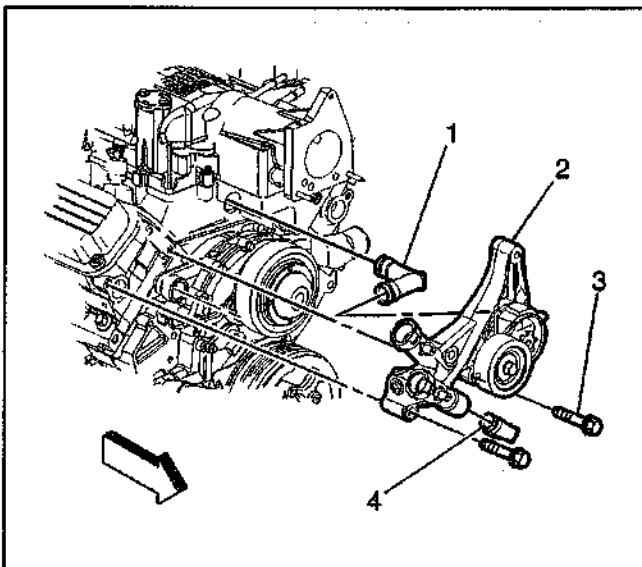


441249

5. Remove the drive belt tensioner bolts (3).

Important: The drive belt tensioner (2) must be rotated if it is difficult to remove. Pulling the tensioner (2) from the top may damage the engine front cover. If necessary, break the plastic thermostat bypass upper pipe (1) to allow rotation of the drive belt tensioner (2), replace the pipe during installation.

6. Remove the drive belt tensioner (2).
7. Remove the thermostat bypass pipes (1, 4) from the tensioner (2), if necessary.



441249

Installation Procedure

1. Install the thermostat bypass pipes (1, 4) to the tensioner, if necessary.
2. Install the drive belt tensioner (2) to the engine.

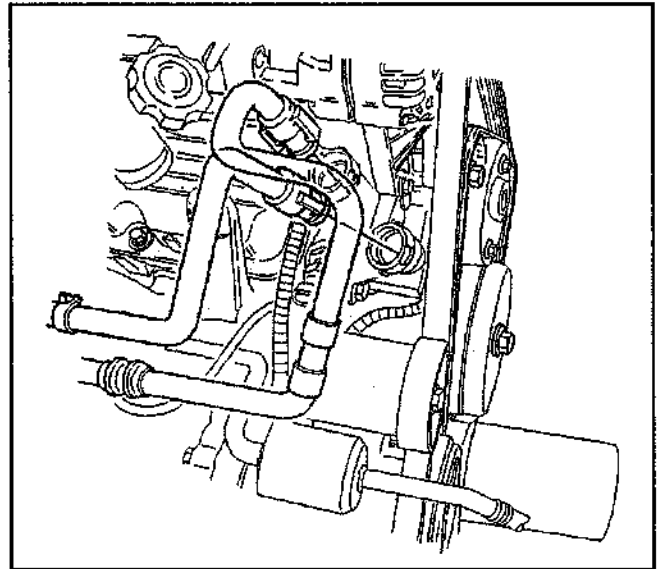
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the drive belt tensioner bolts (3).

Tighten

Tighten the drive belt tensioner bolts (3) to 50 N·m (37 lb ft).

4. Install the heater hoses to the drive belt tensioner.
5. Install the generator. Refer to *Generator Replacement (3.8 L)* in Engine Electrical.
6. Install the drive belt. Refer to *Drive Belt Replacement*.
7. Refill the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.

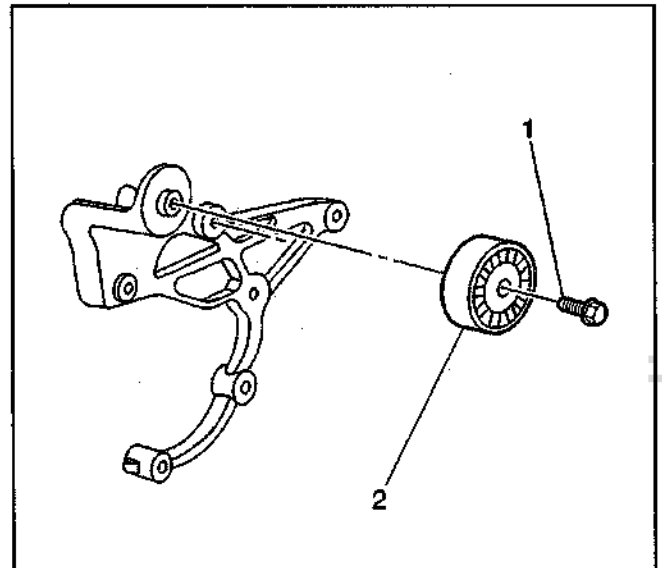


282933

Drive Belt Idler Pulley Replacement

Removal Procedure

1. Remove the serpentine drive belt. Refer to *Drive Belt Replacement*.
2. Remove the drive belt idler pulley bolt (1).
3. Remove the drive belt idler pulley (2).



500350

Installation Procedure

1. Install the drive belt idler pulley (2).

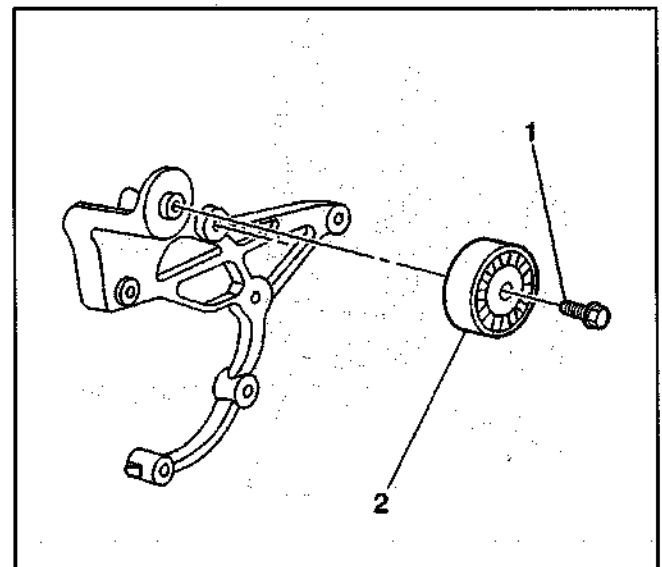
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the drive belt idler pulley bolt (1).

Tighten

Tighten the drive belt idler pulley bolt (1) to 50 N·m (37 lb ft).

3. Install the serpentine drive belt. Refer to *Drive Belt Replacement*.



500350

Engine Mount Inspection

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. Lifting the engine in an unapproved manner may cause component damage.

1. Measure the engine movement at the engine mounts in order to check for damage to the rubber portions of the mount.
 - 1.1. Apply the park brake.
 - 1.2. Start the engine.
 - 1.3. Firmly apply the primary brakes.
 - 1.4. Have an assistant stand to the side of the vehicle to observe for engine movement.
 - 1.5. Slightly load the engine in reverse and drive. If the engine moves more than 24 mm (0.945 in) from the at rest position; in either direction, check the engine mount attachment.
2. If the engine mount attachment is within specifications, replace the engine mount.
3. Replace the engine mount also if any of the following conditions exist:
 - Heat check cracks cover the hard rubber surface.
 - The rubber cushion is separated from the metal plate of the mount.
 - There is a split through the rubber cushion.
4. If the mount is loose, lower the engine and tighten the bolts or the nuts to the engine frame or the bracket. Refer to *Fastener Tightening Specifications*.

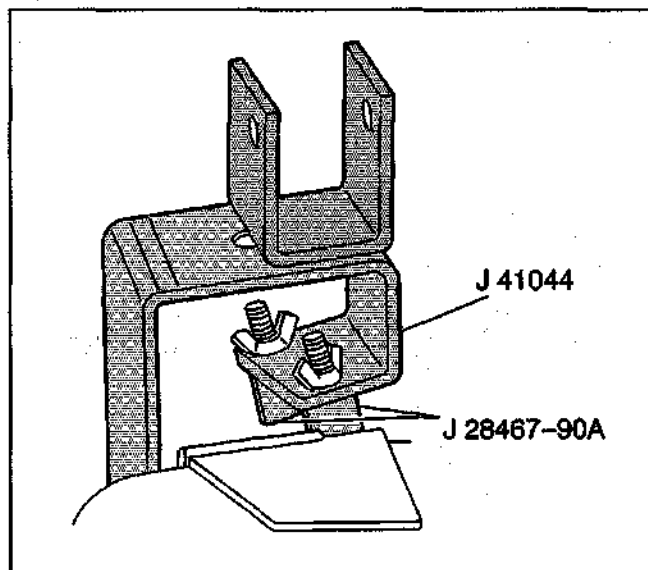
Engine Support Fixture

Installation Procedure

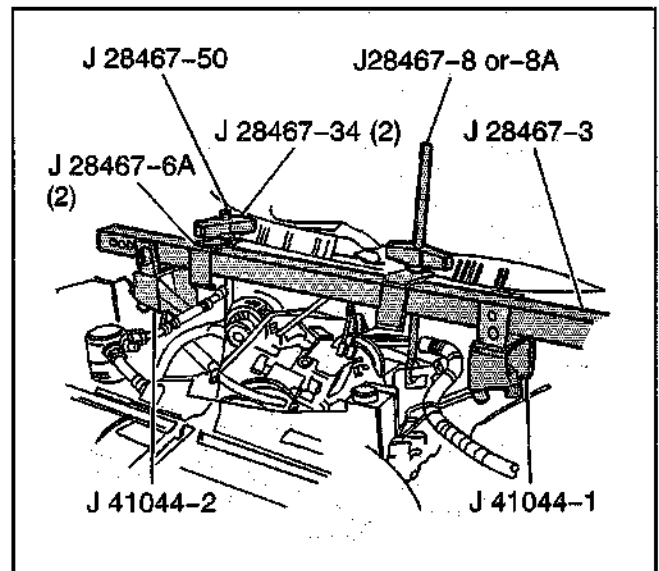
Tools Required

- J 28467-90A Engine Support Adapters
- J 41044 Engine Support Fixture Adapters
- J 28467-B Universal Engine Support Fixture

1. Remove two strut mounting nuts from the left and right side strut towers.
2. Attach the engine support fixture adapters J 28467-90A to the strut tower studs.
3. Install the engine support fixture adapters J 41044-1 and J 41044-2 onto the fixture adapters J 28467-90A on each strut tower.
4. Secure with the wings nuts provided.



5. Place the cross bar J 28467-3 into the engine support adapters J 41044-1 and J 41044-2.
6. Install the quick release pins.
7. Thread the lift hooks J 28467-50 and J 28467-8 or (8A) into the support hook brackets J 28467-6A.
8. Place the support hook brackets J 28467-6A over the cross bar J 28467-3 and connect the hooks to the engine lift brackets.
9. Tighten the large wing nuts J 28467-34.



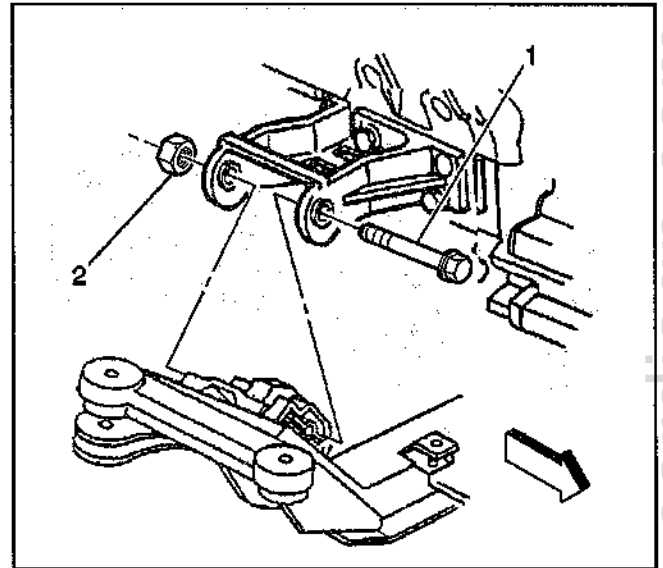
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Engine Mount Replacement

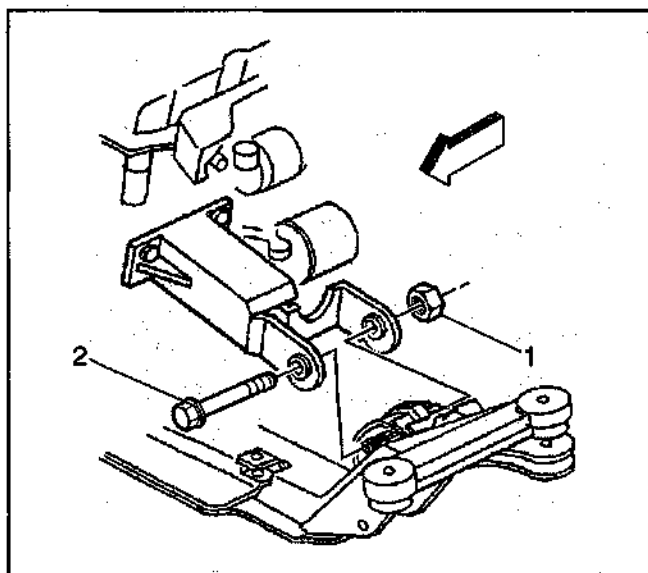
Removal Procedure

Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, crankshaft balancer, or any sheet metal. Due to small clearances between the oil pan and the oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen, resulting in a damaged oil pickup unit. Jacking against the crankshaft balancer may also cause oil seal and/or crankshaft bearing damage. Always use a J 28467-A (Universal Support Fixture) along with J 41044 (Engine Support Adapters) when raising or supporting the engine.

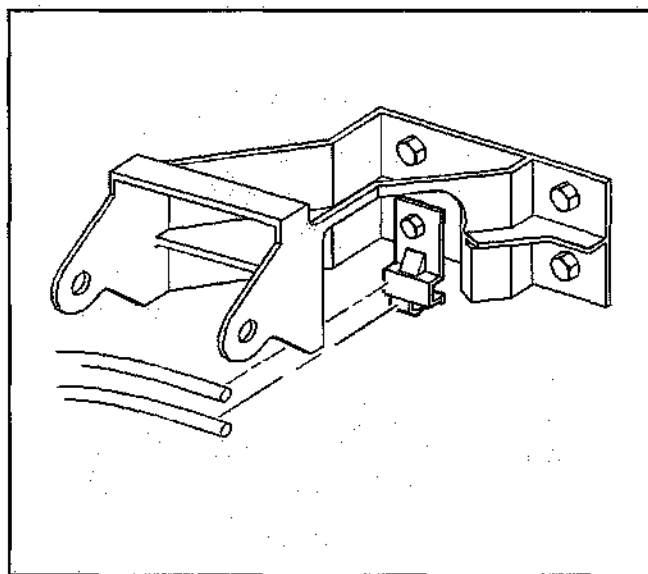
1. Remove the generator. Refer to *Generator Replacement (3.8 L)* in Engine Electrical.
2. Remove the ignition control module. Refer to *Ignition Coil Module Replacement (3.8 L)* in Engine Electrical.
3. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Remove the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.
5. Remove the right side engine mount through bolt nut (2).



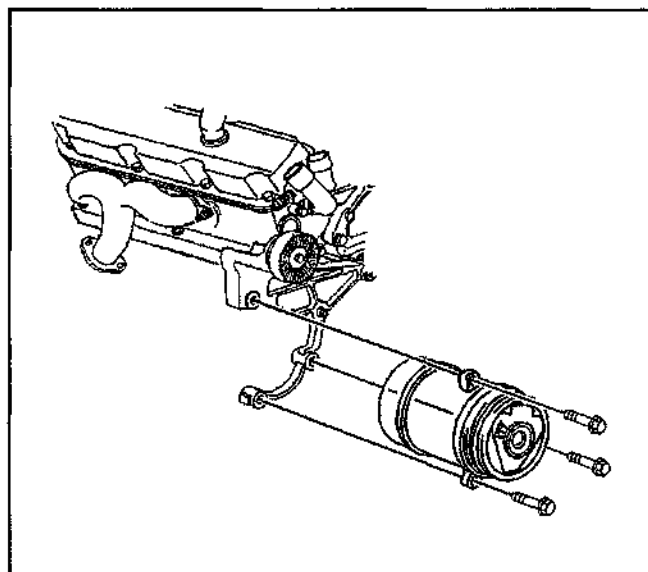
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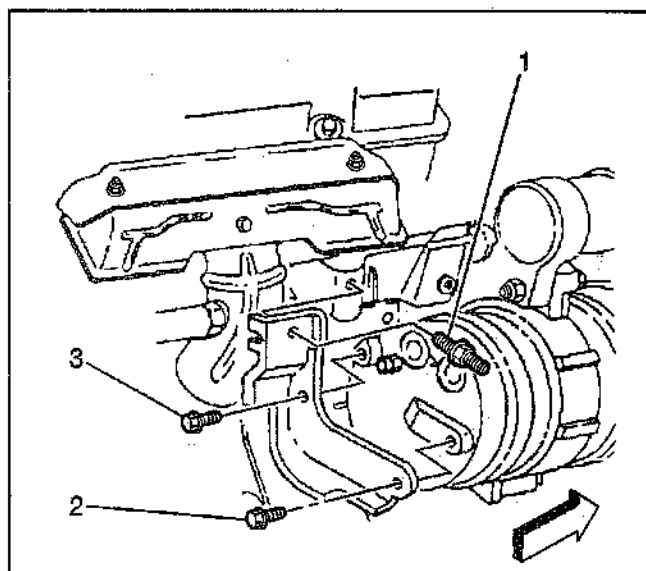
282953

6. Remove the left side engine mount through bolt nut (1).
7. Install the engine support fixture to the engine. Refer to *Engine Support Fixture*.
8. Raise the engine slightly in order to relieve tension on the through bolts.

9. Remove the transmission oil cooler pipe bracket bolt and bracket.

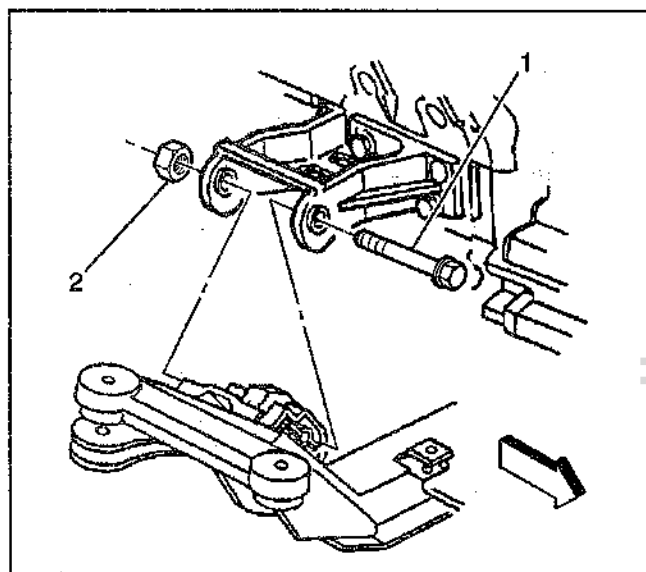
10. Remove the air conditioning compressor bolts.

11. Remove the air conditioning compressor rear bolts (2, 3).
12. Position the A/C compressor forward of the bracket in order to remove the engine mount through bolt without recovering the refrigerant.



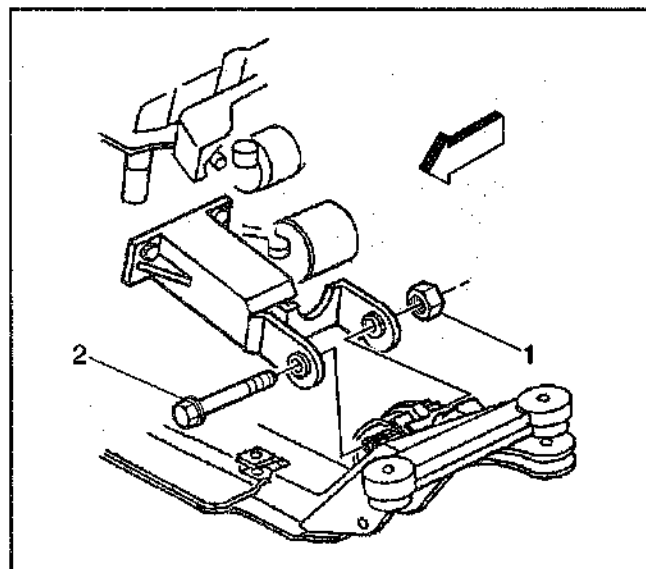
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13. Remove the right engine mount through bolt (1).

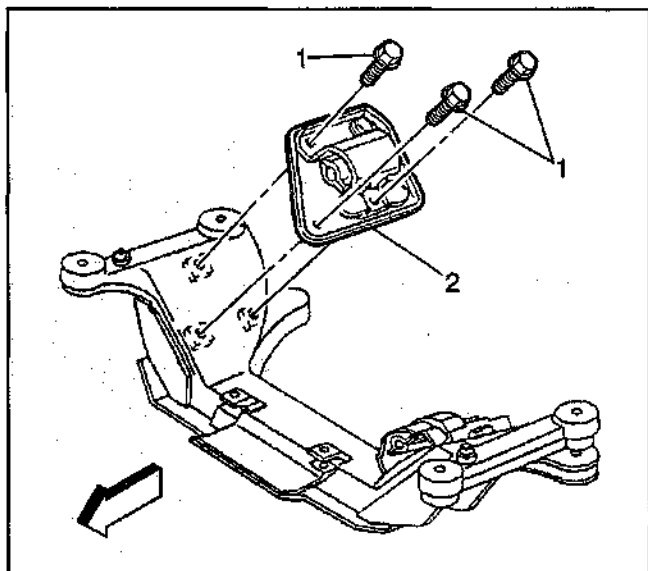


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14. Remove the left engine mount through bolt (2).
15. Raise the engine enough to remove the engine mounts and engine mount brackets.

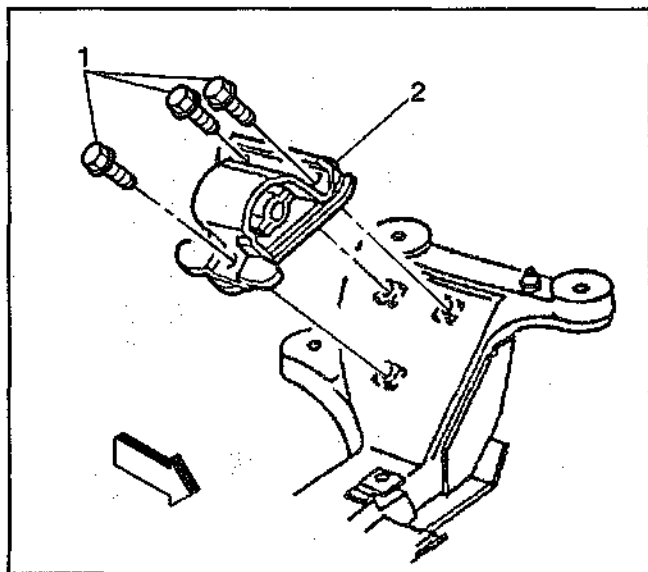


50520



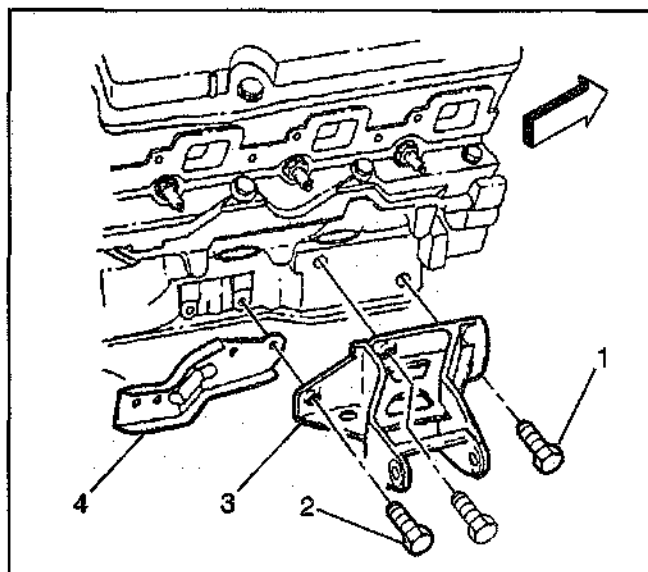
49837

16. Remove the right engine mount bolts (1) and the right engine mount (2).



50625

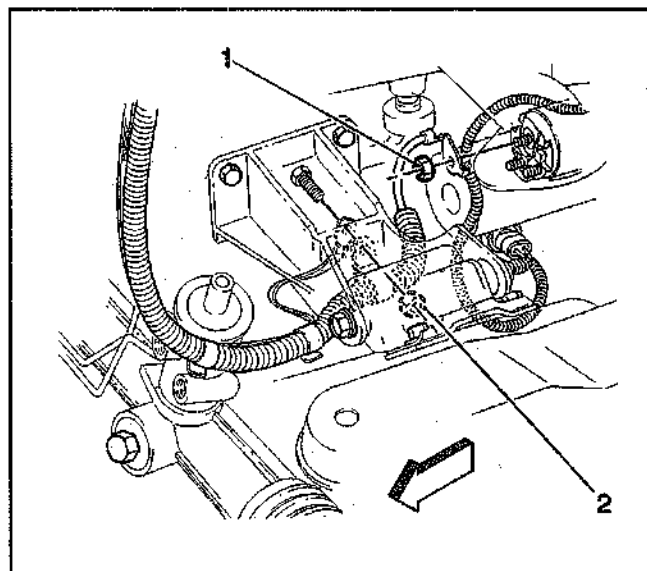
17. Remove the left engine mount bolts (1) and the left engine mount (2).



50517

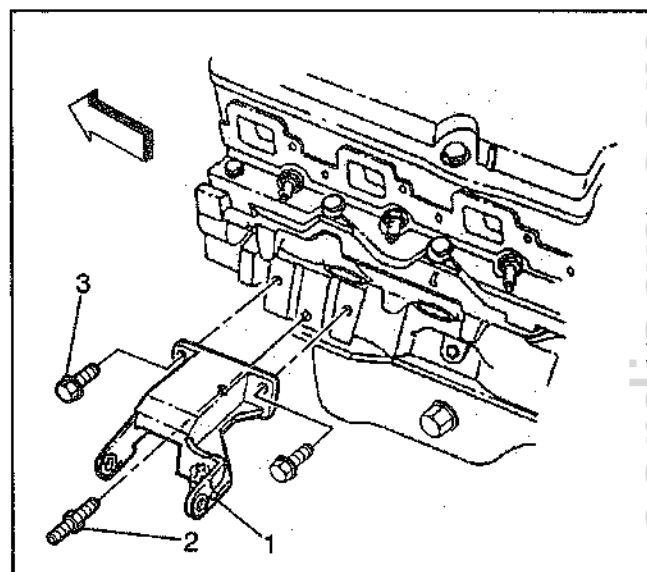
18. Remove the right engine mount bracket bolts (1, 2) and the right engine mount bracket (3).

19. Remove the positive cable from the engine mount stud.
- Remove the battery positive cable nut (2).
 - Remove the harness clamp from the stud.
 - Remove the RF (Radio Frequency) ground strap.



211604

20. Remove the left engine mount bracket bolts (3).
21. Remove the left engine mount bracket stud (2) and the engine mount bracket (1).
22. Visually Inspect the rubber portions of the engine mount for damage.



50546

Installation Procedure

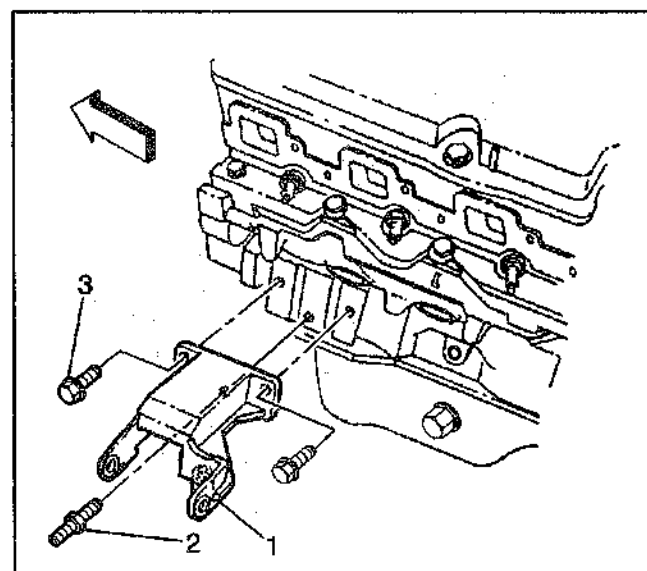
1. Install the left engine mount bracket (1) and stud (2) to the engine block.

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

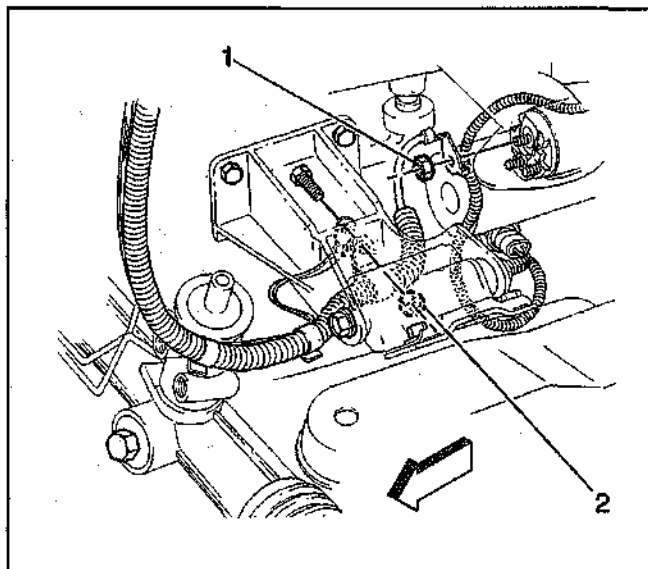
2. Install the left engine mount bracket bolts (3).

Tighten

- Tighten the engine mount bracket bolts (3) to 100 N·m (74 lb ft).
- Tighten the engine mount bracket stud (2) to 87 N·m (64 lb ft).



50546



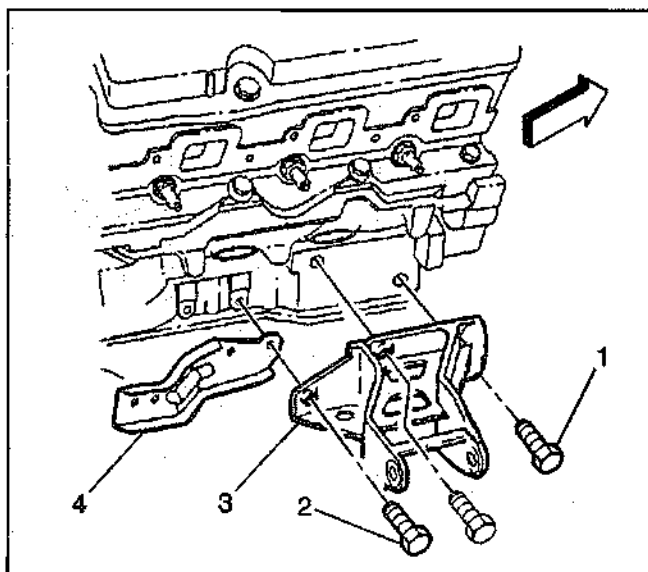
211604

3. Install the positive cable to the engine mount bracket stud.

- Install the RF (Radio Frequency) ground strap.
- Install the harness clamp to the stud.
- Install the battery positive cable nut (2).

Tighten

Tighten the battery positive cable nut (2) to 25 N·m (18 lb ft).

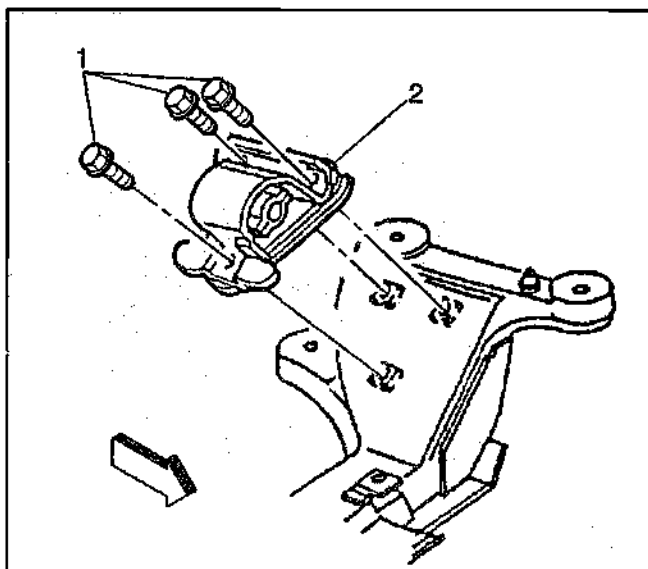


50517

4. Install the right engine mount bracket (3) and bolts (1, 2) to the engine block.

Tighten

- Tighten the two engine mount bracket bolts (10 to 100 N·m (74 lb ft).
- Tighten the engine mount bracket bolt (2) to 50 N·m (37 lb ft).



50525

5. Install the left engine mount (2) and bolts (1) to the crossmember.

Tighten

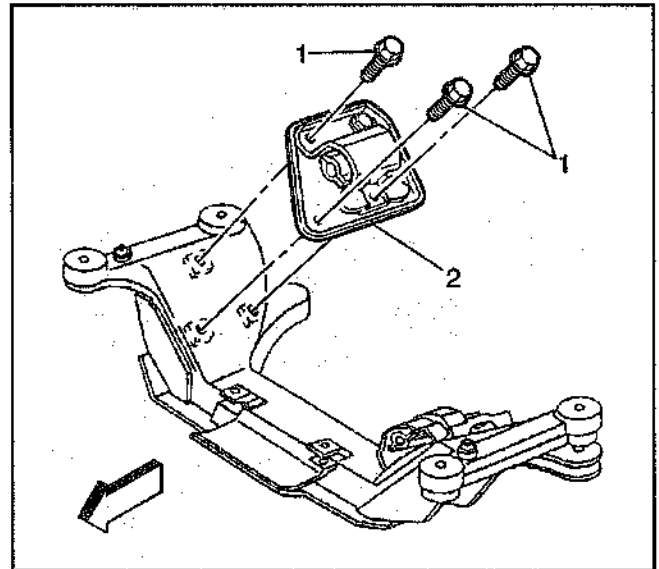
Tighten the left engine mount bolts (1) to 58 N·m (43 lb ft).

6. Install the right engine mount (2) and bolts (1) to the crossmember.

Tighten

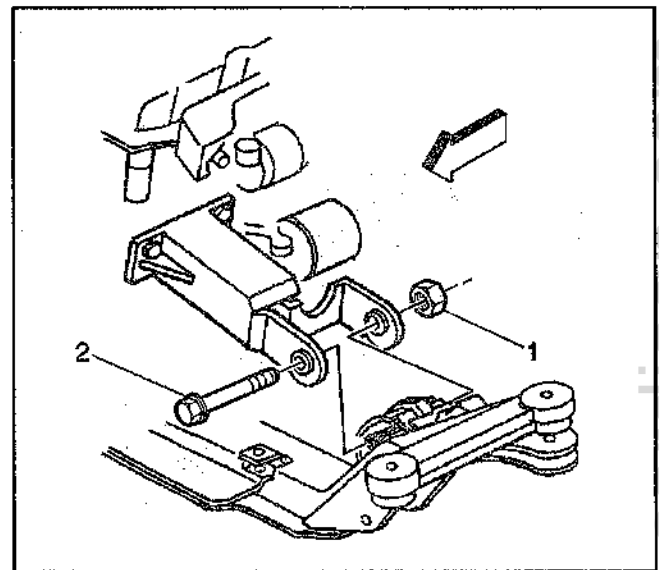
Tighten the right engine mount bolts (2) to 58 N·m (43 lb ft).

7. Lower the engine until the mount bracket and mount through holes line up together.
8. Remove the engine support fixture.



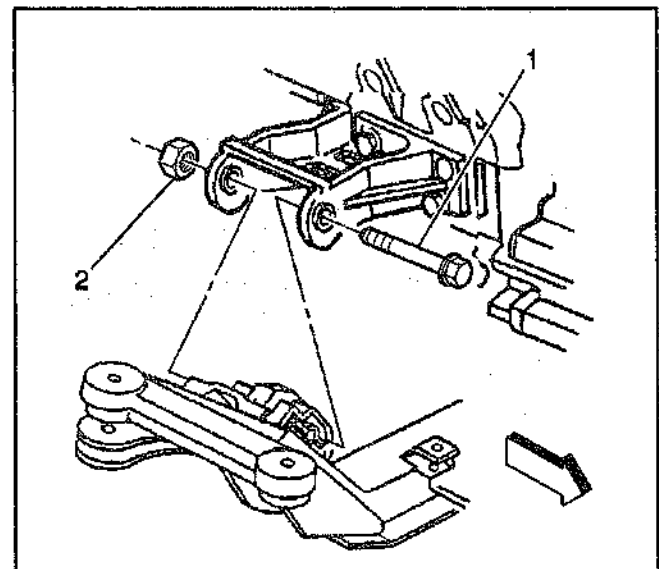
49837

9. Install the left engine mount through bolt (2).

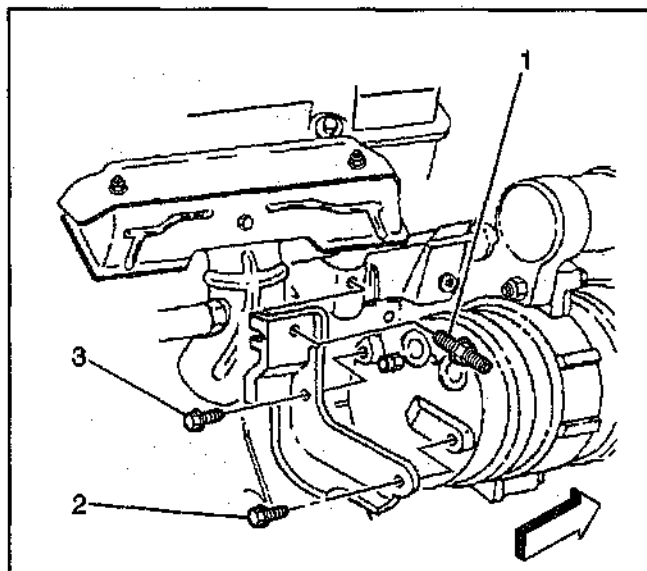


50520

10. Install the right engine mount through bolt (1).



50513

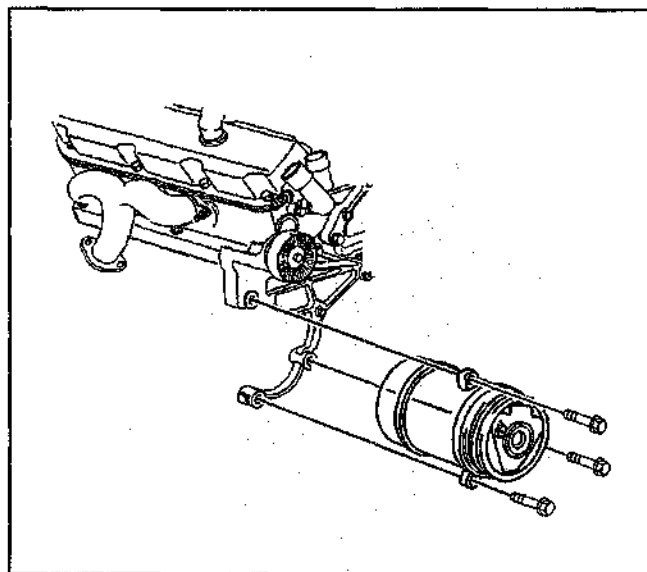


365440

11. Position the A/C compressor rearward to the bracket.
12. Install the air conditioning compressor rear bolts (2, 3).

Tighten

Tighten the air conditioning compressor rear bolts (2, 3) to 30 N·m (22 lb ft).

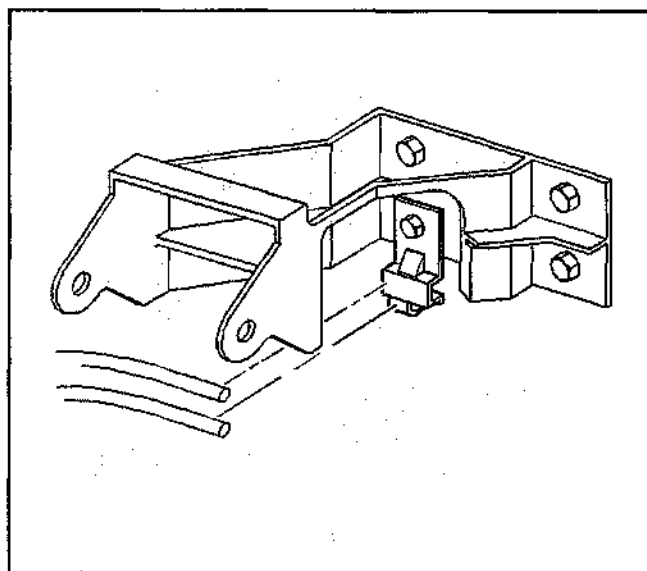


282953

13. Install the air conditioning compressor bolts.

Tighten

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



46662

14. Install the transmission oil cooler pipe bracket and bolt.

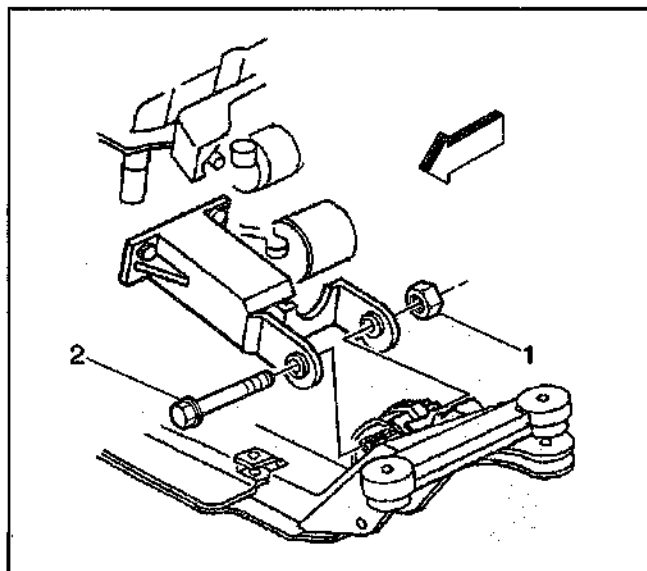
Tighten

Tighten the oil cooler pipe bracket to 17 N·m (13 lb ft).

15. Install the left side engine mount through bolt nut (1).

Tighten

Tighten the engine mount through bolt nut (1) to 80 N·m (59 lb ft).



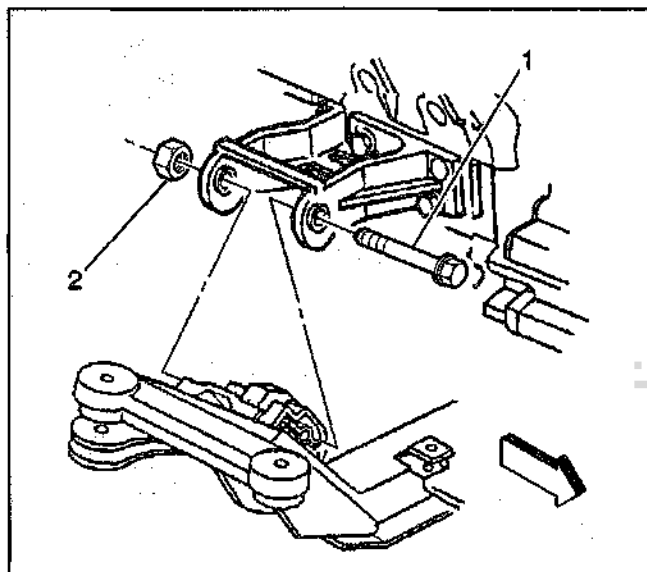
50520

16. Install the right side engine mount through bolt nut (2).

Tighten

Tighten the engine mount through bolt nut (2) to 80 N·m (59 lb ft).

17. Install the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.
18. Lower the vehicle.
19. Install the ignition control module. Refer to *Ignition Coil Module Replacement (3.8 L)* in Engine Electrical.
20. Install the generator. Refer to *Generator Replacement (3.8 L)* in Engine Electrical.



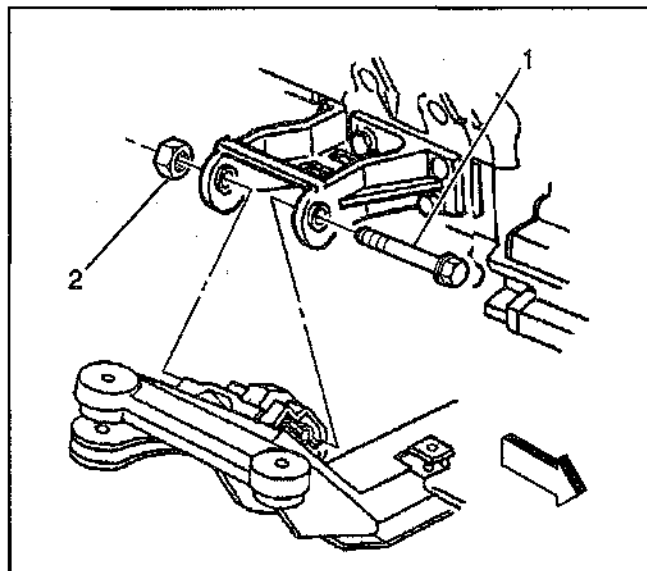
50513

Engine Mount Bracket Replacement

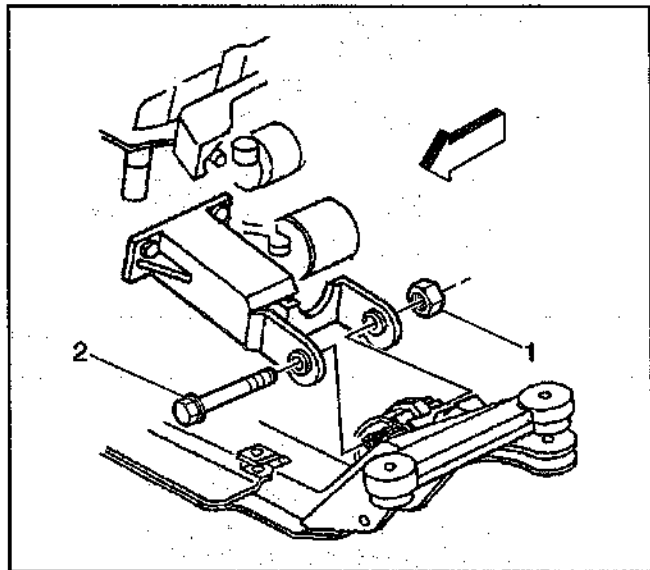
Removal Procedure

Notice: When raising or supporting the engine for any reason, do not use a jack under the oil pan, crankshaft balancer, or any sheet metal. Due to small clearances between the oil pan and the oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen, resulting in a damaged oil pickup unit. Jacking against the crankshaft balancer may also cause oil seal and/or crankshaft bearing damage. Always use a J 28467-A (Universal Support Fixture) along with J 41044 (Engine Support Adapters) when raising or supporting the engine.

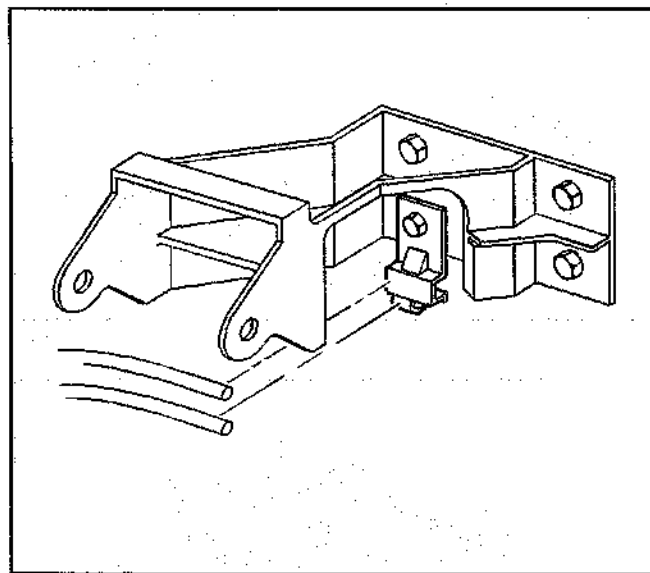
1. Remove the generator. Refer to *Generator Replacement (3.8 L)* in Engine Electrical.
2. Remove the ignition control module. Refer to *Ignition Coil Module Replacement (3.8 L)* in Engine Electrical.



50513



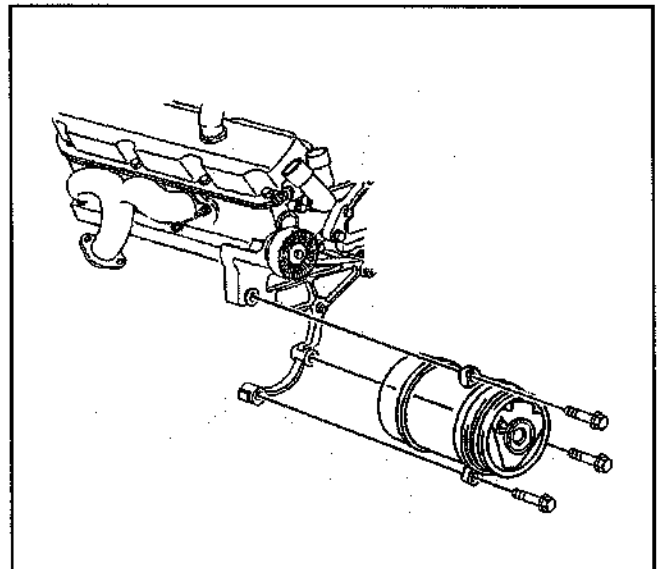
50520



46662

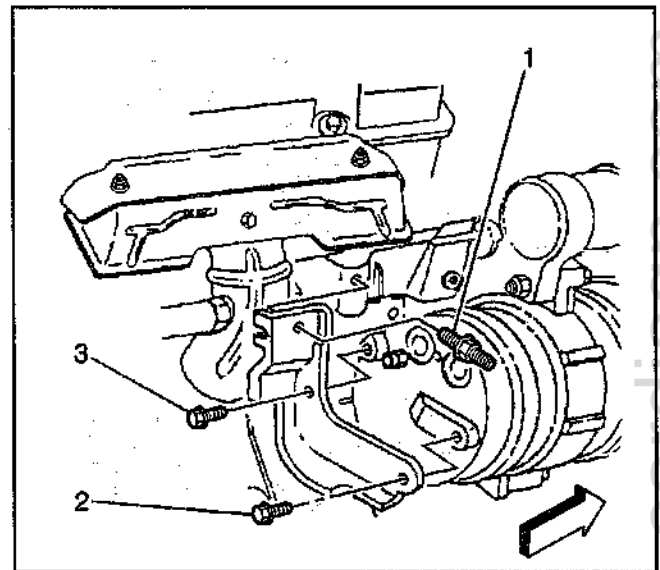
3. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
4. Remove the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.
5. Remove the right side engine mount through bolt nut (2).
6. Remove the left side engine mount through bolt nut (1).
7. Install the engine support fixture. Refer to *Engine Support Fixture*.
8. Raise the engine slightly in order to relieve tension on the through bolts.
9. Remove the transmission oil cooler pipe bracket bolt and bracket.

10. Remove the air conditioning compressor bolts.



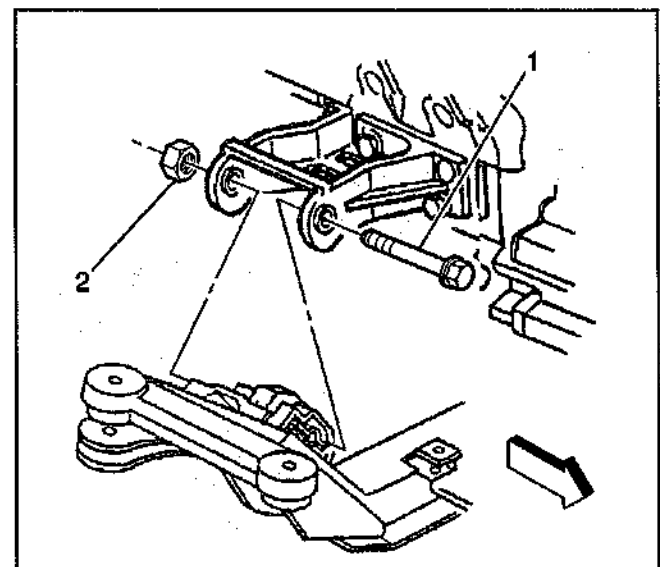
282953

11. Remove the air conditioning compressor rear bolts (2, 3).
12. Position the A/C compressor forward of the bracket in order to remove the engine mount through bolt without recovering the refrigerant.
13. Raise the engine slightly in order to relieve tension on the through bolts.

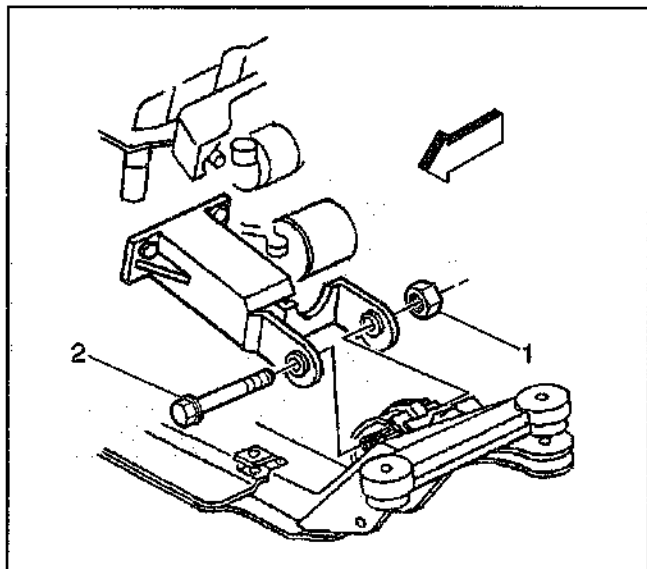


365440

14. Remove the right engine mount through bolt (1).

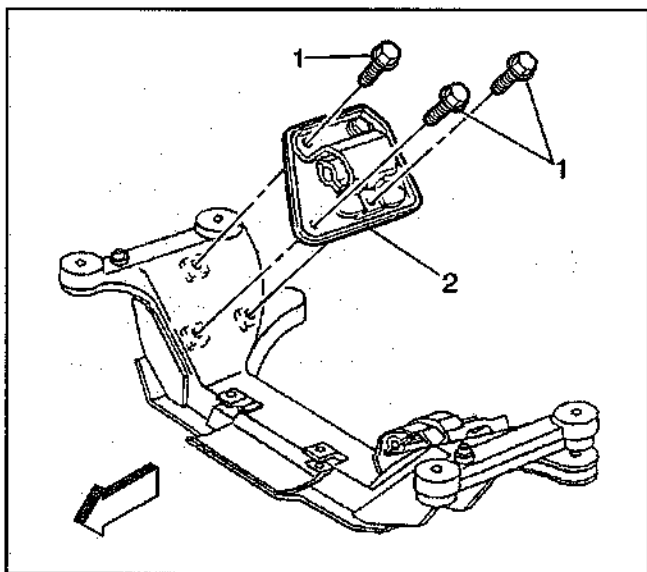


50513



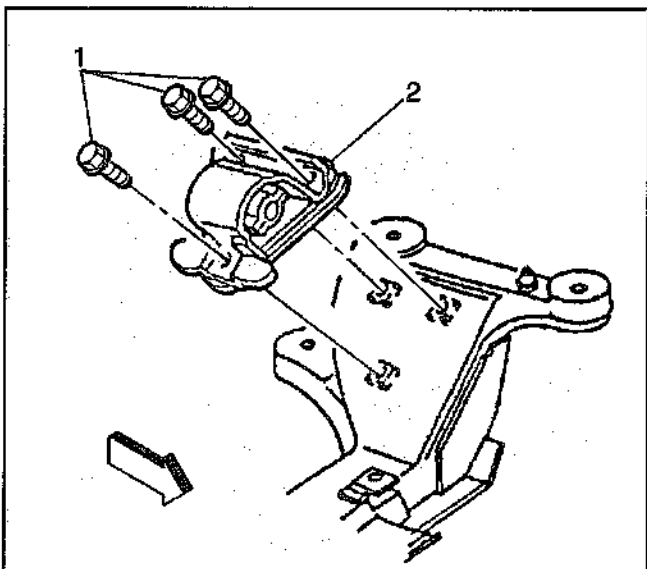
50520

15. Remove the left engine mount through bolt (2).
16. Raise the engine enough to remove the engine mounts and engine mount brackets.



49837

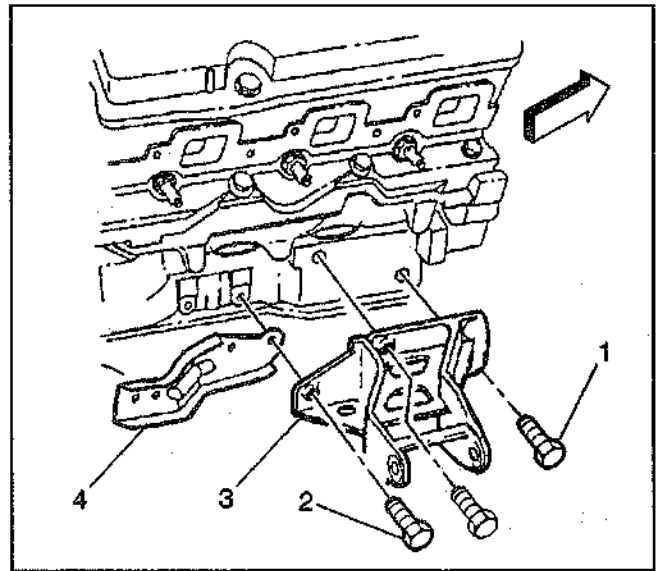
17. Remove the right engine mount bolts (1) and the right engine mount (2).



50525

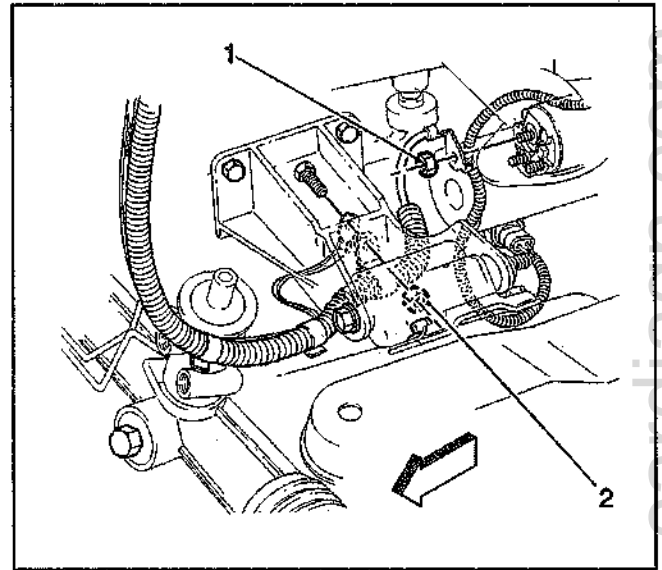
18. Remove the left engine mount bolts (1) and the left engine mount (2).

19. Remove the right engine mount bracket bolts (1, 2) and the right engine mount bracket (3).



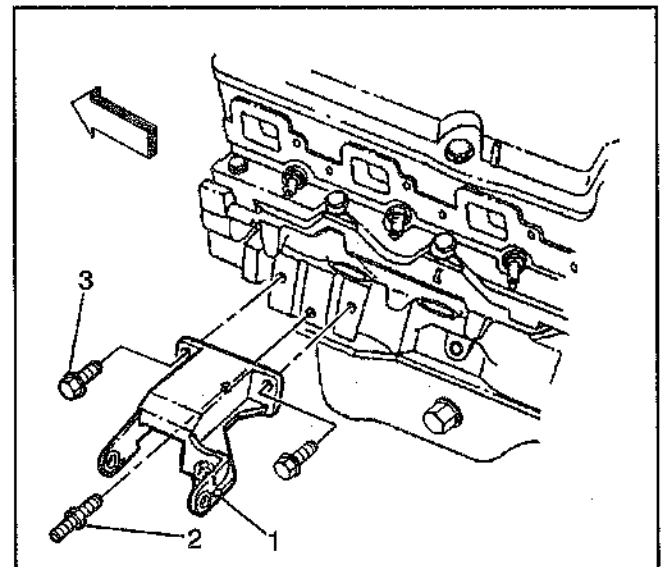
50517

20. Remove the positive cable from the engine mount stud.
- Remove the battery positive cable nut (2).
 - Remove the harness clamp from the stud.
 - Remove the RF (Radio Frequency) ground strap.

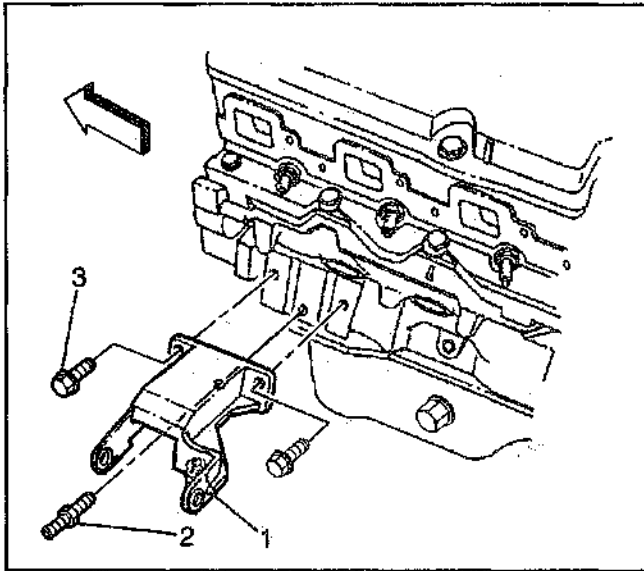


211604

21. Remove the left engine mount bracket bolts (3).
22. Remove the left engine mount bracket stud (2) and the engine mount bracket (1).
23. Visually Inspect the rubber portions of the engine mount for damage.



50546



50546

Installation Procedure

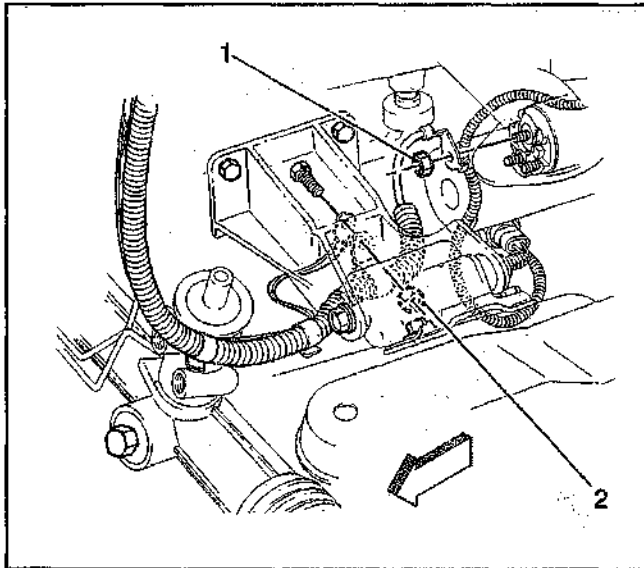
1. Install the left engine mount bracket (1) and stud (2) to the engine block.

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

2. Install the left engine mount bracket bolts (3).

Tighten

- Tighten the engine mount bracket bolts (3) to 100 N·m (74 lb ft).
- Tighten the engine mount bracket stud (2) to 87 N·m (64 lb ft).



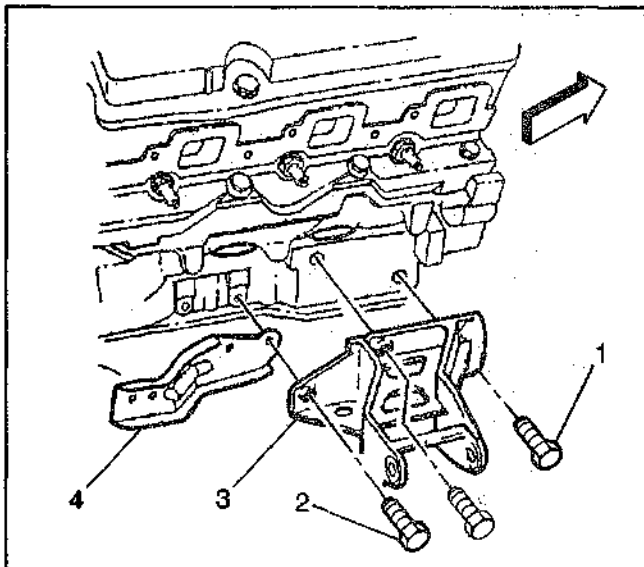
211604

3. Install the positive cable to the engine mount bracket stud.

- Install the RF (Radio Frequency) ground strap.
- Install the harness clamp to the stud.
- Install the battery positive cable nut (2).

Tighten

Tighten the battery positive cable nut (2) to 25 N·m (18 lb ft).



50517

4. Install the right engine mount bracket (3) and bolts (1, 2) to the engine block.

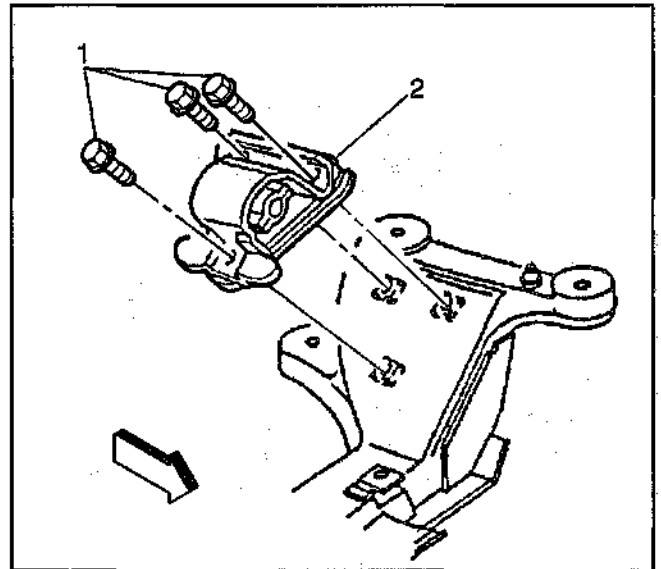
Tighten

- Tighten the two engine mount bracket bolts (10 to 100 N·m (74 lb ft)).
- Tighten the engine mount bracket bolt (2) to 50 N·m (37 lb ft).

5. Install the left engine mount (2) and bolts (1) to the crossmember.

Tighten

Tighten the left engine mount bolts (1) to 58 N·m (43 lb ft).



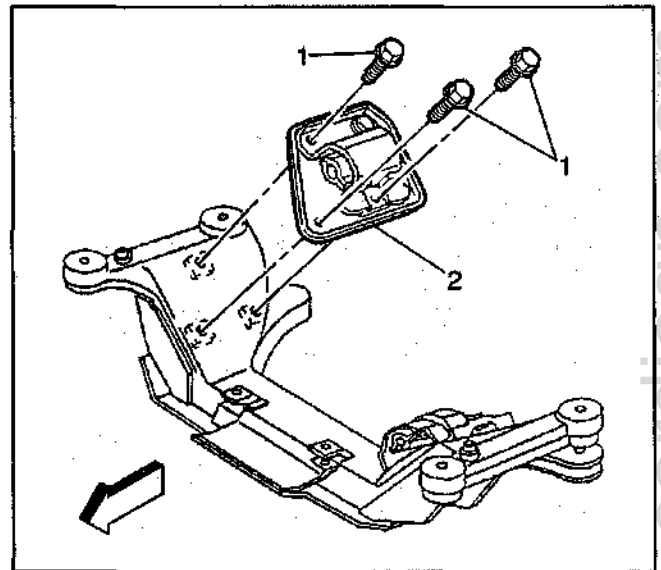
50525

6. Install the right engine mount (2) and bolts (1) to the crossmember.

Tighten

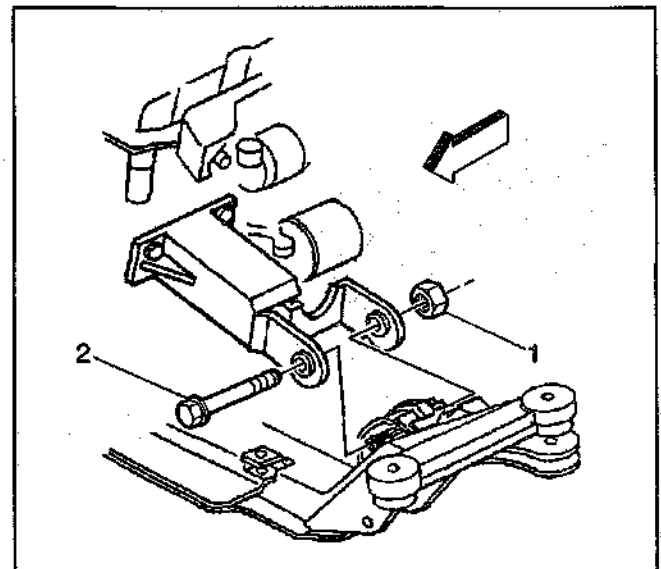
Tighten the right engine mount bolts (2) to 58 N·m (43 lb ft).

7. Lower the engine until the mount bracket and mount through holes line up together.
8. Remove the engine support fixture.

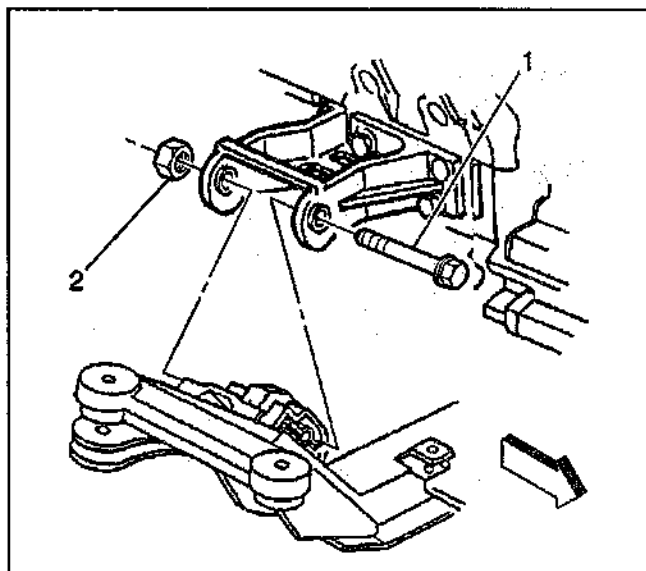


49837

9. Install the left engine mount through bolt (2).

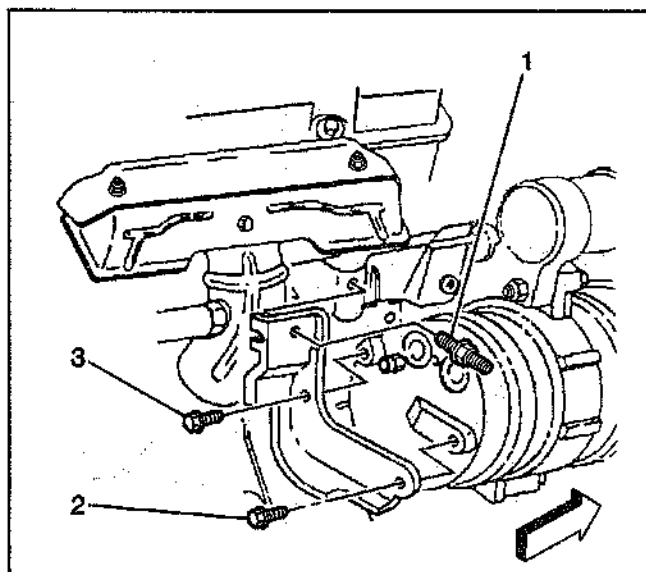


50520



50513

10. Install the right engine mount through bolt (1).

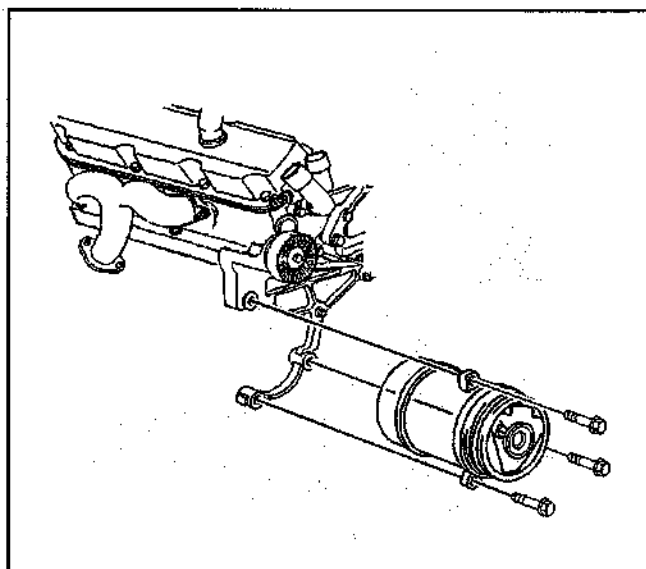


365440

11. Position the A/C compressor rearward to the bracket.
 12. Install the air conditioning compressor rear bolts (2, 3).

Tighten

Tighten the air conditioning compressor rear bolts (2, 3) to 30 N·m (22 lb ft).



282953

13. Install the air conditioning compressor bolts.

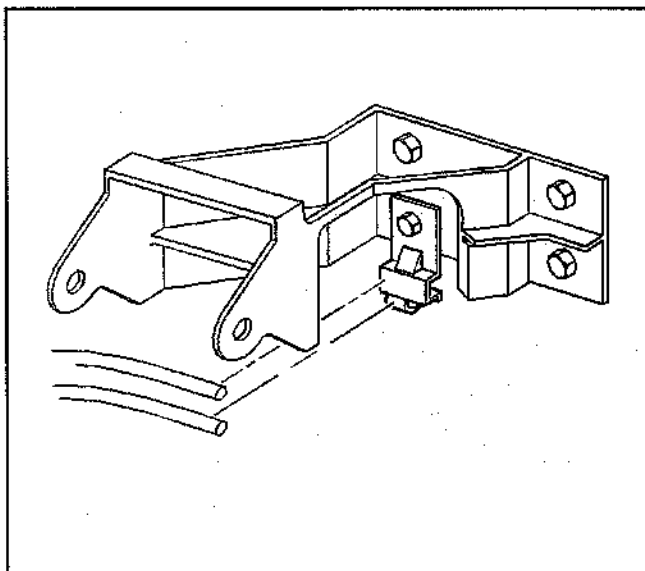
Tighten

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

14. Install the transmission oil cooler pipe bracket and bolt.

Tighten

Tighten the oil cooler pipe bracket to 17 N·m (13 lb ft).

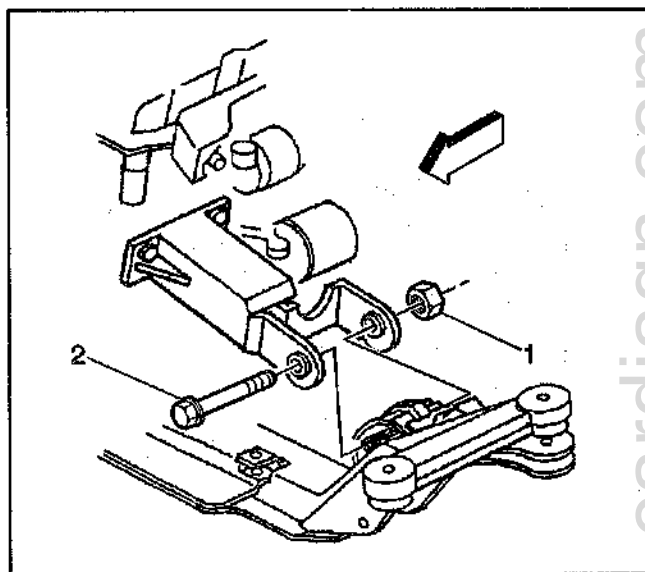


46662

15. Install the left side engine mount through bolt nut (1).

Tighten

Tighten the engine mount through bolt nut (1) to 80 N·m (59 lb ft).



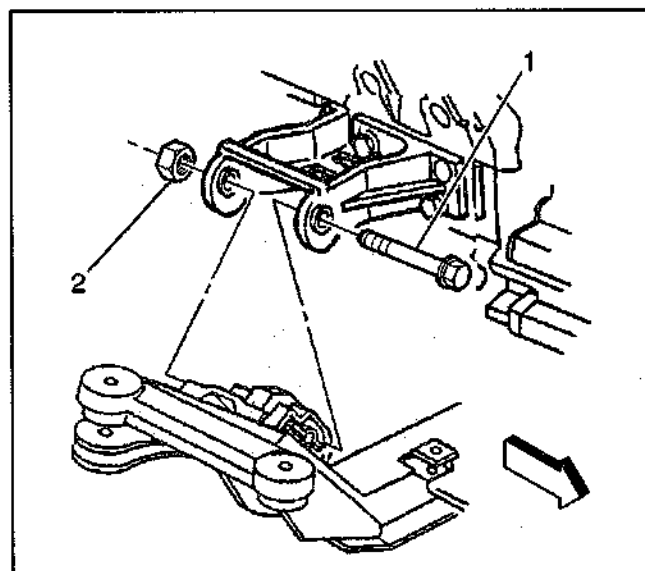
50520

16. Install the right side engine mount through bolt nut (2).

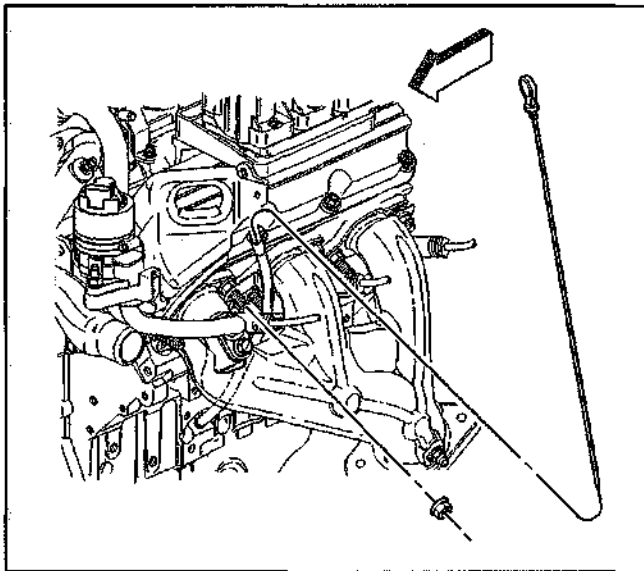
Tighten

Tighten the engine mount through bolt nut (2) to 80 N·m (59 lb ft).

17. Install the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.
18. Lower the vehicle.
19. Install the ignition control module. Refer to *Ignition Coil Module Replacement (3.8 L)* in Engine Electrical.
20. Install the generator. Refer to *Generator Replacement (3.8 L)* in Engine Electrical.



50513

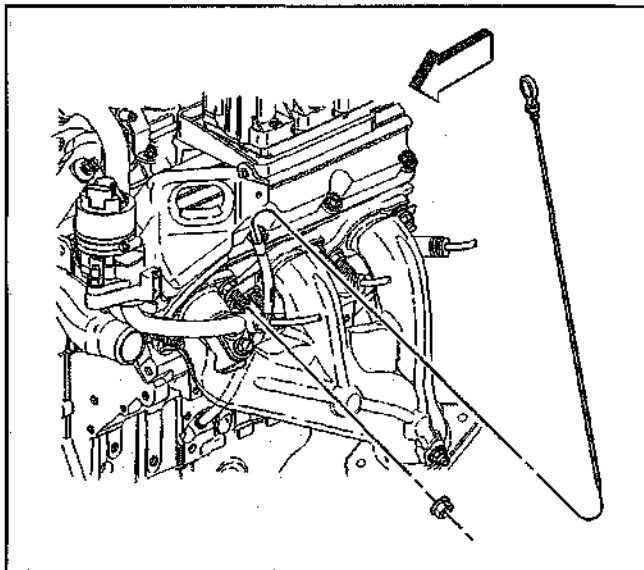


554751

Oil Level Indicator and Tube Replacement

Removal Procedure

1. Remove the oil level indicator from the indicator tube.
2. Remove the oil level indicator tube nut.
3. Remove the oil level indicator tube from the engine block.



554751

Installation Procedure

1. Replace the O-ring seal if necessary.
2. Install the oil level indicator tube to the engine block.

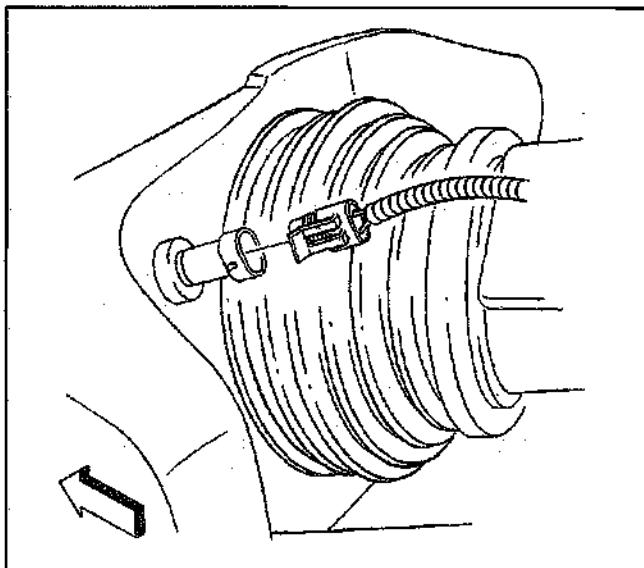
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the oil level indicator tube nut.

Tighten

Tighten the oil level indicator tube nut to 19 N·m (14 lb ft).

4. Install the oil level indicator to the indicator tube.



208554

Intake Manifold Replacement (Upper)

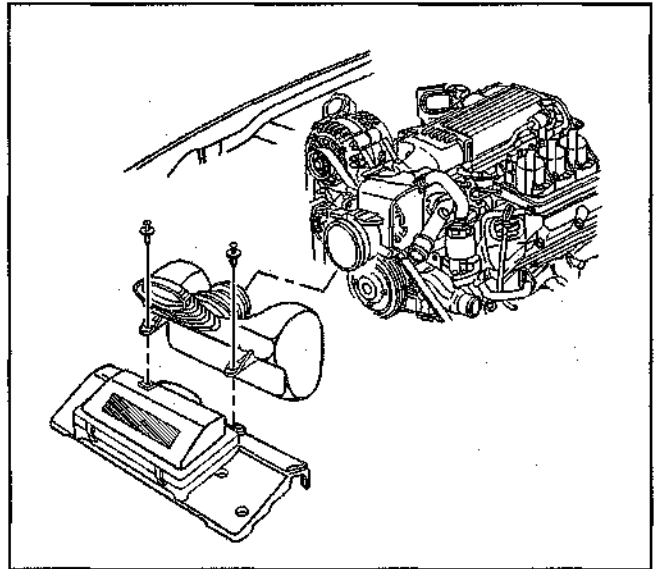
Removal Procedure

Tools Required

J 37088-A Fuel Line Quick Connect Separator

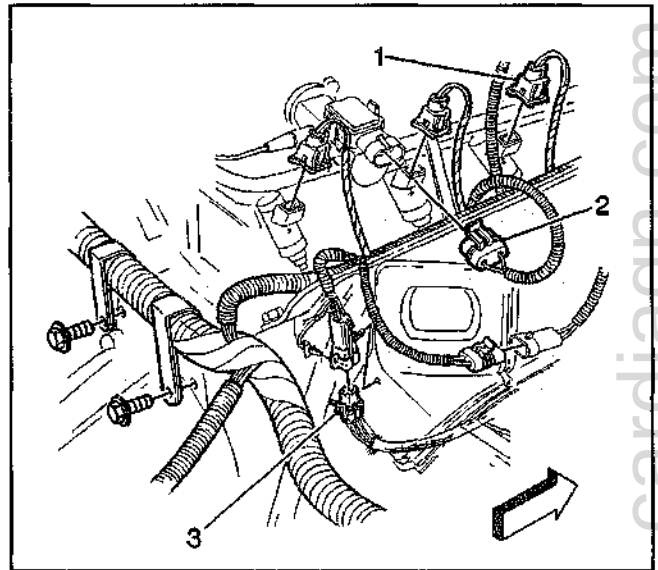
1. Drain the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.
2. Disconnect the intake air temperature (IAT) sensor electrical connector.

3. Remove the air intake duct.
4. Remove the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.



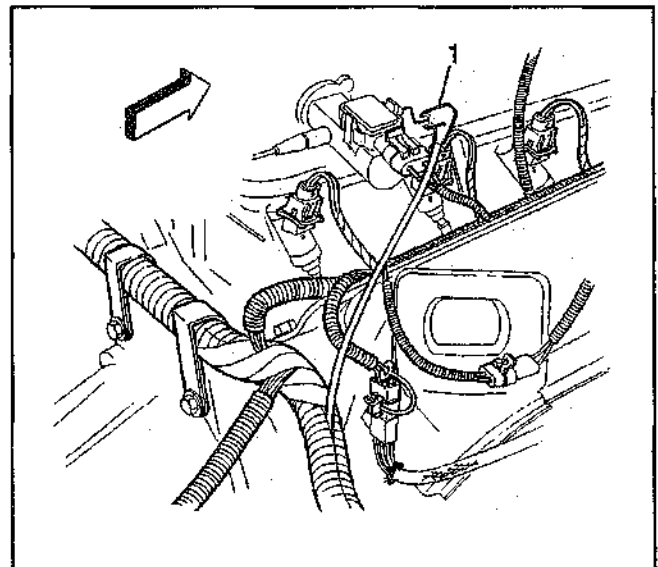
554755

5. Disconnect the fuel injector electrical connectors (1) from the fuel injectors.
6. Disconnect the manifold absolute pressure (MAP) sensor electrical connector (2).

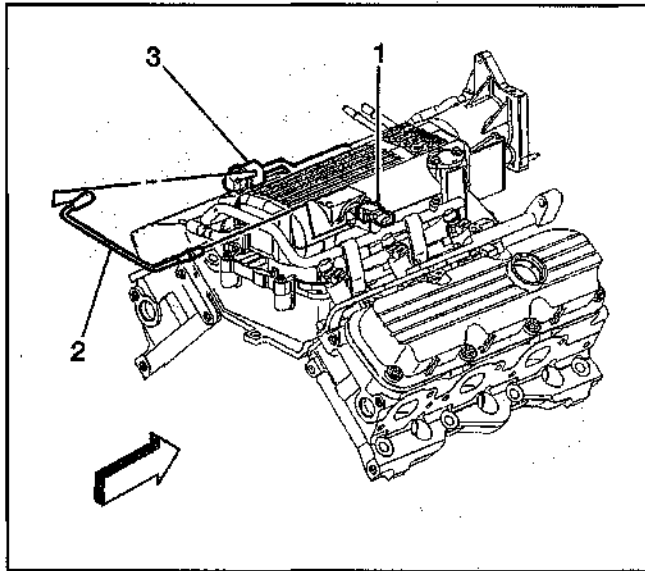


439410

7. Disconnect the engine harness vacuum tube (1) from the vacuum port.



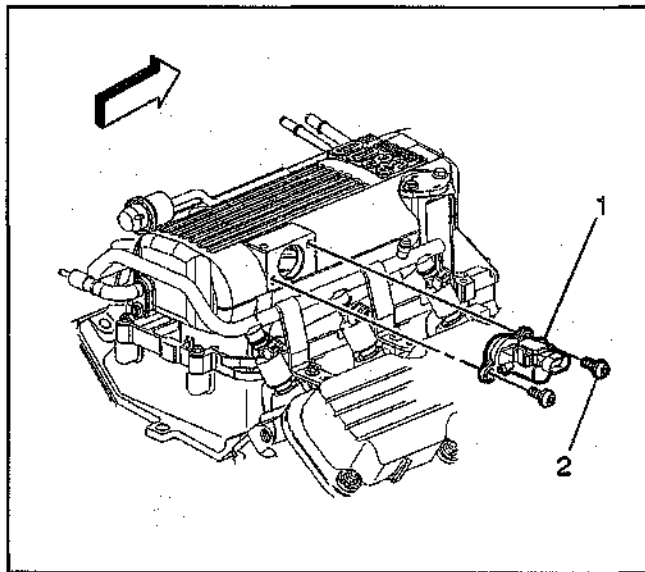
439411



439396

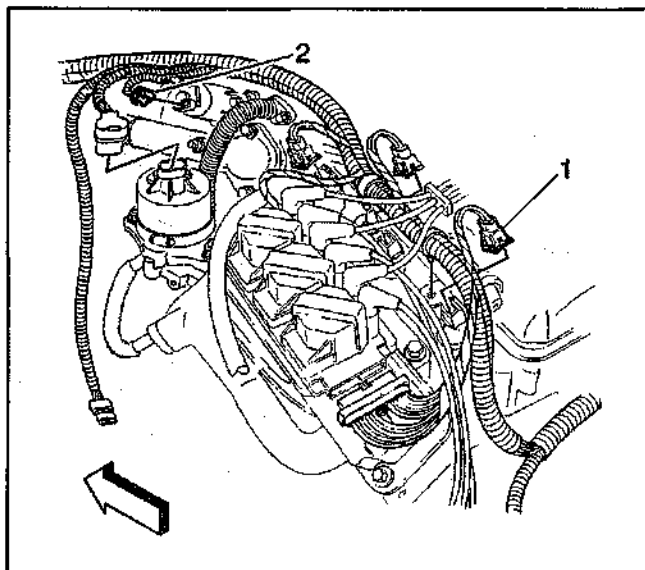
8. Remove the fuel pressure regulator tube (2) from the following components:

- Manifold vacuum source (1)
- Fuel pressure regulator valve (3)



441250

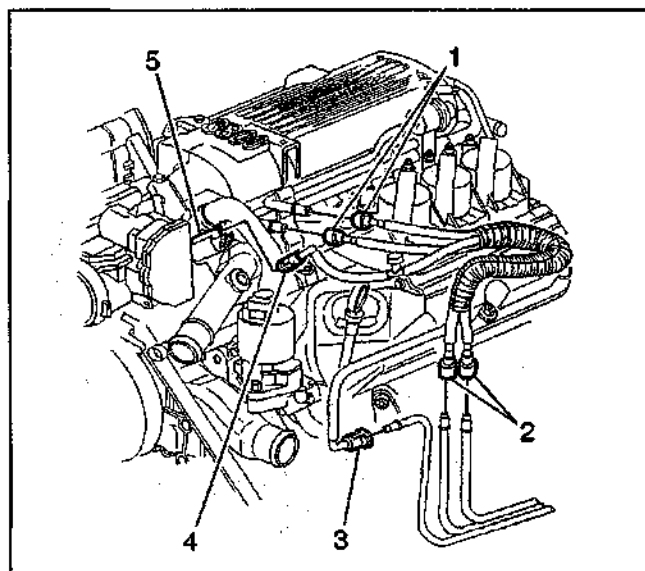
9. Remove the manifold vacuum source screws (2):
10. Remove the manifold vacuum source (1) from the upper intake manifold:



439457

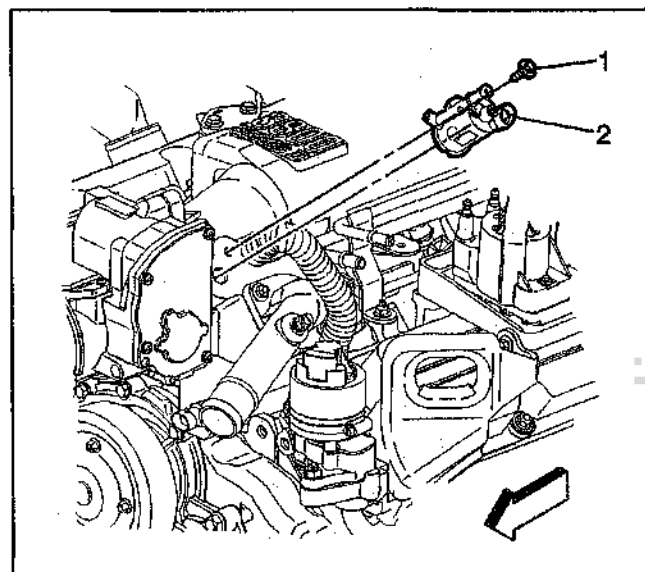
11. Disconnect the fuel injector electrical connectors (1) from the fuel injectors:
12. Disconnect the evaporative emission (EVAP) canister purge valve switch electrical connector (2):
13. Relieve the fuel pressure. Refer to *Fuel Pressure Relief Procedure* in Engine Controls - 3.8 L.

14. Disconnect the fuel lines (1) from the fuel rail using J 37088-A.
15. Disconnect the fuel vapor line (4) from the EVAP canister purge valve (5).



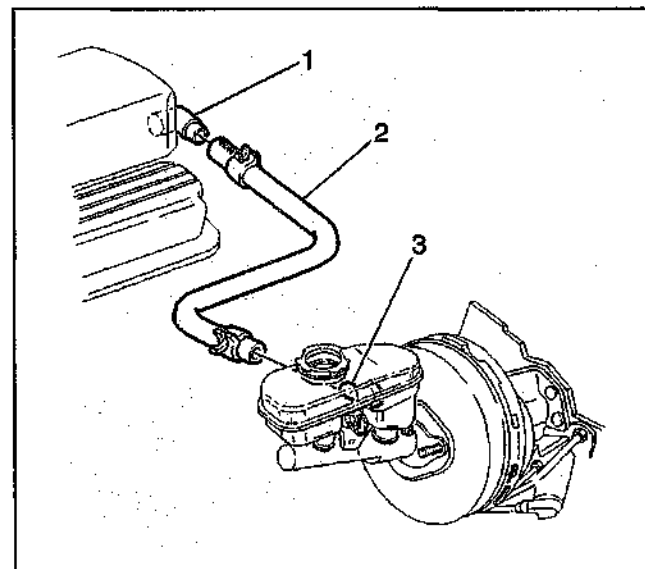
439396

16. Remove the EVAP canister purge valve bolts (1).
17. Remove the EVAP canister purge valve (2) from the upper intake manifold.
18. Remove the ignition control module. Refer to *Ignition Coil Module Replacement (3.8 L)* in Engine Electrical.

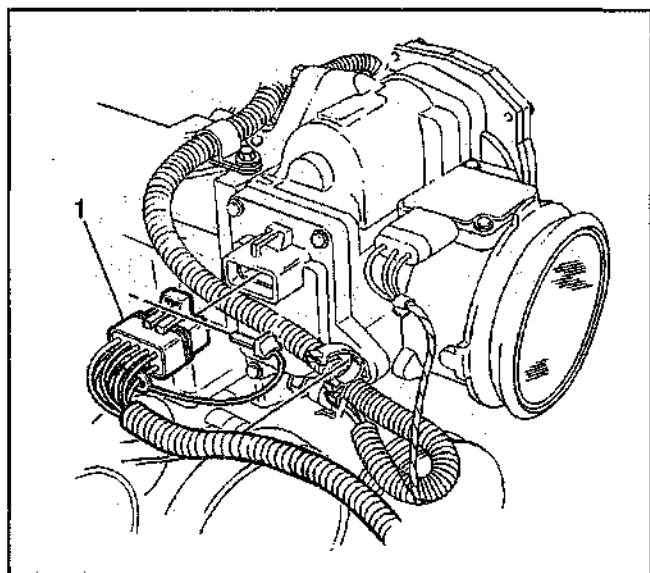


439395

19. Reposition the brake booster hose clamp.
20. Remove the brake booster hose (2) from the upper intake manifold fitting (1).

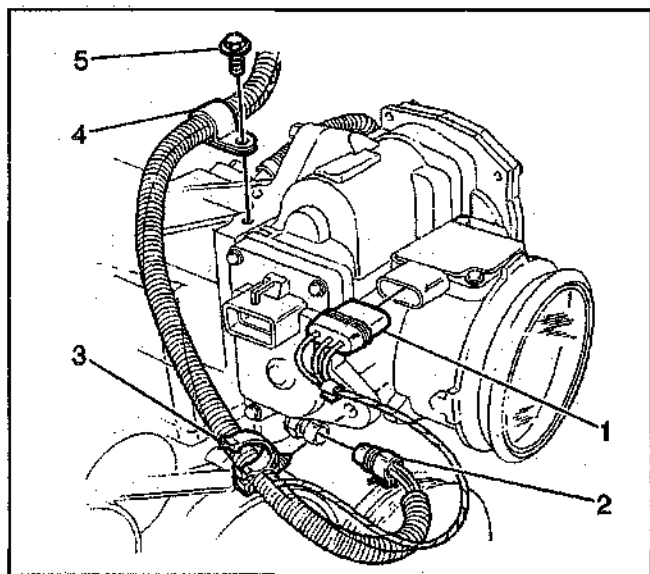


439407



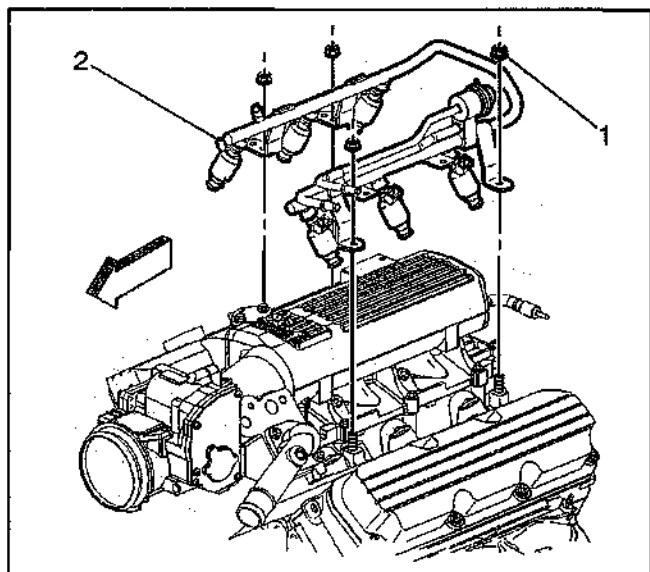
439418

21. Remove the captured secondary lock from the connector.
22. Disconnect the electronic throttle control (ETC) electrical connector (1).



439428

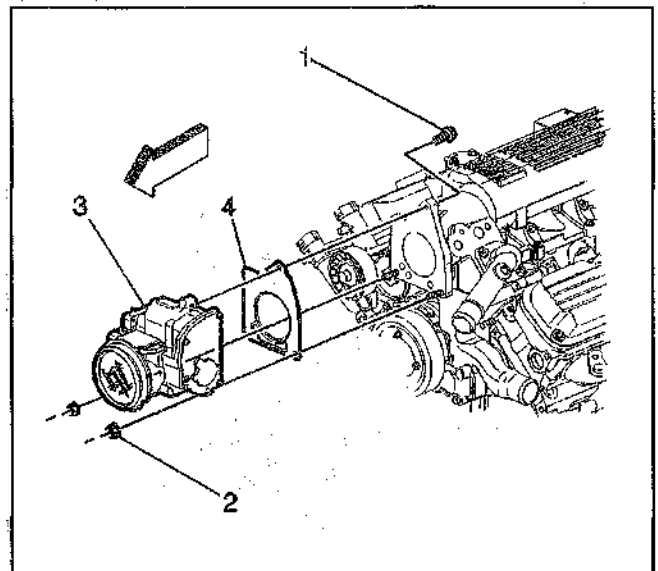
23. Disconnect the following electrical connectors:
 - Mass airflow (MAF) sensor (1)
 - Engine coolant temperature (ECT) sensor (2)
24. Remove the engine harness rosebud clip (3) from the throttle body.
25. Remove the engine harness clamp bolt (5) and harness clamp (4).
26. Reposition the engine wiring harness.
27. Remove the thermostat housing. Refer to *Thermostat Housing Replacement (3.8 L)* in Engine Cooling.
28. Disconnect the wiring harness rosebud clips from the fuel rail.
29. Reposition the wiring harness.



441253

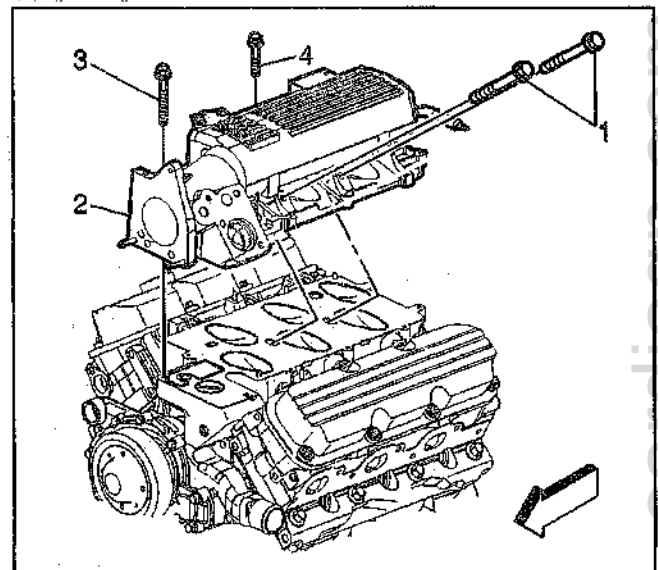
30. Remove the fuel rail nuts (1).
- Important:** Clean any dirt out of the injector bores with compressed air.
31. Remove the fuel rail (2) from the upper intake manifold.

