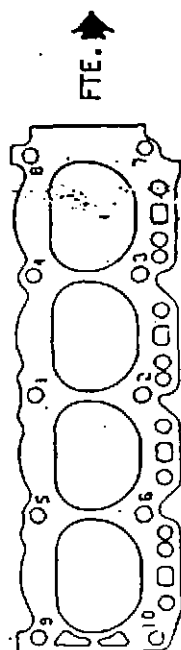


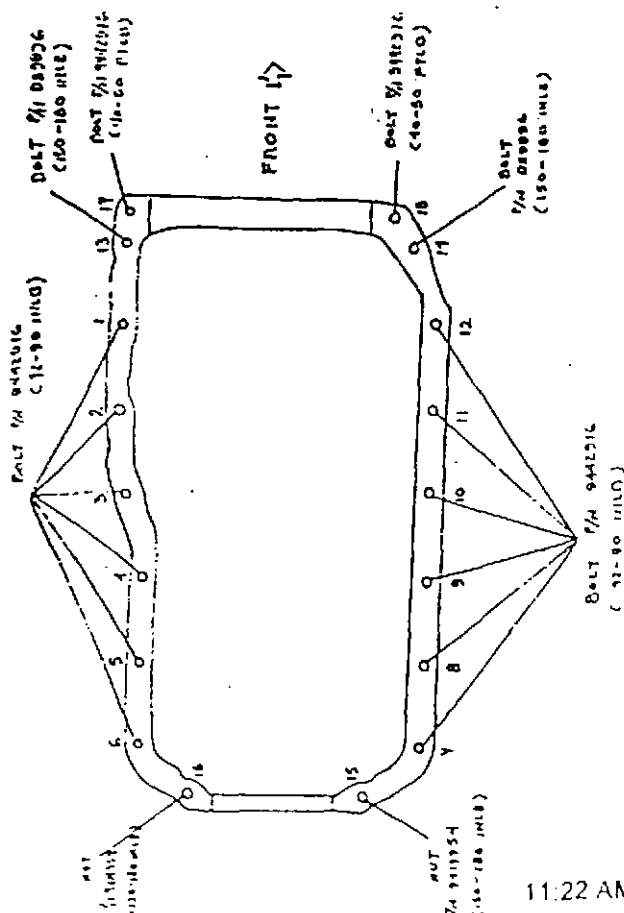
General

GMPT Torques for 1997 3.0L OEM Engines

Component	GM REFERENCE		Static Torque	Note: Static torque values for installation only. Most factory torques are dynamic angle control/monitored.
	GRUPO	HOJA		
CAM GEAR	6X1	2L	72-90 INLB	
VALVE	6Y4	1	100-140 INLB	
VALVE HEAD	6A2	1L	80-100 FTLB	Sequence required- see below (Grupo 6A2 Hoya 1L)
DISTRIBUTER			10 FTLB	
CLAMP BOLT	6Y3	1	(minimum)	
FLYWHEEL	6C3	1L	55-70 FTLB	
FRONT COVER	6J	1L	72-90 INLB	
ROD CAPS	6A1	1	55-70 FTLB	
OIL PAN	6E	1	Bolt 12 @ 80-100 INLB Bolt 2 @ 150-180 INLB Nut 2 @ 150-180 INLB Bolt 2 @ 40-50 INLB	Torque Bolts based upon Oil Pan Fastener location-sequence : A) Torque side position Bolts 1-12 @ 80-100 INLB. B) Torque Bolts 13-14 @ 150-180 INLB. C) Torque rear Nuts 15-16 @ 150-180 INLB. D) Torque Front Pan Bolts 17-18 @ 40-50 INLB.
OIL PUMP	6F	1L	Bolts 100-132 INLB Nut 20-30 FTLB Screw 45-65 INLB	Factory sequence- A) Torque Bolts. B) Torque Nut. C) Torque Screw.
WATER COVER	6A2	1	50-65 INLB	
REAR SEAL HSG.	6C1	2L	120-150 INLB	
ROD CAPS	6D	1L	42-47 FTLB	
SPARK PLUG	6Y4	1	17-27 FTLB	
WATER PUMP	6K2	1L	13-17 FTLB	



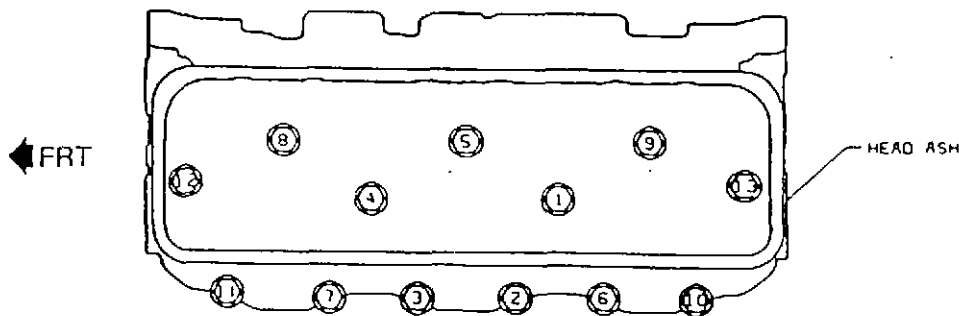
CYLINDER HEAD BOLT/SCREW TIGHTENING SEQUENCE
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BE TIGHTENED IN THE ABOVE SEQUENCE OR
SIMULTANEOUSLY TIGHTENED WITH THE USE OF
A MULTIPLE SPICLE WRENCH.



11.22 AM

GMPT Torques for 1997 4.3L OEM Engines

Component	GM source document		STATIC TORQUE VALUES		Note: Static torque values for installation only. Most factory torques are dynamic angle control/monitored.
	UPC	LTLS	Metric (Nm) Torque	Conversion for FT-LBS	
BALANCE SHAFT RETAINER	6C4	3	S12+/-2 Nm	8.8+/-1.5	
CAM GEAR	6X1	5	S28+/-4 Nm	22.1+/-3	
CAM RETAINER	6X1	2	S12+/-2 Nm	8.8+/-1.5	
CYL HEAD	6A2	3	S88+/-7 Nm	64.9+/-5.2	Sequence required- see UPC 6A2 Sheet 5
DRIVEN GEAR	6C4	5	20 Nm PLUS 35 DEGREES	14.7 FTLB PLUS 35 DEGREES	Factory Specification requires <u>initial Torque PLUS ANGLE ROTATION</u> to assure designed clampload. In lieu of fastening with Angle capable equipment, Static Torque estimate is 13-17 FTLB
FLYWHEEL	6C3	2	S100+/-15 Nm	73.7+/-11	
FRONT COVER	6J	1	S12+/-2 Nm	8.8+/-1.5	
GUIDE- LIFTERS	6X1	6	S16+/-3 Nm	11.8+/-2.2	
INTAKE	6L1	4	D15+/-3Nm	11.1+/-2.2	
MAIN CAPS	6A1	2	S95+/-10 Nm	70+/-7.4	
OIL FILTER	6G5	2	S21+/-3 Nm	15.5+/-2.2	Do not oil Gasket. Gun speed @ 300+/-100 RPM
OIL PAN	6E	4	SCREW S25+/-4 Nm NUT S25+/-4 Nm	SCREW 18.4+/-3 NUT 18.4+/-3	
OIL PUMP	6F	2	S90+/-8 Nm	66.3+/-5.9	
R/A COVER	6X3	2	S12+/-2 Nm	8.8+/-1.5	
REAR SEAL HSG.	6C1	5	S15+/-2 Nm	11.1+/-1.5	
ROD CAPS	6D	1	27 Nm PLUS 70 +/- 3 DEGREES	20 FTLB PLUS 70 +/- 3 DEGREES	Critical Joint - Factory Specification requires <u>initial Torque PLUS ANGLE ROTATION</u> to assure designed clampload. In lieu of fastening with Angle capable equipment, Static Torque estimate is 40-50 FTLB
SPARK PLUG	6Y4	3	S30+/-3 Nm	22.1+/-2.2	
VALVE ROCKER ARM	6X3	1	S25+/-4 Nm	18.4+/-3	Crankshaft to be positioned so that timing mark is @ 60degrees+/-3degrees from TDC
WATER PUMP	6K2	1	S41+/-6 Nm	30.2+/-4.4	

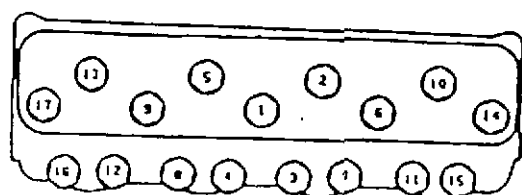


LH SHOWN: RH TYPICAL

HEAD ASH BOLT/SCREWS ARE TO BE TIGHTENED IN THE ABOVE SEQUENCE OR SIMULTANEOUSLY TIGHTENED WITH THE USE OF A MULTIPLE SPINDLE WRENCH.

GMPT Torques for 1997 5.7L OEM Engines

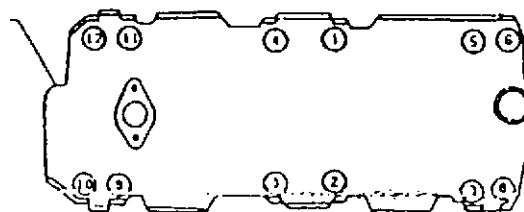
Component	GM source document		STATIC TORQUE VALUES		Note: Static torque values for installation only. Most factory torques are dynamic angle control/monitored.
	UPC	SHEET	Metric (Nm) Torque	Conversion for FT-LBS	
CAM GEAR	6X1	7	S25+/-4 Nm	18.4+/-3	
CAM RETAINER	6X1	3	S12+/-2 Nm	8.8+/-1.5	Roller Cam only
CYL. HEAD	6A2	9	Initial D30+/-3 Nm Short +55degrees Med +65degrees Long +75degrees	Initial D22.1+/-2.2 Short +55degrees Med +65degrees Long +75degrees	Cast Iron Cylinder Heads ONLY- GEN1 & GEN1E Engines. Sequence required- see UPC 6A2 Sheet 9. All angle rotations listed are +/- 3degrees.
CYL. HEAD	6A2	8	Initial D30+/-3 Nm Short +67degrees Med +80degrees Long +80degrees	Initial D22.1+/-2.2 Short +67degrees Med +80degrees Long +80degrees	Aluminum Cylinder Heads ONLY- 7CA & 7CB Engines. Sequence required- see UPC 6A2 Sheet 9. All angle rotations listed are +/- 3degrees.
DEFLECTOR	6C1	7	S40+/-7 Nm	29.5+/-5.2	
FLYWHEEL	6C3	2	S100+/-15 Nm	73.7+/-11	
FRONT COVER	6J4	4	S12.5+/-2.5 Nm	9.2+/-1.8	
INTAKE	6L1	11	S47+/-13 Nm	34.6+/-9.6	GEN 1 ONLY. Sequence reqd.- see UPC 6L1 Sheet 16 Snug to 3-6 Nm (2.2- 4.4 FTLB) before final rundown
MAIN CAPS	6A1	6	S105+/-10 Nm	77.4+/-7.4	
OIL PAN	6E	4	SCREW S12+/-2 Nm NUT S20+/-3 Nm	SCREW 8.8+/-1.5 NUT 14.7+/-2.2	
OIL PUMP	6F	2	S90+/-8Nm	66.3+/-5.9	
R/A COVER	6X3	3	S12+/-2 Nm	8.8+/-1.5	
REAR SEAL HSG.	6C1	6	S15+/-2 Nm	11.1+/-1.5	
ROD CAPS	6D1	1	27 Nm PLUS 55 +/- 3 DEGREES	20 FTLB PLUS 55 +/- 3 DEGREES	Critical Joint - Factory Specification requires <u>initial Torque PLUS ANGLE ROTATION</u> to assure designed clampload. In lieu of fastening with Angle capable equipment, Static Torque estimate is 40-50 FTLB
SPARK PLUG	6Y4	1	S20+/-3 Nm	14.7+/-2.2	
WATER PUMP	6K2	6	S41+/-6 Nm	30.2+/-4.4	



HEAD ASH FASTENERS TIGHTENING SEQUENCE

HEAD ASH FASTENERS ARE TO BE TIGHTENED IN THE ABOVE SEQUENCE OR SIMULTANEOUSLY TIGHTENED WITH THE USE OF A MULTIPLE SPINDLE WRENCH.

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REAR

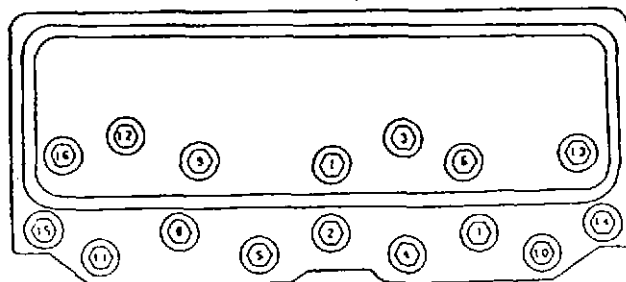
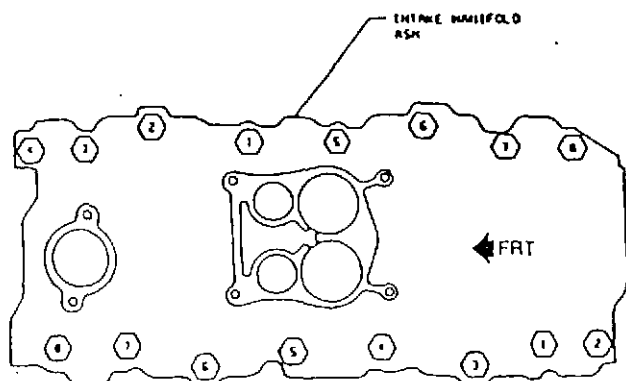
TORQUE REQUIREMENTS

* SNUG ALL FASTENERS TO 3-6 Nm.
THEN TORQUE TO FINAL TORQUE SPECIFICATION.

SEE UPC 6L1 SHEETS 11, 12, 13 & 14 FOR TORQUES.

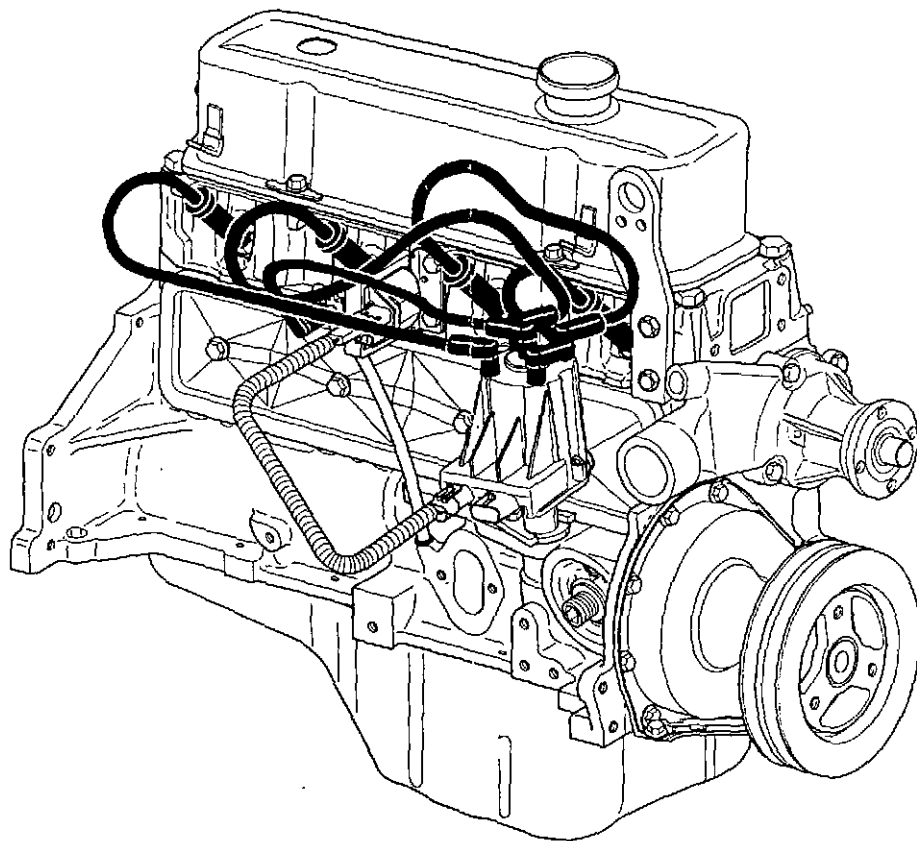
GMPT Torques for 1997 7.4/8.2L OEM Engines

Component	GM source document		STATIC TORQUE VALUES		Note: Static torque values for installation only. Most factory torques are dynamic angle control/monitored.
	UPC	SHEET	Metric (Nm) Torque	Conversion for FT-LBS	
BALANCER BOLT	6C2	3	S150+/-15 Nm	110.6 +/- 11	
Y GEAR	6X1	4	S30+/-4 Nm	22.1 +/-3	
CAM RETAINER	6X1	2	S12+/-2 Nm	8.8+/-1.5	Roller Cam only
CYL. HEAD	6A2	4.0	D115+/-10 Nm	84.8+/-7.4	Sequence required- see UPC 6A2 Sheet 5
DEFLECTOR	6C1	2	S32.5+/-6.5 Nm	24+/-4.8	
FLYWHEEL	6C3	2	D88+/-7 Nm	64.9+/-5.2	
FRONT COVER	6J	2	S12+/-2 Nm	8.8+/-1.5	
INTAKE	6L1	4	S40+/-5 Nm	29.5+/-3.7	Sequence reqd. - see UPC 6L1 Sheet 5. Pretorque all bolts to 34 Nm & final torque all bolts to S40+/-5 Nm
LIFTER GUIDE RETAINER	6X1	7	S21.5+/-4.5 Nm	15.8+/-3.3	
MAIN CAPS	6A1	4	D138+/-10 Nm	101.7+/-7.4	Inboard Caps must be torqued prior to outboard Cap fasteners
OIL PAN	6E	2	S22+/-4 Nm	16.2+/-3	
OIL PUMP	6F	2	S88+/-7 Nm	64.9+/-5.3	
R/A COVER	6X3	4	S8+/-3 Nm	5.9+/-2	
ROD CAPS- BASE 7.4	6D	1	D54+/-7Nm	47.2+/-5.2	
ROD CAPS- IF 7.4 & 8.2	6D	1	D98+/-7Nm	72.2+/-5.2	
SPARK PLUG	6Y4	1	S28.6+/-6.5 Nm	21.1+/-4.8	
VALVE ROCKER ARMS	6X3	1	S54+/-7 Nm	39.8+/-5.2	Align Timing mark 30degrees BTDC (12 O'clock position) & torque all Rocker Arm bolts
WATER PUMP	6K2	1	S40+/-5 Nm	29.5+/-3.7	



CYLINDER HEAD BOLT/SCREW TIGHTENING SEQUENCE
 OPTIMAL CYLINDER HEAD BOLT/SCREWS ARE TO BE TIGHTENED IN THE ABOVE SEQUENCE OR SIMULTANEOUSLY TIGHTENED WITH THE USE OF A MULTIPLE SPINDLE WRENCH.

Industrial/Marine 3.0L Unit Repair Manual



GM **POWERTRAIN**

SECTION 6 ENGINE

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ENGINE TUNE UP

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GENERAL DESCRIPTION

The engine tune up is important to the modern automotive engine with its vastly improved power and performance. The higher compression ratios, improved electrical systems and other advances in design, make today's engines more sensitive and have a decided effect on power, performance and fuel consumption.

It is seldom advisable to attempt a tune up by correction of one or two items only. Time will normally be saved and more lasting results assured if the technician will follow a definite and thorough procedure of analysis and correction of all items affecting power, performance and economy.

The tune up will be performed in two parts. The first part will consist of visual and mechanical checks and adjustments; the second part will consist of an instrument checkout that can be performed with any one of the units

of service equipment available for this purpose. Always follow the instructions provided by the manufacturer of the particular equipment to be used.

Additional checks and adjustments are included in the latter part of this section for use as required. Many of these operations can be used to isolate and correct trouble located during the tune up. Where conditions are uncovered requiring major corrective action, refer to the appropriate section of this manual or the Passenger Car Chassis Overhaul Manual for detailed service information.

Typical illustrations and procedures are used except where specific illustrations or procedures are necessary to clarify the operation. Illustrations showing bench operations are used for clarification, however, all operations can be performed on the vehicle.

MECHANICAL CHECKS AND ADJUSTMENTS

Spark Plug Removal

Remove any foreign matter from around spark plugs by blowing out with compressed air, then disconnect wires and remove plugs.

Test Compression (Fig. 1)

The compression check is important because an engine with low or uneven compression cannot be tuned success-

fully. It is essential that improper compression be corrected before proceeding with the engine tune up.

1. Remove air cleaner and block throttle and choke in wide open position.
2. Hook up starter remote control cable and insert compression gauge firmly in spark plug port.

CAUTION: Whenever the engine is cranked

remotely at the starter, with a special jumper cable or other means, the primary distributor lead must be disconnected from the negative post on the coil and the ignition switch must be in the "ON" position. Failure to do this will result in a damaged grounding circuit in the ignition switch.

3. Crank engine through at least four compression strokes to obtain highest possible reading.
4. Check and record compression of each cylinder.
5. If one or more cylinders read low or uneven, inject about a tablespoon of engine oil on top of pistons in low reading cylinders (through spark plug port). Crank engine several times and recheck compression.
 - If compression comes up but does not necessarily reach normal, rings are worn.
 - If compression does not improve, valves are burnt, sticking or not seating properly.
 - If two adjacent cylinders indicate low compression and injecting oil does not increase compression, the cause may be a head gasket leak between the cylinders. Engine coolant and/or oil in cylinders could result from this defect.

NOTE: If a weak cylinder cannot be located with the compression check, see "Cylinder Balance Test" under "Additional Checks and Adjustments" in this section.

Service and Install Spark Plugs (Fig. 2)

1. Inspect each plug individually for badly worn electrodes, glazed, broken or blistered porcelains and replace plugs where necessary. Refer to spark plug diagnosis information presented in Section 6Y for an analysis of plug conditions.
2. Clean serviceable spark plugs thoroughly, using an abrasive-type cleaner such as sand blast. File the center electrode flat.
3. Inspect each spark plug for make and heat range. All plugs must be of the same make and number.
4. Adjust spark plug gaps to specifications using a round feeler gauge.

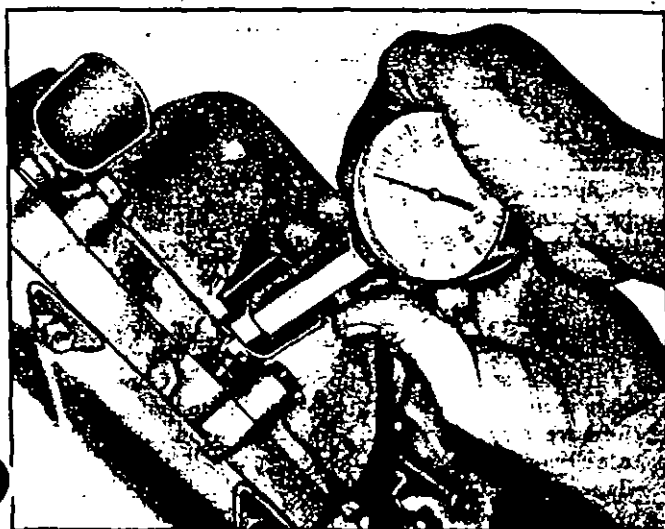


Fig. 1 - Checking Compression

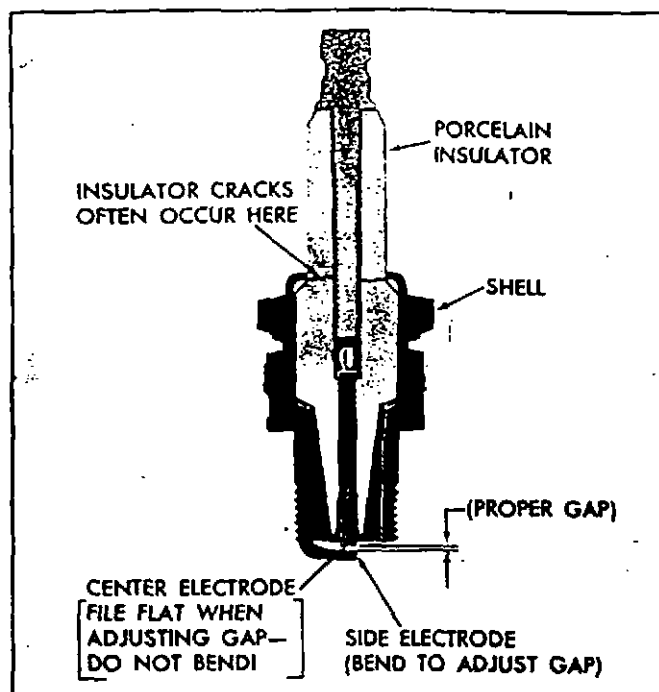


Fig. 2 - Spark Plug Detail

CAUTION: Never bend the center electrode to adjust gap. Always adjust by bending ground or side electrode.

5. If available, test plugs with a spark plug tester.
6. Inspect spark plug hole threads and clean before installing plugs. Corrosion deposits can be removed with a 14 mm. x 1.25 SAE spark plug tap (available through local jobbers) or by using a small wire brush in an electric drill. (Use grease on tap to catch chips.)

CAUTION: Use extreme care when using tap to prevent cross threading. Also crank engine several times to blow out any material dislodged during cleaning operation.

7. Install spark plugs with new gaskets and torque to specifications.

NOTE: The following are some of the greatest causes of unsatisfactory spark plug performance.

- Installation of plugs with insufficient torque to fully seat the gasket.
- Installation of the plugs using excessive torque which changes gap settings.
- Installation of plugs on dirty gasket seal.
- Installation of plugs into corroded spark plug hole threads.

8. Connect spark plug wiring.

Service Ignition System (Fig. 3)

1. Remove distributor cap, clean cap and inspect for cracks, carbon tracks and burned or corroded terminals. Replace cap where necessary.

2. Clean rotor and inspect for damage or deterioration. Replace rotor where necessary.
3. Replace brittle, oil soaked or damaged spark plug wires. Install all wires to proper spark plug. Proper positioning of spark plug wires in supports is important to prevent cross-firing.
4. Tighten all ignition system connections.
5. Replace or repair any wires that are frayed, loose or damaged.

Magnetic Pulse(Breakerless) Distributor

There are no moving parts in the ignition pulse amplifier, and the distributor shaft and bushings have permanent type lubrication, therefore no periodic maintenance is required for the magnetic pulse ignition system. Refer to Section 6Y for an analysis of problems and/or repair procedures encountered on the Transistorized (Magnetic Pulse) ignition system.

Standard (Breaker Point) Distributor (Figs. 4 or 5)

1. Check the distributor centrifugal advance mechanism by turning the distributor rotor in a clockwise direction as far as possible, then releasing the rotor to see if the springs return it to its retarded position. If the rotor does not return readily, the distributor must be disassembled and the cause of the trouble corrected.
2. Check to see that the vacuum spark control operates freely by turning the movable breaker plate counter-clockwise to see if the spring returns to its retarded

position. Any stiffness in the operation of the spark control will affect the ignition timing. Correct any interference or binding condition noted.

3. Examine distributor points and clean or replace if necessary.

- Contact points with an overall gray color and only slight roughness or pitting need not be replaced.
- Dirty points should be cleaned with a clean point file.

Use only a few strokes of a clean, fine-cut contact file. The file should not be used on other metals and should not be allowed to become greasy or dirty. Never use emery cloth or sandpaper to clean contact points since particles will embed and cause arcing and rapid burning of points. Do not attempt to remove all roughness nor dress the point surfaces down smooth. Merely remove scale or dirt.

- Clean cam lobe with cleaning solvent, lubricate cam lobe with "Delco Remy Cam and Ball Bearing Lubricant" or its equivalent and rotate cam lubricator wick 1/2 turn.
- Replace points that are burned or badly pitted.

NOTE: Where prematurely burned or badly pitted points are encountered, the ignition system and engine should be checked to determine the cause of trouble so it can be eliminated. Unless the condition causing point burning or pitting is corrected, new points will provide no

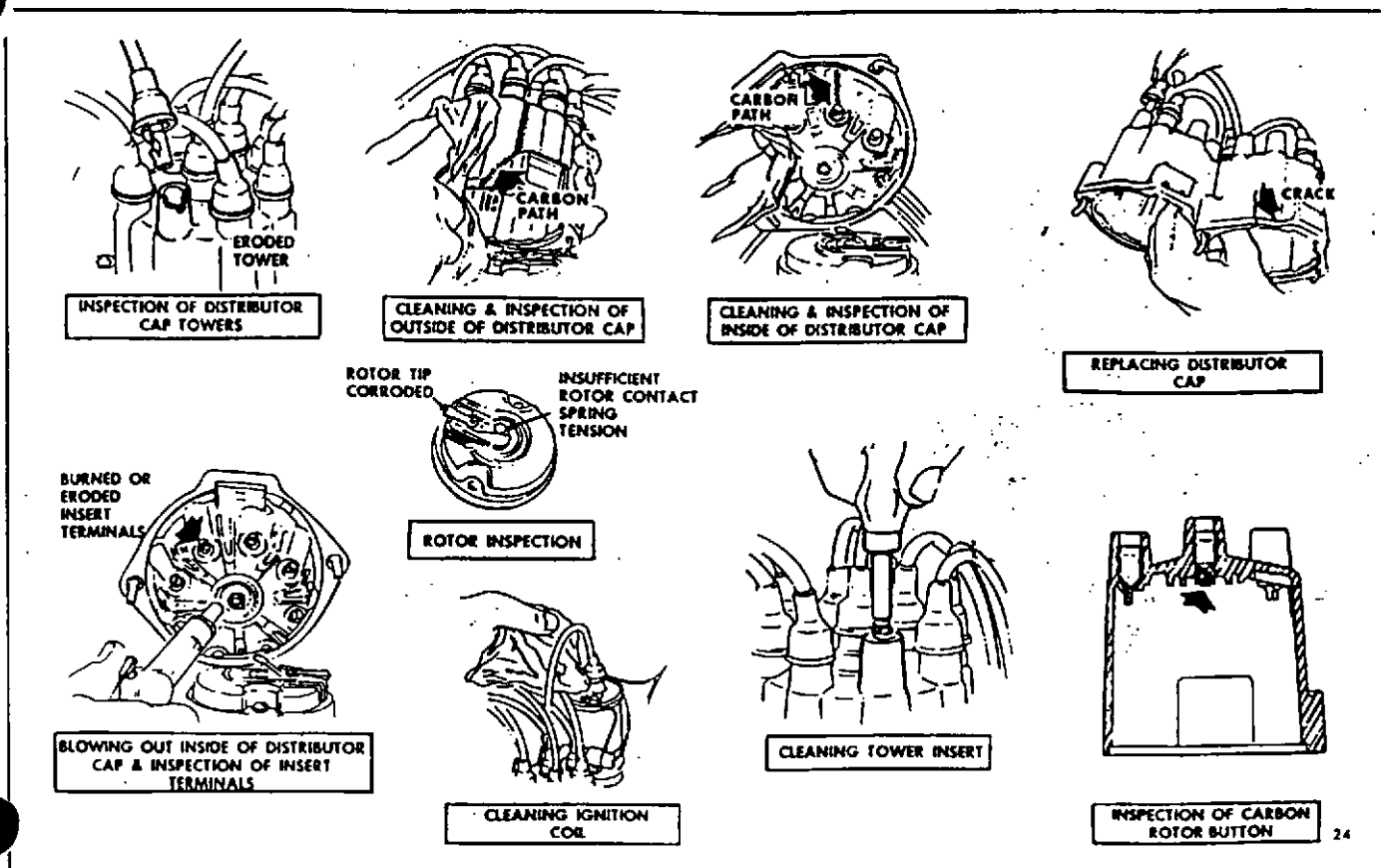


Fig. 3—Cleaning and Inspecting Distributor Cap, Rotor, and Coil

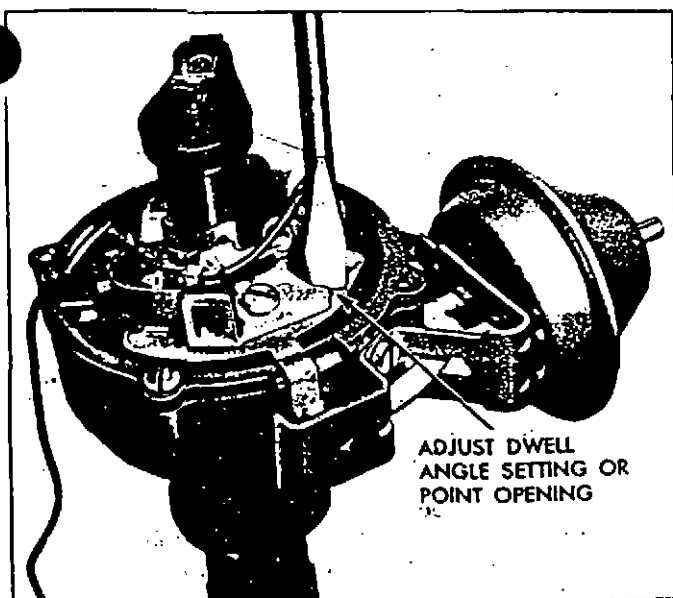


Fig. 4—Distributor (In Line)

better service than the old points. Refer to Section 6Y for an analysis of point burning or pitting.

- Check point alignment (fig. 6) then, adjust distributor contact point gap to .019" (new points) or .016" (used points). Breaker arm rubbing block must be on high point of lobe during adjustment.

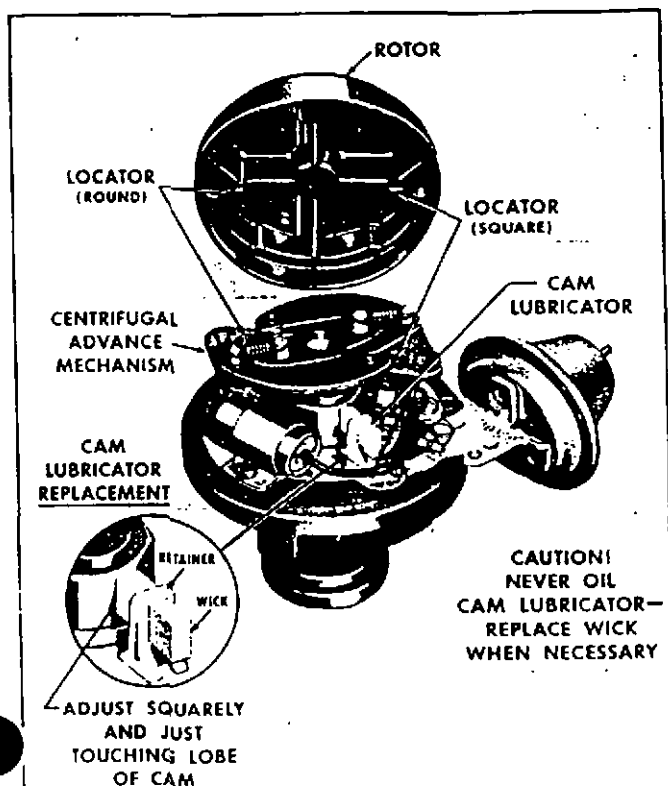


Fig. 5—Distributor (V-8)

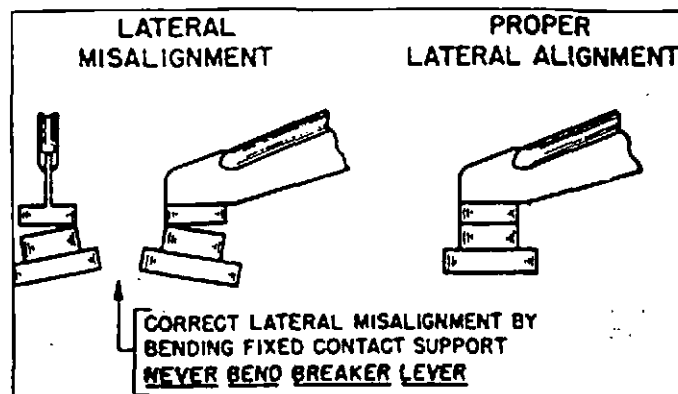


Fig. 6—Point Alignment

NOTE: If contact points have been in service, they should be cleaned with a point file before adjusting with a feeler gauge.

- Check distributor point spring tension (contact point pressure) with a spring gauge hooked to breaker lever at the contact and pull exerted at 90 degrees to the breaker lever. The points should be closed (cam follower between lobes) and the reading taken just as the points separate. Spring tension should be 19-23 ounces. If not within limits, replace.

Excessive point pressure will cause excessive wear on the points, cam and rubber block. Weak point pressure permits bouncing or chattering, resulting in arcing and burning of the points and an ignition miss at high speed.

4. Install rotor and distributor cap. Press all wires firmly into cap towers.

Service Battery and Battery Cables

1. Measure the specific gravity of the electrolyte in each cell (fig. 7). If it is below 1.230 (corrected to

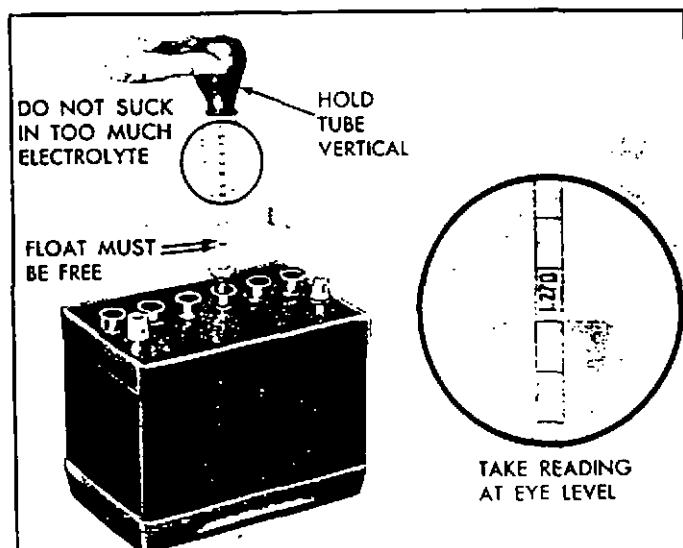


Fig. 7—Testing Specific Gravity of Battery

80°F.) recharge with a slow rate charger, or if desired, further check battery.

2. Connect a voltmeter across the battery terminals and measure the terminal voltage of the battery during cranking (disconnect the coil primary lead at the negative terminal during this check to prevent engine from firing). If the terminal voltage is less than 9.0 volts at room temperature, approximately 80° ± 20°F., the battery should be further checked. See Section 6Y for further tests.
3. Inspect for signs of corrosion on battery, cables and surrounding area, loose or broken carriers, cracked or bulged cases, dirt and acid, electrolyte leakage and low electrolyte level. Fill cells to proper level with distilled water or water passed through a "demineralizer".

The top of the battery should be clean and the battery hold-down bolts properly tightened. Particular care should be taken to see that the top of the battery is kept clean of acid film and dirt. When cleaning batteries, wash first with a dilute ammonia or soda solution to neutralize any acid present and then flush off with clean water. Keep vent plugs tight so that the neutralizing solution does not enter the cell. The hold-down bolts should be kept tight enough to prevent the battery from shaking around in its holder, but they should not be tightened to the point where the battery case will be placed under a severe strain.

To insure good contact, the battery cables should be tight on the battery posts. Oil battery terminal felt washer. If the battery posts or cable terminals are corroded, the cables should be cleaned separately with a soda solution and wire brush. After cleaning and before installing clamps, apply a thin coating of petrolatum to the posts and cable clamps to help retard corrosion.

If the battery has remained undercharged, check for loose or defective fan belt, defective Delcotron, high resistance in the charging circuit, oxidized regulator contact points, or a low voltage setting.

If the battery has been using too much water, the voltage output is too high.

Service Delcotron and Regulator

The Delcotron and regulator tests during tune up consist of the above battery tests; the condition of the battery indicating further tests and adjustments as outlined in Section 6Y.

Service Belts (Fig. 8)

Inspect belt condition.

Check and adjust if necessary for correct tension of belt, as follows:

- Using a strand tension gauge, check the belt tension.
- Adjust belt until the specified tension is reached. (See Tune Up Chart.)

Service Manifold Heat Valve (Figs. 9 or 10)

Check manifold heat control valve for freedom of operation. If shaft is sticking, free it up with GM Manifold Heat Control Solvent or its equivalent.

NOTE: Tap shaft end to end to help free it up.

Tighten Manifold

Tighten intake manifold bolts to specifications in the sequence outlined on Torque Sequence Chart (Fig. 11).

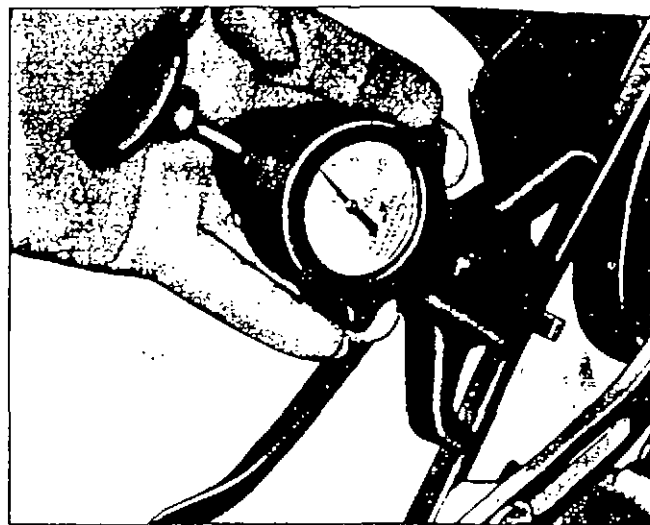


Fig. 8—Checking Fan Belt Tension

A slight leak at the intake manifold destroys engine performance and economy.

Service Fuel Lines and Fuel Filter

1. Inspect fuel lines for kinks, bends or leaks and correct any defects found.
2. Inspect filter and replace if plugged.

NOTE: Refer to Section 8 for the correct fabrication and replacement procedure of fuel lines.

Service Cooling System

1. Inspect cooling system for leaks, weak hoses, loose hose clamps and correct coolant level, and service as required.

NOTE: A cooling system pressure test, as described in "Additional Checks and Adjustments" in this section, may be performed to detect internal or external leaks within the cooling system.



Fig. 9—Manifold Heat Control Valve (In-Line)

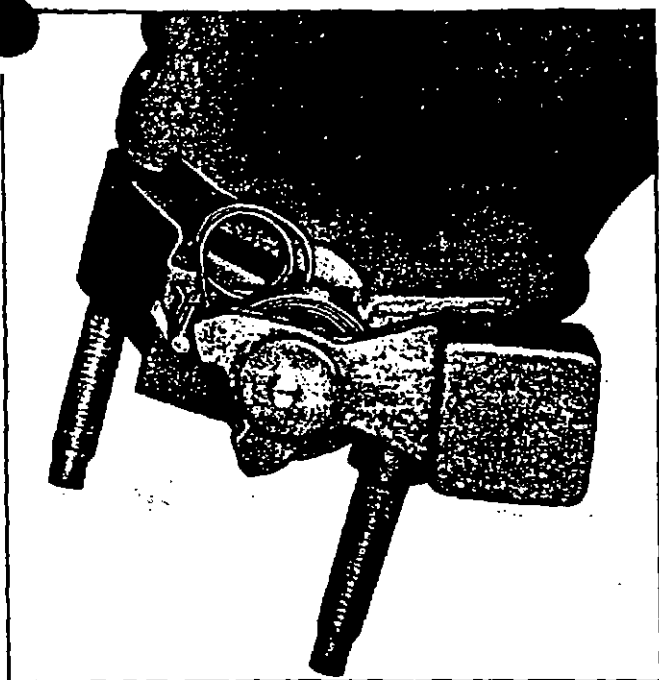


Fig. 10—Manifold Heat Control Valve (V-8)

Check and Adjust Accelerator Linkage

1. Disconnect control linkage at carburetor throttle lever.
2. Hold carburetor throttle lever in wide position.
3. Pull control linkage to wide open position. (On ve-

hicles equipped with automatic transmission, pull through detent).

4. Adjust control linkage to freely enter hole in carburetor throttle lever.

NOTE: Accelerator linkage is outlined in detail in Section 6M.

5. Connect control linkage at throttle lever.

Service Crankcase Ventilation (Fig. 11)

All engines have "Closed Positive" ventilation systems utilizing manifold vacuum to draw fumes and contaminating vapors into the combustion chamber where they are burned. Since it affects every part of the engine, crankcase ventilation is an important function and should be understood and serviced properly.

In the "Closed Positive" ventilation system, air is drawn through the engine, (through a regulating valve) into the manifold, drawing crankcase vapors and fumes with it to be burned. This ventilation system draws the clean air from the carburetor air cleaner and has a nonvented oil filler cap.

1. Ventilation valve may be checked as outlined under "Additional Checks and Adjustments".
2. Inspect for deteriorated or plugged hoses.
3. Inspect all hose connections.
4. On "Closed Positive" ventilation systems, remove flame arrestor if equipped and wash in solvent then dry with compressed air.

Service Air Injection Reactor System

Inspect air injection reactor system for evidence of leaks, deteriorated hoses, cracked air manifolds or tubes

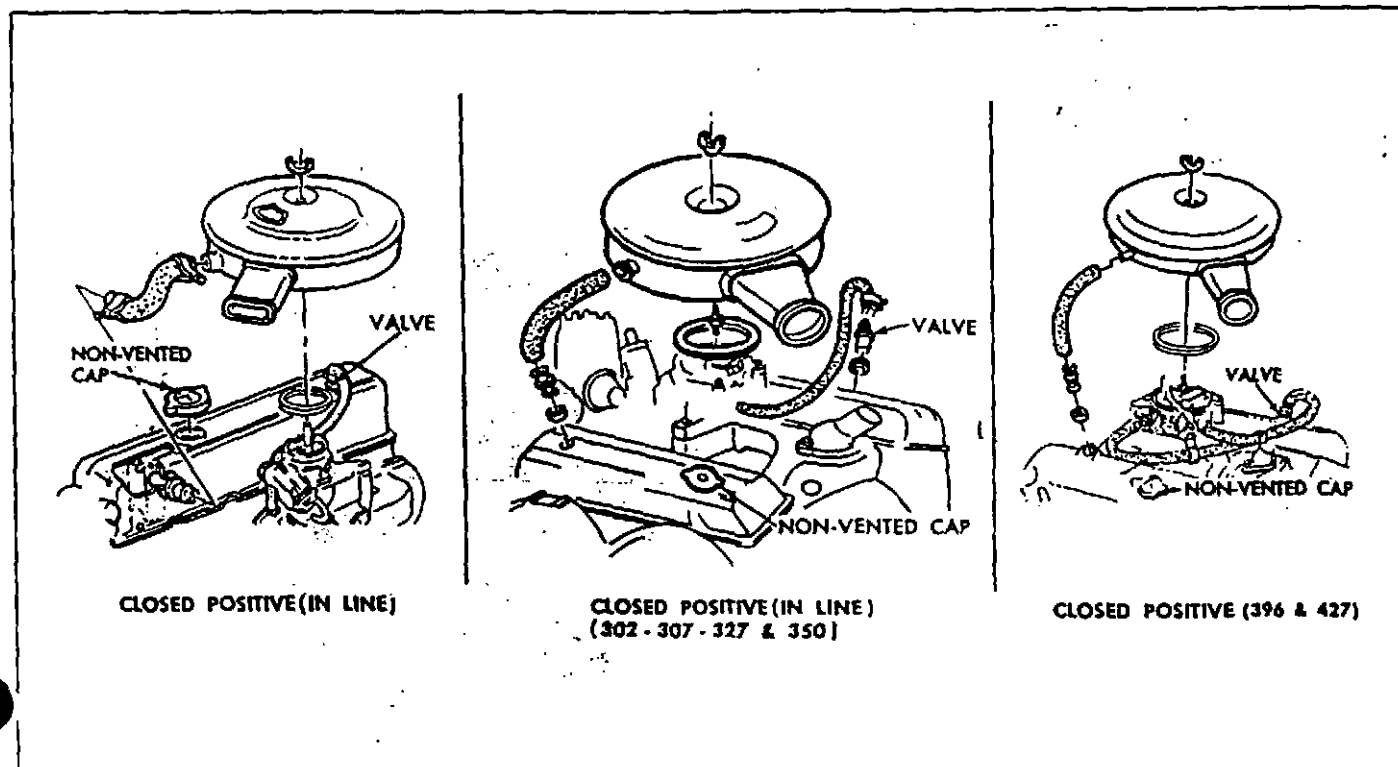


Fig. 11—Crankcase Ventilation Systems

and loose hose clamps. Inspect air injection pump belt condition and tension. Make all necessary repairs as outlined in "Section 6T".

Because of the relationship between "Engine Tune Up" and "Unburned Exhaust Gases", the condition of Engine Tune Up should be checked whenever the Air Injection Reactor System seems to be malfunctioning. Particular care should be taken in checking items that affect fuel-air ratio such as the crankcase ventilation system, the carburetor and the carburetor air cleaner. Carburetors and distributors for engines with the Air Injection Reactor System and Controlled Combustion System are designed, particularly, for these engines; therefore, they must not be interchanged with or replaced by a carburetor or distributor designed for different applications.

Service Choke Assemblies

The passenger car automatic choke assemblies (fig. 12) are shown in their relative installed position when the choke is in fully applied (choke ON--choke rod hitting stop) position. The arrows show the direction the coils and rods move when closing the choke valve.

Choke Adjustment with Remote Choke (Fig. 13)

1. Remove air cleaner and check to see that choke valve and rod move freely.
2. Disconnect choke rod at choke lever.
3. Check choke adjustment as follows:

On all engines except L6 and two barrel V8 engines, hold choke valve closed and push rod downward to contact stop. The top of rod should be even with bottom of hole in choke lever.

On L6 and two barrel V8 engines, hold choke valve closed and pull rod upward to end of travel. The bottom of rod should be even with top of hole in choke lever.

4. If necessary, adjust rod length by bending rod at offset. (Bend must be such that rod enters choke lever hole freely and squarely.)
5. Connect rod at choke lever and install air cleaner.

Choke Adjustment with Manual Choke

1. Remove air cleaner.
2. Push hand choke knob in to within 1/8" of instrument panel.

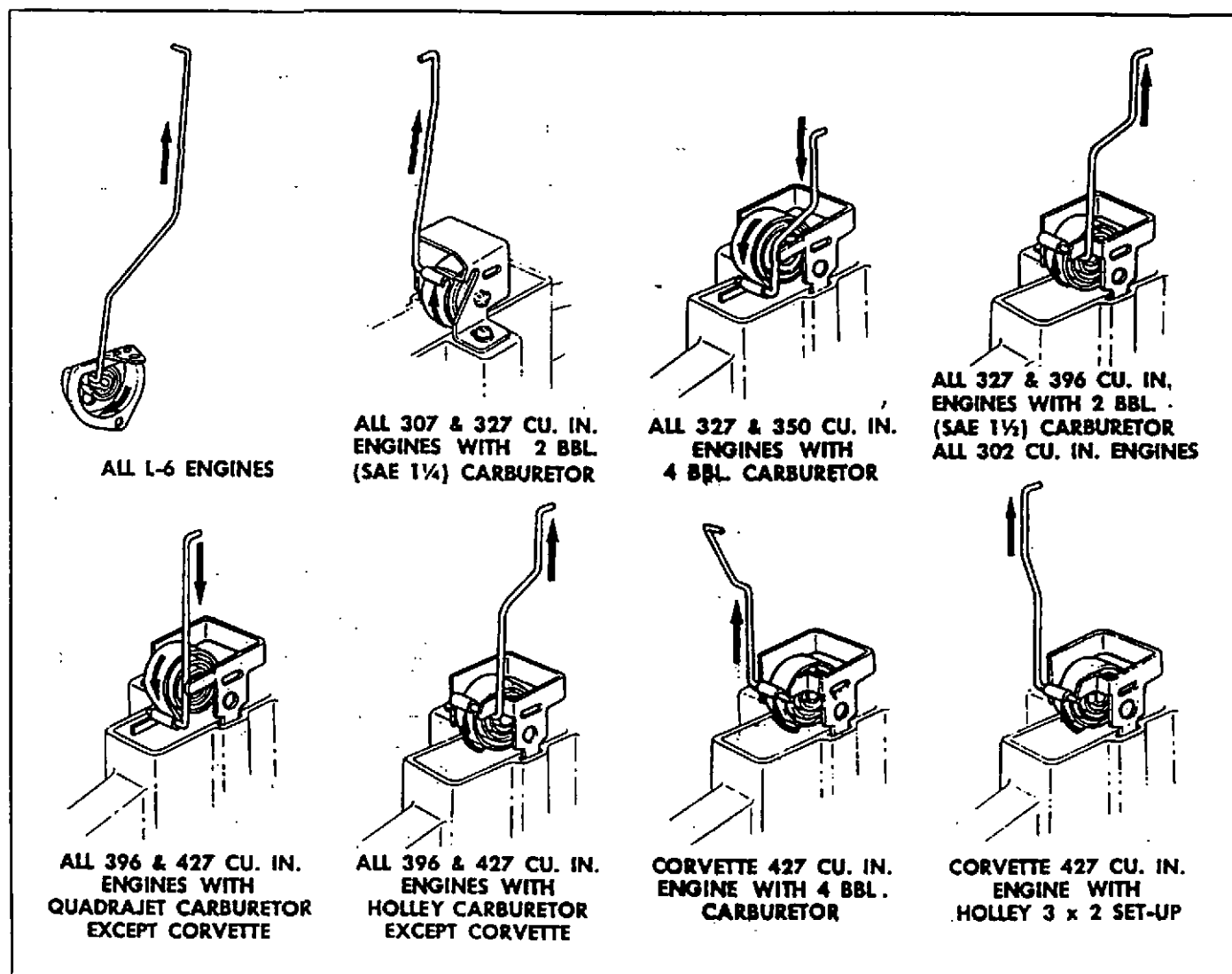


Fig. 12—Carburetor Automatic Choke Assemblies

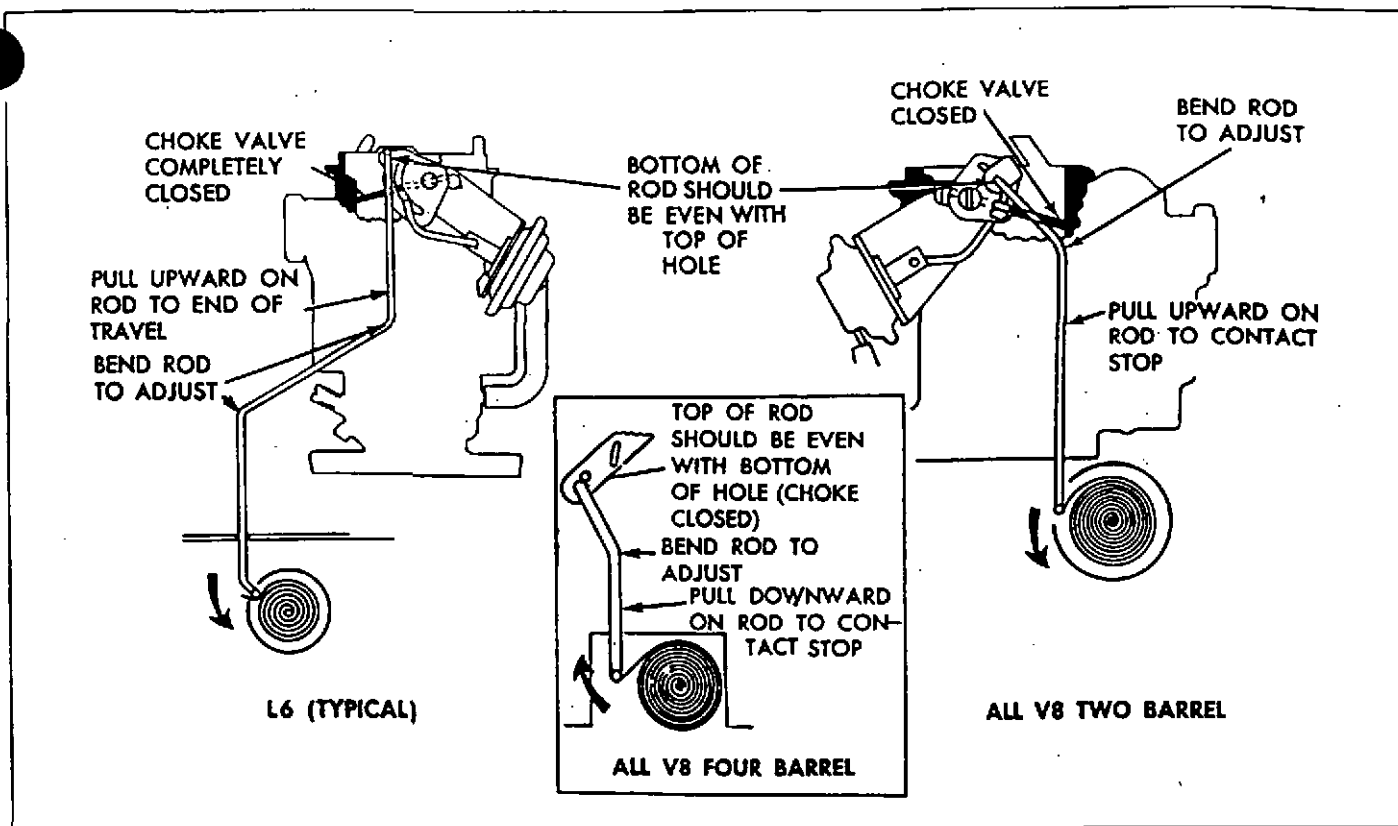


Fig. -13—Automatic Choke Adjustment

3. Loosen choke cable at carburetor bracket and adjust cable through the clip until the choke valve is wide open.

4. Tighten cable clamp at carburetor bracket and check operation of choke valve to ensure full closed and wide open positions.

INSTRUMENT CHECK-OUT

Instrument Hook Up

Connect vacuum gauge, dwell meter, tachometer and timing light as recommended by the manufacturer of the equipment being used.

Check and Adjust Dwell

1. Start engine then check ignition dwell.
2. If dwell is not within specifications, adjust dwell as follows:

V8 ENGINES

- With engine running at idle, raise the adjustment screw window and insert an Allen wrench in the socket of the adjusting screw (fig. 14).
- Turn the adjusting screw as required until a dwell reading of 30° is obtained. A 2° variation is allowable for wear.
- Close access cover fully to prevent the entry of dirt into the distributor.

NOTE: If a dwell meter is not available, turn adjusting screw clockwise until engine starts to misfire, then turn screw one-half turn in the opposite direction to complete adjustment.

IN LINES ENGINES

- Remove distributor cap and recheck point setting.

If dwell is still not within specifications check the distributor as outlined in Section 6Y.

Check Dwell Variation

Slowly accelerate engine to 1500 rpm and note dwell

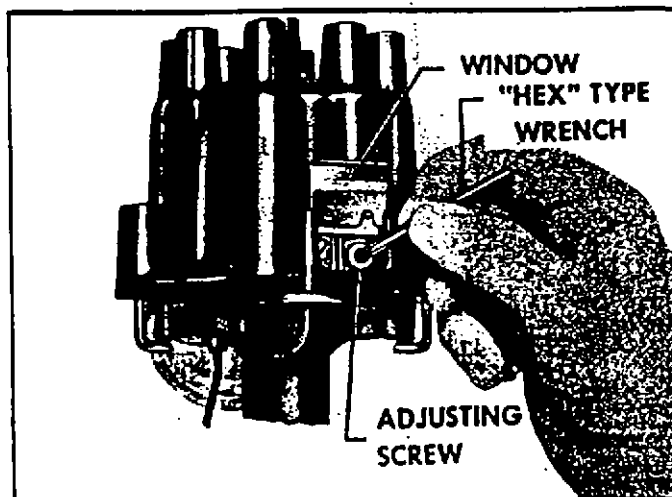


Fig. 14—Setting Point Dwell

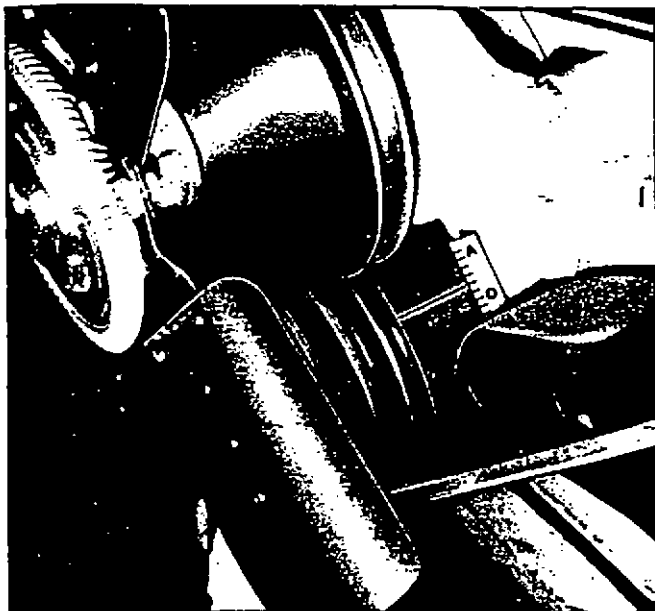


Fig. 15—Ignition Timing Marks

reading. Return engine to idle and note dwell reading. If dwell variation exceeds specifications, check for worn distributor shaft, worn distributor shaft bushing or loose breaker plate.

Check and Adjust Ignition Timing (Fig. 15)

1. Disconnect the distributor spark advance hose and plug the vacuum source opening.
2. Start engine and run at idle speed (see tune up chart).
3. Aim timing light at timing tab.

NOTE: The markings on the tabs are in 2° increments (the greatest number of markings on the "A" side of the "O"). The "O" markings is TDC of #1 cylinder and all BTDC settings fall on the "A" (advance) side of the "O".

4. Adjust the timing by loosening the distributor clamp and rotating the distributor body as required, then tighten the clamp.
5. Stop engine and remove timing light and reconnect the spark advance hose.

Adjust Idle Speed and Mixture (Fig. 16)

1. As a preliminary adjustment, turn idle mixture screws lightly to seat and back out 3 turns.

CAUTION: Do not turn idle mixture screw tightly against seat or damage may result.

2. With engine running at operating temperature (Air cleaner installed, pre-heater valve and choke valve wide open); adjust idle speed screw to bring idle speed to specified rpm (automatic transmission in drive, manual transmission in neutral).

NOTE: On air conditioning vehicles, turn air conditioning "OFF" or "ON" in accordance to instructions on Decal.

3. Adjust idle mixture screw to obtain highest steady idle speed. Adjust idle speed screw to recommended rpm on "DECAL" (Fig. 17).

NOTE: Idle speed adjustment for engines with idle solenoid is as follows: Adjust idle speed to 500 rpm L6 and 600 rpm V8 by adjusting solenoid plunger hex only (Fig. 18). Disconnect wire at solenoid and observe idle speed. De-energizing the solenoid allows the throttle lever to seat against the carburetor idle screw. Adjust the carburetor idle screw as necessary to obtain 400 rpm.

4. Adjust mixture screw in to obtain a 20 rpm drop (lean roll).
5. Adjust mixture screw out 1/4 turn.
6. Repeat Steps 4 and 5 for second mixture screw (if so equipped).
7. Readjust speed screw if necessary to specified idle rpm.

ADDITIONAL CHECKS AND ADJUSTMENTS

Testing Crankcase Ventilation Valve (Fig. 19)

1. Connect tachometer and vacuum gauge as for idle speed and mixture adjustment.
2. Set parking brake, start engine and adjust idle speed and mixture.
3. Disconnect ventilation hose at valve, block opening of valve and read engine rpm change.
4. A change of less than 50 rpm indicates a plugged ventilation valve - replace the valve (fig. 20).

Cylinder Balance Test (Fig. 21)

It is often difficult to locate a weak cylinder. A compression test, for example, will not locate a leaky intake manifold, a valve not opening properly due to a worn camshaft, or a defective spark plug.

With the cylinder balance test, the power output of one cylinder may be checked against another, using a set of grounding leads. When the power output of each cylinder is not equal, the engine will lose power and run roughly.

Perform a cylinder balance test as follows:

1. Connect the tachometer and vacuum gauge.
2. Start engine and run at 1500 rpm.
3. Ground large clip of grounding leads and connect individual leads to all spark plugs except the pair being tested.

Divide the firing order in half and arrange one half over the other. The cylinders to be tested together appear one over the other.

L4 Firing Order

1-3-4-2 = 1-3 = 1-4, 3-2
4-2

L6 Firing Order

1-5-3-6-2-4 = 1-5-3 = 1-6, 5-2, 3-4
6-2-4

V8 Firing Order

1-8-4-3-6-5-7-2 = 1-8-4-3 = 1-6, 8-5, 4-7, 3-2
6-5-7-2

ROCHESTER M

ROCHESTER MV

ROCHESTER 2GV

ROCHESTER 2GV (1-1/2)

HOLLEY 2300C (PRIMARY)

HOLLEY 2300 (SECONDARY)

ROCHESTER 4MV

HOLLEY 4150

APPLICATION CARBURETOR		Chevrolet	Chevelle	Chevy Nova	Camaro	Corvette	V-8																			
							IN LINE																			
							153	230	250	302	307	327	350	396	427											
							90	140	155	290	200	210	235	300	350	370	265	325	350	375	335	390	400	425	430	435
ROCH M				3			3																			
ROCH MV		1	2	3	4			2 3 4 3 4																		
ROCH 2GV(SAE 1 1/4)			2	3	4							2 3 4														
ROCH 2GV(SAE 1 1/2)		1											1				1									
ROCH 4MV		1	2	3	4	5								1 2 3 4 5	5		2 4	2 3 4		1 1 5						
HOLLY 2300	C Prim.					5																	5			5
	Sec.					5																	5			5
HOLLY 4150		1	2	3	4	5				4					5			2 3 4					1 5			

Fig. 16—Idle Speed and Mixture Screws

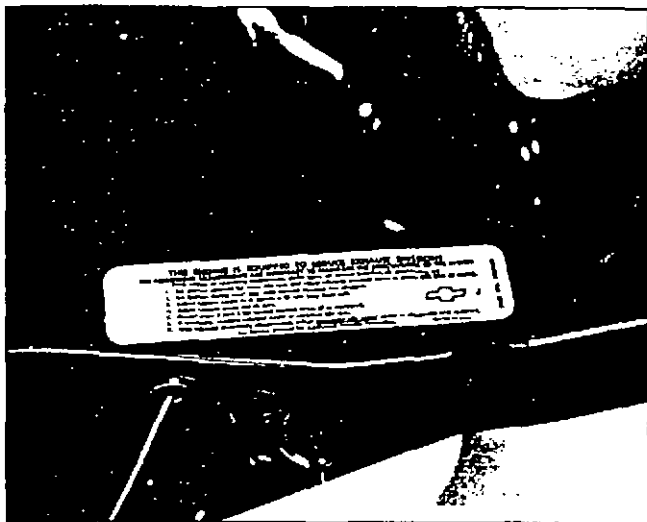


Fig. 17—Tune-Up Decal

4. Operate engine on each pair of cylinders in turn and note engine rpm and manifold vacuum for each pair. A variation of more than 1 inch of vacuum or 40 rpm between pairs of cylinders being tested indicates that the cylinders are off balance.

Battery

The battery should be checked with special testing equipment and to the equipment manufacturers specifications. See Section 6Y for complete information on battery tests.

Ignition

The following additional ignition checks may be made with any of several pieces of equipment available for uncovering the source of engine difficulties. The specific operating instructions of the equipment manufacturer should be followed:

- Cranking voltage
- Ignition switch
- Distributor resistance
- Secondary resistance
- Ignition output and secondary leakage

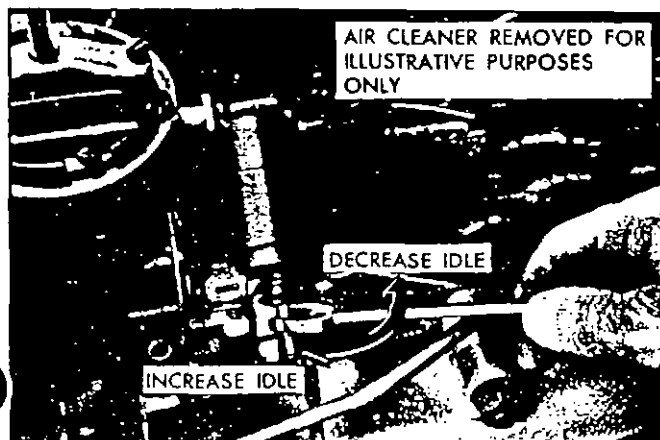


Fig. 18—Adjusting Idle Solenoid

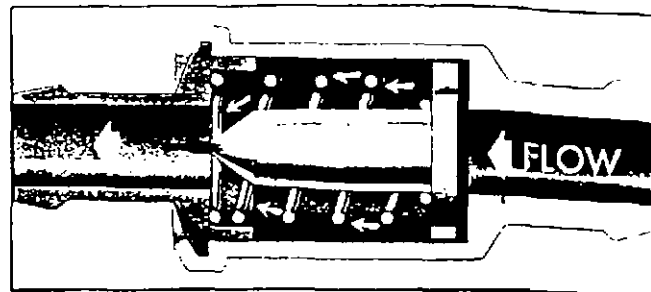


Fig. 19—Crankcase Ventilation Valve

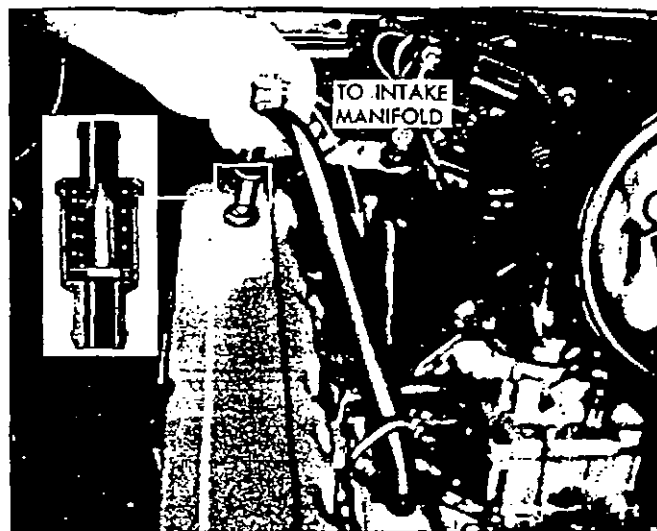


Fig. 20—Installing P.C.V. Valve

Cranking Voltage (Fig. 22)

1. Disconnect coil primary lead at the coil negative terminal to prevent engine from firing during cranking.

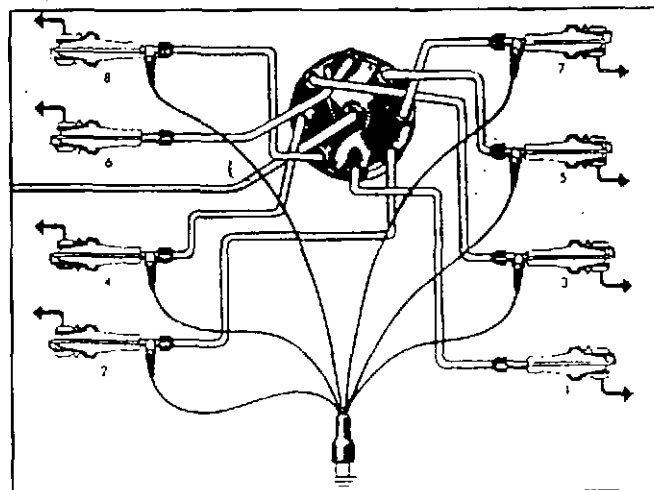


Fig. 21—Cylinder Balance Test

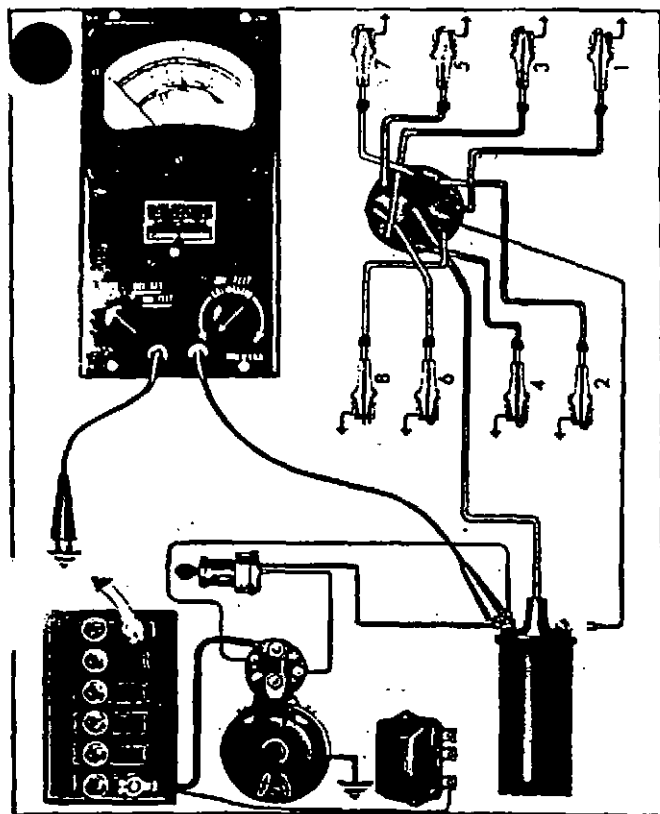


Fig. 22—Testing Cranking Voltage

2. Connect voltmeter between primary terminal of coil (resistance wire side) and ground.
3. Operate starting motor.
 - a. If voltage is 9 volts or more and cranking speed is satisfactory, the battery, starter, cables, starter switch and ignition circuit to coil (bypassing resistance wire) are in good condition.
 - b. If below 9 volts, check circuit until difficulty is located.

Meter reading below specification--Weak battery; defective cables, connections, switch or starter; defective ignition circuit to coil.

Cranking speed below normal--Excessive resistance in cables or starting motor; excessive mechanical drag in engine.

Uneven cranking speed--Uneven compression, defective starter or starter drive.

Ignition Switch

With voltmeter connected as described for the Cranking Voltage Test, turn ignition switch to ON. Voltage should drop to 5 to 7 volts as current is now passing through high resistance wire connected between ignition switch and (+) positive terminal of coil. If battery voltage of 12 volts is obtained, the starter solenoid is by-passing the high resistance wire connected between ignition switch and (+) positive terminal of coil, thus the starter solenoid is not functioning properly to bypass the ignition resistance wire or the ignition circuit is incorrectly wired.

NOTE: The voltage drop (12 to 5-7 volts) will only take place when the points are closed. If

the points are open, the path through the resistance wire will not be completed.

Distributor Resistance

Use equipment as directed by manufacturer. Excessive resistance in primary circuit must be eliminated before continuing with test procedure.

Secondary Resistance

Use equipment as directed by manufacturer.

- Uniform "normal readings" as specified by manufacturer indicate all secondary circuit components are in good condition.
- If all readings are "below normal," check for corroded coil tower terminal, poorly connected or broken coil wire, center cap electrode or rotor tip burned, or an open secondary in coil.
- If readings are "higher than normal" at two or more plugs adjacent in firing order, cross firing is occurring in distributor cap or between spark plug cables concerned.
- If meter reads off scale to left, the coil polarity is reversed. Check for reversed coil primary wires, wrong coil or reversed vehicle battery connections.

Ignition Output and Secondary Leakage

Use equipment as directed by manufacturer.

- GOOD readings indicate both ignition output and secondary insulation are good.
- If all readings are BAD or if ignition test calibrator cannot be adjusted to Set Line, check for high resistance in primary circuit, defective distributor points, coil or condenser.
- If readings are BAD when certain plug wires are lifted off, check for cracks or carbon tracks in distributor cap or defective insulation on those plug wires being lifted off.

Carburetor

Refer to Section 6M to perform adjustments such as idle vent, float level, pump rod and secondary valve.

Fuel Pump

If the owner has complained of poor high speed performance, the fuel pump may be at fault. Too low a pump pressure or volume will cause a high speed "miss" because of lack of fuel delivered to the carburetor, while too high a pressure will cause carburetor flooding. Check fuel pump as outlined in Section 6M.

Cooling System

The following test may be performed with pressure testing equipment available commercially for this purpose. This test provides an excellent means of detecting internal or external leaks within the cooling system.

1. Remove radiator cap.
2. Apply a test pressure of 3 pounds higher than the radiator cap (fig. 23). i.e. 18 pounds for a 15 pound cap.
3. If the pressure will not hold, there is either an internal or external leak in the system.

Cylinder Head Torque and Valve Adjustment

Retorquing the cylinder head bolts is not necessary unless a gasket has been replaced, or a leak is suspected. Valve lash must always be adjusted after the head has been torqued.

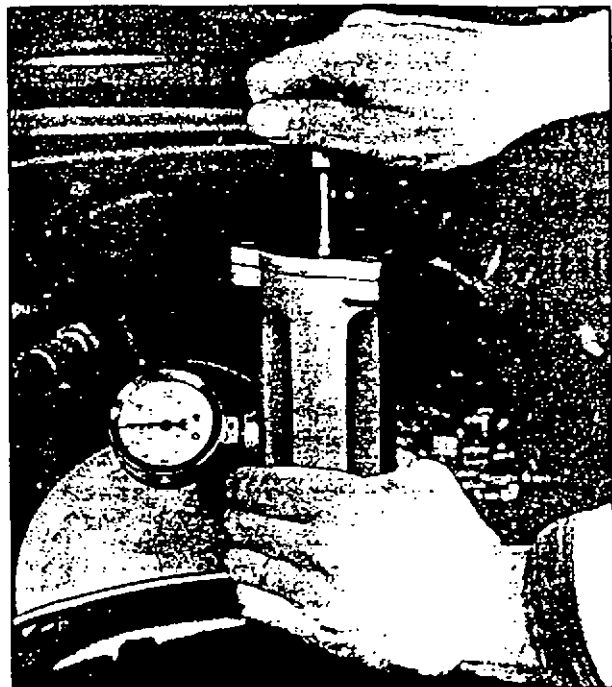


Fig. 23—Cooling System Pressure Check

Before adjusting the valve lash, it is extremely important that the engine be thoroughly warmed up to normalize the expansion of all parts. This is very important because during the warm-up period, the valve clearances will change considerably.

Hydraulic

1. After the engine has been normalized, remove rocker arm covers and gaskets.

CAUTION: Do not pry rocker arm cover loose. Gaskets adhering to cylinder head and rocker arm cover may be sheared by bumping end of rocker arm cover rearward with palm of hand or a rubber mallet.

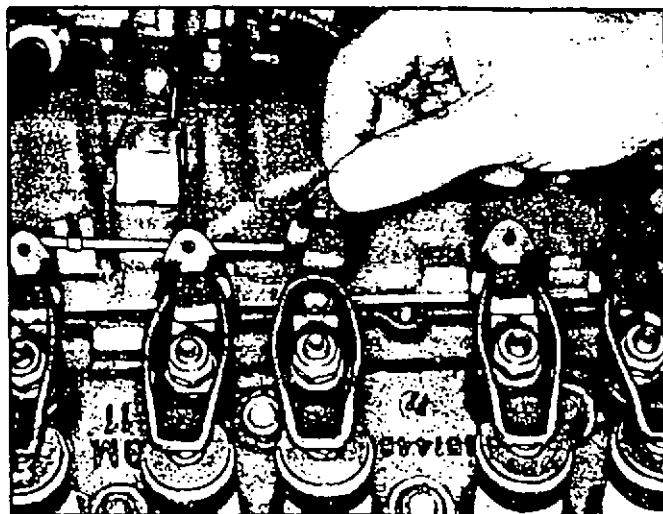


Fig. 24—Oil Deflector Clips Installed

2. With the engine running at idle, back off valve rocker arm nut until the valve rocker arm starts to clatter.
3. Turn rocker arm nut down slowly until the clatter just stops. This is the zero lash position.
4. Turn nut down 1/4 additional turn and pause 10 seconds until engine runs smoothly. Repeat additional 1/4 turns, pausing 10 seconds each time, until nut has been turned down 1 full turn from the zero lash position.

NOTE: This 1 turn preload adjustment must be done slowly to allow the lifter to adjust itself to prevent the possibility of interference, between the inlet valve head and top of piston, which might result in internal damage and/or bent push rods. Noisy lifters should be replaced.

5. Repeat Steps 2, 3 and 4 to adjust the rest of the valves.
6. Clean gasket surfaces on cylinder heads and rocker arm covers with degreaser then install rocker arm covers, using new gaskets, and torque bolts to specifications.

Mechanical

1. Normalize the engine.
2. Remove rocker arm covers and gaskets.

CAUTION: Do not pry rocker arm cover loose. Gaskets adhering to cylinder head and rocker arm cover may be sheared by bumping end of rocker arm cover rearward with palm of hand or a rubber mallet.

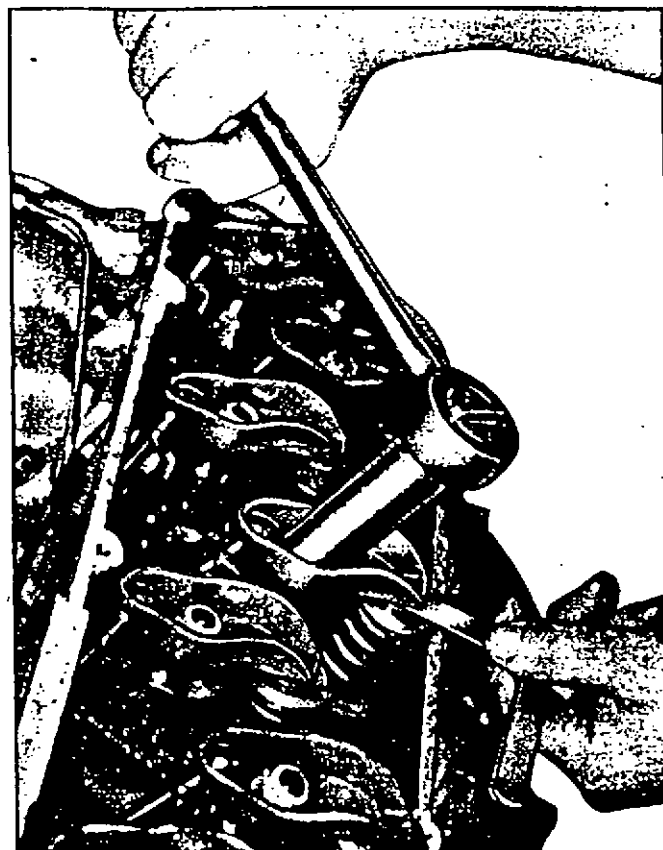


Fig. 25—Valve Adjustment (Mechanical)

3. Use a socket wrench on self-locking rocker arm stud nut and adjust as needed to obtain valve lash (see tune up chart) measured between rocker arm and valve stem with a leaf type feeler gauge (Fig. 25).

4. Stop engine, clean gasket surfaces on cylinder heads and rocker arm covers with degreaser then install rocker arm covers, using new gaskets, and torque bolts to specifications.

ENGINE MECHANICAL

IN-LINE ENGINES

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GENERAL DESCRIPTION

The In Line engines (fig. 1L) covered in this section are the 153 cu. in. L4, the 230 and 250 cu. in. L6, regardless of which passenger vehicle they are used in.

This section covers the removal and installation of engine assemblies; the removal, installation and adjustment of some sub-assemblies and replacement of some components. For service to all components and sub-assemblies (after removal) and removal of some sub-assemblies, refer to Section 6 of the Chassis Overhaul Manual.

Because of the interchangeability and similarity of many engine sub-assemblies and engine parts, regardless of which passenger vehicle they are used in, typical illustrations and procedures are used except where specific illustrations or procedures are necessary to clarify the operation. Although illustrations showing bench operations are used, most single operations, when not part of a general overhaul, should be performed (if practical) with the engine in the vehicle.

COMPONENT REPLACEMENT AND ADJUSTMENT

ENGINE ASSEMBLY

Removal

1. Drain cooling system and engine oil.
2. Remove air cleaner and disconnect battery cables at battery.
3. Remove hood hinge front bolts, loosen the rear bolts. Swing hood up and install Tool J-22382-1.

4. Remove radiator and radiator shroud as outlined in Section 13.
5. Remove fan blade and pulley as outlined in Section 8K.
6. Disconnect wires at:
 - Starter Solenoid
 - Delcotron
 - Temperature Switch

- Oil Pressure Switch
 - Coil
7. Disconnect:
 - Accelerator linkage at manifold bellcrank.
 - Exhaust pipe at manifold flange.
 - Fuel line (from tank) at fuel pump.
 - Vacuum line to power brake unit at manifold (if so equipped).
 8. Remove power steering pump and lay aside (if so equipped).
 9. Raise vehicle.
 10. Remove propeller shaft.

NOTE: If plug for propeller shaft opening in transmission is not available, drain transmission.

11. Disconnect:
 - Shift linkage at transmission.
 - Speedometer cable at transmission.
12. On synchromesh equipped vehicles, disconnect clutch linkage at cross-shaft then remove cross-shaft engine bracket.
13. Connect lifting device or chain to engine lift brackets.
14. Raise engine to take weight off front mounts and remove front mount thru bolts.
15. Remove rear mount to crossmember bolts.
16. Raise engine to take weight off rear mount, then remove crossmember.

NOTE: On Chevrolet vehicles it will be necessary to remove mount from transmission before crossmember can be removed.

NOTE: On Camaro vehicles it is not necessary to completely remove the crossmember. Remove crossmember bolts and slide back.

17. Remove engine-transmission assembly from vehicle as a unit.
18. Remove transmission (and clutch):

Synchromesh Transmission

- a. Remove clutch housing cover plate screws.
- b. Remove bolts attaching the clutch housing to engine block then remove transmission and clutch housing as a unit.

NOTE: Support the transmission, as the last mounting bolt is removed, and as it is being pulled away from the engine (to prevent damage to clutch disc).

- c. Remove starter and clutch housing rear cover.
- d. Loosen clutch mounting bolts a turn at a time (to prevent distortion of clutch cover) until the spring pressure is released. Remove all bolts, clutch disc and pressure plate assembly.

Automatic Transmission

- a. Lower engine, secured by the hoist, and support engine on blocks.
- b. Remove starter and converter housing underpan.
- c. Remove flywheel-to-converter attaching bolts.
- d. Support transmission on blocks.
- e. Remove transmission-to-engine mounting bolts.
- f. With the hoist attached, remove blocks from the

engine only and slowly guide the engine from the transmission.

19. Mount engine in stand.

Installation

1. Attach lifting device or chain to engine lift brackets and remove engine from engine stand.
2. Install transmission (and clutch):

Synchromesh Transmission

- a. Install the clutch on flywheel as outlined in Section 7.
- b. Install clutch housing front cover and starter.
- c. Install transmission and clutch housing as outlined in Section 7.
- d. Install clutch housing cover screws and tighten securely.

Automatic Transmission

- a. Position engine adjacent to the transmission and align the converter with the flywheel.
- b. Bolt transmission to engine, then raise engine and transmission assembly and install flywheel to converter attaching bolts.
- c. Install converter housing underpan and starter.
3. Tilt and lower engine and transmission assembly into the chassis as a unit, guiding engine to align front mounts with frame supports.
4. Install front mount through bolts.
5. Raise engine enough to install rear crossmember, then install crossmember, install rear mount and lower engine.
6. Remove lifting device and torque all mount bolts to specifications.
7. On synchromesh equipped vehicles, install clutch cross shaft engine bracket, then adjust and connect clutch as outlined in Section 7.
8. Connect:
 - Speedometer cable.
 - Shift linkage at transmission.
9. Install propeller shaft.
10. Lower hoist and remove vehicle.
11. Connect:
 - Power steering pump lines (if disconnected).
 - Vacuum line to power brake unit (if disconnected).
 - Fuel line at fuel pump.
 - Exhaust pipe at manifold flange.
 - Accelerator linkage at manifold bellcrank.
12. Connect wires at:
 - Coil
 - Oil pressure switch
 - Temperature switch
 - Delcotron
 - Starter solenoid
13. Install pulley, fan blade and fan belt as outlined in Section 6K.
14. Install radiator and shroud as outlined in Section 13.
15. Remove hood prop tool and install front hinge bolts. Adjust hood as outlined in Section 11.
16. Connect battery cables.
17. Fill with coolant, engine oil and transmission oil, then start engine and check for leaks.
18. Perform necessary adjustments and install air cleaner.

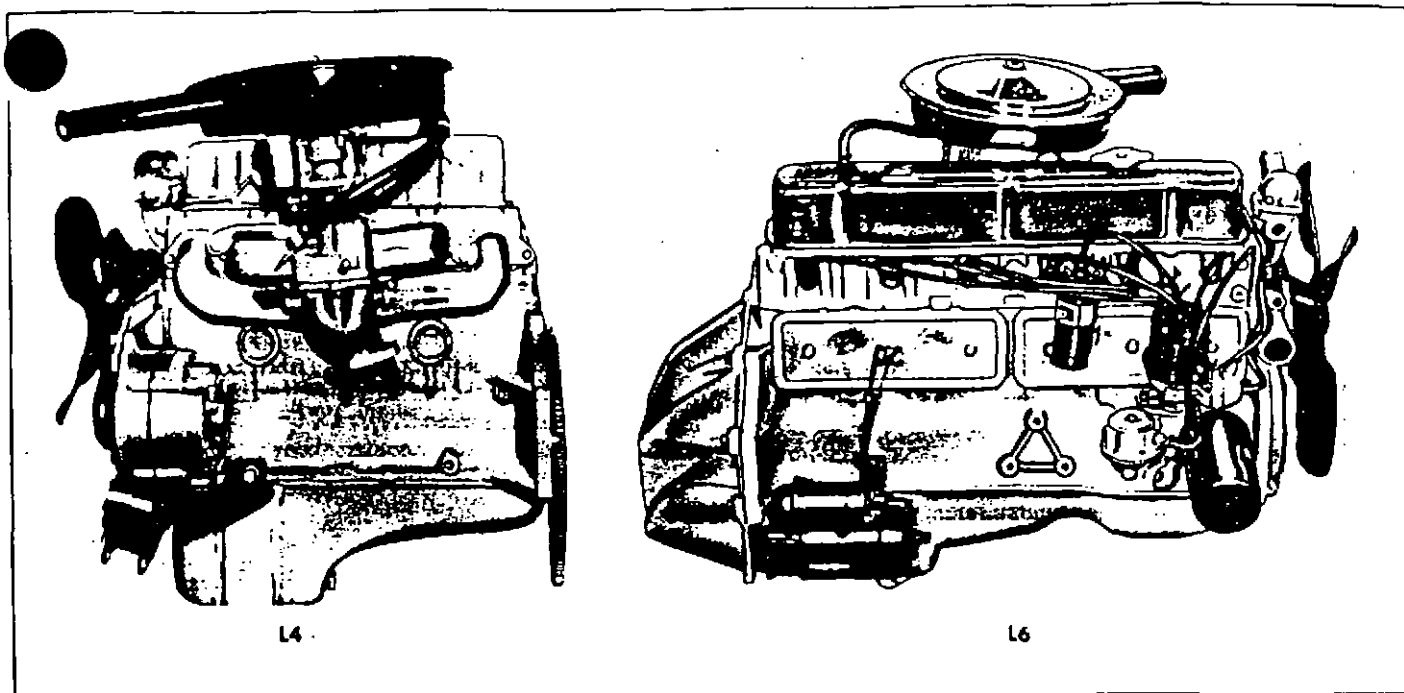


Fig. 1L - In Line Engines (Typical)

MANIFOLD ASSEMBLY

Removal

1. Remove air cleaner.
2. Disconnect both throttle controls at bellcrank and remove throttle return spring.
3. Disconnect fuel and vacuum lines at carburetor. Disconnect choke cable on L4 engines.
4. Disconnect crankcase ventilation hose at rocker arm cover.
5. Disconnect exhaust pipe at manifold flange and discard packing.
6. Remove manifold attaching bolts and clamps then remove manifold assembly and discard gaskets.
7. Check for cracks in manifold castings.
8. If necessary to replace either intake or exhaust manifolds, separate them by removing one bolt and two nuts at center of assembly. Reassemble manifolds using a new gasket. Tighten finger tight and torque to specifications after assembly to cylinder head. Transfer all necessary parts.

Installation

1. Clean gasket surfaces on cylinder head and manifolds.
2. Position new gasket over manifold end studs on head and carefully install the manifold in position making sure the gaskets are in place.
3. Install bolts and clamps while holding manifold in place with hand.
4. Torque bolts to specifications.

NOTE: On L6 engines center bolt and end bolt torque differ.

5. Connect exhaust pipe to manifold using a new packing.

6. Connect crankcase ventilation hose at rocker arm cover.

7. Connect fuel and vacuum lines at carburetor.
8. On L4 engines connect choke cable and adjust as outlined in Section 6M.
9. Connect throttle controls at bellcrank and install throttle return spring.
10. Install air cleaner, start engine, check for leaks and adjust carburetor idle speed and mixture.

ROCKER ARM COVER

Removal

1. Disconnect crankcase ventilation hose(s) at rocker arm cover.
2. Remove air cleaner.
3. Disconnect temperature wire from rocker arm cover clips.
4. Remove rocker arm cover.

Installation

1. Clean gasket surfaces on cylinder head and rocker arm cover with degreaser then, using a new gasket, install rocker arm cover and torque bolts to specifications.
2. Connect temperature wire at rocker arm cover clips.
3. Install air cleaner.
4. Connect crankcase ventilation hoses.

VALVE MECHANISM

Removal

1. Remove rocker arm cover as outlined.
2. Remove rocker arm nuts, rocker arm balls, rocker arms and push rods.

NOTE: Place rocker arms, rocker arm balls and push rods in a rack so they may be reinstalled in the same location.

Installation and Adjustment

NOTE: Whenever new rocker arms and/or

rocker arm balls are being installed, coat bearing surfaces of rocker arms and rocker arm balls with Molykote or its equivalent.

1. Install push rods. Be sure push rods seat in lifter socket.
2. Install rocker arms, rocker arm balls and rocker arm nuts. Tighten rocker arm nuts until all lash is eliminated.
3. Adjust valves when lifter is on base circle of camshaft lobe as follows:
 - a. Mark distributor housing, with chalk, at each cylinder position (plug wire) then disconnect plug wires at spark plugs and coil and remove distributor cap and plug wire assembly (if not previously done).
 - b. Crank engine until distributor rotor points to number one cylinder position and breaker points are open. Both valves on number one cylinder may now be adjusted.
 - c. Back out adjusting nut until lash is felt at the push rod then turn in adjusting nut until all lash is removed. This can be determined by checking push rod side play while turning adjusting nut (fig. 2L). When play has been removed, turn adjusting nut in one full additional turn (to center lifter plunger).
 - d. Adjust the remaining valves, one cylinder at a time, in the same manner.
4. Install distributor cap and spark plug wire assembly.
5. Install rocker arm cover as outlined.
6. Adjust carburetor idle speed and mixture.

VALVE LIFTERS

Hydraulic valve lifters very seldom require attention. The lifters are extremely simple in design readjustments are not necessary, and servicing of the lifters requires only that care and cleanliness be exercised in the handling of parts.



Fig. 2L - Valve Adjustment

Locating Noisy Lifters

Locate a noisy valve lifter by using a piece of garden hose approximately four feet in length. Place one end of the hose near the end of each intake and exhaust valve with the other end of the hose to the ear. In this manner, the sound is localized making it easy to determine which lifter is at fault.

Another method is to place a finger on the face of the valve spring retainer. If the lifter is not functioning properly, a distinct shock will be felt when the valve returns to its seat.

The general types of valve lifter noise are as follows:

1. Hard Rapping Noise--Usually caused by the plunger becoming tight in the bore of the lifter body to such an extent that the return spring can no longer push the plunger back up to working position. Probable causes are:
 - a. Excessive varnish or carbon deposit causing abnormal stickiness.
 - b. Galling or "pickup" between plunger and bore of lifter body, usually caused by an abrasive piece of dirt or metal wedging between plunger and lifter body.
2. Moderate Rapping Noise--Probable causes are:
 - a. Excessively high leakdown rate.
 - b. Leaky check valve seat.
 - c. Improper adjustment.
3. General Noise Throughout the Valve Train--This will, in almost all cases, be a definite indication of insufficient oil supply, or improper adjustment.
4. Intermittent Clicking--Probable causes are:
 - a. A microscopic piece of dirt momentarily caught between ball seat and check valve ball.
 - b. In rare cases, the ball itself may be out-of-round or have a flat spot.
 - c. Improper adjustment.

In most cases where noise exists in one or more lifters all lifter units should be removed, disassembled, cleaned in a solvent, reassembled, and reinstalled in the engine. If dirt, varnish, carbon, etc. is shown to exist in one unit, it more than likely exists in all the units, thus it would only be a matter of time before all lifters caused trouble.

Removal

1. Remove valve mechanism as outlined.
2. Mark distributor housing, with chalk, at each cylinder position (plug wire) then disconnect plug wires at spark plugs and coil and remove distributor cap and plug wire assembly.
3. Crank engine until distributor rotor points to number one position, then disconnect distributor primary lead at coil and remove distributor.
4. Remove push rod covers (discard gaskets).
5. Remove valve lifters.

NOTE: Place valve lifters in a rack so they may be reinstalled in the same location.

Installation

1. Install valve lifters.

NOTE: Whenever new valve lifters are being installed, coat foot of valve lifters with Molykote or its equivalent.

2. Install push rod covers, using new gaskets, and torque bolts to specifications.
3. Install distributor, positioning rotor to number one cylinder position, then connect primary lead at coil.

4. Install and adjust valve mechanism as outlined.
- Adjust ignition timing and carburetor idle speed and mixture.

VALVE STEM OIL SEAL AND/OR VALVE SPRING Replacement

1. Remove rocker arm cover as outlined.
2. Remove spark plug, rocker arm and push rod on the cylinder(s) to be serviced.
3. Apply compressed air to the spark plug hole to hold the valves in place.

NOTE: A tool to apply air to the cylinder is available through local jobbers or may be manufactured. In manufacturing this Tool, a AC-46N Spark Plug or its equivalent is recommended. This will make the Tool universal for all Chevrolet engines. Chisel the spark plug as shown, then drive the porcelain out of the plug by tapping the center electrode against a hard block. Using a 3/8" pipe tap, cut threads in the remaining portion of the spark plug and assemble as shown (fig. 3L).

4. Using Tool J-5892 to compress the valve spring, remove the valve locks, valve cap, valve shield and valve spring and damper (fig. 4L).
5. Remove the valve stem oil seal.
6. To replace, set the valve spring and damper, valve shield and valve cap in place. The close coiled end of the spring is installed against the cylinder head. Compress the spring with Tool J-5892 and install oil seal in the lower groove of the stem, making sure the seal is flat and not twisted.

NOTE: A light coat of oil on the seal will help prevent twisting.

7. Install the valve locks and release the compressor tool, making sure the locks seat properly in the upper groove of the valve stem.

NOTE: Grease may be used to hold the locks in place while releasing the compressor tool.

8. Install spark plug, using a new gasket, and torque to specifications.
9. Install and adjust valve mechanism as outlined.

CYLINDER HEAD ASSEMBLY

Removal

1. Remove manifold assembly as outlined.
2. Remove valve mechanism as outlined.
3. Drain cooling system (block).
4. Remove fuel and vacuum line from retaining clip at water outlet then disconnect wires from temperature sending units.
5. Disconnect upper radiator hose at water outlet housing and battery ground strap at cylinder head.
6. Remove coil (L6 engines only).
7. Remove cylinder head bolts, cylinder head and gasket. Place cylinder head on two blocks of wood to prevent damage.

Installation

CAUTION: The gasket surfaces on both the head and the block must be clean of any foreign

matter and free of nicks or heavy scratches. Cylinder bolt threads in the block and threads on the cylinder head bolt must be cleaned. (Dirt will affect bolt torque.) Do not use gasket sealer on composition steel asbestos gasket.

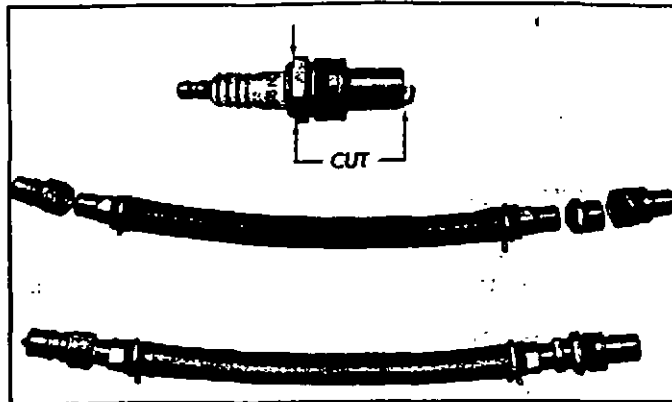


Fig. 3L - Air Adapter Tool

1. Place the gasket in position over the dowel pins with the bead up.
2. Carefully guide cylinder head into place over dowel pins and gasket.
3. Coat threads of cylinder head bolts with sealing compound and install finger tight.
4. Tighten cylinder head bolts a little at a time in the sequence shown on the torque sequence chart until the specified torque is reached.
5. Install coil (if removed).
6. Connect upper radiator hose and engine ground strap.
7. Connect temperature sending unit wires and install fuel and vacuum lines in clip at water outlet.
8. Fill cooling system.
9. Install manifold assembly as outlined.
10. Install and adjust valve mechanism as outlined.

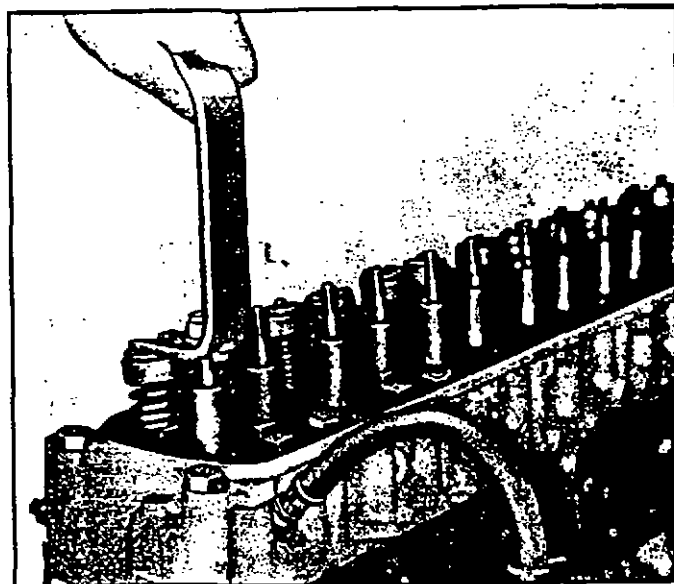


Fig. 4L - Compressing Valve Spring

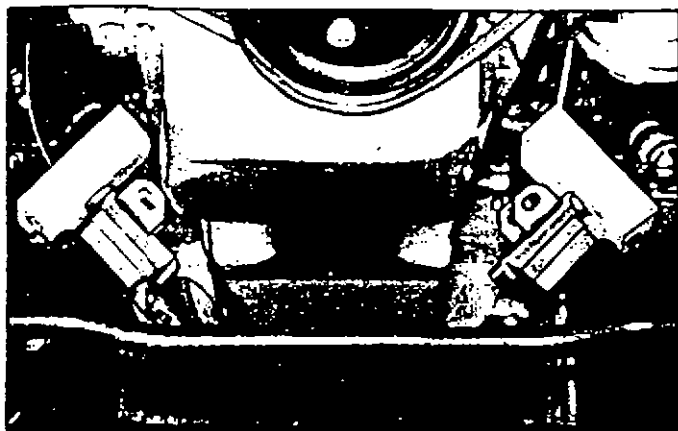


Fig. 5L—Engine Blocked for Pan Removal

NOTE: Do not install rocker arm cover.

11. Start engine and allow warm up then retorquer cylinder head as outlined in Step 4 and readjust valves as outlined under Engine Tune Up.

OIL PAN

Removal

Chevrolet, Camaro and Nova

1. Disconnect battery positive cable.
2. Remove through bolts from engine front mounts.
3. Remove upper radiator mounting panel or side mount bolts.
4. Place a piece of heavy cardboard between fan blade and radiator.
5. Raise vehicle then drain engine oil.
6. Disconnect and remove starter.
7. On vehicles equipped with automatic transmission, remove converter housing underpan.
8. Disconnect steering rod at idler lever then swing steering linkage for oil pan clearance.
9. Rotate crankshaft until timing mark on torsional damper is at 6:00 o'clock position.
10. On Chevrolet and Camaro, use a suitable jack (and a block of wood to prevent damaging oil pan), raise engine enough to insert 2" x 4" wood blocks under engine mounts (fig. 5L), then lower engine onto blocks.
11. On Chevrolet, remove oil pan and discard gaskets and seals.
12. On Camaro, remove oil pan retaining screws and lower pan. Remove the two bolts securing the oil pump assembly and the one nut securing the intake pipe and screen to block. Remove the oil pump and pan and discard gaskets and seals.
13. On Nova remove hood hinge front bolts, loosen rear bolts and swing hood up to install Tool J-22382-1. Connect cantilever hoist or chain fall and raise engine approximately 2".
14. On Nova remove left engine mount and frame bracket. Remove oil pan by lowering it slightly and then rolling it into opening created by removal of left engine mount until oil pan is cleared. Tilt front of pan upward and remove by pulling pan down and to the rear of vehicle. Discard gaskets and seals.

Chevelle (With Manual Transmission)

1. Remove engine from vehicle as outlined.

2. Place engine on jack stands, one at each front mount and one at transmission extension.

CAUTION: Leave engine lift attached to engine. Do not remove all weight of engine from engine lift.

3. Remove starter.
4. Remove oil pan and discard gaskets and seals.

Chevelle (With Automatic Transmission)

1. Disconnect battery positive cable on battery.
2. Remove radiator upper mounting panel and place a piece of heavy cardboard between the fan and radiator.
3. Disconnect starter brace at starter and disconnect and plug fuel line at fuel pump.
4. Raise vehicle on hoist and drain engine oil.
5. Remove converter housing under pan and splash shield.
6. Remove inboard starter bolt and loosen outboard starter bolt. Swing starter outboard to gain adequate clearance to remove oil pan.
7. Rotate crankshaft until timing mark on torsional damper is at 6:00 o'clock position.
8. Remove the both engine mount "through" bolts.
9. Raise front of engine until motor mounts separate from frame brackets. Remove the right motor mount from the engine and install two bolts in the mount holes. Continue raising engine until a 4-1/2" block of wood can be inserted on the right side between the bolts and frame bracket and a 4" block on the left side between mount and frame (fig. 5L).
10. Remove retaining bolts and lower pan, remove front main bearing cap and remove oil pan from vehicle. Discard gaskets and seals.

Installation

1. Thoroughly clean all gasket sealing surfaces.

NOTE: Use a new pan gasket set. Do not use sealer.