32. Remove the throttle body bolt (1) and nuts (2).
33. Remove the throttle body (3) and gasket (4).



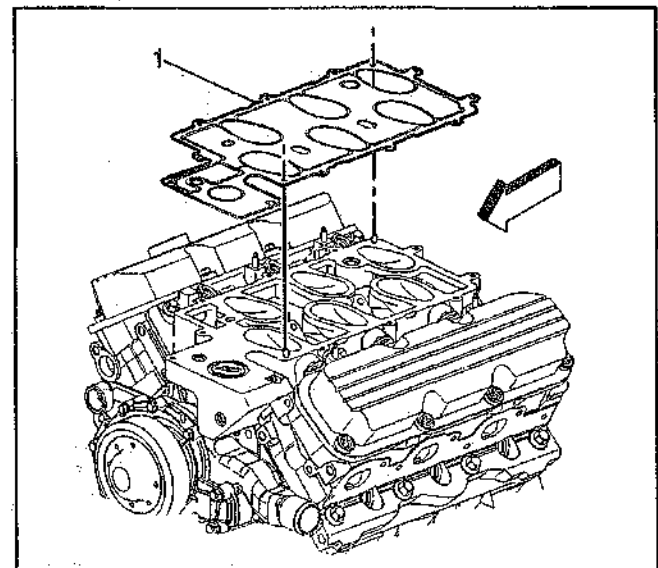
439449

34. Remove the upper intake manifold bolts (1, 3, 4).
35. Remove the upper intake manifold (2).

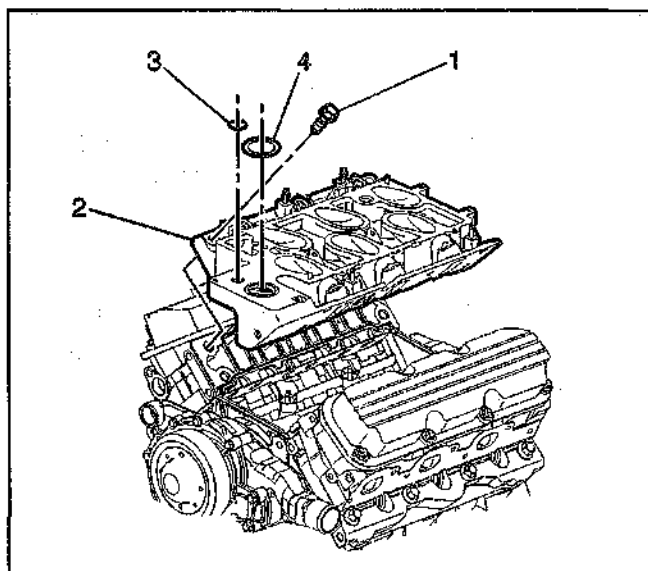


441255

36. Remove the upper intake manifold gasket (1).
37. Clean the upper and lower intake manifold sealing surfaces.

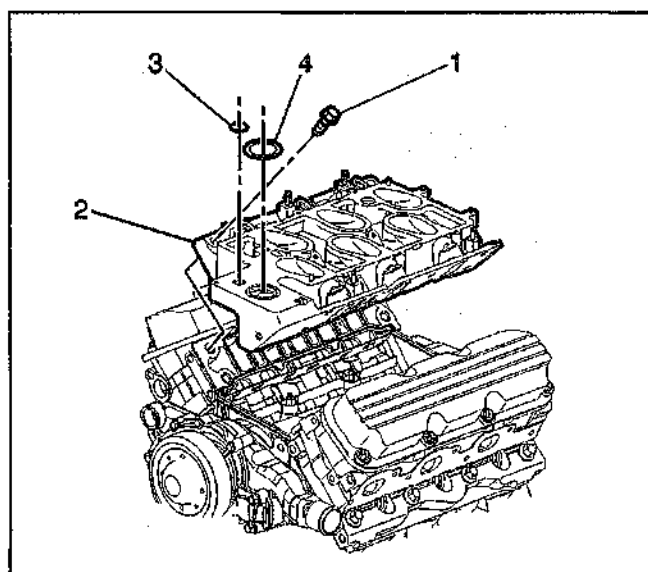


439503



439510

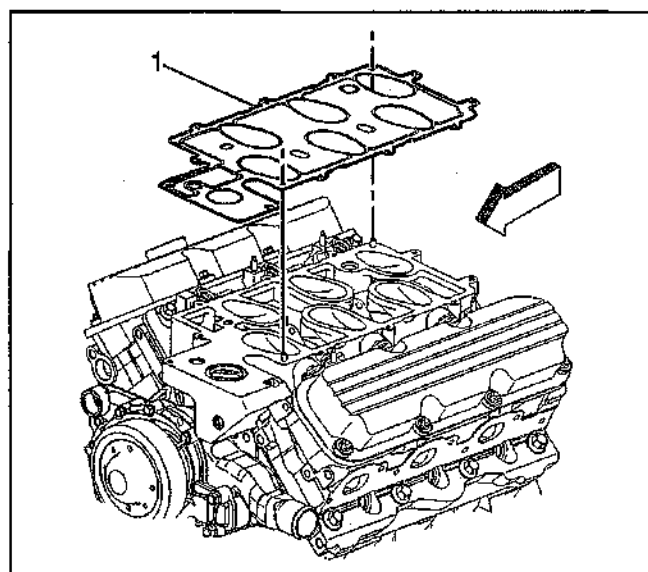
38. Remove the lower intake manifold O-rings seals (3, 4), if necessary.



439510

Installation Procedure

1. Install new lower intake manifold O-ring seal (3, 4), if removed.



439503

2. Install the upper intake manifold gasket (1).

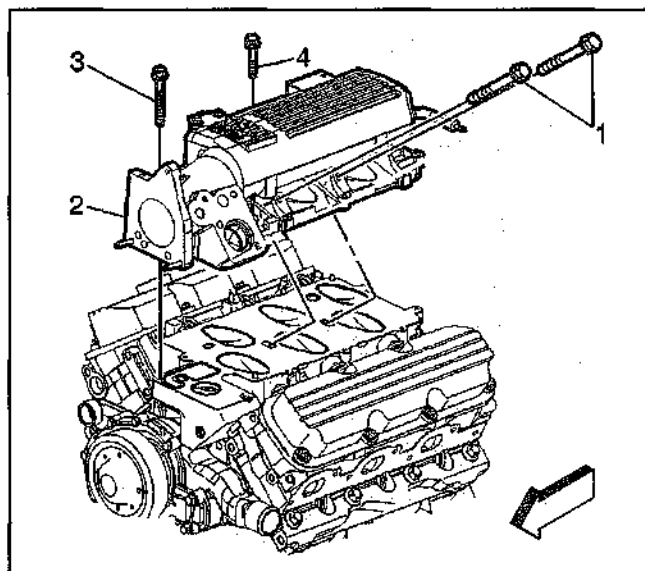
3. Install the upper intake manifold (2) onto the lower intake manifold.

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

4. Install the upper intake manifold bolts (1, 3, 4).

Tighten

- Tighten the upper intake manifold bolt (3) to 15 N·m (11 lb ft).
- Tighten the nine upper intake manifold bolts (4) to 10 N·m (89 lb in).
- Tighten the two upper intake manifold bolts (1) to 30 N·m (22 lb ft).

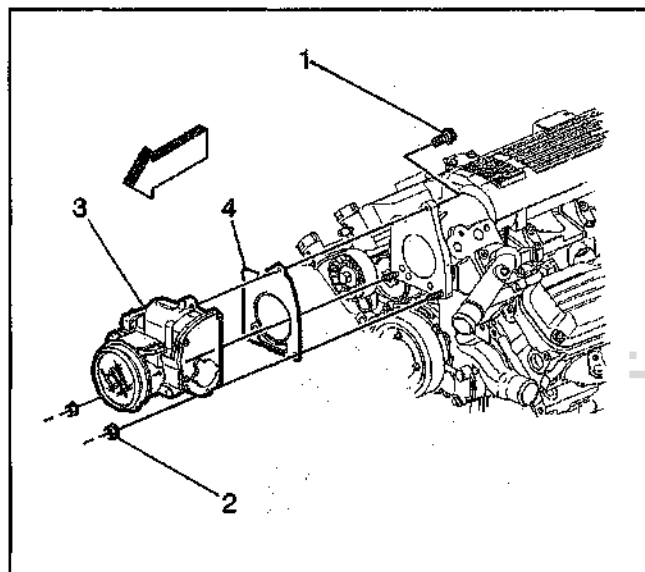


441255

5. Install the throttle body (3) and gasket (4).
6. Install the throttle body bolt (1) and nuts (2).

Tighten

- Tighten the throttle body nuts (2) to 10 N·m (89 lb in).
- Tighten the throttle body bolt (1) to 10 N·m (89 lb in).



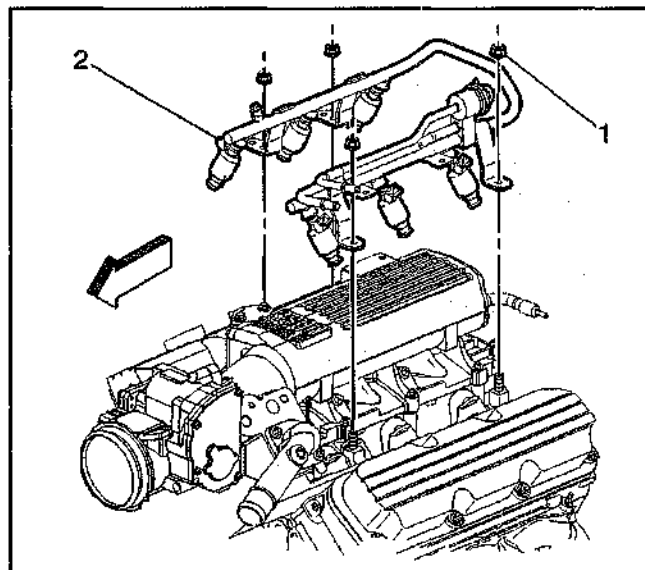
439449

7. Install the fuel rail (2) to the upper intake manifold.
8. Install the fuel rail nuts (1).

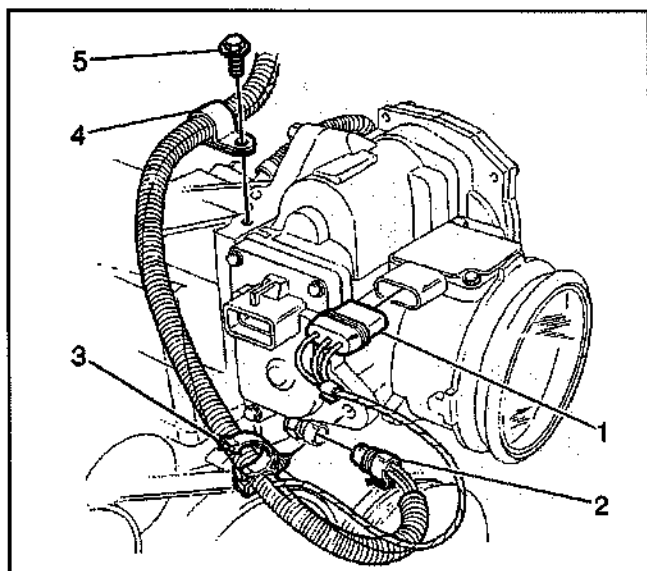
Tighten

Tighten the fuel rail nuts (1) to 8.5 N·m (75 lb in).

9. Position the wiring harness.
10. Connect the wiring harness rosebud clips from the fuel rail.
11. Install the thermostat housing. Refer to *Thermostat Housing Replacement (3.8 L)* in Engine Cooling.
12. Position the engine wiring harness.



441253



439428

13. Install the engine harness clamp (4) and harness clamp bolt (5).

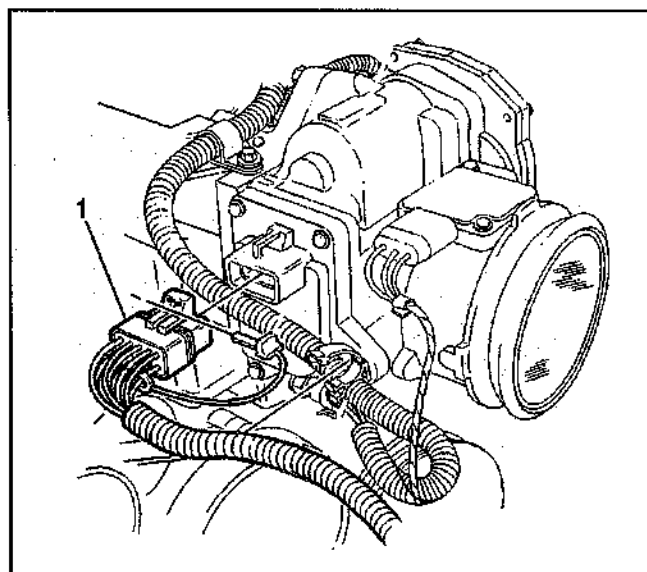
Tighten

Tighten the harness clamp bolt (5) to 6 N·m (53 lb in).

14. Install the engine harness rosebud clip (3) to the throttle body.

15. Connect the following electrical connectors:

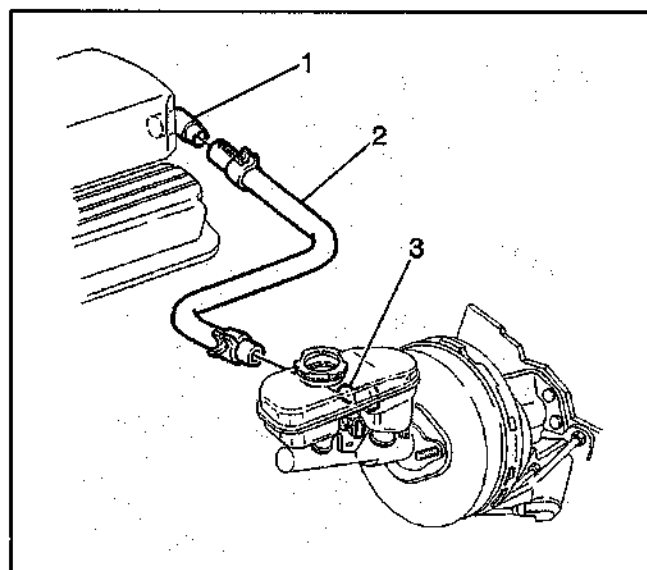
- MAF sensor (1)
- ECT sensor (2)



439418

16. Connect the ETC electrical connector (1).

17. Install the captured secondary lock from the connector.



439407

18. Install the brake booster hose (2) to the upper intake manifold fitting (1).

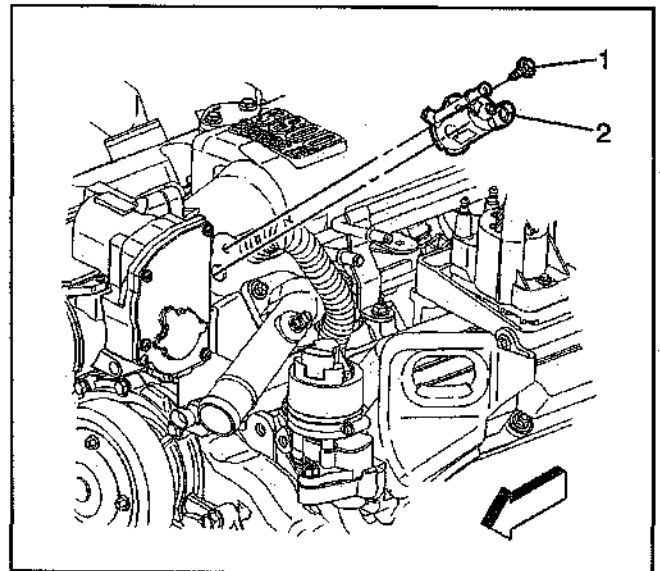
19. Position the brake booster hose clamp.

20. Install the ignition control module. Refer to *Ignition Coil Module Replacement (3.8 L)* in Engine Electrical.

21. Install the EVAP canister purge valve (2) to the upper intake manifold.
22. Install the EVAP canister purge valve bolts (1).

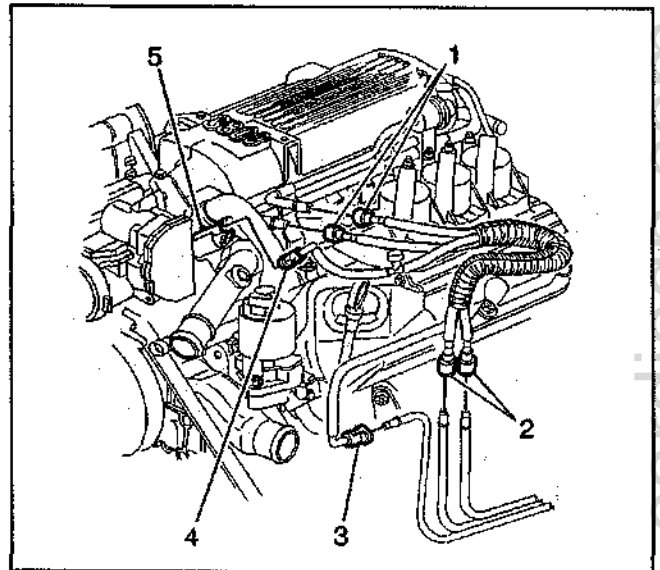
Tighten

Tighten the EVAP canister purge valve bolts (1) to 10 N·m (89 lb in).



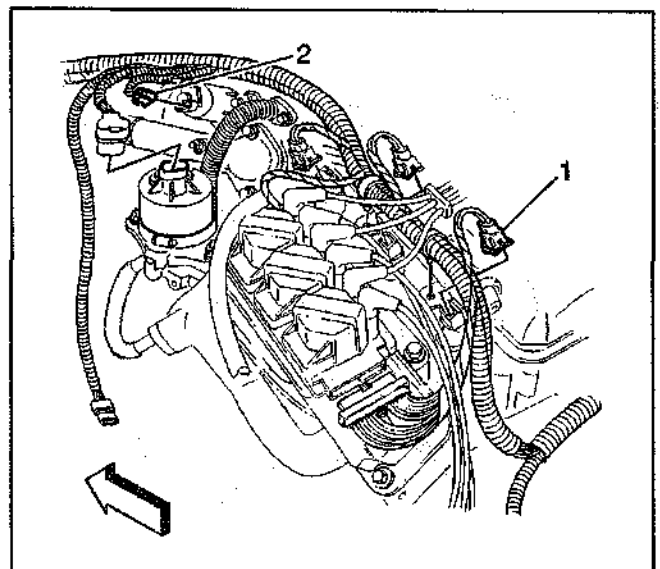
439395

23. Connect the fuel vapor line (4) to the EVAP canister purge valve (5).
24. Connect the fuel lines (1) to the fuel rail.

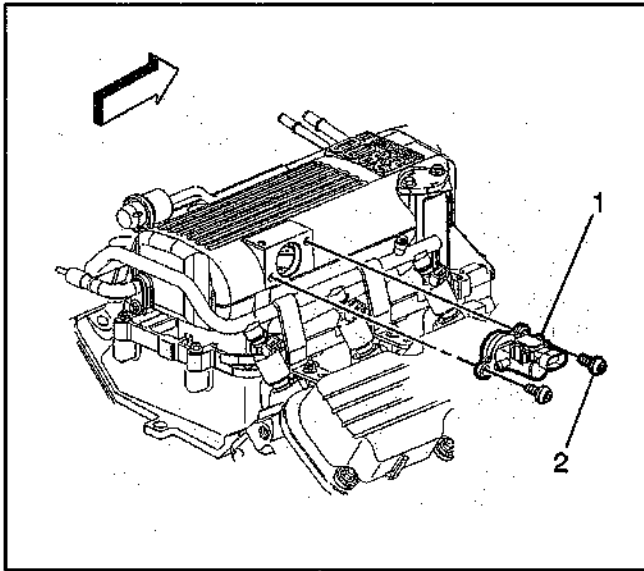


439396

25. Connect the EVAP canister purge valve switch electrical connector (2).
26. Connect the fuel injector electrical connectors (1) to the fuel injectors.



439467

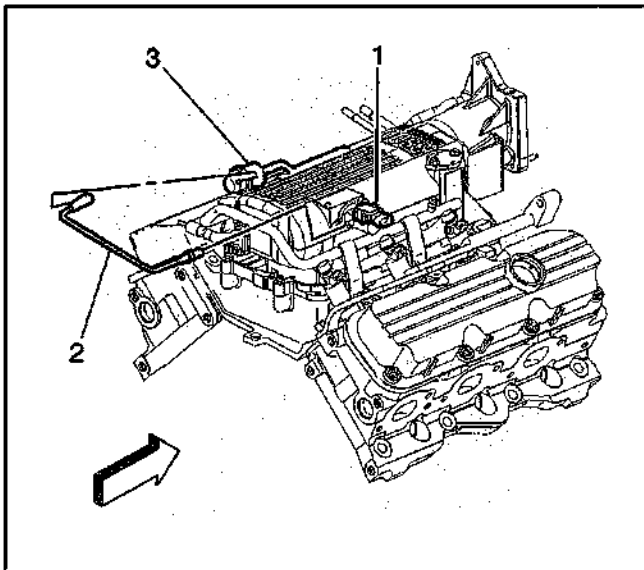


441250

27. Install the manifold vacuum source (1) to the upper intake manifold.
28. Install the manifold vacuum source screws (2).

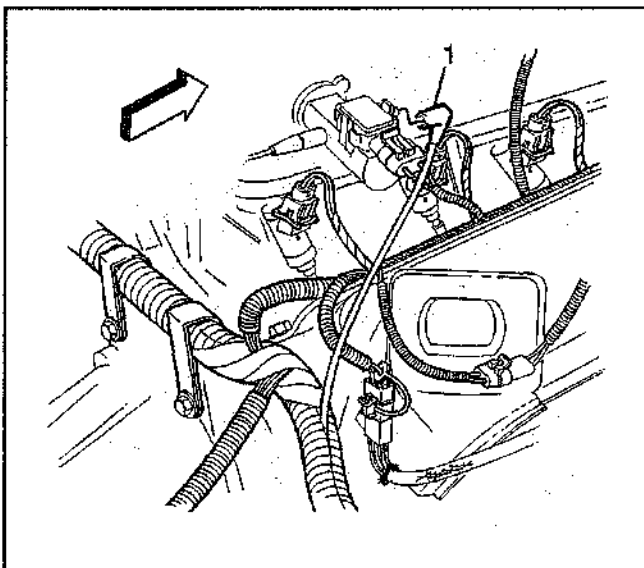
Tighten

Tighten the manifold vacuum source screws (2) to 10 N·m (89 lb in).



439396

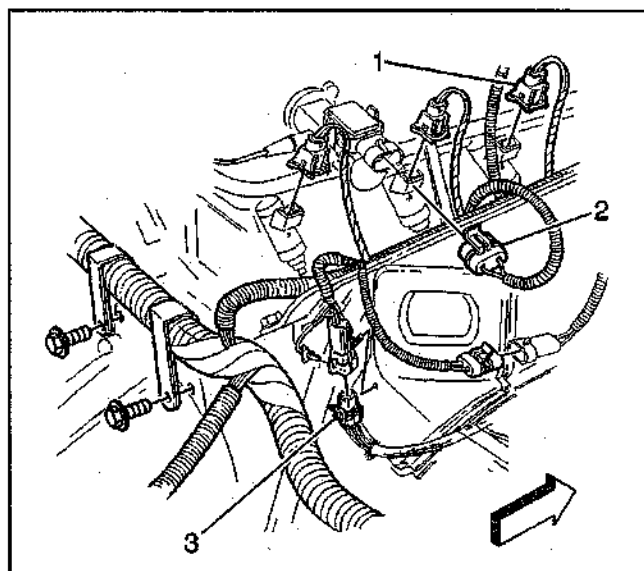
29. Install the fuel pressure regulator tube (2) to the following components:
 - Manifold vacuum source (1)
 - Fuel pressure regulator valve (3)



439411

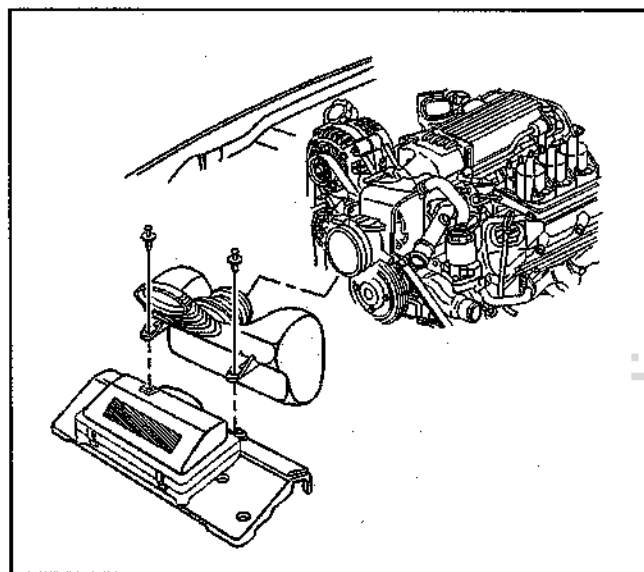
30. Connect the engine harness vacuum tube (1) to the vacuum port.

31. Connect the MAP sensor electrical connector (2).
32. Connect the fuel injector electrical connectors (1) to the fuel injectors.
33. Install the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.



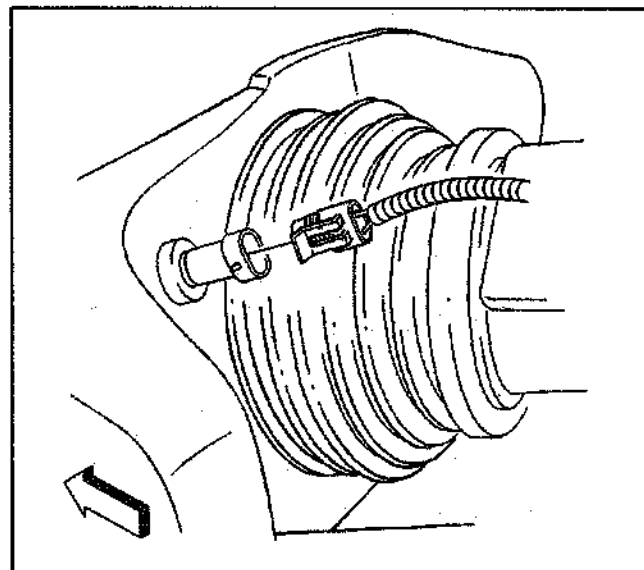
439410

34. Install the air intake duct.

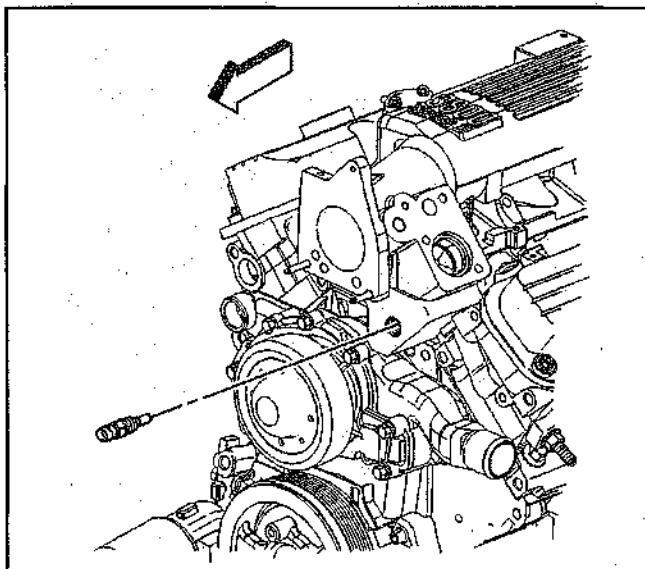


554755

35. Connect the IAT sensor electrical connector.
36. Refill the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.



208554

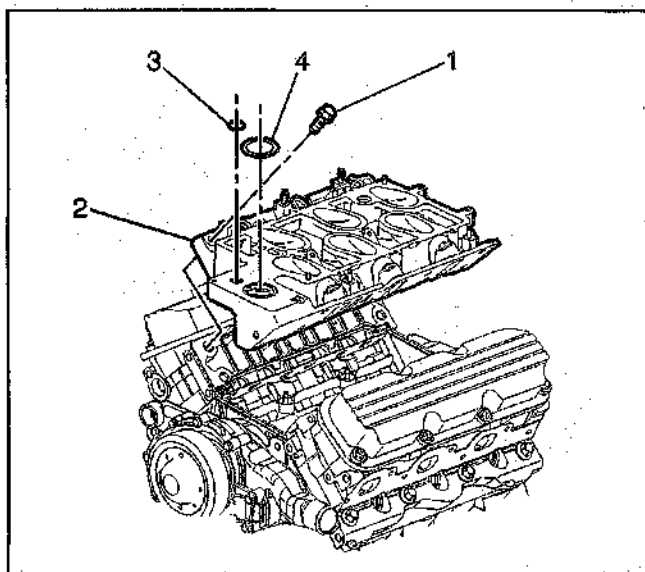


349800

Intake Manifold Replacement (Lower)

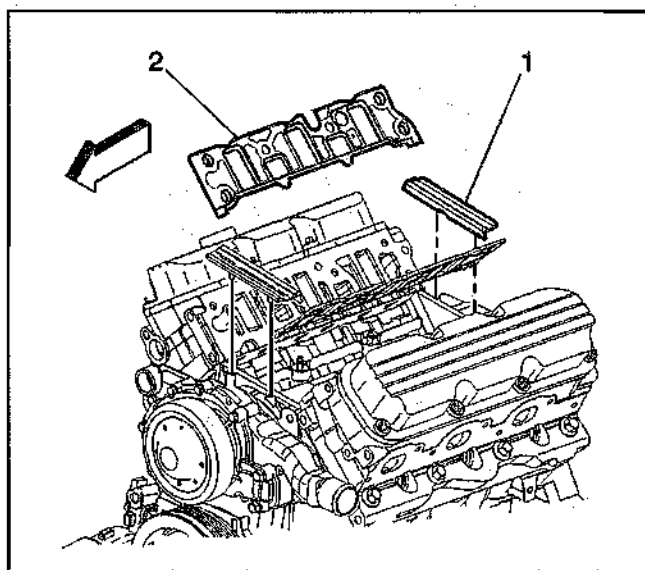
Removal Procedure

1. Remove the upper intake manifold. Refer to *Intake Manifold Replacement (Upper)*.
2. Remove the coolant temperature sensor.



439510

3. Remove the O-ring seals (3, 4), if necessary.
4. Remove the lower intake manifold bolts (1).
5. Remove the lower intake manifold (2).

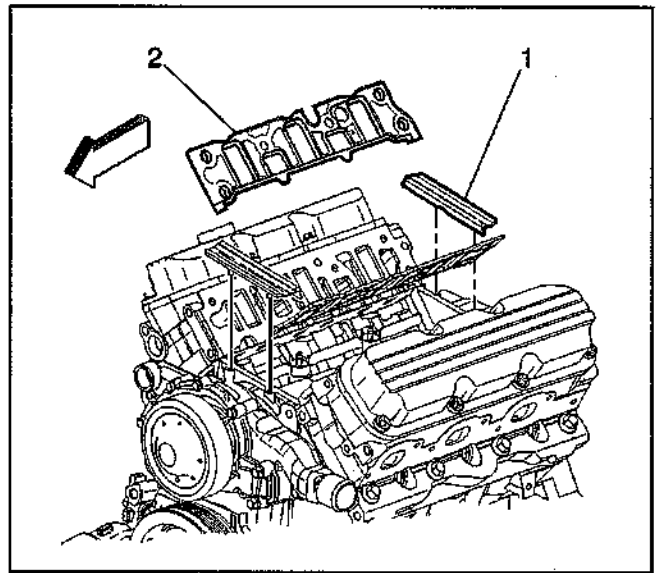


439530

6. Remove the lower intake manifold seals (1).
7. Remove the lower intake manifold gaskets (2).

Installation Procedure

1. Install the lower intake manifold gaskets (2).
2. Install the lower intake manifold seals (1).
Apply silicone sealer GM P/N 12345366 or equivalent to the ends for the manifold seals (2).



439530

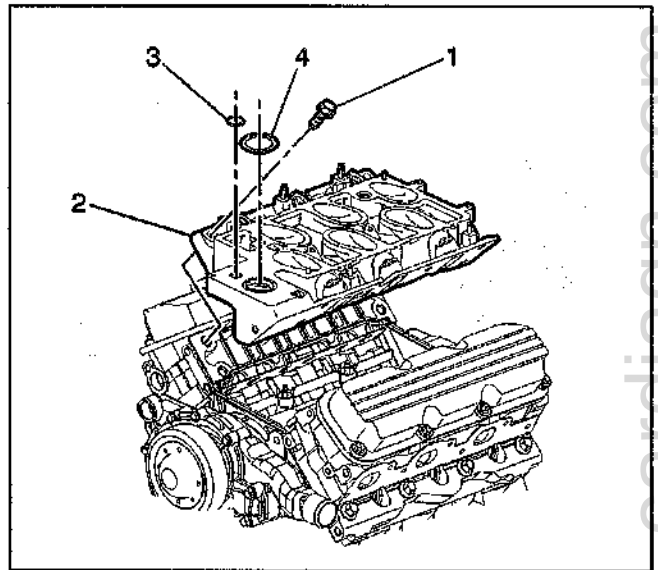
3. Install the lower intake manifold (2).
4. Apply thread lock compound GM P/N 12345493 or equivalent to the bolt threads before installing.

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

5. Install the lower intake manifold bolts (1).

Tighten

Tighten the lower manifold bolts (1) to 15 N·m (11 lb ft).



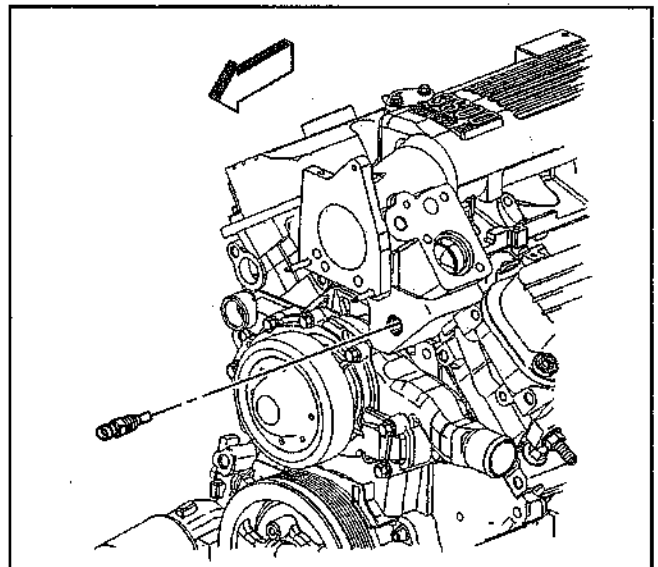
439510

6. Remove the coolant temperature sensor.

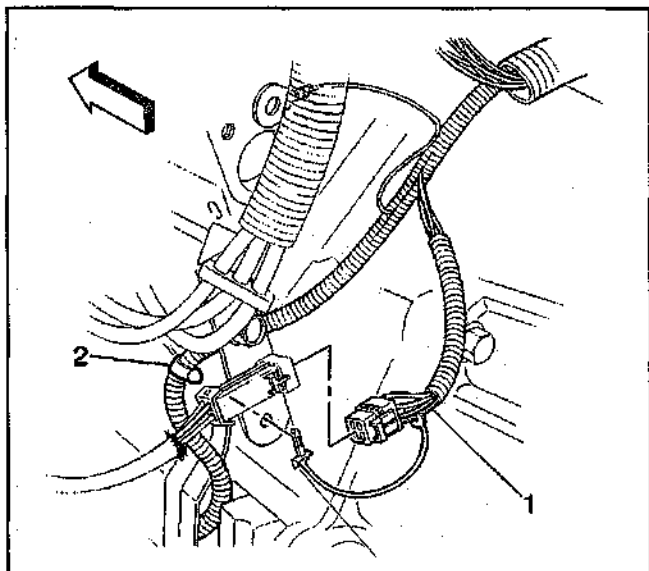
Tighten

Tighten the coolant temperature sensor to 25 N·m (18 lb ft).

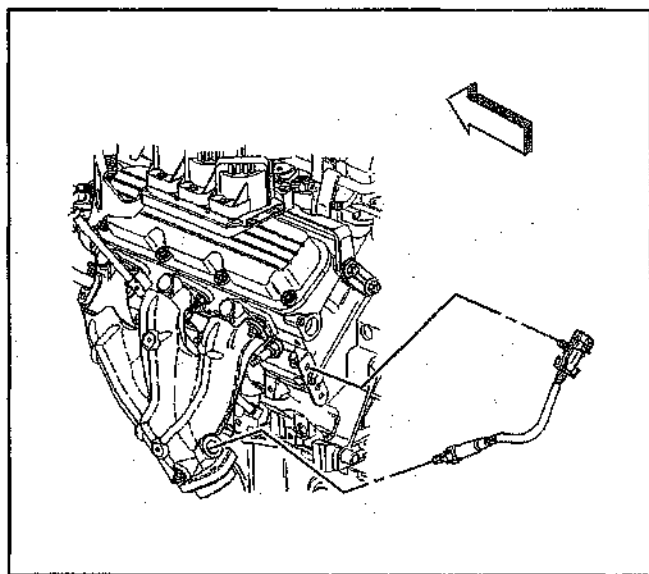
7. Remove the upper intake manifold. Refer to *Intake Manifold Replacement (Upper)*.



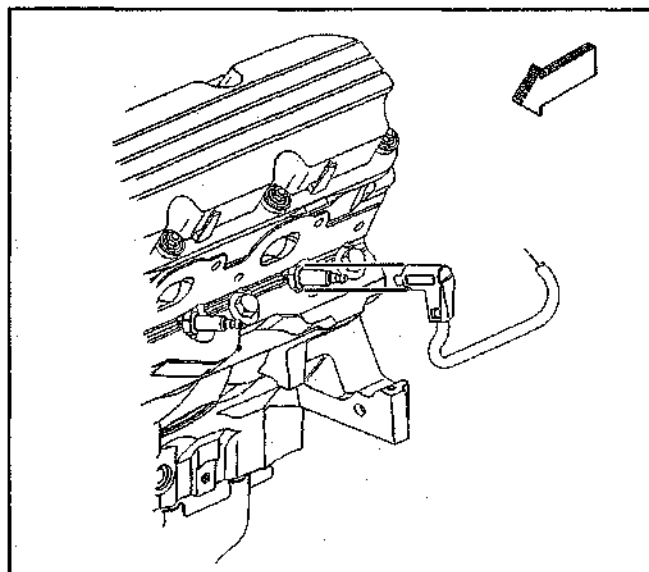
349800



439775



577702



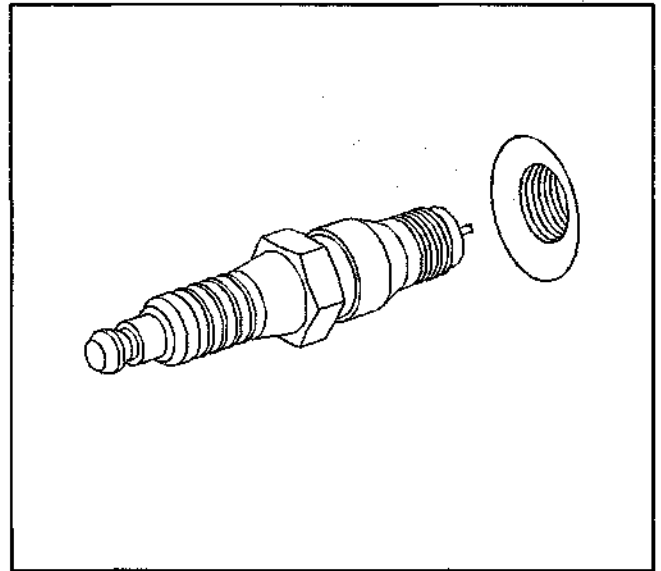
211645

Exhaust Manifold Replacement (Left)

Removal Procedure

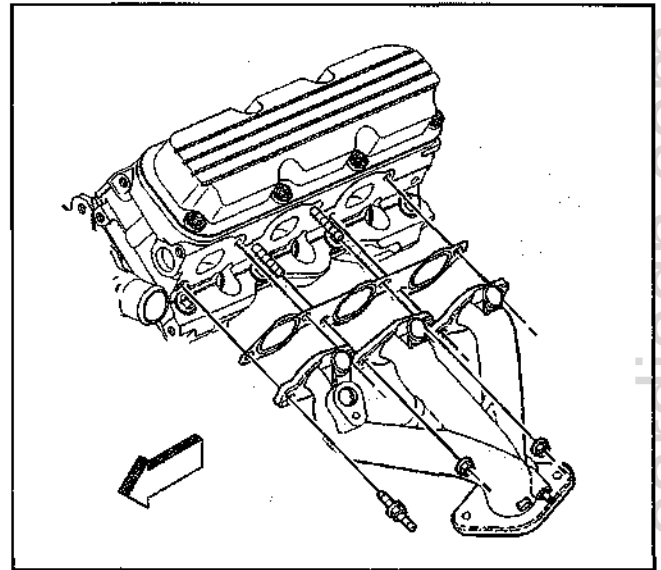
1. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.
3. Disconnect the connector position assurance (CPA) retainer.
4. Disconnect the wiring harness connector (1) from the oxygen sensor.
5. Remove the oxygen sensor connector from the spark plug wire harness bracket.
6. Remove the oxygen sensor from the exhaust manifold.
7. Disconnect the numbers 1, 3 and 5 spark plug wires from the spark plugs.

8. Remove the numbers 3 and 5 spark plugs from the cylinder head.



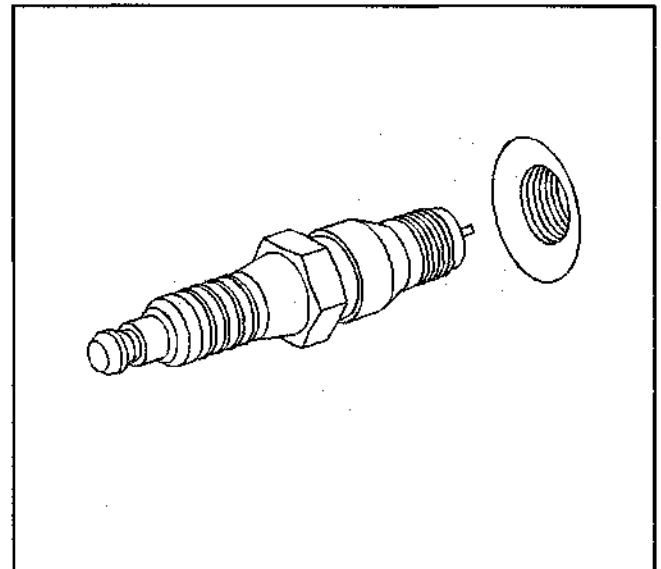
14824

9. Remove the two rear exhaust manifold studs and nut from the exhaust manifold.
10. Lower the vehicle.

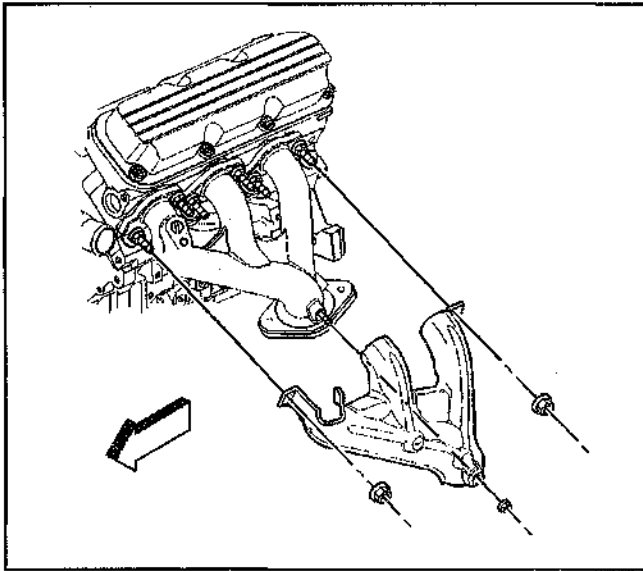


613220

11. Remove the number 1 spark plug from the cylinder head.

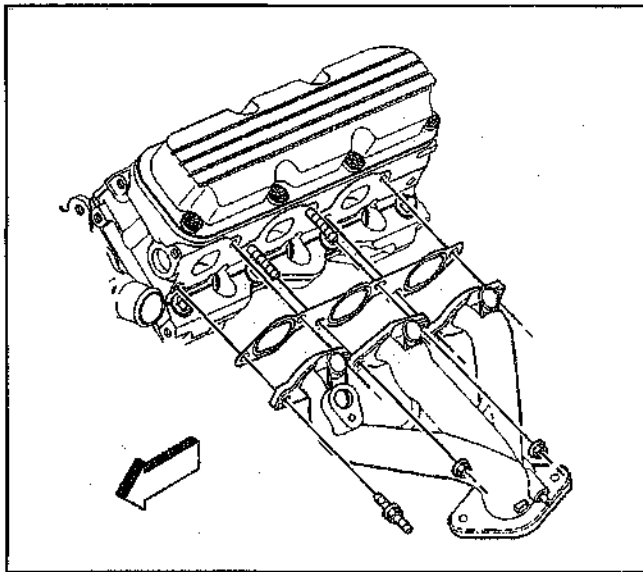


14824



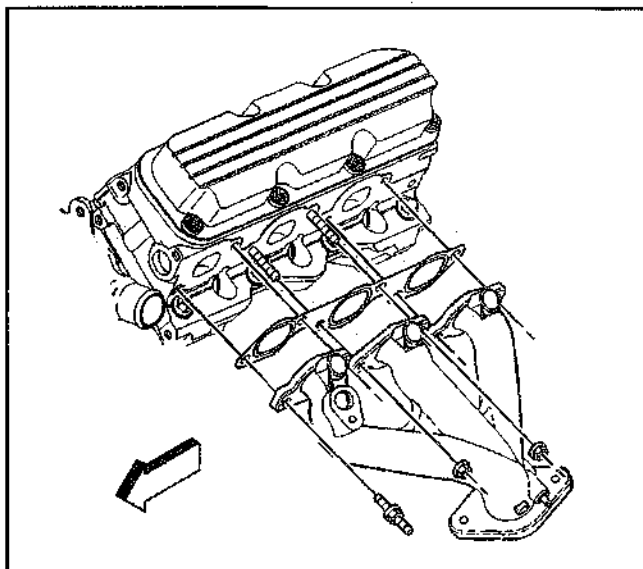
613198

12. Remove the exhaust manifold heat shield nuts.
13. Remove the exhaust manifold heat shields from the exhaust manifold.



613220

14. Remove the exhaust manifold studs and nut from the exhaust manifold.
15. Remove the exhaust manifold and gasket from the cylinder head.
16. Remove the heat shield studs from the exhaust manifold, if necessary.



613220

Installation Procedure

1. Install the heat shield studs to the exhaust manifold, if necessary.
2. Install the exhaust manifold gasket and manifold to the cylinder head studs.

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

3. Install the front two exhaust manifold studs and nut to the exhaust manifold.

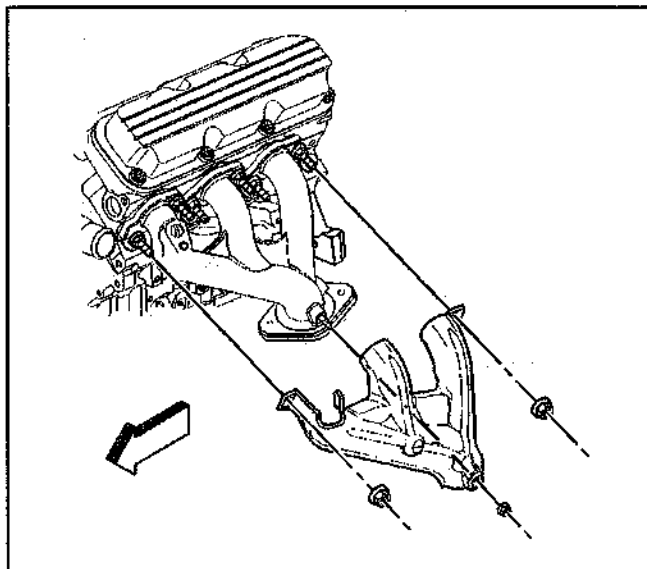
Tighten

- Tighten the two front exhaust manifold studs to 15 N-m (11 lb ft).
- Tighten the exhaust manifold nut to 18 N-m (13 lb ft).

4. Install the exhaust manifold heat shields to the exhaust manifold.
5. Install the exhaust manifold heat shield nuts.

Tighten

Tighten the exhaust manifold heat shield nuts to 10 N·m (89 lb in).



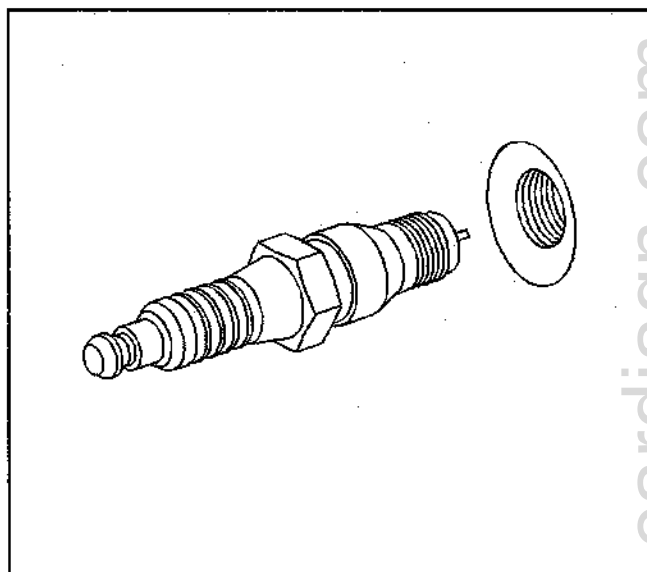
613198

6. Install the number 1 spark plug to the cylinder head.

Tighten

Tighten the number 1 spark plug to 27 N·m (20 lb ft).

7. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.

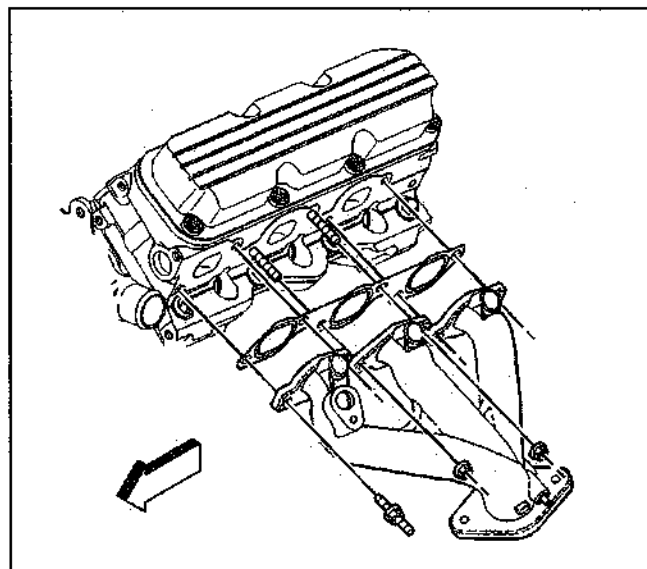


14824

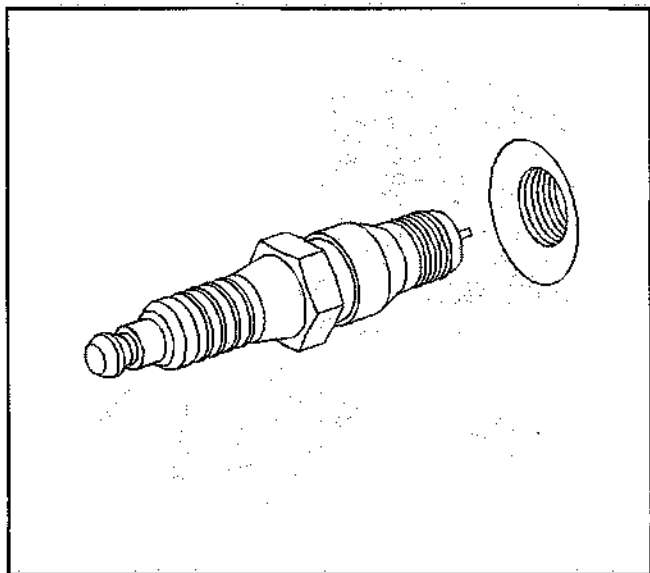
8. Install the two rear exhaust manifold studs and nut to the exhaust manifold.

Tighten

- Tighten the two rear exhaust manifold studs to 15 N·m (11 lb ft).
- Tighten the exhaust manifold nut to 18 N·m (13 lb ft).



613220

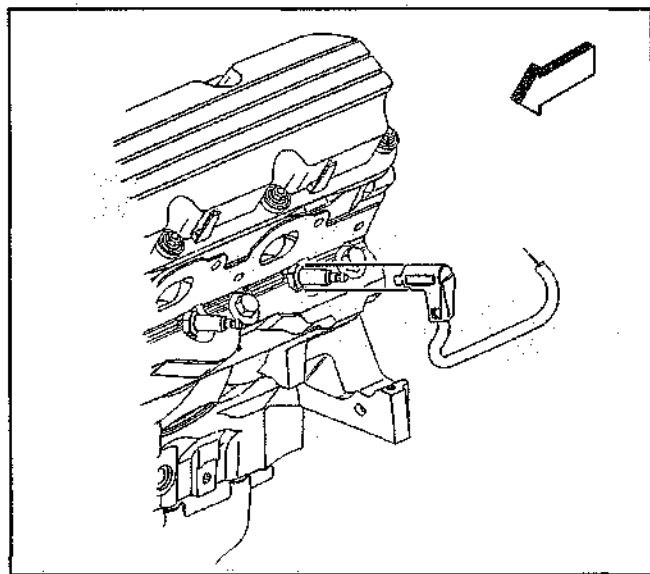


14824

9. Install the numbers 3 and 5 spark plugs to the cylinder head.

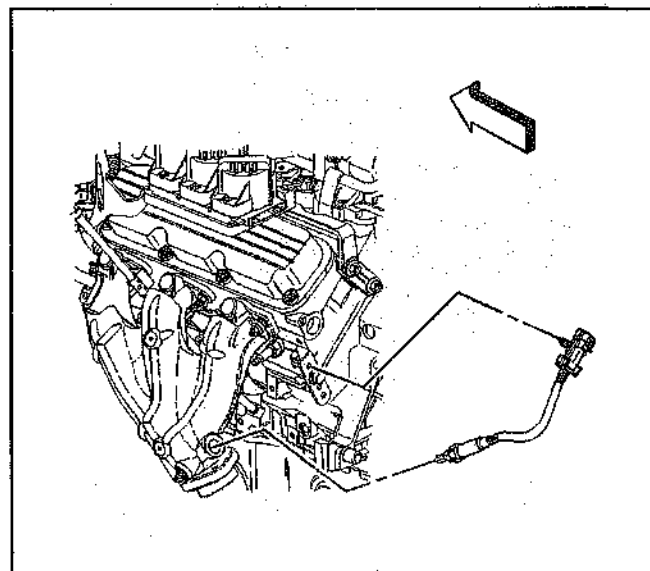
Tighten

Tighten the numbers 3 and 5 spark plugs to 27 N·m (20 lb ft).



211645

10. Connect the numbers 1, 3 and 5 spark plug wires to the spark plugs.



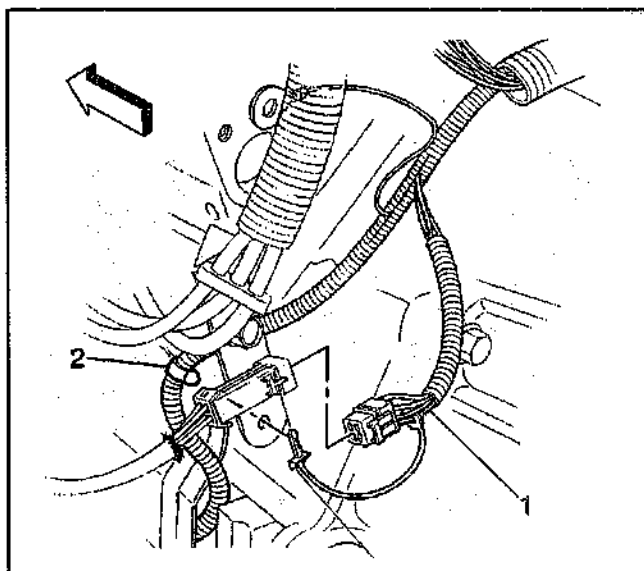
577702

11. Install the oxygen sensor to the exhaust manifold.

Tighten

Tighten the oxygen sensor to 42 N·m (31 lb ft).

12. Install the oxygen sensor connector to the spark plug wire harness bracket.
13. Connect the wire harness connector (1) to the oxygen sensor connector.
14. Connect the CPA retainer.
15. Install the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.
16. Lower the vehicle.

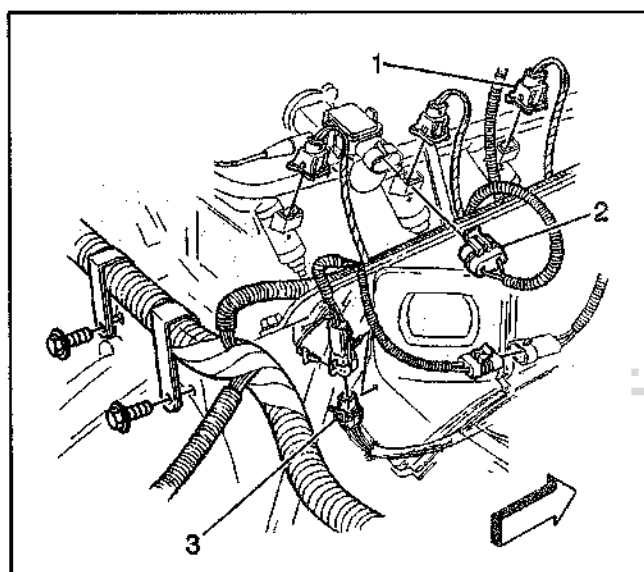


439775

Exhaust Manifold Replacement (Right)

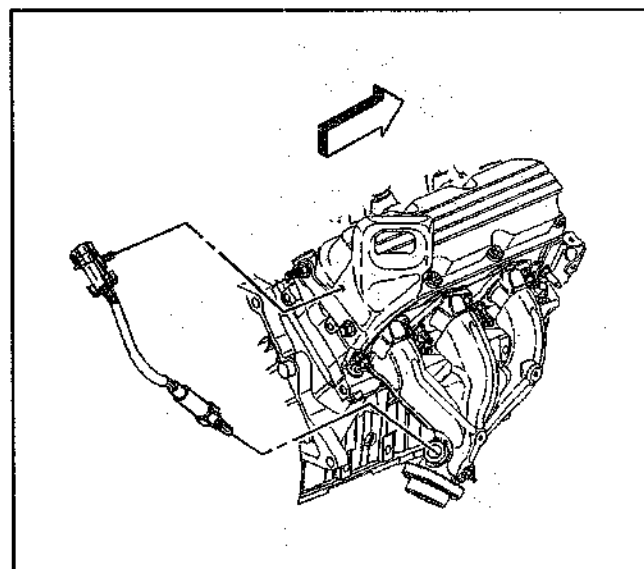
Removal Procedure

1. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.
3. Disconnect the connector position assurance (CPA) retainer.
4. Disconnect the oxygen sensor electrical connector (3) from the harness.

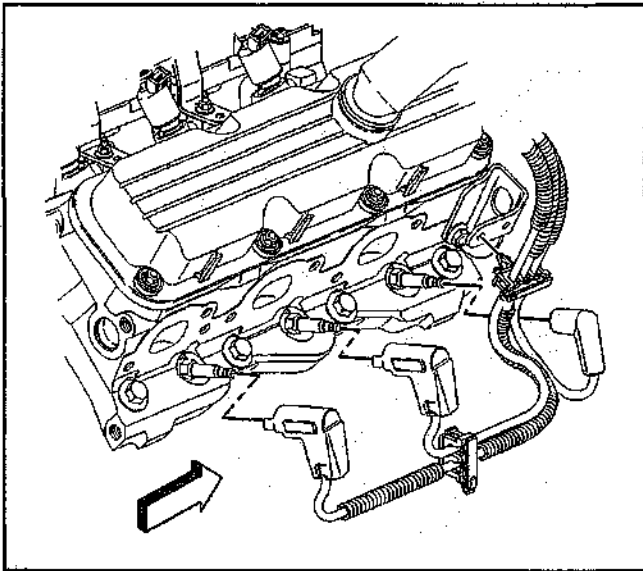


439410

5. Remove the oxygen sensor connector rosebud from the engine lift bracket.
6. Remove the oxygen sensor from the exhaust manifold.

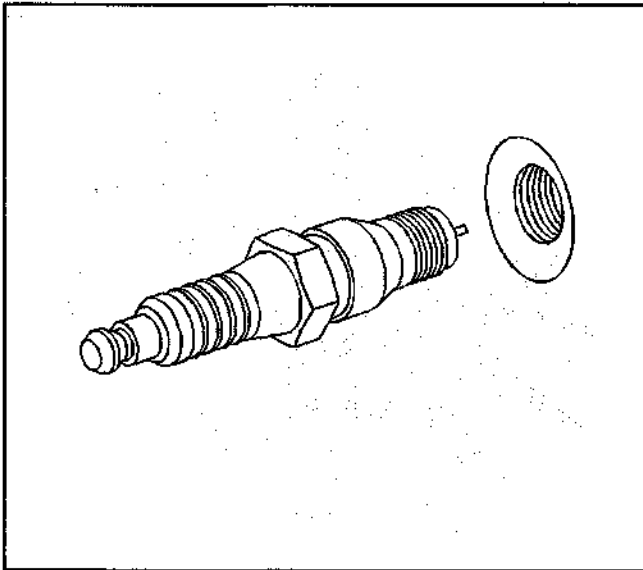


577706



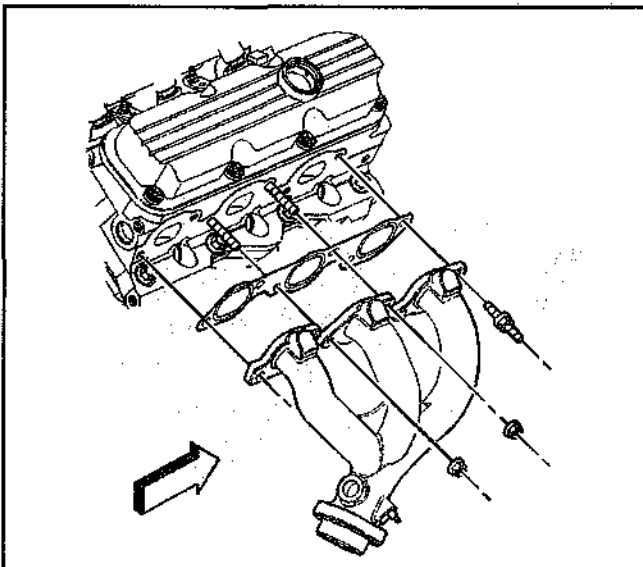
211642

7. Disconnect the numbers 4 and 6 spark plug wires from the spark plugs.



14824

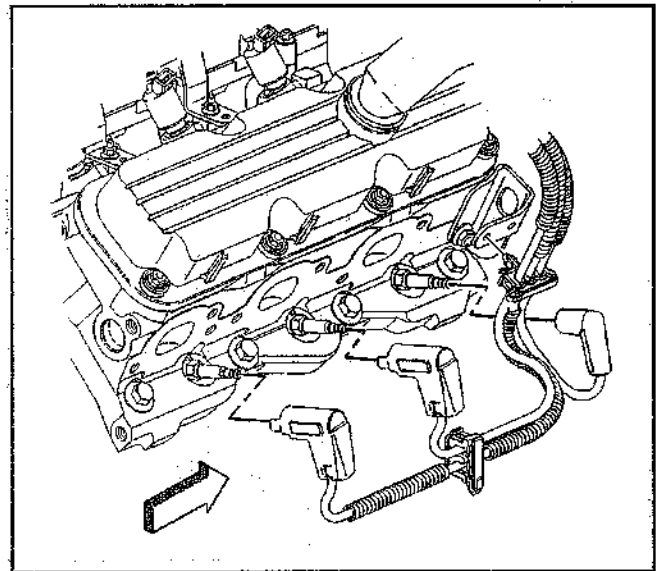
8. Remove the number 6 spark plug from the cylinder head.



613225

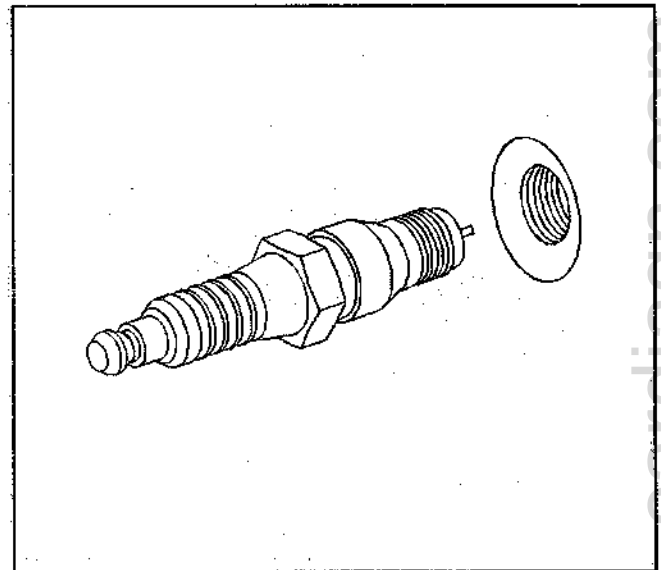
9. Remove the two rear exhaust manifold studs and nut from the exhaust manifold.
10. Lower the vehicle.

11. Disconnect the number 2 spark plug wire from the spark plug.



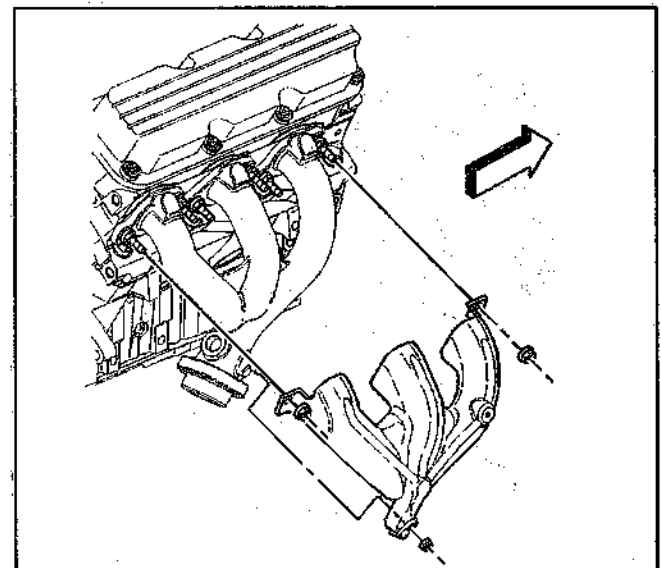
211642

12. Remove the numbers 2 and 4 spark plugs from the cylinder head.

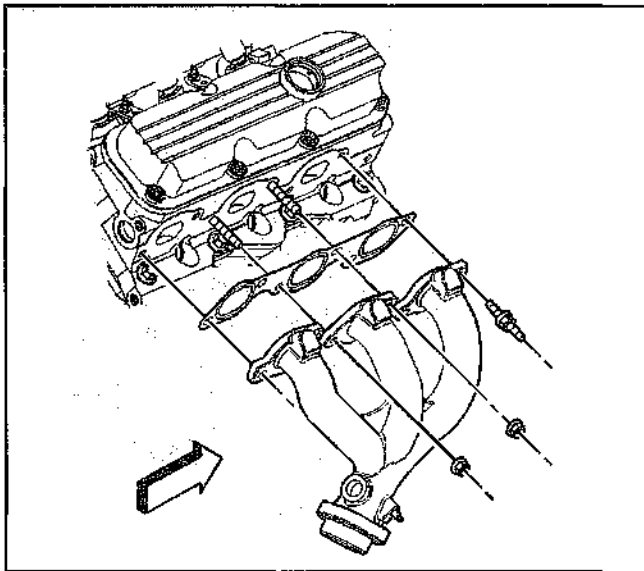


14824

13. Remove the exhaust manifold heat shield nuts.
14. Remove the exhaust manifold heat shields from the exhaust manifold.

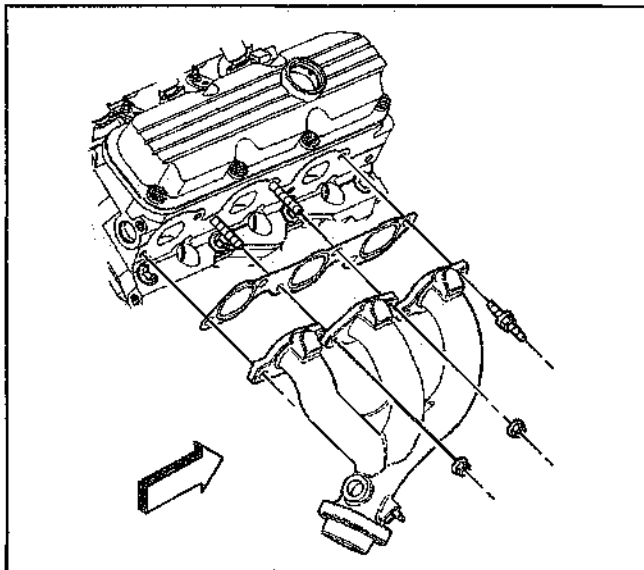


613223



613225

15. Remove the two front exhaust manifold studs and nut from the exhaust manifold.
16. Remove the right exhaust manifold and gasket from the cylinder head.
17. Remove the heat shield studs from the exhaust manifold, if necessary.



613225

Installation Procedure

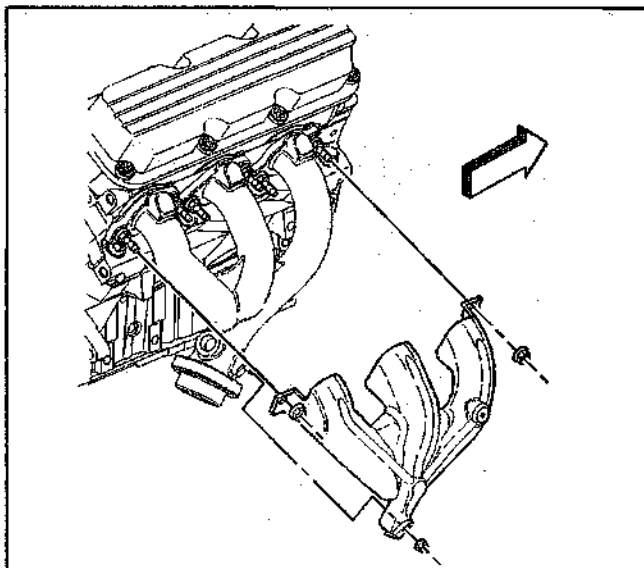
1. Install the heat shield stud to the exhaust manifold, if necessary.
2. Install the right exhaust manifold gasket and manifold to the cylinder head studs.

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

3. Install the two front exhaust manifold studs and nuts to the exhaust manifold.

Tighten

- Tighten the two front exhaust manifold studs to 15 N·m (11 lb ft).
- Tighten the exhaust manifold nuts to 18 N·m (13 lb ft).



613223

4. Install the exhaust manifold heat shields to the exhaust manifold.
5. Install the exhaust manifold heat shield nut.

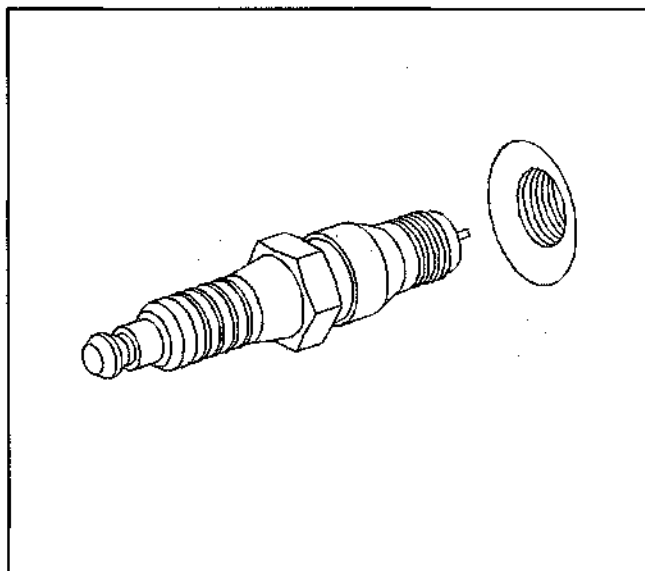
Tighten

Tighten the exhaust manifold heat shield nuts to 10 N·m (89 lb in).

6. Install the numbers 2 and 4 spark plugs to the cylinder head.

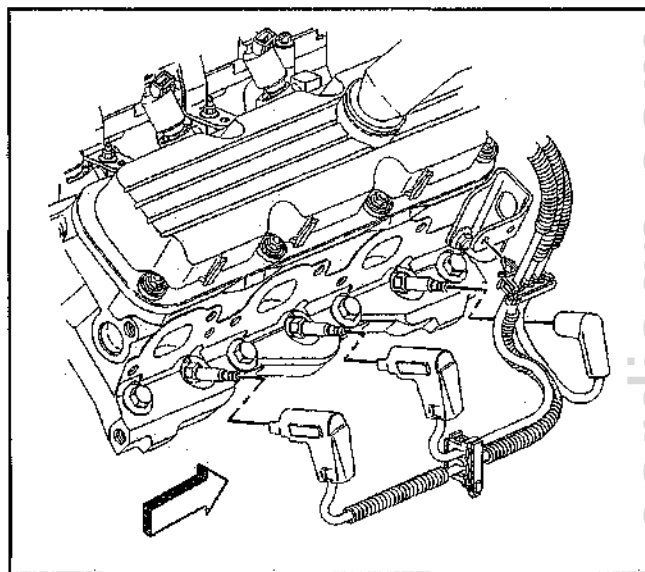
Tighten

Tighten the numbers 2 and 4 spark plugs to 27 N·m (20 lb ft).



14824

7. Connect the number 2 spark plug wire to the spark plug.
8. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.

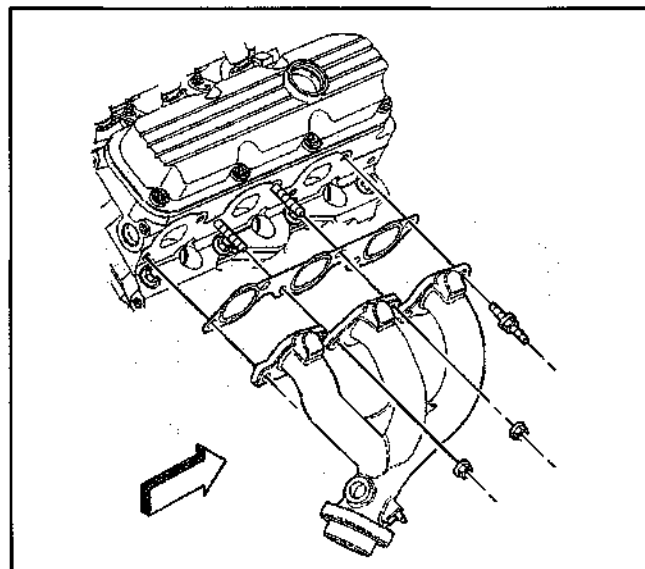


211642

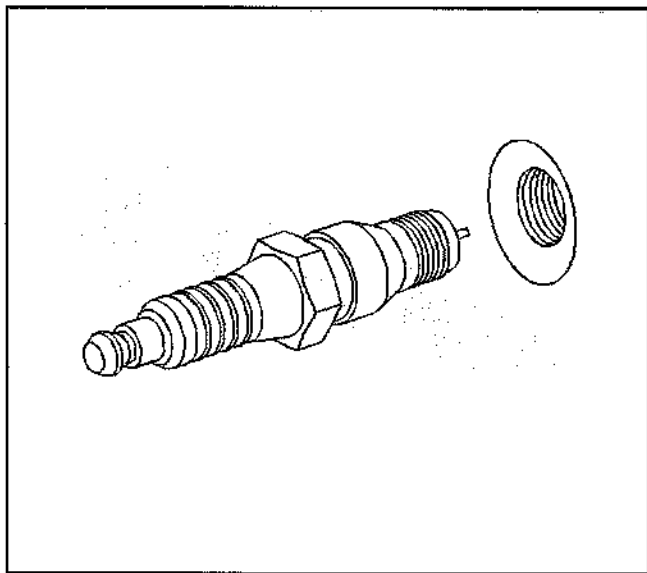
9. Install the two rear exhaust manifold studs and nut to the exhaust manifold.

Tighten

- Tighten the two rear exhaust manifold studs to 15 N·m (11 lb ft).
- Tighten the exhaust manifold nut to 18 N·m (13 lb ft).



613225

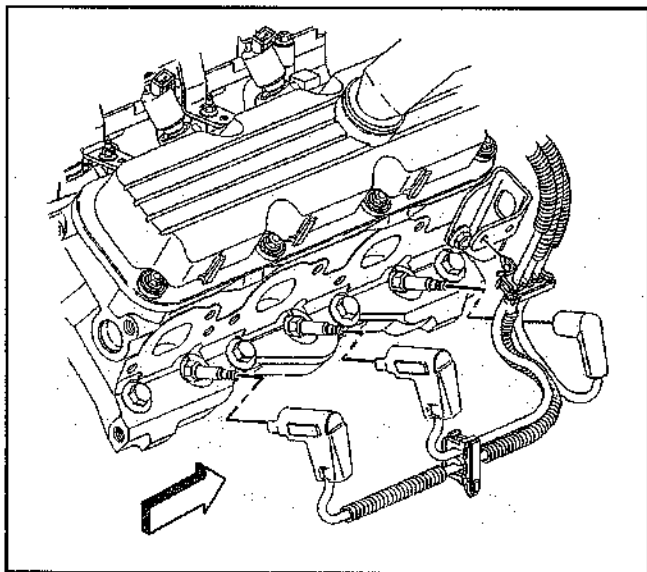


14824

10. Install the number 6 spark plug to the cylinder head.

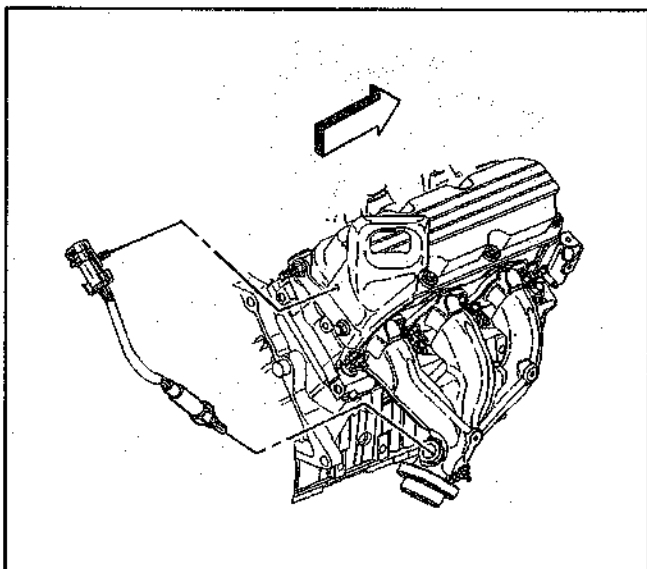
Tighten

Tighten the number 6 spark plug to 27 N·m (20 lb ft).



211642

11. Connect the numbers 4 and 6 spark plug wires to the spark plugs.



577706

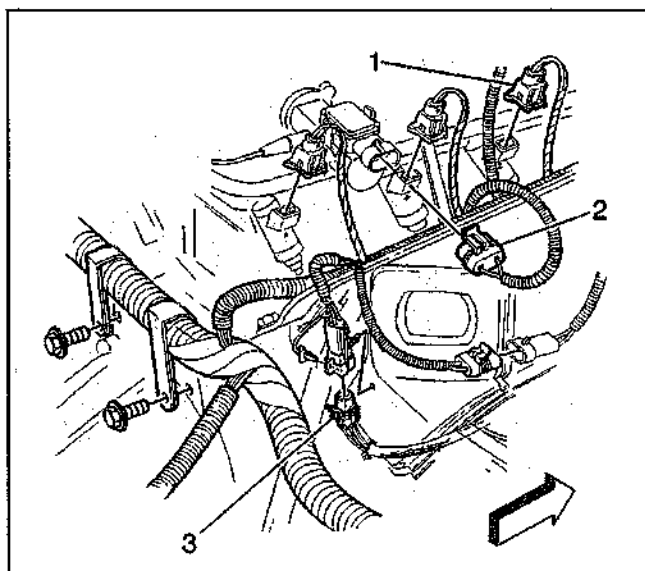
12. Install the oxygen sensor to the exhaust manifold.

Tighten

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

13. Connect the oxygen sensor electrical connector rosebud to the engine lift bracket.

14. Connect the oxygen sensor electrical connector (3) to the wiring harness.
15. Connect the CPA retainer.
16. Install the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.
17. Lower the vehicle.

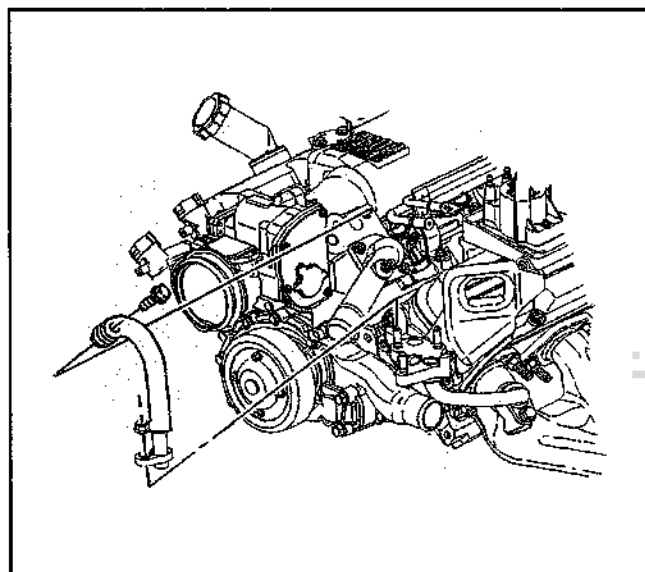


439410

Valve Rocker Arm Cover Replacement (Left)

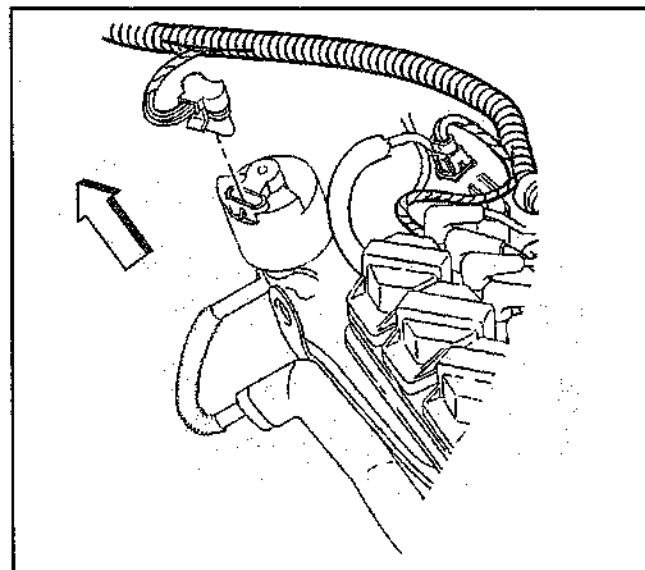
Removal Procedure

1. Remove the ignition control module. Refer to *Ignition Coil Module Replacement (3.8 L)* in Engine Electrical.
2. Remove the exhaust gas recirculation (EGR) valve outlet pipe bolt from the upper intake manifold.
3. Remove the EGR valve outlet pipe nut from the EGR valve adapter.
4. Remove the EGR valve outlet pipe.

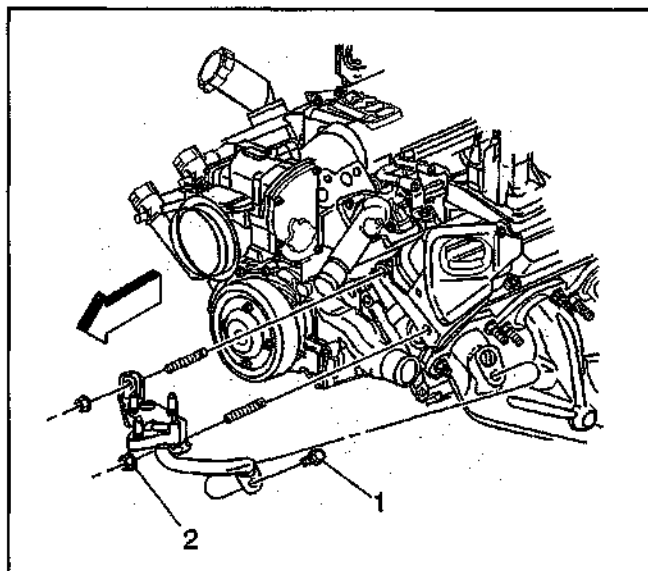


577700

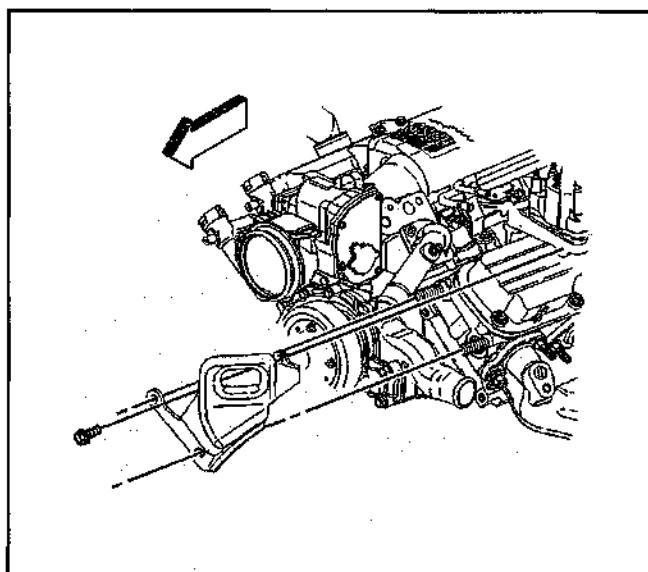
5. Disconnect the EGR valve electrical connector.



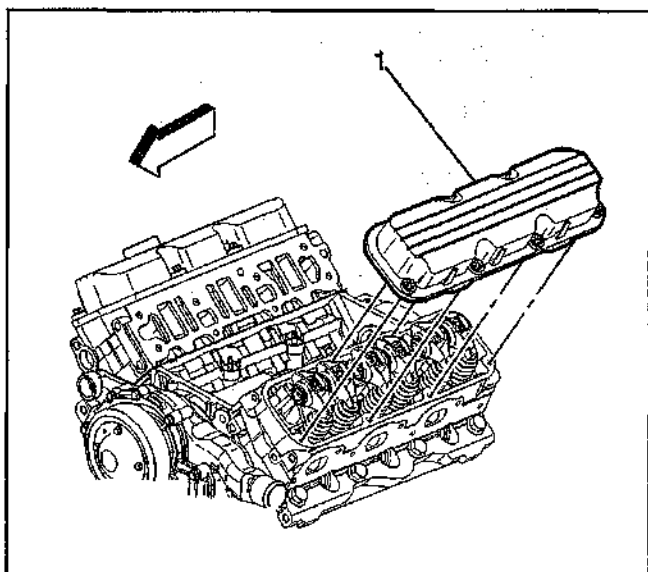
221704



577696



577690



37442

6. Remove the EGR valve adapter nuts (2).
7. Remove the EGR valve adapter bolt (1).
8. Remove the EGR valve adapter from the cylinder head studs.
9. Remove the oil level indicator tube. Refer to *Oil Level Indicator and Tube Replacement*.

10. Remove the engine lift bracket from the cylinder head studs.
11. Remove the top ignition control module bracket bolt.
12. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
13. Remove the rear ignition control module bracket bolts.
14. Lower the vehicle.
15. Remove the ignition control module bracket.

16. Loosen the valve rocker arm cover bolts.
17. Remove the valve rocker arm cover (1).
18. Clean the following items:
 - Valve rocker arm cover
 - Cylinder head gasket surface
 - Valve rocker arm cover bolts

Installation Procedure

1. Apply thread lock adhesive GM P/N 12345493 or equivalent, to the valve rocker arm cover bolt threads.

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

2. Install the valve rocker arm cover (1).
3. Tighten the valve rocker arm cover bolts.

Tighten

Tighten the valve rocker arm cover bolts to 10 N·m (89 lb in).

4. Install the ignition control module bracket.
5. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
6. Install the rear ignition control module bracket bolts.

Tighten

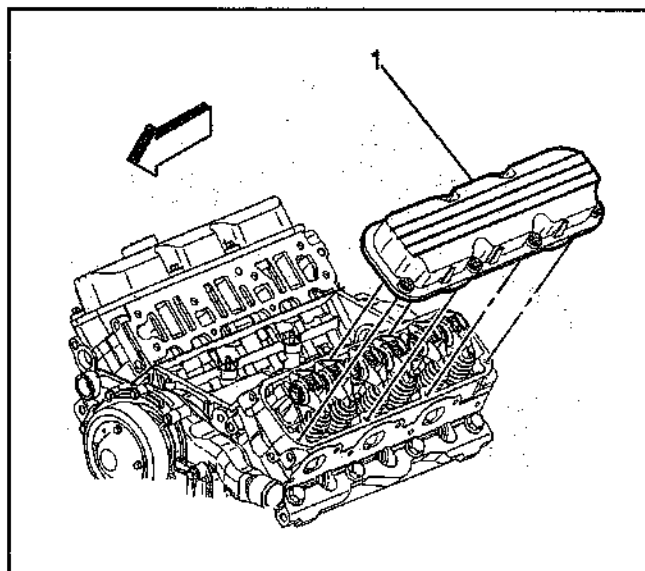
Tighten the rear ignition control module bracket bolts to 50 N·m (37 lb ft).

7. Lower the vehicle.
8. Install the top ignition control module bracket bolt.

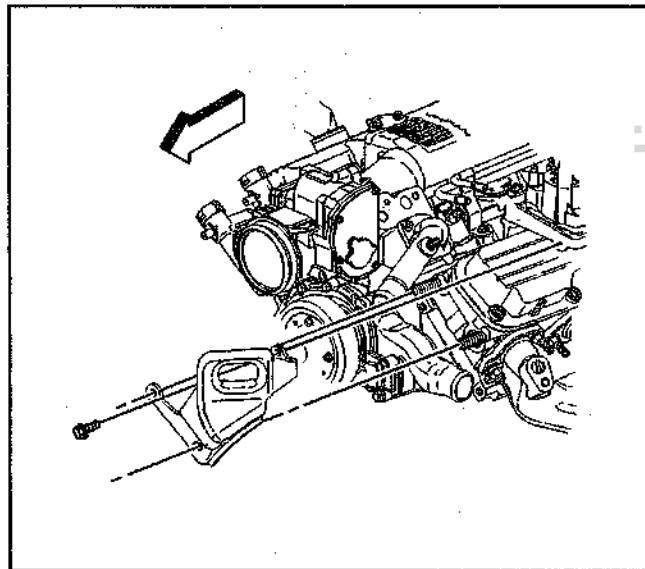
Tighten

Tighten the top ignition control module bracket bolt to 50 N·m (37 lb ft).

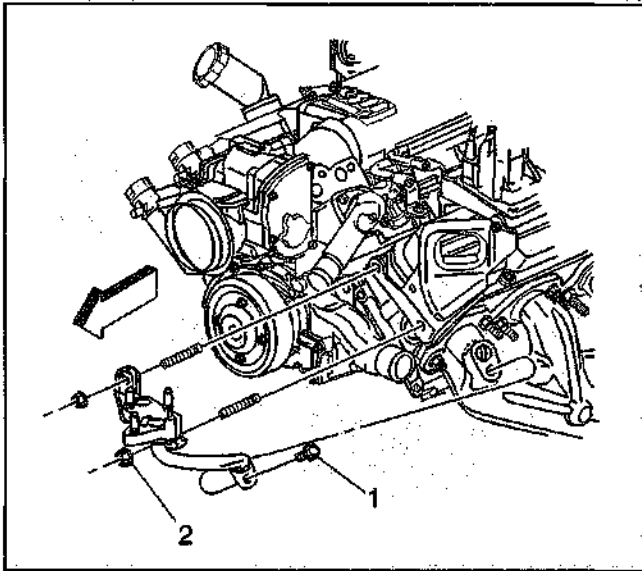
9. Install the engine lift bracket to the cylinder head studs.
10. Install the oil level indicator tube. Refer to *Oil Level Indicator and Tube Replacement*.



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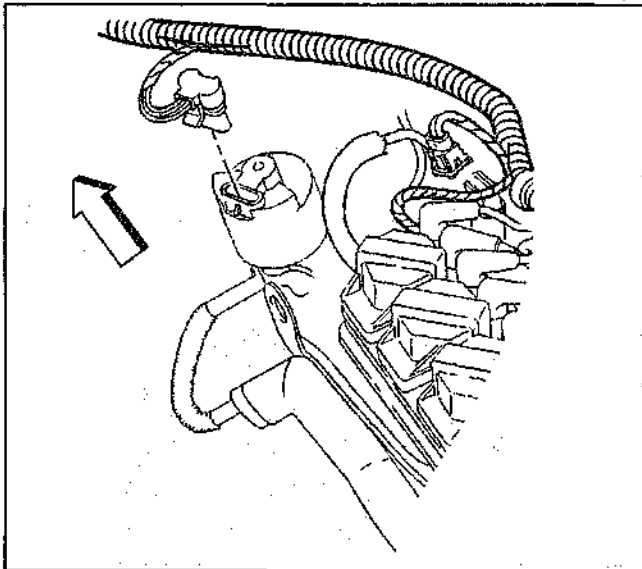


577696

11. Install the EGR valve adapter to the cylinder head studs.
12. Install the EGR valve adapter bolt (1).
13. Install the EGR valve adapter nuts (2).

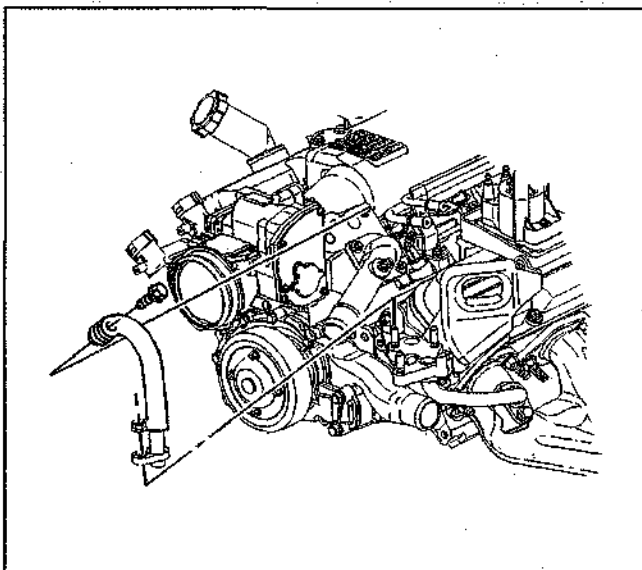
Tighten

- Tighten the EGR valve adapter nuts (2) to 50 N·m (37 lb ft).
- Tighten the EGR valve adapter bolt (1) to 25 N·m (18 lb ft).



221704

14. Connect the EGR valve electrical connector.



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15. Install the EGR valve outlet pipe.
16. Install the EGR valve outlet pipe nut to the EGR valve adapter.
17. Install the EGR valve outlet pipe bolt to the upper intake manifold.

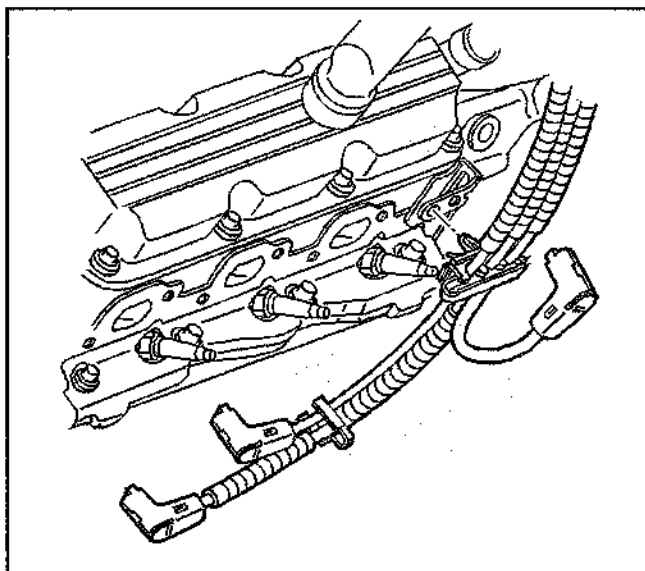
Tighten

- Tighten the EGR valve outlet pipe nut to 29 N·m (21 lb ft).
 - Tighten the EGR valve outlet pipe bolt to 29 N·m (21 lb ft).
18. Install the ignition control module. Refer to *Ignition Coil Module Replacement (3.8 L)* in Engine Electrical.

Valve Rocker Arm Cover Replacement (Right)

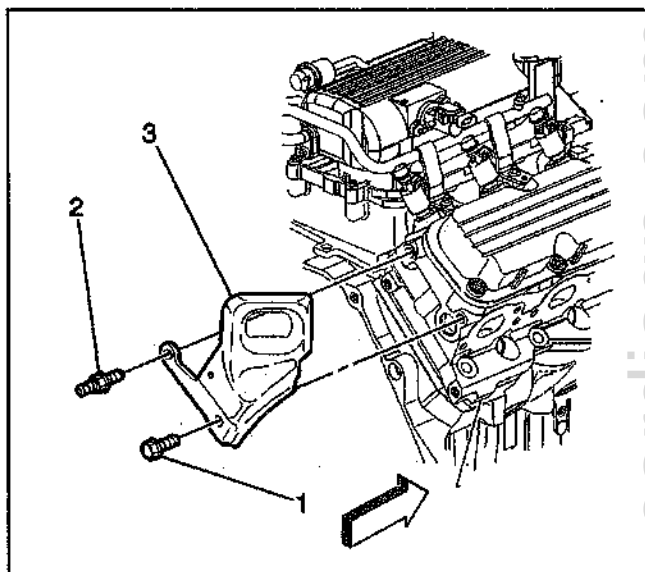
Removal Procedure

1. Remove the generator. Refer to *Generator Replacement (3.8 L)* in Engine Electrical.
2. Remove the spark plug wires from the 1,3 and 5 spark plugs.
3. Remove the spark plug wiring harness from the clip and reposition the harness.
4. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.



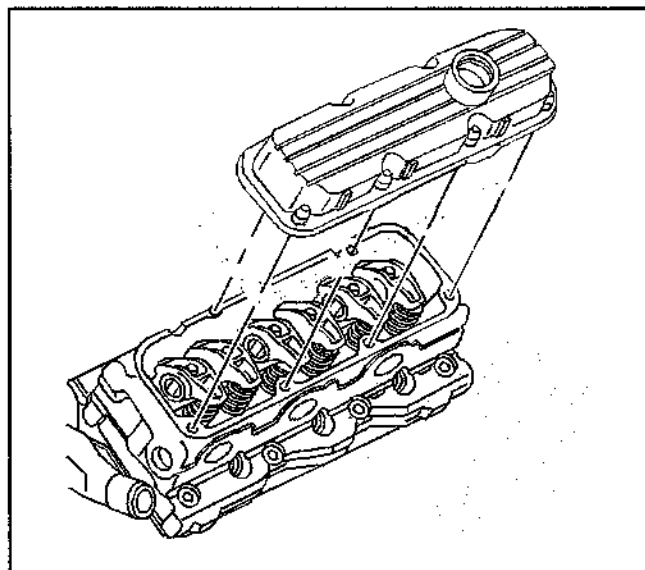
52978

5. Remove the rear engine left bracket bolt (1) and stud (2).
6. Remove the rear engine lift bracket (3).
7. Lower the vehicle.

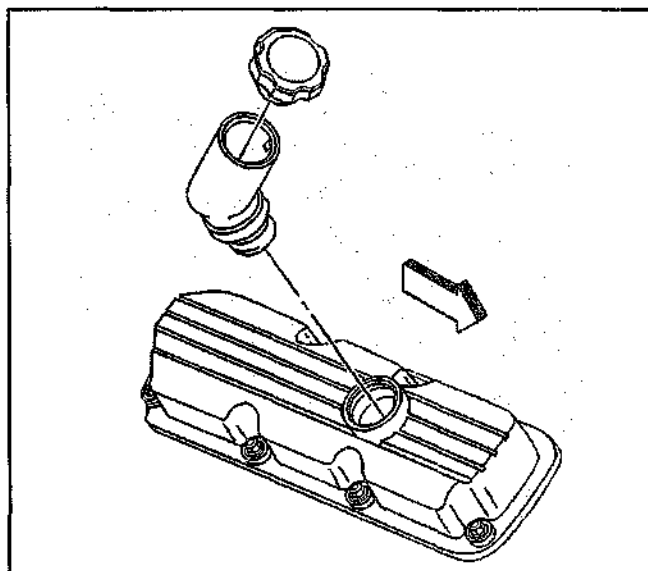


52977

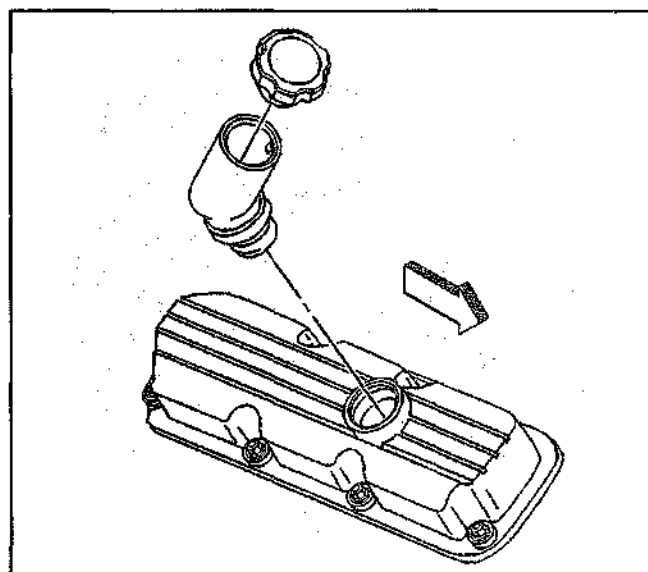
8. Loosen the valve rocker arm cover bolts.
9. Remove the valve rocker arm cover.



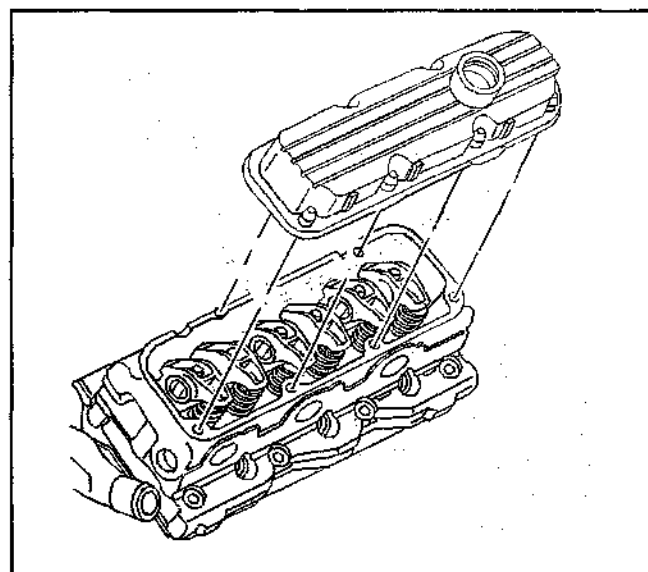
35819



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35819

10. Remove the oil fill tube cap, if necessary.
11. Remove the oil fill tube, if necessary.
To remove the fill tube press the tangs inside the tube in and twist the tube.
12. Clean the following items:
 - Valve rocker arm cover
 - Cylinder head gasket surface
 - Valve rocker arm cover bolts.

Installation Procedure

1. Install the oil fill tube to the valve rocker arm cover, if removed.
2. Install the oil fill tube cap, if removed.

3. Apply thread lock adhesive GM P/N 12345493 or equivalent to the valve rocker arm cover bolt threads.
4. Install the valve rocker arm cover.

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

5. Tighten the valve rocker arm cover bolts.

Tighten

Tighten the valve rocker arm cover bolts to 10 N·m (89 lb in).

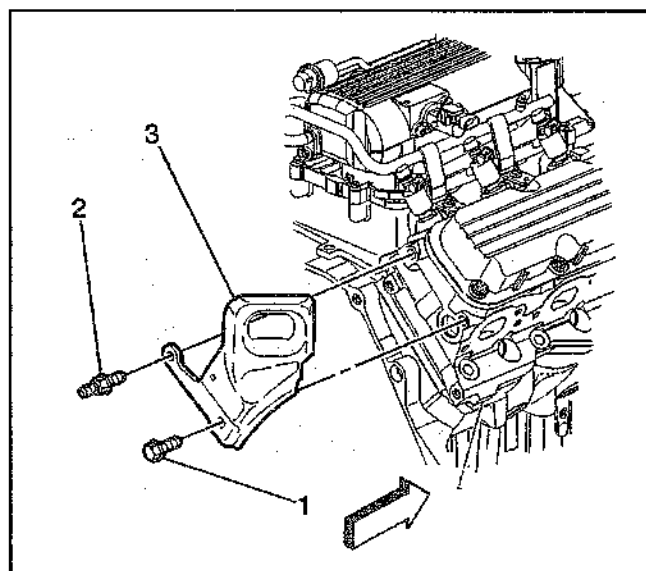
6. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.

7. Install the rear engine lift bracket (3).
8. Install the rear engine lift bracket stud (2) and bolt (1).

Tighten

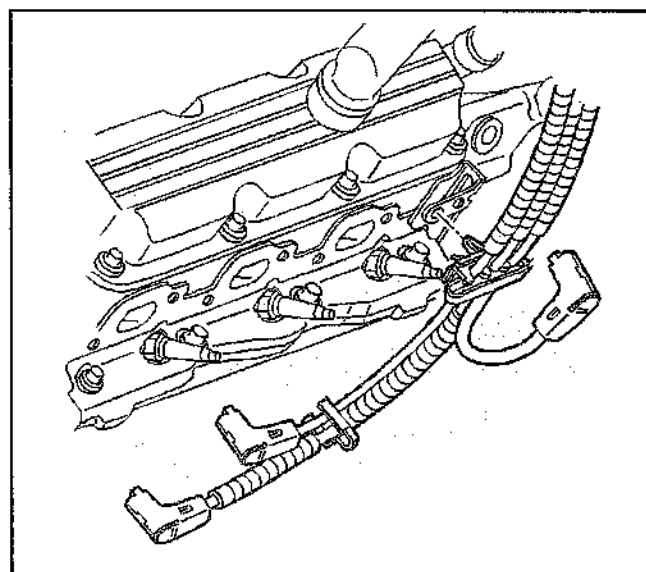
Tighten the rear engine lift bracket stud (2) and bolt (1) to 50 N·m (37 lb in).

9. Lower the vehicle.



52977

10. Install the spark plug wiring harness to the clip.
11. Install the spark plug wires to the 1,3 and 5 spark plugs.
12. Install the generator. Refer to *Generator Replacement (3.8 L)* in Engine Electrical.

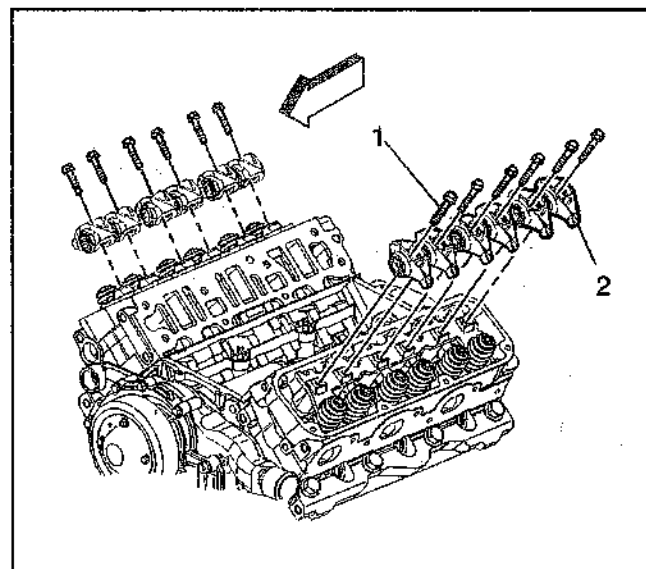


52978

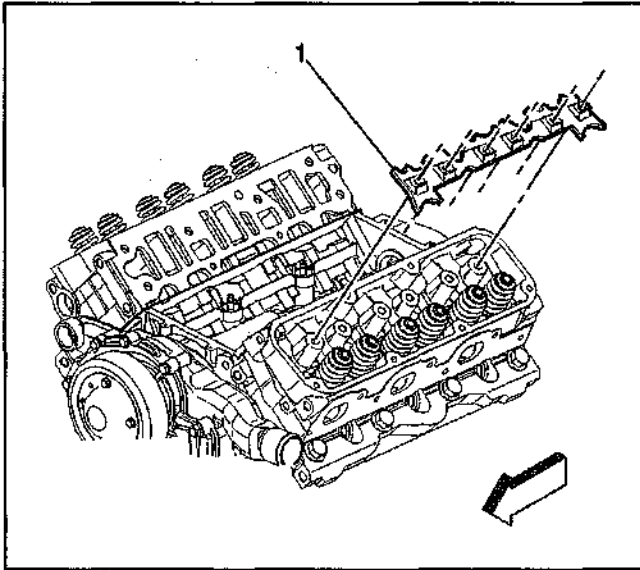
Valve Rocker Arm and Push Rod Replacement

Removal Procedure

1. Remove the valve rocker arm covers. Refer to *Valve Rocker Arm Cover Replacement (Left)* or *Valve Rocker Arm Cover Replacement (Right)*.
2. Remove the valve rocker arm bolts (1).
3. Remove the valve rocker arms (2).

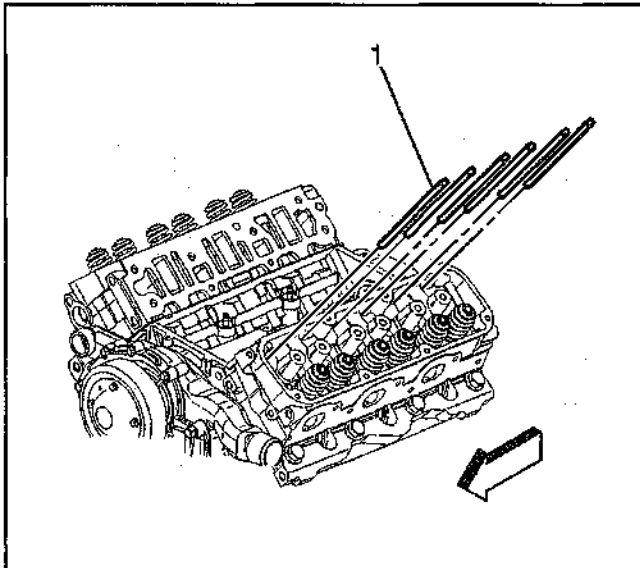


554762



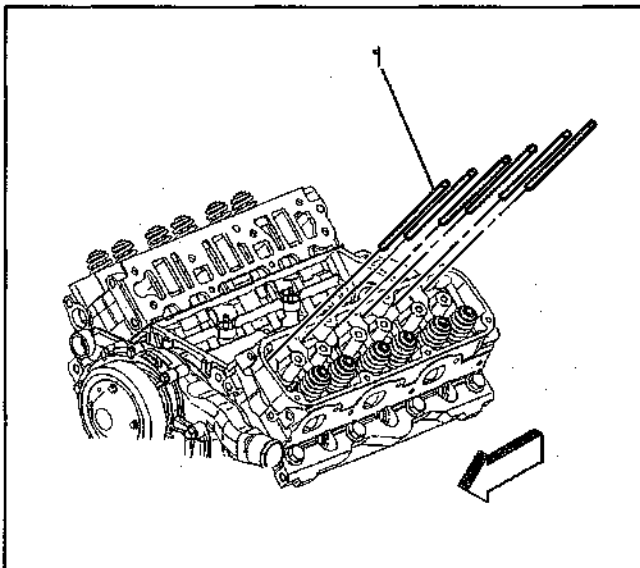
439870

4. Remove the valve rocker arm retainer (1).



439864

5. Remove the pushrods (1).



439864

Installation Procedure

Tools Required

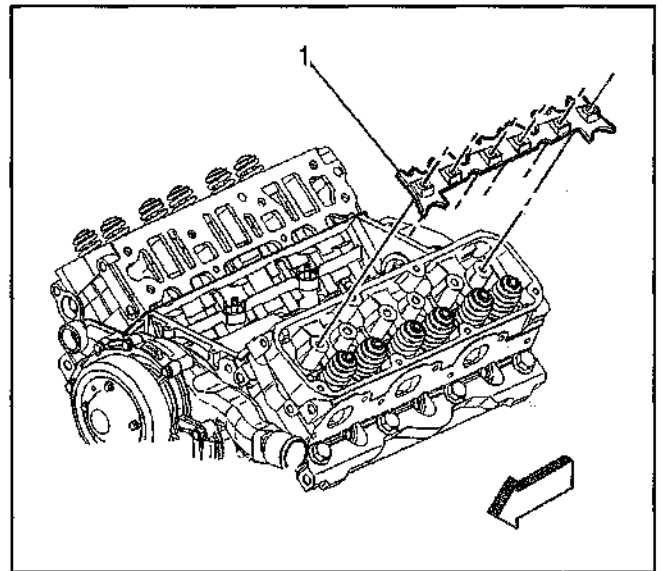
J 36660-A Torque Angle Meter

Important: Reinstall the rocker arms and pushrods in the same locations from which they were removed.

Important: When installing valve rocker arms and pushrods, coat the bearing surfaces with prelude GM P/N 12345501 or equivalent. Install these components in the locations from which they were removed.

1. Install the pushrods (1).

2. Install the valve rocker arm retainer (1).



439870

3. Install the valve rocker arms (2).
4. Apply thread lock adhesive GM P/N 12345493 or equivalent to the rocker arm bolt threads before installing.

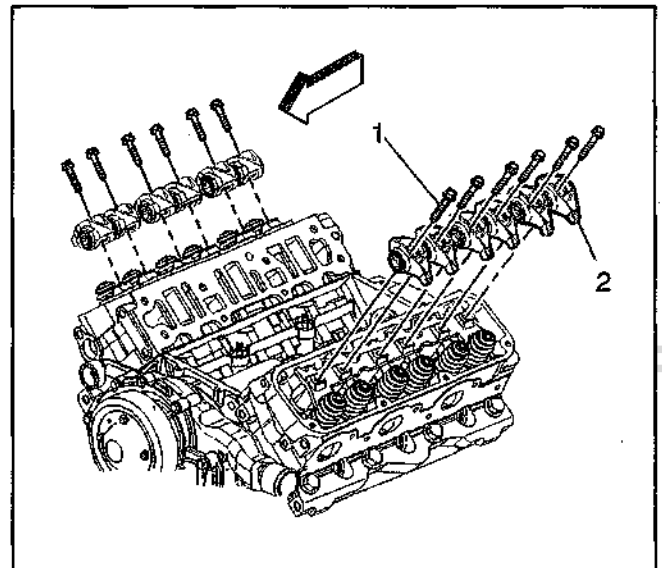
Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the valve rocker arm bolts (1).

Tighten

Tighten the valve rocker arm bolts to 15 N·m (11 lb ft). Use the J 36660-A in order to torque the bolts an additional 90 degrees.

6. Install the valve rocker arm covers. Refer to *Valve Rocker Arm Cover Replacement (Right)* or *Valve Rocker Arm Cover Replacement (Left)*.



554762

Valve Stem Oil Seal and Valve Spring Replacement

Removal Procedure

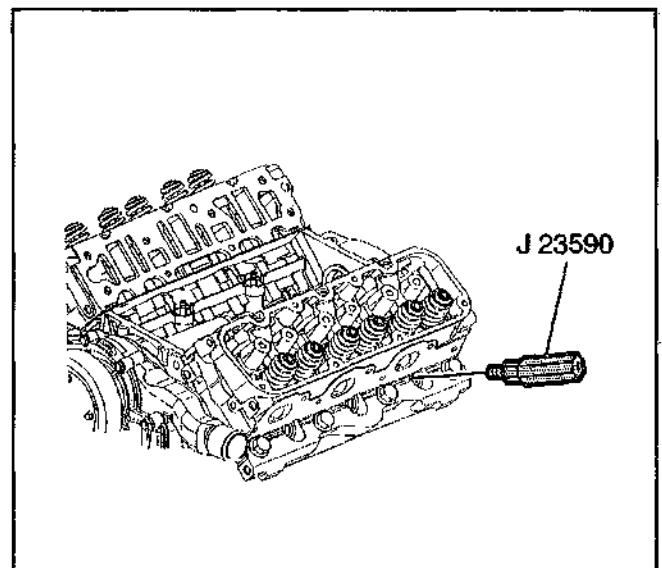
Tools Required

- J 23590 Spark Plug Port Adapter
- J 38606 Valve Spring Compressor

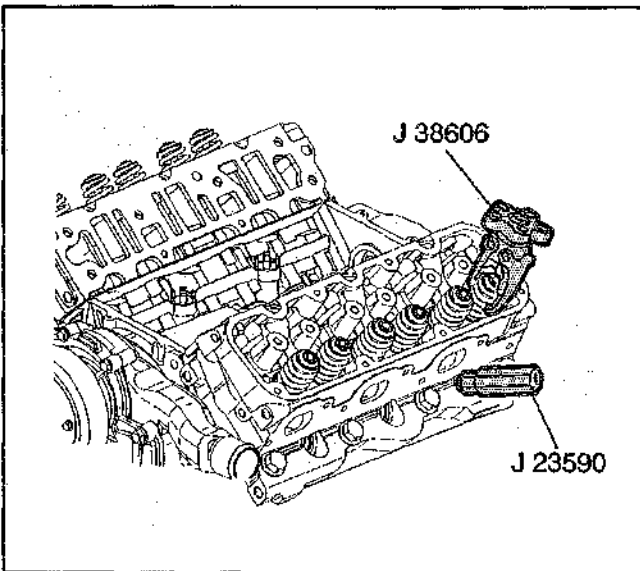
1. Remove the valve rocker arm and push rod. Refer to *Valve Rocker Arm and Push Rod Replacement*.
2. Remove the spark plug. Refer to *Spark Plug Replacement* in Engine Electrical.

Important: Rotate the engine so that the piston in the cylinder being worked on is at top dead center (TDC) before removing the valve keys. This will eliminate the possibility of the valve accidentally falling inside the cylinder.

3. Install the J 23590 to the spark plug port and apply compressed air in order to hold the valves closed.

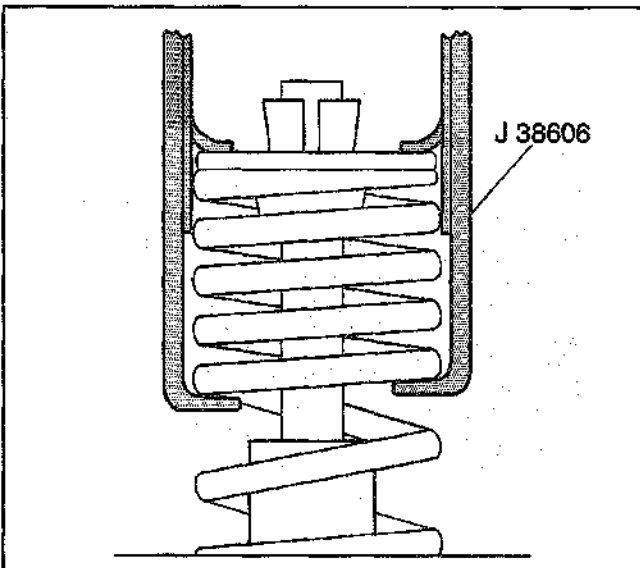


190565



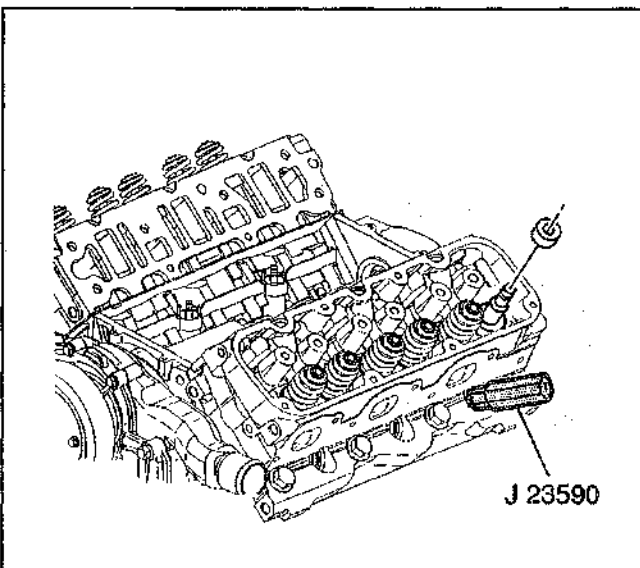
190566

4. Install the J 38606 on the valve spring.



190527

5. Compress the valve spring using the J 38606.
6. Remove the valve keys.
7. Remove the valve spring and cap.



190567

8. Remove the valve stem oil seal.
9. Inspect the valve spring for bent, cracked or broken parts. Replace it if damaged. Refer to *Cylinder Head Clean and Inspect*.

Installation Procedure**Tools Required**

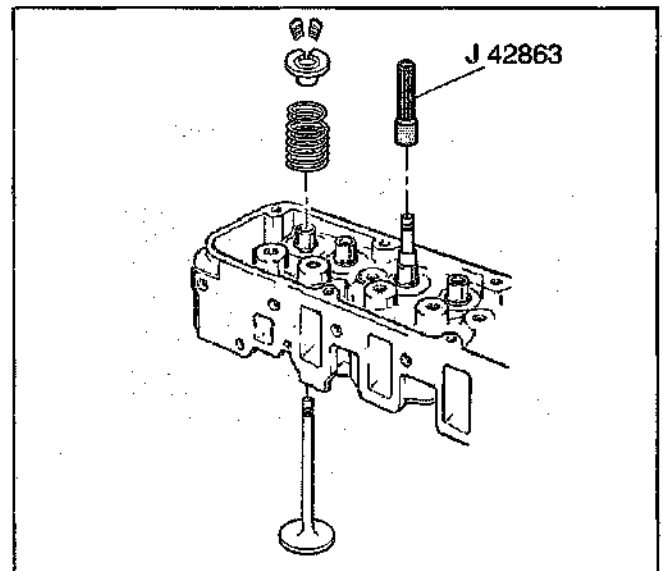
- J 42863 Valve Seal Installer
- J 38606 Valve Spring Compressor
- J 23590 Spark Plug Port Adapter

Important: The color of the replacement seal may not be the same color as the original seal. Install the seals in their correct location based on GM part and package description. Ensure that the seal is fully seated on the valve guide.

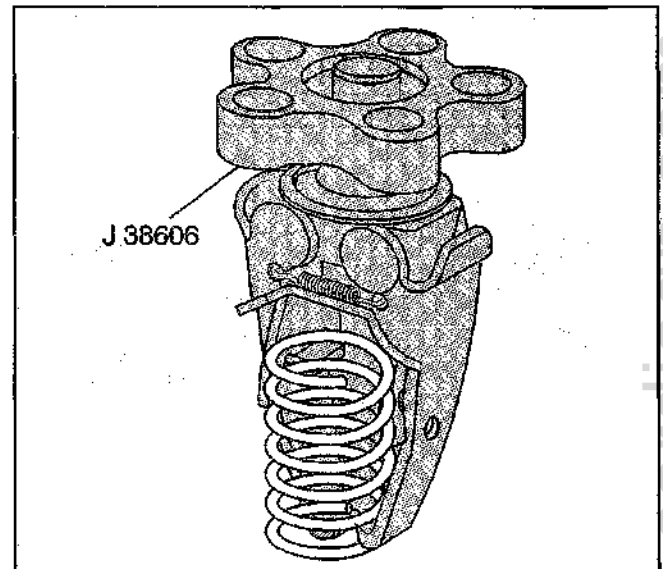
1. Place the valve stem oil seal over the valve stem so the seal begins to contact the valve guide.

Important: Use hand pressure only when installing the valve seal using J 42863. Using too much force may cause damage to the oil seal and possibly lead to excessive oil consumption.

2. Using J 41512 push the valve stem oil seal over the valve guide.
3. Install the J 38606 on the valve spring.

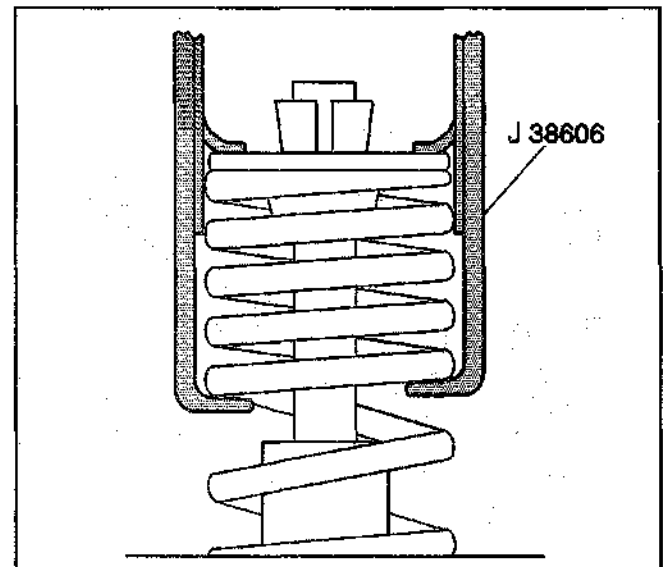


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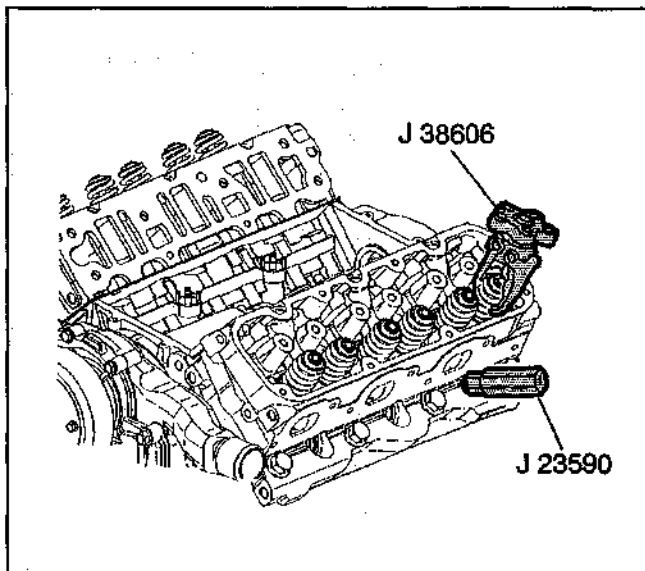


154517

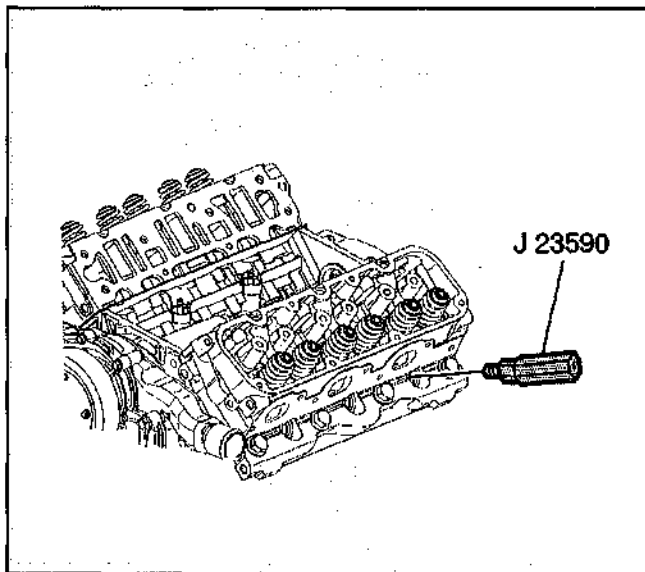
4. Compress the valve spring using the J 38606.



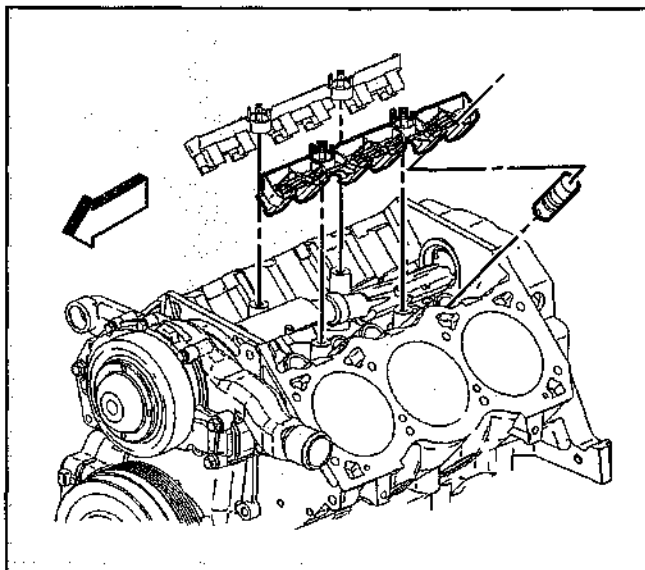
190527



190566



190565



41374

5. Using install the valve spring and the valve cap.
6. Install the valve keys.
7. Release the valve spring.
8. Ensure that the valve keys are seated.
9. Remove the J 38606.

10. Disconnect the air pressure, and remove the J 23590.
11. Install the spark plug. Refer to *Spark Plug Replacement* in Engine Electrical.
12. Install the push rod and valve rocker arm. Refer to *Valve Rocker Arm and Push Rod Replacement*.

Valve Lifter Replacement

Removal Procedure

1. Remove the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
2. Remove the valve rocker arms and the pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
3. Loosen the valve lifter guide bolts.
4. Remove the valve lifter guide.
5. Remove the valve lifters.

Installation Procedure

1. Coat the valve lifters with prelube, GM P/N 12345501 or equivalent prior to installation.
2. Install the valve lifters.
3. Install the valve lifter guide.

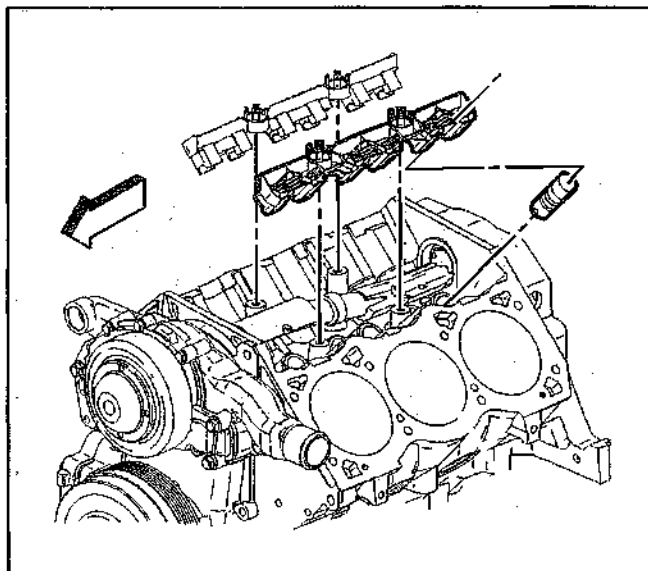
Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Tighten the valve lifter guide bolts.

Tighten

Tighten the valve lifter guide bolts to 30 N·m (22 lb ft).

5. Install the valve rocker arms and pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
6. Install the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.

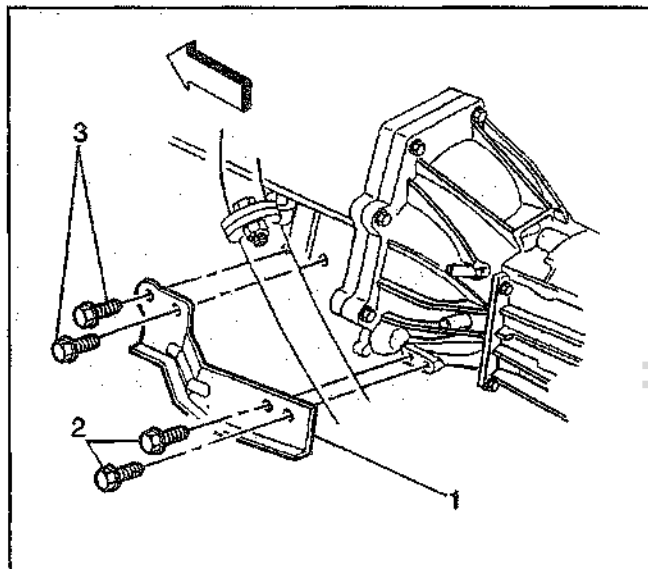


41374

Crankshaft Balancer Replacement**Removal Procedure****Tools Required**

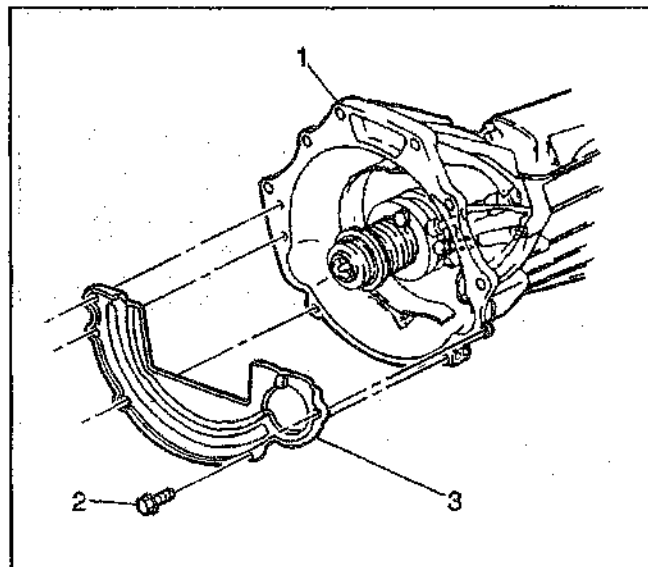
- J 38197 Crankshaft Balancer Puller
- J 37096 Flywheel Holding Tool

1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the starter motor. Refer to *Starter Motor Replacement (3.8 L)* in Engine Electrical.
4. If equipped with the M49 manual transmission remove the following components:
5. Remove the transmission brace bolts (2, 3).
6. Remove the transmission brace (1).

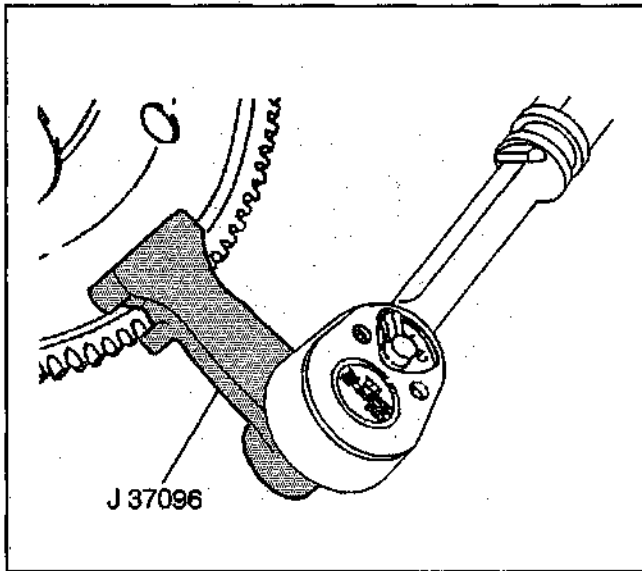


349561

7. Remove the flywheel housing inspection cover bolts (2).
8. Remove the flywheel housing inspection cover (3).
9. If equipped with the 4L60-E automatic transmission remove the torque converter cover. Refer to *Torque Converter Cover Replacement (3.8 L)* in Automatic Transmission - 4L60-E.

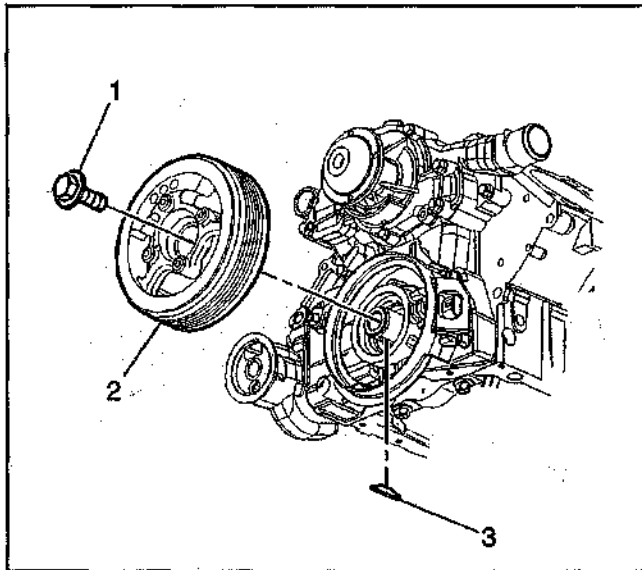


349560



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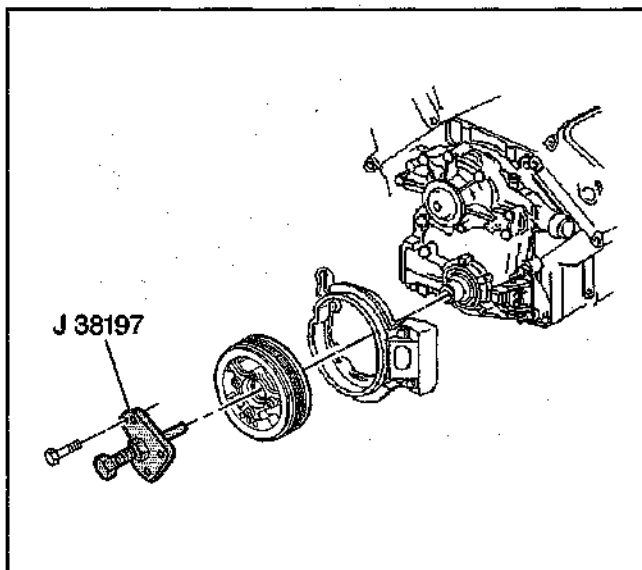
10. Use J 37096 in order to hold the flywheel.



440746

11. Remove the crankshaft balancer bolt (1) from the balancer (2).

12. Remove the key (3) from the crankshaft.



313955

13. Remove the crankshaft balancer using the J 38197.

13.1. Invert J 38197-2 so the leg of the tool is facing away from the crankshaft balancer.

13.2. Install the silver bolts J 38197-4 to the crankshaft balancer.

13.3. Remove J 38197-1, J 38197-2, and J 38197-4 from the crankshaft balancer.

Installation Procedure**Tools Required**

J 36660-A Torque Angle Meter

1. Lubricate the seal surface of the crankshaft balancer with engine oil.
2. Install the crankshaft balancer (2).
3. Align the key slot in the balancer (2) to the key slot in the crankshaft.
4. Install the key (3)

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

5. Install the crankshaft balancer bolt (1).

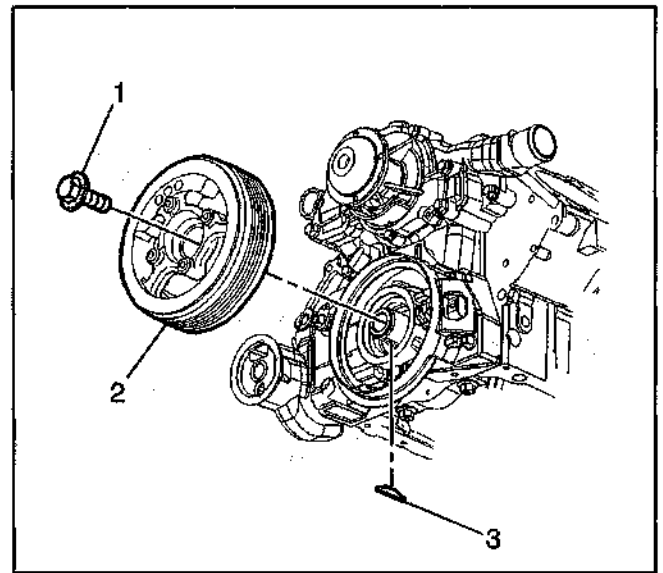
Tighten

Tighten the crankshaft balancer bolt (1) to 150 N·m (111 lb ft). Use the J 36660-A to torque the crankshaft balancer bolt (1) an additional 114 degrees.

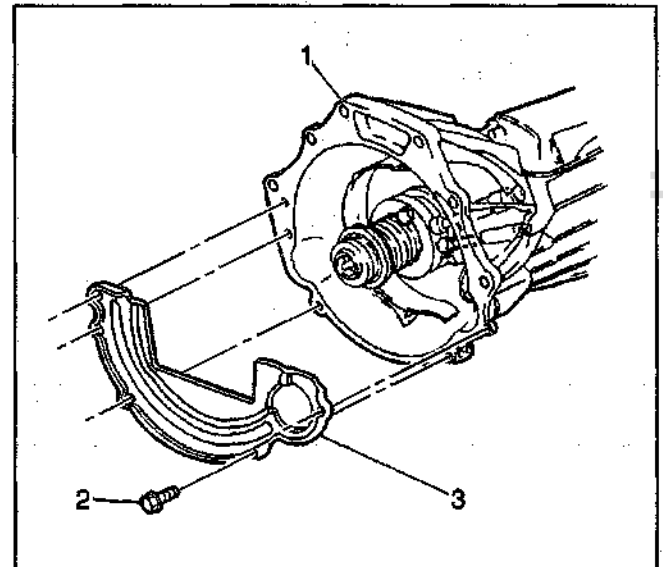
6. Remove the J 37096.
7. If equipped with the 4L60-E automatic transmission install the torque converter cover. Refer to *Torque Converter Cover Replacement (3.8 L)* in Automatic Transmission - 4L60-E.
8. If equipped with the M49 manual transmission install the following components:
9. Install the flywheel housing inspection cover (3).
10. Install the flywheel housing inspection cover bolts (2).

Tighten

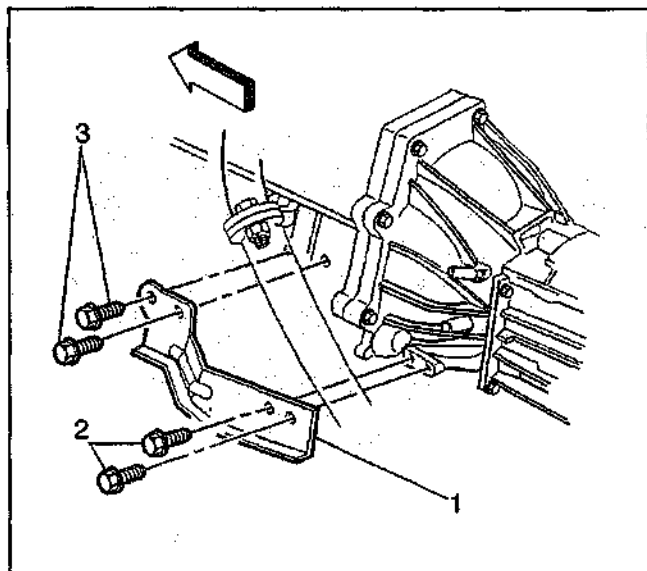
Tighten the flywheel housing inspection cover bolts (2) to 48 N·m (35 lb ft).



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349561

11. Install the transmission brace (1).
12. Install the transmission brace bolts (2, 3).

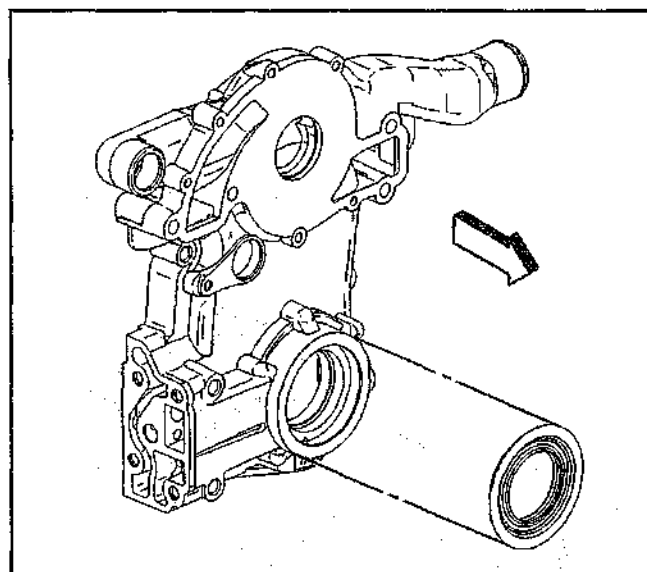
Tighten

- Tighten the brace bolts (3) to the engine block to 28 N·m (21 lb ft).
 - Tighten the brace bolts (2) to the transmission to 50 N·m (37 lb ft).
13. Install the starter motor. Refer to *Starter Motor Replacement (3.8 L)* in Engine Electrical.
 14. Lower the vehicle.
 15. Install the drive belt. Refer to *Drive Belt Replacement*.
 16. Perform the crankshaft position (CKP) system variation learn procedure. Refer to *CKP System Variation Learn Procedure* in Engine Controls - 3.8 L.

Crankshaft Front Cover Oil Seal Replacement

Removal Procedure

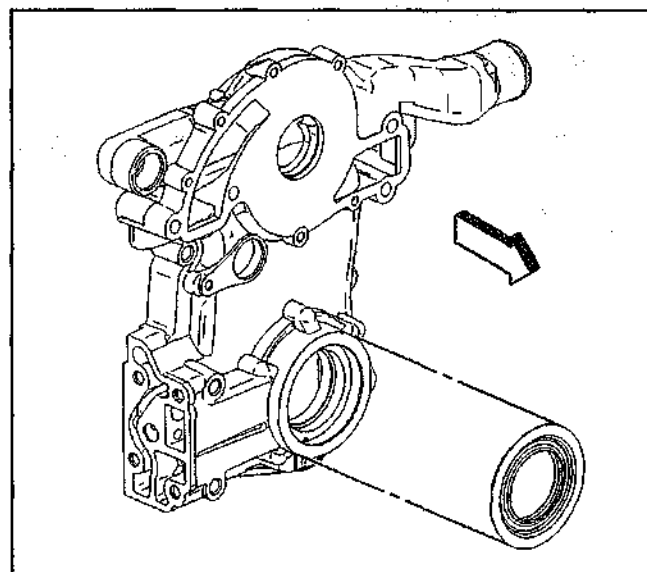
1. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
2. Use a screwdriver to pry out the crankshaft front oil seal. Use care in order to avoid damage to the seal bore or seal contact surfaces.



50499

Installation Procedure**Tools Required***J 35354 Seal Installer*

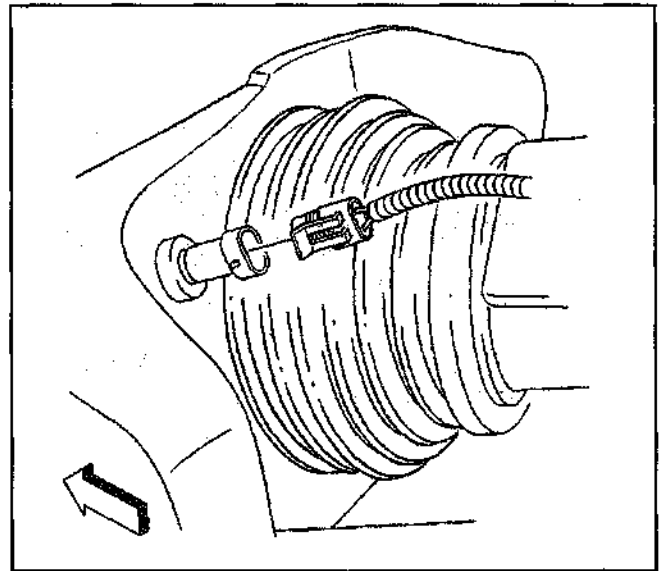
1. Install the crankshaft front oil seal. Use the *J 35354* and a soft faced hammer.
2. Remove the *J 35354*.
3. Coat the outside seal surface of the crankshaft balancer with lubricant GM P/N 12377985 or equivalent.
4. Install the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.



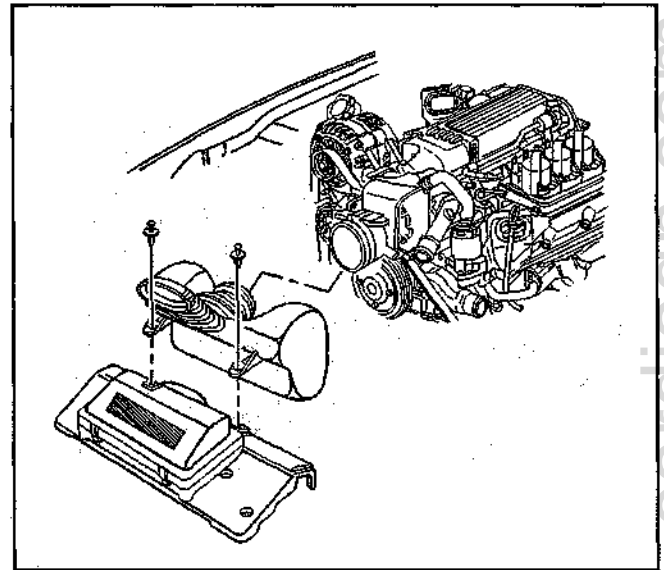
50499

Engine Front Cover Replacement**Removal Procedure**

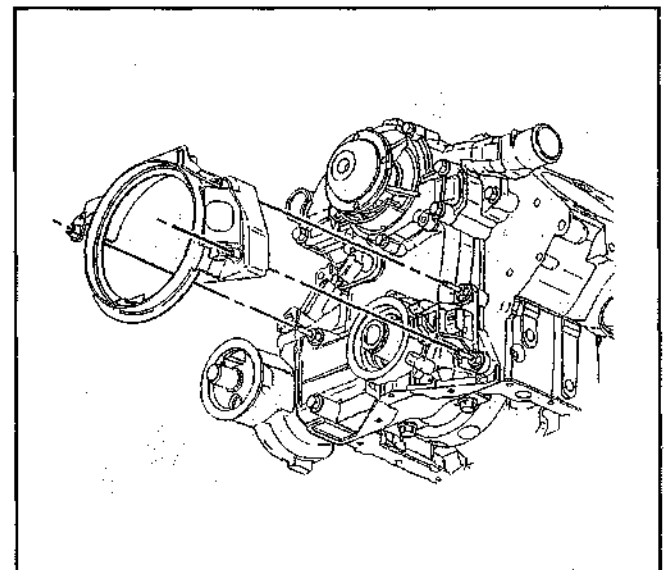
1. Drain the engine oil.
2. Drain the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.
3. Disconnect the intake air temperature (IAT) sensor electrical connector.
4. Remove the air intake duct.
5. Loosen the coolant pump pulley bolts.
6. Remove the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.
7. Remove the power steering pump. Refer to *Power Steering Pump Replacement (V8)* in Power Steering System.
8. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
9. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
10. Disconnect the crankshaft position sensor electrical connector.
11. Remove the crankshaft position sensor shield.



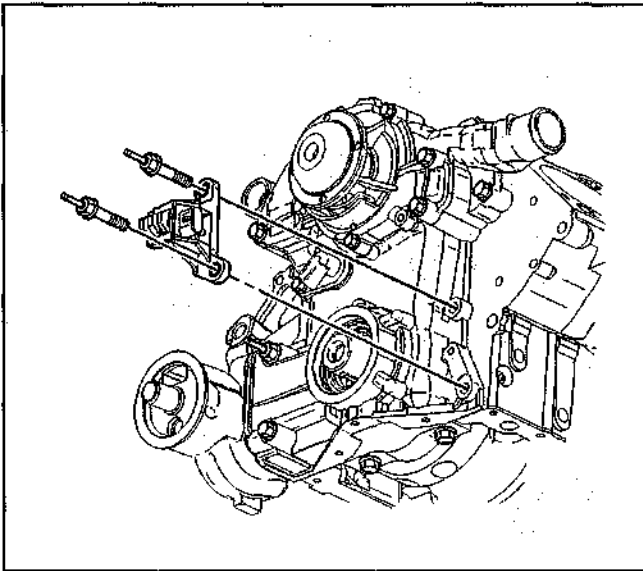
208554



554755

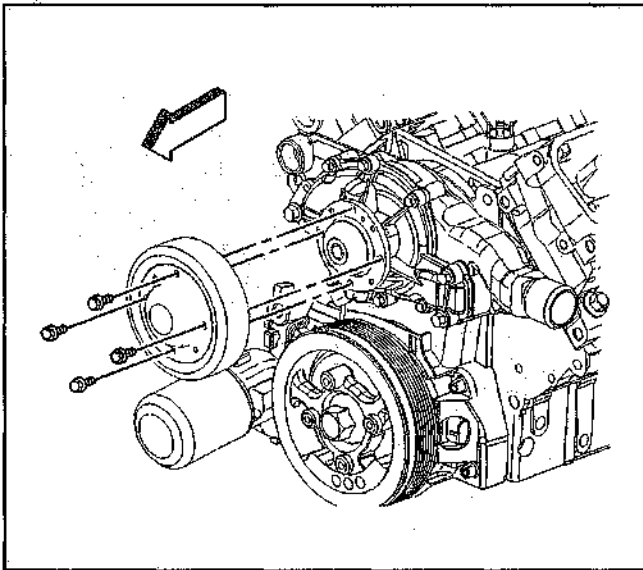


440841



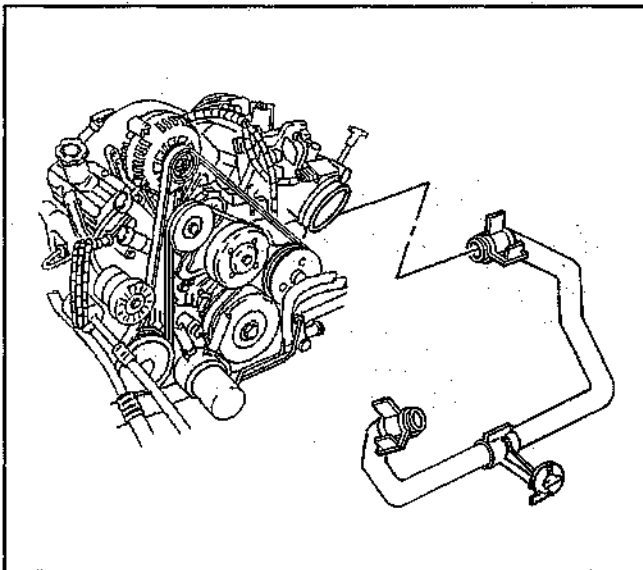
554767

12. Remove the crankshaft position sensor studs.
13. Remove the crankshaft position sensor.
14. Remove the oil pan to front cover bolts.
15. Loosen the oil pan bolts, to drop the oil pan slightly in order to add clearance for the front cover installation.
16. Lower the vehicle.



221711

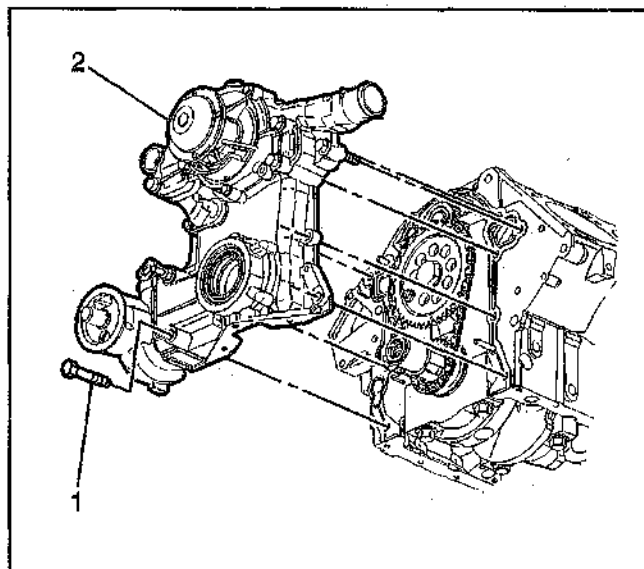
17. Remove the coolant pump pulley bolts.
18. Remove the coolant pump pulley.



221689

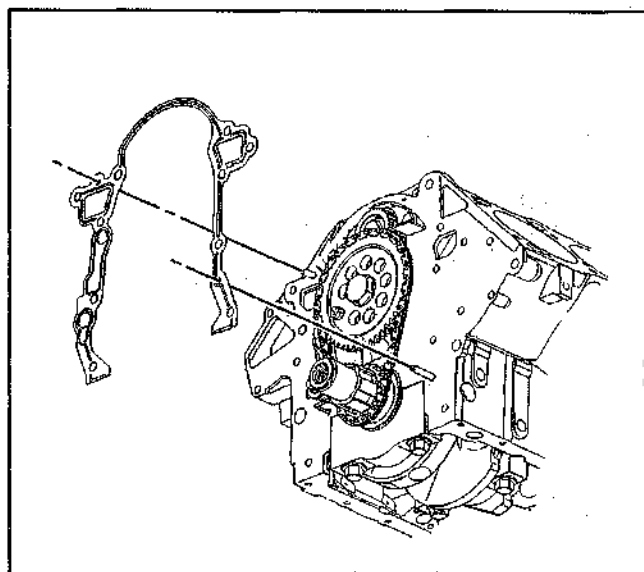
19. Remove the radiator outlet hose from the front cover.

20. Remove the engine front cover studs and bolts (1).
21. Remove the engine front cover (2).



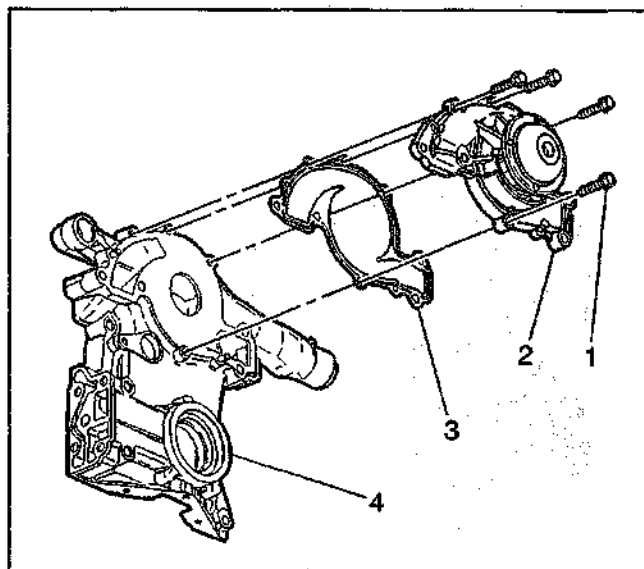
50504

22. Remove the engine front cover gasket from the engine block.

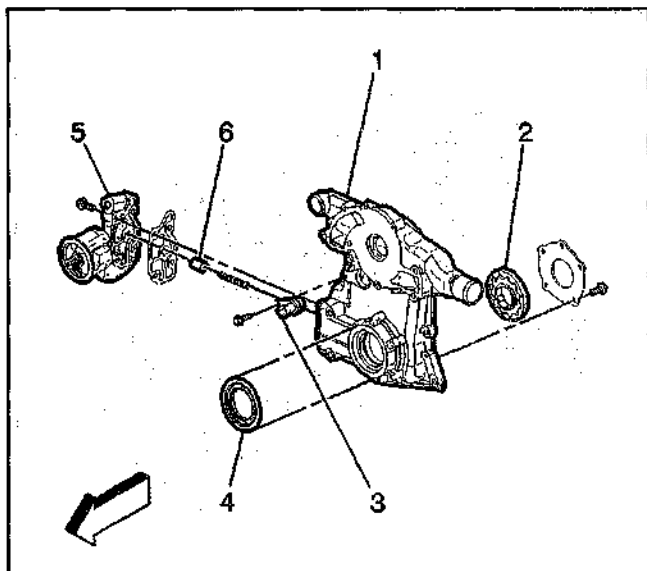


440843

23. Remove the coolant pump bolts (1).
24. Remove the coolant pump (2).
25. Remove the coolant pump gasket (3) from the front cover (4).



11687



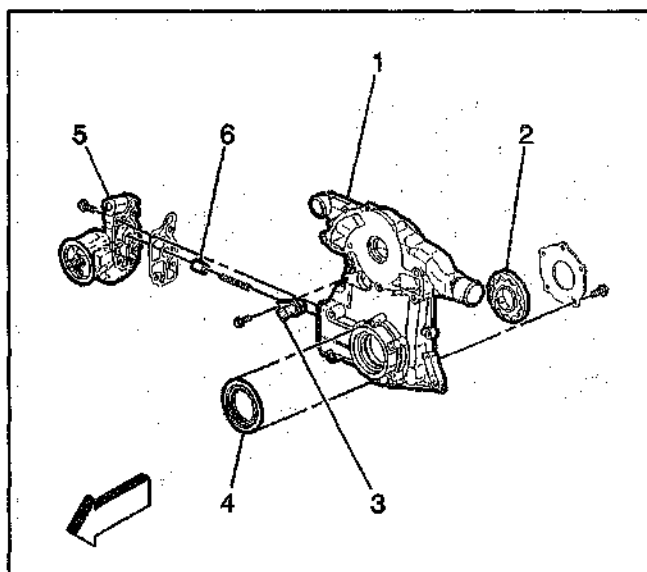
445496

26. If replacing the front cover (1), disassemble the following components:

- Oil pump gear set (2)
- Camshaft sensor (3)
- Oil filter adapter (5) and gasket
- Oil pressure relief valve (6) and spring

27. Remove the crankshaft front oil seal (4).

28. Clean the engine front cover and engine block surfaces.



445496

Installation Procedure

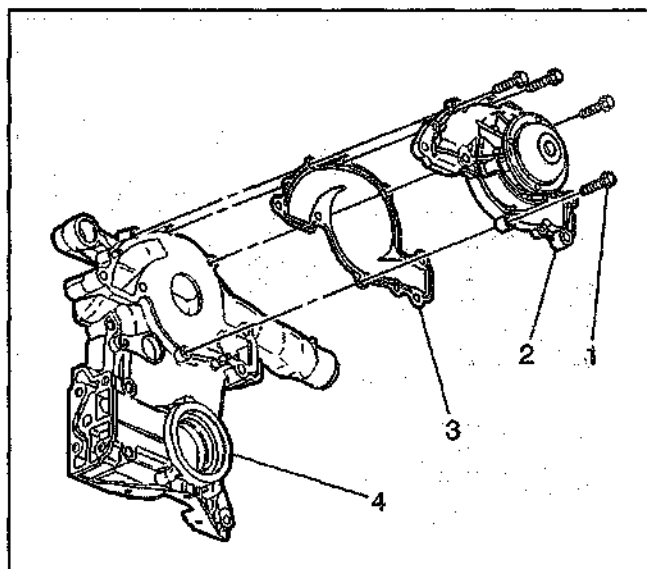
Tools Required

- J 36660-A Torque Angle Meter
- J 35354 Seal Installer

1. If replacing the front cover (1), assemble the following parts:

- Oil pump gear set (2)
- Camshaft sensor (3)
- Oil filter adapter (5) and a new gasket
- Oil pressure relief valve (6) and spring

2. Install a new crankshaft front oil seal (4)



11687

3. Install the coolant pump gasket (3) to the front cover (4).

4. Install the coolant pump (2).

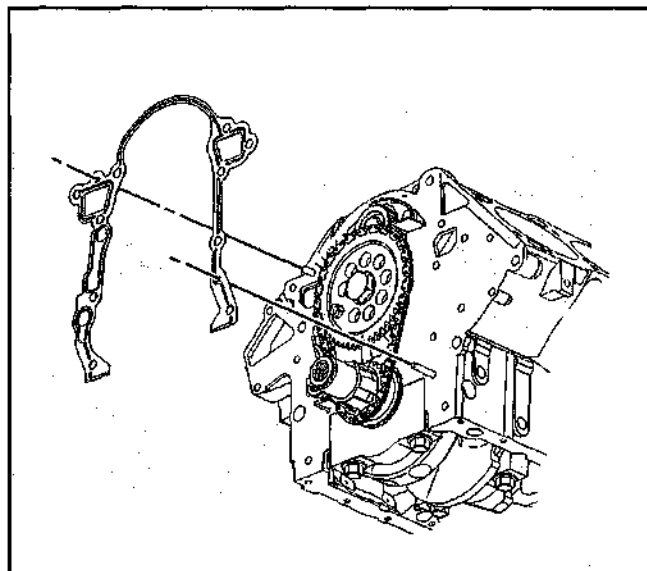
Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the coolant pump bolts (1).

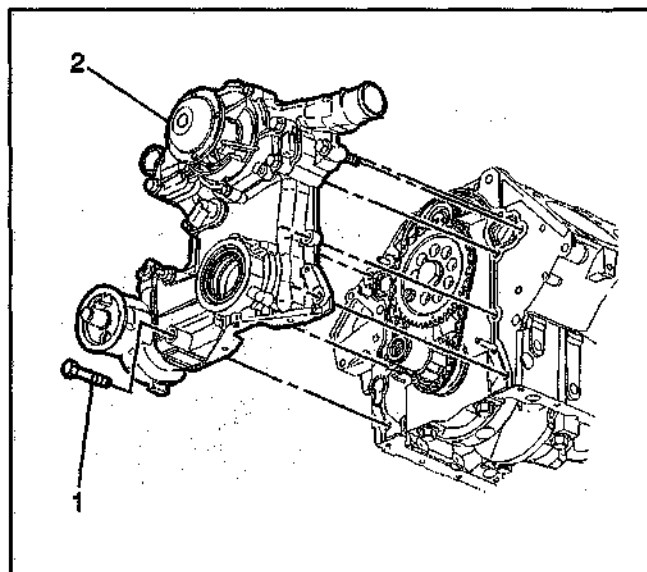
Tighten

Tighten the coolant pump bolts (1) to 15 N·m (11 lb ft). Use the J 36660-A to torque the coolant pump bolts (1) an additional 80 degrees.

6. Install a new engine front cover gasket to the engine block.



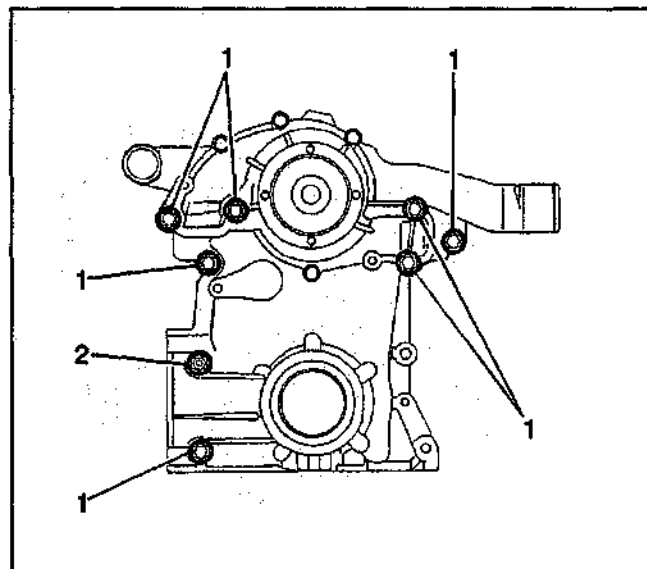
7. Install the engine front cover (2).

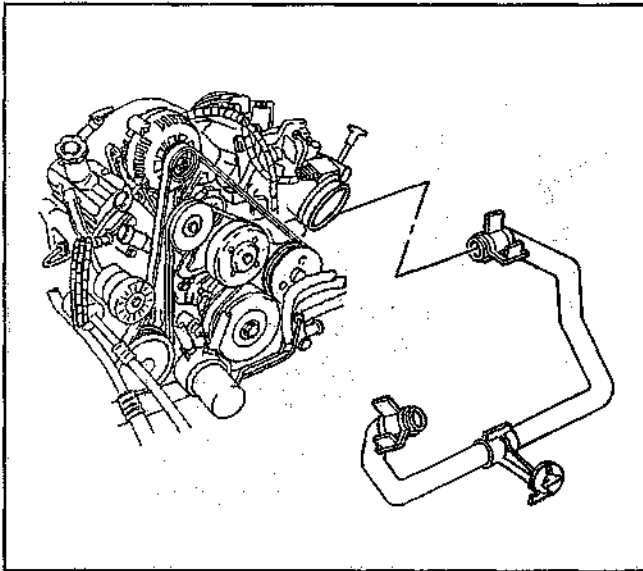


8. Apply sealant GM P/N 12346004 or equivalent to the engine front cover bolts (1) and stud (2).
9. Install the engine front cover bolts (1) and stud (2).

Tighten

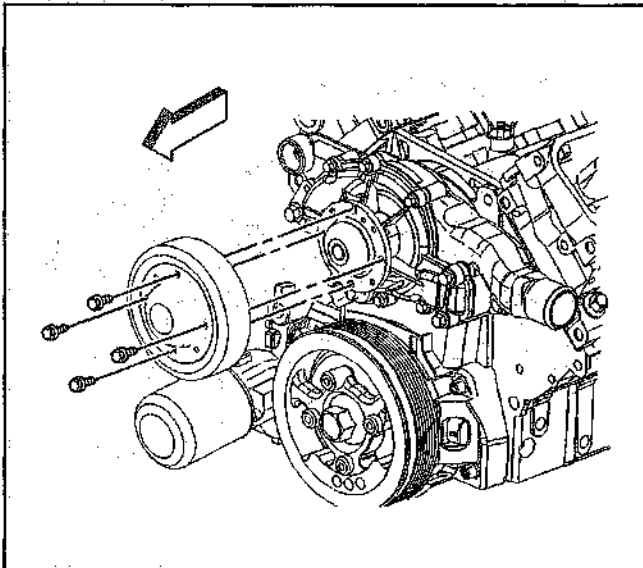
Tighten the front cover bolts (1) and stud (2) to 20 N·m (15 lb ft). Use the *J 36660-A* to torque the front cover bolts (1) and stud (2) an additional 40 degrees.





221669

10. Install the radiator outlet hose to the front cover.



221711

11. Install the coolant pump pulley.
12. Install the coolant pump pulley bolts.

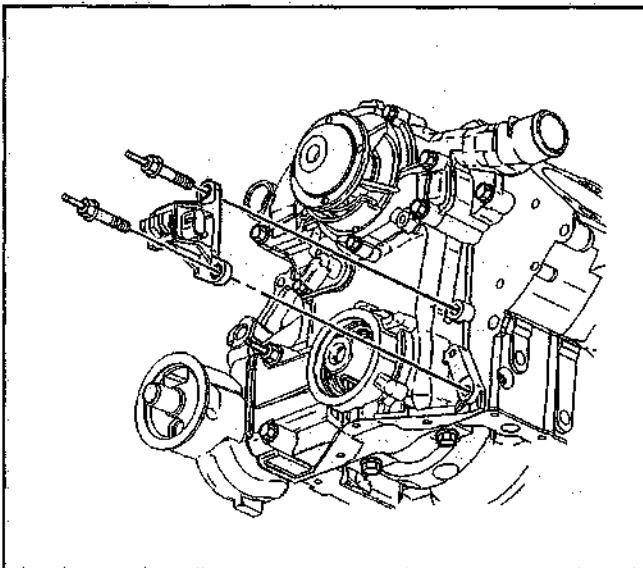
Tighten

Tighten the coolant pump pulley bolts to 13 N·m (115 lb in).

13. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
14. Install the oil pan to front cover bolts.

Tighten

Tighten the oil pan bolts to 14 N·m (10 lb ft).



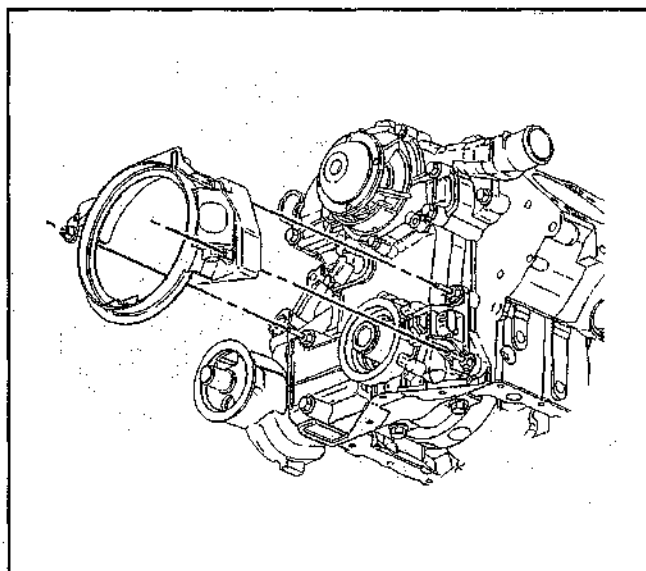
554767

15. Install the crankshaft position sensor.
16. Apply sealant GM P/N 12346004 or equivalent to the crankshaft position sensor studs.
17. Install the crankshaft position sensor studs.

Tighten

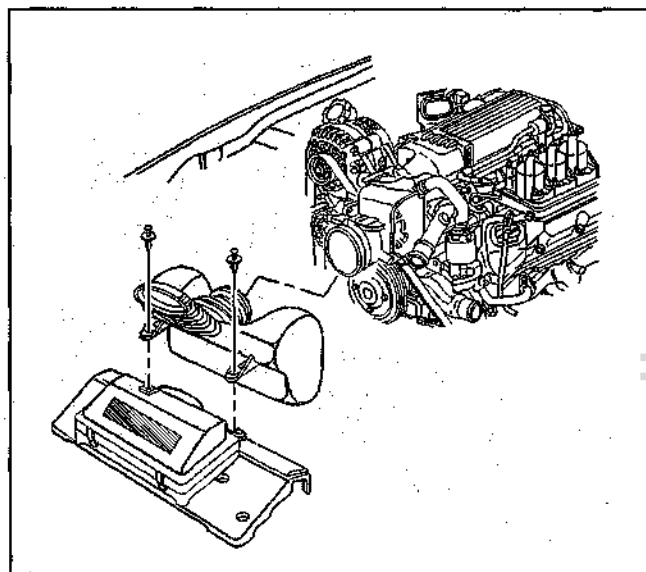
Tighten the crankshaft position sensor studs to 20 N·m (15 lb ft). Use the J 36660-A to torque the crankshaft position sensor studs an additional 40 degrees.

18. Install the crankshaft position sensor shield.
19. Connect the crankshaft position sensor electrical connector.
20. Install the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
21. Lower the vehicle.
22. Install the power steering pump. Refer to *Power Steering Pump Replacement (V8)* in Power Steering System.
23. Install the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.



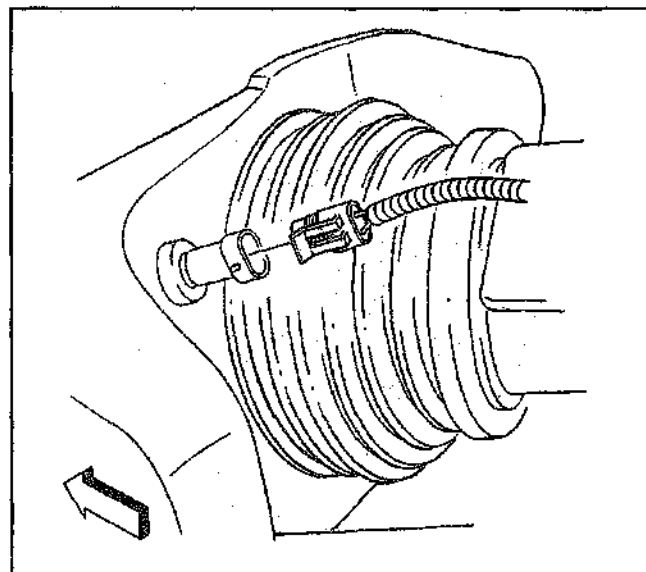
440841

24. Install the air intake duct.

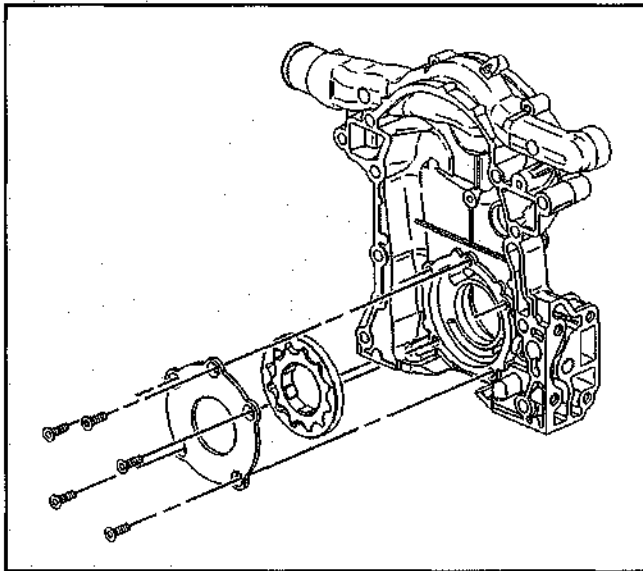


554755

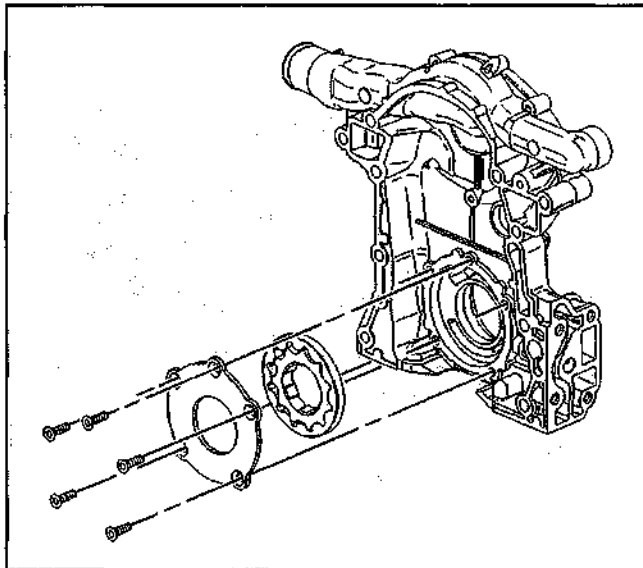
25. Connect the intake air temperature (IAT) sensor electrical connector.
26. Refill the engine oil.
27. Refill the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.



208554



153600



153600

Oil Pump Cover and Gear Set Replacement

Removal Procedure

1. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.
2. Remove the oil pump cover attaching screws.
3. Remove the oil pump cover.
4. Remove the oil pump gear set.
5. Inspect the oil pump gear set and housing. Refer to *Oil Pump Clean and Inspect*.

Installation Procedure

1. Lubricate the oil pump gear set with petroleum jelly.
2. Install the oil pump gear set.
3. Pack the oil pump cavity with petroleum jelly.
4. Install the oil pump cover.

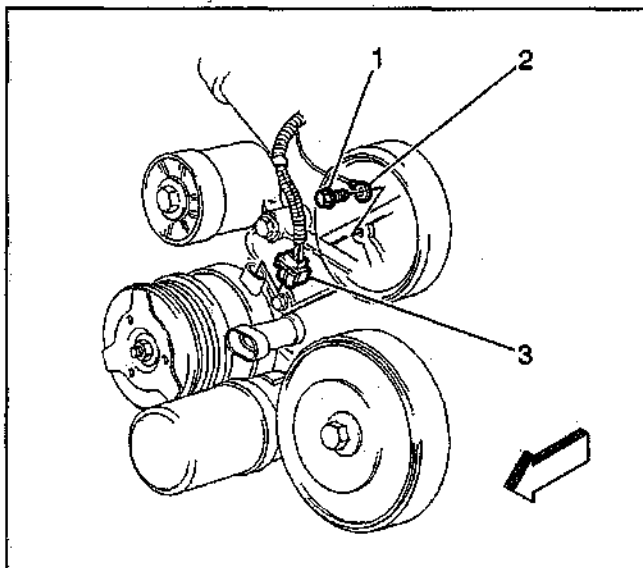
Notice: Refer to *Fastener Notice* in Cautions and Notices.

5. Install the oil pump cover screws.

Tighten

Tighten the oil pump cover screws to 11 N·m (98 lb in).

6. Install the engine front cover. Refer to *Engine Front Cover Replacement*.



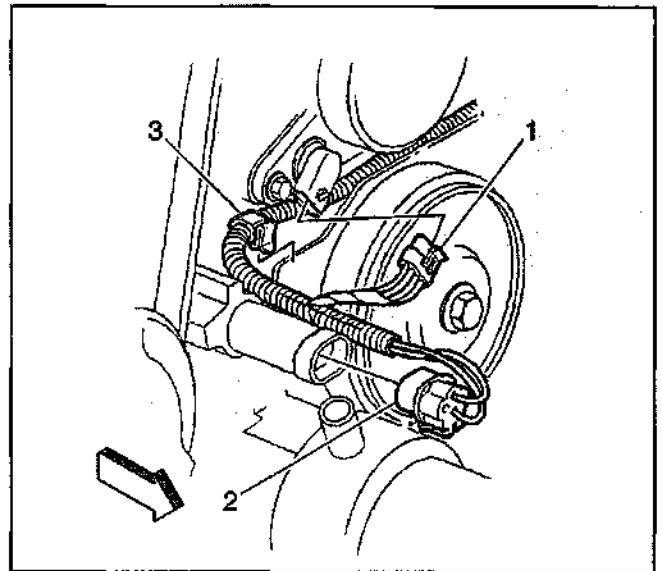
445688

Oil Filter Adapter and Valve Assembly Replacement

Removal Procedure

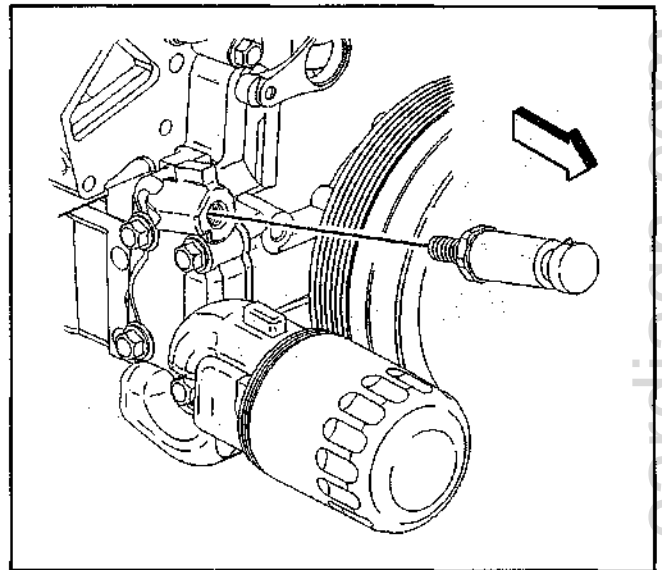
1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Remove the engine ground strap bolt (1) and ground strap (2).
3. Disconnect the air conditioning compressor electrical connector (3).
4. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
5. Drain the engine oil.
6. Remove the air conditioning compressor mounting bracket. Refer to *Compressor Mounting Bracket Replacement (3.8 L)* in Heating, Ventilation and Air Conditioning.

7. Disconnect the oil pressure sensor electrical connector (2).



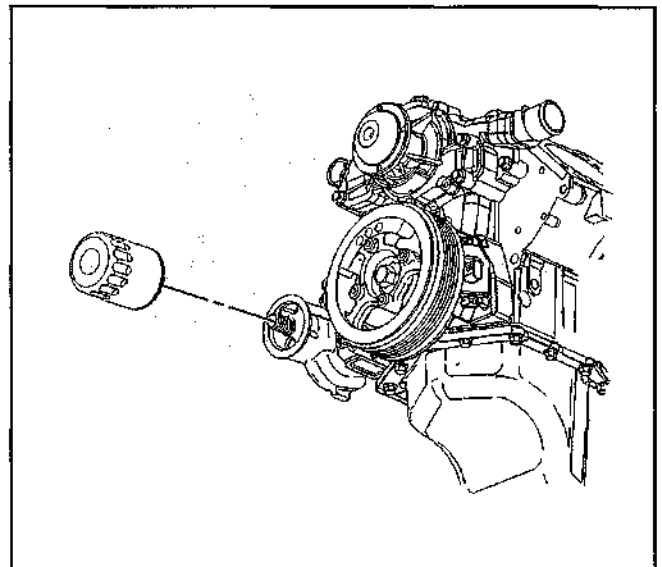
440853

8. Remove the oil pressure sensor.

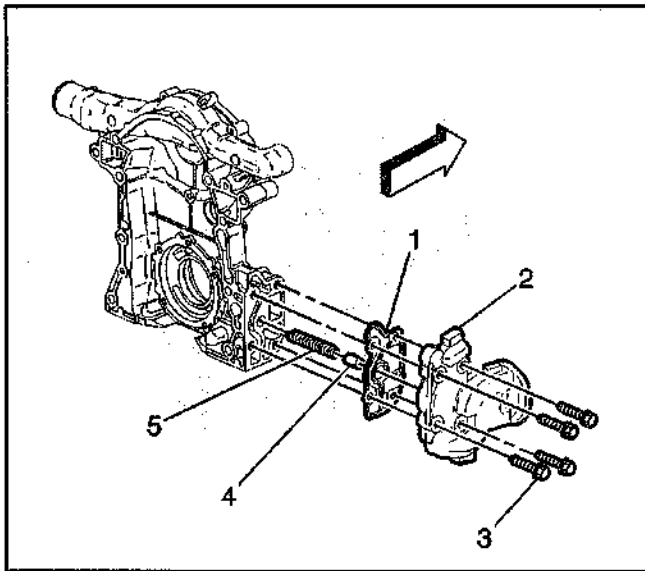


440848

9. Remove the engine oil filter.

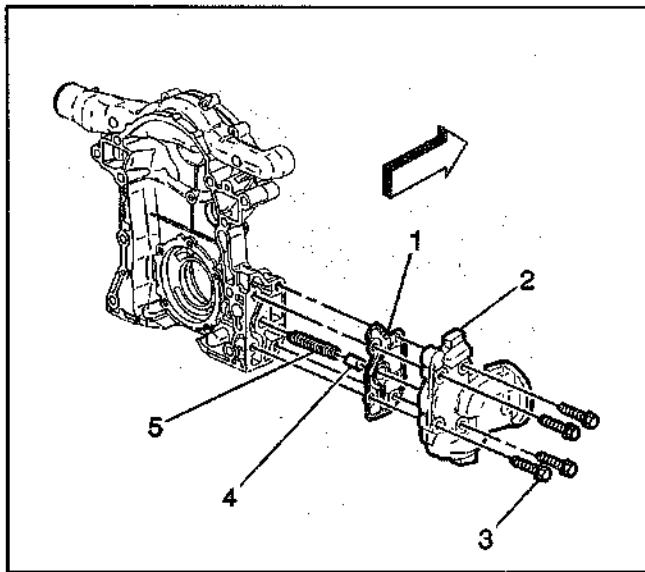


440847



440844

10. Remove the oil filter adapter bolts (3).
11. Remove the oil filter adapter (2) and gasket (1).
12. Remove the pressure relief valve (4) and spring (5).
13. Clean the parts in a suitable solvent. Dry the parts.
14. Clean all of the gasket sealing surfaces.
15. Inspect the following areas:
 - The oil pressure relief valve (4) and the valve bore for burrs
 - The spring (5) for loss of tension, replace the spring if you are in doubt.



440844

Installation Procedure

Tools Required

J 36660-A Torque Angle Meter

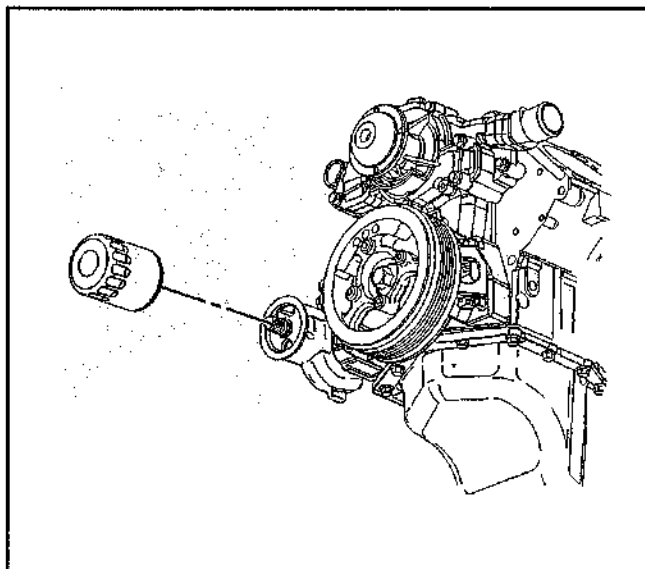
1. Install the pressure relief valve (4) and spring (5).
2. Install the oil filter adapter (2) and gasket (1).

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

3. Install the oil filter adapter bolts (3).

Tighten

Tighten the oil filter adapter bolts (3) to 15 N·m (11 lb ft). Use the J 36660-A to torque the oil filter adapter bolts (3) an additional 50 degrees.



440847

4. Install a new oil filter.

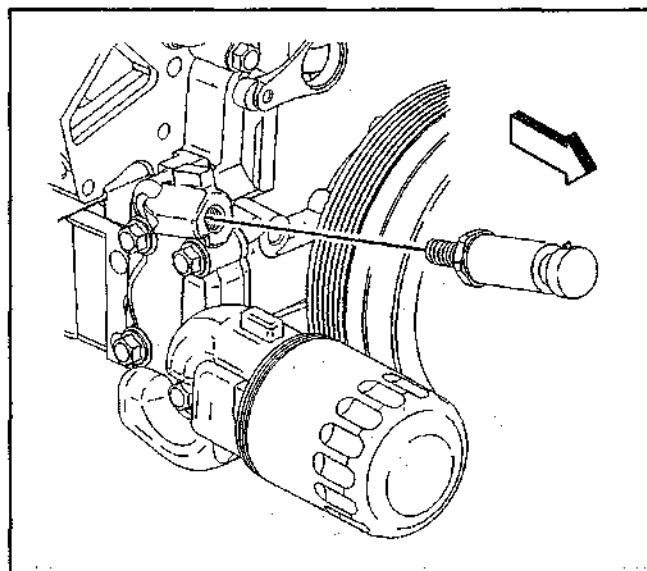
Tighten

Tighten the oil filter to 30 N·m (22 lb ft).

5. Install the oil pressure sensor.

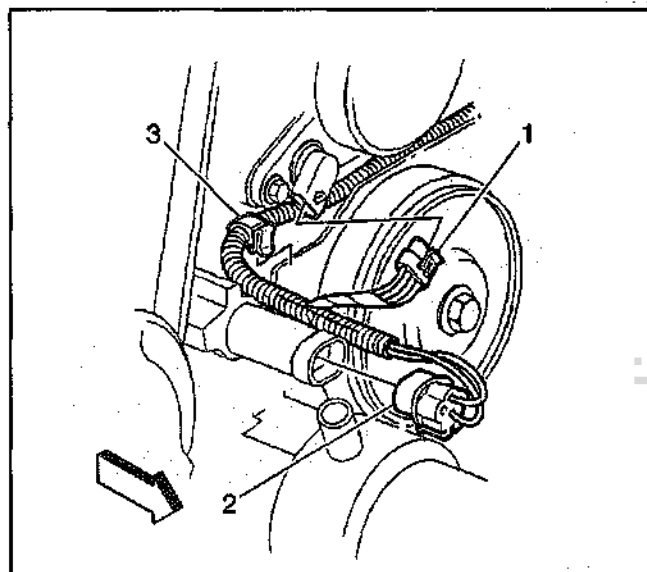
Tighten

Tighten the oil pressure sensor to 16 N·m (12 lb ft).



440848

6. Connect the oil pressure sensor electrical connector (2).
7. Install the air conditioning compressor mounting bracket. Refer to *Compressor Mounting Bracket Replacement (3.8 L)* in Heating, Ventilation and Air Conditioning.
8. Lower the vehicle.



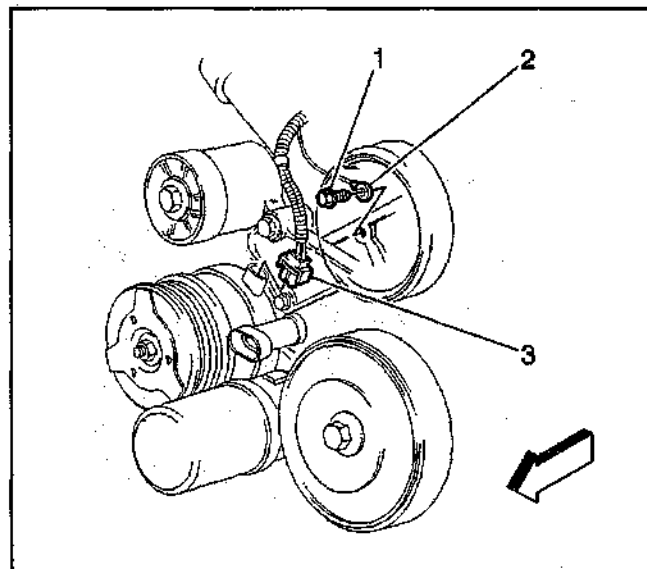
440853

9. Connect the air conditioning compressor electrical connector (3).
10. Install the engine ground strap (2) and bolt (1).

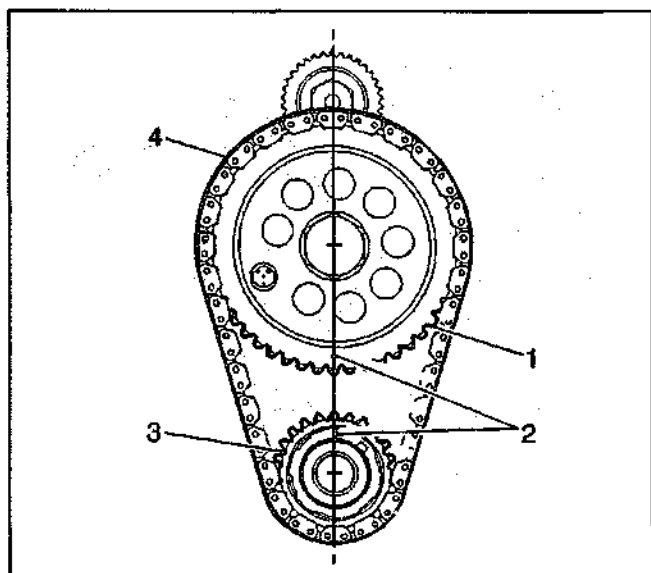
Tighten

Tighten the engine ground strap bolt to 25 N·m (18 lb ft).

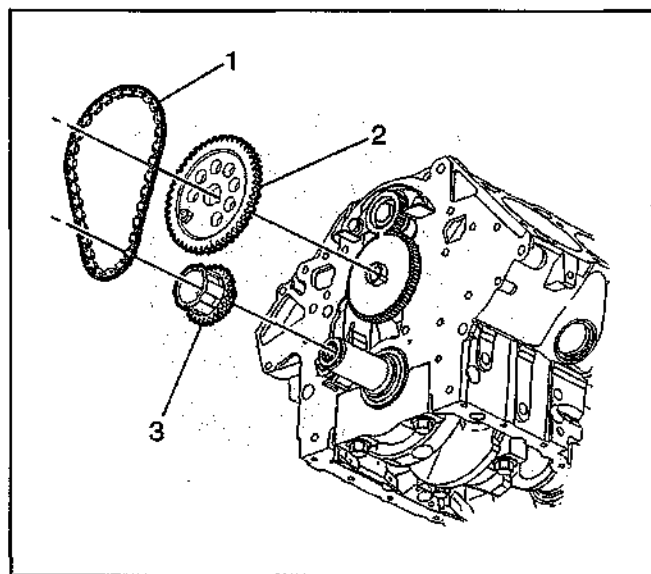
11. Install the drive belt. Refer to *Drive Belt Replacement*.
12. Refill the engine oil.



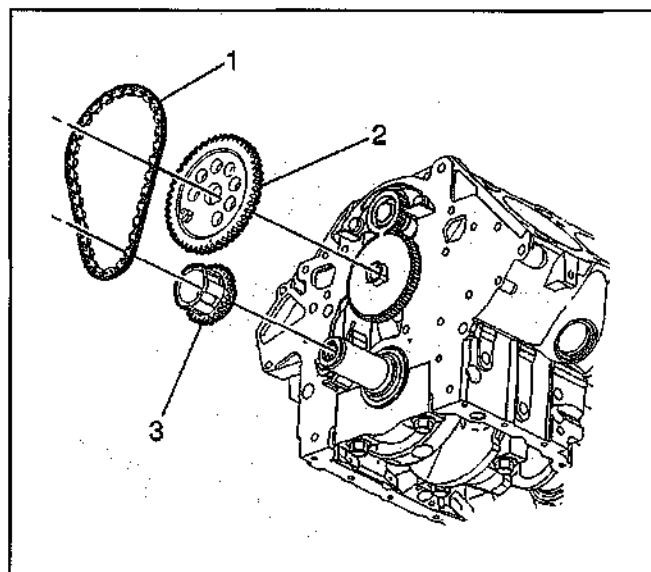
445688



550171



550172



550172

Timing Chain and Sprockets Replacement

Removal Procedure

1. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.
2. Align the timing marks (2) on the sprockets (1, 3) so that they are as close together as possible.
3. Remove the timing chain dampener.
4. Remove the camshaft sprocket bolt.

5. Remove the timing chain (1) and camshaft sprocket (2).

Important: If the crankshaft sprocket does not come off easily, a light blow on the edge of the sprocket (with a plastic mallet) should dislodge the sprocket.

6. Remove the crankshaft sprocket (3).
7. Clean the timing chain.
8. Clean the sprockets.
9. Inspect all the components for wear or damage.
10. If the balance shaft timing has been disturbed. Refer to *Balance Shaft Removal and Balance Shaft Installation*.
11. Use the following steps if the pistons have been moved in the engine:
 - 11.1. Turn the crankshaft in order to set the number one piston is at top dead center.
 - 11.2. With the sprocket installed, turn the camshaft in order to have the timing mark straight down.

Installation Procedure

Tools Required

J 36660-A Torque Angle Meter

1. Install the timing chain (1) onto the sprockets (2, 3) with the timing marks in their closest together position.
2. Install the timing chain (1) and sprockets (2, 3).

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

3. Install the camshaft sprocket bolt.

Tighten

Tighten the camshaft sprocket bolt to 100 N·m (74 lb ft). Use the J 36660-A to torque the camshaft sprocket bolt an additional 90 degrees.

4. Install the timing chain dampener.

5. Install the timing chain dampener bolt.

Tighten

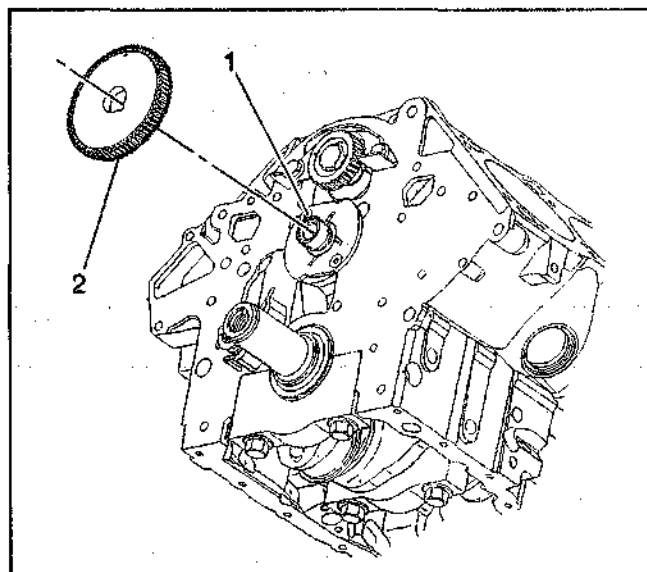
Tighten the dampener bolt to 22 N·m (16 lb ft).

Important: Rotate the engine two revolutions and check the timing marks. Ensure the marks are aligned.

6. Install the engine front cover. Refer to *Engine Front Cover Replacement*.

Camshaft Replacement**Removal Procedure**

1. Recover the refrigerant. Refer to *Refrigerant Recovery and Recharging* in Heating, Ventilation and Air Conditioning.
2. Remove the radiator with the A/C condenser. Refer to *Radiator Replacement* in Engine Cooling.
3. Remove the valve lifters. Refer to *Valve Lifter Replacement*.
4. Remove the timing chain and sprockets. Refer to *Timing Chain and Sprockets Replacement*.
5. Remove the balance shaft gear (2) from the camshaft (1).

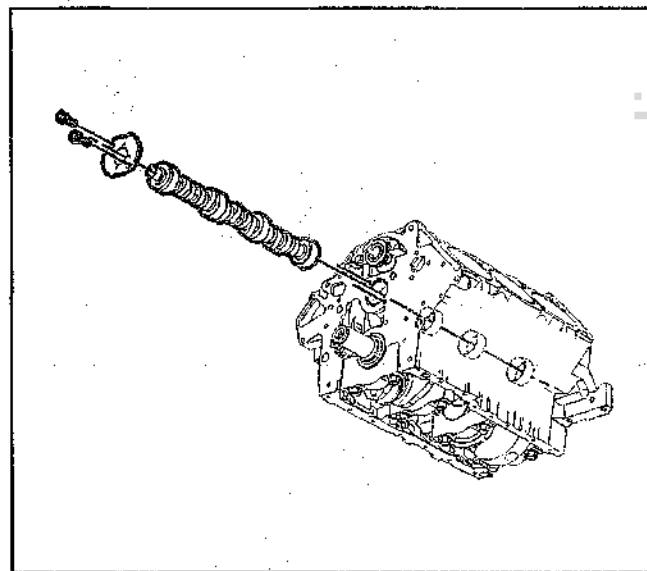


441129

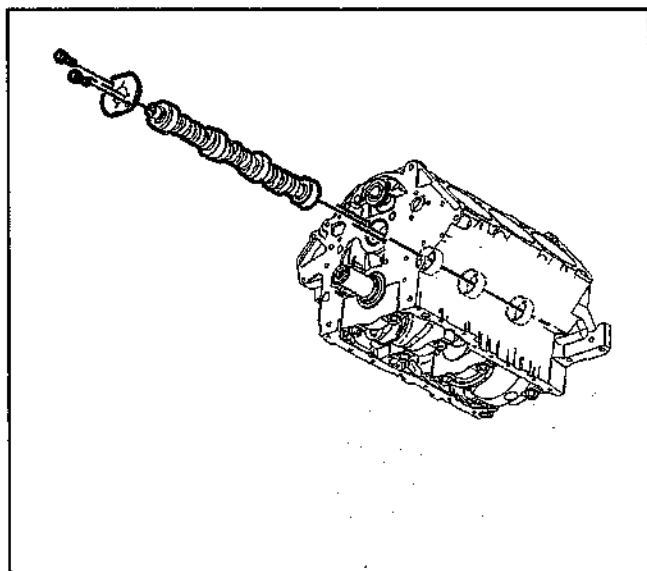
6. Remove the camshaft thrust plate bolts.
7. Remove the camshaft thrust plate.
8. Remove the camshaft key.

Notice: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

9. Use the following procedure to remove the camshaft:
 - 9.1. Install three 5/16-18 x 4 in bolts in the camshaft bolt holes.
 - 9.2. Carefully rotate and pull the camshaft out.
10. Inspect the camshaft and bearings. Refer to *Camshaft and Bearings Clean and Inspect*.