2. Install rear seal in rear main bearing cap.
3. Install front seal on crankcase front cover pressing tips into holes provided in cover.
4. Install side gaskets on cylinder block (fig. 6L).
5. Complete installation as follows:

Chevrolet, Camaro and Nova

- a. If crankshaft was rotated while pan was off, place timing mark at 6:00 o'clock position.
- b. On Chevrolet, install oil pan and torque bolts to specifications.
- c. On Camaro, raise oil pump and pan into position. Install oil pump and pick-up and torque attaching bolts to specifications. Install oil pan screws and torque to specifications.
- d. On Nova install pan by tilting front upward on its side and inserting into the space on the left of engine. Roll pan under engine and then upward and install pan bolt. Torque pan bolts to specifications.
- e. On Nova install left engine mount and frame bracket. Lower engine and remove engine hoist.
- f. On Nova remove Tool J-22382-1 and install hood hinge bolts. Align hood hinges to original positions and tighten to specifications.
- g. Using a suitable jack (and a block of wood to

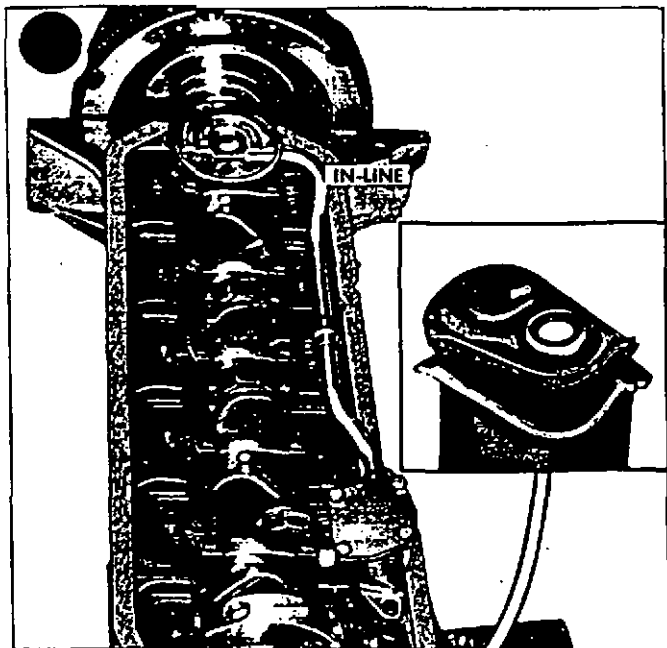


Fig. 6L—Pan Gaskets and Seals

prevent damaging oil pan) raise engine enough to remove 2" x 4" wood blocks, then lower engine. On vehicles equipped with automatic transmission install converter housing underpan, then connect transmission cooler lines.

- i. Install and connect starter.
- j. Lower vehicle and install fan blades as outlined in Section 6K.
- k. Connect upper and lower radiator hoses.
- l. Install through bolts in engine front mounts.
- m. Connect battery positive cable.
- n. Fill radiator with coolant and fill engine with oil, then start engine and check for leaks.

Chevelle (With Manual Transmission)

- a. Install oil pan and torque bolts to specifications.
- b. Install starter.
- c. Install engine as outlined.

Chevelle (With Automatic Transmission)

- a. If crankshaft was rotated while pan was off, place timing mark at 6:00 o'clock position.
- b. Place oil pan under engine, align main bearing upper half and install bearing cap. Torque bolts to specifications.
- c. Install oil pan and torque bolts to specifications.
- d. Raise engine and remove blocks. Install right motor mount and lower engine. Install front mount "through" bolts and torque bolts to specifications.
- e. Install inboard starter bolts and torque both bolts to specifications.
- f. Install converter housing underpan and splash shield.
- g. Lower vehicle and fill engine with oil.
- h. Connect starter brace and fuel line at pump.
- i. Install radiator upper mounting panel.
- j. Connect battery positive cable.

OIL PUMP

Removal

1. Remove oil pan as outlined.
2. Remove two flange mounting bolts, pickup pipe bolt, then remove pump and screen as an assembly.

Installation

1. Align oil pump drive shafts to match with distributor tang, then install oil pump to block positioning flange over distributor lower bushing. Use no gasket.

NOTE: Oil pump should slide easily into place, if not, remove and reposition slot to align with distributor tang.

2. Install oil pan using new gaskets and seals as outlined.

OIL SEAL (REAR MAIN)

Replacement

The rear main bearing oil seal can be replaced (both halves) without removal of the crankshaft.

NOTE: Always replace the upper and lower seal as a unit. Install with the lip facing toward the front of the engine.

1. With the oil pan and oil pump removed, remove the rear main bearing cap.
2. Remove oil seal from the annular tang by prying from the bottom with a small screw driver (fig. 7L).
3. Lubricate the lip of a new seal with engine oil. Keep oil off the parting line surface as this is treated with glue. Insert seal in cap and roll it into place with finger and thumb, using light pressure so seal tangs at parting line do not cut bead on back of seal.
4. To remove the upper half of the seal, use a small hammer to tap a brass pin punch on one end of seal until it protrudes far enough to be removed with pliers (fig. 8L).

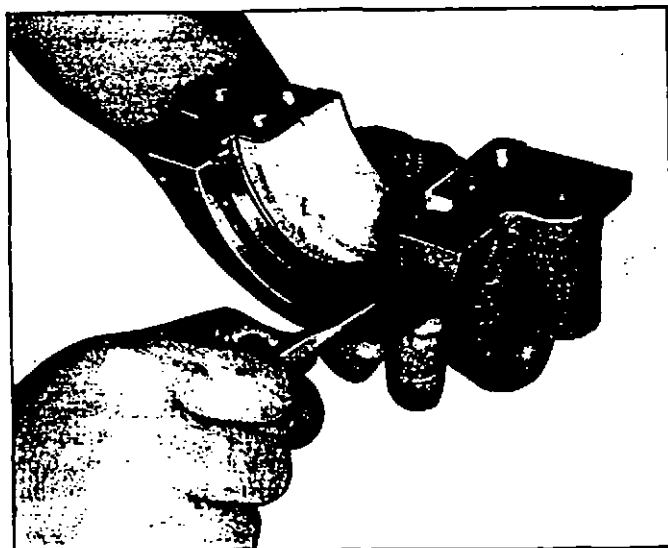


Fig. 7L—Removing Oil Seal (Lower Half) Typical

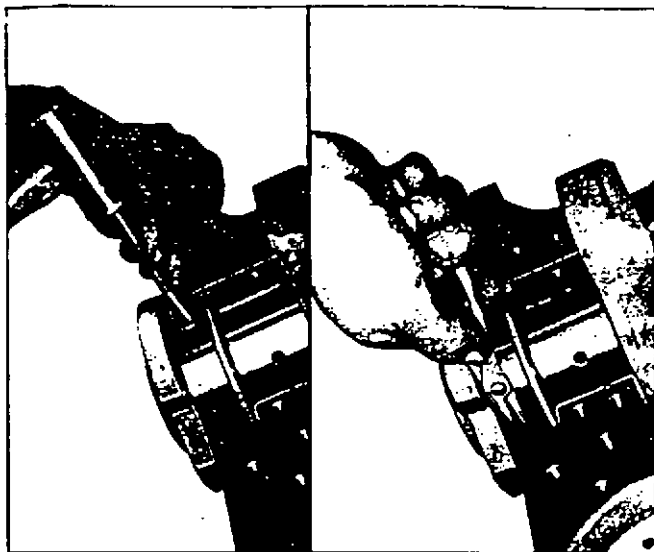


Fig. 8L—Removing Oil Seal (Upper Half) Typical

NOTE: Always wipe crankshaft surface clean before installing a new seal.

5. Lubricate the lip of a new seal with engine oil. Keep oil off the parting line surface. Gradually push with a hammer handle, while turning crankshaft, until seal is rolled into place. (Similar to installing a main bearing.) Be careful that seal tangs at parting line do not cut bead on back of seal. Use sealer at parting line on cap half of seal and cylinder block in seal area (fig. 9L).
6. Install the rear main bearing cap (with new seal) and torque to specifications.

CRANKSHAFT PULLEY AND HUB (Nova with L4 Engine)

Removal

1. Drain radiator and disconnect upper and lower radiator hoses at radiator.

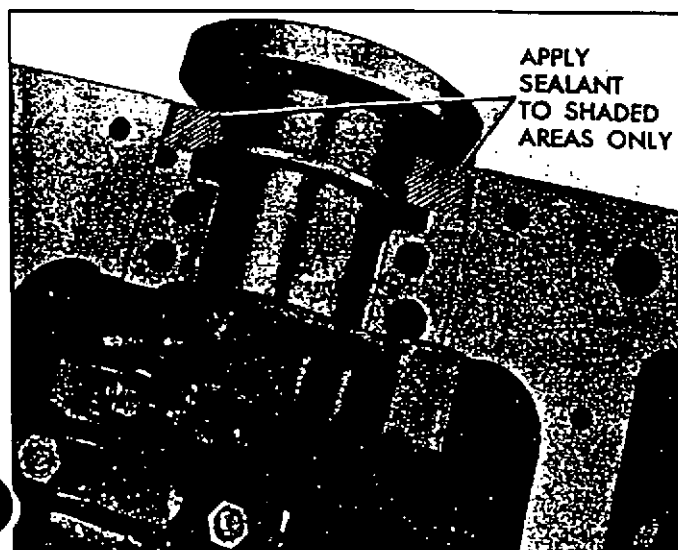


Fig. 9L—Sealing Bearing Cap

2. Remove radiator core as outlined in Section 13.
3. Remove fan belt. Remove crankshaft pulley from pulley hub.
4. Install puller Tool J-6978 to pulley hub with two 3/8" x 2" and one 5/16" x 2" bolts and remove hub then remove puller tool.

Installation

1. Coat oil seal contact area on hub with engine oil position hub over crankshaft and key and start hub into position with a mallet. Using Tool J-5590 drive onto crankshaft until it bottoms against crankshaft gear.

NOTE: Crankshaft extends slightly through hub and a tool is necessary to drive hub completely into bottomed position.

2. Install pulley onto hub.

NOTE: There are two 3/8" holes and one 5/16" hole that must be matched on hub in order to properly position timing mark.

3. Install fan belt and adjust using strand tension gauge.
4. Install radiator as outlined in Section 13.

TORSIONAL DAMPER

Removal

1. Remove radiator core, as outlined in Section 13.
2. Remove fan belt and (if so equipped) accessory drive pulley and belt.
3. Install Tool J-6978 to damper and turn puller screw to remove damper (fig. 10L). Remove tool.

Installation

1. Coat front cover oil seal contact area of damper with engine oil.

CAUTION: It is necessary to use installer Tool J-22197 to prevent the inertia weight section from walking off the hub during installation of damper.

2. Attach damper installer Tool J-22197 to damper. Tighten fingers of tool to prevent weight from moving (fig. 11L).
3. Position damper on crankshaft and drive into position, using J-5590, until it bottoms against crankshaft gear (fig. 11L). Remove installer tool.
4. Install fan belt and adjust using strand tension gauge.

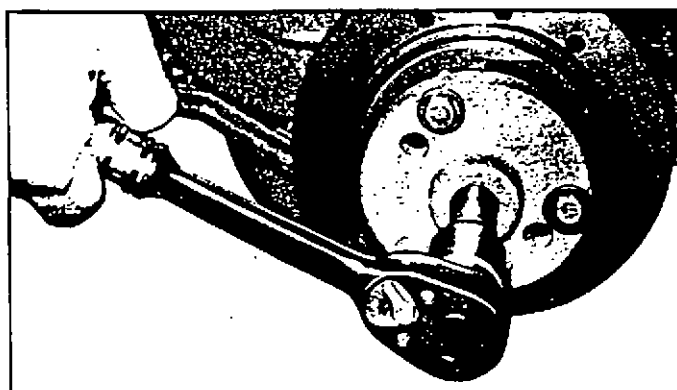


Fig. 10L—Removing Torsional Damper

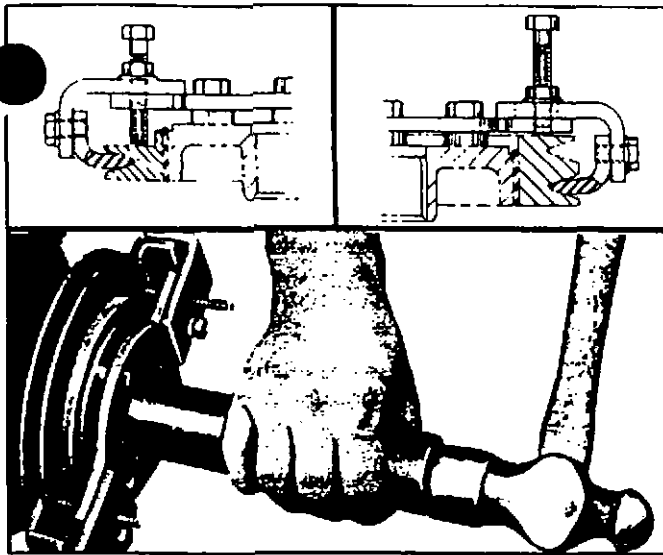


Fig. 11L—Installing Torsional Damper

5. If so equipped, install accessory drive pulley and belt.
6. Install radiator core as outlined in Section 13.
7. Fill cooling system and check for leaks.

CRANKCASE FRONT COVER

Removal

Remove oil pan as outlined.

2. Remove crankshaft pulley and hub or torsional damper as outlined.
3. Remove crankcase front cover attaching bolts, remove cover and gasket.

Installation

1. Clean gasket surfaces on block and crankcase front cover.
2. Install centering Tool J-966 or Tool J-21742 in crankcase front cover seal (fig. 12L).
3. Coat the gasket with gasket sealer and place in position on cover, then install crankcase front cover to block and torque bolts to specifications.
4. Remove centering tool.

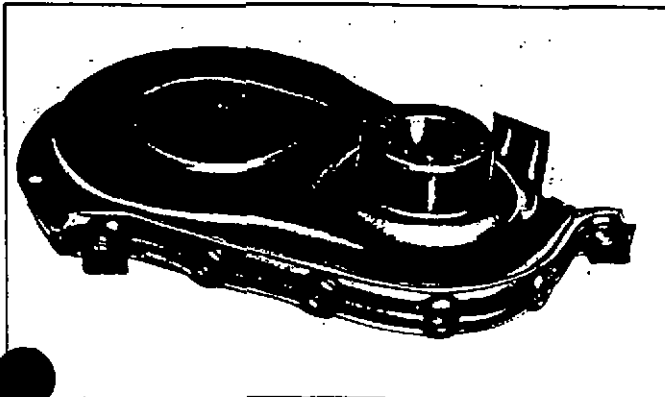


Fig. 12L—J-23042 Centering Tool in Cover

NOTE: It is important that centering tool be used to align crankcase front cover so that crankshaft hub or torsional damper installation will not damage seal and to position seal evenly around the balancer or hub surface.

5. Install crankshaft hub and/or torsional damper as outlined.
6. Install oil pan with new gaskets and seals as outlined.

OIL SEAL (FRONT COVER)

Replacement

With Cover Removal

1. With cover removed, pry old seal out of cover from the front with screw driver being careful not to distort cover.
2. Install new seal so that open end of the seal is toward the inside of cover and drive it into position with Tool J-995 (fig. 13L).

CAUTION: Support cover at sealing area. (Tool J-971 may be used as support.)

Without Cover Removal

1. With crankshaft pulley and hub or torsional damper removed, pry old seal out of cover from the front with a large screw driver, being careful not to damage the seal surface on the cover.
2. Install new seal so that open end of seal is toward the inside of cover and drive it into position with Tool J-8340 (fig. 14L).

CAMSHAFT

Measuring Lobe Lift

NOTE: Procedure is similar to that used for checking valve timing. If improper valve operation is indicated, measure the lift of each

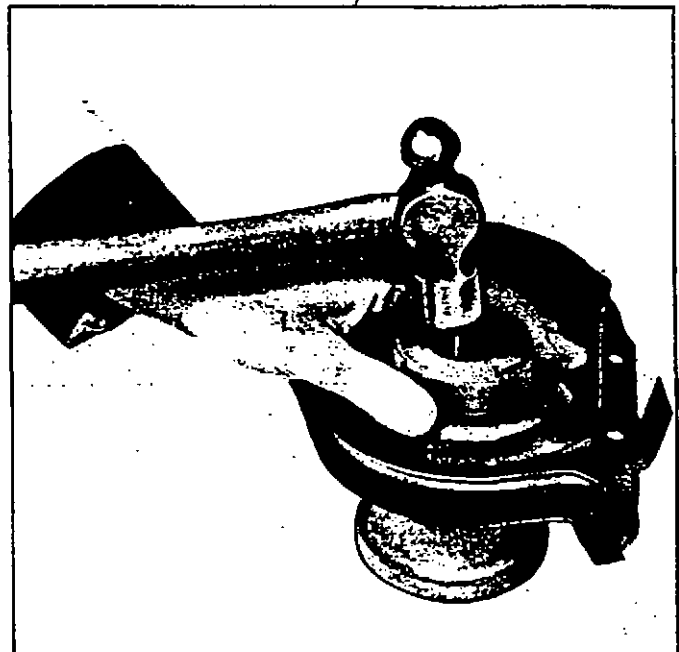


Fig. 13L—Installing Oil Seal (Cover Removed)

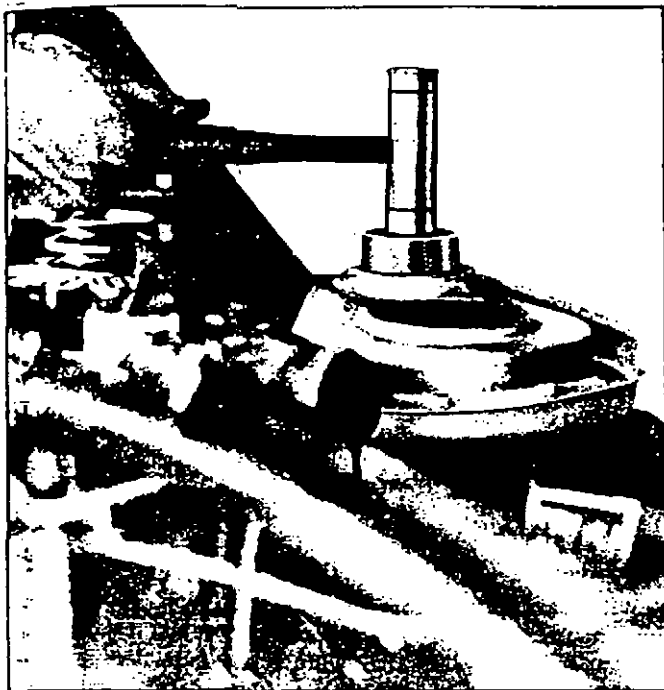


Fig. 14L—Installing Oil Seal (Cover Installed)

push rod in consecutive order and record the readings.

1. Remove valve mechanism as outlined.
2. Position indicator with ball socket adapter (Tool J-8520) on push rod (fig. 15L).
3. Rotate the crankshaft slowly in the direction of rotation until the lifter is on the heel of the cam lobe. At this point, the push rod will be in its lowest position.

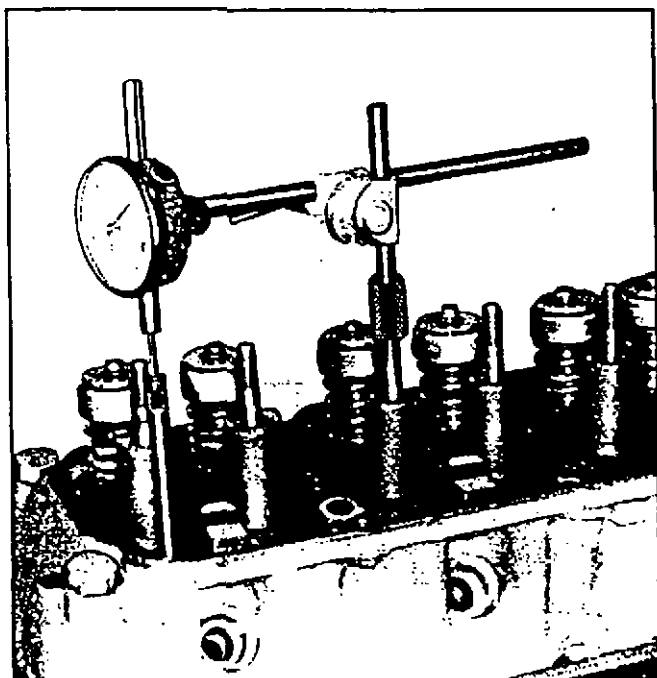


Fig. 15L—Measuring Camshaft Lobe Lift

4. Set dial indicator on zero, then rotate the crankshaft slowly, or attach an auxiliary starter switch and "bump" the engine over, until the push rod is in the fully raised position.

CAUTION: The primary distributor lead must be disconnected from the negative post on the coil and the ignition switch must be in the ON position. Failure to do this will result in a damaged grounding circuit in the ignition switch.

5. Compare the total lift recorded from the dial indicator with specifications.
6. Continue to rotate the crankshaft until the indicator reads zero. This will be a check on the accuracy of the original indicator reading.
7. If camshaft readings for all lobes are within specifications, remove dial indicator assembly.
8. Install and adjust valve mechanism as outlined.

Removal (Camaro)

1. Remove engine and proceed as outlined in the Chassis Overhaul Manual.

Removal (Except Camaro)

1. Remove valve lifters as outlined.
2. Remove crankcase front cover as outlined.
3. Remove radiator as outlined in Section 13.
4. Remove grille as outlined in Section 13.
5. Remove fuel pump as outlined in Section 6M.
6. Align timing gear marks then remove the two camshaft thrust plate bolts by working through holes in the camshaft gear (fig. 16L).
7. Remove the camshaft and gear assembly by pulling it out through the front of the block.

NOTE: Support camshaft carefully when removing so as not to damage camshaft bearings.

Installation

1. Install the camshaft and gear assembly in the engine block, being careful not to damage camshaft bearings or camshaft.
2. Turn crankshaft and camshaft so that the valve timing marks on the gear teeth will line up (fig. 16L).

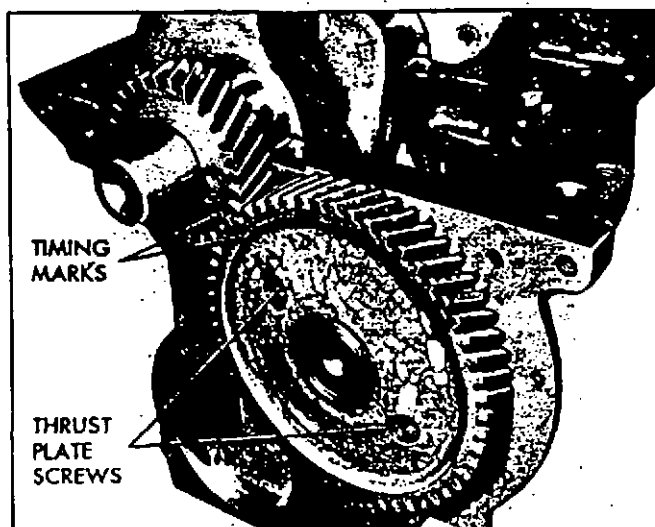


Fig. 16L—Timing Gear Marks

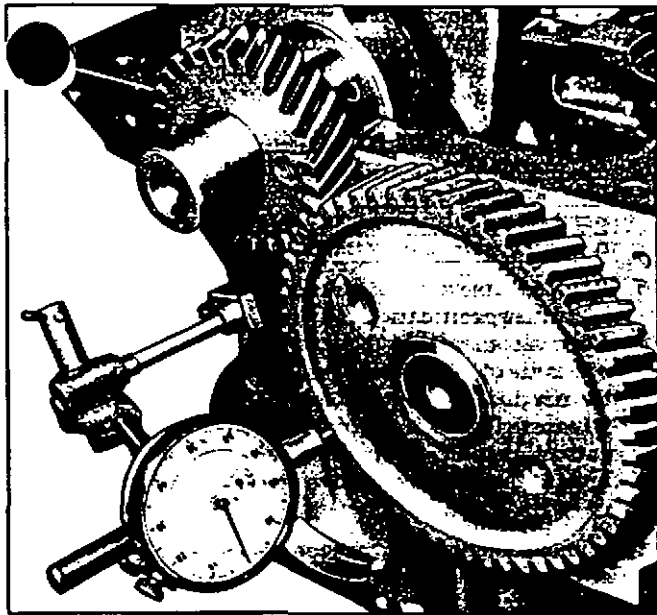


Fig. 17L—Checking Camshaft Gear Runout

Push camshaft into position. Install camshaft thrust plate-to-block bolts and torque to specifications.

3. Check camshaft and crankshaft gear run out with a dial indicator (fig. 17L). The camshaft gear run out should not exceed .004" and the crankshaft gear run out should not exceed .003".
4. If gear run out is excessive, the gear will have to be removed and any burrs cleaned from the shaft or the gear will have to be replaced.
5. Check the backlash between the timing gear teeth with a dial indicator (fig. 18L). The backlash should not be less than .004" nor more than .006".
6. Install fuel pump as outlined in Section 6M.

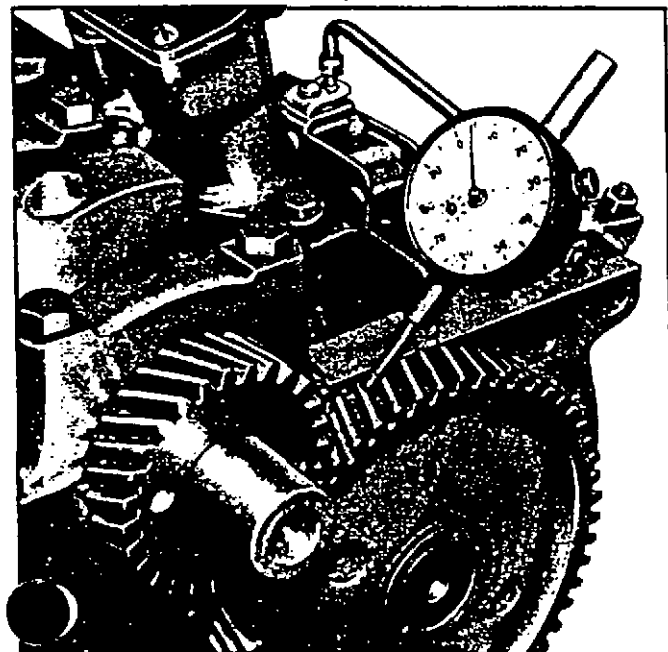


Fig. 18L—Checking Timing Gear Backlash

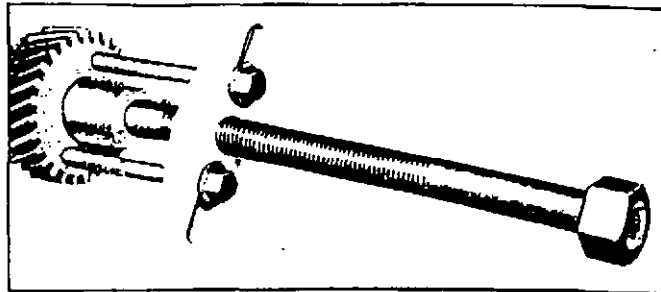


Fig. 19L—Removing Crankshaft Gear

7. Install grille as outlined in Section 13.
8. Install crankcase front cover as outlined.
9. Install radiator as outlined in Section 13.
10. Install valve lifters as outlined.

TIMING GEARS

Replacement

With camshaft removed, crankshaft gear may be removed using Tool J-8105 (fig. 19L). To install crankshaft gear use Tool J-5590 (fig. 20L). For camshaft gear replacement, refer to Section 6, "Camshaft Disassembly" of the Overhaul Manual.

FLYWHEEL

Removal

With transmission and/or clutch housing and clutch removed from engine, remove the flywheel.

Installation

1. Clean the mating surfaces of flywheel and crankshaft to make certain there are no burrs.
2. Install flywheel on crankshaft and position to align dowel hole of crankshaft flange and flywheel (fig. 21L).

NOTE: On Automatic Transmission equipped engines, the flywheel must be installed with the flange collar to transmission side (fig. 21L).

3. Install bolts and torque to specifications.

ENGINE MOUNTS

Engine mounts (fig. 22L) are the non-adjustable type

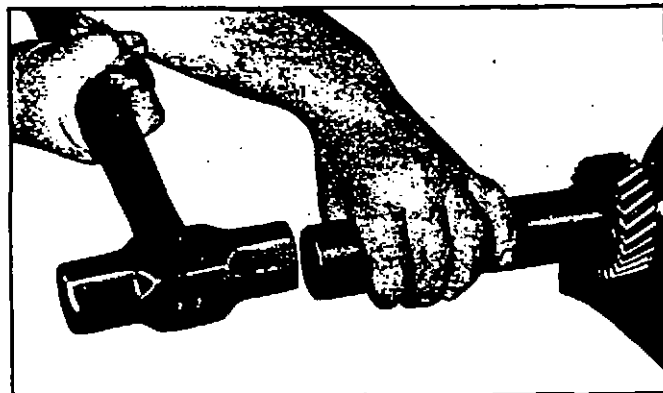


Fig. 20L—Installing Crankshaft Gear

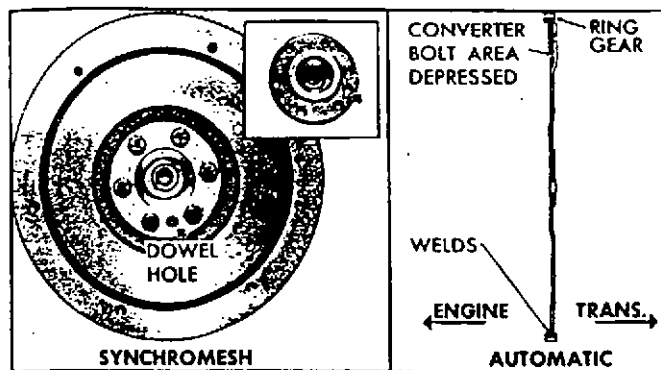


Fig. 21L—Flywheel Installation (Typical)

and seldom require service. Broken or deteriorated mounts should be replaced immediately, because of the added strain placed on other mounts and drive line components.

Front Mount Replacement

Chevrolet, Chevelle, and Camaro

1. Remove nut, washer, spacer then engine mount through-bolt.
2. Raise engine to release weight from mount.
3. Remove mount, stop bracket and frame bracket assembly from crossmember, then remove stop bracket and mount from frame bracket.

4. Install stop bracket and new mount on frame bracket, then install assembly on crossmember.
5. Lower engine, install through-bolt and tighten all mount bolts to specified torques.

Nova

1. Remove nut, washer and engine mount through-bolt.
2. Raise engine to release weight from mount.
3. Remove bracket-to-mount bolt, then, remove mount.
4. Install new mount on bracket.
5. Lower engine, install through-bolt and tighten all mount bolts to specified torques.

Rear Mount Replacement

Chevrolet

1. Remove crossmember-to-mount bolts.
2. Raise transmission to release weight from mount.
3. Remove mount-to-transmission bolts, then remove mount and spacer.
4. Install spacer and new mount on transmission.
5. While lowering transmission, align and start crossmember-to-mount bolts.
6. Lower transmission and tighten all mounting bolts to specified torques.

Chevelle and Camaro

1. Remove crossmember-to-mount bolts.
2. Raise transmission to release weight from mount.
3. Remove mount-to-transmission bolts, then remove mount.

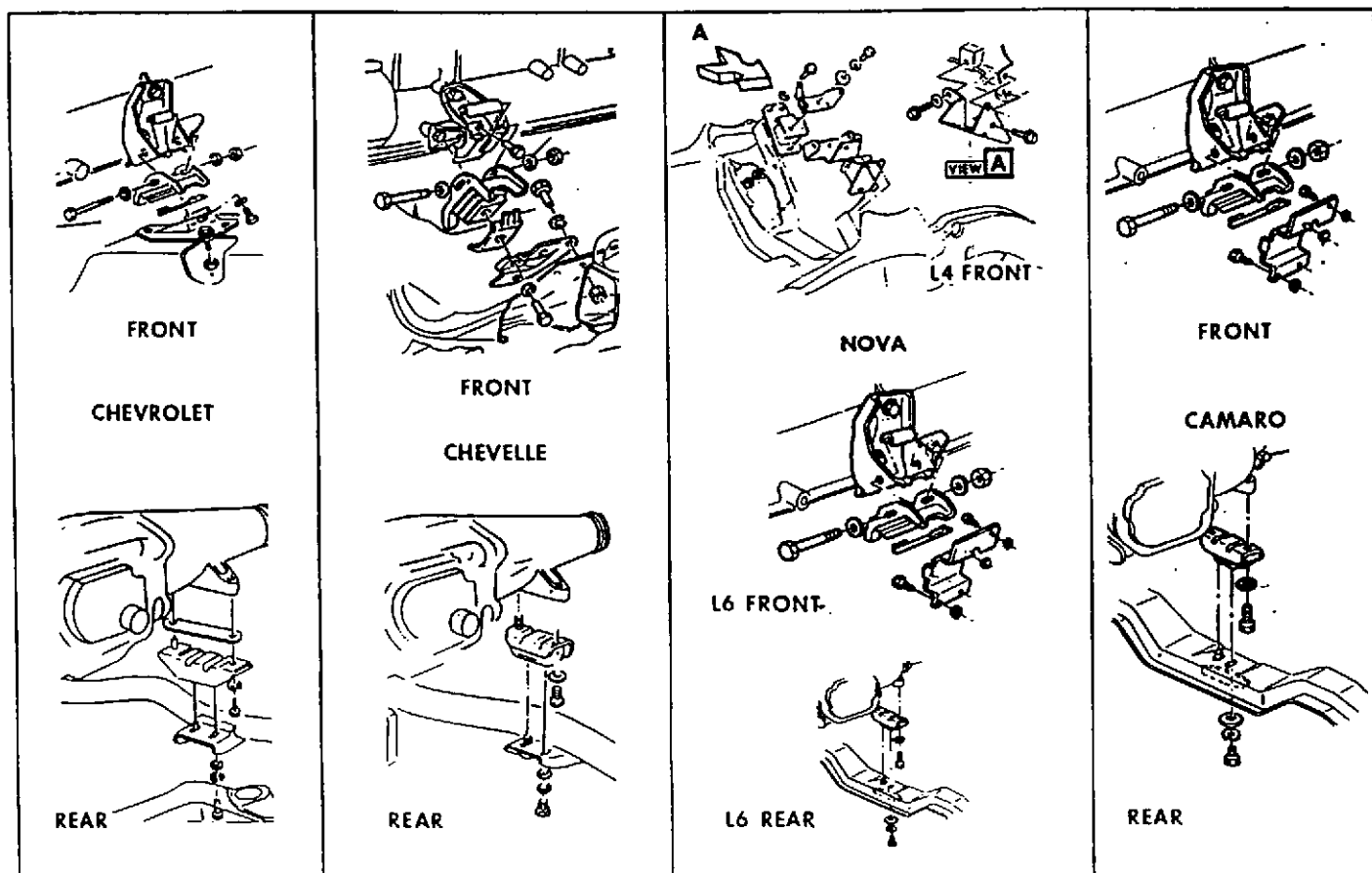


Fig. 22L—Engine Mounts

4. Install new mount on transmission.

While lowering transmission align and start crossmember-to-mount bolts.

5. Lower transmission and tighten all mounting bolts to specified torques.

Nova

1. Remove crossmember-to-mount bolts.

2. Raise transmission to release weight from mount.

3. Remove mount-to-transmission bolts, then remove mount.

4. Install new mount on transmission.

5. While lowering transmission align and start crossmember-to-mount bolts.

6. Lower transmission and tighten all mounting bolts to specified torques.

ENGINE MECHANICAL

V-8 ENGINES

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GENERAL DESCRIPTION

The V8 engines (fig. 1V) covered in this section are the 302, 307, 327, 350, 396, and 427 cu. in. engines, regardless of which passenger vehicle they are used in.

This section covers the removal and installation of engine assemblies; the removal, installation and adjustment of some sub-assemblies and replacement of some components. For service to all components and sub-assemblies (after removal) and removal of some sub-assemblies, refer to Section 6 of the Chassis Overhaul Manual.

Because of the interchangeability and similarity of many engines, engine sub-assemblies and engine parts, regardless of which passenger vehicle they are used in, typical illustrations and procedures are used except where specific illustrations or procedures are necessary to clarify the operation. Although illustrations showing bench operations are used, most single operations, when not part of a general overhaul, should be performed (if practical) with the engine in the vehicle.

COMPONENT REPLACEMENT AND ADJUSTMENT

ENGINE ASSEMBLY

Removal

Drain cooling system and engine oil.

2. Remove air cleaner and disconnect battery cables at battery.

3. Remove hood hinge front bolts, loosen the rear bolts. Swing hood up and install Tool J-22382-1.

4. Remove radiator and shroud as outlined in Section 13.

5. Remove fan blade and pulley as outlined in Section 6K.

ENGINE

SECTION 6

[illegible]

Displacement		153	230	250	302	307	327	350				396				427													
Horsepower		90	140	155	200	200	210	235	255	300	350	370	385	325	350	376	390	400	425	435									
PISTON PIN:																													
Diameter		.9270"-.9213"																											
Clearance		Production		.00015"-.00025"																.00045"-.00055"		.00035"-.00045"		.00030"-.00040"		.00045"-.00055"		.00030"-.00040"	
Service				.001" (Max.)																									
Fit in Rod				.0008"-.0016"⊕		.0001"-.0003"⊕		.0008"-.0016"⊕																		.0001"-.0008"		.0008"⊕-.0016"⊕	
CRANKSHAFT:																													
Main Journal		Diameter		All 2.2983"-2.2993"		#1-2-3-4 2.4479"-2.4488"		#1-2 2.7484" 2.7483"		#2-3-4 2.7481" 2.7480"		#5 2.7478" 2.7488"		#1 2.7484" 2.7483"		#2-3-4 2.7481" 2.7480"		#5 2.7478" 2.7488"		#1-2-3-4 2.7481"-2.7490"									
Taper		Production		.0002" (Max.)																									
		Service		.001" (Max.)																									
Out of Round		Production		.0002" (Max.)																									
		Service		.001" (Max.)																									
Main Bearing Clearance		Production		All .003"-.0029"		All .0008"-.0020"		#1-2-3-4 .0008"-.0020"		#1-2 .0010"-.0022"		#2-4 .0013"-.0025"		#5 .0015"-.0031"		#1-2-3-4 .0013"-.0025"		#5 .0015"-.0031"											
		Service																											
Service																													
Crankshaft End Play				.002"-.004"		.003"-.011"		.006"-.010"																					
Diameter				1.999"-2.000"		2.099"-2.100"		2.199"-2.200"		2.199"-2.200"		2.1985" 2.1995"		2.1985"-2.1995"		2.1985"-2.1995"													
Crank-pin		Production		.0003" (Max.)																									
		Service		.001" (Max.)																									
Out of Round		Production		.002" (Max.)																									
		Service		.001" (Max.)																									
Rod Bearing Clearance		Production		.0007"-.0027"		.0007"-.0028"		.0007"-.0028"		.0007"-.0028"		.0008"-.0025"		.0014"-.0030"		.0009"-.0025"		.0014"-.0030"											
		Service																											
Rod Side Clearance				.0085"-.0125"		.009"-.013"		.015"-.021"		.015"-.021"		.019"-.025"		.019"-.025"		.015"-.021"		.019"-.025"											
⊕ Interfer		⊕ Clearance																											

Displacement		153		230		250		302		307		327		350		396		427													
		90		140		155		200		200		210		235		255		300		350		375		390		400		425		430	
CAMSHAFT:																															
Lobe Lift .002"	Intake		.1712"		.1896"		.2217"		.3234"		.260"		.300"		.3234"		.2343"		.2714"		.3057"		.2714"		.3057"		.3286"		.3057"		
	Exhaust		.1712"		.1896"		.2217"		.3234"		.2733"		.308"		.3234"		.2343"		.2714"		.3057"		.2714"		.3057"		.3412"		.3057"		
Journal Diameter																															
1.8082"-1.8092"																															
Camshaft Runout																															
.0015" (Max.)																															
VALVE SYSTEM:																															
Lifter	Hydraulic		Mech.		Hydraulic		Mech.		Hydraulic		Mech.		Hydraulic		Mech.		Hydraulic		Mech.		Hydraulic		Mech.		Hydraulic		Mech.		Mechanical		
Rocker Arm Ratio	1.75:1		1.50:1		1.50:1																										
Valve Lash	Intake		One Turn Down From Zero Lash		.030"		One Turn Down From Zero Lash		.030"		One Turn Down From Zero Lash		.024"		One Turn Down From Zero Lash		.024"		One Turn Down From Zero Lash		.024"		One Turn Down From Zero Lash		.024"		.024"		.024"		
	Exhaust		One Turn Down From Zero Lash		.030"		One Turn Down From Zero Lash		.030"		One Turn Down From Zero Lash		.028"		One Turn Down From Zero Lash		.028"		One Turn Down From Zero Lash		.028"		One Turn Down From Zero Lash		.028"		.028"		.028"		
Face Angle (Int. & Exh.)																															
45°																															
Seat Angle (Int. & Exh.)																															
46°																															
Seat Runout (Int. & Exh.)																															
.002" (Max.)																															
Seat Width	Intake		1/32" - 1/16"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		
	Exhaust		1/32" - 1/16"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		1/16" - 3/32"		
Stem Clearance	Int.		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		
	Exh.		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		.0010"-.0027"		
Service																															
R/L Limit Production + .001" Intake - .002" Exhaust																															
Valve Spring (Outer) @ In.	Free Length		2.08"		1.92"		1.90"		2.03"		2.11"		2.09"		2.21"		2.09"		2.21"		2.09"		2.21"		2.09"		2.21"		2.09"		
	Closed		78-86		54-64 @ 1.66"		78-84 @ 1.70"		84-96		94-106 @ 1.88"		104-120 @ 1.38"		104-120 @ 1.38"		104-120 @ 1.38"		104-120 @ 1.38"		104-120 @ 1.38"		104-120 @ 1.38"		104-120 @ 1.38"		104-120 @ 1.38"		104-120 @ 1.38"		
Valve Spring (Inner) @ In.	Open		170-180		170-184		180-192		194-206 @ 1.25"		210-230		303-327 @ 1.38"		303-327 @ 1.38"		303-327 @ 1.38"		303-327 @ 1.38"		303-327 @ 1.38"		303-327 @ 1.38"		303-327 @ 1.38"		303-327 @ 1.38"		303-327 @ 1.38"		
	Installed Height ± 1/32"		1.26"		1.33"		1.27"		1.26"		1.26"		1.26"		1.26"		1.26"		1.26"		1.26"		1.26"		1.26"		1.26"		1.26"		
Free Length																															
N.A.																															
Valve Spring (Inner) @ In.	Closed		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		
	Open		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		
Installed Height ± 1/32"																															
N.A.																															
Damping	Free Length		1.94"		N.A.		N.A.		1.94"		1.94"		1.94"		1.94"		1.94"		1.94"		1.94"		1.94"		1.94"		1.94"		1.94"		
	Approx. # of Colls		4		N.A.		N.A.		4		4		4		4		4		4		4		4		4		4		4		

ENGINE TORQUES

Size	Usage	In Line			V-8					
		153	230	250	302	307	327	350	396	427
1/4-20	Camshaft Thrust Plate	80 lb. in.								
	Crankcase Front Cover				80 lb. in.					
	Flywheel Housing Pans				80 lb. in.					
	Oil Filler Bypass Valve				80 lb. in.					
	Oil Pan (To Crankcase)				80 lb. in.					
	Oil Pan (To Front Cover)	55 lb. in.			80 lb. in.					
	Oil Pump Cover	70 lb. in.			80 lb. in.					
	Rocker Arm Cover				55 lb. in.					
11/32-24	Connecting Rod Cap	35 lb. ft.								
5/16-18	Camshaft Sprocket				20 lb. ft.					
	Clutch Pressure Plate	20 lb. ft.								
	Oil Pan (To Crankcase)	125 lb. in.			65 lb. in.					
	Oil Pump	115 lb. in.								
	Push Rod Cover	80 lb. in.								
	Water Pump	15 lb. in.								
3/8-16	Clutch Pressure Plate				35 lb. ft.					
	Distributor Clamp				20 lb. ft.					
	Flywheel Housing				30 lb. ft.					
	Manifold (Exhaust)				20 lb. ft. ①					
	Manifold (Exhaust to Inlet)	25 lb. ft.								
	Manifold (Inlet)				30 lb. ft.					
	Manifold Clamp (L6 Outer)	20 lb. ft.								
	Manifold Clamp (All Others)	30 lb. ft.								
	Thermostat Housing	30 lb. ft.								
	Water Outlet				20 lb. ft.					
	Water Pump				30 lb. ft.					
3/8-24	Connecting Rod Cap				45 lb. ft.					
7/16-14	Cylinder Head				65 lb. ft.					
	Main Bearing Cap	65 lb. ft.			75 lb. ft. ②					
	Oil Pump				65 lb. ft.					
	Rocker Arm Stud				50 lb. ft.					
7/16-20	Flywheel				60 lb. ft.					
	Torsional Damper				60 lb. ft.					
	Connecting Rod Cap				70 lb. ft. ④					
1/2-13	Cylinder Head	95 lb. ft.								
	Main Bearing Cap				105 lb. ft.					
1/2-14	Temperature Sending Unit				20 lb. ft.					
1/2-20	Torsional Damper				85 lb. ft.					
	Oil Filter	Hand Tight			25 lb. ft.					
	Oil Pan Drain Plug				20 lb. ft.					
14mm	Spark Plug				25 lb. ft.					

① Inside bolts on 302-307-350 engines 30 lb. ft.

② Outer bolts on engines with 4 bolt caps 65 lb. ft.

③ Aluminum head short bolts 65 lb. ft. long bolts 75 lb. ft.

④ RPO L88 & ZL1

TUNE UP CHART

Every 12,000 miles—Have engine tune-up operations performed to maintain maximum engine performance and fuel economy.

E Type		In Line										396										427									
Displacement		153	230	250	302	307	327	350			370	375	390	400	425	430	435	435													
Horsepower		90	140	155	290	200	210	235	255	300	350	370	375	390	400	425	430	435													
Compression ①		130										160										150									
Standard		AC-R46N										AC-R44										AC-R43N									
S P L A U R G K		AC-R46N										AC-R44										AC-R43N									
Cold		AC-R44N										AC-R43										AC-RC42N									
Cap		31" - 34"										20" - 32"										.035									
Point Dwell		.018" (Used) .018" (New)										.018" (Used) .018" (New)										.018" (Used) .018" (New)									
Point Gap		.018" (Used) .018" (New)										.018" (Used) .018" (New)										.018" (Used) .018" (New)									
Arm Spring Tension		19 - 23 Ounces										19 - 23 Ounces										19 - 23 oz.									
Condenser		.18 - .23 Microfarad										.18 - .23 Microfarad										.18 - .23 Microfarad									
TDC		4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B													
Synchro.		4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B													
Auto.		4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B	4" B													
Fan & P/S		50 lb. Min. 75 + 5 lbs. (Used) 125 + 5 lbs. (New) Using Strand Tension Gauge										50 lb. Min. 75 + 5 lbs. (Used) 125 + 5 lbs. (New) Using Strand Tension Gauge										50 lb. Min. 75 + 5 lbs. (Used) 125 + 5 lbs. (New) Using Strand Tension Gauge									
A/C Compressor		65 lb. Min. 95 + 5 lbs. (Used) 140 + 5 lbs. (New) Using Strand Tension Gauge										65 lb. Min. 95 + 5 lbs. (Used) 140 + 5 lbs. (New) Using Strand Tension Gauge										65 lb. Min. 95 + 5 lbs. (Used) 140 + 5 lbs. (New) Using Strand Tension Gauge									
A.I.R. Pump		35 lb. Min. 55 + 5 lbs. (Used) 75 + 5 lbs. (New) Using Strand Tension Gauge										35 lb. Min. 55 + 5 lbs. (Used) 75 + 5 lbs. (New) Using Strand Tension Gauge										35 lb. Min. 55 + 5 lbs. (Used) 75 + 5 lbs. (New) Using Strand Tension Gauge									
Air Cleaner		①										①										①									
Valve Lash		Hydraulic - One Turn Down From Zero Lash										Hydraulic - One Turn Down From Zero Lash										Hydraulic - One Turn Down From Zero Lash									
Exhaust ④		Hydraulic										Hydraulic										Hydraulic									
Idle rpm		750	700	700	700	700	700	700	700	700	700	750	700	700	800	800	800	800													
Auto.		600	550 ④	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600													
Fuel Pump		3 to 4-1/2										3 to 4-1/2										3 to 4-1/2									
Volume		5 to 6-1/2										5 to 6-1/2										5 to 6-1/2									
Crankcase Vent		One Pint in 30 - 45 Seconds										One Pint in 30 - 45 Seconds										One Pint in 30 - 45 Seconds									
Service at 12,000 Miles		Service at 12,000 Miles										Service at 12,000 Miles										Service at 12,000 Miles									

④ 6 Cylinder Engine—Rotate cam lubricator 180° at 12,000 mile intervals—Replace at 24,000 mile intervals.

⑤ 8 Cylinder Engine—Change cam lubricator end for end at 12,000 mile intervals—Replace at 24,000 mile intervals.

⑥ Replace filter element located in carburetor inlet every 12 months or 12,000 miles whichever occurs first.

⑦ PSI at cranking speed, throttle wide open - Maximum variation, 20 lbs. between cylinders.

⑧ At idle speed with vacuum advance line disconnected and plugged. A = A.T.D.C.; B = B.T.D.C.

⑨ CAUTION: In addition to its function of filtering air drawn into the engine through the carburetor, the air cleaner also acts as a flame arrestor in the event the engine backfires. Because backfiring may cause fire in the engine compartment, the air cleaner should be installed at all times unless its removal is necessary for repair or maintenance service.

Paper Element Type—First 12,000 miles, inspect element for dust leaks, holes or other damage, replace if necessary. If satisfactory, rotate element 180° from original installed position. Replace element at 24,000 miles. Element must not be washed, oiled, tapped or cleaned with an air hose. If so equipped, replace "Bottle" filter every 24,000 miles.

Polyurethane Type—Every 12,000 miles clean element in suitable solvent such as Kerosene, squeeze out all solvent, then soak in engine oil and squeeze out. Then squeeze in a clean dry cloth to remove excess oil.

Flame Arrestor—Every 12,000 miles—Clean the arrestor (located in the base of the air cleaner) with kerosene or a suitable solvent. Dry with compressed air.

① Mechanical - Set with engine at operating temperature and running.

② Automatic Transmission - Set idle with transmission in drive.

③ Air Conditioned Vehicles - Set idle with air conditioning turned "OFF" except on specifications indicated by *.

④ Adjust timing at 800 rpm.

⑤ Corvette 4'B

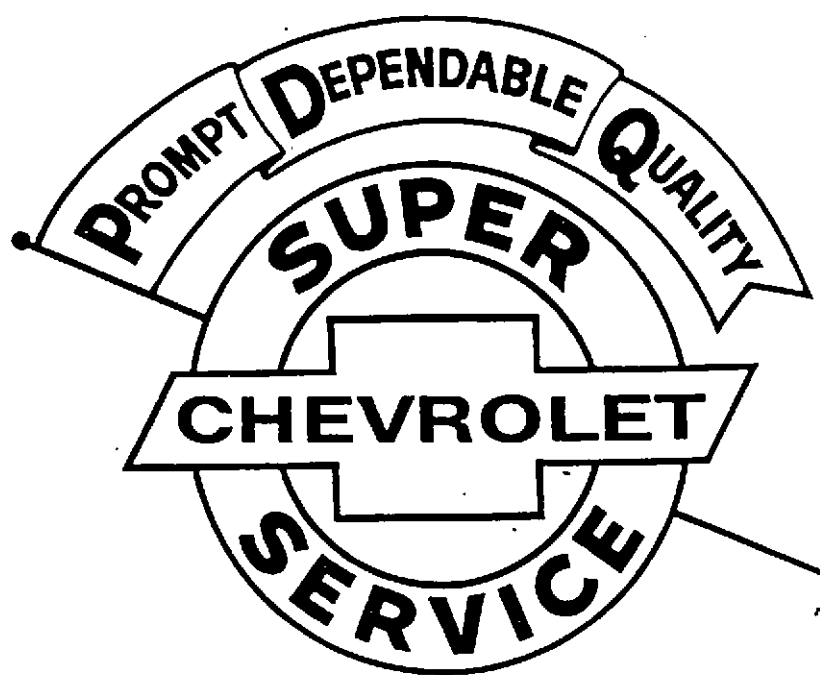
⑥ Idle solenoid is used to obtain these settings.

CARBURETOR

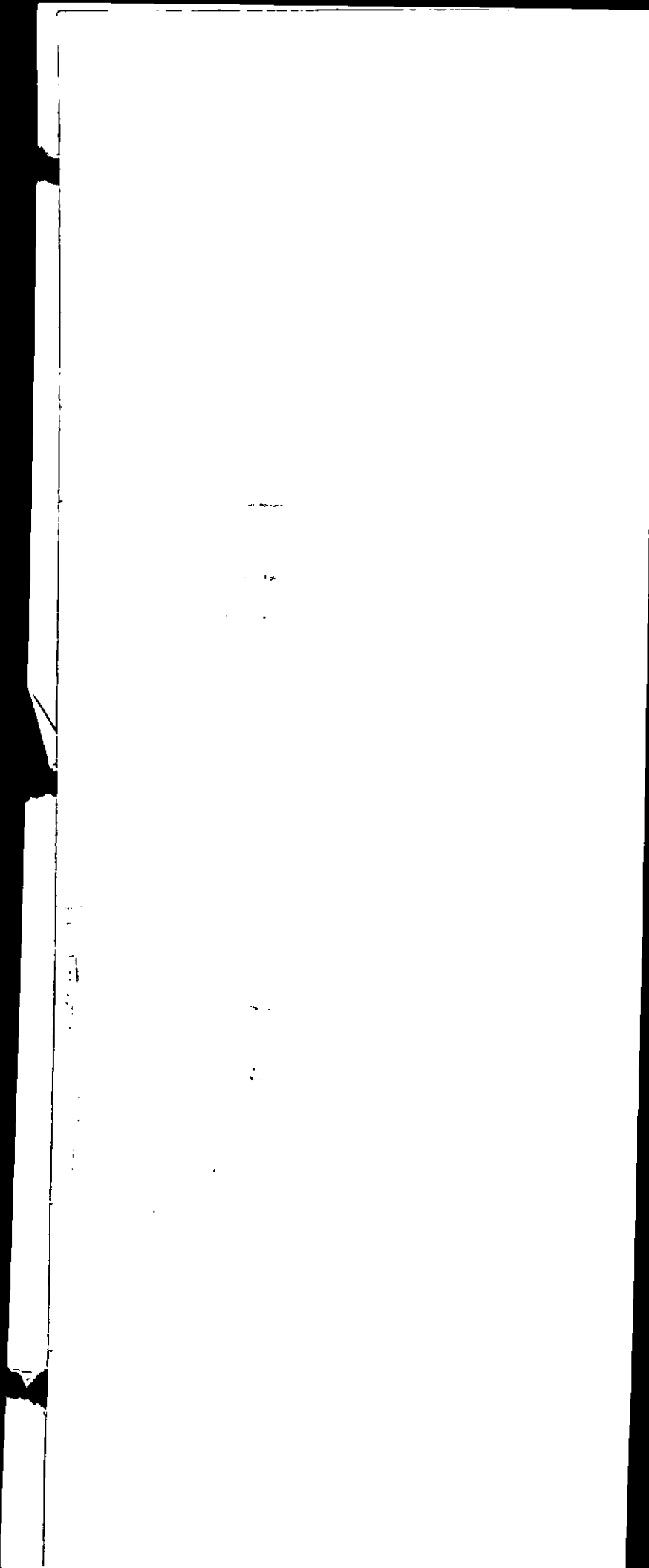
SECTION 6M

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① Air Conditioning
② Bottom of rod should be even with top of hole.
③ Top of rod should be even with bottom of hole.



3.0 L



3.0 L
Relead

631-467-2722

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3.0L

NOTICE: Always use the correct fastener in the proper location. When you replace a fastener, use ONLY the exact part number of that application.

General Motors will call out those fasteners that require a replacement after removal. General Motors will also call out the fasteners that require thread lockers or thread sealant.

UNLESS OTHERWISE SPECIFIED, Do Not use supplemental coatings (paints, greases or other corrosion inhibitors) on threaded fasteners or fastener joint interfaces. Generally, such coating adversely affect the fastener torque and the joint clamping force, and may damage the fastener.

When you install fasteners, use the correct tightening sequence and specifications.

Following these instructions can help you avoid damage to parts and systems.

Engine Mechanical - 3.0L

Specifications

Fastener Tightening Specifications

Application	N·m	Lb Ft	Lb In
Camshaft Retainer Bolts	9		80
Connecting Rod Cap Nuts	61	45	
Crankshaft Bearing Cap Bolts	75-95	55-70	
Crankshaft Rear Oil Seal Retainer Nuts	17-20		150-180
Cylinder Head Bolts	122	90	
Distributor Hold Down Bolt	27	20	
Flywheel Bolts	88	65	
Front Cover Bolts	3-4		27-35
Ignition Coil Bracket Attaching Bolts	22	16	
Intake to Exhaust Manifold Attaching Nuts and Bolt	27-34	20-25	
Intake/Exhaust Manifold to Head (2 center)	27-34	20-25	
Intake/Exhaust Manifold to Head (outer)	20-27	15-20	
Lift Bracket Bolts	27-41	20-30	
Oil Pan Nuts (rear)	19		165
Oil Pan Bolts (to crankcase)	9		80
Oil Pan Bolts (to front cover)	5		45
Oil Pan Studs to Oil Seal Retainer or Crankcase	2		15
Oil Pump Cover	8		72
Oil Pump to Block	14		120
Oil Pump Pickup	7		60
Pushrod Cover Bolts	5		40
Rocker Arm Cover Bolts	5		40
Spark Plugs	30	22	
Water Pump Bolts	20	15	

Sealers, Adhesives and Lubricants

GM Part Number	Type of Material	Application
1052080	Sealant	Rear camshaft bearing hole plug
1052080	Sealant	Cylinder head bolt threads
1052914	Sealant	Oil pan sealing surfaces
1052365	Lubricant	Valve train component prelube
1052080	Sealant	Valve rocker arm stud threads
1052080	Sealant	Oil level indicator tube

Engine Mechanical Specifications (1 of 2)

Application	Metric	English
General Data		
Engine Type	L4	
Displacement	3.0L	181 CID
Bore	101.60 mm	4.000 in
Stroke	91.44 mm	3.60 in
Compression Ratio	9.25:1	
Firing Order	1-3-4-2	
Spark Plug Gap	0.9 mm	0.035 in
Lubrication System		
Oil Pressure (Minimum - Hot)	41.4 kPa at 1,000 engine rpm 124.1 kPa at 2,000 engine rpm 165.5 kPa at 4,000 engine rpm	6.0 psig at 1,000 engine rpm 18.0 psig at 2,000 engine rpm 24.0 psig at 4,000 engine rpm
Oil Capacity (With Oil Filter Change)	3.81	4.00 qts
Oil Pump Type	Gear Driven	
Cylinder Block		
Bore Diameter	101.5873-101.6635 mm	3.9995-4.0025 in
Bore Out-of-Round Production	0.0254 mm (Maximum)	0.001 in (Maximum)
Bore Out-of-Round Service Limit	0.0508 mm (Maximum)	0.002 in (Maximum)
Bore Taper Thrust Side Production	0.0127 mm (Maximum)	0.0005 in (Maximum)
Bore Taper Thrust Side Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Bore Taper Relief Side Production	0.0127 mm (Maximum)	0.0005 in (Maximum)
Bore Taper Relief Side Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Runout - Rear Face of Block to Crankshaft Center Line	0.05 mm (Maximum)	0.002 in (Maximum)
Piston		
Piston-To-Bore Clearance Production	0.0635-0.0889 mm	0.0025-0.0035 in
Piston-To-Bore Clearance Service Limit	0.0889 mm	0.0035 in (Maximum)
Piston Rings		
Piston Compression Ring Groove Clearance Production Top	0.03048-0.07366 mm	0.0012-0.0029 in
Piston Compression Ring Groove Clearance Production 2nd	0.03048-0.07366 mm	0.0012-0.0029 in
Piston Compression Ring Groove Clearance Service Limit	0.09906 mm (Maximum)	0.0039 in (Maximum)
Piston Compression Ring Gap Top Production *	0.254-0.508 mm	0.01-0.02 in
Piston Compression Ring Gap 2nd Production *	0.4318-0.635 mm	0.017-0.025 in
Piston Compression Ring Gap Top Service Limit *	0.88 mm (Maximum)	0.035 in (Maximum)
Piston Compression Ring Gap 2nd Service Limit *	0.88 mm (Maximum)	0.035 in (Maximum)
Piston Oil Ring Groove Clearance Production	0.0254-0.1524 mm	0.001-0.006 in
Piston Oil Ring Groove Clearance Service Limit	0.1778 mm (Maximum)	0.007 in (Maximum)
Piston Oil Ring Gap Production *	0.25-0.76 mm	0.01-0.03 in
Piston Oil Ring Gap Service Limit *	1.016 mm (Maximum)	0.04 in (Maximum)
Piston Pin		
Diameter	23.545-23.548 mm	0.9270-0.927 in
Clearance in Piston Production	0.00762-0.01651 mm	0.0003-0.00065 in
Clearance in Piston Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Fit in Connecting Rod	0.02032-0.050292 mm (Interference)	0.0008-0.00198 in (Interference)

* Measured in cylinder bore

Engine Mechanical Specifications (2 of 2)

Crankshaft		
Crankshaft Journal Diameter (All)	58.3666-58.4047 mm	2.2979-2.2994 in
Crankshaft Journal Taper Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Crankshaft Journal Taper Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Crankshaft Journal Out-of-Round Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Crankshaft Journal Out-of-Round Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Crankshaft Bearing Clearance Production #1 - #4	0.0254-0.06096 mm	0.001-0.0024 in
Crankshaft Bearing Clearance Production #5	0.0406-0.0889 mm	0.0016-0.0035 in
Crankshaft Bearing Clearance Service Limit #1 - #4	0.0254-0.0635 mm	0.001-0.0025 in
Crankshaft Bearing Clearance Service Limit #5	0.0381-0.0889 mm	0.0015-0.0035 in
Crankshaft End Play	0.05-0.1524 mm	0.002-0.006 in
Crankshaft Sprocket Runout	0.07 mm (Maximum)	0.003 in (Maximum)
Connecting Rod		
Connecting Rod Journal Diameter	53.2892-53.3273 mm	2.0980-2.0995 in
Connecting Rod Journal Taper Production	0.00762 mm (Maximum)	0.0003 in (Maximum)
Connecting Rod Journal Taper Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Connecting Rod Journal Out-of-Round Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Connecting Rod Journal Out-of-Round Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Rod Bearing Clearance Production	0.04318-0.06858 mm	0.0017-0.0027 in
Rod Bearing Clearance Service Limit	0.0762 mm (Maximum)	0.003 in (Maximum)
Rod Side Clearance	0.1524-0.4318 mm	0.006-0.017 in
Camshaft		
Journal Diameter	47.440-47.490 mm	1.8677-1.8697 in
End Play	0.0762-0.2032 mm	0.003-0.008 in
Camshaft Sprocket Runout	0.1 mm (Maximum)	0.004 in (Maximum)
Timing Sprocket Teeth Backlash	0.10-0.15 mm	0.004-0.006 in
Lobe Lift Intake	6.4247 mm	0.25294
Lobe Lift Exhaust	6.4247 mm	0.25294
Lobe Lift Service Limit	±0.0254 mm	±0.001 in
Valve System		
Valve Lifter	Hydraulic	
Valve Rocker Arm Ratio	1.75:1	
Valve Lash	Half to One Turn Down From Zero Lash	
Face Angle	45 Degrees	
Seat Angle	46 Degrees	
Seat Runout	0.05 mm (Maximum)	0.002 in (Maximum)
Seat Width Intake	1.27-1.778 mm	0.050-0.070 in
Seat Width Exhaust	1.524-2.032 mm	0.060-0.080 in
Stem Clearance Intake Production	0.0254-0.06858 mm	0.001-0.0027 in
Stem Clearance Exhaust Production	0.01778-0.06858 mm	0.0007-0.0027 in
Stem Clearance Intake Service Limit	0.09398 mm (Maximum)	0.0037 in (Maximum)
Stem Clearance Exhaust Service Limit	0.1193 mm (Maximum)	0.0047 in (Maximum)
Valve Spring Free Length	52.324 mm	2.06 in
Valve Spring Pressure Closed	444-490 N at 40.89 mm	100-110 lb at 1.61 in
Valve Spring Pressure Open	925-987 N at 30.99 mm	208-222 lb at 1.22 in
Valve Spring Installed Height Intake	41.91 mm	1.65 in
Valve Spring Installed Height Exhaust	41.91 mm	1.65 in
Valve Lift Intake	11.25 mm	0.443 in
Valve Lift Exhaust	11.25 mm	0.443 in
Cylinder Head Warp		
Cylinder Head Deck (measured within a 152.4 mm (6.0 in) area)	0.0762 mm	0.003 in
Cylinder Head Deck (measuring the overall length of the cylinder head)	0.1778 mm	0.007 in

Diagnostic Information and Procedures

Base Engine Noise Diagnosis

Step	Action	Value	Yes	No
1	1. With the engine running, try to determine if the noise is timed to the crankshaft speed or the camshaft speed. 2. Using a timing light, two knocks per flash is the crankshaft or one knock per flash is the camshaft. Is the noise timed to the crankshaft speed?	—	Go to Step 2	Go to Step 3
2	1. Remove the rod bearings and inspect the bearings and the journals for wear. 2. If the parts are OK, remove the crankshaft and inspect the main bearings and journals for wear. 3. Replace the parts as necessary. Does the engine continue to knock?	—	Go to Step 3	System OK
3	Check to see if the noise is timed to the camshaft speed. Is the noise timed to the camshaft speed?	—	Go to Step 5	Go to Step 4
4	1. Inspect for loose accessory attachments, the flywheel. 2. Tighten or adjust as necessary. Does the engine continue to knock?	—	Go to Step 5	System OK
5	1. Remove the pushrod cover. • Refer to <i>Pushrod Cover Removal</i> . 2. Rotate the engine and measure the lifter movement in the bore. 3. Compare the measurement with the specifications in <i>Engine Mechanical Specifications</i> . Is the camshaft within specifications?	—	Go to Step 7	Go to Step 6
6	Replace the camshaft. Refer to <i>Camshaft Removal and Installation</i> . Does the engine continue to knock?	—	Go to Step 7	System OK
7	1. Remove the rocker arms, the pushrods and the lifters. 2. Inspect the parts for excessive wear or damage. 3. Replace the parts as necessary. Are the repairs complete?	—	System OK	—

Engine Compression Test

Perform the following steps in order to conduct a compression test:

1. Conduct the following steps in order to check cylinder compression:
 - 1.1. Engine should be at room temperature.
 - 1.2. Disconnect the two electrical connectors from the distributor.
 - 1.3. Remove the spark plugs.
 - 1.4. Throttle plates should be wide open.
 - 1.5. Battery should be at or near full charge.
2. For each cylinder, crank engine through four compression strokes.
3. The lowest cylinder reading should not be less than 70% of the highest.
4. No cylinder reading should be less than 689 kPa (100 psi).

Important: The results of a compression test will fall into the following categories:

1. Normal — Compression builds up quickly and evenly to specified compression on each cylinder.
2. Piston Rings — Compression low on first stroke. Tends to build up on the following strokes but does not reach normal. Improves considerably with addition of oil.
3. Valves — Compression low on first stroke. Does not tend to build up on the following strokes. Does not improve much with addition of oil. Use approximately three squirts from a plunger-type oiler.

Engine Noise Diagnosis

There are four steps to diagnosing engine noise. You must determine the following conditions:

- Type of noise.
- The exact operating condition under which the noise exists.
- Determine the rate and location of the noise.
- Compare the sounds in other engines to make sure you are not trying to correct a normal condition.

Identify the type of noise. For example, a light rattle or low rumble.

Remember, engine noises are generally synchronized to either engine speed (caused by the crankshaft, pistons or connecting rods) or one-half engine speed (valve train noise). Try to determine the rate at which the noise is occurring.

Knocks Cold and Continues for 2 to 3 Minutes

- Engine flywheel contacting the splash shield. Reposition the splash shield.
- Loose or broken crankshaft balancer or drive pulleys. Tighten or replace as necessary.
- Excessive piston to bore clearance. Replace the piston.

- 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.

Knocks on Start-Up but Only Lasts a Few Seconds

- Improper oil viscosity. Install recommended oil viscosity for expected temperatures.
- Excessive piston to bore clearance.
- Excessive piston pin to piston clearance.
- Excessive crankshaft end clearance.
- Excessive crankshaft bearing clearance.

Knocks at Idle Hot

- Detonation or spark knock. Check operation of ignition controls or knock sensor circuit.
- Loose flywheel bolts.
- Exhaust leak at manifold. Tighten the exhaust manifold bolts and/or replace the gasket.
- Excessive connecting rod bearing clearance. Replace the bearings as necessary.
- Excessive piston pin clearance.
- Excessive crankshaft thrust bearing clearance.
- Bent connecting rod.

Valve Train Diagnosis

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

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

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

Oil Consumption Diagnosis

Excessive oil consumption (not due to leaks) is the use of 1.9L (2 qts.) or more of engine oil within 50 hours of use. The causes of excessive oil consumption include the following conditions:

- External oil leaks. Tighten bolts and/or replace gaskets and oil seals as necessary.
- Incorrect oil level or improper reading of oil level indicator. With the engine at a level surface, allow adequate drain down time and check for the correct oil level.
- Improper oil viscosity. Use a recommended SAE viscosity for the prevailing temperatures.
- Continuous high speed operation and/or severe usage.
- Crankcase ventilation system restrictions or malfunctioning components. Possible improper PCV valve.
- Valve guides and/or valve stem oil seals worn, or the seal omitted. Ream guides and install oversize service valves and/or new valve stem oil seals.
- Piston rings broken, improperly installed, worn or not seated properly. Allow adequate time for rings to seat. Replace broken or worn rings as necessary.
- Piston improperly installed or mis-fitted.

Low or No Oil Pressure Diagnosis and Testing

- Low oil level. Fill to full mark on oil level indicator.
- Incorrect or malfunctioning oil pressure switch.
- Incorrect or malfunctioning oil pressure gauge.
- Improper oil viscosity for the expected temperature.
- Oil pump worn or dirty.
- Malfunctioning oil pump pressure regulator valve.
- Plugged oil filter.
- Oil pump screen loose, plugged or damaged.
- Excessive bearing clearance. Replace as necessary.
- Cracked, porous or restricted oil galleries. Repair or replace the engine block.
- Oil galley plugs missing or incorrectly installed. Install the plugs or repair as necessary.
- Oil diluted by moisture or unburned fuel mixtures.

Oil Leak Diagnosis

Most fluid oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions a fluid leak may be difficult to locate or repair.

Use the following steps in order to find the leak:

1. Identify the fluid, determine whether it is engine oil, transmission fluid or power steering fluid.
2. At what point is the fluid leaking from? After running the engine at normal operating temperature, place a large sheet of paper under the engine. After a few minutes, you should be able to find the approximate location of the leak by the drippings on the paper.

3. Visually check around the suspected component. Check around the gasket mating surfaces for leaks. A mirror is useful for finding leaks in areas that are hard to reach.
4. If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam or spray solvent. Clean the area well, then dry the area. Run the engine for several minutes at normal operating temperature and varying speeds. After running the engine, visually check the suspected area. If you still cannot locate the leak, try using the powder or black light and dye method.

Perform the following steps in order to perform the powder method:

1. Clean the suspected area.
2. Apply an aerosol-type powder (such as foot powder) to the suspected area.
3. Run the engine under normal operating conditions.
4. Visually inspect the suspected area. You should be able to trace the leak path over the white powder surface to the source.

Perform the following steps in order to use the black light and dye method:

Tools Required

J 39400 Leak Detector

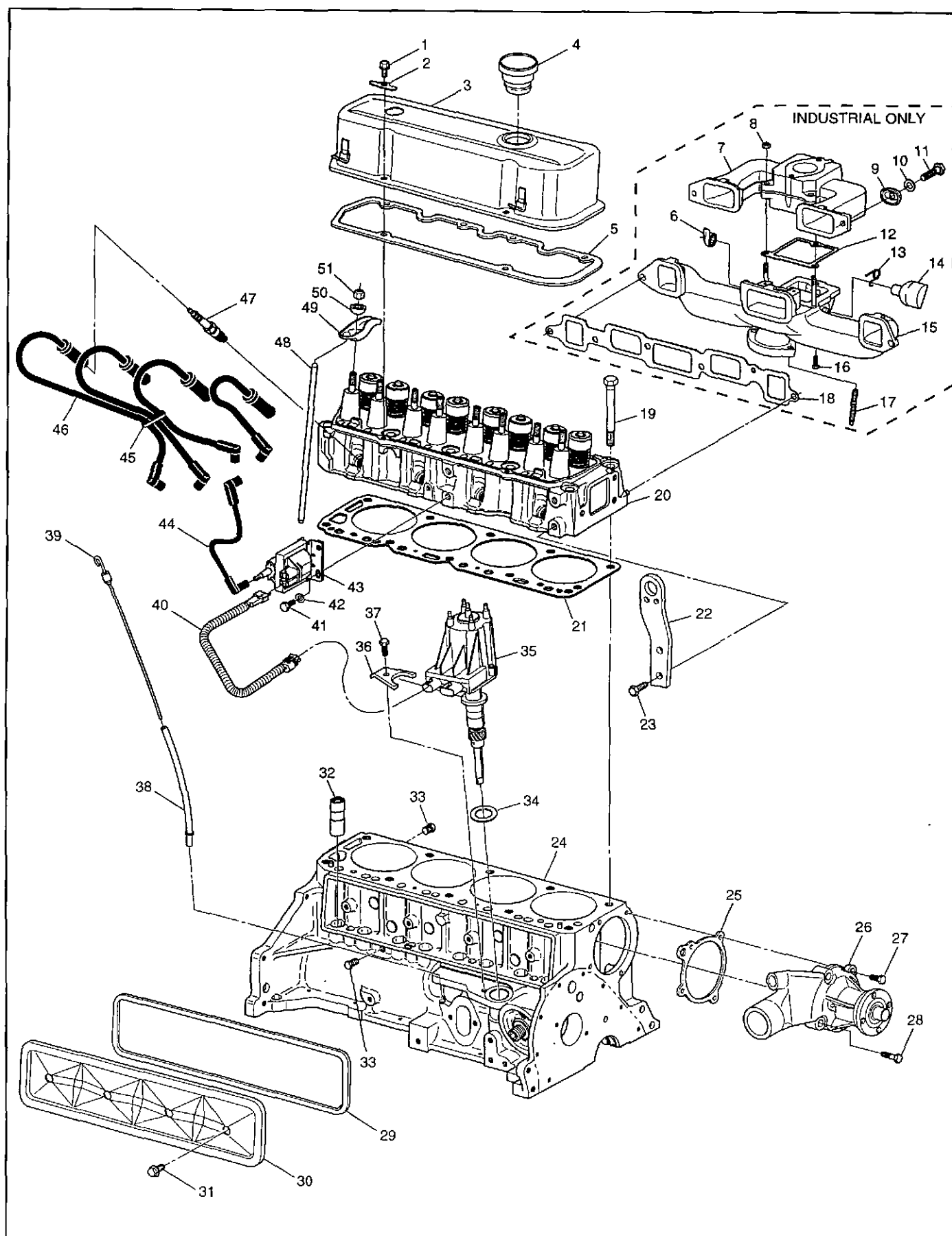
1. Pour specified amount of dye into the leaking component.
2. Run the engine under normal operating conditions as directed by the J 39400.
3. Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

Repairing the Leak

Once the origin of the leak has been pinpointed and traced back to its source, the cause of the leak must be determined in order for it to be repaired properly. If a gasket is replaced, but the sealing surface is damaged, the new gasket will not repair the leak. Before attempting to repair a leak, be sure that the gasket and sealing surfaces are correct.

Perform the following steps in order to check for gasket leaks:

1. Inspect the fluid level/pressure for being too high.
2. Check the crankcase ventilation system for restrictions or malfunctioning components.
3. Inspect for improperly tightened fasteners or dirty/damaged threads.
4. Look for warped flanges or sealing surfaces.
5. Check for scratches, burrs or other damage to the sealing surface.
6. Look for a damaged or worn gasket.
7. Check for cracking or porosity of the component.
8. Check for use of an improper sealant used (where applicable).

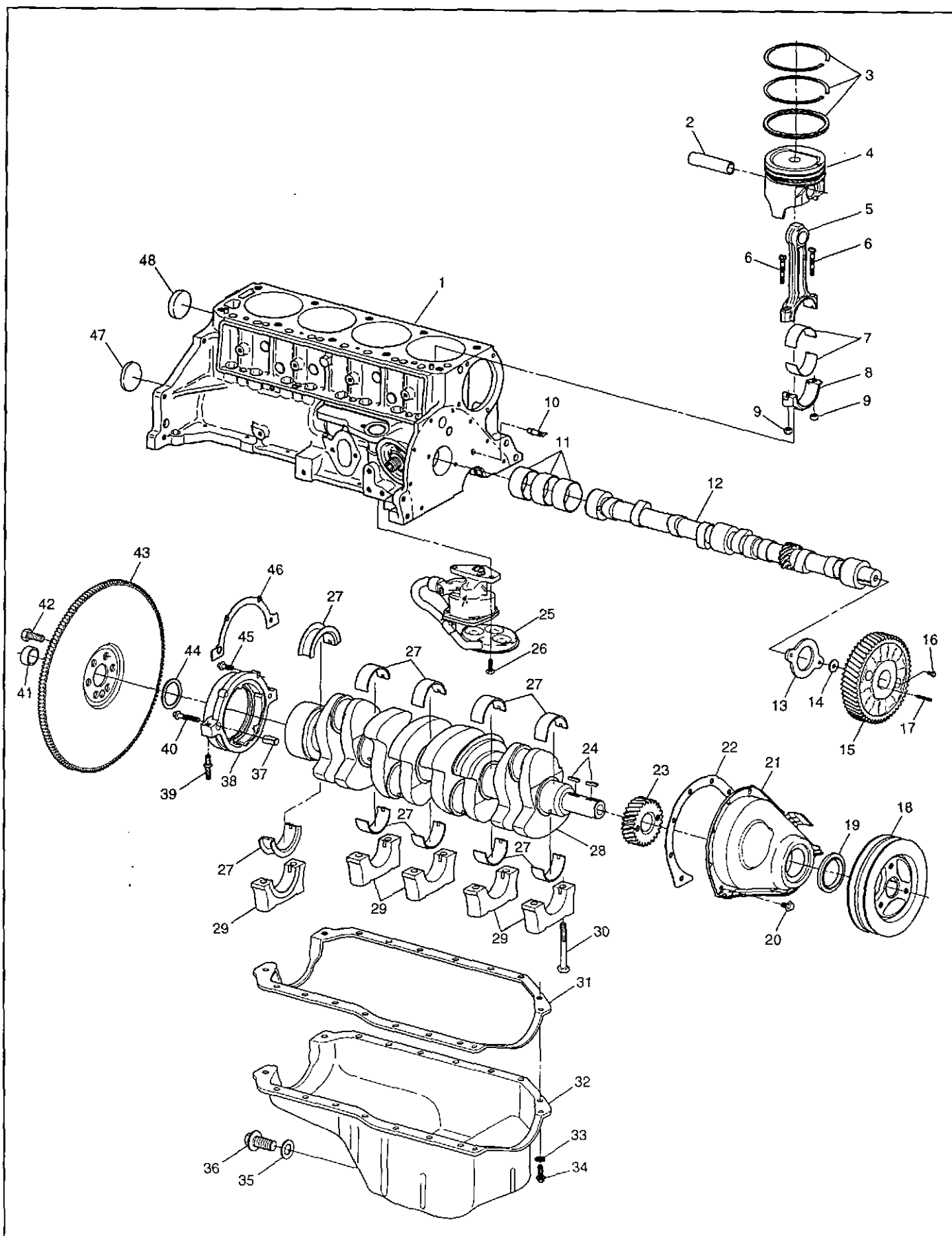


Block Explode #1

VE001-3L

Disassembled View (1 of 4)

- 1 VALVE ROCKER ARM COVER BOLT
- 2 VALVE ROCKER ARM COVER REINFORCEMENT
- 3 VALVE ROCKER ARM COVER
- 4 OIL FILLER CAP
- 5 VALVE ROCKER ARM COVER GASKET
- 6 EFE VALVE THERMOSTAT
- 7 INTAKE MANIFOLD
- 8 INTAKE MANIFOLD NUT
- 9 INTAKE/EXHAUST MANIFOLD CLAMP
- 10 INTAKE/EXHAUST MANIFOLD WASHER
- 11 INTAKE/EXHAUST MANIFOLD BOLT
- 12 INTAKE/EXHAUST MANIFOLD GASKET
- 13 EFE VALVE SPRING
- 14 EFE VALVE BUSHING
- 15 EXHAUST MANIFOLD
- 16 INTAKE/EXHAUST MANIFOLD BOLT
- 17 EXHAUST MANIFOLD STUD
- 18 INTAKE/EXHAUST MANIFOLD GASKET
- 19 CYLINDER HEAD BOLT
- 20 CYLINDER HEAD
- 21 CYLINDER HEAD GASKET
- 22 LIFT BRACKET
- 23 LIFT BRACKET BOLT
- 24 ENGINE BLOCK
- 25 WATER PUMP GASKET
- 26 WATER PUMP
- 27 WATER PUMP BOLT
- 28 WATER PUMP BOLT
- 29 PUSHROD COVER GASKET
- 30 PUSHROD COVER
- 31 PUSHROD COVER BOLT
- 32 VALVE LIFTER
- 33 ENGINE BLOCK COOLANT PLUG
- 34 DISTRIBUTOR GASKET
- 35 DISTRIBUTOR
- 36 DISTRIBUTOR HOLD DOWN
- 37 DISTRIBUTOR HOLD DOWN BOLT
- 38 OIL LEVEL INDICATOR TUBE
- 39 OIL LEVEL INDICATOR
- 40 PRIMARY IGNITION HARNESS
- 41 IGNITION COIL BOLT
- 42 IGNITION COIL WASHER
- 43 IGNITION COIL
- 44 IGNITION COIL WIRE
- 45 SPARK PLUG WIRE RETAINER
- 46 SPARK PLUG WIRE HARNESS
- 47 SPARK PLUG
- 48 VALVE PUSHROD
- 49 VALVE ROCKER ARM
- 50 VALVE ROCKER ARM BALL
- 51 VALVE ROCKER ARM NUT

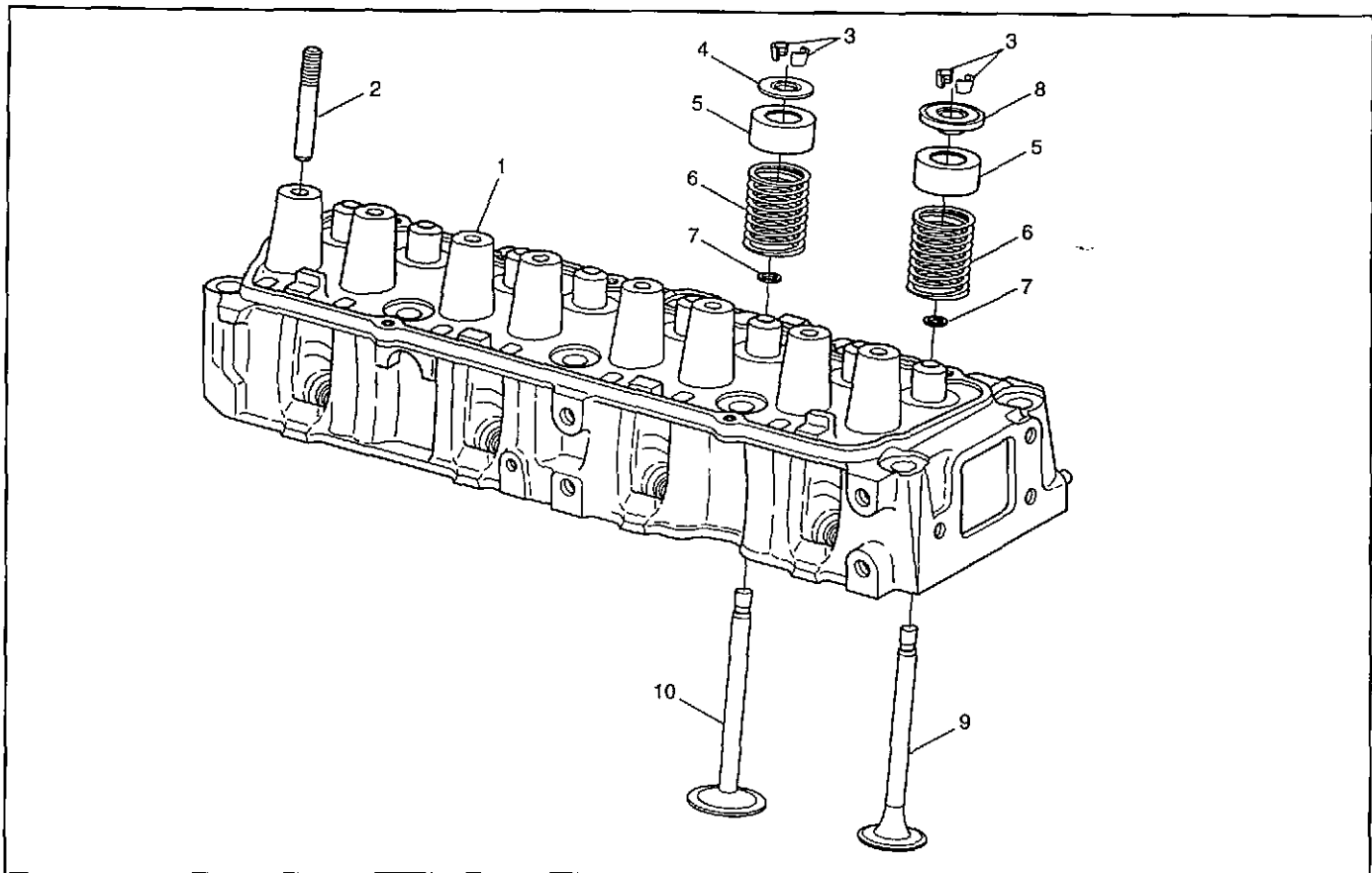


Block Explode #2

VE002-3L

Disassembled View (2 of 4)

- 1 ENGINE BLOCK
- 2 PISTON PIN
- 3 PISTON RING KIT
- 4 PISTON
- 5 CONNECTING ROD
- 6 CONNECTING ROD BOLT
- 7 CONNECTING ROD BEARING KIT
- 8 CONNECTING ROD CAP
- 9 CONNECTING ROD NUT
- 10 OIL NOZZLE
- 11 CAMSHAFT BEARINGS
- 12 CAMSHAFT
- 13 CAMSHAFT RETAINER
- 14 CAMSHAFT RETAINER WASHER
- 15 CAMSHAFT SPROCKET
- 16 CAMSHAFT RETAINER BOLT
- 17 CAMSHAFT WOODRUFF KEY
- 18 CRANKSHAFT PULLEY
- 19 ENGINE FRONT COVER SEAL
- 20 ENGINE FRONT COVER BOLT
- 21 ENGINE FRONT COVER
- 22 ENGINE FRONT COVER GASKET
- 23 CRANKSHAFT SPROCKET
- 24 CRANKSHAFT KEYWAY
- 25 OIL PUMP
- 26 OIL PUMP BOLT
- 27 CRANKSHAFT BEARING KIT
- 28 CRANKSHAFT
- 29 CRANKSHAFT BEARING CAP
- 30 CRANKSHAFT BEARING CAP BOLT
- 31 OIL PAN GASKET
- 32 OIL PAN
- 33 OIL PAN WASHER
- 34 OIL PAN BOLT
- 35 OIL DRAIN PLUG WASHER
- 36 OIL DRAIN PLUG
- 37 CRANKSHAFT REAR OIL SEAL HOUSING PIN
- 38 CRANKSHAFT REAR OIL SEAL HOUSING
- 39 CRANKSHAFT REAR OIL SEAL HOUSING STUD
- 40 CRANKSHAFT REAR OIL SEAL HOUSING BOLT
- 41 CLUTCH PILOT BEARING
- 42 ENGINE FLYWHEEL BOLT
- 43 ENGINE FLYWHEEL
- 44 CRANKSHAFT REAR OIL SEAL
- 45 CRANKSHAFT REAR OIL SEAL HOUSING BOLT
- 46 CRANKSHAFT REAR OIL SEAL HOUSING GASKET
- 47 CAMSHAFT REAR BEARING HOLE PLUG
- 48 ENGINE BLOCK CORE PLUG

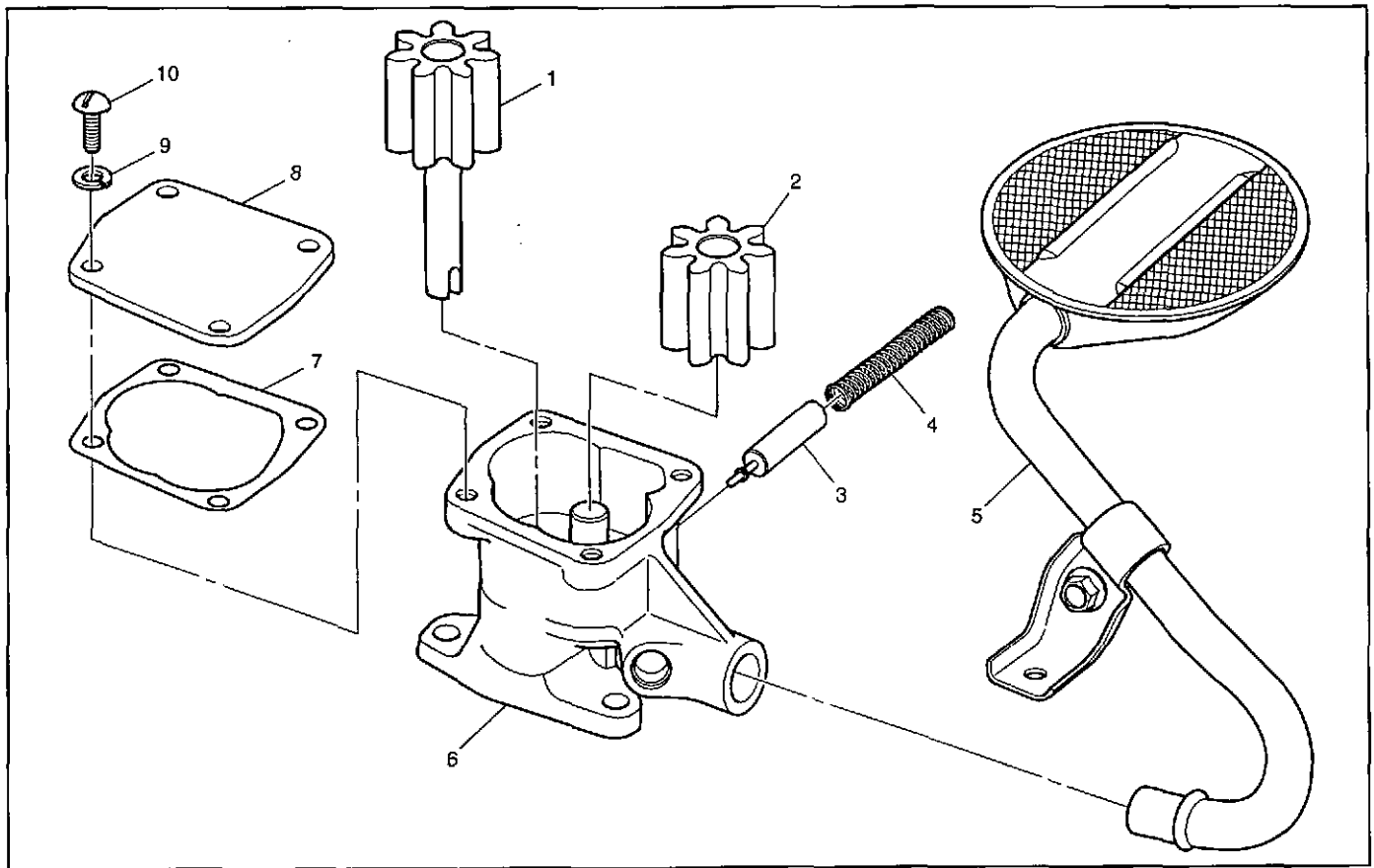


Head Explode

VE003-3L

Disassembled View (3 of 4)

- 1 CYLINDER HEAD
- 2 VALVE ROCKER ARM STUD
- 3 VALVE STEM KEY
- 4 VALVE SPRING CAP INTAKE
- 5 VALVE STEM OIL SHIELD
- 6 VALVE SPRING
- 7 VALVE STEM OIL SEAL
- 8 VALVE SPRING CAP EXHAUST
- 9 EXHAUST VALVE
- 10 INTAKE VALVE



Oil Pump Explode

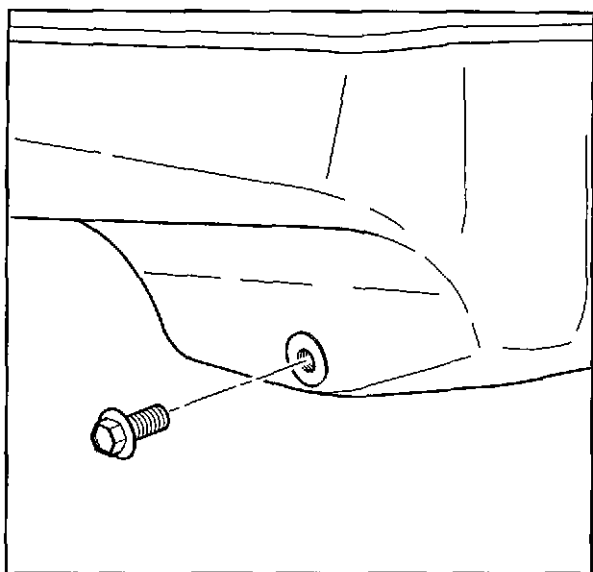
VE004-3L

Disassembled View (4 of 4)

- 1 DRIVE GEAR
- 2 DRIVEN GEAR
- 3 OIL PRESSURE RELIEF VALVE
- 4 OIL PRESSURE RELIEF VALVE SPRING
- 5 OIL PUMP SCREEN
- 6 OIL PUMP
- 7 OIL PUMP COVER GASKET
- 8 OIL PUMP COVER
- 9 OIL PUMP COVER WASHER
- 10 OIL PUMP COVER BOLT

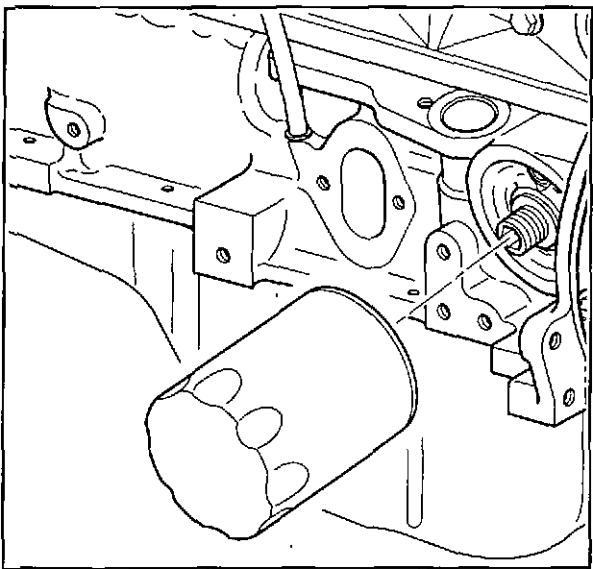
Draining Fluids and Oil Filter Removal

1. Remove the oil pan drain plug and allow the oil to drain.



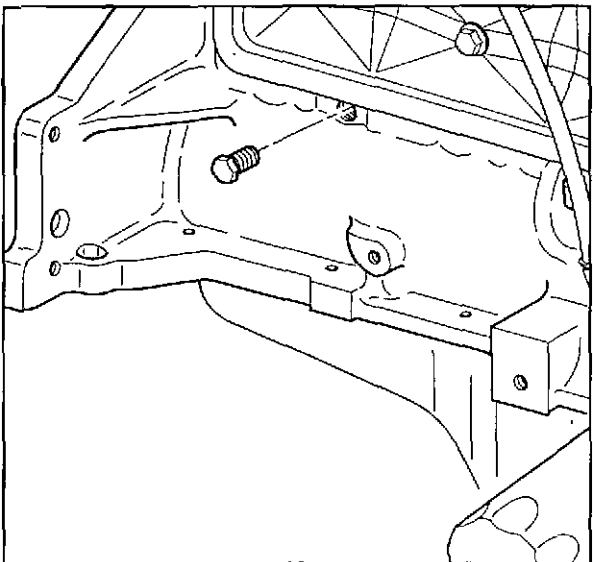
VE005-3L

2. Remove the oil filter.



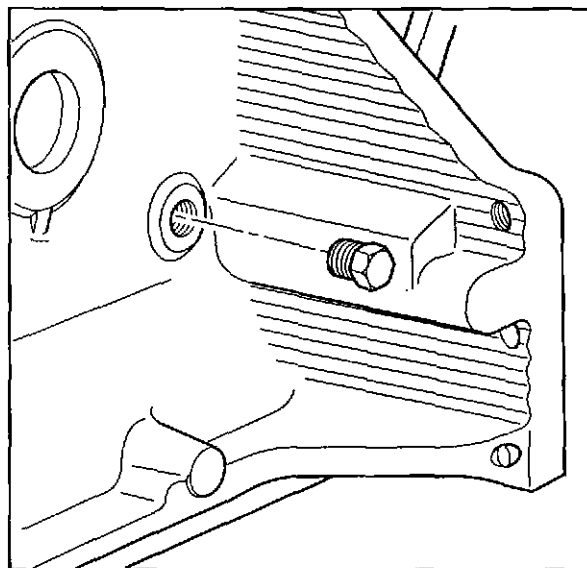
VE006-3L

3. Remove right rear engine block coolant plug and allow the coolant to drain.



VE007-3L

4. Remove the left rear engine block coolant plug and allow the coolant to drain.

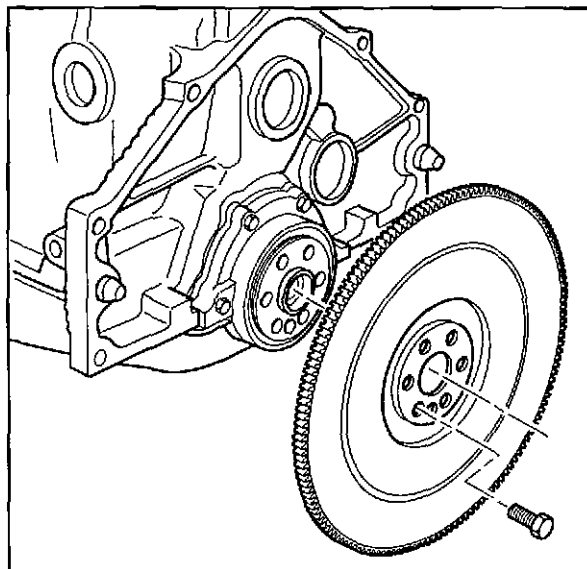


VE008-3L

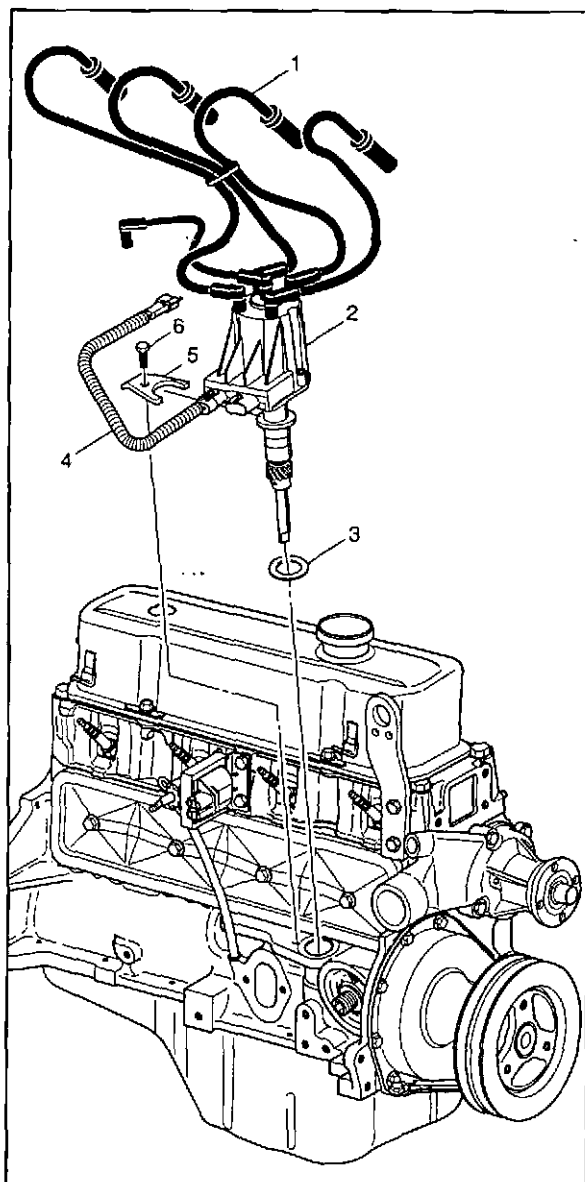
Engine Flywheel Removal

Important: Note the position and direction of the engine flywheel before removal. The flywheel center alignment hole is a tapered fit to the crankshaft. The engine flywheel must be reinstalled to the original position and direction.

1. Remove the engine flywheel bolts.
2. Remove the engine flywheel.



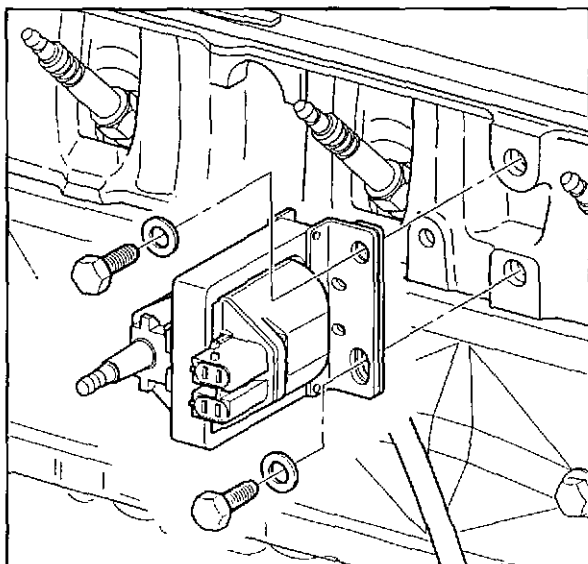
VE009-3L



VE010-3L

Distributor Removal

1. Disconnect the secondary ignition wires (1) from the spark plugs and the ignition coil.
2. Disconnect the primary ignition harness (4) from the ignition coil. Do not remove the wires from the distributor unless it is necessary.
3. Remove the distributor hold down bolt (6).
4. Remove the distributor (2) and gasket (3).



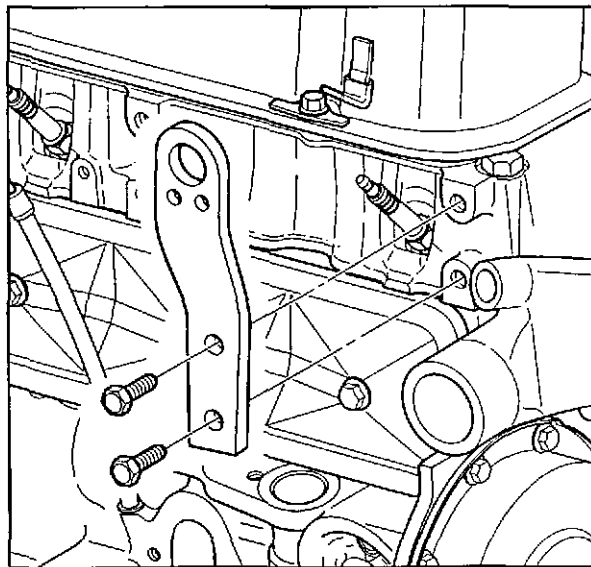
VE011-3L

Ignition Coil Removal

1. Remove the ignition coil bracket attaching bolts.
2. Remove the ignition coil.

Lift Bracket Removal

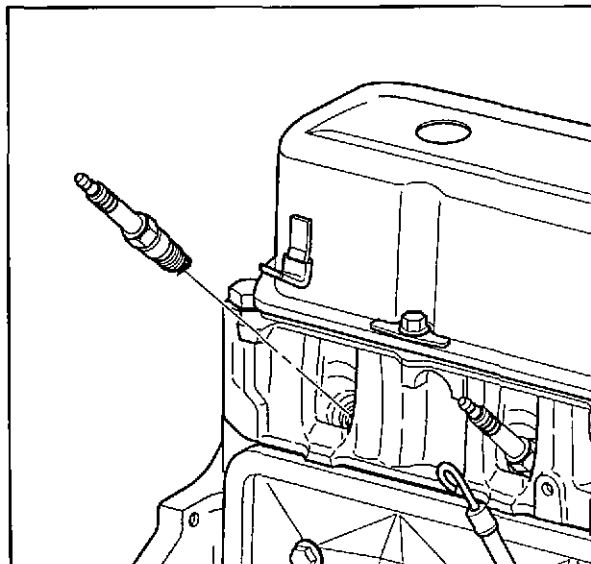
1. Remove the lift bracket bolts.
2. Remove the lift bracket.



VE012-3L

Spark Plug Removal

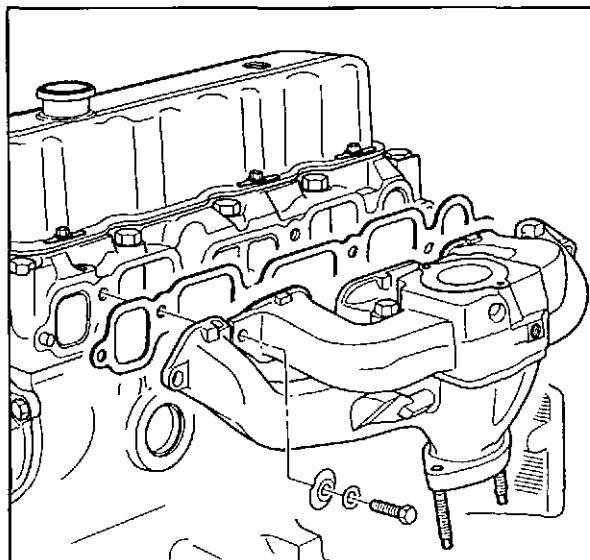
1. Remove the spark plugs.



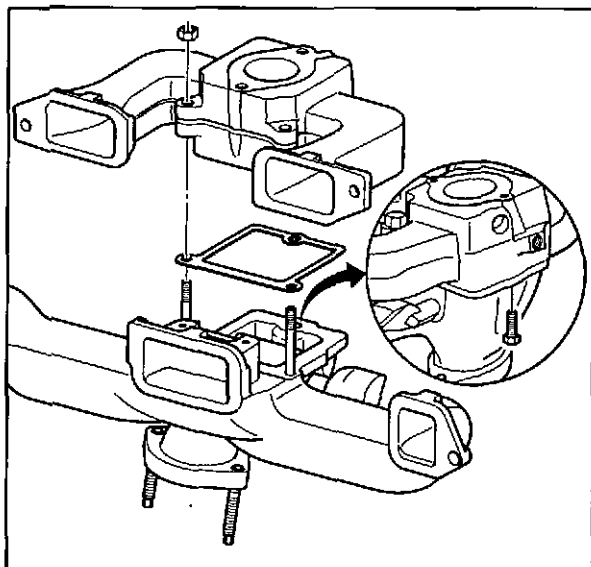
VE013-3L

Intake/Exhaust Manifold Removal

1. Remove the intake/exhaust manifold bolts.
2. Remove the intake/exhaust manifold.
3. Remove the intake/exhaust manifold gaskets.



VE014-3L



VE015-3L

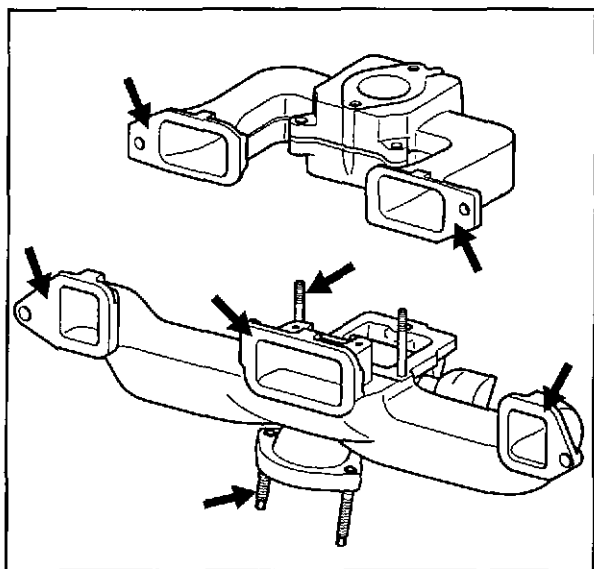
Intake/Exhaust Manifold Disassemble and Assemble

If necessary to replace either the intake or exhaust manifold, separate them as follows:

1. Remove the one attaching bolt and the two nuts at the center of the assembly.
2. Reassemble manifolds using a new gasket.

Tighten

Tighten the bolts to 27-34 N•m (20-25 lb ft).

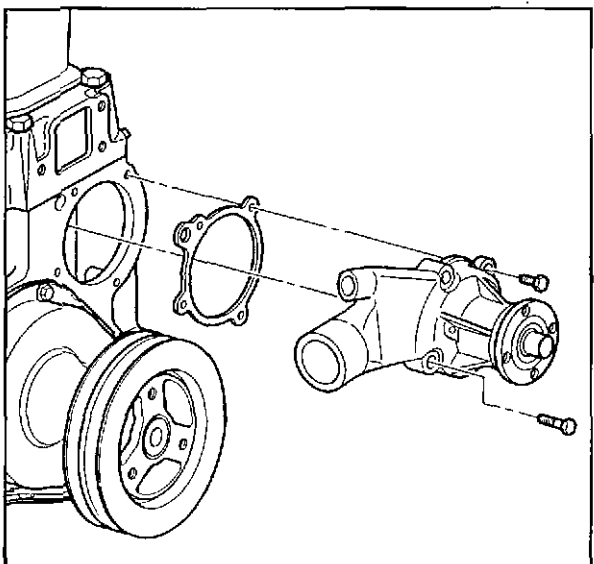


VE016-3L

Intake/Exhaust Manifold Clean and Inspect

Clean and inspect the following areas:

- The manifold bolts and studs.
- All manifold sealing surfaces.
- Any old RTV from the manifold.



VE017-3L

Water Pump Removal

Make sure the coolant is drained.

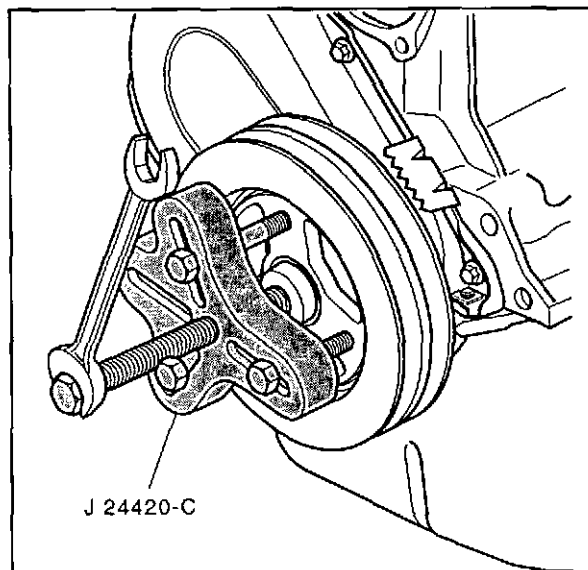
1. Remove the water pump bolts.
2. Remove the water pump and gasket.
3. Discard the water pump gasket.
4. Inspect the water pump for the following:
 - Gasket sealing surfaces for excessive scratches or gouges.
 - Excessive side-to-side play in the pulley shaft.
 - Leakage at the water inlet housing or rear cover gaskets areas.
 - Leakage at the water pump vent hole.

A stain around the vent hole is acceptable. If leakage occurs at the vent hole with the engine running and the cooling system pressurized, replace the pump.

Crankshaft Pulley Removal

Tools Required

- J 24420-C Universal Crankshaft Pulley Remover
1. Use the J 24420-C in order to remove the crankshaft pulley.

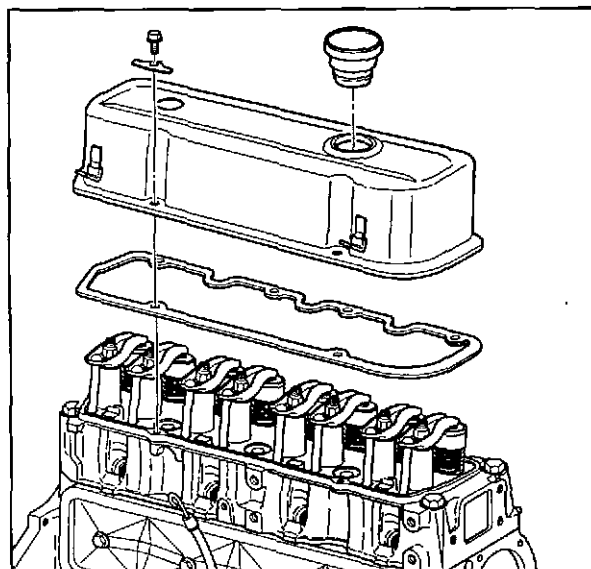


J 24420-C

VE018-3L

Valve Rocker Arm Cover Removal

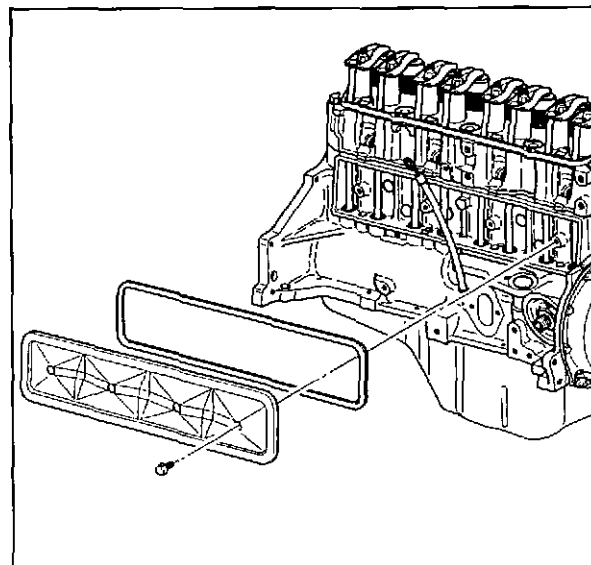
1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover.
3. Remove the gasket.



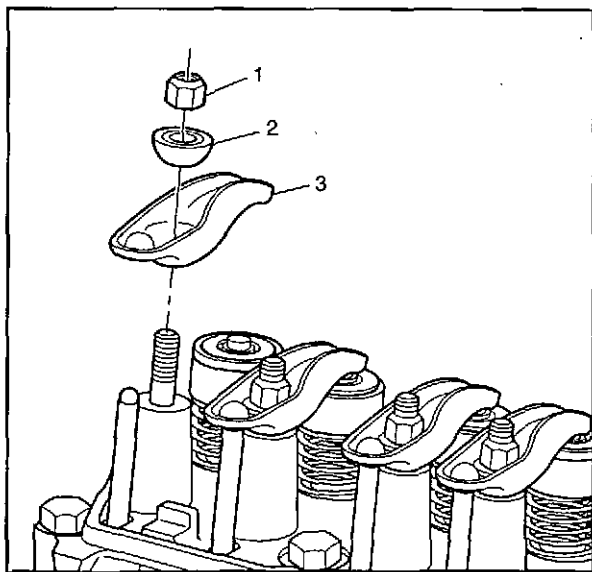
VE019-3L

Pushrod Cover Removal

1. Remove the pushrod cover bolts.
2. Remove the pushrod cover.
3. Remove the gasket.



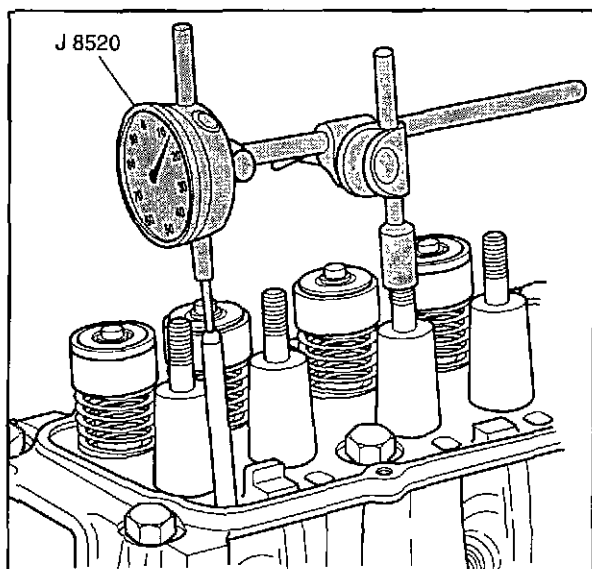
VE020-3L



VE021-3L

Valve Rocker Arm and Pushrod Removal

1. Remove the following components from the cylinder head:
 - 1.1. The valve rocker arm nuts (1).
 - 1.2. The valve rocker arm balls (2).
 - 1.3. The valve rocker arms (3).



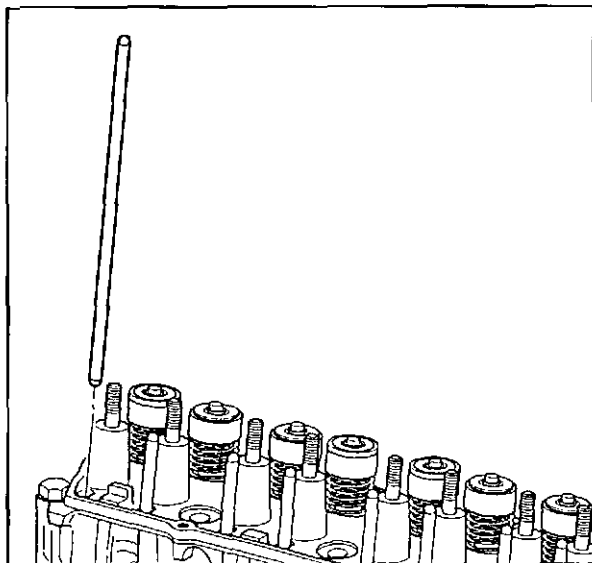
VE022-3L

Measuring Camshaft Lobe Lift

Tools Required

- J 8520 Camshaft Lobe Lift Indicator

1. Position the J 8520 with the ball socket adapter on the valve pushrod. Be sure that the valve pushrod is in the valve lifter socket.
2. Slowly rotate the crankshaft until the valve lifter roller is on the heel of the cam lobe. The valve pushrod will be in its lowest position.
3. Set the J 8520 on zero.
4. Slowly rotate the crankshaft until the valve pushrod is raised fully.
5. Compare the total lift shown on the J 8520 with the specifications. Refer to *Engine Mechanical Specifications*.
6. Remove the J 8520.



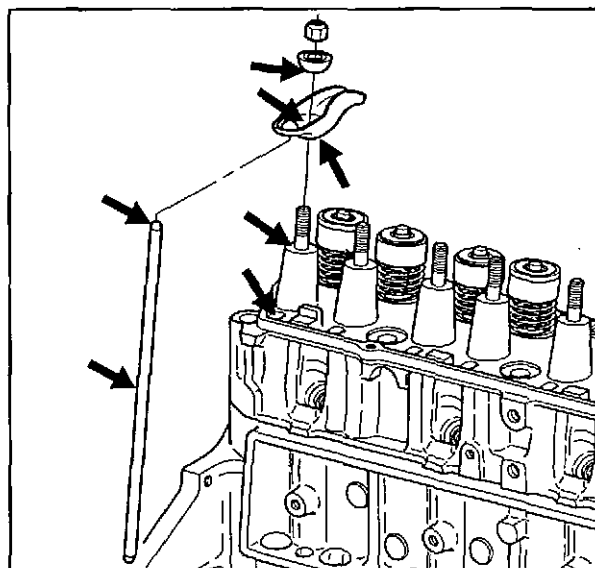
VE023-3L

2. Remove the valve pushrods.
3. Place the following parts in a rack so that they can be reinstalled in their original locations:
 - The valve rocker arms.
 - The valve rocker arm balls.
 - The valve pushrods.

Valve Train Components Inspect (Cylinder Head)

Inspect the following areas:

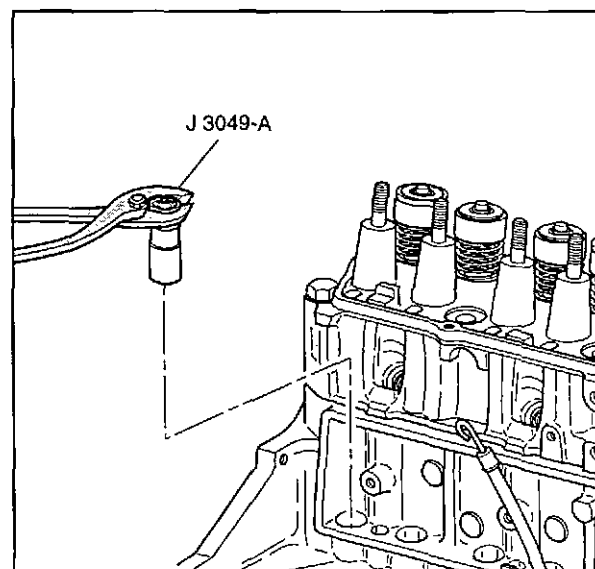
- The valve rocker arms and ball at the mating surfaces. These surfaces should be smooth and free of scoring or other damage.
- The valve pushrod sockets and valve stem mating surfaces. These surfaces should be smooth with no scoring or exceptional wear.
- The valve pushrods for bends or scored ends.



VE024-3L

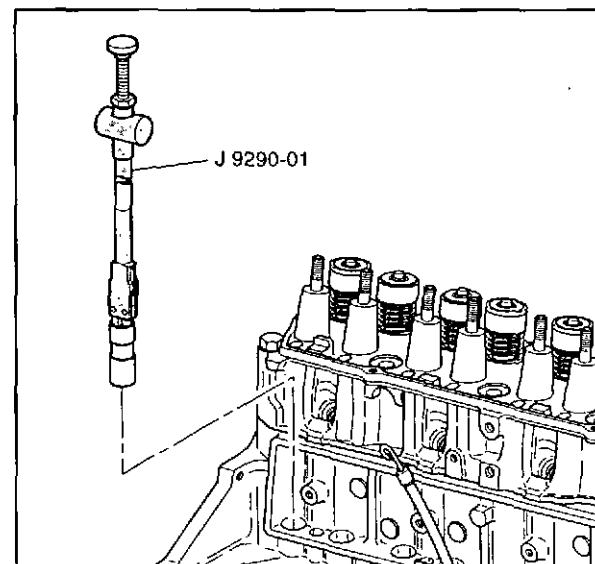
Valve Lifter Removal**Tools Required**

- J 3049 Valve Lifter Remover (Plier Type)
 - J 9290-01 Valve Lifter Remover (Slide Hammer Type)
1. Use the J 3049 in order to remove the valve lifters.

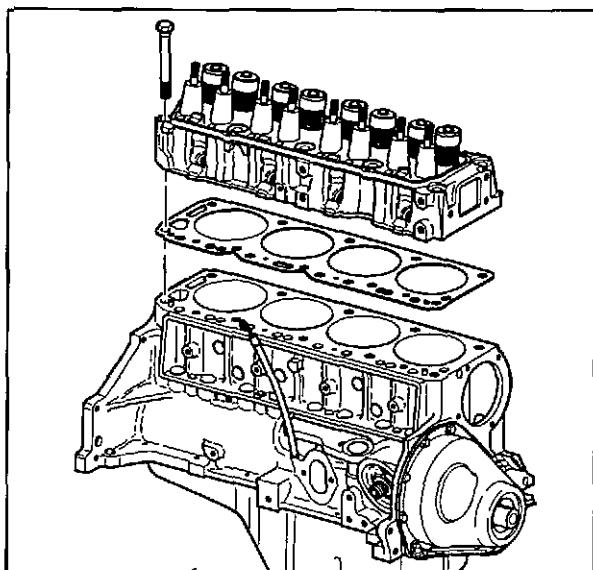


VE025-3L

2. If the valve lifters cannot be removed with the J 3049 use the J 9290-01 in order to remove the valve lifters.



VE026-3L



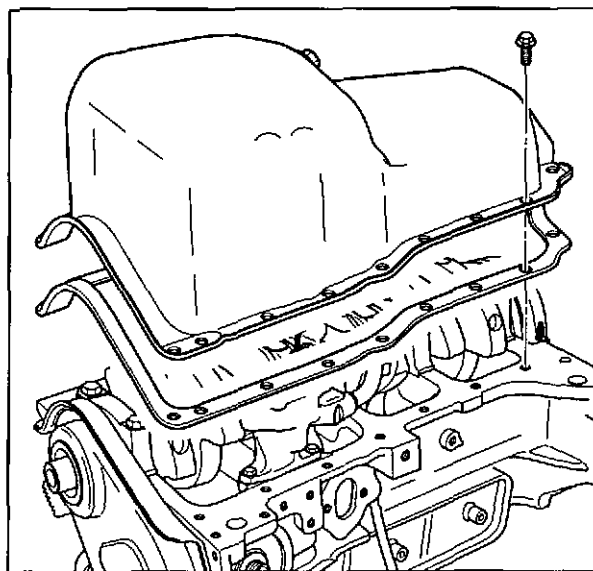
VE027-3L

Cylinder Head Removal

1. Remove the cylinder head bolts.

Notice: After removal, place the cylinder head on two wood blocks to prevent damage.

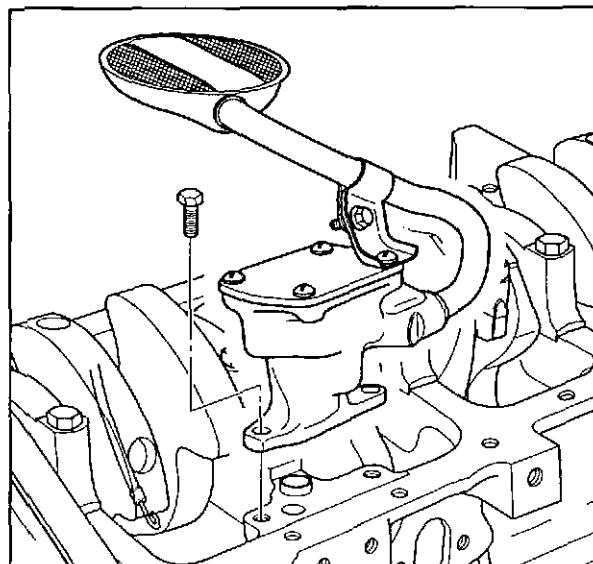
2. Remove the cylinder head.
3. Remove the gasket.
4. Discard the gasket



VE028-3L

Oil Pan Removal

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



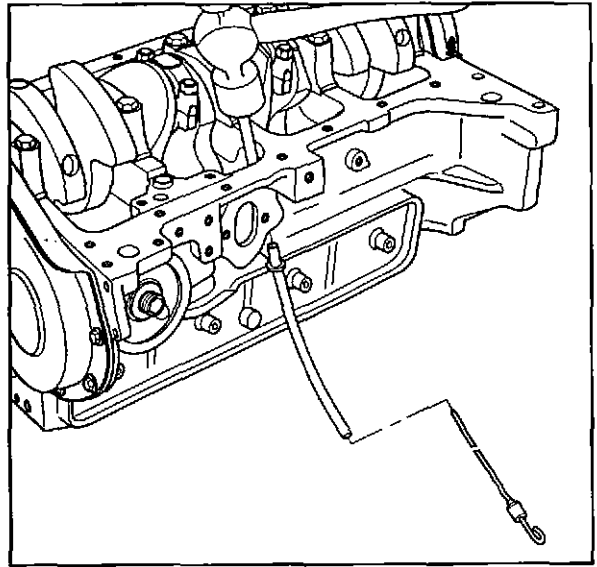
VE029-3L

Oil Pump Removal

1. Remove the bolts that attach the oil pump to the engine block.
2. Remove the oil pump and gasket.
3. Discard the gasket.

Oil Level Indicator and Tube Removal

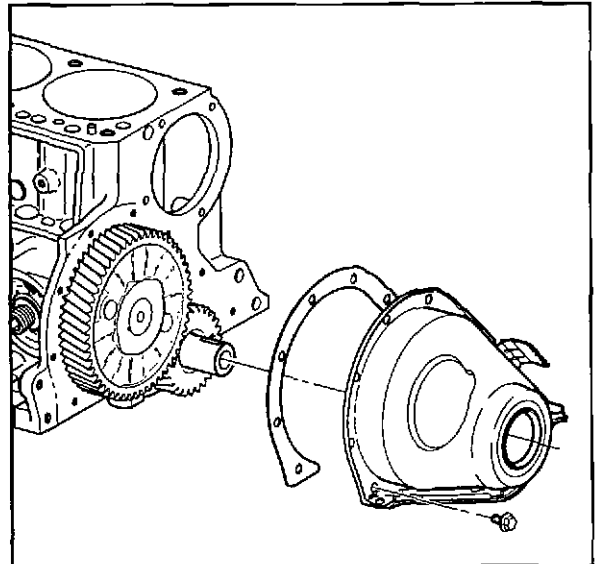
1. Remove the oil level indicator from the tube.
2. Use a drift punch in order to remove the oil level indicator tube from the engine block.



VE128-3L

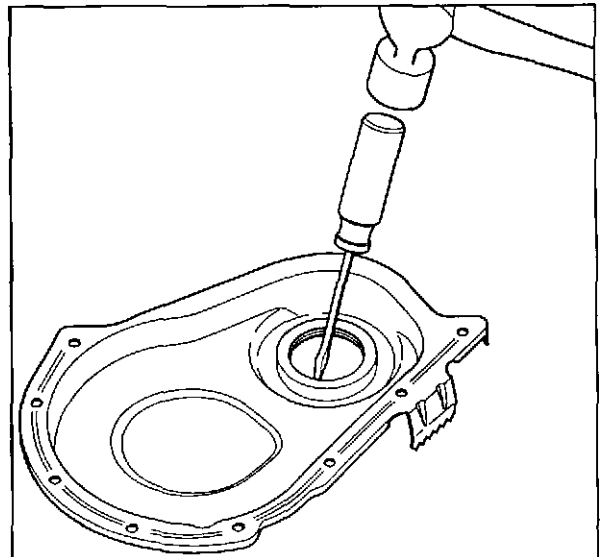
Engine Front Cover Removal

1. Remove the engine front cover bolts.
2. Remove the engine front cover.
3. Remove the gasket.
4. Discard the gasket.

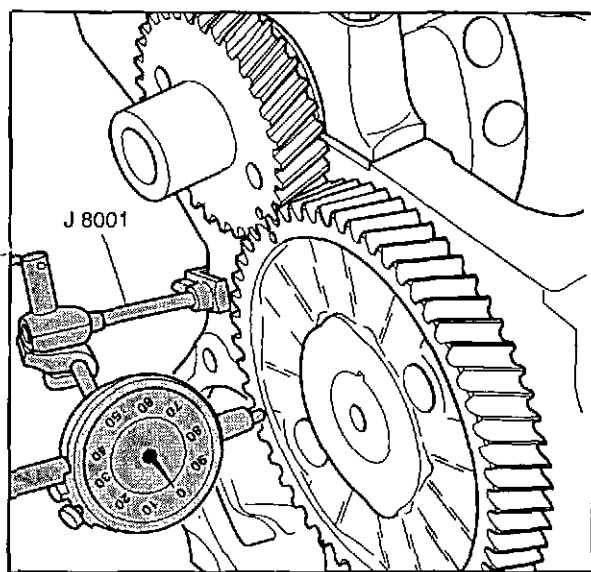


VE030-3L

5. Remove the oil seal from the front cover.
6. Clean the engine front cover in solvent.
7. Inspect the engine front cover for damage to the gasket surface or the oil seal surface.



VE031-3L

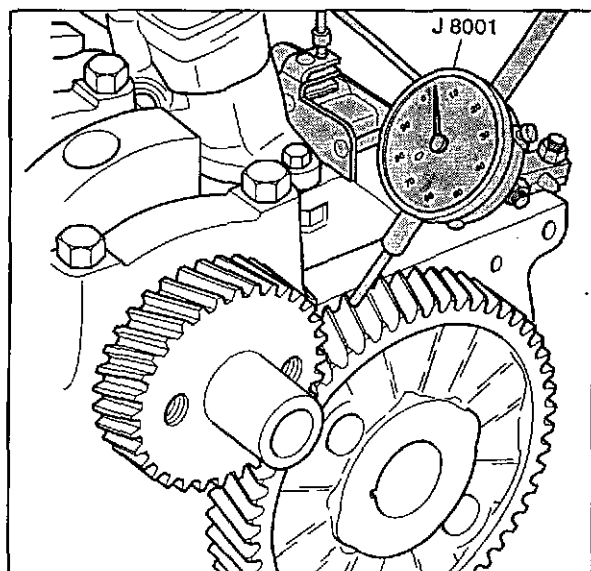


VE032-3L

Measuring Crankshaft and Camshaft Sprocket Runout

Tools Required

- J 8001 Dial Indicator
1. Use the J 8001 in order to measure the crankshaft and camshaft sprocket runout. Refer to *Engine Mechanical Specifications*.
 2. If the sprocket runout exceeds specifications, clean and remove any burrs from the shaft or replace the sprocket.

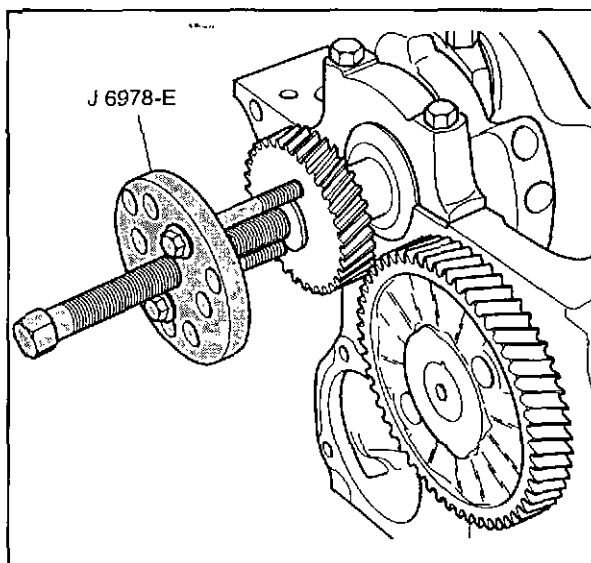


VE033-3L

Measuring Timing Sprocket Teeth Backlash

Tools Required

- J 8001 Dial Indicator
1. Use the J 8001 in order to measure the backlash between the timing sprocket teeth.
 2. Refer to *Engine Mechanical Specifications*.



VE034-3L

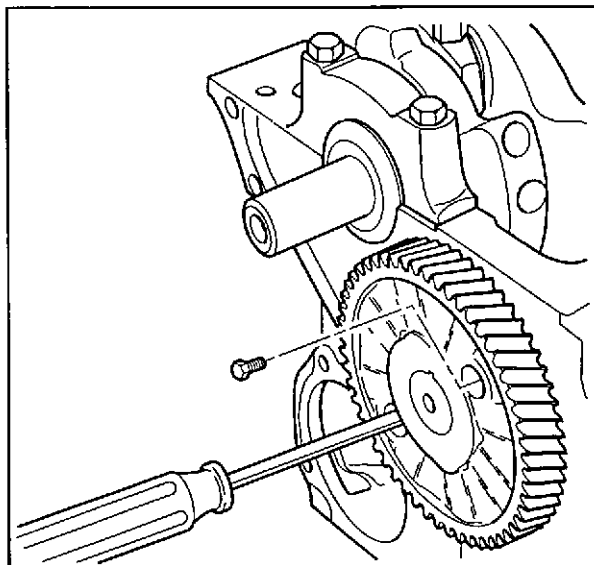
Crankshaft Sprocket Removal

Tools Required

- J 6978-E Crankshaft Sprocket Puller
1. Use the J 6978-E in order to remove the crankshaft sprocket.
 2. If necessary, remove the crankshaft keys.

Camshaft Removal

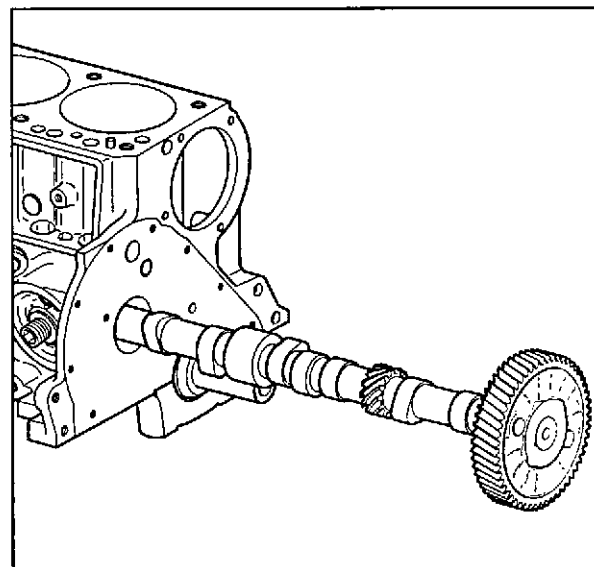
1. Remove the two camshaft retainer bolts, working through the holes in the camshaft sprocket.



VE035-3L

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

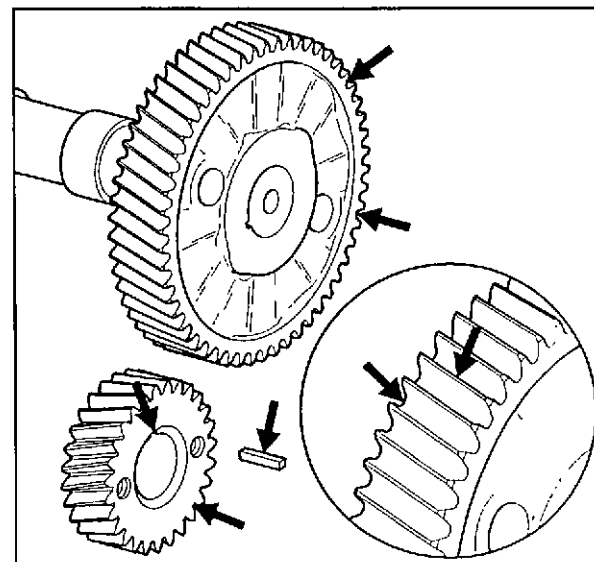
2. Carefully rotate and pull the camshaft out of the bearings.



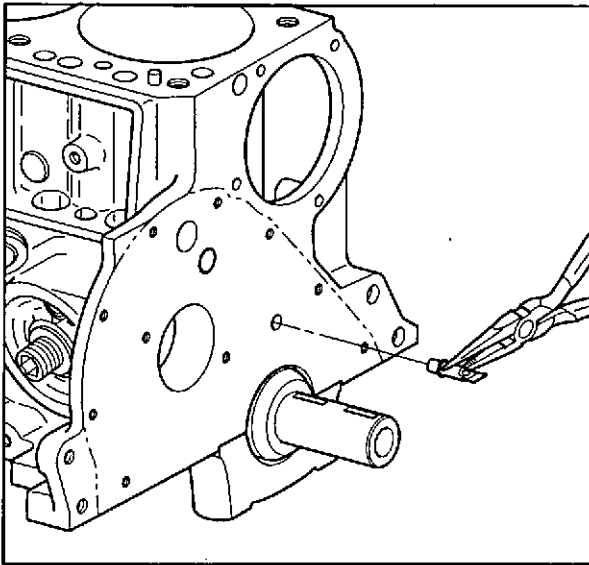
VE125-3L

Crankshaft and Camshaft Sprocket Inspect

- The camshaft and crankshaft sprockets for wear.
- One edge of worn teeth or that are no longer concentric.
- The valley between worn teeth.
- The keys and crankshaft keyways for wear.



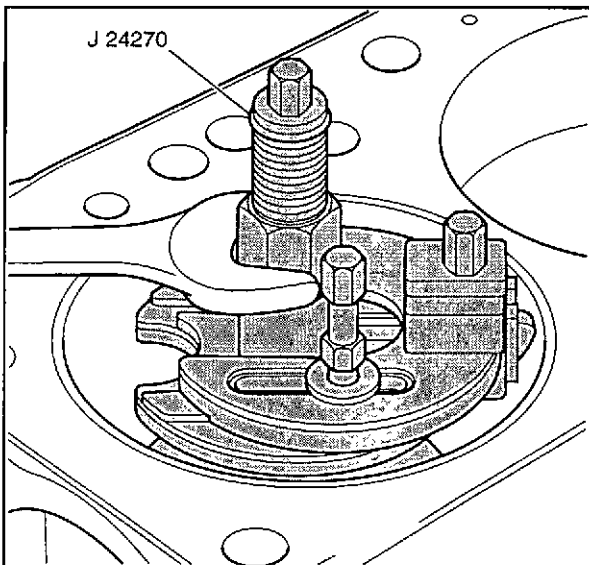
VE126-3L



VE127-3L

Timing Gear Oil Nozzle Removal

1. Remove the oil nozzle with pliers.



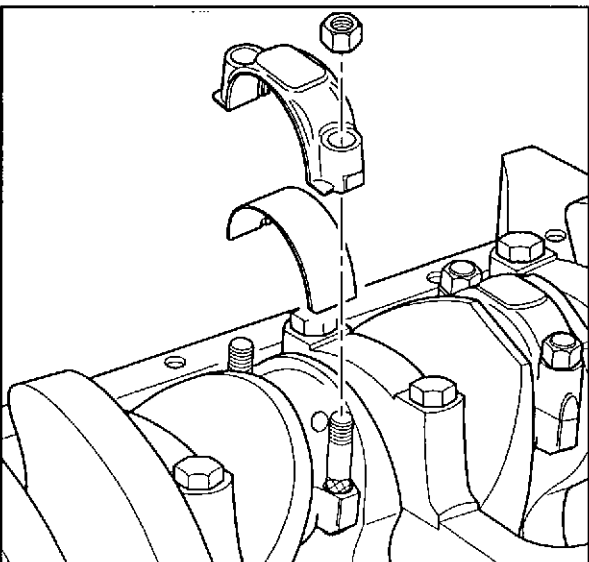
VE036-3L

Piston, Connecting Rod and Bearing Removal

Tools Required

- J 5239 Connecting Rod Guide Tool
- J 24270 Ridge Reamer

1. Remove the ring ridge as following:
 - 1.1. Turn the crankshaft until the piston is at the bottom of the stroke.
 - 1.2. Place a cloth on top of the piston.
 - 1.3. Use the J 24270 to remove the cylinder ring ridge.
 - 1.4. Turn the crankshaft so the piston is at the top of the stroke.
 - 1.5. Remove the cloth.
 - 1.6. Remove the cutting debris.

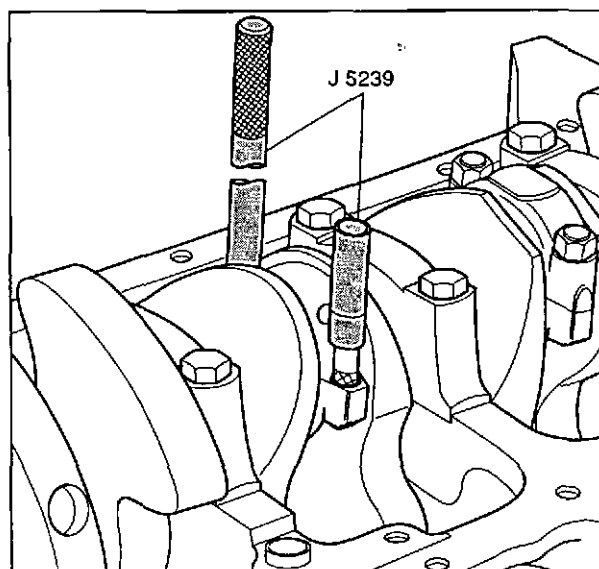


VE037-3L

Important: Place matchmarks or numbers on the connecting rods and the connecting rod caps. Upon removal of the piston and connecting rod assembly, install the connecting rod caps to the matching connecting rods.

2. Remove the connecting rod nuts.
3. Remove the connecting rod cap.
4. Remove the connecting rod bearings.
 - Keep bearings with the original connecting rod and connecting rod cap.
 - Wipe the oil from the bearings.
 - Wipe the oil from the crankpins.

5. Use the J 5239 in order to remove the connecting rod and the piston out of the engine block.
6. Use a hammer and tap lightly on the end of the connecting rod guide tool to remove the piston and connecting rod assembly from the cylinder bore.

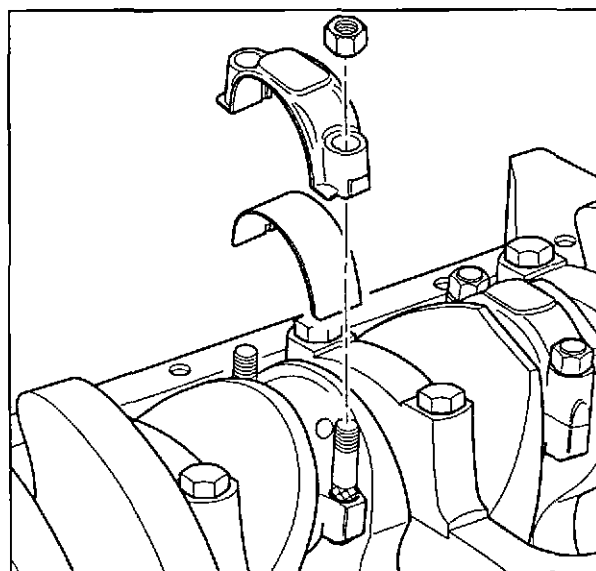


VE038-3L

Crankshaft and Bearings Clean and Inspect (Connecting Rod Bearing Clearance)

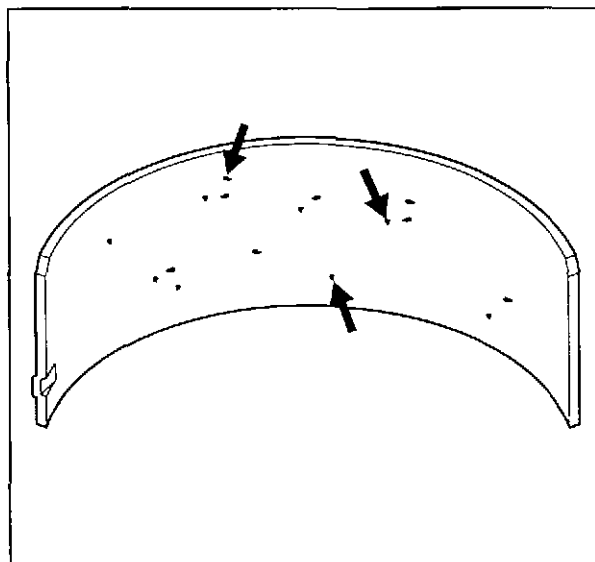
Important: Connecting rod bearings are a precision insert type. Connecting rods are of a powdered metal design and cannot be shimmed or filed for bearing fit. If clearances are found to be excessive, a new bearing and/or connecting rod are required. Do not rotate the crankshaft while gauging plastic is between the crankshaft journal and the bearing surface.

1. Remove the connecting rod nuts.
2. Remove the connecting rod cap and bearing.

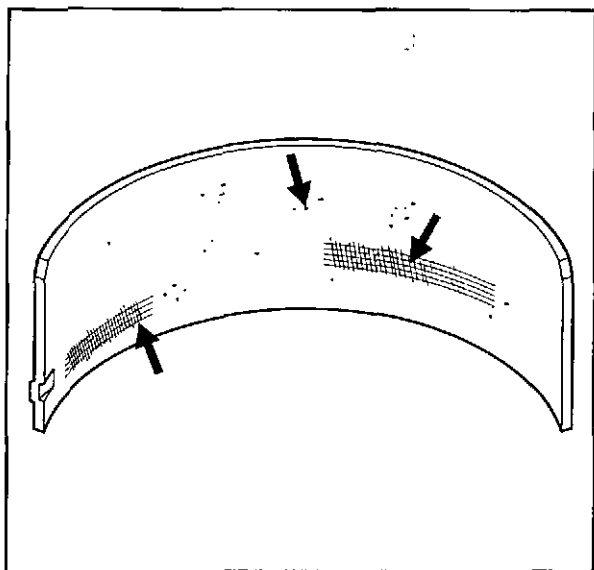


VE037-3L

3. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

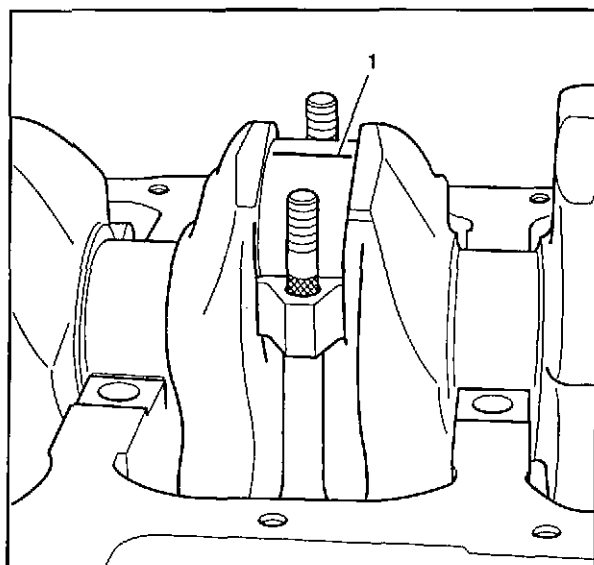


VE039-3L



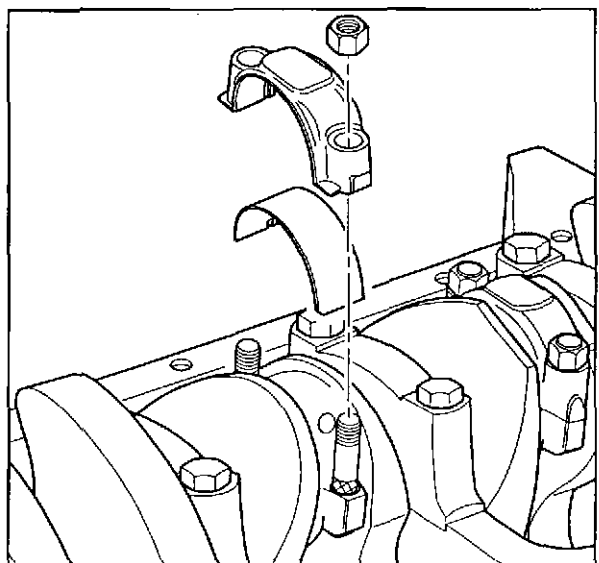
VE040-3L

4. Inspect the crankshaft bearings for excessive scoring or discoloration.
5. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.



VE041-3L

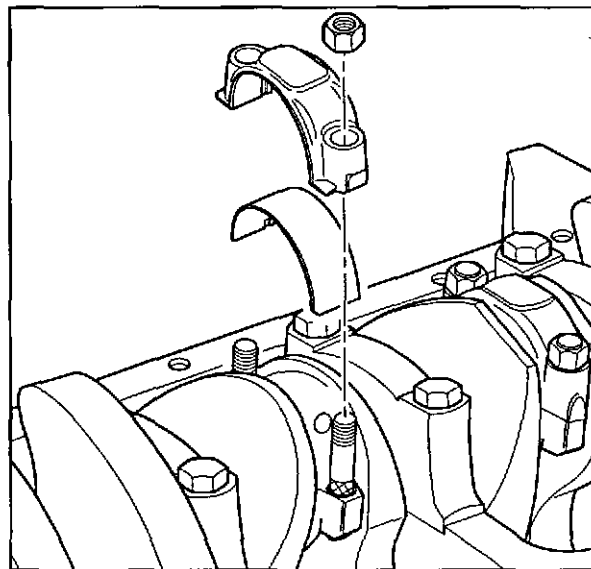
6. Install the gauging plastic (1) onto the connecting rod bearing journal. Install the gauging plastic the full width of the journal.



VE037-3L

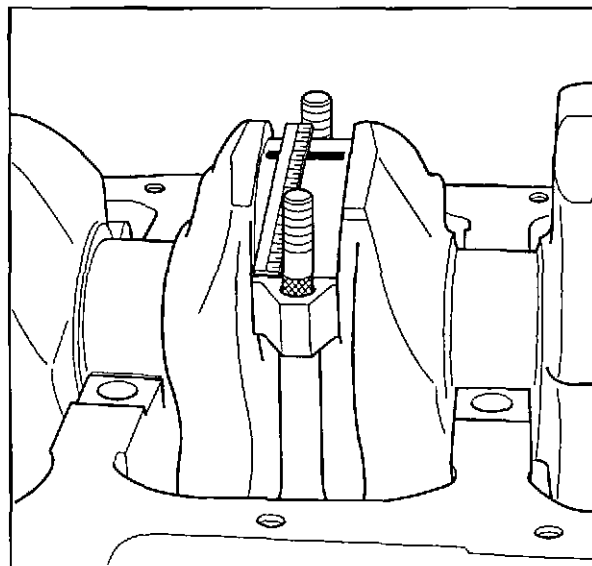
7. Install the connecting rod cap and bearing.
Tighten
Tighten the nuts evenly to 61 N•m (45 lb ft).

8. Remove the connecting rod nuts.
9. Remove the connecting rod cap and bearing.



VE037-3L

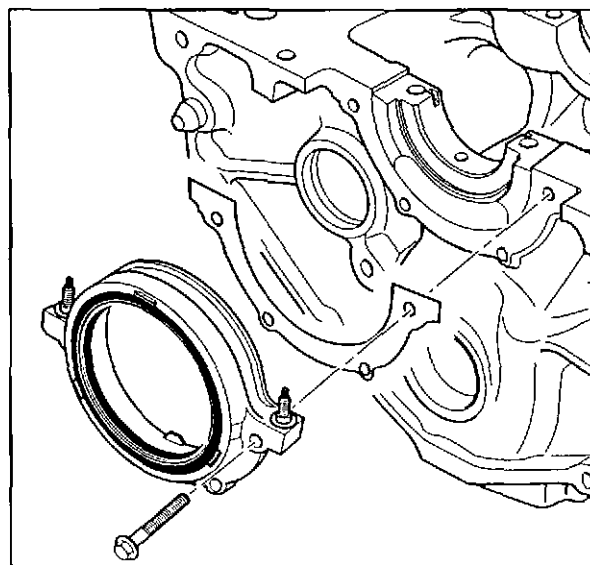
10. Measure the gauging plastic at its widest area using the scale supplied with the plastic gauging kit.
11. Compare the measurements to *Engine Mechanical Specifications*.



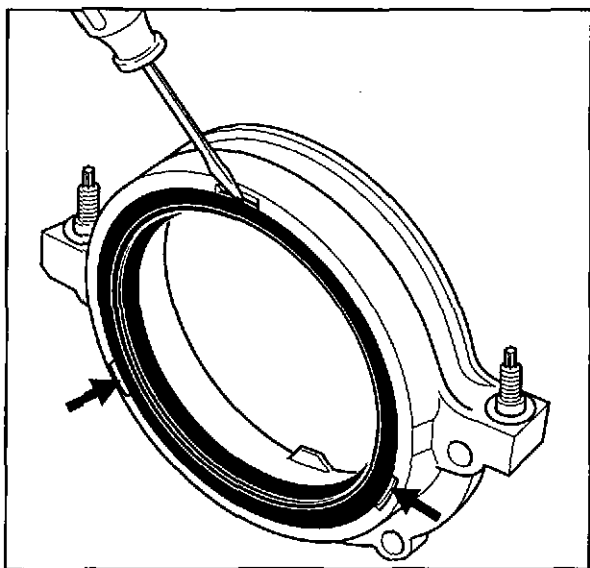
VE042-3L

Crankshaft Rear Oil Seal and Housing Removal

1. Remove the crankshaft rear oil seal housing bolts.
2. Remove the crankshaft rear oil seal housing, seal and gasket.

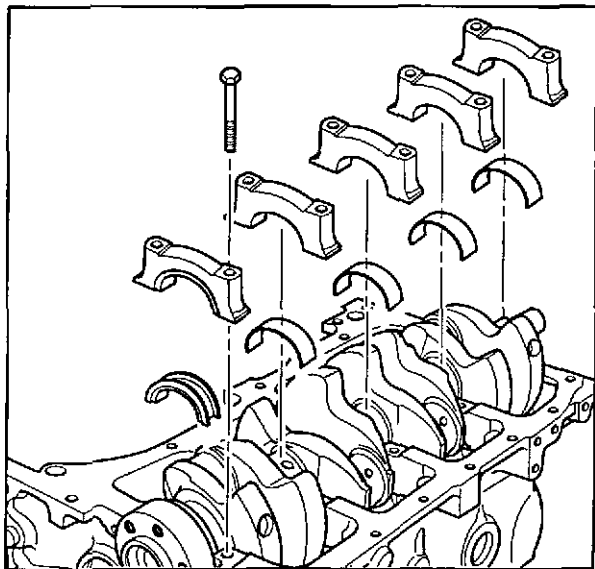


VE043-3L



VE044-3L

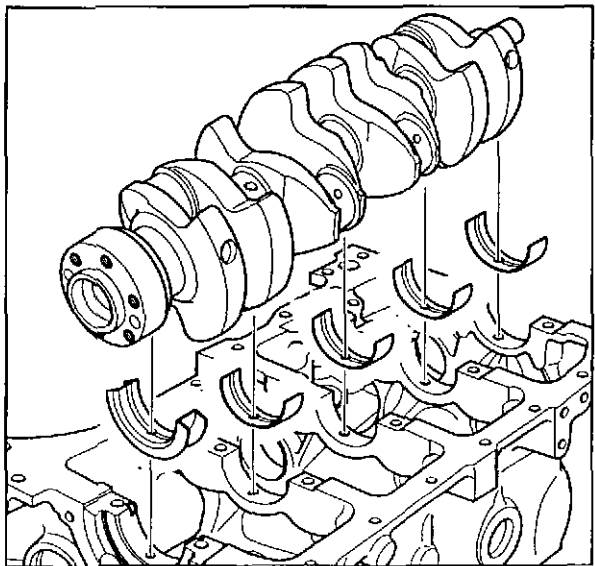
3. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.



VE045-3L

Crankshaft , Bearings and Bearing Cap Removal

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



VE046-3L

3. Remove the crankshaft.
4. Remove the crankshaft bearings from the bearing caps and from the engine block.

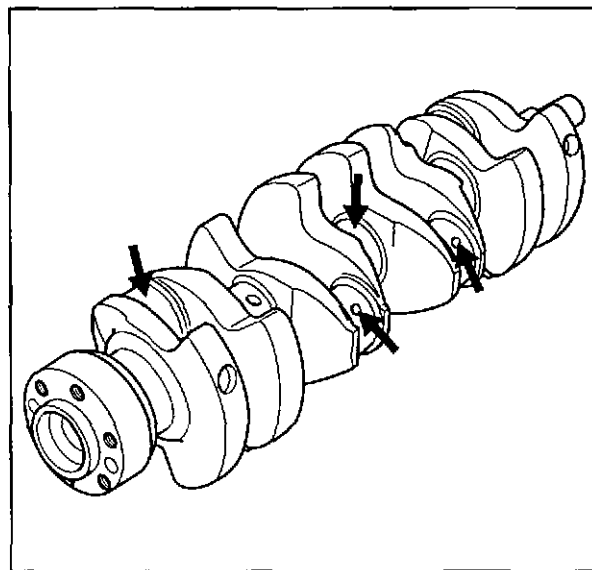
Crankshaft and Bearings Clean and Inspect

Tools Required

- J 7872 Magnetic Base Indicator Set

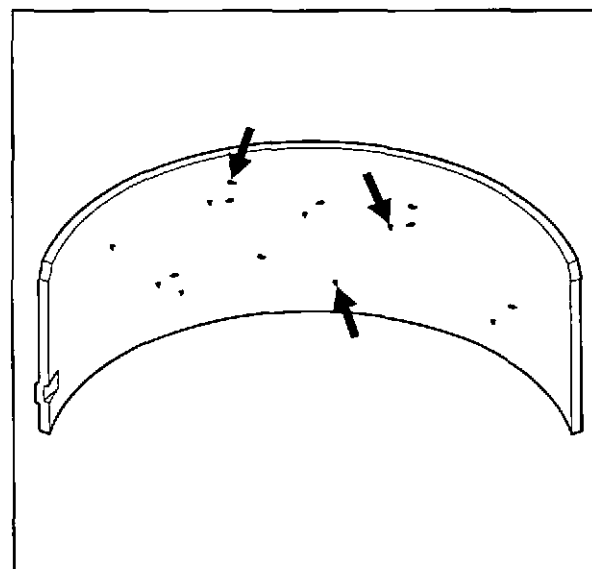
Caution: *Wear safety glasses in order to avoid eye damage.*

1. Clean the crankshaft in solvent.
2. Inspect the crankshaft oil passages for restrictions.
3. Dry the crankshaft with compressed air.
4. Inspect the crankpins for scoring or wear.



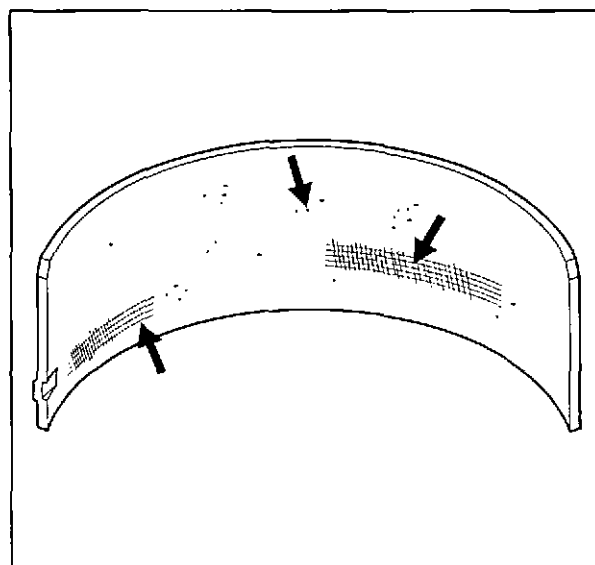
VE047-3L

5. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

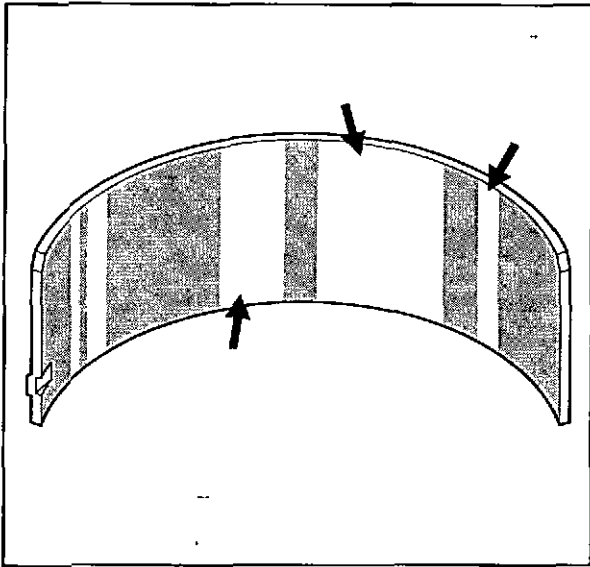


VE039-3L

6. Inspect the crankshaft bearings for excessive scoring or discoloration.
7. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

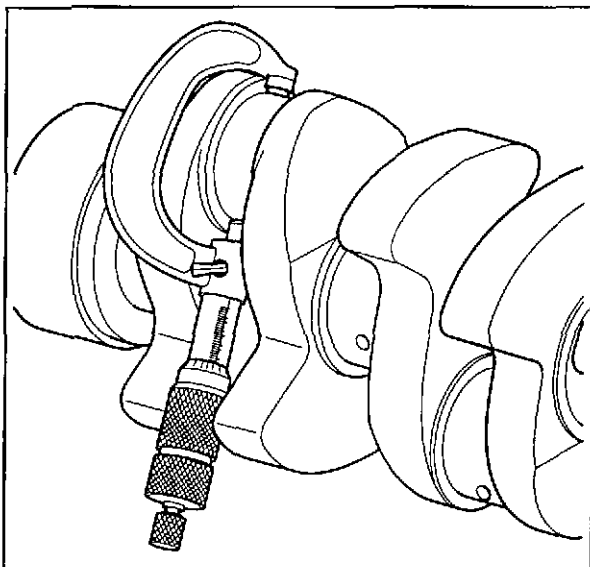


VE040-3L



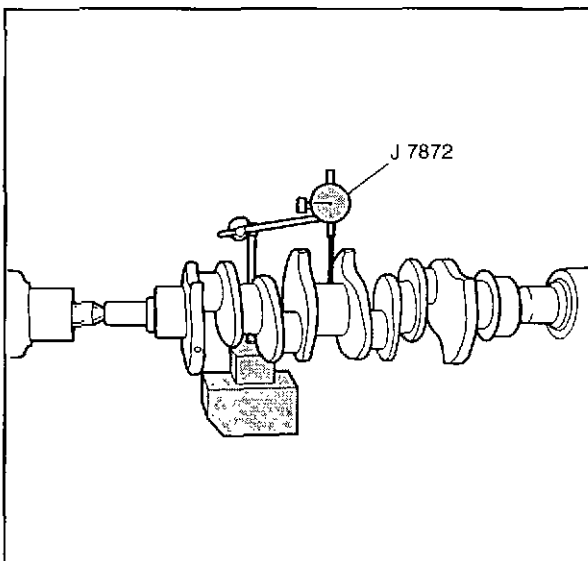
VE048-3L

8. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.
 - If the lower half of the bearing is worn or damaged, both the upper and lower halves must be replaced.



VE049-3L

9. Measure the crankpins for out-of-round, taper or undersize with a micrometer. Refer to *Engine Mechanical Specifications*.



VE050-3L

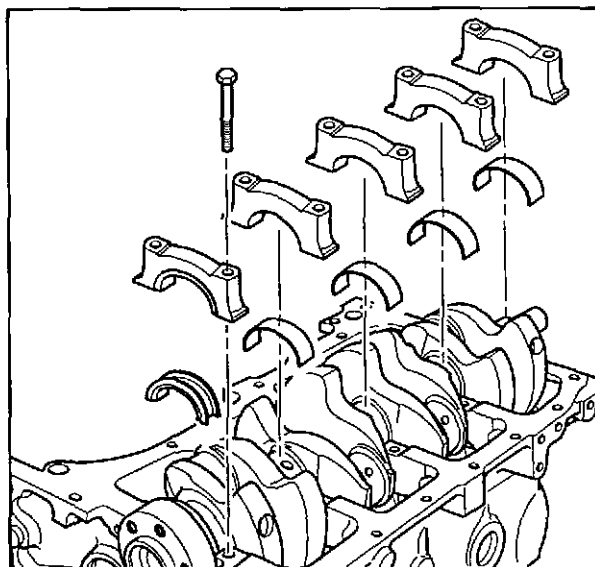
10. Support the crankshaft front and rear journals on V-blocks.
11. Measure the crankshaft run-out at front and rear intermediate journals with J 7872. Refer to *Engine Mechanical Specifications*.
12. Replace or recondition crankshaft if measurements are not within specifications.

Crankshaft and Bearings Clean and Inspect (Main Bearing Clearance)

Important: Crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. Crankshaft bearing clearances are critical. If the clearances are found to be excessive, new bearings and/or engine block and cap repair may be required.

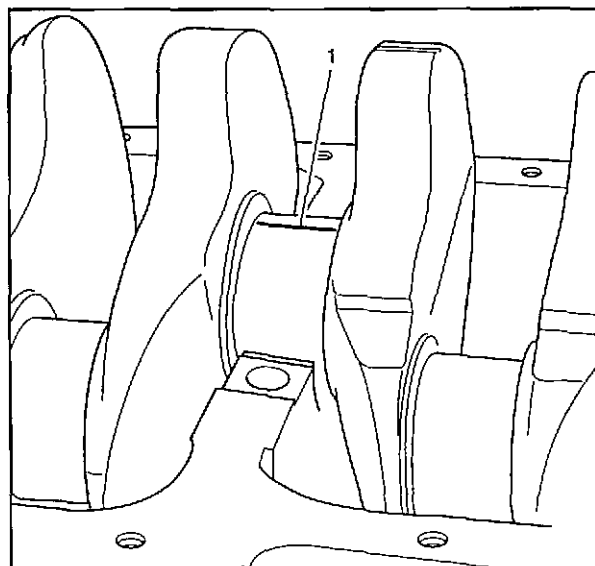
Do not rotate the crankshaft while gauging plastic is between the crankshaft journal and the bearing surface.

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



VE045-3L

3. Install gauging plastic (1) onto the crankshaft journal. Install the gauging plastic the full width of the crankshaft bearing journal.

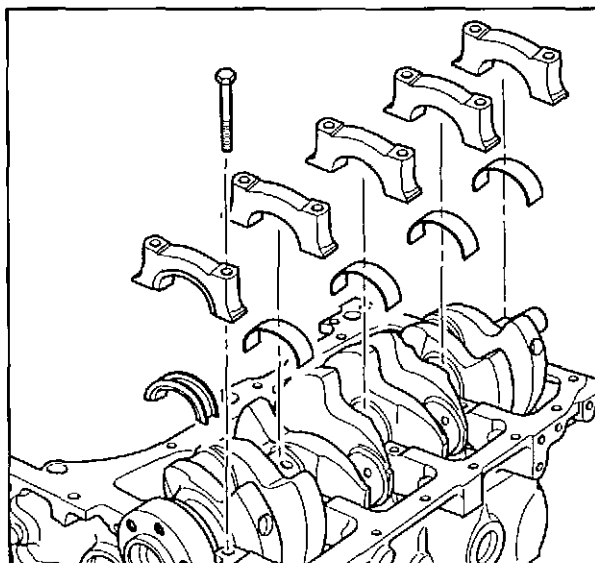


VE051-3L

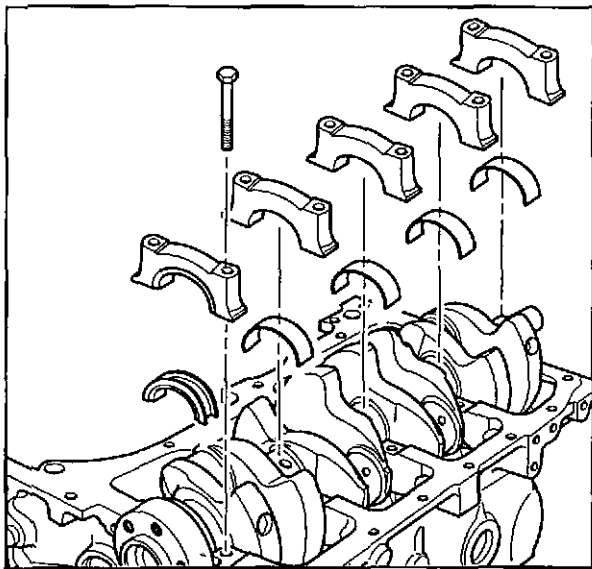
4. Install the bearing, bearing cap and bolts.

Tighten

Tighten the crankshaft bearing cap bolts to 88 N•m (65 lb ft).

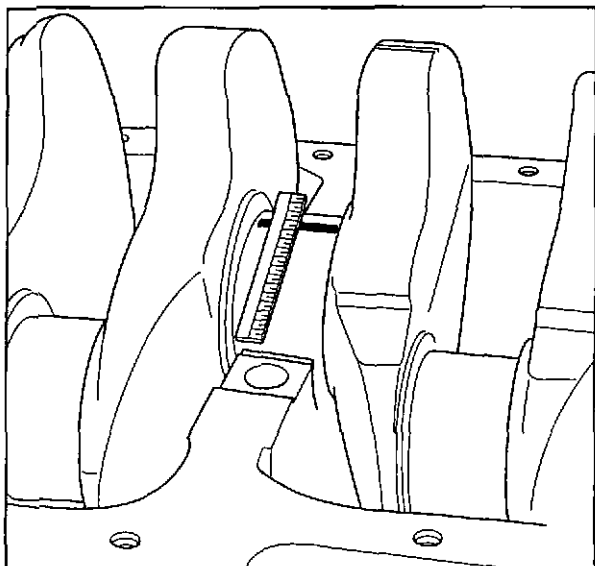


VE045-3L



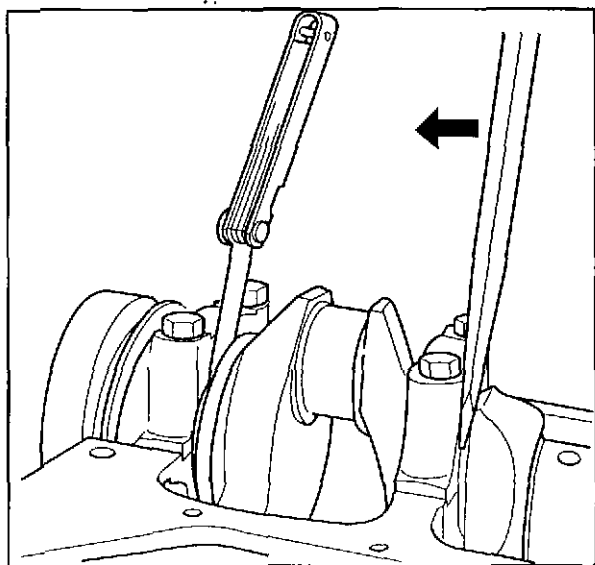
VE045-3L

5. Remove the crankshaft bearing cap bolts.
6. Remove the crankshaft bearing caps.



VE052-3L

7. Measure the gauging plastic at its widest area using the scale supplied with the plastic gauging kit.
8. Compare the measurements to *Engine Mechanical Specifications*.
 - If the gauging plastic shows irregularity in the journal exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
 - If the clearance is greater than *Engine Mechanical Specifications*, select and install an undersized bearing set. Measure the clearance with gauging plastic.
 - If clearance cannot be brought to specifications, grind the crankshaft for use with the next undersized bearing.



VE053-3L

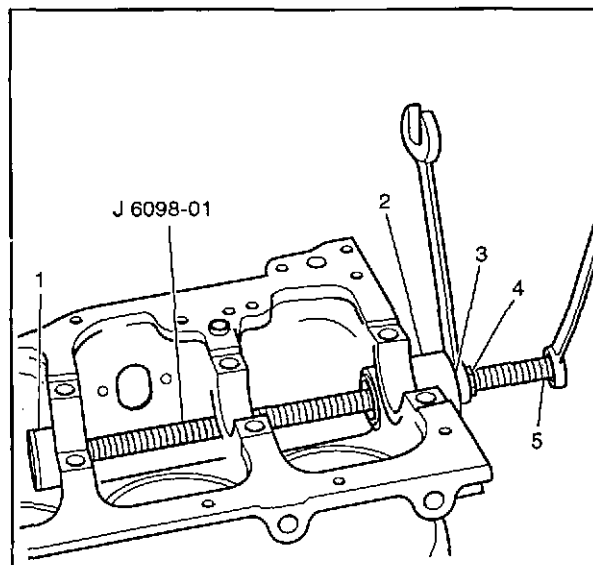
9. Use a dial indicator or feeler gauge in order to measure end play between the front of the rear of the crankshaft bearing cap and the crankshaft thrust surface in order to determine the crankshaft end play.
10. If you use a feeler gauge, measure between the thrust surface of the crankshaft bearing and the crankshaft. Refer to *Engine Mechanical Specifications*.

Camshaft Bearing Removal

Tools Required

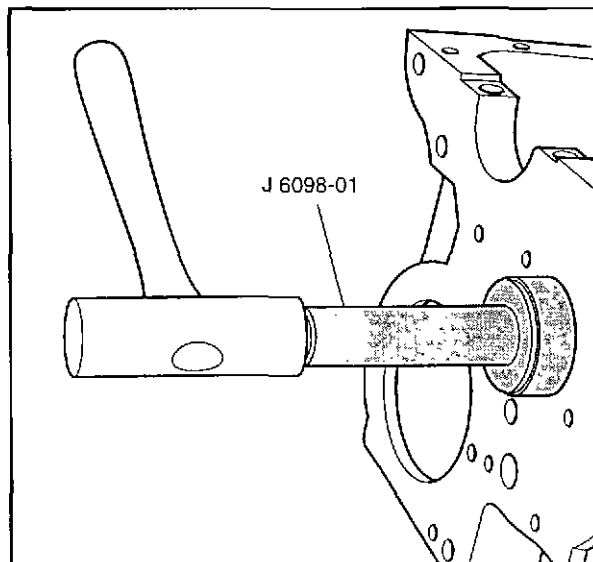
- J 6098-01 Camshaft Bearing Remover/Installer

1. Remove the camshaft rear bearing hole plug.
2. Use the J 6098-01 in order to remove the inner camshaft bearings. Repeat the following procedure for each of the inner camshaft bearings:
 - 2.1. With the nut (4) and the thrust washer (3) installed to the end of the puller screw threads, index the pilot (2) in the camshaft front bearing and install the puller screw through the pilot (2) and the bearing to be removed.
 - 2.2. Install the bearing tool (1) with the shoulder toward the bearing.
 - 2.3. Using two wrenches, hold puller screw (5) while you turn the nut (4) in order to draw the bearing out of the bore.
 - 2.4. When the bearing has been pulled from the bore, remove the bearing tool and the bearing from the puller screw.
 - 2.5. Index the pilot in the rear camshaft bearing in order to remove the rear inner camshaft bearing.

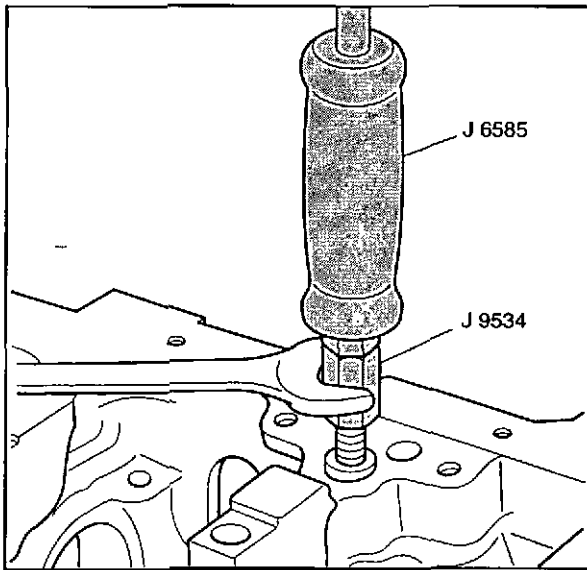


VE054-3L

3. Use the J 6098-01 in order to remove the front and rear camshaft bearings.
 - 3.1. Assemble the bearing tool to the driver.
 - 3.2. Drive the front and rear camshaft bearings out of the block bore. Drive inward toward the center of the engine block.



VE055-3L

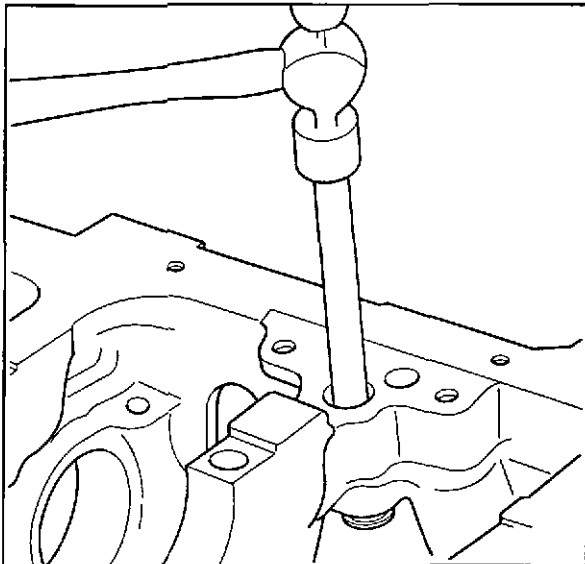


VE056-3L

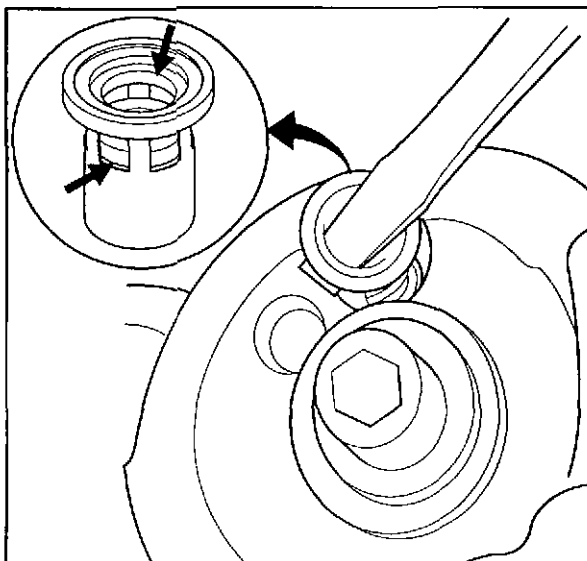
Distributor Lower Bushing and Thrust Washer Removal

Tools Required

- J 9534 Distributor Lower Bushing Remover
 - J 6585 Slide Hammer
1. Install the J 9534 into the distributor lower bushing.
 2. Use the J 6585 in order to remove the bushing.
 3. Use a drift punch up through the bushing bore in order to drive the thrust washer (if installed) out of the bore.
 4. Clean the bushing bore in the cylinder block and inspect for burrs or damage.



VE057-3L



VE058-3L

Oil Filter Bypass Valve Removal and Installation

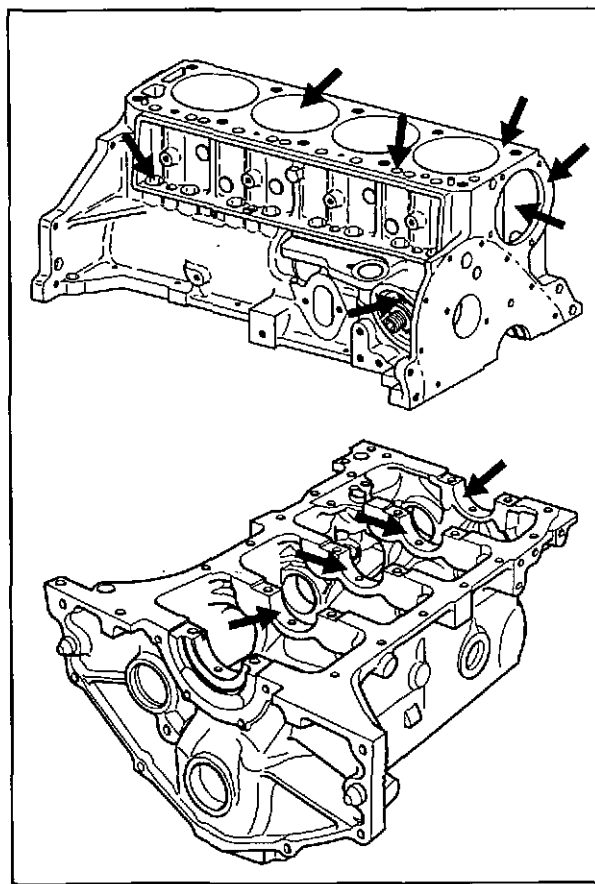
1. Check the spring and fiber valve for operation.
2. Inspect for a cracked or broken valve.
3. Use a screwdriver in order to pry the valve out.
4. Use a 9/16 in thin-wall deep socket in order to tap the new bypass valve in place.

Cylinder Block Clean and Inspect

1. Clean the following areas:
 - The engine block in solvent, removing all sludge, dirt or debris

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

- Dry the block with compressed air.
 - The gasket surfaces.
 - The coolant passages.
 - The oil passages.
 - The main bearing caps.
2. Inspect the following areas:
 - The cylinder walls for excessive scratches, gouging or ring ridge.
 - The coolant jackets for cracks.
 - The valve lifter bores for excessive scoring or wear.
 - The crankshaft bearing webs for cracks.
 - The gasket sealing surfaces for excessive scratches or gouging.
 - The oil passages for restrictions.
 - All threaded bolt holes for thread damage.

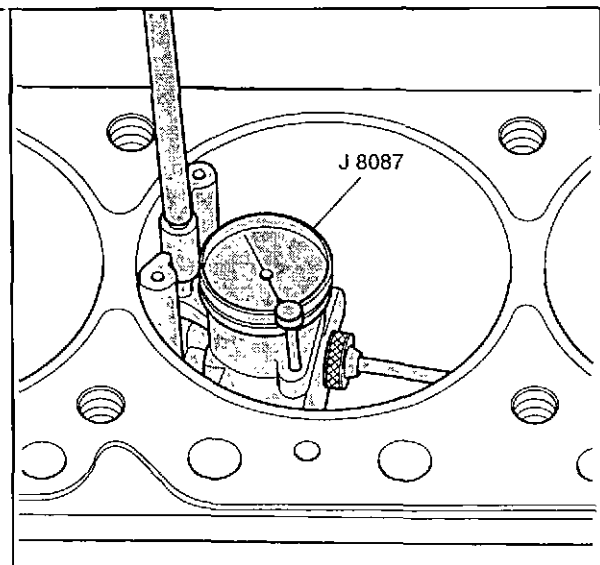


VE059-3L

Cylinder Bore Measurements

Tools Required

- J 8087 Cylinder Bore Gauge
1. Use the J 8087 in order to check cylinder bore taper and out-of-round as follows:
 - 1.1. Set the gauge so that the thrust pin must be forced in about 1/4 in to enter the gauge in the cylinder bore.
 - 1.2. Center the gauge in the cylinder and turn the dial to "0."
 - 1.3. Work the gauge up and down to determine the taper.
 - 1.4. Turn the gauge to different point around the cylinder to determine the out-of-round condition. Refer to *Engine Mechanical Specifications*.



VE060-3L

Cylinder Boring and Honing

Boring Procedure

1. Before you start the honing or reboring process, measure all new pistons with the micrometer, contacting at points exactly 90° from the piston pin centerline. Refer to *Piston Selection*. Select the smallest piston for the piston fitting. Slightly varied pistons in a set may provide correction, in case the first piston is too loosely fitted.
2. Before you use any type of boring bar, file the top of the cylinder block in order to remove any dirt or burrs. If you do not check the cylinder block, the boring bar may be tilted, this could result in the rebored cylinder wall being at incorrect right angles from the crankshaft.
3. Carefully follow the instructions furnished by the manufacturer regarding the use of the equipment.
4. When you rebore cylinders, make sure all crankshaft bearing caps are in place. Tighten the bearing caps to the proper torque in order to avoid distortion of the bores in the final assembly. The crankshaft must be clear of the boring cutter when you bore each cylinder. Cover or tape the crankshaft bearings and other internal parts to protect during the boring or honing process.

Honing Procedure

1. When honing the cylinders, follow the manufacturer's recommendations for use, cleaning and lubrication. Use only clean, sharp stones of the proper grade for the amount of material you remove. Dull, dirty stones cut unevenly and generate excessive heat. When using coarse or medium-grade stones, leave sufficient metal so that all stone marks may be removed with the fine stones you use for finishing in order to provide for proper clearance.
2. During the honing process, thoroughly clean the cylinder bore. Check for a correct fit of the piston you select for the individual cylinder.
3. When honing to eliminate taper in the cylinder, make full strokes of the hone in the cylinder. Repeatedly check the measurement at the top, the middle and the bottom of the 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.

4. When finished honing a cylinder bore to fit a piston, move the hone up and down at a sufficient speed to obtain very fine, uniform surface finish marks in a

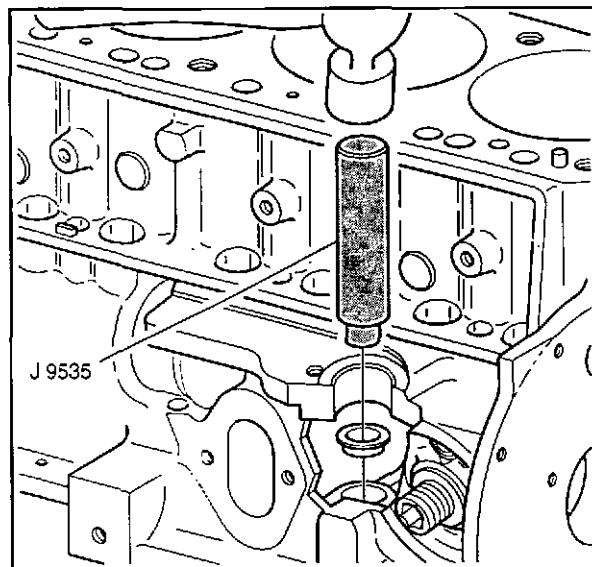
cross hatch pattern at 45-65 degrees.

5. The finish marks should be clean but not sharp. The finish marks should be free from imbedded particles and torn or folded metal.
6. By measuring the piston to be installed at the sizing point specified and by adding the average of the clearance specification, you can determine the finish hone cylinder measurement. Refer to *Engine Mechanical Specifications*. Measure the block and the piston at normal room temperature.
7. True up the refinished cylinder bores to have less than the specified out-of-round or taper. You must finish hone each bore in order to remove all stone or cutter marks and in order to provide a smooth surface.
8. For piston-to-bore tolerance specifications, Refer to *Engine Mechanical Specifications*.
9. 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 you wash the bore, brush the dry bore clean with a power-driven fiber brush.
10. Permanently mark the piston for the cylinder to which the piston has been fitted.
11. Apply clean engine oil to each bore in order to prevent rusting.

Distributor Lower Bushing and Thrust Washer Installation

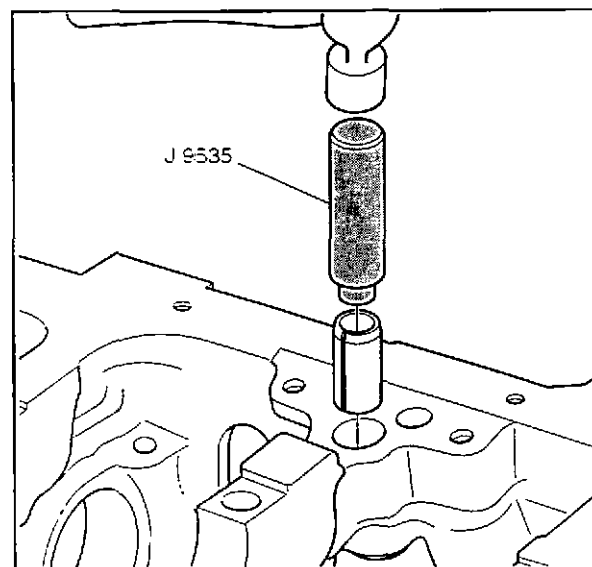
Tools Required

- J 9535 Distributor Lower Bushing Installer
1. Use the J 9535 in order to drive the thrust washer (if removed) into the cylinder block.
 2. Use the J 9535 with the driver-bolt in the driver handle.



VE061-3L

3. Install the driver into the new bushing from the large inside diameter.
4. Drive the new bushing into the cylinder block until the J 9535 bottoms against the cylinder block.

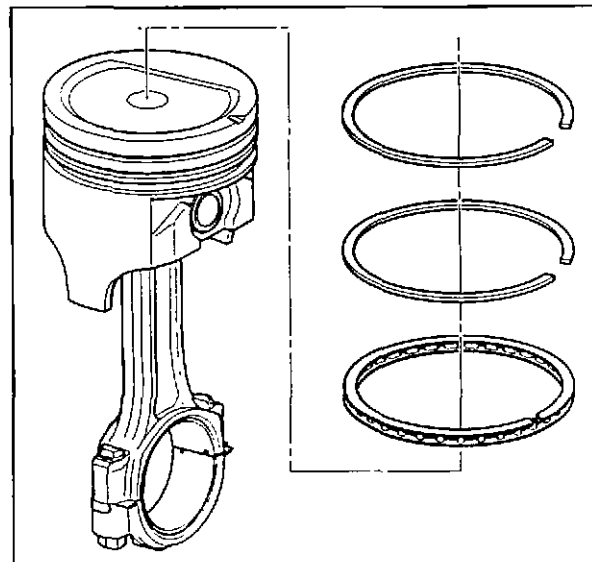


VE062-3L

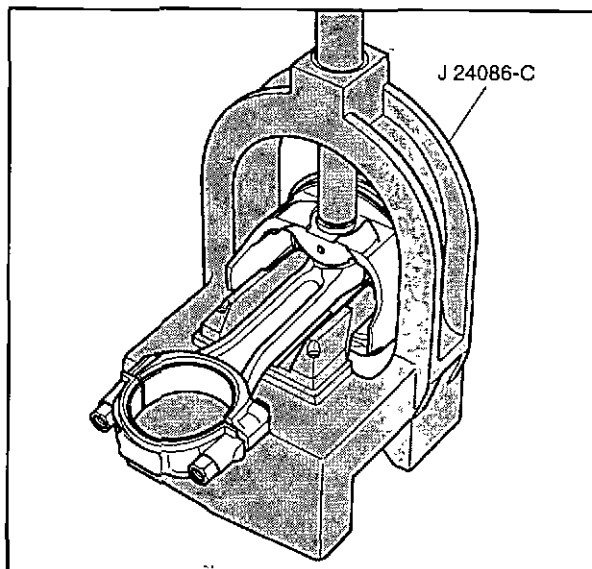
Piston and Connecting Rod Disassemble

Tools Required

- J 24086-C Piston Pin Removal Set
1. Remove the piston rings from the pistons.



VE063-3L



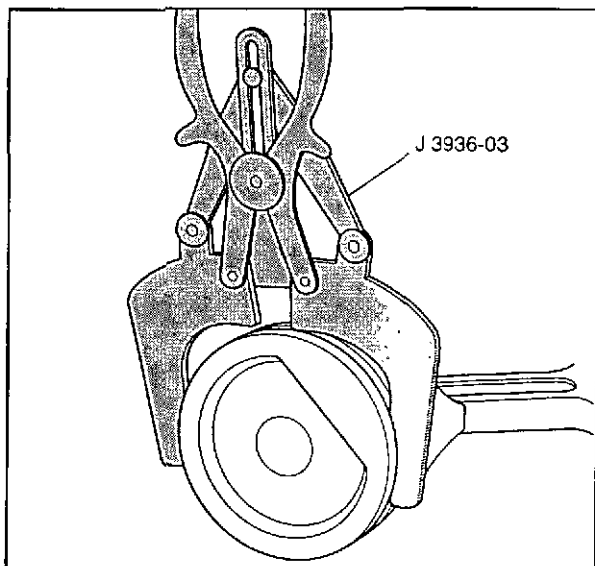
VE064-3L

2. Remove the pin from the piston.

Notice: After the J 24086-C Installer bottoms on the support assembly, do not exceed 34,475 kPa (5000 psi) or the tool may be damaged.

Piston and Connecting Rod Clean and Inspect

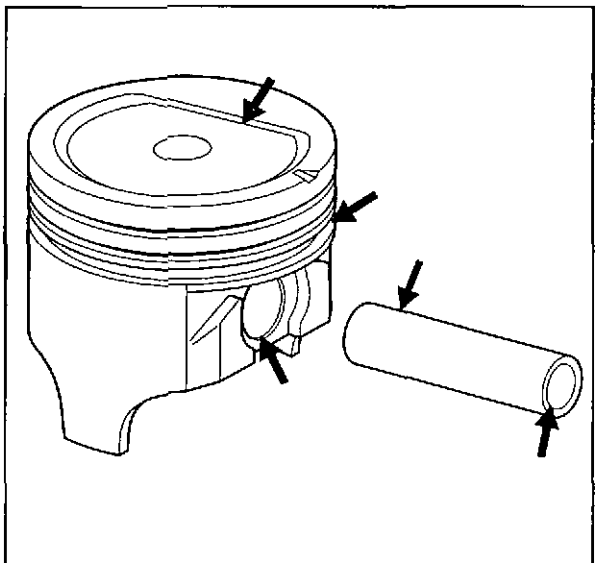
1. Clean the piston ring grooves with a groove cleaner.



VE065-3L

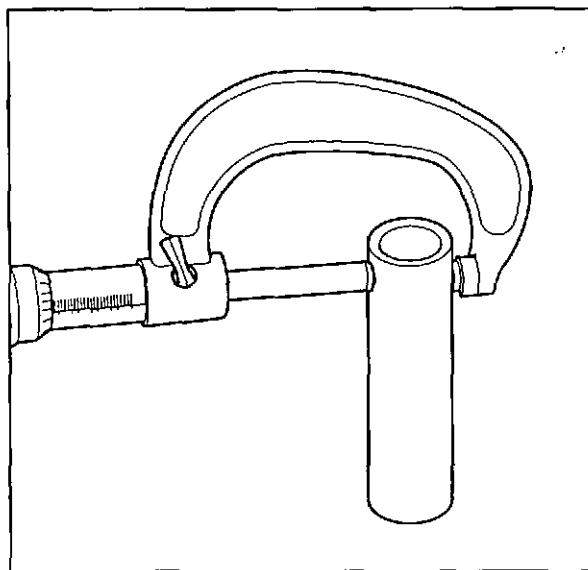
Caution: Wear safety glasses in order to avoid eye damage.

2. Clean the connecting rod in cleaning solvent.
3. Clean the varnish from the piston skirts and the pins with cleaning solvent.
4. Dry the components with compressed air.
5. Do not use a wire brush in order to clean any part of the piston.
6. Clean the piston oil ring holes and the slots.
7. Inspect the connecting rod for twisting, nicks and cracks. Replace any damaged connecting rods.
8. Inspect the pistons for the following conditions:
 - Cracked ring lands, skirts or pin bosses.
 - Nicks or spurs in the grooves that may cause binding.
 - Warped or worn ring lands.
 - Scuffed or damaged skirts.
 - Eroded areas at the top of the piston.
 - Worn piston bores and piston pins.
9. Replace pistons that are damaged or show signs of excessive wear.



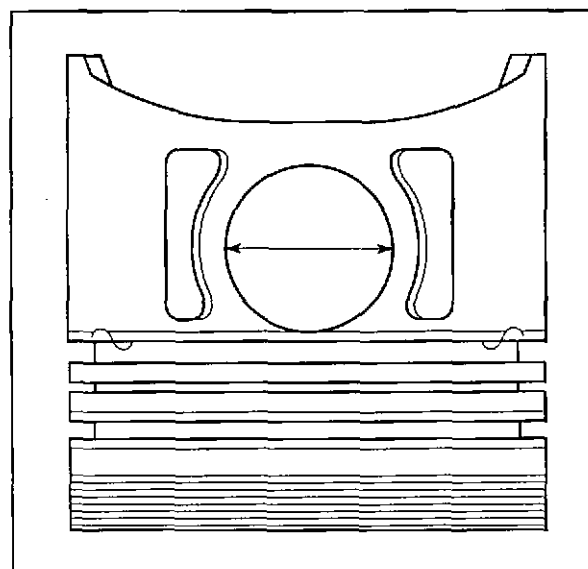
VE066-3L

10. Measure the pin bore-to-piston clearance.
 - 10.1. The piston pin bores and the piston pins must be free of varnish or scuffing when being measured.
 - 10.2. Use a micrometer in order to measure the piston pin.



VE067-3L

- 10.3. Use an inside micrometer in order to measure the piston pin bore. Replace the piston and piston pin if the clearance is in excess of 0.0254 mm (0.001 in).
 - 10.4. Match the piston and piston pin. Do not service separately.

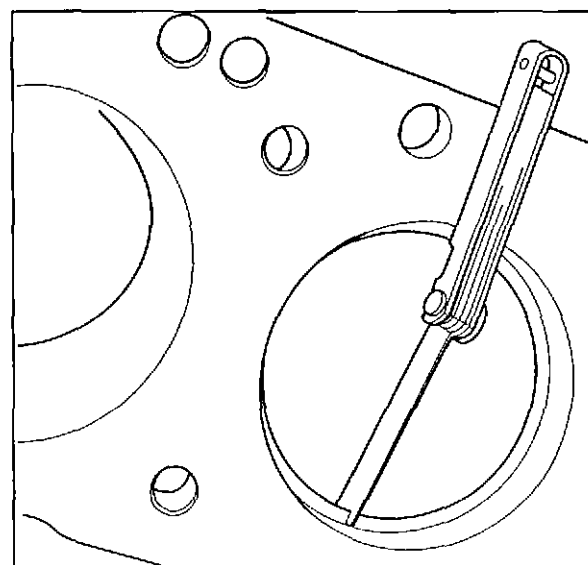


VE068-3L

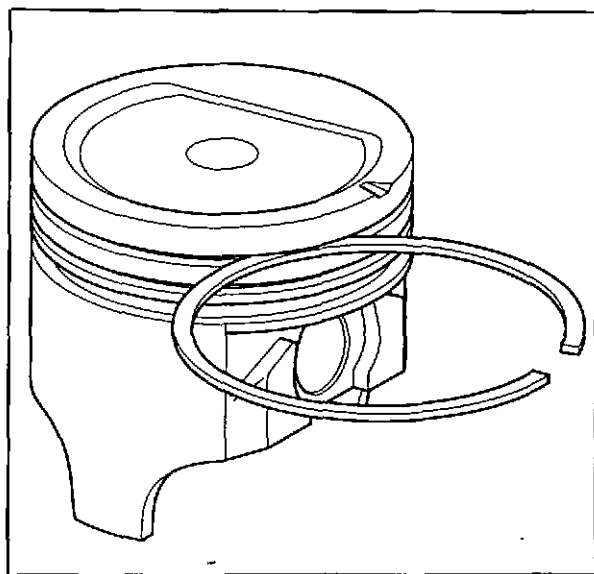
11. Measure the piston compression ring end gap.

Important: Fit each compression ring to the cylinder in which it will be used.

- 11.1. Place the compression ring into the cylinder bore.
 - 11.2. Push the compression ring into the cylinder bore approximately 6.5 mm (0.25 in) above the ring travel. The ring must be square to the cylinder wall.
 - 11.3. Use a feeler gauge in order to measure the end gap.
 - 11.4. Select another size ring set if the end gap exceeds specifications.

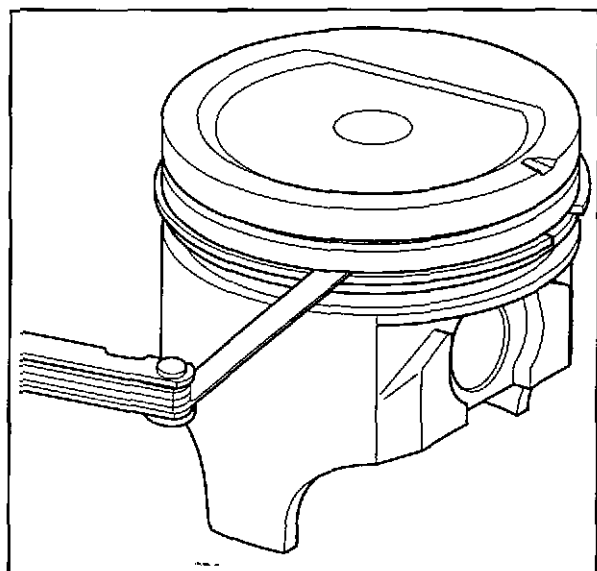


VE069-3L



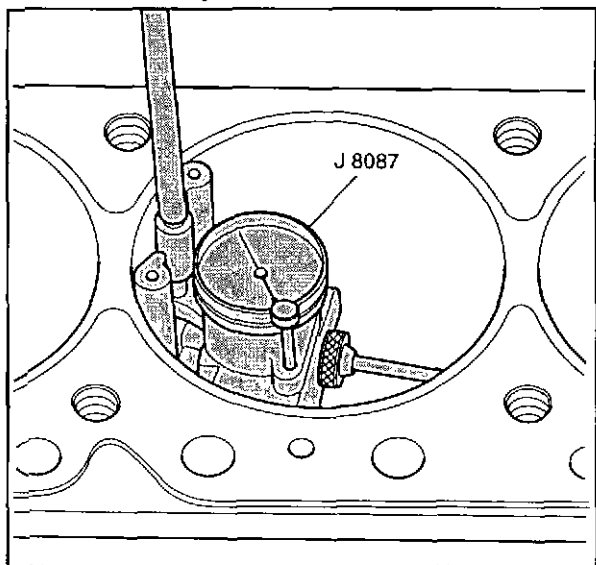
VE070-3L

12. Measure the piston ring side clearance.
 - 12.1. Roll the piston ring entirely around its ring groove on the piston.
 - 12.2. Dress the groove with a fine cut file if the ring groove causes binding.
 - 12.3. Replace the piston ring if a distorted piston ring causes binding.



VE071-3L

- 12.4. Use a feeler gauge in order to measure the side clearance of the piston ring and groove.
- 12.5. Try another piston ring if the side clearance is too small.



VE060-3L

Piston Selection

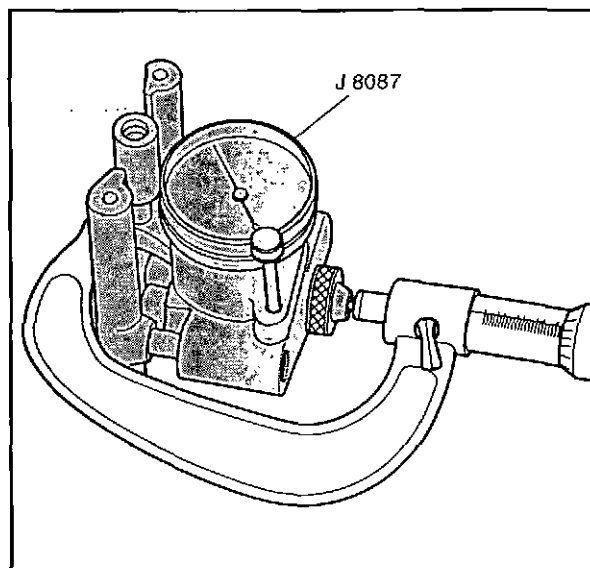
Important: Measurements of all components should be taken with the components at normal room temperature.

For proper piston fit, the engine block cylinder bores must not have excessive wear or taper.

A used piston and pin set may be reinstalled if, after cleaning and inspection, they are within specifications.

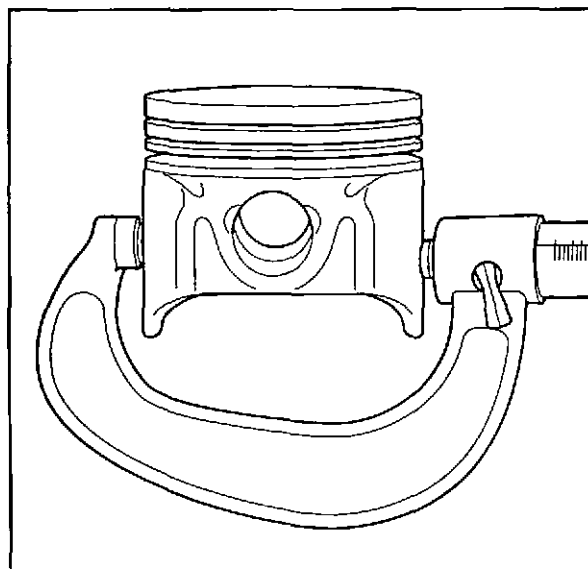
1. Inspect the engine block cylinder bore. Refer to *Cylinder Block Clean and Inspect*.
2. Inspect the piston and piston pin. Refer to *Piston and Connecting Rod Clean and Inspect*.
3. Use a boring gauge in order to measure the cylinder bore diameter at a point of 66 mm (2.5 in) from the top of the cylinder bore.

4. Measure the bore gauge with a micrometer and record the reading.



VE072-3L

5. With a micrometer or caliper at a right angle to the piston, measure the piston 11 mm (0.433 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance, Refer to *Engine Mechanical Specifications*.
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances. If the proper fit cannot be obtained, the cylinder bore may require boring or honing. Refer to *Cylinder Boring and Honing*.
9. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation to the proper cylinder.



VE073-3L

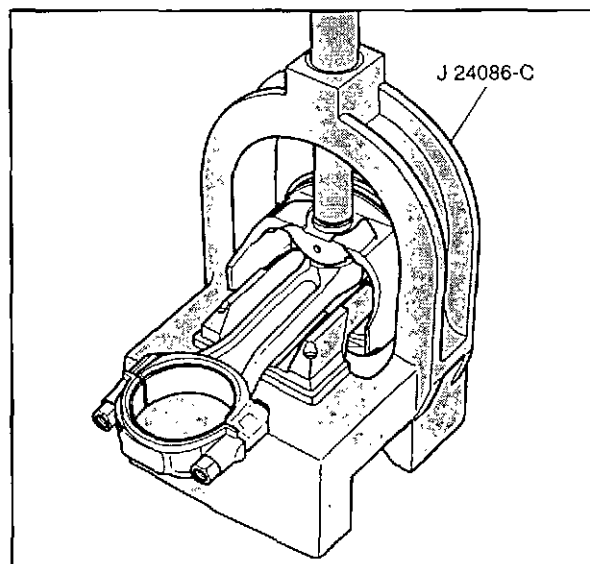
Piston and Connecting Rod Assemble

Tools Required

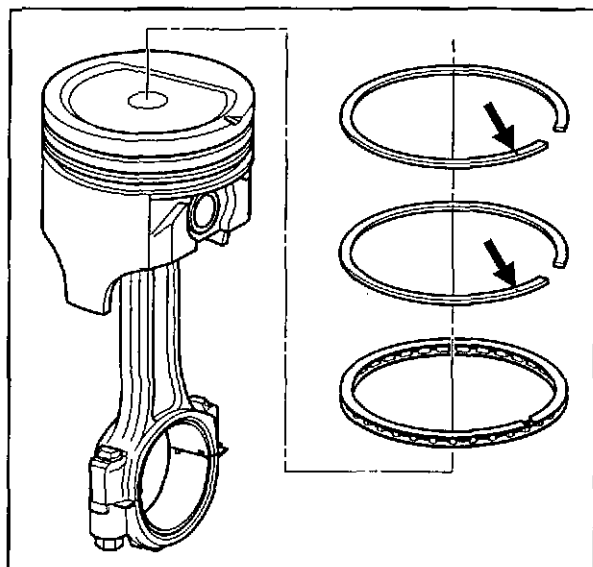
- J 24086-C Piston Pin Removal Set

Important: When assembling the piston and connecting rod, the flange or the heavy side on the connecting rod must face toward the front of the piston (stamped arrow in top of the piston head).

1. Install the piston pin and connecting rod assembly.
 - 1.1. Lubricate the piston pin holes in both the piston and the connecting rod assembly.
 - 1.2. Press the piston pin into the piston and connecting rod assembly using the J 24086-C.
 - 1.3. Inspect for freedom of movement of the piston on the piston pin.



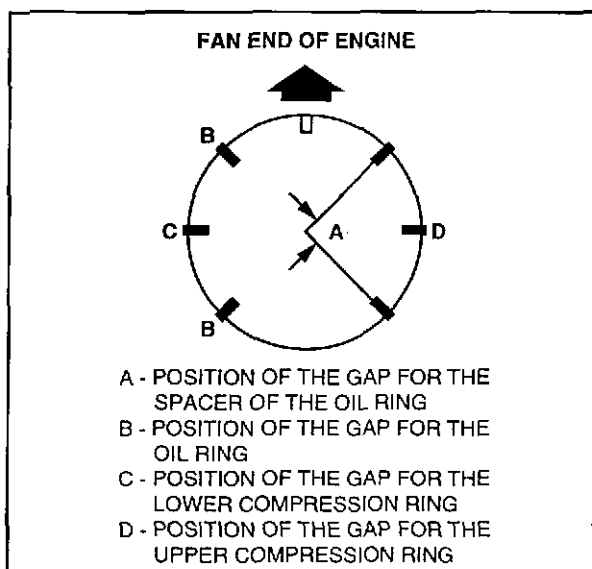
VE064-3L



VE123-3L

2. Install the piston rings onto the piston.

The marked side of the piston rings must face toward the top of the piston.



VE074-3L

3. Use the following procedure in order to locate the piston ring gaps:

- 3.1. Install the oil ring spacer in groove and insert anti-rotation tang in oil hole.
- 3.2. Hold the spacer ends together and install lower oil ring rail with the gap properly located.
- 3.3. Install the upper oil ring rail with the gap properly located.
- 3.4. Flex the oil ring assembly to make sure the rings are free.
- 3.5. Install the lower compression ring.
- 3.6. Install the upper compression ring.

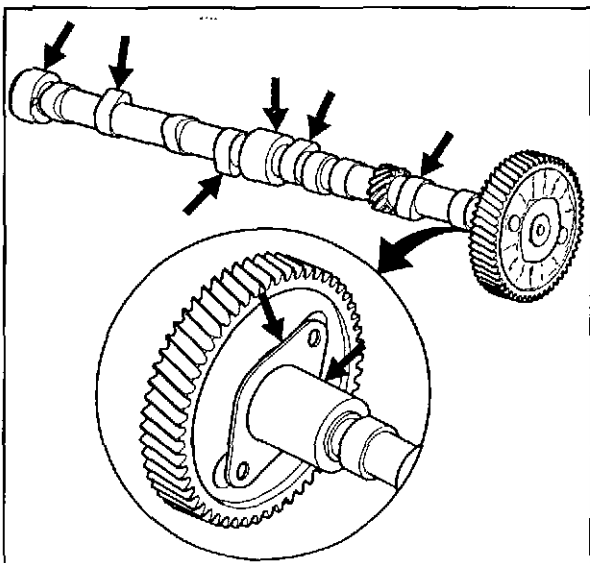
Camshaft and Bearings Clean and Inspect

Tools Required

- J 7872 Magnetic Base Indicator Set

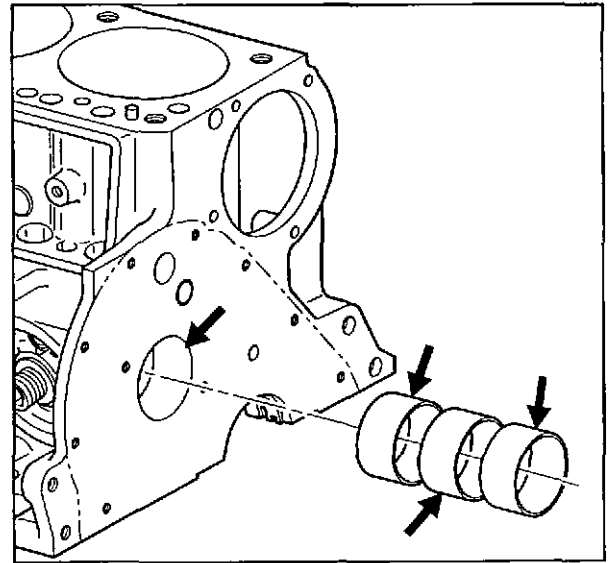
Caution: Wear safety glasses in order to avoid eye damage.

1. Clean the camshaft in solvent.
2. Dry the camshaft with compressed air.
3. Inspect the camshaft bearing journals for scoring or excessive wear.
4. Inspect the camshaft valve lifter lobes for scoring or excessive wear.
5. Inspect the camshaft retainer plate for wear.