35815



35615

Installation Procedure

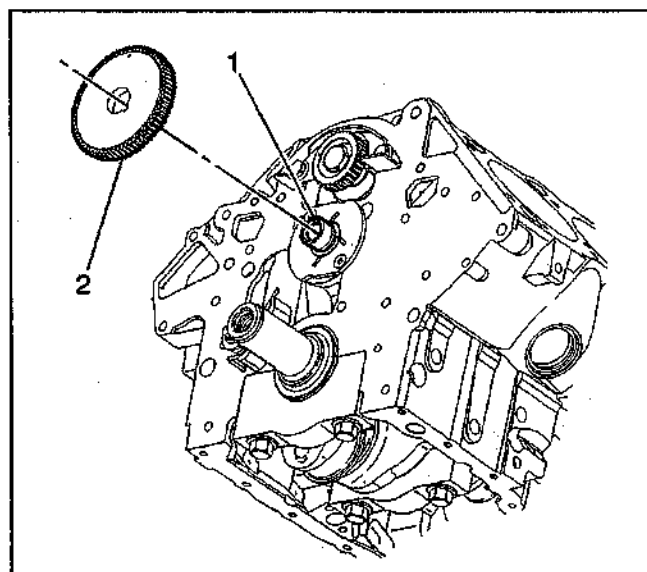
1. Coat the camshaft with prelube GM P/N 12345501 or equivalent before installation.
2. Install the camshaft.
3. Install the camshaft key.
4. Install the camshaft thrust plate.

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

5. Install the camshaft thrust plate bolts.

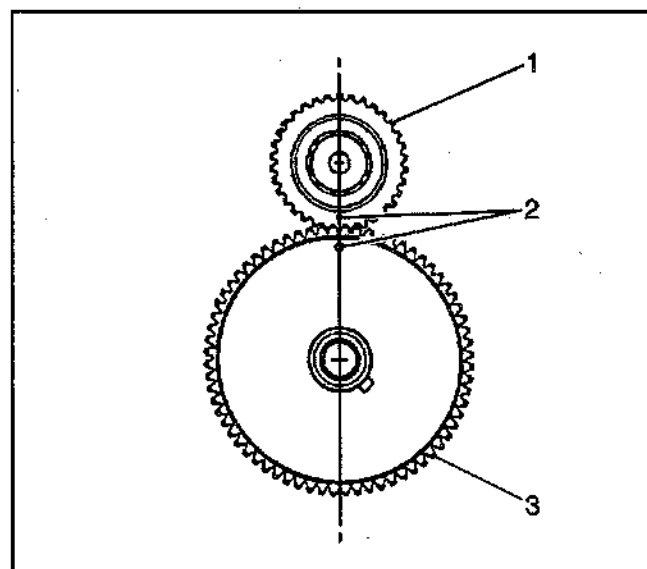
Tighten

Tighten the camshaft thrust plate bolts to 15 N·m (11 lb ft).



441129

6. Install the balance shaft drive gear (2) to the camshaft (1).

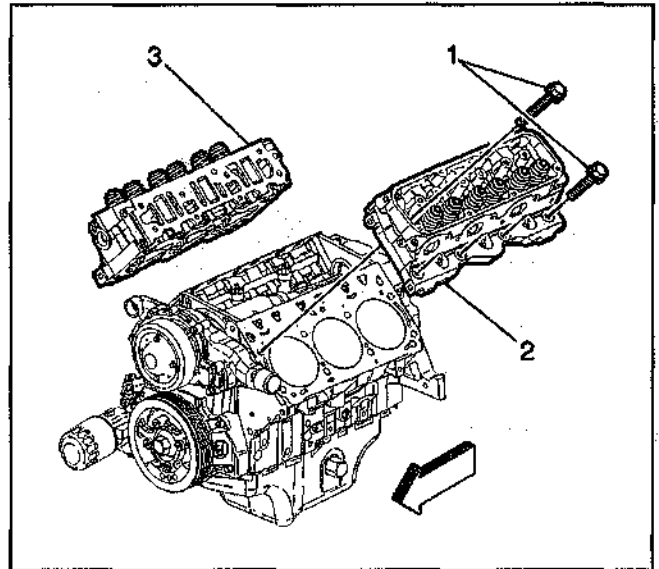


441151

7. Align the timing marks (2) on the balance shaft gear (1) and the balance shaft drive gear (3).
8. Install the timing chain and sprockets. Refer to *Timing Chain and Sprockets Replacement*.
9. Install the valve lifters. Refer to *Valve Lifter Replacement*.
10. Install the radiator with the A/C condenser. Refer to *Radiator Replacement* in Engine Cooling.
11. Charge the A/C system. Refer to *Refrigerant Recovery and Recharging* in Heating, Ventilation and Air Conditioning.

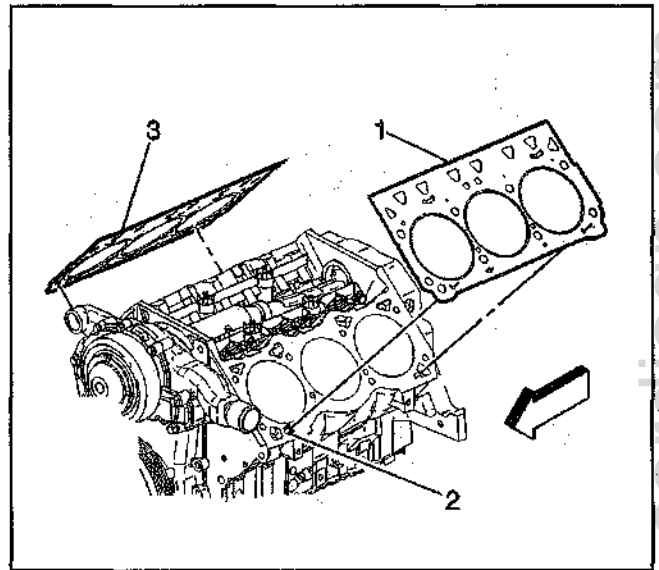
Cylinder Head Replacement (Left)**Removal Procedure**

1. Drain the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.
2. Remove the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
3. Remove the right exhaust manifold. Refer to *Exhaust Manifold Replacement (Left)* in Engine Exhaust.
4. Remove the valve rocker arms and pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
5. Remove the cylinder head bolts (1).
6. Remove the left cylinder head (2).



441261

7. Remove the left cylinder head gasket (1).
8. Disassemble the cylinder head. Refer to *Cylinder Head Disassemble*.



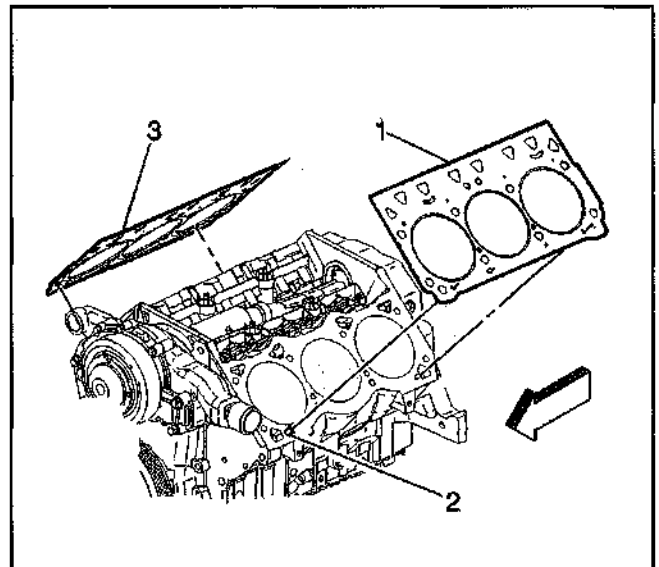
441262

Installation Procedure**Tools Required**

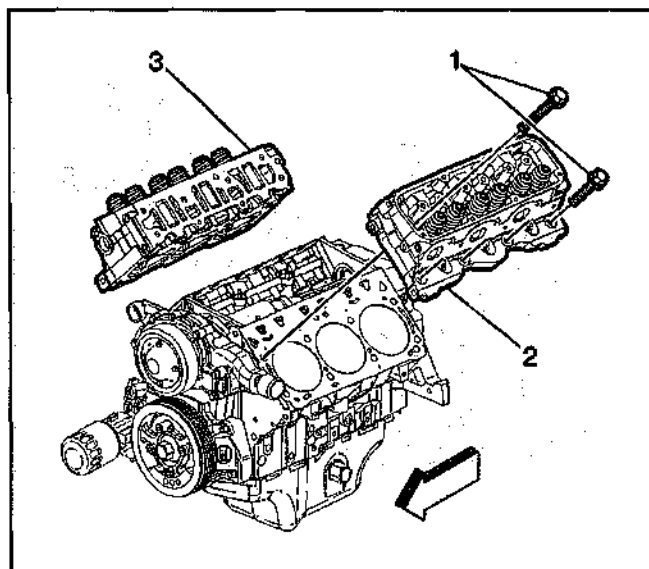
J 36660-A Torque Angle Meter

Important: The arrow on the gasket must point to the front of the engine. Failure to install the gasket properly will cause gasket failure and possible engine failure.

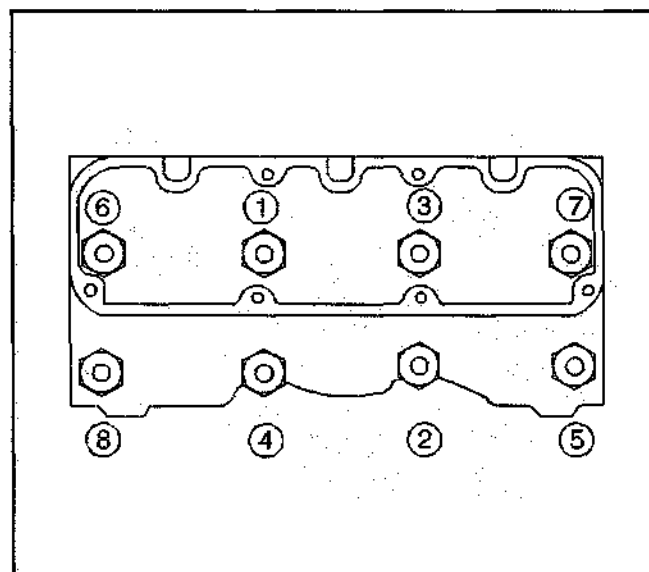
1. Assemble the cylinder head. Refer to *Cylinder Head Assemble*.
2. Install a new left cylinder head gasket (1) to the alignment pins (2).



441262



441261



38826

3. Install the left cylinder head (2).

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

4. Torque the cylinder head bolts following the given sequence.
5. Install the cylinder head bolts.

Tighten

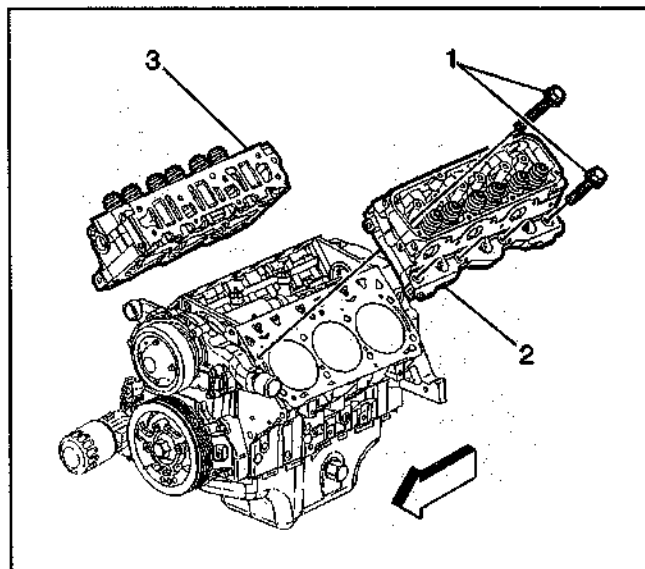
Tighten the cylinder head bolts to 50 N·m (37 lb ft) in sequence shown. Use the J 36660-A to torque the cylinder head bolts an additional 120 degrees.

6. Install the valve rocker arms and pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
7. Install the left exhaust manifold. Refer to *Exhaust Manifold Replacement (Left)* in Engine Exhaust.
8. Install the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
9. Refill the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.
10. Change the engine oil and filter. Refer to *Engine Oil and Oil Filter Replacement*.

Cylinder Head Replacement (Right)

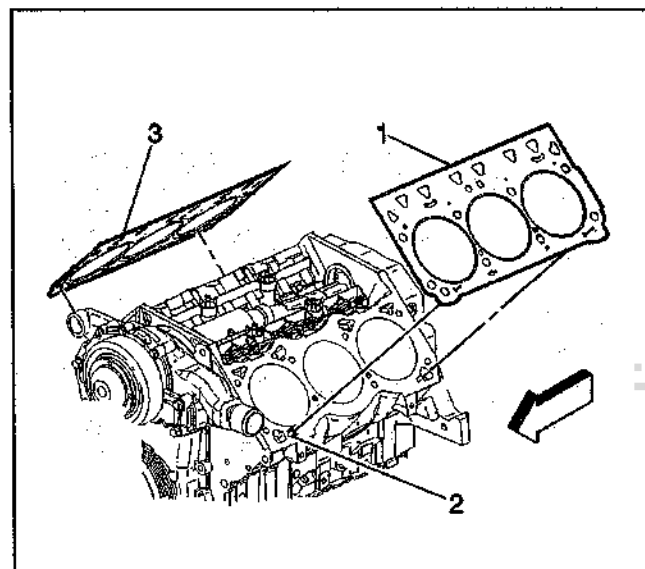
Removal Procedure

1. Drain the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.
2. Remove the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
3. Remove the right exhaust manifold. Refer to *Exhaust Manifold Replacement (Right)*.
4. Remove the valve rocker arms and the pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
5. Remove the cylinder head bolts (1).
6. Remove the right cylinder head (3).



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7. Remove the right cylinder head gasket (3).
8. Disassemble the cylinder head. Refer to *Cylinder Head Disassembly*.



441262

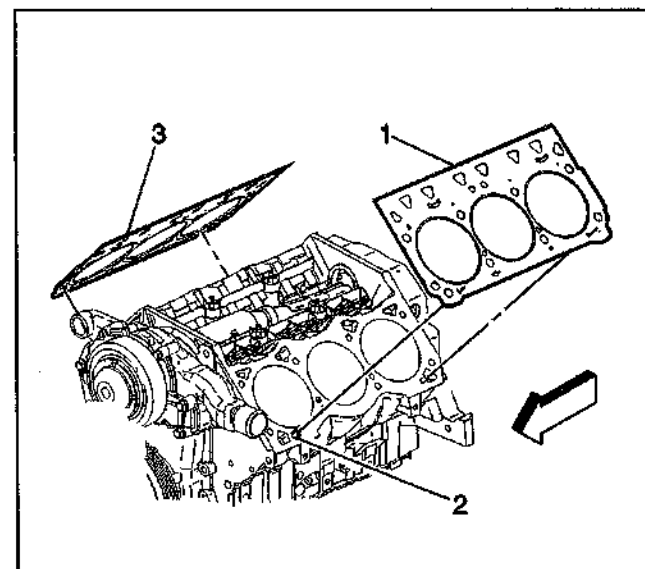
Installation Procedure

Tools Required

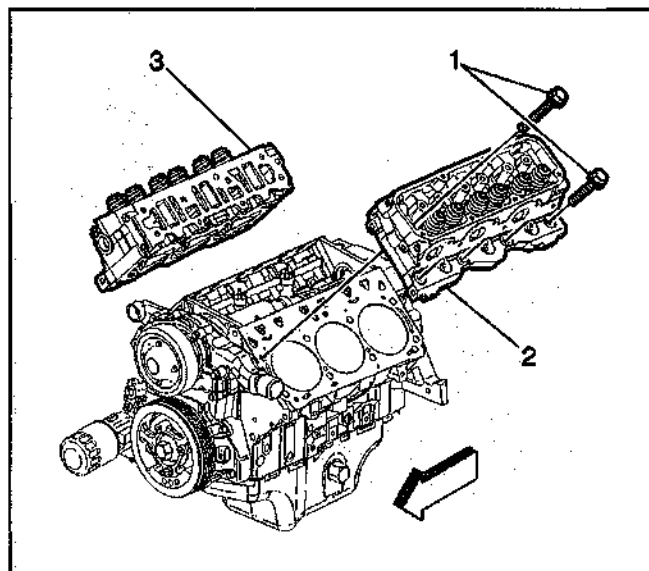
J 36660-A Torque Angle Meter

Important: The arrow on the gasket must point to the front of the engine. Failure to install the gasket properly will cause gasket failure and possible engine damage.

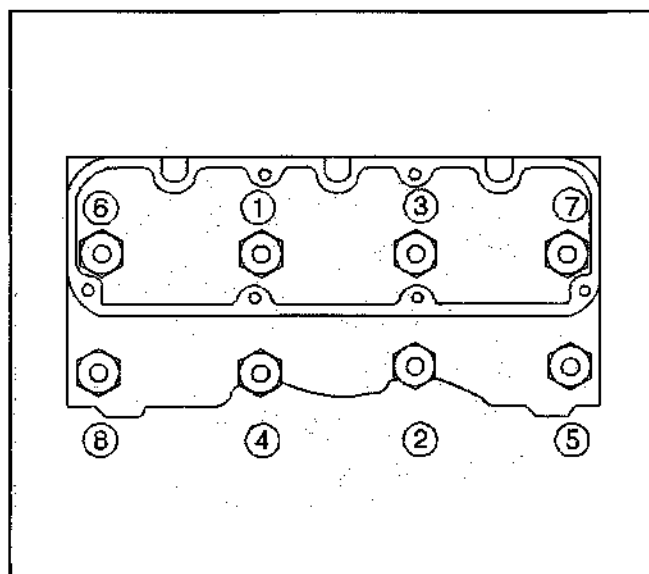
1. Install the new right cylinder head gasket (3) to the alignment pins (2).



441262



441261



38826

2. Install the right cylinder head (3).

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

3. Tighten the cylinder head bolts following the given sequence.

Tighten

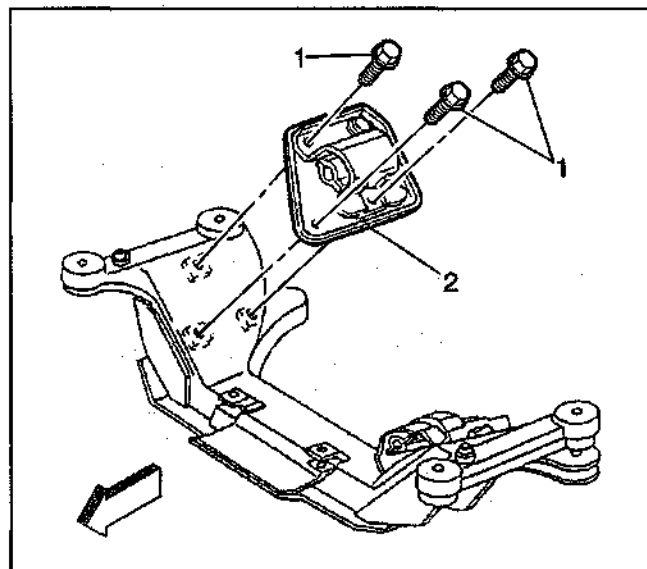
Tighten the cylinder head bolts to 50 N·m (37 lb ft) in sequence shown. Use the *J 36660-A* to torque the cylinder head bolts an additional 120 degrees.

4. Install the pushrods and the valve rocker arms. Refer to *Valve Rocker Arm and Push Rod Replacement*.
5. Install the right exhaust manifold. Refer to *Exhaust Manifold Replacement (Right)* in Engine Exhaust.
6. Install the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
7. Refill the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.
8. Change the engine oil and filter. Refer to *Engine Oil and Oil Filter Replacement*.

Oil Pan Replacement

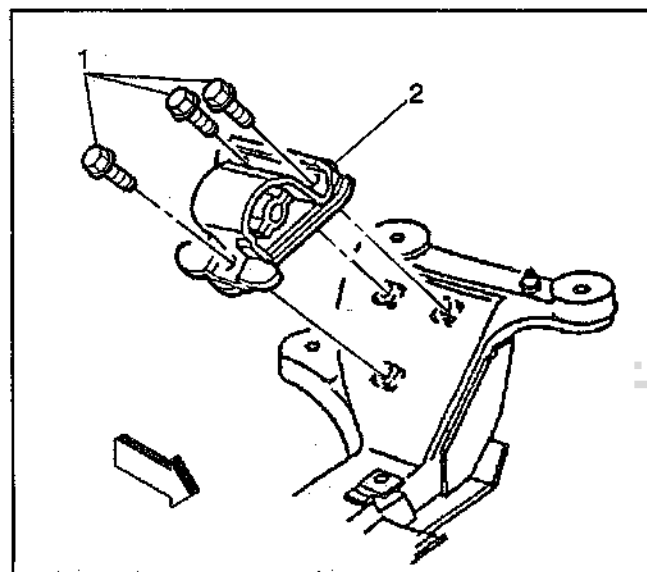
Removal Procedure

1. Install the engine support fixture to the engine. Refer to *Engine Support Fixture*.
2. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Drain the engine oil.
4. Remove the right side engine mount (2) to cradle bolts (1).



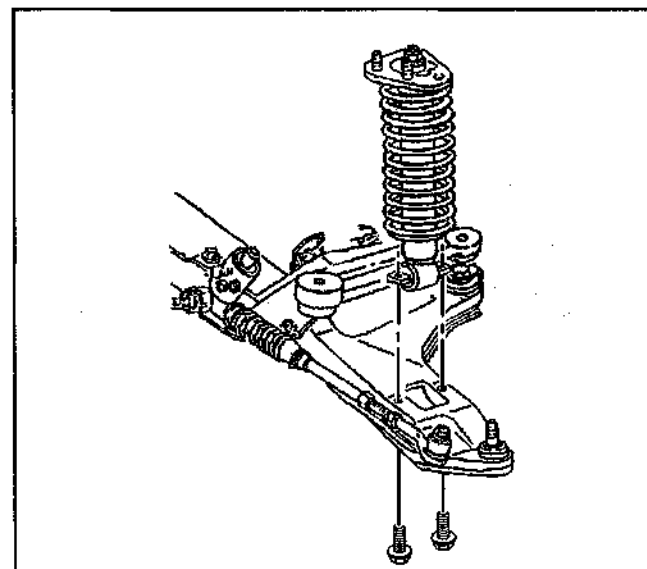
49837

5. Remove the left side engine mount (2) to cradle bolts (1).

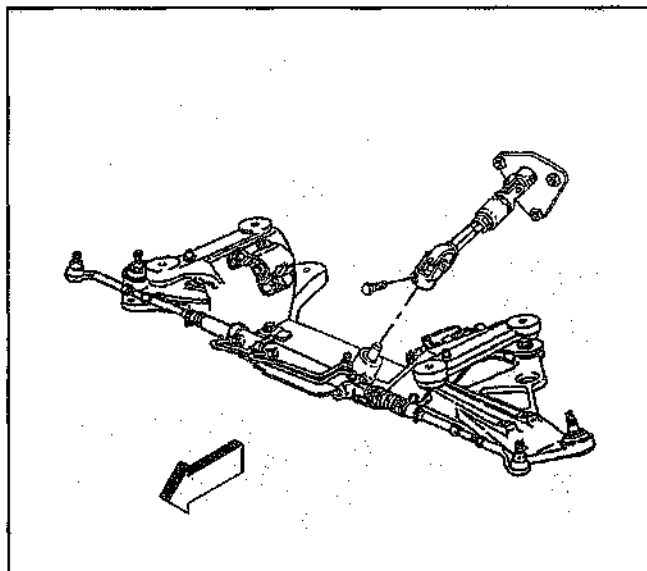


50525

6. Remove the right and left side shock absorber lower mounting bolts.

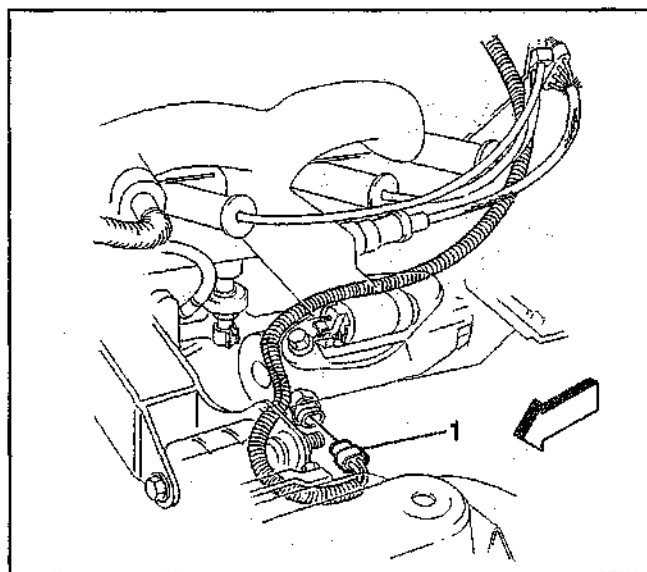


220629



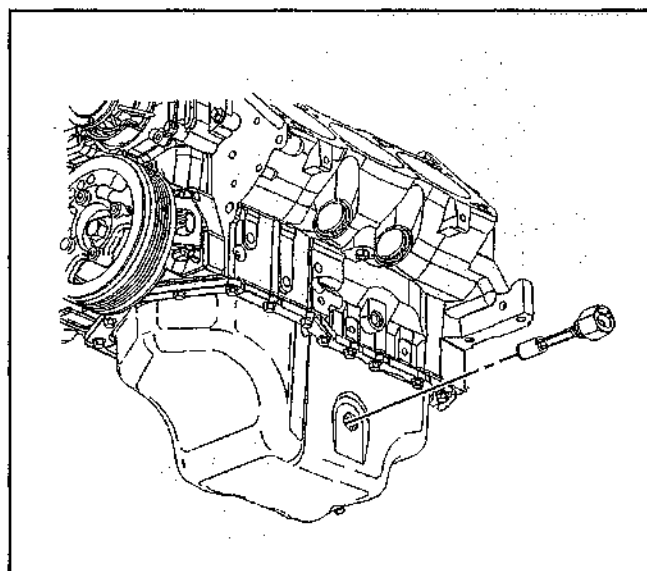
220630

7. Remove the intermediate steering shaft bolt from the rack and pinion.
8. Support the engine cradle with appropriate equipment.



440680

9. Disconnect the oil level sensor electrical connector (1).

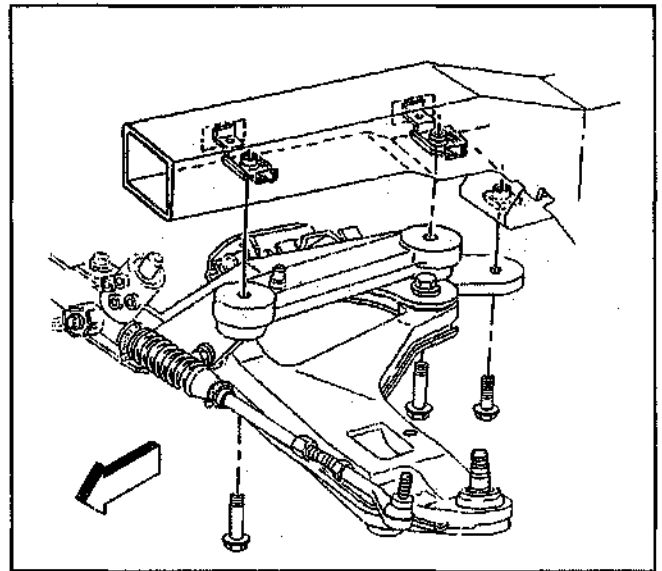


441263

Notice: Remove the oil level sensor, located in the oil pan, before the oil pan is removed. The sensor may be damaged if the oil pan is removed first.

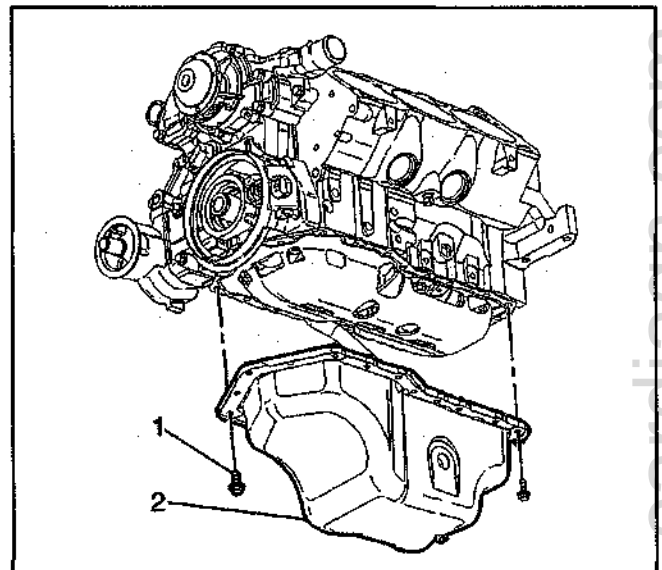
10. Remove the oil level sensor from the oil pan.
11. Remove the starter motor. Refer to *Starter Motor Replacement (3.8 L)* in Engine Electrical.

12. Remove the front crossmember bolts.



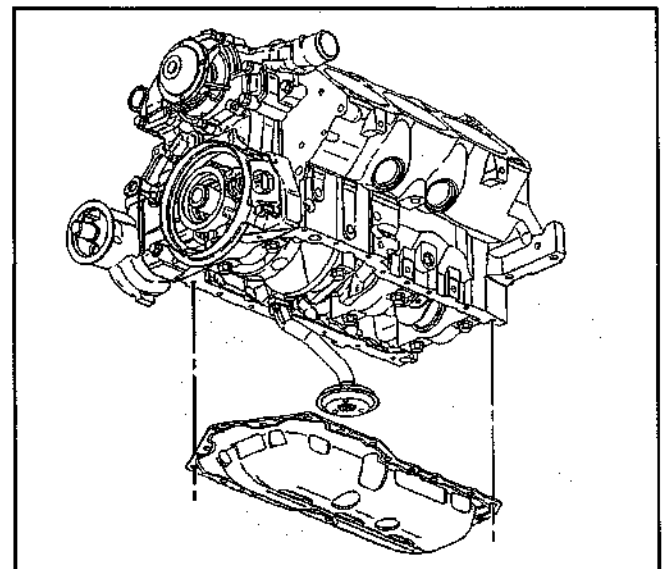
220632

13. Remove the oil pan bolts (1).
14. Remove the oil pan (2).
- Lower the rear of the oil pan while rotating the pan outward.

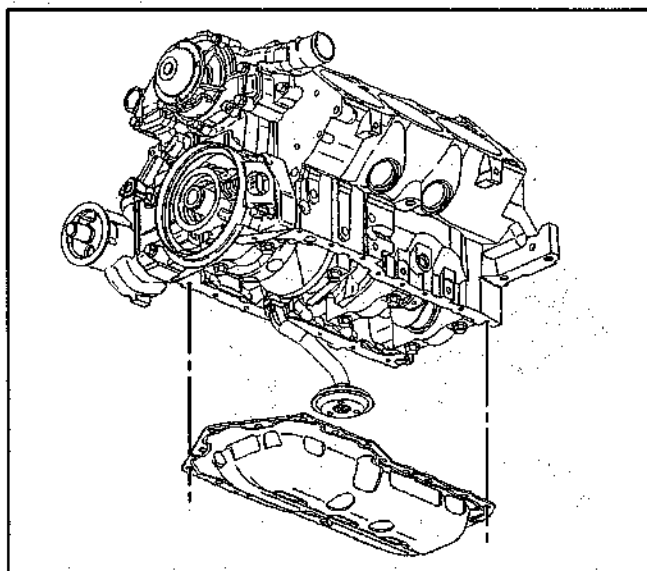


441269

15. Remove the oil pan gasket.
16. Clean the oil pan gasket mating surface.



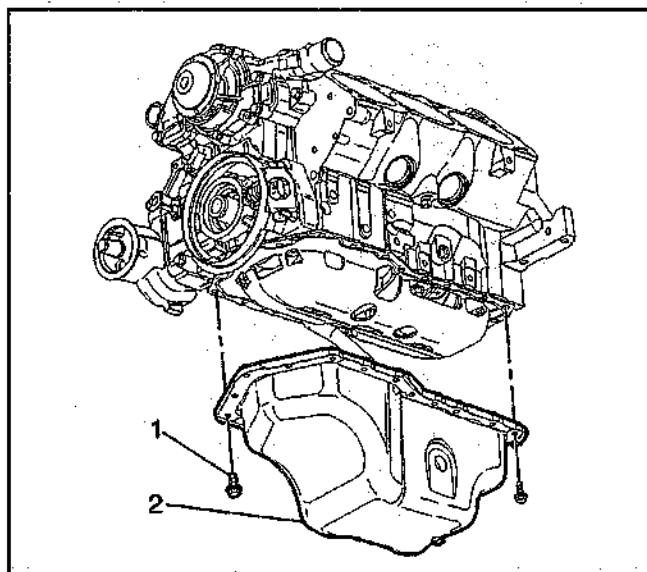
441265



441265

Installation Procedure

1. Install the oil pan gasket.



441269

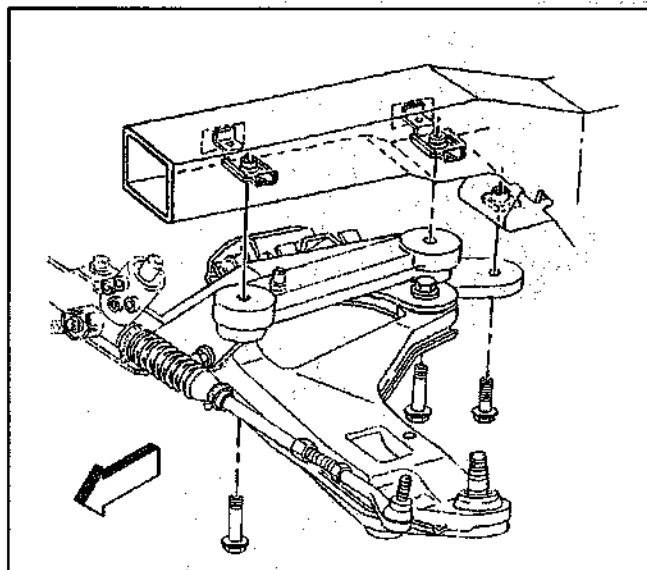
2. Install the oil pan (2).

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

3. Install the oil pan bolts (1).

Tighten

Tighten the oil pan bolts to 14 N·m (10 lb ft).



220632

4. Install the front crossmember bolts.

Tighten

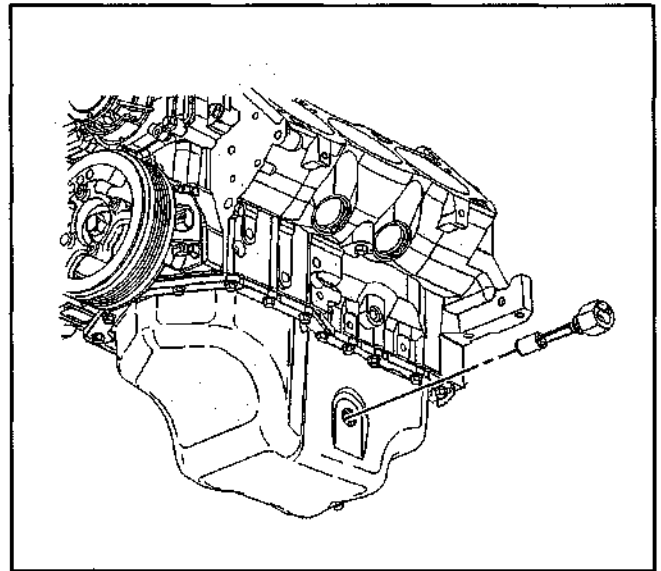
- Tighten the upper four crossmember bolts to 125 N·m (92 lb ft).
- Tighten the lower two crossmember bolts to 145 N·m (107 lb ft).

5. Install the starter motor. Refer to *Starter Motor Replacement (3.8 L)* in Engine Electrical.

6. Install the oil level sensor to the oil pan.

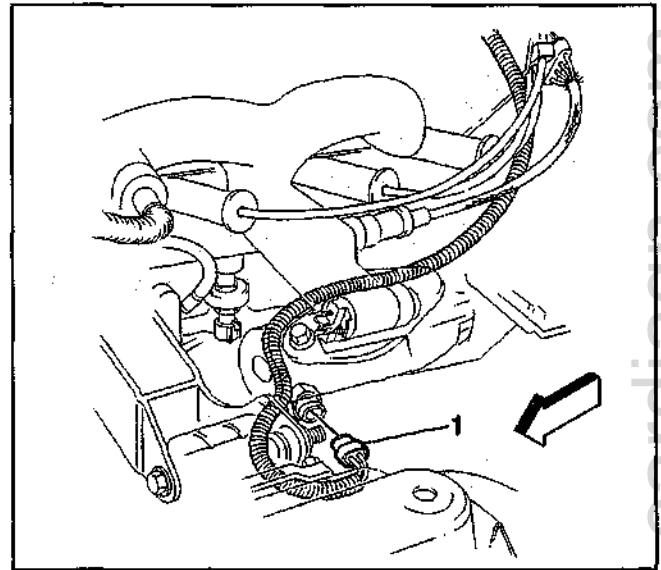
Tighten

Tighten the oil level sensor to 20 N·m (15 lb ft).



441263

7. Connect the oil level sensor electrical connector (1).
8. Remove the equipment used to support the engine cradle.

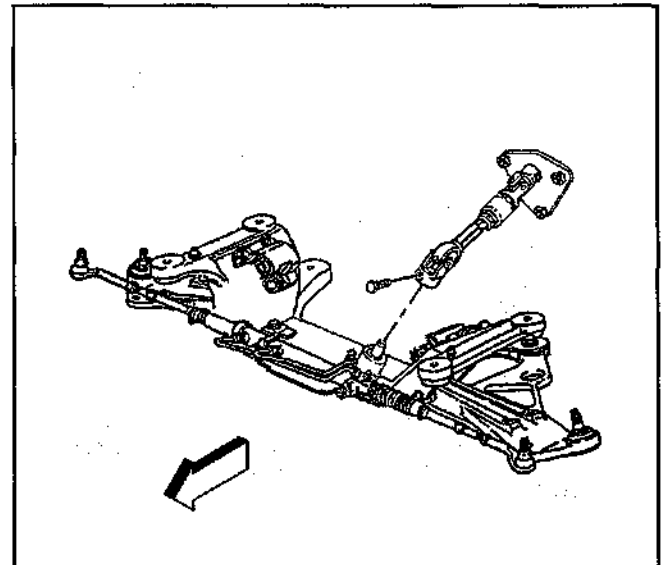


440880

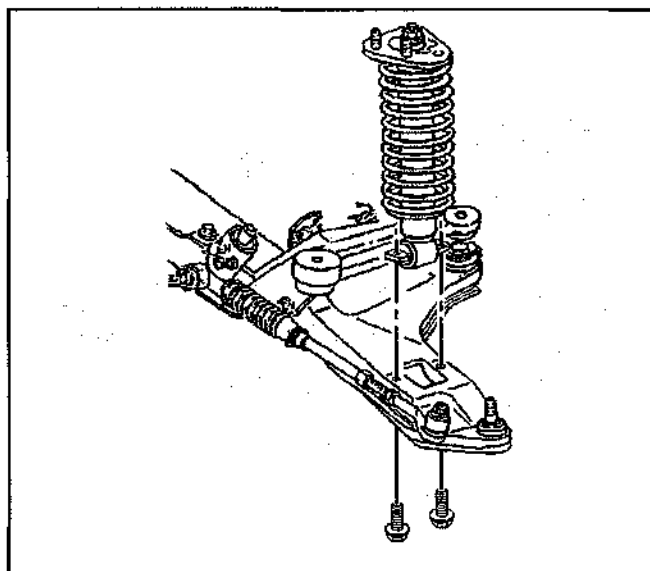
9. Install the intermediate steering shaft from the rack and pinion.

Tighten

Tighten the intermediate shaft bolt to 47 N·m (35 lb ft).



220630

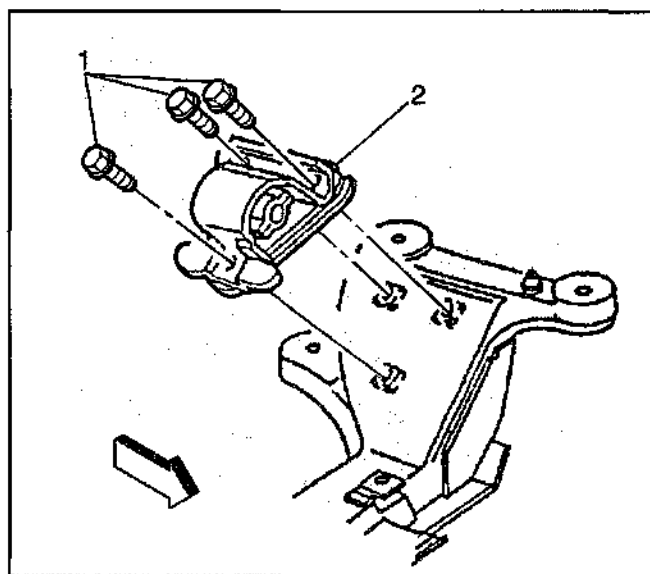


220629

10. Install the right and left side shock absorber lower mounting bolts.

Tighten

Tighten the shock bolts to 65 N·m (48 lb ft).

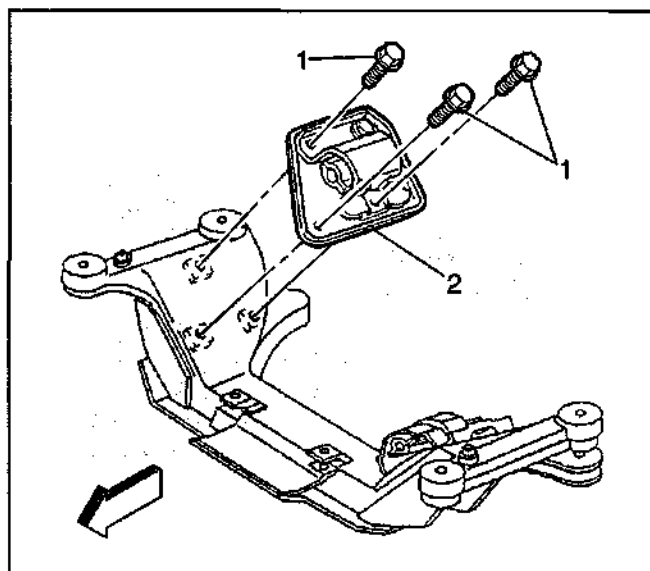


50525

11. Install the left side engine mount (2) to cradle bolts (1).

Tighten

Tighten the left side engine mount to cradle bolts (1) to 58 N·m (43 lb ft).



49837

12. Install the right side engine mount (2) to cradle bolts (1).

Tighten

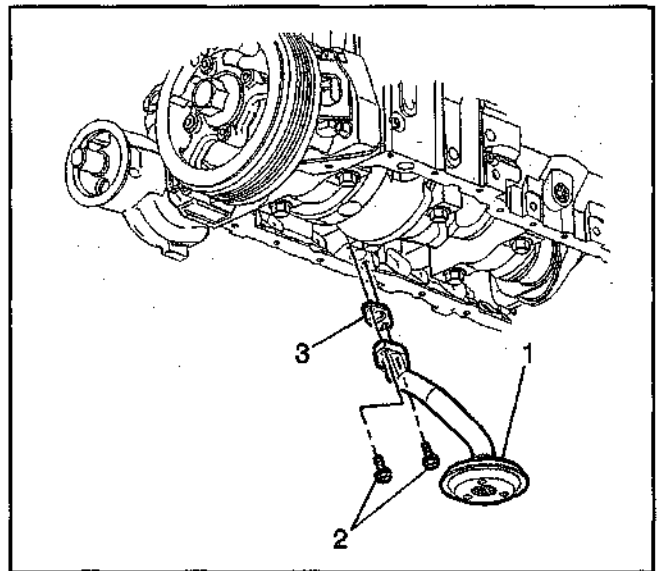
Tighten the right side engine mount to cradle bolts (1) to 58 N·m (43 lb ft).

13. Lower the vehicle.
14. Remove the engine support fixture.
15. Change the engine oil and filter. Refer to *Engine Oil and Oil Filter Replacement*.

Oil Pump Pipe and Screen Assembly Replacement

Removal Procedure

1. Remove the oil pan. Refer to *Oil Pan Replacement*.
2. Remove the oil pump screen attaching bolts (2).
3. Remove the oil pump screen (1).
4. Remove the oil pump screen gasket (3).
5. Clean the screen and housing with solvent and blow dry with compressed air.
6. Clean the gasket mating surfaces on the pipe flange and cylinder block.



441270

Installation Procedure

1. Install the oil pump screen gasket (3).
2. Install the oil pump screen (1).

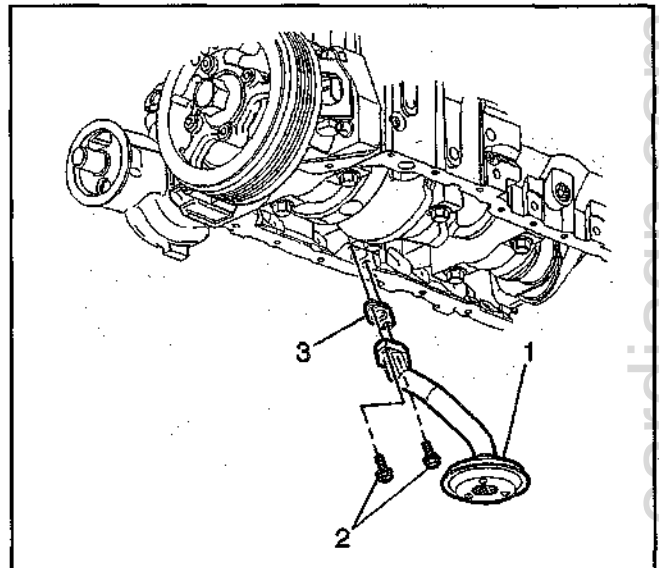
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the oil pump screen bolts (2).

Tighten

Tighten the oil pump screen bolts (2) to 15 N·m (11 lb ft).

4. Install the oil pan. Refer to *Oil Pan Replacement*.



441270

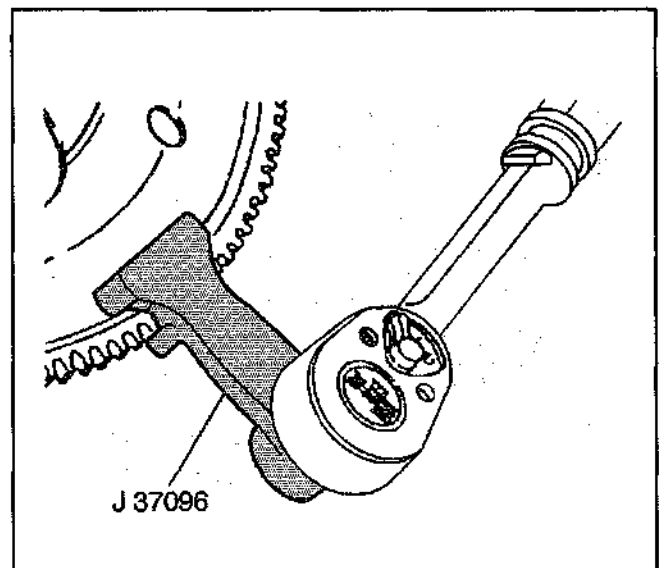
Engine Flywheel Replacement

Removal Procedure

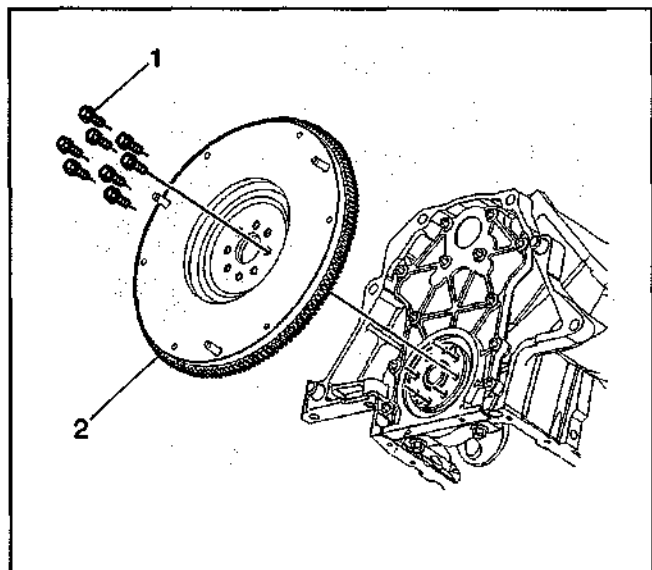
Tools Required

J 37096 Flywheel Holding Tool

1. If equipped with a manual transmission remove the clutch pressure plate and driven disc. Refer to *Clutch Pressure Plate and Clutch Driven Plate (3.8 L)* in Clutch.
2. Remove the automatic transmission, if equipped. Refer to *Transmission Replacement (3.8 L)* in automatic Transmission - 4L60-E.
3. Use the J 37096 to hold the flywheel to loosen the flywheel bolts.



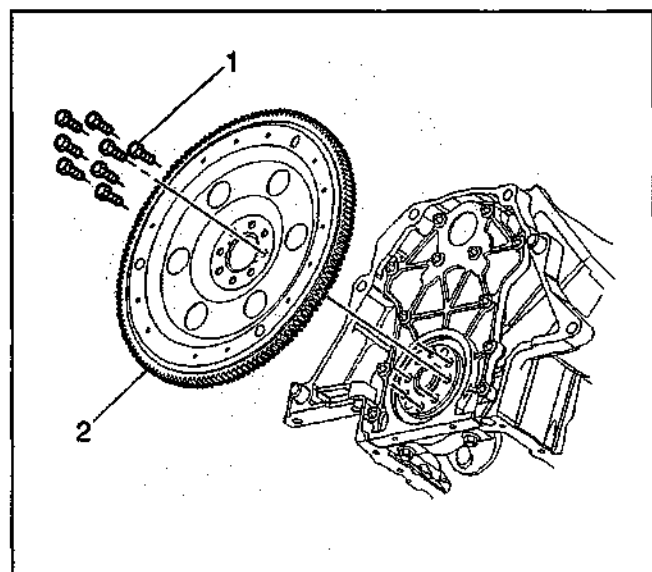
309963



441112

4. If equipped with the manual transmission, remove the following components:

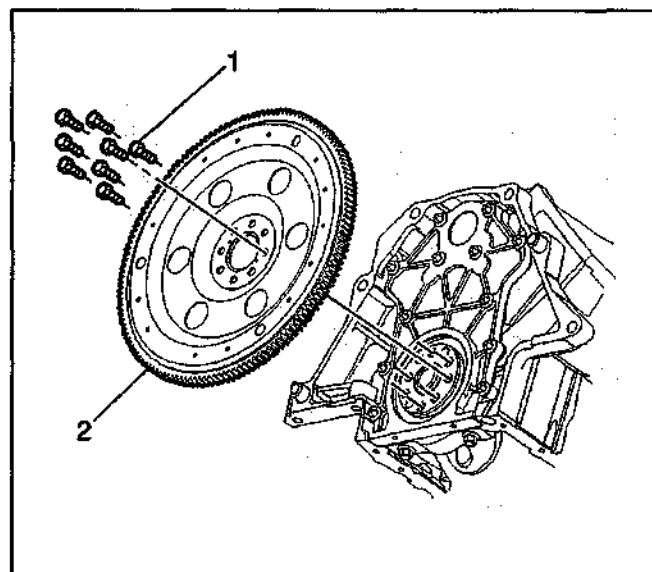
- 4.1. Remove the flywheel bolts (1).
- 4.2. Remove the flywheel (2).



441271

5. If equipped with the automatic transmission, remove the following components:

- 5.1. Remove the flywheel bolts (1).
- 5.2. Remove the flywheel (2).



441271

Installation Procedure

Tools Required

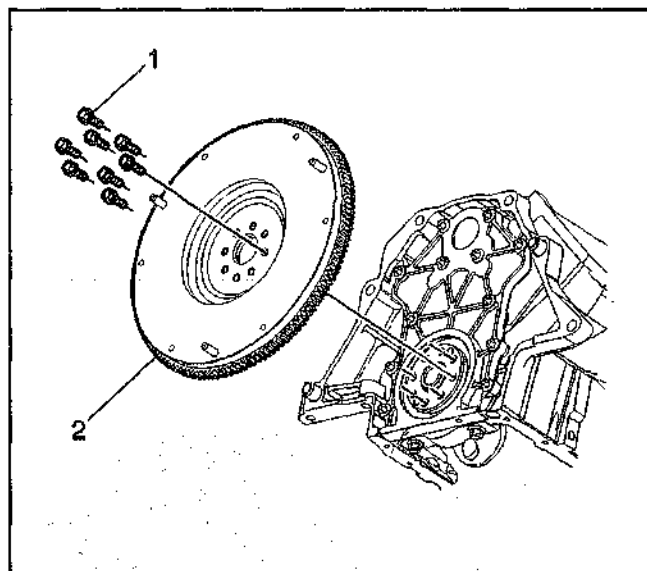
- J 36660-A Torque Angle Meter
- J 37096 Flywheel Holding Tool

1. If equipped with the automatic transmission, install the following components:

- 1.1. Install the flywheel (2).
- 1.2. Install the flywheel bolts (1) finger tight.

2. If equipped with the manual transmission, install the following components:

- 2.1. Install the flywheel (2).
- 2.2. Install the flywheel bolts (1) finger tight.



441112

3. Use the J 37096 to hold the flywheel when tightening the flywheel bolts.

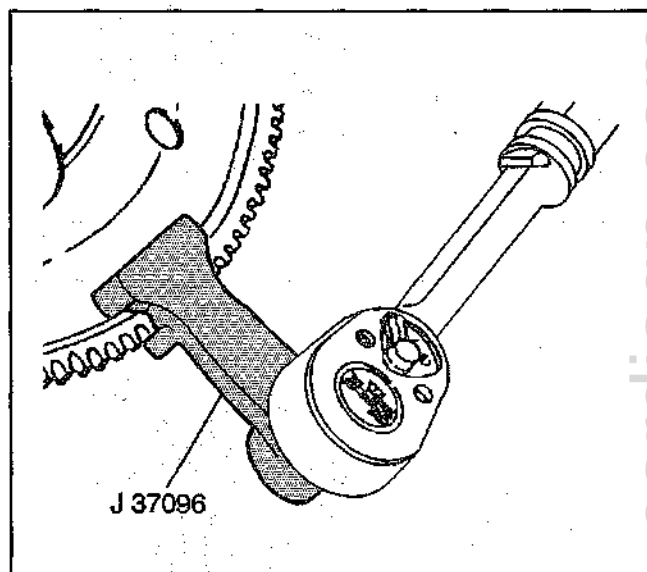
Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Tighten the flywheel bolts.

Tighten

Tighten the flywheel bolts to 15 N·m (11 lb ft). Use the J 36660-A to torque the flywheel bolts an additional 50 degrees.

5. Install the automatic transmission, if equipped. Refer to *Transmission Replacement* (3.8 L) in automatic Transmission - 4L60-E.
6. If equipped with a manual transmission install the clutch pressure plate and driven disc. Refer to *Clutch Pressure Plate and Clutch Driven Plate* (3.8 L) in Clutch.



309963

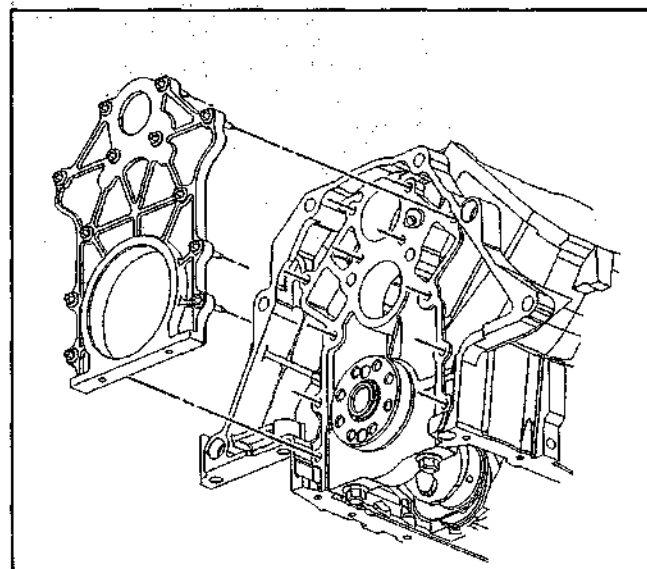
Crankshaft Rear Oil Seal and Housing Replacement

Removal Procedure

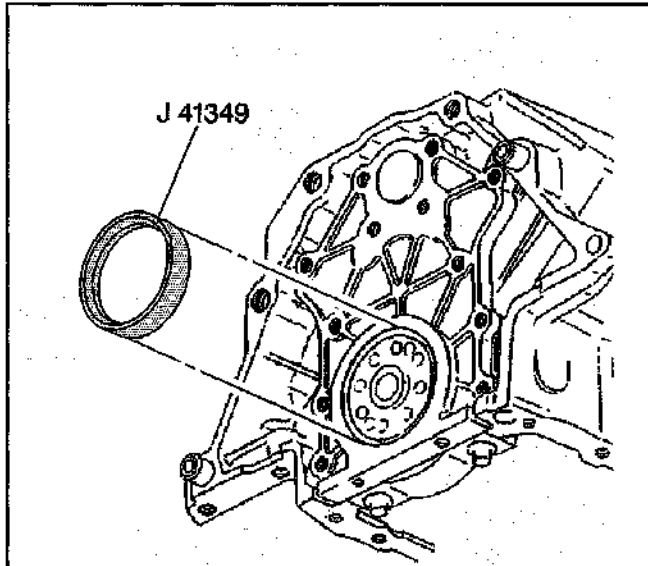
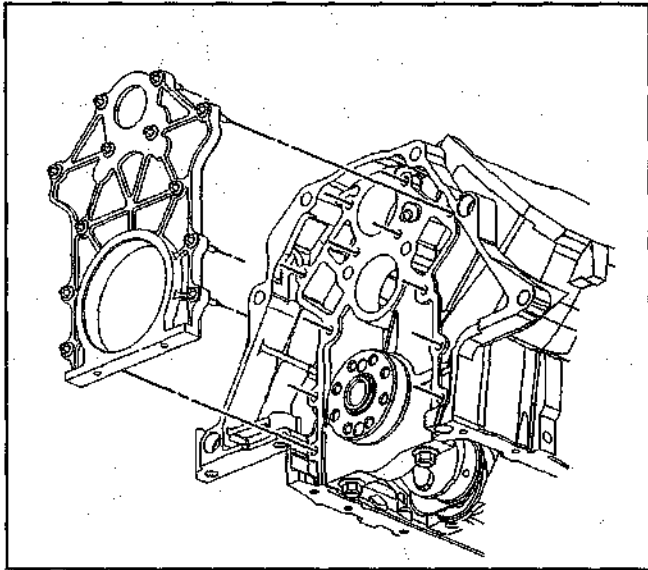
1. Drain the engine coolant from the cooling system. Refer to *Draining and Filling Cooling System* (3.8 L) in Engine Cooling.
2. Remove the engine flywheel. Refer to *Engine Flywheel Replacement*.
3. Loosen all of the oil pan bolts.
4. Remove the crankshaft rear oil seal housing bolts.
5. Remove the crankshaft rear oil seal housing.
6. Remove the rear oil seal housing gasket.

Important: Make sure not to damage the crankshaft OD surface with any tool.

7. Remove the oil seal from the housing.



153604



8. Clean the gasket surfaces of the oil seal housing and the engine block.
9. Inspect the ID of the oil seal housing bore. Replace the crankshaft rear oil seal housing as required.
10. Inspect the crankshaft for nicks or burrs on the surface that contacts the seal.
11. Repair or replace the crankshaft as required.

Installation Procedure

Tools Required

- J 36660-A Torque Angle Meter
- J 41349 Crankshaft Rear Oil Seal Housing Aligning Tool

Notice: Do not use sealers or adhesives on rear main oil seal housing gasket. Use of sealers or adhesives on this gasket may cause oil leaks.

1. Install the crankshaft rear oil seal housing gasket over the bolts for alignment.

Important: The plastic inserts in the crankshaft rear oil seal housing are used to aid assembly only. The inserts are not required for service.

2. Finger tighten the crankshaft rear oil seal housing bolts.

3. Apply engine oil to both sides of the J 41349.

Notice: Sealability of the rear main oil seal depends on the correct alignment of the rear main oil seal housing and the oil pan. Incorrect alignment may cause oil leaks.

4. Install the J 41349 over the crankshaft. Twist the tool to aid in sliding the tool over the crankshaft.
5. Raise the oil pan and finger tighten the oil pan bolts.

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

6. Tighten the crankshaft rear oil seal housing bolts.

Tighten

Tighten the crankshaft rear oil seal housing bolts to 15 N·m (11 lb ft). Use the J 36660-A to torque the crankshaft rear oil seal housing bolt an additional 50 degrees.

7. Remove the J 41349.
8. Tighten the oil pan bolts.

Tighten

Tighten the oil pan bolts to 14 N·m (10 lb ft).

9. Remove the engine flywheel. Refer to *Engine Flywheel Replacement*.
10. Refill the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.

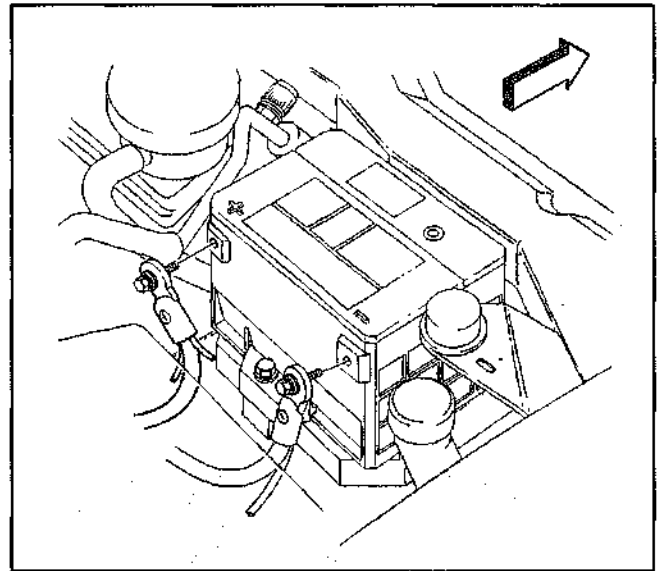
Engine Replacement

Removal Procedure

Tools Required

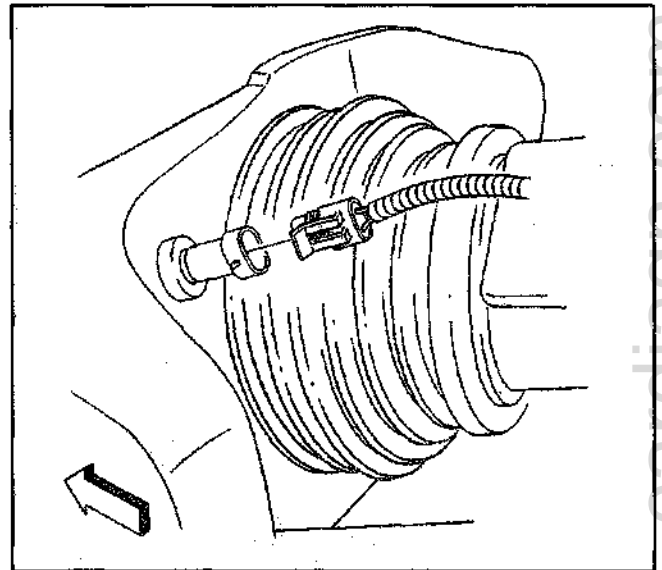
- J 37088-A Fuel Line Disconnect Tool Set
- J 39549 Ball Joint/Tie Rod Separator
- J 39580 Universal Engine Support Table
- J 21366 Converter Holding Strap

1. Remove the starter motor. Refer to *Starter Motor Replacement (3.8 L)* in Engine Electrical.
2. Disconnect the positive battery cable.



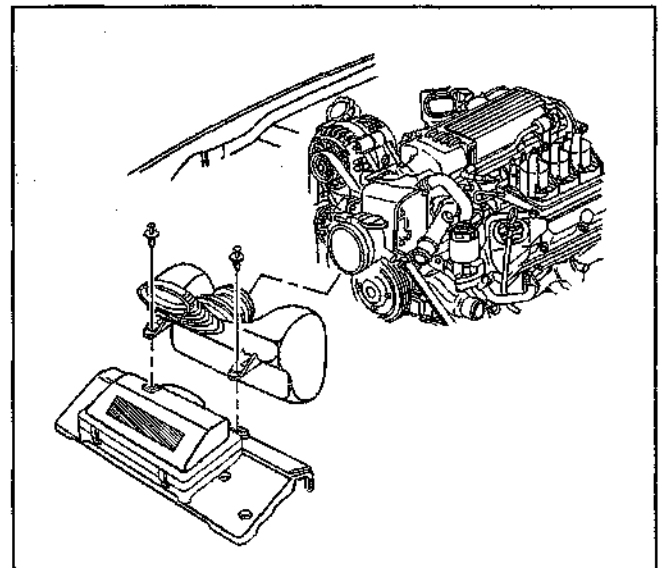
211587

3. Disconnect the intake air temperature (IAT) sensor electrical connector.

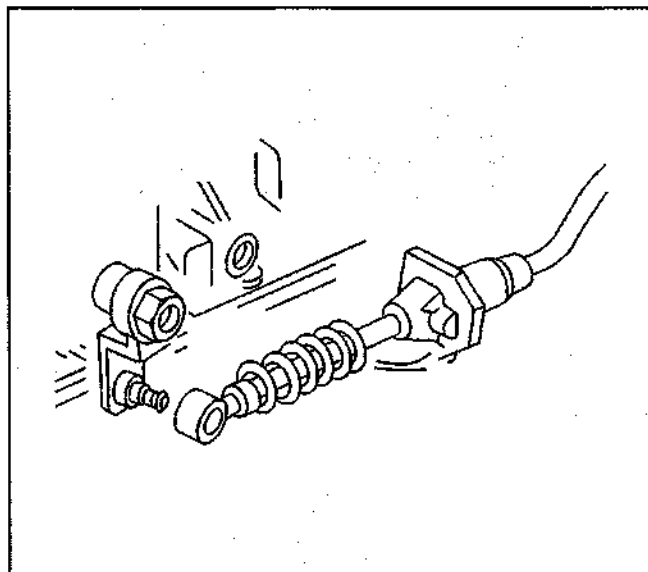


208554

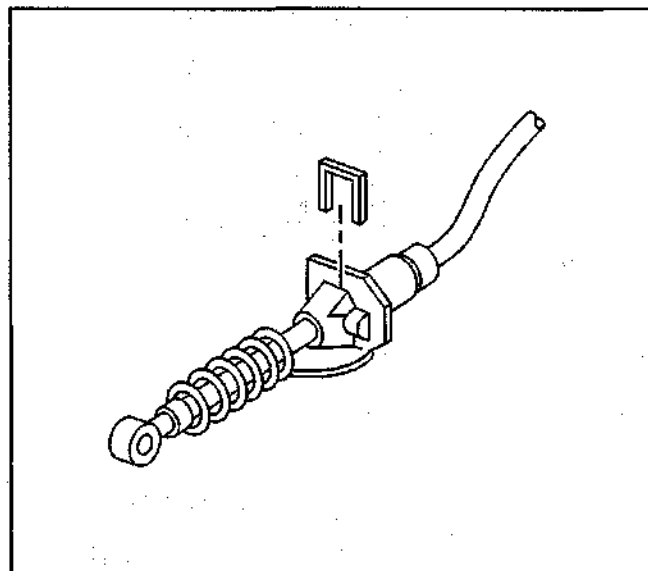
4. Remove the air intake duct.
5. Recover the refrigerant. Refer to *Refrigerant Recovery and Recharging* in Heating, Ventilation and Air Conditioning.
6. Relieve the fuel pressure. Refer to *Fuel Pressure Relief Procedure* in Engine Controls - 3.8 L.
7. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
8. Drain the engine oil.
9. Remove the front wheels. Refer to *Tire and Wheel Removal and Installation* in Tires and Wheels.
10. Drain the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.
11. Remove the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.



554755



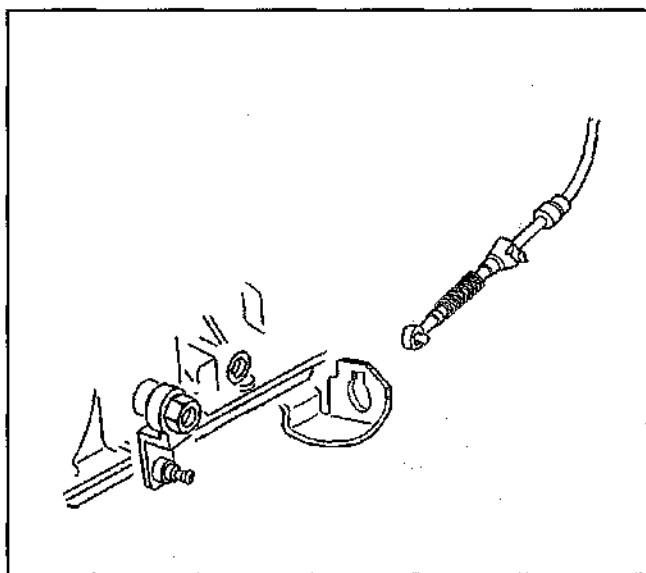
209264



341079

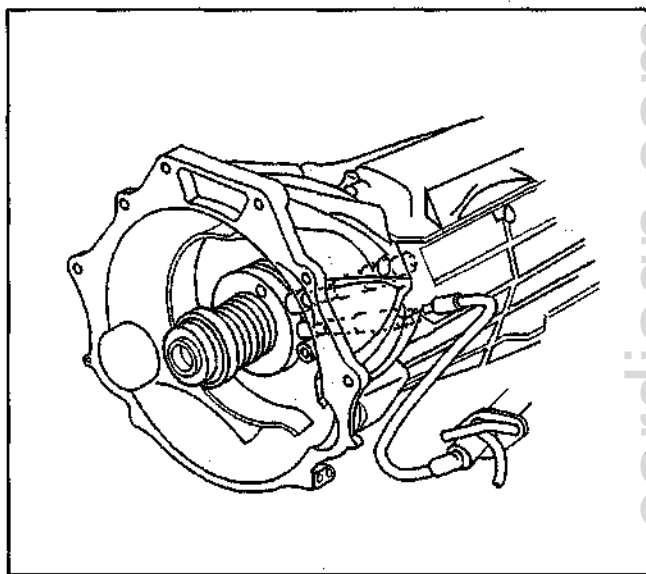
12. Drain the transmission fluid, if equipped with a manual transmission.
13. Remove the propeller shaft. Refer to *Propeller Shaft Replacement - One Piece* or *Propeller Shaft Replacement - Two Piece* in Propeller Shaft.
14. Remove the torque arm. Refer to *Torque Arm Replacement* in Rear Suspension.
15. On vehicles equipped with a automatic transmission, unsnap the transmission range selector lever cable from the range selector lever at the transmission.
16. Remove the retainer from the range selector lever cable.

17. Remove the range selector lever cable from the cable bracket.



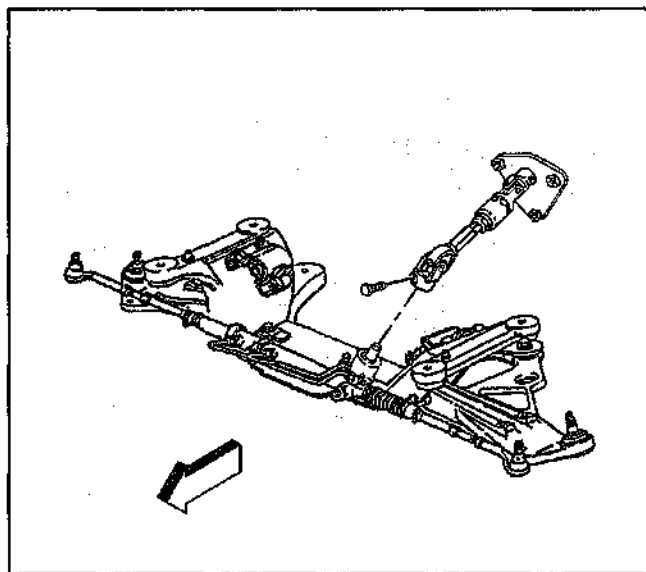
208276

18. On vehicles equipped with a manual transmission, disconnect the clutch actuator cylinder line from the actuator cylinder using J 36221.
19. Remove the left side front air deflector. Refer to *Air Deflector Replacement - Front Bumper Fascia* in Bumpers.
20. Remove the stabilizer bar bracket bolts.
21. Remove the stabilizer bar brackets.

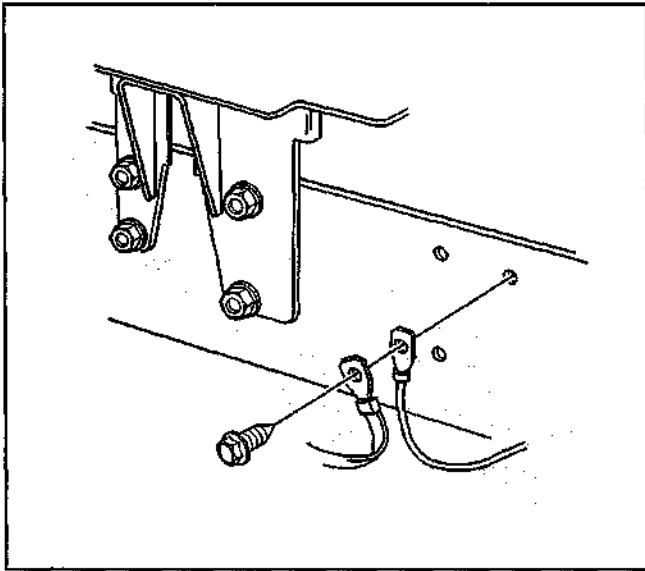


43255

22. Remove the steering gear coupling shield.
23. Remove the intermediate steering shaft bolt and shaft from the rack.

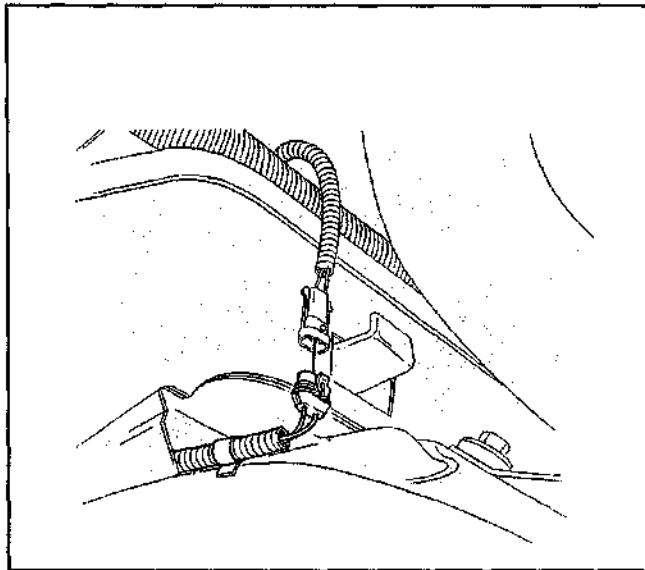


220630



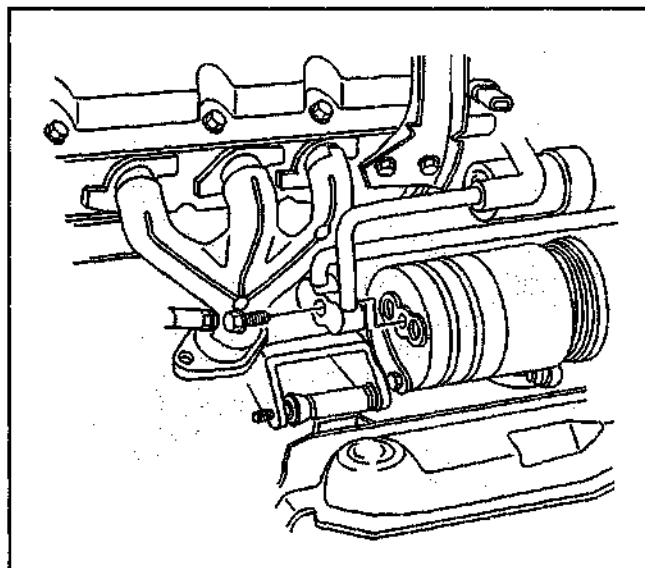
346034

24. Remove the wiring harness ground bolt and RF (Radio Frequency) ground strap and cruise control ground lead from the front rail.
25. Disconnect the knock sensor electrical connectors.



346036

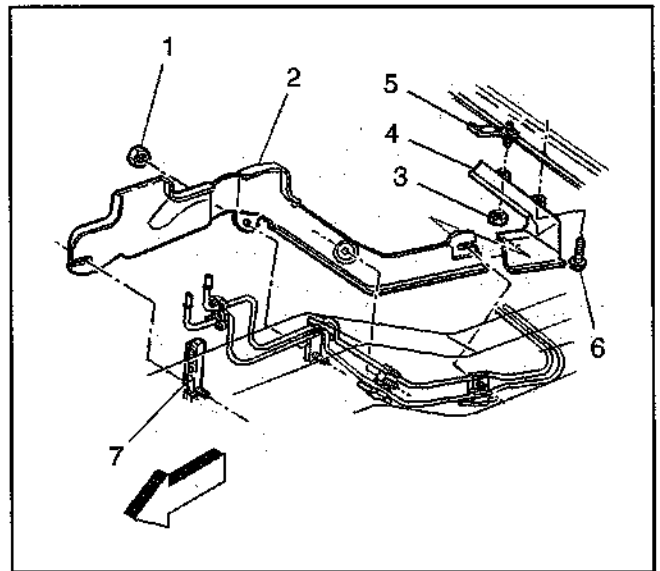
26. Disconnect the wheel speed sensors electrical connectors.



569444

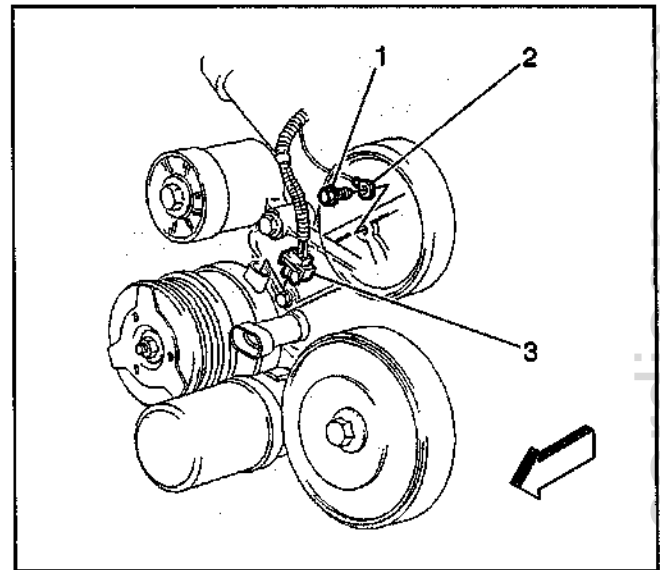
27. Remove the air conditioning (A/C) compressor and condenser hose nut at the condenser.
28. Discard the O-ring.

29. Remove the front fuel pipe heat shield nuts (1).
30. Remove the front fuel pipe heat shield (2).
31. Disconnect the brake lines from the brake pipe clip.
32. Lower the vehicle.



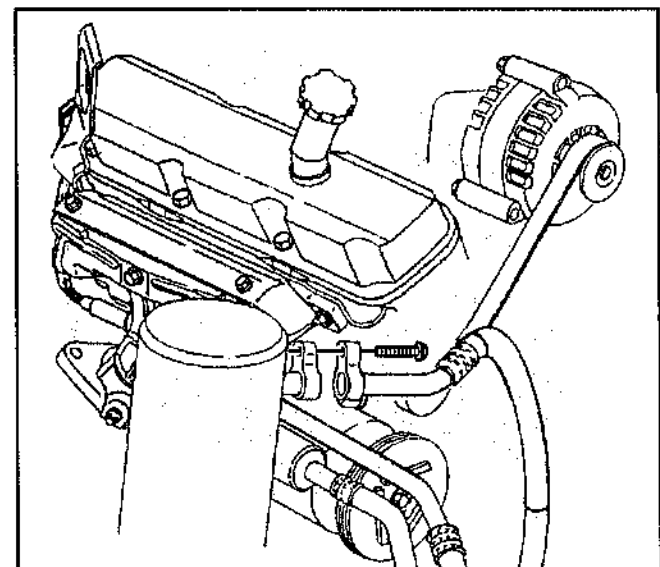
173551

33. Remove the engine wiring harness ground bolt (1).
34. Remove the engine ground.

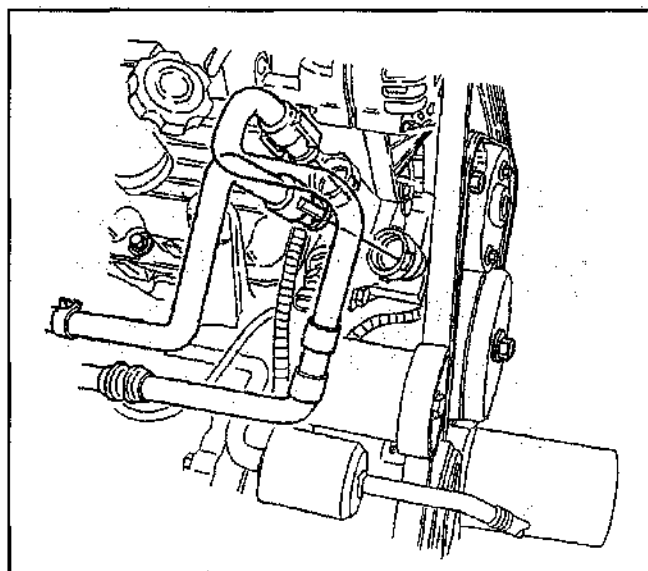


445688

35. Remove the A/C compressor and condenser hose bolt at the accumulator.
36. Discard the O-ring.

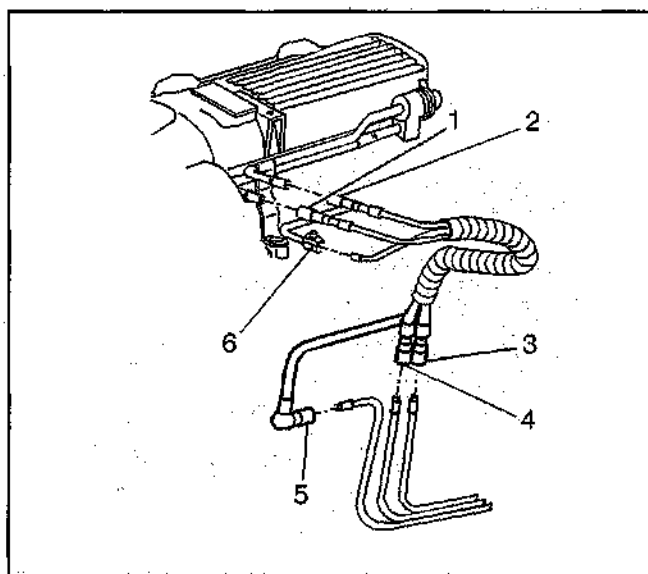


282936



282933

37. Remove the heater hoses from the drive belt tensioner.

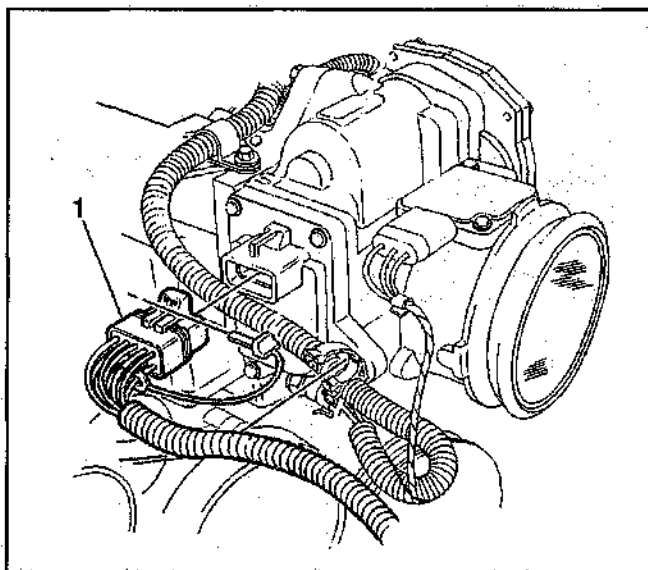


215517

38. Using *J 37088-A* disconnect the following pipes:

- The fuel feed (1) from the fuel rail
- The fuel return (2) from the fuel rail

39. Disconnect the EVAP pipe (6) at the engine.



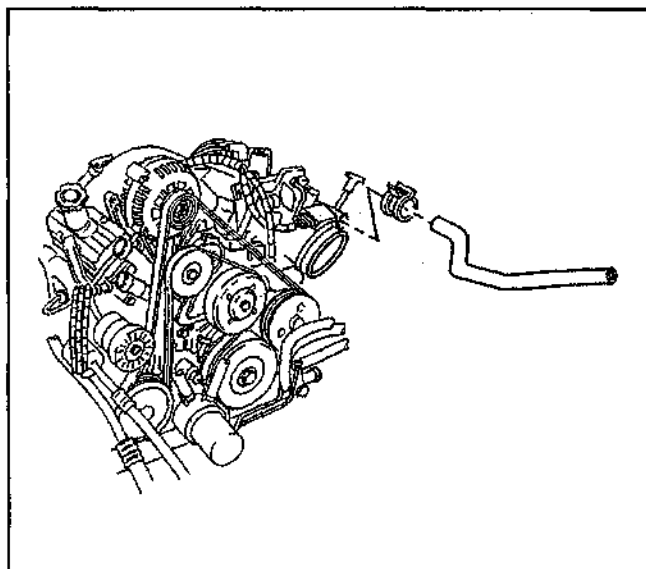
439418

40. Remove the capture secondary lock from the electrical connector.

41. Disconnect the electronic throttle control (ETC) electrical connector (1).

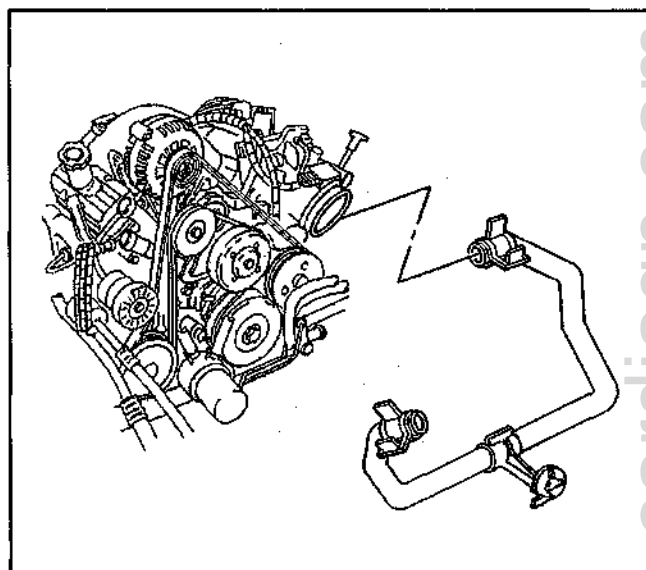
42. Remove the forward lamp harness branch from the wire harness clip.

43. Remove the inlet hose from the water outlet.



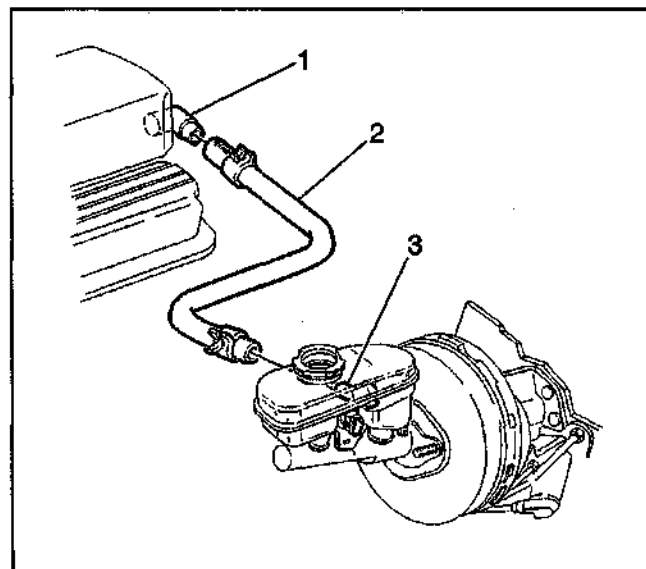
221680

44. Remove the outlet hose from the water pump.

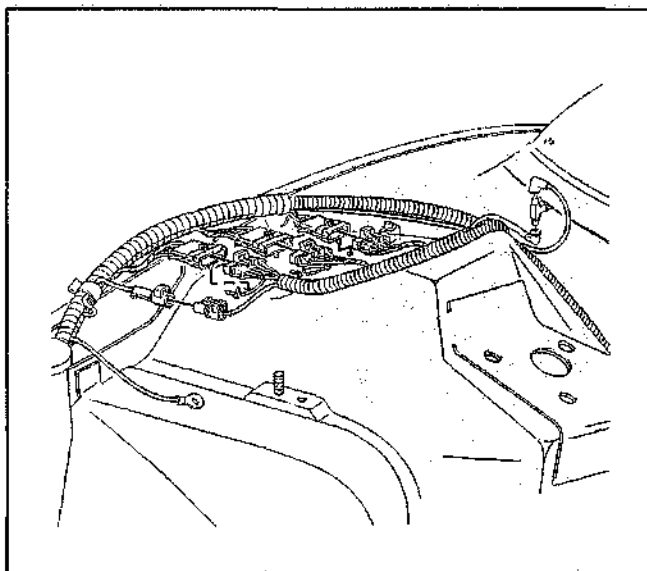


221689

45. Remove the brake booster vacuum hose (2) from the intake manifold fitting (1).
46. Remove the front two brake pipes from the brake modulator.

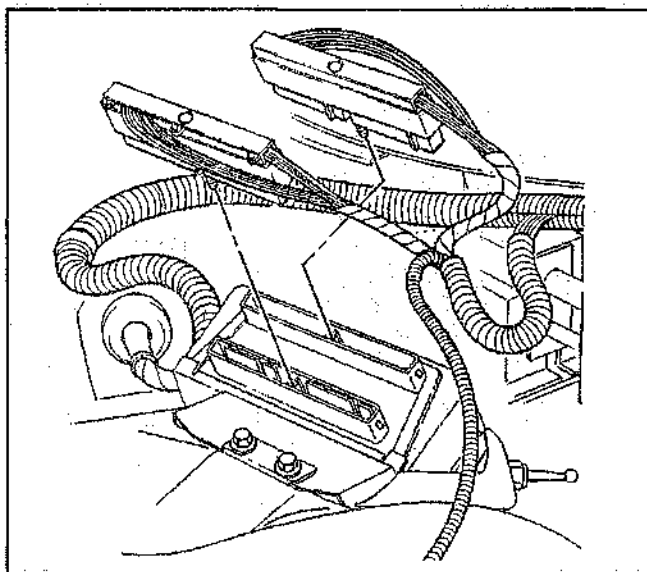


439407



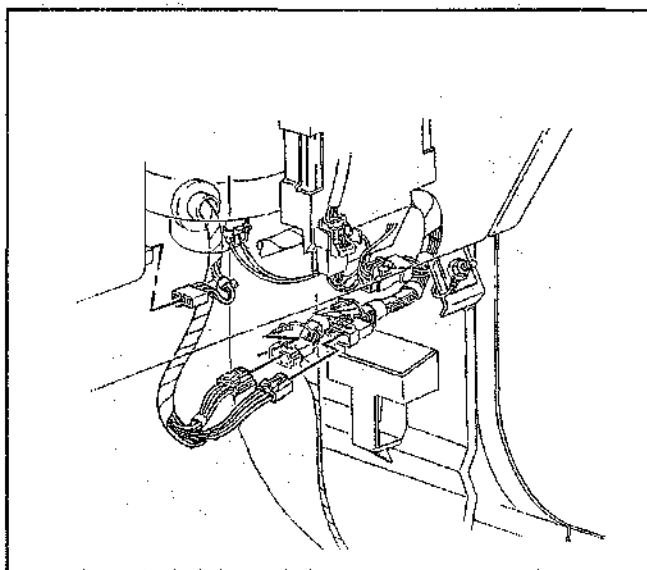
346047

47. Disconnect the captured secondary locks.
48. Disconnect the forward lamp harness from the engine harness.
49. Disconnect the engine harness vacuum tube from the bottom of the vacuum check valve.



346043

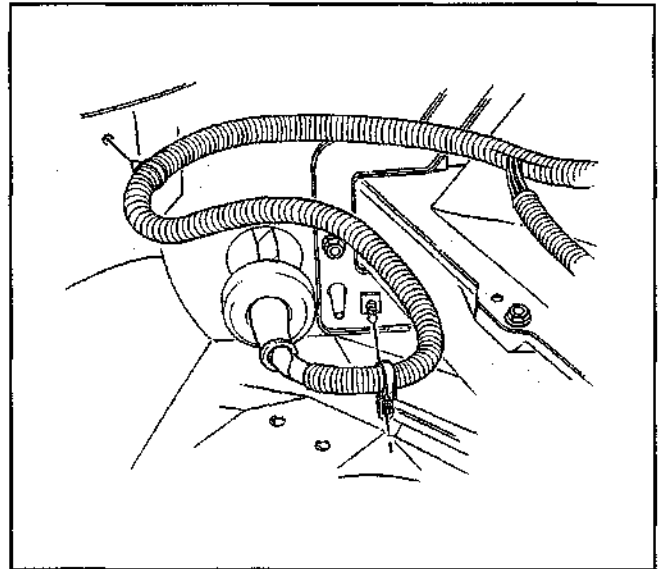
50. Disconnect the powertrain control module (PCM) connectors.
51. Remove the PCM from the vehicle.
52. Remove the right side insulator panel. Refer to *Closeout/Insulator Panel Replacement - Right* in Instrument Panel, Gauges and Console.
53. Remove the hinge pillar trim panel. Refer to *Trim Replacement - Hinge Pillar* in Interior Trim.



346038

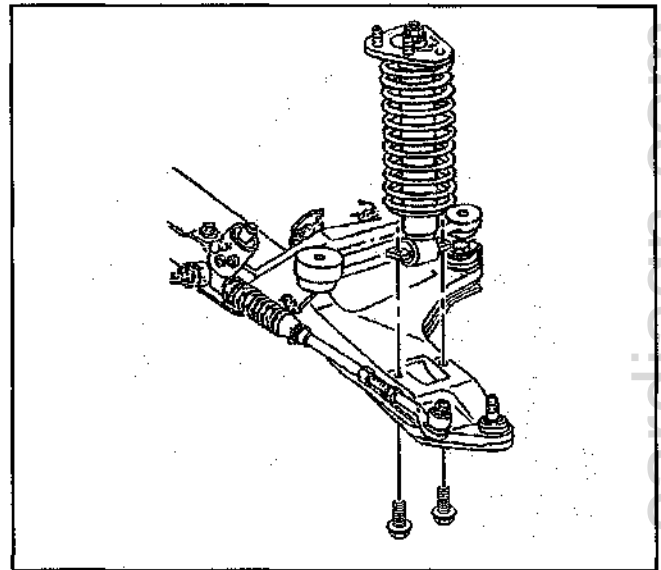
54. Disconnect the engine wiring harness from the instrument panel wiring harness.

55. Remove the engine wire harness through the front of dash. Place the harness on top of the engine.
56. Remove the floor shift control, if equipped. Refer to *Floor Shift Control Replacement in Automatic Transmission - 4L60-E*.
57. Remove the transmission control, if equipped. Refer to *Shift Control Assembly Replacement in Manual Transmission - M49*.
58. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.



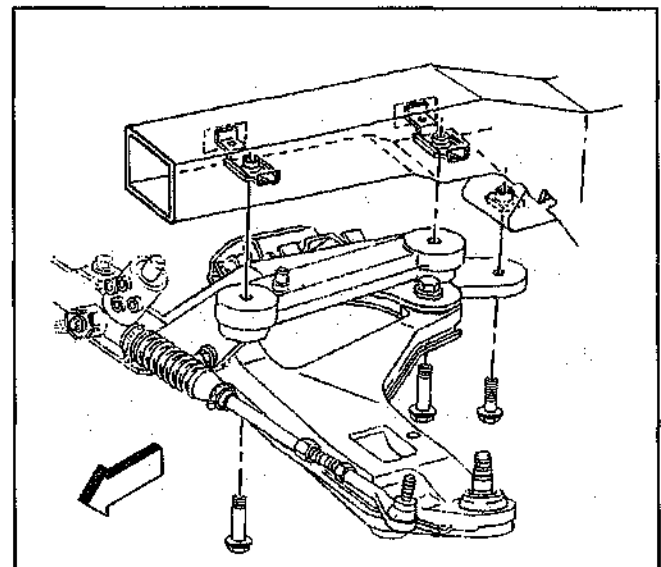
346041

59. Remove the right and left side shock absorber lower mounting bolts.
60. Remove the cotter pins and nuts from the left and right upper ball joints.
61. Using *J 39549* separate the upper control arms from the steering knuckles.
62. Support both steering knuckles.
63. Position *J 39580* below the engine.
64. Lower the vehicle.
65. Lay the engine wire harness on top of the engine.

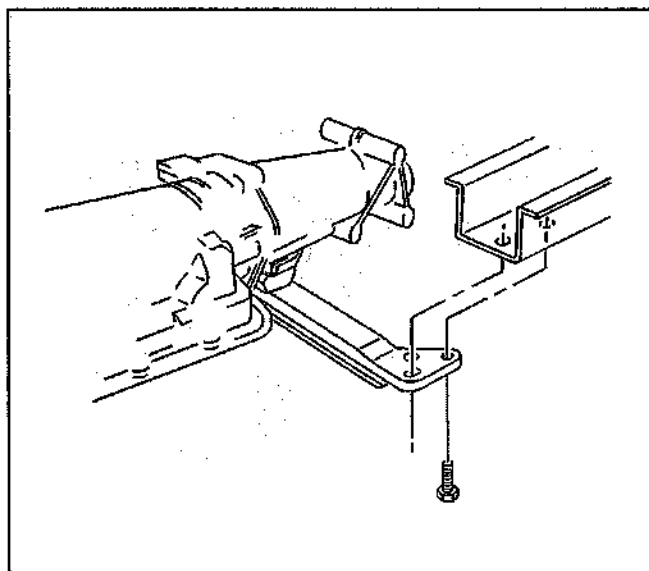


220629

66. Remove the front crossmember bolts.

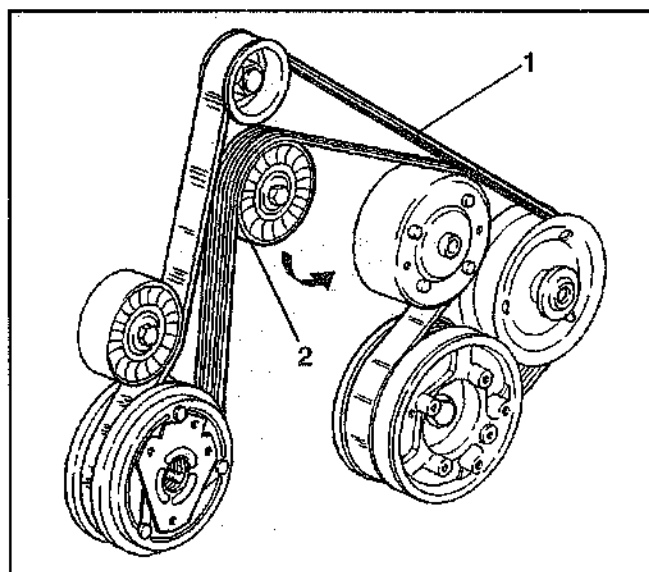


220632



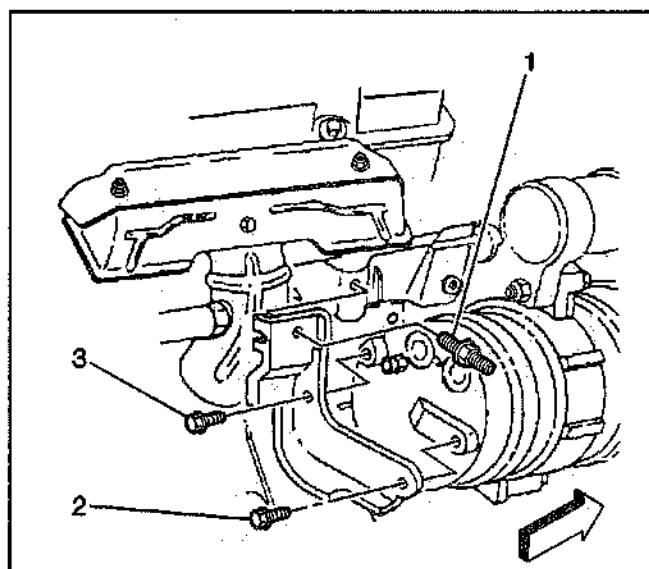
208587

67. Remove the transmission support bolts.
68. Raise the vehicle and remove the engine and transmission from the vehicle.
69. Secure the crossmember to the *J 39580*.