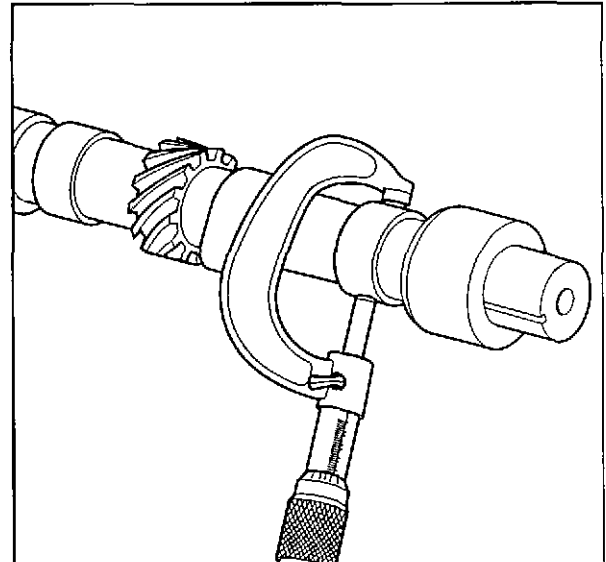
VE075-3L

6. Inspect the camshaft bearings for proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in their engine block bearing bores.
7. Inspect the camshaft bearings for excessive wear or scoring. Bearings with excessive wear or scoring must be replaced.



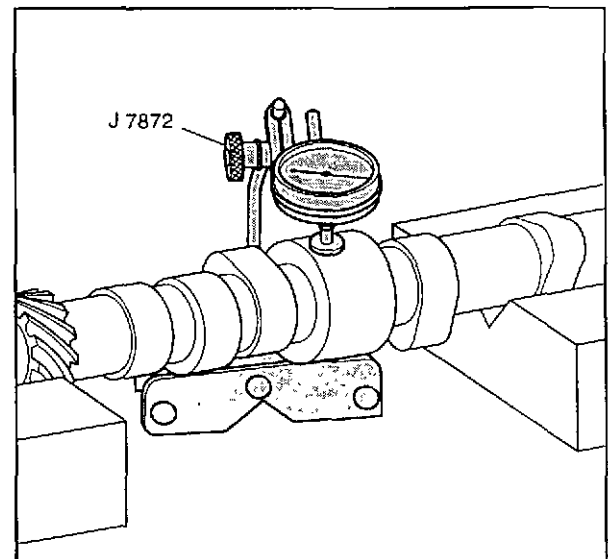
VE076-3L

8. Measure the camshaft for out-of-round, taper or undersize with a micrometer. Refer to *Engine Mechanical Specifications*.



VE077-3L

9. Support the camshaft front and rear journals on V-blocks.
10. Measure the camshaft run-out at the intermediate journal with J 7872. Refer to *Engine Mechanical Specifications*.
11. Replace camshaft if measurements are not within specifications.



VE078-3L

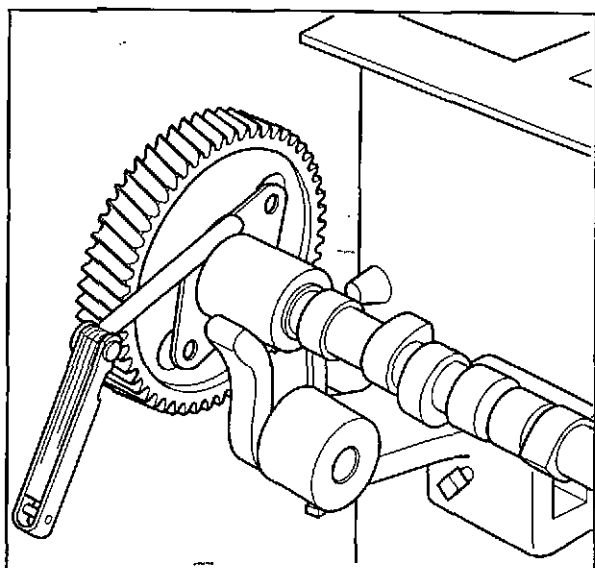
Camshaft Sprocket and Retainer Removal and Installation

Removal

Tools Required

- J 791 Camshaft Sprocket Remover

1. If the inspection indicated that the camshaft, gear and retainer were in good condition, the camshaft end play should be checked. Refer to *Engine Mechanical Specifications*.

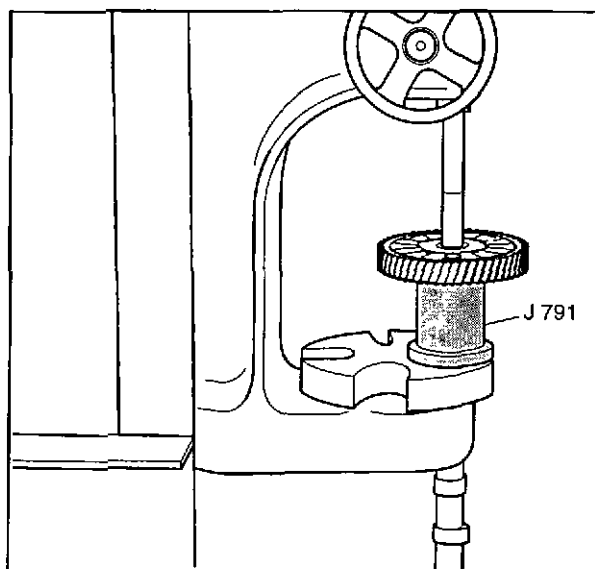


VE079-3L

2. If the inspection indicated that the camshaft, gear or retainer should be replaced, the gear must be removed from the camshaft as follows:
 - 2.1. Place the camshaft through the J 791.
 - 2.2. Place the end of the remover on the table of a press and press the camshaft out of the gear.

Important:

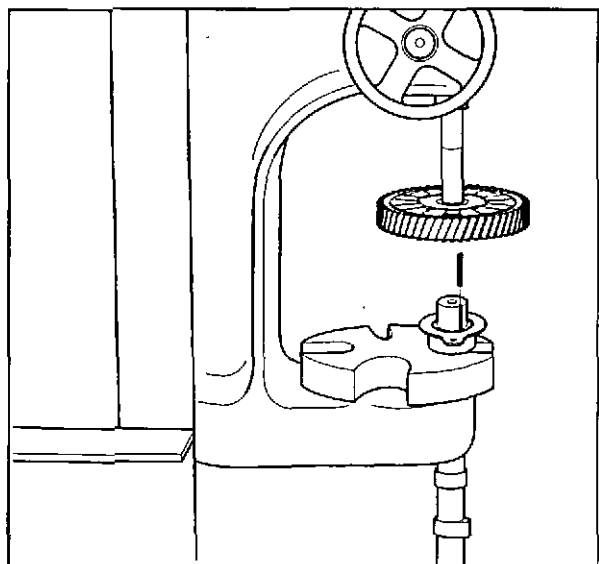
The retainer must be positioned so that the woodruff key in the camshaft does not damage it when the camshaft is pressed out of the gear. Also, support the hub of the gear or the gear will be seriously damaged.



VE080-3L

Installation

1. Install the camshaft sprocket, retainer and gear spacer ring to the camshaft as follows:
 - 1.1. Firmly support the camshaft at the back of the front journal in an arbor press.
 - 1.2. Place the gear spacer ring and retainer over the end of the camshaft and install the woodruff key in the camshaft keyway.
 - 1.3. Align the sprocket keyway with the woodruff key in the camshaft and press it onto the shaft until it bottoms against the gear spacer ring.



VE081-3L

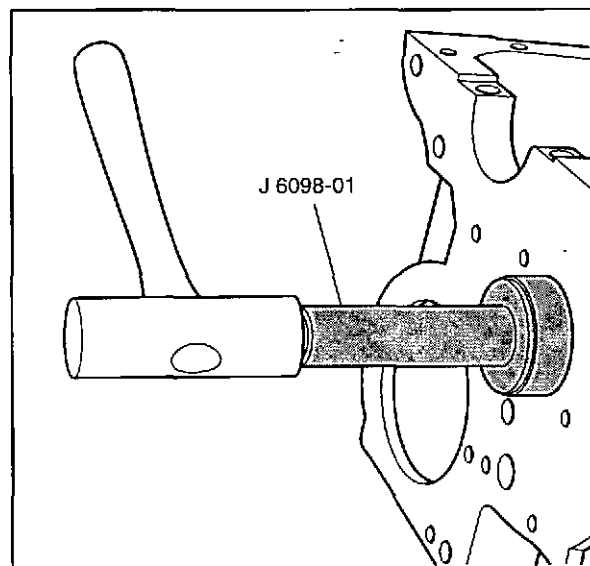
Camshaft Bearing Installation

Tools Required

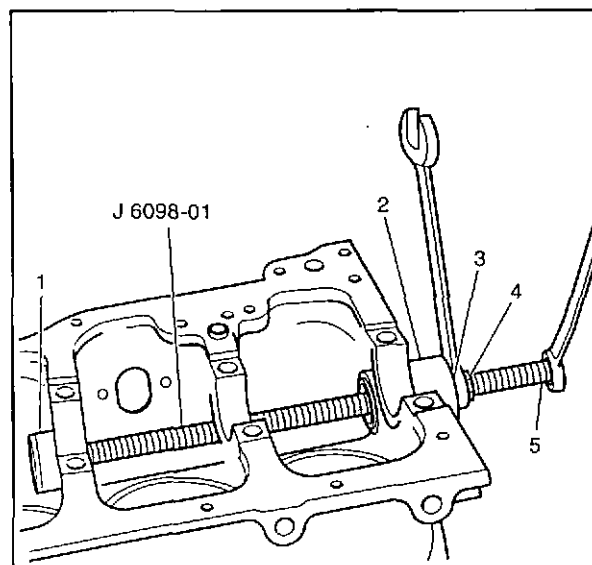
- J 6098-01 Camshaft Bearing Installer

Important:

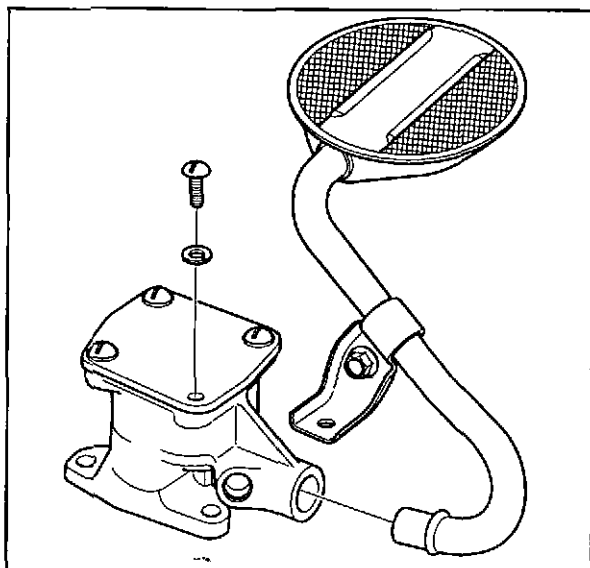
- A loose camshaft bearing may be caused by an enlarged, out of round or damaged engine block bearing bore.
 - The outer front and rear camshaft bearings must be installed first. These bearings serve as guides for the tool pilot and help center the inner bearings during the installation process.
 - The camshaft bearing oil holes must align with the oil galleys in the engine block. An improperly aligned camshaft bearing oil galley hole will restrict oil flow to the bearing and camshaft journal.
1. Use the J 6098-01 in order to install the front and rear camshaft bearings:
 - 1.1. Assemble the bearing tool to the driver handle.
 - 1.2. Align the oil holes.
 - 1.3. Drive the front and the rear camshaft bearings inward toward the center of the engine block.
 2. Use the J 6098-01 in order to install the inner camshaft bearings. Repeat the following steps for each of the inner camshaft bearings:
 - 2.1. With the nut (4) and the thrust washer (3) installed to the end of the puller screw threads, index the pilot in the camshaft front bearing and install the puller screw through the pilot (2).
 - 2.2. Index the camshaft bearing in the bore. Make sure you align the oil galley holes.
 - 2.3. Install the puller screw through the bearing bore and bearing to be installed and assemble bearing tool (1) to the puller screw with the shoulder toward the bearing. Make sure that enough threads are engaged.
 - 2.4. Using two wrenches, hold the puller screw (5) while you turn the nut in order to draw the bearing into the bore. When the bearing has been pulled into the bore, remove the bearing tool and the puller screw and check the alignment of the bearing oil hole to the bore oil hole.
 3. Install a new camshaft rear bearing hole plug. Coat the plug outside diameter with GM P/N 1052080 sealant, or the equivalent.



VE055-3L



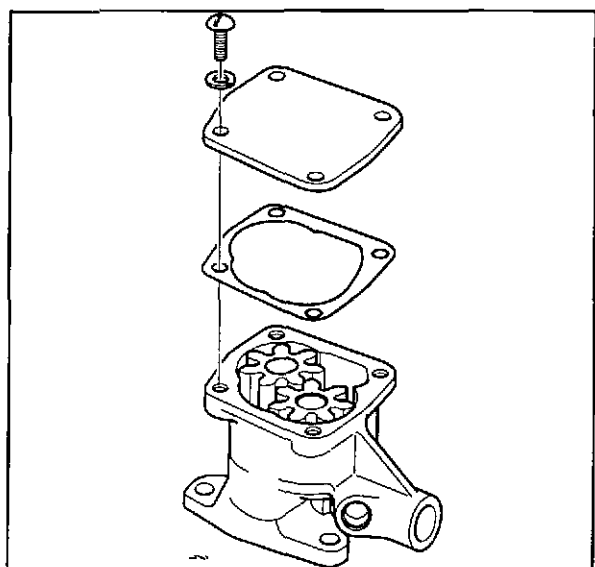
VE054-3L



VE082-3L

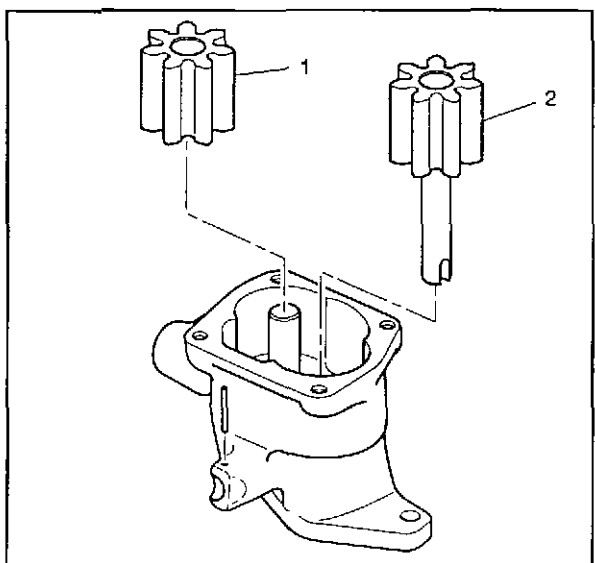
Oil Pump Disassemble

1. If necessary, remove the oil pump screen.
 - The oil pump screen has a press fit in to the pump cover.
 - Do not remove the screen from the pipe. The pipe and screen are serviced as a complete assembly.



VE083-3L

2. Remove the cover bolts.
3. Remove the pump cover.

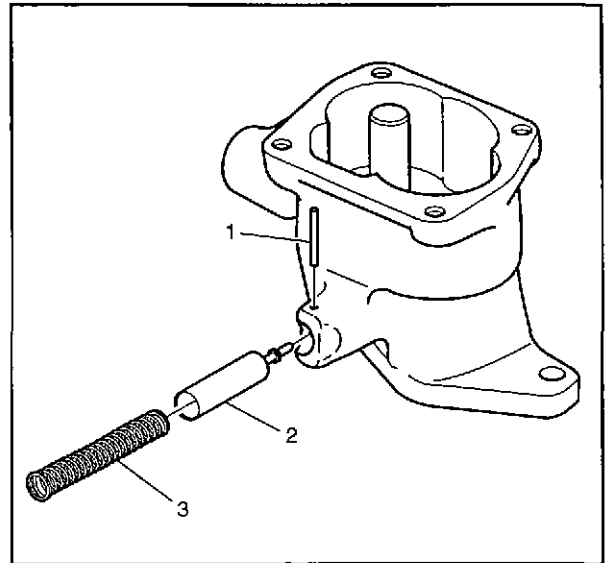


VE084-3L

4. Remove the drive gear (2) and the driven gear (1). Matchmark the gear teeth for assembly.

5. Remove the following items:

- The retaining pin (1).
- The pressure relief valve spring (3).
- The pressure relief valve (2).



VE085-3L

Oil Pump Clean and Inspect

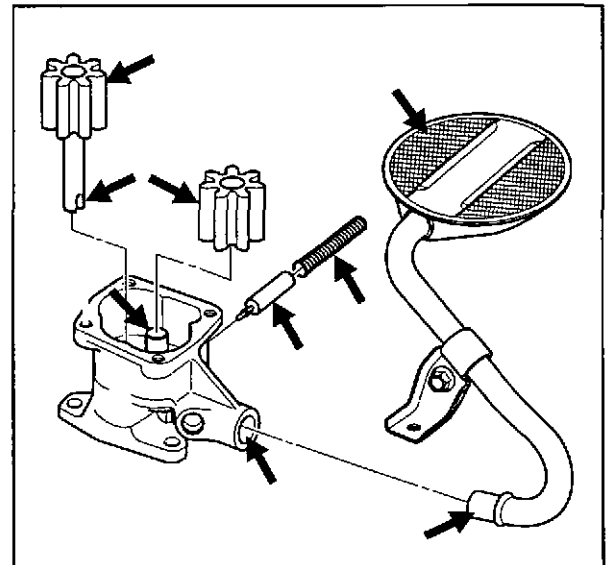
Important: The internal parts of the oil pump are not serviced separately. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

The oil pump pipe and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the pipe and screen assembly.

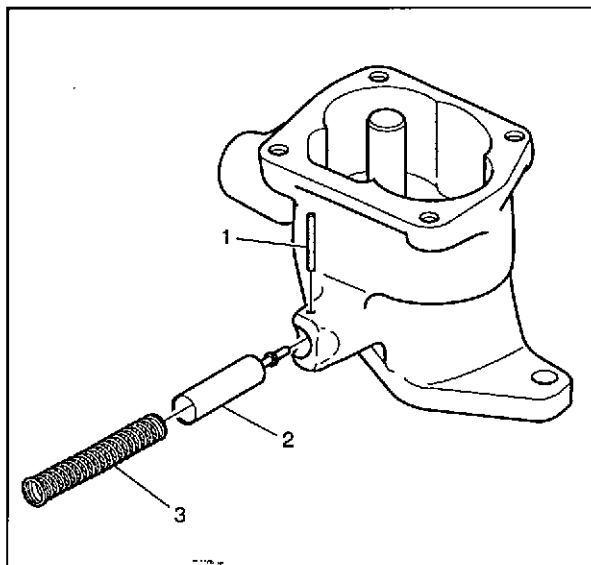
1. Clean all of the parts in cleaning solvent.

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

2. Dry the parts with compressed air.
 3. Inspect the following areas:
 - The oil pump housing and cover for cracks, scoring, casting imperfections and damaged threads.
 - The drive gear shaft (If the shaft is loose in the oil pump housing, replace the oil pump).
 - The pressure relief valve for scoring and sticking (Burr may be removed with a fine oil stone).
 - The pressure relief valve spring for loss of tension.
 - The oil pump screen for broken wire mesh or looseness (If the pipe is loose or has been removed from the screen, the oil pump screen must be replaced).
 - The gears for chipping, galling and wear.
- Important:** If the drive gear and driveshaft are worn, replace the entire oil pump.
- The drive gear and driveshaft for looseness and wear.



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VE085-3L

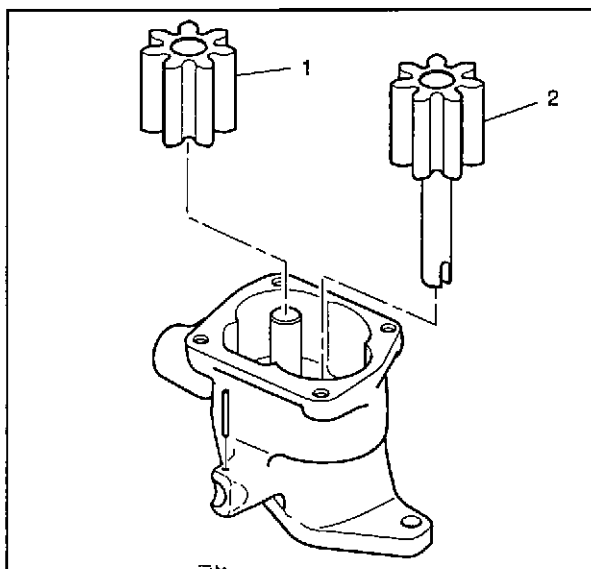
Oil Pump Assemble

Tools Required

- J 21882 Oil Suction Pipe Installer

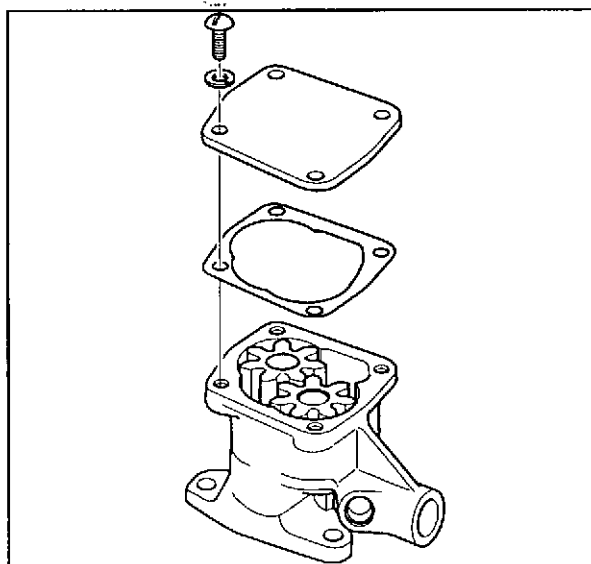
Important: Replace the pressure relief valve spring when you reuse the oil pump.

1. Install the following items:
 - The pressure relief valve (2).
 - The pressure relief valve spring (3).
 - The retaining pin (1).



VE084-3L

2. Coat the drive gear, the driven gear and the housing gear surfaces with clean engine oil.
3. Install the drive gear (2) and the driven gear (1) into the pump body. Align the matchmarks on the gears. Install the smooth side of the gear toward the pump cover.



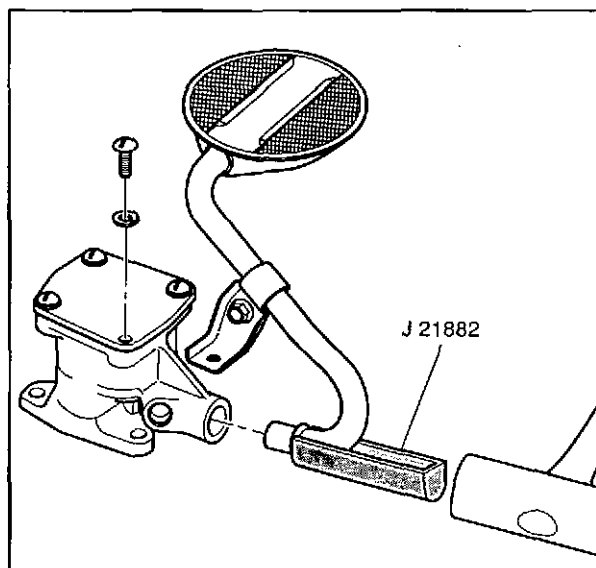
VE083-3L

4. Install the pump cover.
5. Install the cover bolts.

Tighten

Tighten the bolts to 8 N•m (72 lb in).

6. Inspect the pump for smoothness of operation by turning the oil pump driveshaft by hand.
7. Install the oil pump screen.
 - 7.1. If removed, replace the oil pump screen. The oil pump screen must have a good press fit into the oil pump body.
 - 7.2. Mount the oil pump in a soft jawed vise.
 - 7.3. Apply sealer to the end of the pipe.
 - 7.4. Use the J 21882 and a soft-faced hammer in order to tap the oil pump screen into the pump body. The screen must align parallel with the bottom of the oil pan when it is installed.



VE087-3L

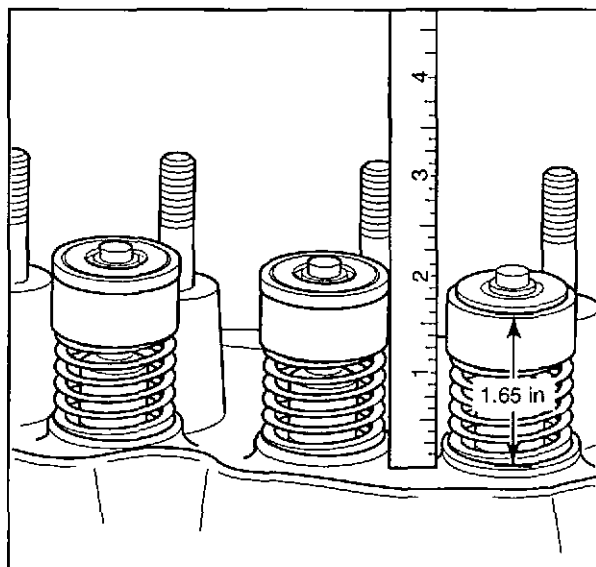
Cylinder Head Disassemble

Tools Required

- J 8062 Valve Spring Compressor

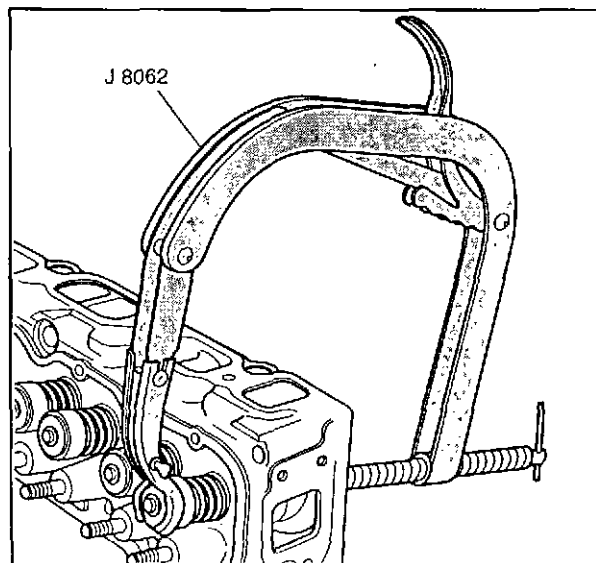
Important: Mark, organize or sort the cylinder head components for assembly. Return the components to their original location during assembly.

1. Measure the valve spring installed height using a ruler. Measure from the machined surface of the cylinder head to the top of the valve spring cap. Refer to *Engine Mechanical Specifications*

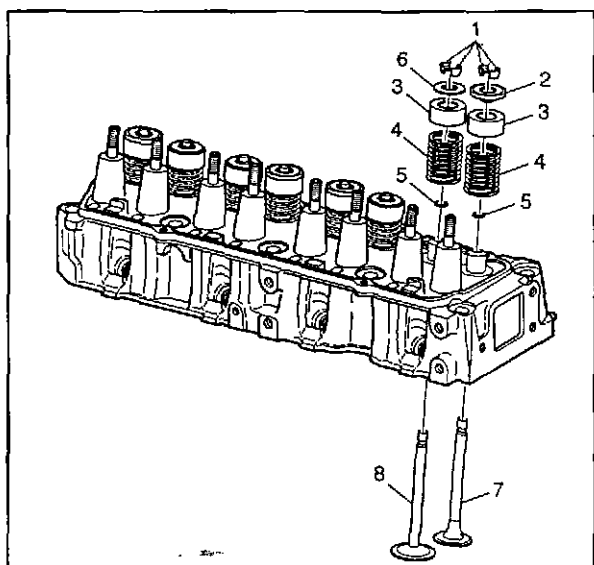


VE088-3L

2. Use the J 8062 in order to compress the valve springs.



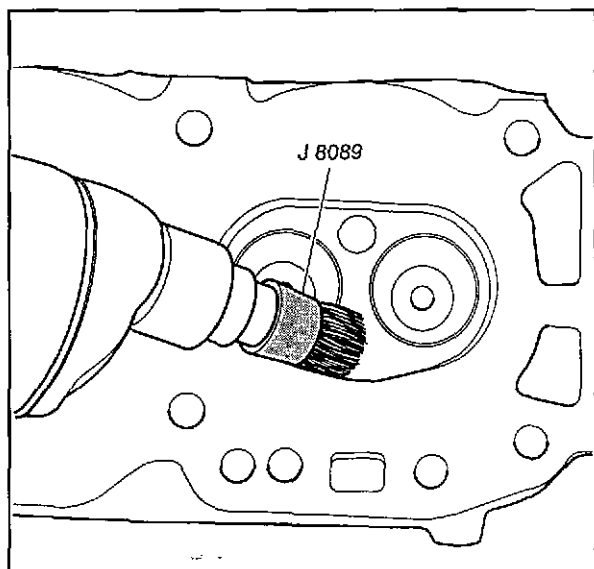
VE089-3L



VE090-3L

3. Remove the valve stem keys (1).
4. Remove the cap from the valve spring (2&6).
5. Remove the valve stem oil shield (3).
6. Remove the valve spring (4).
7. Remove the valve stem oil seal (5).
8. Remove the valve (7&8).

Important: Place the valves in a rack in the proper sequence so that you can install them in the same order.



VE091-3L

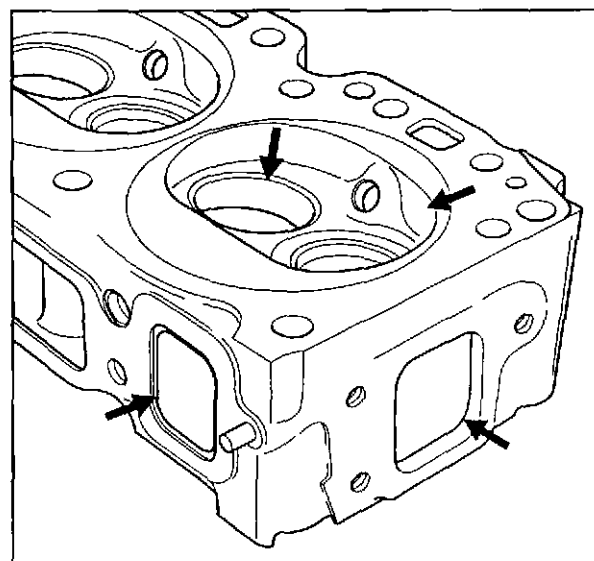
Cylinder Head Clean and Inspect

Tools Required

- J 8089 Carbon Remover Brush
- J 9666 Valve Spring Tester
- J 8001 Dial Indicator

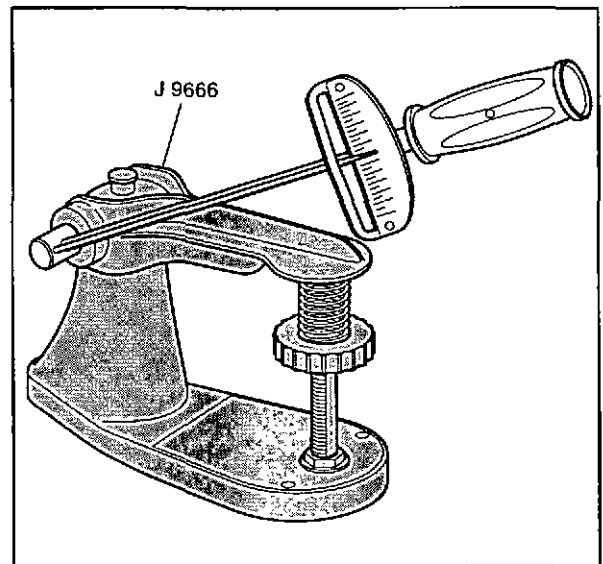
Caution: Wear safety glasses in order to avoid eye damage.

1. Use the J 8089 in order to clean the carbon from the combustion chambers and the valve ports. Be careful not to scuff the chamber.
2. Clean the following areas:
 - 2.1. The carbon and the sludge from the valve pushrods and the valve rocker arms.
 - 2.2. The valve stems and heads on a buffing wheel.
 - 2.3. The cylinder head and engine block gasket surfaces.
 - 2.4. The bolt holes and threads in the cylinder head and the engine block.
3. Inspect the following areas:
 - 3.1. The cylinder head for cracks in the exhaust ports and the combustion chambers.
 - 3.2. The cylinder head for external cracks in the water chamber.
 - 3.3. The valves for burned heads, cracked faces or damaged stems.



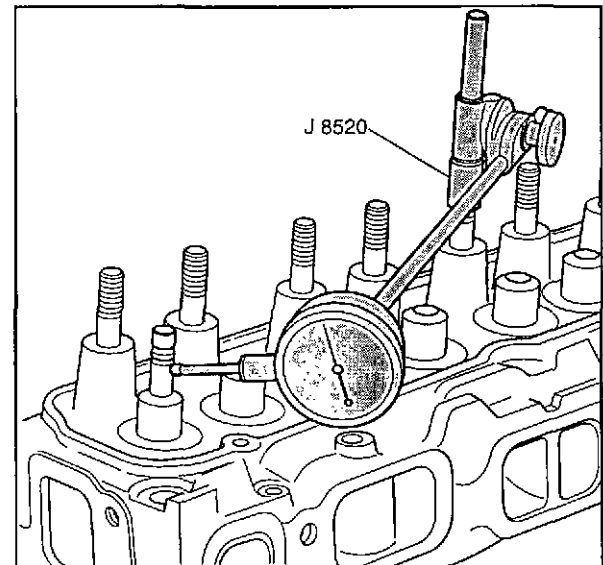
VE092-3L

4. Use the J 9666 and a flex bar torque wrench in order to measure the valve spring pressure.
 - Replace the valve spring if the spring pressure is less than 444 N (100 lb.) at 40.9 mm (1.61 in). Refer to *Engine Mechanical Specifications*.

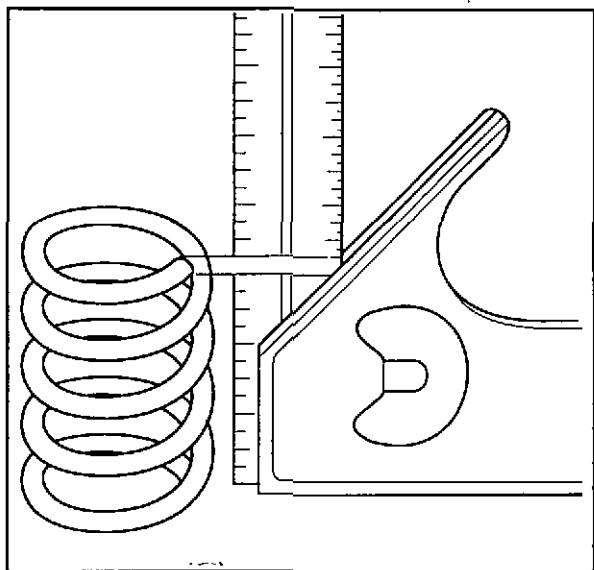


VE093-3L

5. Excessive valve stem-to-bore clearance will cause excessive oil consumption and may cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
 - 5.1. Install the valve into the guide.
 - 5.2. Install the J 8520 onto the cylinder head.
 - 5.3. Locate the indicator so that the movement of the valve stem from side to side (crosswise to the cylinder head) will cause a direct movement of the indicator stem.
 - 5.4. The indicator stem must contact the side of the valve stem just above the valve guide.
 - 5.5. Drop the valve head about 1.6 mm (0.0064 in) off the valve seat.
 - 5.6. Use light pressure and move the valve stem from side to side in order to obtain a clearance reading.
 - 5.7. If the valve stem to guide clearance is excessive, the valve must be replaced and/or the guide must be repaired to obtain the proper clearances. Refer to *Engine Mechanical Specifications*.

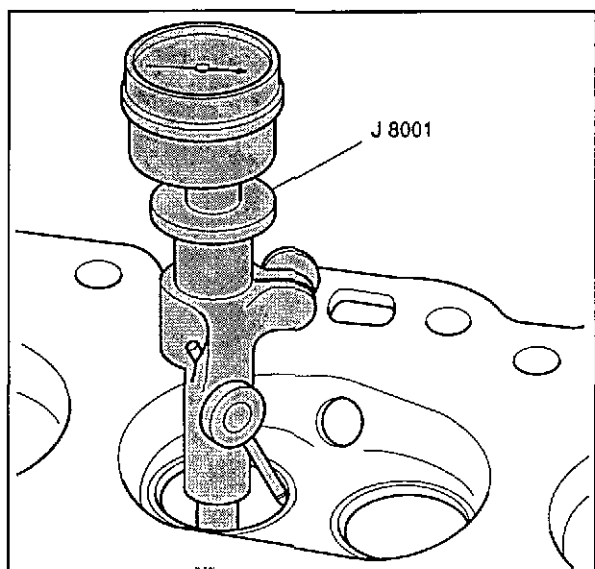


VE094-3L



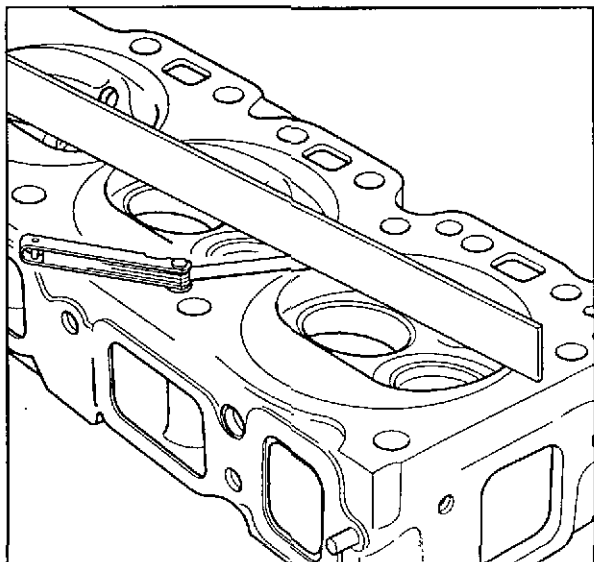
VE095-3L

6. Inspect the valve springs for squareness.



VE096-3L

7. Measure the valve seat runout.
- Use the J 8001 in order to check the valve seat runout.
 - The valve seats should be concentric to within 0.0508 mm (0.002 in).

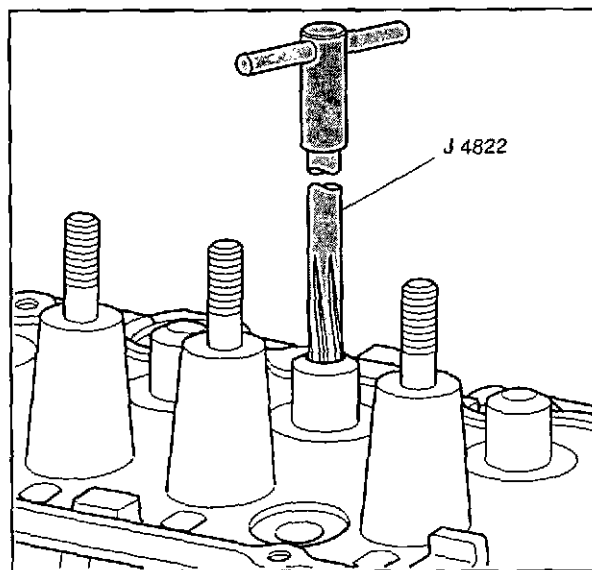


VE097-3L

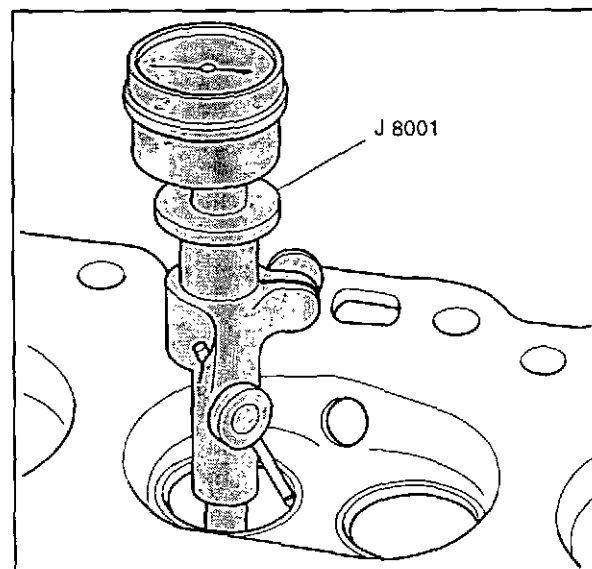
8. Measure the cylinder head for warpage with a straight edge and a feeler gauge. A cylinder head with excessive warpage must be repaired or replaced. Refer to *Engine Mechanical Specifications*.

Valve Guide Reaming/Valve and Seat Grinding

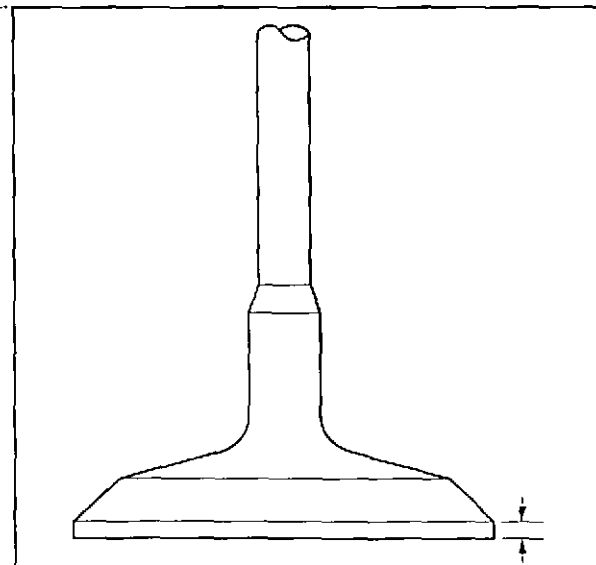
1. Ream the valve guides for oversize valves if the clearance exceeds the specifications.
 2. Service valves are available in the standard and 0.038 mm (0.015 in).
 3. Ream the valve guide bores for the service valves as necessary.
-
4. Reconditioning the valve seats is very important.
 5. Recondition the valve seat after reaming the valve guide bores or installing the new valve guides.
 - The valves must seat perfectly for the engine to deliver optimum power and performance.
 - Cooling the valve heads is another important factor. Good contact between each valve and its seat in the cylinder head is necessary to ensure that the heat in the valve head is properly carried away.
 - Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the guide.
 - The valve seats should be concentric to within 0.0508 mm (0.002 in) total indicator reading.
 6. Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the head and the stem.
 - Replace the valves that show excessive wear or are warped.
 - Replace the valve if the edge of the head is less than 0.8 mm (0.031 in) thick after grinding.
 - Several different types of equipment are available for reconditioning valves and valve seats. Use the manufacturers recommendations of equipment to obtain the proper results.



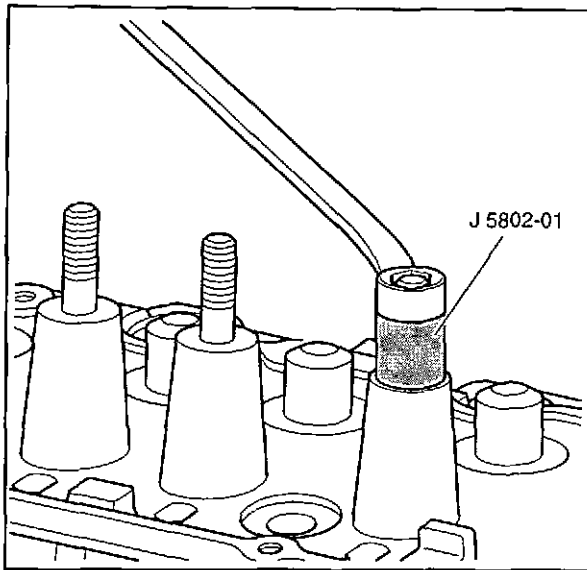
VE098-3L



VE096-3L



VE099-3L



VE100-3L

Rocker Arm Stud Removal and Installation

Tools Required

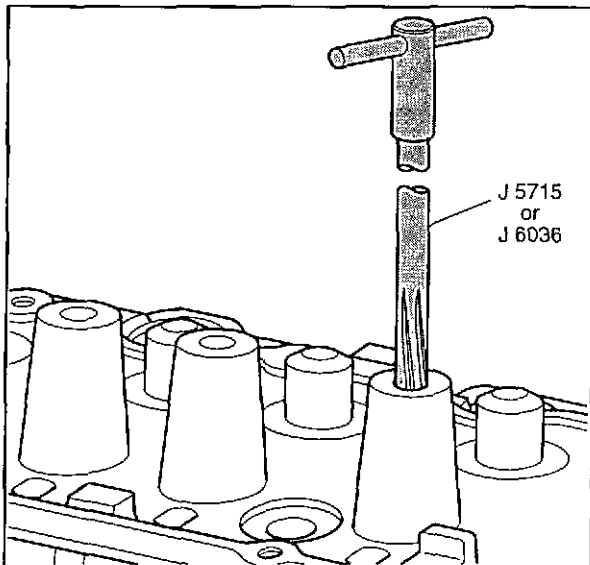
- J 5802-01 Rocker Arm Stud Remover
- J 6880 Rocker Arm Stud Installer

Rocker arm studs with damaged threads or with loose fit in cylinder head should be replaced with new, oversize studs.

1. Remove the old stud by placing J 5802-01 over the stud, installing nut and flat washer and removing the stud by turning out.

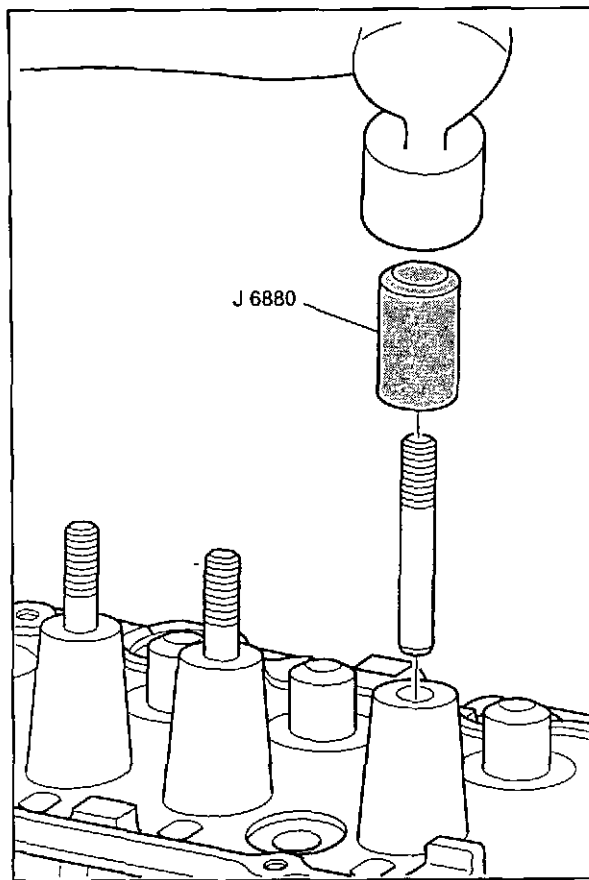
2. Ream the hole for the oversize stud.

Important: Do not attempt to install an oversize stud without reaming the stud hole.



VE101-3L

3. Coat the press-fit area of the stud with Perfect Seal.
4. Install the new stud, using J 6880 as a guide.

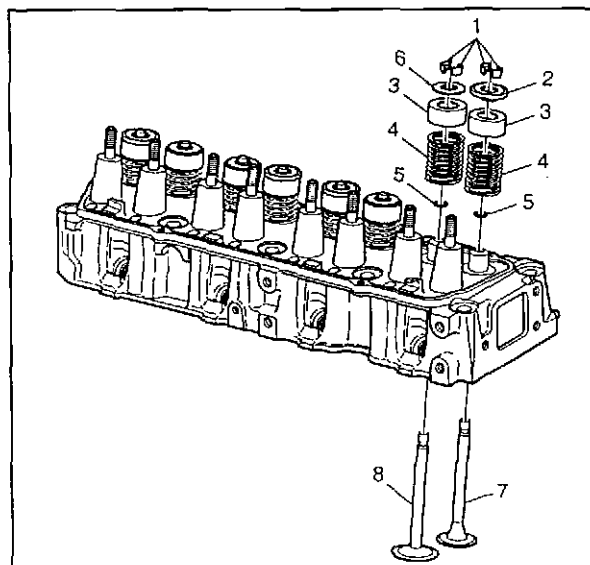


VE102-3L

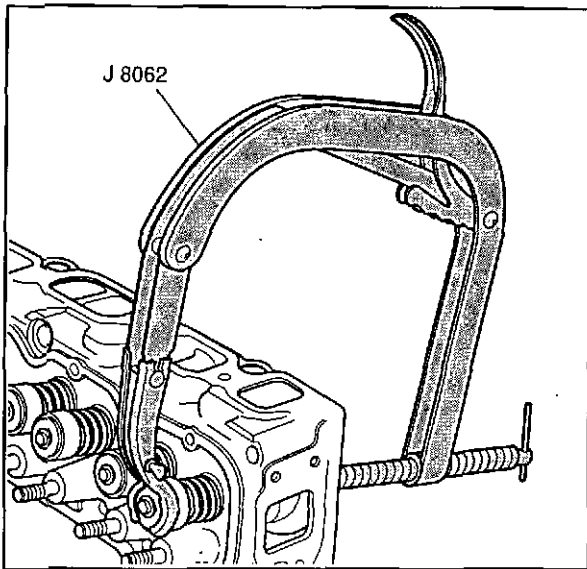
Cylinder Head Assemble

Tools Required

- J 8062 Valve Spring Compressor
1. Install the valve (7&8) into the proper port.
 2. Lubricate oil seal (5) with clean engine oil.
 3. Install the oil seal onto the valve stem.
 4. Install the valve spring (4).
 5. Install the valve stem oil shield (3).
 6. Install the cap on the valve spring (2&6).



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VE089-3L

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

7. Use the J 8062 in order to compress the valve spring.
8. Install the valve stem keys.
 - 8.1. Use grease to hold the keys in place while disconnecting the J 8062.
 - 8.2. Make sure that the keys seat properly in the upper groove of the valve stem.
 - 8.3. Tap the end of the valve stem with a plastic-faced hammer in order to seat the keys if necessary.

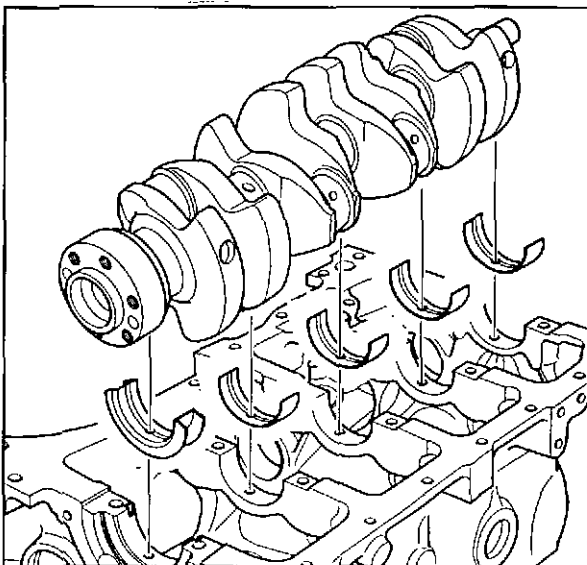
Service Prior to Assembly

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all components. Refer to *Cleanliness and Care*.
- Use the proper tools to measure components when checking for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When components are reinstalled into an engine, return the components to their original location, position and direction. Refer to *Separating Parts*.
- During assembly, lubricate all moving parts with clean engine oil or engine assembly lubricant (unless otherwise specified). This will provide initial lubrication when the engine is first started. Refer to *Sealers, Adhesives and Lubricants*.

Crankshaft, Bearings and Bearing Cap Installation

Important

- Crankshaft bearing caps must be installed to the proper location and direction.
 - When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.
 - Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.
1. Install the crankshaft bearings into the engine block and the crankshaft bearing caps.
 2. Coat the crankshaft bearings with clean engine oil.
 3. Install the crankshaft.

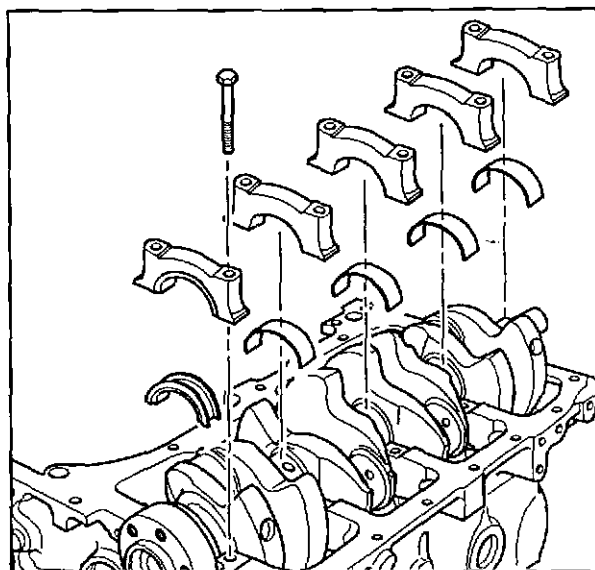


VE046-3L

4. Install the crankshaft bearing caps with the crankshaft bearings.
5. Be sure that the cap directional arrows point toward the front of the engine block and the cap is in its original position.
6. Install the crankshaft bearing cap bolts.
7. Thrust the crankshaft rearward in order to set and align the thrust bearings and the bearing caps.
8. Thrust the crankshaft forward in order to align the rear faces of the rear crankshaft bearings.

Tighten

Tighten all of the bolts to 88 N•m (65 lb ft).



VE045-3L

Crankshaft Rear Oil Seal and Housing Installation**Tools Required**

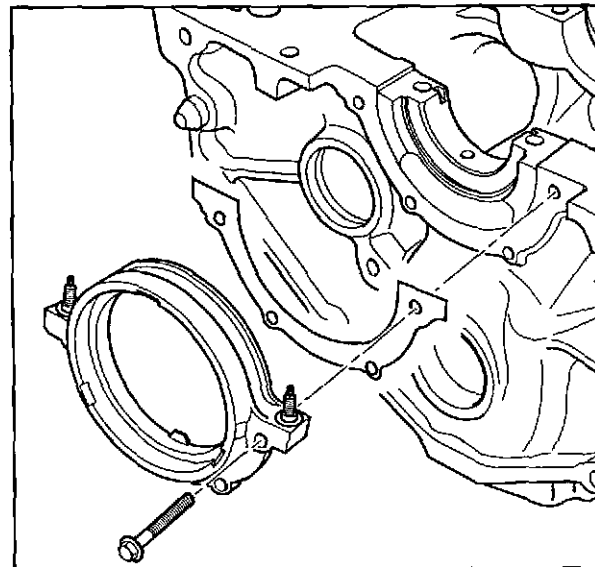
- J 35621 Crankshaft Rear Oil Seal Installer

Important: Always use a new crankshaft rear oil seal and new crankshaft rear oil seal housing gasket when you install the crankshaft rear oil seal housing.

1. Install the new gasket and the crankshaft rear oil seal housing on to the studs.
2. Install the rear oil seal housing nuts and bolts.

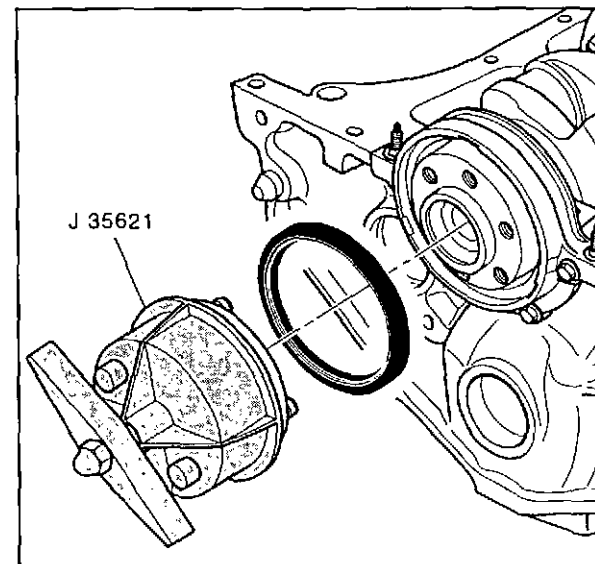
Tighten

Tighten the crankshaft rear oil seal housing nuts and bolts to 15 N•m (135 lb in).

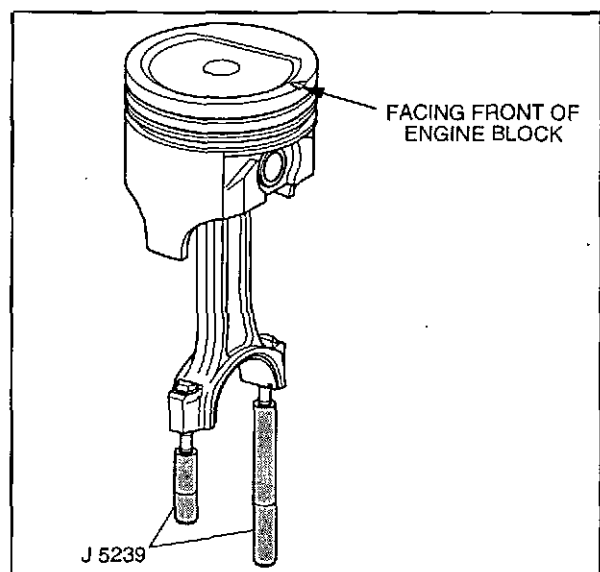


VE103-3L

3. Coat the new oil seal entirely with clean engine oil.
4. Install the seal onto the J 35621.
5. Install the J 35621 onto the rear of the crankshaft. Tighten the screws snugly in order to ensure that the seal will be installed squarely over the crankshaft.
6. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing. Tighten the wing nut on the J 35621 until the oil seal bottoms.
7. Remove the J 35621 from the crankshaft rear oil seal housing.



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VE124-3L

Piston, Connecting Rod and Bearing Installation

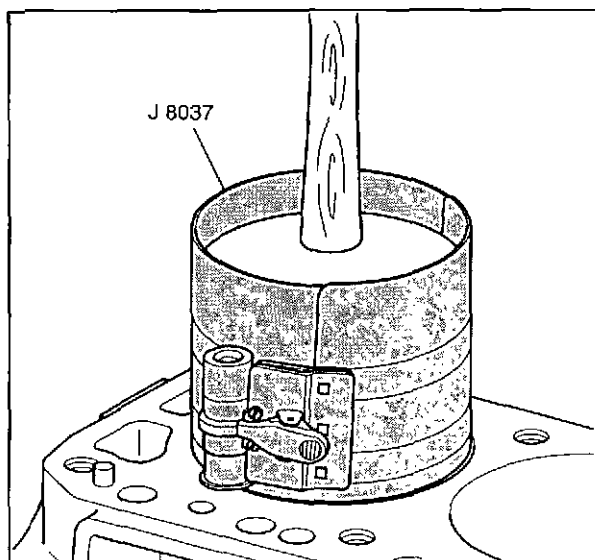
Tools Required

- J 5239 Guide Set
- J 8037 Piston Ring Compressor

Important

- The piston and cylinder bore have been measured and the bore has been sized for the proper clearance. Install the piston and connecting rod assembly into the proper cylinder bore.
- The piston alignment mark **MUST** face the front of the engine block.

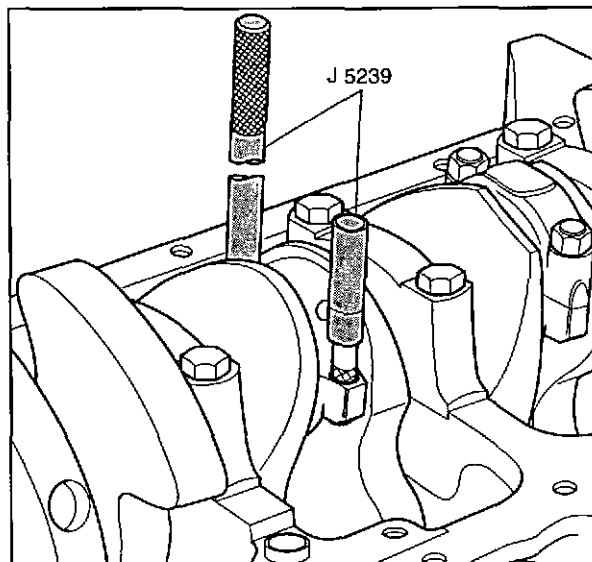
1. Lubricate the following components with clean engine oil:
 - The piston.
 - The piston rings.
 - The cylinder bore.
 - The bearing surfaces.
2. Install the connecting rod bearing into the connecting rod and bearing cap.
3. Install the J 5239 onto the connecting rod.
4. Install the J 8037 or equivalent onto the piston and compress the piston rings.



VE105-3L

5. Install the piston assembly into its matched bore with the stamped arrow facing forward.
6. Use the J 8037 and the J 5239 and lightly tap the top of the piston with a wooden hammer handle.
 - Hold the J 8037 firmly against the engine block until all of the piston rings enter the cylinder bore.
 - Use the J 5239 in order to guide the connecting rod onto the crankshaft journal.

7. Remove the J 5239.

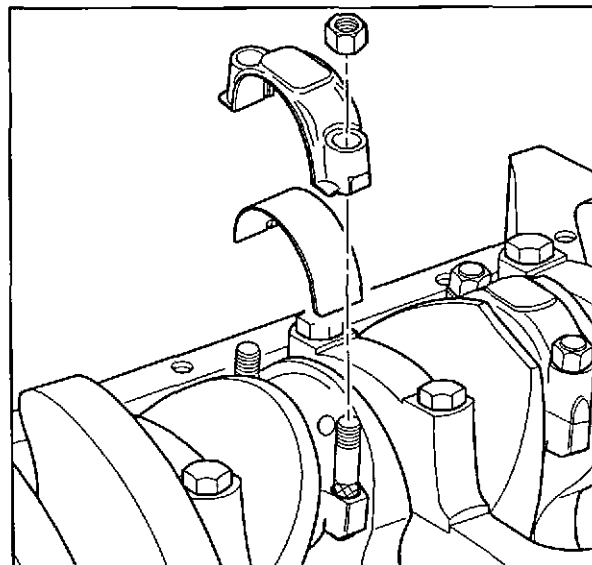


VE038-3L

8. Install the connecting rod cap and nuts.

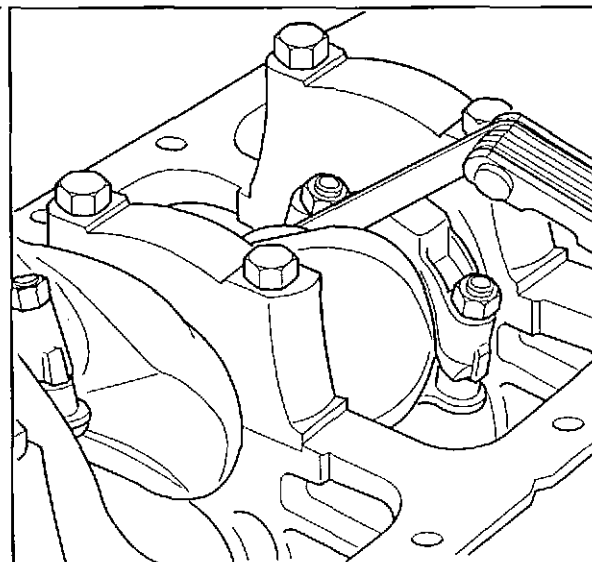
Tighten

Tighten the nuts evenly to 61 N•m (45 lb ft).

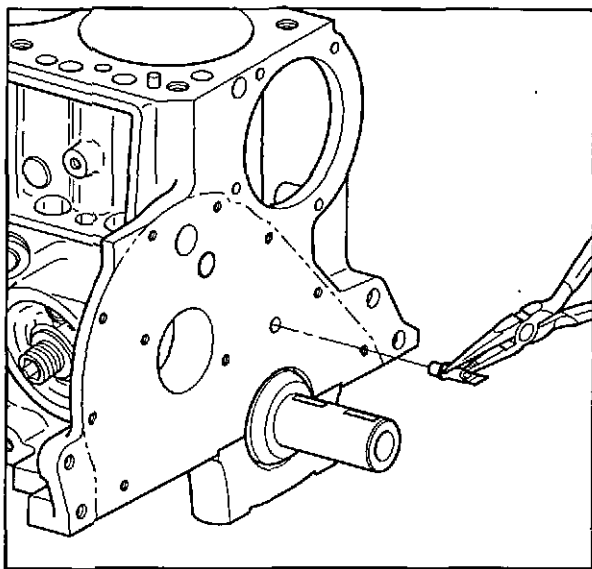


VE037-3L

8. When all of the connecting rod bearings are installed, tap each connecting rod assembly lightly parallel to the crankpin in order to make sure that they have clearance.
9. Use a feeler gauge or a dial indicator in order to measure the side clearance between the connecting rod caps. Refer to *Engine Mechanical Specifications*.



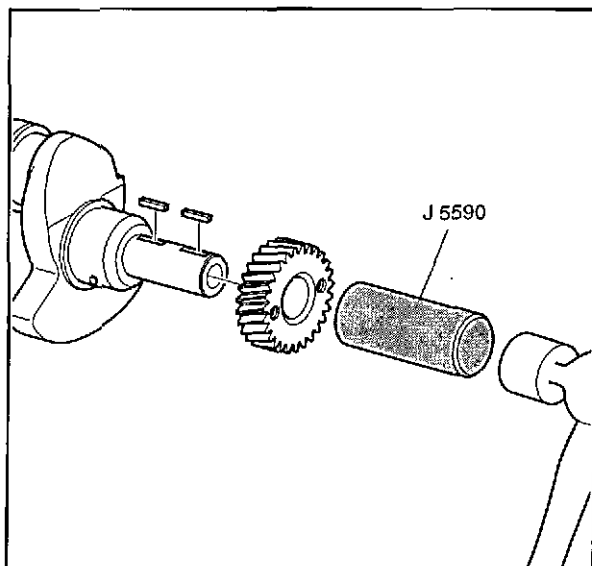
VE106-3L



VE127-3L

Timing Gear Oil Nozzle Installation

1. Drive the new nozzle in place (oil hole facing up) with a suitable light plastic or rubber hammer.

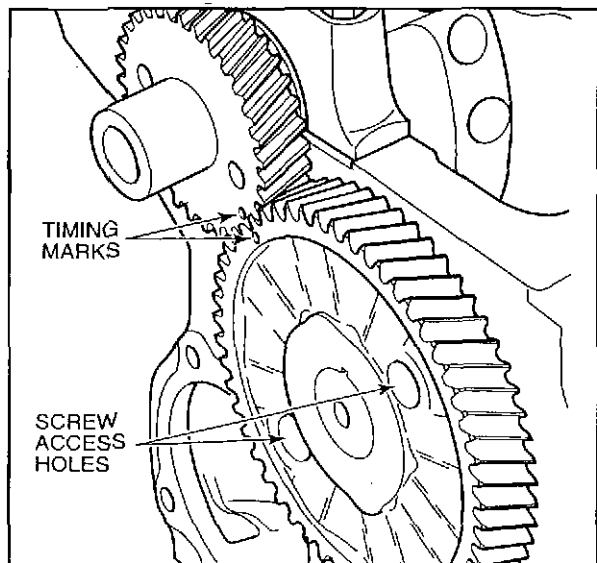


VE107-3L

Crankshaft Sprocket Installation

Tools Required

- J 5590 Crankshaft Sprocket Installer
1. Install the keys into the crankshaft keyways.
 2. Use the J 5590 in order to install the crankshaft sprocket.



VE108-3L

Camshaft Installation

Important: If camshaft replacement is required, the valve lifters must also be replaced.

1. Carefully rotate and install the camshaft into the engine.
2. Install the two camshaft retainer bolts working through the holes in the camshaft sprocket. Be sure to align the camshaft and the crankshaft sprocket alignment marks.

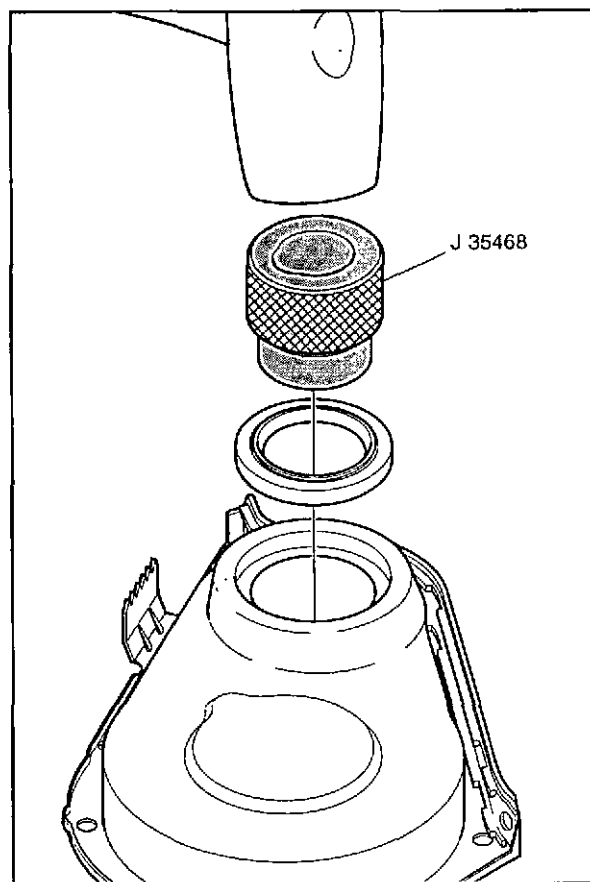
Tighten

Tighten the camshaft retainer bolts to 9 N•m (80 lb in).

Engine Front Cover and Oil Seal Installation

Tools Required

- J 35468 Engine Front Cover Aligner and Oil Seal Installer
1. Use the J 35468 in order to install the engine front cover oil seal.

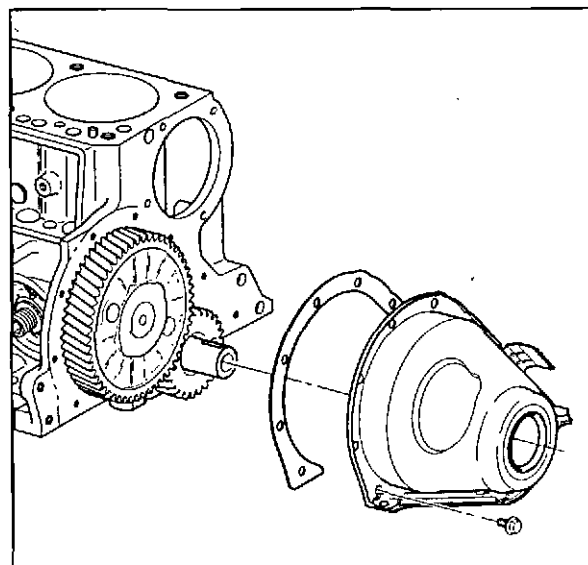


VE109-3L

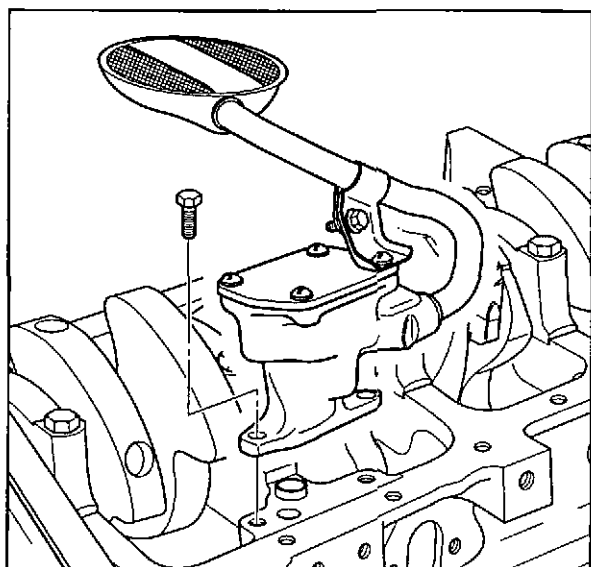
2. Install the engine front cover gasket.
3. Install the engine front cover and bolts.

Tighten

Tighten engine front cover bolts to 3.4 N•m (30 lb in).



VE030-3L



VE110-3L

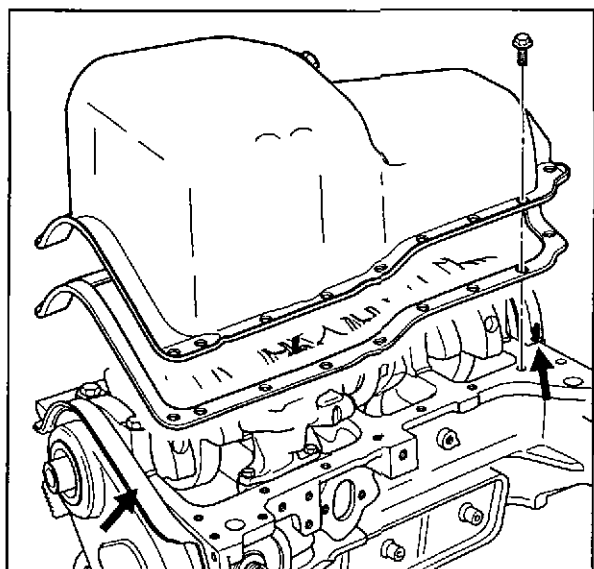
Oil Pump Installation

Important: Inspect the oil pump and engine block oil galley passages. These surfaces must be clear and free of debris or restrictions.

1. Install the oil pump.
2. Install the bolts that attach the oil pump to the engine block.

Tighten

Tighten the oil pump bolts to 14 N•m (120 lb in).



VE111-3L

Oil Pan Installation

Important: Apply the sealer 25 mm (1.0 in) in either direction of the radius cavity of the junctions.

1. Apply a small amount of sealer, GM P/N 1052914 or equivalent, 10 mm (0.393 in) wide and 20 mm (0.787 in) long at the engine front cover to engine block junction.
2. Apply a small amount of sealer, GM P/N 1052914 or equivalent, 25 mm (1.0 in) long at the crankshaft rear oil seal housing to engine block junction.
3. Install the new oil pan gasket.
4. Install the oil pan.
5. Install the nuts and bolts to the oil pan.

Tighten

Tighten the rear oil pan nuts to 18.6 N•m (165 lb in).

Tighten the oil pan bolts to the crankcase to 9 N•m (80 lb in).

Tighten the oil pan bolts to the front cover to 5 N•m (45 lb in).

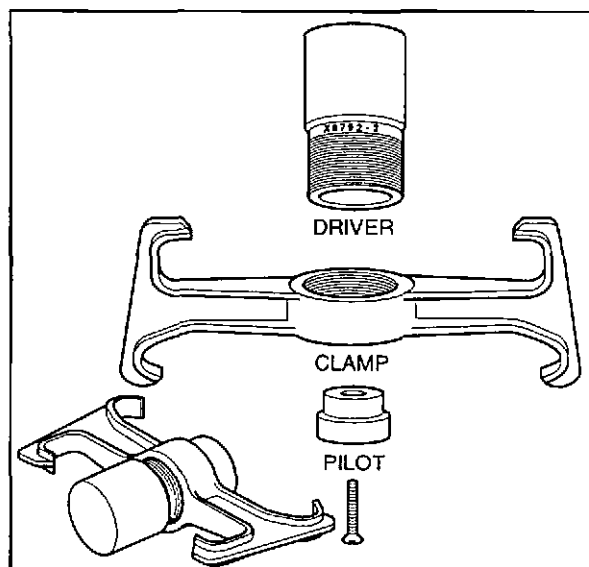
Tighten the oil pan studs to the oil seal retainer to 1.7 N•m (15 lb in).

Crankshaft Pulley Installation

Tools Required

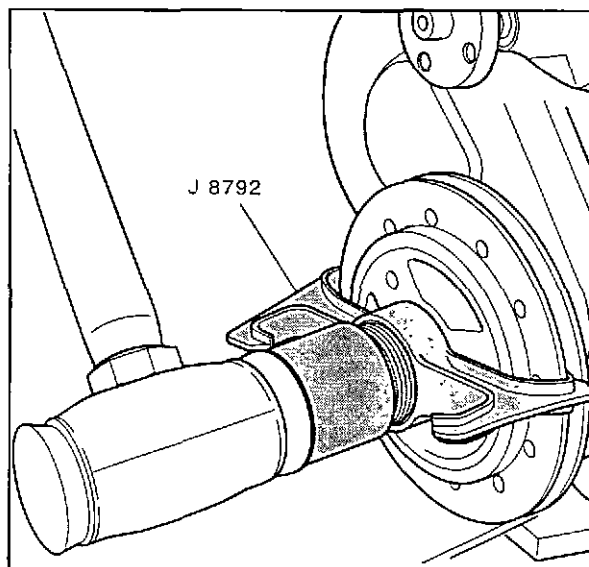
- J 8792 Crankshaft Pulley Installer

1. Coat the front cover oil seal contact area of the crankshaft pulley with clean engine oil.
2. Assemble the J 8792 as shown.



VE112-3L

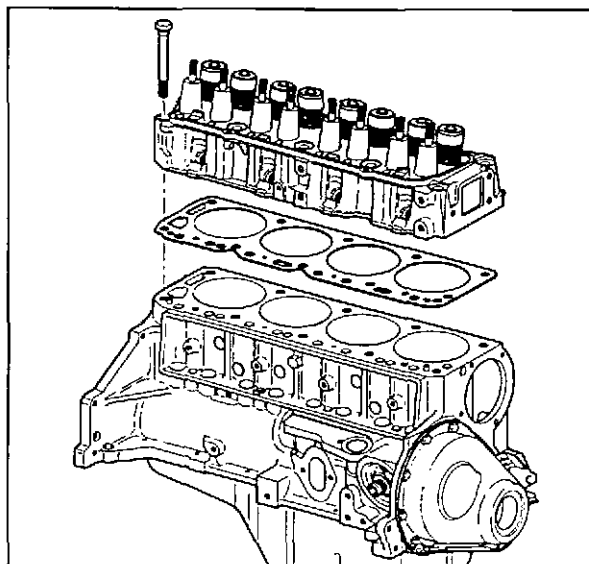
3. Install the J 8792 onto the crankshaft pulley.
4. Position the pulley on the crankshaft and drive into position until it bottoms against the crankshaft sprocket.



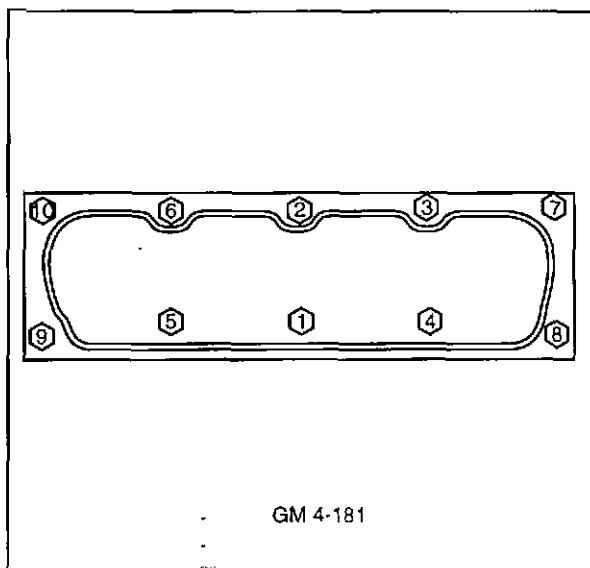
VE113-3L

Cylinder Head Installation

1. Install the new cylinder head gasket over the locating pins.
2. Install the cylinder head over the locating pins and the gasket.



VE114-3L



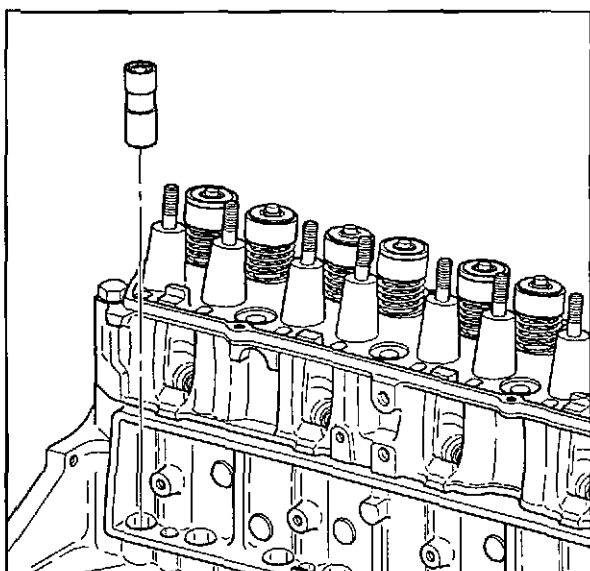
GM 4-181

VE115-3L

3. Install the cylinder head bolts finger tight.

Tighten

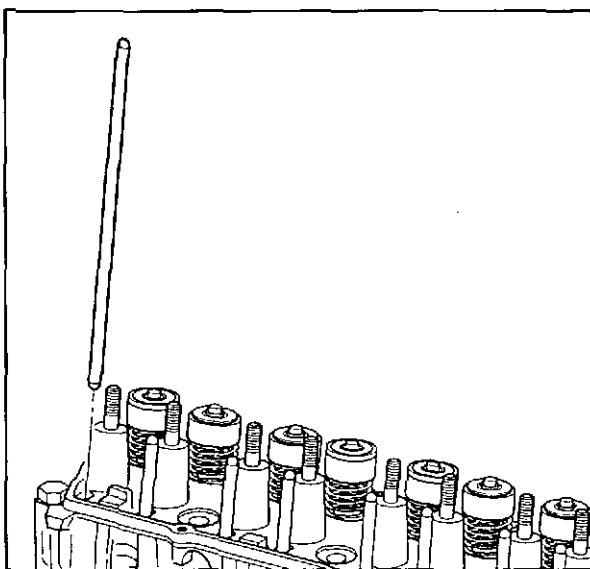
Tighten the cylinder head bolts in sequence to 122 N•m (90 lb ft).



VE116-3L

Valve Lifter Installation

1. Coat the bottom of the valve lifters with prelube, GM P/N 1052365 or equivalent.
2. If reusing the valve lifters, install in their original location.
3. Install the valve lifters.



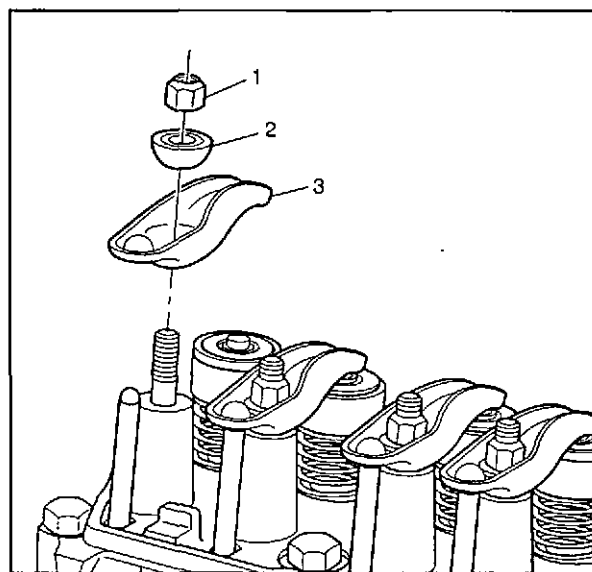
VE023-3L

Valve Rocker Arm and Pushrod Installation

Important: Be sure to keep parts in order. Parts must be installed from where they were removed.

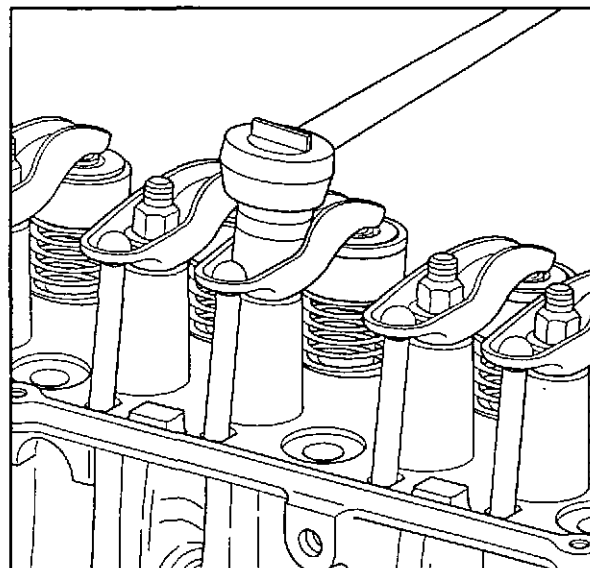
1. Install the valve pushrods. Be sure that the valve pushrods seat in the valve lifter sockets.

2. Install the following components:
 - 2.1. The valve rocker arms (3).
 - 2.2. The valve rocker arm balls (2).
 - 2.3. The valve rocker arm nuts (1).

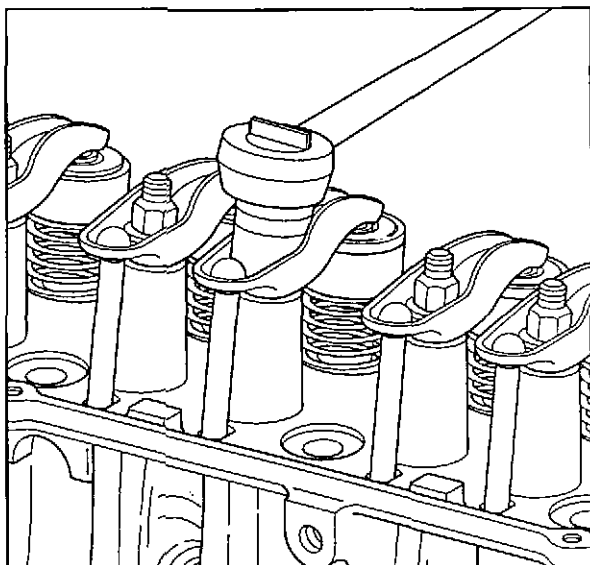


VE021-3L

3. Adjust the valve rocker arm nuts as follows:
 - 3.1. Turn the crankshaft until the mark on the crankshaft pulley lines up with "0" on the timing tab and number 1 cylinder is at top dead center.
 - 3.2. Place fingers on the number 1 valves as the mark approaches "0." If the valves move as the mark approaches "0," the engine is on number 4 top dead center and should be rotated one more revolution in order to reach number 1 top dead center.
 - 3.3. With the engine at number 1 top dead center, adjust the following valves:
 - The exhaust valves 1,3
 - The intake valves 1,2,4
 - 3.4. Adjust the correct valves as follows:
 - 3.4.1. Back off the valve rocker arm nut until the lash is felt in the valve pushrod.
 - 3.4.2. Tighten the valve rocker arm nut until all the lash is removed.
 - 3.4.3. Zero lash can be felt by moving the valve pushrod up and down between your thumb and forefinger until there is no more movement.
 - 3.4.4. When all the free play is gone, tighten the valve rocker arm nut 1 additional turn (360 degrees).

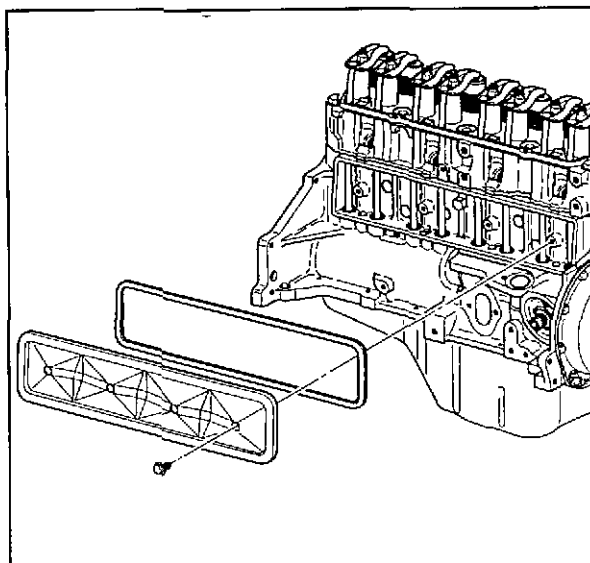


VE117-3L



VE117-3L

- 3.5. Turn the crankshaft 1 revolution until the mark on the crankshaft pulley lines up with "0" on the timing tab. This is number 4 top dead center.
- 3.6. With the engine at number 4 top dead center, adjust the following valves:
 - The exhaust valves 2,4
 - The intake valves 3
- 3.6.1. Back off the valve rocker arm nut until the lash is felt in the valve pushrod.
- 3.6.2. Tighten the valve rocker arm nut until all the lash is removed.
- 3.6.3. Zero lash can be felt by moving the valve pushrod up and down between your thumb and forefinger until there is no more movement.
- 3.6.4. When all the free play is gone, tighten the valve rocker arm nut 1 additional turn (360 degrees).



VE118-3L

Pushrod Cover Installation

1. Install the pushrod cover gasket.
2. Install the pushrod cover.
3. Install the pushrod cover bolts.

Tighten

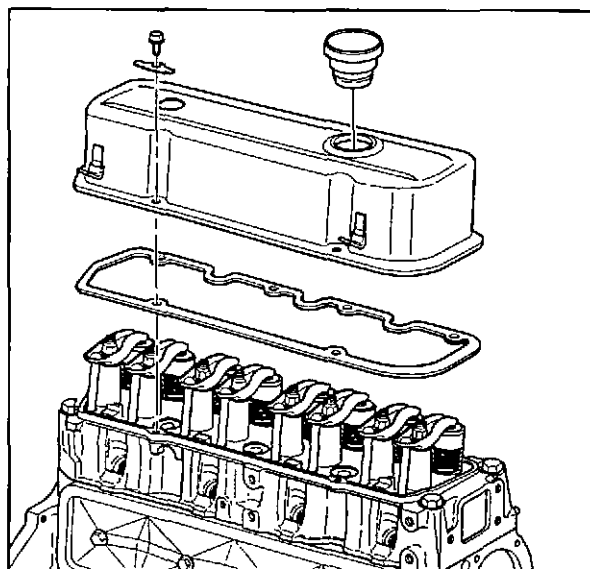
Tighten the pushrod bolts to 4.5 N•m (40 lb in).

Valve Rocker Arm Cover Installation

1. Install the valve rocker arm cover gasket.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm bolts.

Tighten

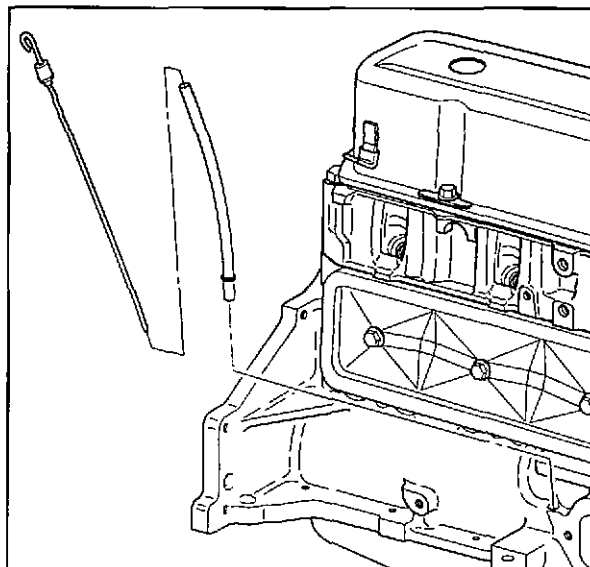
Tighten the valve rocker arm cover bolts to 4.5 N•m (40 lb in).



VE119-3L

Oil Level Indicator and Tube Installation

1. Install the oil level indicator tube into the engine block.
2. Use a light plastic or rubber hammer in order to tap the tube until it seats in the engine block.
3. Install the oil level indicator into the tube.



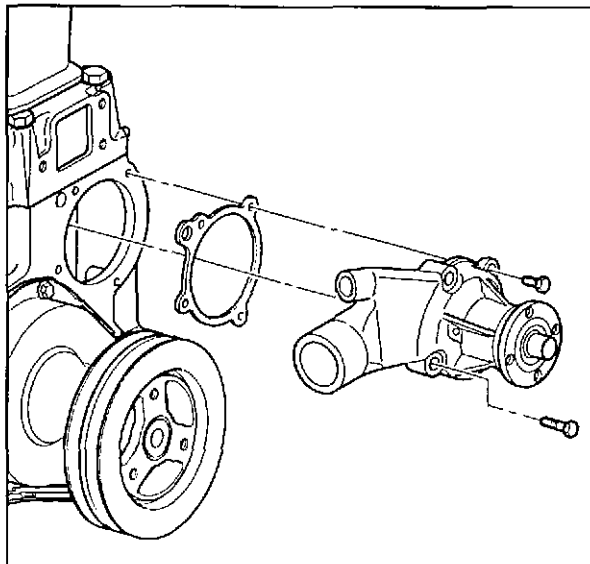
VE120-3L

Water Pump Installation

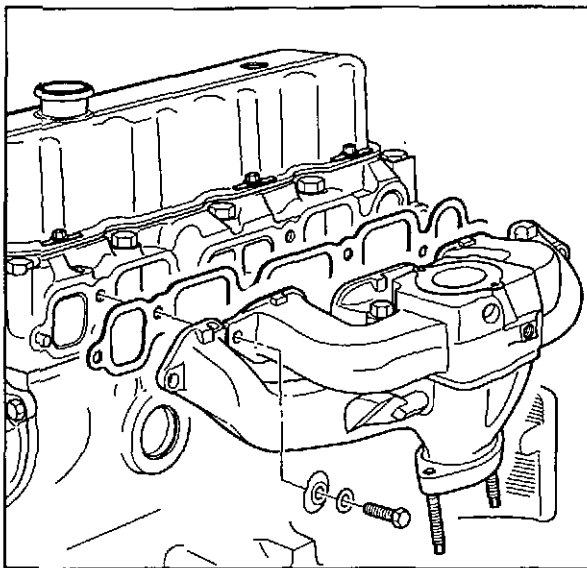
1. Position the water pump and gasket to the engine block.
2. Install the water pump bolts.

Tighten

Tighten the water pump bolts to 20 N•m (15 lb ft).



VE017-3L



VE014-3L

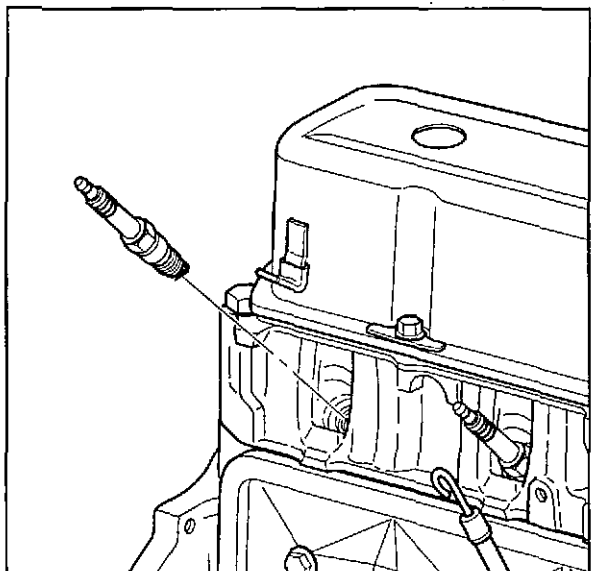
Intake/Exhaust Manifold Installation

1. Install the intake/exhaust manifold gasket over the locating pins on the cylinder head.
2. Install the bolts and clamps while holding the manifold in place.

Tighten

Tighten the two center bolts to 27-34 N•m (20-25 lb ft).

Tighten the end bolts to 20-27 N•m (15-20 lb ft).



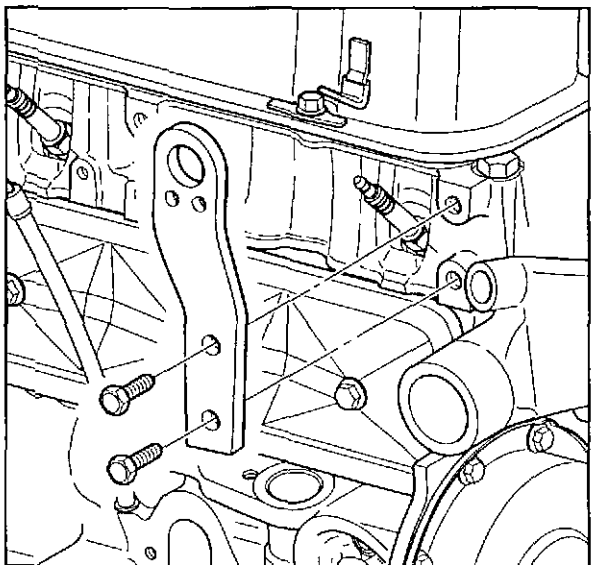
VE013-3L

Spark Plug Installation

1. Install the spark plugs.

Tighten

Tighten the spark plugs to 30 N•m (22 lb ft).



VE012-3L

Lift Bracket Installation

1. Install the lift bracket.
2. Install the lift bracket bolts.

Tighten

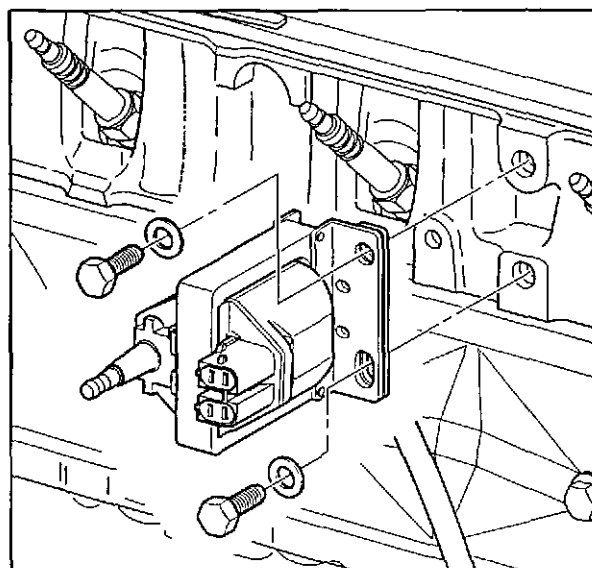
Tighten the lift bracket bolts to 54 N•m (40 lb ft).

Ignition Coil Installation

1. Install the ignition coil.
2. Install the ignition coil bracket attaching bolts.

Tighten

Tighten the attaching bolts to 22 N•m (16 lb ft).



VE011-3L

Distributor Installation

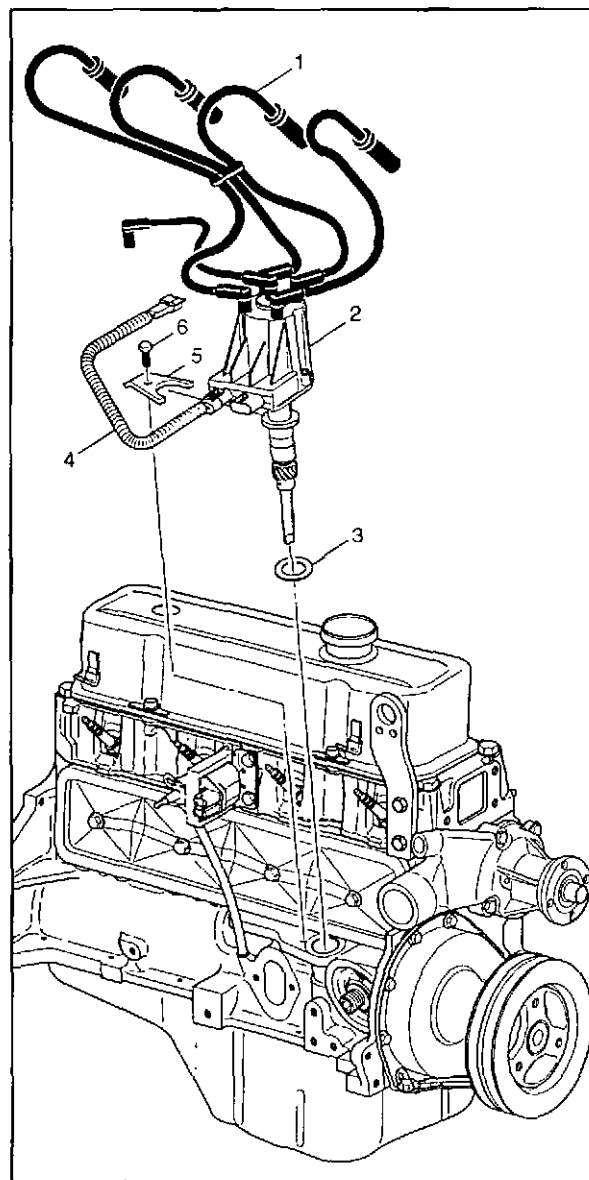
Important: To ensure correct ignition timing, the distributor must be installed in the correct position. Position the engine at top dead center on number one cylinder. The distributor cap must be removed in order to position the rotor when installing the distributor.

1. Install the distributor (2) and new gasket (3), making sure the distributor rotor is pointing to number one tower on the distributor cap.
2. Install the distributor hold down (5) and bolt (6).

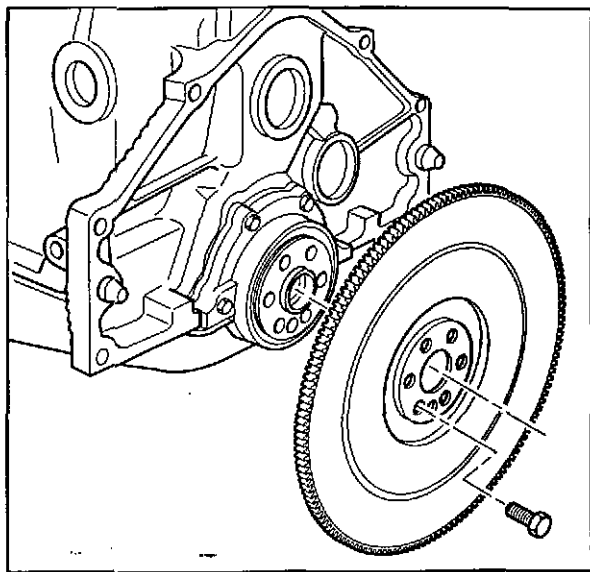
Tighten

Tighten the hold down bolt to 27 N•m (20 lb ft).

3. Connect the primary ignition harness (4) to the ignition coil.
4. Connect the secondary ignition wires (1) to the spark plugs and the ignition coil.



VE010-3L



VE009-3L

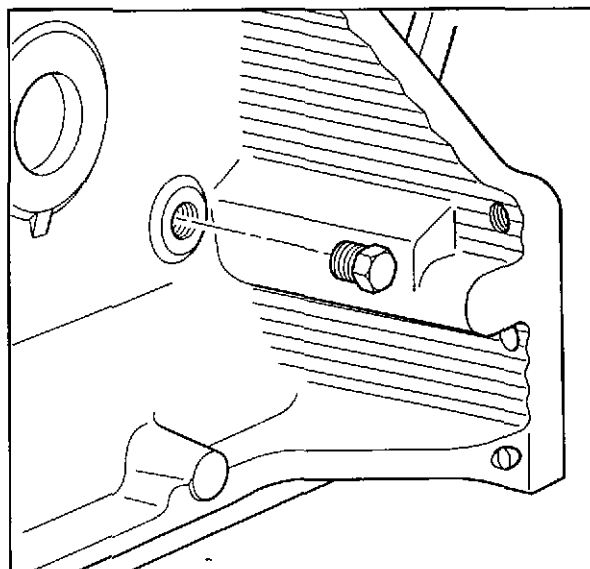
Engine Flywheel Installation

Important: Note the position and direction of the engine flywheel before removal. The flywheel center alignment hole is a tapered fit to the crankshaft. The engine flywheel must be reinstalled to the original position and direction. The engine flywheel will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts.

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

Tighten

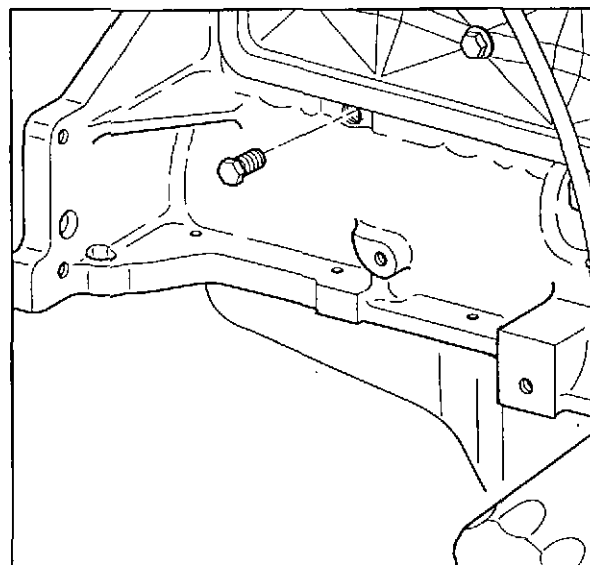
Tighten the flywheel bolts to 88 N•m (65 lb ft).



VE008-3L

Engine Block Coolant Plug/Oil Filter Installation

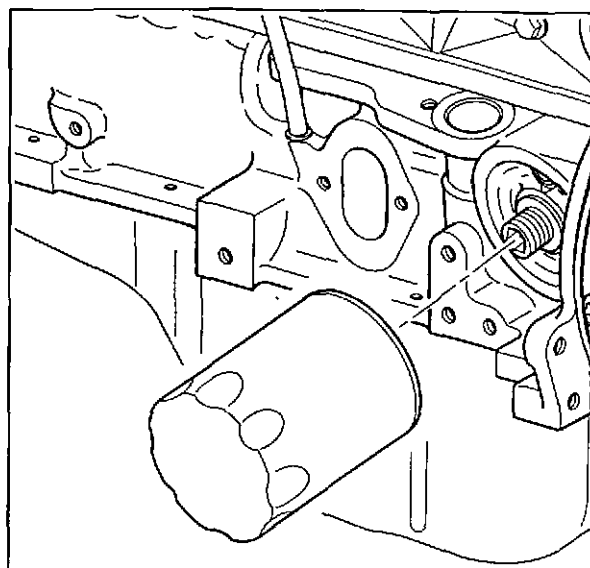
1. Install the left rear engine block coolant plug.



VE007-3L

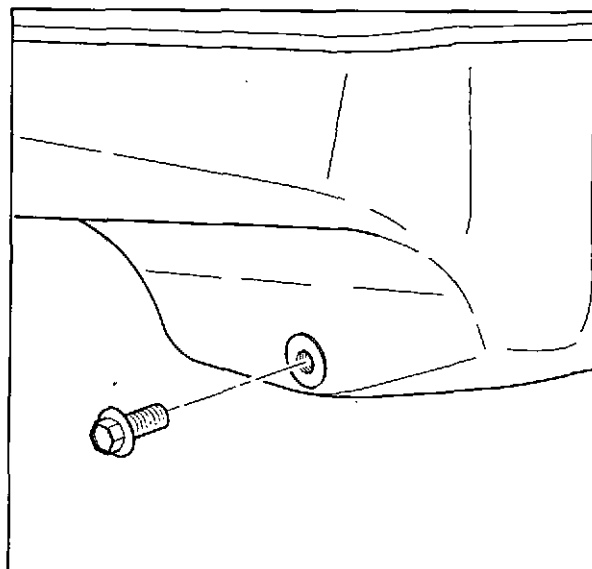
2. Install the right rear engine block coolant plug.

3. Install the oil filter.



VE006-3L

4. Install the oil pan drain plug.



VE005-3L

Description and Operation

Engine Component Description

Engine Block

The engine block has four cylinders arranged in an "in-line" construction. Starting at the front of the engine, the cylinders are numbered 1-2-3-4. The firing order of the cylinders is 1-3-4-2. The cylinders are encircled by coolant jackets.

Cylinder Head

The cylinder head has one intake and one exhaust valve per cylinder. A spark plug is located between the valves in the side of the cylinder head. The valve guides are integral and the valve rocker arms are retained on individual threaded studs.