41363

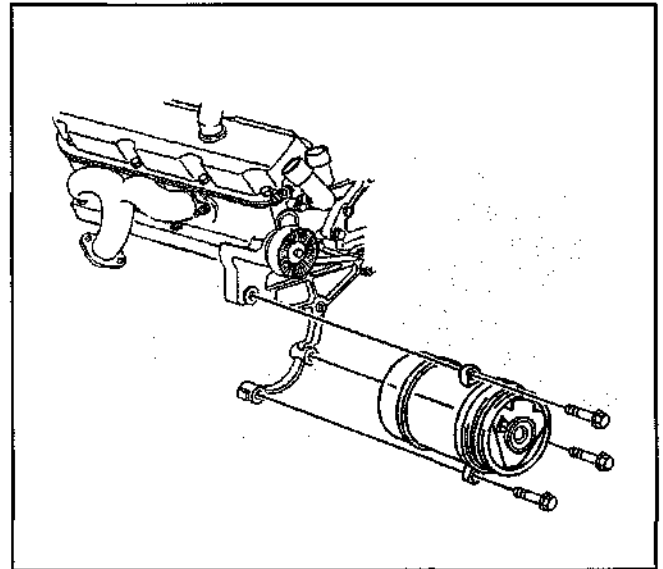
70. Position a hex-head socket on the belt tensioner pulley bolt.
71. Rotate the drive belt tensioner (2) clockwise to relieve the tension on the drive belt (1).
72. Remove the drive belt (1) from the tensioner (2) and pulleys.



365440

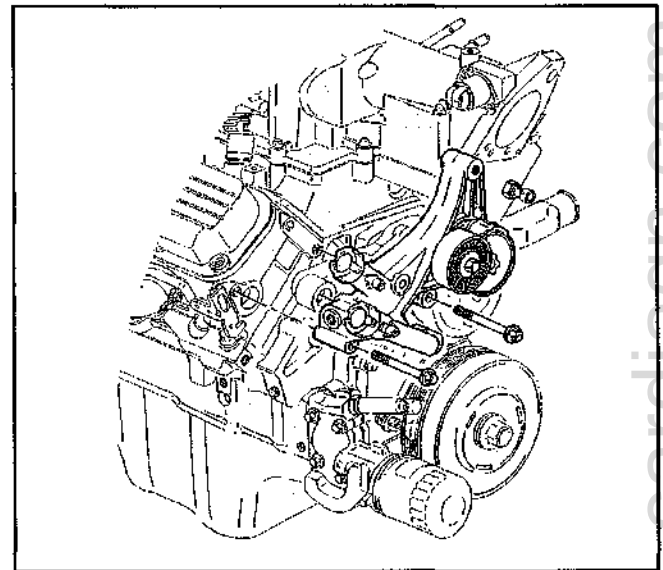
73. Remove the A/C compressor rear bolts (2, 3).
74. Remove the A/C compressor rear bracket stud (1).
75. Remove the A/C compressor rear bracket.

76. Remove the A/C compressor bolts.
77. Remove the A/C compressor.



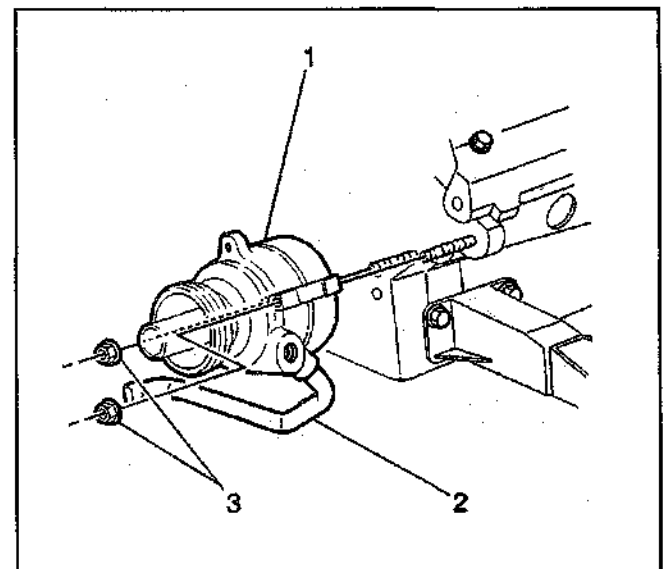
282953

78. Remove the drive belt tensioner bolts.
79. Remove the drive belt tensioner.

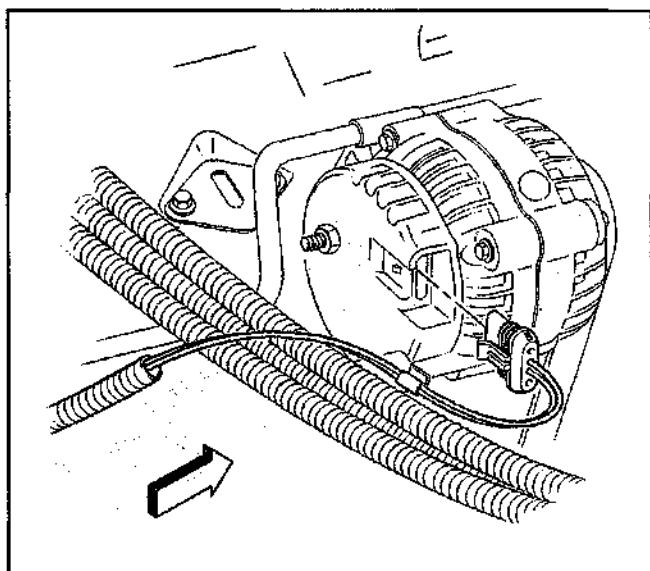


35904

80. Remove the power steering pump nuts (3).
81. Reposition the power steering pump to crossmember.

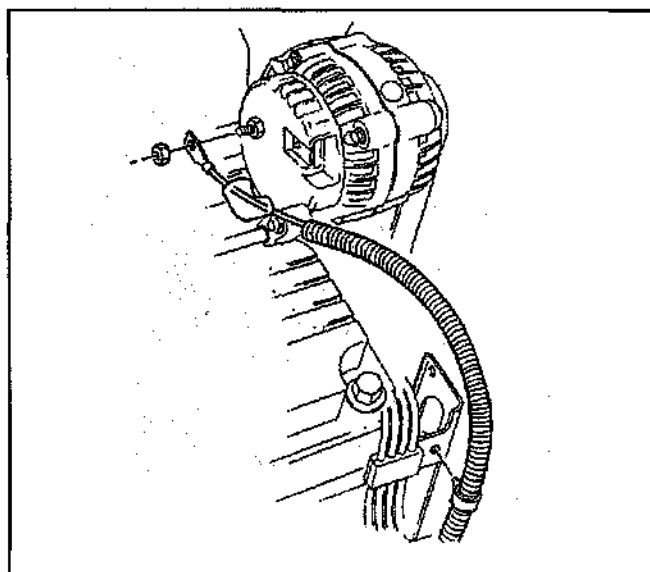


290569



211637

82. Disconnect the generator electrical connector.

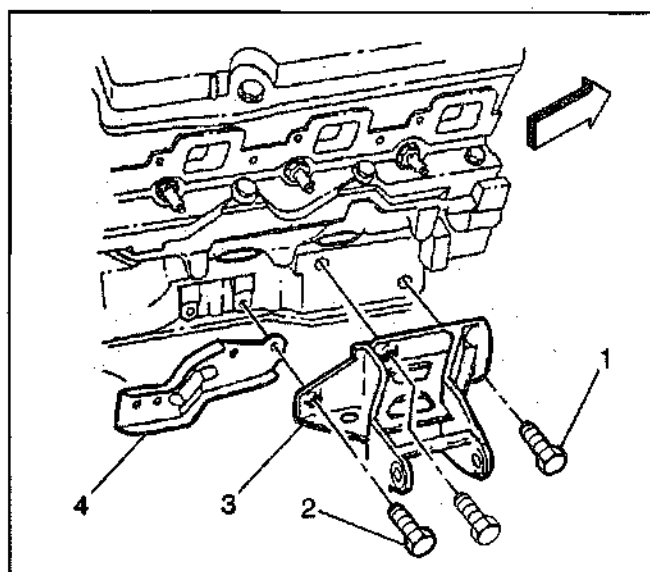


43670

83. Remove the positive cable nut from the generator terminal.

84. Remove the generator from the engine.

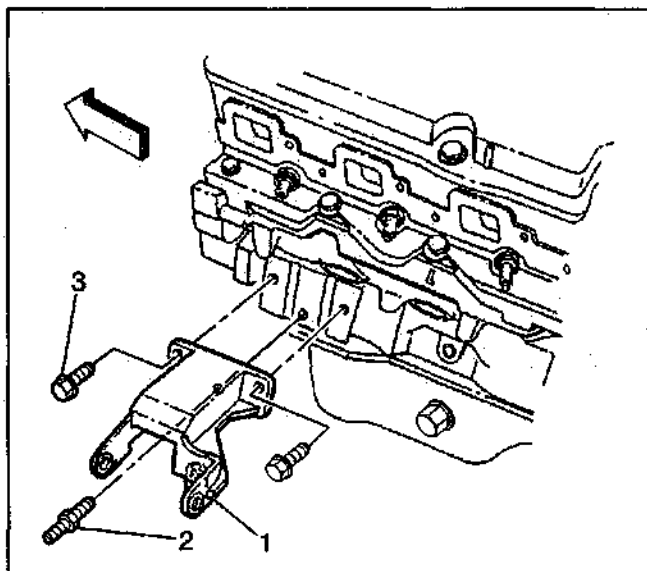
85. Install a lifting device to the engine.



50517

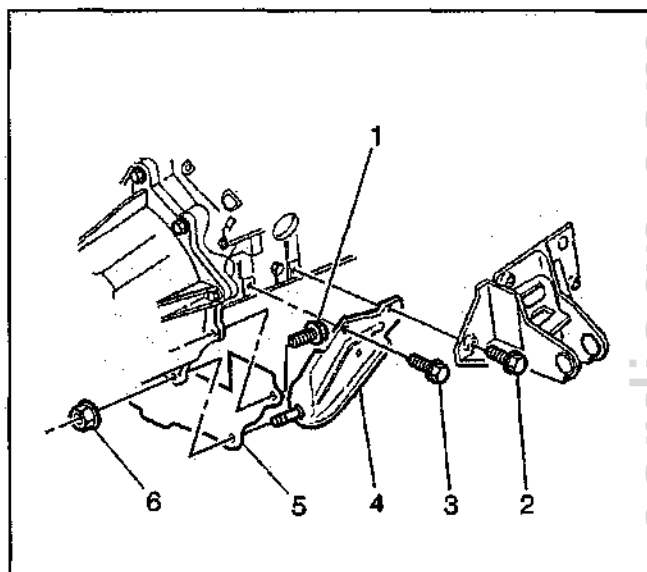
86. Remove the right engine mount bracket bolts (1, 2) and the right engine mount bracket (3).

87. Remove the left engine mount bracket bolts (3).
88. Remove the left engine mount bracket stud (2) and the left engine mount bracket (1).
89. With the aid of an assistant, raise the engine and transmission from the crossmember.



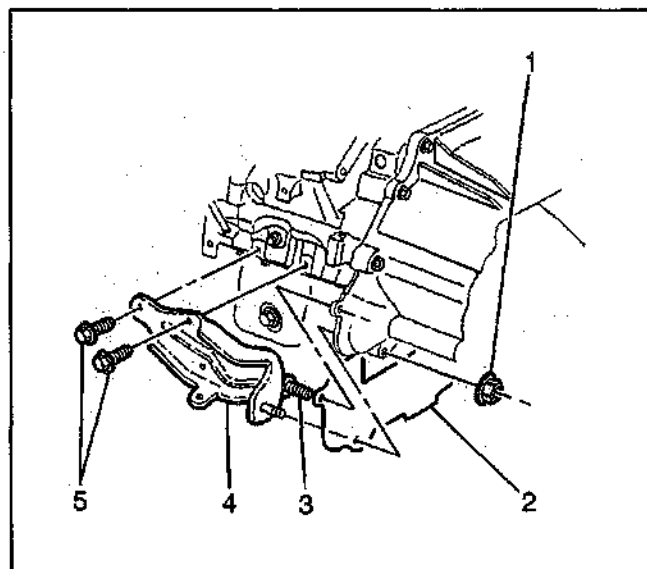
50546

90. If equipped with the automatic transmission, remove the following:
91. Right side transmission support brace bolts (1, 2, 3).
92. Right side transmission support but (6).
93. Right side transmission support (4).

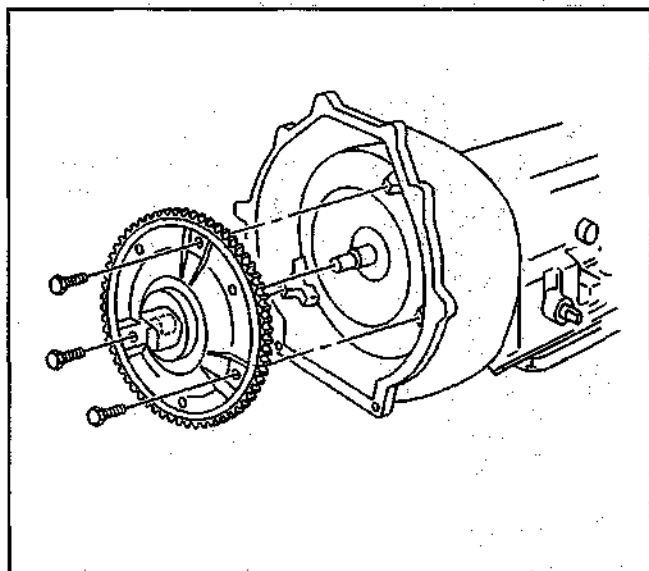


208574

94. Left side transmission support brace bolts (3, 5).
95. Left side transmission support nut (1).
96. Left side transmission support (4).
97. Remove the torque converter cover (2).

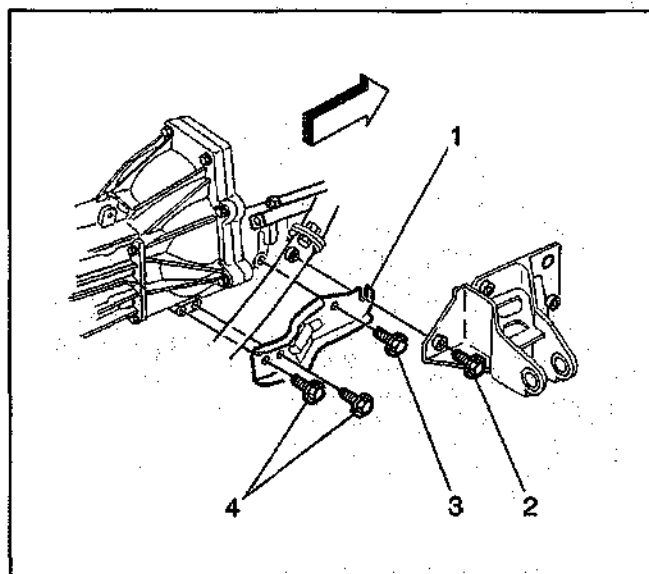


208577



208580

98. Remove the flywheel to torque converter bolts.

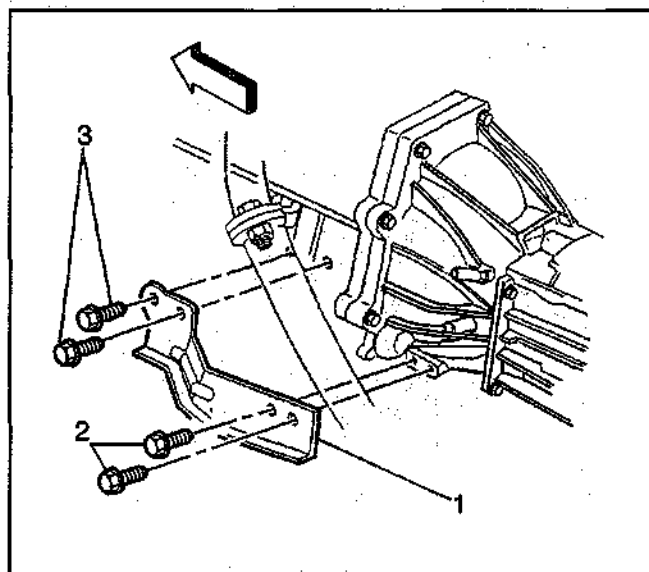


448855

99. If equipped with the manual transmission remove the following:

100. Right side transmission support bolts (3, 4).

101. Right side transmission support (1).



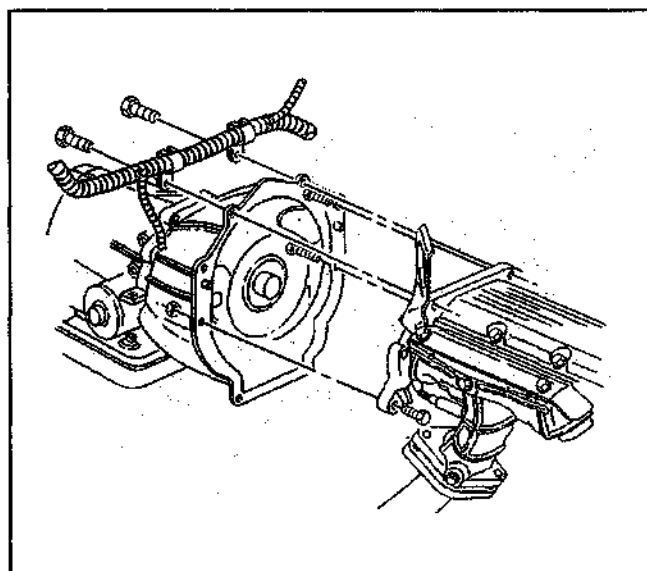
349661

102. Left side transmission support bolts (2, 3).

103. Left side transmission support (1).

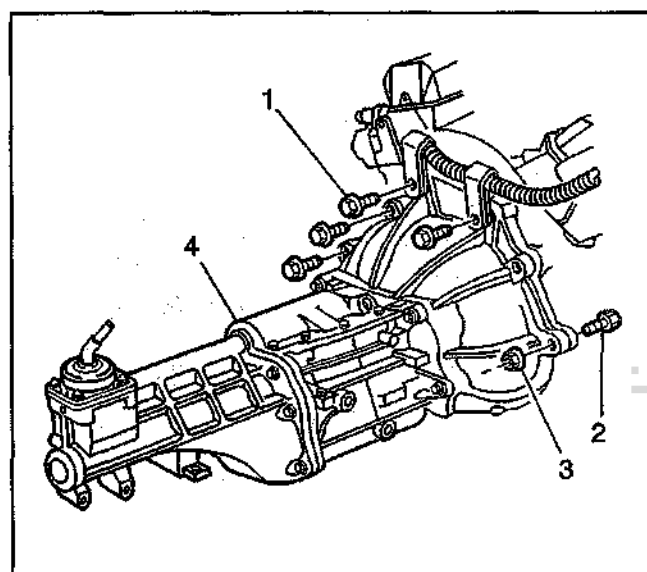
104. Disconnect the electrical connectors from the transmission.

105. For the automatic transmission, remove the transmission to engine bolts and nut.
106. Separate the transmission from the engine.
107. Attach the *J 21366* to the transmission.



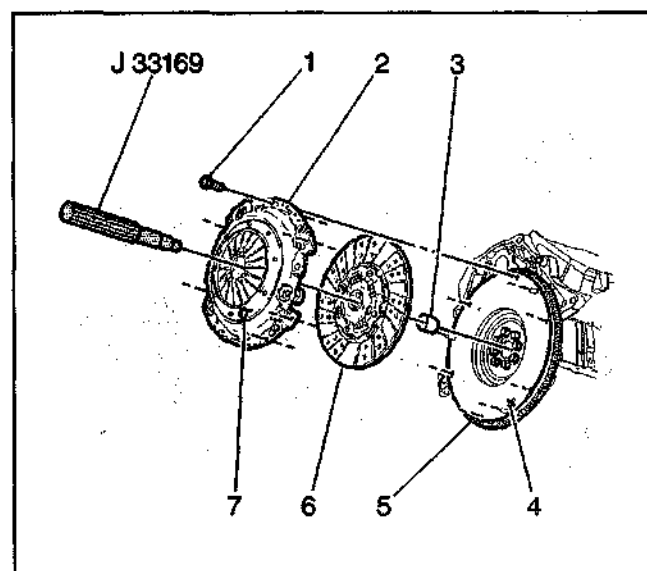
208594

108. For the manual transmission, remove the flywheel housing to engine bolts (1, 2) and nuts (3).
109. Separate the flywheel housing from the engine.

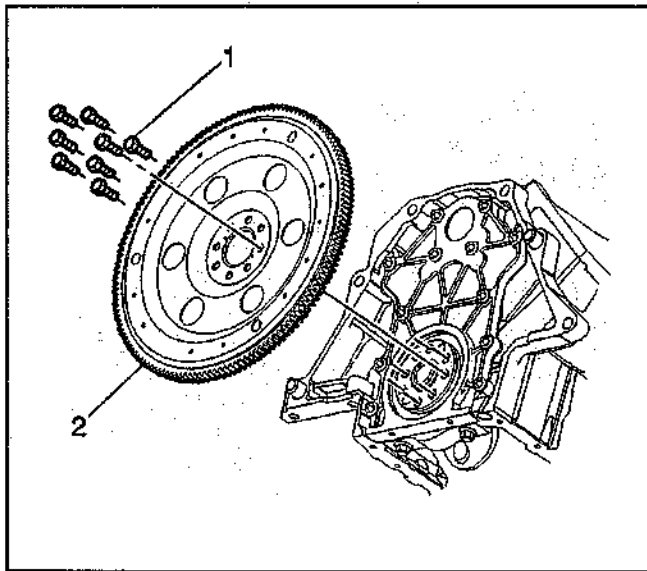


441492

110. For the manual transmission, remove the pressure plate bolts (1).
111. Remove the pressure plate (2) and the clutch disc (6) from the flywheel (5).

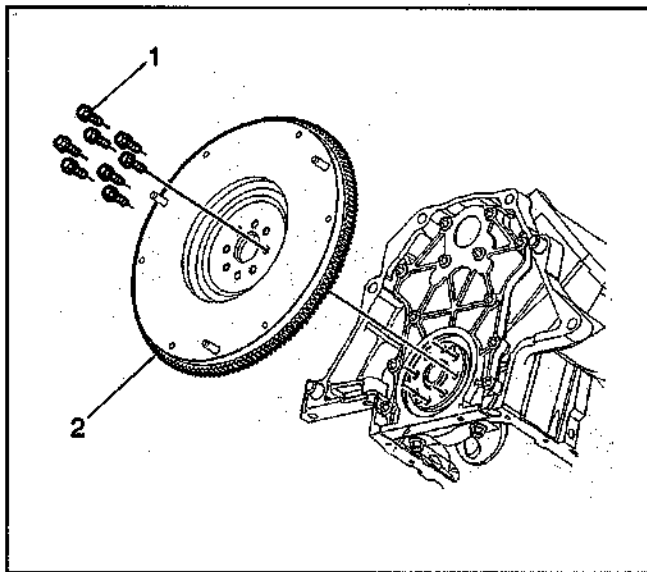


441865



441271

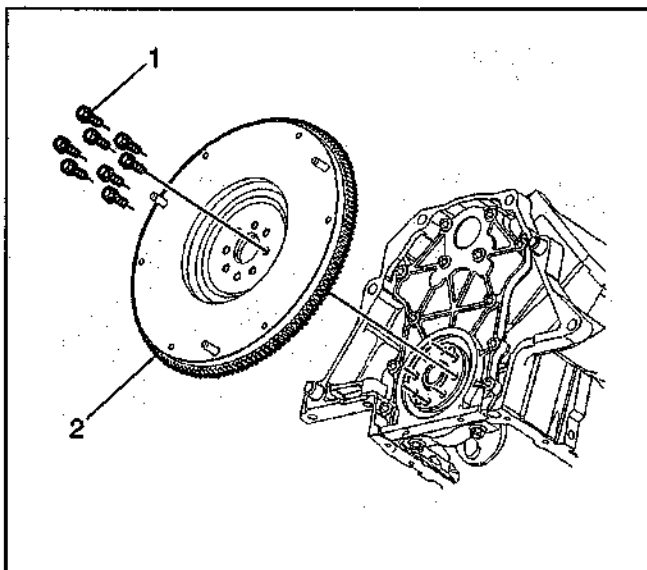
112. For the automatic transmission, remove the flywheel bolts (1) and flywheel (2).



441112

113. For the manual transmission, remove the flywheel bolts (1) and flywheel (2).

114. Install the engine to a engine stand.



441112

Installation Procedure

Tools Required

- J 36660-A Torque Angle Meter
- J 39580 Universal Engine Support Table
- J 21366 Converter Holding Strap

1. Install engine lifting devise and remove engine from the stand.

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

2. For the manual transmission, install the flywheel (2) and flywheel bolts (1).

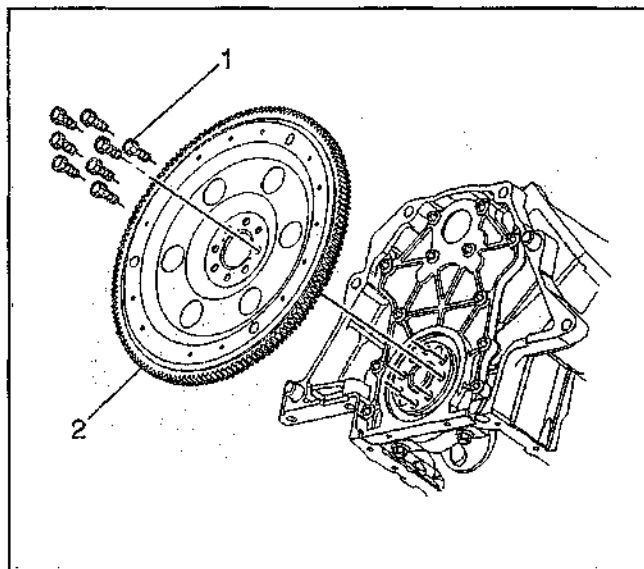
Tighten

Tighten the flywheel bolts (1) to 15 N·m (11 lb ft). Use the J 36660-A to torque the flywheel bolts an additional 50 degrees.

3. For the automatic transmission, install the flywheel (2) and flywheel bolts (1).

Tighten

Tighten the flywheel bolts (1) to 15 N·m (11 lb ft). Use *J 36660-A* to torque the flywheel bolts an additional 50 degrees.



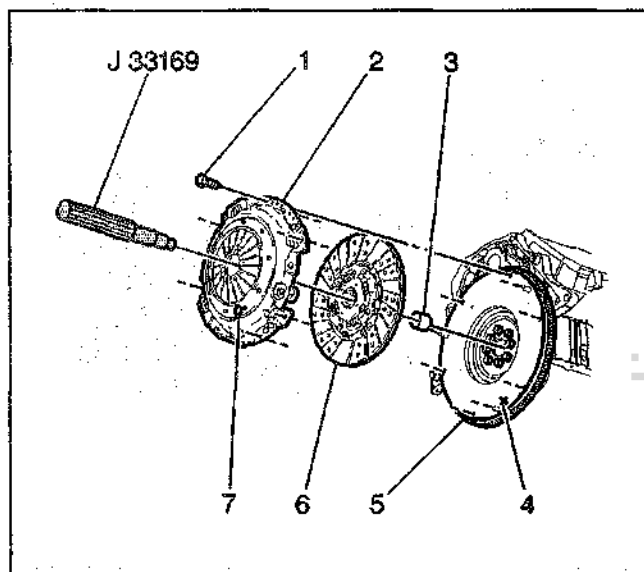
441271

4. For the manual transmission, install the clutch disc (6) and pressure plate (2) to the flywheel (5).
5. Install the pressure plate bolts (1).

Tighten

Tighten the pressure plate bolts (1) to 20 N·m (15 lb ft). Use *J 36660-A* to torque the pressure plate bolts (1) an additional 45 degrees.

6. Align the flywheel housing to the engine.



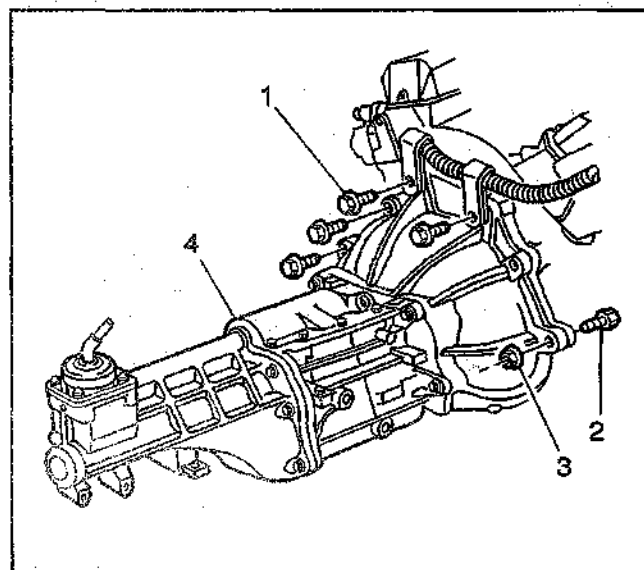
441865

7. For the manual transmission, install the flywheel housing to engine bolts (1, 2) and nuts (3).

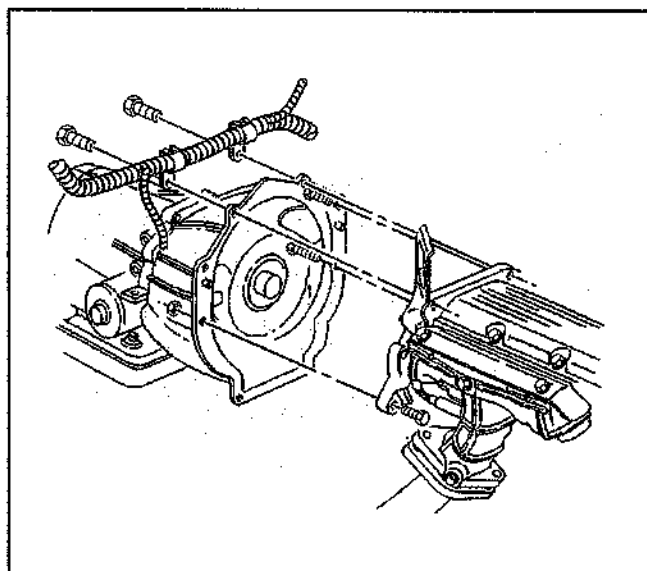
Tighten

Tighten the flywheel housing to engine bolts (1, 2) and nuts (3) to 95 N·m (70 lb ft).

8. If equipped with a automatic transmission remove the *J 21366* from the transmission.



441492



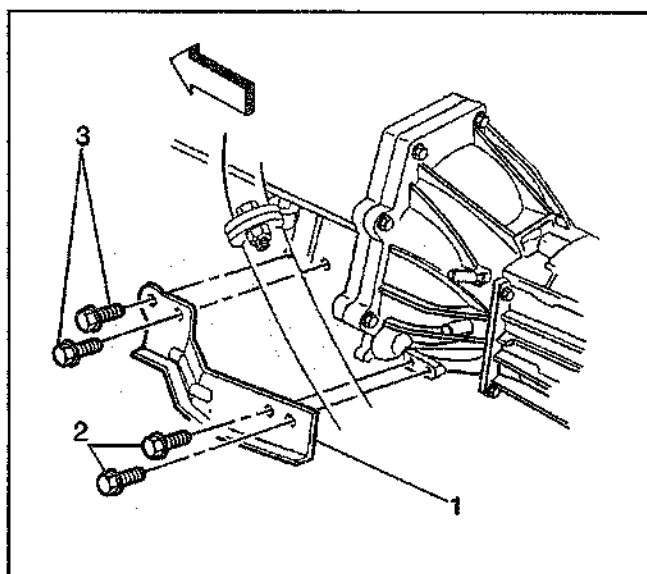
208594

9. For the automatic transmission, install the transmission to engine bolts and nut.

Tighten

Tighten the transmission to engine bolts and nut to 95 N-m (70 lb ft).

10. Connect the electrical connectors to the transmission.



349561

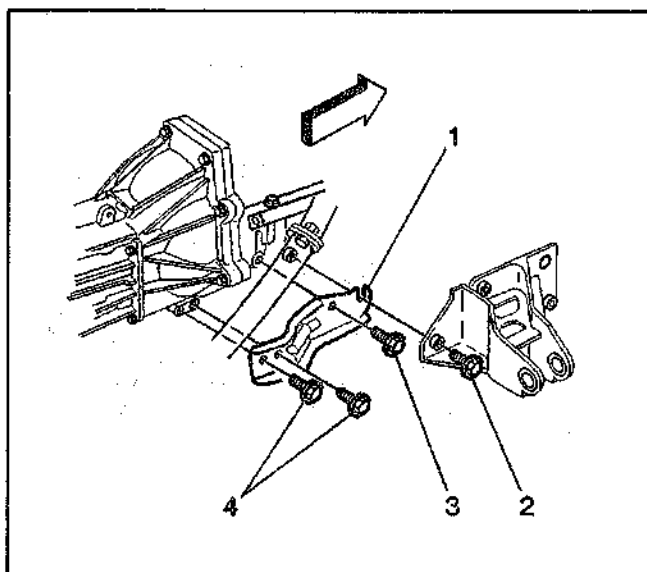
11. If equipped with the manual transmission install the following:

12. Left side transmission support (1).

13. Left side transmission support brace bolts (2, 3).

Tighten

- Tighten the left side transmission support brace bolts (2) to 50 N-m (37 lb ft).
- Tighten the left side transmission support brace bolts (3) to 28 N-m (21 lb ft).



448855

14. Right side transmission support (1).

15. Right side transmission support brace bolts (3, 4).

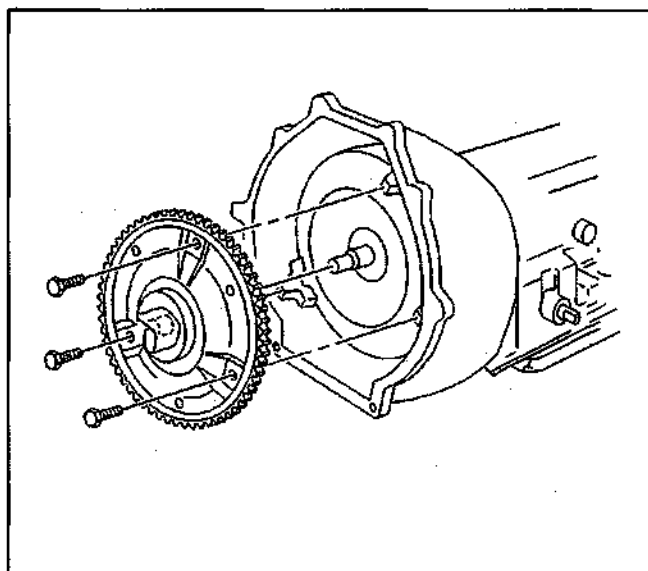
Tighten

Tighten the right side transmission support brace bolts (3, 4) to 50 N-m (37 lb ft).

16. If equipped with the automatic transmission install the following:
17. Install the torque converter to flywheel bolts.

Tighten

Tighten the torque converter to flywheel bolts to 63 N·m (47 lb ft).

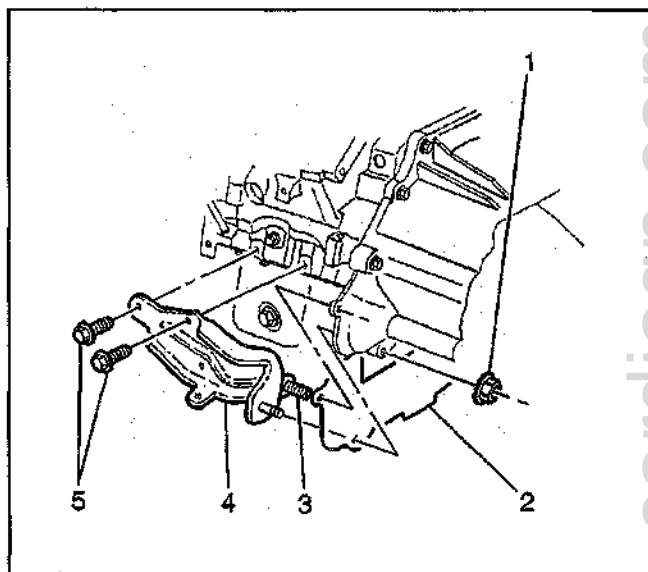


208580

18. Install the torque converter cover (2).
19. Left side transmission support (4).
20. Left side transmission support bolts (3, 5).
21. Left side transmission support nut (1).

Tighten

- Tighten the left side transmission support bolts (3) to 8.5 N·m (75 lb in).
- Tighten the left side transmission support bolts (5) to 28 N·m (21 lb ft).
- Tighten the left side transmission support nut (1) to 80 N·m (59 lb ft).



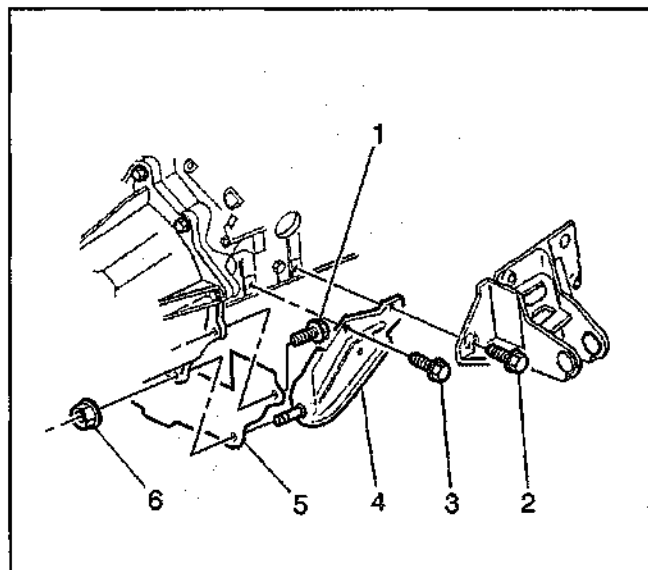
208577

22. Right side transmission support (4).
23. Right side transmission support brace bolts (1, 2, 3).
24. Right side transmission support nut (6).

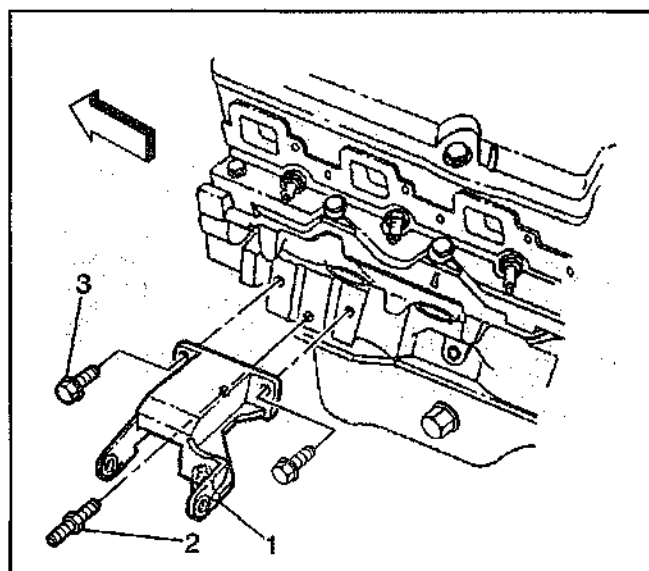
Tighten

- Tighten the right side transmission support brace bolts (1) to 8.5 N·m (75 lb in).
- Tighten the right side transmission support bolts (2, 3) to 50 N·m (37 lb ft).
- Tighten the right side transmission support nut (6) to 80 N·m (59 lb ft).

25. With the aide of an assistant, lower the engine and transmission to the crossmember.



208574

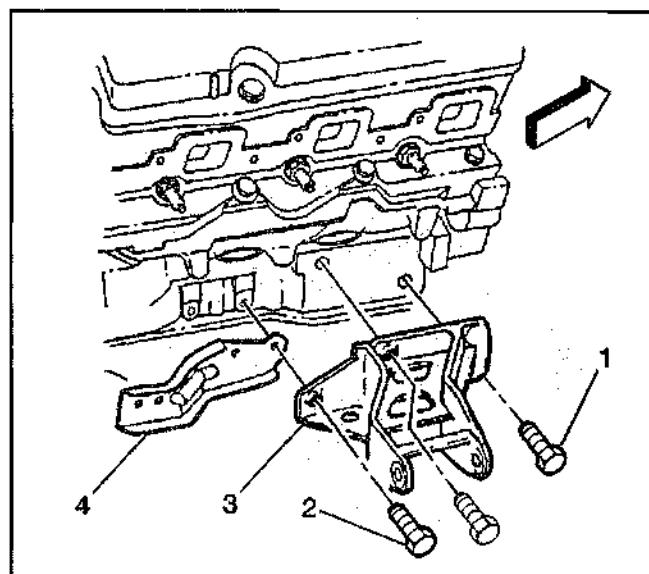


50546

26. Install the left engine mount bracket (1) and mount bracket stud (2).
27. Install the left engine mount bracket bolts (3).

Tighten

- Tighten the left engine mount bracket bolt (3) to 100 N·m (74 lb ft).
- Tighten the left engine mount bracket stud (2) to 87 N·m (64 lb ft).



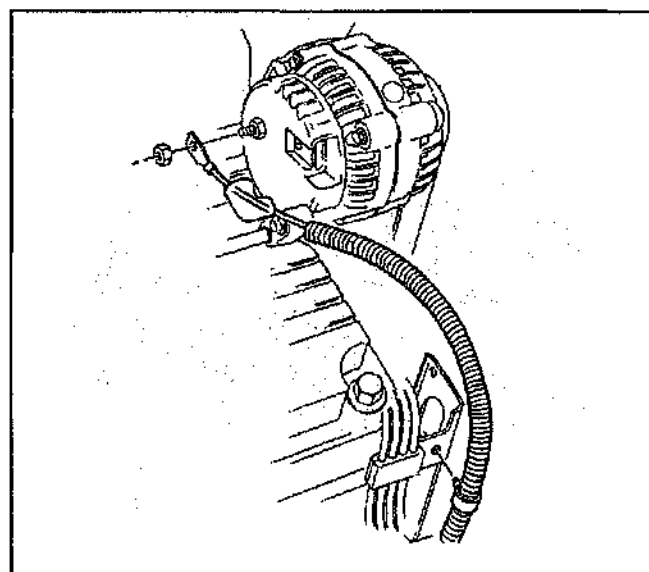
50517

28. Install the right engine mount bracket (3) and the engine mount bracket bolts (1, 2).

Tighten

- Tighten the two right engine mount bracket bolts (1) to 100 N·m (74 lb ft).
- Tighten the right engine mount bracket bolt (2) to 50 N·m (37 lb ft).

29. Remove the lifting devise from the engine.



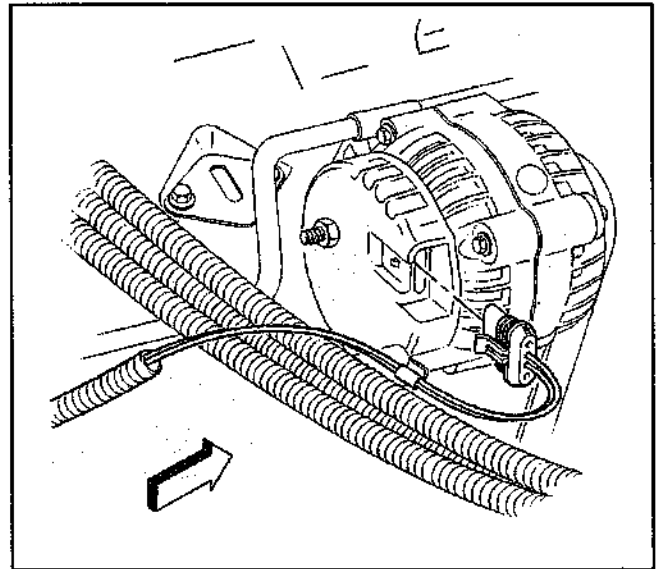
43670

30. Install the generator to the engine.
31. Install the positive cable nut to the generator terminal.

Tighten

Tighten the positive cable nut to generator terminal to 22 N·m (16 lb ft).

32. Connect the generator electrical connector.

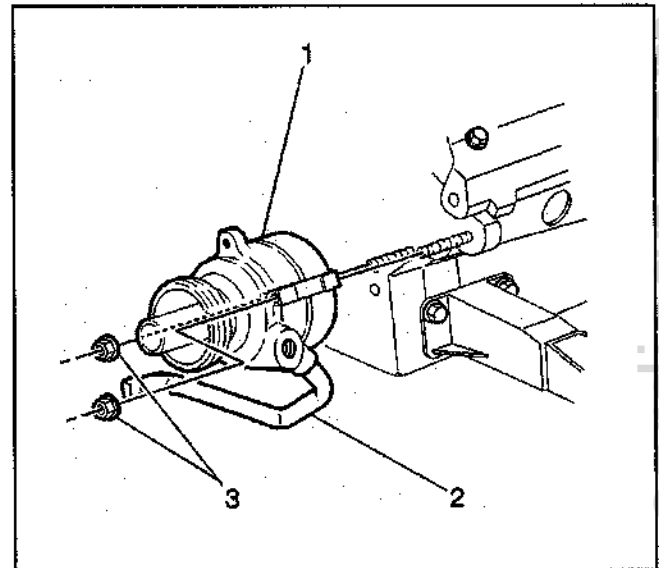


211637

33. Install the power steering pump.
 34. Install the power steering pump nuts (3).

Tighten

Tighten the power steering nuts (3) to 30 N·m (22 lb ft).

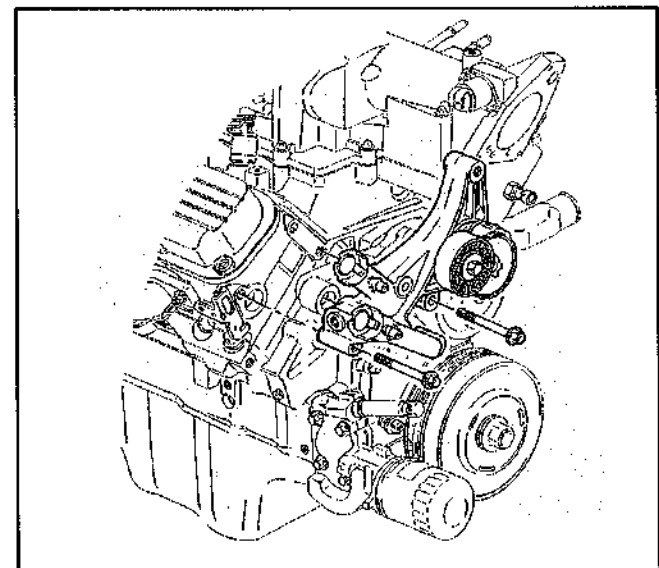


290569

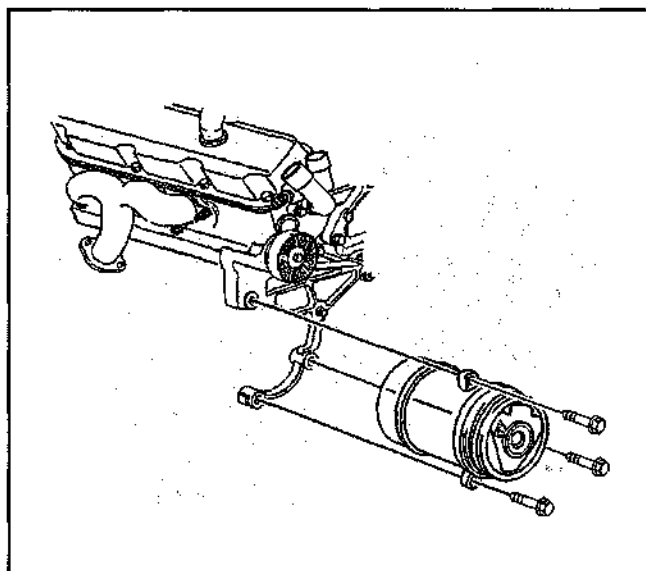
35. Install the drive belt tensioner.
 36. Install the drive belt tensioner bolts.

Tighten

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



35904

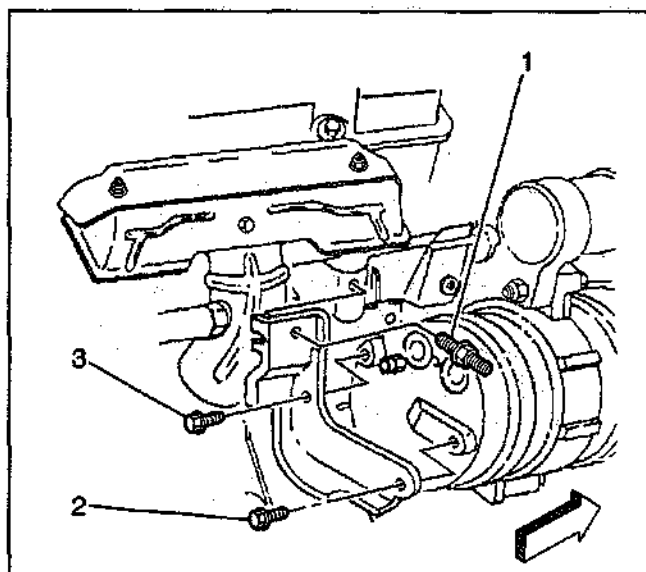


282953

37. Install the A/C compressor.
38. Install the A/C compressor bolts.

Tighten

Tighten the A/C compressor bolts to 50 N·m (37 lb ft).

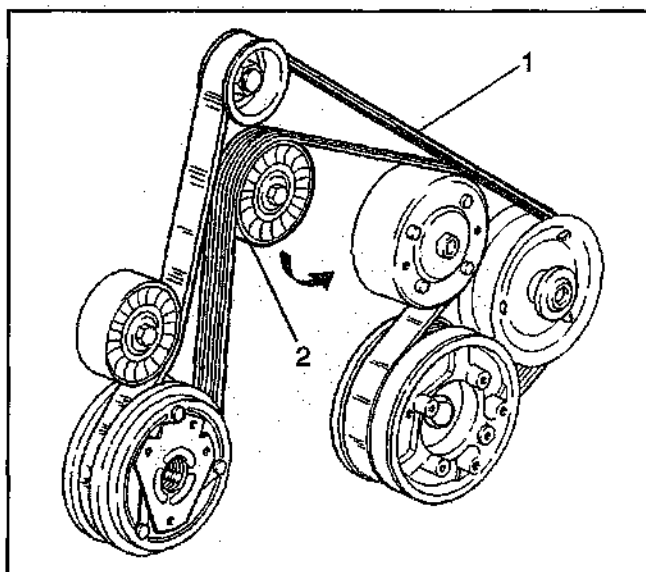


365440

39. Install the A/C compressor rear bracket.
40. Install the A/C compressor rear bracket stud (1).
41. Install the A/C compressor rear bolts (2, 3).

Tighten

- Tighten the A/C compressor rear bracket stud (1) to 50 N·m (37 lb ft).
- Tighten the A/C compressor rear bolts (2, 3) to 30 N·m (22 lb ft).



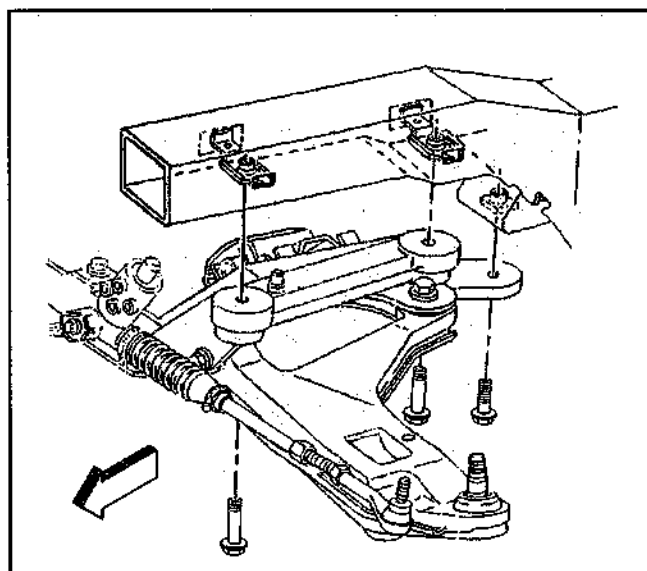
41363

42. Route the drive belt (1) around the pulleys.
43. Position a hex-head socket on the belt tensioner pulley bolts.
44. Rotate the drive belt tensioner (2) clockwise to relieve the tension on the drive belt (1).
45. Install the drive belt (1) onto the tensioner (2).
46. Remove the crossmember to J 39580 security straps.
47. Lower the vehicle and install the engine and transmission to the vehicle.
48. Align the crossmember to the vehicle body.

49. Install the front crossmember bolts

Tighten

- Tighten the upper four cradle bolts to 125 N·m (92 lb ft).
- Tighten the lower two cradle bolts to 145 N·m (107 lb ft).



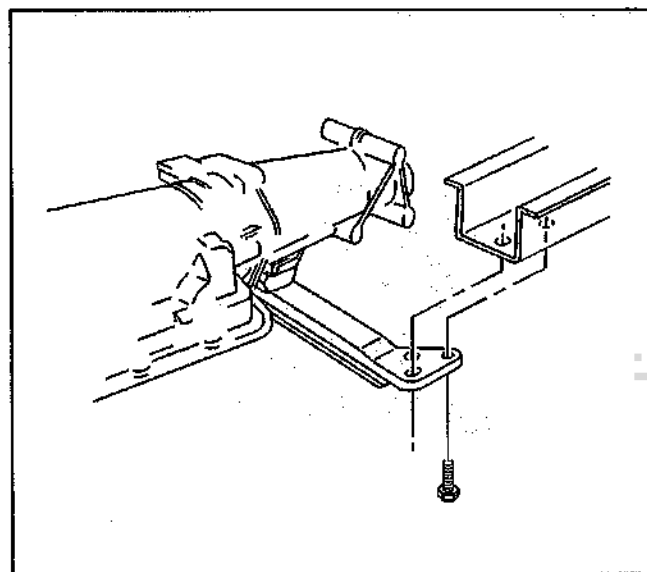
220632

50. Install the transmission support bolts.

Tighten

Tighten the transmission support bolts to 57 N·m (42 lb ft).

51. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
52. Remove the J 39580 from below the vehicle.
53. Remove the supports from both steering knuckles.
54. Connect the ball stud to the steering knuckle.



208587

55. Install the nuts and cotter pins to the left and right upper ball joints.

Tighten

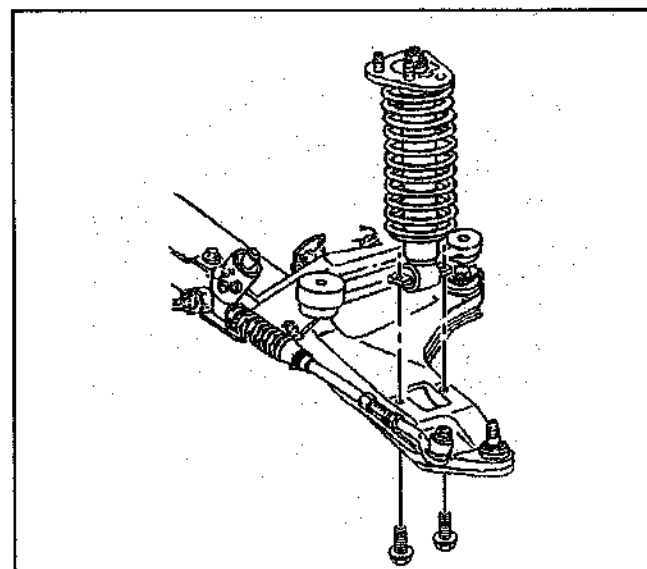
Tighten the upper ball joint nuts to 53 N·m (39 lb ft).

56. Install the right and left side shock absorber lower mounting bolts.

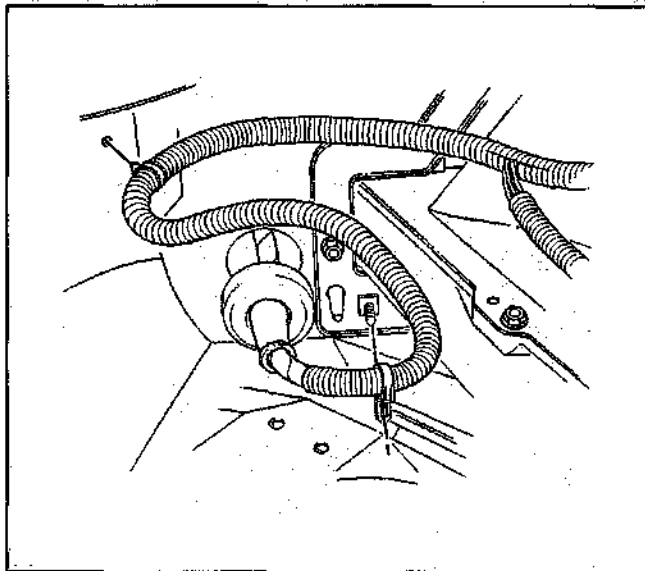
Tighten

Tighten the shock bolts to 65 N·m (48 lb ft).

57. Lower the vehicle.
58. Install the transmission control, if equipped. Refer to *Shift Control Assembly Replacement* in Manual Transmission - M49.
59. Install the floor shift control, if equipped. Refer to *Floor Shift Control Replacement* in Automatic Transmission - 4L60-E.

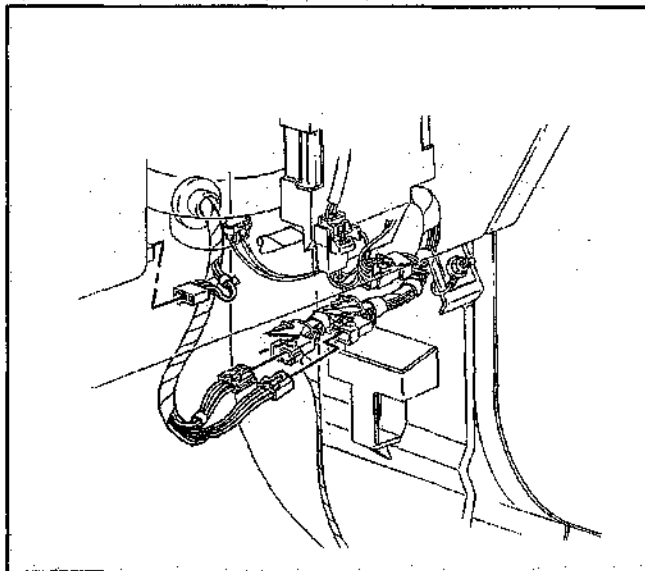


220629



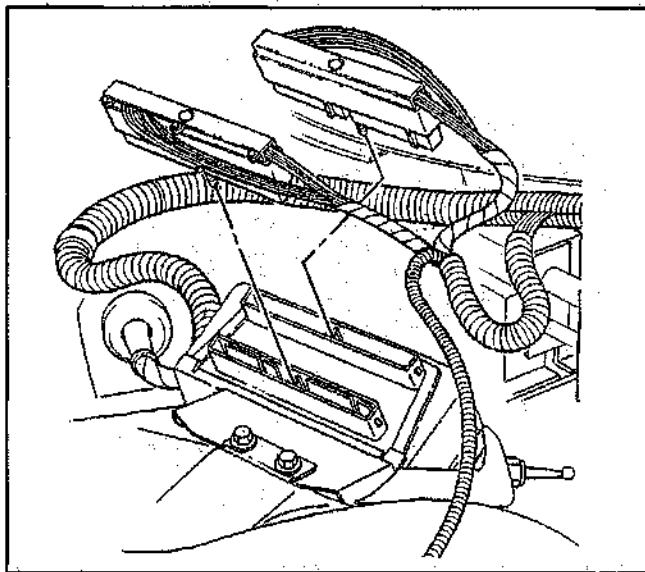
346041

60. Install the engine wire harness through the front of dash.



346039

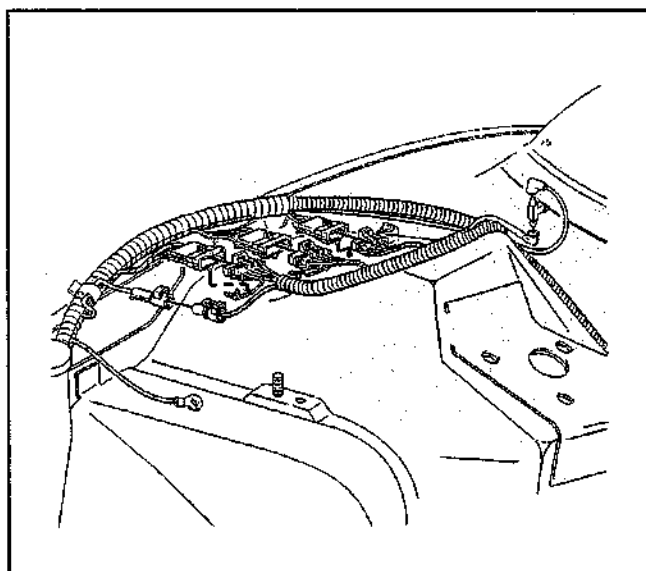
61. Connect the engine wiring harness to the instrument panel wiring harness.
62. Install the hinge pillar trim panel. Refer to *Trim Replacement - Hinge Pillar* in Interior Trim.
63. Install the right side insulator panel. Refer to *Closeout/Insulator Panel Replacement - Right* in Instrument Panel, Gauges and Console.



346043

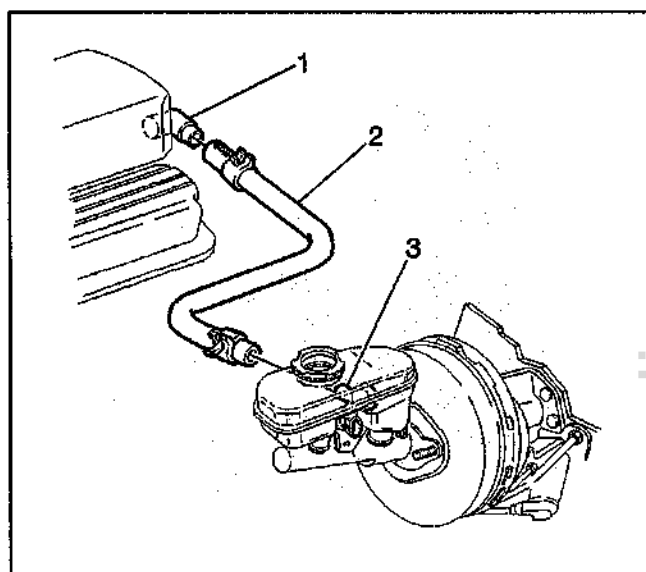
64. Install the PCM to the vehicle.
65. Connect the PCM connectors.

66. Connect the engine harness vacuum tube to the bottom of the vacuum check valve.
67. Connect the forward lamp harness to the engine harness.
68. Connect the captured secondary locks.
69. Install the front two brake pipes to the brake modulator.



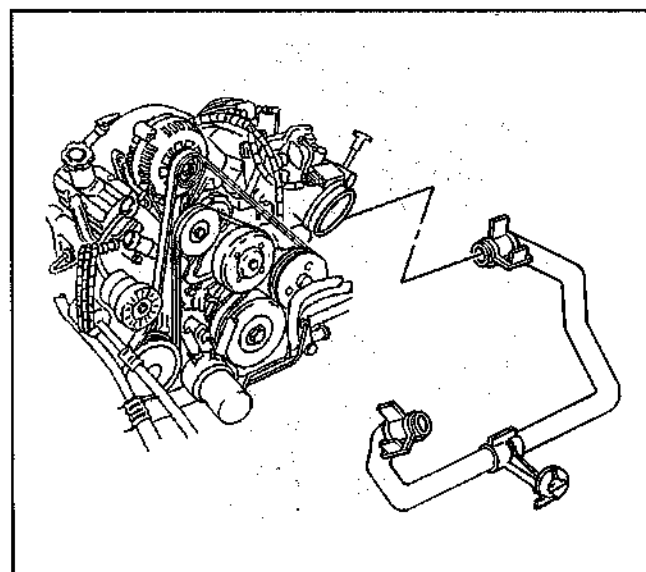
346047

70. Install the brake booster vacuum hose (2) to the intake manifold fitting (1).

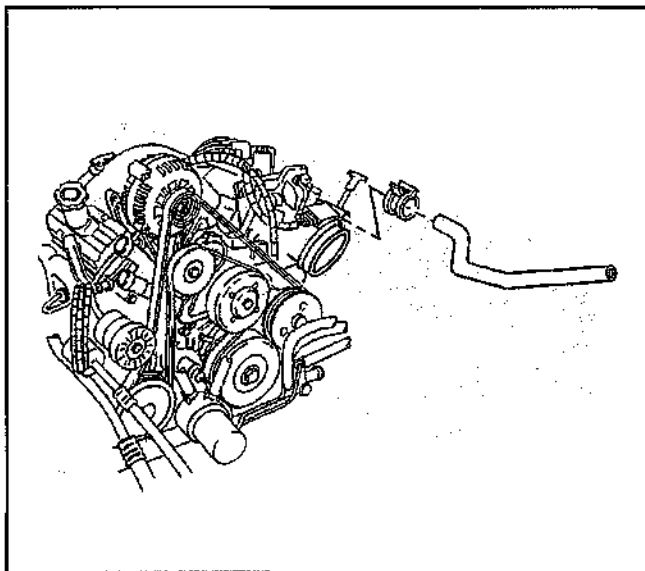


439407

71. Install the outlet hose to the water pump.

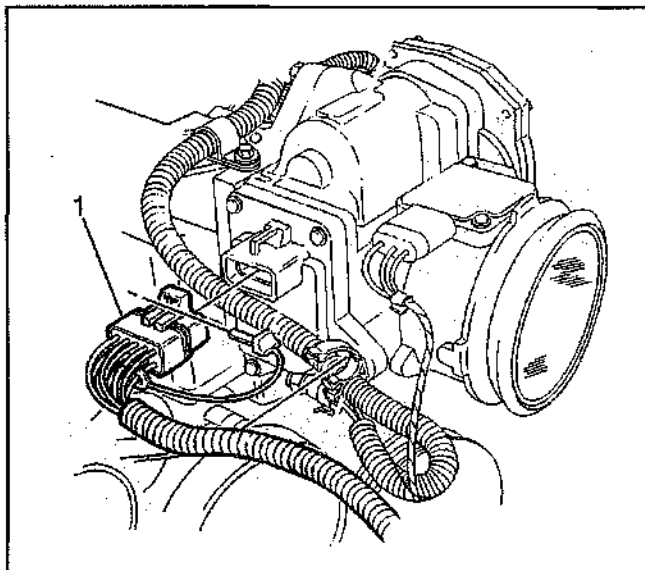


221689



221680

72. Install the inlet hose to the water outlet.

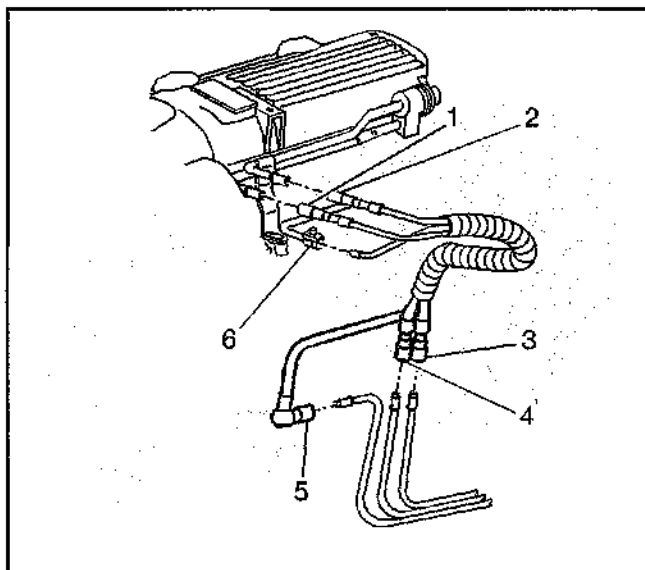


439418

73. Install the forward lamp harness branch to the wire harness clip.

74. Connect the electronic throttle control (ETC) electrical connector (1).

75. Install the capture secondary lock to the electrical connector.



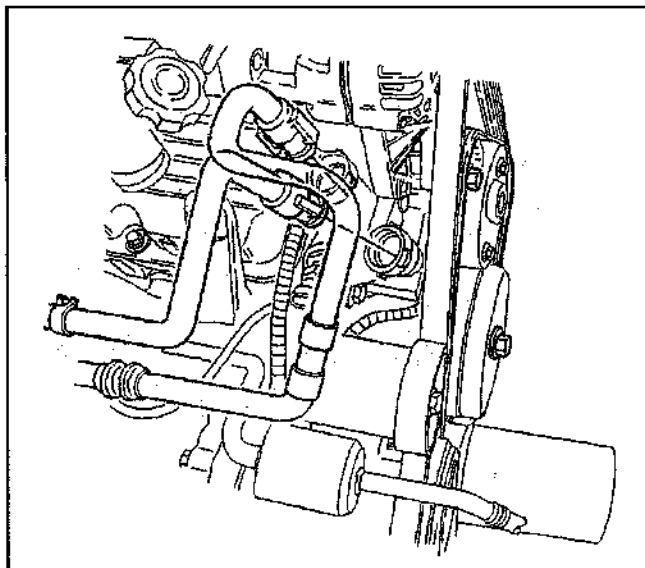
215517

76. Connect the EVAP pipe (6) at the engine.

77. Connect the fuel return pipe (2) to the fuel rail.

78. Connect the fuel feed pipe (1) to the fuel rail.

79. Install the heater hoses to the drive belt tensioner.

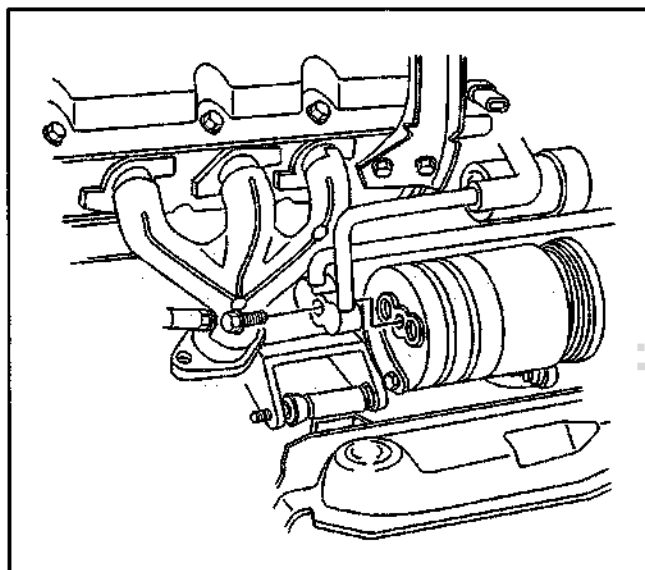


282933

80. Install a new O-ring.
 81. Install the A/C compressor and condenser hose bolt at the accumulator

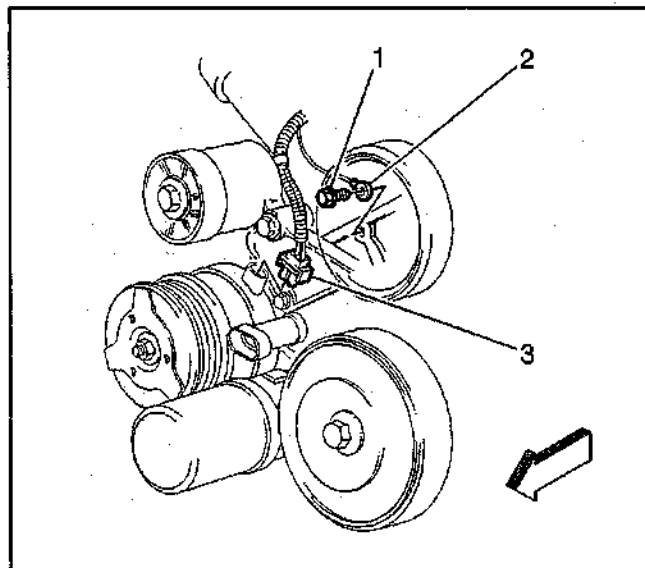
Tighten

Tighten A/C compressor and condenser hose bolt at the accumulator to 48 N·m (36 lb ft).

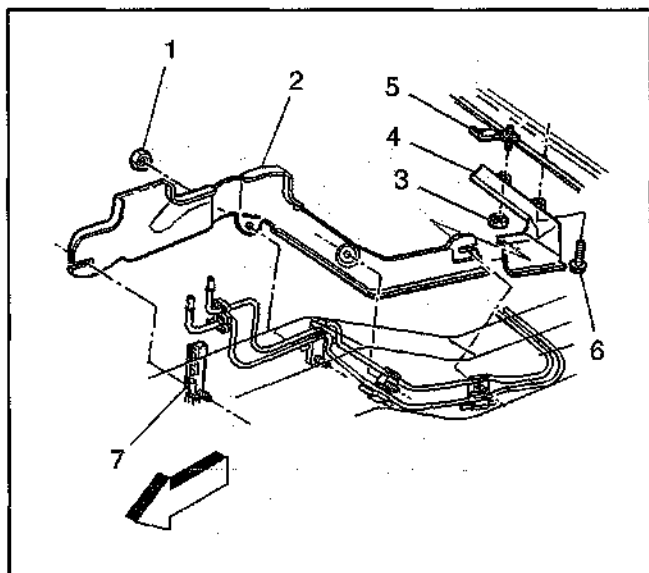


589444

82. Install the engine ground.
 83. Install the engine wiring harness ground bolt (1) to 25 N·m (18 lb ft).
 84. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
 85. Connect the brake lines to the brake pipe clip.



445688

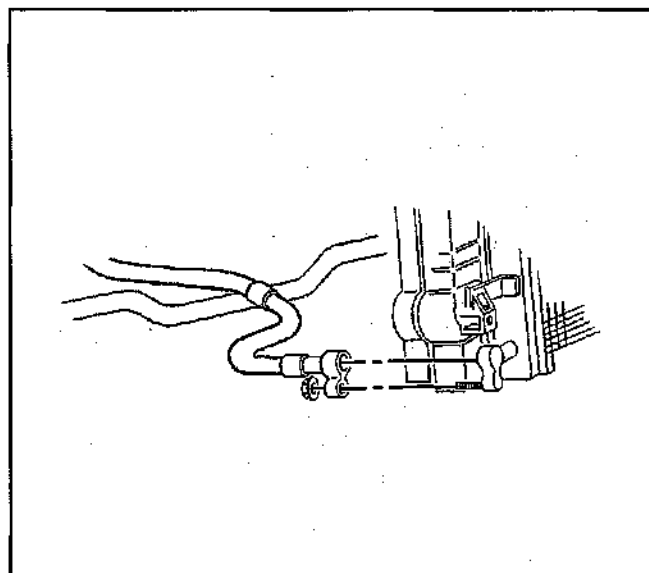


173551

86. Install the front fuel pipe heat shield (2).
87. Install the front fuel pipe heat shield nuts (1).

Tighten

Tighten the front fuel pipe heat shield nuts (1) to 5 N·m (44 lb in).

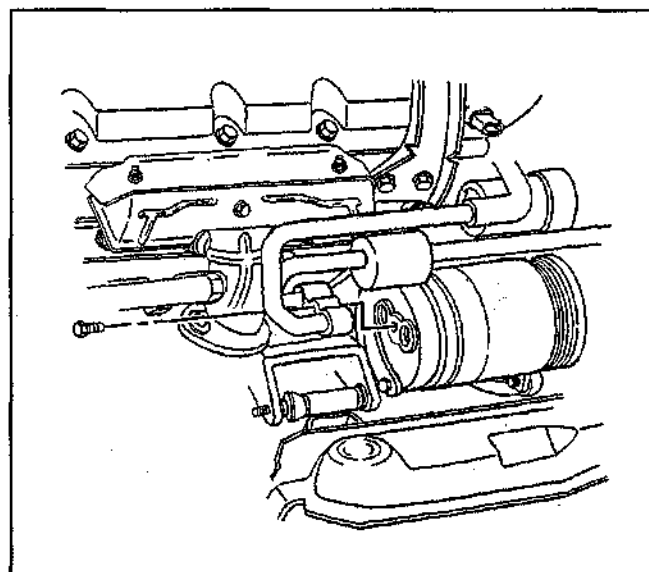


365450

88. Install a new O-ring.
89. Install the A/C compressor and condenser hose nut at the condenser.

Tighten

Tighten the A/C compressor and condenser hose nut at the condenser to 16 N·m (12 lb ft).



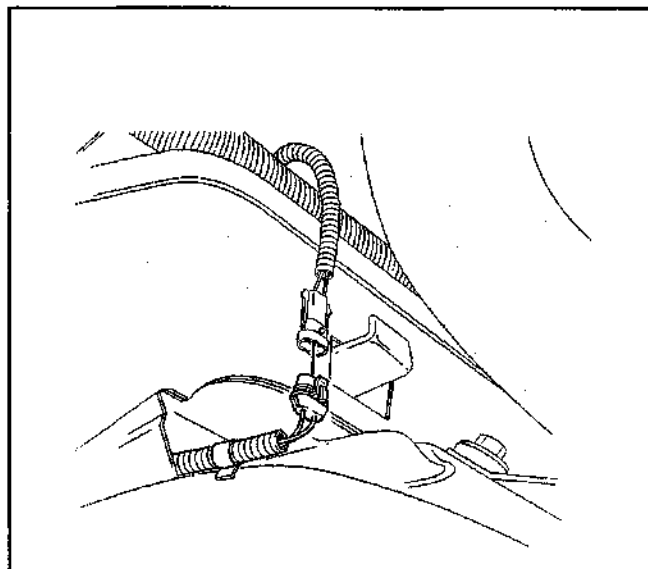
365423

90. Install a new O-ring.
91. Install the A/C compressor and condenser hose bolt.

Tighten

Tighten the A/C compressor and condenser hose bolt to 33 N·m (24 lb ft).

92. Connect the wheel speed sensors electrical connectors.
93. Connect the knock sensors electrical connectors.

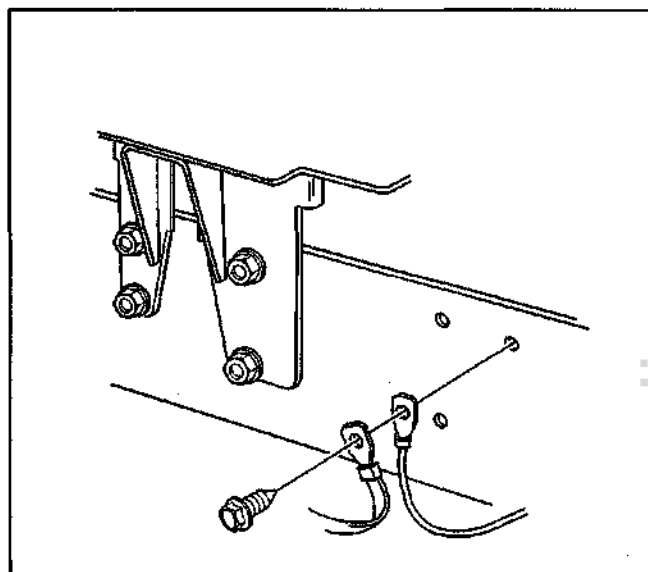


346036

94. Install the RF ground strap, cruise control lead and wiring harness ground bolt to the front rail.

Tighten

Tighten the wiring harness ground bolt to 12 N·m (106 lb in).



346034

95. Install the intermediate steering shaft and bolt to the rack.

Tighten

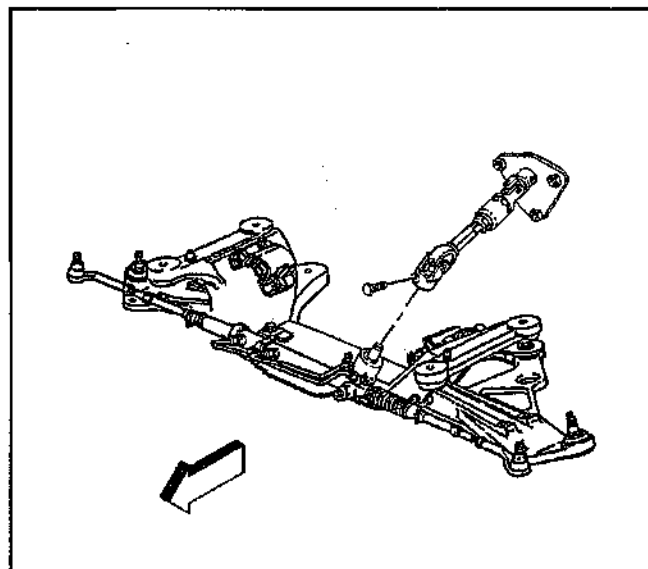
Tighten the intermediate shaft bolt to 47 N·m (35 lb ft).

96. Install the steering gear coupling shield.
97. Install the stabilizer bar brackets.
98. Install the stabilizer bar bracket bolts.

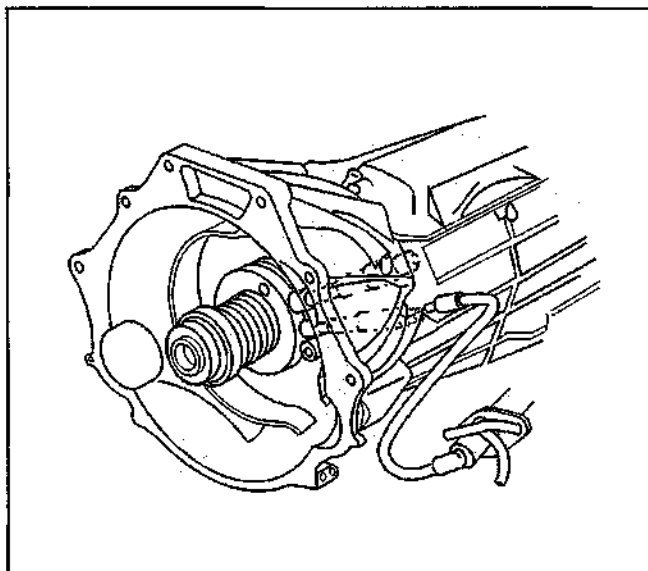
Tighten

Tighten the stabilizer bar bracket bolts to 55 N·m (41 lb ft).

99. Install the left side front air deflector. Refer to *Air Deflector Replacement - Front Bumper Fascia in Bumpers*.

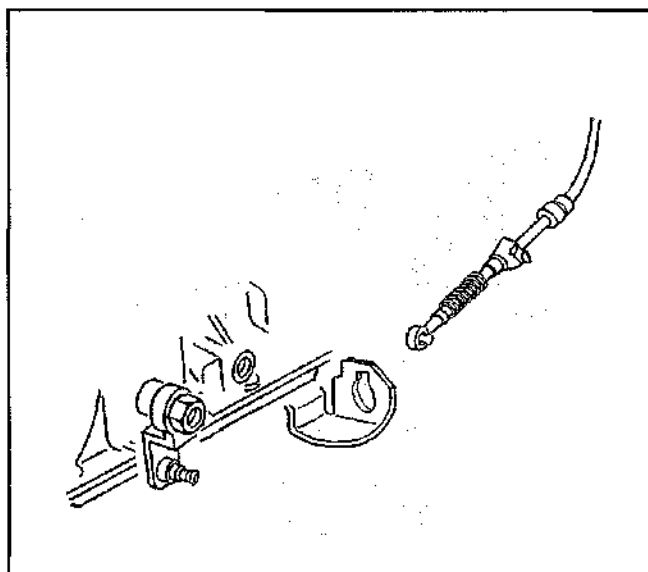


220630



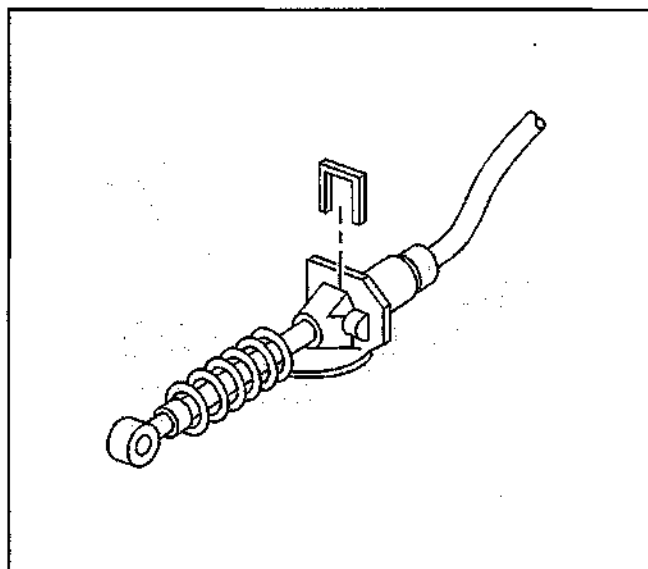
43255

100. On vehicles equipped with a manual transmission, connect the clutch actuator cylinder line to the actuator cylinder.



208276

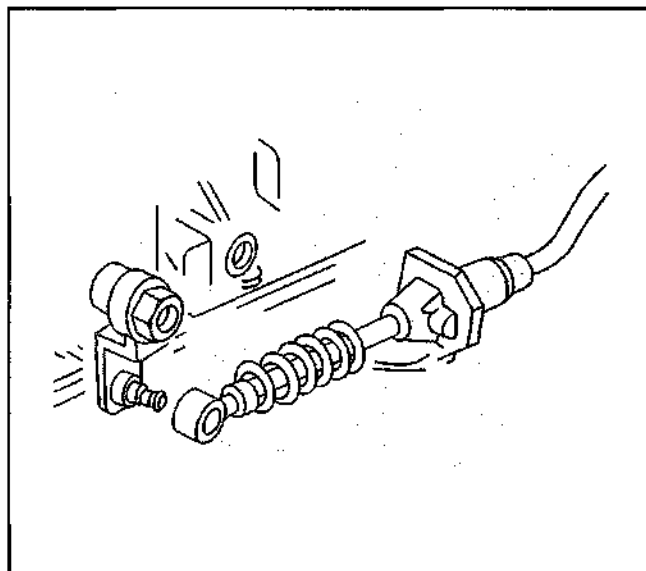
101. On vehicles equipped with a automatic transmission, install the range selector lever cable to the cable bracket.



341079

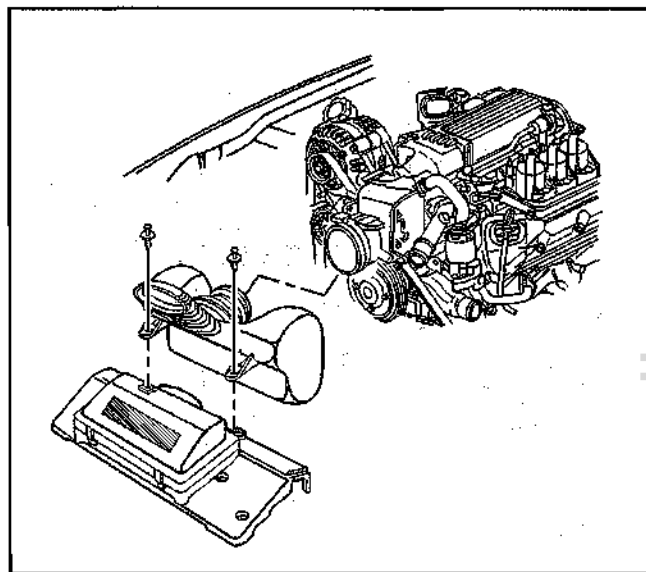
102. Install the retainer to the range selector lever cable.

103. Snap the transmission range selector lever cable to the range selector lever at the transmission.
104. Install the torque arm. Refer to *Torque Arm Replacement* in Rear Suspension.
105. Install the propeller shaft. Refer to *Propeller Shaft Replacement - One Piece* or *Propeller Shaft Replacement - Two Piece* in Propeller Shaft.
106. Install the 3-way catalytic converter. Refer to *Catalytic Converter Replacement (3.8 L)* in Engine Exhaust.
107. Install the front wheels. Refer to *Tire and Wheel Removal and Installation* in Tires and Wheels.
108. Lower the vehicle.



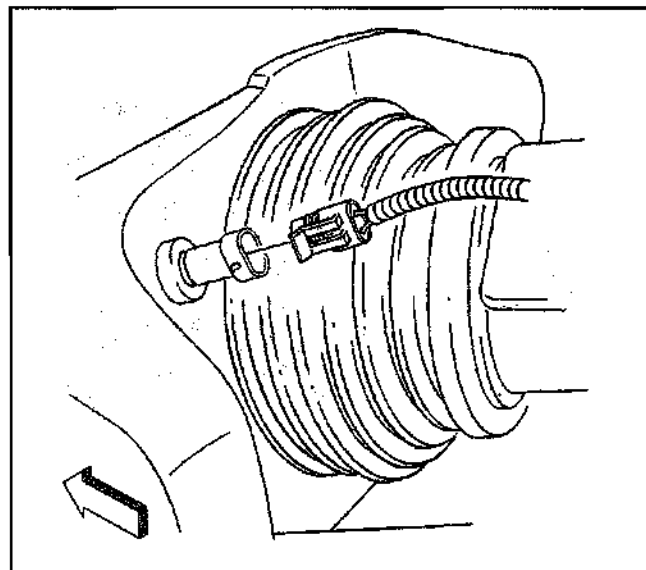
208264

109. Install the air intake duct.

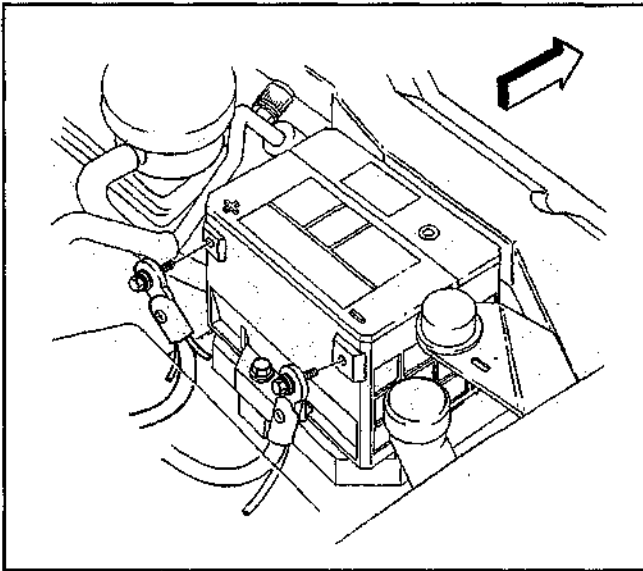


554755

110. Connect the intake air temperature (IAT) sensor electrical connector.



208554



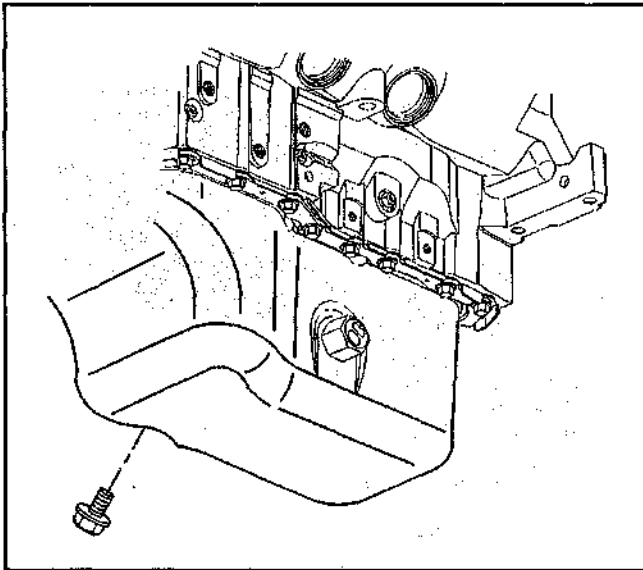
211587

111. Connect the positive battery cable.
112. Install the starter motor. Refer to *Starter Motor Replacement (3.8 L)* in Engine Electrical.
113. Refill the engine oil.
114. Refill the transmission fluid.
115. Refill the engine coolant. Refer to *Draining and Filling Cooling System (3.8 L)* in Engine Cooling.
116. Recharge the refrigerant. Refer to *Refrigerant Recovery and Recharging* in Heating, Ventilation and Air Conditioning.
117. Bleed the brakes. Refer to *Hydraulic Brake System Bleeding (Manual Bleeding)* or *Hydraulic Brake System Bleeding (Pressure Bleeding)* in Hydraulic Brakes.
118. Bleed the clutch hydraulic system. Refer to *Hydraulic Clutch Bleeding* in Clutch.
119. Perform the crankshaft position (CKP) system variation learn procedure. Refer to *CKP System Variation Learn Procedure* in Engine Controls - 3.8 L.

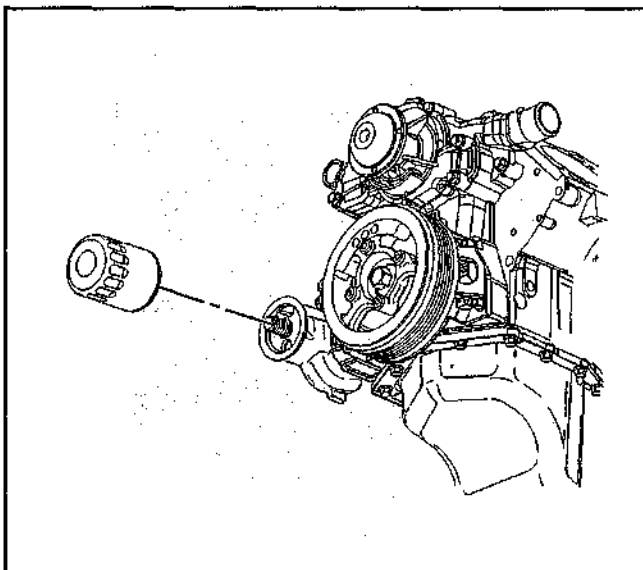
Engine Oil and Oil Filter Replacement

Removal Procedure

1. Raise and suitably support the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Position the oil drain pan under the engine oil drain plug.
3. Remove the engine oil drain plug.
4. Clean and inspect the engine oil drain plug, replace if necessary.
5. Clean and inspect the engine oil drain plug sealing surface on the oil pan, replace the oil pan if necessary.
6. Remove the oil filter.
7. Clean and inspect the oil filter sealing area on the oil filter adapter, replace if necessary. Refer to *Oil Filter Adapter Removal*.



190564



440847

Installation Procedure

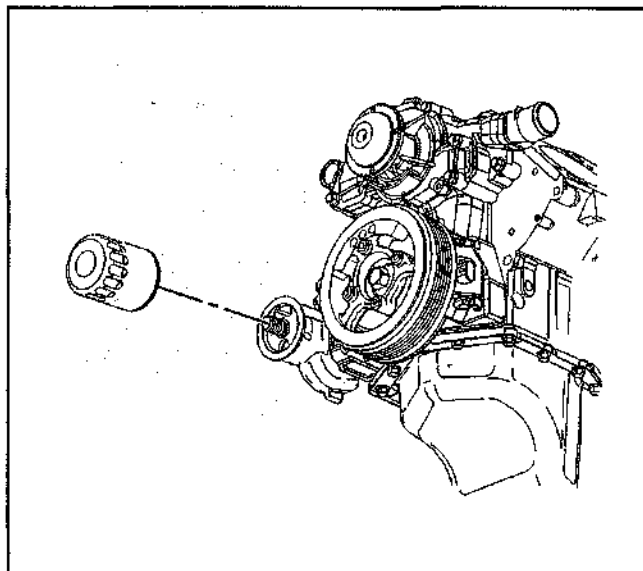
1. Lightly oil the replacement oil filter gasket with clean engine oil.

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

2. Install a new engine oil filter.

Tighten

Tighten the engine oil filter to 30 N·m (22 lb ft).



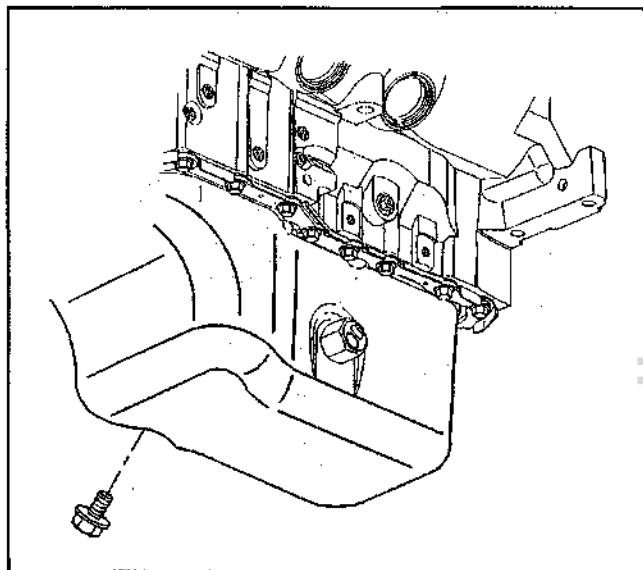
440847

3. Install the engine oil drain plug.

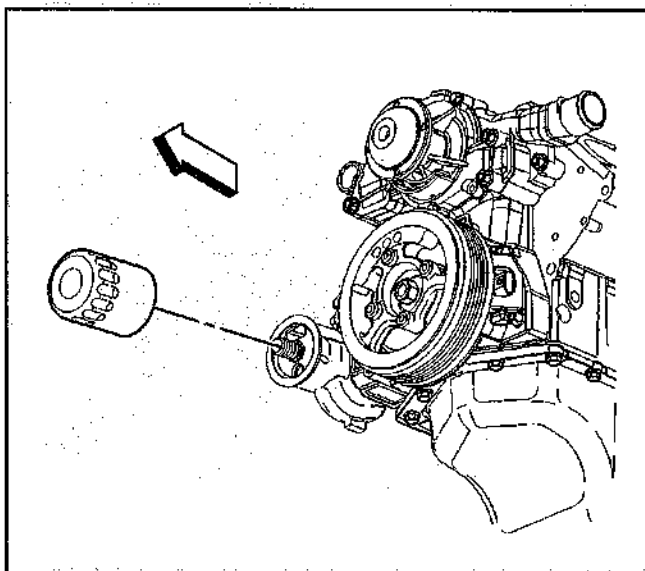
Tighten

Tighten the engine oil drain plug to 30 N·m (22 lb ft).

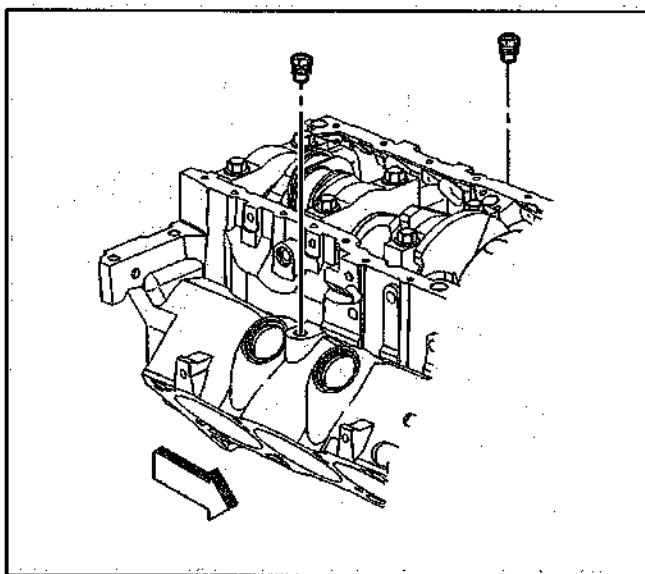
4. Remove the oil drain pan.
5. Lower the vehicle.
6. Fill the engine with new engine oil.
7. Start the engine.
8. Inspect for oil leaks after engine start up.
9. Turn off the engine and allow the oil a few minutes to drain back into the oil pan.
10. Remove the oil level indicator from the oil level indicator tube.
11. Clean off the indicator end of the oil level indicator with a clean paper towel or cloth.
12. Install the oil level indicator into the oil level indicator tube until the oil level indicator handle contacts the top of the oil level indicator tube.
13. Again, remove the oil level indicator from the oil level indicator tube keeping the tip of the oil level indicator down.
14. Check the level of the engine oil on the oil level indicator.
15. If needed add or drain the engine oil to the correct level.