Crankshaft

The crankshaft is cast nodular iron and is supported by five crankshaft bearings. The bearings are retained by crankshaft bearing caps that are machined with the engine block for proper alignment and clearances.

Camshaft

A billet steel one piece camshaft is supported by four full round, sleeve-type bearings. These bearings are a press fit into the engine block. The camshaft timing sprocket is mounted to the front of the camshaft and is driven the crankshaft sprocket.

Pistons and Connecting Rods

The pistons are made of cast-aluminum alloy using two compression rings and one oil control ring assembly. The piston pins are a press fit in the connecting rods and a floating fit in the pistons.

Valve Train

The valve train is a ball-pivot type. Motion is transmitted from the crankshaft through the valve lifter and valve pushrod to the valve rocker arm. The valve rocker arm pivots on its ball and transmits the camshaft motion to the valve. The valve lifters keep all parts of the valve train in constant contact. Each lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment.

Lubrication

The oil pump is gear driven from the camshaft. Oil is drawn from the oil pan through a pickup screen and tube. The gear type oil pump has a pressure regulator valve which controls the lubrication system pressure by bypassing excess oil back to the oil pan sump.

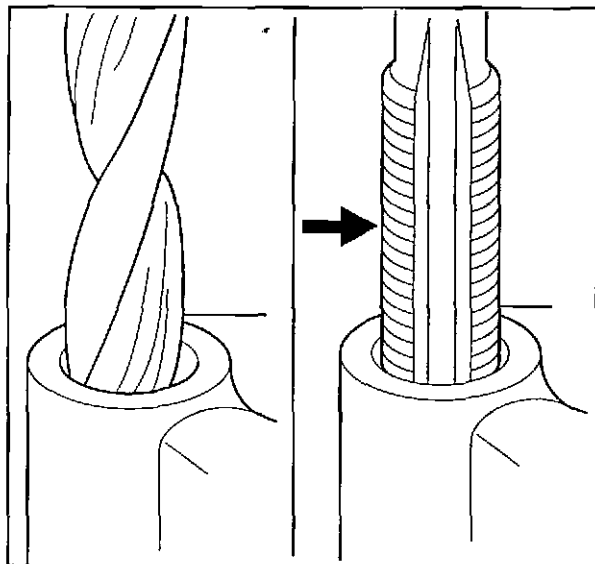
Pressurized oil from the oil pump flows to the full flow filter. A bypass valve allows oil to bypass the filter if it becomes clogged or restricted. Oil then flows into an oil passage that runs along the right side of the block and intersects the lifter bosses. Oil from this passage is routed to the crankshaft main bearings and camshaft bearings through smaller drilled passages. Oil is supplied to the connecting rod bearings by holes drilled in the crankshaft. Oil is supplied to the rocker arms through holes in the hydraulic lifters which feed oil up the pushrods to the rocker arms. The oil is metered by discs under the pushrod seat.

Many internal engine parts have no direct oil feed and are supplied by either gravity or splash from other direct feed components. Timing gears are lubricated by oil supplied through a passage from the front of the camshaft to a calibrated nozzle above the crankshaft gear.

Thread Repair

Tools Required

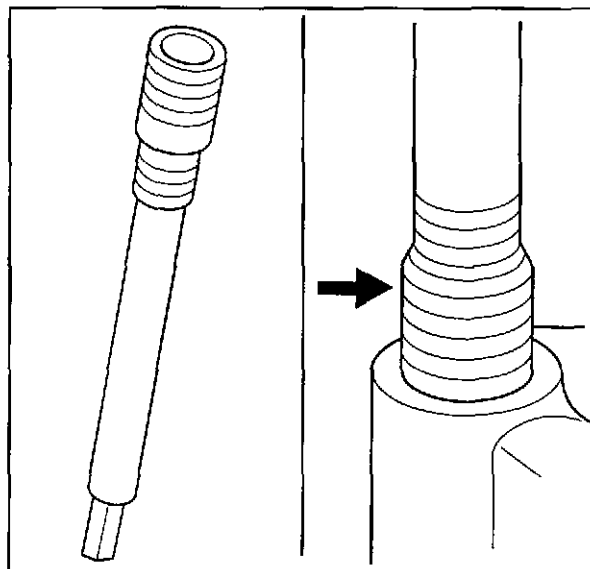
General purpose thread repair kits. These kits are available commercially



VE121-3L

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

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



VE122-3L

5. Thread the insert onto the mandrel of the installer. Engage the tang of the insert onto the end of the mandrel.

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

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

Cleanliness and Care

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly. Refer to *Separating Parts*.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

- Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
- This grit is abrasive and has been known to cause internal engine damage.

4. Assembling components:

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

Tighten bolts to specifications. Do not overtighten.

Replacing Engine Gaskets

1. Gasket reuse and applying sealants:
 - Do not reuse any gasket unless specified.
 - Gaskets that can be reused will be identified in the service procedure.
 - Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.
2. Separating components:
 - Use a rubber mallet to separate components.
 - Bump the part sideways to loosen the components.
 - Bumping should be done at bends or reinforced areas to prevent distortion of the parts.
3. Cleaning gasket surfaces:
 - Remove all gasket and sealing material from the part using a plastic or wood scraper (if required).
 - Care must be taken to avoid gouging or scraping the aluminum sealing surfaces.
 - Do not use any other method or technique to remove sealant or gasket material from a part.
 - Do not use abrasive pads, sand paper or power tools to clean gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.

Use of RTV and Anaerobic Sealer

Important: Three types of sealer are commonly used in engines. These are RTV sealer, anaerobic gasket eliminator sealer and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the three types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

Pipe Joint Compound

- Pipe joint compound is a pliable sealer that does not completely harden. This type sealer is used where two nonrigid parts (such as the oil pan and the engine block) are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifolds, head gasket or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.
- To remove the sealant or the gasket material, Refer to *Replacing Engine Gaskets*.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- Room Temperature Vulcanizing (RTV) sealant hardens when exposed to air. This type sealer is used where two nonrigid parts (such as the oil pan and the engine block) are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifolds, head gasket or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.
- To remove the sealant or the gasket material, Refer to *Replacing Engine Gaskets*.
- Apply RTV to a clean surface. Use a bead size as specified in the service procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when the bolt is tightened.
- Assemble components while RTV is still wet (within three minutes). Do not wait for RTV to skin over.
- Tighten the bolts to specifications. Do not overtighten.

Anaerobic Sealer

- Anaerobic gasket eliminator hardens in the absence of air. This type sealer is used where two rigid parts (such as castings) are assembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.
- To remove the sealant or the gasket material, Refer to *Replacing Engine Gaskets*.
- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be resealed must be clean and dry.
- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when the bolt is tightened.
- Tighten the bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

Separating Parts

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

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

Mark or identify the following components:

- Piston and the piston pin.
- Piston assembly to the specific cylinder bore.
- Piston rings to the specific piston assembly and cylinder bore.
- Connecting rod to the crankshaft journal.
- Connecting rod to bearing cap.
- Crankshaft main and connecting rod bearings.
- Camshaft and valve lifters.
- Valve lifters, guides, pushrods, pivot supports and rocker arms.
- Valve to the valve guide.
- Valve spring and shim.
- Engine block main bearing cap location and direction.
- Oil pump drive and driven gears.

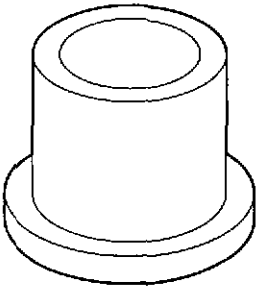
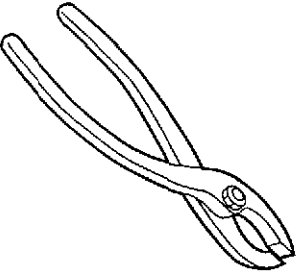
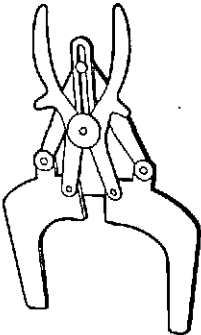
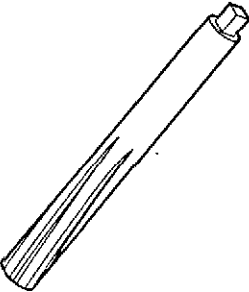
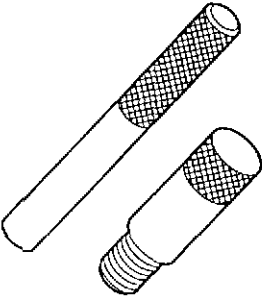
Tools and Equipment

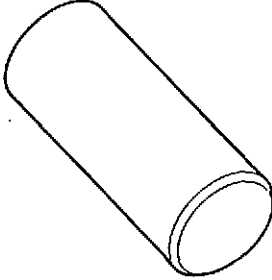
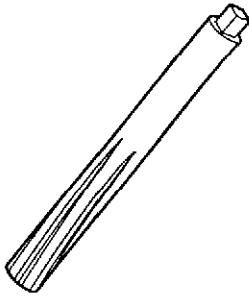
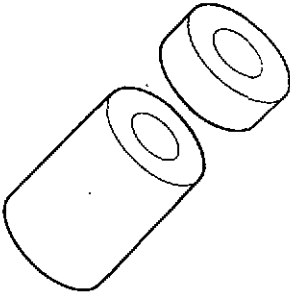
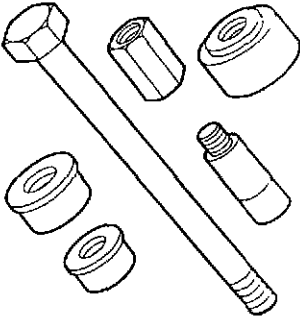
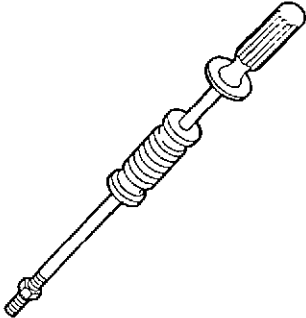
Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

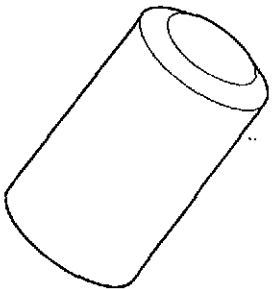
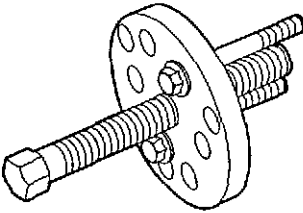
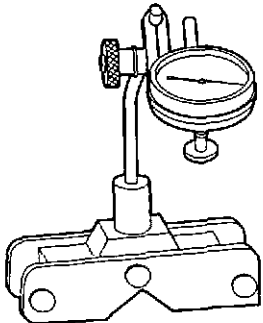
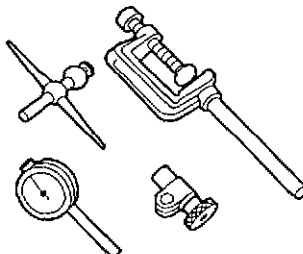
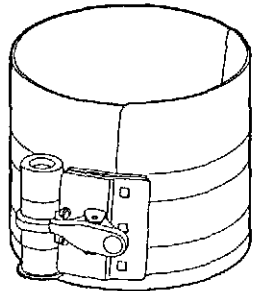
To properly service the engine assembly, the following items should be readily available:

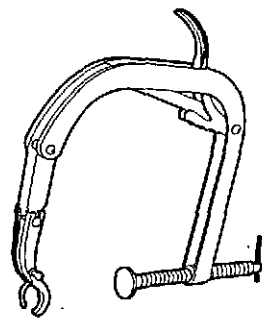
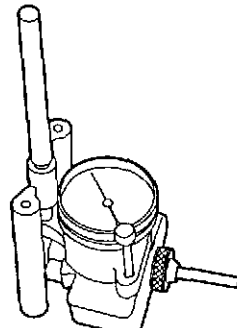
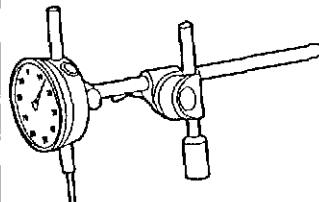
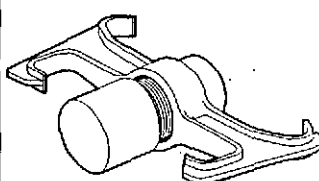
- Approved eye protection and safety gloves.
- A clean, well-lit work area.
- A suitable parts cleaning tank.
- A compressed air supply.
- Trays or storage containers to keep parts and fasteners organized.
- An adequate set of hand tools.
- Approved engine repair stand.
- An approved engine lifting device that will adequately support the weight of the components.

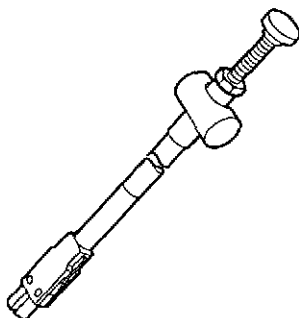
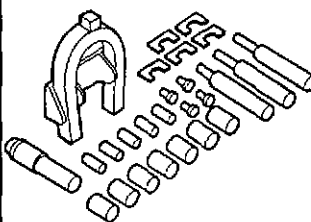
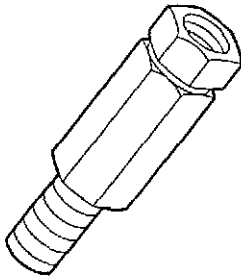
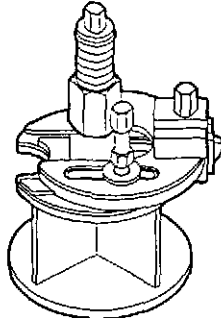
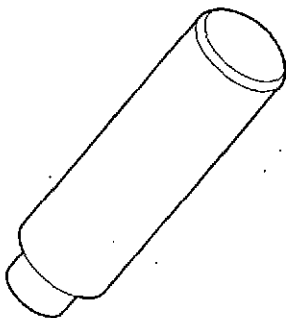
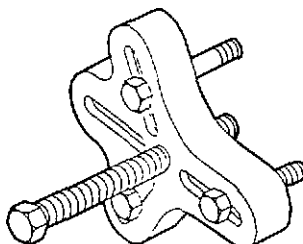
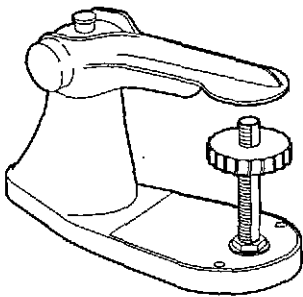
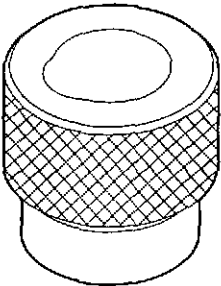
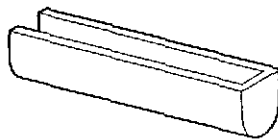
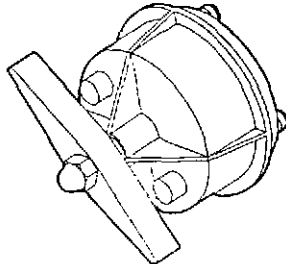
Special Tools and Equipment

	J 791 Camshaft Sprocket Remover
	J 3049-A Valve Lifter Remover
	J 3936-03 Piston Ring Groove Cleaner
	J 4822 Valve Guide Reamer
	J 5239 Connecting Rod Bolt Guide Set

	J 5590 Crankshaft Sprocket Installer
	J 5715 or J 6036 Rocker Stud Hole Reamer
	J 5802-01 Rocker Arm Stud Remover
	J 6098-01 Camshaft Bearing Remover/Installer
	J 6585 Slide Hammer

	J 6880 Rocker Arm Stud Remover
	J 6978-E Crankshaft Sprocket Puller
	J 7872 Magnetic Base Dial Indicator
	J 8001 Dial Indicator
	J 8037 Piston Ring Compressor

	J 8062 Valve Spring Compressor
	J 8087 Cylinder Bore Gauge
	J 8089 Carbon Remover Brush
	J 8520 Camshaft Lobe Lift Indicator
	J 8792 Crankshaft Pulley Installer

	J 9290-01 Valve Lifter Remover (Slide Hammer Type)		J 24086-C Piston Pin Remover/Installer Set
	J 9534 Distributor Lower Bushing Remover		J 24270 Ridge Reamer
	J 9535 Distributor Lower Bushing Installer		J 24420-C Universal Crankshaft Pulley Remover
	J 9666 Valve Spring Tester		J 35468 Engine Front Cover Aligner and Oil Seal Installer
	J 21882 Oil Suction Pipe Installer		J 35621 Crankshaft Rear Oil Seal Installer

3.0L MARINE ENGINE SPECIFICATIONS

All Specifications are in INCHES unless otherwise noted

PISTON PIN:			
Diameter			.92700-.92718
Clearance	Production		.0003-.00065
In Piston	Service limit		.001 (Maximum)
Fit in Rod			.0008-.00198 Interference
CRANKSHAFT:			
	Diameter	ALL	2.2979-2.2994
Main Journal	Taper	Prod.	.0002 (Maximum)
		Serv. Lim	.0010 (Maximum)
	Out of Round	Prod.	.0002 (Maximum)
		Serv. Lim	.0010 (Maximum)
X	Production	#1-#4	.0010-.0024
		#5	.0016-.0035
	Service Limit	#1-#4	.0010-.0025
		#5	.0015-.0035
Crankshaft End Play			.002-.006
Crankpin	Diameter		2.0980-2.0995
	Taper	Prod.	.0003 (Maximum)
		Serv. Lim	.0010 (Maximum)
	Out of Round	Prod.	.0002 (Maximum)
		Serv. Lim	.0010 (Maximum)
Rod Bearing Clearance	Production		.0017-.0027
	Service Limit		.0030
Rod Side Clearance			.006-.017
CAMSHAFT:			
Lobe Lift +0.001	Intake		.25294
	Exhaust		.25294
Journal Diameter			1.8677-1.8697
Camshaft End Play			.003-.008

3.0L MARINE ENGINE SPECIFICATIONS

All Specifications are in INCHES unless otherwise noted

VALVE SYSTEM:			
Lifter			Hydraulic
Rocker Arm Ratio			1.75:1
Valve Lash	Intake	Half To One Turn Down	
	Exhaust	From Zero Lash	
Face Angle (Intake & Exhaust)			45 Degrees
Seat Angle (Intake & Exhaust)			46 Degrees
Seat Runout (Intake & Exhaust)			.002 (Maximum)
Seat Width	Intake		.050-.070
	Exhaust		.060-.080
Stem Clearance	Production	Intake	.0010-.0027
		Exhaust	.0007-.0027
	Service	Intake	Hi Limit +.001
		Exhaust	Hi Limit +.002
Valve Spring (Outer)	Free Length		2.06
	Pressure	Closed	208-222 @ 1.22
	lbs @ in.	Open	100-110 @ 1.61
	Installed Height +-. 1/32"		1.65
Valve	Free Length		
Spring	Approx. # of coils		Damper Not To Be Used
Damper			

3.0L MARINE ENGINE SPECIFICATIONS
TORQUE SPECIFICATIONS

Item	
Rocker Arm Cover Bolts	40 LB.IN
Cylinder Head Bolts	90 LB.FT
Torsional Damper Bolt	50 LB.FT
Front Cover Bolts	30 LB.IN
Oil Pan Nuts	165 LB.IN
Oil Pan Bolts (to crankcase)	80 LB.IN
Oil Pan Bolts (to front cover)	45 LB.IN
Rear Crankshaft Oil Seal Retainer Nuts	135 LB.IN
Camsshaft Sprocket Bolts	80 LB.IN
Connecting Rod Cap Nuts	45 LB.FT
Main Bearing Cap Bolts	65 LB.FT
Flywheel Bolts	65 LB.FT
Spark Plugs	22 LB.FT
Water Pump Bolts	15 LB.FT
Oil Pan Studs To Oil Seal Retainer or Crankcase	15 LB.IN
1 LH Front head bolt	85 LB.FT

3.0L MARINE ENGINE SPECIFICATIONS

!! Specifications are in INCHES unless otherwise noted

GENERAL DATA:			
Type	L4		
Displacement	3.0L (181 Cu.In.)		
RPO			
Bore	4.00		
Stroke	3.60		
Compression Ratio	9.25:1		
Firing Order	1-3-4-2		
CYLINDER BORE:			
Diameter	3.9995-4.0025		
Round	Service	.0020 (Maximum)	
	Production: Thrust side	.0005 (Maximum)	
Taper	Relief Side	.0005 (Maximum)	
	Service	.0010 (Maximum)	
PISTON:			
Clearance	Production	.0025-.0035	
	Service Limit	.0035 (Maximum)	
PISTON RING:			
IC			
ID	Production	Top	.0012-.0029
IN	Groove	2nd	
IP	Clearance		
IR	Service	Hi Limit Production +0.001	
IS			
IS	Production	Top	.010-.020
IS	Gap	2nd	.017-.025
IS			
IN	Service Limit	Hi Limit Production +0.010	
	Groove	Production	.001-.006
ID	Clearance	Service Limit	Hi Limit Production +0.001
IS			
IL	Gap	Production	.010-.030
IS		Service Limit	Hi Limit Production +0.010

4.3L

SECTION 6A3B

4.3L V6

RPO LB4, VIN Z

CAUTION: On vehicles equipped with Supplemental Inflatable Restraint (SIR), refer to CAUTIONS in Section 9J under "ON-VEHICLE SERVICE" and the SIR Component and Wiring Location view in Section 9J before performing service on or around SIR components or wiring. Failure to follow CAUTIONS could result in possible air bag deployment, personal injury or otherwise SIR repairs.

NOTICE: Always use the correct fastener in the correct location. Use the correct fastener part number to replace a fastener. If the correct fastener part number is not available, a fastener of equal size and strength may be used. Do not use a fastener that is stronger when the correct fastener part number is not available in the following applications:

- Some bolts are designed to permanently stretch, and if a stronger fastener is used, the part will not be tightened correctly. These permanently stretching bolts will be called out. The correct part number fasteners must be used to replace this type of fastener because there is no available equivalent.
- Other bolts are designed to break if over tightened to prevent part damage. Using a stronger fastener may cause part damage to occur. Fasteners that need to be replaced when removed will be called out. The correct tightening specification and sequence must be used when installing fasteners. Part or system damage may occur if the above instructions are not followed.

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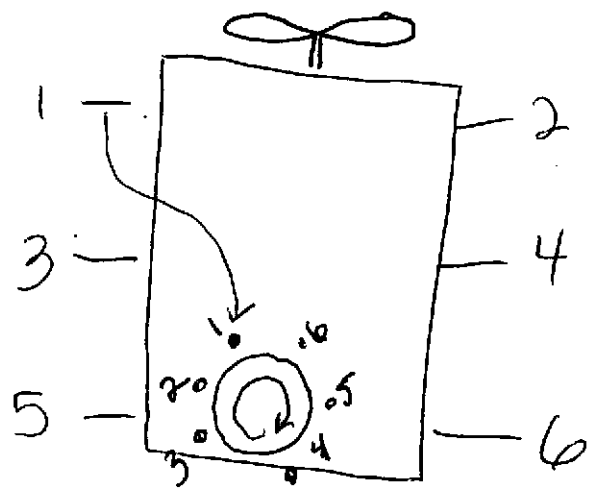
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16-5-4-3-2

2



GENERAL DESCRIPTION

ENGINE CONSTRUCTION

The 4.3L (262 CID) (VIN Z) engine is a liquid-cooled 90-degree V6 type with overhead valves, cast-iron block, cylinder heads, and cast-ductile balance shaft.

For engine identification, refer to SECTION 0A. For engine component identification refer to figures 1 through 4.

CYLINDER BLOCK

The cylinder block has 6 cylinders arranged in a "V" shape with 3 cylinders in each bank. Starting at the front of the engine, cylinders in the right bank are numbered 1-3-5 and cylinders in the left bank are numbered 2-4-6 (when viewed from the front of the engine). The firing order of the cylinders is 1-6-5-4-3-2. The cylinders are encircled by coolant jackets.

CYLINDER HEADS

The cylinder heads have one intake and one exhaust valve for each cylinder. A spark plug is located between the valves in the side of the cylinder head. The valve guides are integral and the rocker arms are retained on individual threaded-in studs.

CRANKSHAFT

The crankshaft is supported by four main bearing parts. The number four bearing at the rear of the engine is the end thrust bearing. The bearings are retained by bearing caps that are machined with the block for proper alignment and clearances.

CAMSHAFT

The camshaft is supported by four full round, sleeve type bearings. A sprocket on the crankshaft drives a timing chain which in turn drives the camshaft through a sprocket.

PISTONS AND CONNECTING RODS

The pistons are made of cast aluminum alloy using two compression rings and one oil control ring. Piston pins are offset 1.6 mm (1/16 inch) toward the major thrust side (right side) to reduce piston slap as the connecting rod travels from one side of the piston to the other side after a stroke. The pins are a press fit in the connecting rod and a floating fit in the piston.

BALANCE SHAFT

A cast-ductile balance shaft is mounted in the crankcase above and inline with the camshaft for enhanced engine smoothness under all operating conditions. A camshaft gear drives the gear attached to the balance shaft. The front end of the balance shaft is supported by a ball bearing and the opposite end uses a sleeve bearing.

VALVE TRAIN

The valve train is a ball pivot type. Motion is transmitted from the camshaft through the hydraulic lifter and pushrod to the rocker arm. The rocker arm pivots on its ball and transmits the camshaft motion to the valve.

The hydraulic valve lifters with roller followers keep all parts of the valve train in constant contact. Each lifter acts as an automatic adjuster and maintains zero lash in the valve train and eliminates the need for periodic valve adjustment.

INTAKE MANIFOLD

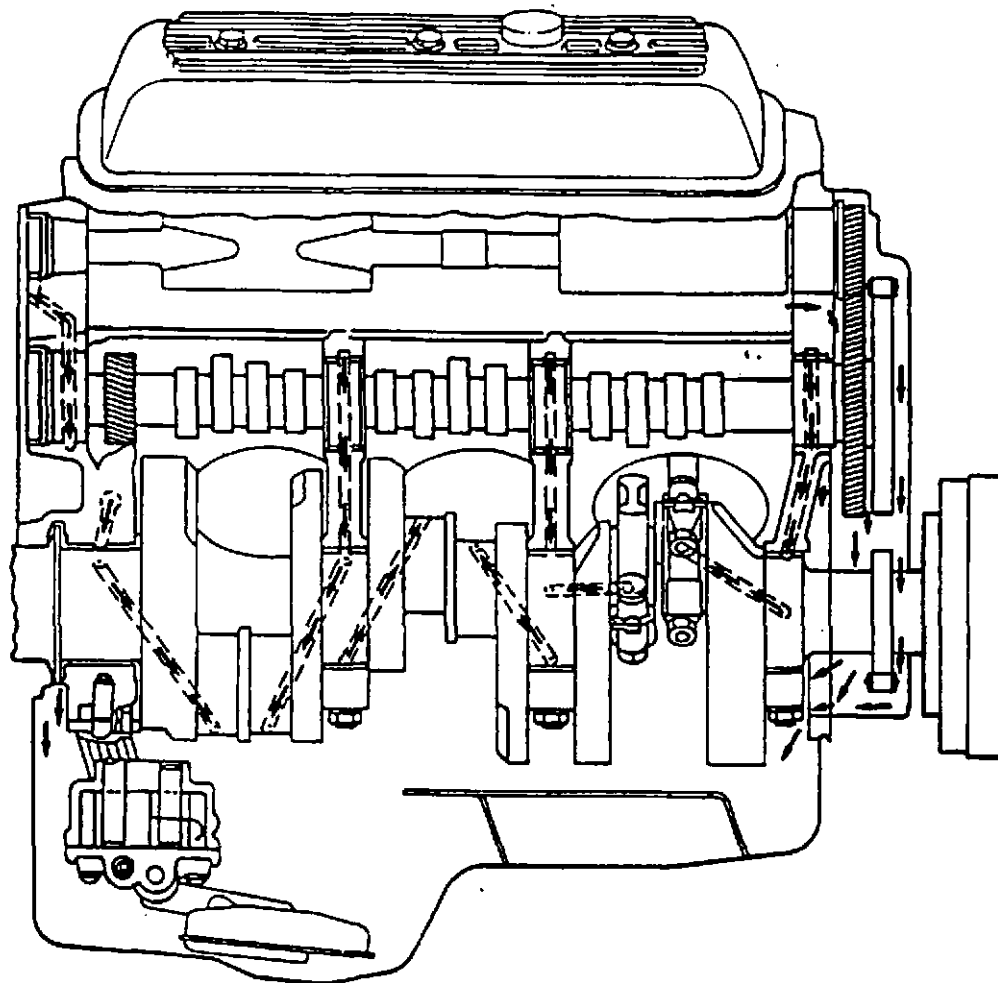
A cast-aluminum intake manifold is used that has an exhaust gas recirculation (EGR) port cast into it for the mixture of exhaust gases with the fuel and air mixture.

ENGINE LUBRICATION

A lubrication schematic is shown in figure 5. The gear type oil pump is driven from the distributor shaft, which is gear driven from the camshaft. Oil is drawn into the oil pump through a pickup screen and pipe.

Pressurized oil is routed to the oil filter. In case of excessive oil pressure, a bypass valve is provided. Filtered oil flows into the main gallery and then to the camshaft, balance shaft rear bearing, and crankshaft bearings. The valve lifter oil gallery supplies oil to the valve lifters. Oil flows from the hydraulic lifters through the hollow pushrods to the rocker arms. Oil from overhead drains back to the crankcase through oil drain holes.

The timing chain is drip fed from the front camshaft bearing. The pistons and piston pins are lubricated by oil splash.



V0503

Figure 5—Engine Lubrication Diagram

DISASSEMBLY OF THE ENGINE

TOOLS AND SHOP EQUIPMENT

A clean well-lit work area should be available. Other necessary equipment includes: a suitable parts cleaning tank, compressed air supply, trays to keep parts and fasteners organized, and an adequate set of hand tools.

An approved engine repair stand will aid the work and help prevent personal injury or component damage.

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

Some precision measuring tools are required for inspection of certain critical components. Torque wrenches are necessary for the correct assembly of various parts.

ACCESSORY REMOVAL

The various procedures in this manual assume that the engine accessories have been removed. These accessories may include one or more of the following:

- Hydraulic Pump
- Generator
- Air Conditioning Compressor
- Cooling Fan
- Distributor
- TBI Unit

It is beyond the scope of this section to cover in detail the many different accessory installations. Refer to the appropriate Truck Service Manual for this information.

Diagrams of emissions and vacuum hose routings, wiring harness routing, accessory drive belt layout, etc. should be found before removing accessories.

CLEANING

Remove the engine accessories before cleaning, to provide better access to the engine's exterior surfaces. After removing the TBI unit, distributor, etc., cover the openings with tape to prevent the entry of contaminants.

Methods used to clean the engine will depend on the means which are available. Steam cleaning, pressure washing, or solvent cleaning are some of the acceptable methods. Allow the engine to dry thoroughly before beginning any work.

It is important that the engine be as clean as possible to prevent dirt, coolant, or any other contaminants from entering critical areas during disassembly.

DRAINING THE ENGINE

 Remove or Disconnect

1. Oil pan drain plug and washer.
 - Allow the oil to drain into a proper container.
2. Oil filter.
3. Coolant drain plug and or knock sensor from the block.
 - Allow the coolant to drain from the block into a proper container.

 Install or Connect

NOTICE: For steps 1 and 2 refer to "Notice" on page 6A3B-1.

1. Oil pan drain plug and washer.

 Tighten

- Drain plug to 25 N.m (18 lbs. ft.).

2. Coolant drain plug and or knock sensor into the block.

 Tighten

- Coolant drain plugs or knock sensor to 14 N.m (124 lbs. in.).

EGR VALVE REMOVAL

 Remove or Disconnect

1. Bolts.
2. EGR valve.
3. Gasket.

EXHAUST MANIFOLD REMOVAL

 Remove or Disconnect

1. Exhaust manifold bolts, washers, and tab washers.
2. Heat shields.
3. Exhaust manifold.

COOLANT PUMP REMOVAL

 Remove or Disconnect

1. Coolant pump bolts.
2. Coolant pump.
3. Gaskets.

ROCKER ARM COVER REMOVAL

 Remove or Disconnect (Figure 6)

1. Rocker arm cover bolts (1).
2. Rocker arm covers (2).
3. Gaskets.

INTAKE MANIFOLD REMOVAL

 Remove or Disconnect

1. Intake manifold bolts.
2. Intake manifold.
3. Gaskets.

VALVE TRAIN COMPONENT REMOVAL

 Important

- Store all reusable components in an exact order so they can be reassembled in the same position from which they were removed.

 Remove or Disconnect (Figure 7)

1. Rocker arm nuts (21), balls (22), and rocker arms (23).
2. Push rods (24).
3. Bolt (19).
4. Guide assembly (20).
5. Hydraulic lifters (26).
 - Remove the lifters one at a time and place them in an organizer rack.

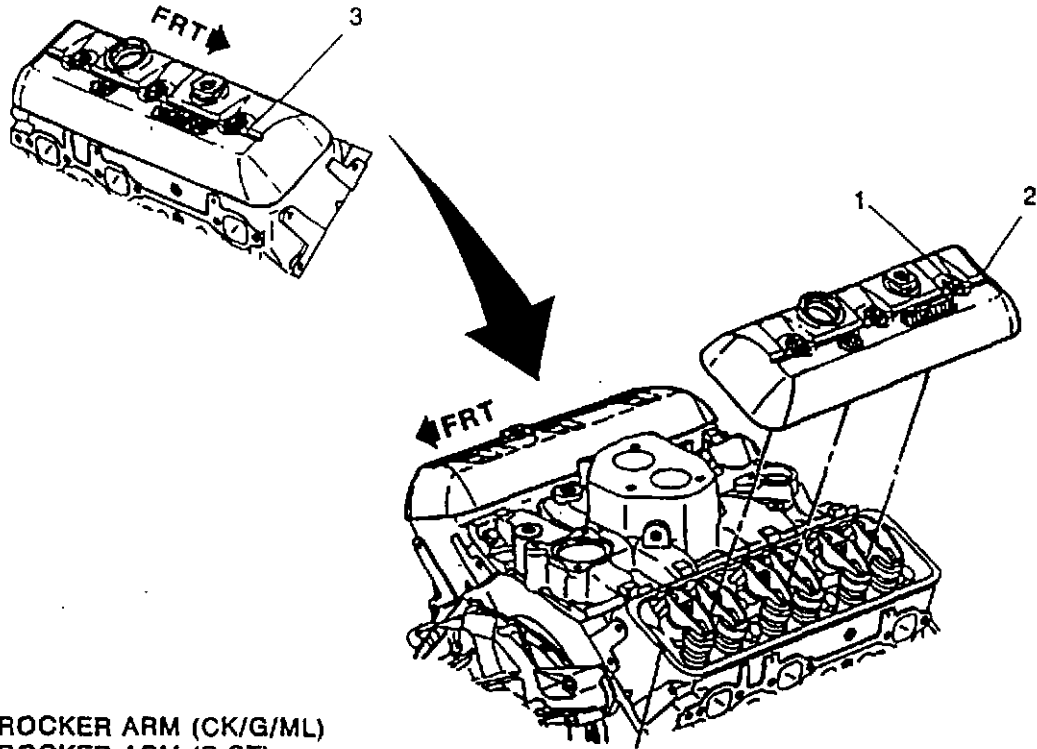
CYLINDER HEAD REMOVAL

 Remove or Disconnect

1. Engine lift bracket.
2. Cylinder head bolts.
3. Cylinder heads.
4. Head gaskets.

TORSIONAL DAMPER REMOVAL

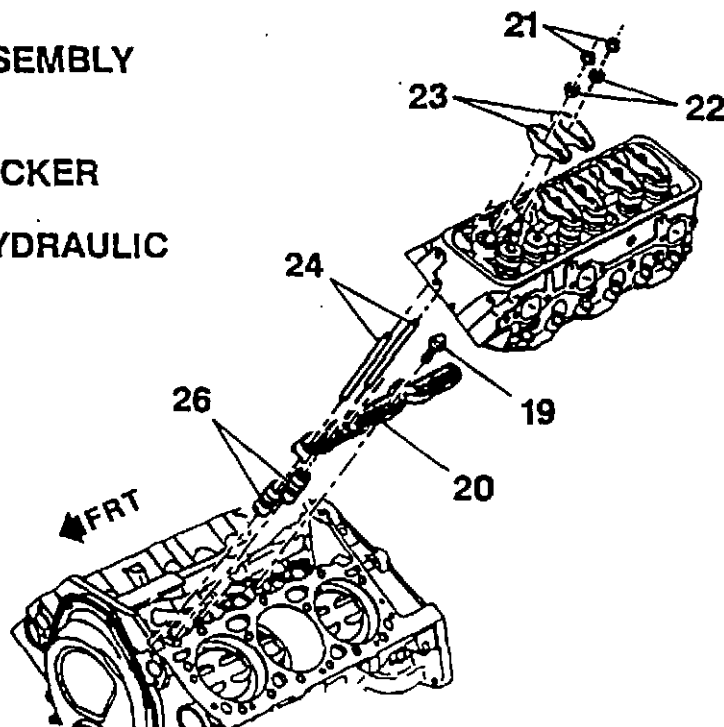
NOTICE: The inertial weight section of the torsional damper is assembled to the hub with a rubber sleeve. The removal procedures must be followed (with the proper tools) or movement of the inertia weight section of the hub will destroy the tuning of the torsional damper and the engine timing reference.



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Figure 6—Rocker Arm Cover and Components

- 19. BOLT
- 20. GUIDE ASSEMBLY
- 21. NUT
- 22. BALL
- 23. ARMS, ROCKER
- 24. PUSHROD
- 26. LIFTER, HYDRAULIC



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Figure 7—Valve Train Components

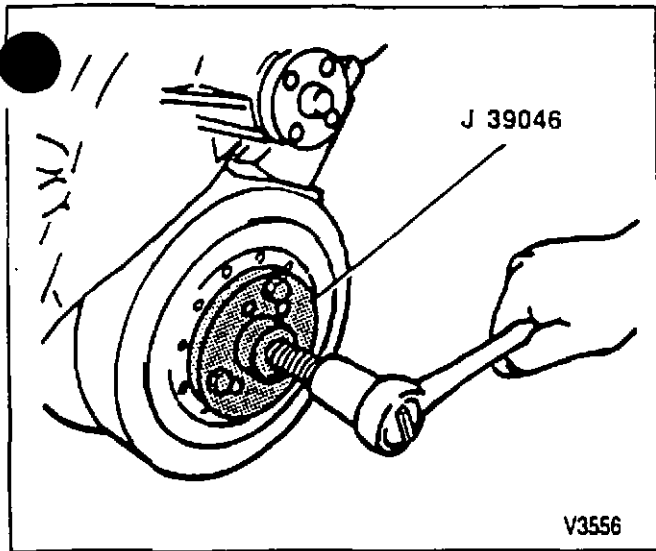


Figure 8—Removing the Torsional Damper

↔ Remove or Disconnect (Figure 8)

Tool Required:

J 39046 Torsional Damper Puller and Installer

1. Torsional damper bolt.
2. Torsional damper using J 39046 (figure 8).
3. Crankshaft key.

OIL PAN REMOVAL

↔ Remove or Disconnect (Figure 9)

1. Oil pan nuts (125).
2. Oil pan bolts (129).
3. Clips (130) and studs (128).
4. Reinforcements.
5. Oil pan (72).
6. Gasket (70).

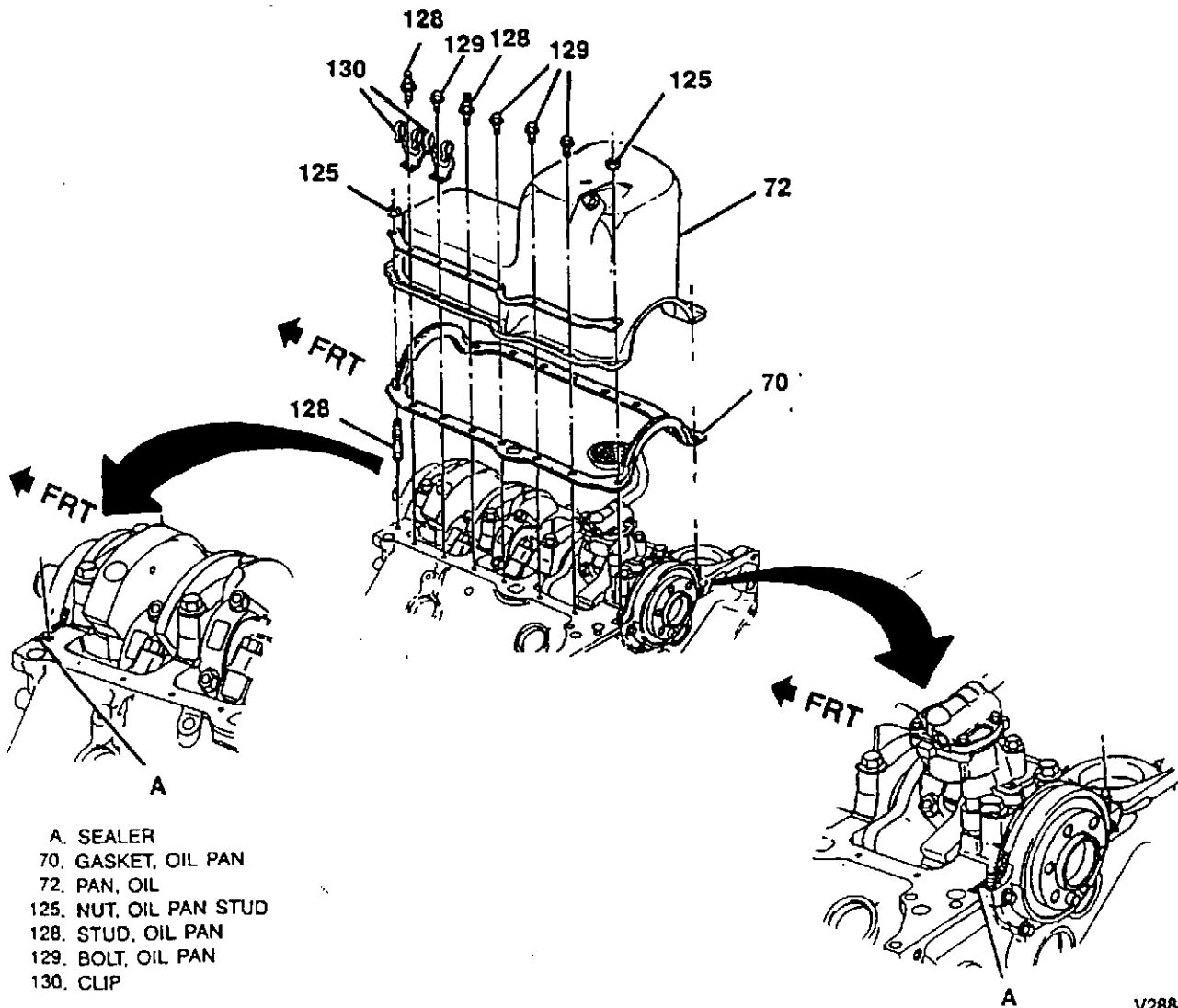
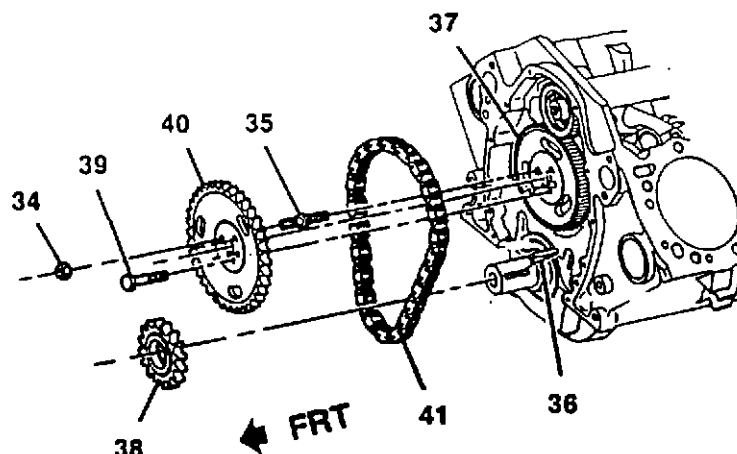


Figure 9—Oil Pan and Components

- 34. NUT
- 35. STUD
- 36. KEY
- 37. GEAR, BALANCE SHAFT DRIVE
- 38. SPROCKET, CRANKSHAFT
- 39. BOLT
- 40. SPROCKET, CAMSHAFT
- 41. CHAIN, TIMING



V2629

Figure 10—Camshaft and Components

OIL PUMP REMOVAL

Remove or Disconnect

1. Oil pump to main bearing cap bolt.
2. Complete oil pump assembly.
3. Shaft extension.

FLYWHEEL REMOVAL

Remove or Disconnect

1. Flywheel bolts.
2. Flywheel.

FRONT COVER REMOVAL

Remove or Disconnect

1. Front cover bolts.
2. Front cover.
3. Front cover gasket.

TIMING CHAIN AND CAMSHAFT SPROCKET REMOVAL

Remove or Disconnect (Figures 10 and 11)

- Check timing chain free play. If the timing chain can be moved back and forth in excess of 16 mm (5/8 inch), make a note that the timing chain should be replaced during assembly.

1. Camshaft sprocket bolts (39) and nut (34).
2. Camshaft sprocket (40) and timing chain (41) together.

- The sprocket has a light interference fit on the camshaft. Tap the sprocket on its lower edge to loosen it.

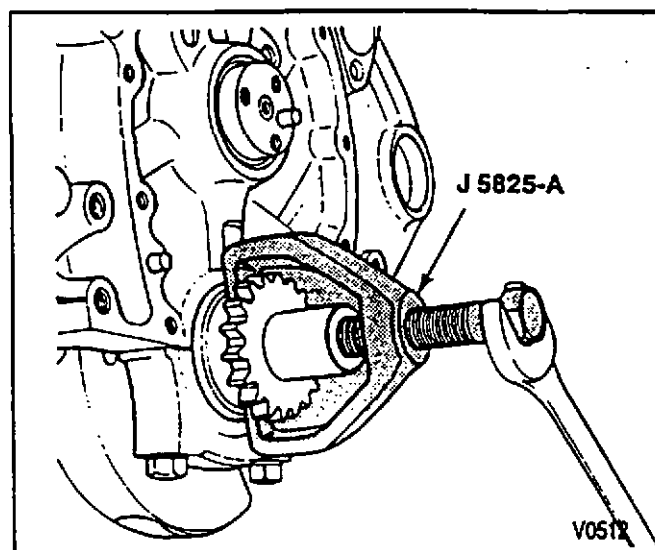


Figure 11—Removing the Crankshaft Sprocket

CAMSHAFT REMOVAL

Remove or Disconnect (Figures 10 through 12)

Tools Required:

J 5825-A Crankshaft Gear Remover

1. Balance shaft drive gear nut.
2. Balance shaft drive gear (37).
3. Crankshaft sprocket (38), if necessary. Use J 5825 (figure 11).
4. Camshaft retainer bolts and camshaft retainer.
5. Camshaft.

- A. Install three 5/16-18 inch bolts 100-125 mm (4-5 inches) long into the camshafts threaded holes. Use these bolts to handle the camshaft (figure 12).

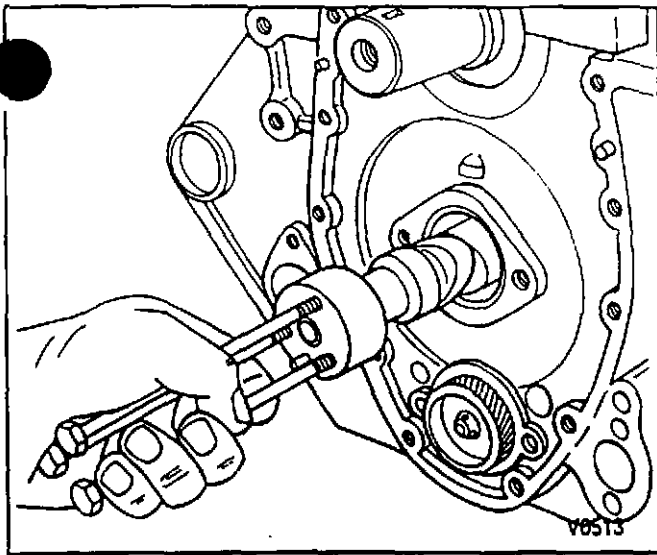


Figure 12—Removing the Camshaft

BALANCE SHAFT REMOVAL

Remove or Disconnect (Figure 13)

Tools Required:

J 38834 Balance Shaft Bearing Service Kit
J 26941 Bearing Remover

1. Bolt (49).
2. Driven gear (42).
3. Retainer bolts (48).
4. Retainer (43).

5. Balance shaft (47) using a soft faced hammer (figure 13).
6. Balance shaft rear bearing (45) using J 38834 and J 26941.

Important

- The balance shaft with front bearing are serviced as an assembly.
- Use only the correct tools for bearing and shaft installation.
- Inspect the balance shaft driven gear and the drive gear for nicks and burrs.

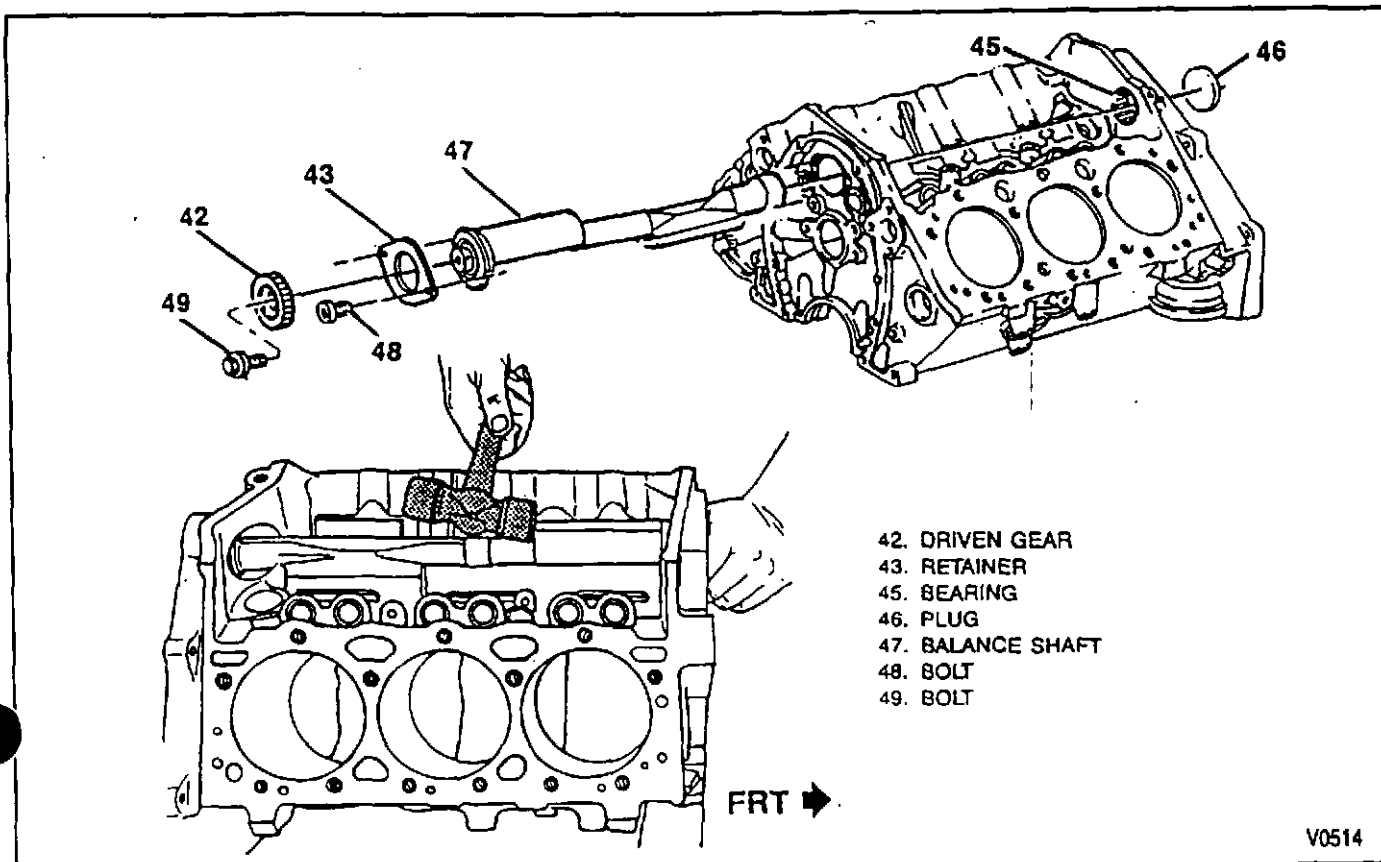
PISTON AND CONNECTING ROD REMOVAL

Remove or Disconnect (Figures 14 and 15)

Tools Required:

J 5239 Guide Set
J 24270 Ridge Reamer

1. Ridge or deposits from the upper end of the cylinder bores as follows:
 - A. Rotate the crankshaft until the piston is at BDC.
 - B. Place a cloth on top of the piston.
 - C. Perform the cutting operation with J 24270.
 - D. Rotate the crankshaft until the piston is at TDC.
 - E. Remove the cloth and cuttings.
 - F. Repeat this procedure for each piston.
2. Mark the cylinder numbers on the tops of each piston.



42. DRIVEN GEAR
43. RETAINER
45. BEARING
46. PLUG
47. BALANCE SHAFT
48. BOLT
49. BOLT

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Figure 13—Removing Balance Shaft Assembly

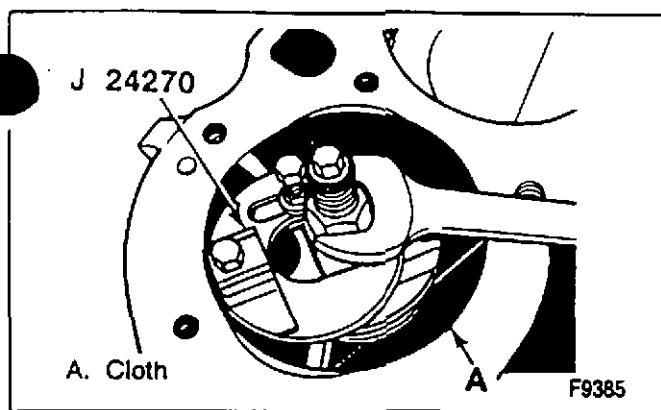


Figure 14—Removing the Cylinder Ridge

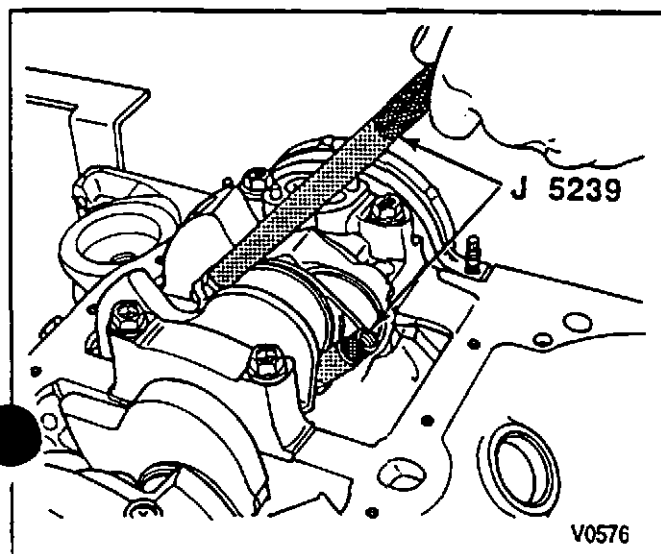


Figure 15—Removing the Connecting Rod and Piston

- Marking them from the front to the rear, with the engine in an upright position and viewed from the front:
 - The right bank is numbered 1-3-5.
 - The left bank is numbered 2-4-6.
- 3. Check the connecting rod and cap for identification marks.
 - Mark the parts if required.
 - Marking them from the front to the rear, with the engine in an upright position and viewed from the front:
 - The right bank is numbered 1-3-5.
 - The left bank is numbered 2-4-6.

! Important

- Store the connecting rod, bearings and cap together as mating parts, so they may be reassembled in the same position from which they were removed.
- 4. Connecting rod cap.
- 5. Connecting rod and piston.
 - Attach J 5239 to the connecting rod bolts (figure 15).
 - Use the long guide rod of J 5239 to push the connecting rod and piston out of the bore through the top of the engine.
- 6. Connecting rod bearings.

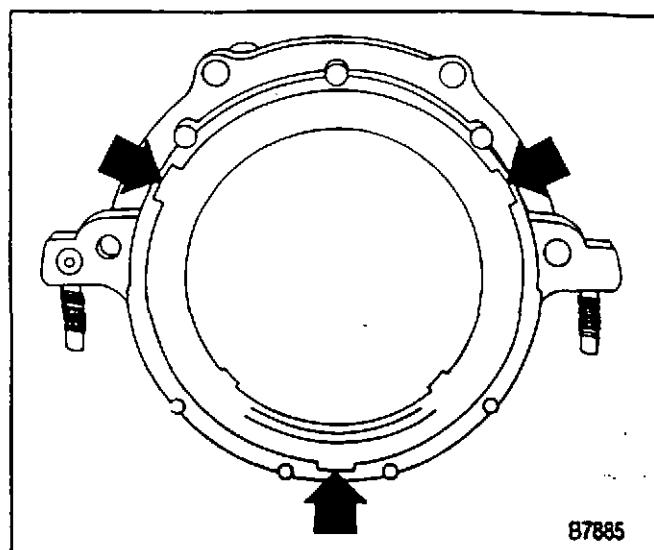


Figure 16—Seal Removal Notches

CRANKSHAFT REAR OIL SEAL REMOVAL

- ↔ Remove or Disconnect (Figure 16)**

NOTICE: When removing the crankshaft rear oil seal, be careful to not damage the crankshaft sealing surface. A minor scratch can cause a major oil leak.

- ↔ Remove or Disconnect**

- Crankshaft rear oil seal. Insert a screwdriver into the notches provided in the seal retainer and pry the seal out (figure 16).

CRANKSHAFT REAR OIL SEAL RETAINER REMOVAL

- ↔ Remove or Disconnect (Figure 17)**

1. Screws (50) and nuts (51).
2. Seal retainer (52).
3. Gasket (54).

CRANKSHAFT REMOVAL

- ! Important**

- Check the main bearing caps for location markings. Mark the caps if necessary. The caps must be returned to their original locations during assembly.

- ↔ Remove or Disconnect**

1. Main bearing cap bolts.
2. Main bearing caps and lower main bearing inserts.
3. Crankshaft from the cylinder block with extreme care, taking care to avoid damage to crankshaft journals and thrust flange surfaces.
4. Upper main bearing inserts.

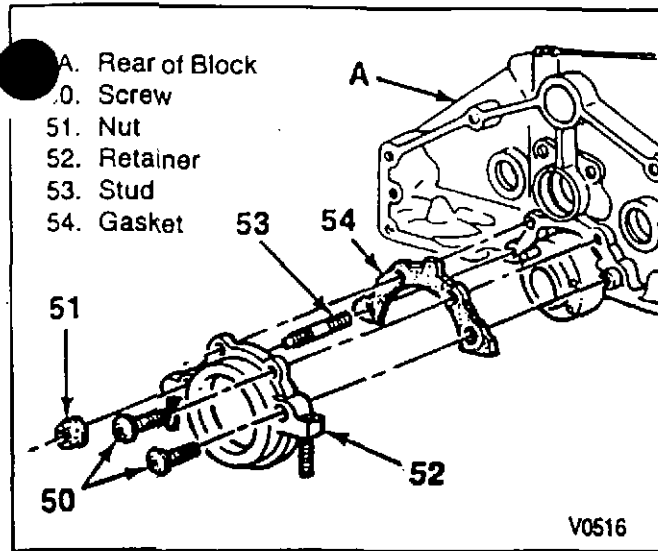


Figure 17—Crankshaft Rear Oil Seal Retainer

MAIN BEARING REMOVAL (WITHOUT REMOVING CRANKSHAFT)

Important

- Check the main bearing caps for location markings. Mark the caps if necessary. The caps must be returned to their original locations during assembly.

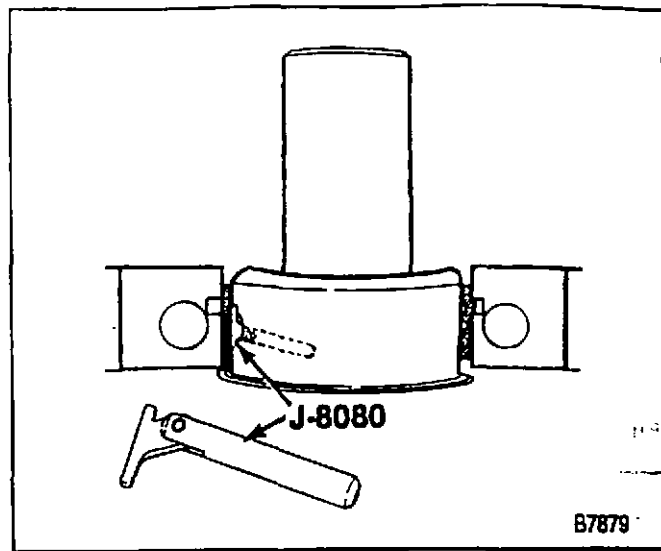


Figure 18—Removing the Main Bearing Insert

Remove or Disconnect (Figure 18)

Tool required:

J 8080 Main Bearing Remover/Installer

1. Main bearing cap bolts.
2. Main bearing caps.
3. Lower main bearing inserts from the main bearing caps.
4. Upper main bearing inserts.
 - A. Insert J 8080 into the crankshaft oil hole (figure 18).
 - B. Rotate the crankshaft to turn the upper main bearing insert out of the block.

CLEANING, INSPECTION, AND REPAIR

NOTICE: The following is recommended gasket cleaning procedure for General Motors engine components. Carefully remove all gasket material from the part using a plastic or wood scraper. Use Loctite brand "Chisel Gasket Remover" (P/N 79040) Permatex brand "Gasket Remover" (P/N 4MA) or equivalent. Follow all safety recommendations and directions that are on the can.

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

NOTICE: If the engine is damaged internally and needs to be rebuilt, make sure all foreign material is completely flushed out of the cooling system/oil cooler system (if equipped). Failure to flush out the debris can result in damage to the rebuilt engine.

A solvent tank large enough to hold the larger engine parts will be needed as well as various bristle brushes and gasket scrapers. A source of compressed air will also be helpful in the cleaning operations.

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. They should not be used in operations for which they are not designed. These special tools, when they are properly used, will also minimize possible damage to engine.

Some precision measuring tools are required for inspection of certain critical components. These include micrometers, torque wrenches, feeler gages, dial indicator set, etc. The inspection work, when performed with the proper methods and tools, is most important. The rebuilt engine cannot be expected to perform properly if the parts are worn beyond acceptable limits are reused.

CYLINDER BLOCK

Remove or Disconnect

1. Oil pressure fitting and sensor.
2. Coolant drain plugs.

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3. Oil filter adapter bolts.
4. Oil filter adapter and gasket.
5. Camshaft and balance shaft cup plugs (89).
6. Front oil gallery cup plugs (86).
7. Rear oil gallery plugs (87, 88, and 90).



Clean (Figure 19)

- Sealing material from mating surfaces
- Boil cylinder block in caustic solution.
 - Flush with clean water or steam.
- Cylinder bores.
- Threaded holes.
- Oil galleries and passages.
- Scale deposits from coolant passages.
- Spray or wipe cylinder bores and machined surfaces with engine oil.



Inspect

1. All expansion plugs for lack of fit or leakage.
2. Valve lifter bores for deep scratches and deposits.
3. Cracks in the block.
 - Cylinder walls.
 - Coolant jackets.
 - Engine mount bosses.
 - Main bearing webs.
4. Main bearing bores and caps.
 - All main bearing bores should be rounded and uniform in ID at all of the bearing supports.
 - The area where the main bearing inserts contact the main bearing bore should be smooth.
 - If a main bearing cap is found to be damaged, replace the cap and line-bore the block.
5. Cylinder head mounting surface for flatness, using a precision straight edge and feeler gage (figure 20).
 - A. Set the straight edge on the sealing surface to be inspected.
 - B. Take the feeler gage and at various locations, check the gap between the straight edge and the sealing surface.
 - C. If the gap is greater than 0.05 mm (0.002 inch) within 152 mm (6 inches) at any sealing location, the block must be replaced.
 - D. If the gap is found to be less than 0.05 mm (0.002 inch) at any sealing location and a cause for leakage is suspected, then the minor irregularities may be carefully machined from the block.
6. Oil pan, timing cover, and intake manifold mounting surfaces for nicks. Minor irregularities may be cleaned up with a flat file.

CYLINDER BORE



Inspect

- Cylinder bores for scoring or other damage.



Measure

- Cylinder bore taper and out-of-round. Refer to SECTION 6A.

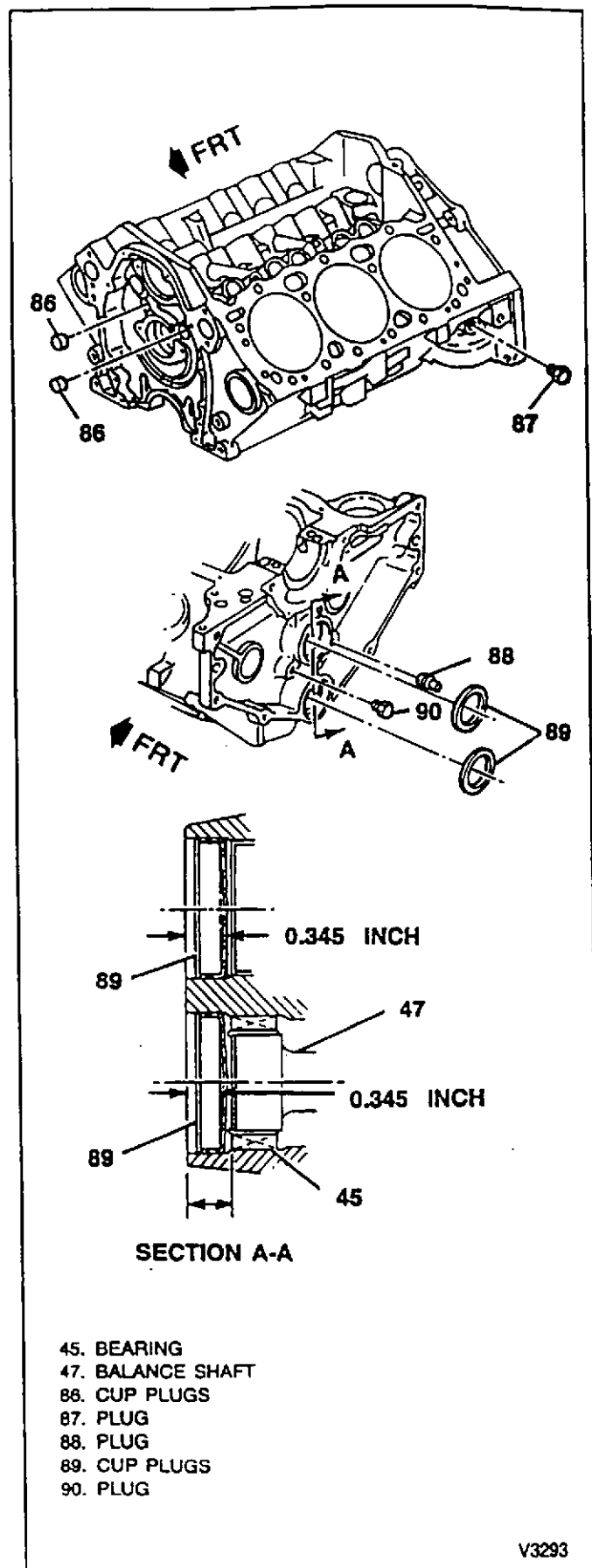


Figure 19—Engine Block Coolant Drain and Oil Gallery Plugs

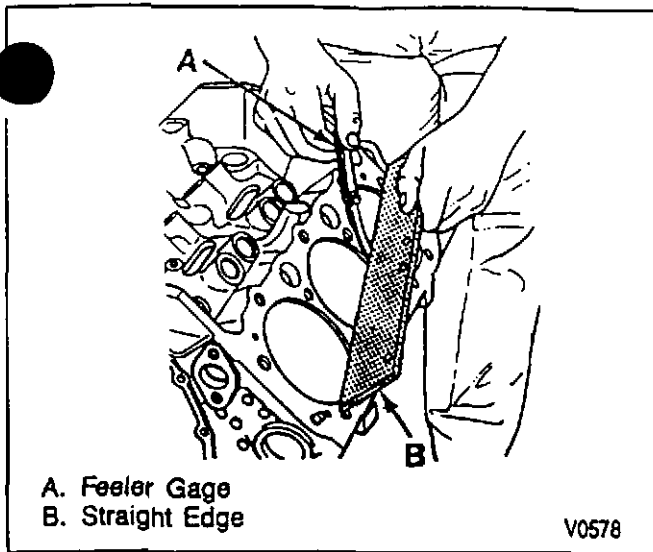


Figure 20—Measuring Block Surface Flatness

Cylinder Bore Reconditioning

Refer to SECTION 6A.

Install or Connect

NOTICE: For steps 2, 4, 5, and 6 refer to "Notice" on page 6A3B-1.

1. Front oil gallery plugs (86).

- Coat plug outside diameter with sealant (GM P/N 1052080) or equivalent.

2. Rear oil gallery plugs (87, 88, and 90).

Tighten

- Plug (87) to 30 N.m (22 lbs. ft.).
- Plug (88) to 40 N.m (30 lbs. ft.).
- Plug (90) to 40 N.m (30 lbs. ft.).

3. Camshaft and balance shaft cup plugs (89) to proper depth.

- Coat plug outside diameter with sealant (GM P/N 1052080) or equivalent.

4. Oil filter adapter, gasket, and bolts.

Tighten

- Bolts to 22 N.m (16 lbs. ft.).

5. Coolant drain plugs.

Tighten

- Plugs to 20 N.m (15 lbs. ft.).

6. Oil pressure fitting and sensor.

Tighten

- Fitting to 11 N.m (97 lbs. in.) plus turn for alignment if necessary.

PISTON AND CONNECTING ROD ASSEMBLY

Notice: The connecting rod, bearing and cap need to be stored together as mating parts, so they may be reassembled in the same position from which they were removed.

Refer to SECTION 6A and perform the following:

Disassemble

- Components as required.
- Marking parts if required.
- Marking parts from the front to the rear, with the engine in an upright position and viewed from the front.
 - The right bank is numbered 1-3-5.
 - The left bank is numbered 2-4-6.

Clean

- Components as outlined.

Inspect

- Components as outlined.

Measure

- Piston pin diameter and clearance.
- Piston to bore clearance and fit of pistons.
- Ring end gap and ring clearances.
- Ring fit.

Assemble

- Components as outlined.
- The connecting rod and cap and check for identification marks.
- The numbers on the connecting rod and bearing cap. The connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from the block or cylinder, new connecting rod bearings must be fitted and connecting rod should be numbered to correspond with the new cylinder number.

Inspect

- Ring fit.

INTAKE AND EXHAUST MANIFOLDS

Clean

- Mating surfaces on intake manifold and cylinder head.
- Excessive carbon buildup in the exhaust passages of the intake manifold.
- Scale and deposits from the coolant passages of the intake manifold.
- EGR passage of excessive carbon deposits.

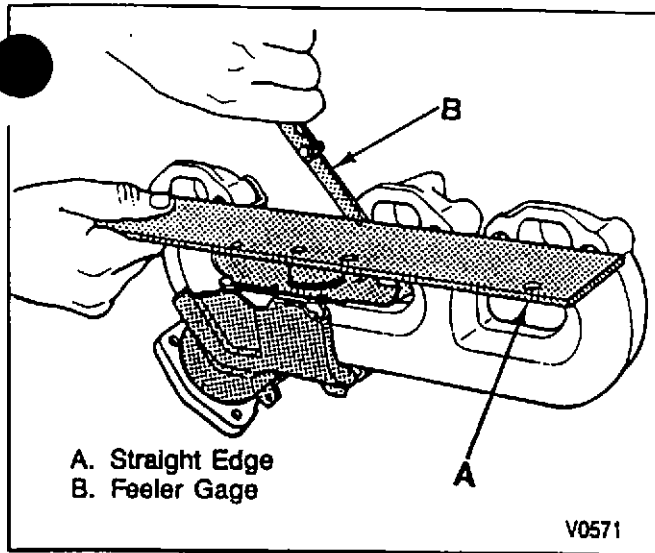


Figure 21—Checking Alignment of Manifold Flanges

 Inspect (Figure 21)

- Manifolds for cracks, broken flanges, and gasket surface damage.
- Alignment of manifold flanges. Use a straight edge and feeler gage. If the flanges do not align, the manifold is warped and should be replaced.

CAMSHAFT

 Important

- Do not attempt to repair the camshaft, replace it if damaged.
- Whenever the camshaft is replaced, a new set of lifters must also be installed.

 Inspect

- Bearing surfaces and lobes for:
 - Wear

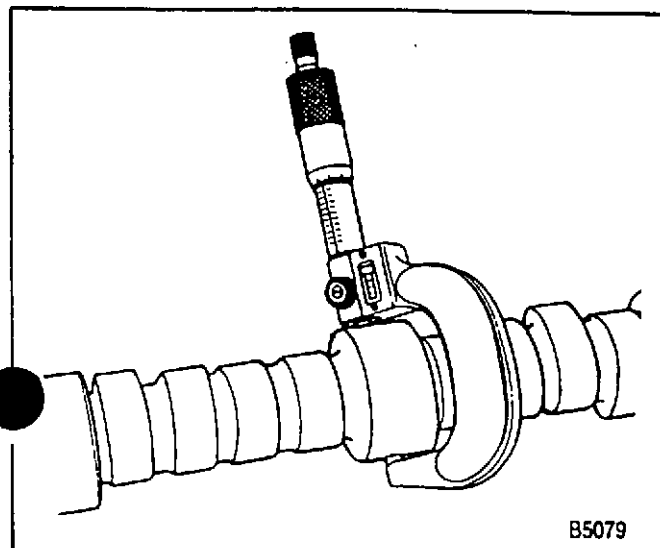


Figure 22—Checking the Camshaft Journals

- Sprocket.
- Keyway and threads.
 - Galling
 - Gouges
 - Overheating

 Measure

- Camshaft journal diameters (figure 22). Refer to "Engine Specifications" in the back of this section for proper diameters.

CAMSHAFT BEARINGS

Refer to SECTION 6A for replacement procedures.

TIMING CHAIN AND SPROCKETS

 Inspect

- Sprockets for chipped teeth and wear.
 - Excessively worn sprockets will rapidly wear a new chain.
- Timing chain for damage.
 - An excessively worn chain will rapidly wear a new set of sprockets.

CRANKSHAFT SPROCKET REPLACEMENT

 Remove or Disconnect (Figure 23)

Tool Required:

J 5825-A Crankshaft Sprocket Puller

1. Crankshaft sprocket using J 5825-A.
2. Key (if necessary).

 Install or Connect (Figure 23)

Tool Required:

J 5590 Crankshaft Sprocket Installer

1. Key (if removed).
2. Crankshaft sprocket using J 5590.

FRONT COVER

 Clean

- Old gasket from the gasket surfaces.

 Inspect

- Front cover for damage, dents, or cracks.

 Remove or Disconnect

- Oil seal from the front cover.
 - A. Pry the seal out with a large screwdriver.
 - B. Be careful not to distort the front cover.

 Install or Connect (Figure 24)

Tool Required:

J 35468 Front Cover Aligner and Oil Seal Installer

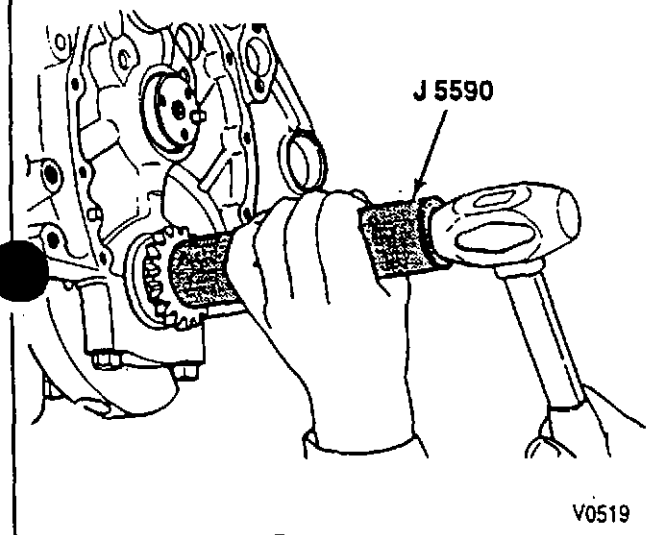
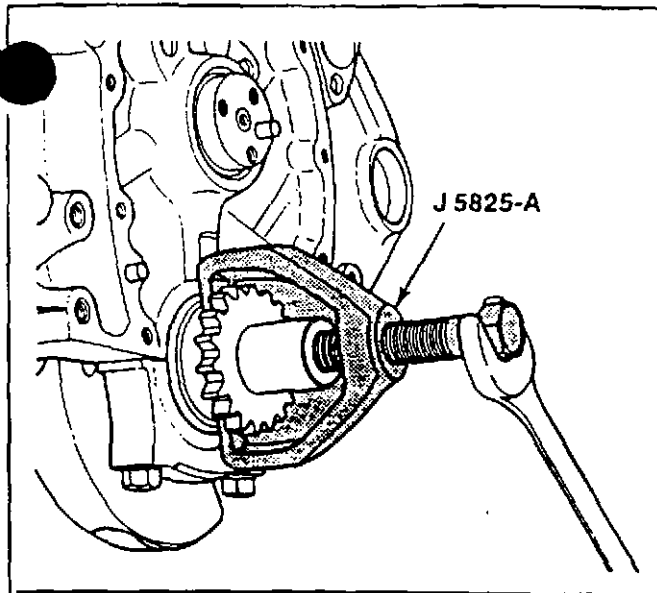


Figure 23—Installing the Crankshaft Sprocket

- New seal so that the open end of the seal is toward the inside of the cover.
- A. Support the cover at the seal area.
- B. Drive the seal into position with J 35468.
- C. Lubricate the seal with engine oil before installing the torsional damper.

COOLANT PUMP



Clean

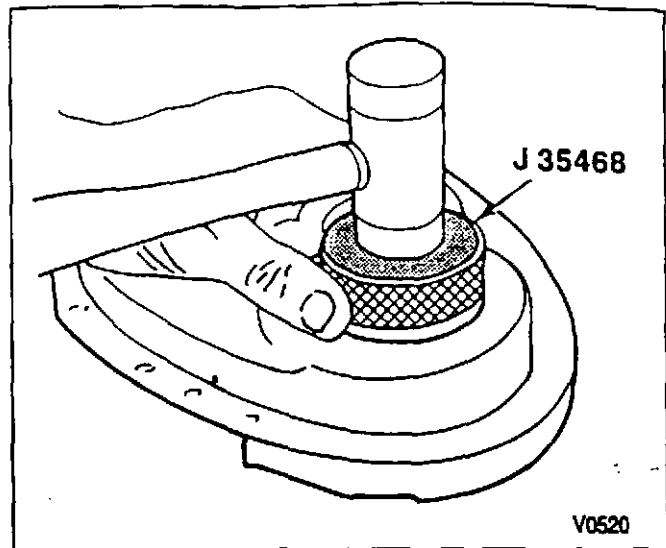
- All gasket mating surfaces. Be sure old gasket material is removed and free of oil or other foreign materials.

Notice: Do not immerse the pump in solvent. The solvent may enter the pump's permanently lubricated bearings and cause premature bearing failure.



Inspect

- Coolant pump shaft for rotation and end play. The shaft and fan hub should turn straight and smoothly. If the hub wobbles or the shaft is noisy or feels



Figure—24 Installing Oil Seal (Cover Removed)

"lumpy" when turned, replace the coolant pump. If the shaft end play exceeds 0.381 mm (0.015 inch), replace the coolant pump.

- Coolant pump body at the drain (weep) hole. Slight staining around the weep hole is normal. Replace the coolant pump only if coolant is dripping from the weep hole while the engine is running or while the system is pressurized.

OIL PAN AND ROCKER ARM COVERS



Clean

- Parts in solvent. Remove all sludge and varnish.
- Old gaskets from the gasket surfaces.



Inspect

- Gasket flanges for bending or damage.
- Rubber grommets and parts on the rocker arm cover for deterioration.
- Oil pan for rock damage or cracks.
- Oil pan deflector for lack of fit.
- Drain plug threads for stripping.

OIL PUMP



Remove or Disconnect (Figure 25)

1. Shaft extension (1).
 - Do not remove the pickup pipe and screen unless replacement is required.
 - The pickup pipe has a press fit in to the pump cover.
 - Do not remove the screen from the pipe. The pickup screen and pipe are serviced as a complete assembly only.
2. Pickup pipe and screen (10).
3. Screws (9).
4. Pump cover (5).
 - Mark where the idler gear (4) and drive gear (3) mesh together, so they can be reinstalled with the same gear teeth indexed.

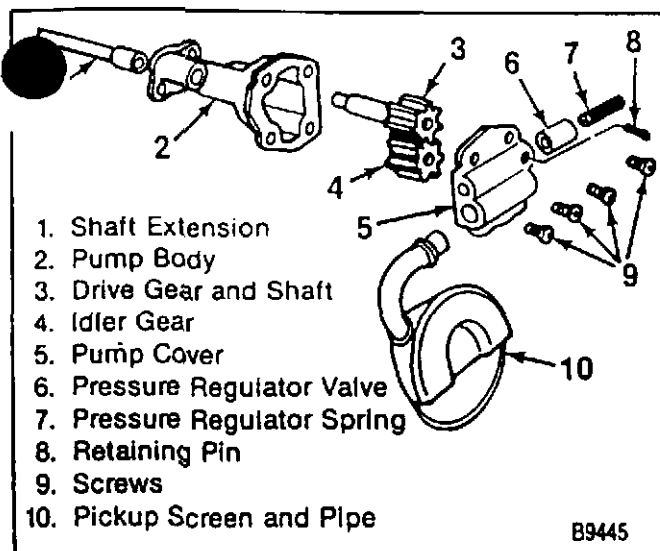


Figure 25—Oil Pump Components

- Pressure regulator valve (6) for fit. The regulator valve should slide freely in its bore without sticking or binding.

Install or Connect (Figures 25 and 26)

Tool Required:

J 21882 Pickup Tube and Screen Installer

1. Pressure regulator valve (6) into the pump cover.
2. Pressure regulator spring (7) into the pump cover.
3. Retaining pin (8) into the pump cover.
4. Drive gear and shaft (3) into the pump body.
5. Idler gear (4) into the pump body.

- Match together the index marks on the two gears made during disassembly.

6. Pump cover (5).

NOTICE: Refer to "Notice" on page 6A3B-1.

7. Screws (9).



Tighten

- Screws to 9 N.m (80 lbs. in.).

- With the shaft extension (1) installed on the pump, turn the drive shaft by hand to check for smooth operation.

NOTICE: Be careful of twisting, shearing, or collapsing the pipe when installing it to the pump. A damaged pipe can cause lack of lubrication and engine failure.

8. Pickup screen and pipe.

- A. If the pickup screen and pipe assembly was removed, it should be replaced with a new part. Loss of press fit condition could result in an air leak and loss of oil pressure.
- B. Mount the oil pump in a soft-jawed vise.
- C. Apply sealer to the end of the pipe.
- D. Tap the pickup screen and pipe into place, using J 21882 and a hammer.



Clean

- All parts in clean solvent and dry them with compressed air.

Inspect (Figure 25)

- Pump body (2) for cracks, wear, or other damage.
- Inside of the cover (5) for cracks and wear that would permit oil to leak past the ends of the gears.
- Gears (3 and 4) for wear.
- Drive gear and shaft (3) for lack of fit in the pump body (2).
- The pump gears, cover, and body are not serviced separately. If any of the parts are damaged or worn, the entire oil pump assembly must be replaced.
- Pickup screen and pipe (10) for damage to the screen or loose fit of the pipe.

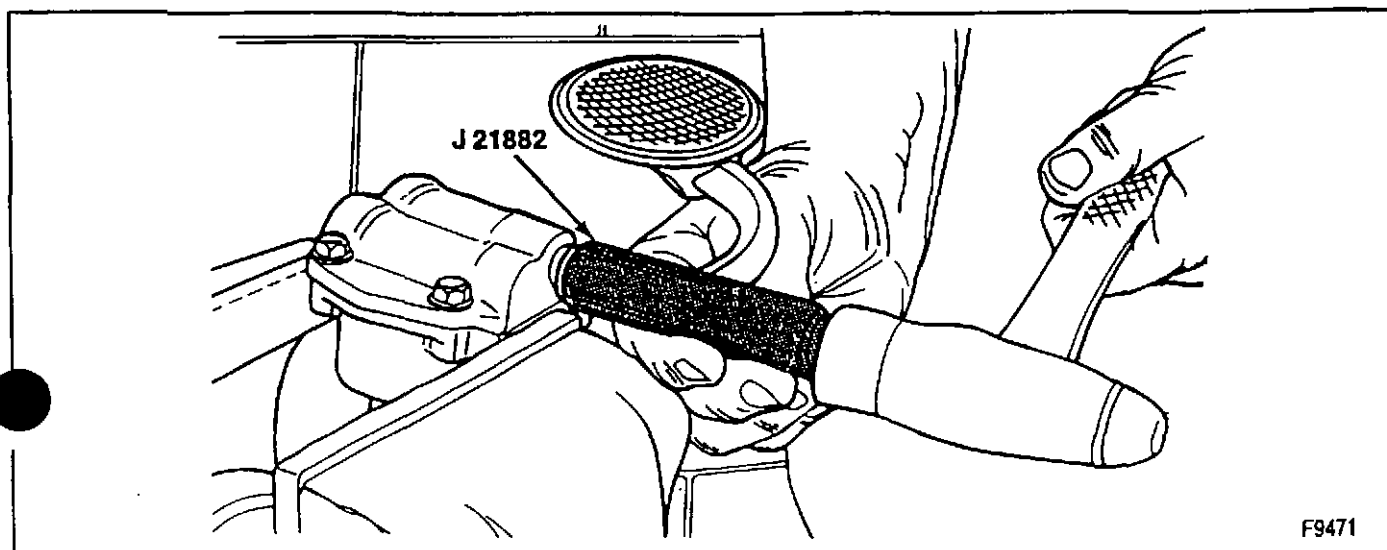


Figure 26—Installing the Oil Pump Screen

E. The pump screen must be parallel with the bottom of the oil pan when installed.

Oil pump drive shaft and connector (1).

VALVE TRAIN COMPONENTS



Important

- Store all reusable components in an exact order, so they may be reassembled in the same position from which they were removed.

PUSHRODS, ROCKER ARMS, BALLS, AND NUTS



Clean

- All parts in clean solvent and dry them with compressed air.
- Make sure the oil passages through the pushrods are clear.



Inspect

- Rocker arms and balls at their mating surfaces. These surfaces should be free from wear or damage.
- Rocker arm areas that contact the valve stems and the socket areas that contact the ends of the pushrods. These areas should be free of wear or damage.
- Rocker arm nuts.
- Pushrod ends for scoring, roughness, or bends.
 - Roll the pushrod on a flat surface to determine its straightness. If the rod is bent, the rod will not roll freely. Replace if necessary.

HYDRAULIC LIFTERS

The type of hydraulic lifters used in this engine are the roller type.

Hydraulic lifters are serviced only as an assembly. No internal parts are available. Service is limited to a disassembly and cleaning. Discard any valve lifter (s) that are worn.



Important

- Whenever the camshaft needs to be replaced, a new set of hydraulic lifters must also be installed.

CYLINDER HEAD

Cylinder head disassembly is covered in this procedure. Refer to SECTION 6A for information regarding the following:

- Cleaning
- Inspection
- Measuring clearances
- Valve grinding
- Valve guide reconditioning



Disassemble (Figures 27 and 28)

Tool Required:

J 8062 Valve Spring Compressor

1. Valve keepers (67).

- A. Compress the springs with J 8062 (figure 28).
- B. Remove the keepers (67).
- C. Remove J 8062.

2. Intake valve components (figure 27).

- A. Cap (68).
- B. Shield (69).
- C. Seal (71).
- D. Damper (72).
- E. Spring (73).

3. Exhaust valve components (figure 27).

- A. Rotator (75).
- B. Shield (69).
- C. Seal (71).
- D. Damper (72).
- E. Spring (73).

4. O-ring seals (70).

5. Valves (74 and 76).

- Place the valves (74 and 76) in an organizer rack so they can be replaced in their original position at reassembly.

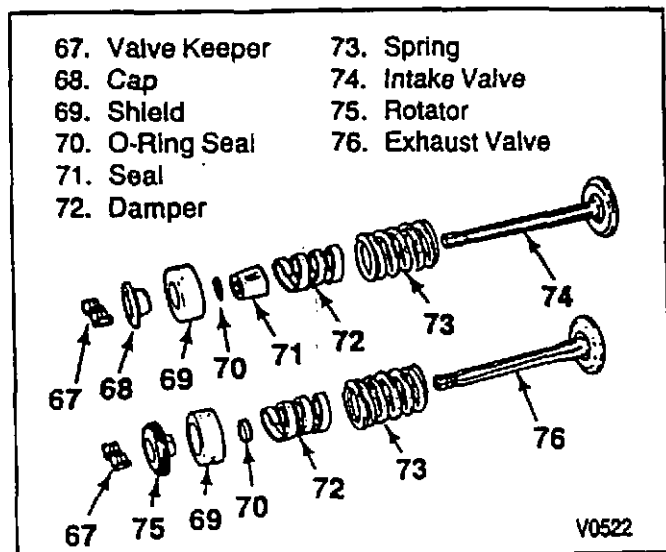


Figure 27—Valves and Components

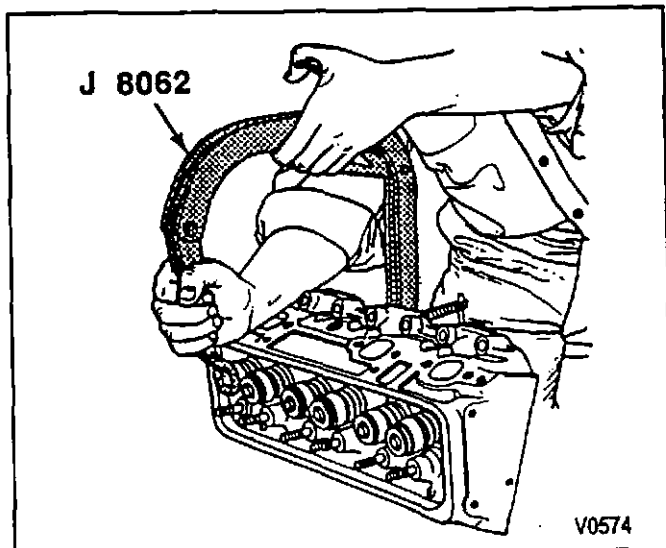


Figure 28—Compressing the Valve Springs

ROCKER ARM STUD REPLACEMENT

The 4.3L VIN Z engine has screw-in rocker arm studs with positive stop shoulders. You must follow the replacement procedures outlined below under "Screw-In Studs." No valve adjustment is necessary. When the valve train requires service, you simply tighten the rocker arm nuts to 27 N·m (20 lbs. ft.).

Remove or Disconnect

- Rocker arm stud by unscrewing.

Install or Connect

NOTICE: Refer to "Notice" on page 6A3B-1.

- Rocker arm stud.

Tighten

- Rocker arm stud to 47 N·m (35 lbs. ft.). Refer to SECTION 6A and perform the following:

Clean

- Components as outlined.

Inspect

- Components as outlined.

Measure

- Valve stem clearance.
 - Valve spring tension and free length.
- Other information outlined includes:
- Valve and seat grinding.
 - Valve guide reaming.

Assemble (Figures 29)

Tools Required:

- J 8062 Valve Spring Compressor
- J 23738-A Vacuum Pump

- Valves (74 and 76).
 - Lubricate the valve stems with engine oil.
 - Insert the valves (74 and 76) into the proper valve guides until the face of the valve contacts the valve seat.
- Seal (71) (intake valves only).
 - Install the seal (71) over the valve stem.
 - Hold the valve (74) against the valve seat.
 - Push the seal (71) down the valve stem until it bottoms out against the head.
- Springs (73) and dampers (72).
- Shields (69).
- Cap (68) or rotator (75).
 - Compress the valve spring using J 8062 (figure 28), enough so the lower valve stem groove can be seen clearly.
- O-ring seal (70) onto the valve stem's lower groove, making sure the seal (70) is flat and not twisted.

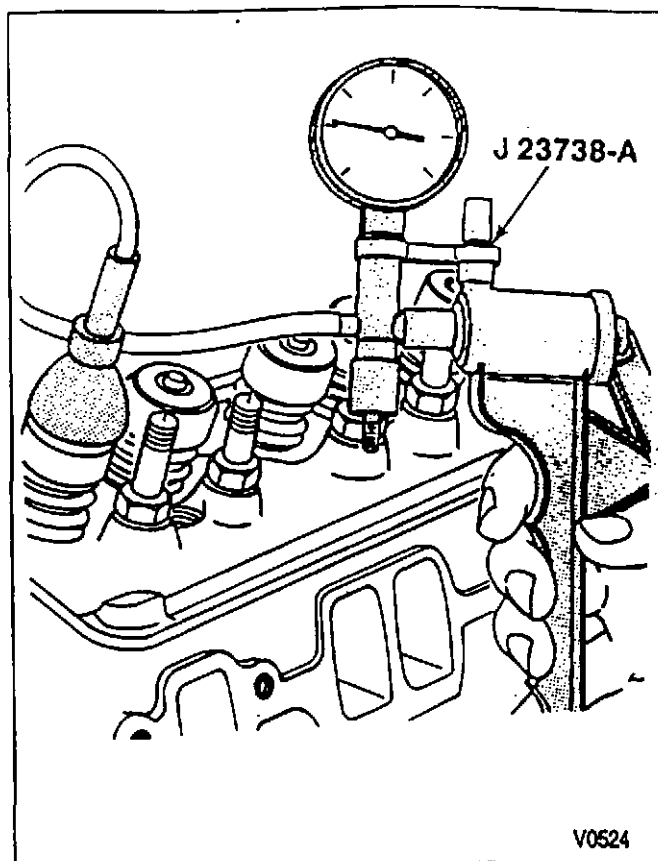


Figure 29—Checking the Valve Seals

- Apply a small amount of grease to the area of the upper valve stem groove.
- Assemble the two valve keepers into the upper groove using the grease to hold them in place.
- Release the compressor tool J 8062, making sure the valve keepers stay in place.
- Repeat the preceding steps on the remaining valves.

Inspect

- O-ring seals for leakage (figure 29).
 - Place the suction cup supplied with J 23738-A over the shield.
 - Connect J 23738-A to the suction cup and apply a vacuum.
 - Watch the vacuum pump gage, no air should be able to leak past the seal.
 - If the seal will not hold a vacuum, it may have been damaged or improperly installed.
 - Repeat the preceding steps on the remaining valves.

Measure

- Valve spring installed height of each spring as follows:
 - Use a narrow thin scale. A cutaway scale may be helpful.
 - From the top of the shim or the spring to the top of the shield.

3. If this measurement exceeds the amount given in "Engine Specifications," install valve spring seat shims, approximately 1.6-mm (1/16-inch) thick, between the spring and cylinder head. NEVER shim the spring so as to give an installed height under the specified amount.

THERMOSTAT AND COOLANT OUTLET

Remove or Disconnect

1. Bolts.
2. Stud.
3. Coolant outlet.
4. Gasket.
5. Thermostat (with gasket).

Inspect

- Coolant outlet for cracks.

Install or Connect

1. Thermostat.
2. New gasket.
3. Coolant outlet.

NOTICE: Refer to "Notice" on page 6A3B-1.

4. Bolt.
5. Stud.

Tighten

- Bolts to 28 N·m (21 lbs. ft.).
- Stud to 28 N·m (21 lbs. ft.).

TORSIONAL DAMPER

Inspect

Torsional damper weight for signs of shifting on the hub. Replace as needed. Area of the torsional damper hub shaft that contacts the front crankshaft seal for roughness or nicks. Replace the damper if this condition exists. If damper is replaced, new balance weights of the same size must be installed on the new damper in the same location as the old damper.

CRANKSHAFT AND BEARINGS

Some engines may have rear main bearings that are 0.008 inch wider than standard across the thrust faces. The crankshaft on these engines can be identified by ".008" stamped on the rear counterweight.

Clean

- Crankshaft with solvent.
 - Do not scratch the bearing journals.
 - Remove all sludge from the oil passages with compressed air.
- Main bearing inserts.
 - Wipe free of oil with a soft cloth.

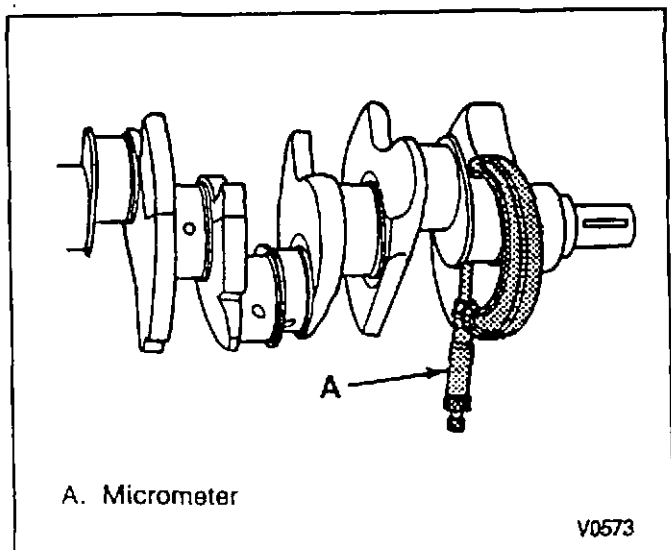
Inspect

- Crankshaft for cracks.
 - Use the magnaflux method, if available.
 - Crankpins, main bearing journals and thrust surfaces for scoring, nicks or damage caused by lack of lubrication.
 - Main bearing inserts for scoring or other damage.

Measure

- Main bearing and connecting rod journal diameters (figure 30). Compare with "Engine Specifications."
- Main bearing and connecting rod journals for taper and out-of-round.
 - Maximum journal taper is 0.001 inch.
 - Maximum out-of-round is 0.002 inch.
- Crankshaft run-out.
 - A. Mount the crankshaft in V-blocks or between centers.
 - B. Use a dial indicator.
 - C. If the main journals are misaligned, the crankshaft is bent and must be replaced. The main bearings must also be replaced at the same time.
 - D. Grind or replace the crankshaft if necessary.

In general, the lower inserts (except the # 1 bearing) show the greatest wear and distress from fatigue. Upon inspection, if a lower insert is suitable for reuse, it can be assumed that the upper insert is also satisfactory. If a lower insert shows evidence of wear or damage, both the upper and lower inserts must be replaced.



A. Micrometer

V0573

Figure 30—Measuring the Crankshaft Journals

ASSEMBLY OF THE ENGINE

PRIOR TO ASSEMBLY

The importance of cleanliness during the assembly procedure cannot be overstressed. Dirt will cause premature wear of the rebuilt engine.

Lubricate all moving parts lightly with engine oil or engine assembly lubricant (unless otherwise specified) during assembly. This will provide initial lubrication when the engine is started.

CRANKSHAFT AND MAIN BEARING INSTALLATION

Main bearings are of the precision insert type and do not use shims for adjustment. If clearances are excessive, both upper and lower bearing inserts will be required. Service bearings are available in standardize and 0.001-inch, 0.002-inch, 0.009-inch, 0.010-inch and 0.020-inch undersize.

Selective fitting of both rod and main bearing inserts is necessary in production to obtain close tolerances. For this reason you may find one half of a standard insert with one half of a 0.001-inch undersize insert which will decrease the clearance 0.0005 inch from using a full standard bearing.

Some engines may have rear main bearings that are 0.008-inch wider than standard across the thrust faces.

- The crankshaft on these engines can be identified by ".008" stamped on the rear counterweight.
- If the rear main bearings are replaced, they must have the proper distance between thrust faces to obtain proper crankshaft end play.

INSPECTING CRANKSHAFT END PLAY

↔ Install or Connect

NOTICE: For steps 4 and 6, refer to "Notice" on page 6A3B-1.

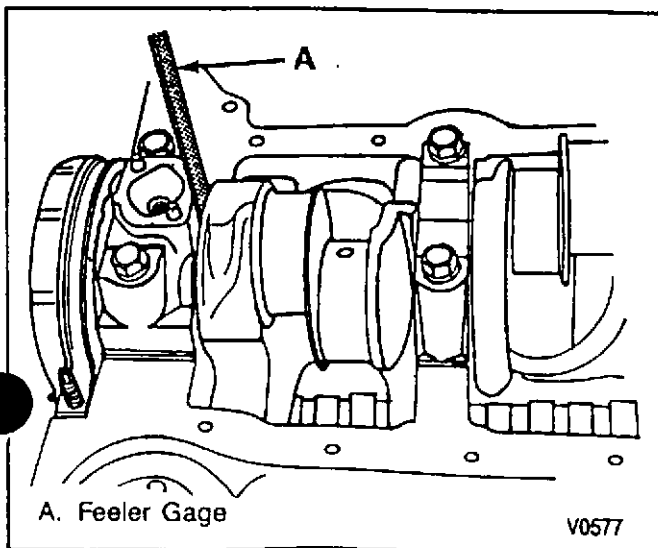


Figure 31—Measuring Crankshaft End Play

1. Upper main bearing inserts to the block.

! Important

- If any undersized bearings are used, they must be fitted to the proper journals.

2. Crankshaft.
3. Lower main bearing inserts to the main bearing caps.

Measure

- Main bearing clearance. Refer to SECTION 6A.
- Apply engine oil to the main bearing inserts.

4. Main bearing caps (except rear cap) and bolts to the block.

Tighten

- Main bearing cap bolts (except rear cap) to 110 N.m (81 lbs. ft.).

5. Rear main bearing cap.
6. Rear main bearing cap bolts.

Tighten

- Rear main bearing cap bolts to 14 N.m (124 lbs. in.).

Measure

- Crankshaft end play, as follows:
 - Firmly thrust the crankshaft first rearward then forward. This will line up the rear main bearing and crankshaft thrust surfaces.

Tighten

- The rear main bearing cap bolts to 110 N.m (81 lbs. ft.).

Measure

- With the crankshaft wedged forward, measure at the front end of the rear main bearing with a feeler gage (figure 31). The proper clearance is 0.051-0.152 mm (0.005 to 0.018 inch).
- If correct end play cannot be obtained, be certain that the correct size rear main bearing has been installed.
- Production engines may have rear main bearings that are 0.008 inch wider across the thrust faces than standard.

 Inspect

● Crankshaft for binding. Try turning the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the main bearing cap bolts one pair at a time until the tight bearing is located. Burrs on the bearing cap, foreign matter between the insert and the block or the bearing cap, or a faulty insert could cause a lack of clearance at the bearing.

 Tighten

- All main bearing cap bolts to 110 N.m (81 lbs. ft.).

CRANKSHAFT REAR OIL SEAL RETAINER INSTALLATION

 Clean

- Gasket surfaces on the block and seal retainer.

 Install or Connect (Figure 32)

1. New gasket (54) to the block.
 - It is not necessary to use sealant to hold the gasket in place.
2. Seal retainer (52).

NOTICE: Refer to "Notice" on page 6A3B-1.

- Screws (50) and nuts (51).

 Tighten

- Screws and nuts to 15 N.m (11 lbs. ft.).

CRANKSHAFT REAR OIL SEAL INSTALLATION

 Install or Connect (Figure 33)

Tool Required:
J 35621 Seal Installer

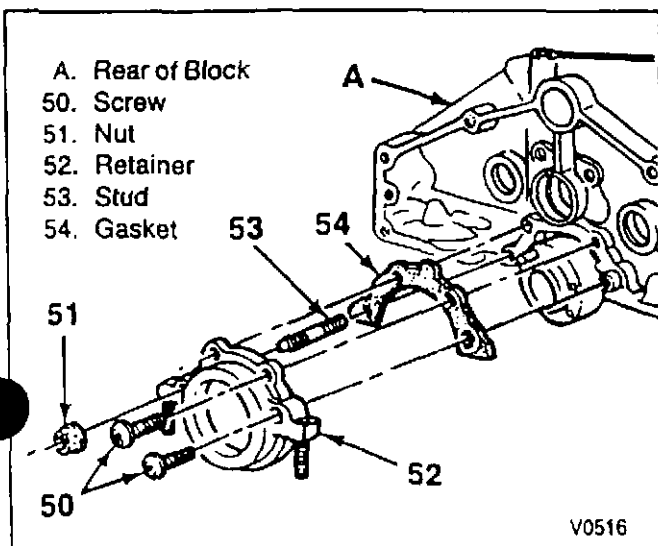


Figure 32—Crankshaft Rear Oil Seal Retainer

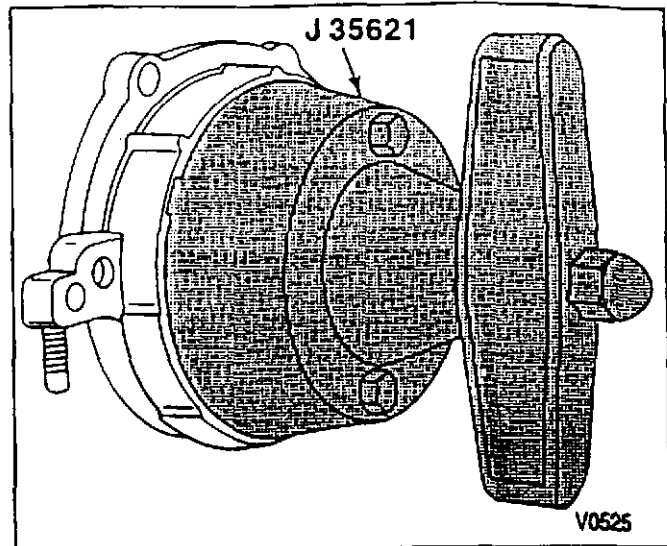


Figure 33—Installing the Crankshaft Rear Oil Seal

- Crankshaft rear oil seal.

- A. Lubricate the inner and outer diameter of the seal with engine oil.
- B. Install the seal on J 35621.
- C. Position J 35621 against the crankshaft. Thread the attaching screws into the tapped holes in the crankshaft.
- D. Tighten the screws securely with a screwdriver. This will ensure that the seal is installed squarely over the crankshaft.
- E. Turn the handle until it bottoms.
- F. Remove J 35621.

CAMSHAFT INSTALLATION

 Install or Connect (Figures 34 and 35)

- Coat the camshaft lobes and journals with a high quality engine oil supplement (GM Engine Oil Supplement or equivalent).
- Apply Engine Oil Supplement (GM P/N 1052367), or equivalent to all the teeth on the distributor drive gear.

1. Two or three 5/16-18 bolts 100-125 mm (4-5 inches) long into the camshaft threaded holes. Use these bolts to handle the camshaft.
2. Camshaft to the engine (figure 35). Handle the camshaft carefully to prevent damage to the camshaft bearings.

NOTICE: Refer to "Notice" on page 6A3B-1.

3. Camshaft retainer and retainer bolts.

 Tighten

- Bolts to 14 N.m (124 lbs. in.).