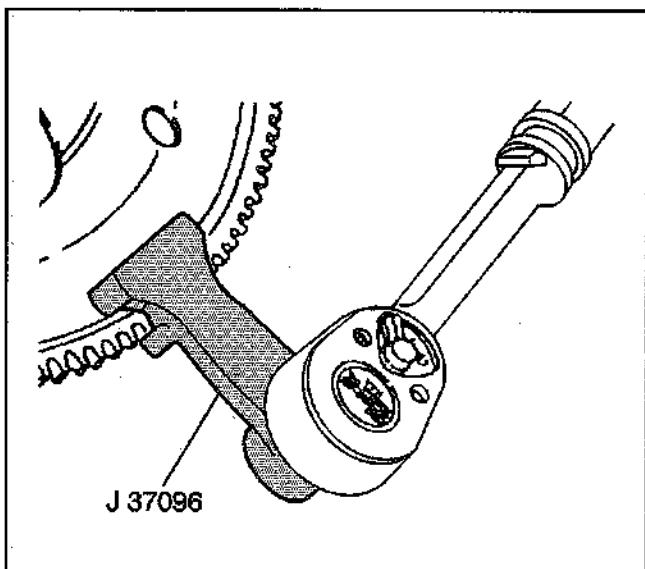
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211914



309963

Draining Fluids and Oil Filter Removal

Draining the Engine

1. Remove the oil drain plug.
2. Drain the engine oil.
3. Remove the oil filter.

4. Remove the coolant drain plugs.
5. Drain the coolant.

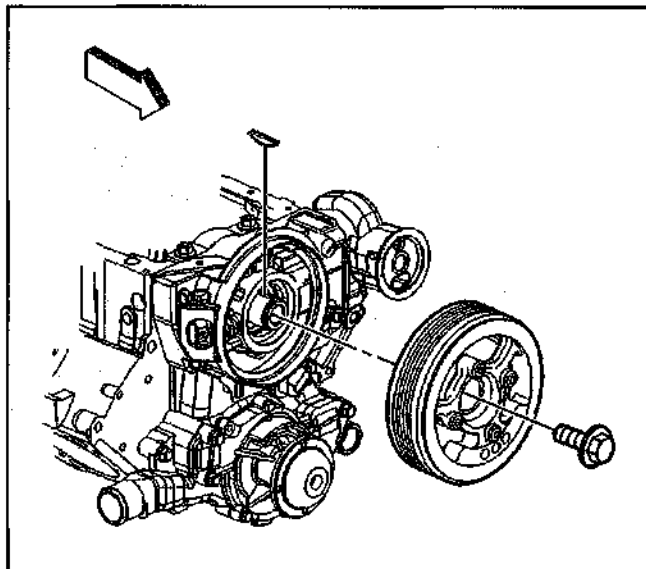
Crankshaft Balancer Removal

Tools Required

- J 37096 Flywheel Holding Tool
- J 38197 Crankshaft Balancer Puller

1. Use J 37096 to hold the flywheel.

2. Remove the crankshaft balancer bolt.

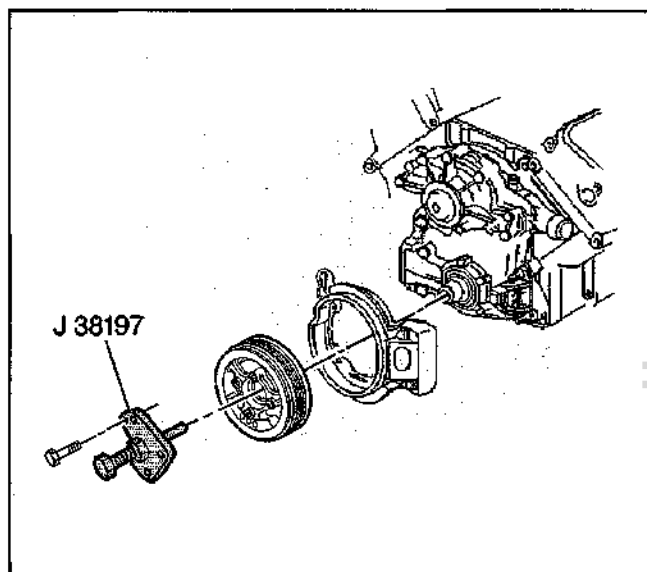


192730

3. Use J 38197 to remove the crankshaft balancer.

Important: Do not separate the crankshaft pulley from the crankshaft balancer. Service the crankshaft pulley and the crankshaft balancer as an assembly.

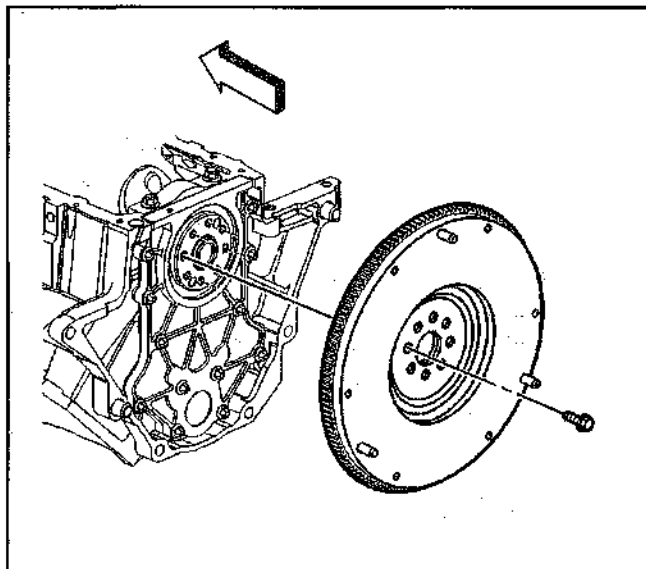
- 3.1. Invert J 38197-2 so the leg of the tool is facing away from the crankshaft balancer.
- 3.2. Install the silver screws J 38197-4 to the crankshaft balancer.
- 3.3. Turn J 38197-1 to remove the crankshaft balancer from the crankshaft.
- 3.4. Remove J 38197-1, J 38197-2, and J 38197-4 from the crankshaft balancer.



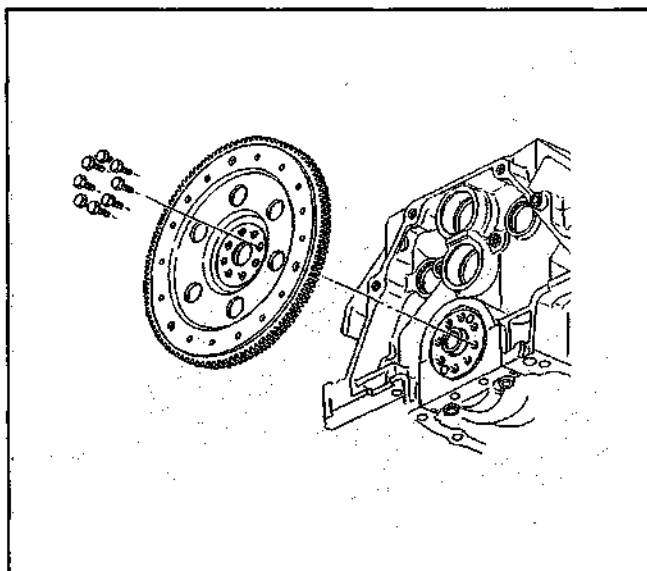
313955

Engine Flywheel Removal (Manual Transmission)

1. Remove the flywheel bolts. Discard the bolts.
2. Remove the flywheel.
3. Inspect the flywheel for damage. If the flywheel is damaged, replace the flywheel.
4. Inspect the crankshaft and flywheel mating surfaces for burrs. If necessary, replace the flywheel.



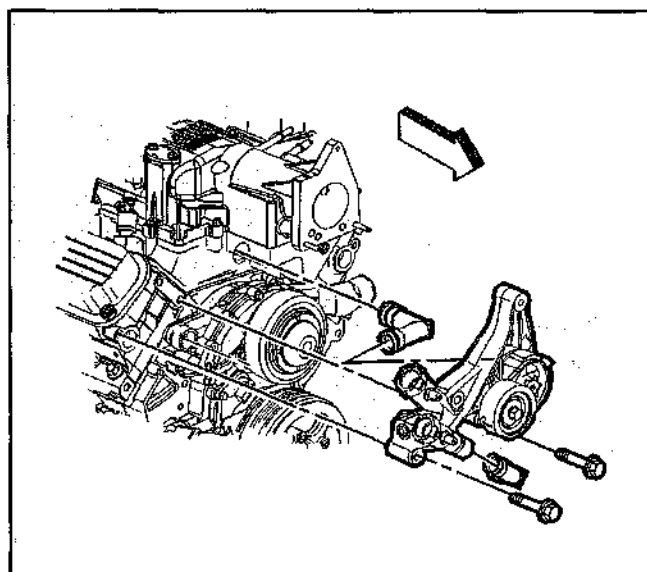
192727



36665

Engine Flywheel Removal (Automatic Transmission)

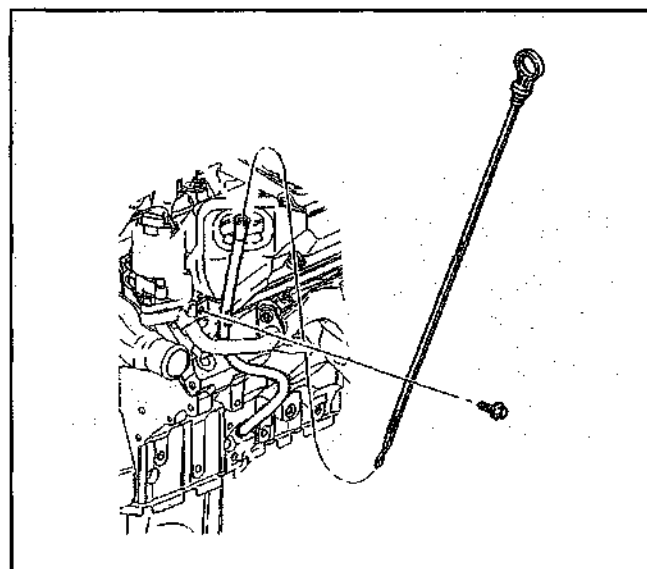
1. Remove the flywheel bolts. Discard the bolts.
2. Remove the flywheel.
3. Inspect the flywheel for damage. If the flywheel is damaged, replace the flywheel.
4. Inspect the crankshaft and flywheel mating surfaces for burrs. If necessary, replace the flywheel.



313973

Drive Belt Tensioner Removal

1. Remove the drive belt tensioner bolts.
2. Remove the drive belt tensioner.



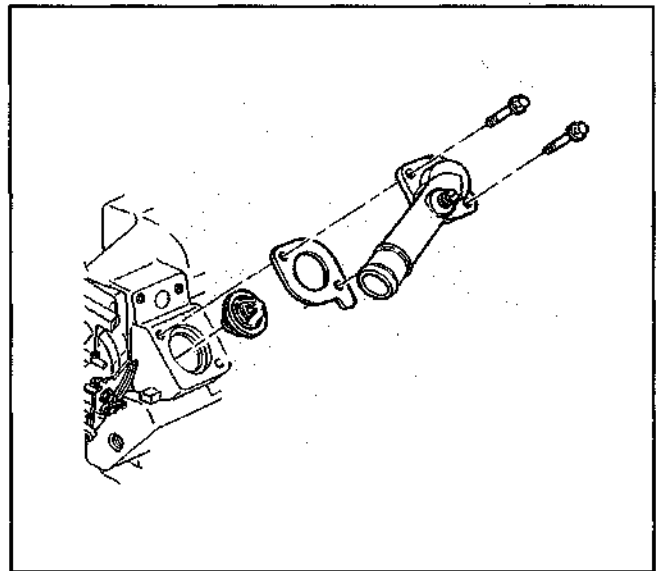
36615

Oil Level Indicator and Tube Removal

1. Remove the oil level indicator bolt.
2. Remove the oil level indicator.

Water Outlet Removal

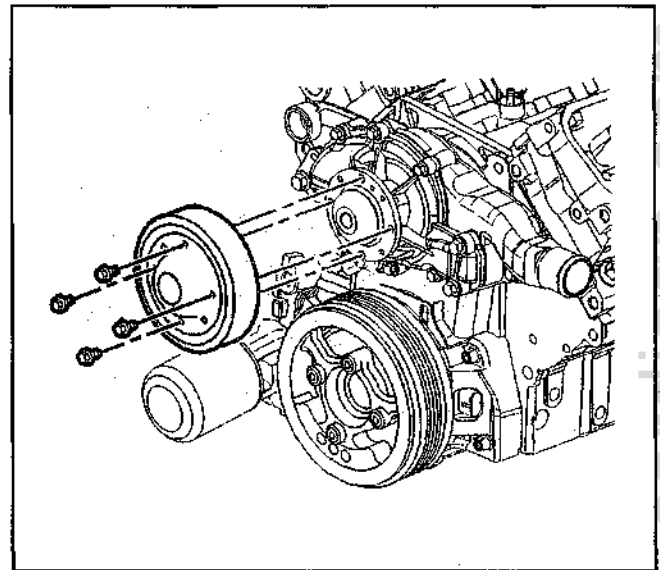
1. Remove the water outlet bolts.
2. Remove the water outlet.
3. Remove the water outlet gasket.
4. Remove the thermostat.



36621

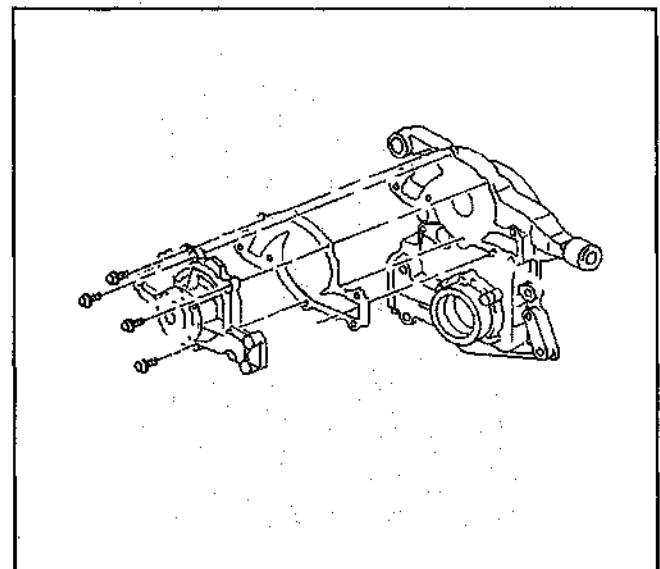
Water Pump Removal

1. Remove the water pump pulley bolts.
2. Remove the water pump pulley.

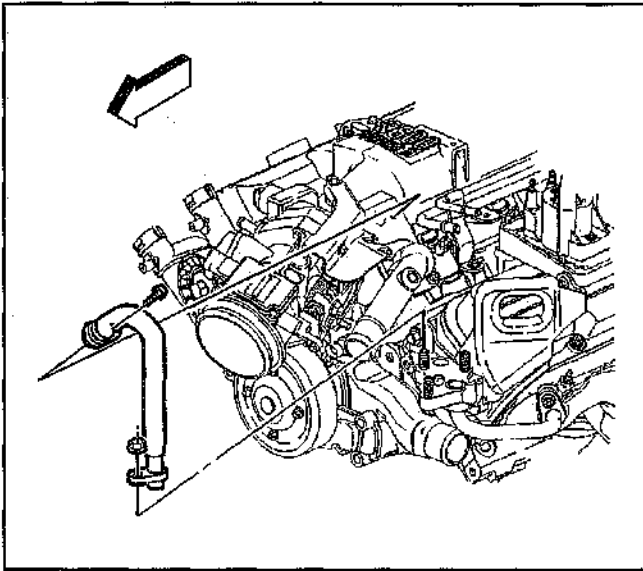


313967

3. Remove the water pump bolts.
4. Remove the water pump.
5. Remove the water pump gasket.



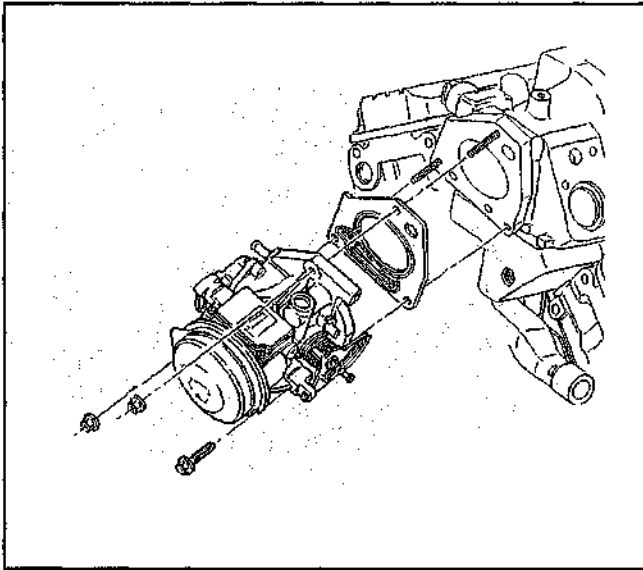
36600



36609

Intake Manifold Removal (Upper)

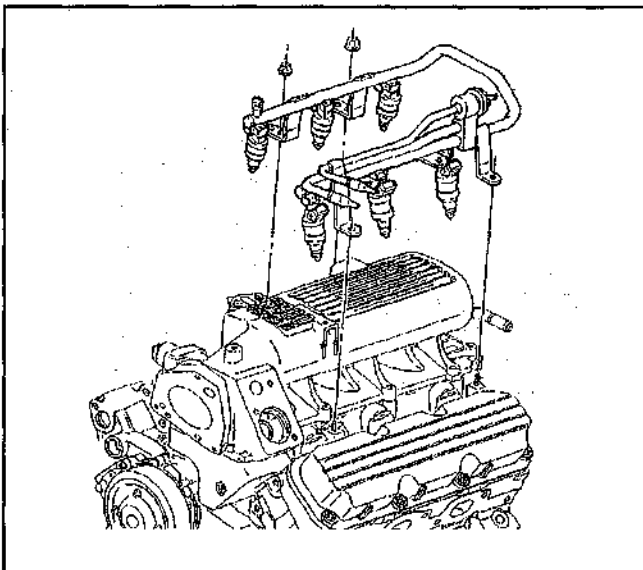
1. Remove the right spark plug wires.
2. Remove the manifold vacuum source.
3. Remove the EGR outlet pipe bolt and nut.
4. Remove the EGR outlet pipe from the intake manifold.



36624

Notice: The two bolts which fasten the lower intake manifold to the cylinder head are accessible only after the upper intake is removed. The bolts are located in the right front and left rear corners of the lower intake manifold. Remove the upper intake manifold to service the lower intake.

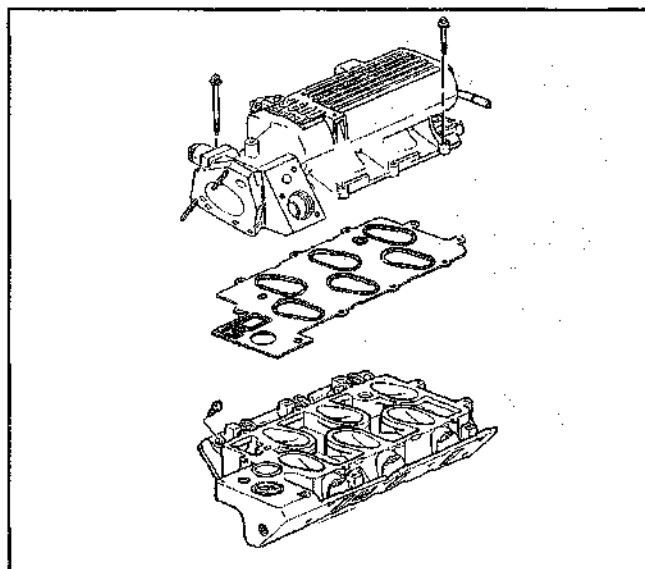
5. Remove the throttle body nuts and bolt.
6. Remove the throttle body.
7. Remove the throttle body gasket.



36631

8. Remove the fuel injector rail nuts.
9. Remove the fuel injector rail.

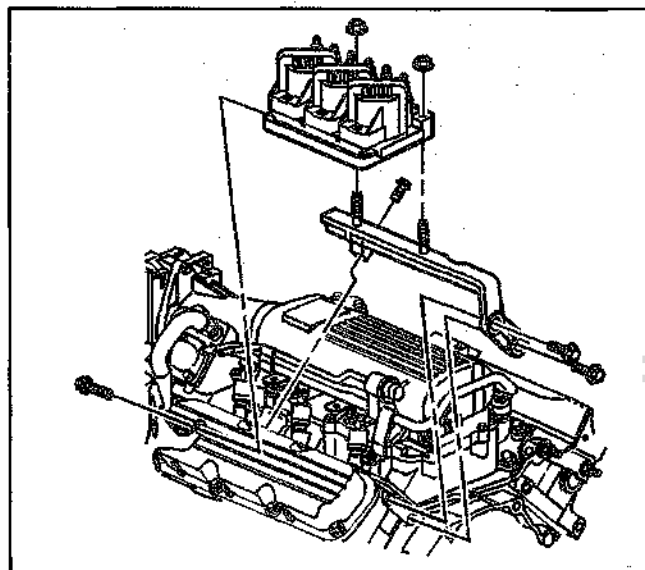
10. Remove the upper intake manifold bolts.
11. Remove the upper intake manifold.
12. Remove the upper intake manifold gasket.



36634

Intake Manifold Removal (Lower)

1. Remove the ignition control module and bracket.
2. Remove the generator bracket.

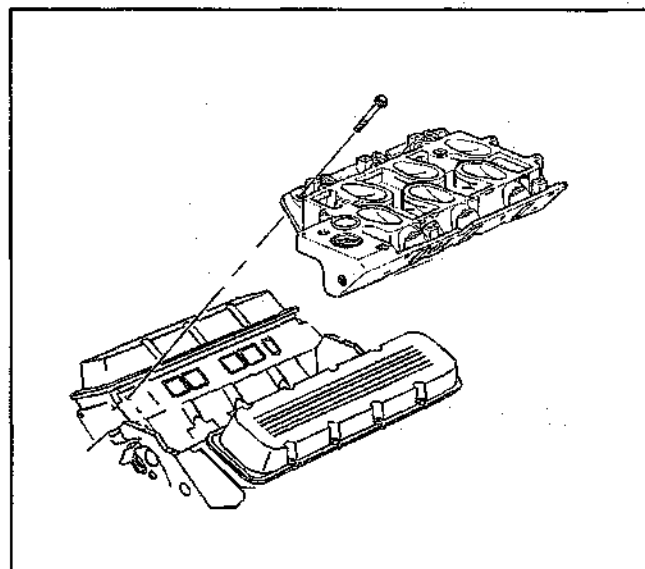


566980

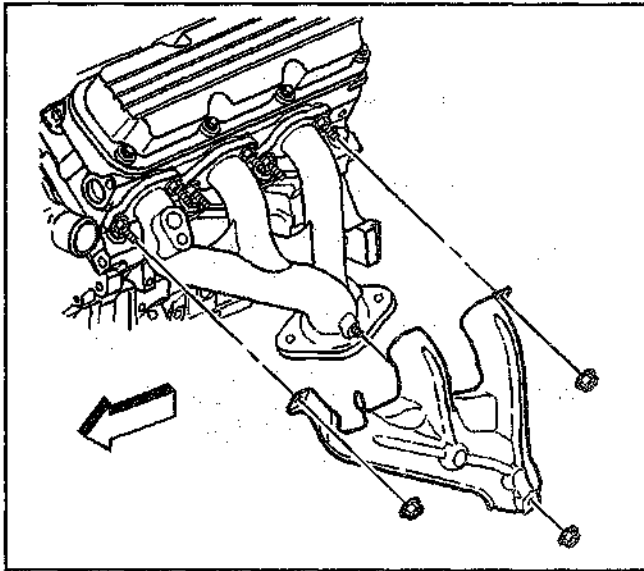
3. Remove the lower intake manifold bolts.

Notice: The two bolts which fasten the lower intake manifold to the cylinder head are accessible only after the upper intake is removed. The bolts are located in the right front and left rear corners of the lower intake manifold. Remove the upper intake manifold to service the lower intake.

4. Remove the lower intake manifold.
5. Remove the lower intake manifold gasket.



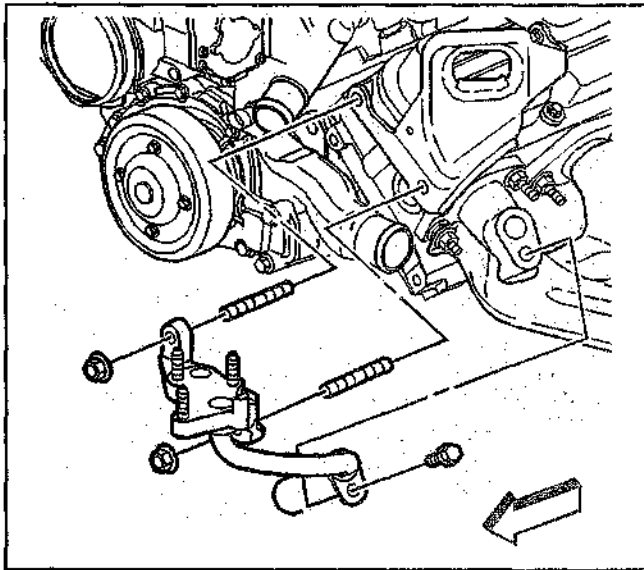
50046



589352

Exhaust Manifold Removal (Left Side)

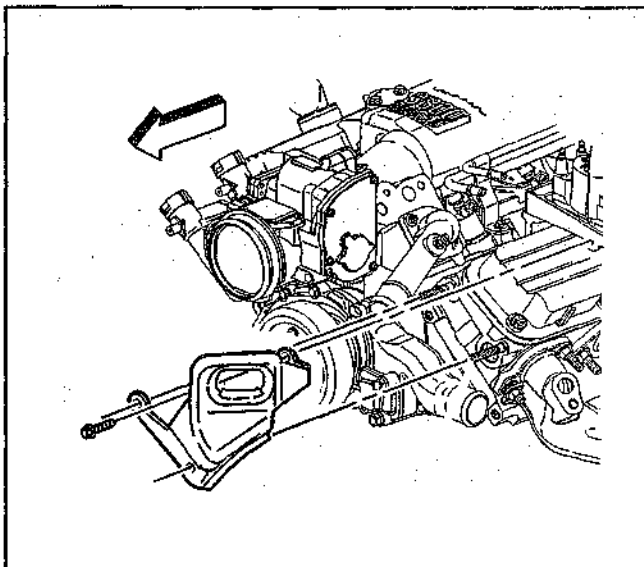
1. Remove the exhaust manifold heat shield nuts.
2. Remove the exhaust manifold heat shield.



589355

Important: When removing the EGR inlet tube from the left exhaust manifold, inspect the pipe for leaks during installation. Replace the EGR adapter if the pipe leaks.

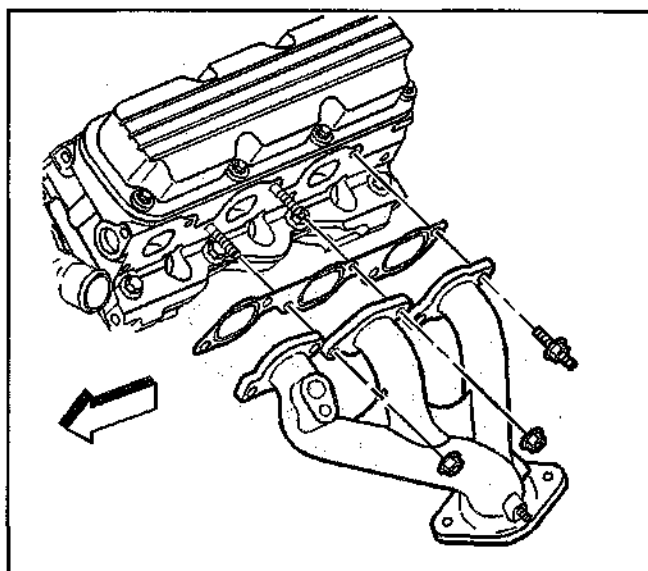
3. Remove the EGR inlet pipe bolt and nuts.
4. Remove the EGR inlet pipe from the exhaust manifold.



566982

5. Remove the engine lift hook.

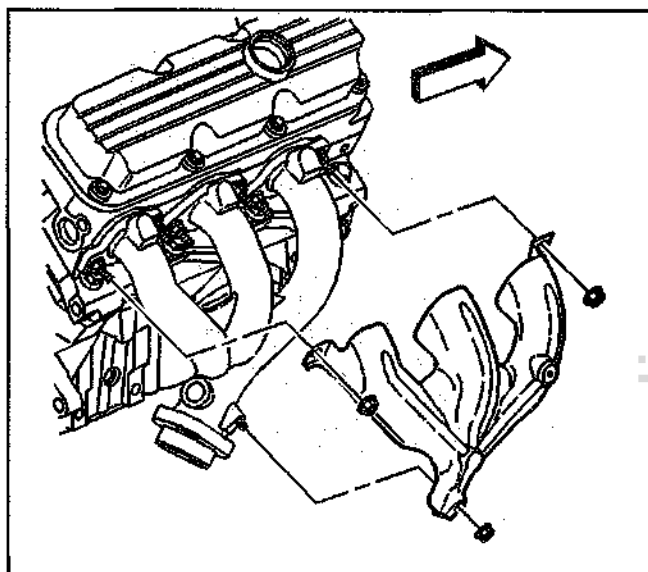
6. Remove the exhaust manifold nuts.
7. Remove the exhaust manifold.
8. Remove the exhaust manifold gasket.



589361

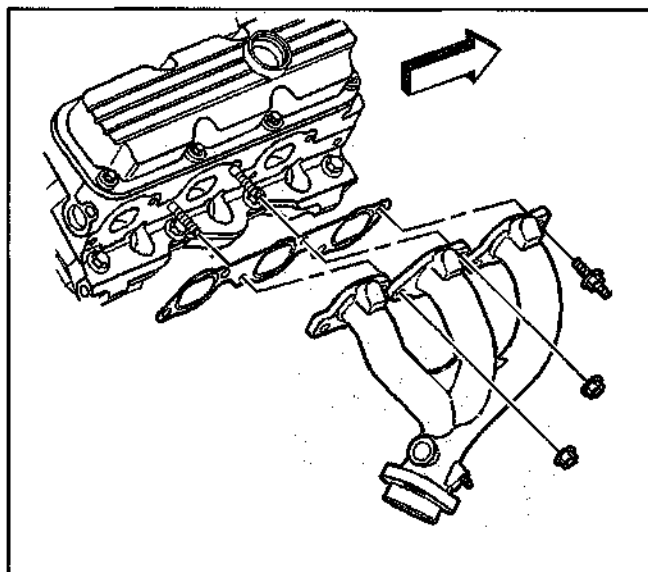
Exhaust Manifold Removal (Right Side)

1. Remove the exhaust manifold heat shield nuts.
2. Remove the exhaust manifold heat shield.

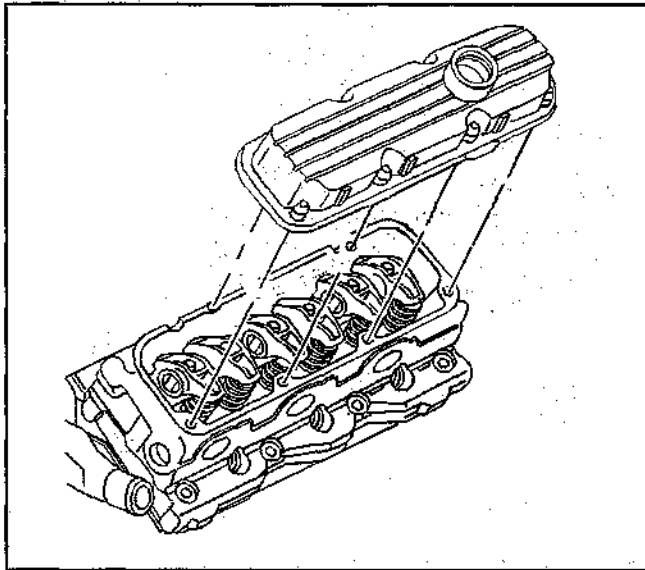


589365

3. Remove the exhaust manifold nuts.
4. Remove the exhaust manifold.
5. Remove the exhaust manifold gasket.



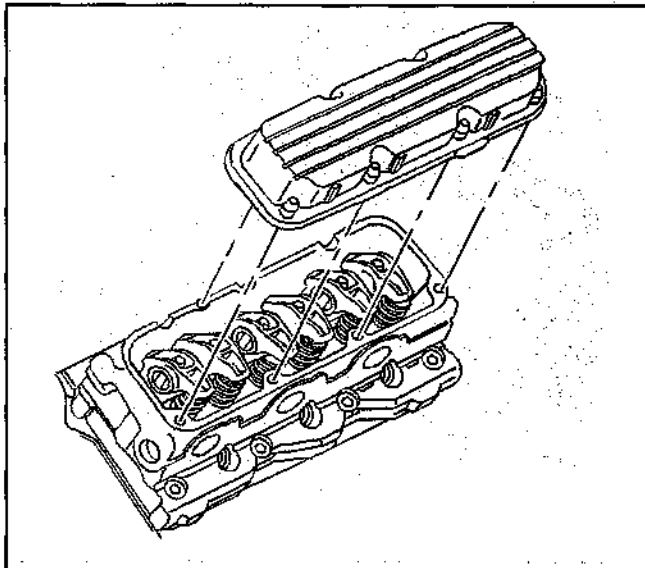
589366



35819

Valve Rocker Arm Cover Removal (Left Side)

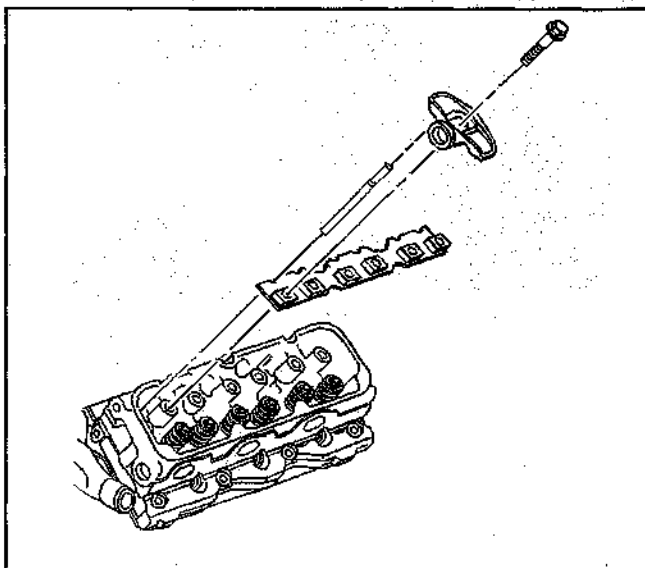
1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover.



63414

Valve Rocker Arm Cover Removal (Right Side)

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover.



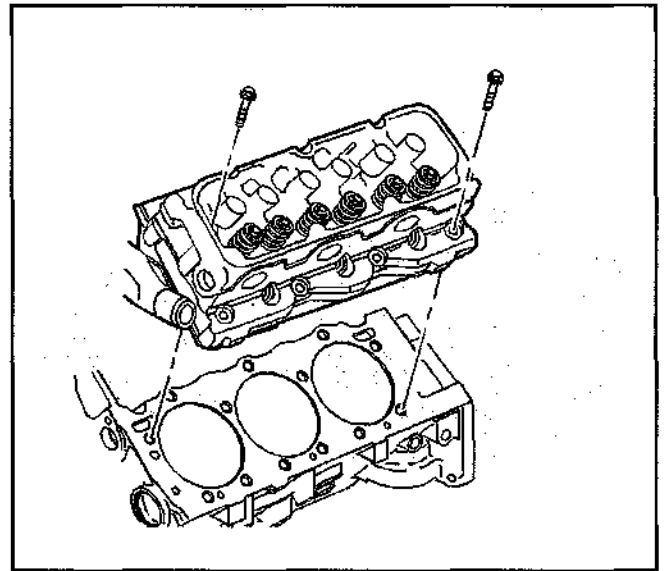
35840

Valve Rocker Arm and Push Rod Removal

1. Remove the valve rocker arm bolts.
2. Remove the valve rocker arm.
3. Remove the push rods.

Cylinder Head Removal

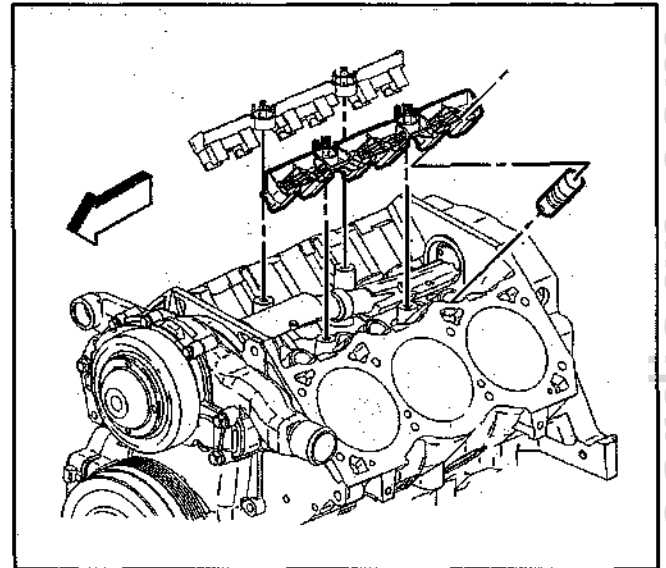
1. Remove the cylinder head bolts.
2. Discard the cylinder head bolts.
3. Remove the cylinder head.
4. Remove the cylinder head gasket.



35842

Valve Lifter Removal

1. Remove the valve guide retainer bolts.
2. Remove the valve guide retainers.
3. Remove the valve lifters.

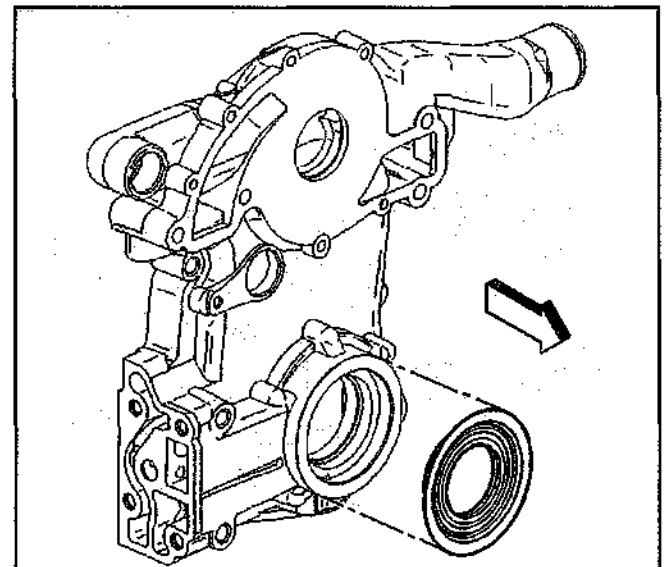


41374

Crankshaft Front Oil Seal Removal

Important: Do not damage the seal bore or the contact surfaces.

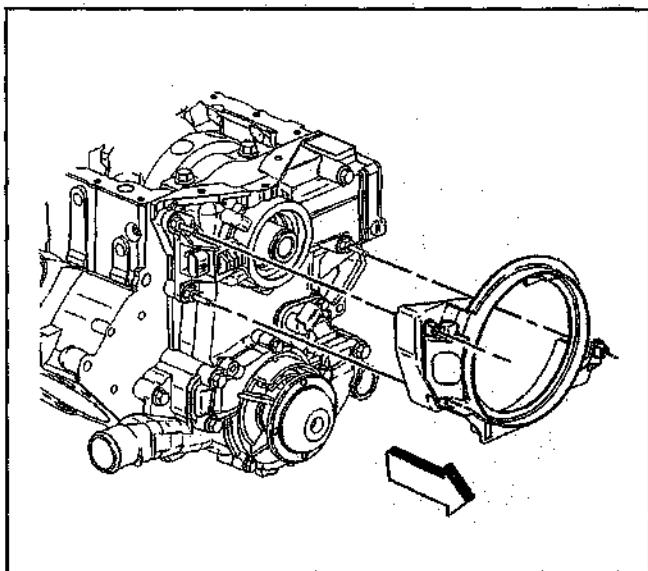
Use a screwdriver to pry out the crankshaft front oil seal.



26135

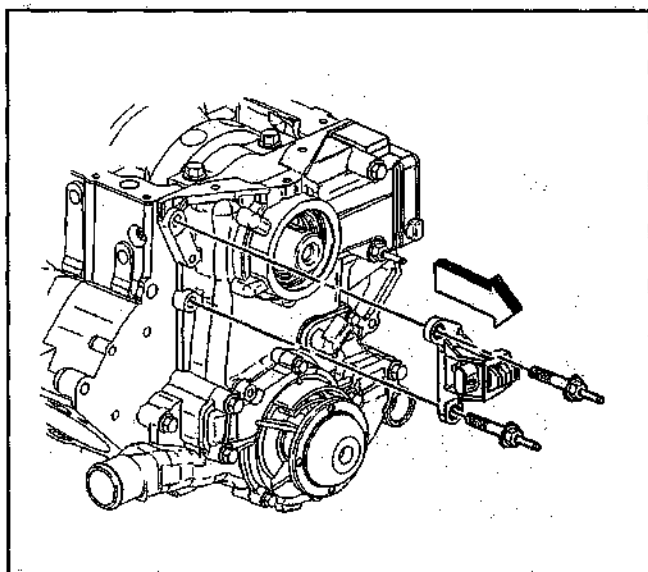
Engine Front Cover Removal

1. Remove the crankshaft position sensor shield.



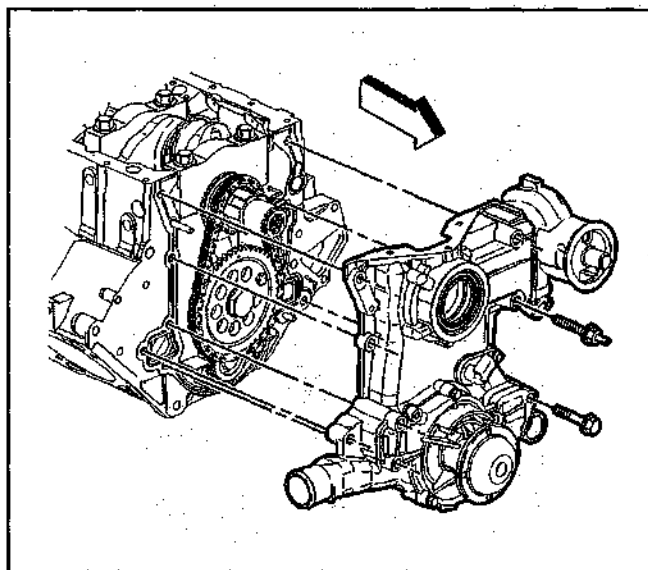
35844

2. Remove the crankshaft position sensor studs.
3. Remove the crankshaft position sensor.
4. Remove the bolts connecting the oil pan to the engine front cover.



36589

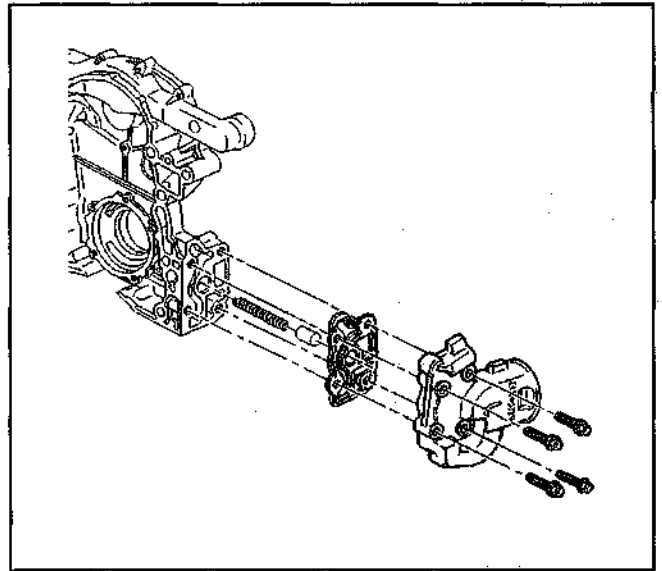
5. Remove the engine front cover bolts and stud.
6. Remove the engine front cover.
7. Remove the engine front cover gasket.



345236

Oil Filter Adapter Removal

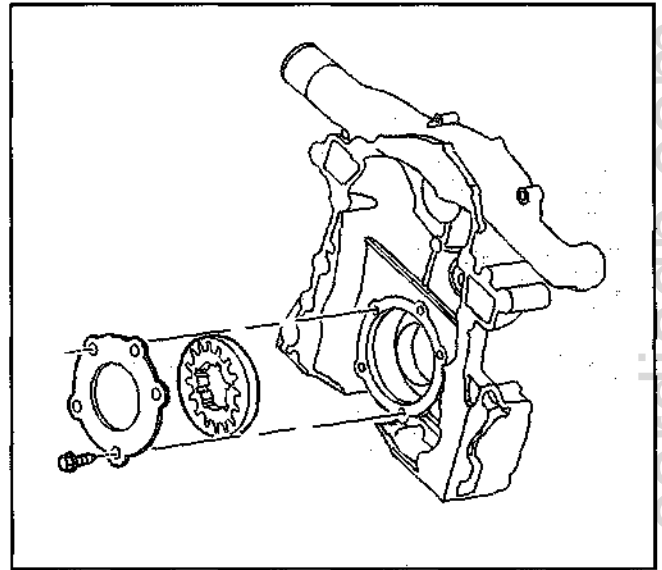
1. Remove the oil filter adapter bolts from the engine front cover.
2. Remove the oil filter adapter.
3. Remove the oil filter adapter gasket.
4. Remove the oil pressure relief valve.
5. Remove the oil pressure relief valve spring.



36655

Oil Pump Cover and Gear Set Removal

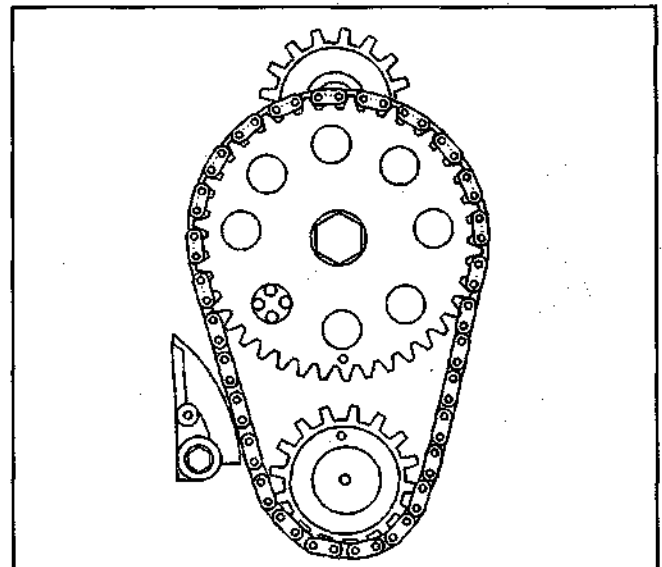
1. Remove the oil pump cover screws.
2. Remove the oil pump cover.
3. Remove the oil pump gears.



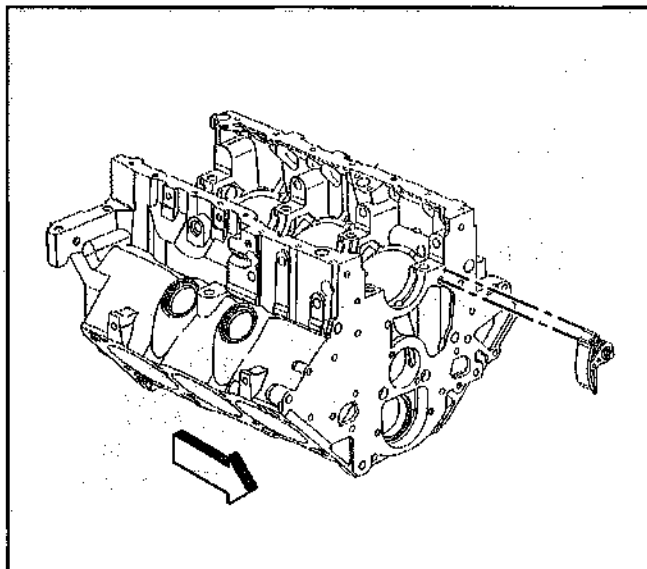
26160

Timing Chain and Sprockets Removal (VIN K)

1. Align the timing marks on the sprockets.

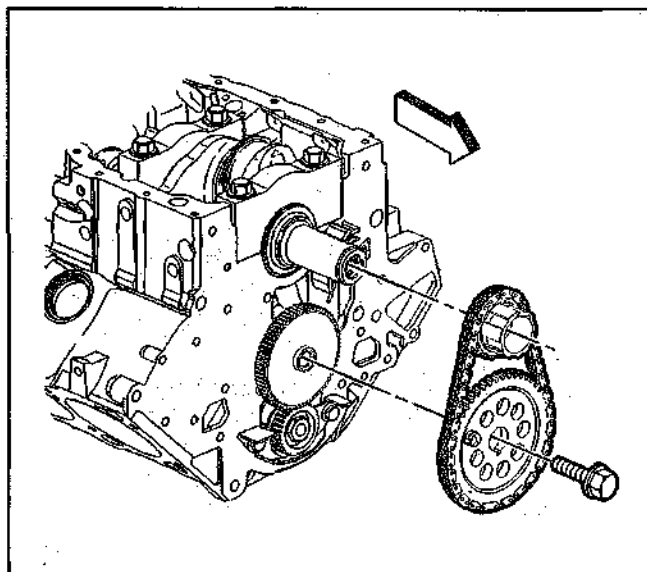


192708



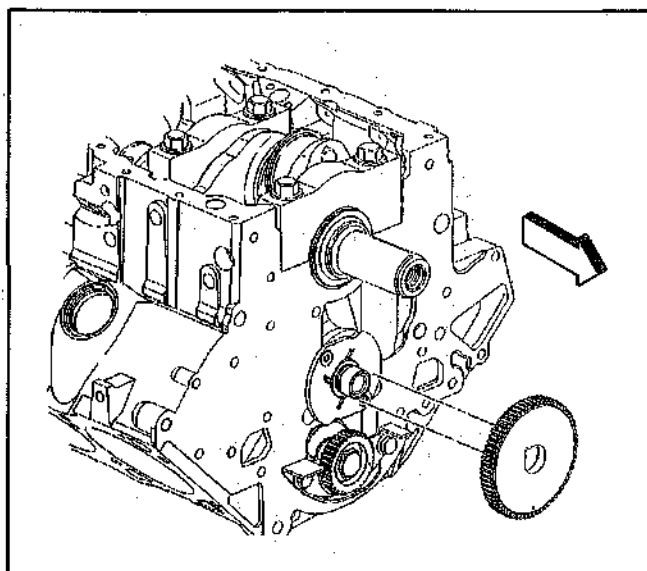
154523

2. Remove the timing chain dampener.



192716

3. Remove the camshaft sprocket bolt.
4. Remove the camshaft sprocket.
5. Remove the timing chain.
6. Remove the crankshaft sprocket.
7. Remove the crankshaft balancer key.

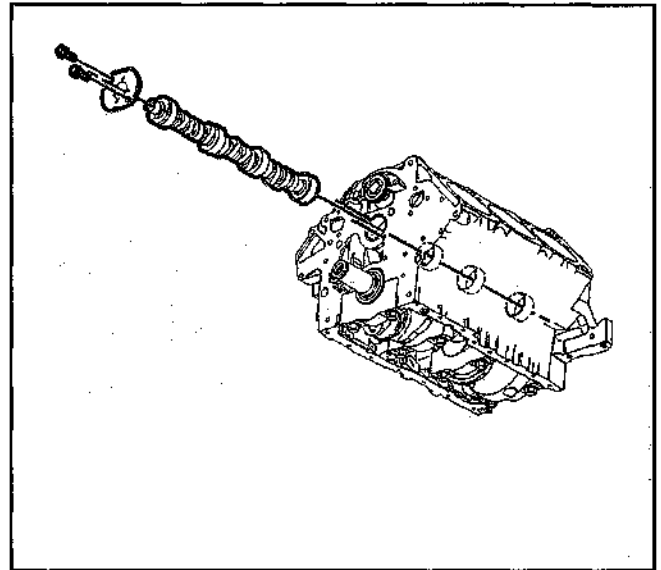


154519

8. Remove the balance shaft drive gear.

Camshaft Removal

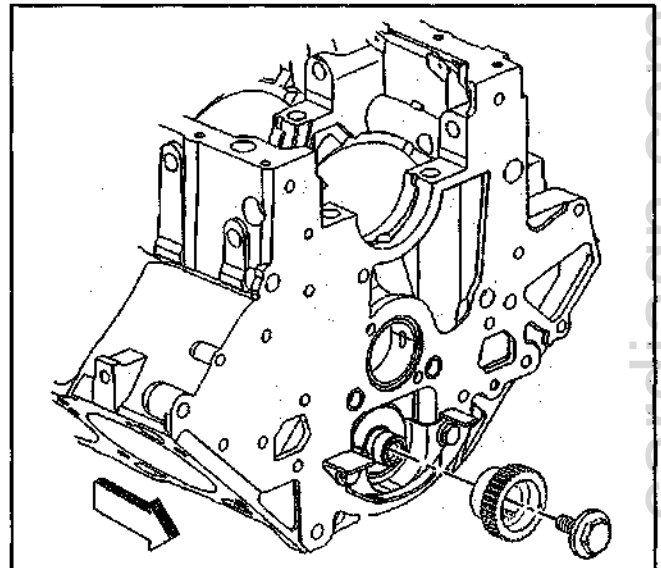
1. Remove the camshaft thrust plate screws.
2. Remove the camshaft thrust plate.
3. Remove the camshaft. Carefully rotate and pull the camshaft out of the camshaft bearings.



35815

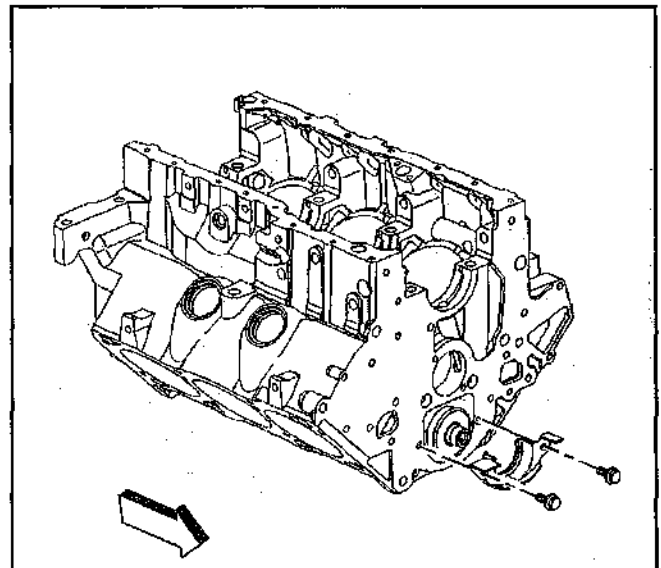
Balance Shaft Removal**Tools Required***J 6125-1B* Slide Hammer

1. Remove the balance shaft driven gear bolt.
2. Remove the balance shaft driven gear.

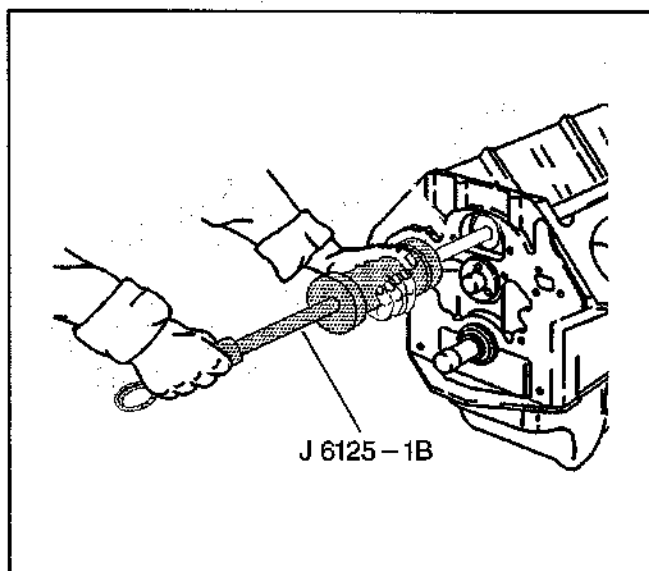


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3. Remove the balance shaft retainer bolts.
4. Remove the balance shaft retainer.

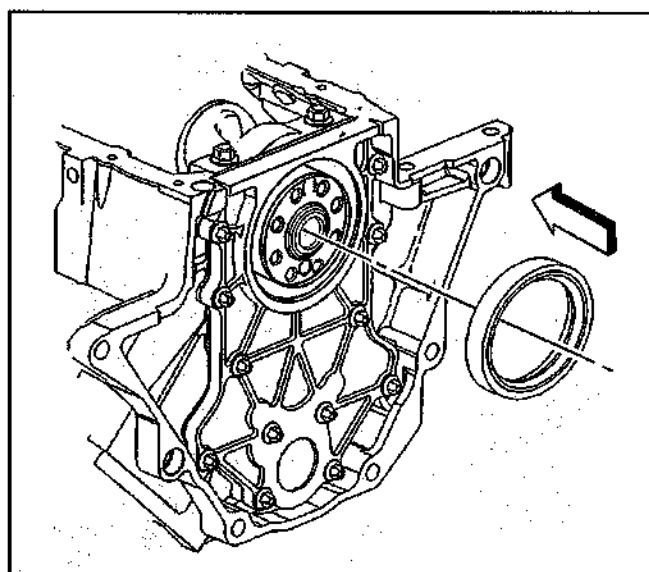


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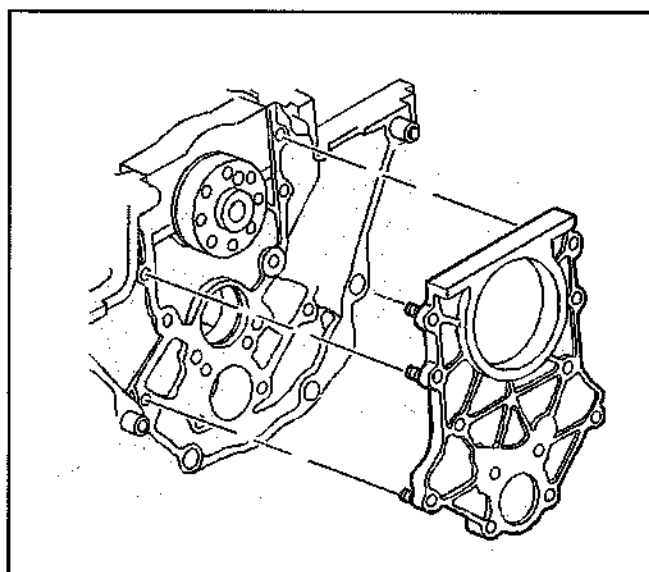
5. Use *J 6125-1B* to remove the balance shaft.



26129

Crankshaft Rear Oil Seal Removal

Important: Do not damage the crankshaft or the crankshaft rear oil seal housing.
Pry the crankshaft rear oil seal out with a screwdriver.



26125

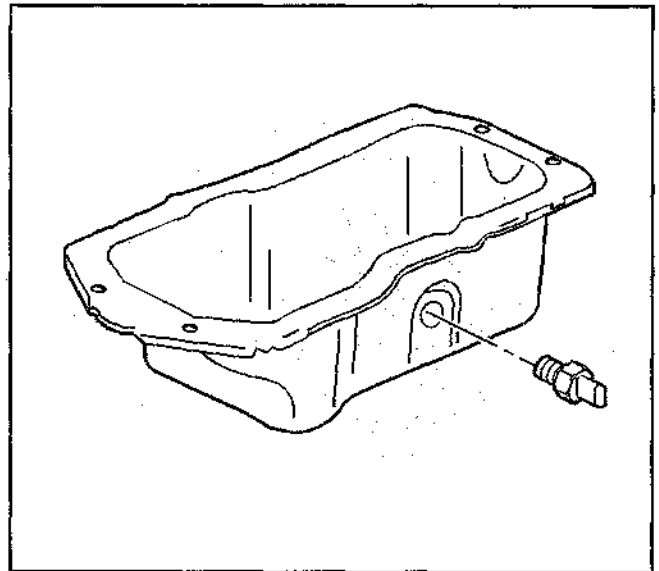
Crankshaft Rear Oil Seal and Housing Removal

1. Remove the crankshaft rear oil seal housing bolts. The bolts may remain in the crankshaft rear oil seal housing.
2. Remove the crankshaft rear oil seal housing.

Oil Pan Removal

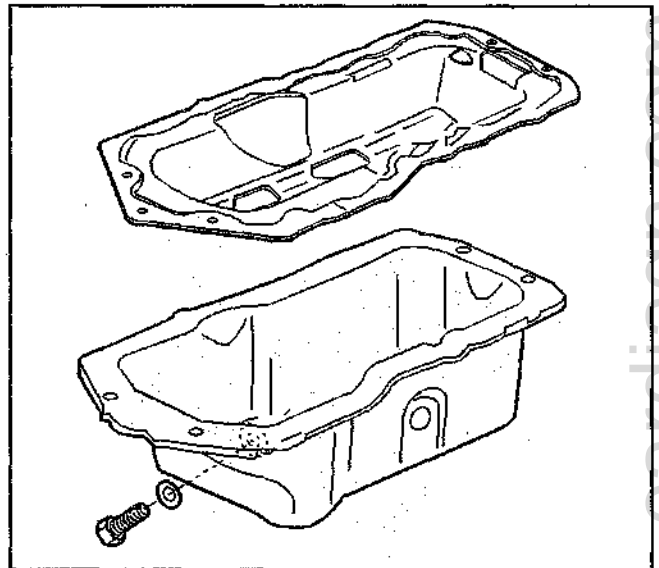
Notice: Remove the oil level sensor, located in the oil pan, before the oil pan is removed. The sensor may be damaged if the oil pan is removed first.

1. Remove the oil level sensor.



35861

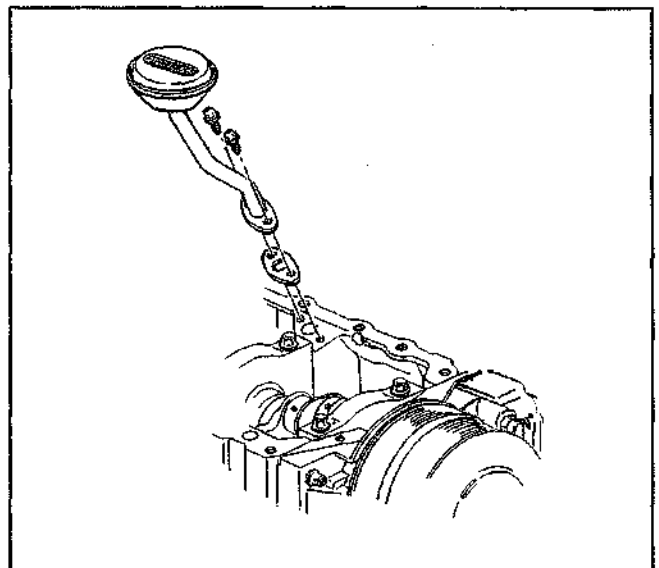
2. Remove the oil pan bolts.
3. Remove the oil pan.
4. Remove the oil pan gasket.



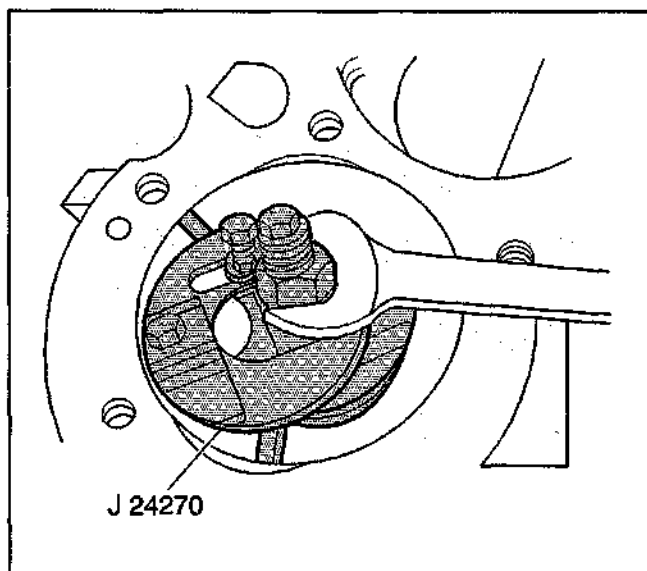
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Oil Pump Pipe and Screen Assembly Removal

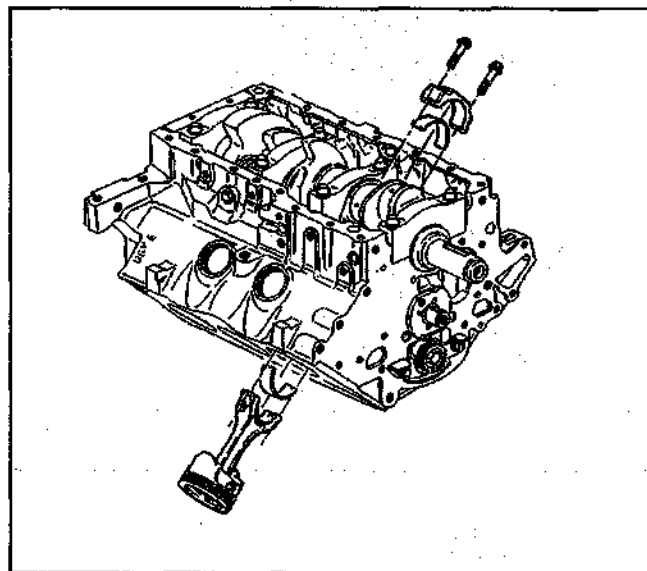
1. Remove the oil pump pipe and screen assembly bolts.
2. Remove the oil pump pipe and screen assembly.
3. Remove the oil pump pipe and screen assembly gasket.
4. Use solvent to clean the oil pump pipe and screen.



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Piston, Connecting Rod, and Bearing Removal

Tools Required

- J 41507 Connecting Rod Assembly Guide
- J 24270 Cylinder Ridge Reamer

1. Mark the connecting rod cap and the connecting rod for proper installation.

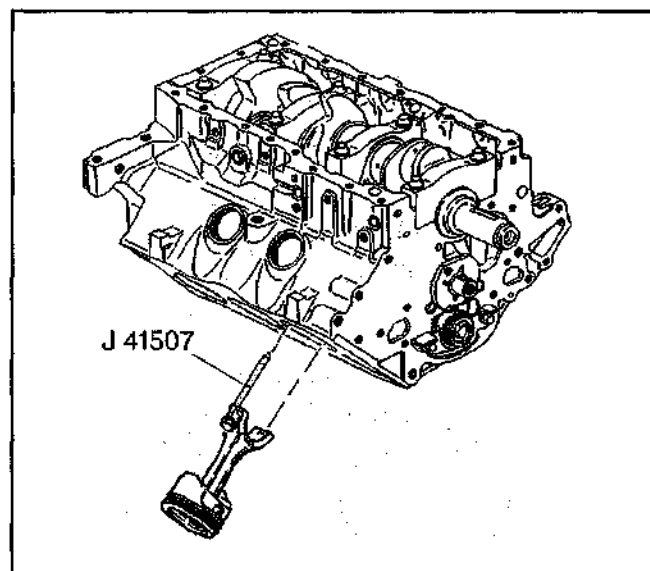
Notice: If there is a pronounced ridge at the top of the piston travel, the ridge must be removed with a ridge reamer before the piston and connecting rod assembly are removed. Applying force may break the piston rings or damage the piston.

2. Use the J 24270 to remove the cylinder bore ring ridge.
 - 2.1. Turn the crankshaft until the piston is at the bottom of the stroke.
 - 2.2. Cover the piston with a cloth.
 - 2.3. Remove the cylinder ring ridge.
 - 2.4. Turn the crankshaft until the piston is at the top of the stroke.
 - 2.5. Remove the cloth.
 - 2.6. Remove the metal shavings from the cylinder and piston.
3. Remove the connecting rod bolts.
4. Remove the connecting rod cap.

5. Install *J 41507* to the connecting rod. Hand tighten the tool to the connecting rod.
6. Use hand pressure on *J 41507* to push the connecting rod towards the top of the cylinder.

Important: Mark the piston with the number of the cylinder from which it was removed. Mark the piston as to what is the front for proper reassembly.

7. Remove the piston, the connecting rod, and the connecting rod bearings.



38180

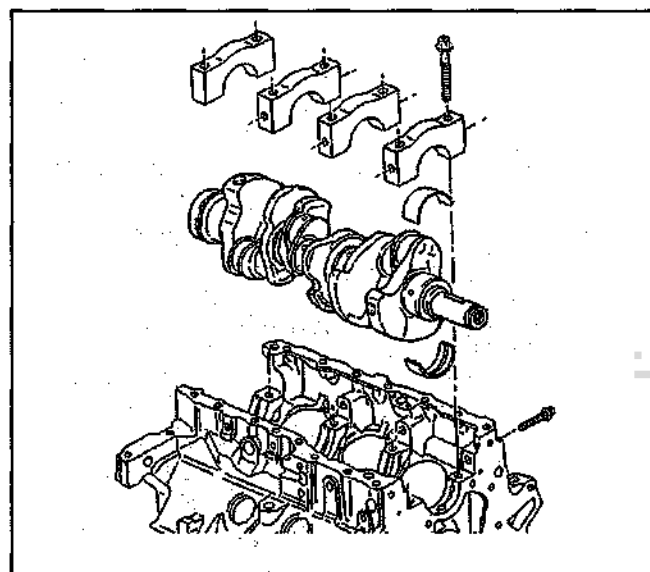
Crankshaft and Bearings Removal

Tools Required

- *J 6125-1B* Slide Hammer
- *J 41348* Main Bearing Cap Puller

Important: This engine has side bolts on all of the main caps except the rear cap. These bolts must be removed to service the caps.

1. Remove the crankshaft main bearing cap side bolts.
2. Remove the crankshaft main bearing cap bolts.



35963

Notice: Main bearing caps are press fit. Remove the caps carefully for service. *J 41348* has been designed to work with *J 6125-B* in order to prevent damage to the bearing and cap. *J 41348* MUST be installed properly into the bolt holes of the caps and *J 6125-B* attached to *J 41348* in order to properly remove the main cap without damaging the bearing or the cap. Any deviation from this procedure may cause damage to the cap and the bearing and may result in future engine damage.

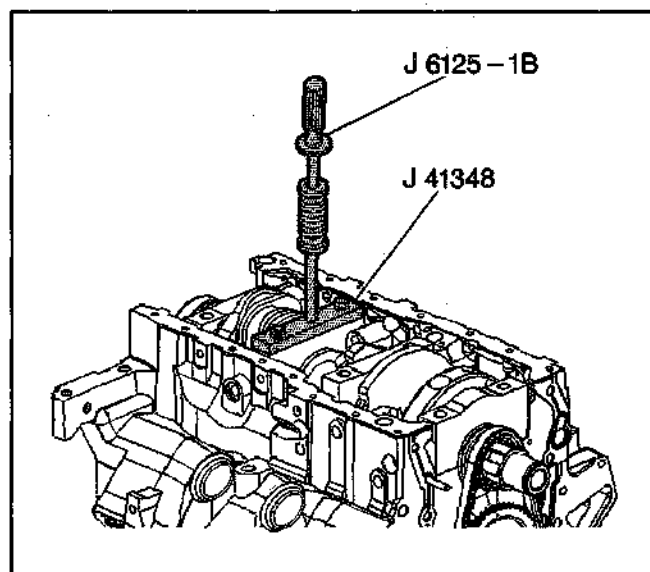
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install *J 41348* into the crankshaft main bearing cap bolt holes.

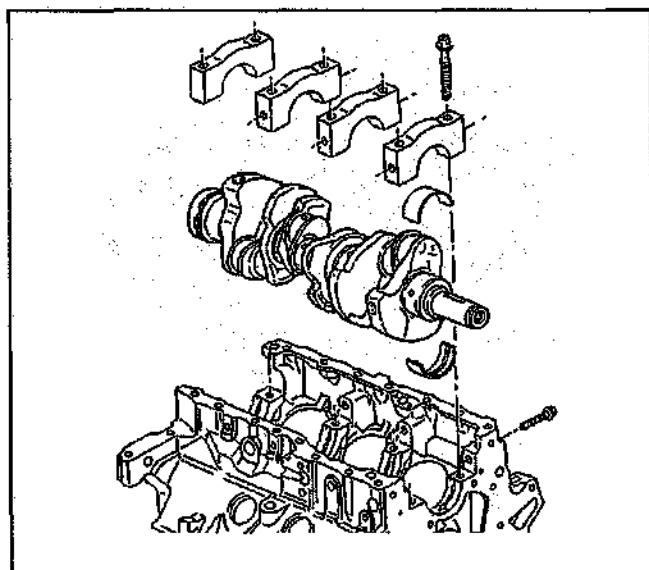
Tighten

Tighten the bolts on *J 41348* to 12 N·m (100 lb in).

4. Install *J 6125-1B* to *J 41348*.
5. Use *J 6125-1B* to remove the crankshaft main bearing caps.

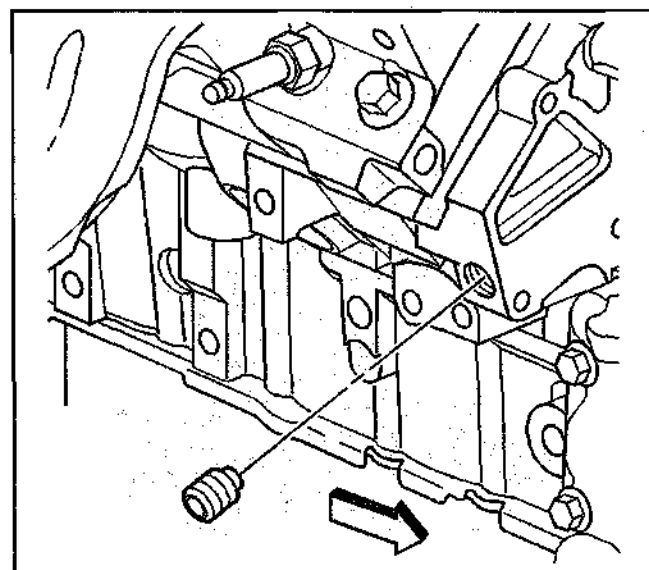


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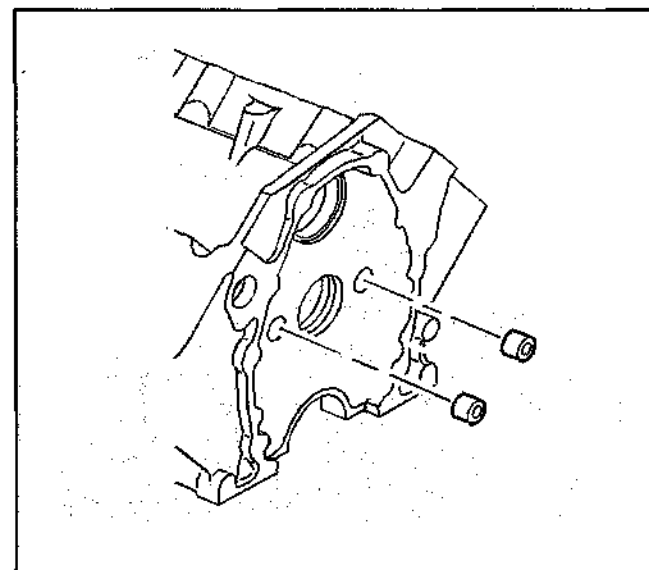
6. Remove the crankshaft.
7. Remove the upper main bearings from the engine block.



589370

Engine Block Plug Removal

1. Remove the threaded coolant jacket plugs.

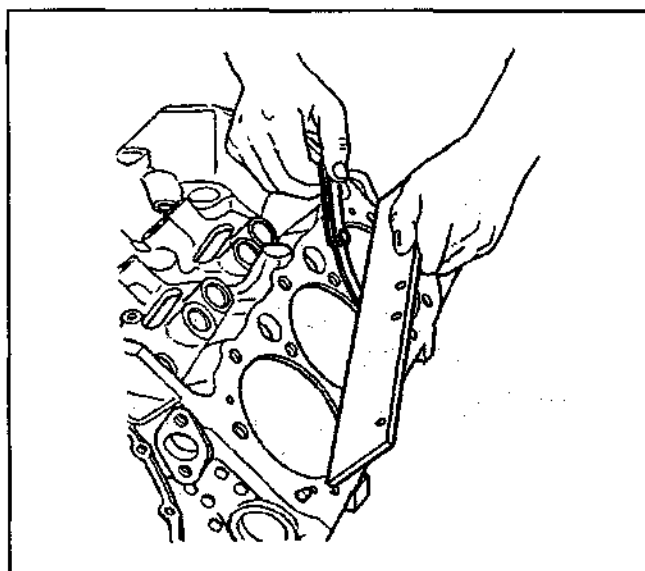


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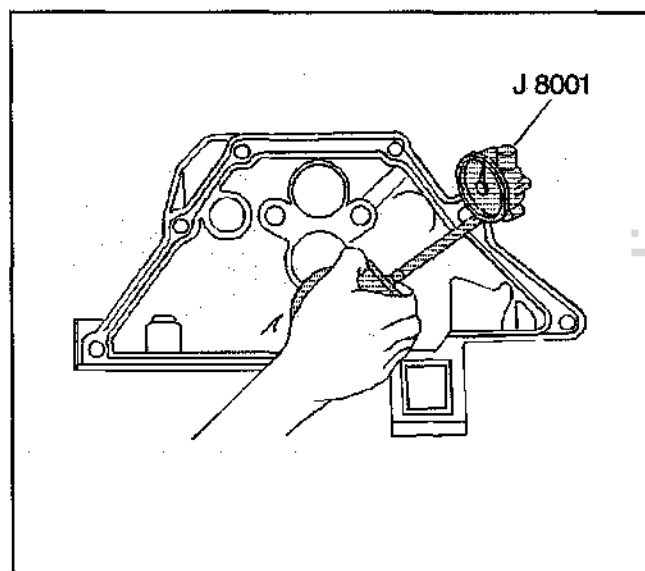
2. Remove the remaining plugs using the following procedure.
 - 2.1. Obtain a suitable self-threading screw.
 - 2.2. Drill a hole into the plug.
 - 2.3. Install the self-threading screw.
 - 2.4. Use the screw to pry out the plug.

Engine Block Clean and Inspect**Tools Required**

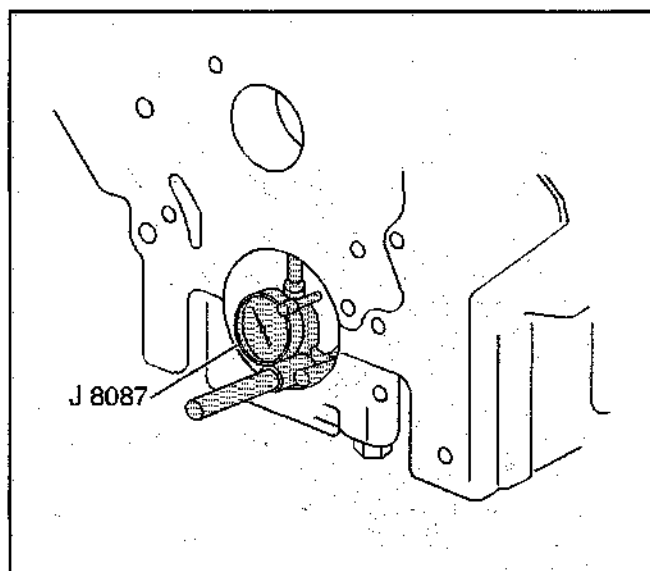
- J 8087 Cylinder Bore Checking Gauge
 - J 8001 Dial Indicator Set
1. Clean the sealing material from the gasket mating surfaces.
 2. Boil the engine block in caustic solution.
 3. Flush the engine block with clean water or steam.
 4. Clean the oil passages.
 5. Clean the blind holes.
 6. Spray the cylinder bores and the machined surfaces with engine oil.
 7. Inspect the threaded holes. Clean the holes with a tap. If necessary, drill out the holes and install thread inserts. Refer to *Thread Repair*.
 8. Use a straight edge and a feeler gage to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
 9. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.
 10. Inspect the mating surfaces of the transmission case.
- Notice:** A broken flywheel may result if the transmission case mating surface is not flat.
11. Use the following procedure to measure the engine block flange runout at the six mounting bolt hole bosses:
 - 11.1. Temporarily install the crankshaft. Measure the crankshaft flange runout.
 - 11.2. Hold the gauge plate flat against the crankshaft flange.
 - 11.3. Place J 8001 on the transmission mounting bolt hole boss. Set the indicator to 0.
 - 11.4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary more than 0.254 mm (0.010 in).
 - 11.5. Recheck the crankshaft flange runout if the readings vary more than 0.254 mm (0.010 in).



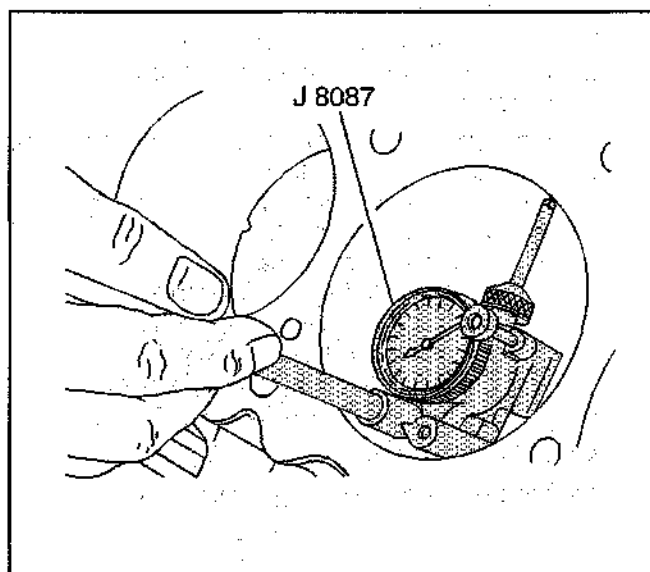
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12. Inspect the crankshaft main bearing bores. Use *J 8087* to measure the bearing bore concentricity and alignment at the following locations:

- The camshaft
- The crankshaft

Important: Recondition the engine block with the crankshaft main bearing caps and the crankshaft main bearing cap side bolts installed and tightened to specification.

13. Ensure that the crankshaft main bearing caps are installed correctly. The arrows should point toward the front of the engine.
14. Replace the engine block if the bores are out of specification.

15. Use *J 8087* to inspect the cylinder bores. Inspect for the following items:

- Wear
- Taper
- Run-out
- Ridging

Important: If the bore is worn beyond the limits, refit the bore with oversized pistons. Select the smallest available oversize piston. Refer to *Piston Selection*.

16. Leave sufficient material to allow honing when fitting the piston.

Cylinder Boring and Honing

Boring Procedure

1. Before honing or boring, measure all of the new pistons. Select the smallest piston for the piston fitting. Slightly varied pistons in a set may provide correction, if the first piston is too loosely fitted.
2. Before using any type of boring bar, file the top of the engine block to remove any dirt or burrs. If the cylinder block is not straight, the boring bar may be tilted, causing the bored cylinder wall to have incorrect right angles to the crankshaft.
3. Carefully follow the instructions furnished by the manufacturer regarding use of equipment.
4. Install all crankshaft main bearing caps to specification when boring cylinders. Cover or tape the crankshaft bearings and other internal parts to protect these parts during the boring or honing operation.
5. Leave 0.03 mm (0.001 in) on the diameter for finish honing when performing the final cut with a boring bar. Carefully perform the honing and boring operation to maintain the specified clearances between pistons, rings, and cylinder bores.

Honing Procedure

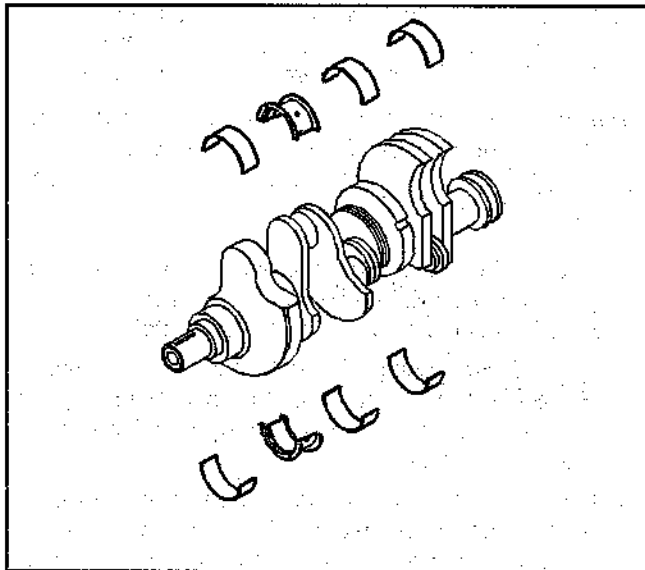
1. Follow the manufacturer's recommendations for use, cleaning, and lubrication when honing the cylinders. Use only clean, sharp stones of the proper grade for the amount of material to be removed. Dull, dirty stones cut unevenly and generate excessive heat. When using coarse or medium-grade stones, leave sufficient metal so all stone marks may be removed with the fine stones used for finishing to provide the proper clearance.
2. During the honing operation, thoroughly clean the cylinder bore. Check for the correct piston fit.

3. Make full strokes in the cylinder to eliminate taper. Repeatedly check the measurement at the top, the middle, and the bottom of the cylinder bore.

Notice: Handle the pistons with care. Do not force the pistons through the cylinder until you hone the cylinder to the correct size. The piston can be distorted through careless handling.

Important: The finish marks should be clean but not sharp. The finish marks should be free from imbedded particles and torn or folded metal.

4. When finish honing a cylinder bore to fit a piston, move the hone up and down at a sufficient speed to obtain a fine and uniform surface finish in a cross hatch pattern.
5. Determine the finish hone cylinder measurement by measuring the piston to be installed, and by adding the average of the clearance specification. Measure the block and the piston at normal room temperature.
6. True up the refinished cylinder bores. Final hone each cylinder bore to remove all stone or cutter marks.
7. After final honing and before the piston is checked for fit, clean the bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material will wear the new rings, the cylinder bores, and the bearings lubricated by the contaminated oil. After washing dry the bore.
8. Permanently mark the piston for the cylinder to which the piston has been fitted.
9. Apply clean engine oil to each bore to prevent rusting.



Crankshaft and Bearings Clean and Inspect

Tools Required

- J 36660-A Torque Angle Meter
- J 8087 Cylinder Bore Checking Gauge

1. Clean the crankshaft of the following elements:
 - Oil
 - Sludge
 - Carbon
2. Inspect the crankshaft oil passages for obstructions.
3. Inspect the crankshaft keyway for nicks or wear.
4. Inspect the crankshaft threads.

Important: If cracks, severe gouges or burned spots are found, the crankshaft must be replaced. Slight roughness may be removed with a fine polishing cloth soaked in clean engine oil. Burrs may be removed with a fine oil stone.

5. Inspect the crankshaft bearing journals and the crankshaft thrust surfaces for the following conditions:
 - Cracks
 - Chips
 - Gouges
 - Roughness
 - Grooves
 - Overheating (discoloration)
6. Inspect the corresponding crankshaft bearings for embedded foreign material and determine the source.

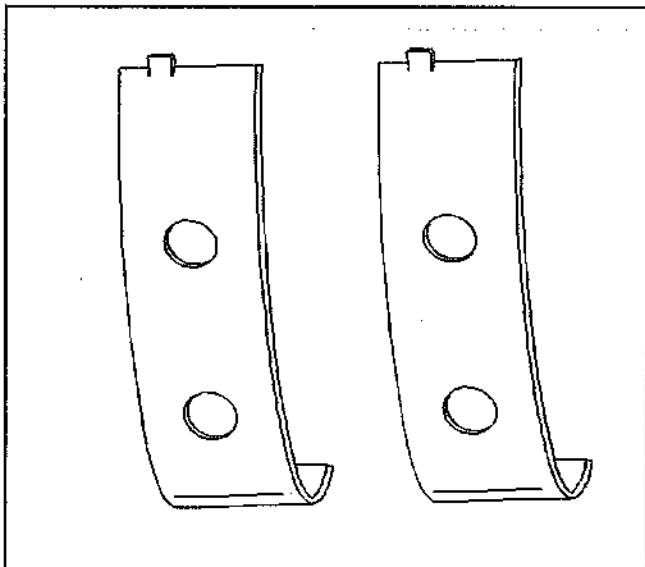
Important: Note the location of the crankshaft main bearing high spots. If they are not in line, the crankshaft is bent and must be replaced.

7. Inspect the crankshaft bearings for uneven side-to-side wear. This may indicate a bent crankshaft or a tapered bearing journal.

Important: The crankshaft bearings are of the precision insert type. The crankshaft bearings are available in standard and various undersizes.

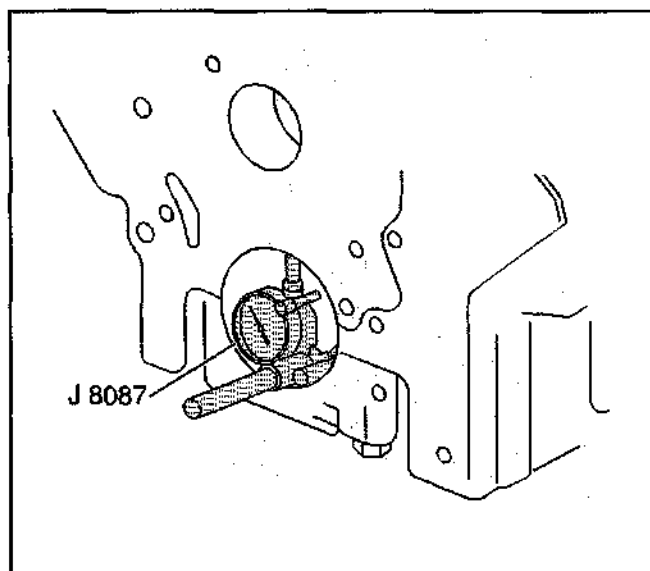
Notice: Do not scrape, shim, or file bearing inserts. If the bearing surface of the insert is touched with bare fingers, the skin oil and acids will etch the bearing surface.

8. Inspect the outer surfaces of the crankshaft bearings for the following conditions:
 - Wear - surface wear indicates either movement of the insert or high spots in the surrounding material (spot wear).
 - Overheating or discoloration
 - Looseness or rotation indicated by flattened tangs and wear grooves
9. Inspect the thrust surfaces of the main thrust bearing for the following conditions:
 - Wear
 - Grooving (Grooves are caused by irregularities of the crankshaft thrust surface.)



Important: If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

10. Using the J 8087 inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:
 - 10.1. Tighten the bearing cap to specification.
 - 10.2. Measure the bearing bore using J 8087 for taper and out-of-round.
 - 10.3. No taper or out-of-round should exist.



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Bearing Selection

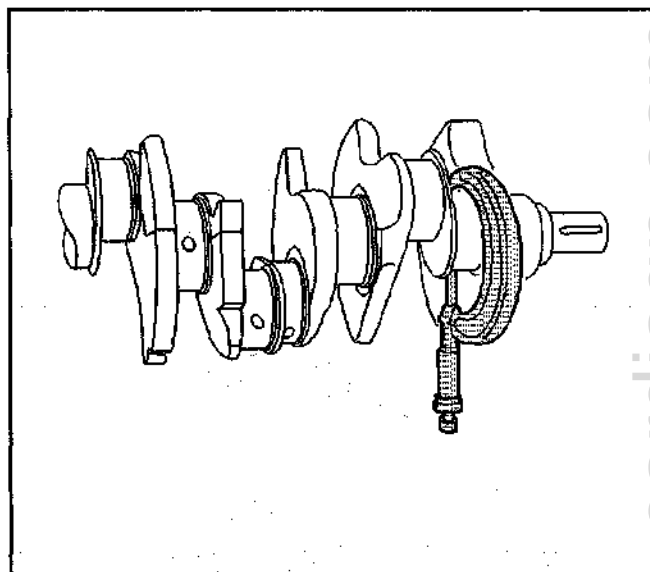
Measure the bearing clearance to determine the correct replacement bearing insert size. There are two methods to measure bearing clearance. Method A gives more reliable results and is preferred.

- Method A yields measurement from which the bearing clearance can be computed.
- Method B yields the bearing clearance directly. Method B does not give any indication of bearing run-out.

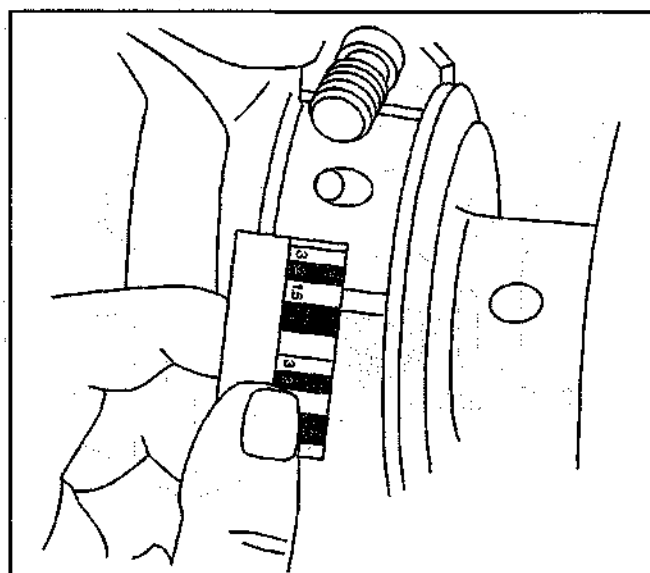
Method A

Important: Do not mix inserts of different nominal size in the same bearing bore.

1. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
2. Measure the crankshaft bearing journal taper and runout.
3. Install the crankshaft bearing inserts. Tighten the bearing cap bolts to specification.
4. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
5. Measure the crankshaft main bearing inside diameter with an inside micrometer.
6. Select a set of bearing inserts that will produce the desired clearance.
7. If the specified clearances cannot be met, the crankshaft journals must be reconditioned and undersized bearing inserts installed.



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Method B

Important: Do not mix inserts of different nominal size in the same bearing bore.

1. Clean the used bearing inserts.
2. Install the used bearing inserts.
3. Place a piece of gaging plastic across the entire bearing width.
4. Install the bearing caps.

Notice: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

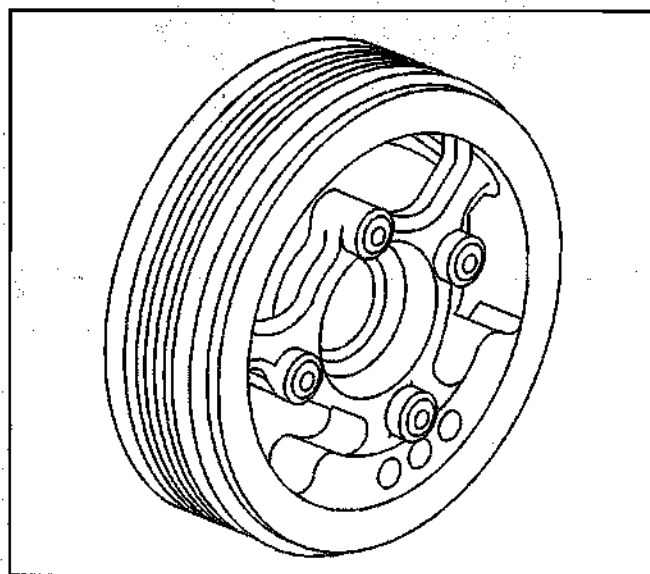
5. Install the bearing cap bolts to specification.

Important: Do not rotate the crankshaft.

6. Remove the bearing cap, leaving the gaging plastic in place. It does not matter whether the gaging plastic adheres to the journal or to the bearing cap.
7. Measure the gaging plastic at its widest point with the scale printed on the gaging plastic package.
8. Remove the gaging plastic.
9. Select a set of bearing inserts that will produce the desired clearance.

Crankshaft Balancer Clean and Inspect

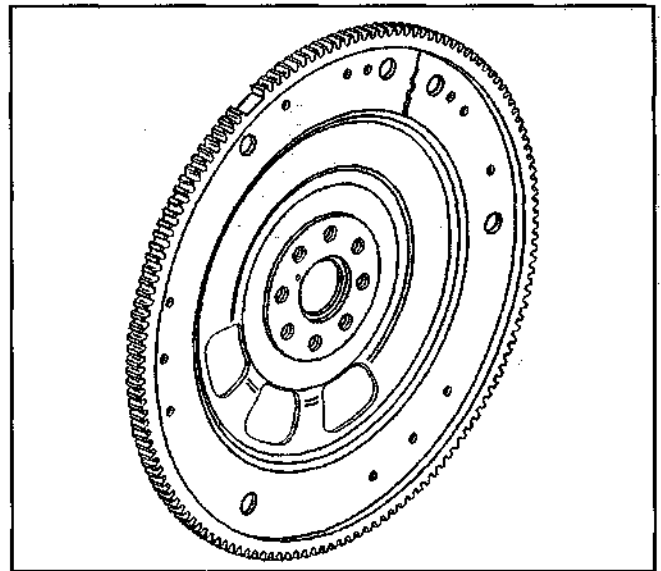
- Inspect the crankshaft balancer for damage.
- Inspect the outside of the crankshaft balancer mounting shaft for grooves.
- Replace the crankshaft balancer if grooves are present and appear to be causing an oil leak.



313962

Engine Flywheel Clean and Inspect (Automatic Transmission)

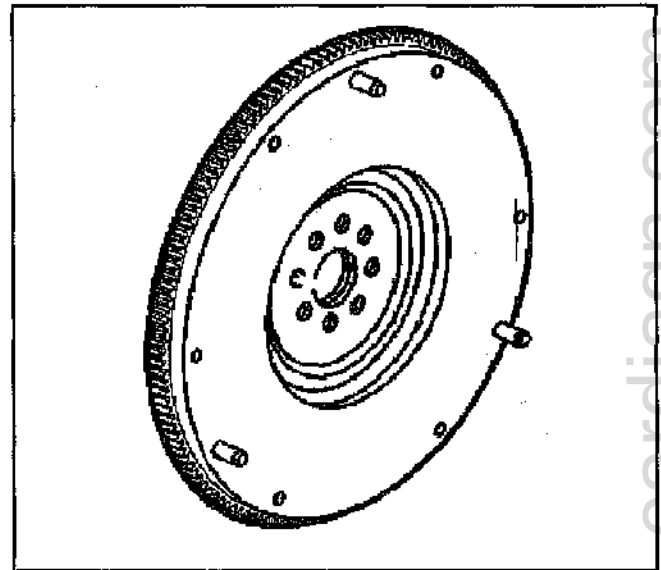
- Clean the flywheel.
- Inspect the engine flywheel for damage and cracks.
- Inspect the engine flywheel ring gear for damaged teeth.
- Replace the flywheel if any damage is found.



187014

Engine Flywheel Clean and Inspect (Manual Transmission)

- Clean the flywheel.
- Inspect the engine flywheel for damage and cracks.
- Inspect the engine flywheel ring gear for damaged teeth.
- Replace the flywheel if any damage is found.

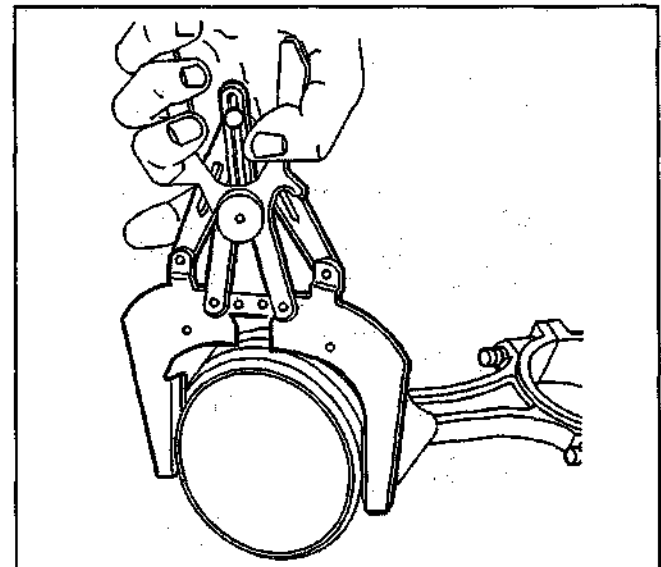


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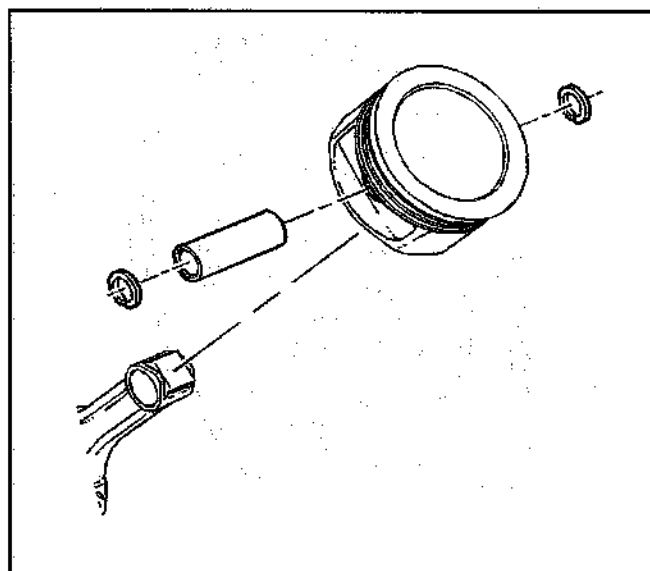
Piston and Connecting Rod Disassemble

Caution: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

1. Remove the piston rings. Use a suitable tool to expand the rings. Piston rings must not be reused.



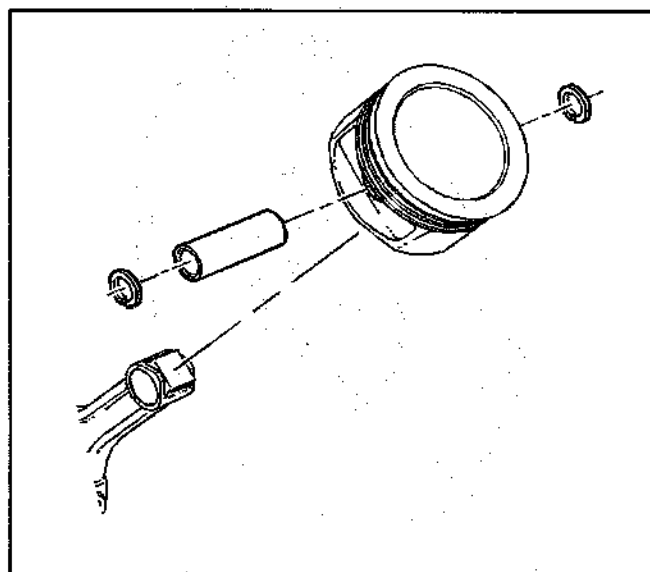
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Important: Two retainers hold the piston pins in place. Reuse the retainers if they are not damaged. Ensure the piston pin is not damaged.