- 34. NUT
- 35. STUD
- 36. KEY
- 37. GEAR, BALANCE SHAFT DRIVE
- 38. SPROCKET, CRANKSHAFT
- 39. BOLT
- 40. SPROCKET, CAMSHAFT
- 41. CHAIN, TIMING

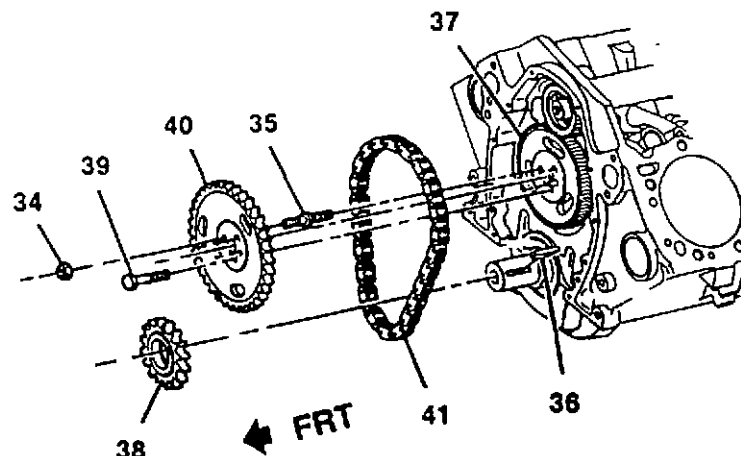


Figure 34—Camshaft and Components

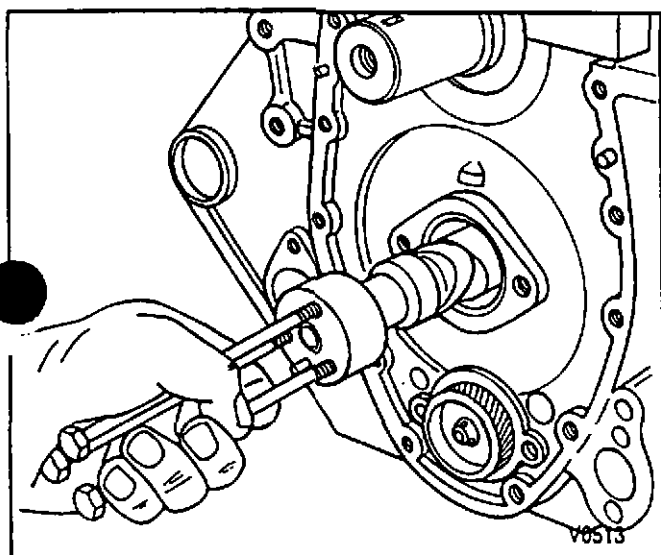


Figure 35—Installing Camshaft

BALANCE SHAFT INSTALLATION

 Install or Connect (Figures 36 and 37)

NOTICE: For steps 3, 4, and 6, refer to "Notice" on page 6A3B-1

Tools Required:

- J 38834 Balance Shaft Bearing Service Kit
- J 36996 Balance Shaft Installer
- J 8092 Driver Handle
- J 36660 Torque/Angle Meter

1. Balance shaft rear bearing (45) using J 38834 (figure 36).
 - Dip bearing in clean engine oil before installation.
2. Balance shaft (47) into block using J 36996 and J 8092.
 - A. Dip the front balance shaft bearing into clean engine oil before assembly.

B. Retaining ring on balance shaft front bearing must be seated on case.

3. Install balance shaft bearing retainer (43) and bolts (48).

 Tighten

- Balance shaft retainer bolts (48) to 14 N.m (124 lbs. in.).

4. Balance shaft driven gear (42) and bolt (49).

 Tighten

- Balance shaft driven gear bolt (49) to 20 N.m (15 lbs. ft.) plus an additional turn of 35 degrees using J 36660.

- Rotate balance shaft (47) by hand to make sure there is clearance between the balance shaft (47) and retainer (43). If balance shaft (47) does not rotate freely, check to be sure retaining ring on front bearing is seated on case.
- Turn the camshaft so, with the balance shaft drive gear temporarily installed, the timing mark on the drive gear is straight up.
- With the balance shaft drive gear removed, turn the balance shaft so the timing mark on the driven gear points straight down.

5. Balance shaft drive gear (37) onto camshaft.

 Important

- Make sure the timing marks on the balance shaft drive gear and driven gear line up (figure 37).

6. Balance shaft drive gear bolt.

 Tighten

- Bolt to 16 N.m (12 lbs. ft.).

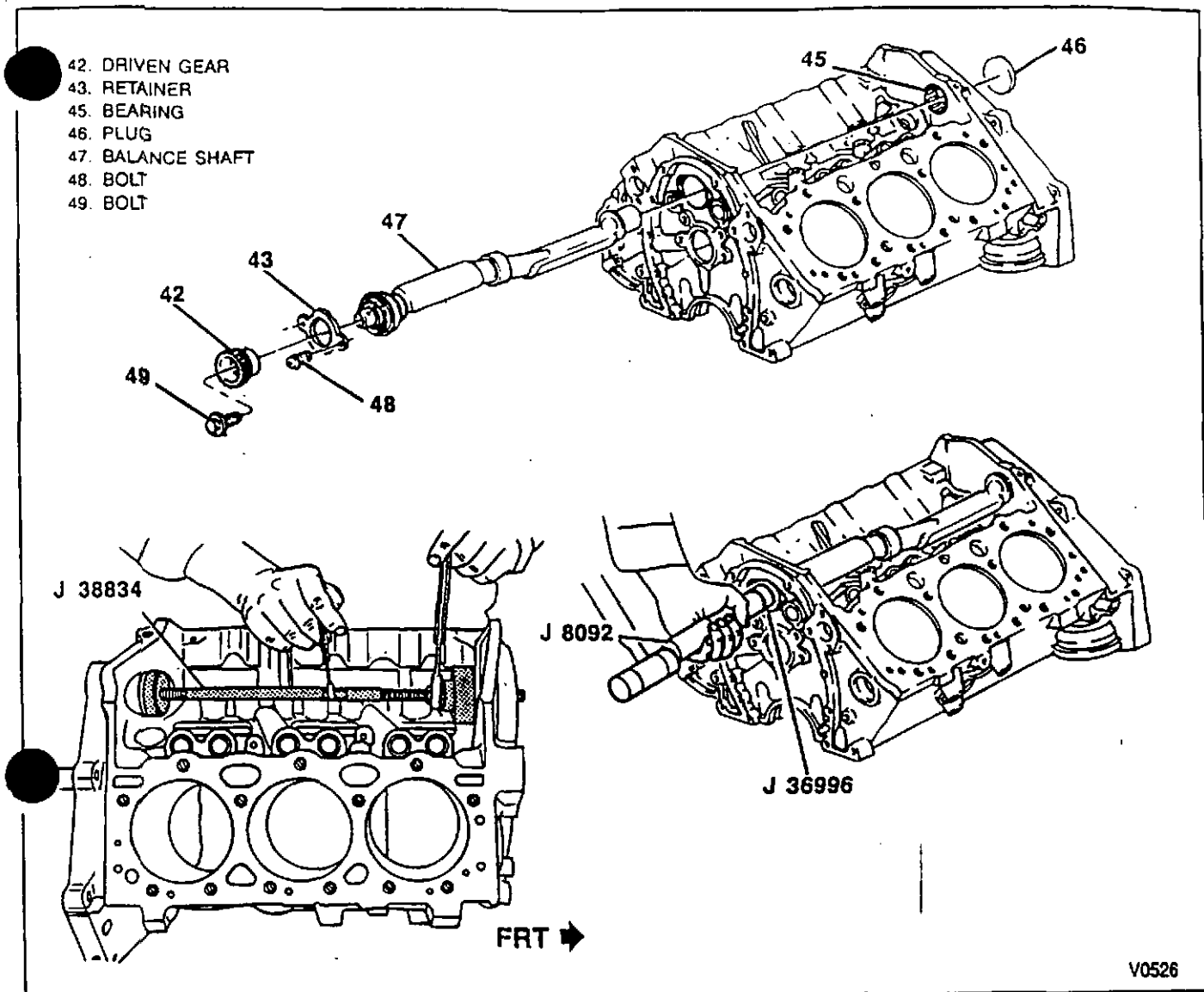


Figure 36—Installing Balance Shaft and Components

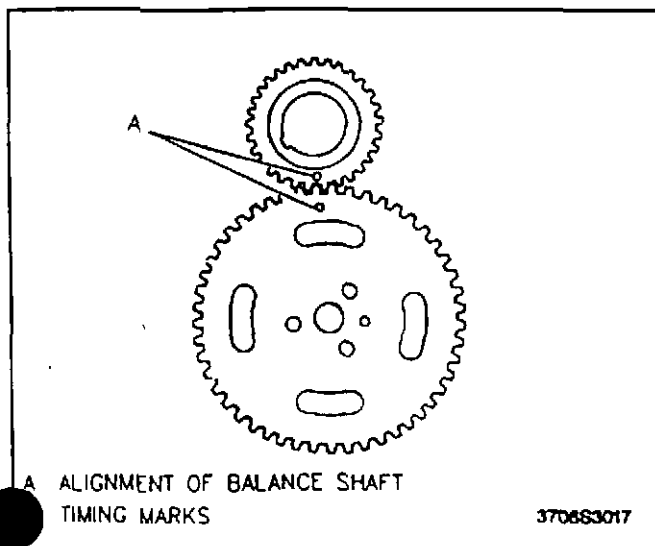


Figure 37—Balance Shaft Drive Gear-to-Driven Gear Timing Marks

TIMING CHAIN AND SPROCKET INSTALLATION

Install or Connect (Figures 37 and 38)

1. Camshaft sprocket and timing chain.

Important

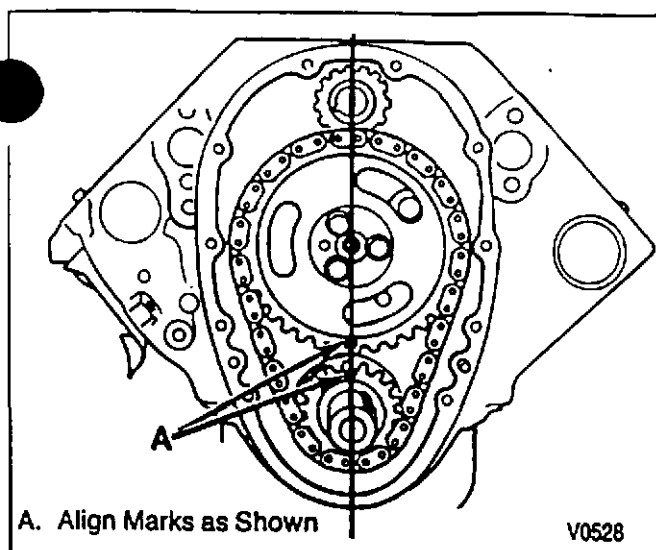
- Line up the timing marks on the camshaft sprocket and crankshaft sprocket (figure 38).
- The number 4 cylinder is at top dead center of the compression stroke with the timing marks in this position (figure 38).

NOTICE: Refer to "Notice" on page 6A3B-1.

2. Camshaft sprocket bolts (39) and nut (34).

Tighten

- Camshaft sprocket bolts (39) and nut (34) to 28 N.m (21 lbs. ft.).



A. Align Marks as Shown

V0528

Figure 38—Camshaft-to-Crankshaft Timing Marks

FRONT COVER INSTALLATION

Install or Connect

1. Front cover gasket to the front cover.
• Use gasket cement to hold the gasket in place.
2. Front cover to the engine.

NOTICE: Refer to "Notice" on page 6A3B-1.

3. Front cover bolts.

Tighten

- Front cover to block bolts to 14 N.m (124 lbs. in.).

TORSIONAL DAMPER INSTALLATION

Install or Connect (Figure 39)

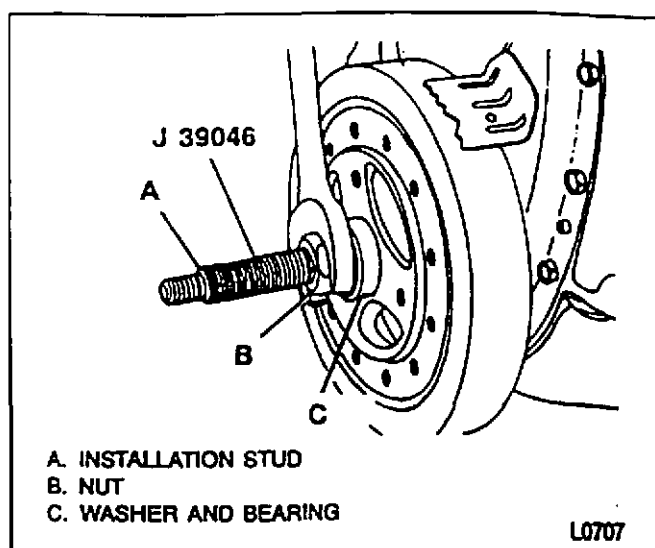
Tool Required:

J 39046 Torsional Damper Puller and Installer

1. Crankshaft key (if removed).

NOTICE: The inertial weight section of the torsional damper is assembled to the hub with rubber type material. The correct installation procedures with the proper tool must be followed or movement of the inertial weight section of the hub will destroy the tuning of the torsional damper.

2. Stud (item A, figure 39) to the crankshaft. Thread the stud fully into the tapped hole in the crankshaft.
3. Torsional damper over the end of the stud. Align the keyway in the torsional damper shaft with the crankshaft key.
4. Bearing, washer, and nut (figure 39).
A. Turn the nut to pull the vibration damper into place.
B. Remove the tool.



- A. INSTALLATION STUD
B. NUT
C. WASHER AND BEARING

L0707

Figure 39—Installing the Torsional Damper

NOTICE: Refer to "Notice" on page 6A3B-1.

5. Torsional damper bolt and washer.

Tighten

- Bolt to 95 N.m (70 lbs. ft.).

PISTON AND CONNECTING ROD INSTALLATION

CONNECTING ROD BEARING SELECTION

Connecting rod bearings are of the precision insert type and do not use shims for adjustment. **DO NOT FILE RODS OR ROD CAPS.** If clearances are excessive, install a new bearing. Service bearings are available in standard size and 0.0014-mm undersize for use with new and used standard size crankshafts.

Install or Connect (Figures 40 through 42)

Tools Required:

J 5239 Connecting Rod Guide Set

J 8037 Ring Compressor

J 36660 Torque/Angle Meter

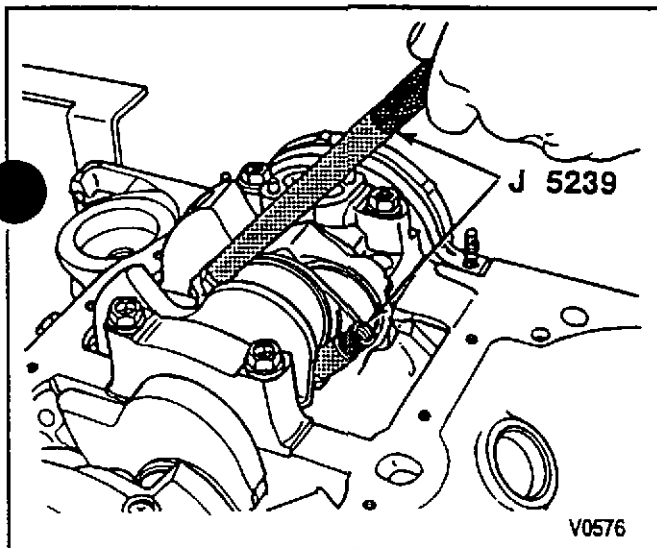
- Lubricate the cylinder walls lightly with engine oil.
- Make sure the piston is installed in the matching cylinder.

1. Connecting rod bearings.
 - A. Make sure that the bearing inserts are of the proper size.
 - B. Install the bearing inserts in the connecting rod and connecting rod cap.
 - C. Lubricate the bearings with engine oil.
2. Piston and connecting rod into the proper bore.
 - A. With the connecting rod cap removed, install J 5239 onto the connecting rod bolts (figure 40).
 - B. Locate the piston ring end gaps (figure 41). Lubricate the piston and rings with engine oil.
 - C. Without disturbing the ring end gap location, install J 8037 over the piston.

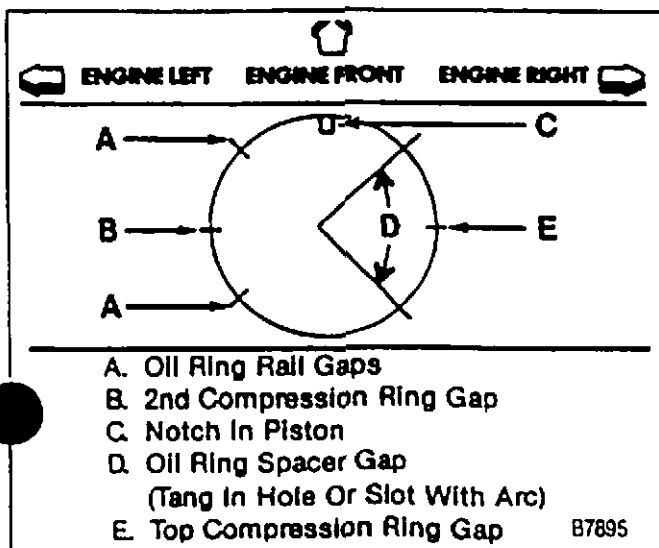
- D. The piston must be installed so that the notch in the piston faces the front of the engine (figure 41).
- E. Place the piston in its matching bore. The connecting rod bearing tang slots must be on the side opposite the camshaft. Using light taps with a hammer handle, tap the piston down into its bore (figure 42). Guide the connecting rod to the crankpin with J 5239 (figure 40). Hold the ring compressor against the block until all rings have entered the cylinder bore.
- F. Remove J 5239 from the connecting rod bolts.

Important

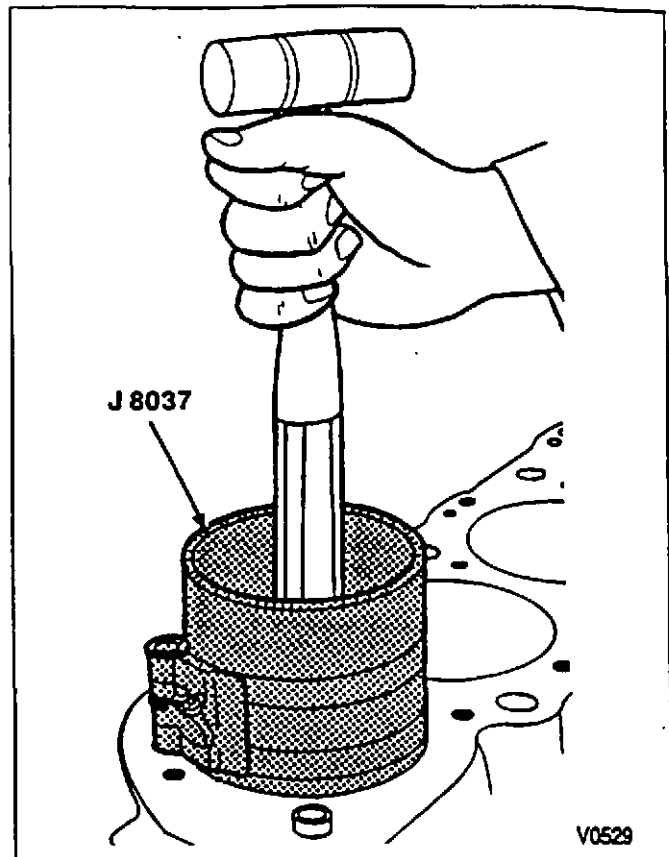
- Each connecting rod and bearing cap should be marked, beginning at the front of the engine. Cylinders 1, 3, and 5 are the right bank and 2, 4, and 6 are the left bank (when viewed from the front of the engine). The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from one



Figure—40 Guiding the Connecting Rod



Figure—41 Piston Ring End Gap Location



Figure—42 Installing the Piston

block or cylinder to another, new connecting rod bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.

NOTICE: Refer to "Notice" on page 6A3B-1.

3. Connecting rod cap with bearing insert and nut.

Measure

- Connecting rod bearing clearance. Refer to SECTION 6A.

Tighten

- Connecting rod bolt nuts to 27 N.m (20 lbs. ft.).
- Connecting rod bolt nuts an additional 70 degrees using J 36660.

Measure

- Connecting rod side clearance (figure 43). The proper clearance is 0.015 to 0.046 inch.

OIL PUMP INSTALLATION

Install or Connect

- Oil pump to the engine.
 - Align the slot in the oil pump shaft with the tang on the distributor shaft.
 - The oil pump should slide easily into place.
 - No gasket is used.

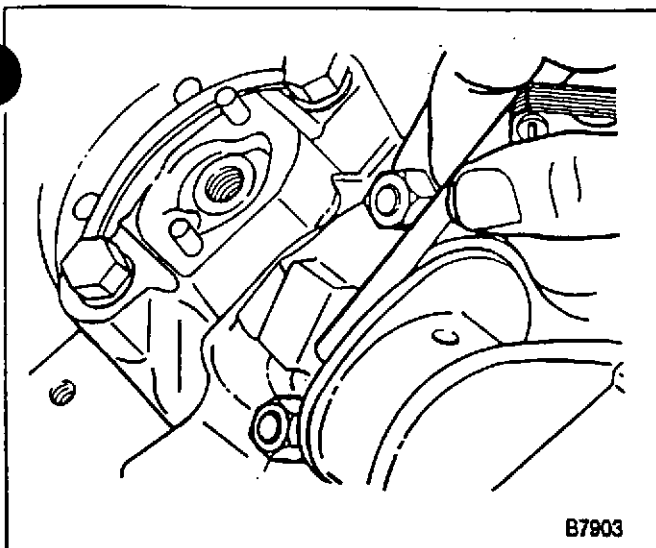


Figure 43—Measuring Connecting Rod Side Clearance

NOTICE: Refer to "Notice" on page 6A3B-1.

2. Oil pump to main bearing cap bolt.



- Oil pump to main bearing cap bolt to 88 N.m (65 lbs. ft.).

OIL PAN INSTALLATION



Install or Connect (Figure 44)

- Apply RTV sealant (GM P/N 12346141) or equivalent to the front cover to block joint and to the crankshaft rear retainer seal to block joint. Apply the sealant about 25 mm (1 inch) in both directions from each of the four corners (figure 44).

1. Oil pan gasket (27) to the block.
2. Oil pan (29) to the gasket (27).
3. Reinforcements (28).

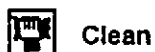
NOTICE: Refer to "Notice" on page 6A3B-1.

4. Oil pan clips, bolts (83), nuts (82), and studs (84).



- Bolts (83) and studs (84) to 11 N.m (97 lbs. in.).
- Four corner nuts (82) to 23 N.m (17 lbs. ft.).

CYLINDER HEAD INSTALLATION



Clean

- Gasket surfaces on the block and cylinder head.



Install or Connect (Figure 45)

1. Head gasket.
 - Do not use sealer on composition gaskets.
 - Place the gasket over the block dowel pins.
2. Cylinder head. Carefully guide the cylinder head into place over the dowel pins and gasket.

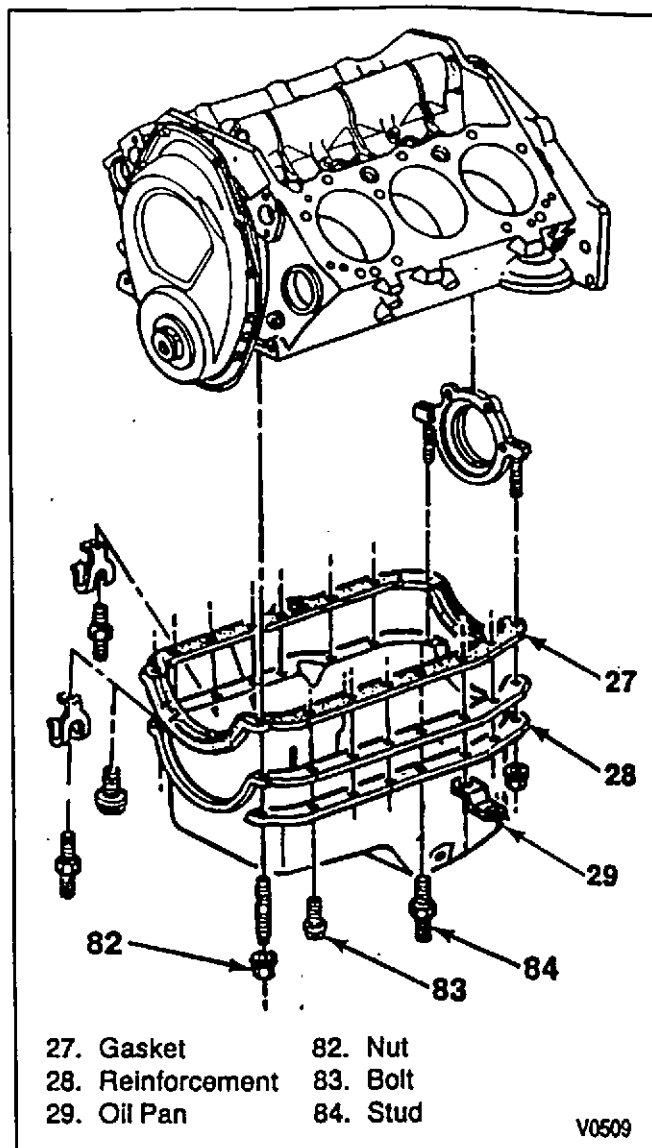


Figure 44—Oil Pan and Components

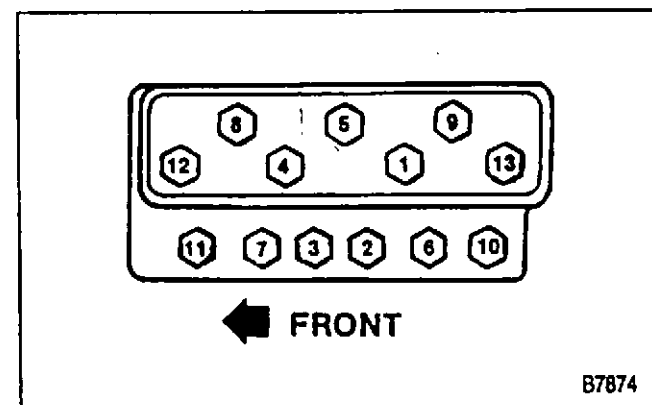


Figure 45—Cylinder Head Bolt Tightening Sequence

NOTICE: Refer to "Notice" on page 6A3B-1.

3. Cylinder head bolts. Coat threads of the cylinder head bolts with sealing compound (GM P/N 1052080) or equivalent and install finger-tight.

**Tighten**

- Cylinder head bolts in three steps, using the sequence shown in figure 45.

- The first sequence to 34 N.m (25 lbs. ft.).
- The second sequence to 61 N.m (45 lbs. ft.).
- Final torque sequence to 90 N.m (65 lbs. ft.).

4. Engine lift bracket.

VALVE TRAIN COMPONENT INSTALLATION

**Important**

- Replace all hydraulic lifters, change the engine oil and filter and add GM Engine Oil Supplement (GM P/N 1052367 or equivalent) to the engine oil whenever a new camshaft is installed.

**Install or Connect (Figures 46 and 47)**

- Lubricate the hydraulic lifter bodies and feet with Engine Oil Supplement (GM P/N 1052367) or equivalent.

- Hydraulic lifters to the block.
- Guide assembly.

**Tighten**

- Guide assembly bolts to 16 N.m (12 lbs. ft.).

3. Pushrods.

- Seat the pushrods into the socket of the hydraulic lifters.

- Coat mating surfaces of the rocker arms (23) and balls (22) with Engine Oil Supplement (GM P/N 1052367) or equivalent.

- Rocker arms (23) with balls (22) on to the proper stud.

- Rocker arm nuts (21) on to the studs.

- Align the push rod into the rocker arm while tightening rocker arm nut (21).

**Important**

- No lash adjustment is needed.

VALVE ADJUSTMENT

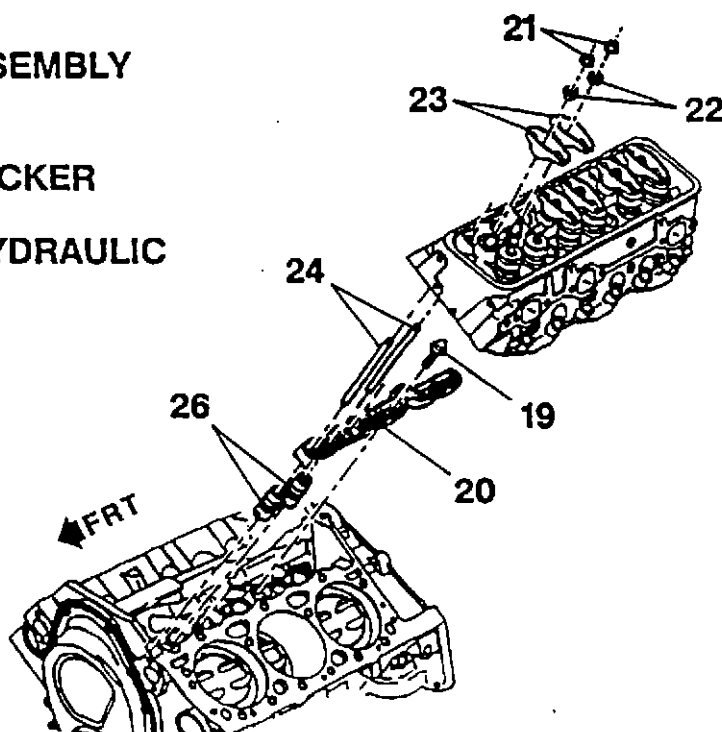
The 4.3L VIN Z engine has screw-in rocker arm studs with positive stop shoulders, no valve adjustment is necessary. When the valve train requires service, you simply tighten the rocker arm nuts to 27 N.m (20 lbs.ft.).

INTAKE MANIFOLD INSTALLATION

**Install or Connect (Figures 47 and 48)**

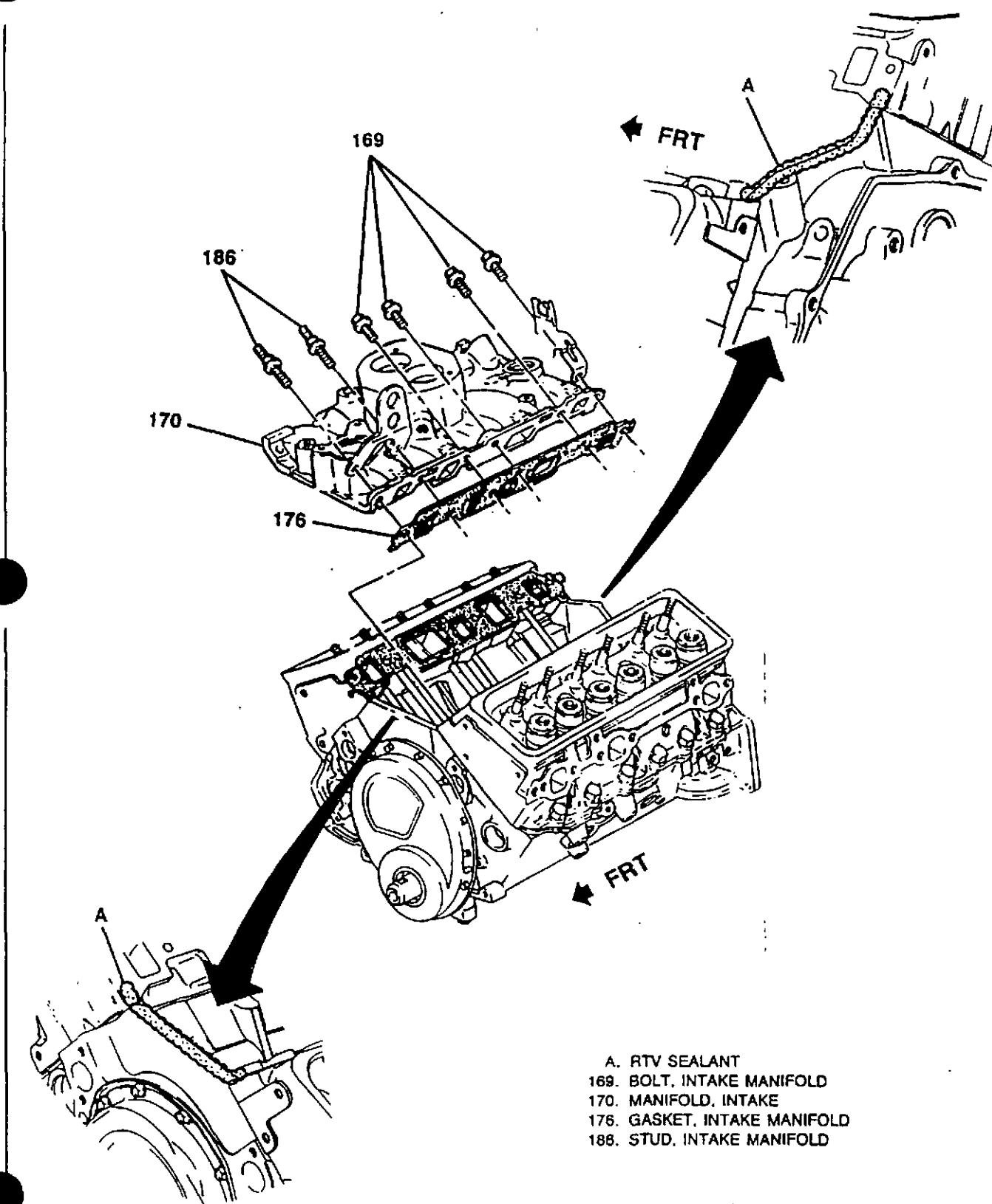
- Gaskets to the cylinder head with the port blocking plates facing the rear of the engine.

- BOLT
- GUIDE ASSEMBLY
- NUT
- BALL
- ARMS, ROCKER
- PUSHROD
- LIFTER, HYDRAULIC



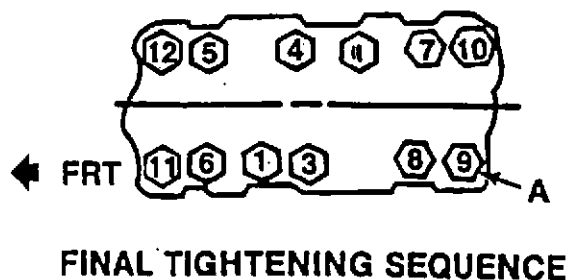
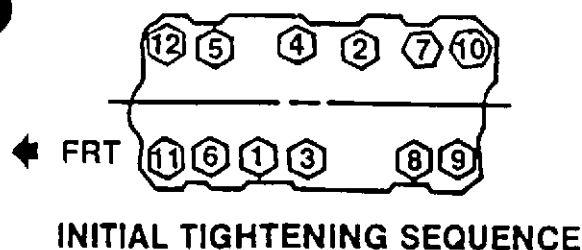
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Figure 46—Valve Train Components



V2974

Figure 47—Intake Manifold and Components



- A. Bolt 56 N·m (41 ft.lbs)
All Other Bolts 47 N·m (35 ft.lbs)

B7873

Figure 48—Intake Manifold Bolt Tightening Sequence

2. RTV to the front and rear sealing surfaces on the block. Apply a 5-mm (3/16-inch) bead of RTV (GM P/N 1052366) or equivalent to the front and rear of the block as shown in figure 47. Extend the bead 13 mm (1/2 inch) up each cylinder head to seal and retain the gaskets.
3. Intake manifold to the engine.

NOTICE: Refer to "Notice" on page 6A3B-1.

4. Intake manifold bolts.



Tighten

- A. Intake manifold bolts to 47 N·m (35 lbs. ft.) using the tightening sequence shown in figure 48.
- B. Retorque, intake manifold bolts using the tightening sequence shown in figure 48.

ROCKER ARM COVER INSTALLATION

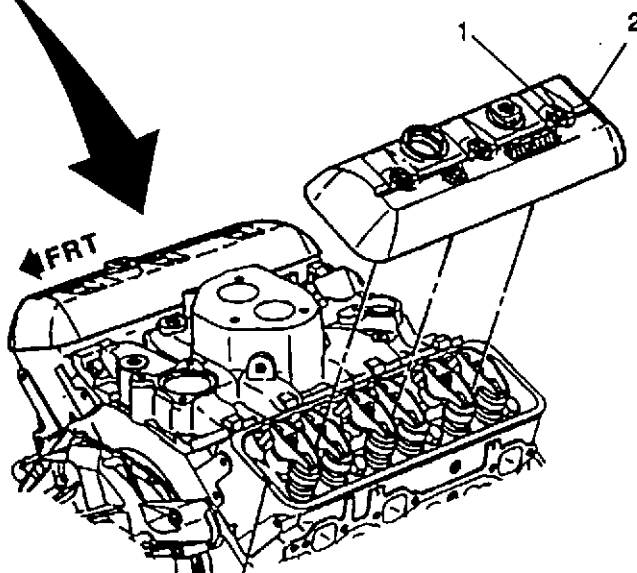
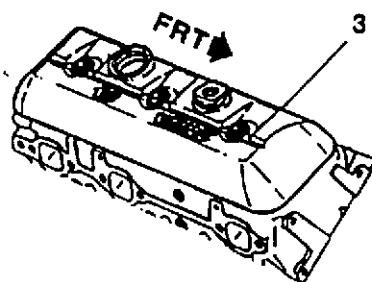


Install or Connect (Figure 49)

1. Rocker arm cover (2 or 3).
2. New gasket.

NOTICE: Refer to "Notice" on page 6A3B-1.

3. Rocker arm cover bolts (1) and washers.



1. BOLT
2. COVER, VALVE ROCKER ARM (CK/G/ML)
3. COVER, VALVE ROCKER ARM (P,ST)

3006r4807

Figure 49—Rocker Arm Cover and Components

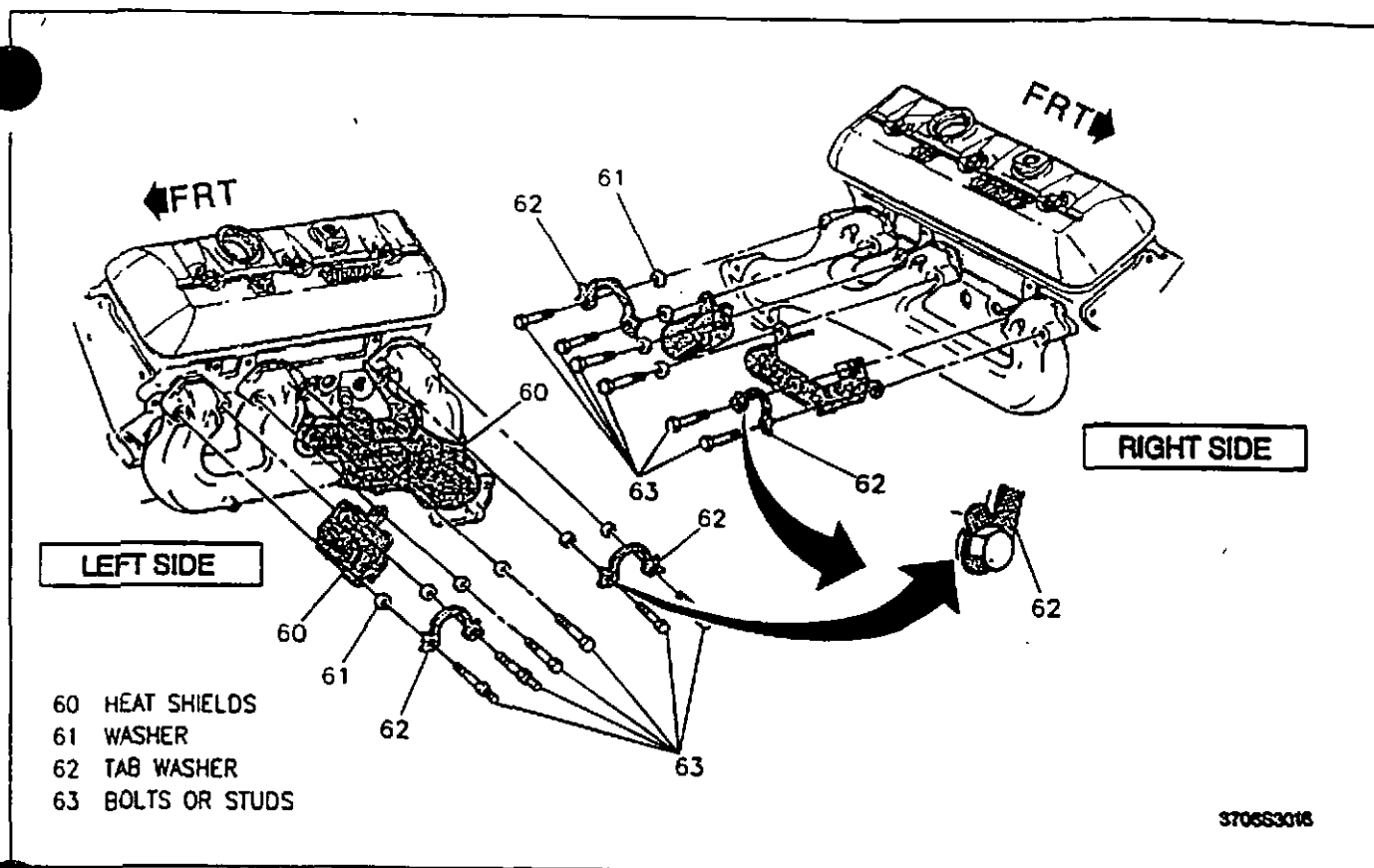


Figure 50—Exhaust Manifolds and Components



Tighten

- Rocker arm cover bolts (1) to 10 N.m (90 lbs. in.).

EXHAUST MANIFOLD INSTALLATION



Install or Connect (Figure 50)

1. Exhaust manifold.
2. Heat shield.

NOTICE: Refer to "Notice" on page 6A3B-1.

3. Exhaust manifold bolts, washers, and tab washers.



Tighten

- A. Bolts on center exhaust tube to 36 N.m (26 lbs. ft.).
- B. Bolts on front and rear exhaust tubes to 28 N.m (20 lbs. ft.).
- C. Bend the tab washers over the heads of all bolts.

EGR VALVE INSTALLATION



Install or Connect

1. New gasket.
2. EGR valve.

NOTICE: Refer to "Notice" on page 6A3B-1

3. Bolts.



Tighten

- Bolts to 22 N.m (16 lbs. ft.).

FLYWHEEL INSTALLATION



Install or Connect

1. Flywheel.

NOTICE: Refer to "Notice" on page 6A3B-1.

2. Flywheel bolts.



Tighten

- Bolts to 100 N.m (74 lbs. ft.).

COOLANT PUMP INSTALLATION**Install or Connect**

1. Gaskets.
2. Coolant pump.

NOTICE: Refer to "Notice" on page 6A3B-1.

3. Coolant pump bolts.

**Tighten**

- Coolant pump bolts to 40 N.m (30 lbs. ft.).

**ENGINE ACCESSORY
INSTALLATION**

Install the engine accessories (distributor, oil filter, generator, etc.) as directed in the proper on-vehicle Truck Service Manual. Connect all vacuum hoses and electrical equipment the same way as removed.

ENGINE SET-UP AND TESTING

After overhaul, the engine should be tested before installing it in the vehicle.

1. Install oil filter.
2. Fill the crankcase with the proper quantity and grade of engine oil.

**Important**

- If a new camshaft or hydraulic lifters were installed, add Engine Oil Supplement (GM P/N 1052367) or equivalent to the engine oil.

3. Fill the cooling system with the proper quantity and grade of coolant. Refer to SECTION 6B1.

**Important**

- Whenever the cooling system is serviced or drained for service procedures, 2 coolant sealant pellets, (GM P/N 3634621) or equivalent, must be added to the cooling system.
 - The pellets must be added to the radiator or the pressurized coolant reservoir.
—Pellets must be crushed prior to installation.
 - Do not place pellets into a non-pressurized coolant recovery reservoir. On these systems, the pellets must be added to the radiator.
 - The sealant pellets may leave a film on the sides of pressurized and non-pressurized coolant recovery reservoirs. This film is normal.
4. Crank the engine several times. Listen for any unusual noises or evidence that parts are binding.
 5. Use the proper on-vehicle Truck Service Manual or Emission Control Label for specifications on ignition timing adjustment.
 6. Start the engine and listen for unusual noises.
 7. Run the engine speed at about 1000 RPM until the engine is at operating temperature.
 8. Listen for sticking lifters and other unusual noises.
 9. Check for oil and coolant leaks while the engine is running.

SPECIFICATIONS

ENGINE SPECIFICATIONS (4.3L)

All Specifications are in INCHES unless otherwise noted.

GENERAL DATA:					
Type			V6		
Displacement			4.3L (262 Cu. In.)		
RPO (VIN Code)			LB4 (Z)		
Bore			4.00		
Stroke			3.48		
Compression Ratio			9.10*		
Firing Order			1-6-5-4-3-2		
Oil Pressure (Minimum HOT)			6 psi @ 1000 RPM; 18 psi @ 2000 RPM; 24 psi @ 4000 RPM		
CYLINDER BORE:					
Diameter			4.0007-4.0017		
Out Of Round	Production		0.001 (Maximum)		
	Service		0.002 (Maximum)		
Taper	Production	Thrust Side	0.0005 (Maximum)		
		Relief Side	0.001 (Maximum)		
	Service		0.001 (Maximum)		
PISTON:					
Clearance	Production		0.0007-0.0024		
	Service Limit		0.0024 (Maximum)		
PISTON RING:					
COMPRESSION OIL	Groove Clearance	Production	Top	0.0012-0.0032	
			2nd		
		Service Limit		0.0042 (Maximum)	
	Gap	Production	Top	0.010-0.020	
			2nd	0.010-0.025	
		Service Limit		0.035 (Maximum)	
	Groove Clearance	Production		0.002-0.007	
		Service Limit		0.008 (Maximum)	
	Gap	Production		0.015-0.055	
		Service Limit		0.065	
PISTON PIN:					
Diameter			0.9270-0.9273		
Clearance In Piston	Production		0.0002-0.0007		
	Service Limit		0.001 (Maximum)		
Fit In Rod			0.0008-0.0016 Interference		
EXHAUST MANIFOLD:					
Surface Flatness			0.010 (Maximum)		
INLET MANIFOLD:					
Surface Flatness			0.010 (Maximum)		
CYLINDER HEAD:					
Surface Flatness			0.004 (Overall)		
BALANCE SHAFT:					
Front Bearing Journal Diameter			2.1648-2.1654		
Rear Bearing Journal Diameter			1.4994-1.500		
Rear Bearing Journal Clearance			0.001-0.0036		

*Except Vehicles with a GVW rating of 8500 lbs. or greater, Compression ratio is 8.30.

SPECIFICATIONS

ENGINE SPECIFICATIONS (4.3L) (CONT.)

All Specifications are in INCHES unless otherwise noted.

DISPLACEMENT:			4.3L (LB4, VIN Z)
CRANKSHAFT:			
Main Journal	Diameter	#1	2.4484-2.4493
		#2, #3	2.4481-2.4490
		#4	2.4479-2.4488
	Taper	Production	0.0002 (Maximum)
		Service Limit	0.001 (Maximum)
	Out Of Round	Production	0.0002 (Maximum)
Service Limit		0.001 (Maximum)	
Main Bearing Clearance	Production	#1	0.0008-0.0020
		#2, #3	0.0011-0.0023
		#4	0.0017-0.0032
	Service Limit	#1	0.0010-0.0015
		#2, #3	0.0010-0.0025
		#4	0.0025-0.0035
Crankshaft End Play			0.005-0.018
Crankshaft Runout			0.001 (Maximum)
Crankpin	Diameter		2.2487-2.2497
	Taper	Production	0.0005
		Service Limit	0.001 (Maximum)
	Out Of Round	Production	0.0005
		Service Limit	0.001 (Maximum)
	Rod Bearing Clearance	Production	
Service Limit		0.0030	
Rod Side Clearance			0.015-0.046
CAMSHAFT:			
Lobe Lift ± 0.002	Intake		0.234
	Exhaust		0.257
Journal Diameter			1.8682-1.8692
			0.004-0.012
VALVE SYSTEM:			
Lifter			Hydraulic
Rocker Arm Ratio			1.50:1
Valve Lash	Intake		Torque Rocker Arm Nut to 27 N·m (20 lbs. ft.)
	Exhaust		
Face Angle (Intake & Exhaust)			45°
Seat Angle (Intake & Exhaust)			46°
Seat Runout (Intake & Exhaust)			0.002 (Maximum)
Seat Width	Intake		0.035-0.060
	Exhaust		0.062-0.093
Stem Clearance	Production	Intake	0.0010-0.0027
		Exhaust	0.0010-0.0027
	Service	Intake	High Limit Production +0.001
		Exhaust	High Limit Production +0.002
Valve Spring (Outer)	Free Length		2.03
	Pressure lbs. @ in.	Closed	76-84 lbs. @ 1.70-in.
		Open	194-206 lbs. @ 1.25-in.
	Installed Height $\pm 1/32$ "		1.690-1.710
Valve Spring Damper	Free Length		1.86
	Approx # of Coils		4

SPECIFICATIONS (CONT.)

FASTENER TIGHTENING SPECIFICATIONS

Item	N·m	Lbs. Ft.	Lbs. In.
Balance Shaft Drive Gear Retaining Bolt	16	12	—
Balance Shaft Driven Gear Bolt (Torque Plus a 35° Turn)	20	15	—
Balance Shaft Retainer Bolt	14	—	124
Camshaft Sprocket Bolts	28	21	—
Camshaft Thrust Plate Screws	14	—	124
Connecting Rod Bolt Nuts (Torque Plus 70°)	27	20	—
Coolant Outlet Bolts	28	21	—
Coolant Pump Bolts	40	30	—
Crankshaft Rear Oil Seal Retainer Screws and Nuts	15	11	—
Cylinder Head Bolts (In Sequence)	90	65	—
EGR Valve Bolt	22	16	—
Engine Block Drain Plug	20	15	—
Exhaust Manifold Bolts			
Center Two Bolts	36	26	—
All Other Bolts	28	20	—
Flywheel Bolts	100	74	—
Flywheel Housing Bolts	44	32	—
Front Cover Bolts	14	—	124
Hydraulic Lifter Guide Assembly Retainer Bolts	16	12	—
Intake Manifold Bolts (In Sequence)	47	35	—
Main Bearing Cap Bolts	110	81	—
Oil Filter Adapter Bolts	22	16	—
Oil Gallery Plug, Left Rear	40	30	—
Oil Gallery Plug, Right Rear	40	30	—
Oil Gallery Plug, Left Side Rear	30	22	—
Oil Pan Bolts	11	—	97
Oil Pan Drain Plug	25	18	—
Oil Pan Nuts	23	17	—
Oil Pan Studs to Oil Seal Retainer or Engine Block	23	17	—
Oil Pressure Fitting	11	—	97
Oil Pump Bolt	88	65	—
Oil Pump Cover Bolts	9	—	80
Rocker Arm Cover Bolts	10	—	90
Rocker Arm Nuts	27	20	—
Rocker Arm Stud	47	35	—
Torsional Damper Bolt	95	70	—

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20. Valve Stem Key	163. Bolt	700. Rocker Arm Cover Bolt
21. Inlet Valve Spring Cap	164. Coolant Outlet	701. Rocker Arm Cover
22. Valve Stem Oil Shield	165. Coolant Outlet Gasket	702. Rocker Arm Cover Gasket
23. Valve Stem Oil Seal (O-Ring)	166. Thermostat	704. Crankcase Vent Tube Grommet
24. Inlet Valve Stem Seal	167. Vacuum Fitting	705. Crankcase Vent Valve Grommet
26. Valve Spring with Damper	168. Engine Coolant Temperature Sensor	
27. Inlet Valve	169. Bolt	
28. Exhaust Valve Rotator	170. Intake Manifold	
29. Exhaust Valve	171. Oil Pressure Sensor	
40. Lifter Restrictor Retainer Bolt	172. Oil Pressure Fitting	
41. Lifter Restrictor Retainer	173. E.G.R. Valve Gasket	
42. Rocker Arm Nut	174. E.G.R. Valve	
43. Rocker Arm Ball	175. Bolt	
44. Rocker Arm	176. Intake Manifold Gasket	
45. Push Rod	177. Nut	
46. Valve Lifter Guide (Restrictor)	178. Power Booster Vacuum Pipe	
47. Lifter	179. Exhaust Manifold	
48. Flat Washer	180. Power Booster Vacuum Pipe Fitting	
50. Cylinder Head Bolt	181. Plug	
51. Spark Plug	182. Coolant Temperature Sensor	
52. Coolant Temperature Sensor	183. Crankcase Ventilation Valve	
53. Drain Plug	184. Oil Filler Cap	
54. Cylinder Head Gasket	185. Oil Filler Tube	
60. Heat Shield	186. Bolt	
61. Washer		
62. Exhaust Manifold Lock		
63. Bolt/Stud		
162. Stud		

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Figure 2—Cylinder Head, Manifolds, and Components -Legend

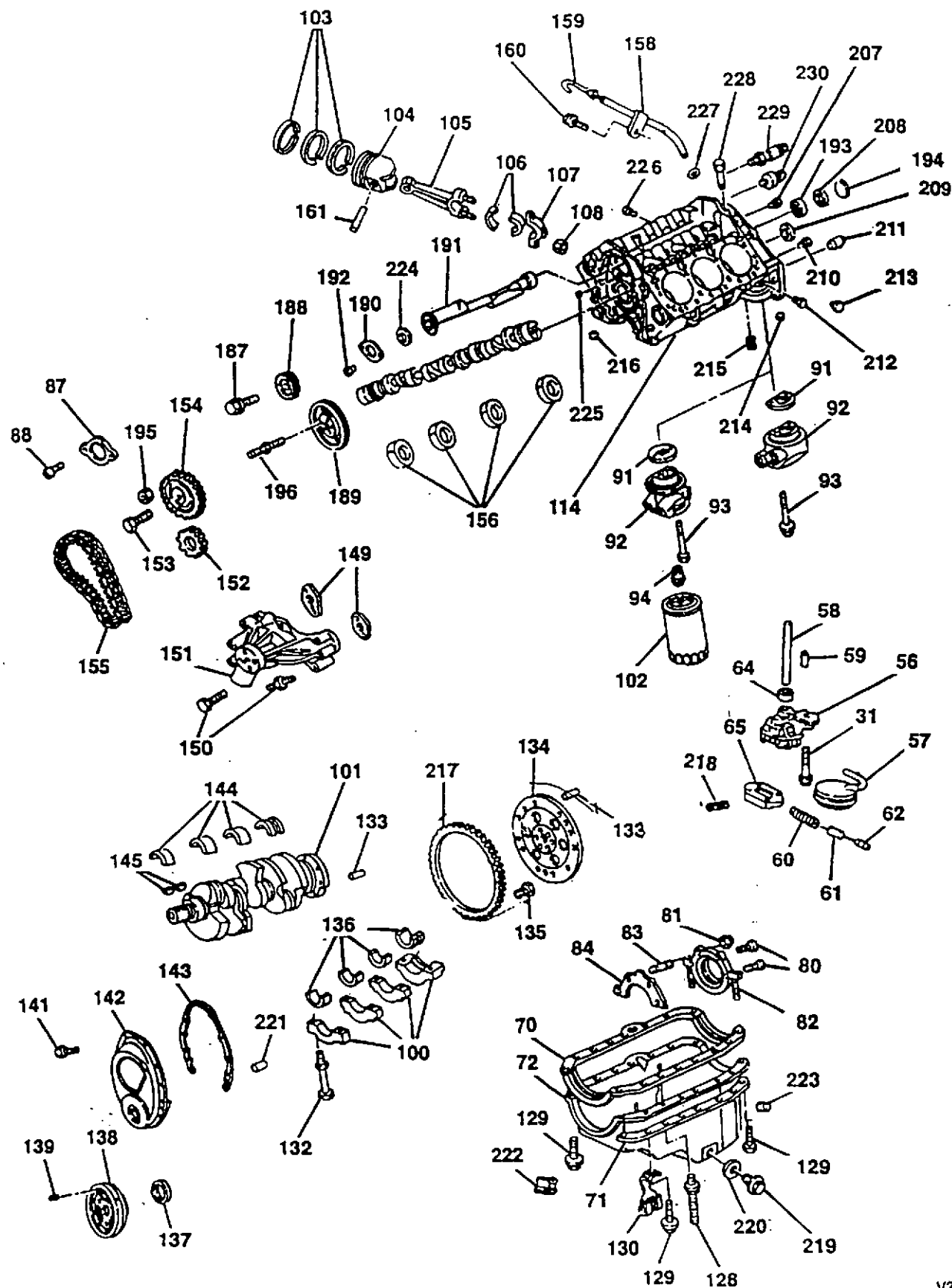


Figure 3—Cylinder Block and Components

SPECIAL TOOLS



1. J 39046



2. J 8062



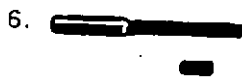
3. J 35468



4. J 8080



5. J 8037



6. J 5239



7. J 23738 - A



8. J 5802 - 01



9. J 5715



10. J 6038



11. J 6880



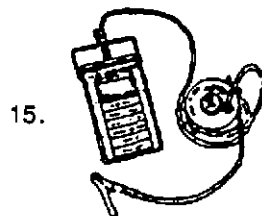
12. J 5825 - A



13. J 5590



14. J 35621



15. J 36660

1. TORSIONAL DAMPER REMOVER AND INSTALLER
2. VALVE SPRING COMPRESSOR
3. CRANKSHAFT SEAL INSTALLER
4. MAIN BEARING REPLACER
5. PISTON RING COMPRESSOR
6. GUIDE SET
7. VACUUM PUMP
8. STUD REMOVER

9. REAMER (0.003 INCH OVERSIZE)
10. REAMER (0.013 INCH OVERSIZE)
11. STUD INSTALLER
12. CRANKSHAFT GEAR PULLER
13. CRANKSHAFT GEAR INSTALLER
14. REAR CRANKSHAFT SEAL INSTALLER
15. TORQUE/ANGLE METER

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NOTES

Engine Mechanical - 4.3L

Specifications

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Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Control Cable Bracket Stud to Throttle Body	12 N.m	106 lb in
Accelerator Control Cable Bracket Stud to Intake Manifold	6 N.m	53 lb in
Accelerator Control Cable Bracket Stud Nut	12 N.m	106 lb in
Air Cleaner Adapter Stud	8 N.m	71 lb in
Air Conditioning (A/C) Compressor Mounting Bolt	50 N.m	37 lb ft
Balance Shaft Retainer Bolt	12 N.m	106 lb in
Balance Shaft Driven Gear Bolt		
First Pass	20 N.m	15 lb ft
Final Pass	35 degrees	
Battery Cable Bracket Bolt to Oil Pan	12 N.m	106 lb in
Battery Negative Cable Bolt to Engine	35 N.m	26 lb ft
Battery Positive Cable Junction Block Bracket Bolt	25 N.m	18 lb ft
Belt Idler Pulley Bolt	50 N.m	37 lb ft
Camshaft Retainer Bolt	12 N.m	106 lb in
Camshaft Sprocket Bolt	25 N.m	18 lb ft
Connecting Rod Nut		
First Pass	27 N.m	20 lb ft
Final Pass	70 degrees	
Crankshaft Balancer Bolt	95 N.m	70 lb ft
Crankshaft Bearing Cap Bolt (Preferred Method)		
First Pass	20 N.m	15 lb ft
Final Pass	73 degrees	
Crankshaft Bearing Cap Bolt (Optional Strategy)	105 N.m	77 lb ft
Crankshaft Position Sensor Bolt	8 N.m	71 lb in
Crankshaft Pulley Bolt	58 N.m	43 lb ft
Crankshaft Rear Oil Seal Housing Bolt and Nut	12 N.m	106 lb in
Crankshaft Rear Oil Seal Housing Retainer Stud	6 N.m	53 lb in
Cylinder Head Bolt (Preferred Method)		
All Bolts First Pass in Sequence	30 N.m	22 lb ft
Long Bolts Final Pass in Sequence	75 degrees	
Medium Bolts Final Pass in Sequence	65 degrees	
Short Bolts Final Pass in Sequence	55 degrees	
Cylinder Head Bolt (Optional On-Vehicle Strategy)		
First Pass in Sequence	35 N.m	26 lb ft
Second Pass in Sequence	60 N.m	44 lb ft
Final Pass in Sequence	90 N.m	66 lb ft
Cylinder Head Core Hole Plug	20 N.m	15 lb ft
Distributor Cap Bolt	2.4 N.m	21 lb in
Distributor Clamp Bolt	25 N.m	18 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
EGR Valve Bolt		
First Pass	7 N.m	62 lb in
Final Pass	30 N.m	22 lb ft
EGR Valve Inlet Pipe Clamp Bolt	25 N.m	18 lb ft
EGR Valve Inlet Pipe Nut at Intake Manifold	25 N.m	18 lb ft
EGR Valve Inlet Pipe Nut at Exhaust Manifold	30 N.m	22 lb ft
Engine Block Left Side Oil Gallery Plug	20 N.m	15 lb ft
Engine Block Left Rear Oil Gallery Plug	30 N.m	22 lb ft
Engine Block Right Rear Oil Gallery Plug	20 N.m	15 lb ft
Engine Block Coolant Drain Hole Plug	20 N.m	15 lb ft
Engine Block Oil Gallery Plug	20 N.m	15 lb ft
Engine Coolant Heater Bolt/Screw	2 N.m	18 lb in
Engine Coolant Temperature (ECT) Sensor	20 N.m	15 lb ft
Engine Flywheel Bolt	100 N.m	74 lb ft
Engine Front Cover Bolt	12 N.m	106 lb in
Engine Lift Bracket Bolt (Special Tool J 41427)	15 N.m	11 lb ft
Engine Lift Front Bracket Stud	35 N.m	26 lb ft
Engine Mount Bolt to Engine Bracket	50 N.m	37 lb ft
Engine Mount Engine Bracket Bolt to Engine	50 N.m	37 lb ft
Engine Mount Frame Bracket Through-bolt	60 N.m	44 lb ft
Engine Mount Frame Side Mount Bolt	50 N.m	37 lb ft
Engine Oil Level Sensor	20 N.m	15 lb ft
Engine Oil Pressure Gauge Sensor	30 N.m	22 lb ft
Engine Oil Pressure Gauge Sensor Fitting (Plus Required Angle)	15 N.m	11 lb ft
Engine Wiring Harness Bracket Bolt to Battery Positive Cable Junction Block Bracket	12 N.m	106 lb in
Engine Wiring Harness Bracket Bolt to Generator and Drive Belt Tensioner Bracket	25 N.m	18 lb ft
Engine Wiring Harness Bracket Bolt to Rear Right Side Cylinder Head	25 N.m	18 lb ft
Engine Wiring Harness Bracket Nut to Evaporative Emission (EVAP) Canister Purge Solenoid Valve Stud	10 N.m	88 lb in
Engine Wiring Harness Bracket Nut to Intake Manifold Stud	12 N.m	106 lb in
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Stud to Intake Manifold	10 N.m	88 lb in
Exhaust Manifold Bolt/Stud		
First Pass	15 N.m	11 lb ft
Final Pass	30 N.m	22 lb ft
Fan and Water Pump Pulley Bolt	25 N.m	18 lb ft
Frame Cross Bar Bolt	100 N.m	74 lb ft
Fuel Meter Body Bracket Bolt	10 N.m	88 lb in
Fuel Pipe Bracket Bolt	6 N.m	53 lb in
Fuel Pipe Bracket Bolt to Rear of Cylinder Head	30 N.m	22 lb ft
Fuel Pipe Retainer Nut	3 N.m	27 lb in
Fuel Supply Pipe Nut (Fuel Tank Side)	30 N.m	22 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Generator Mounting Bolt	50 N.m	37 lb ft
Generator and Drive Belt Tensioner Bracket Bolt to Engine	41 N.m	30 lb ft
Generator and Drive Belt Tensioner Bracket Stud to Engine	20 N.m	15 lb ft
Generator and Drive Belt Tensioner Bracket Stud Nut	41 N.m	30 lb ft
Ground Wire Bolt to Rear of Left Side Cylinder Head	16 N.m	12 lb ft
Ground Wire Nut to Rear of Right Side Cylinder Head	16 N.m	12 lb ft
Heater Hose Bracket Bolt to Generator and Drive Belt Tensioner Bracket	25 N.m	18 lb ft
Ignition Coil Stud	12 N.m	106 lb in
Knock Sensor	20 N.m	15 lb ft
Lower Intake Manifold Bolt		
First Pass in Sequence	3 N.m	27 lb in
Second Pass in Sequence	12 N.m	106 lb in
Final Pass in Sequence	15 N.m	11 lb ft
Oil Cooler Pipe Bracket to Oil Pan Bolt	12 N.m	106 lb in
Oil Filter	30 N.m	22 lb ft
Oil Filter Adapter Bolt	21 N.m	15 lb ft
Oil Filter Fitting	35 N.m	26 lb ft
Oil Level Indicator Tube Bolt	12 N.m	106 lb in
Oil Pan Baffle Bolt	12 N.m	106 lb in
Oil Pan Bolt and Nut	25 N.m	18 lb ft
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan Skid Plate Bolt	20 N.m	15 lb ft
Oil Pump Bolt to Rear Crankshaft Bearing Cap	90 N.m	66 lb ft
Oil Pump Cover Bolt	12 N.m	106 lb in
Power Steering Pump Bracket Bolt to Engine	41 N.m	30 lb ft
Power Steering Pump Bracket Stud to Engine	20 N.m	15 lb ft
Power Steering Pump Bracket Stud Nut	41 N.m	30 lb ft
Power Steering Pump Bolt	50 N.m	37 lb ft
Power Steering Pump Nut to Engine	41 N.m	30 lb ft
Power Steering Pump Rear Bracket Nut	50 N.m	37 lb ft
Secondary Air Injection (AIR) Check Valve Pipe Bracket Bolt to Exhaust Manifold	10 N.m	88 lb in
Secondary Air Injection (AIR) Check Valve Pipe Stud Nut	25 N.m	18 lb ft
Spark Plug		
Initial Installation (NEW Cylinder Head)	30 N.m	22 lb ft
All Subsequent Installations	15 N.m	11 lb ft
Spark Plug Wire Support Bolt	12 N.m	106 lb in
Starter Motor Bolt	50 N.m	37 lb ft
Starter Motor Wiring Harness/Transmission Cooler Pipe Bracket to Oil Pan Bolt	12 N.m	106 lb in
Throttle Body Stud	9 N.m	80 lb in
Transmission to Oil Pan Bolt	47 N.m	35 lb ft
Transmission Cover Bolt	12 N.m	106 lb in
Upper Intake Manifold Stud		

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
First Pass	5 N.m	44 lb in
Final Pass	9 N.m	80 lb in
Upper Radiator Hose Support Bracket to Exhaust Manifold Stud Nut	36 N.m	27 lb ft
Valve Lifter Pushrod Guide Bolt	16 N.m	12 lb ft
Valve Rocker Arm Ball Stud	47 N.m	35 lb ft
Valve Rocker Arm Cover Bolt	12 N.m	106 lb in
Valve Rocker Arm Nut	25 N.m	18 lb ft
Water Outlet Stud	25 N.m	18 lb ft
Water Pump Bolt	45 N.m	33 lb ft

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Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
Engine Type	V6	
Regular Production Option (RPO) Code LF6 VIN Code X, and RPO Code L35 VIN Code W		
Displacement	4.3L	262 CID
Bore	101.60 mm	4.012 in
Stroke	88.39 mm	3.480 in
Compression Ratio	9.2:1	
Firing Order	1-6-5-4-3-2	
Spark Plug Gap	1.52 mm	0.060 in
Oil Pressure (Minimum Hot)	41.4 kPa at 1,000 RPM (Minimum) 124.1 kPa at 2,000 RPM 165.4 kPa at 4,000 RPM	6.0 psig at 1,000 RPM (Minimum) 18.0 psig at 2,000 RPM 24.0 psig at 4,000 RPM
Balance Shaft		
Rear Bearing Journal Clearance	0.050–0.088 mm	0.0020–0.0035 in
Rear Bearing Journal Diameter	38.085–38.100 mm	1.4994–1.500 in
Camshaft		
End Play	0.0254–0.2286 mm	0.001–0.009 in
Journal Diameter	47.440–47.490 mm	1.8677–1.8696 in
Lobe Lift Exhaust (L35)	7.20–7.30 mm	0.283–0.287 in
Lobe Lift Exhaust (LF6)	6.54–6.64 mm	0.257–0.261 in
Lobe Lift Intake (L35)	6.97–7.07 mm	0.274–0.278 in
Lobe Lift Intake (LF6)	6.76–6.86 mm	0.266–0.270 in
Connecting Rod		
Connecting Rod Bearing Clearance (Production)	0.038–0.078 mm	0.0015–0.0031 in
Connecting Rod Bearing Clearance (Service)	0.025–0.076 mm	0.0010–0.0030 in
Connecting Rod Side Clearance	0.15–0.44 mm	0.006–0.017 in
Connecting Rod Journal Diameter	57.116–57.148 mm	2.2487–2.2497 in
Connecting Rod Journal Taper (Production)	0.00508 mm (Maximum)	0.0003 in (Maximum)
Connecting Rod Journal Taper (Service)	0.025 mm (Maximum)	0.001 in (Maximum)

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Connecting Rod Journal Out-of-Round (Production)	0.007 mm (Maximum)	0.0002 in (Maximum)
Connecting Rod Journal Out-of-Round (Service)	0.025 mm (Maximum)	0.001 in (Maximum)
Crankshaft		
Crankshaft Bearing Clearance (#1-Production)	0.02-0.508 mm	0.0008-0.0020 in
Crankshaft Bearing Clearance (#2, #3, and #4-Production)	0.028-0.058 mm	0.0011-0.0023 in
Crankshaft Bearing Clearance (#1-Service)	0.0254-0.05 mm	0.0010-0.0020 in
Crankshaft Bearing Clearance (#2, #3, and #4-Service)	0.025-0.063 mm	0.0010-0.025 in
Crankshaft End Play	0.050-0.20 mm	0.002-0.008 in
Crankshaft Journal Diameter (Journal #1)	62.199-62.217 mm	2.4488-2.4495 in
Crankshaft Journal Diameter (Journals #2 and #3)	62.191-62.215 mm	2.4485-2.4494 in
Crankshaft Journal Diameter (Journal #4)	62.179-62.203 mm	2.4480-2.4489 in
Crankshaft Journal Out-of-Round (Production)	0.005 mm (Maximum)	0.0002 in (Maximum)
Crankshaft Journal Out-of-Round (Service)	0.025 mm (Maximum)	0.001 in (Maximum)
Crankshaft Journal Taper (Production)	0.007 mm (Maximum)	0.0003 in (Maximum)
Crankshaft Runout	0.025 mm (Maximum)	0.001 in (Maximum)
Cylinder Bore		
Diameter	101.618-101.643 mm	4.0007-4.0017 in
Out-of-Round (Production)	0.0127 mm (Maximum)	0.0005 in (Maximum)
Out-of-Round (Service)	0.05 mm (Maximum)	0.002 in (Maximum)
Taper (Production Relief Side)	0.025 mm (Maximum)	0.001 in (Maximum)
Taper (Production Thrust Side)	0.012 mm (Maximum)	0.0005 in (Maximum)
Taper (Service)	0.025 mm (Maximum)	0.001 in (Maximum)
Cylinder Head		
Surface Flatness	0.10 mm (Maximum)	0.004 in (Maximum)
Exhaust Manifold		
Surface Flatness	0.05 mm (Maximum)	0.002 in (Maximum)
Intake Manifold		
Surface Flatness	0.10 mm (Maximum)	0.004 in (Maximum)
Lubrication System		
Engine Oil Capacity Without Filter Change	3.75 liters	4 quarts
Engine Oil Capacity With Filter Change	4.148 liters	4.42 quarts
Oil Pan		
Oil Pan Alignment at Rear of Engine Block	0.3 mm (Maximum)	0.011 in (Maximum)
Piston		
Piston Bore Clearance (Production)	0.018-0.061 mm	0.0007-0.0024 in
Piston Bore Clearance (Service)	0.075 mm (Maximum)	0.0029 mm (Maximum)
Piston Pin		
Diameter	23.545-23.548 mm	0.9270-0.9270 in
Clearance in Piston (Production)	0.013-0.023 mm	0.0005-0.0009 in
Clearance in Piston (Service)	0.025 mm (Maximum)	0.001 in (Maximum)
Fit in Connecting Rod	0.021-0.040 mm (Interference)	0.0008-0.0016 in (Interference)
Piston Rings (End Gap Measured in Cylinder Bore)		

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Piston Compression Ring Groove Clearance (Production-Top Groove)	0.030-0.070 mm	0.0012-0.0027 in
Piston Compression Ring Groove Clearance (Production-2nd Groove)	0.040-0.080 mm	0.0015-0.0031 in
Piston Compression Ring Groove Clearance (Service)	0.085 mm (Maximum)	0.0033 in (Maximum)
Piston Compression Ring Gap (Production-Top Groove)	0.25-0.40 mm	0.010-0.016 in
Piston Compression Ring Gap (Production-2nd Groove)	0.46-0.66 mm (Maximum)	0.018-0.026 in (Maximum)
Piston Compression Ring Gap (Service-Top Groove)	0.5 mm (Maximum)	0.19 in (Maximum)
Piston Compression Ring Gap (Service-2nd Groove)	0.8 mm (Maximum)	0.31 in (Maximum)
Piston Oil Ring Groove Clearance (Production)	0.046-0.096 mm	0.0018-0.0037 in
Piston Oil Ring Groove Clearance (Service)	0.10 mm (Maximum)	0.0039 in (Maximum)
Piston Oil Ring Gap (Production)	0.25-0.76 mm	0.009-0.029 in
Piston Oil Ring Gap (Service)	0.90 mm (Maximum)	0.035 in (Maximum)
Valve System		
Valve Face Angle	—	45 degrees
Valve Lash	Net Lash No Adjustment	
Valve Lifter	Hydraulic Roller Type	
Valve Lift Exhaust (L35)	10.879 mm	0.4280 in
Valve Lift Exhaust (LF6)	9.887 mm	0.3890 in
Valve Lift Intake (L35)	10.527 mm	0.4140 in
Valve Lift Intake (LF6)	10.215 mm	0.4020 in
Valve Rocker Arm Ratio	1.5:1	
Valve Seat Angle	—	46 degrees
Valve Seat Runout	0.05 mm (Maximum)	0.002 in (Maximum)
Valve Seat Width (Exhaust)	1.575-2.362 mm	0.065-0.098 in
Valve Seat Width (Intake)	0.89-1.52 mm	0.035-0.060 in
Valve Spring Free Length	51.3 mm	2.02 in
Valve Spring Pressure (Closed)	338-374 N at 43.2 mm	76-84 lb at 1.70 in
Valve Spring Pressure (Open)	832-903 N at 32.3 mm	187-203 lb at 1.27 in
Valve Spring Installed Height (Exhaust)	42.92-43.43 mm	1.670-1.700 in
Valve Spring Installed Height (Intake)	42.92-43.43 mm	1.670-1.700 in
Valve Stem Clearance (Exhaust-Production)	0.025-0.069 mm	0.0010-0.0027 in
Valve Stem Clearance (Intake-Production)	0.025-0.069 mm	0.0010-0.0027 in
Valve Stem Clearance (Exhaust-Service)	0.025-0.094 mm	0.0010-0.0037 in
Valve Stem Clearance (Intake-Service)	0.025-0.094 mm	0.0010-0.0037 in

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GM SPO Group Numbers

Application	GM SPO Group Number
Accelerator Control Cable Bracket	3.454
Balance Shaft	0.659
Balance Shaft Bearing Kit (Rear)	0.659
Balance Shaft Gear Kit (Includes Drive and Driven Gears)	0.529

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
Balance Shaft Retainer	0.659
Belt Idler Pulley (Grooved)	1.062
Belt Idler Pulley (Smooth)	1.062
Camshaft Bearing	0.539
Camshaft Retainer	0.529
Camshaft Sprocket	0.736
Camshaft Timing Chain	0.724
Clutch Pilot Bearing	0.649
Connecting Rod	0.603
Connecting Rod Bearing Kit	0.616
Coolant Radiator	1.219
Crankshaft Balancer	0.659
Crankshaft Balancer Key	0.662
Crankshaft Bearing Kit	0.096
Crankshaft Front Oil Seal	0.213
Crankshaft Rear Oil Seal	0.137
Crankshaft Rear Oil Seal Housing	0.137
Crankshaft Rear Oil Seal Housing Retainer Stud	0.137
Crankshaft Rear Oil Seal Housing Gasket	0.137
Crankshaft Rear Oil Seal Retainer Stud	0.137
Crankshaft Position Sensor	2.383
Crankshaft Position Sensor Reluctor Ring	2.383
Crankshaft Position Sensor Seal (O-ring)	2.383
Crankshaft Pulley	0.659
Crankshaft Sprocket	0.728
Cylinder Head	0.269
Cylinder Head Gasket	0.289
Distributor	2.361
Distributor Clamp	2.363
Distributor Gasket	2.363
Dowel Pin (Cylinder Head Locator)	8.939
Dowel Straight Pin (Transmission Locator)	8.939
Drive Belt Tensioner	1.060
EGR Valve	3.670
EGR Valve Gasket	3.680
EGR Valve Inlet Pipe	3.675
Evaporative Emission Canister Purge Solenoid Valve	3.130
Evaporative Emission Canister Purge Solenoid Valve Harness	3.145
Engine Block	N.S.
Engine Block Core Hole Plug	0.034
Engine Block Oil Gallery Plug	1.531
Engine Camshaft	0.519
Engine Coolant Heater	1.152
Engine Coolant Temperature Sensor	1.150
Engine Coolant Temperature Gauge Sensor	1.150

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
Engine Coolant Thermostat	1.246
Engine Crankshaft	0.646
Engine Flywheel	0.666
Engine Front Cover	0.206
Engine Mount	0.029
Engine Mount Bracket	0.029
Engine Oil Level Sensor	1.516
Engine Oil Pressure Gauge Sensor	1.800
Engine Oil Pressure Gauge Sensor Fitting	1.800
Engine Piston Kit (Piston and Pin)	0.629
Engine Wiring Harness Bracket	2.559
Exhaust Manifold	3.601
Exhaust Manifold Gasket	3.270
Exhaust Manifold Heat Shield	3.602
Exhaust Valve	0.297
Expansion Cup Plug (Balance Shaft Rear Bearing Hole)	8.970
Expansion Cup Plug (Camshaft Rear Bearing Hole)	8.970
Fan & Water Pump & A/C Compressor & Generator & Power Steering Pump Belt	1.066
Fan & Water Pump & Generator & Power Steering Pump Belt	1.066
Fan and Water Pump Pulley	1.062
Flywheel Locator Pin	0.669
Front Groove Pin (Crankshaft Balancer)	8.940
Fuel Pipe (Included in Fuel Injection Feed and Return Pipe Kit only)	3.163
Fuel Pipe Retainer Bracket (Included in Fuel Injection Feed and Return Pipe Kit only)	3.163
Fuel Injector (O-ring) Seal Kit	3.331
Generator & Drive Belt Tensioner Bracket	1.060
Ignition Coil	2.170
Ignition Coil Wire Harness	2.240
Intake Valve	0.296
Knock Sensor	2.383
Lower Intake Manifold (Included in Lower Intake Manifold Kit only)	3.265
Lower Intake Manifold Gasket Kit	3.270
MAP Sensor	3.682
MAP Sensor Seal	3.682
Oil Fill Cap	1.758
Oil Fill Tube	1.745
Oil Fill Tube (Lower) Bracket	1.750
Oil Filter	1.836
Oil Filter Adapter	1.840
Oil Filter Adapter Gasket	1.840
Oil Filter Adapter Seal (O-ring)	1.844
Oil Filter Bypass Valve	1.837
Oil Filter Fitting	1.855
Oil Level Indicator	1.516
Oil Level Indicator Tube	1.516

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
Oil Pan	1.426
Oil Pan Drain Plug	1.453
Oil Pan Drain Plug Seal (O-ring)	1.456
Oil Pan Gasket	1.429
Oil Pump	1.652
Oil Pump Cover	1.723
Oil Pump Drive Shaft	1.639
Oil Pump Drive Shaft Retainer	1.639
Oil Pump Pressure Relief Valve	1.609
Oil Pump Pressure Relief Valve Spring	1.609
Oil Pump Pressure Relief Valve Spring Bore Plug	1.609
Oil Pump Pressure Relief Valve Spring Straight Pin	1.609
Oil Pump Screen	1.656
PCV Tube	1.762
PCV Valve	1.745
PCV Valve Cover	1.745
PCV Valve Elbow	1.762
PCV Valve Hose	1.762
Pin (Oil Pump Locator)	1.723
Piston Ring Kit	0.643
Power Steering Pump Bracket	6.606
Radiator Air Deflector	1.272
Radiator Fan Shroud	1.277
Radiator Hose Support	1.166
Secondary Air injection (AIR) Check Valve	3.670
Secondary Air injection (AIR) Check Valve Gasket	3.680
Secondary Air injection (AIR) Check Valve (Crossover) Pipe	3.675
Secondary Air injection (AIR) Check Valve Pipe	3.675
Spark Plug	2.270
Spark Plug Wire	2.240
Spark Plug Wire Shield	2.251
Spark Plug Wire Support	2.251
Spring Type S Pin (Crankshaft Rear Oil Seal Housing Locator)	8.940
Starter Motor	2.041
TBI Fuel Meter	3.734
Throttle Body	3.335
Throttle Body to Upper Manifold Gasket (Included in Service Kits only)	N.S.
Torque Converter Housing Access Hole Plug (Rubber/at Oil Pan)	4.104
Transmission Brace	4.081
Transmission Cover	4.105
Upper Intake Manifold (included in Upper Intake Manifold Kit only)	3.625
Upper Intake Manifold to Lower Intake Manifold Gasket (Included in Intake Manifold Seal Kit)	3.270
Valve Lifter	0.459
Valve Lifter Pushrod Guide	0.439

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
Valve Pushrod	0.426
Valve Rocker Arm (Included in Valve Rocker Arm Kit only)	N.S.
Valve Rocker Arm Ball	0.429
Valve Rocker Arm Ball Stud	0.429
Valve Rocker Arm Cover	0.386
Valve Rocker Arm Cover Bolt Grommet	0.423
Valve Rocker Arm Cover Gasket	0.423
Valve Rocker Arm Kit (Valve Rocker Arm, Ball, Nut)	0.333
Valve Rocker Arm Nut	0.429
Valve Spring	0.303
Valve Spring Cap	0.309
Valve Stem Key	0.310
Valve Stem Oil Seal	0.308
Water Outlet	1.153
Water Pump Gaskets	1.079
Water Pump Inlet Hose	1.097
Water Pump Kit (with Gaskets)	1.069

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Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number
Balancer Shaft Driven Gear Bolt Threads	Threadlock	12345382
Coolant Sealing Pellets	Sealant	3634621
Crankshaft Balancer Keyway	Adhesive	12346141
Cylinder Head Bolt Threads	Sealant	12346004
Engine Block to Crankshaft Rear Oil Seal Housing Junction at the Oil Pan Sealing Surfaces	Adhesive	12346141
Engine Block to Engine Front Cover Junction at the Oil Pan Sealing Surfaces	Adhesive	12346141
Engine Block at the Lower Intake Manifold Sealing Surfaces	Adhesive	12346141
Engine Block Coolant Drain Hole Plug Threads	Sealant	12346004
Engine Block Oil Gallery Plug	Sealant	12346004
Engine Coolant Temperature (ECT) Gauge Sensor Threads	Sealant	12346004
Engine Oil	SAE 5W-30 Oil	12345610
Engine Oil Pressure Sensor Threads	Sealant	12346004
Engine Oil Pressure Sensor Fitting Threads	Sealant	12346004
Engine Oil Supplement	Lubricant	1052367
Exhaust Manifold Bolt /Stud Threads	Threadlock	12345493
Expansion Cup Plug (Balance Shaft Rear Bearing Hole)	Sealant	12346004
Expansion Cup Plug (Camshaft Rear Bearing Hole)	Sealant	12346004
Knock Sensor Threads	Sealant	12346004
Lower Intake Manifold Bolt Threads	Threadlock	12345382
Oil Level Indicator Tube	Sealant	12346004
Oil Pump Screen Tube	Sealant	12346004

Sealers, Adhesives, and Lubricants (cont'd)

Application	Type of Material	GM Part Number
Valve Rocker Arm Stud Threads	Threadlock	12345493
Valve Train Component Prelube	Lubricant	12345501
Water Pump Bolt Threads	Sealant	12346004

Diagnostic Information and Procedures

SIE-ID - 195364

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

Test Procedure

1. Disconnect the positive ignition coil wire plug from ignition coil.
2. Disconnect the fuel injector electrical connector.
3. Remove all the spark plugs.
4. Block the throttle plate wide open.
5. Charge the battery if the battery is not fully charged.
6. Start with the compression gauge at zero. Then crank the engine through four compression strokes (four puffs).
7. Make the compression check the same for each cylinder. Record the reading.

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 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). ($1035 \times 70\% = 725$) ($150 \times 70\% = 105$).

8. If some cylinders have low compression, inject approximately 15 ml (one tablespoon) of engine oil into the combustion chamber through the spark plug hole.
 - 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 two cylinders.

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Engine Noise Diagnosis

Symptom	Cause
When diagnosing engine noise complaints use the following steps to isolate the source of the engine noise: - Determine the type of noise For example, is the noise a light rattle/tapping or a low rumble/knocking? - The exact operating condition under which the noise exists Note factors such as the ambient temperature, the amount of engine warm-up time, the engine temperature, the engine RPM, and other specifics. - At what rate the noise occurs, and at what location in the engine Engine noises are generally synchronized to either engine speed (crankshaft, engine flywheel, connecting rods, crankshaft balancer, or pistons and related components) or one-half engine speed (valve train noise such as valve rocker arms, valve lifters, and camshaft timing chain). Determine the rate at which the noise is occurring. - Compare the engine sounds to other engines, and make sure you are not trying to correct a normal condition.	
Noise on Start-Up but Only Lasts a Few Seconds	- Improper oil viscosity. Install the recommended oil viscosity for the expected temperatures. - Worn or dirty valve lifters - Excessive piston-to-cylinder bore clearance - Excessive piston pin-to-bore clearance - Excessive crankshaft bearing clearance
Knocks Cold and Continues for 1 to 2 Minutes	- Loose or broken crankshaft balancer or accessory drive components - Excessive piston-to-bore clearance A cold piston knock which disappears in 1.5 minutes should be considered acceptable. - A cold engine knock usually disappears when the specific cylinders secondary ignition circuit is grounded out.
Intermittent Noise on Idle, Disappearing When Engine Speed is Increased	- Improper oil viscosity. Install the recommended oil viscosity for the expected temperatures. - Lower than specified oil pressure Install an oil pressure gauge and measure the engine oil pressure. - Dirty or worn valve lifter
Valve Train Noise (Rattle/Tapping)	The following conditions may cause valve train noise: - Lower than specified oil pressure - Worn or faulty oil pump - Loose oil pump-to-engine block bolt - Loose valve rocker arm attachments - Worn valve rocker arms and/or valve pushrods - Broken valve spring - Sticking valves - Worn, dirty, or faulty valve lifters - Worn engine camshaft lobes - Worn valve guides or valve stems - Bent, broken, or damaged timing chain sprocket teeth

Engine Noise Diagnosis (cont'd)

Symptom	Cause
Knocks Hot at Idle (Rumble/Knocking)	The following conditions may cause a knocking noise: • Malfunctioning accessory drive system components • Loose or broken crankshaft balancer • Detonation or spark knock Check for proper operation of the cooling, knock, and ignition control components. Refer to diagnostic information in Engine Controls. • Excessive connecting rod bearing clearance • Excessive piston pin-to-bore clearance • Bent connecting rod • Excessive crankshaft bearing clearance • Loose torque converter bolts (if equipped) • Cracked or damaged engine flywheel • Exhaust leak at the exhaust manifold • Combustion chamber deposits
Exhaust System Noise and/or Leakage	Exhaust system noise and/or leakage may be caused by the following conditions: • Improperly installed or misaligned exhaust system components • A cracked or broken exhaust manifold • Damaged or worn exhaust manifold gaskets and/or seals • Burnt or rusted out exhaust system components • Broken or loose exhaust clamps and/or brackets

SIE-ID - 356567

Valve Train Diagnosis

General Information

Symptom	Cause
• A light tapping noise at 1/2 engine speed, or any varying frequency, may indicate a valve train problem. • Tapping noises will typically increase with increased engine speed. • Before attempting to diagnose a valve train noise, check for the proper engine oil level and then allow the engine to obtain normal operating temperature. Following this procedure will bring all engine components to a normal state of expansion. • Sit in the driver's seat, then operate the engine at various speeds and listen for any abnormal engine noise.	

General Information (cont'd)

Symptom	Cause
Valve Train Noise	• Low engine oil pressure • A worn or faulty oil pump • A loose or plugged oil pump screen • Loose valve rocker arm attachments (causing excessive valve lash) • A worn or damaged valve rocker arm ball • A worn valve rocker arm and/or valve pushrod • A broken valve spring • Sticking valves • Valve lifters worn, dirty, or faulty • A broken valve lifter guide • Engine camshaft lobes worn • Worn valve guides or valve stems • Worn or damaged valve stem keys • Bent valve pushrods • Excessive free play in the camshaft timing chain • Bent, broken, or damaged camshaft sprocket teeth

Diagnostic Table

Step	Action	Value(s)	Yes	No
DEFINITION: A light tapping noise at 1/2 engine speed, or any varying frequency.				
1	Is there valve train noise?	—	Go to Step 2	System OK
2	Check for a high engine oil level. An engine with the engine oil level above the FULL mark on the oil level indicator allows the crankshaft counterweights to churn the engine oil into foam. When the foamy engine oil is pumped into the valve lifters, the valve lifters become noisy. A solid column of engine oil ensures proper valve lifter operation. Is the engine oil level too high?	—	Go to Step 3	Go to Step 4
3	Drain the engine oil to the proper level. Is the tapping noise gone?	—	System OK	Go to Step 6
4	Check for a low engine oil level. An engine with the engine oil level below the ADD mark on the oil level indicator may allow the oil pump to pump air at high engine RPM. Is the engine oil level below the ADD mark on the oil level indicator?	—	Go to Step 5	Go to Step 6
5	Add the engine oil as required. Is the tapping noise gone?	—	System OK	Go to Step 6
6	Check for the proper engine oil pressure. Refer to <i>Engine Mechanical Specifications and Oil Pressure Diagnosis and Testing</i> . Is the engine oil pressure within specifications?	41.4 kPa (6 psi)	Go to Step 11	Go to Step 7
7	Check the oil pump screen for damage or a loose fit to the oil pump. Is the oil pump screen loose or is the oil pump screen damaged?	—	Go to Step 8	Go to Step 9
8	Repair as required. Is the tapping noise gone?	—	System OK	Go to Step 9

Diagnostic Table (cont'd)

Step	Action	Value(s)	Yes	No
9	Check for a damaged oil pump or loose bolts. Refer to <i>Oil Pump Clean and Inspect</i> . Is the oil pump damaged or are the bolts loose?	—	Go to Step 10	Go to Step 11
10	Repair as required. Is the tapping noise gone?	—	System OK	Go to Step 11
11	Remove and inspect the valve lifters, the valve rocker arms, and the valve pushrods. Refer to <i>Valve Rocker Arm and Push Rods Clean and Inspect</i> and <i>Valve Lifters and Guides Clean and Inspect</i> . Are the components worn or damaged?	—	Go to Step 12	Go to Step 13
12	Replace the components as required. Is the tapping noise gone?	—	System OK	Go to Step 13
13	Perform an engine camshaft lobe lift test. Refer to <i>Camshaft and Bearings Clean and Inspect</i> . Is the engine camshaft lobes within specifications?	—	Go to Step 15	Go to Step 14
14	Replace the engine camshaft and valve lifters. Is the tapping noise gone?	—	System OK	Go to Step 15
15	Remove the engine front cover and inspect the camshaft timing chain and sprockets for excessive wear or damage. Refer to <i>Timing Chain and Sprockets Clean and Inspect</i> . Are the components worn or damaged?	—	Go to Step 17	Go to Step 16
16	Replace the components as required. Is the tapping noise gone?	—	System OK	Go to Step 17
17	Perform a complete disassembly of the engine and inspect all components. Are the components worn or damaged?	—	Go to Step 18	System OK
18	Replace the components as required. Did you complete the worn or damaged component replacement?	—	System OK	—

SIE-ID - 69356

Oil Consumption Diagnosis

Excessive oil consumption (not due to leaks) is the use of 1.9 liters (2 quarts) of engine oil within 3 200 kilometers (2,000 miles). However, during initial engine break-in periods 4 828–6 437 kilometers (3,000–4,000 miles) oil consumption may exceed 1.9 liters (2 quarts) or more. The causes of excessive oil consumption include the following conditions:

- External oil leaks. Tighten the bolts and/or replace gaskets and oil seals as necessary.
- Incorrect oil level or improper reading of oil level indicator. With the vehicle on a level surface, allow adequate drain down time and check for the correct oil level.
- Improper oil viscosity. Use recommended SAE viscosity for the prevailing temperatures.
- Continuous high speed driving and/or severe usage.
- Crankcase ventilation system restrictions or malfunctioning components.

- Valve guides and/or valve stem oil seals worn, or the seal omitted. Ream the valve guides and install oversize service valves and/or new valve stem oil seals.
- Piston rings broken, improperly installed, worn, or not seated properly. Allow adequate time for the piston rings to seat. Replace broken or worn piston rings as necessary.
- Piston improperly installed or miss-fitted.

SIE-ID - 23360

Oil Pressure Diagnosis and Testing

1. With the vehicle on a level surface, allow adequate drain down time (2–3 minutes) and measure for a low engine oil level.
Add the recommended grade engine oil, and fill the crankcase until the oil level measures FULL on the oil level indicator.
2. Operate the engine and verify low or no oil pressure on the vehicle oil pressure gauge or the oil indicator light.
Listen for a noisy valve train or a knocking noise.

3. Inspect for the following:
 - Engine oil diluted by moisture or unburned fuel mixtures
 - Improper engine oil viscosity for the expected temperature
 - Incorrect or faulty oil pressure gauge sensor
 - Incorrect or faulty oil pressure gauge
 - Plugged oil filter
 - Malfunctioning oil filter bypass valve
4. Remove the oil pressure gauge sensor or another engine block oil gallery plug.
5. Install an oil pressure gauge and then measure the engine oil pressure.
6. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
 - Oil pump worn or dirty
 - Malfunctioning oil pump pressure relief valve
 - Oil pump screen loose, plugged, or damaged
 - Excessive bearing clearance
 - Cracked, porous or restricted oil galleries
 - Engine block oil gallery plugs missing or incorrectly installed
 - Broken valve lifters

SIE-ID - 204344

Oil Leak Diagnosis

Step	Action	Value(s)	Yes	No
DEFINITION: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.				
1	1. Operate the vehicle until it reaches normal operating temperature. Refer to <i>Engine Mechanical Specifications</i> . 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. 5. Are drippings present?	—	Go to Step 2	Go to Step 3
2	1. Identify the type of fluid and the approximate location of the leak. 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 3. Can you identify the source of the leak?	—	Go to Step 10	Go to Step 4

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several 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. 6. 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 3. Can you identify the source 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 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. 5. Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 7
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components 3. Can you identify the source of the leak?	—	Go to Step 10	Go to Step 8
8	1. Using the J 28428-E, Dye and Light Kit, identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. 2. 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 3. Can you identify the source of the leak?	—	Go to Step 10	Go to Step 12

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
10	1. Check for the following conditions: • 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. Is there mechanical damage to the engine?	—	Go to Step 11	—
11	Repair or replace all damaged components.	—	Go to Step 1	—
12	System OK.	—	—	—

SIE-ID - 377404

Drive Belt Diagnosis

Definitions

The following are symptomatic noises of the drive belt system:

Chirping

The following items are indications of chirping:

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

Squeal

The following items are indications of squeal:

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

Whine

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

Faint Cycle Rumbling

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

Pilling

The following items are indications of pilling:

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

Multiple-ribbed type drive belts wear evenly with their

pulleys. Unusual wear indicates a correction is needed. The following diagnostic tables will aid in diagnosing drive belt system conditions.

Drive Belt Diagnosis

Step	Action	Value(s)	Yes	No
1	Check for misalignment of the pulleys. Are any of the pulleys misaligned?	—	Go to Step 2	Go to Step 3
2	Replace any misaligned pulleys. Is the chirp still present?	—	Go to Step 3	System OK
3	Check for bent or cracked brackets. Are there any bent or cracked brackets?	—	Go to Step 4	Go to Step 5
4	Replace any bent or cracked brackets. Is the chirp still present?	—	Go to Step 5	System OK
5	Check for any loose or missing fasteners. Are there any loose or missing fasteners?	—	Go to Step 6	Go to Step 7
6	Tighten any loose fasteners and properly install any missing fasteners. Refer to <i>Fastener Tightening Specifications (ERROR - NOT IN CURRENT PSD)</i> Is the chirp still present?	—	Go to Step 7	System OK
7	Check for a bent pulley flange. Is the pulley flange bent?	—	Go to Step 8	Go to Step 9
8	Replace the pulley flange. Is the chirp still present?	—	Go to Step 9	System OK
9	Check for severe pilling, exceeding 1/3 of the belt groove depth. Is there severe pilling?	—	Go to Step 10	—
10	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> Is the chirp still present?	—	—	System OK

Drive Belt Squeal

Step	Action	Value(s)	Yes	No
11	Check for a misaligned pulley. Is there a pulley misaligned?	—	Go to Step 13	Go to Step 12
12	Check for incorrect belt length. Refer to <i>Drive Belt Tensioner Diagnosis</i> Is the belt length correct?	—	Go to Step 14	Go to Step 15
13	Repair or install new parts as necessary. Is the repair complete?	—	System OK	—
14	Check for a malfunctioning drive belt tensioner. Refer to <i>Drive Belt Tensioner Diagnosis</i> Is the tensioner malfunctioning?	—	Go to Step 13	Go to Step 15
15	Check for correct pulley size. Are the pulleys the correct size?	—	Go to Step 16	Go to Step 13
16	Check for siezed bearings. Is there a siezed bearing?	—	Go to Step 13	System OK

Drive Belt Whine

Step	Action	Value	Yes	No
17	Check for a worn accessory component bearing. Is a bearing making the noise?	—	Go to Step 18	System OK
18	Install new parts as necessary Is the repair complete?	—	System OK	—

Drive Belt Rumbling

Step	Action	Value(s)	Yes	No
19	Check for severe pilling. Is there severe pilling of more than 1/3 of the rib depth?	—	Go to Step 19	System OK
20	Clean the drive belt pulleys. Are the drive belt pulleys clean?	—	Go to Step 20	Go to Step 21
21	Install a new accessory drive belt. Is the repair complete?	—	System OK	—

Drive Belt Vibration

Step	Action	Value(s)	Yes	No
22	Check for loose or missing fasteners. Are there loose or missing fasteners?	—	Go to Step 22	Go to Step 24
23	Re-tighten or replace as necessary. Is the repair complete?	—	System OK	—
24	Check for damaged fan blades. Are there damaged fan blades?	—	Go to Step 25	Go to Step 26
25	Replace as necessary. Refer to <i>Fan Clutch Replacement</i> Is the replacement complete?	—	System OK	—
26	Check for a bent fan clutch or coolant pump shaft. Is the fan clutch or coolant pump shaft bent?	—	Go to Step 27	Go to Step 28
27	Replace as necessary. Refer to <i>Water Pump Replacement (4.3L)</i> Is the repair complete?	—	System OK	—
28	Check for bent or cracked brackets. Are there bent or cracked brackets?	—	Go to Step 29	System OK
29	Replace the brackets as necessary. Is the repair complete?	—	System OK	—

Drive Belt Falls Off

Step	Action	Value(s)	Yes	No
30	Check for a misaligned or a bent pulley. Are the pulleys misaligned?	—	Go to Step 31	Go to Step 32
31	Replace any misaligned or bent pulleys. Does the drive belt continue to fall off?	—	Go to Step 32	System OK
32	Check for a bent or a cracked bracket. Are any of the brackets bent or cracked?	—	Go to Step 33	Go to Step 34
33	Replace the damaged brackets. Does the drive belt continue to fall off?	—	Go to Step 34	System OK
34	Check for loose or missing fasteners. Are there any loose or missing fasteners?	—	Go to Step 35	Go to Step 36
35	Replace any missing fasteners and tighten to specifications. Refer to <i>Fastener Tightening Specifications (ERROR - NOT IN CURRENT PSD)</i> Does the drive belt continue to fall off?	—	Go to Step 36	System OK
36	Check for a misaligned power steering pump pulley. Is the power steering pump pulley misaligned?	—	Go to Step 37	Go to Step 38

Drive Belt Falls Off (cont'd)

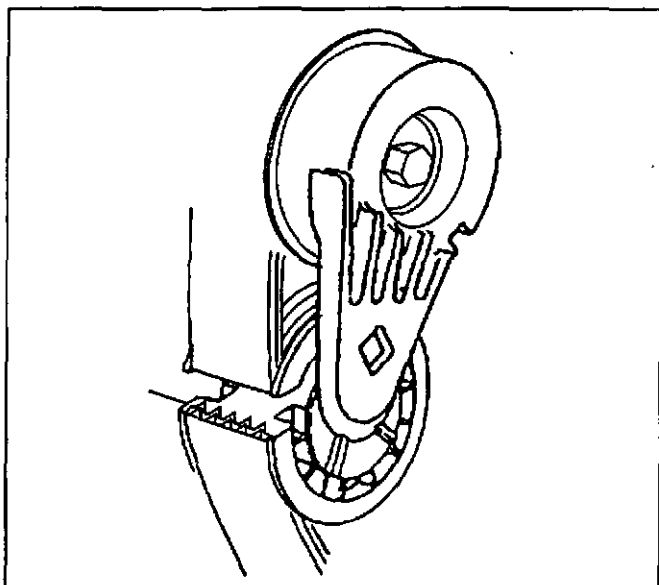
Step	Action	Value(s)	Yes	No
37	Realign or replace the power steering pump pulley. Refer to <i>Power Steering Pump Replacement (4.3L)</i> Does the drive belt continue to fall off?	—	Go to Step 38	System OK
38	Check for a damaged drive belt. Is the drive belt damaged?	—	Go to Step 39	Go to Step 40
39	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> Does the drive belt continue to fall off?	—	Go to Step 40	System OK
40	Check for a malfunctioning drive belt tensioner. Is the drive belt tensioner malfunctioning?	—	Go to Step 41	Go to Step 42
41	Replace the drive belt tensioner. Does the drive belt continue to fall off?	—	Go to Step 42	System OK
42	Check for worn idler or tensioner pulley bearings. Are the idler or tensioner pulley bearings worn?	—	Go to Step 43	—
43	Replace the worn bearings. Does the drive belt continue to fall off?	—	—	System OK

Drive Belt Diagnosis

Step	Action	Value(s)	Yes	No
44	Check to see if the ribs in the drive belt do not match the grooves in the pulley. Do the ribs in the drive belt match the grooves in the pulley?	—	—	Go to Step 45
45	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> Is there still excessive wear in either outside groove of the drive belt?	—	—	System OK

General Instructions

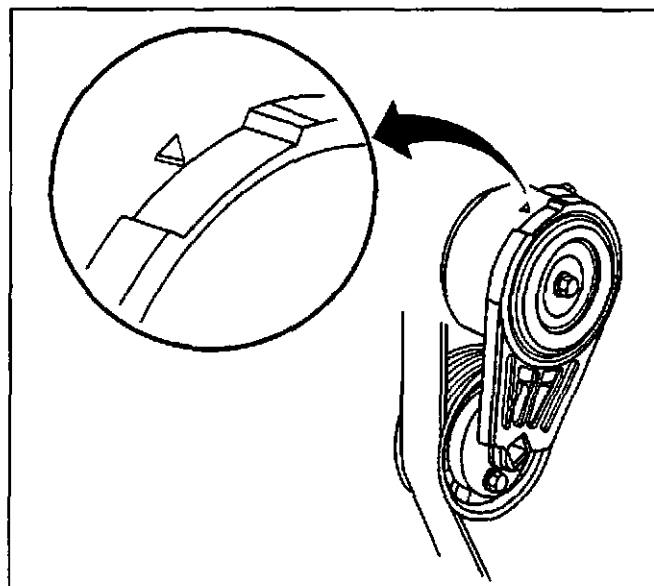
The following graphics illustrate the correct way to route the drive belt over the pulleys, and some examples of incorrect belt placement.



1. Observe the drive belt correctly installed on the

pulley.

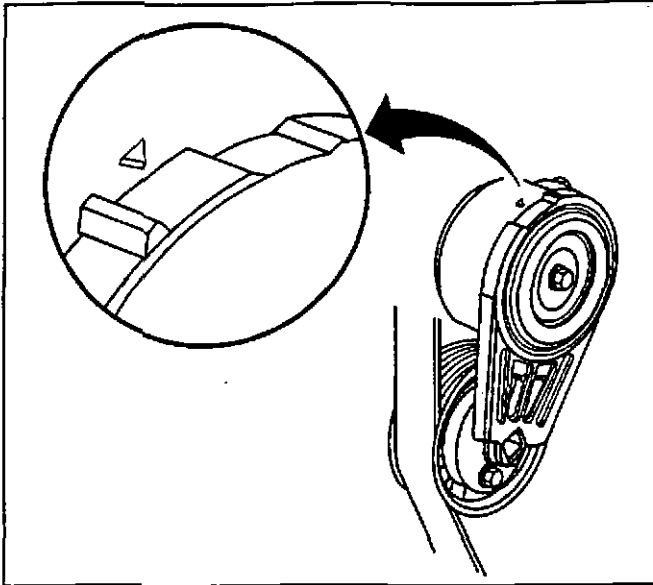
2. Each groove on the drive belt rests inside a matching groove in the pulley.



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

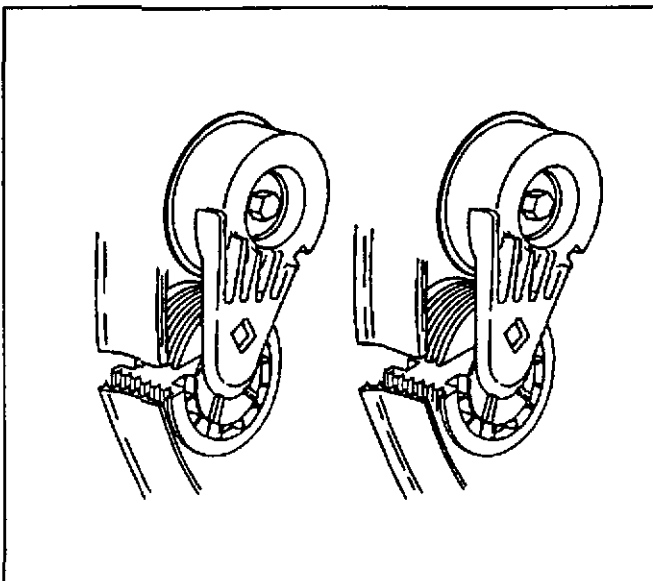
331327

4. A new drive belt should fall inside this range.



369211

5. When installing a used drive belt, observe the indicator on the tensioner.
6. A used drive belt should fall inside this range.



172993

7. Observe these incorrectly installed drive belts:
8. Avoid mis-positioning the belt by one or more grooves.

SIE-ID = 415142

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
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. • It usually occurs on cold damp mornings. • Verify the condition by spraying water on the belt. The noise should stop momentarily.			
1	Check for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step	Go to Step 3

Drive Belt Chirping Diagnosis (cont'd)

Step	Action	Yes	No
2	Replace any misaligned pulleys. Is the chirp still present?	Go to Step 3	System OK
3	Check for bent or cracked brackets. Are there any bent or cracked brackets?	Go to Step 4	Go to Step 5
4	Replace any bent or cracked brackets. Is the chirp still present?	Go to Step 5	System OK
5	Check for any loose or missing fasteners. Are there any loose or missing fasteners?	Go to Step 6	Go to Step 7
6	Tighten any loose fasteners. Replace any missing fasteners. Refer to <i>Fastener Tightening Specifications</i> . Is the chirp still present?	Go to Step 7	System OK
7	Check for a bent pulley flange. Is there a bent pulley flange?	Go to Step 8	Go to Step 9
8	Replace the pulley. Is the chirp still present?	Go to Step 9	System OK
9	Check for severe pilling, exceeding 1/3 of the belt groove depth. Is there severe pilling?	Go to Step 10	—
10	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> .	—	System OK

SIE-ID - 415145

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
DEFINITION: The following items are indications of 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.			
1	Check for a misaligned pulley. Is there a pulley misaligned?	Go to Step 3	Go to Step 2
2	Check for correct drive belt length. Refer to <i>Drive Belt Replacement</i> . Is the drive belt the correct length?	Go to Step 4	Go to Step 5
3	Repair or install new parts as necessary. Is the repair complete?	System OK	—
4	Check the drive belt tensioner for proper operation. Refer to <i>Drive Belt Tensioner Diagnosis</i> . Is the drive belt tensioner operating correctly?	Go to Step 3	Go to Step 5
5	Check for correct pulley size. Are the pulleys the correct size?	Go to Step 6	Go to Step 3
6	Check for seized bearings. Is there a seized bearing?	Go to Step 3	System OK

SIE-ID - 415155

Drive Belt Whine Diagnosis

Step	Action	Yes	No
DEFINITION: A high pitched continuous noise that may be caused by a failed bearing.			

Drive Belt Whine Diagnosis (cont'd)

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

SIE-ID = 415159

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No
DEFINITION: A low pitch tapping noise caused by drive belt misalignment. This noise occurs on cold start-up at idle. A low frequency noise heard once per revolution of the drive belt.			
1	Check for severe pilling. Is there severe pilling of more than 1/3 of the rib depth?	Go to Step 2	System OK
2	Clean the drive belt pulleys. Is the repair complete?	System OK	Go to Step 3
3	Install a new drive belt. Refer to <i>Drive Belt Replacement</i> . Is the repair complete?	System OK	—

SIE-ID = 415162

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
DEFINITION: The vibration is engine-speed related. The vibration may be sensitive to accessory load. Refer to <i>Engine Related Vibration</i> in <i>Vibration Diagnosis and Correction</i> .			
1	Check the drive belt for wear, damage, debris build-up and missing drive belt ribs. Is the drive belt worn or damaged?	Go to Step 2	Go to Step 3
2	Replace as necessary. Refer to <i>Drive Belt Replacement</i> . Is the repair complete?	System OK	Go to Step 3
3	Check for loose or missing fasteners. Are there loose or missing fasteners?	Go to Step 4	Go to Step 5
4	Re-tighten or replace as necessary. Is the repair complete?	System OK	—
5	Check for damaged fan blades or bent fan clutch shaft. Are there damaged fan blades or a bent fan clutch shaft?	Go to Step 6	Go to Step 7
6	Replace as necessary. Refer to <i>Fan Clutch Replacement</i> in <i>Engine Cooling</i> . Is the replacement complete?	System OK	—
7	Check for a bent water pump shaft. Is the water pump shaft bent?	Go to Step 8	Go to Step 9
8	Replace as necessary. Refer to <i>Water Pump Replacement (4.3L)</i> in <i>Engine Cooling</i> . Is the repair complete?	System OK	—
9	Check for bent or cracked brackets. Are there bent or cracked brackets?	Go to Step 10	System OK

Drive Belt Vibration Diagnosis (cont'd)

Step	Action	Yes	No
10	Replace the brackets as necessary. Is the repair complete?	System OK	—

SIE-ID = 415165

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
DEFINITION: The following items can cause the drive belt to fall off.			
1	Check for misaligned or bent pulley. Are the pulleys misaligned?	Go to Step 2	Go to Step 3
2	Replace the misaligned or bent pulleys. Does the drive belt continue to fall off?	Go to Step 3	System OK
3	Check for a bent or a cracked bracket. Are any of the brackets bent or cracked?	Go to Step 4	Go to Step 5
4	Replace the damaged brackets. Does the drive belt continue to fall off?	Go to Step 5	System OK
5	Check for loose or missing fasteners. Are there any loose or missing fasteners?	Go to Step 6	Go to Step 7
6	Replace any missing fasteners and tighten to specifications. Refer to <i>Fastener Tightening Specifications</i> . Does the drive belt continue to fall off?	Go to Step 7	System OK
7	Check for a misaligned power steering pump pulley. Is the power steering pump pulley misaligned?	Go to Step 8	Go to Step 9
8	Realign or replace the power steering pump pulley. Refer to <i>Power Steering Pump Replacement (4.3L)</i> in Power Steering Systems. Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Check for a damaged drive belt. Is the drive belt damaged?	Go to Step 10	Go to Step 11
10	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Check for drive belt tensioner for operating correctly. Refer to <i>Drive Belt Tensioner Diagnosis</i> . Is the drive belt tensioner operating correctly?	Go to Step 12	Go to Step 13
12	Replace the drive belt tensioner. Refer to <i>Drive Belt Tensioner Replacement</i> . Does the drive belt continue to fall off?	Go to Step 13	System OK
13	Check for worn drive belt idler and drive belt tensioner pulley bearings. Are the drive belt idler or the drive belt tensioner pulley bearings worn?	Go to Step 14	—
14	Replace the worn bearings. Does the drive belt continue to fall off?	—	System OK

SIE-ID = 415166

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
DEFINITION: Wear at the outside ribs of the drive belt due to a incorrectly installed drive belt.			

Drive Belt Excessive Wear Diagnosis (cont'd)

Step	Action	Yes	No
1	Check to see if the ribs in the drive belt do not match the grooves in the pulley. Do the ribs in the drive belt match the grooves in the pulley?	—	Go to Step 2
2	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Is there still excessive wear in either outside groove of the drive belt?	—	System OK

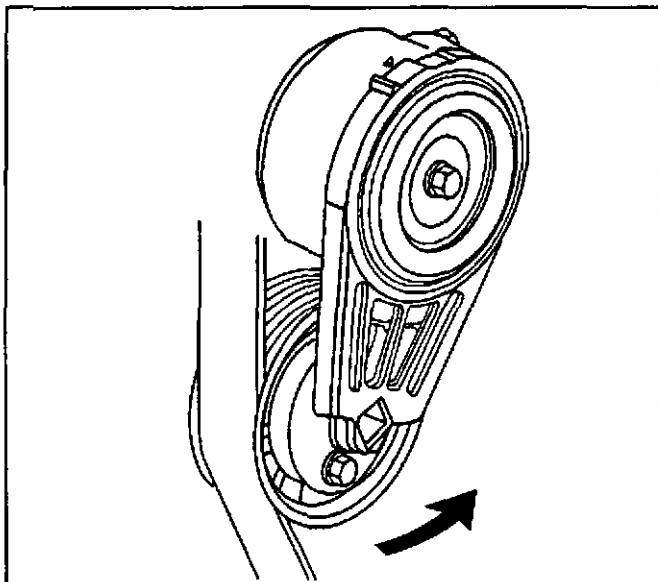
SIE-ID - 329668

Drive Belt Tensioner Diagnosis

Inspection Procedure

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.



374176

Notice: SIO-ID - 3753 Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Position a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise.
3. Move the drive belt tensioner through its full travel.
 - The movement should feel smooth
 - There should be no binding
 - The tensioner should return freely
4. If any binding is observed, replace the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.
5. Install the drive belt. Refer to *Drive Belt Replacement*.

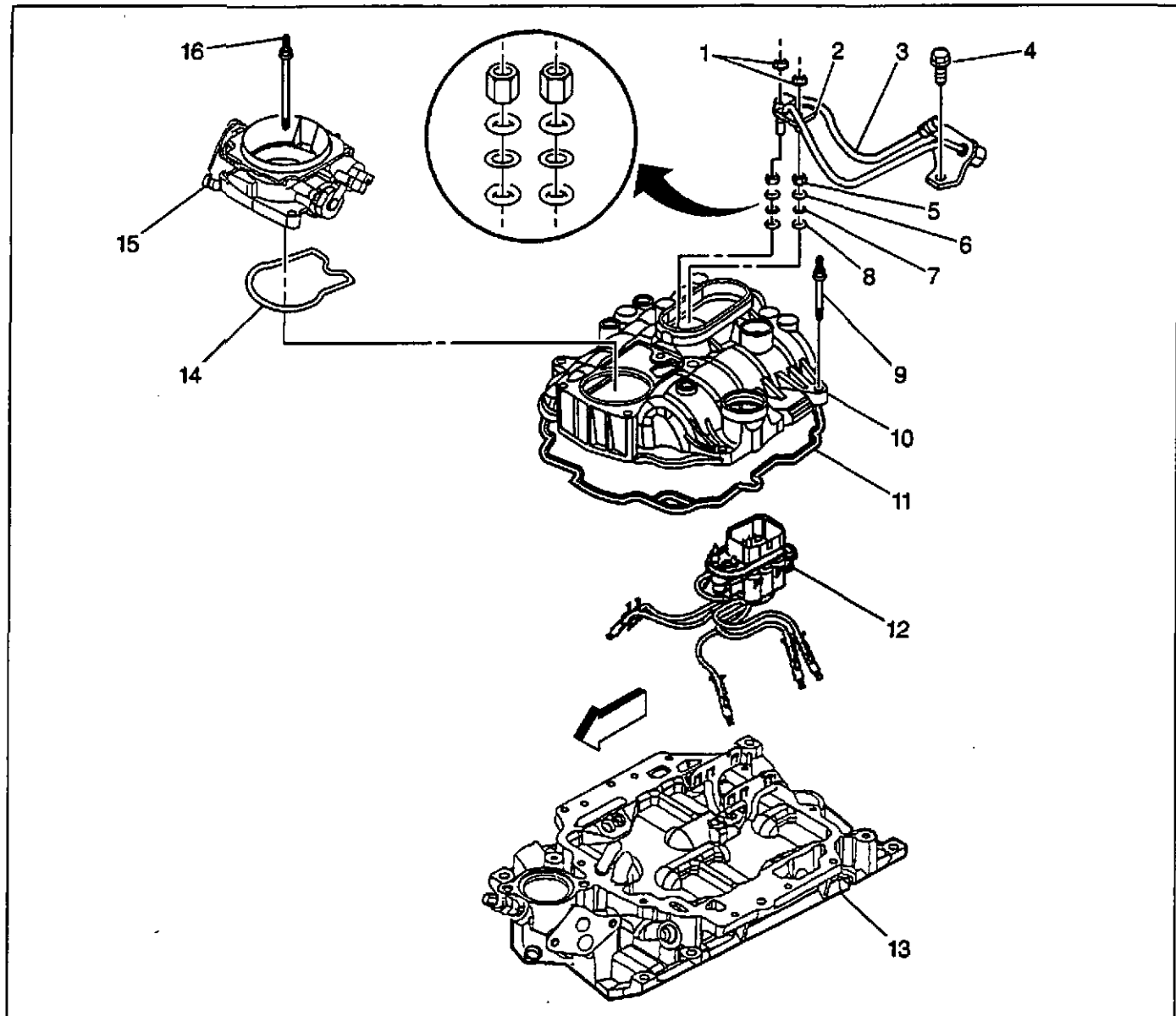
Visual Identification

SIE-ID = 356632

Disassembled Views

SIO-ID = 356346

Upper and Lower Intake Manifold View



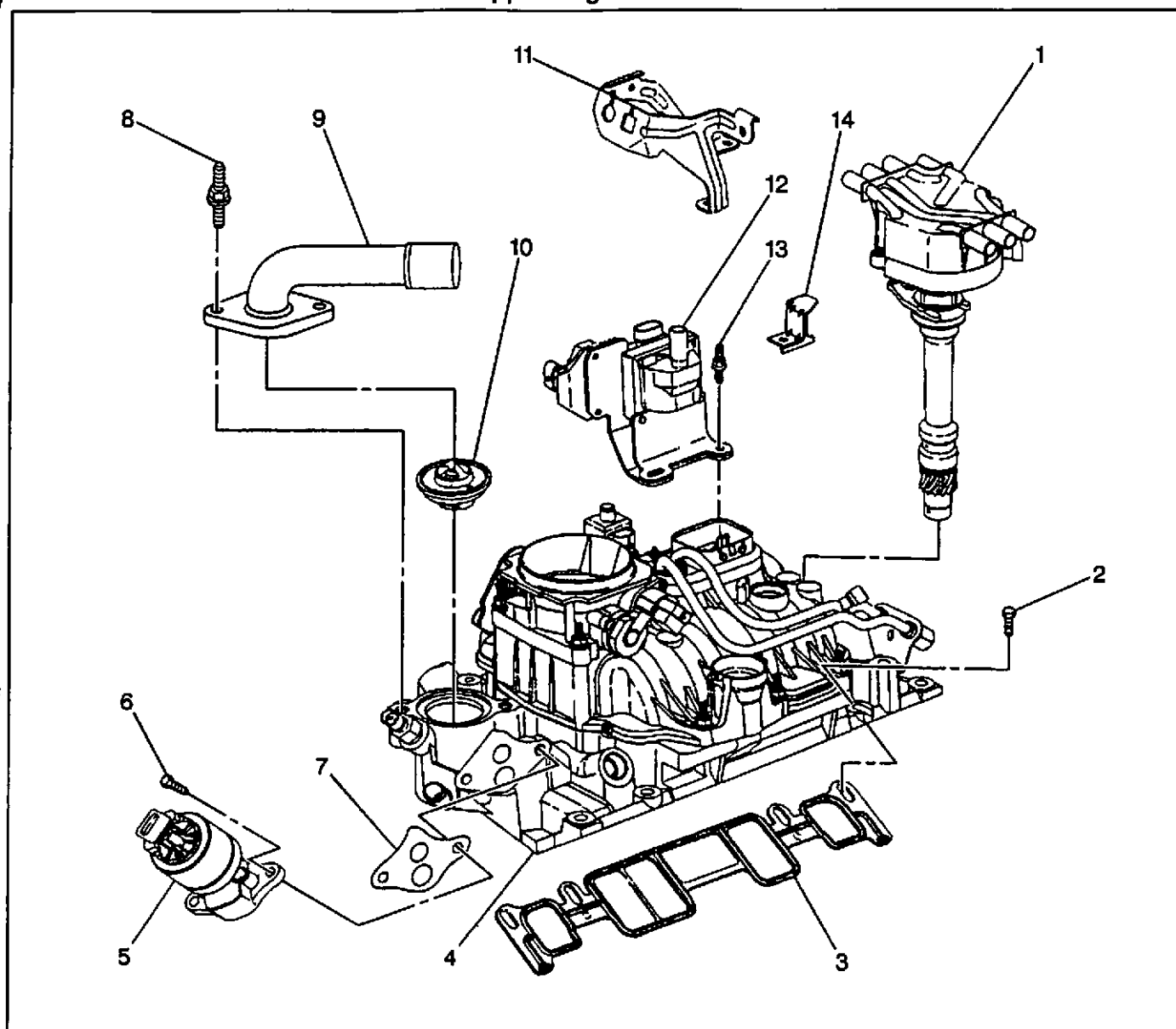
334238

Legend

(1) Fuel Pipe Retainer Bracket Nuts	(12) TBI Fuel Meter
(2) Fuel Pipe Retainer	(13) Intake Manifold
(3) Fuel Pipe	(14) Throttle Body to Upper Intake Manifold Gasket
(4) Fuel Pipe Bolt	(15) Throttle Body
(5) Fuel Seal Retainer	(16) Throttle Body Attaching Stud
(6) Upper Fuel Seal (Yellow O-ring)	
(7) Spacer Ring (Metal Flat Washer)	
(8) Lower Fuel Seal (Black O-ring)	
(9) Upper Manifold Attaching Stud	
(10) Upper Intake Manifold	
(11) Upper Intake to Lower Intake Manifold Gasket	

S10-ID - 358357

Upper Engine View 1



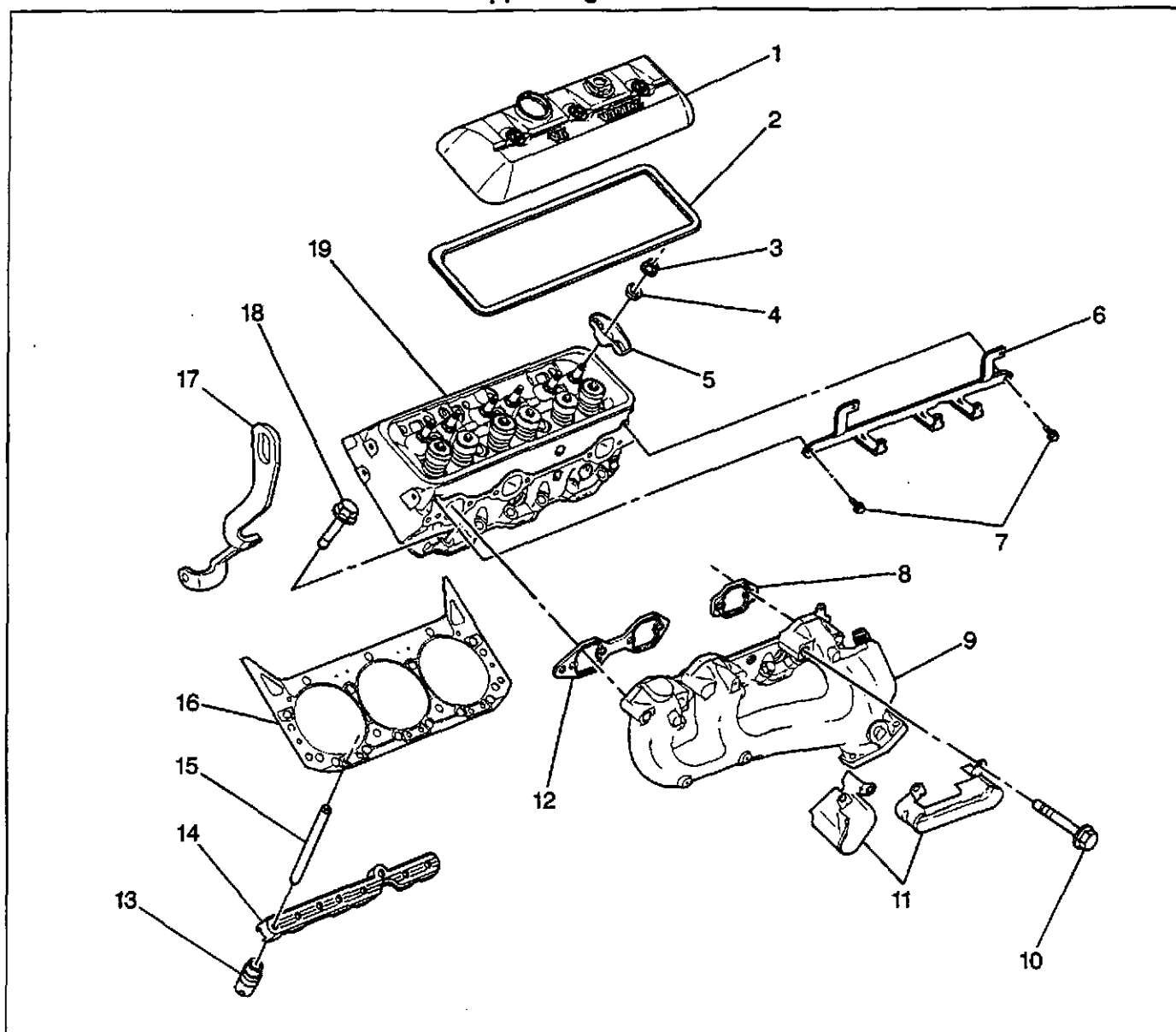
334252

Legend

- (1) Distributor
- (2) Intake Manifold Bolt (Lower)
- (3) Intake Manifold Gasket (Lower)
- (4) Intake Manifold Assembly
- (5) EGR Valve
- (6) EGR Valve Bolt
- (7) EGR Valve Gasket
- (8) Water Outlet Stud
- (9) Water Outlet
- (10) Engine Coolant Thermostat
- (11) Accelerator Control Cable Bracket
- (12) Ignition Coil
- (13) Ignition Coil Stud
- (14) EVAP Purge Solenoid Valve Bracket

SIO-ID - 356359

Upper Engine View 2



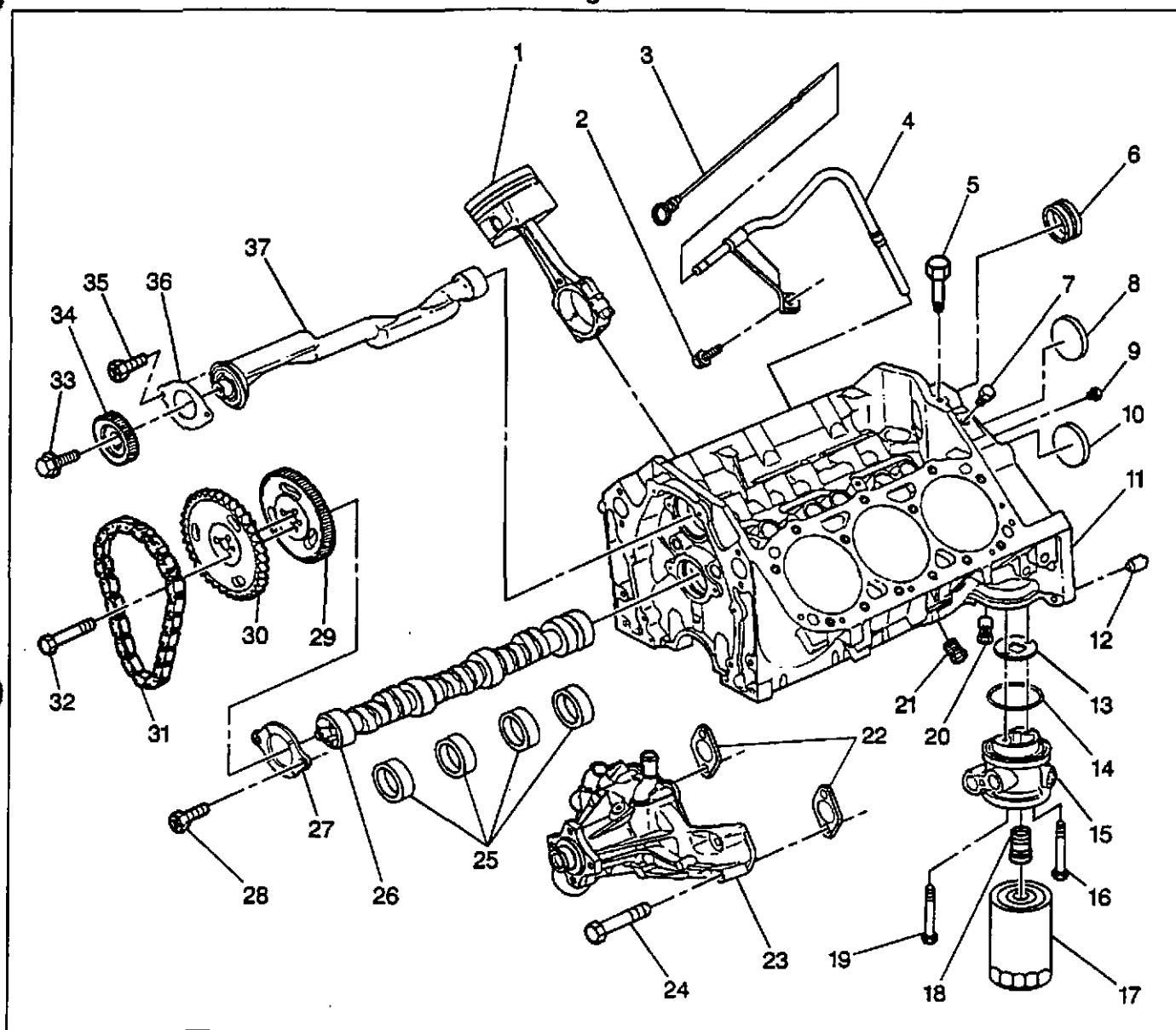
328524

Legend

(1) Valve Rocker Arm Cover	(16) Cylinder Head Gasket
(2) Valve Rocker Arm Cover Gasket	(17) Engine Lift Front Bracket
(3) Valve Rocker Arm Nut	(18) Cylinder Head Bolt
(4) Valve Rocker Arm Ball	(19) Cylinder Head
(5) Valve Rocker Arm	
(6) Spark Plug Wire Support	
(7) Spark Plug Wire Support Bolt	
(8) Exhaust Manifold Gasket	
(9) Exhaust Manifold	
(10) Exhaust Manifold Bolt	
(11) Spark Plug Wire Shields	
(12) Exhaust Manifold Gasket	
(13) Valve Lifter	
(14) Valve Lifter Pushrod Guide	
(15) Valve Pushrod	

SIO-ID - 356362

Lower Engine View 1



328520

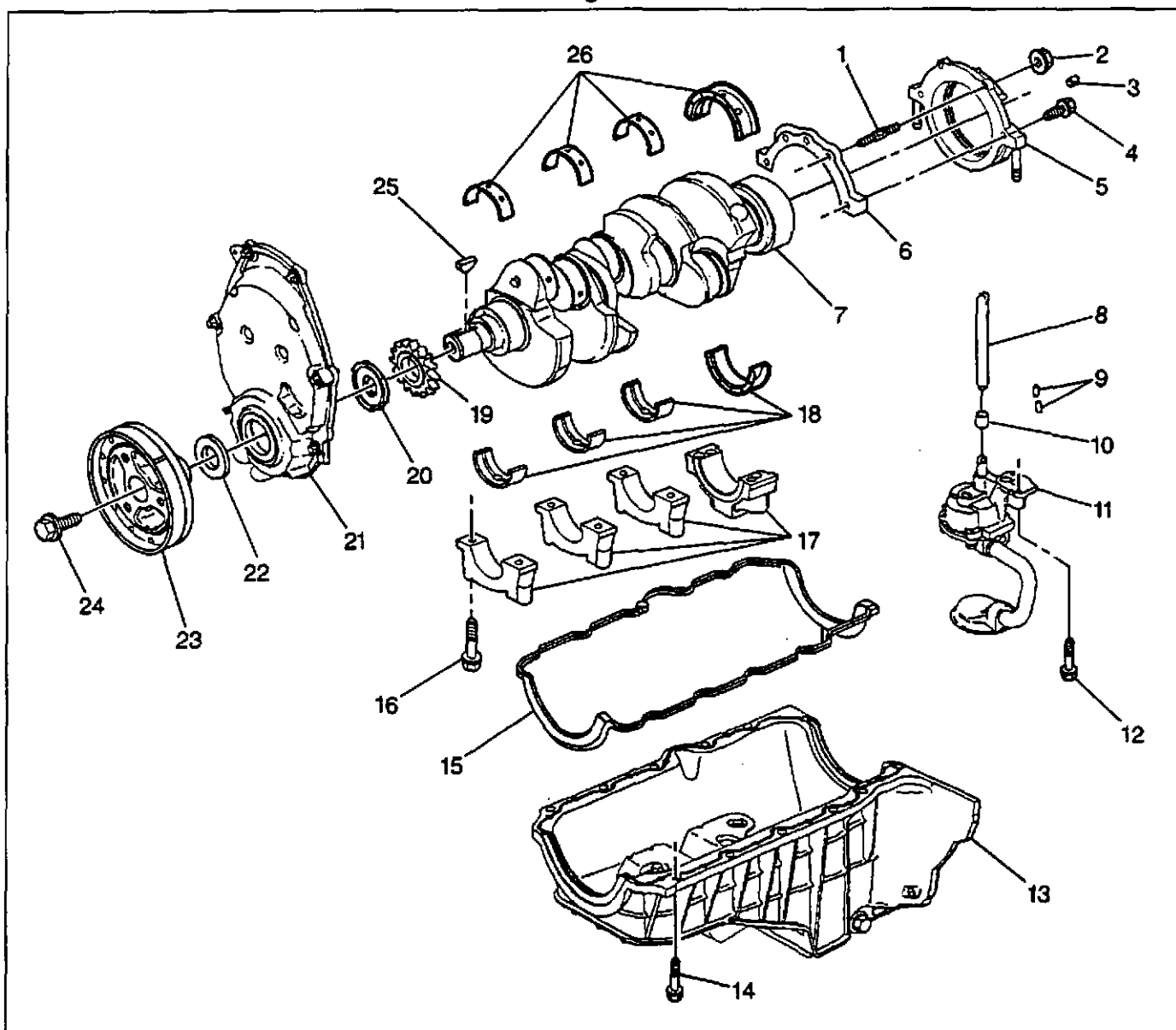
Legend

(1) Piston Assembly	(14) Oil Filter Adapter Seal (O-ring)
(2) Oil Level Indicator Tube Bolt	(15) Oil Filter Adapter (Typical)
(3) Oil Level Indicator	(16) Oil Filter Adapter Bolt
(4) Oil Level Indicator Tube	(17) Oil Filter
(5) Engine Oil Pressure Sensor Fitting	(18) Oil Filter Fitting
(6) Balance Shaft Bearing (Rear)	(19) Oil Filter Adapter Bolt
(7) Engine Block Oil Gallery Plug	(20) Oil Filter Bypass Valve
(8) Expansion Cup Plug (Balance Shaft Rear Bearing Hole)	(21) Engine Coolant Drain Hole Plug
(9) Engine Block Rear Oil Gallery Plug	(22) Water Pump Gasket
(10) Expansion Cup Plug (Camshaft Rear Bearing Hole)	(23) Water Pump
(11) Engine Block	(24) Water Pump Bolt
(12) Dowel Straight Pin (Transmission Locator)	(25) Camshaft Bearings
(13) Oil Filter Adapter Gasket	(26) Engine Camshaft
	(27) Camshaft Retainer

- (28) Camshaft Retainer Bolt
- (29) Balance Shaft Drive Gear
- (30) Camshaft Sprocket
- (31) Camshaft Timing Chain
- (32) Camshaft Sprocket Bolt
- (33) Balance Shaft Gear Bolt
- (34) Balance Shaft Driven Gear
- (35) Balance Shaft Retainer Bolt
- (36) Balance Shaft Retainer
- (37) Balance Shaft

SIO-ID - 356451

Lower Engine View 2

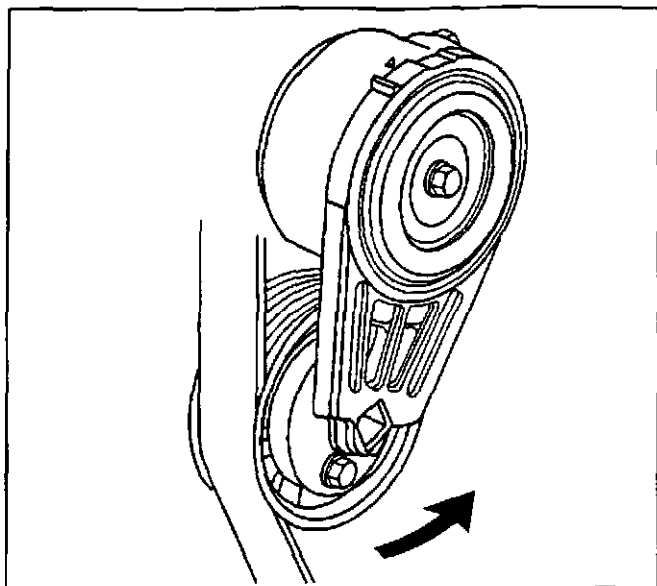


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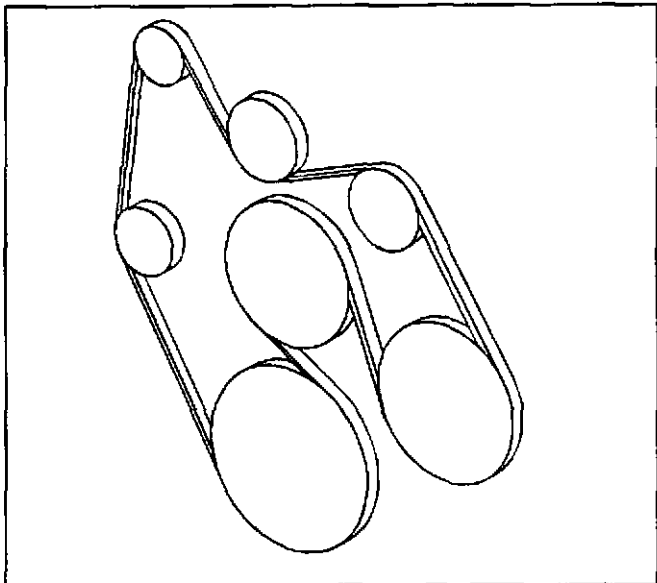
Legend

(1) Crankshaft Rear Oil Seal Housing Retainer Stud	(5) Crankshaft Rear Oil Seal Housing
(2) Crankshaft Rear Oil Seal Housing Nut	(6) Crankshaft Rear Oil Seal Housing Gasket
(3) Flywheel Locator Pin	(7) Crankshaft
(4) Crankshaft Rear Oil Seal Housing Bolt	(8) Oil Pump Drive Shaft

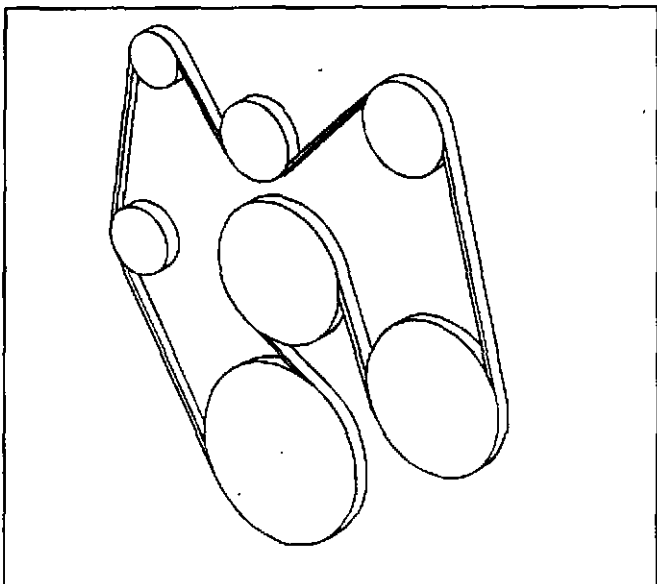
- (9) Oil Pump Locator Pin
 - (10) Oil Pump Drive Shaft Retainer
 - (11) Oil Pump
 - (12) Oil Pump Bolt
 - (13) Oil Pan
 - (14) Oil Pan Bolt
 - (15) Oil Pan Gasket
 - (16) Crankshaft Bearing Cap Bolt
 - (17) Crankshaft Bearing Cap
 - (18) Crankshaft Bearings (Lower)
 - (19) Crankshaft Sprocket
 - (20) Crankshaft Position Sensor Reluctor Ring
 - (21) Engine Front Cover
 - (22) Crankshaft Front Oil Seal
 - (23) Crankshaft Balancer
 - (24) Crankshaft Balancer Bolt
 - (25) Crankshaft Balancer Key
 - (26) Crankshaft Bearings (Upper)
-



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Repair Instructions

SIE-ID - 329690

Drive Belt Replacement

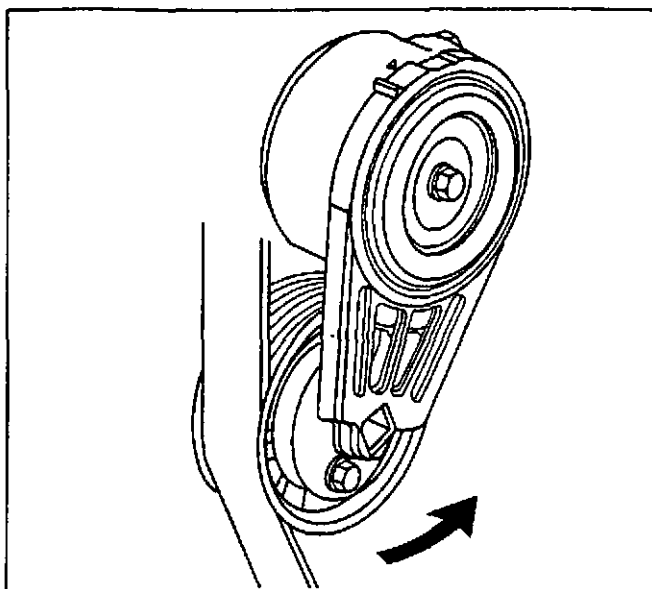
Removal Procedure

1. Install a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise.
2. Remove the drive belt.
3. Slowly release the tension on the drive belt tensioner arm.

Installation Procedure

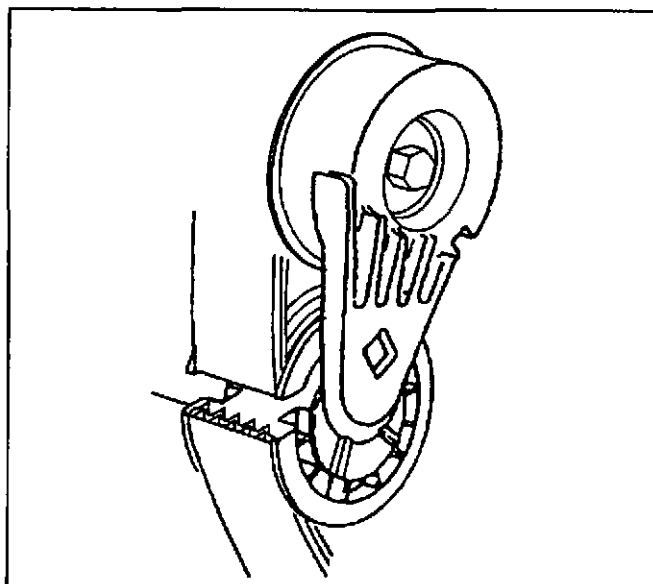
1. Route the drive belt over all the pulleys except the drive belt tensioner arm.
2. Observe the drive belt routing for the vehicles without air conditioning.
3. Observe the drive belt routing for the vehicles with air conditioning.

4. Install a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise.
5. Install the drive belt over the drive belt tensioner pulley.
6. Slowly release the tension on the drive belt tensioner arm.



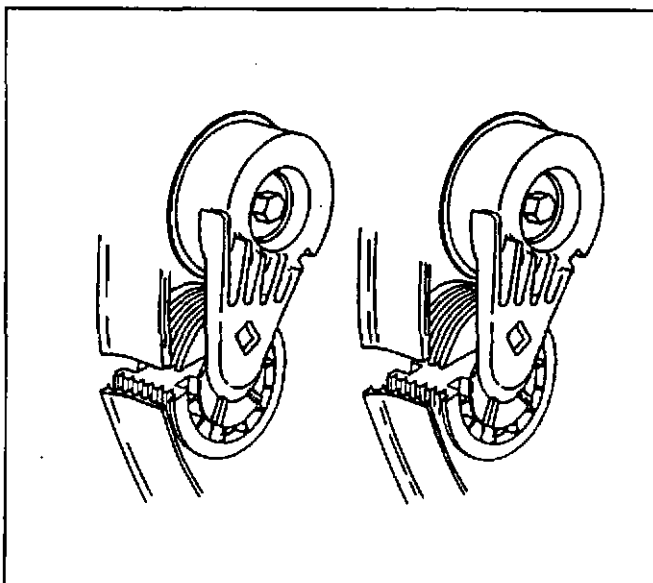
374176

7. Inspect for the drive belt being properly installed on the pulleys.

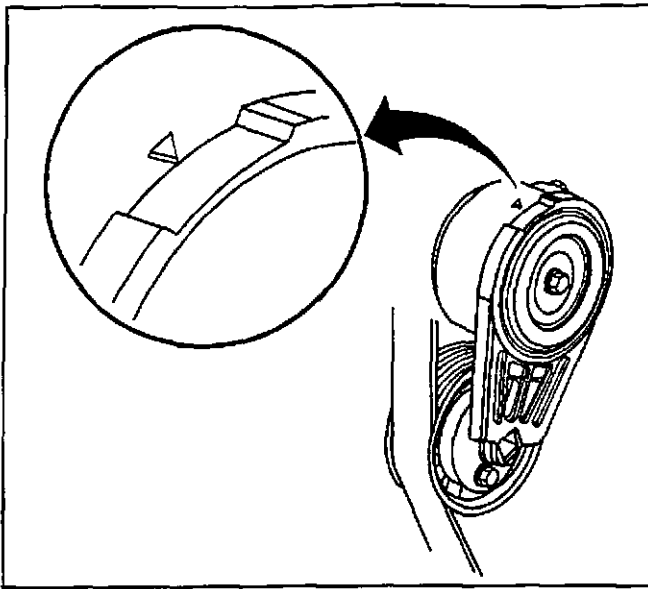


172992

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

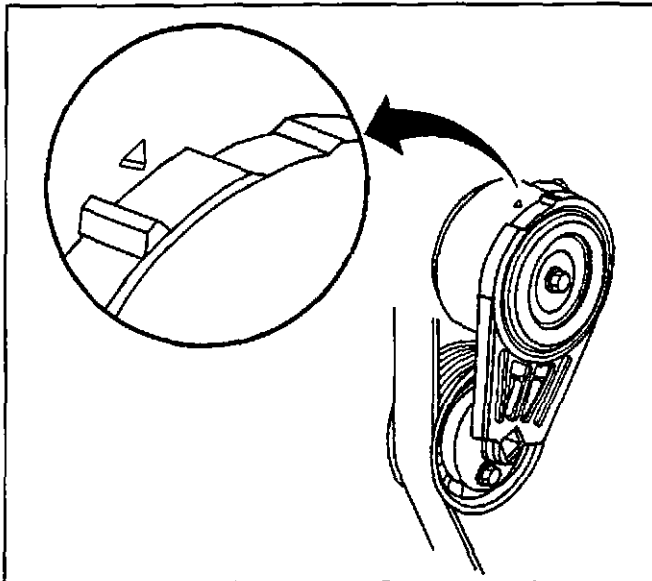


172993



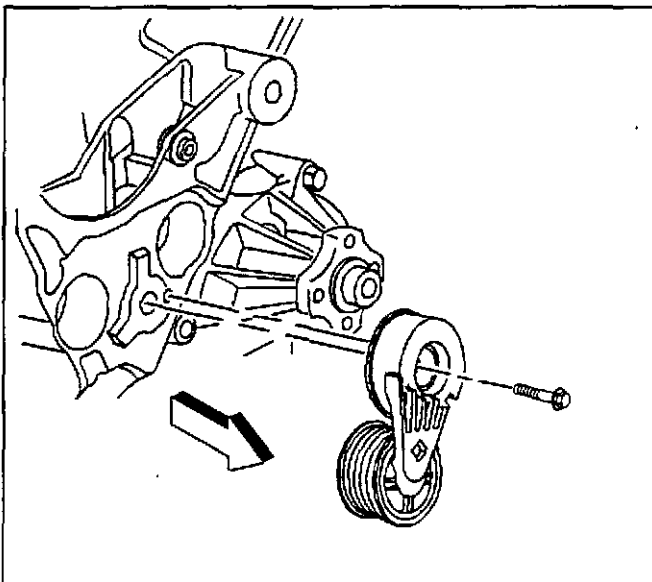
331327

9. Confirm for the proper drive belt size and the correct drive belt routing by observing the location of the fix pointer and the index marks on the drive belt tensioner. With a new drive belt installed the fix pointer should align within the indentation on the drive belt tensioner.



369211

10. With a used drive belt installed the fix pointer should not align past the index mark.



43854

SIE-ID - 329694

Drive Belt Tensioner Replacement

Removal Procedure

1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Remove the bolt.
3. Remove the drive belt tensioner.

Installation Procedure

1. Install the drive belt tensioner assembly.

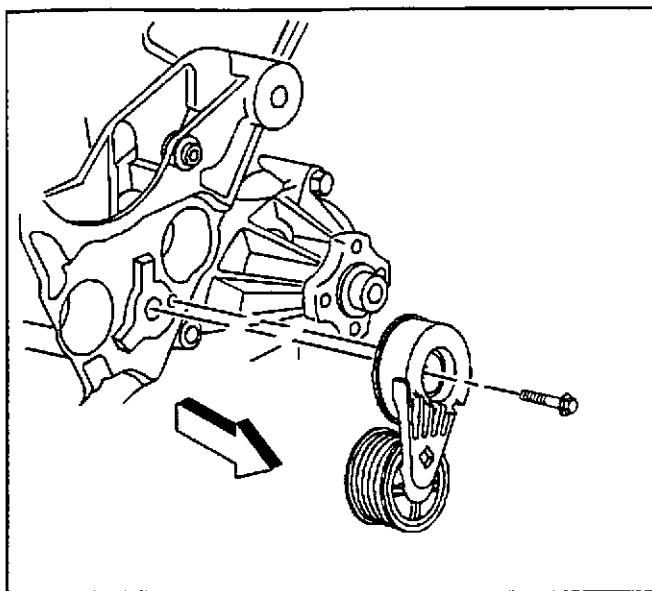
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the attaching bolt.

Tighten

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

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

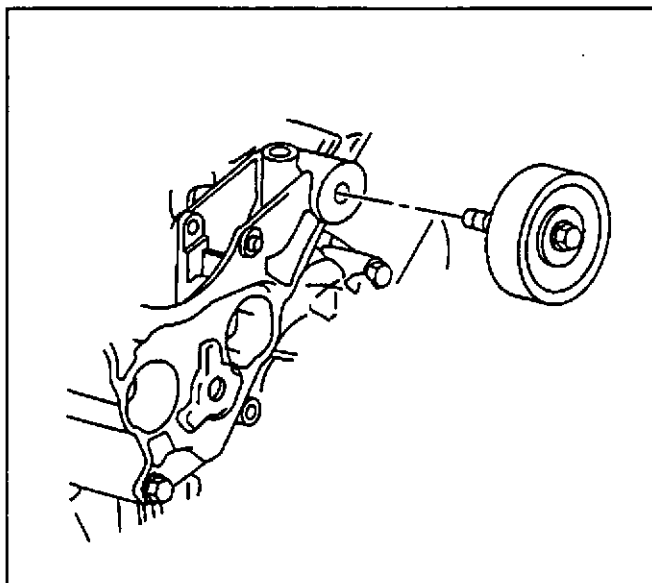


43854

SIE-ID = 329696

Drive Belt Idler Pulley Replacement (Right side)**Removal Procedure**

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



310229

Installation Procedure

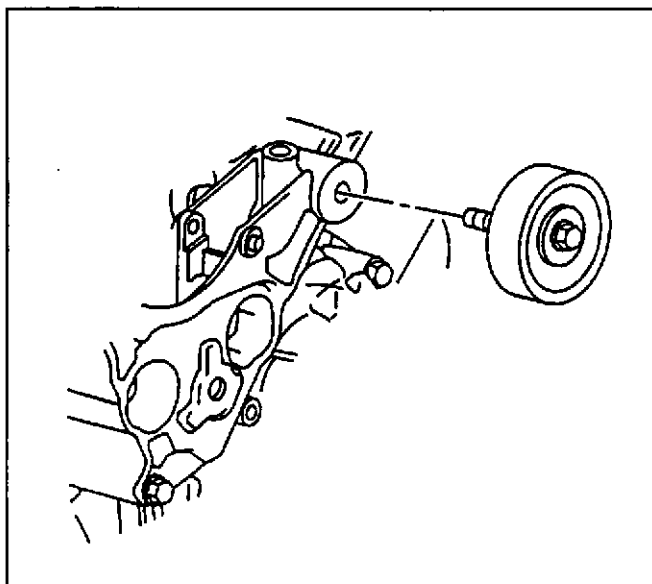
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the drive belt idler pulley and bolt to the generator mounting bracket.

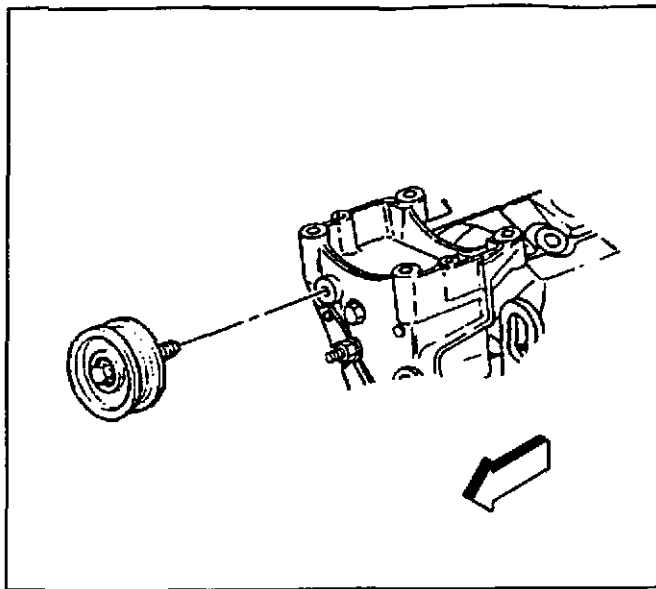
Tighten

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

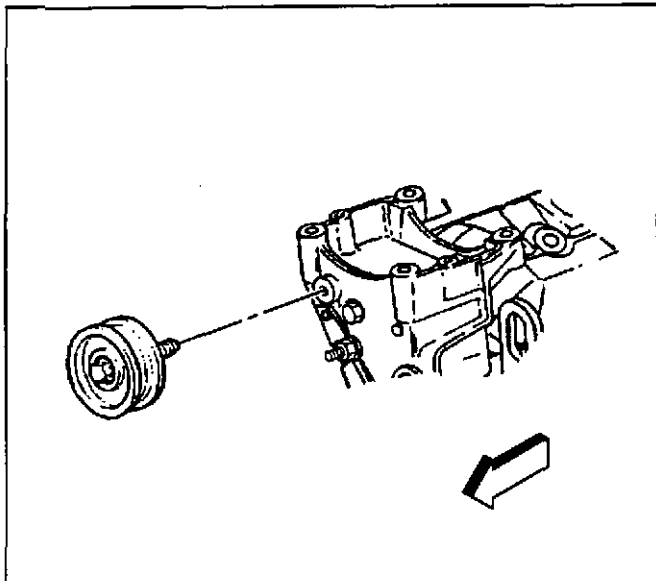
2. Install the drive belt. Refer to *Drive Belt Replacement*.



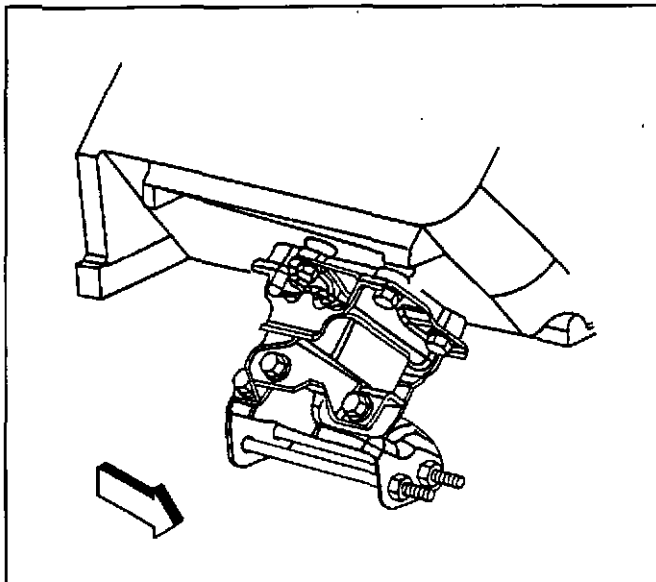
310229



338506



338506



315378

SIE-ID - 357857

Drive Belt Idler Pulley Replacement (Without A/C)

Removal Procedure

1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Remove the belt idler pulley bolt.
3. Remove the belt idler pulley from the power steering pump mounting bracket.

Installation Procedure

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

1. Install the belt idler pulley and the bolt to the power steering pump mounting bracket.

Tighten

Tighten the bolt to 50 N.m 37 lb ft).

2. Install the drive belt. Refer to *Drive Belt Replacement*.

SIE-ID - 329698

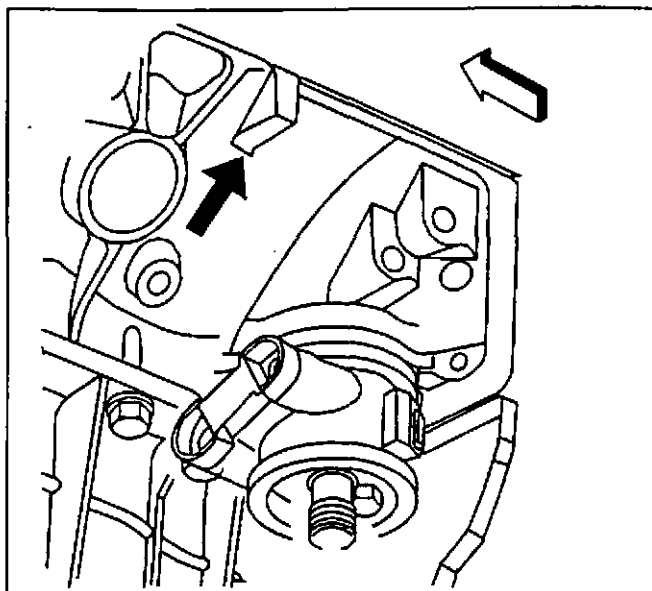
Engine Mount Inspection

Notice: Refer to *Engine Mounts Notice* in Cautions and Notices.

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Inspect for loose or missing bolts at the following locations:
 - Engine mount bracket to engine
 - Engine mount frame bracket to frame
 - Engine mount to engine mount bracket
 - Engine mount to engine mount frame bracket
3. Replace missing or loose bolts. Refer to *Engine Mount Replacement*.

Notice: Refer to *Raising Engine Notice* in Cautions and Notices.

4. Using a jack on the square tab at the rear of the engine block (left side shown the right side requires removal of the starter) raise the engine in order to complete the following tasks:
 - Remove weight from the engine mount.
 - Place a slight tension on the rubber cushion.
 - Observe the engine mount while raising the engine.
5. Replace the engine mount if the following conditions exist:
 - Heat check cracks cover the hard rubber surface.
 - The rubber cushion is separated from the metal plate of the engine mount.
 - There is a split through the rubber cushion.



374320

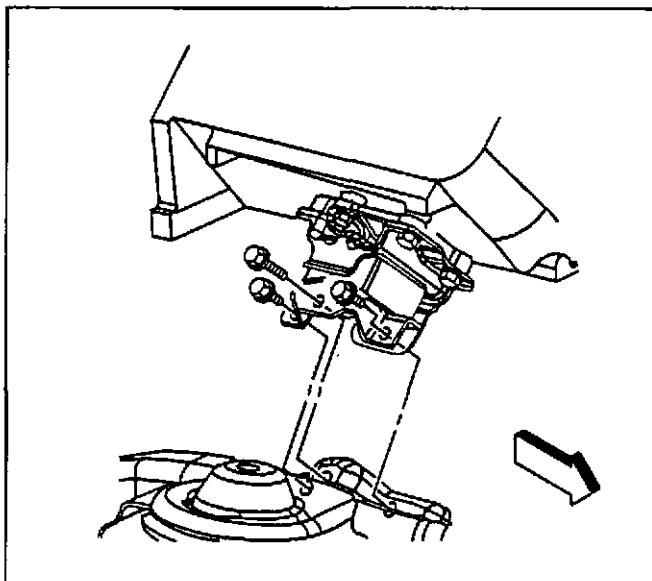
SIE-ID - 329708

Engine Mount Replacement

Removal Procedure

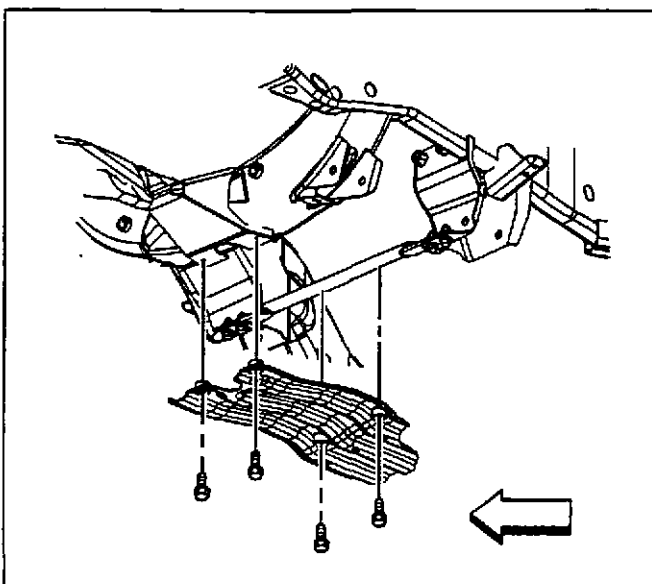
Notice: Refer to *Engine Mounts Notice* in Cautions and Notices.

1. From under the hood, remove the three bolts holding the engine mount to the engine mount frame bracket.

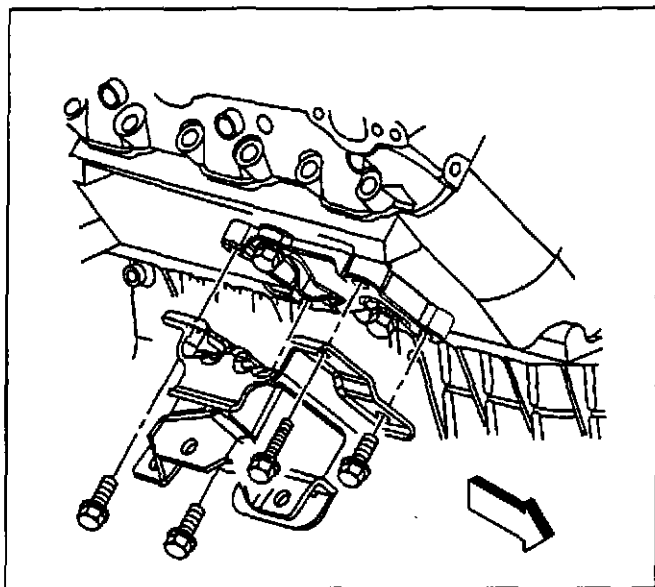


310259

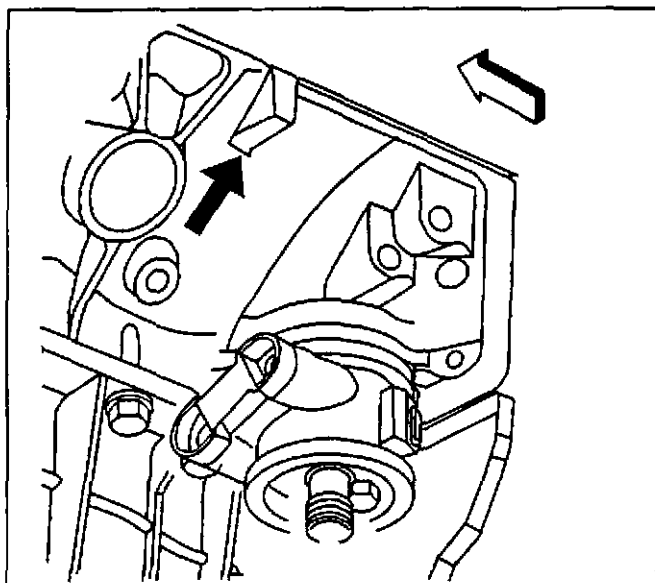
2. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the oil pan skid plate.



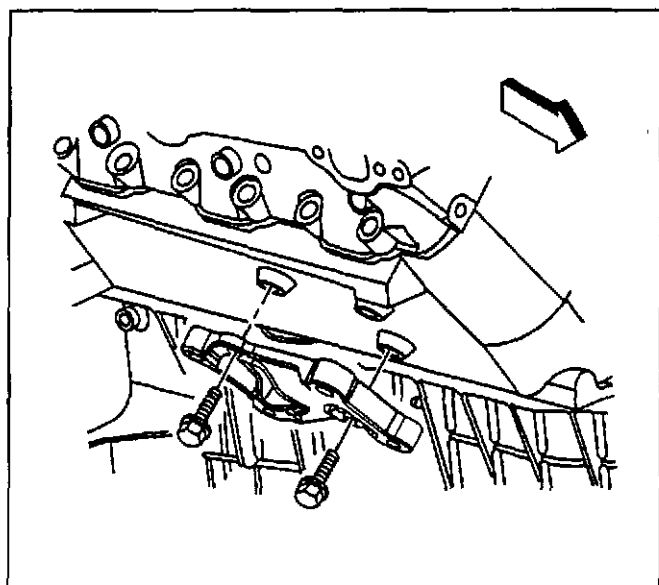
309158



310267



374320



310262

Notice: *SIO-ID - 221323* 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.

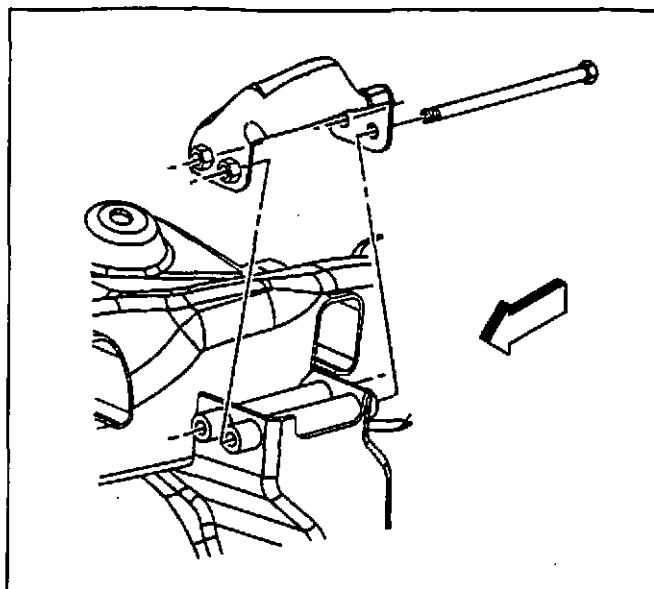
4. Remove the bolts holding the engine mount to the engine mount bracket and the engine.

5. Using a jack on the square tab (left side shown) at the rear of the engine block, raise the engine. In order to access the square tab on the right side remove the starter. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.

6. Remove the engine mount.

7. Remove the engine mount bracket to the engine, if necessary.

8. In order to replace the engine mount frame bracket, remove the two through-bolts.
9. Remove the engine mount frame bracket.



310271

Installation Procedure

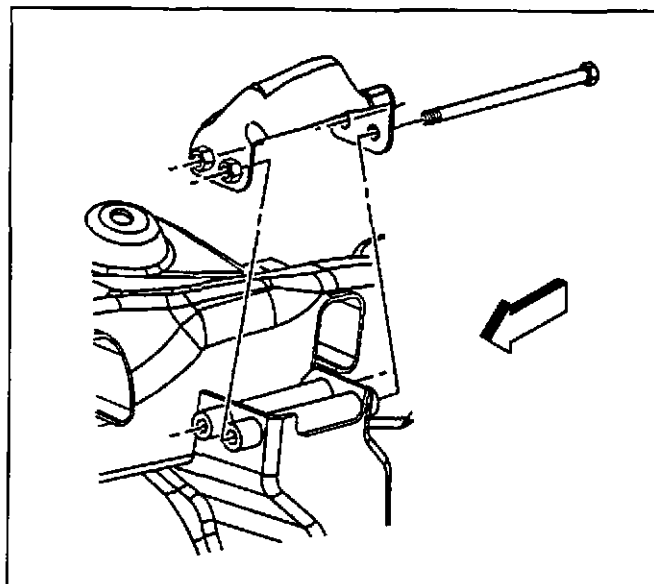
1. Position the engine mount frame bracket on the frame.

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

2. Install the two through-bolts.

Tighten

Tighten the through-bolts to 60 N·m (44 lb ft).

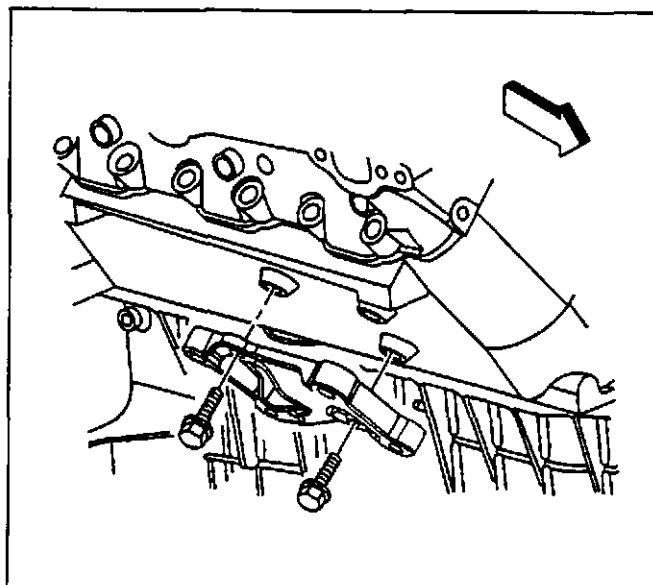


310271

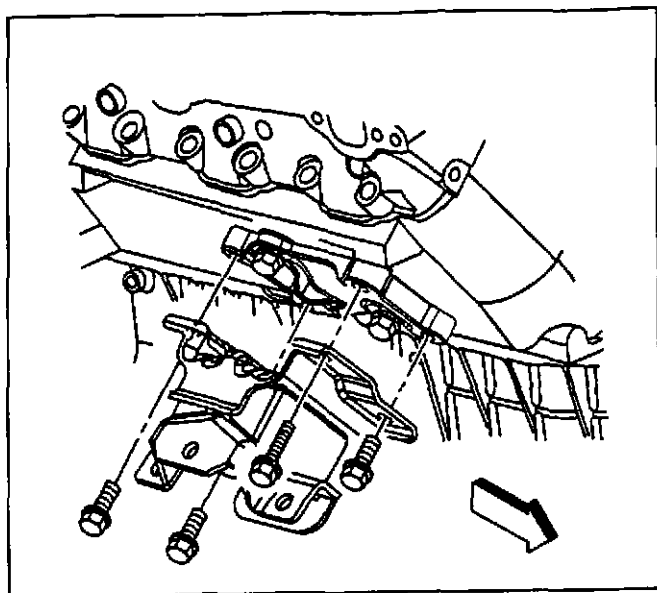
3. Install the engine mount bracket to the engine, if removed.
4. Install the bolts holding the engine mount bracket to the engine.

Tighten

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



310262



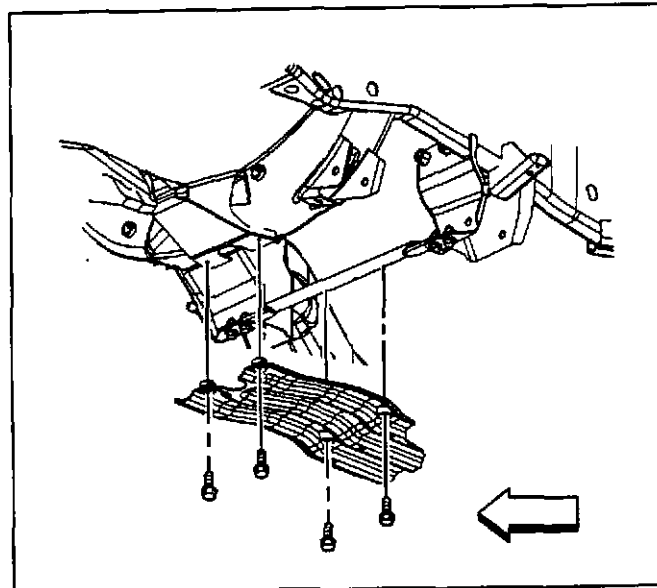
310267

5. Install the engine mount.
6. Install the long bolt holding the engine mount and the engine mount bracket to the engine.
7. Install the three bolts holding the engine mount to the engine mount bracket.

Tighten

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

8. Lower the engine.



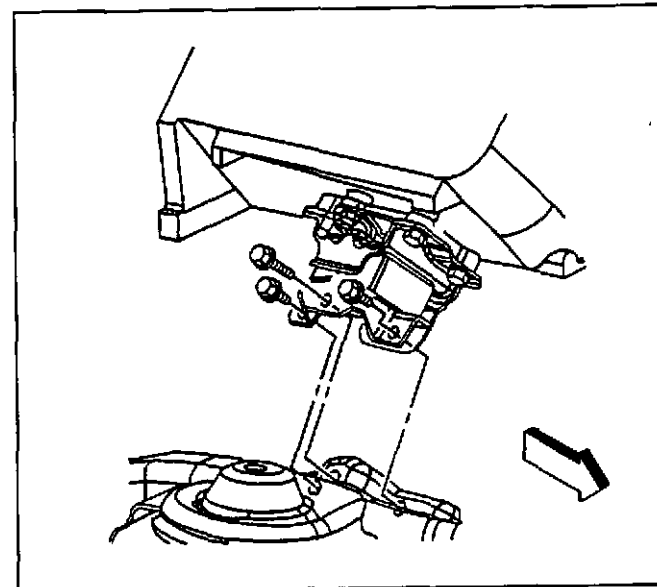
309158

9. Install the oil pan skid plate.

Tighten

Tighten the bolts to 20 N.m (15 lb ft).

10. Lower the vehicle.



310259

11. Install the three bolts holding the engine mount to the engine mount frame bracket.

Tighten

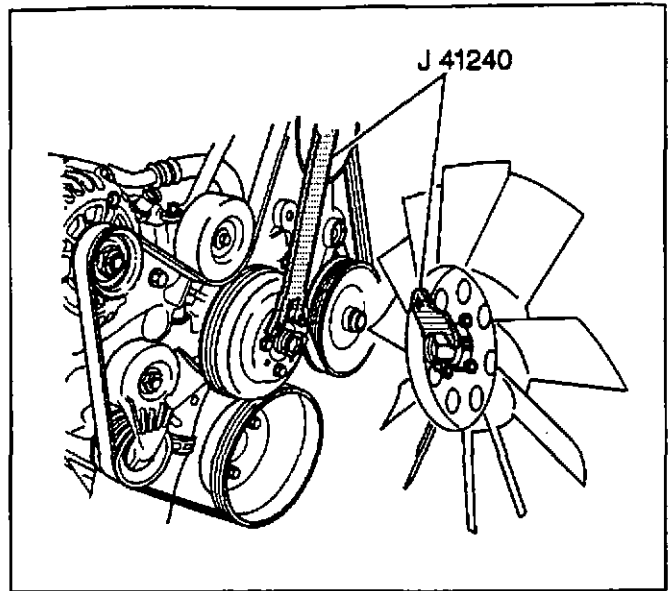
Tighten the engine mount to engine mount frame bracket bolts to 50 N.m (37 lb ft).

SIE-ID - 357862

Accessory Mounting Brackets Replacement (P/S Pump Mounting Bracket)

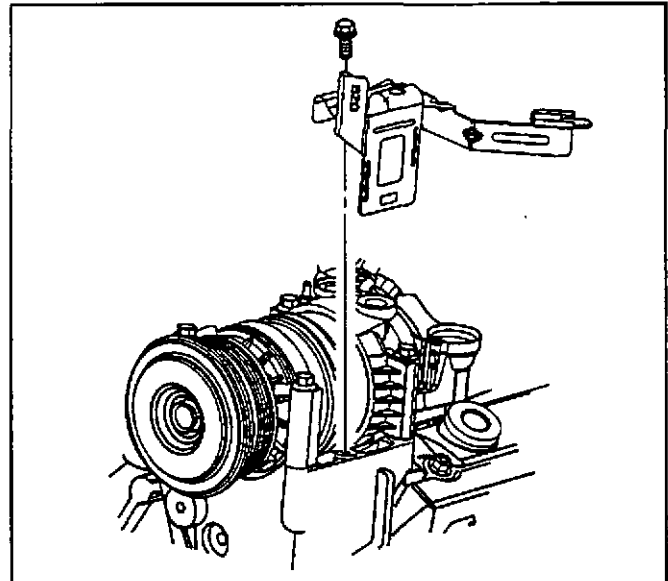
Removal Procedure

1. Remove the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.
2. Remove the drive belt. Refer to *Drive Belt Replacement*.



42910

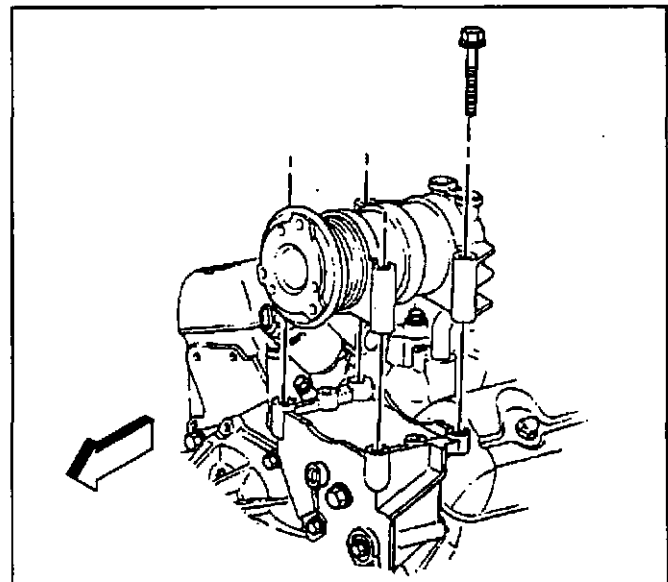
3. Remove the bolt holding the positive battery cable junction block bracket to the power steering pump mounting bracket.
4. Move the bracket with the wiring harness and the junction block aside.



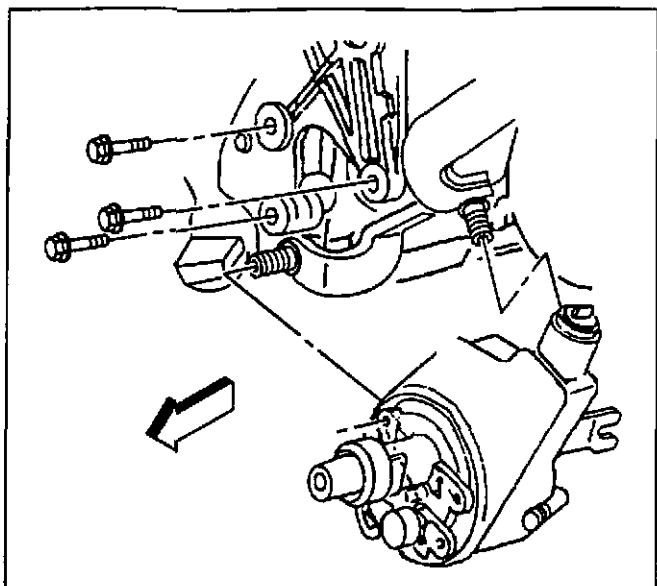
394403

Important: Do not evacuate the air conditioning system.

5. Remove the mounting bolts for the air conditioning (A/C) compressor, if equipped.
6. Move the A/C compressor aside and support.
7. Remove the drive belt idler pulley if not equipped with A/C. Refer to *Drive Belt Idler Pulley Replacement (Without A/C)*.
8. Remove the power steering pump pulley. Refer to *Power Steering Pump Replacement (4.3L)* in Power Steering Systems.

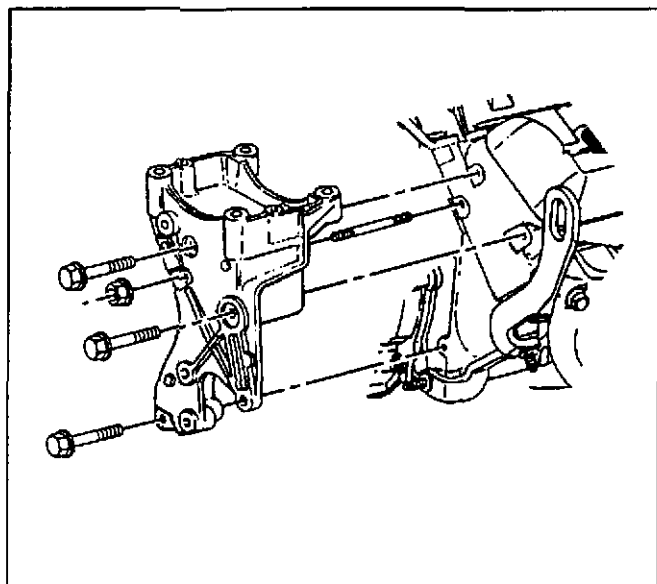


281151



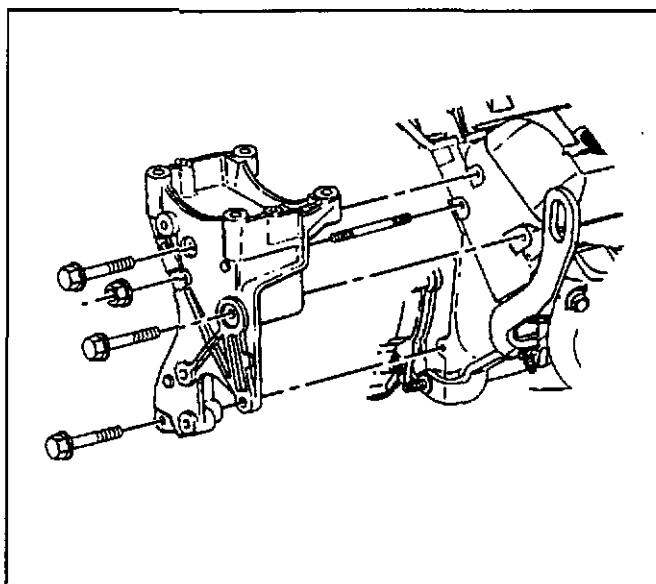
288829

9. Remove the three bolts holding the power steering pump to the power steering pump mounting bracket. The power steering pump can remain on the engine.



188295

10. Remove the three bolts and nut holding the power steering pump mounting bracket to the engine.
11. Slide the power steering pump mounting bracket off the stud and the power steering pump.



188295

Installation Procedure

1. Slide the power steering pump mounting bracket on the stud and the power steering pump.

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

2. Install the three bolts and the nut.

Tighten

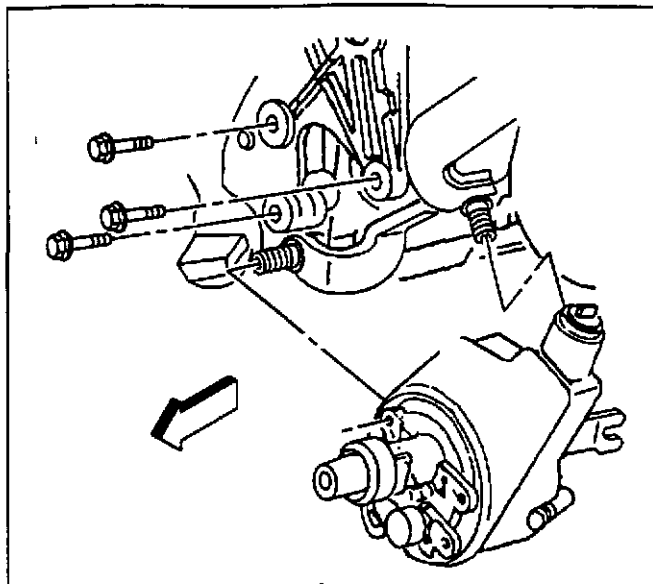
Tighten the power steering pump mounting bracket bolts and nut to 41 N·m (30 lb ft).

3. Install the three bolts for the power steering pump.

Tighten

Tighten the power steering pump mounting bracket to power steering pump bolts to 50 N·m (37 lb ft).

4. Install the power steering pump pulley. Refer to *Power Steering Pump Replacement (4.3L)* in Power Steering Systems.
5. Install the air conditioning compressor, if equipped. Refer to *Compressor Replacement (4.3L)* in HVAC Systems with AC - Manual.

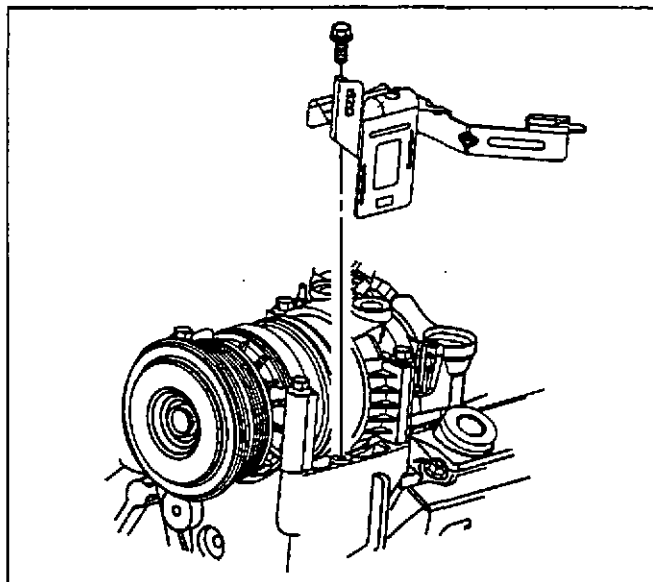


288829

6. Position the positive battery cable junction block bracket along with the wiring harness on the power steering pump mounting bracket.
7. Install the junction block bracket bolt.

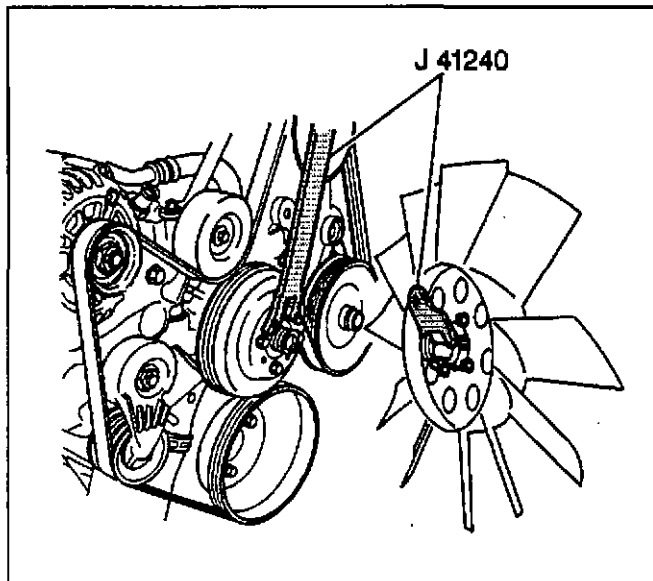
Tighten

Tighten the junction block bracket bolt to 25 N·m (18 lb ft).

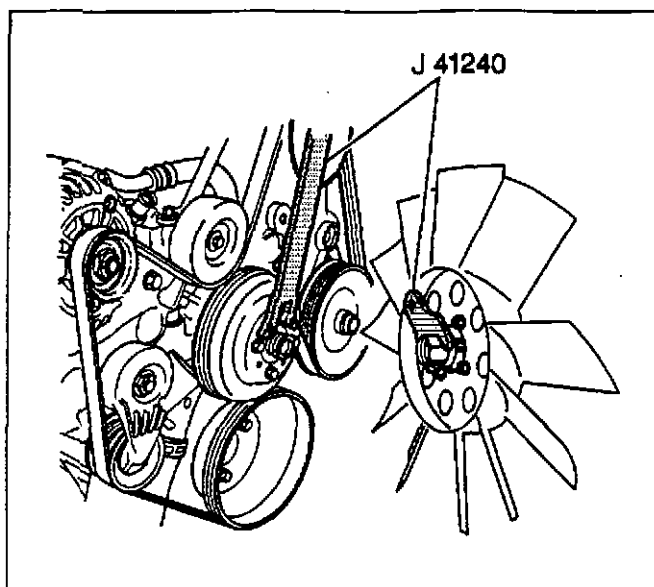


394403

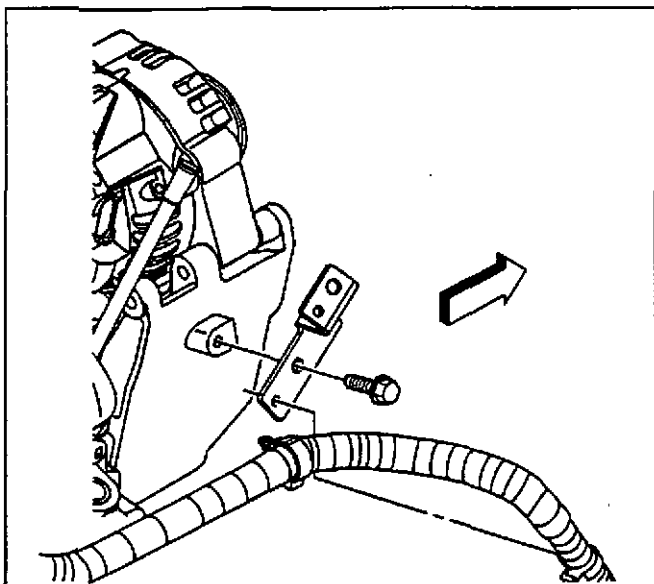
8. Install the drive belt idler pulley if not equipped with A/C. Refer to *Drive Belt Idler Pulley Replacement (Without A/C)*.
9. Install the drive belt. Refer to *Drive Belt Replacement*.
10. Install the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.



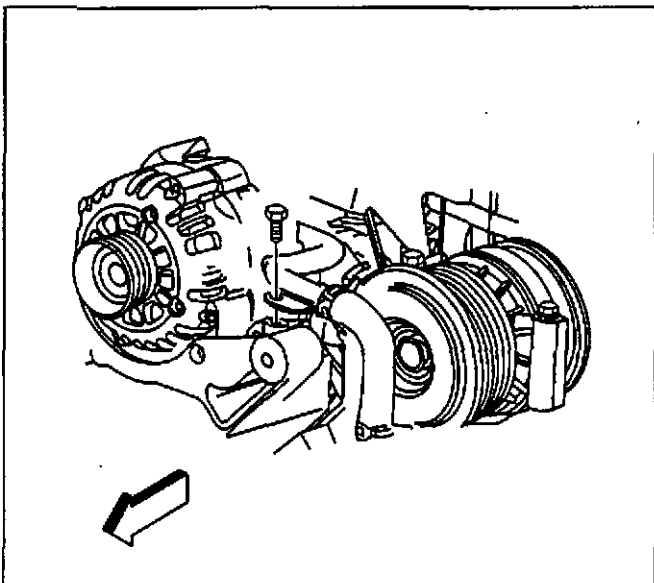
42910



42910



334162



316440

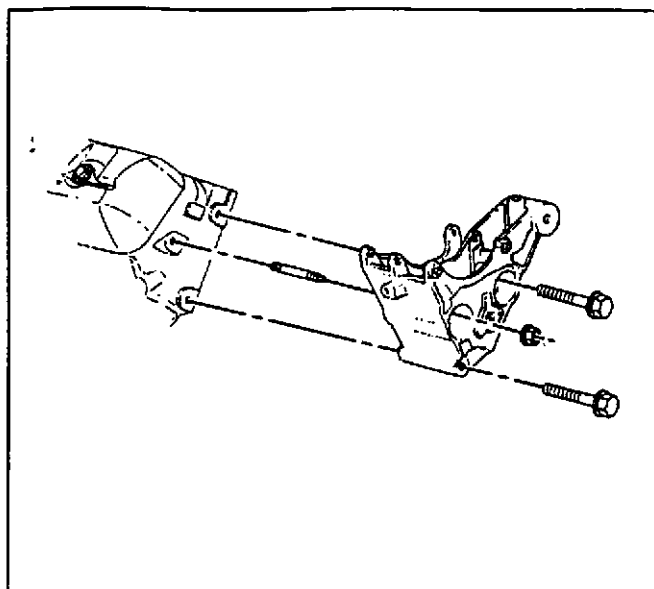
SIE-ID - 357926

Accessory Mounting Brackets Replacement (Generator Mounting Bracket)

Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.
2. Remove the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.
3. Remove the drive belt. Refer to *Drive Belt Replacement*.
4. Remove the bolt holding the bracket for the wiring harness and the A/C hose, if equipped from the generator mounting bracket.
5. Remove the generator. Refer to *Generator Replacement (4.3L)* in Engine Electrical.
6. Remove the bolt holding the heater hose bracket to the generator mounting bracket.
7. Remove the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.
8. Remove the drive belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement (Right side)*.

9. Remove the two bolts and nut holding the generator bracket to the engine.
10. Slide the generator bracket off of the stud.



198643

Installation Procedure

1. Slide the generator bracket on the stud.

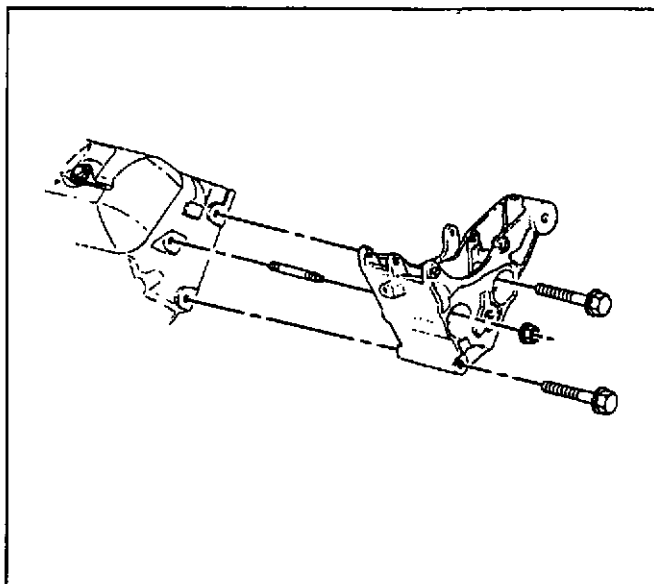
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the two bolts and the nut.

Tighten

Tighten the generator bracket bolts and nut to 41 N.m (30 lb ft).

3. Install the drive belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement (Right side)*.
4. Install the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.

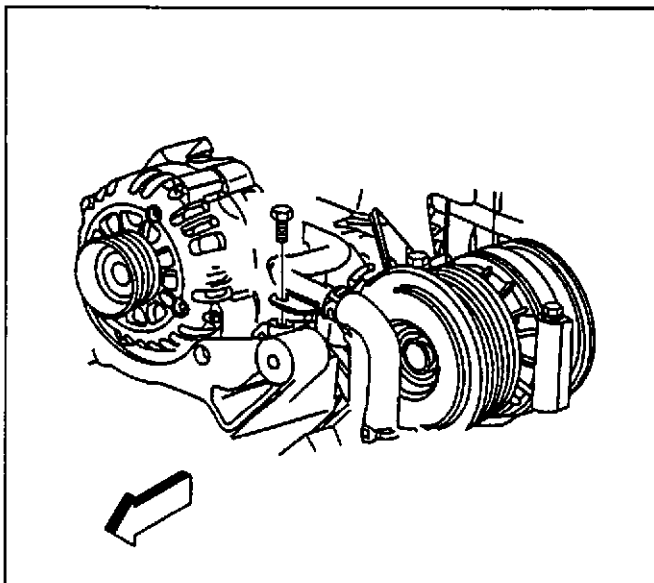


198643

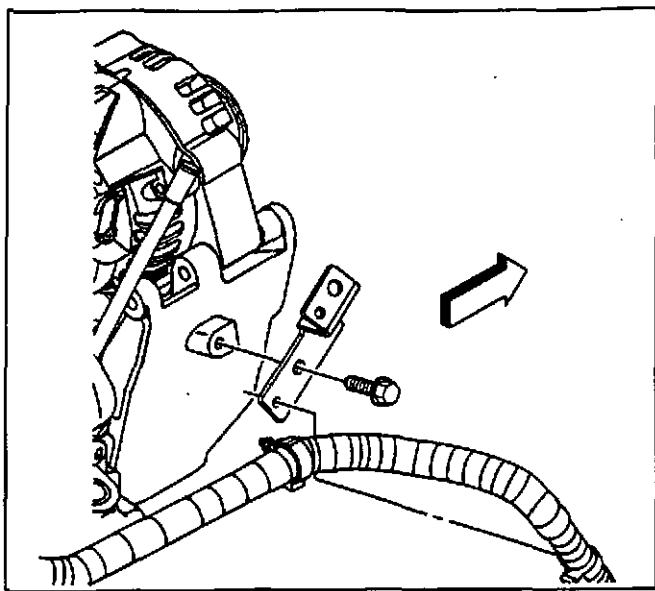
5. Install the bolt holding the heater hose bracket to the generator mounting bracket.

Tighten

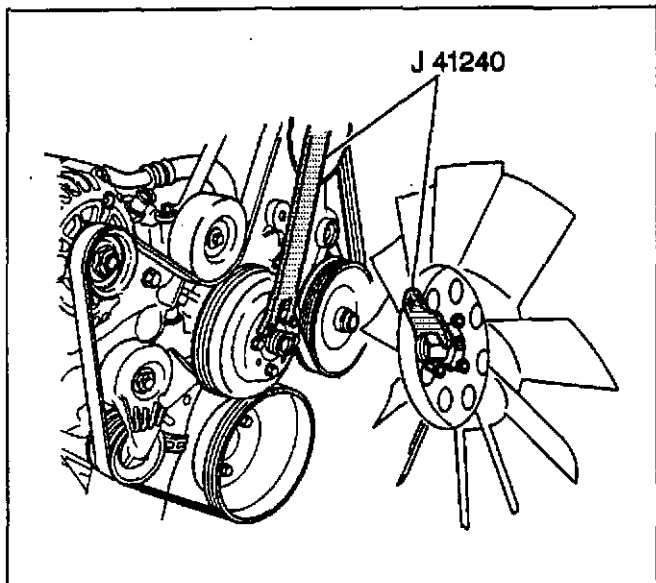
Tighten the heater hose bracket bolt to 25 N.m (18 lb ft).



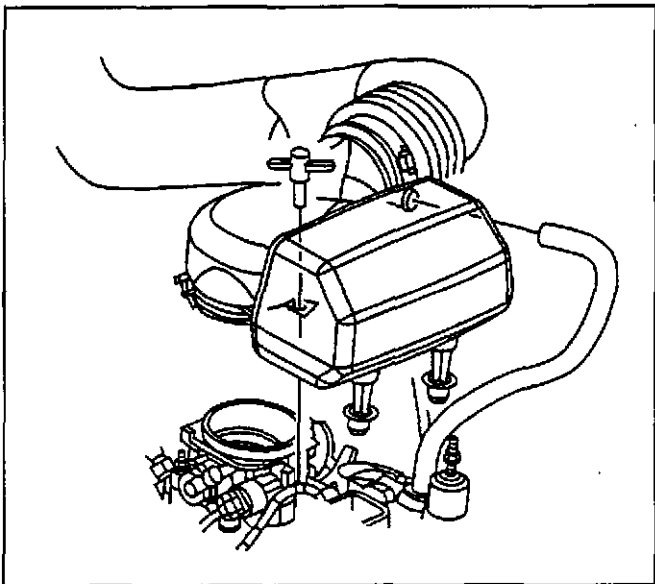
316440



334162



42910



310234

6. Install the bolt holding the bracket for wiring harness and the A/C hose, if equipped to the generator mounting bracket.

Tighten

Tighten the wiring harness bracket bolt to 25 N.m (18 lb ft).

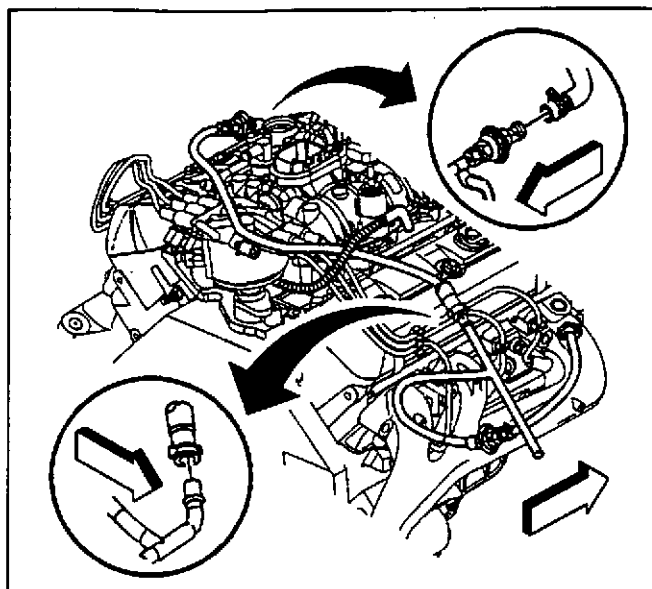
7. Install the generator. Refer to *Generator Replacement (4.3L)* in Engine Electrical.
8. Install the drive belt. Refer to *Drive Belt Replacement*.
9. Install the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.
10. Connect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.

SIE-ID = 329715

Intake Manifold Replacement (Upper)**Removal Procedure**

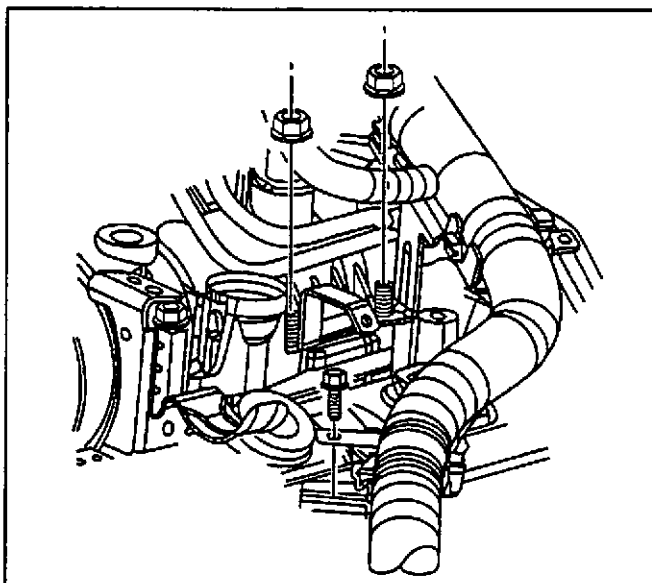
1. Disconnect the PCV hose from the air inlet duct.
2. Remove the air inlet duct from the mass air flow (MAF) sensor and the throttle body.
3. Disconnect the following electrical connectors:
 - The A/C pressure switch, if equipped
 - The throttle position (TP) sensor
 - The idle air control (IAC) motor
 - The fuel meter body assembly connector
 - The manifold absolute pressure (MAP) sensor
 - The EVAP canister purge solenoid valve

4. Disconnect the secondary air injection (AIR) crossover pipe from the AIR pipe assemblies, if equipped.
5. Remove the AIR crossover pipe, if equipped.



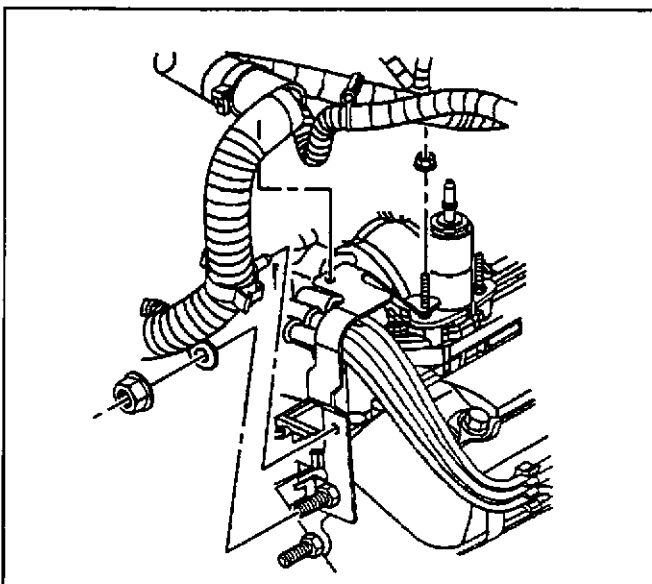
398868

6. Remove the two nuts holding the engine wiring harness bracket to the upper intake studs.
7. Remove the bracket from the studs.

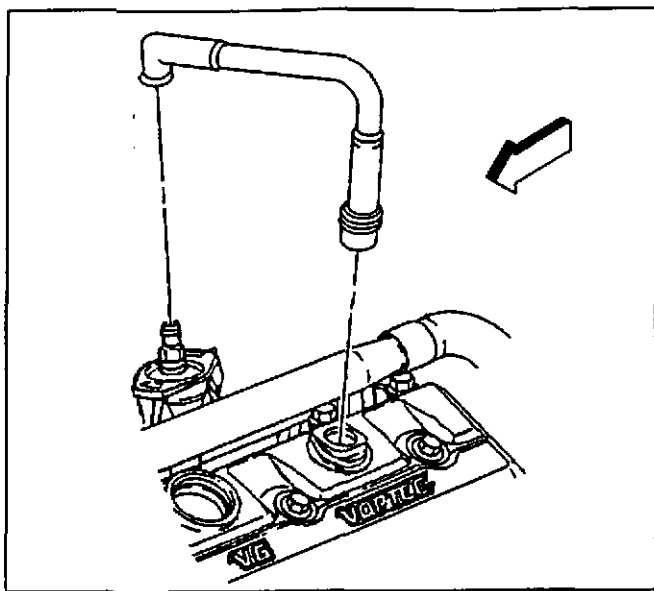


310241

8. Remove the nut holding the engine wiring harness bracket to the stud at the EVAP canister purge solenoid valve.
9. Remove the bolt holding the brackets for the wiring harness to the rear of the cylinder head.
10. Move the wiring harness and brackets aside.
11. Remove the EVAP canister purge solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls.

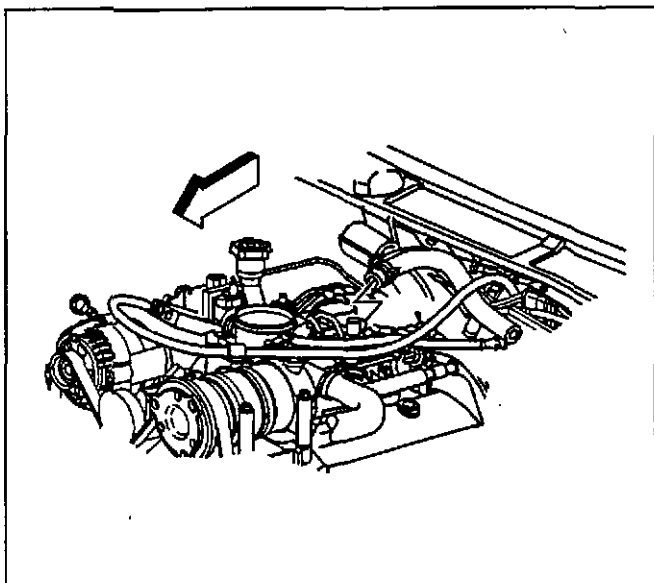


310243



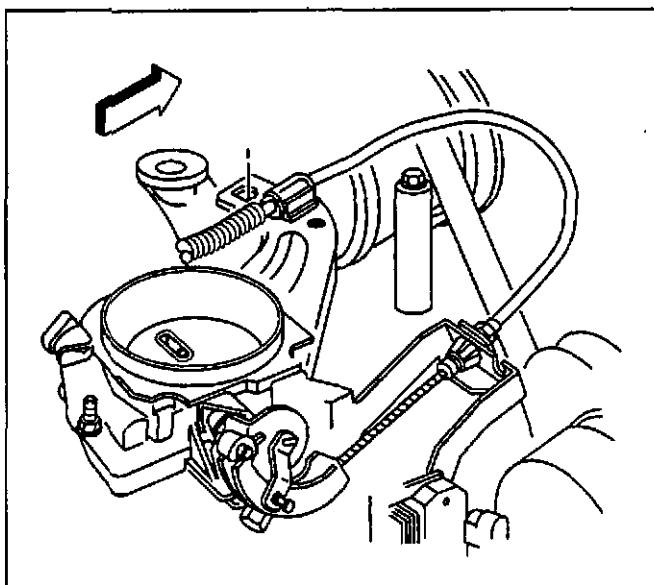
172995

12. Remove the PCV valve hose from the intake manifold and the valve rocker arm cover.



346148

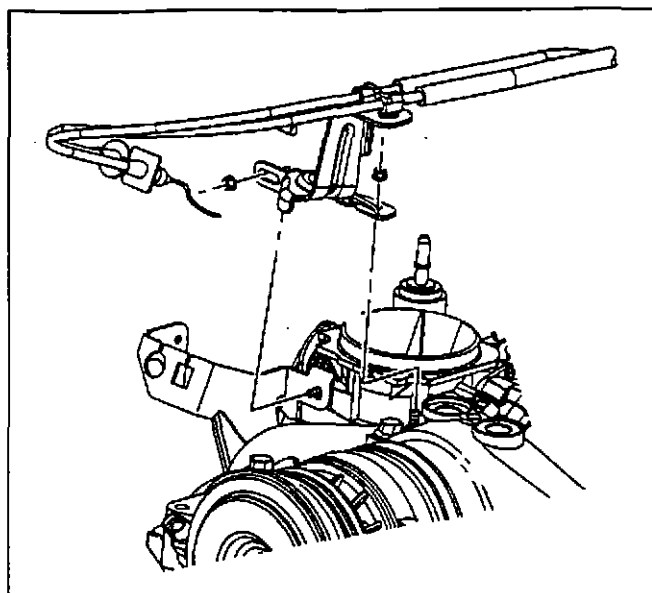
13. Disconnect the vacuum brake booster hose from the intake manifold.



216754

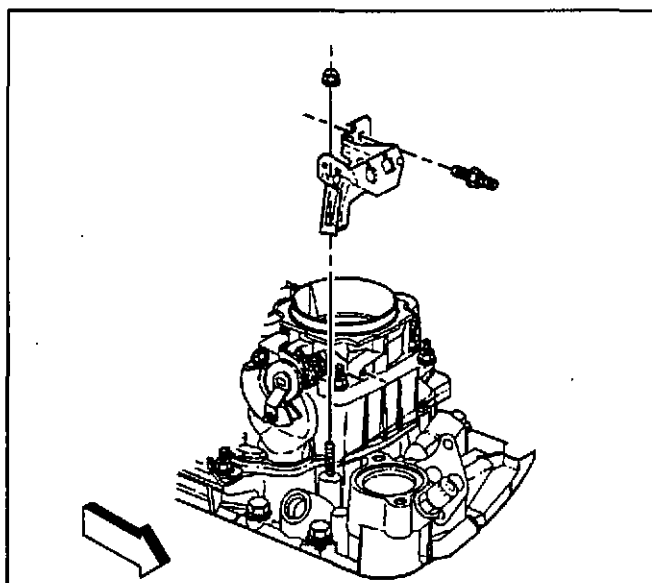
14. Disconnect the accelerator control cable from the throttle shaft. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.
15. Disconnect the cruise control cable, if equipped. Refer to *Cruise Control Cable Replacement* in Cruise Control.

16. Remove the engine wiring harness clip from the accelerator control cable bracket.
17. Remove the accelerator control cable bracket from the throttle body.