2. Remove the piston pin retaining clips.
3. Remove the piston pin.



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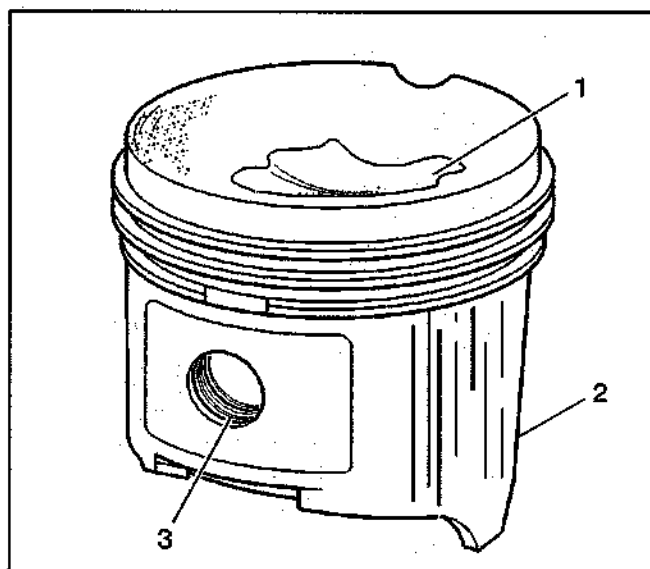
Piston, Connecting Rod, and Bearings Clean and Inspect

Caution: Bodily injury may occur if the carburetor cleaning fluid is exposed to the skin or if the fumes are inhaled.

1. Clean the piston and connecting rod in solvent.

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

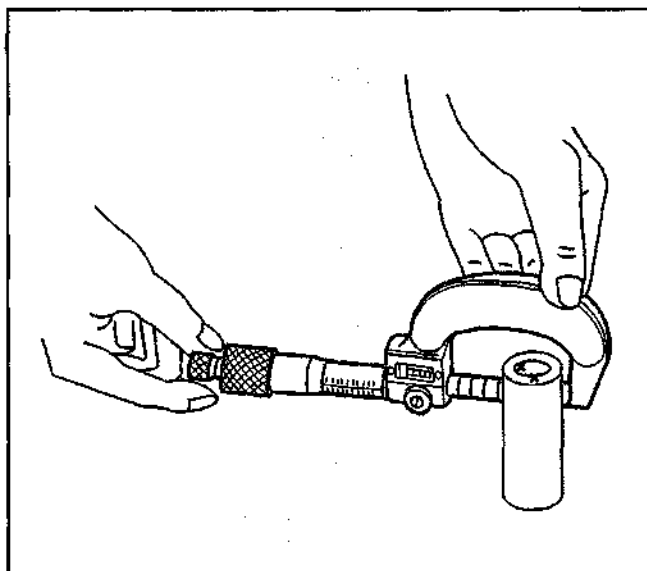
2. Dry the components with compressed air.
3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the piston oil lubrication holes and slots.



156168

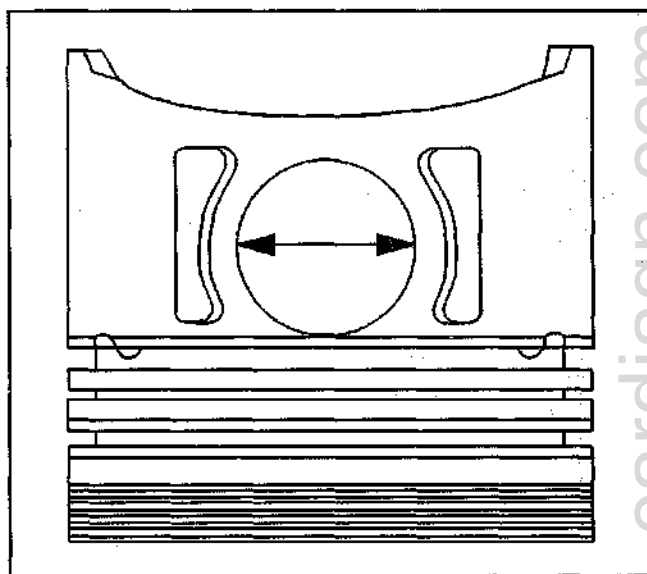
5. Inspect the piston for the following conditions:
 - Eroded areas (1) on top of the piston
 - Scuffed or damaged skirt (2)
 - Damage to the pin bore (3)
 - Cracks in the piston ring lands, the piston skirt, or the pin bosses
 - Piston ring grooves for nicks, burrs, or other warpage which may cause the piston ring to bind.
6. Inspect the piston for scoring, wear or other damage.

7. To determine the piston-to bore clearance, use a micrometer and measure the piston pin.



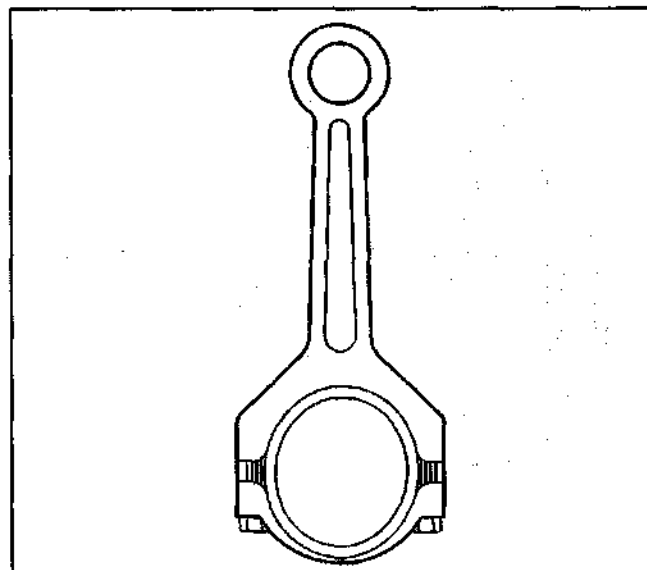
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8. To determine the piston pin-to bore clearance, use an inside micrometer and measure the piston pin bore.
9. To determine the piston pin-to-bore clearance, subtract the piston pin diameter from the piston pin bore diameter.

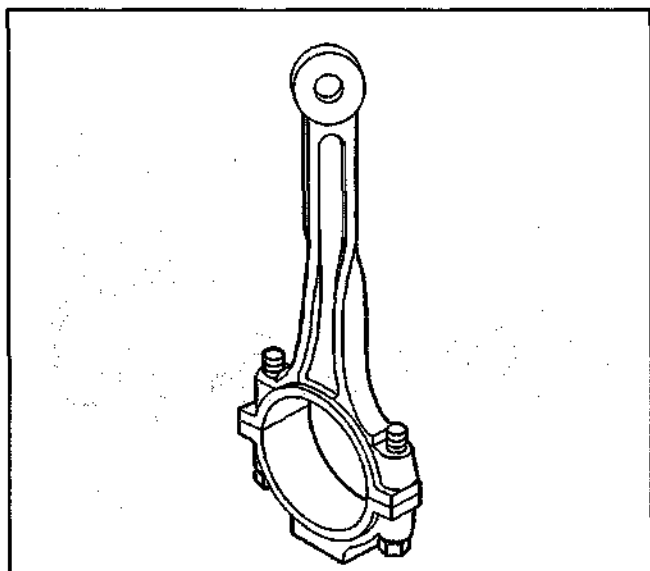


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10. Inspect the connecting rod for an out-of-round bearing bore.

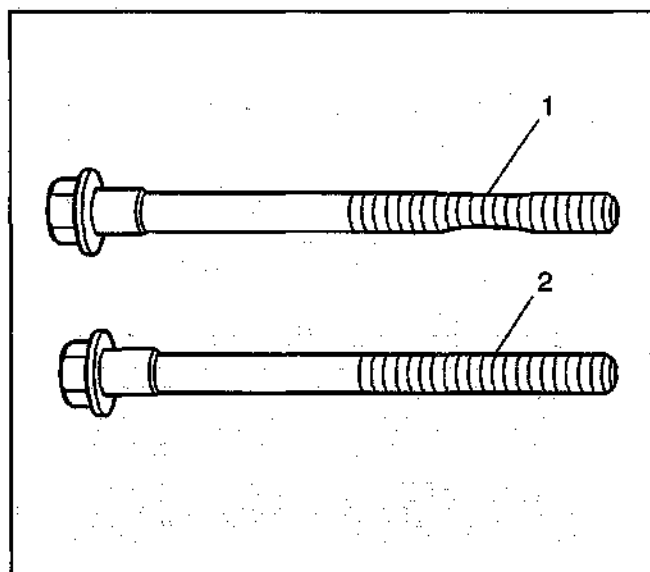


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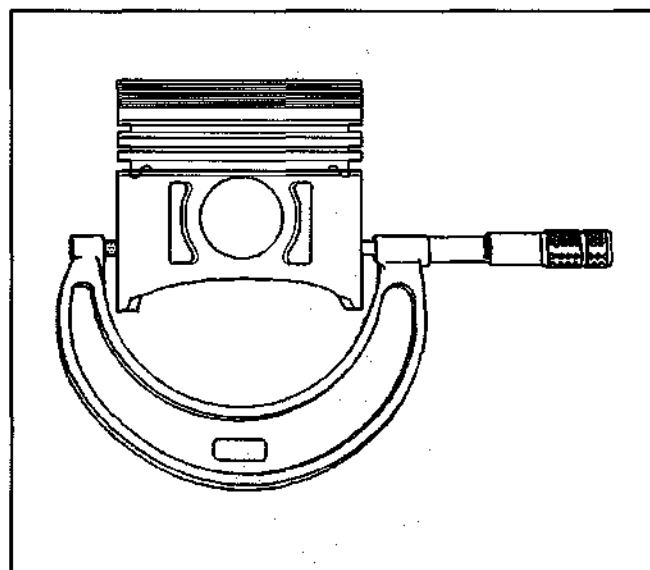
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11. Inspect the connecting rod for twisting.



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12. Inspect the connecting rod cap bolts for stretch (compare to known good bolt). (1) is a stretched bolt, (2) is a new or good bolt.



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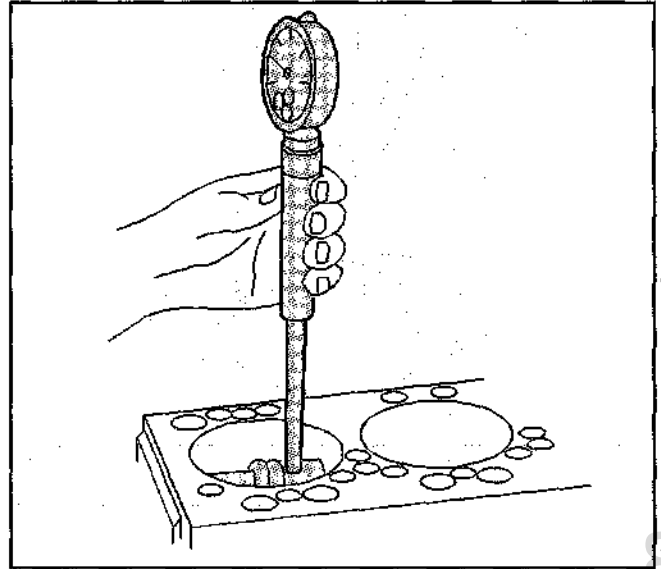
Piston Selection

1. Measure the piston diameter. Remove the piston pin to measure the piston for size and taper.
2. Replace the piston with a standard or an oversized piston if the piston is damaged.

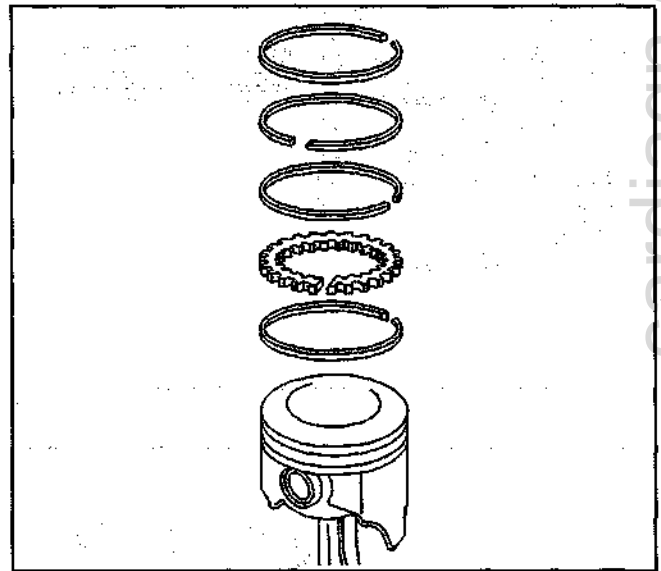
Important: Consider both the piston condition and the cylinder bore condition when fitting the pistons. Production and service pistons have the same nominal weight. Production and service pistons can be intermixed without affecting the engine balance. If necessary, fit used pistons to any cylinder of the engine. Ensure that the pistons are in good condition.

3. Measure the cylinder bore. If the cylinder bore is worn beyond specifications, rebore the cylinder bore. Use the following procedure to hone the cylinder bore to the correct size:
 - 3.1. Select a piston.
 - 3.2. Hone the cylinder bore to obtain the recommended clearance.

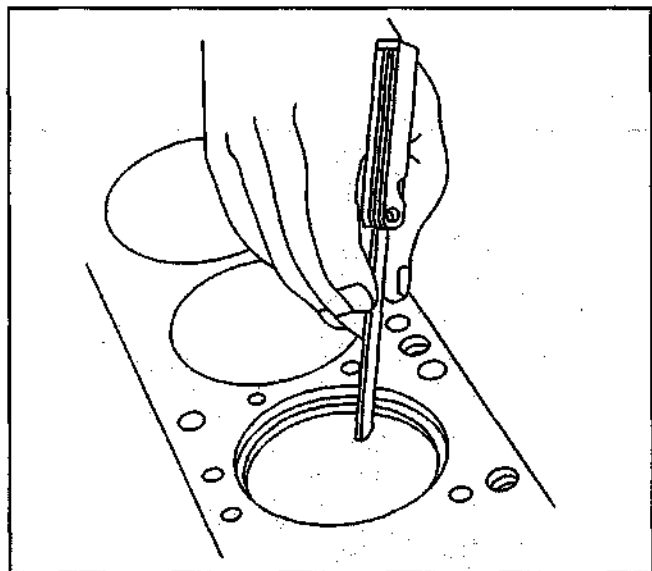
- 3.3. Scrub the cylinder bore and the piston with soap and water. Remove all foreign material. Dry the cylinder bore. Rub clean engine oil into the cylinder bore.
4. Use the following procedure to measure piston-to-cylinder bore clearance:
 - 4.1. Measure the cylinder bore with a telescoping gauge. If the cylinder bore is damaged, rebore or hone the cylinder bore to size.
 - 4.2. Subtract the piston diameter from the cylinder bore diameter to determine the piston-to-bore clearance.
 - 4.3. Compare the piston-to-bore clearance with the specifications to determine if the clearance is within the acceptable range.
5. If the used piston is not within the acceptable clearance range, check the service piston sizes to determine if a new piston can be selected. Service pistons are available in standard and 0.508 mm (0.020 in) oversize.
6. If the cylinder bore needs reconditioning, measure the new piston diameter and hone the cylinder bore to the correct clearance.
7. Select a new piston. Mark the piston to identify the corresponding cylinder.
8. Select a set of new piston rings.
9. Place each ring, one at a time, into the corresponding cylinder.
10. Place the piston for that cylinder, upside down (top of the piston pushing on the ring). Push the ring down to the bottom of the ring travel.
11. Remove the piston.



4987

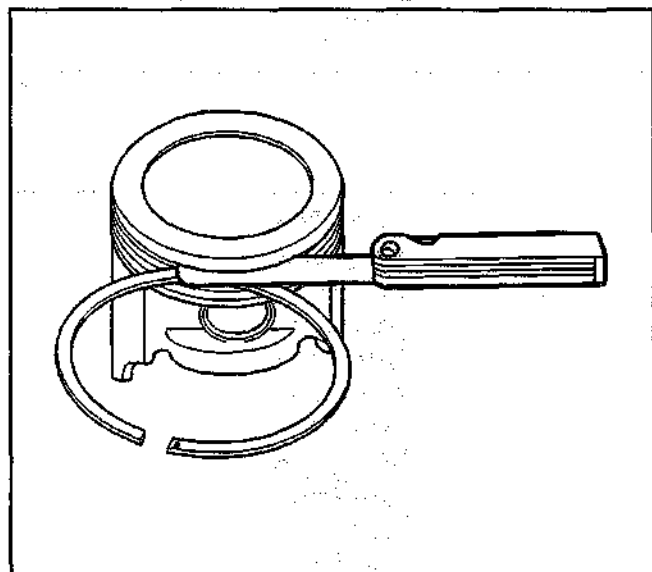


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12. Measure the ring gap.
13. If the ring gap is not within an acceptable specification range, increase the ring gap. Do this by filing any excess material from the ends of the ring.



22934

14. Measure the piston ring side clearance (compression rings).

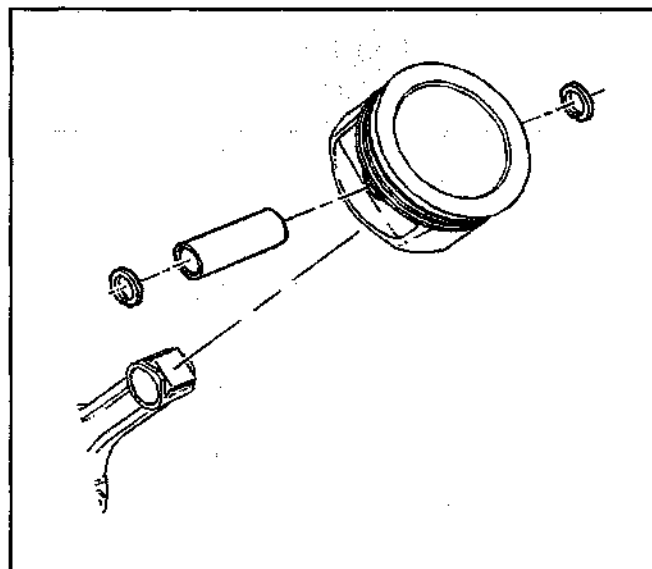
Notice: Do not cut the ring groove with a file or a rough edged tool. Good performance and durability depends on the straightness and smoothness of the ring groove.

15. Use the following procedure to measure piston compression ring side clearance:

- 15.1. Roll the piston ring around the groove.
- 15.2. Measure the side clearance.
- 15.3. If the ring is too tight, check for nicks or burrs.

Use emery cloth to remove burrs.

- 15.4. Determine if the ring is within specifications. If necessary, replace the ring.



35866

Piston and Connecting Rod Assemble

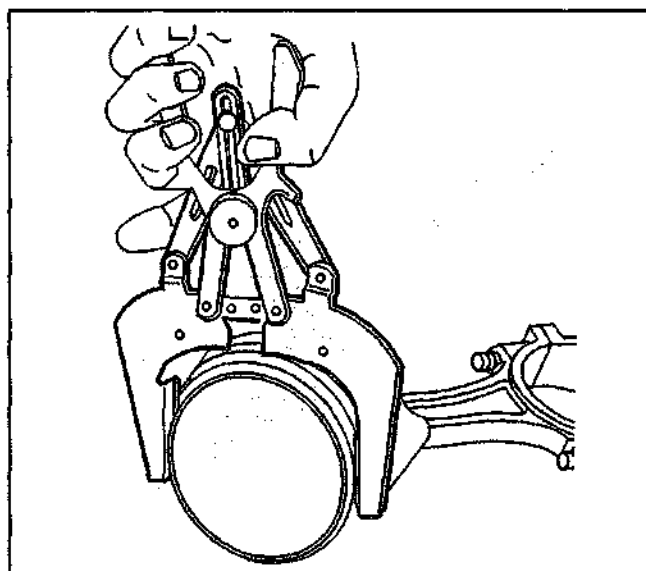
1. Coat the piston pin with oil.
2. Install one piston pin retainer into the retaining groove.
3. Install the connecting rod and piston pin. The connecting rod can be installed in either direction. Push the piston pin in until it bottoms against the installed piston pin retainer.
4. Install the second piston pin retainer.
5. Ensure the piston pin moves freely.

Important: To provide an effective compression seal, the ring gaps must be staggered.

Notice: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

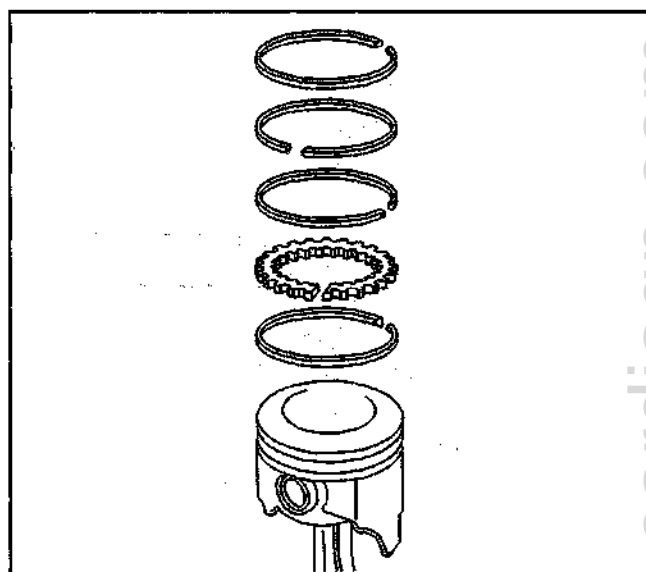
6. Install the following components of the bottom ring assembly (oil control ring):

- 6.1. The expander
- 6.2. The lower oil control ring
- 6.3. The upper oil control ring



4977

7. Install the middle ring (compression ring) with the manufacturer's mark facing up.
8. Install the top ring (compression ring).



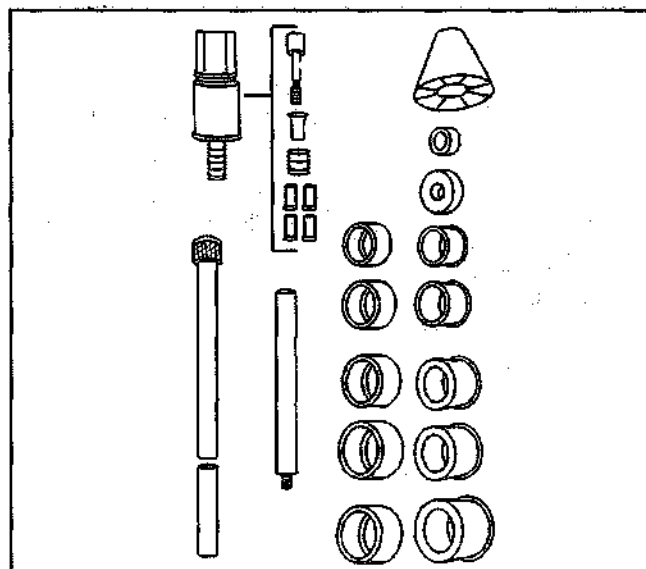
4967

Camshaft Bearing Removal

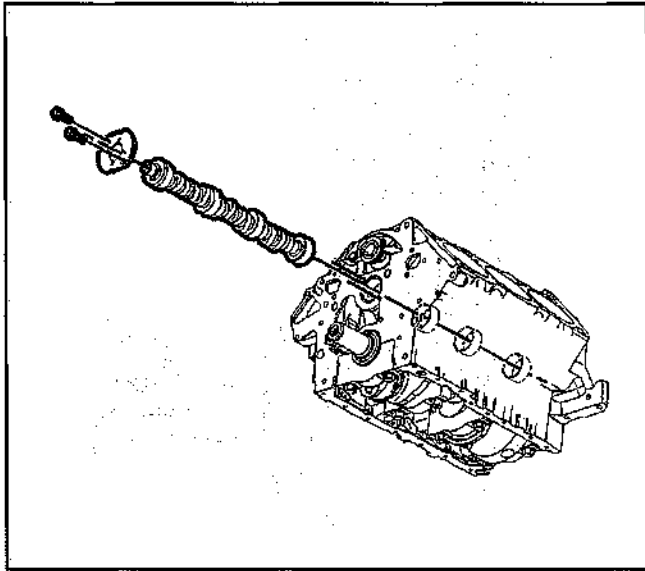
Tools Required

J 33049 Camshaft Bearing Remover/Installer

1. Select the expander assembly and driving washer.
2. Assemble J 33049.

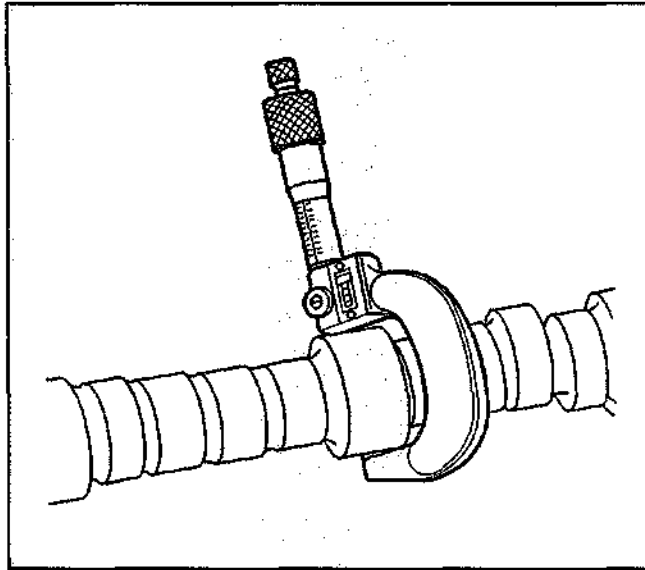


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3. Drive out the camshaft bearings.



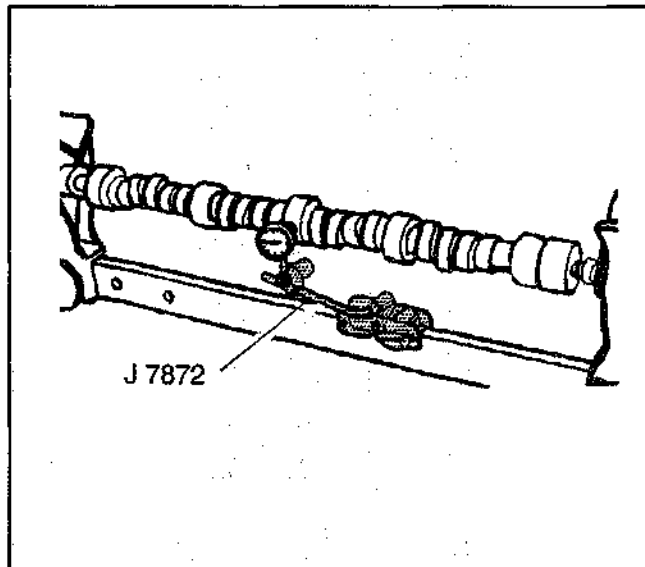
35212

Camshaft and Bearings Clean and Inspect

Tools Required

J 7872 Magnetic Base Indicator Set

1. Measure the camshaft journals with a micrometer.
If the camshaft journals are not within specifications, replace the camshaft. Refer to Engine Mechanical Specifications.



35211

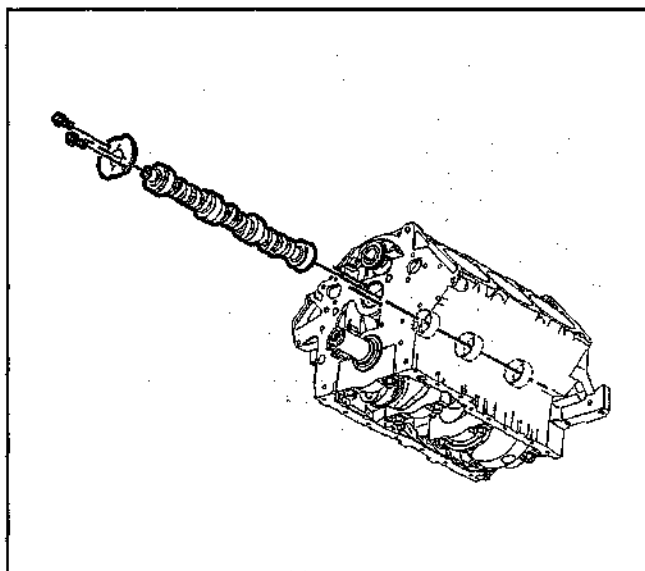
2. Measure the camshaft runout using J 7872.
 - 2.1. Mount the camshaft in V-blocks between centers.
 - 2.2. Use J 7872 to check the intermediate camshaft journal.
3. If the runout exceeds specifications, the camshaft is bent and should be replaced. Refer to Engine Mechanical Specifications.

Camshaft Bearing Installation

Tools Required

J 33049 Camshaft Bearing Installer

1. Select the camshaft bearings.



35815

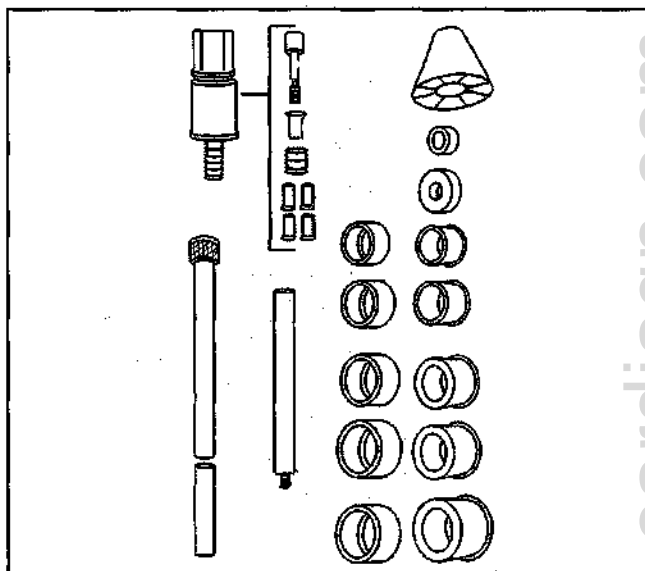
2. Use the following procedure to install the camshaft bearings:

- 2.1. Assemble *J 33049* according to the manufacturer's instructions.

- 2.2. Place the bearing on the tool.

Notice: Severe engine damage may result if the oil holes are not correctly aligned.

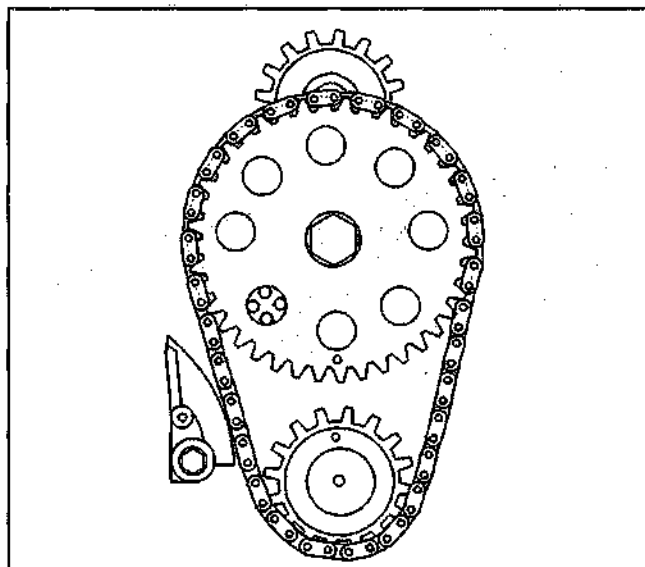
- 2.3. Index the bearing oil holes with the engine block oil passages.



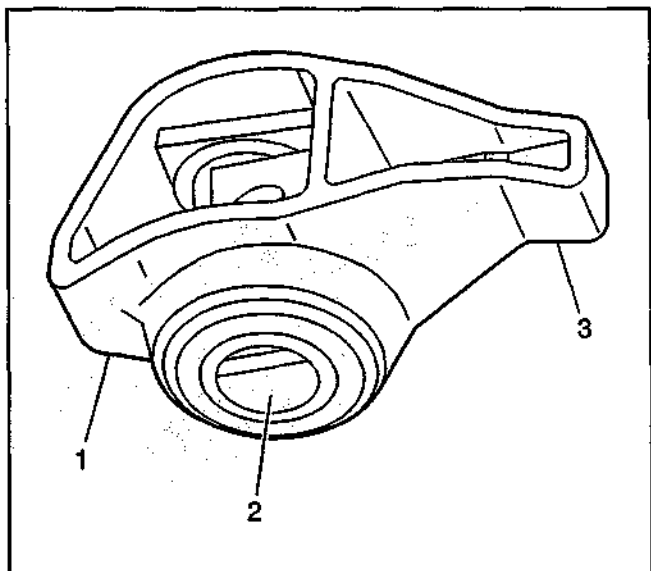
622704

Timing Chain and Sprockets Clean and Inspect (VIN K)

1. Inspect the timing chain and sprockets for damage.
2. Inspect the timing chain for overall in and out movement. Movement should not exceed 25 mm (1 in).
3. Inspect the sprockets for wear.



192708



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Valve Rocker Arm and Push Rods Clean and Inspect

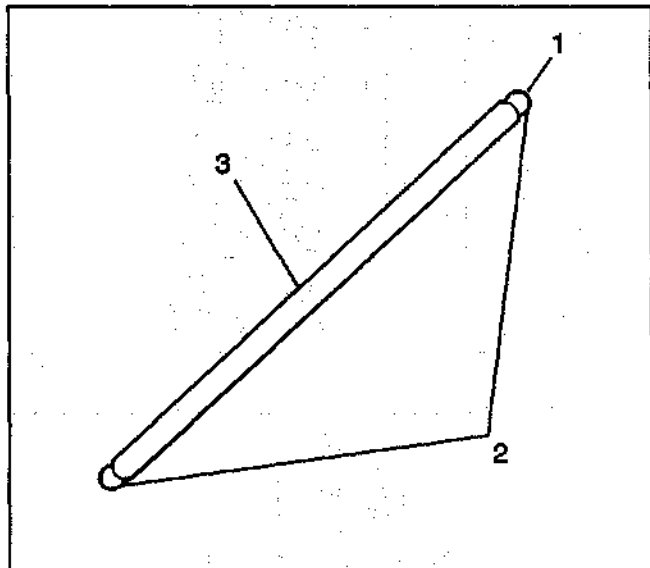
Important: Parts that are to be reused must be marked, sorted, and organized for assembly.

- Mark, sort, and organize the components for assembly.

Caution: Bodily injury may occur if the carburetor cleaning fluid is exposed to the skin or if the fumes are inhaled.

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

- Clean the components with cleaning solvent.
- Dry the components with compressed air.
- Inspect the valve rocker components for the following:
 - Valve rocker arm valve pushrod socket contact surface (1)
The contact surface must be smooth with no scoring or excessive wear.
 - Valve rocker arm roller pivot for binding or damage (2)
 - Valve rocker arm valve stem contact surface (3)
The contact surface should be smooth with no scoring or excessive wear.
- Inspect the valve pushrods for the following:
 - Restriction of the oil passage (1)
 - Wear or scoring of the end contact surfaces (2)
The end contact surfaces must be smooth with no scoring or excessive wear.
 - Shaft for bends (3)
Roll the valve pushrod on a flat surface to determine if the valve pushrod is bent.



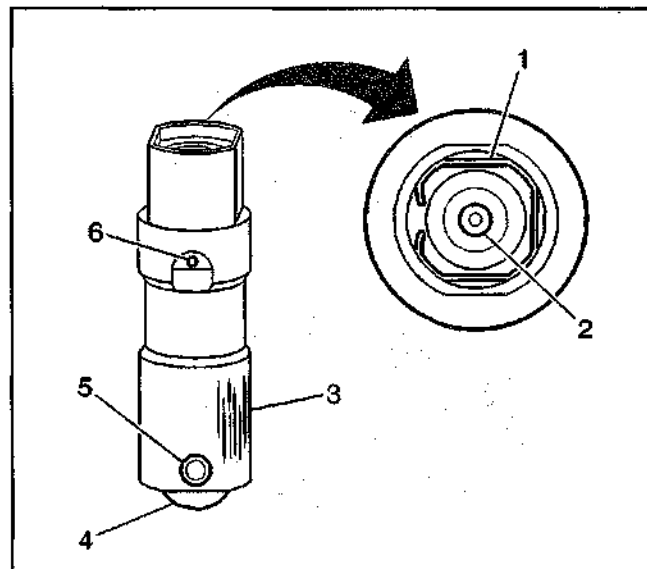
488857

Valve Lifters and Guides Clean and Inspect

1. Keep the valve lifters in order so they can be installed in their original position.

Important: When new valve lifters are installed, coat the valve lifters with camshaft and lifter prelude GM P/N 1052365 (or equivalent).

2. Inspect the following areas of the valve lifters:
 - The retaining clip (1)
 - The push rod socket for wear (2)
 - The valve lifter body for wear and scuffing (3)
 - The valve lifter bore for wear
 - The valve lifter roller assembly for wear (4)
 - The valve lifter roller pin for damage (5)
 - The oil hole for plugging (6)
3. Inspect the valve lifter guides for cracks or damage.



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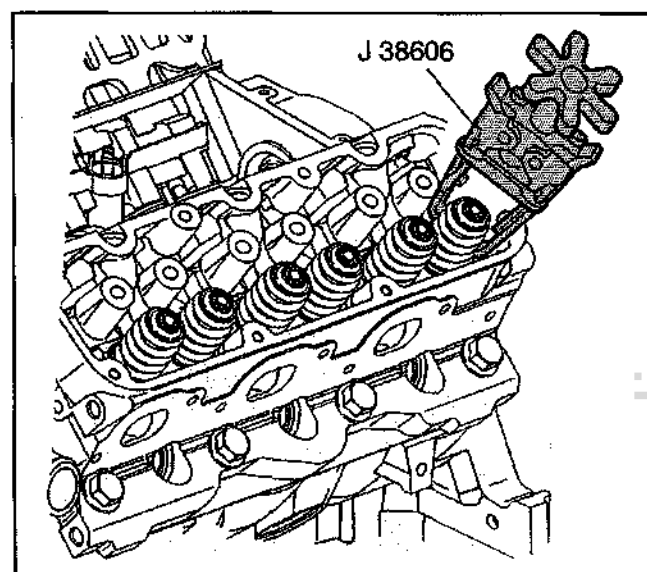
Cylinder Head Disassemble

Tools Required

J 38606 Valve Spring Compressor

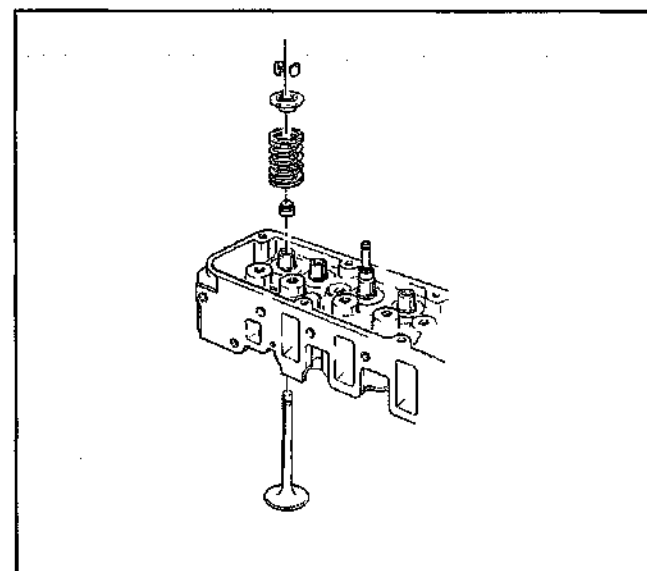
Important: During disassembly, ensure the valve train components are kept together and identified so they can be reinstalled in their original locations and with the same mating surfaces as when removed.

1. Use J 38606 to compress the valve spring.

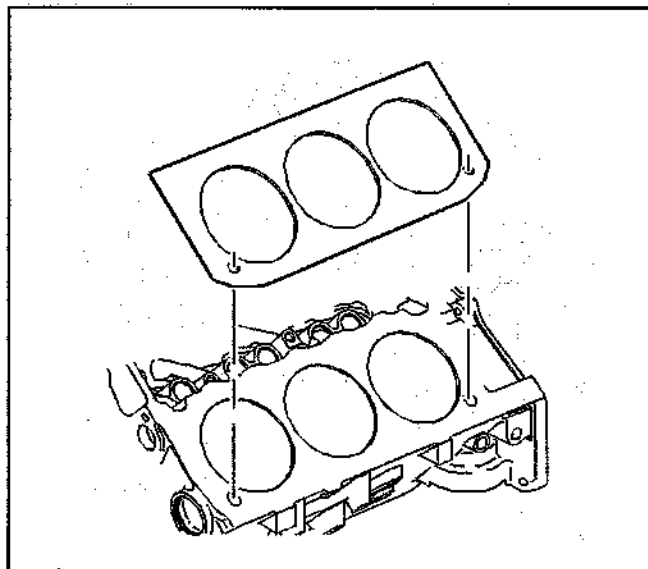


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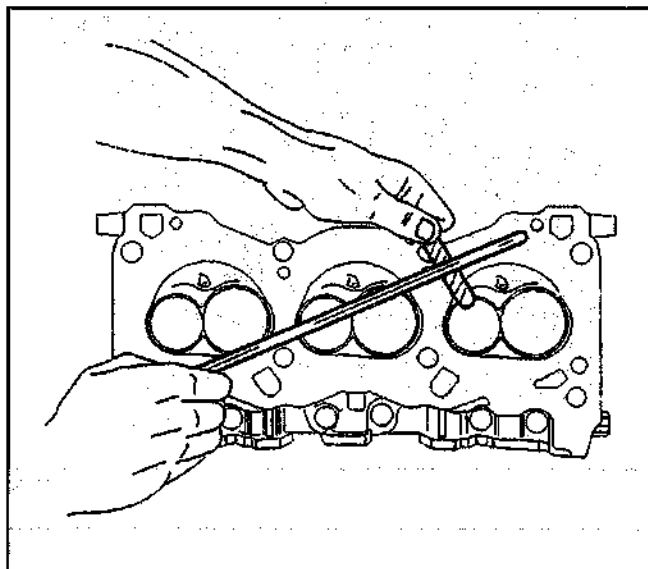
2. Remove the valve keys.
3. Remove the valve cap and spring.
4. Remove the valve stem oil seal by prying up on the bottom.



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Cylinder Head Clean and Inspect

Tools Required

J 9666 Valve Spring Tester

1. Inspect the cylinder head gasket and the mating surfaces for leaks, corrosion, and blowby.
2. If the gasket failed, determine the cause. Gasket failure is caused by the following conditions:
 - Improper installation
 - A loose or warped cylinder head
 - Missing dowel pins
3. Clean the cylinder head of all foreign material. Do not use a motorized wire brush on any gasket sealing surface.
4. Clean the threaded holes.
5. Inspect the cylinder head for cracks typically between the valve seats and inside of the exhaust ports.

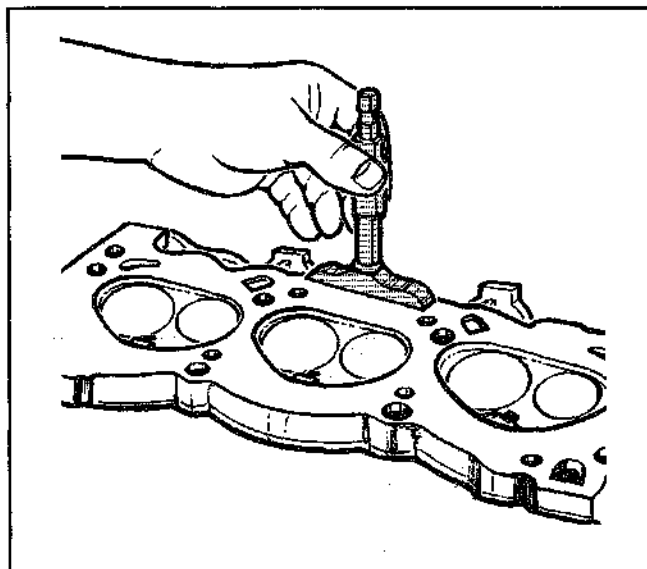
Important: Do not attempt to weld the cylinder head. If the cylinder head is damaged, replace the cylinder head.

6. Inspect the cylinder head deck for corrosion.
7. Inspect the following locations for flatness:
 - The cylinder head deck
 - The intake manifold mating surface
 - The exhaust manifold mating surface
8. Recondition the surfaces by parallel grinding. Replace the cylinder head if more than 0.254 mm (0.010 in) is removed.

9. Measure the height from the deck surface to the cast pads. Do this to determine if the cylinder head has sufficient deck surface thickness to resurface.

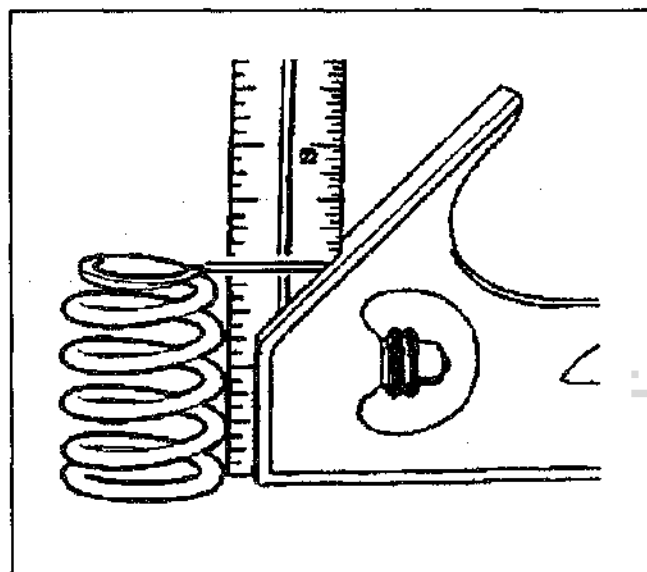
New cylinder heads measure from 1.372–1.676 mm (0.054–0.066 in). If the cylinder head does not meet the minimum thickness after resurfacing, replace the cylinder head.

10. Inspect all of the threaded holes for damage. Repair the threaded holes, if necessary.
11. Inspect the valve seating surfaces.
12. Inspect the cooling jacket plugs.
13. Inspect the valve guides for wear. Clean the valve guides.
14. Inspect the valve seats for excessive wear and hot spots.



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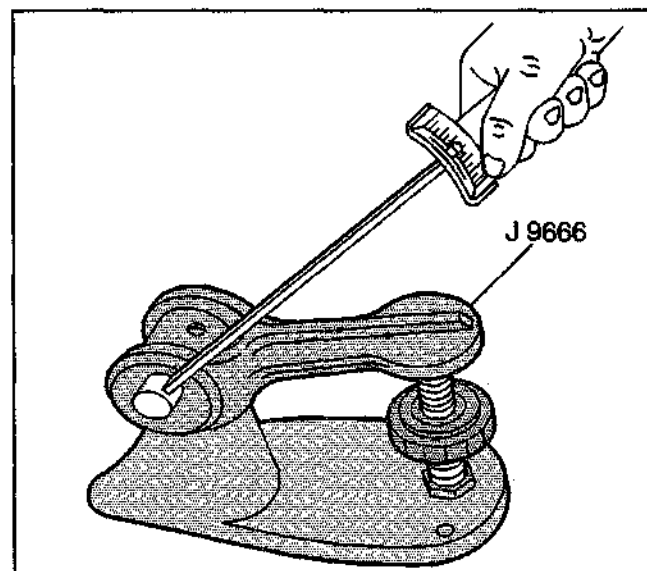
15. Inspect the valve springs expanded height.
16. Inspect the valve spring ends. If the valve spring ends are not parallel, the valve spring is bent. Replace the bent valve spring.



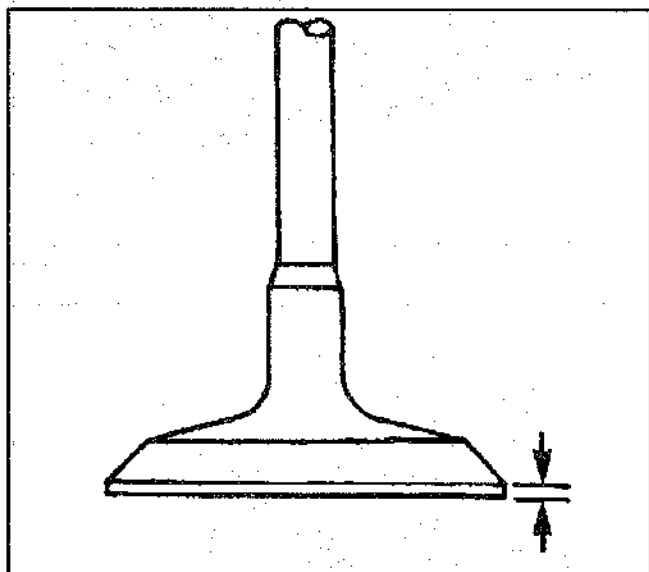
63468

17. Using the J 9666 test the valve spring load. If the valve spring load is below specification, replace the valve spring.
18. Inspect the valve spring seating surface of the valve spring retainers for wear or gouging. If the seating surface is damaged, replace the valve spring retainers.
19. Use the following procedure to measure the valve seat concentricity:
 - 19.1. Lift the valve off its seat.
 - 19.2. Apply a dab of blue dye to the valve face.
 - 19.3. Seat and rotate the valve.

The blue dye traces transferred to the valve seat are an indication of concentricity of the valve seat.



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20. Use the following procedure to measure the valve runout:

- 20.1. Clean off the blue dye.
- 20.2. Apply blue dye to the valve seat.
- 20.3. Seat and rotate the valve.

The traces of blue dye transferred to the valve indicates valve runout.

- 20.4. Recondition the valve seat or valve face, if needed.

Valve Guide Reaming/Valve and Seat Grinding

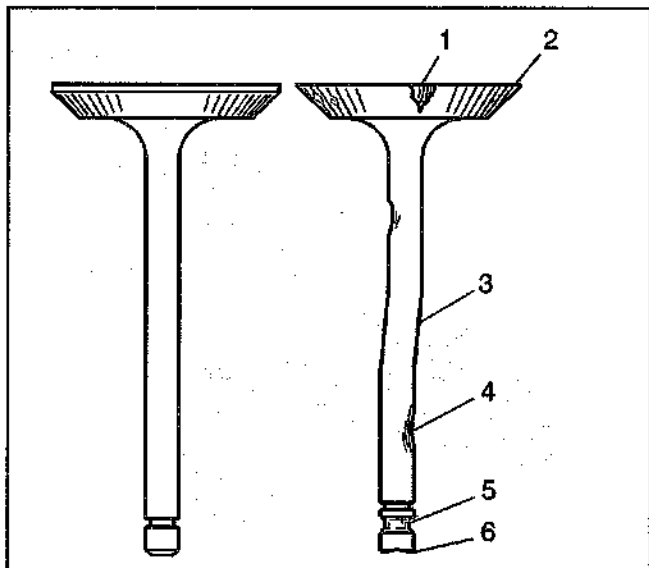
Tools Required

J 8001 Dial Indicator Set

1. Recondition the valve seats by grinding. Use an oscillating type valve seat grinder. Follow the grinder manufacturer's instructions. If the valve seat is too wide after grinding, use a 20 degree stone or a 70 degree stone in order to narrow the valve seat. The 20 degree stone will lower the seat. The 70 degree stone will raise the seat. Replace or recondition the valves if the seats are reconditioned.
2. After grinding the valves, measure the valve margin. Replace the valve if less than the minimum recommended specification.

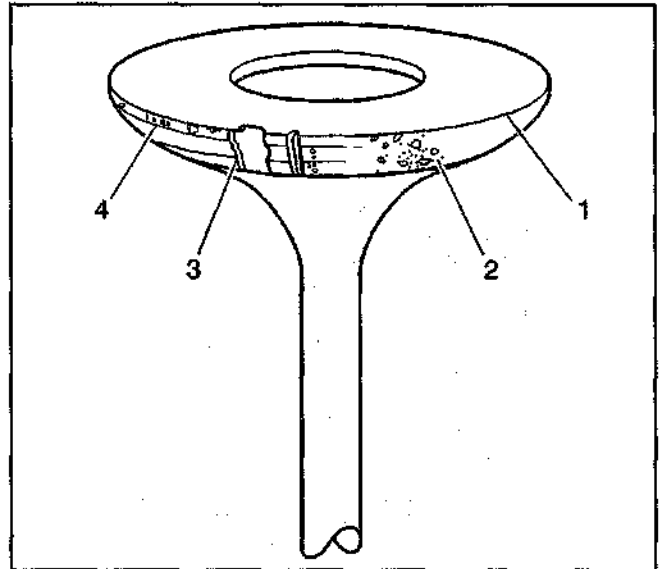
Notice: Clean the valve guides before reaming. Packing of chips or carbon may result in the reamer jamming into the valve guide or broken reamer flutes.

3. Clean any foreign material from the valves. Use a wire brush to remove carbon. Do not scratch the valve stem. Soak the valves in carburetor cleaning fluid to remove varnish.
4. Use a suitable tool to clean the valve guides.
5. Follow the grinder manufacturer's instructions. Ensure that the new surface is perpendicular to the valve stem.
6. Inspect the valve key grooves for chipped or worn lands (5). Replace the valve if the valve key groove is damaged.
7. Inspect the valve stem tip for wear (6). Recondition the valve stem tip by grinding.
8. Inspect the valve stem for burrs and scratches (4). Use an oil stone to remove burrs and minor scratches.
9. Inspect the valve stem for straightness (3). Use V blocks to inspect the valve head for bending or distortion. Replace any bent or distorted valves.
10. Inspect the valve face for grooving (1, 2). If the groove is so deep that refacing the valve face would result in a knife edge, replace the valve.



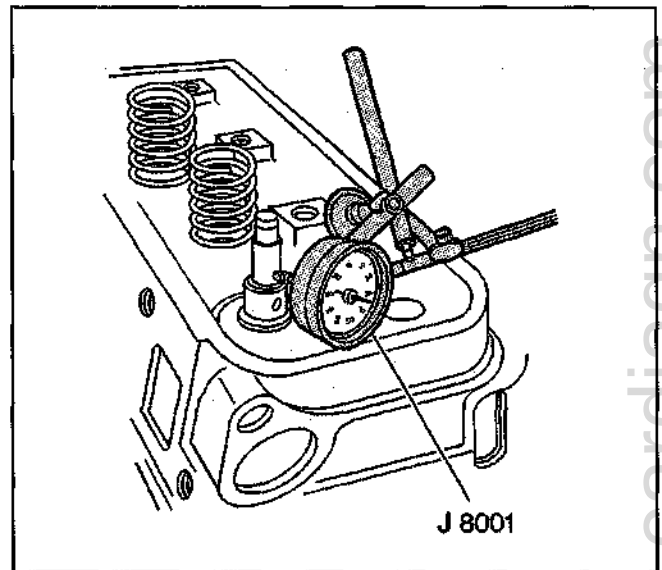
156174

11. Inspect the valve face for burning, pitting, or cracking (1, 2, 3, 4). If pieces of the valve face are broken off, inspect the corresponding piston and cylinder head area for damage.



156173

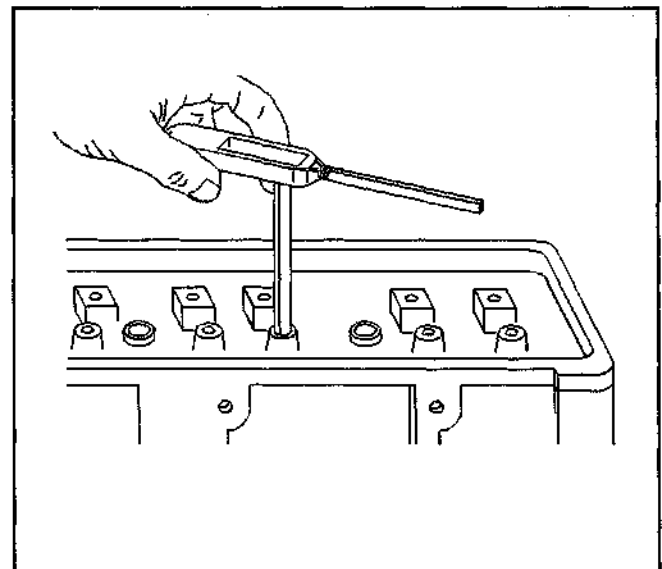
12. Measure the valve movement:
- 12.1. Insert the valve into the guide.
 - 12.2. Lift the valve 2 mm (1/8 in) off of the seat.
 - 12.3. Move the valve from side to side.
 - 12.4. Use J 8001 to measure the amount of movement.



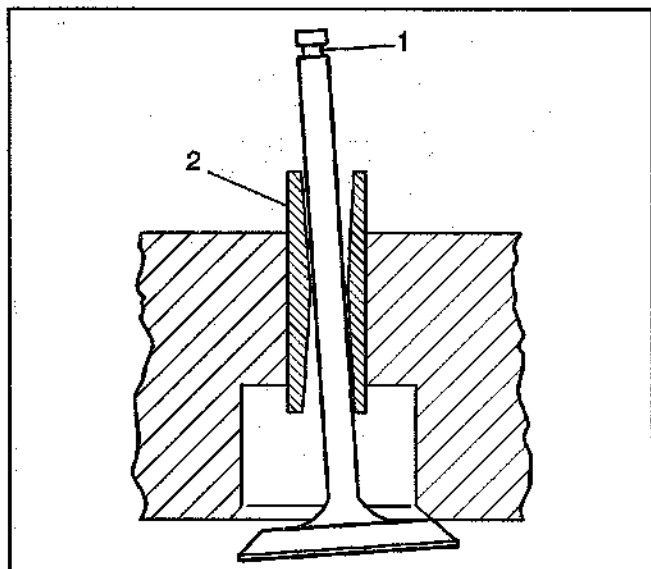
40076

Important: Clean the valve guide before reaming to avoid breaking the reamer flutes. Do not push down on the reamer.

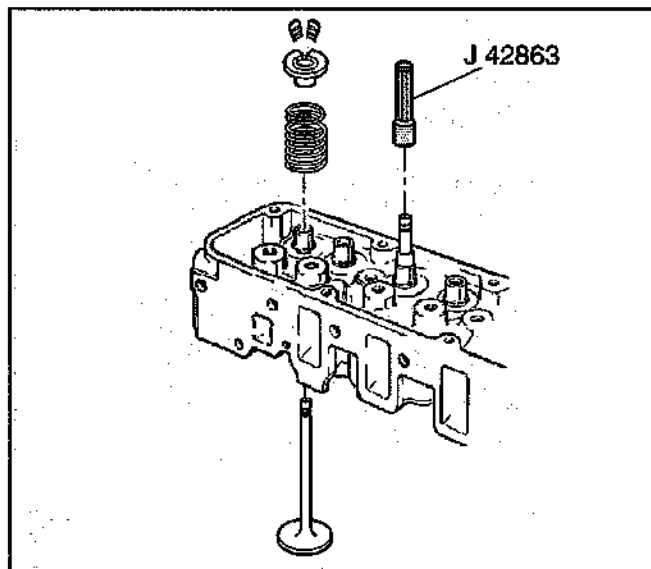
- 13. Ream the valve guides for oversize valves if the clearance exceeds the specifications.
- 14. Ream the valve guide bores for the oversize valves.
- 15. Recondition the valve seats after reaming the valve guide bores or installing the new valve guides.



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16. Inspect the valve stem for straightness. Use V blocks to inspect the valve head for bending or distortion. Replace any bent or distorted valves.

- It is essential that the valve guide bores are free of 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 to ensure the correct relationship between the valve head and the valve stem.

Replace the valve if the valve stem is warped (2), or if the valve stem shows signs of excessive wear.

Inspect the valve key area (1) for damage and carbon build up.

Replace the valve if the edge of the head is less than 0.79 mm (0.031 in) thick after grinding.

- Use the manufacturer's recommendations of equipment for the proper results.

Cylinder Head Assemble

Tools Required

- J 38606 Valve Spring Compressor
- J 42863 Valve Seal Installer

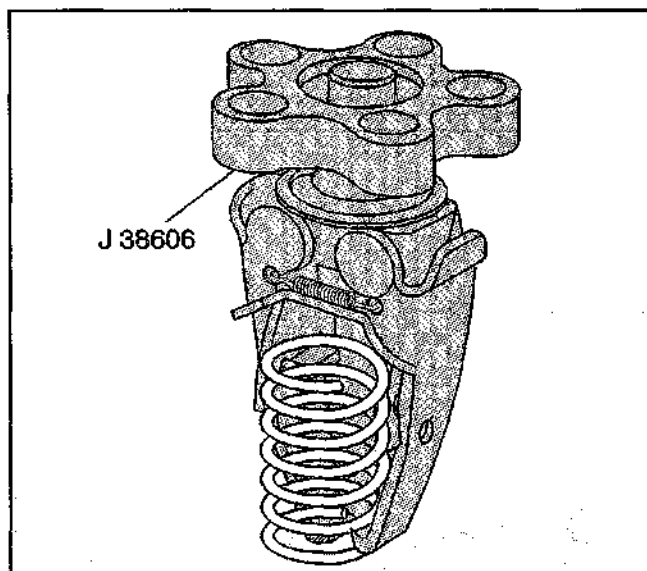
1. Install the valves. The valves are available in standard size and 0.015 in oversize.

Be sure to use oversize valve seals if oversize valves are used.

Important: Use hand pressure only when installing the valve seal using J 42863. Using too much force may cause damage to the oil seal and possibly lead to excessive oil consumption.

2. Place the valve stem oil seal over the valve stem so the seal begins to contact the valve guide.
3. Use J 42863 to push the valve stem oil seal over the valve guide.

4. Use J 38606 to install the valve spring and the valve cap.
5. Install the valve keys.
6. Use the following procedure to measure the valve stem height:
 - 6.1. Place the valve in the guide. Hold the valve in the closed position.
 - 6.2. Use a valve stem height gauge to measure the valve stem height.
 - 6.3. The measurement should be 49–50 mm (1.93–1.97 in).

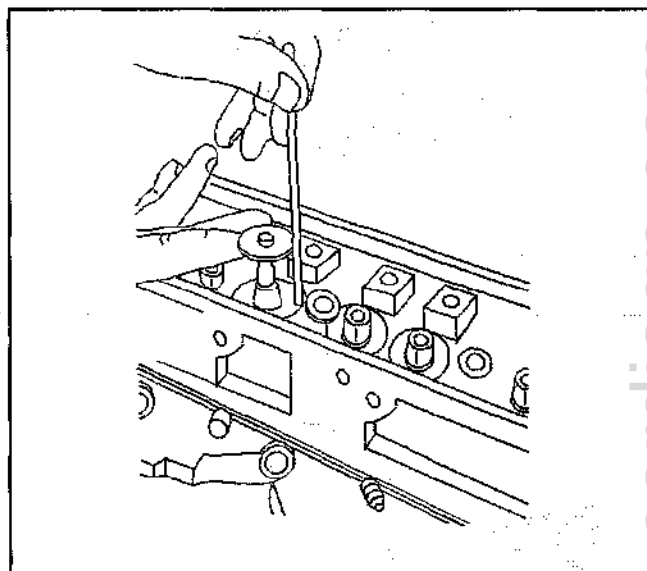


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Important: Grinding the valves increases the valve stem height and the valve spring installed height. Add shims to correct the valve spring installed height.

7. Use the following procedure to measure the valve spring installed height:
 - 7.1. Place the valve in the valve guide.
 - 7.2. Install the valve spring cap and the valve cap keys.
 - 7.3. Seat the valve spring retainer by pulling up.
 - 7.4. Use a steel machinists' rule to measure the distance from the spring seat to the bottom of the valve spring cap.
 - 7.5. The measurement should be 42–44 mm (1.69–1.75 in).

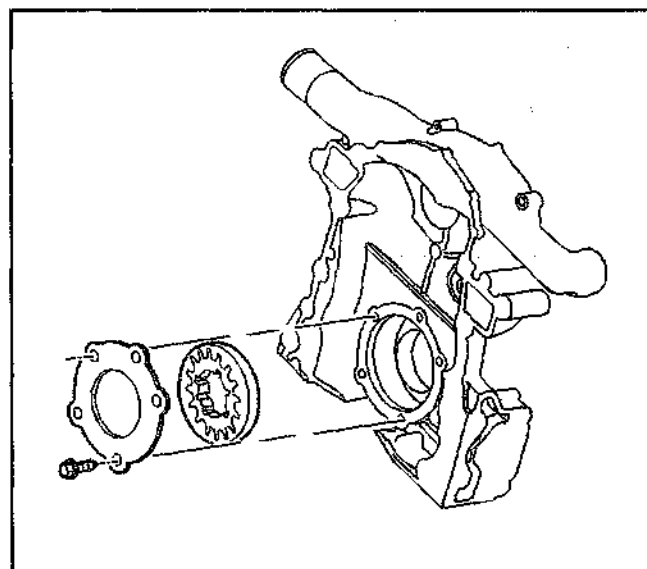
If the measurement is not within specifications add shims under the valve spring.



40072

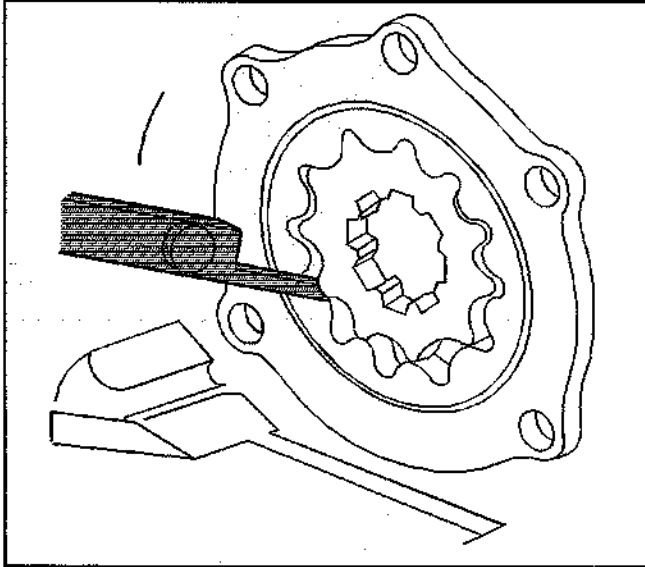
Oil Pump Clean and Inspect

1. Use a suitable solvent to clean the oil pump.
2. Remove all old gasket material from the engine front cover and from the engine block.
3. Inspect the oil pump cover and the engine front cover for the following damage:
 - Cracks
 - Scoring
 - Porous or damaged casting
 - Damaged threads
 - Excessive wear
4. Inspect the pressure regulator valve for the following damage:
 - Scoring
 - Sticking in the bore
 - Burrs
 - Foreign material

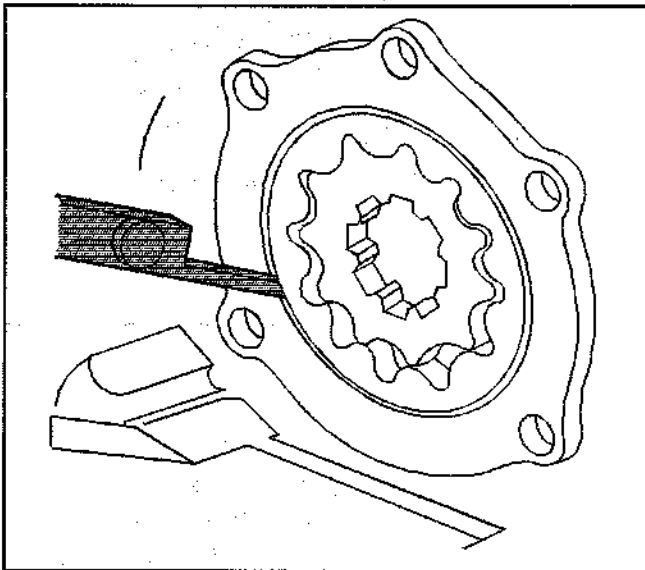


26160

5. Inspect the pressure regulator spring for loss of tension or bending. Replace the pressure regulator spring if damaged.
6. Inspect the oil pump gears for the following conditions:
 - Chipping
 - Galling
 - Scoring
 - Excessive wear
7. Measure the inner oil pump gear tip clearance.



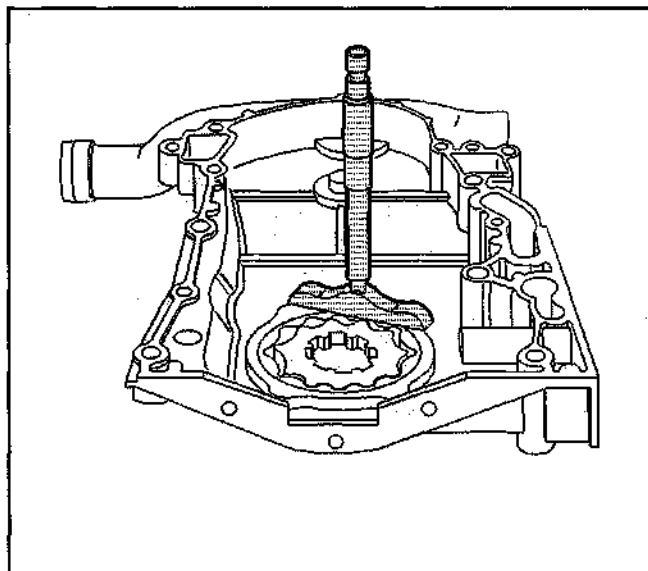
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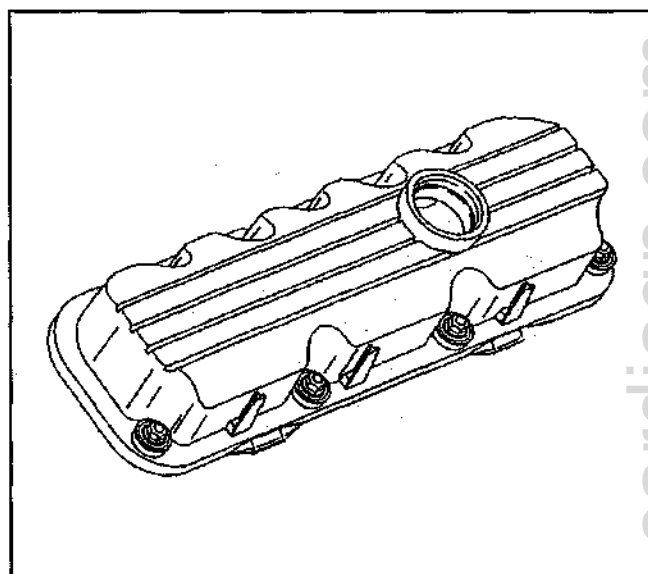
8. Measure the outer oil pump gear diameter clearance.

9. Measure the oil pump gear end clearance.
10. Measure the pressure regulator valve-to-bore clearance.



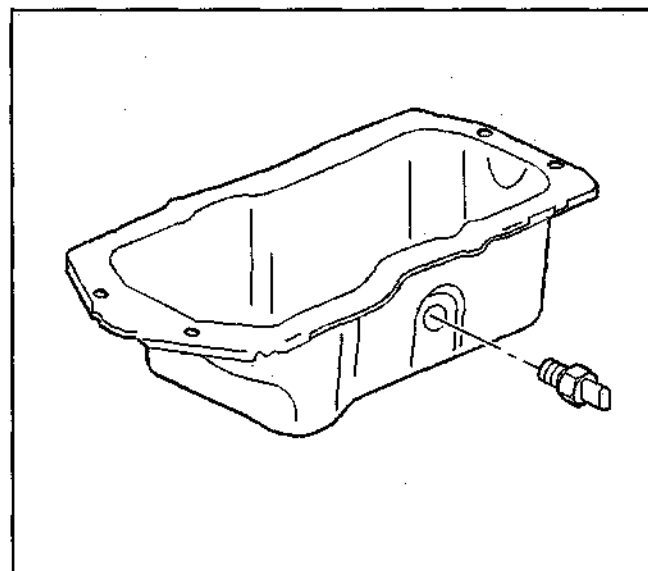
Valve Rocker Arm Cover Clean and Inspect

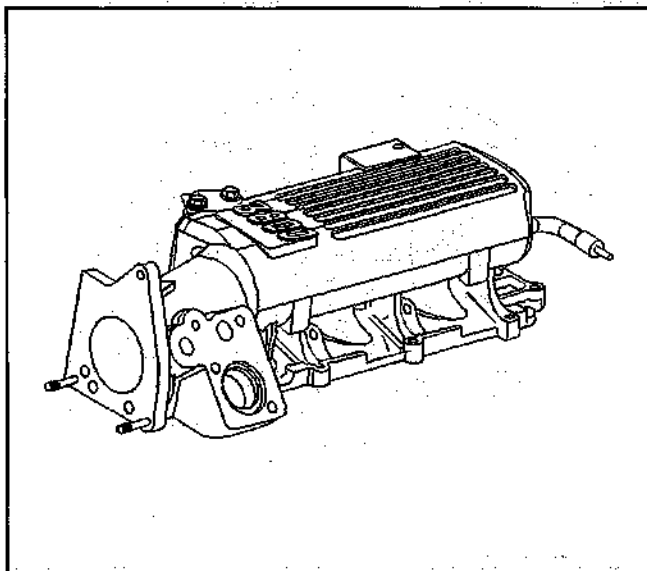
- Clean the valve rocker arm cover mating surface.
- Clean the valve rocker arm cover. Remove all the sludge and the oil deposits.
- Inspect the valve rocker arm cover for damage. Replace the valve rocker arm cover if any damage is found.



Oil Pan Clean and Inspect

- Clean the oil pan mating surface.
- Clean the oil pan. Remove all the sludge and the oil deposits.
- Inspect the threads for the oil level sensor and the engine oil drain plug.
- Inspect the oil pan for dents or distortion.
- Repair or replace the oil pan as necessary.

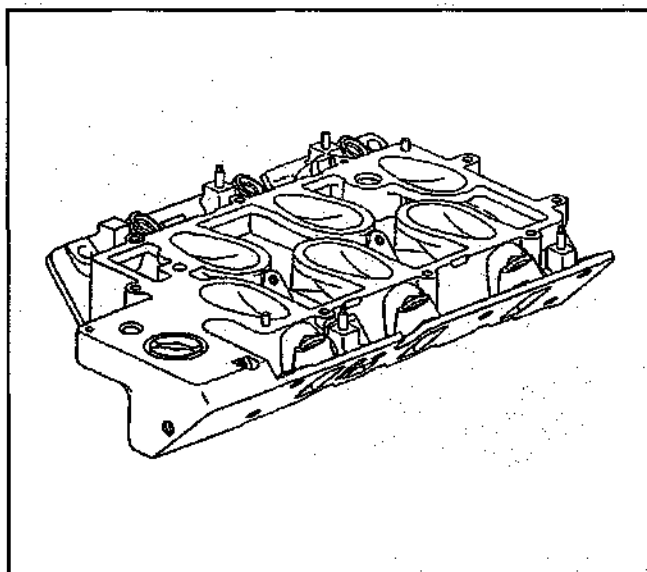




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Intake Manifold Clean and Inspect (Upper)

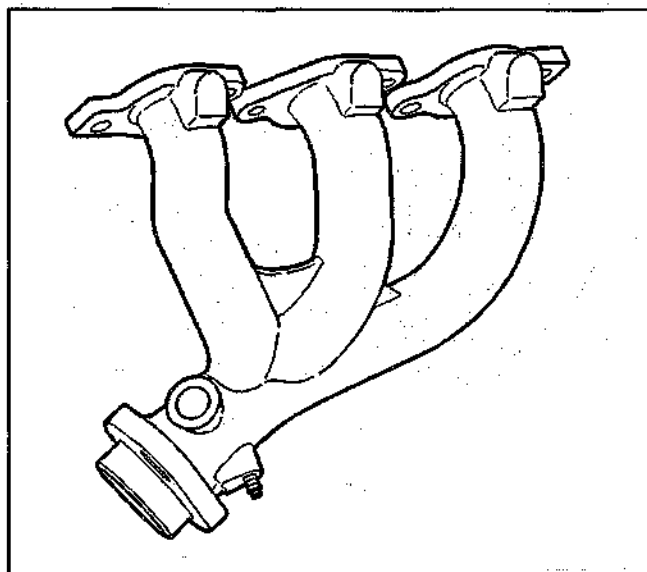
- Clean the upper intake manifold mating surfaces.
- Clean the upper intake manifold.
- Inspect the upper intake manifold for damage.
- Replace the upper intake manifold as necessary.



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Intake Manifold Clean and Inspect (Lower)

- Clean the lower intake manifold mating surfaces.
- Clean the lower intake manifold.
- Inspect the threaded holes for damage.
- Inspect the lower intake manifold for damage or nicks in the mating surfaces.
- Replace or repair the lower intake manifold as necessary.

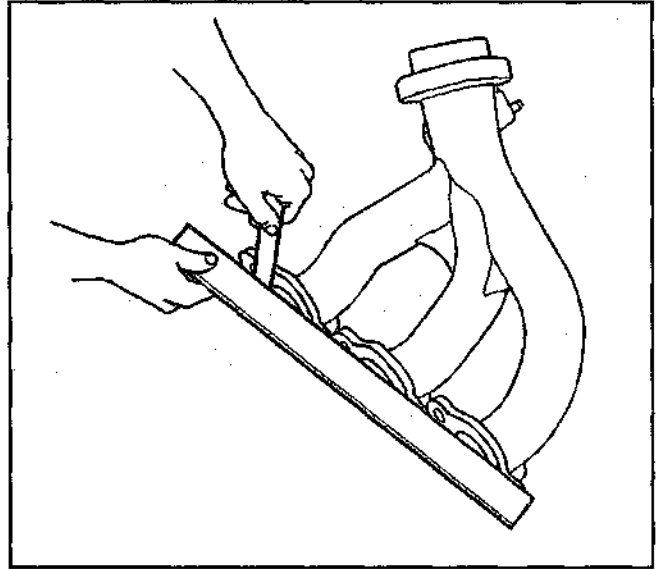


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Exhaust Manifold Clean and Inspect

1. Clean the exhaust manifold mating surfaces.
2. Clean the exhaust manifold.
3. Inspect the exhaust manifold mating surfaces for damage.

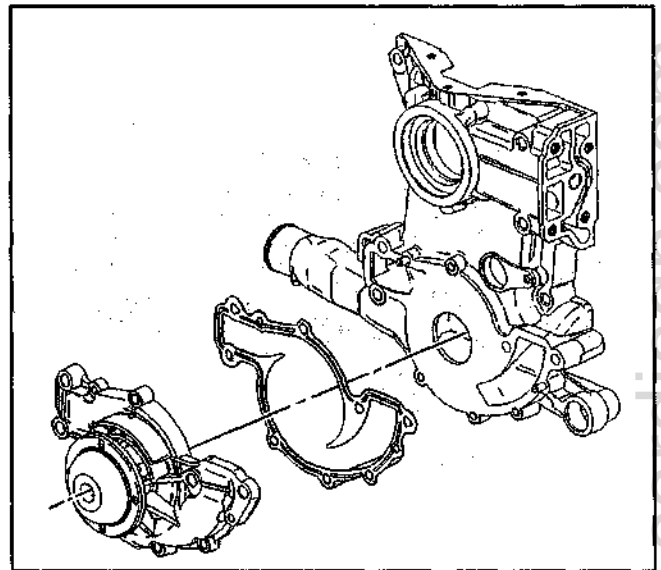
4. Inspect the exhaust manifold flange for straightness, using a straight edge and a feeler gauge.
5. If the exhaust manifold flange is warped more than 0.05 mm (0.002 in) replace the exhaust manifold.



589375

Water Pump Clean and Inspect

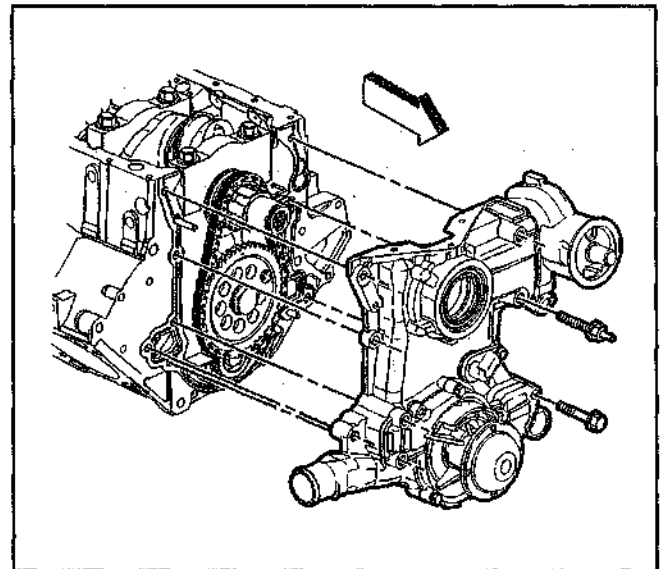
- Clean the water pump mating surface.
- Clean the water pump.
- Inspect the water pump shaft for looseness.
- Inspect the water pump vanes for damage.
- Inspect the water pump mating surfaces for nicks.
- Repair or replace the water pump as necessary.



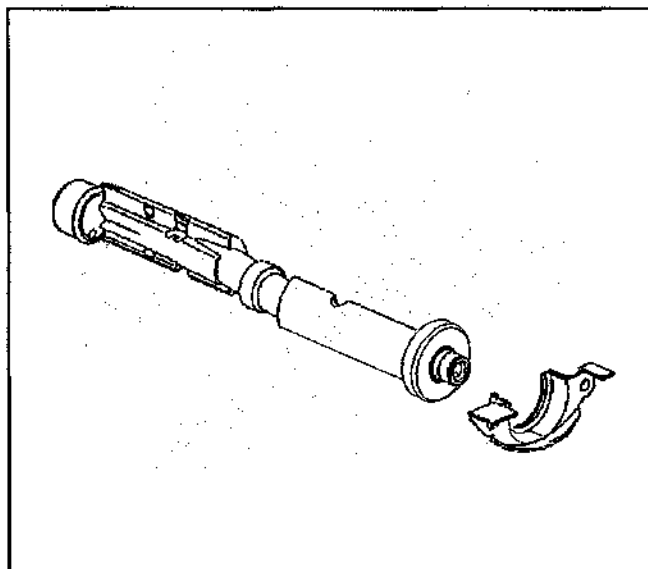
187022

Engine Front Cover Clean and Inspect

- Clean the engine front cover mating surface.
- Clean the engine front cover.
- Inspect the engine front cover threaded holes.
- Inspect the engine front cover for damage.
- Inspect the engine front cover mating surfaces for nicks.
- Repair or replace the engine front cover as necessary.



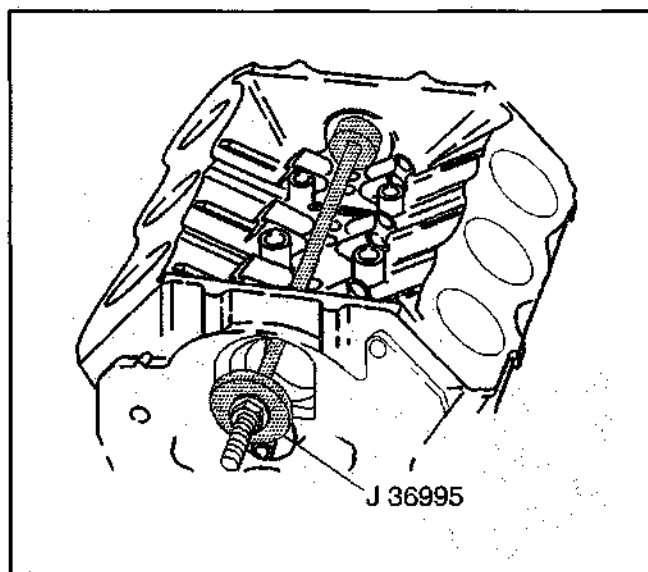
345236



388909

Balance Shaft Clean and Inspect

1. Clean the balance shaft.
2. Inspect the balance shaft bearing/bushing journals for excessive wear.
3. Inspect the balance shaft driven gear and the balance shaft drive gear for nicks and burrs.
4. Inspect the balance shaft retainer for damage.
5. Inspect the balance shaft threads for damage.
6. Repair or replace the balance shaft components as necessary.



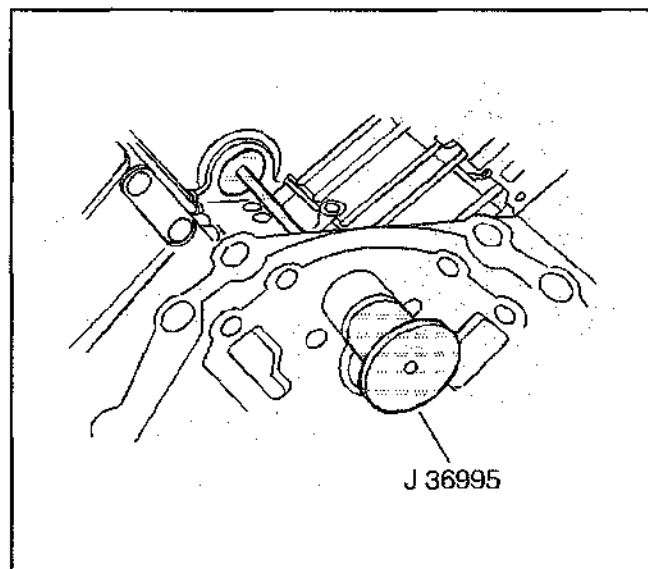
36706

Balance Shaft Bearing and/or Bushing Removal

Tools Required

J 36995 Balance Shaft Bearing Remover/Installer

1. Use *J 36995* to remove the balance shaft bearing.
2. Use *J 36995* to remove the balance shaft bushing. It may take a considerable amount of force to loosen the bushing from the block bore.



36707

Balance Shaft Bearing and/or Bushing Installation

Tools Required

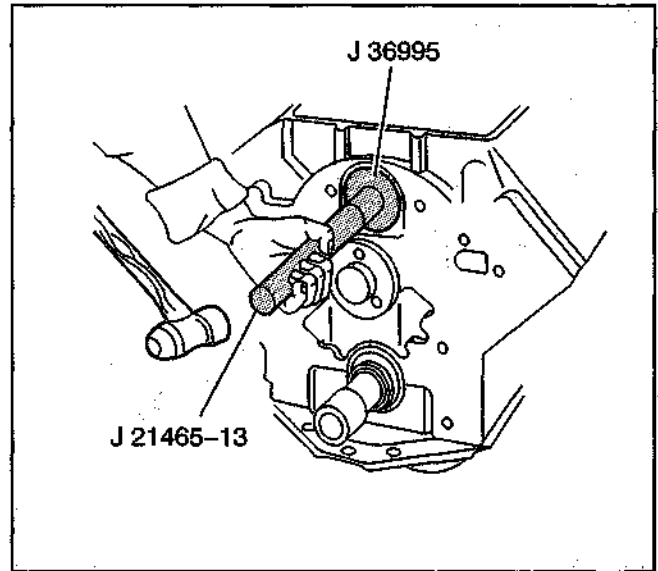
- *J 21465-13* Drive Handle Extension
- *J 36995* Balance Shaft Bearing Remover/Installer

1. Dip the balance shaft bushing in clean engine oil.

Important: The *J 36995* installs the balance shaft bushing to the correct depth. The balance shaft bushing is properly installed when *J 36995* fully contacts the balance shaft bore or the engine block/transaxle mounting flange.

2. Use the balance shaft bushing installers to install the balance shaft bushing.
3. Remove *J 36995*.

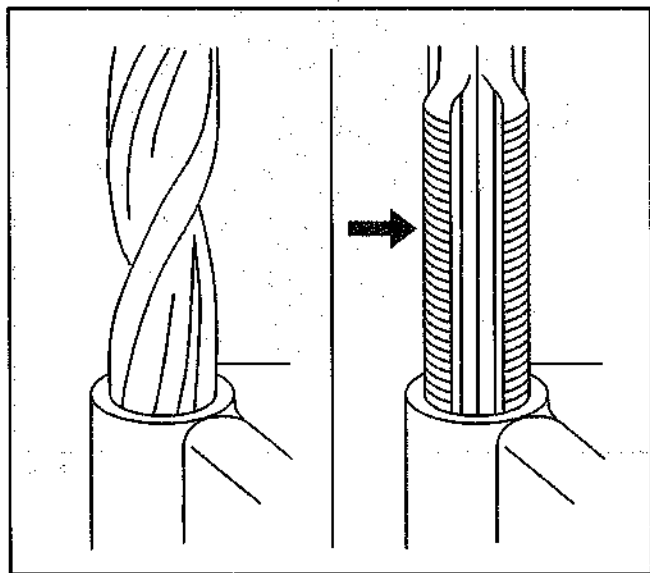
4. Dip the balance shaft bearing into clean engine oil.
5. Use *J 21465-13* and *J 36995* to install the balance shaft bearing into the engine block.



622251

Thread Repair

General purpose thread repair kits are available commercially.



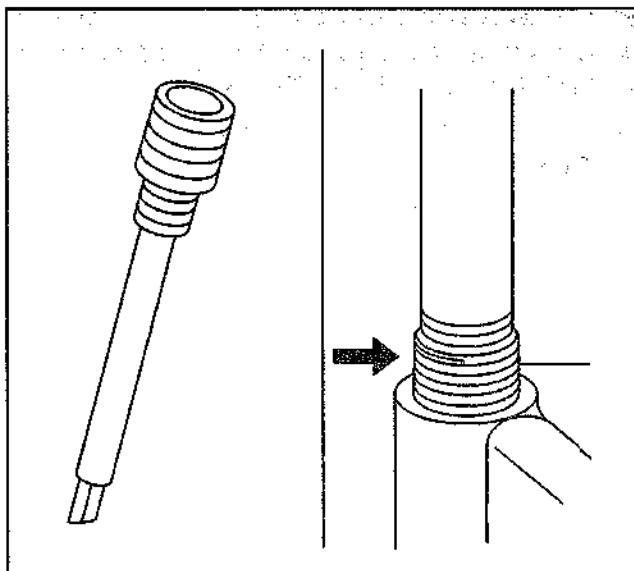
4962

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

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

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

1. Determine the size, the pitch, and the depth of the damaged thread.
2. Adjust the stop collars on the cutting tool as needed. Tap the stop collars to the required depth.
3. Drill out the damaged thread.
4. Remove the chips.
5. Apply clean engine oil to the top thread.
6. Use the tap in order to cut new thread.
7. Clean the thread.



4963

8. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the thread insert onto the end of the mandrel.

Important: The thread insert should be flush to 1 turn below the surface.

9. Lubricate the thread insert with clean engine oil (except when installing in aluminum) and install the thread insert.
10. If the tang of the thread insert does not break off when backing out the thread insert installer, break off the tang using a drift punch.

Service Prior to Assembly

Dirt will cause premature wear of the rebuilt engine. Clean all of the components. Use the proper tools in order to measure components when inspecting for excessive wear. Repair or replace the components that are not within the manufacturers specification. When components are reinstalled into an engine, return the components to their original location, position, and direction. During assembly, lubricate all of the moving parts with clean engine oil or engine assembly lubricant (unless otherwise specified). This will provide initial lubrication when the engine is first started.

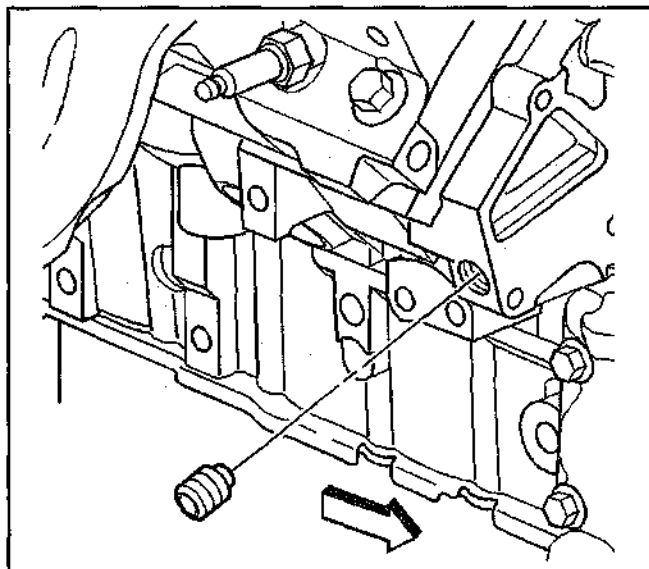
Engine Block Plug Installation

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

1. Install the threaded oil jacket plugs.

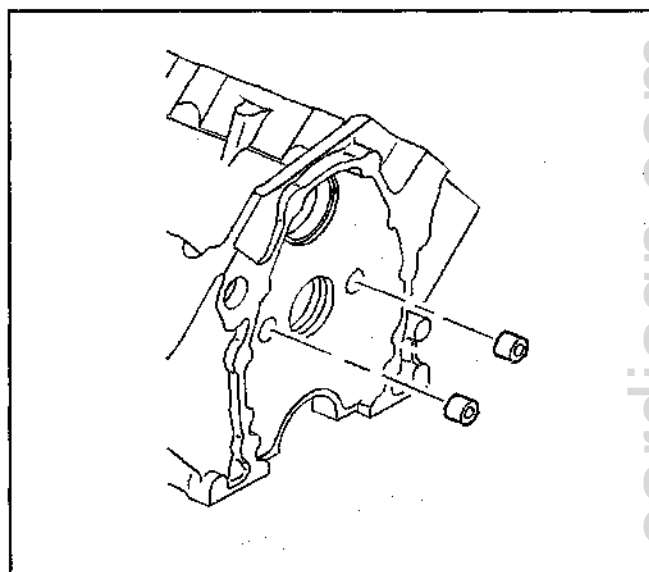
Tighten

Tighten the oil jacket plugs to 30 N·m (22 lb ft).



589370

2. Install the remaining oil gallery plugs using GM P/N 12346004 sealant or equivalent.



26198

Crankshaft and Bearings Installation

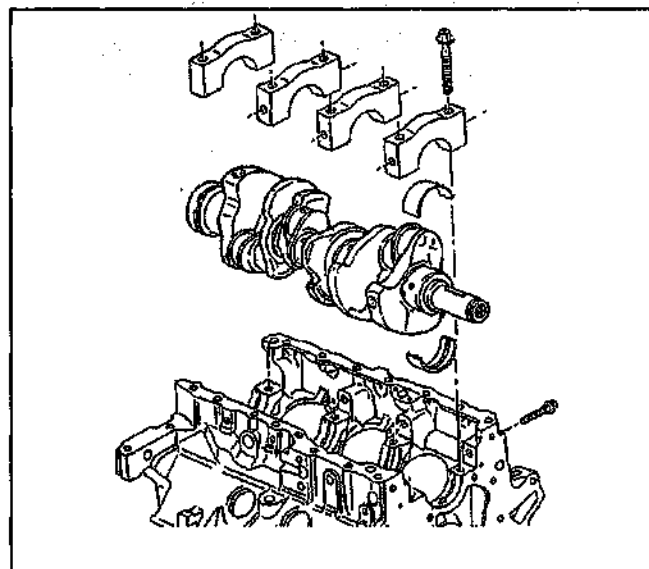
Tools Required

J 36660-A Torque Angle Meter

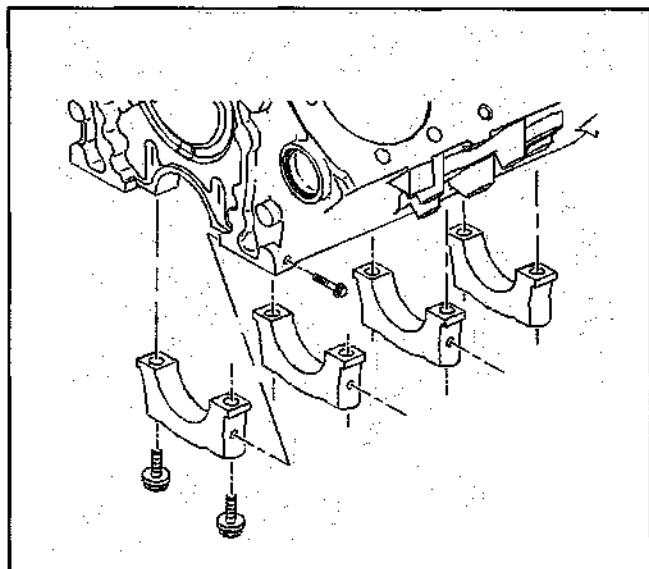
1. Install the upper crankshaft main bearings.
2. Install the crankshaft. Lubricate the crankshaft to crankshaft main bearing contact areas with engine oil or engine assembly lubricant.

Notice: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

3. Install the lower crankshaft main bearings into the main bearing caps.



35863



26153

4. Install the crankshaft main bearing caps. Use GM P/N 1052942 sealer at the number 4 crankshaft main bearing cap to the engine block surface.

Notice: Refer to *Permanently Stretching Bolt Notice* in Cautions and Notices.

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

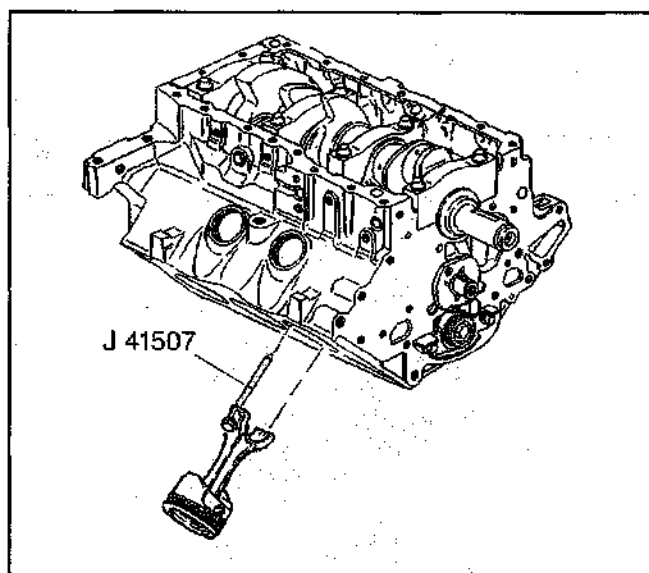
5. Install the crankshaft main bearing cap bolts. Start the crankshaft main bearing cap bolts by hand. Ensure the bottom of the crankshaft main bearing cap is parallel to the bottom of the channel.

Tighten

- Tighten the crankshaft main bearing cap bolts in equal increments. Do not completely tighten one bolt at a time to prevent the cap from being cocked.
 - Tighten the bolts to 70 N·m (52 lb ft) to fully seat the crankshaft main bearing caps. Loosen the bolts 360 degrees counterclockwise.
 - Tighten the bolts to 20 N·m (15 lb ft), then 40 degrees (30 lb ft).
 - Use *J 36660-A* to tighten the bolts in steps: 35 degrees + 35 degrees + 40 degrees for a total of 110 degrees.
6. Install the side main bolts. Apply GM P/N 12345493 or equivalent to the side main bolts.

Tighten

Tighten the side crankshaft main bearing cap bolts to 15 N·m (11 lb ft). Use *J 36660-A* to tighten the bolts an additional 45 degrees.



36190

Piston, Connecting Rod, and Bearing Installation

Tools Required

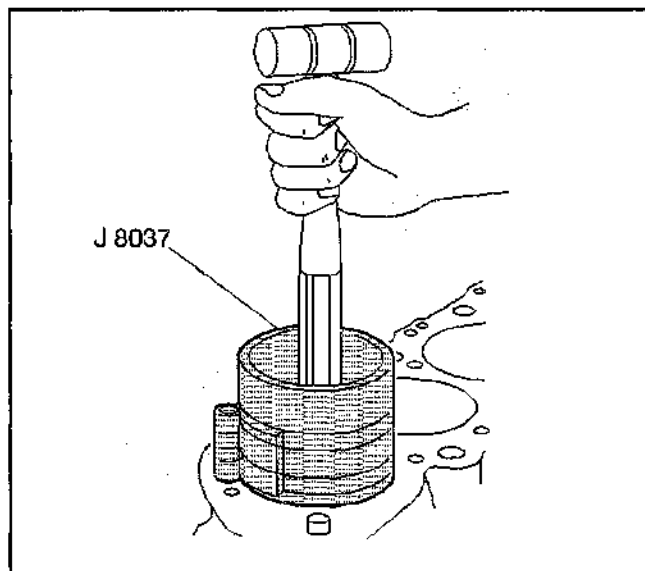
- *J 36660-A* Torque Angle Meter
 - *J 8037* Piston Ring Compressor
 - *J 41507* Connecting Rod Guide
1. Position the crankshaft so the connecting rod journal is opposite the piston and connecting rod assembly being installed. This will aid in the installation of the connecting rod assembly.
 2. Lubricate the cylinder wall with engine oil.
 3. Install the connecting rod bearing inserts.
 4. Lubricate the connecting rod bearing insert surface with engine oil.
 5. Install *J 41507* to the connecting rod. Hand tighten the tool to the connecting rod.
 6. Install *J 8037* to the piston.

Notice: Guide the lower connecting rod end carefully to avoid damaging the crankshaft journal.

7. Use *J 8037* to compress the piston rings for installation of the piston and connecting rod assembly.
8. Install the piston and connecting rod assembly into the engine.

Important: Ensure the arrow on top of the piston or the markings made during removal face towards the front of the engine or are in the same location as when removed.

9. Use *J 41507* to pull the connecting rod into place.
10. Remove *J 41507*.



5159

11. Install the connecting rod bearing cap.

Notice: Refer to *Permanently Stretching Bolt* Notice in Cautions and Notices.

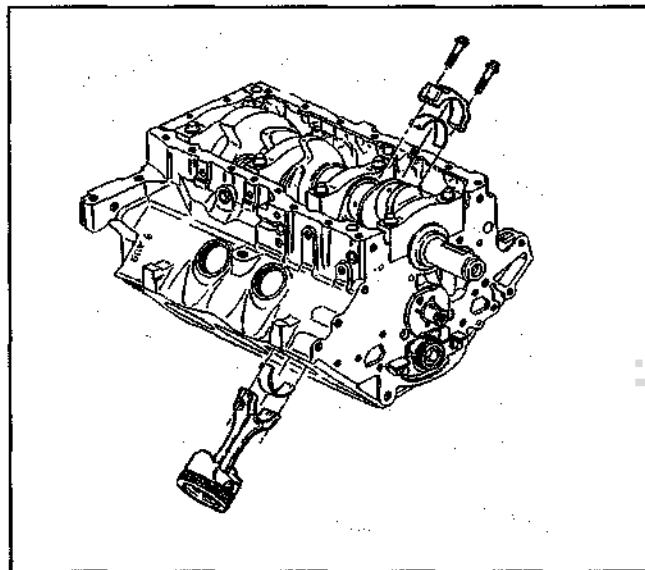
Notice: Refer to *Fastener* Notice in Cautions and Notices.

12. Install the connecting rod bearing cap bolts.

Tighten

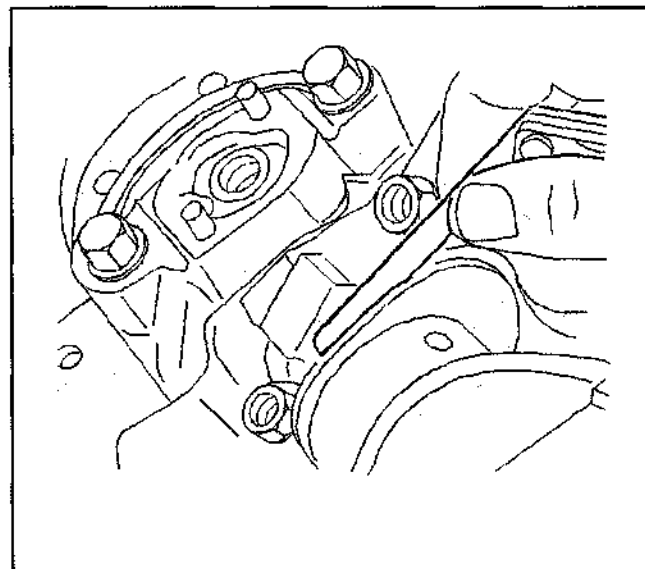
Tighten the connecting rod bearing cap bolts to 27 N·m (20 lb ft) + 50 degrees using *J 36660-A*.

13. Pry the connecting rod back and forth and check for binding. If necessary loosen and retighten the connecting rod bearing cap.

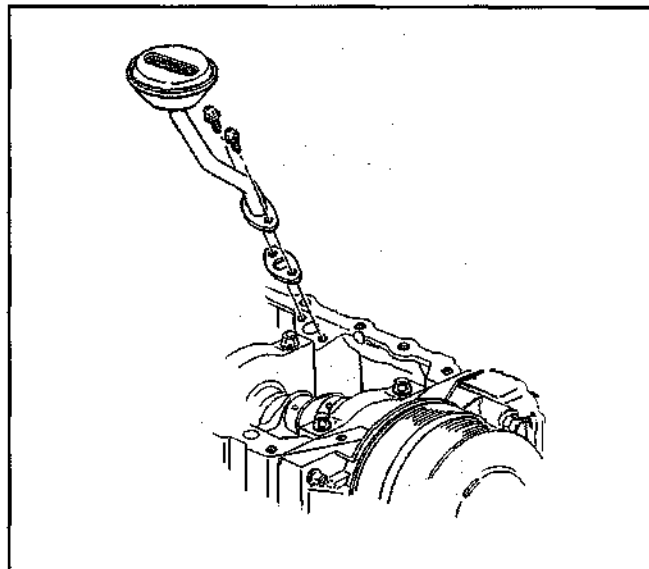


38153

14. Measure the connecting rod side clearance.



5163



26202

Oil Pump Pipe and Screen Assembly Installation

1. Install the oil pump pipe and screen assembly gasket.

Important: The oil pan gasket must be installed before the oil pump pipe and screen assembly.

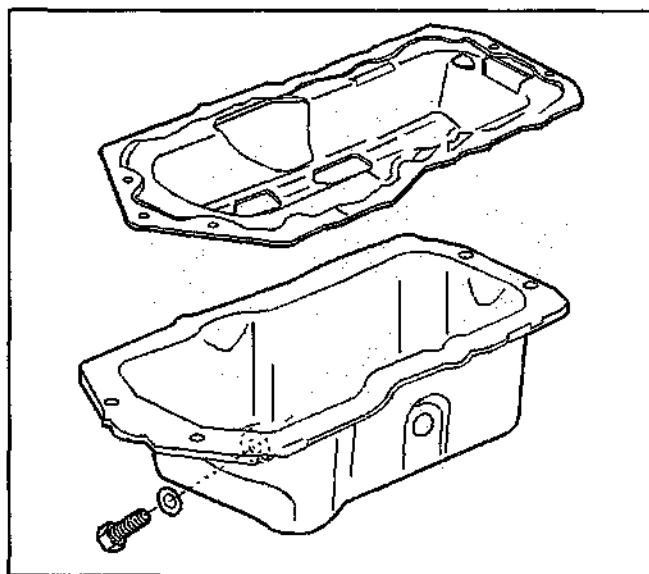
2. Install the oil pan gasket.
3. Install the oil pump pipe and screen assembly.

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

4. Install the oil pump pipe and screen assembly bolts.

Tighten

Tighten the bolts to 15 N·m (11 lb ft).



44775

Oil Pan Installation

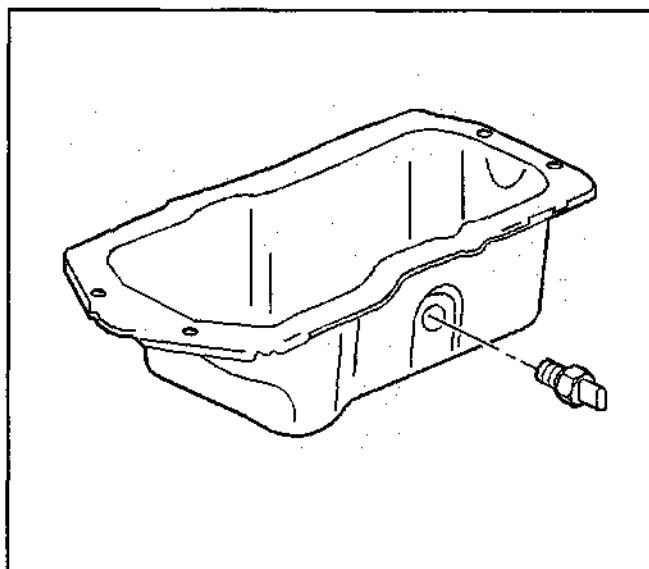
1. Install the oil pan gasket to the oil pan flange.
2. Install the oil pan.
3. Clean the oil pan bolts.
4. Apply one drop of GM P/N 12345382 to each bolt.

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

5. Install the oil pan bolts.

Tighten

Tighten the bolts to 14 N·m (125 lb in).



35861

Notice: Install the oil level sensor, located in the oil pan, after the oil pan is installed. The sensor may be damaged if the oil level sensor is installed first.

6. Install the oil level sensor.

Tighten

Tighten the oil level sensor to 20 N·m (15 lb ft).

Camshaft Installation

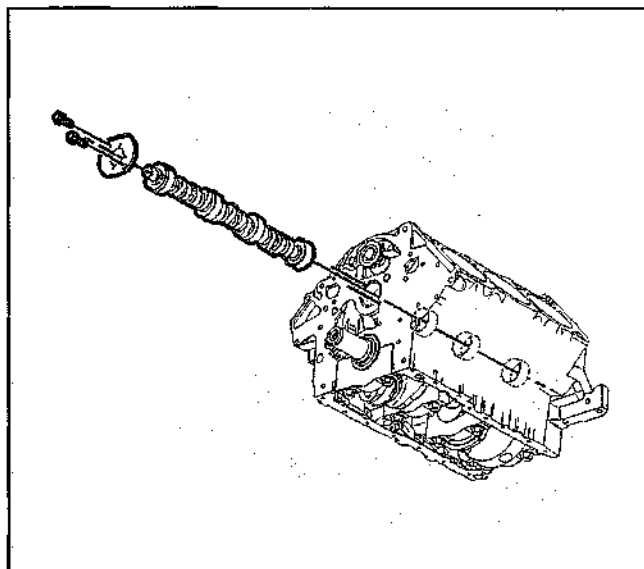
1. Coat the camshaft with prelube GM P/N 12345507 or equivalent.
2. Install the camshaft.
3. Install the camshaft thrust plate.

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

4. Install the camshaft thrust plate bolts.

Tighten

Tighten the bolts to 15 N·m (11 lb ft).

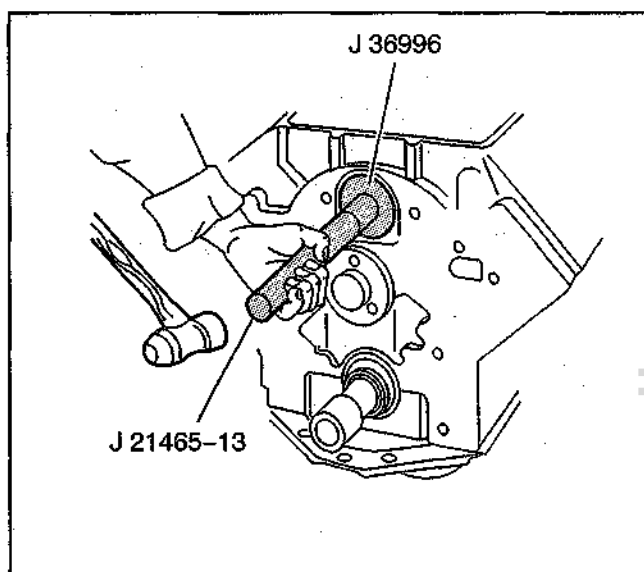


35815

Balance Shaft Installation

Tools Required

- J 8001 Dial Indicator
 - J 21465-13 Drive Handle Extension
 - J 36660-A Torque Angle Meter
 - J 36996 Balance Shaft Installer
1. Use J 21465-13 and J 36996 to install the balance shaft into the engine block.



566836

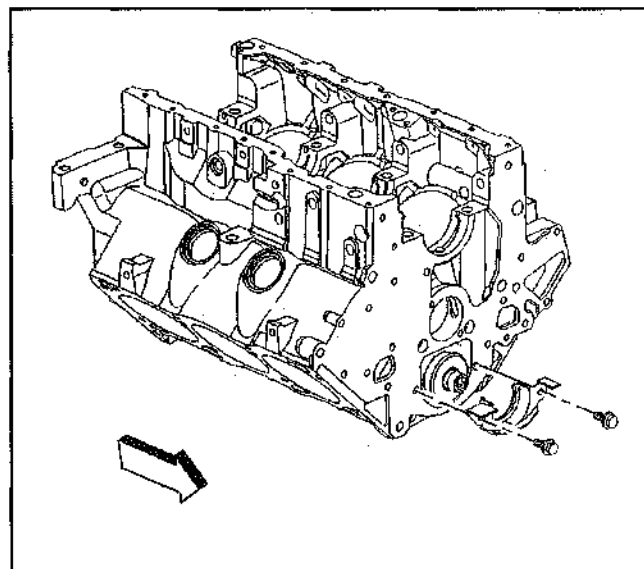
2. Install the balance shaft bearing retainer.

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

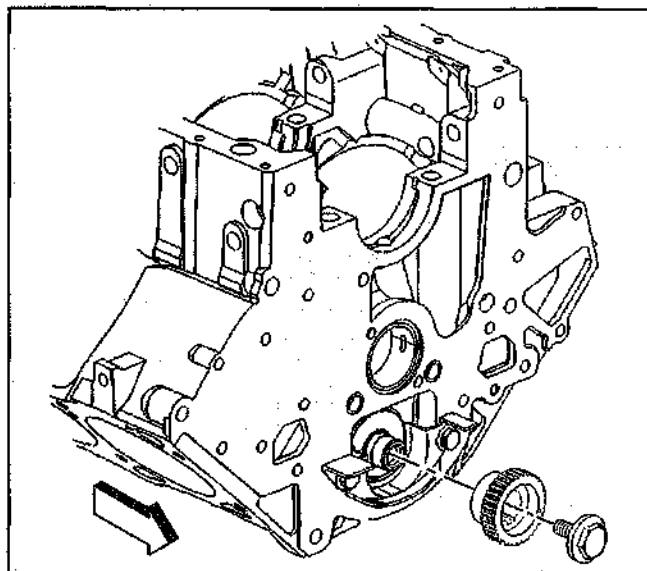
3. Install the balance shaft bearing retainer bolts.

Tighten

Tighten the balance shaft retainer bolts to 30 N·m (22 lb ft).



42237



154521

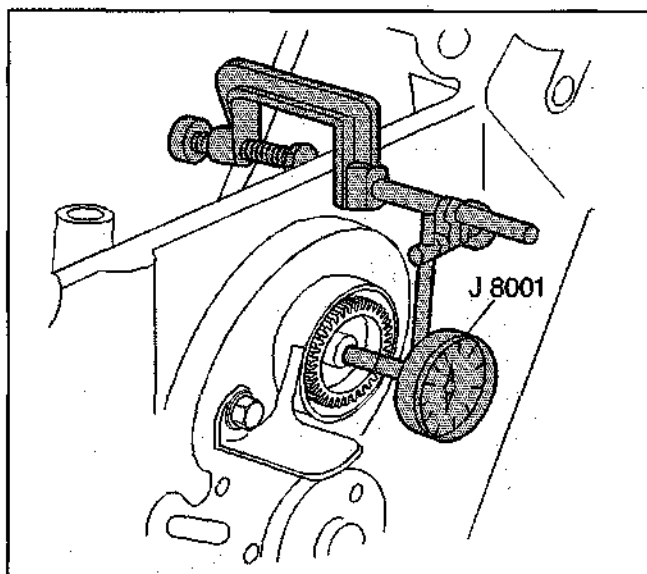
4. Install the balance shaft driven gear.

Notice: Refer to *Permanently Stretching Bolt Notice* in Cautions and Notices.

5. Install the balance shaft driven gear bolt.

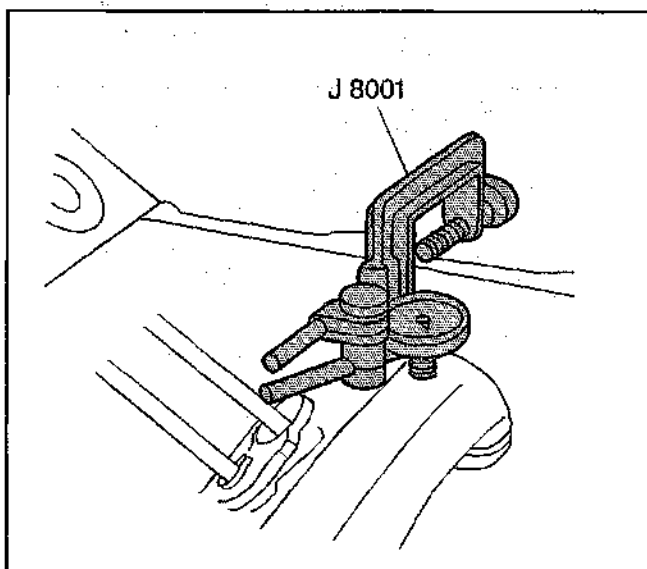
Tighten

Tighten the balance shaft driven gear bolt to 22 N·m (16 lb ft). Use J 36660-A to tighten the bolt an additional 70 degrees.



38470

6. Using J 8001 measure the balance shaft end play. End play must not exceed 0.028 mm (0.008 in).



38472

7. Using J 8001 measure the balance shaft radial play at the rear. Radial play must be between 0.0127–0.119 mm (0.0005–0.0047 in).

8. Install the balance shaft drive gear.

9. Install the camshaft sprocket.

10. Turn the camshaft so the timing mark on the camshaft sprocket is straight down.

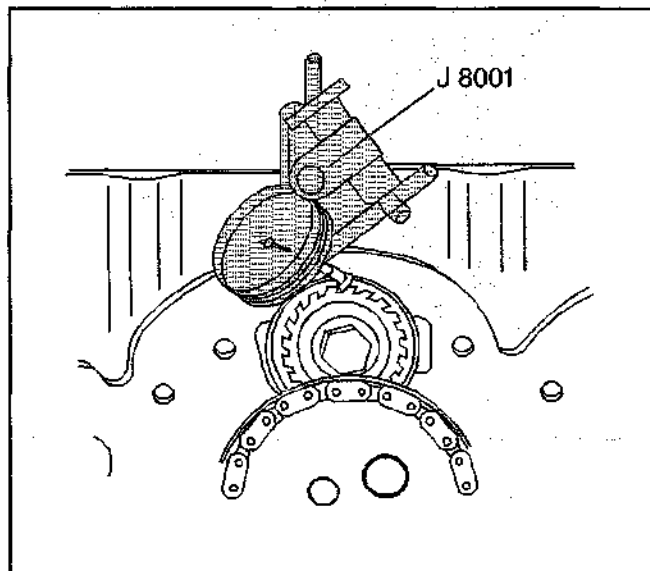
11. Remove the camshaft sprocket and balance shaft drive gear.

12. Turn the balance shaft so the timing mark on the balance shaft driven gear points straight down.

13. Install the balance shaft drive gear.

14. Align the marks on the balance shaft driven gear and the balance shaft drive gear. Do this by turning the balance shaft.

15. Turn the crankshaft so the number one piston is at top dead center.
16. Install the timing chain.
17. Install the camshaft sprocket.
18. Using *J 8001* measure the gear lash at four places. Measure every quarter turn. Gear lash must be between 0.050–0.127 mm (0.002–0.005 in).



38477

Crankshaft Rear Oil Seal and Housing Installation

Tools Required

- *J 36660-A* Torque Angle Meter
 - *J 41349* Crankshaft Rear Oil Seal Aligning Tool
1. Clean the gasket from the crankshaft rear oil seal housing.
 2. Clean the crankshaft rear oil seal housing.
 3. Inspect the crankshaft rear oil seal housing for damage.

Notice: Do not use sealers or adhesives on rear main oil seal housing gasket. Use of sealers or adhesives on this gasket may cause oil leaks.

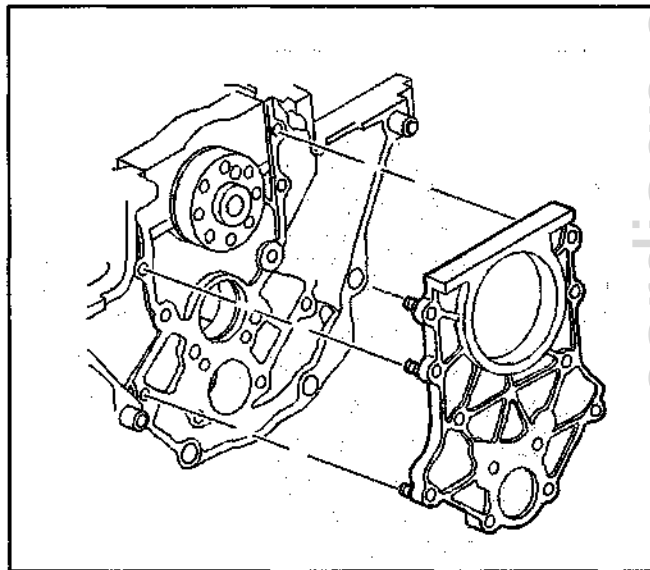
4. Install the crankshaft rear oil seal housing gasket over the bolts for alignment.

Important: The plastic inserts in the crankshaft rear oil seal housing are used to aid assembly only. The inserts are not required for service.

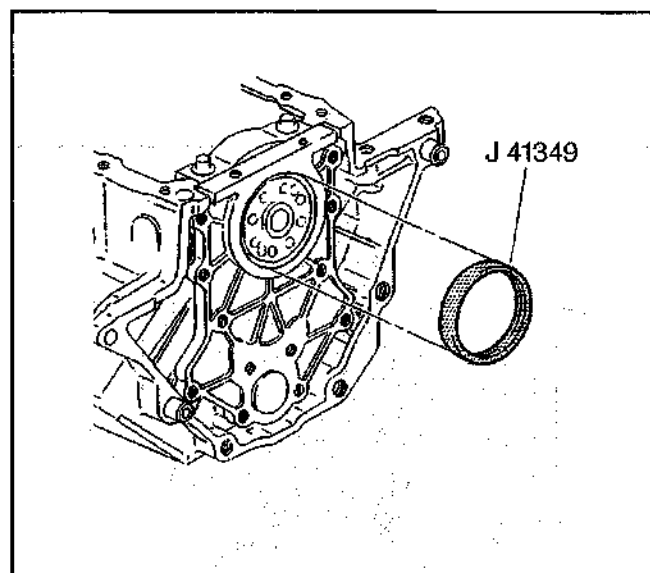
5. Install the crankshaft rear oil seal housing. Hand tighten the crankshaft rear oil seal housing bolts.

Notice: Sealability of the rear main oil seal depends on the correct alignment of the rear main oil seal housing and the oil pan. Incorrect alignment may cause oil leaks.

6. Apply engine oil to both sides of *J 41349*.



26125



44779

7. Install *J 41349* over the crankshaft. Twist the tool to aid in sliding the tool over the crankshaft.
8. Place a straight edge on the engine block oil pan flange and the crankshaft rear oil seal housing flange. Use a feeler gage to ensure there is no more than 0.10 mm (0.004 in) step on each side. Rotate the crankshaft rear oil seal housing to make the step equal on each side. Replace the crankshaft rear oil seal housing if the rotation does not make the step equal.

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

9. Tighten the crankshaft rear oil seal housing bolts.

Tighten

Tighten the crankshaft rear oil seal housing bolts to 15 N·m (11 lb ft). Use *J 36660-A* to tighten the bolts an additional 50 degrees.

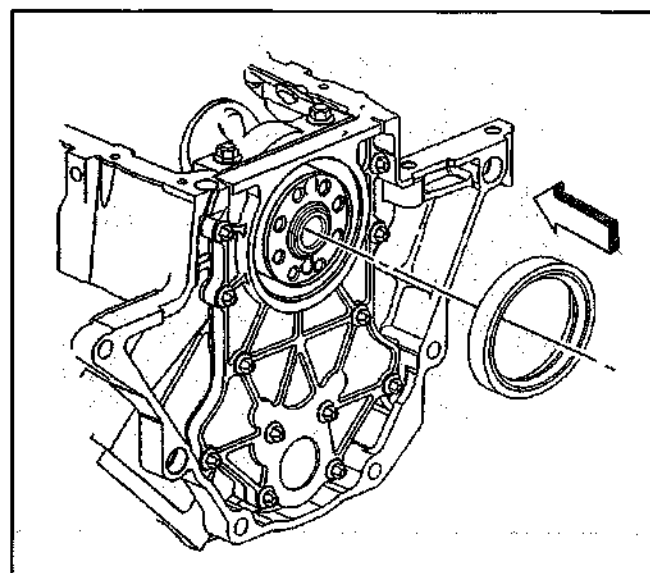
10. Remove *J 41349*.
11. Recheck the step height on each side to ensure the crankshaft rear oil seal housing did not move. If the step height is beyond specification, reinstall the crankshaft rear oil seal housing and measure the step again. Replace the crankshaft rear oil seal housing if the clearance is still beyond specification.

Crankshaft Rear Oil Seal Installation

Tools Required

J 38196 Crankshaft Rear Oil Seal Installer

1. Apply engine oil to the inside diameter and the outside diameter of the crankshaft rear oil seal.
2. Slide the crankshaft rear oil seal over the mandrel until the back bottoms squarely against the collar of the tool.

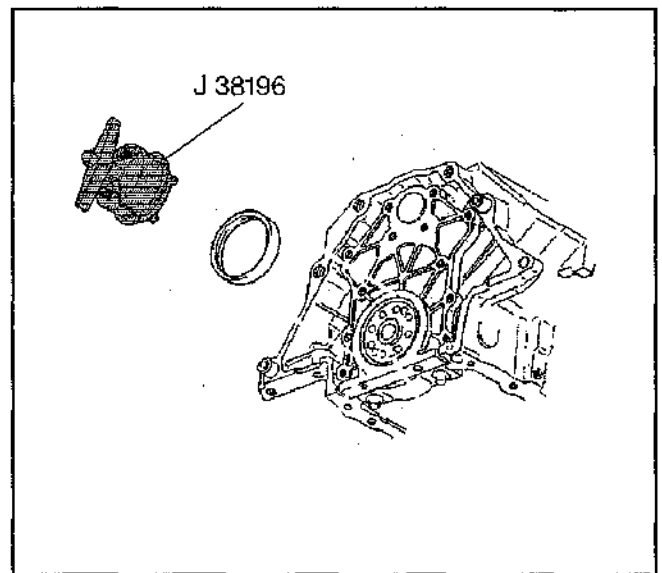


26129

3. Use the following procedure to install the seal:

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

- 3.1. Attach *J 38196* to the crankshaft by hand or tighten attaching screws to 5 N·m (54 lb in).
- 3.2. Turn the T handle of *J 38196* so the collar pushes the crankshaft rear oil seal into the bore. Turn the handle until the tool is bottomed out. Ensure the crankshaft rear oil seal is seated properly.
- 3.3. Loosen the T handle of *J 38196* until it comes to a stop.
- 3.4. Remove the attaching screws.



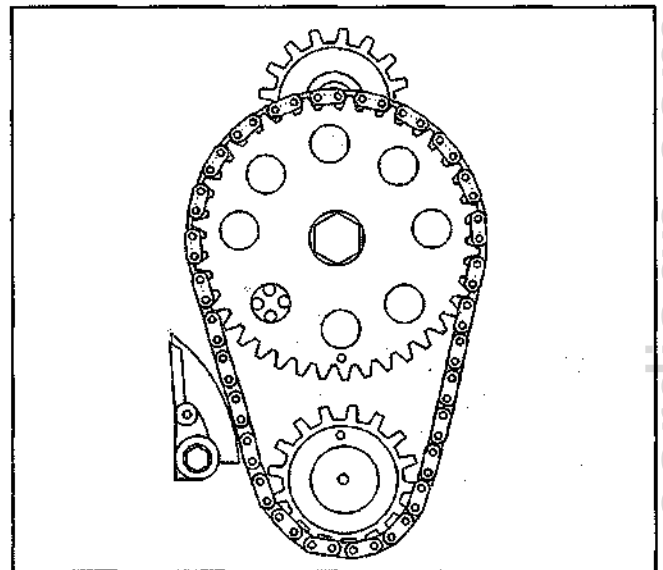
37747

Timing Chain and Sprockets Installation (VIN K)

Tools Required

J 36660-A Torque Angle Meter

1. Install the crankshaft balancer key into the crankshaft keyway.
The crankshaft balancer key should be parallel to the crankshaft or with a slight incline.
2. Install the timing chain on the sprockets. Align the timing marks.



192706

3. Install the timing chain, the crankshaft sprocket, and the camshaft sprocket.

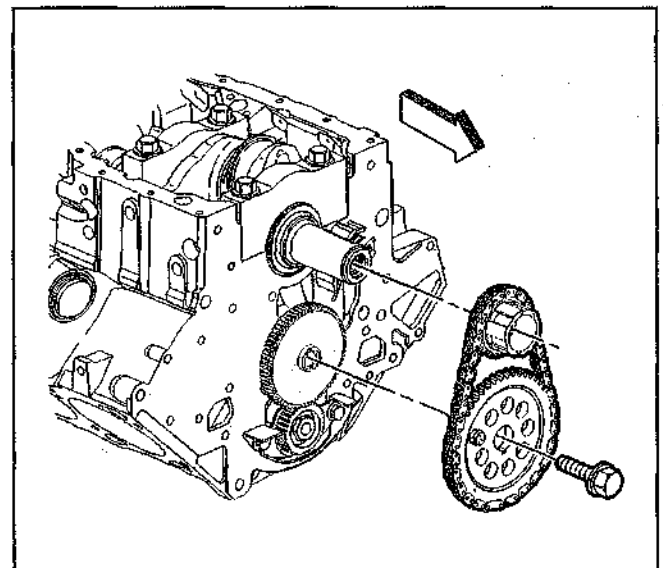
Notice: Refer to *Permanently Stretching Bolt Notice* in Cautions and Notices.

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

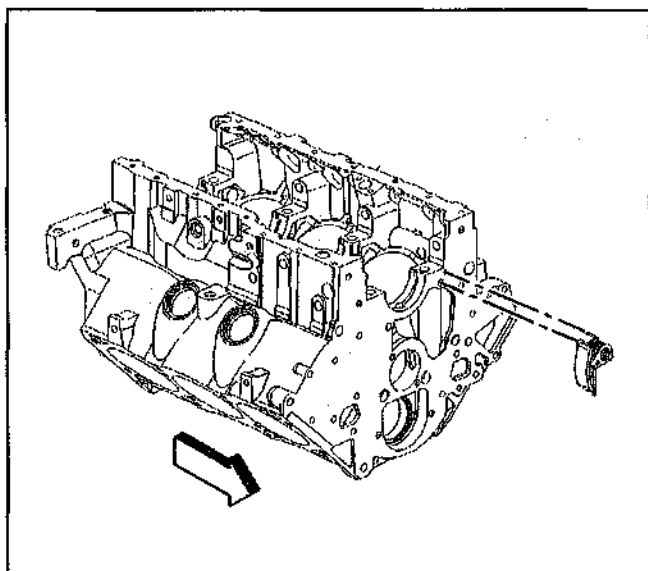
4. Install the camshaft sprocket bolt.

Tighten

Tighten the camshaft sprocket bolt to 100 N·m (74 lb ft). Use *J 36660-A* to tighten the camshaft sprocket bolt an additional 90 degrees.



192716

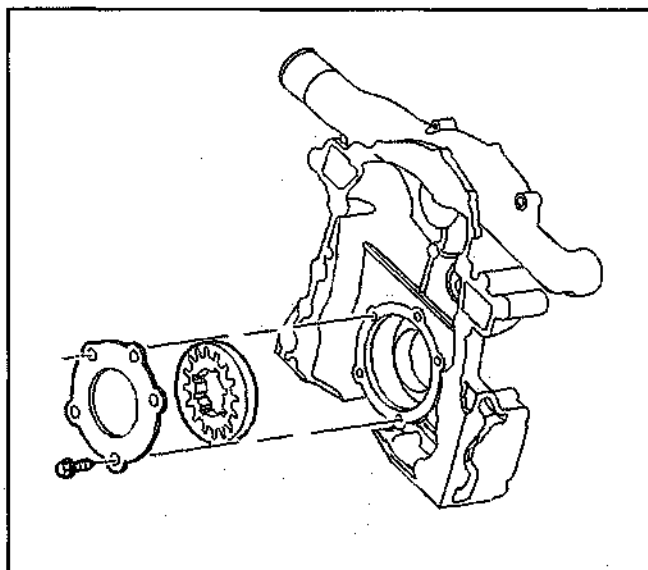


154523

5. Install the timing chain damper.

Tighten

Tighten the timing chain damper bolt to 22 N·m (16 lb ft).



26160

Oil Pump Cover and Gear Set Installation

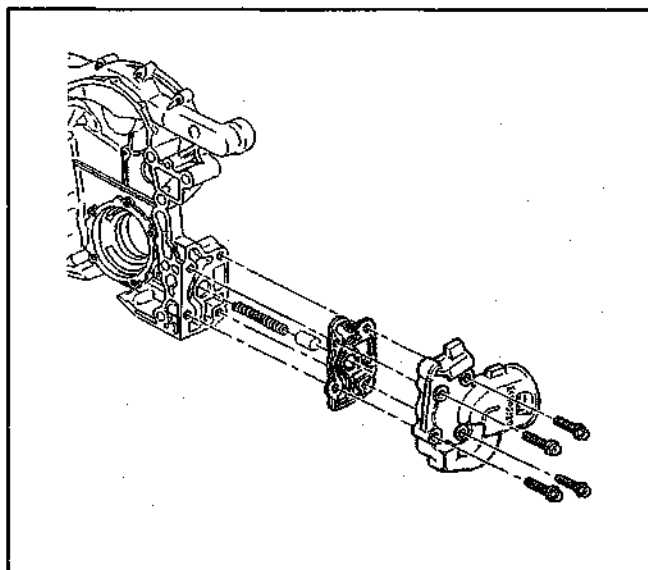
1. Lubricate the oil pump gears with petroleum jelly.
2. Install the oil pump gears.
3. Pack the oil pump cavity with petroleum jelly.
4. Install the oil pump cover.

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

5. Install the oil pump cover screws.

Tighten

Tighten the screws to 11 N·m (98 lb in).



36655

Oil Filter Adapter Installation

1. Install the oil pressure relief valve spring into the engine front cover.
2. Install the oil pressure relief valve into the engine front cover.
3. Install a new oil filter adapter gasket.
4. Install the oil filter adapter.

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

5. Install the oil filter adapter bolts.

Tighten

Tighten the oil filter adapter bolts to 15 N·m + 50° (11 lb ft + 50°).

Engine Front Cover Installation

Tools Required

J 36660-A Torque Angle Meter

1. Install the engine front cover gasket.
2. Install the engine front cover.

Align the cogs on the crankshaft sprocket with the cogs on the oil pump in the engine front cover.

3. Apply sealant GM P/N 12346004 or equivalent to the engine front cover bolt threads.

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

4. Install the engine front cover bolts.

Tighten

Tighten the engine front cover bolts to 20 N·m (15 lb ft). Use J 36660-A to tighten the engine front cover bolts an additional 40 degrees.

5. Install the oil pan to engine front cover bolts.

Tighten

Tighten the oil pan bolts to 14 N·m (125 lb in).

6. Install the oil filter.

Tighten

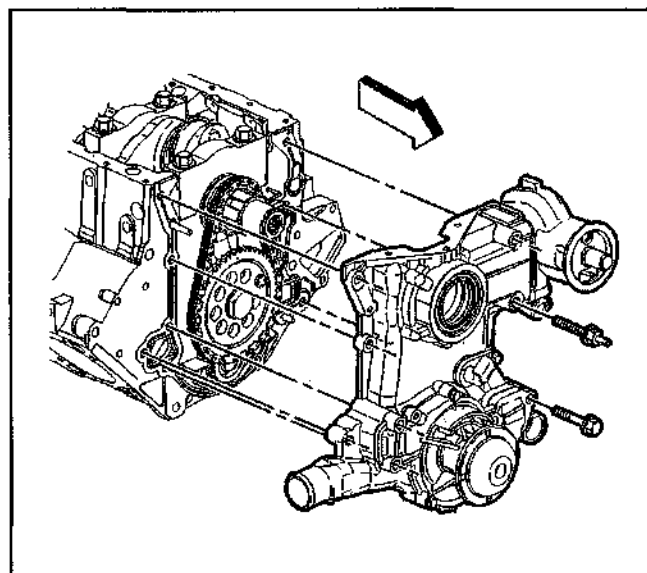
Tighten the oil filter to 19 N·m (14 lb ft).

7. Apply sealant GM P/N 12345382 or equivalent to the crankshaft position sensor stud threads.

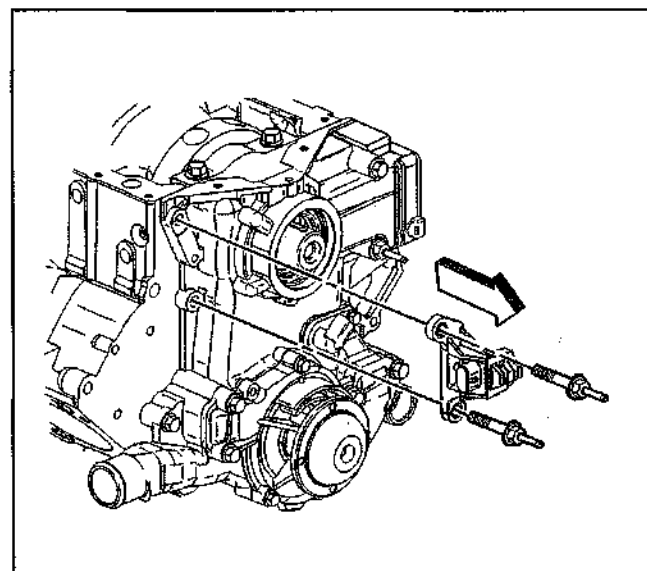
8. Install the crankshaft position sensor.

Tighten

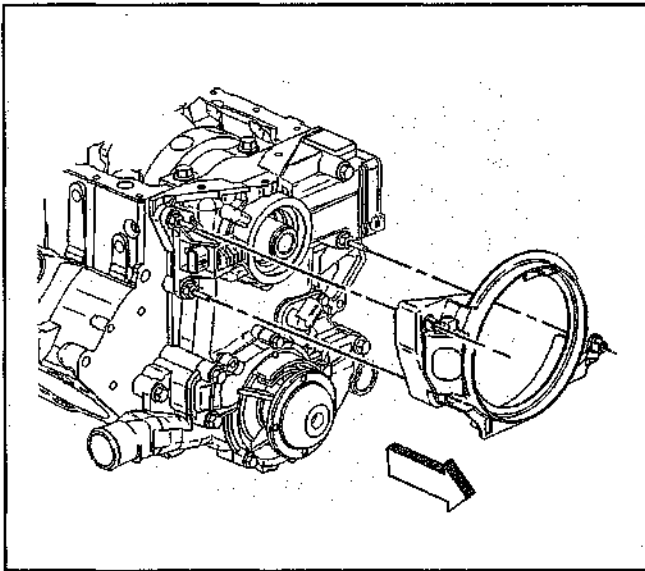
Tighten the crankshaft position sensor studs to 30 N·m (22 lb ft).



345236

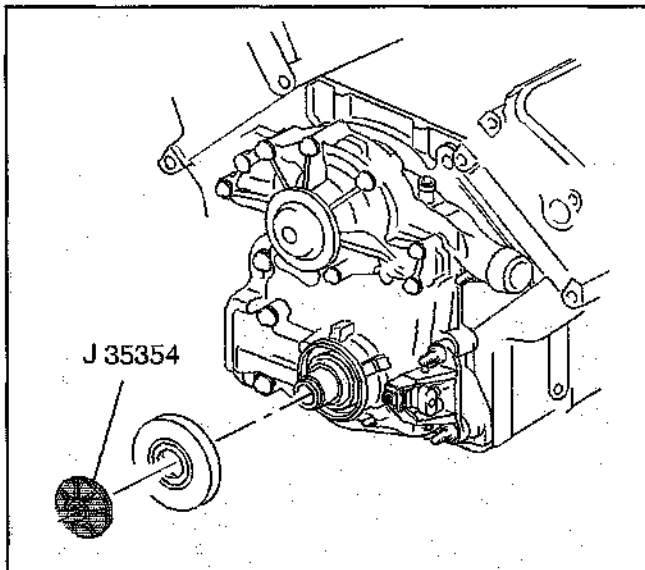


36589



35844

9. Install the crankshaft position sensor shield.



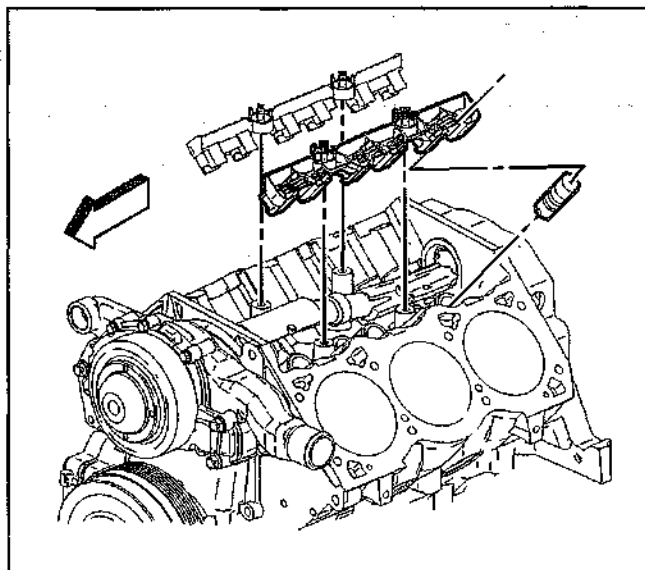
36662

Crankshaft Front Oil Seal Installation

Tools Required

J 35354 Seal Installer

1. Coat the inside diameter of the crankshaft front oil seal with lubricant GM P/N 10522497 or equivalent.
2. Use J 35354 and a soft faced hammer to install the crankshaft front oil seal.
3. Remove J 35354.



41374

Valve Lifter Installation

1. Dip the valve lifters in prelube GM P/N 12345501 or equivalent.
2. Install the valve lifters.
3. Install the valve lifter guides.

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

4. Install the valve lifter guide bolts.

Tighten

Tighten the valve lifter guide bolts to 30 N·m (22 lb ft).

Cylinder Head Installation

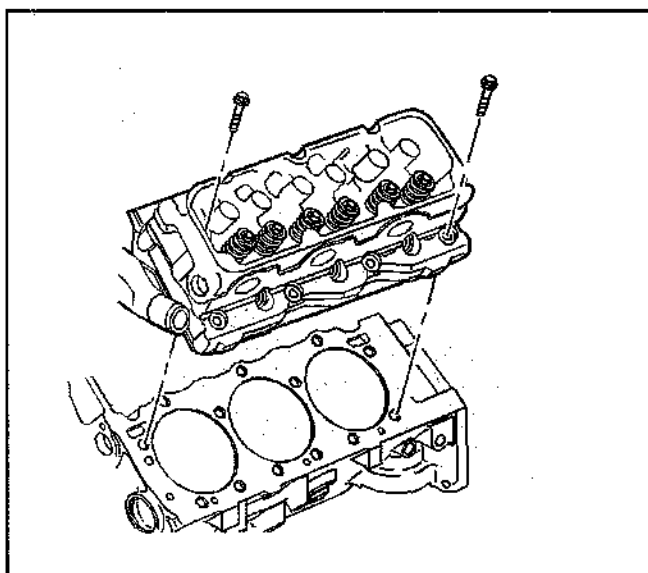
Tools Required

J 36660-A Torque Angle Meter

1. Install the cylinder head gasket. Ensure the arrows point towards the front of the engine. The left cylinder head gasket has the letter L stamped next to the arrow.

Notice: Refer to *Permanently Stretching Bolt Notice* in Cautions and Notices.

2. Install the cylinder head.



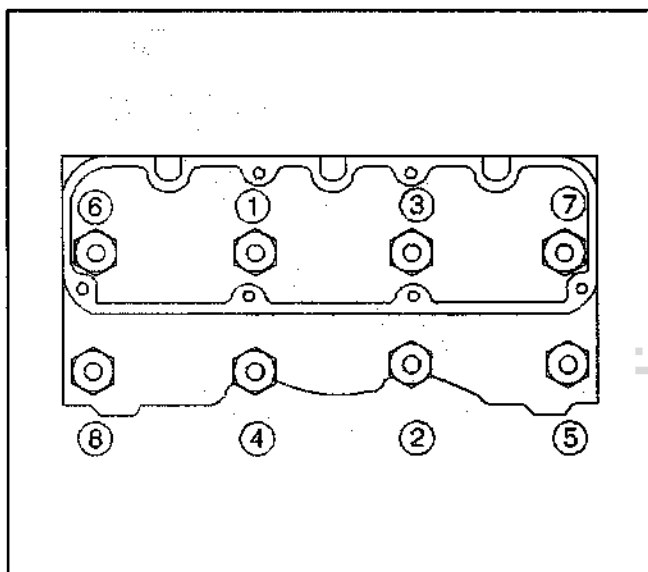
35842

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

3. Install new cylinder head bolts.

Tighten

Tighten the cylinder head bolts to 50 N·m (37 lb ft) in sequence. Using J 36660-A rotate each cylinder head bolt an additional 120 degrees.



38826

Valve Rocker Arm and Push Rod Installation

Tools Required

J 36660-A Torque Angle Meter

1. Install the push rods.
2. Install the push rod guide plates.
3. Install the valve rocker arms.

Notice: Refer to *Permanently Stretching Bolt Notice* in Cautions and Notices.

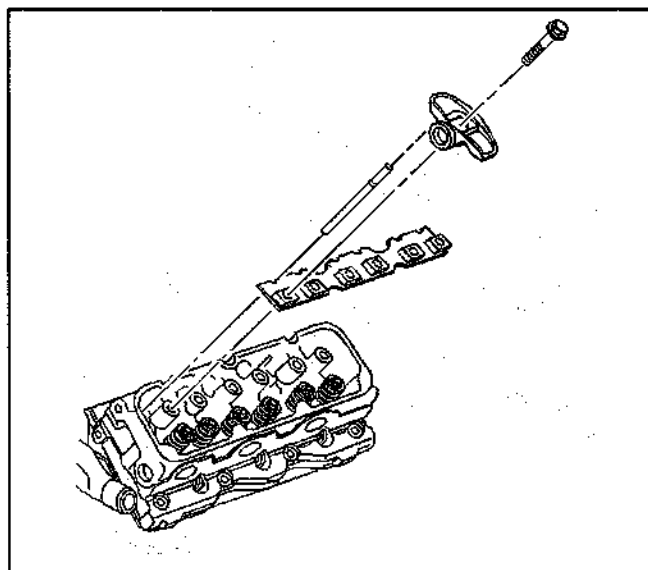
4. Apply GM P/N 12345493 threadlocker or equivalent to the valve rocker arm bolt threads.

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

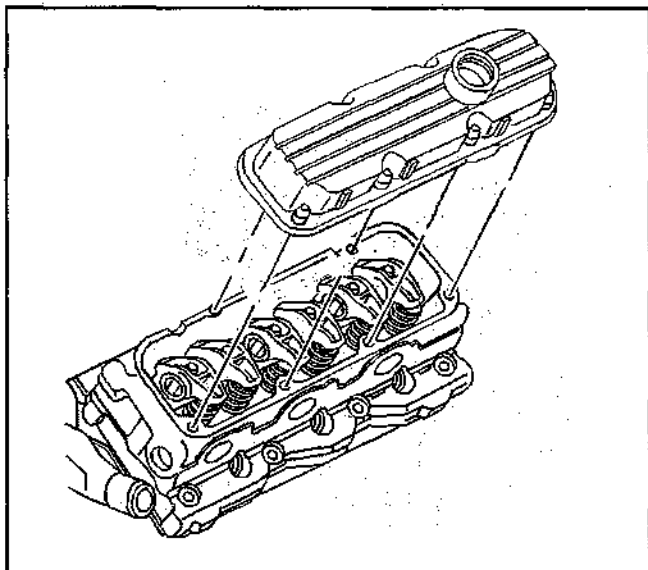
5. Install the valve rocker arm bolts.

Tighten

Tighten the valve rocker arm bolts to 15 N·m (11 lb ft) + 90 degrees using J 36660-A.



35840



35819

Valve Rocker Arm Cover Installation (Left Side)

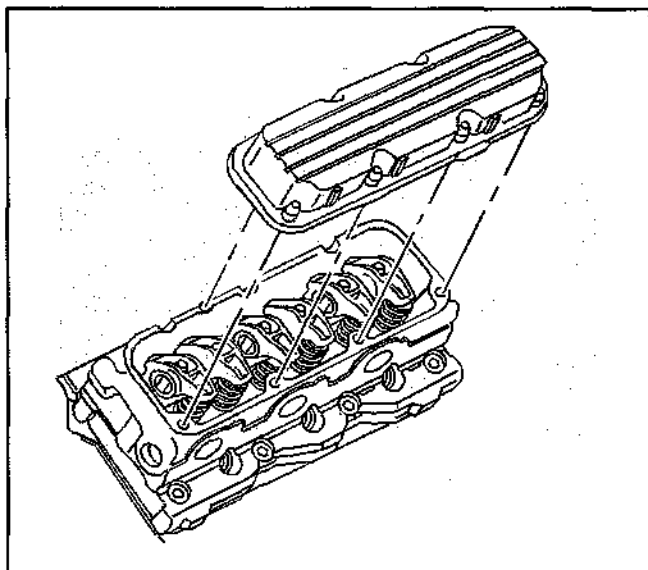
1. Install the valve rocker arm cover.
2. Apply GM P/N 12345382 threadlocker or equivalent to threads.

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

3. Install the valve rocker arm cover bolts.

Tighten

Tighten the valve rocker arm cover bolts to 10 N·m (89 lb in).



63414

Valve Rocker Arm Cover Installation (Right Side)

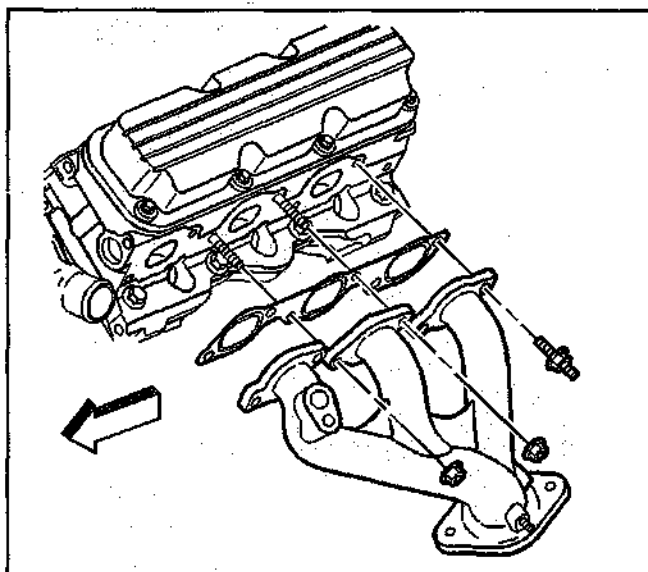
1. Install the valve rocker arm cover.
2. Apply GM P/N 12345382 threadlocker or equivalent to the threads.

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

3. Install the valve rocker arm cover bolts.

Tighten

Tighten the valve rocker arm cover bolts to 10 N·m (89 lb in).



589361

Exhaust Manifold Installation (Left Side)

1. Install the exhaust manifold gasket to the cylinder head.
2. Install the exhaust manifold to the cylinder head.

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

3. Install the exhaust manifold nuts.

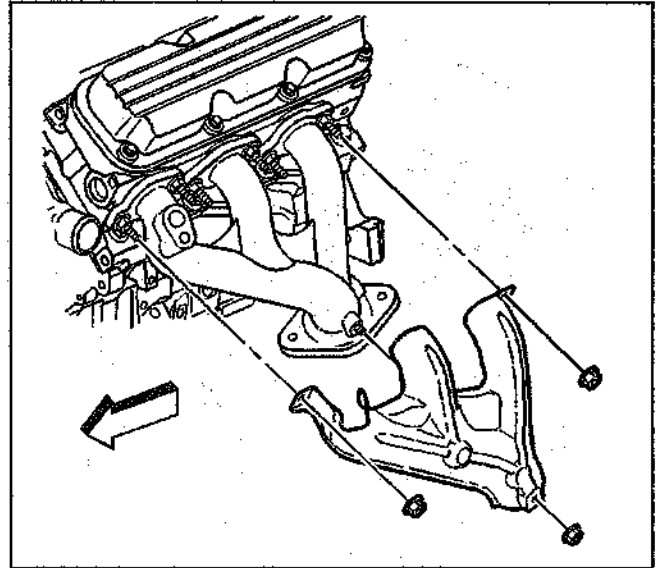
Tighten

Tighten the nuts 23 N·m (17 lb ft).

4. Install the exhaust manifold heat shield.
5. Install the exhaust manifold heat shield nuts.

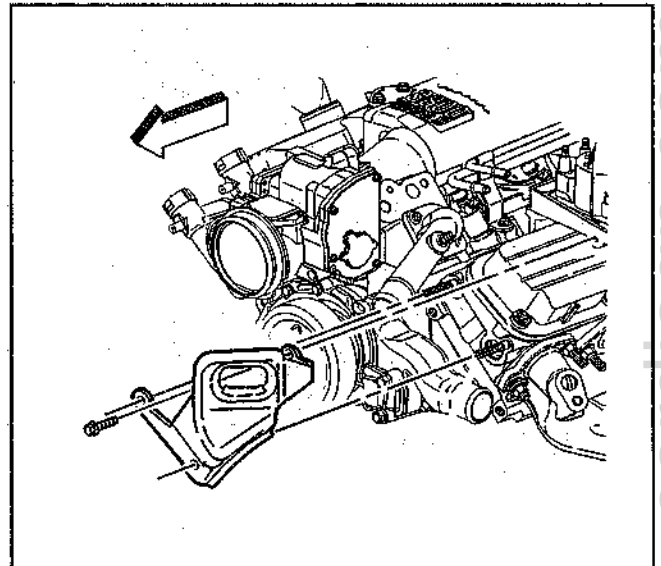
Tighten

- Tighten the two end nuts to 23 N·m (17 lb ft).
- Tighten the bottom nut to 10 N·m (89 lb in).



569352

6. Install the engine lift hook.



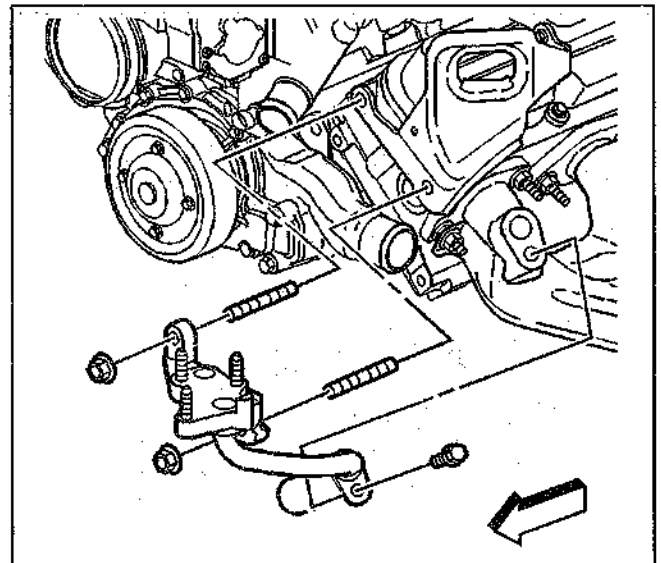
566982

Important: Inspect the EGR inlet pipe for leaks. Replace the EGR adapter if the pipe leaks.

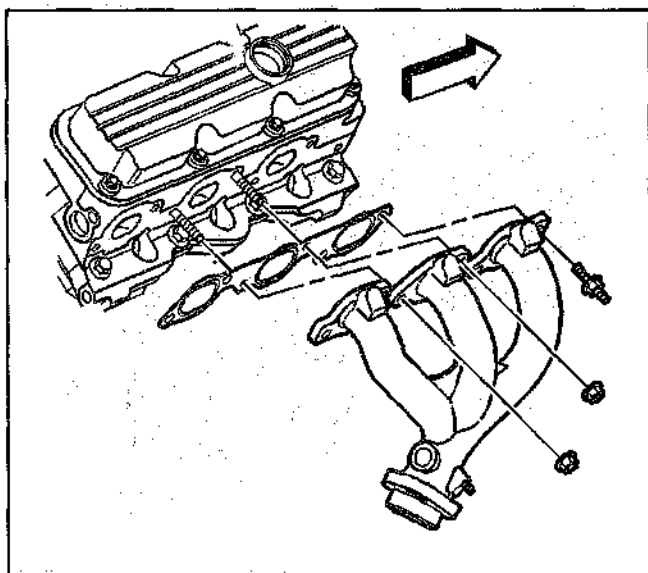
7. Install the EGR inlet pipe to the exhaust manifold.
8. Install the EGR inlet pipe bolt and nuts.

Tighten

Tighten the nuts to 50 N·m (36 lb ft) and the bolt to 25 N·m (18 lb ft).



599355



589366

Exhaust Manifold Installation (Right Side)

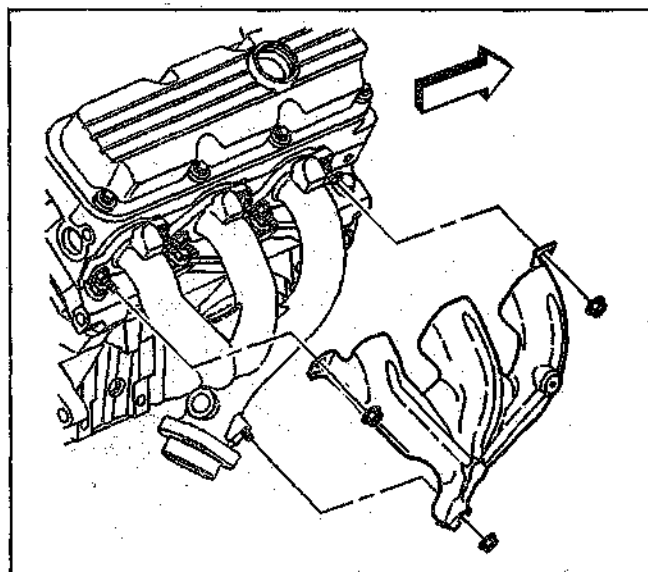
1. Install the exhaust manifold gasket to the cylinder head.
2. Install the exhaust manifold to the cylinder head.

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

3. Install the exhaust manifold nuts.

Tighten

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

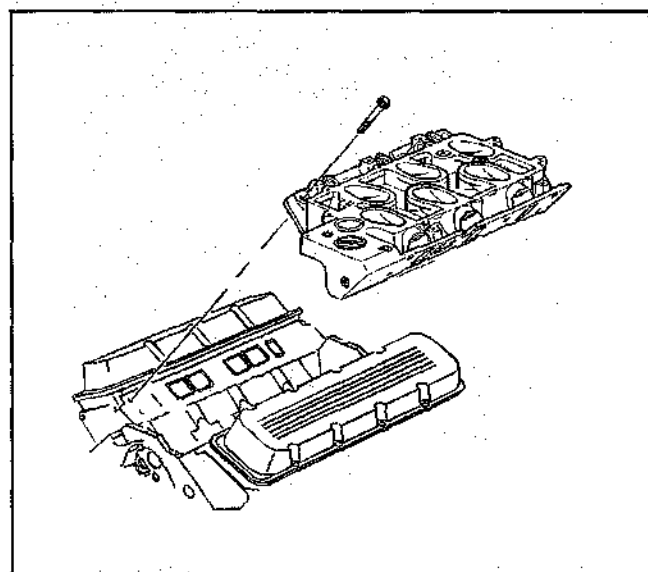


589365

4. Install the exhaust manifold heat shield.
5. Install the exhaust manifold heat shield nuts.

Tighten

- Tighten the two end heat shield nuts to 23 N·m (17 lb ft).
- Tighten the bottom nut to 10 N·m (89 lb in).



50046

Intake Manifold Installation (Lower)

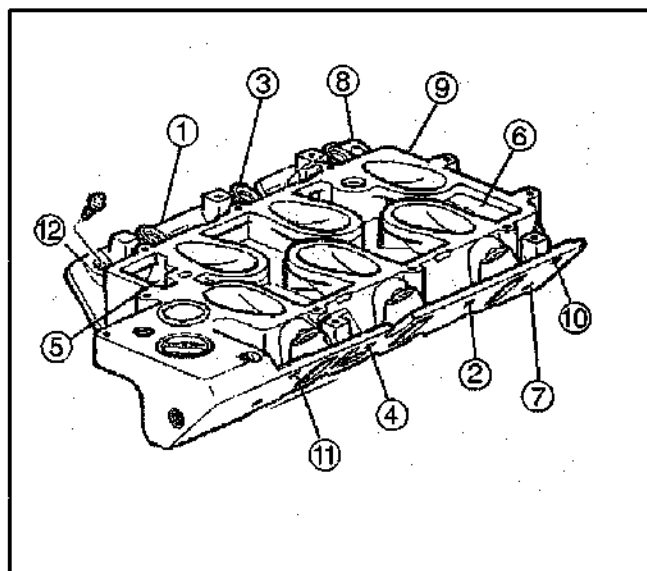
1. Install the lower intake manifold gasket.
2. Install the lower intake manifold.
3. Apply GM P/N 12345382 threadlocker or equivalent on the threads.

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

4. Install the lower intake manifold bolts.

Tighten

Tighten the bolts in sequence to 15 N·m (11 lb ft).



50288

5. Install the generator bracket.
6. Install the ignition control module bracket.

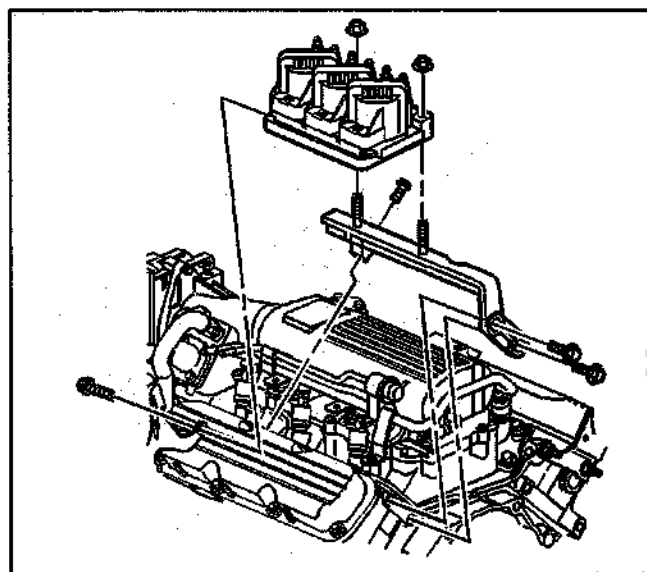
Tighten

Tighten the ignition control module bracket bolts to 50 N·m (37 lb ft).

7. Install the ignition control module and nuts.

Tighten

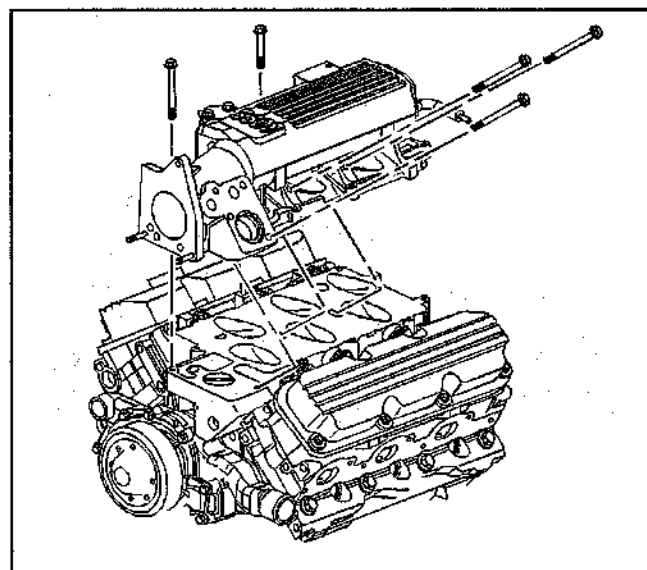
Tighten the ignition control module nuts to 30 N·m (22 lb ft).



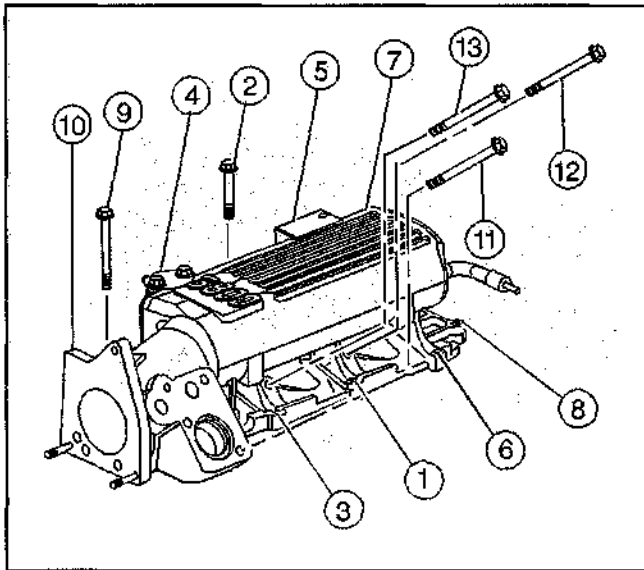
566980

Intake Manifold Installation (Upper)

1. Install the upper intake manifold gasket.
2. Install the upper intake manifold.
3. Install the water outlet.



403782



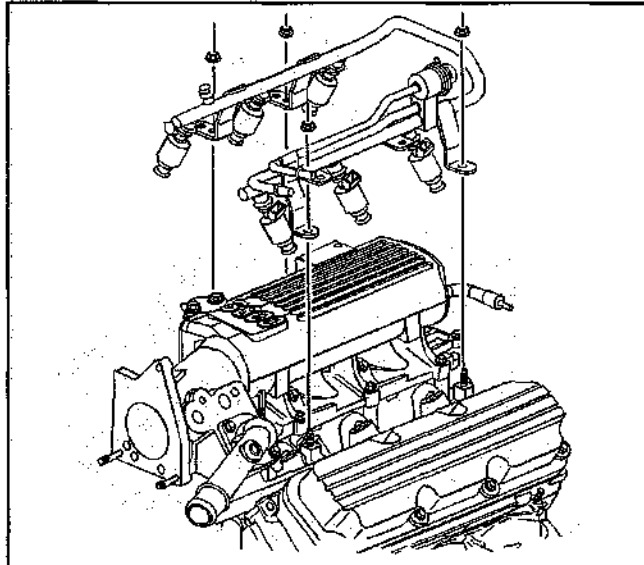
403789

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

4. Install the upper intake manifold bolts.

Tighten

- Tighten the vertical bolts in sequence to 15 N·m (11 lb ft).
- Tighten the two water outlet bolts in sequence to 27 N·m (20 lb ft).
- Tighten the side bolts in sequence to 30 N·m (22 lb ft).



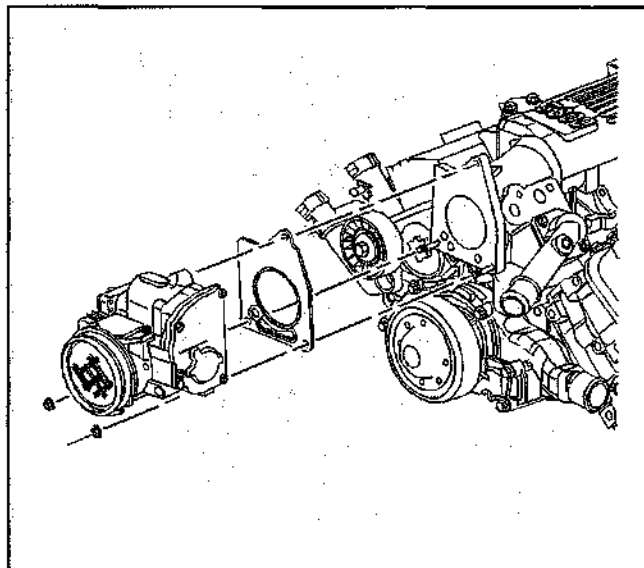
403779

5. Install the fuel injector rail.

6. Install the fuel injector rail nuts.

Tighten

- Tighten the fuel injector rail nuts to 9 N·m (80 lb in).



403776

7. Install the throttle body gasket.

8. Install the throttle body.

9. Install the throttle body nuts and bolt.

Tighten

- Tighten the throttle body nuts and bolt to 10 N·m (89 lb in).

10. Install the EGR outlet pipe to the intake manifold.

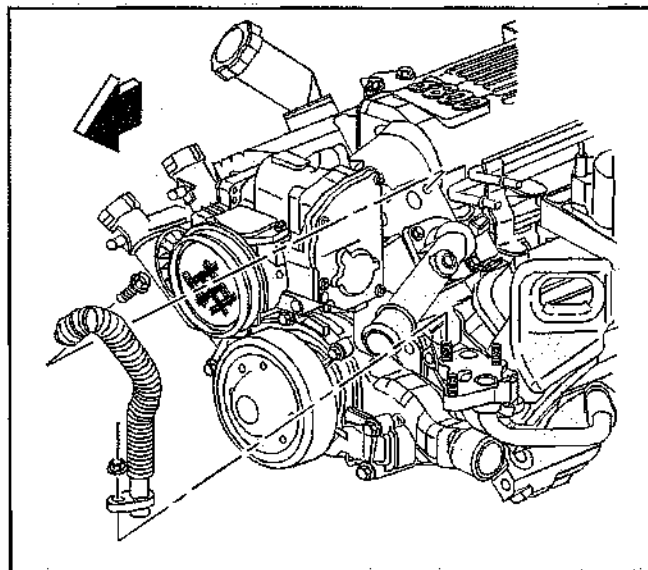
Tighten

Tighten the EGR outlet pipe bolt and nut to 29 N·m (21 lb ft).

11. Install the manifold vacuum source.
12. Install the rear generator mounting bracket and bolts.

Tighten

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



403772

Water Pump Installation

Tools Required

J 36660-A Torque Angle Meter

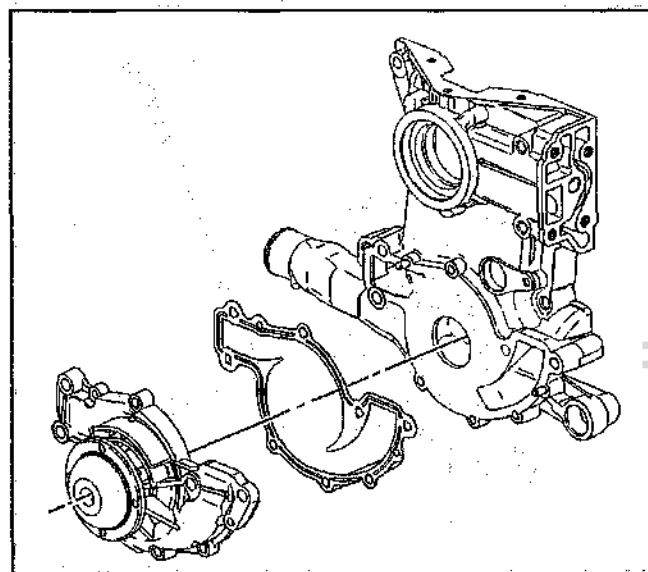
1. Install the water pump gasket.
2. Install the water pump.

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

3. Install the water pump bolts.

Tighten

Tighten the water pump bolts to 15 N·m (1.1 lb ft). Use J 36660-A to tighten the bolt an additional 80 degrees.

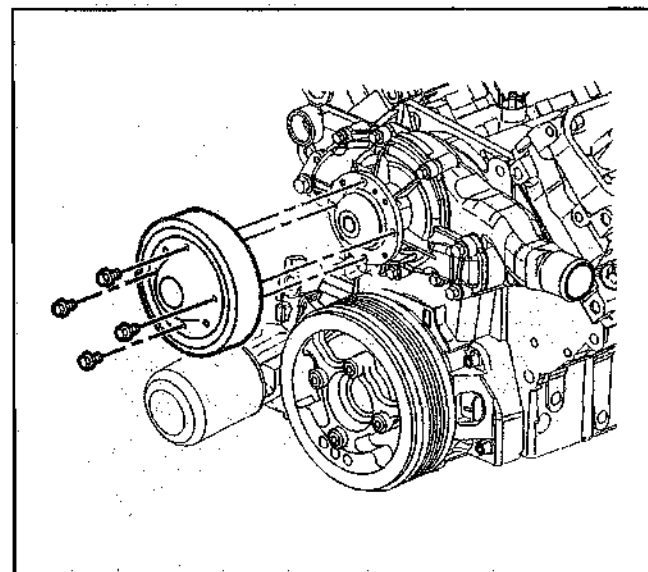


187022

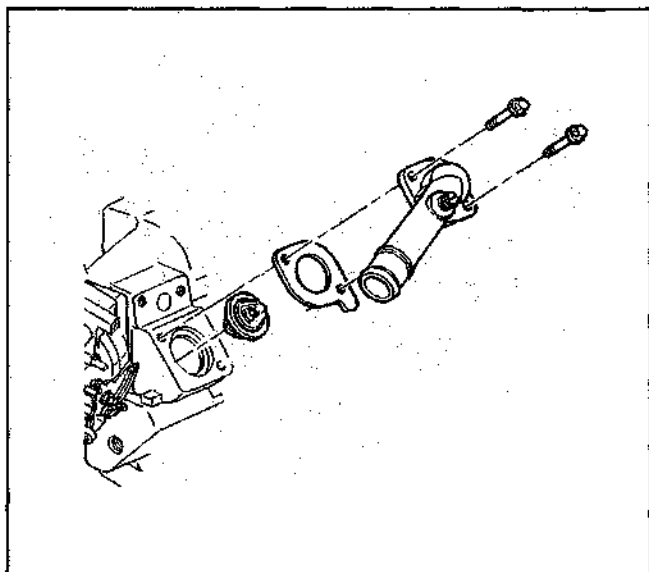
4. Install the water pump pulley.
5. Install the water pump pulley bolts.

Tighten

Tighten the water pump pulley bolts to 13 N·m (116 lb in).



313967



36621

Water Outlet Installation

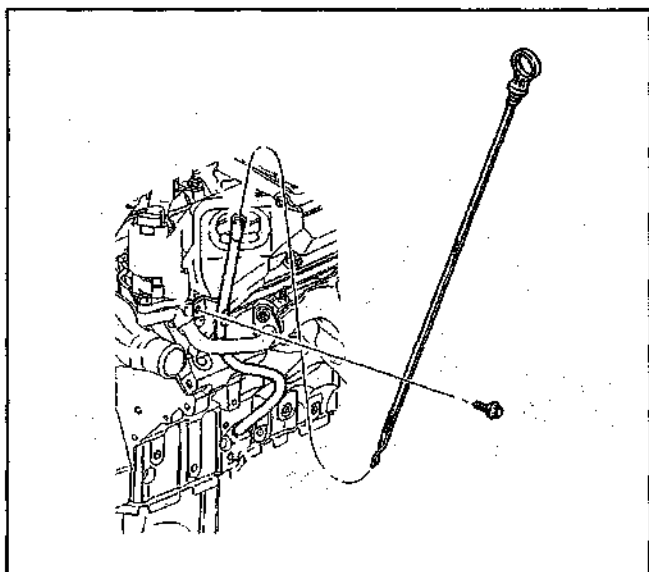
1. Install the thermostat.
2. Install the water outlet gasket.
3. Install the water outlet.

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

4. Install the water outlet bolts.

Tighten

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



36615

Oil Level Indicator and Tube Installation

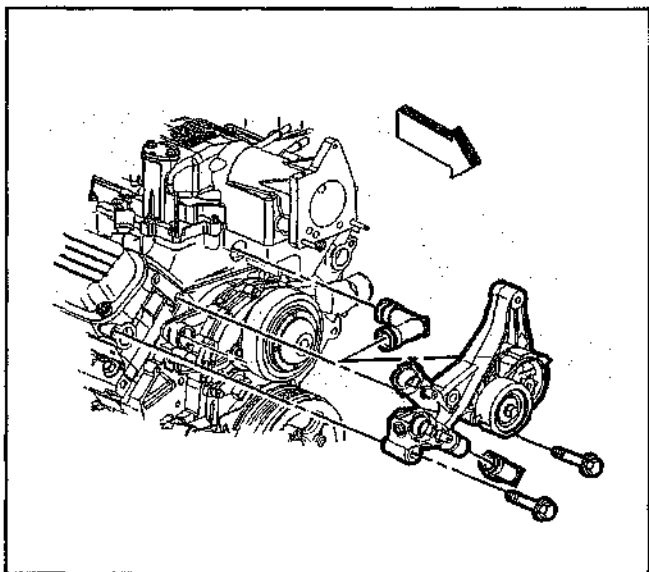
1. Install the oil level indicator tube.
 - Lubricate the O-ring with engine oil and make sure it is in place.
 - Make sure the assembly is fully seated in the engine block.

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

2. Install the oil level indicator tube bolt.

Tighten

Tighten the bolt to 10 N·m (89 lb in).



313973

Drive Belt Tensioner Installation

1. Install the drive belt tensioner.
2. Install the heater water bypass inlet pipe to the lower intake manifold and to the tensioner.

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

3. Install the tensioner bolts.

Tighten

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

Engine Flywheel Installation (Automatic Transmission)

Tools Required

J 36660-A Torque Angle Meter

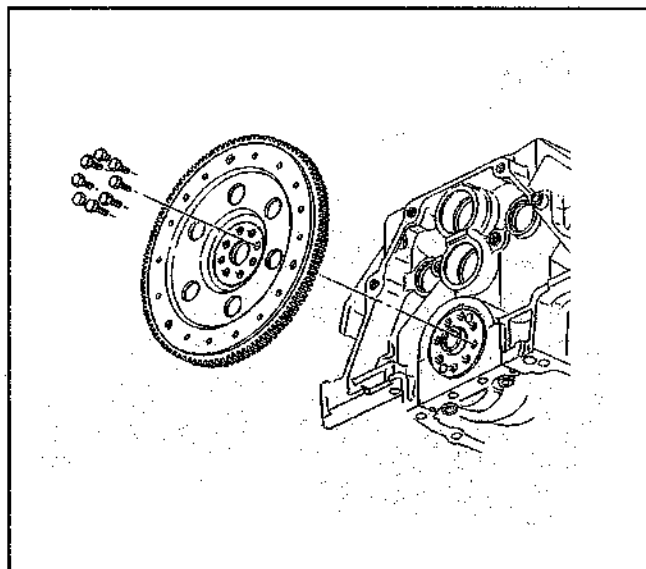
1. Install the flywheel.

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

2. Install the new flywheel bolts.

Tighten

Tighten the bolts to 15 N·m (11 lb ft). Use the J 36660-A to tighten the bolts an additional 50 degrees.



36665

Engine Flywheel Installation (Manual Transmission)

Tools Required

J 36660-A Torque Angle Meter

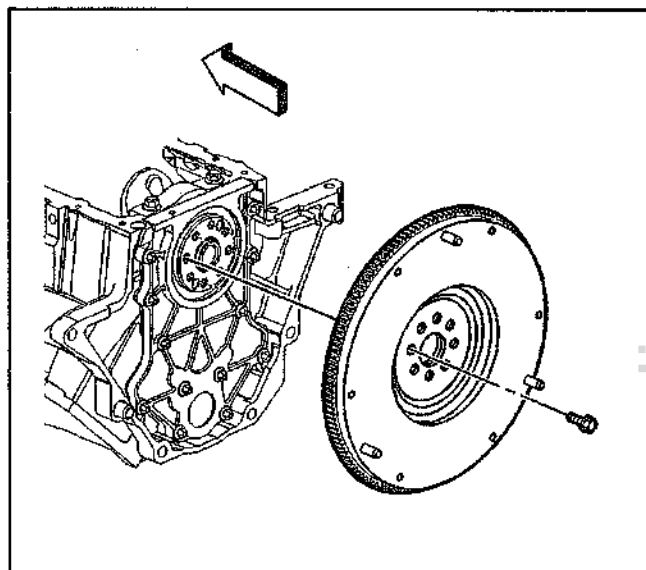
1. Install the flywheel.

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

2. Install the new flywheel bolts.

Tighten

Tighten the bolts to 15 N·m (11 lb ft). Use J 36660-A to tighten the bolts an additional 50 degrees.



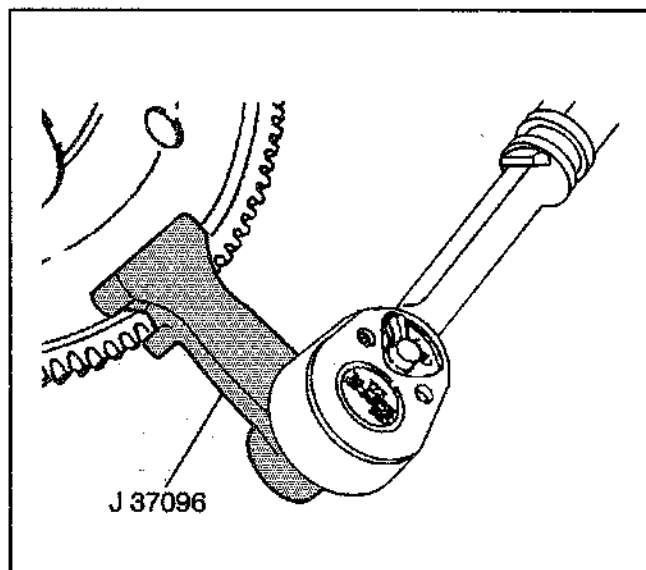
192727

Crankshaft Balancer Installation

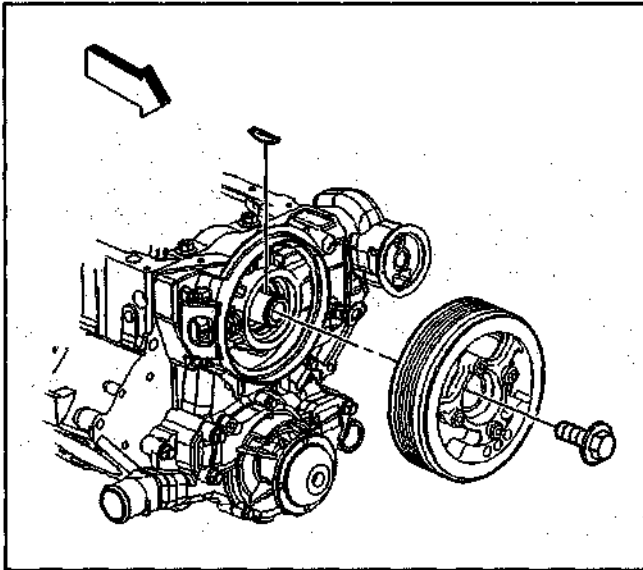
Tools Required

- J 37096 Flywheel Holding Tool
- J 36660-A Torque Angle Meter

1. Lubricate the seal surface of the crankshaft balancer with engine oil.
2. Install the crankshaft balancer.
3. Use J 37096 to hold the flywheel.



309963



192730

Notice: Refer to *Permanently Stretching Bolt Notice* in Cautions and Notices.

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

4. Install the crankshaft balancer bolt.

Tighten

Tighten the crankshaft balancer bolt to 150 N·m (111 lb ft). Use J 36660-A to tighten the crankshaft balancer bolt an additional 114 degrees.

Description and Operation

Engine Component Description

Engine Construction

Starting at the front of the engine, the cylinders of the left bank are numbered 1-3-5 and the cylinders of the right bank are numbered 2-4-6. The crankshaft is supported in the engine block by four bearings. The crankshaft is counterbalanced by the flywheel, the crankshaft balancer, and the weights cast into the crankshaft. Additional counterbalancing is obtained from the balance shaft which rides in the engine block above the camshaft and is driven by the camshaft. All 3800 engines are even-firing, the cylinders fire at equal 120 degree intervals of crankshaft rotation. The location of the crankshaft journals has been offset by 30 degrees to fire the cylinders at 120 degree intervals of crankshaft rotation. The camshaft lobes and timing also reflect the 120 degree intervals. The even firing crankshaft provides an equal interval of 120 degrees between ignition of each of the cylinders throughout the firing order. The firing order is 1-6-5-4-3-2. The aluminum alloy pistons have slipper skirts and are cam turned. Four drilled holes or casted slots in the oil ring grooves permit drain back of the oil collected by the oil ring. The camshaft is supported by four bearings in the engine block and is driven by the crankshaft through sprockets and a timing chain. The cylinder heads are cast iron and incorporate integral valve stem guides. Right and left cylinder heads are identical and are interchangeable, but it is good practice to reinstall the cylinder heads on the side from which they are removed. The intake manifold is bolted to the inner faces of both cylinder heads so it connects with all inlet ports.

Each exhaust and intake valve has a valve spring to insure positive seating throughout the operating speed range. The valve rocker arms for each bank of the cylinders pivot on pedestals bolted to the cylinder head. Hydraulic roller valve lifters and tubular push rods are used to operate overhead rocker arms and valves of both banks of the cylinders from a single camshaft. This system requires no lash adjustment at the time of assembly or service.

In addition to its normal function of a cam follower, each valve lifter also serves as an automatic adjuster which maintains zero lash in the valve train under all operating conditions. By eliminating all lash in the valve train and also providing a cushion of oil to absorb operating shocks, the valve lifter promotes quiet valve operation. It also eliminates the need for periodic valve adjustment to compensate for wear of parts.

Oil is supplied to the valve lifter through a hole in the side of the valve lifter body which indexes with a groove and a hole in the valve lifter plunger. Oil is then metered past the oil metering valve in the valve lifter, through the push rods to the valve rocker arms.

When the valve lifter begins to move up the camshaft lobe, the check ball is held against its seat in the plunger by the check ball spring which traps the oil in the base of the valve lifter body below the plunger.

The plunger and the valve lifter body then raise as a unit, pushing up the push rod to open the valve. The force of the valve spring which is exerted on the plunger through the valve rocker arm and push rod, causes a slight amount of leakage between the plunger and the valve lifter body. This leakage allows a slow escape of trapped oil in the base of the valve lifter body. As the valve lifter rolls down the other side of the camshaft lobe and reaches the base circle or valve closed position, the plunger spring quickly moves the plunger back (up) to its original position. This movement causes the check ball to open against the ball spring, and any oil inside the plunger is drawn into the base of the valve lifter. This restores the valve lifter to the zero lash.

Drive Belt System Description

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
 - The power steering pump, if belt driven
 - The generator
 - The A/C compressor, if equipped
 - The engine cooling fan, if belt driven
 - The water pump, if belt driven
 - The vacuum pump, if equipped
 - The air compressor, if equipped

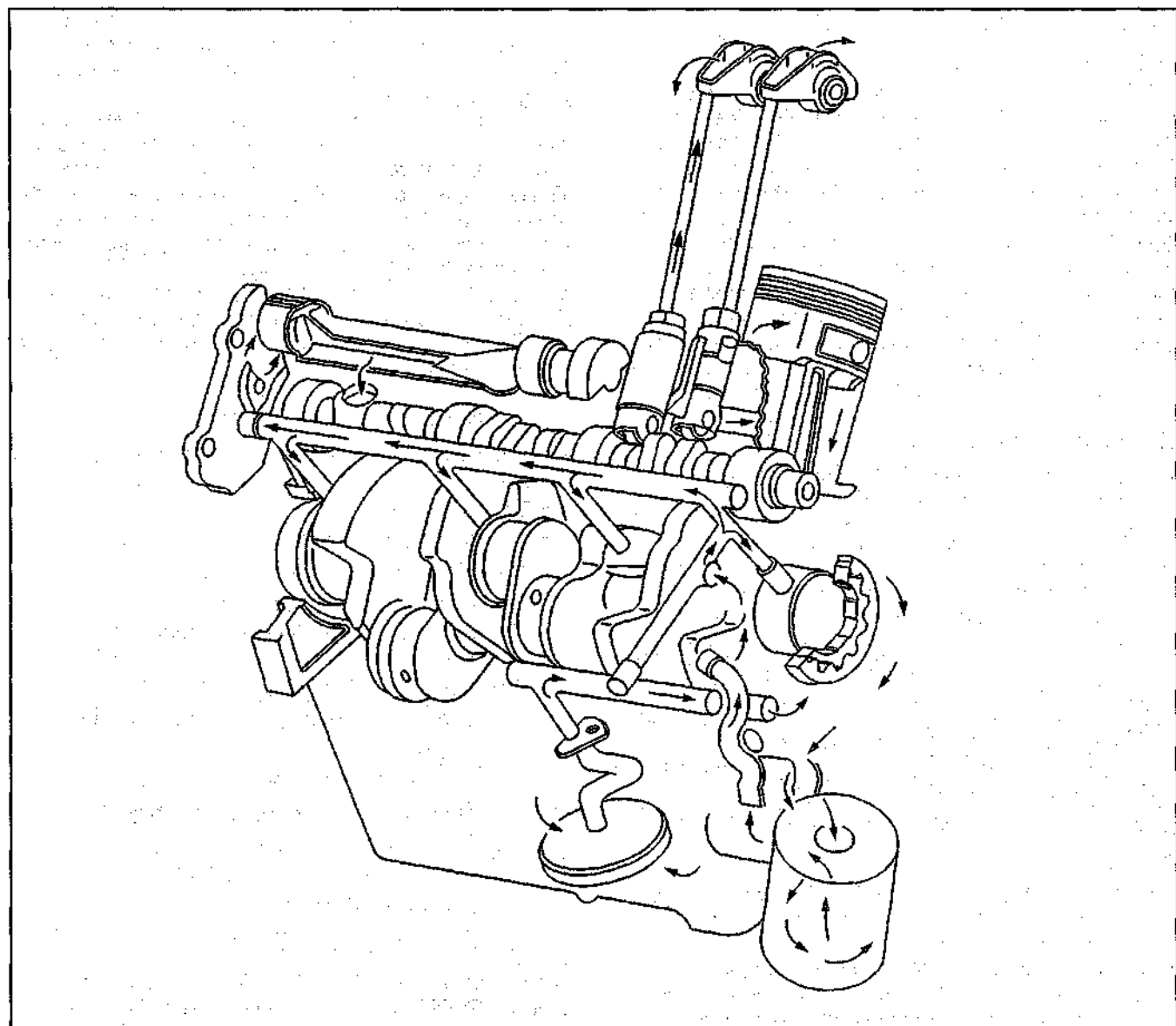
The drive belt system may use one belt or two belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers (chloroprene or EPDM) and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

Lubrication Description



44529

The engine lubrication system is of the force-feed type. The oil is supplied under full pressure to the crankshaft, connecting rods, valve lifters, camshaft, and rear balance shaft bearing. A controlled volume of oil is supplied to the valve rocker arms and push rods. All other moving parts are lubricated by gravity flow or splash. The engine oil is stored in the lower crankcase (oil pan) which is filled through a filler opening in the valve rocker arm cover. A removable oil level indicator, on the left side of the engine block, is provided to check the oil level. The oil pump is located in the engine front cover and is driven by the crankshaft. It is a gerotor-style pump which is a combination of a gear and a rotor pump. It is connected by a passage in the cylinder block to an oil screen and pipe assembly. The screen is submerged in the oil supply and has ample volume for all operating conditions. If the screen becomes clogged, oil may be drawn into the system through the

oil pressure relief valve in the oil filter adapter. Oil is drawn into the pump through the screen and pipe assembly, and a passage in the crankcase, connecting to the passages in the engine front cover. Oil is discharged from the oil pump to the oil filter adapter. The oil filter adapter consists of an oil filter bypass valve and a nipple for installation of an oil filter. The spring-loaded oil pressure relief valve, located in the engine front cover, limits the oil pressure. The oil filter bypass valve opens when the oil filter is restricted to approximately 68.95 kPa (10 psi) of pressure difference between the oil filter inlet and discharge. The oil will then bypass the oil filter and channel unfiltered oil directly to the main oil galleries of the engine. A full-flow oil filter is externally mounted to the oil filter adapter on the lower right front side of the engine. If the filter element becomes restricted, not allowing engine oil to pass through, a spring-loaded bypass valve opens.

The main oil galleries run the full length of the engine block and cut into the valve lifter guide holes to supply oil at full pressure to the valve lifters. Holes, drilled from the crankshaft bearings to the main oil gallery, intersect the camshaft bearing bores to supply oil to the cam bearings.

Oil is transferred from the crankshaft bearings to the connecting rod bearings through holes drilled in the crankshaft. Pistons, piston pins, and cylinder walls are lubricated by oil splash from the crankshaft and connecting rods.

Each valve rocker arm and valve is supplied with oil through the tubular push rod. The oil comes from the inside of the valve lifter passing around the metering valve and through a hole in the push rod seat. Oil from the push rod passes through a hole in the push rod seat, and emerges on top of the push rod seat boss.

Cleanliness and Care

An automobile engine is a combination of many of the following surfaces:

- Machined
- Honed
- Polished
- Lapped

The tolerances of these surfaces are measured in the ten-thousandths of an inch. When you service any internal engine part, cleanliness and care are important. Apply a liberal coating of engine oil to the friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, practice proper cleaning and protection procedures to the machined surfaces and to the friction areas.

Notice: Engine damage may result if an abrasive paper, pad, or motorized wire brush is used to clean any engine gasket surfaces.

Whenever you remove the valve train components, keep the components in order. Follow this procedure in order to install the components in the same locations and with the same mating surfaces as when removed.

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

Disconnect the negative battery cables before you perform any major work on the engine. For more information on the disconnection of the battery, refer to Engine Electrical.

Replacing Engine Gaskets

1. Do not reuse any gasket unless otherwise specified. Reusable gaskets will be identified in the service procedure. Do not apply sealant to any gasket or sealing surface unless called out in the service procedure.
2. Use a rubber mallet in order to separate components. Bump the part sideways in order to loosen the components. Perform the bumping at the bends or at the reinforced areas in order to prevent the distortion of components.

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

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 component.

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.

3. Remove all of the gasket and the sealing material from the component using a plastic or a wood scraper. Do not gouge or scrape the sealing surfaces.

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

- Prevent you from properly seating the bolt
 - Cause damage when you tighten the bolt
4. When assembling components, use only the sealant specified in the service procedure. Ensure that the sealing surfaces are clean and free of debris or oil. When applying sealant to a component, apply a bead size as specified in the service procedure.
 5. Tighten the bolts to the specifications.

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

The components of an internal combustion engine develop wear patterns with their mating components. During disassembly of the engine, parts should be separated and kept in order so they may be reinstalled in the same location from which they were removed.

Service Precautions

Important: Follow the engine service information below. This information is important in order to prevent damage and in contributing to reliable engine performance.

In order to avoid damage to the engine oil pan, use a block of wood between the jack and the oil pan. Ensure that the block of wood extends past the complete width of the oil pan. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the oil pan to bend against the pump screen. This condition results in a damaged oil pick-up unit.

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

When working on the engine, remember that the 12-volt electrical system is capable of causing short circuits. When performing any work where electrical terminals may possibly be grounded, disconnect the ground cable of the battery at the battery.

Any time you remove the air cleaner, cover the intake opening. This procedure protects against the accidental entrance of foreign material. Foreign material may follow the intake passage into the cylinder. This condition causes extensive damage when you start the engine.

In the mechanical procedures described in this section, generally no references will be made to the removal of optional equipment such as the power steering pump, the air conditioning compressor, etc.

If you need to remove any optional equipment in order to perform other service, refer to the appropriate section of this service manual for the specific information.

Installation Precautions

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

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

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

Any time the throttle body or air induction tube is removed, the intake opening should be covered. This will protect against the accidental entrance of foreign material which could follow the intake passage into the cylinder and cause extensive damage when the engine is started.

Tools and Equipment

Work in a clean and well-lit area. Have the following components available before you begin to work:

- A suitable parts cleaning tank
- A compressed air supply
- Trays, in order to keep the parts and the fasteners organized
- An adequate set of hand tools

An approved engine repair stand will prevent personal injury or damage to the engine components. The special tools are designed in order to quickly and safely accomplish the operations for which the tools are intended. Using the tools will minimize possible damage to the engine components. Precision measuring tools are required for the inspection of certain critical components. Torque wrenches are needed for the correct assembly of various parts.

Special Tools and Equipment

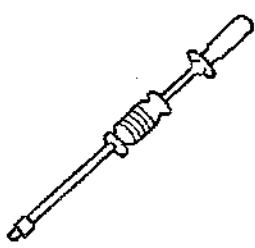
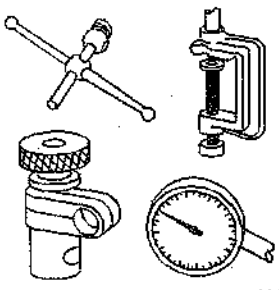
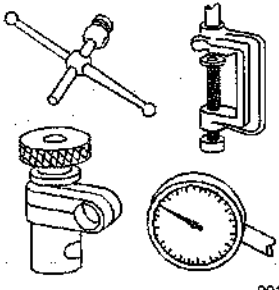
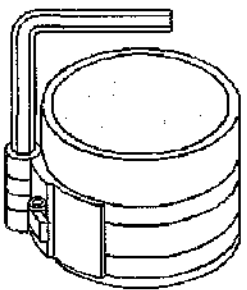
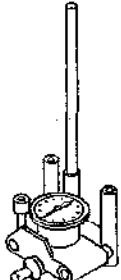
Illustration	Tool Number/Description
 4965	J 6125-1B Slide Hammer
 2014	J 7872 Magnetic Base Indicator Set
 2014	J 8001 Dial Indicator Set
 3403	J 8037 Universal Piston Ring Compressor
 5110	J 8087 Cylinder Bore Checking Gauge

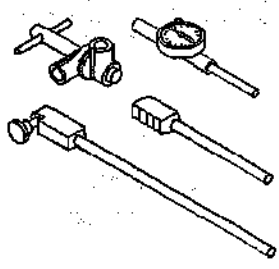
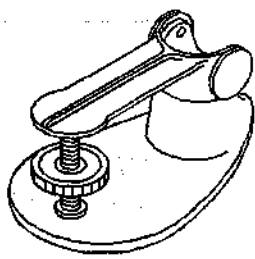
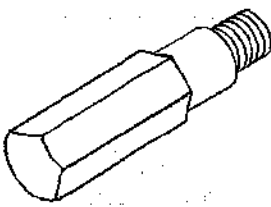
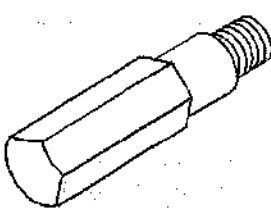
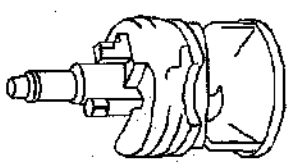
Illustration	Tool Number/Description
 3408	J 8520 Dial Indicator Adapter
 5112	J 9666 Valve Spring Tester
 3400	J 21465-13 Drive Handle Extension
 3400	J 23590 Spark Plug Port Adapter
 3412	J 24270 Cylinder Ridge Reamer

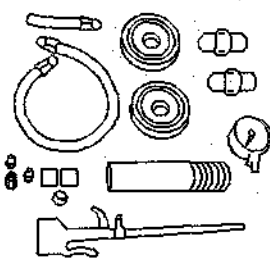
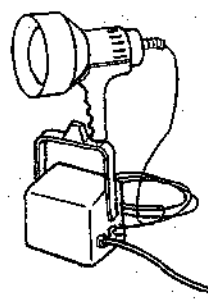
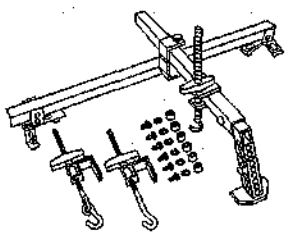
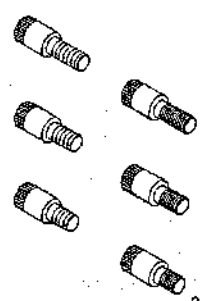
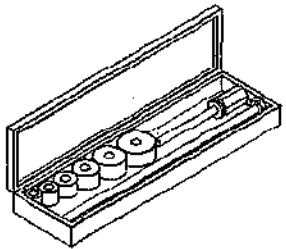
Illustration	Tool Number/Description
 60304	J 25087-C Oil Pressure Test Kit
 62292	J 28428-E High Intensity Black Light
 190562	J 28467-B Engine Support Fixture
 367798	J 28467-90A Engine Support Adapters
 5118	J 33049 Camshaft Bearing Remover/Installer Set

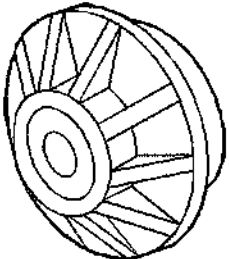
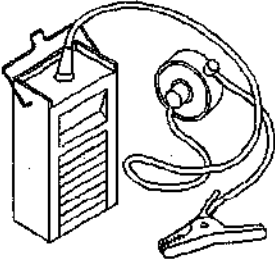
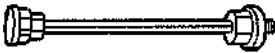
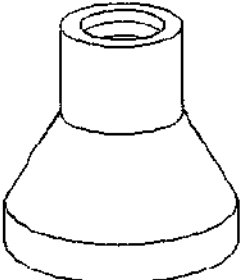
Illustration	Tool Number/Description
 37773	J-35354 Seal Installer
 3413	J-36660 Torque Angle Meter
 62295	J-35667-A Cylinder Leakdown Tester
 38285	J-36995 Balance Shaft Bearing Remover/Installer
 3411	J-36996 Balance Shaft Installer

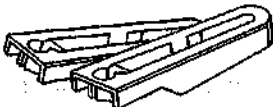
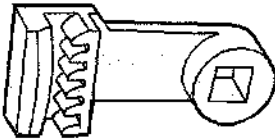
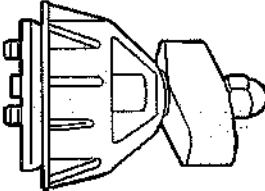
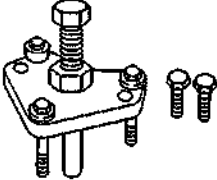
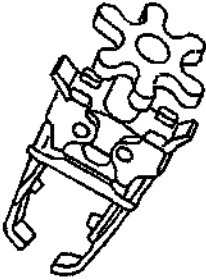
Illustration	Tool Number/Description
 13542	J-37088-A Fuel Line Quick Connect Separator
 37623	J-37096 Flywheel Holding Tool
 38068	J-38196 Crankshaft Rear Oil Seal Installer
 13547	J-38197 Crankshaft Balancer Puller
 49850	J-38606 Valve Spring Compressor

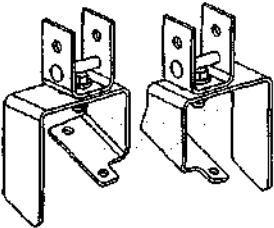
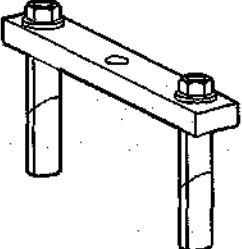
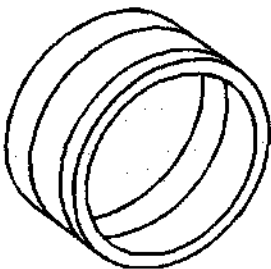
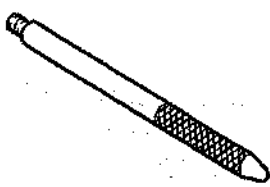
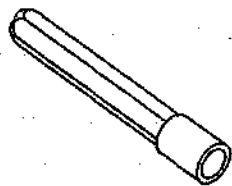
Illustration	Tool Number/Description
 220634	J 41044 Engine Support Adapters
 38515	J 41348 Main Bearing Cap Puller
 49648	J 41349 Crankshaft Rear Oil Seal Housing Alignment Tool

Illustration	Tool Number/Description
 38090	J 41507 Connecting Rod Guide
 223541	J 42863 Valve Seal Installer