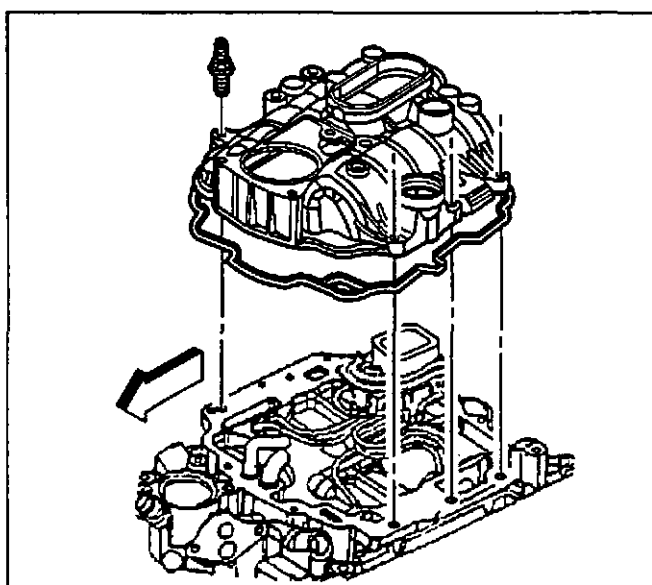
398030

18. Remove the accelerator control cable bracket from the intake manifold and the throttle body.
19. Move the accelerator control cable brackets with the cables aside.
20. Remove the fuel lines from the fuel meter body assembly. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls.

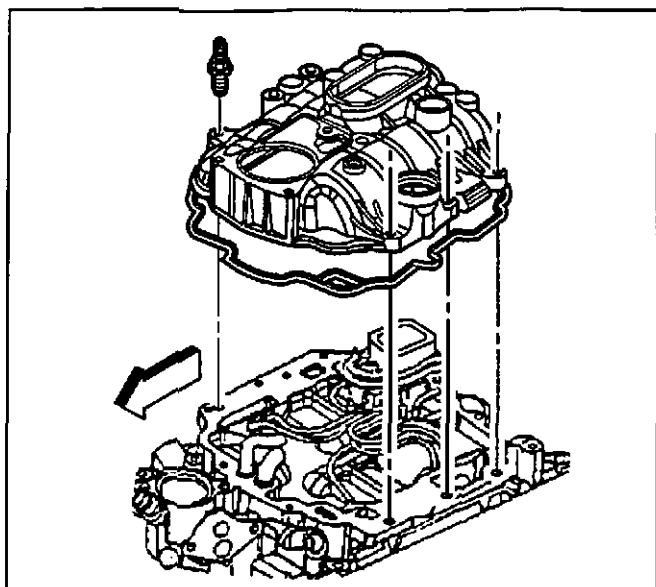


398033

21. Remove the upper intake manifold. Refer to *Intake Manifold Disassemble*.
22. Clean all sealing surfaces. Refer to *Intake Manifold Clean and Inspect*.



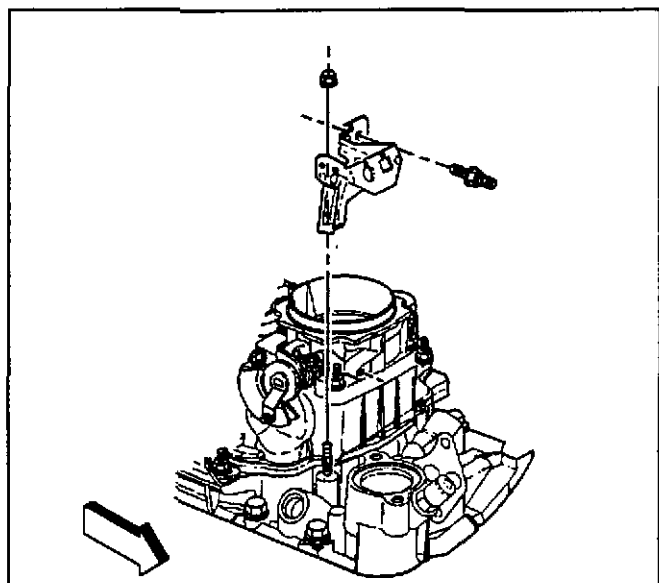
334513



334513

Installation Procedure

1. Install the upper intake manifold.
Refer to *Intake Manifold Assemble*.
2. Install the fuel lines to the fuel meter body assembly. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls.



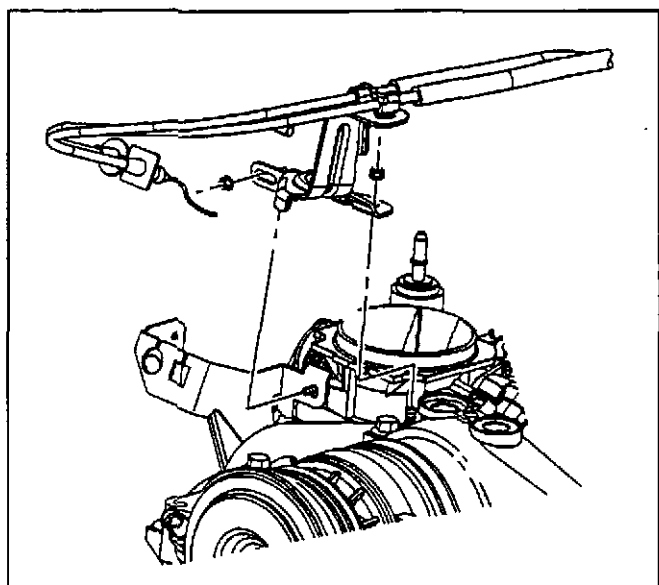
398033

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

3. Install the accelerator control cable bracket to the throttle body and the intake manifold.

Tighten

Tighten the cable bracket studs and nuts to 12 N.m (106 lb in).



398030

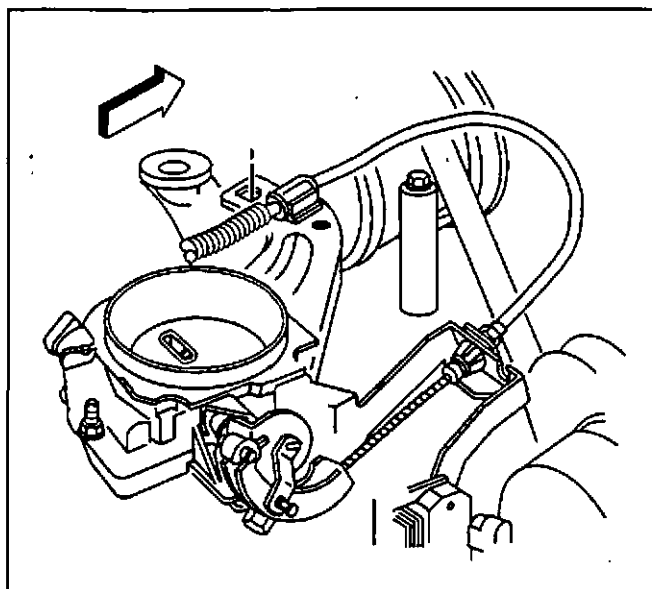
4. Install the accelerator control cable bracket and nuts to the throttle body.

Tighten

Tighten the cable bracket nuts to 10 N.m (88 lb in).

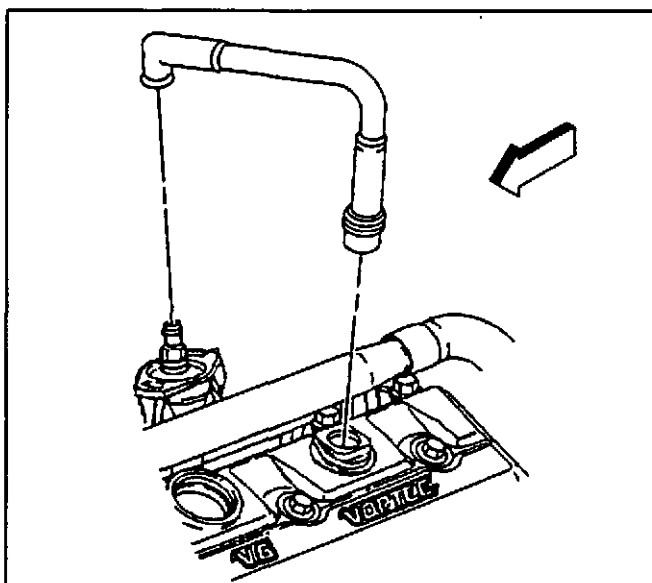
5. Install the wiring harness clip to the accelerator control cable bracket.

6. Install the cruise control cable, if equipped. Refer to *Cruise Control Cable Replacement* in Cruise Control.
7. Install the accelerator cable to the throttle shaft. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.



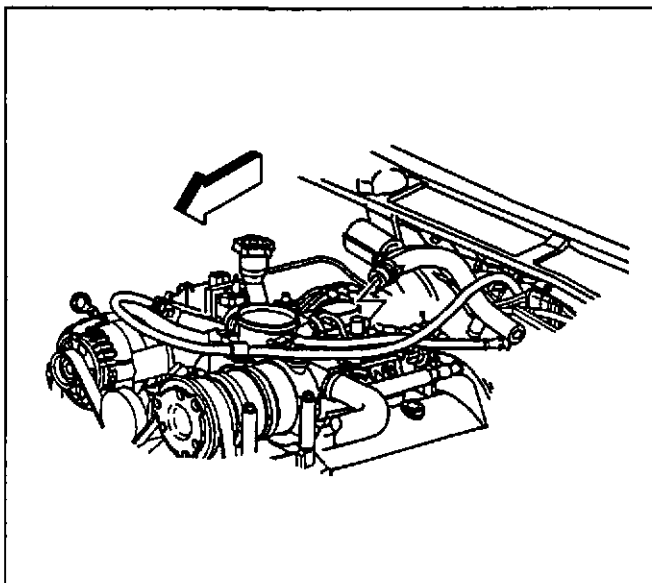
216754

8. Connect the PCV valve hose to the intake manifold and the valve rocker arm cover.

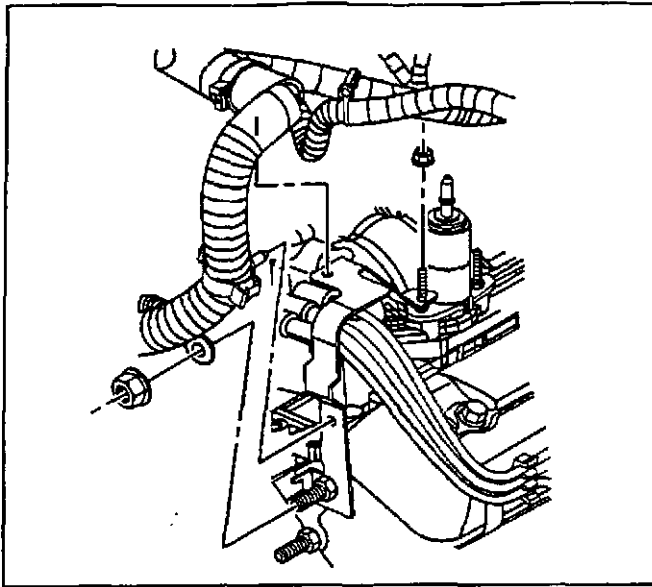


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9. Connect the vacuum brake booster hose to the intake manifold.
10. Install the EVAP canister purge solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls.



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11. Position the engine wiring harness and brackets.
12. Install the bolt holding the brackets for the wiring harness to the rear of the right cylinder head.

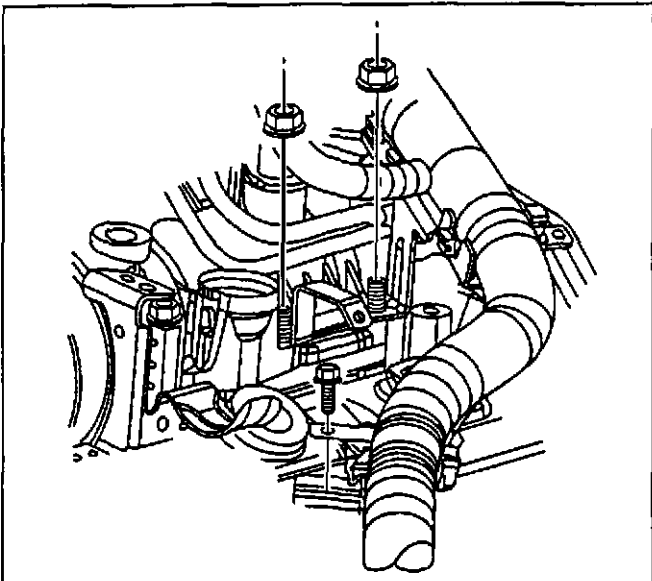
Tighten

Tighten the wiring harness bracket bolt to 25 N·m (18 lb ft).

13. Install the nut holding the wiring harness bracket to the stud at the EVAP canister purge solenoid valve.

Tighten

Tighten the wiring harness bracket nut to 10 N·m (88 lb in).



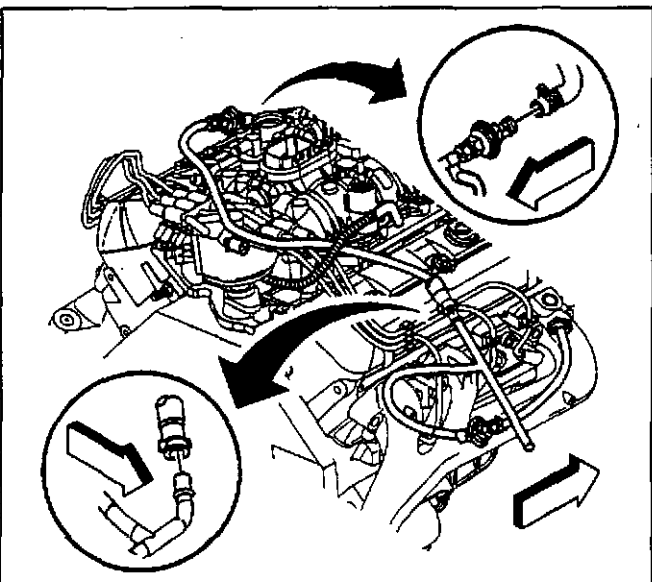
310241

14. Install the engine wiring harness bracket on the upper intake studs.
15. Install the nuts.

Tighten

Tighten the wiring harness bracket nuts to 12 N·m (106 lb in).

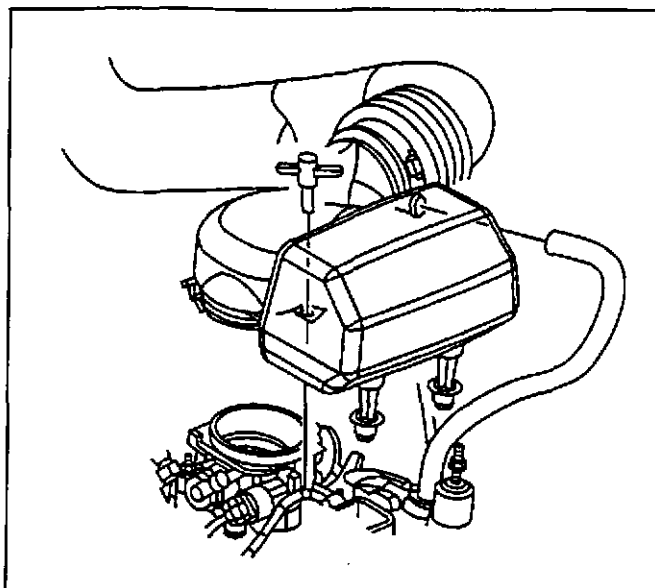
16. Connect the following electrical connectors:
 - The A/C pressure switch, if equipped
 - The throttle position (TP) sensor
 - The idle air control (IAC) motor
 - The fuel meter body assembly connector
 - The manifold absolute pressure (MAP) sensor
 - The EVAP canister purge solenoid valve



398868

17. Connect the AIR crossover pipe to the AIR pipe assemblies.

18. Install the air inlet duct to the throttle body assembly and the MAF sensor.
19. Connect the PCV hose to the air inlet duct.



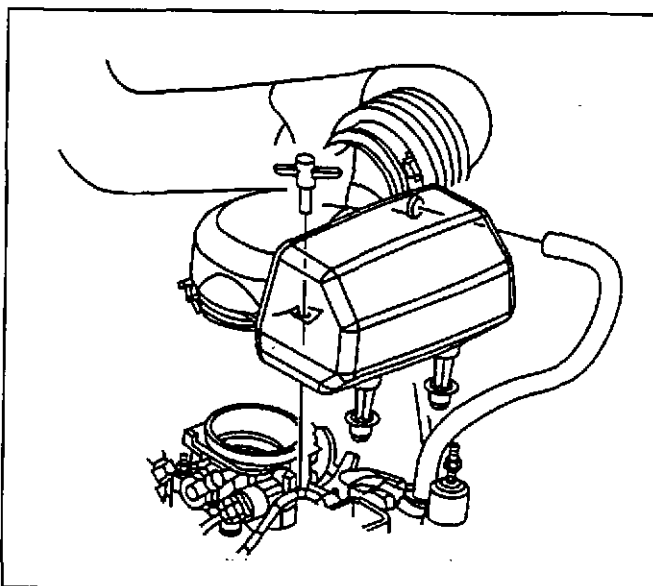
310234

SIE-ID - 331941

Intake Manifold Replacement (Lower)

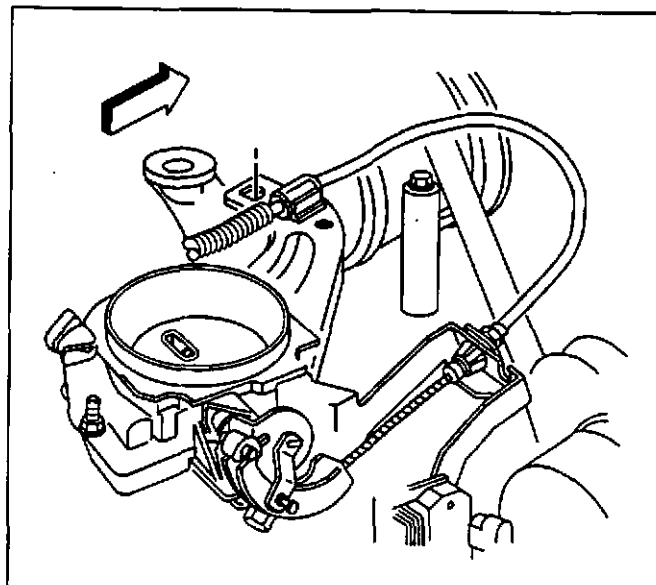
Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.
2. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Disconnect the PCV hose from the air inlet duct.
4. Remove the air inlet duct from the throttle body and the mass air flow (MAF) sensor.

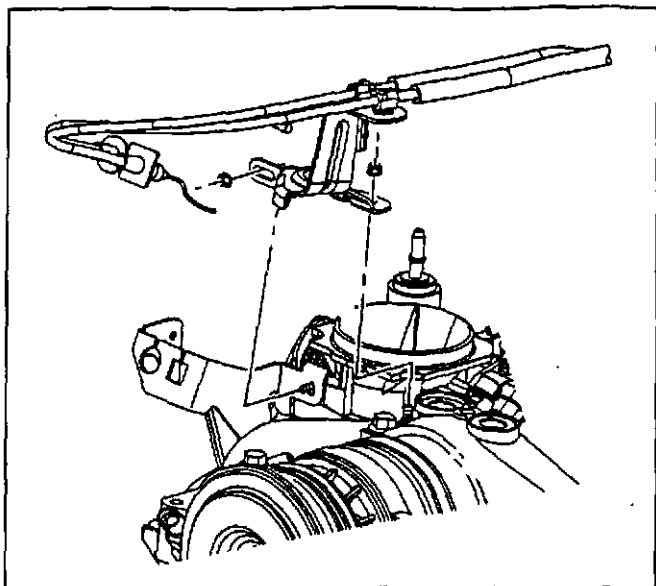


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5. Remove the accelerator cable from the throttle shaft. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.
6. Disconnect the cruise control cable, if equipped. Refer to *Cruise Control Cable Replacement* in Cruise Control.

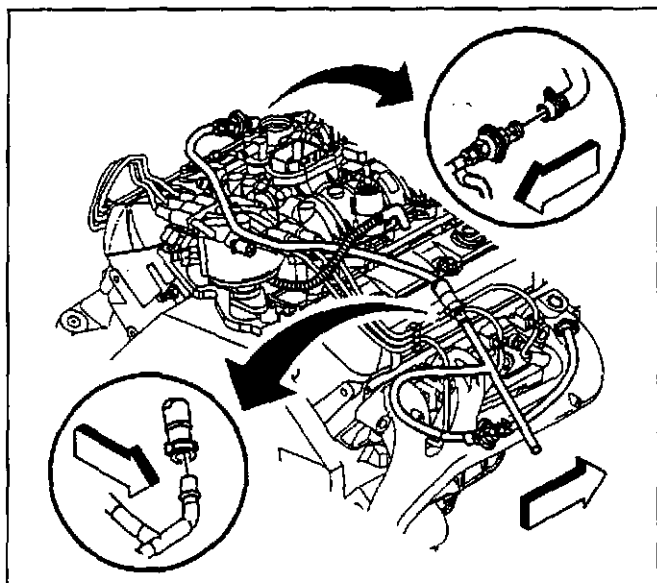


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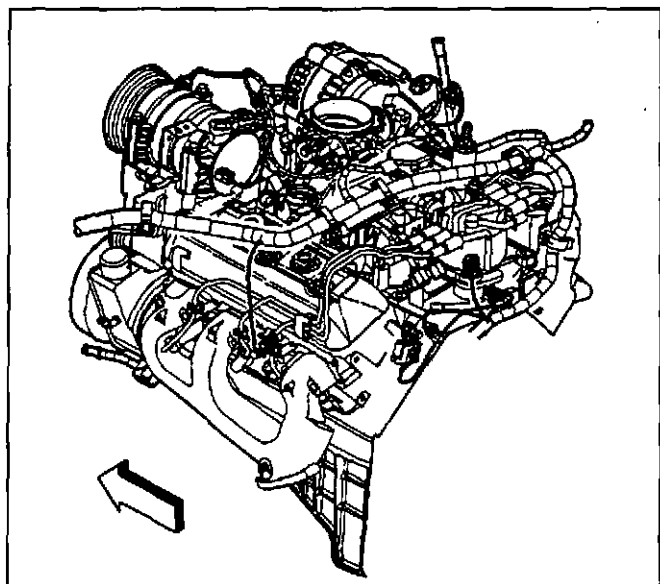
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7. Remove the wiring harness clip from the accelerator control cable bracket.
8. Remove the accelerator control cable bracket from the throttle body.
9. Move the accelerator control cable bracket with the cables aside.



398868

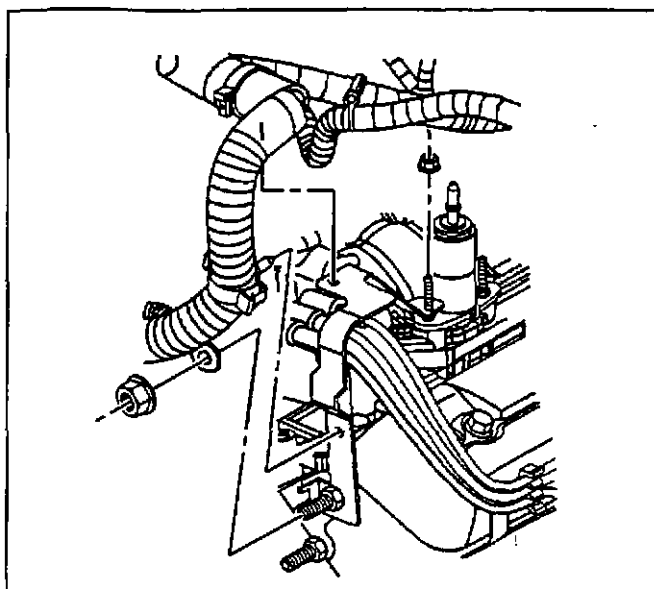
10. Disconnect the secondary air injection (AIR) crossover pipe from the AIR pipe assemblies, if equipped.
11. Remove the AIR crossover pipe, if equipped.



333816

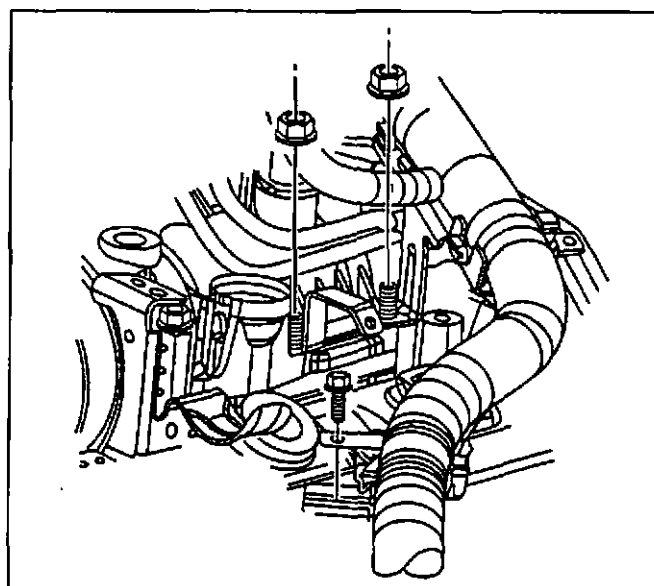
12. Disconnect the following electrical connectors:
 - The fuel meter body assembly
 - The EVAP canister purge solenoid valve
 - The idle air control (IAC) motor
 - The throttle position (TP) sensor
 - The manifold absolute pressure (MAP) sensor
 - The engine coolant temperature (ECT) sensor
 - The A/C compressor high pressure switch, if equipped
 - The A/C clutch switch, if equipped
 - The exhaust gas recirculation (EGR) valve
 - The ignition control module (ICM)
 - The ignition coil wire

13. Remove the nut holding the bracket for the engine wiring harness to the EVAP purge solenoid valve stud.
14. Remove the nut holding the ground wire to the engine wiring harness bracket stud.
15. Remove the bolt holding the bracket for the engine wiring harness bracket.



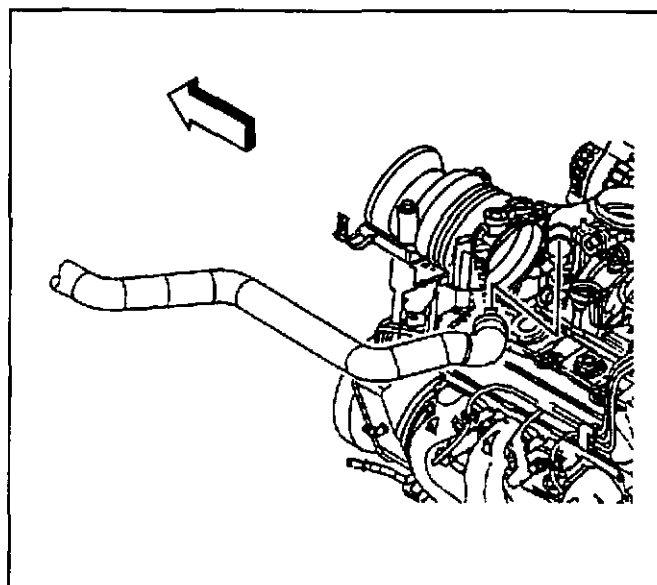
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16. Remove the two nuts holding the engine wiring harness bracket to the upper intake studs.
17. Remove the engine wiring harness bracket from the studs.
18. Move the engine wiring harness with the brackets aside.

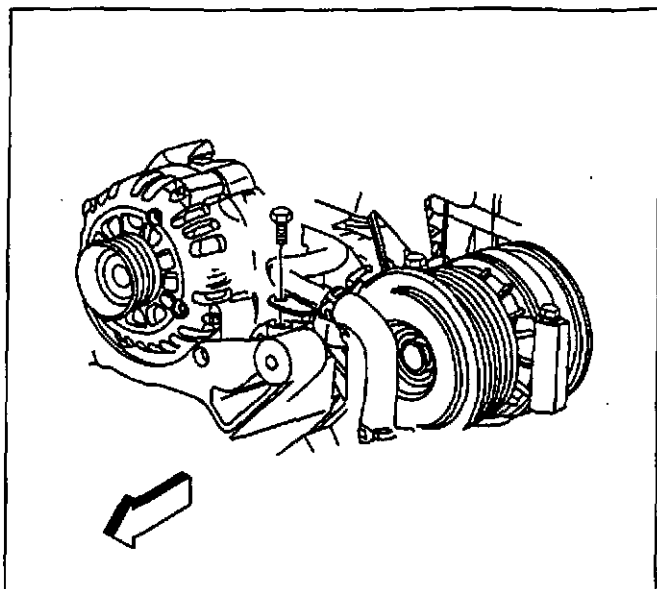


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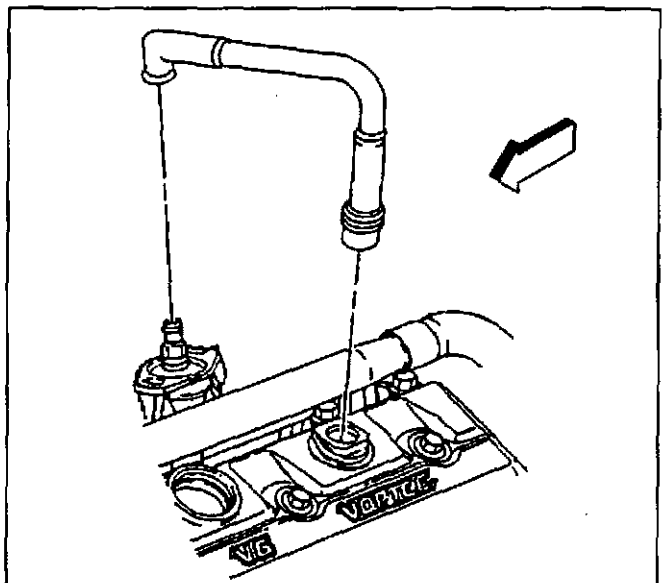
19. Remove the radiator inlet hose at the water outlet. Refer to *Radiator Hose Replacement - Inlet (4.3L)* in Engine Cooling..
20. Remove the water pump inlet hose from the intake manifold.
21. Remove the coolant recovery tank hose.



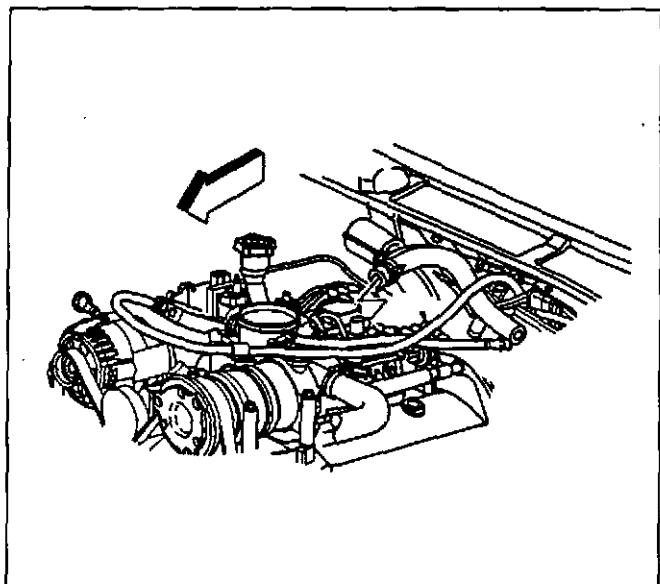
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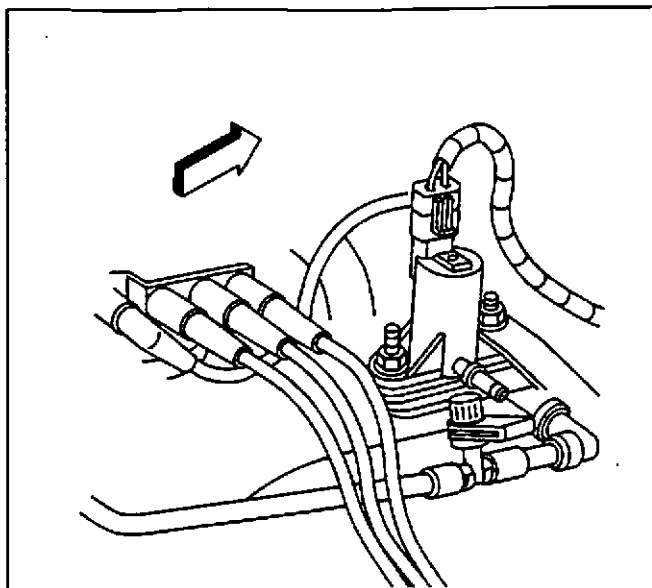
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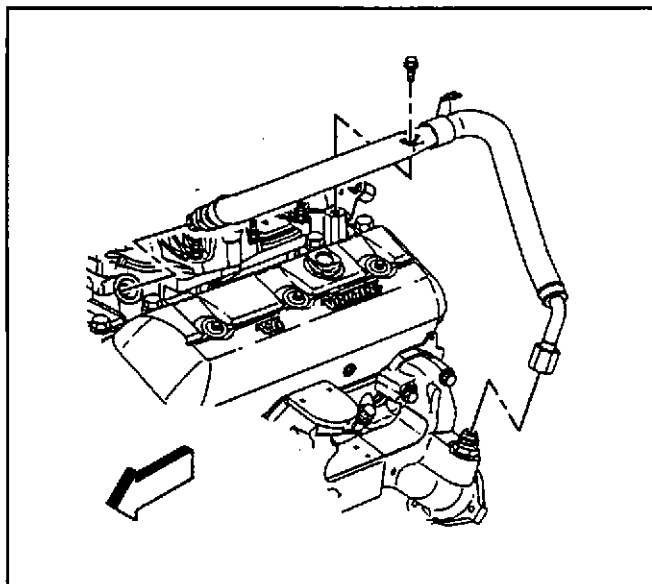
22. Remove the bolt holding the bracket for the heater hose tube from the generator bracket.
23. Remove the heater hoses from the engine. Refer to *Heater Hoses Replacement (4.3L)* in Heating and Ventilation (Non-A/C).
24. Remove the distributor. Refer to *Distributor Replacement (HVS Systems)* in Engine Electrical.
25. Disconnect the fuel supply and return pipes at the rear of the intake manifold. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls.
26. Disconnect PCV valve hose from the intake manifold.
27. Disconnect the vacuum brake booster hose from the intake manifold.

28. Disconnect the hose to the EVAP canister purge solenoid valve.



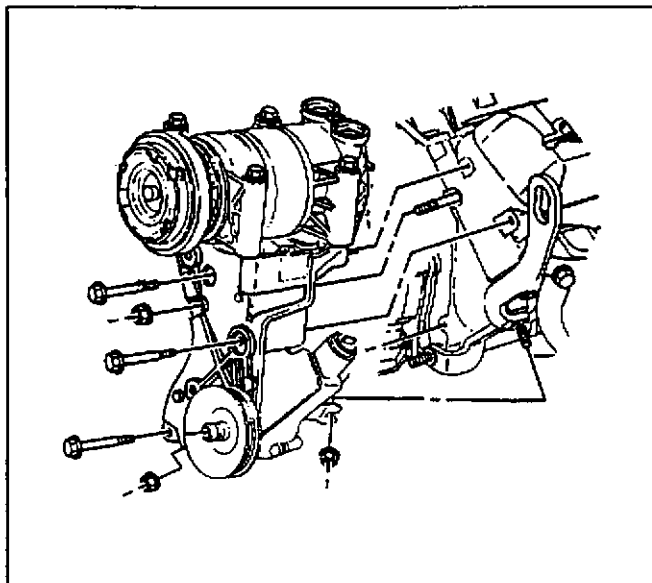
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29. Remove the exhaust gas recirculation (EGR) valve inlet pipe from the intake and the exhaust manifolds.

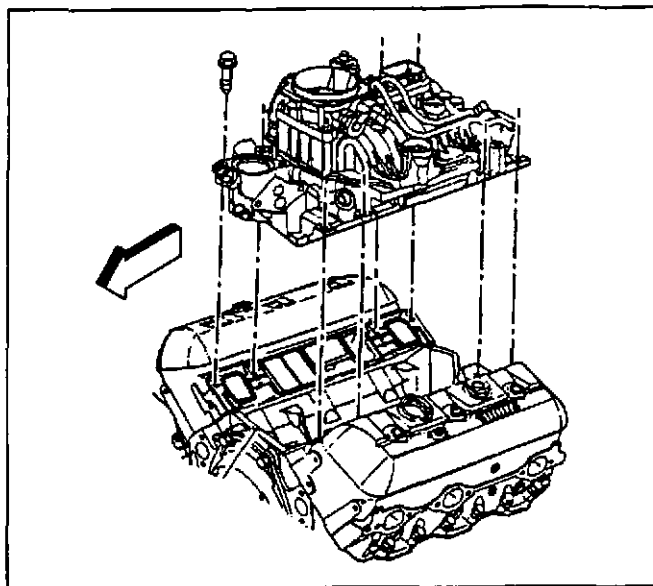


172982

30. In order to remove the front intake manifold bolt, perform the following:
 - 30.1. Remove the drive belt. Refer to *Drive Belt Replacement*.
 - 30.2. Loosen the power steering pump rear bracket side nut.
 - 30.3. Remove the power steering pump rear bracket front nut.
 - 30.4. Remove the bolts and the nut for the power steering pump mounting bracket.
 - 30.5. Leave the A/C compressor, if equipped, and the power steering pump on the bracket.
 - 30.6. Slide the power steering pump mounting bracket forward to access the bolt at the front of the intake manifold.

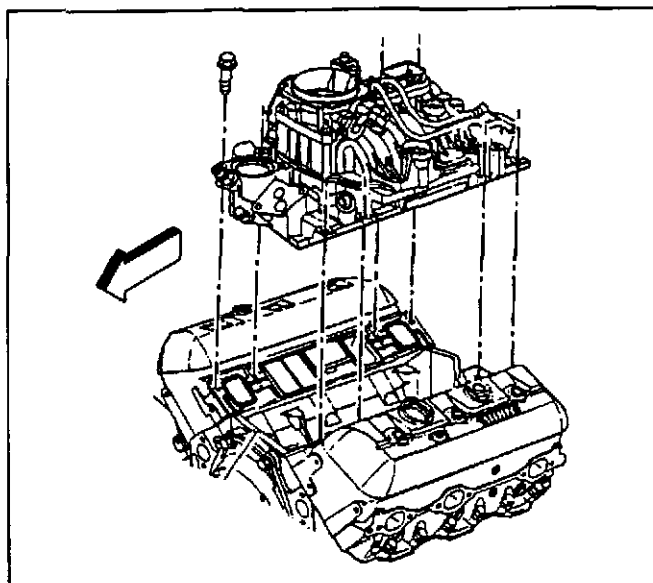


340090



31510

31. Remove the lower intake manifold bolts.
32. Remove the lower intake manifold. Refer to *Intake Manifold Removal*.
33. Clean all sealing surfaces. Refer to *Intake Manifold Clean and Inspect*.

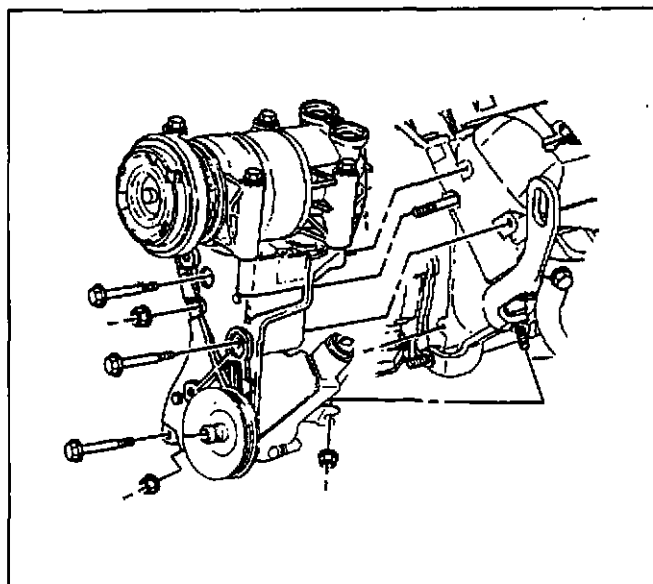


31510

Installation Procedure

Notice: *SI0-1D - 382467* Proper lower intake manifold fastener tightening sequence and torque is critical. Always follow the tightening sequence, and torque the intake manifold bolts using the 3 step method. Failing to do so may distort the crankshaft bearing bore alignment and cause damage to the crankshaft bearings.

1. Install the lower intake manifold. Refer to *Intake Manifold Installation*.



340090

2. Position the power steering pump mounting bracket.
3. Install the three bolts and the nut.
- Notice:** Refer to *Fastener Notice* in Cautions and Notices.
4. Install the front nut for the power steering pump rear bracket.

Tighten

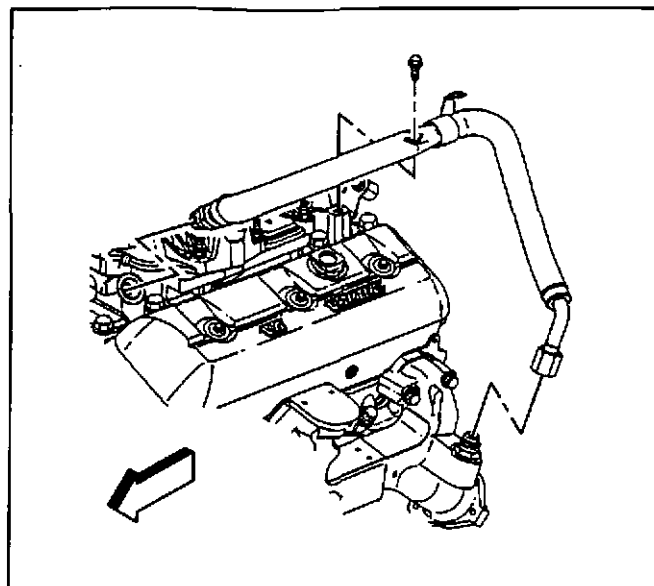
Tighten the power steering pump mounting bracket bolts, the nut, and the power steering pump rear bracket nut to 41 N·m (30 lb ft).

5. Install the drive belt. Refer to *Drive Belt Replacement*.

6. Install the EGR valve inlet pipe to the intake and exhaust manifolds.

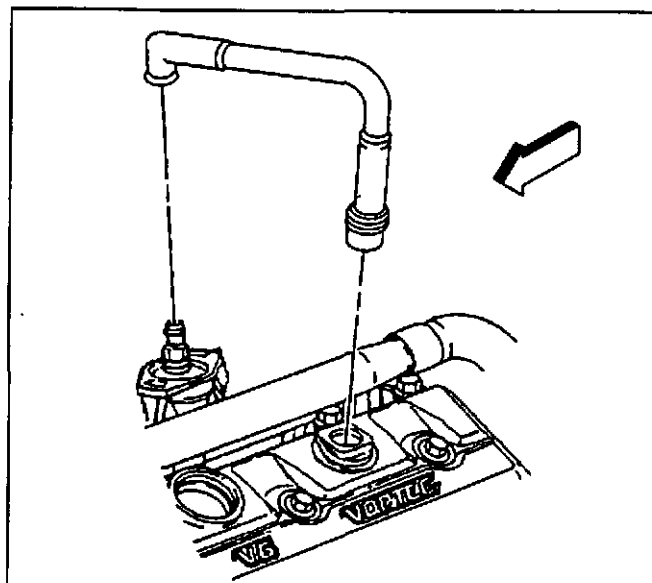
Tighten

- 6.1. Tighten the EGR valve inlet pipe intake manifold nut to 25 N·m (18 lb ft).
- 6.2. Tighten the EGR valve inlet pipe exhaust manifold nut to 30 N·m (22 lb ft).
- 6.3. Tighten the EGR valve inlet pipe clamp bolt 25 N·m (18 lb ft).



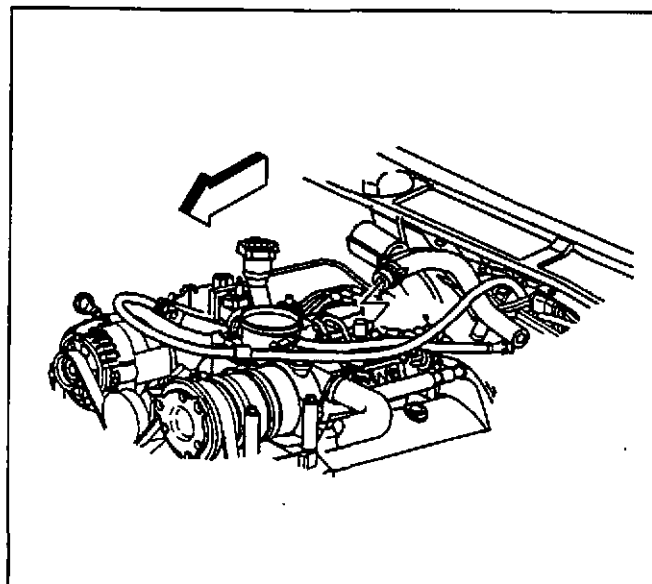
172982

7. Install the PCV valve hose to the intake manifold.

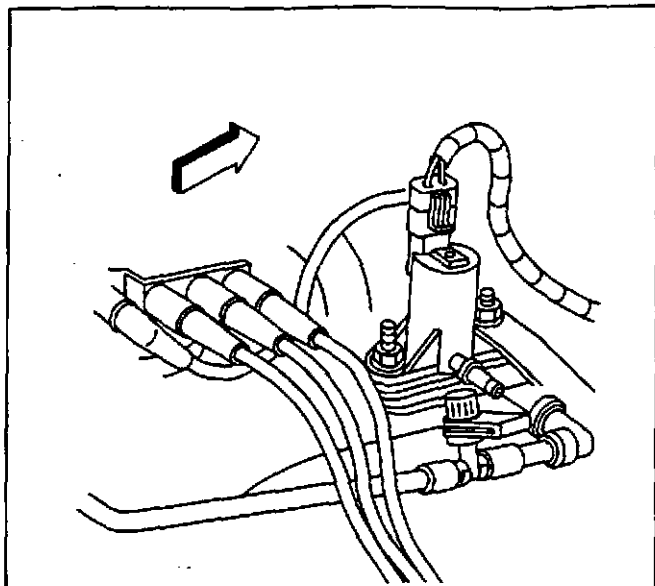


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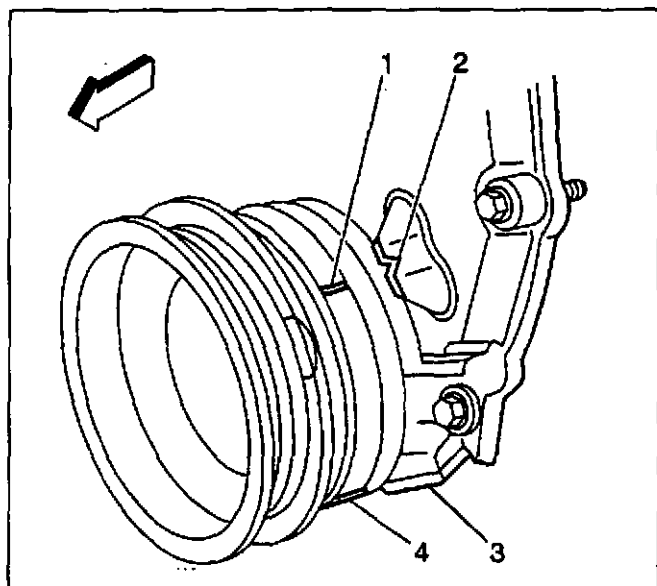
8. Install the vacuum brake booster hose to the intake manifold.



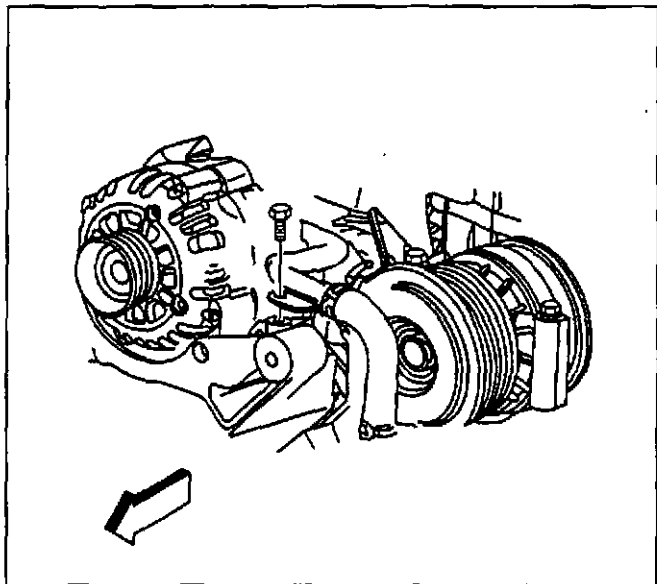
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9. Install the EVAP canister purge solenoid valve hose.
10. Install the fuel supply and return pipes to the rear of the intake manifold. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls.

Important: In order to install the distributor for the correct engine timing, position the engine to number one cylinder top dead center.

11. Remove the spark plug for number one cylinder.
12. Rotate the crankshaft until number one cylinder is in the compression stroke.
13. Align the two reference marks on the crankshaft balancer (1) and (4) with the two alignment marks (2) and (3) on the front cover.
14. Install the spark plug. Refer to *Spark Plug Replacement (4.3L, 4.8L, 5.3L, 6.0L)* in Engine Electrical.
15. Install the distributor. Refer to *Distributor Replacement (HVS Systems)* in Engine Electrical.
16. Install the water pump inlet hose to the intake manifold.
17. Install the coolant recovery tank hose.
18. Install the heater hoses to the engine. Refer to *Heater Hoses Replacement (4.3L)* in Heating and Ventilation (Non-A/C).
19. Install the bolt holding the bracket for the heater hose tube to the generator bracket.
Tighten
Tighten the bolt to 25 N.m (18 lb ft).
20. Install the radiator inlet hose to the water outlet. Refer to *Radiator Hose Replacement - Inlet (4.3L)* in Engine Cooling.
21. Refill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.

22. Position the engine wiring harness and the brackets.
23. Install the bolt at the rear of the right cylinder head for the wiring harness bracket.

Tighten

Tighten the wiring harness bracket bolt to 25 N·m (18 lb ft).

24. Install the nut holding the wiring harness bracket to the EVAP purge canister solenoid stud.

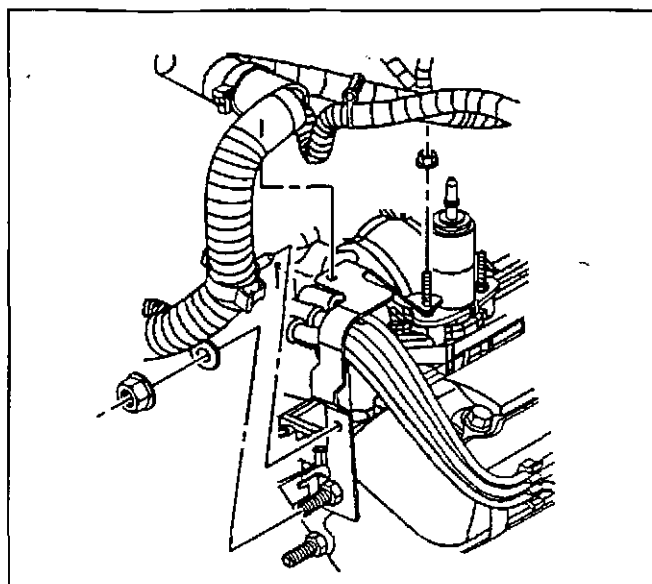
Tighten

Tighten the engine wiring harness bracket nut to 10 N·m (88 lb in).

25. Install the nut holding the ground wire to the stud at the rear of the cylinder head.

Tighten

Tighten the nut to 16 N·m (12 lb ft).

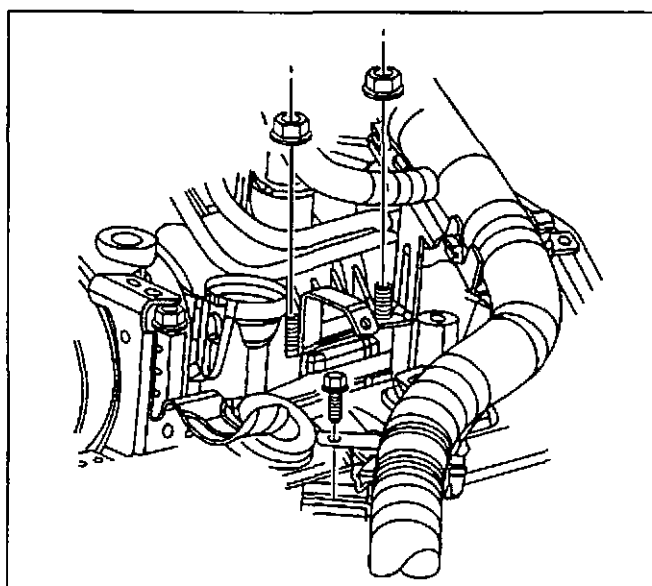


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26. Install the nuts holding the bracket for the engine wiring harness to the upper intake studs.

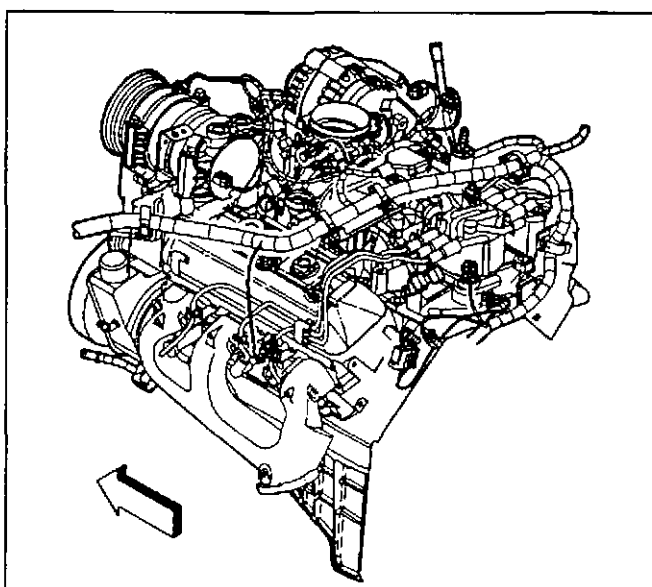
Tighten

Tighten the wiring harness bracket nuts 12 N·m (106 lb in).

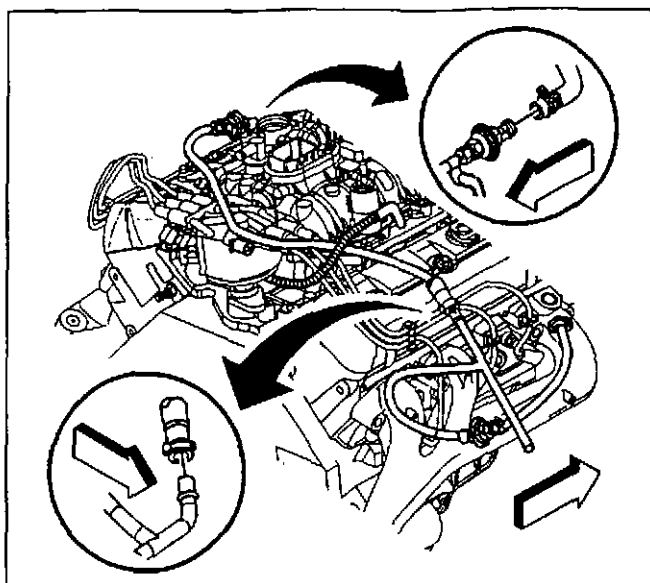


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27. Connect the following electrical connectors:
 - The fuel meter body assembly
 - The EVAP canister purge solenoid valve
 - The idle air control (IAC) motor
 - The throttle position (TP) sensor
 - The manifold absolute pressure (MAP) sensor
 - The engine coolant temperature (ECT) gauge sensor
 - The A/C compressor high pressure switch, if equipped
 - The A/C clutch switch, if equipped
 - The exhaust gas recirculation (EGR) valve
 - The engine coolant temperature (ECT) sensor
 - The ignition control module (ICM)
 - The ignition coil wire

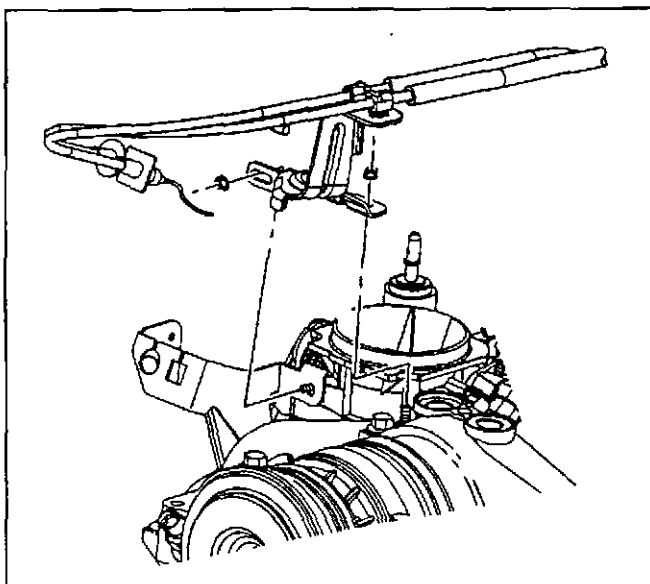


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28. Connect the AIR crossover pipe to the AIR pipe assemblies.



398030

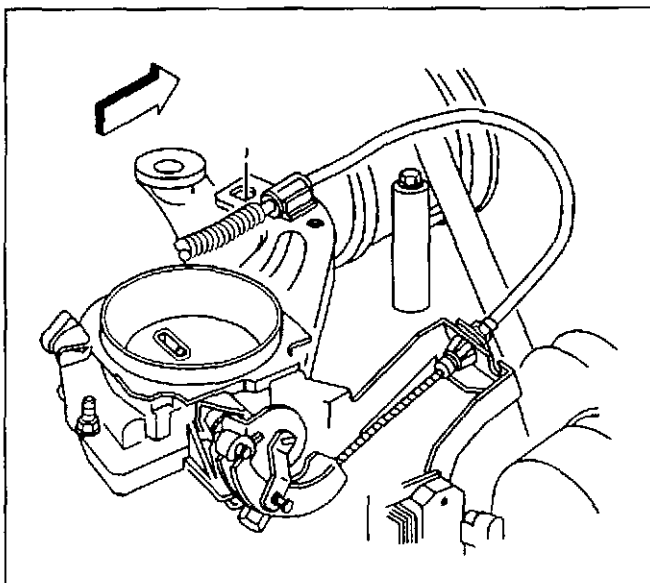
Notice: Refer to *Fastener Notice* in Cautions and Notices.

29. Install the accelerator control cable bracket with the cables, and the nuts to the throttle body.

Tighten

Tighten the nuts to 10 N.m (88 lb in).

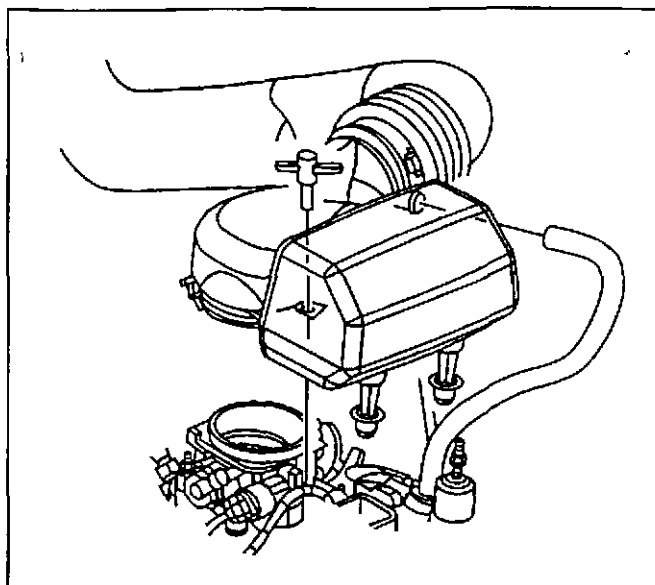
30. Install the engine wiring harness clip to the accelerator control cable bracket.
31. Install the accelerator and cruise control cables, if equipped into the accelerator control cable bracket.



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32. Install the accelerator cable to the throttle shaft. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.
33. Install the cruise control cable, if equipped. Refer to *Cruise Control Cable Replacement* in Cruise Control.

34. Install the air inlet duct to the throttle body and the MAF sensor.
35. Connect the PCV hose.
36. Connect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.



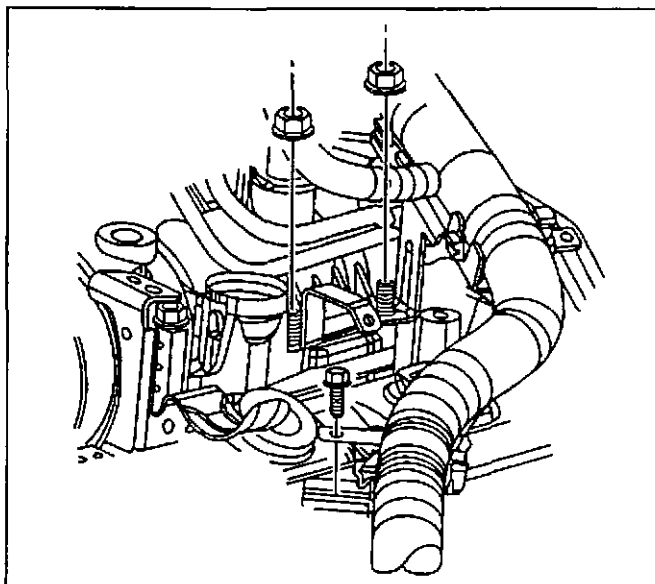
310234

SIE-ID = 328722

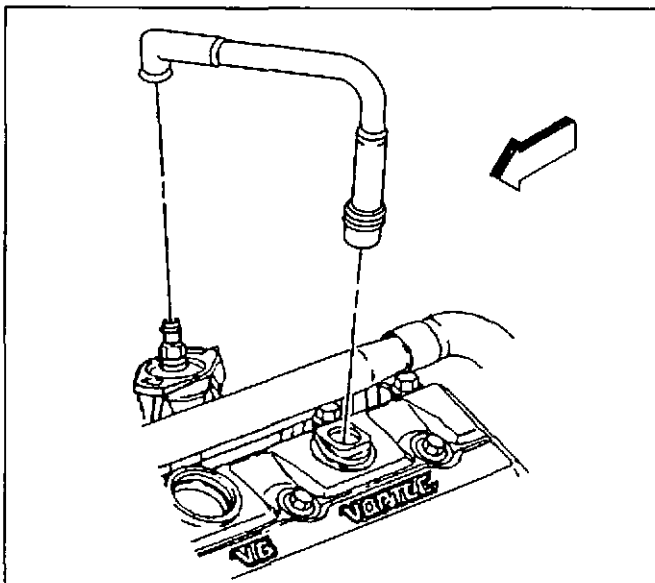
Valve Rocker Arm Cover Replacement (Left)

Removal Procedure

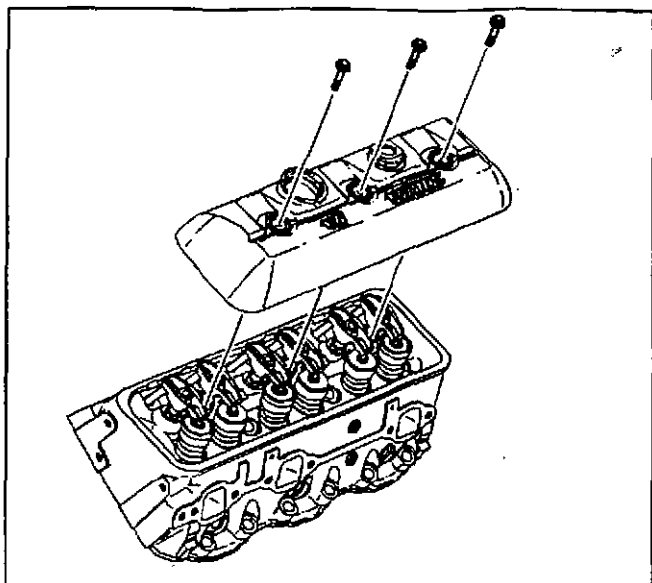
1. Remove the nuts holding the bracket for the engine wiring harness to the upper intake manifold studs.
2. Remove the bolt holding the engine wiring harness bracket to the positive battery cable junction block bracket.
3. Disconnect the engine coolant temperature (ECT) gauge sensor.
4. Move the engine wiring harness and bracket aside.
5. Remove the PCV valve and the hose assembly from the intake manifold and the valve rocker arm cover.



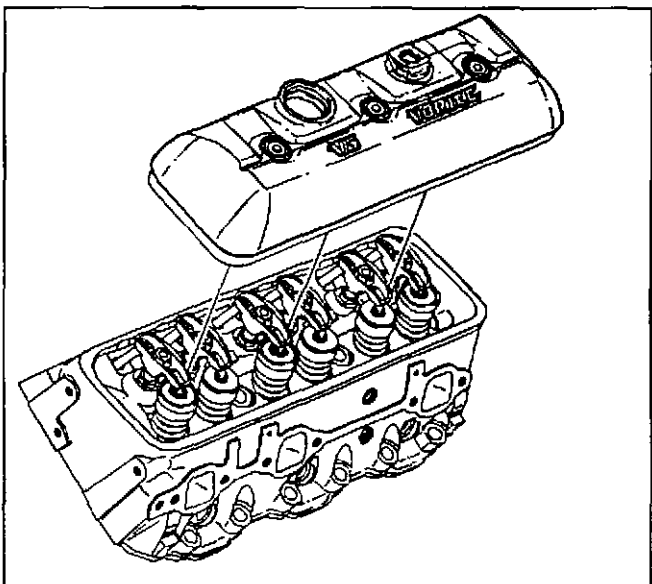
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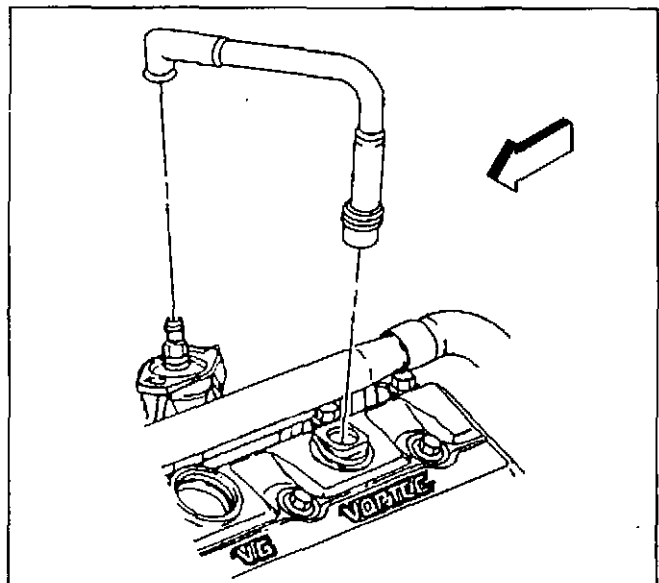
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Important: The A/C compressor and the power steering pump mounting bracket removal is not necessary.

6. Remove the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Removal (Left)*.
7. Clean all sealing surfaces. Refer to *Valve Rocker Arm Cover Clean and Inspect*.

Installation Procedure

1. Install the valve rocker arm cover and bolts. Refer to *Valve Rocker Arm Cover Installation (Left)*.
2. Install the PCV valve and the hose assembly to the intake manifold and the valve rocker arm cover.

3. Reposition the engine wiring harness.
 4. Connect the ECT gauge sensor.
- Notice:** Refer to *Fastener Notice* in Cautions and Notices.
5. Install the bracket and the nuts for the engine wiring harness to the lower intake manifold studs.

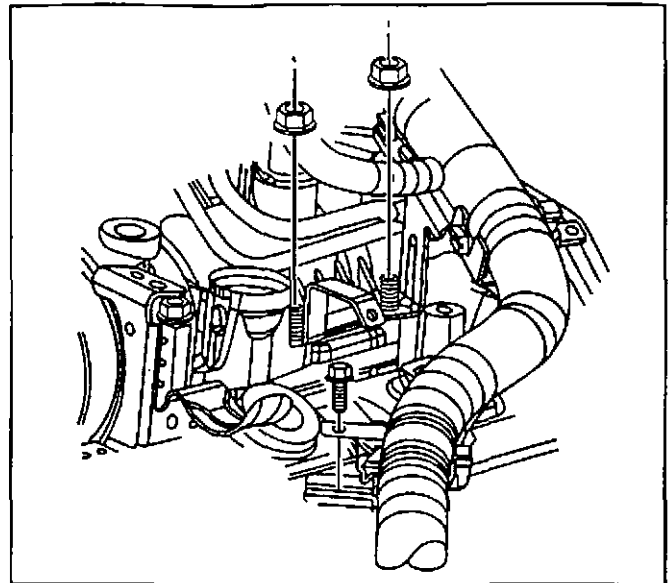
Tighten

Tighten the wiring harness bracket nuts to 12 N·m (106 lb in).

6. Install the bolt for the engine wiring harness bracket to the positive battery cable junction block bracket.

Tighten

Tighten the wiring harness bracket nuts to 12 N·m (106 lb in).



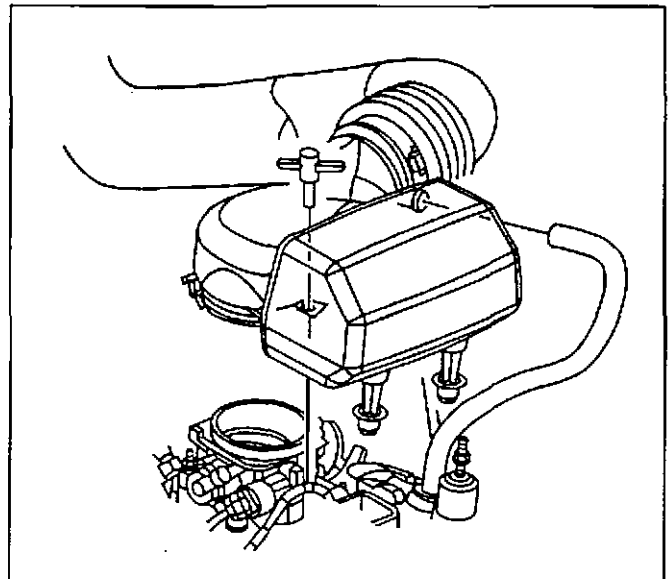
310241

SIE-ID = 329728

Valve Rocker Arm Cover Replacement (Right)

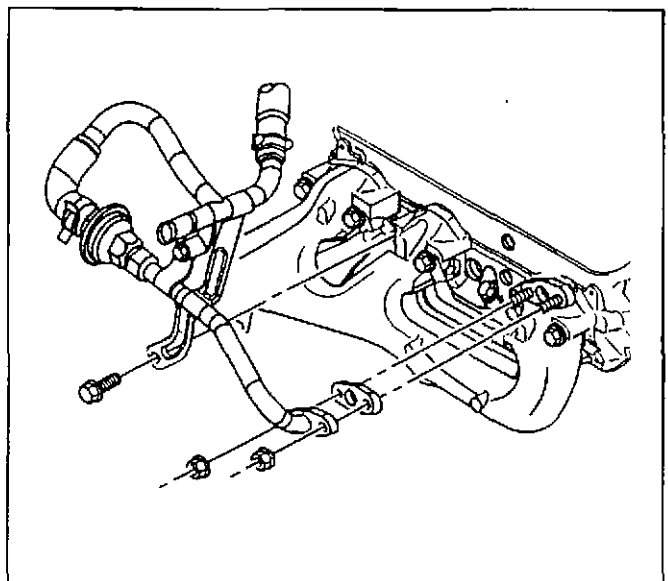
Removal Procedure

1. Disconnect the PCV hose from the air inlet duct.
2. Remove the air inlet duct from the throttle body and the mass air flow (MAF) sensor.

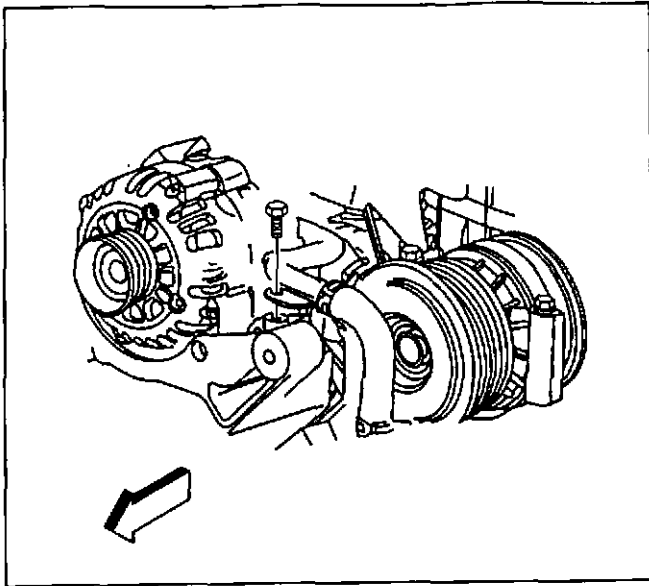


310234

3. Disconnect the secondary air injection (AIR) pipe assembly from the AIR crossover pipe and the AIR pump, if equipped.
4. Remove the AIR pipe assembly from the exhaust manifold, if equipped.

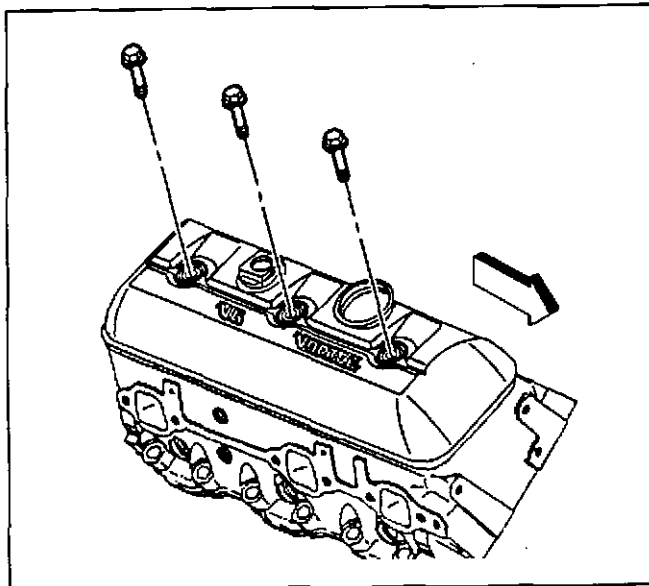


332026



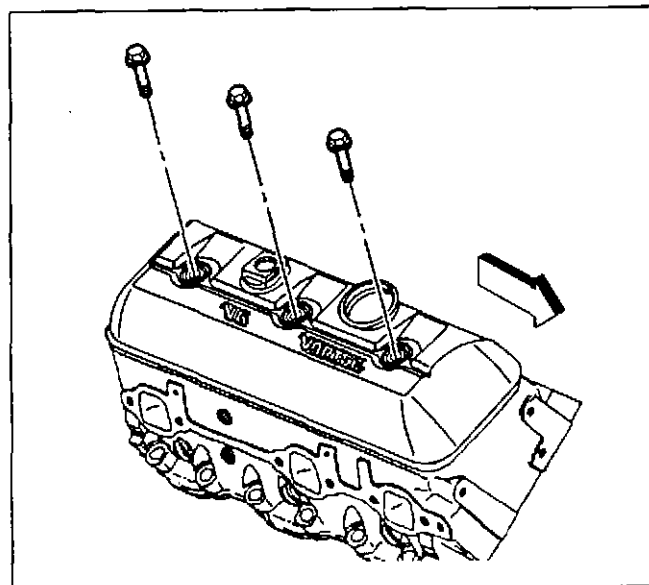
316440

5. Remove the heater hose bracket bolt.
6. Move and secure the heater hoses out of the way.
7. Move and secure the engine wiring harness out of the way.



328568

8. Remove the right valve rocker arm cover. Refer to *Valve Rocker Arm Cover Removal (Right)*.
9. Clean all sealing surfaces. Refer to *Valve Rocker Arm Cover Clean and Inspect*.



328568

Installation Procedure

1. Install the right valve rocker arm cover and bolts. Refer to *Valve Rocker Arm Cover Installation (Right)*.

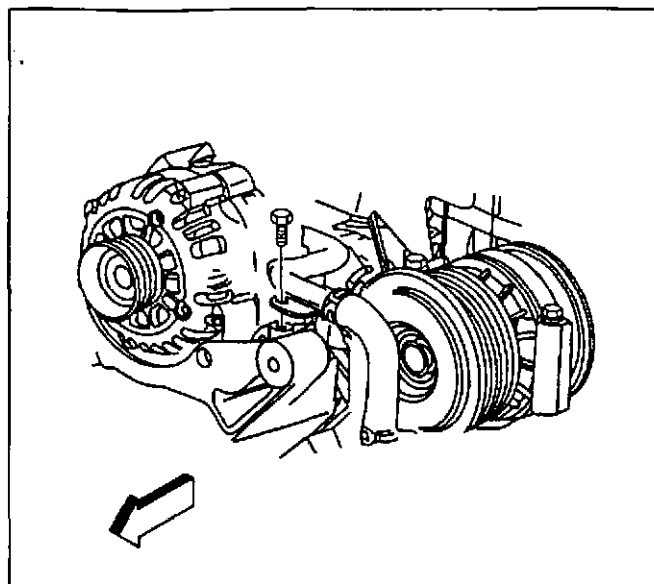
2. Reposition the engine wiring harness.
3. Reposition the heater hoses.

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

4. Install the heater hose bracket bolt.

Tighten

Tighten the bracket bolt to 25 N.m (18 lb ft).



316440

5. Install the AIR pipe assembly to the exhaust manifold.

Install the AIR pipe nuts to the exhaust manifold.

Tighten

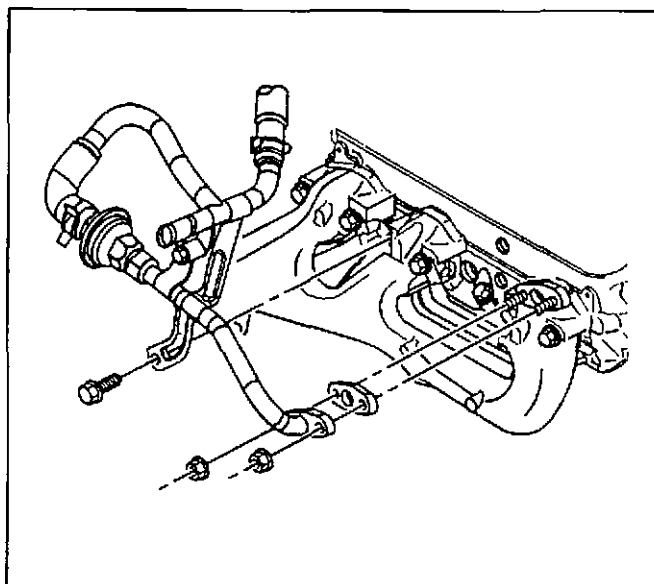
Tighten the AIR pipe nuts to 25 N.m (18 lb in).

6. Install the AIR pipe assembly bracket bolt to the exhaust manifold.

Tighten

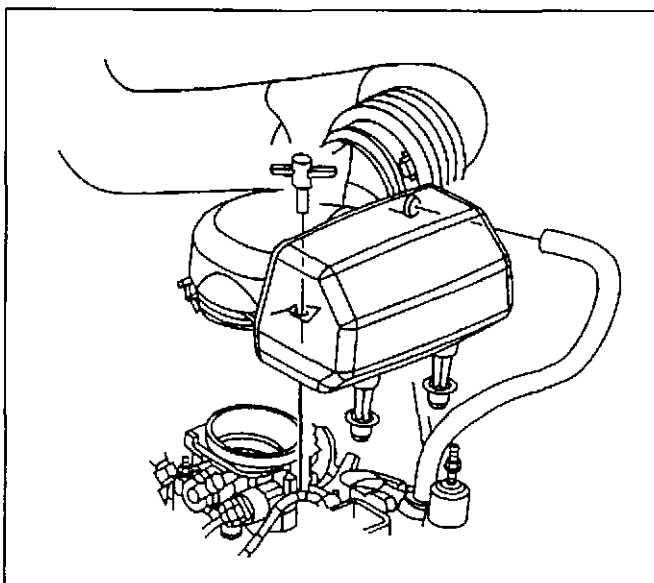
Tighten the AIR pipe bracket bolt to 10 N.m (88 lb in).

7. Connect the AIR pipe assembly to the AIR pump and the AIR crossover pipe.

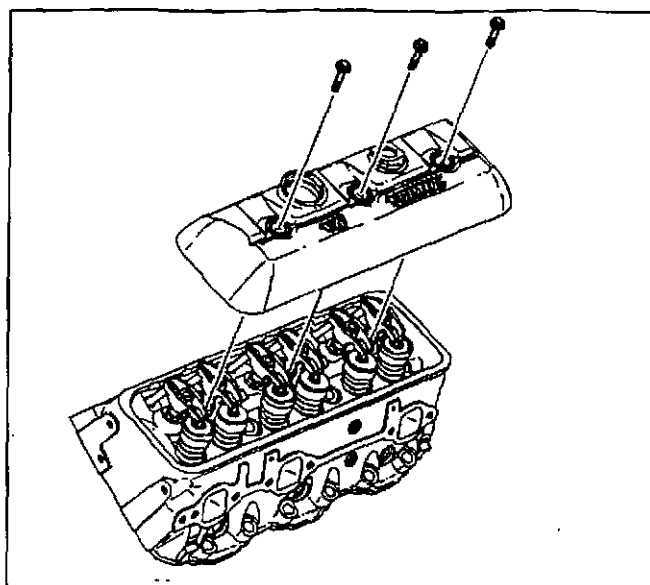


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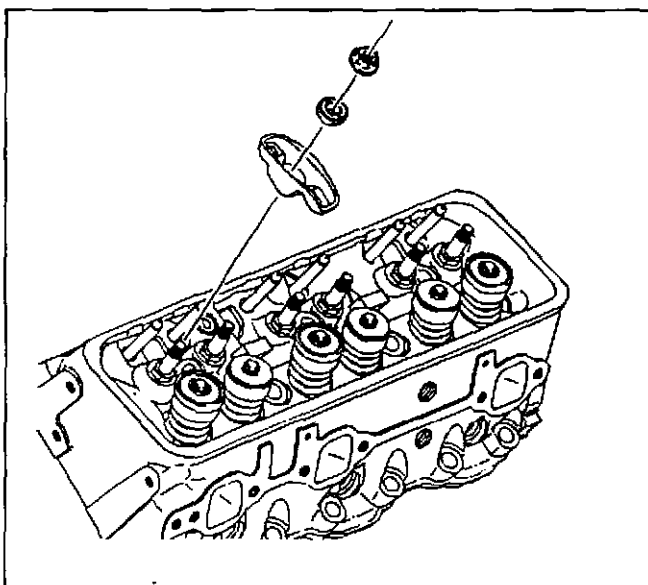
8. Install the air inlet duct to the MAF sensor and the throttle body.
9. Install the PCV hose.



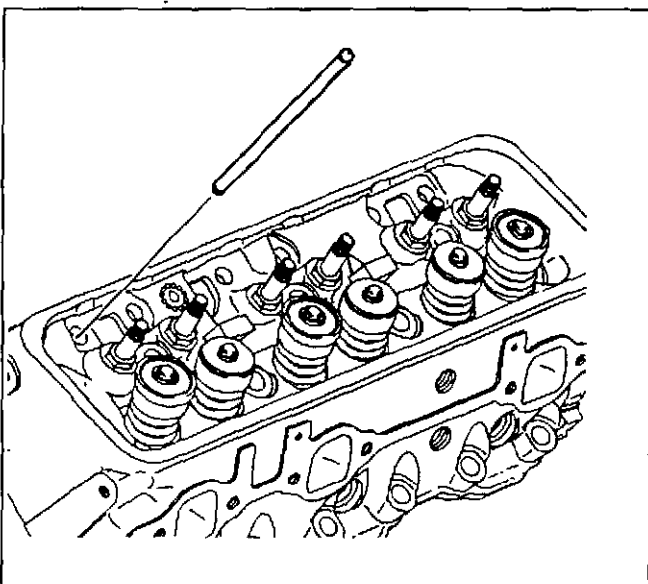
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SIE-ID - 329729

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

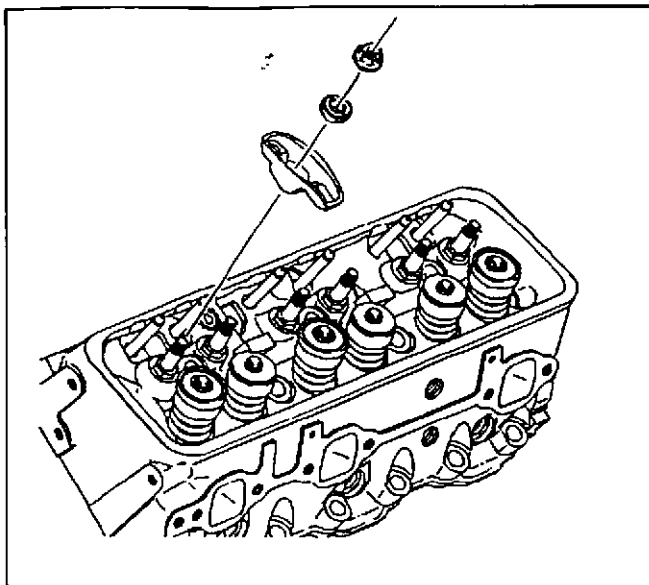
1. Remove the valve rocker arm cover.
 - Refer to *Valve Rocker Arm Cover Replacement (Left)*.
 - Refer to *Valve Rocker Arm Cover Replacement (Right)*.

2. Remove the valve rocker arm nut and the valve rocker arm with the valve rocker arm ball. Refer to *Valve Rocker Arm and Push Rod Installation*.
3. Remove the valve pushrods.
4. Clean and inspect the valve rocker arms and the valve pushrods. Refer to *Valve Rocker Arm Cover Clean and Inspect*.

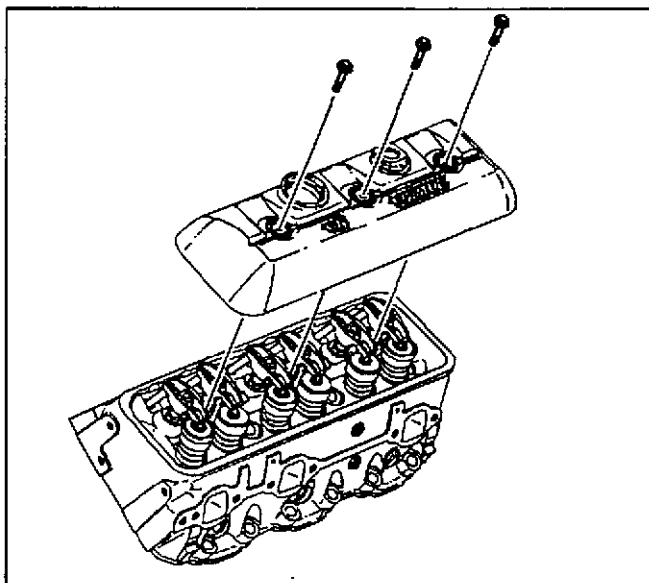
Installation Procedure

1. Install the valve pushrod.

2. Install the valve rocker arm nut and the valve rocker arm with the valve rocker arm ball. Refer to *Valve Rocker Arm and Push Rod Installation*.



3. Install the valve rocker arm cover.
 - Refer to *Valve Rocker Arm Cover Replacement (Left)*.
 - Refer to *Valve Rocker Arm Cover Replacement (Right)*.



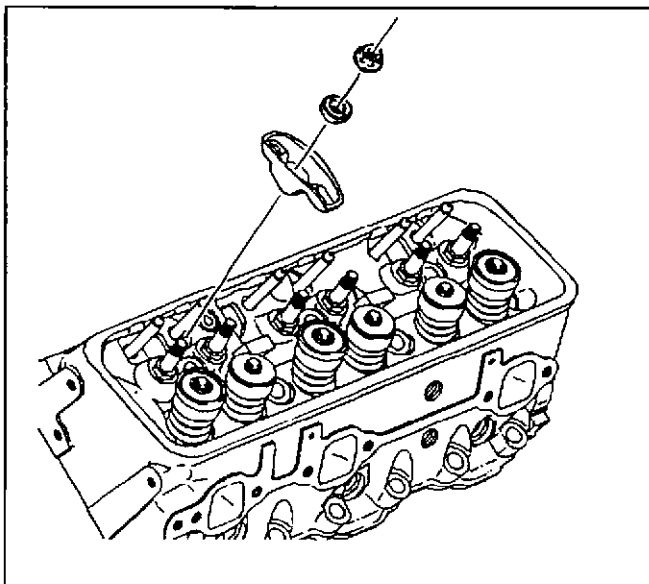
SIE-ID = 329731

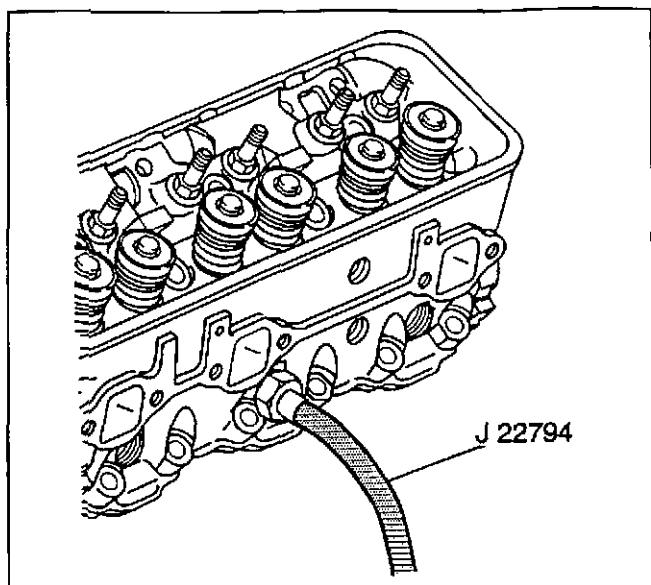
Valve Stem Oil Seal and Valve Spring Replacement

Removal Procedure

Tools Required

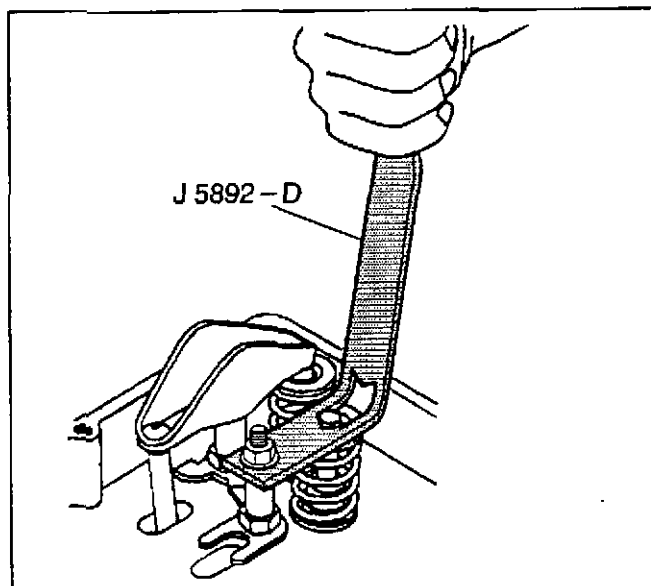
- J 22794 Spark Plug Port Adapter
 - J 38606 Valve Spring Compressor
 - J 5892-D Valve Spring Compressor
1. Remove the valve rocker arms. Refer to *Valve Rocker Arm and Push Rod Replacement*.
 2. Remove the spark plugs. Refer to *Spark Plug Replacement (4.3L, 4.8L, 5.3L, 6.0L)* in Engine Electrical.





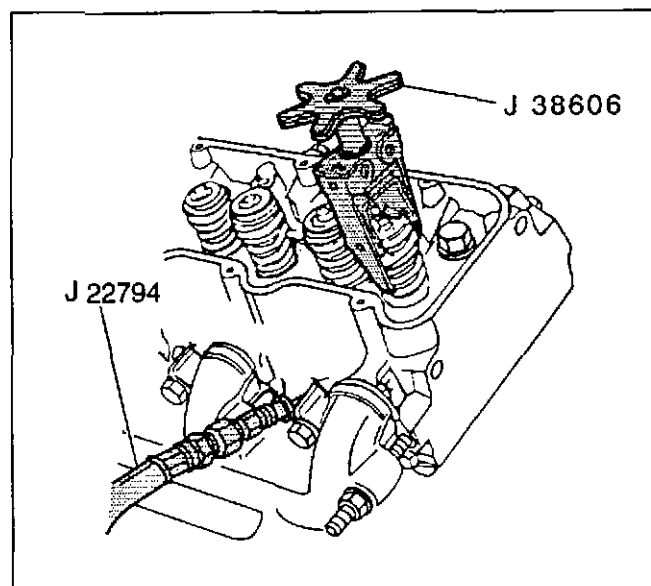
218209

3. Install the *J 22794* into the spark plug hole.
4. Apply compressed air in order to hold the valves in place.
5. Install a valve rocker arm nut.



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6. Use the *J 5892-D* in order to compress the valve spring.

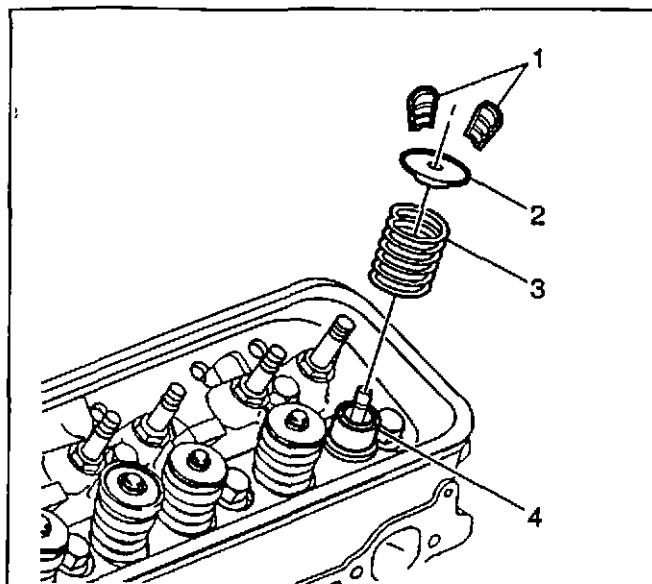


218211

Notice: When using *J 38606* ensure that the jaws are completely engaged on the valve spring. If the jaws are not completely engaged the jaws may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratch.

7. Use *J 38606* when *J 5892-D* will not fit.

8. Remove the valve keys (1).
9. Carefully release the valve spring tension.
10. Remove the *J 5892-D* or the *J 38606*.
11. Remove the valve spring cap (2) and the valve spring (3).
12. Remove the valve stem oil seal (4).



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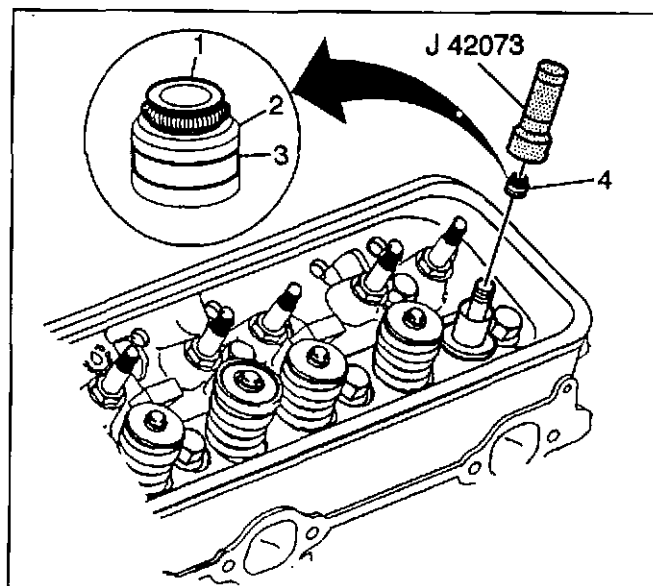
Installation Procedure

Tools Required

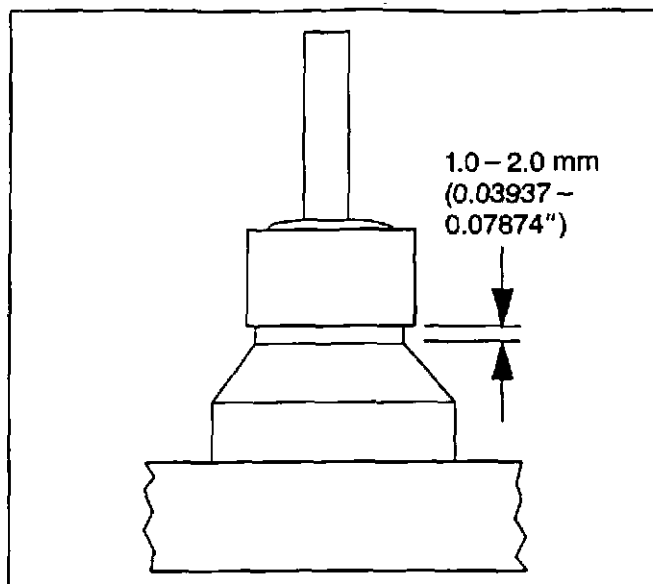
- *J 22794* Spark Plug Port Adapter
- *J 38606* Valve Spring Compressor
- *J 42073* Valve Stem Seal Installer
- *J 5892-D* Valve Spring Compressor

Important: The exhaust valve oil seal has the letters EX (1) molded into the top of the seal. The seal material is brown in color (2) with a white stripe (3) painted on the outside diameter of the seal or the material may be off-white in color (2) with no paint stripe. The intake valve seal is black in color. The exhaust and intake valve seals are not interchangeable.

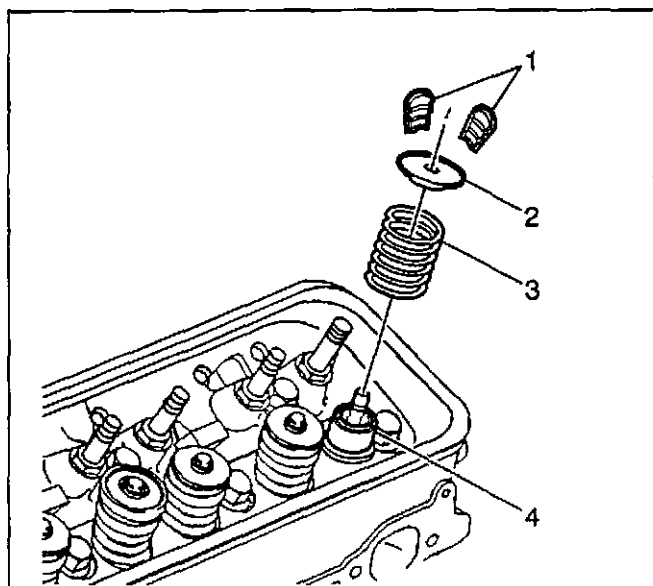
1. Select the proper valve stem oil seal for the specific valve guide.
2. Lubricate the valve stem oil seal and the outside diameter of the valve guide with clean engine oil.
3. Assemble the valve stem oil seal onto the valve guide using the *J 42073* and a hammer.
4. Install the valve stem oil seal onto the valve guide until the installation tool bottoms against the valve spring seat.



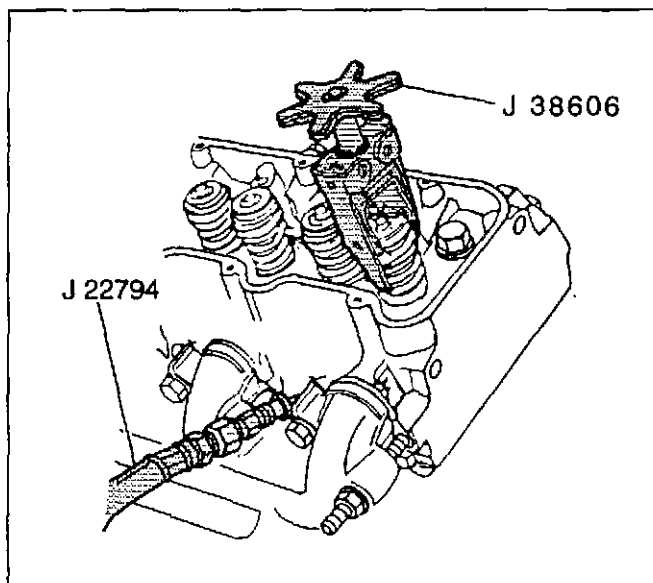
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5. Inspect the oil seal. The seal should not be bottomed against the valve guide. There should be a 1–2 mm (0.03937– 0.07874 in) gap between the bottom edge of the valve stem oil seal and the valve guide.

6. Install the valve spring (3).
7. Install the valve spring cap (2) on the valve stem.
8. Compress the valve spring (3) using the J 5892-D.

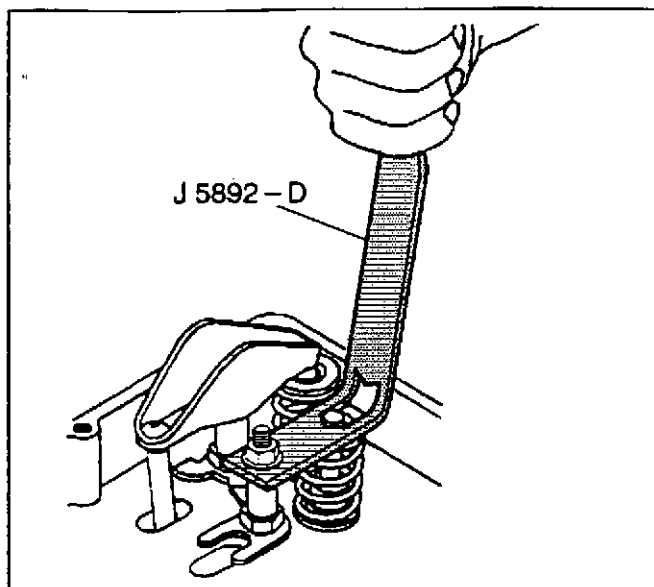
Notice: When using J 38606 ensure that the jaws are completely engaged on the valve spring. If the jaws are not completely engaged the jaws may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratch.

9. Use the J 38606 if the clearance does not permit use of the J 5892-D.

Notice: Make sure that the valve stem keys are properly seated in the valve spring cap. Engine damage could occur if not properly installed.

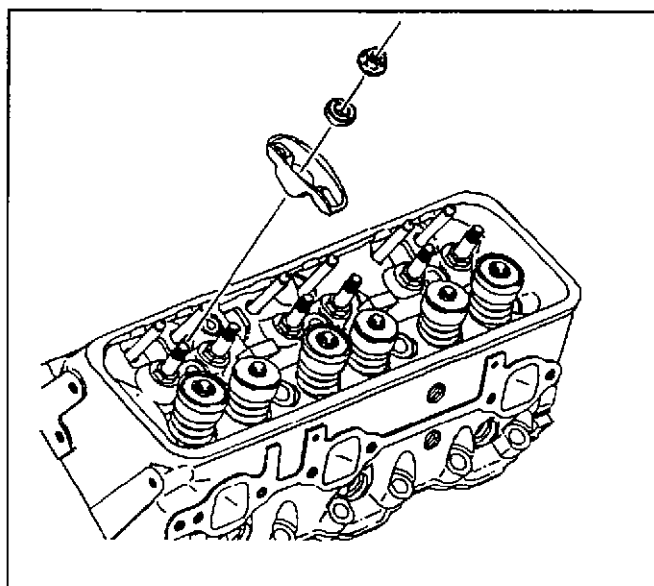
10. Install the valve stem keys. Use grease in order to hold the valve keys in place.

11. Carefully release the valve spring pressure, making sure the valve stem keys stay in place.



1964

12. Remove the *J 5892-D* or the *J 38606* and the *J 22794*.
13. Install the spark plugs. Refer to *Spark Plug Replacement (4.3L, 4.8L, 5.3L, 6.0L)* in Engine Electrical.
14. Install the valve rocker arms to the cylinder head. Refer to *Valve Rocker Arm and Push Rod Replacement*.



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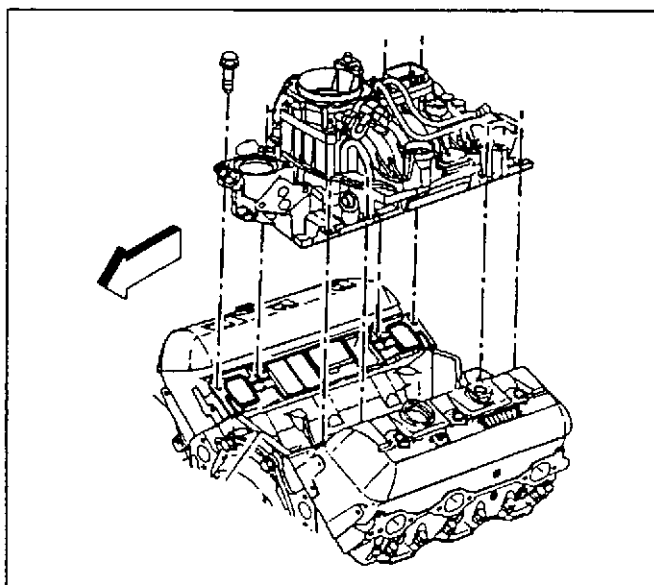
Valve Lifter Replacement

Removal Procedure

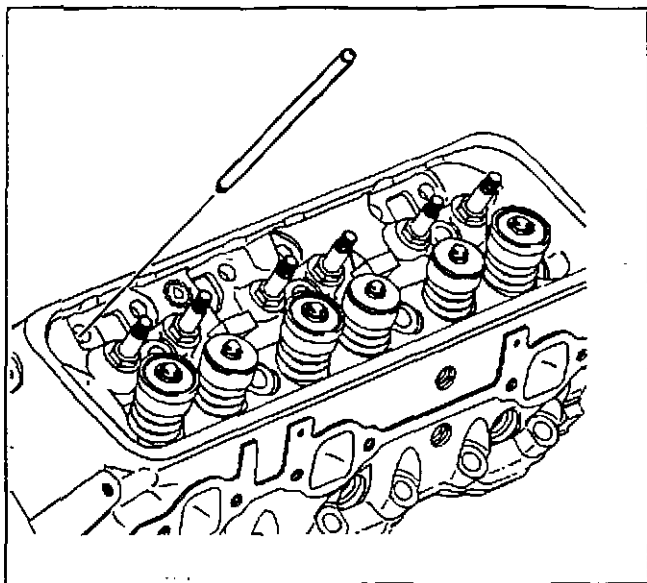
Tools Required

J 3049-A Valve Lifter Remover

1. Remove the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.

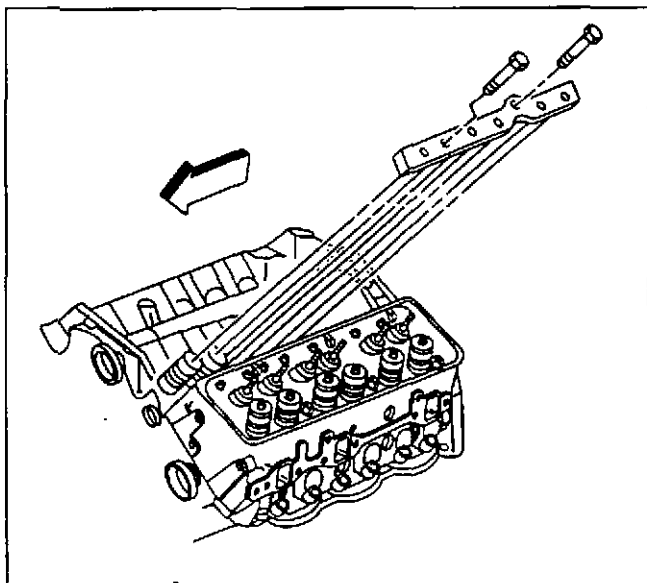


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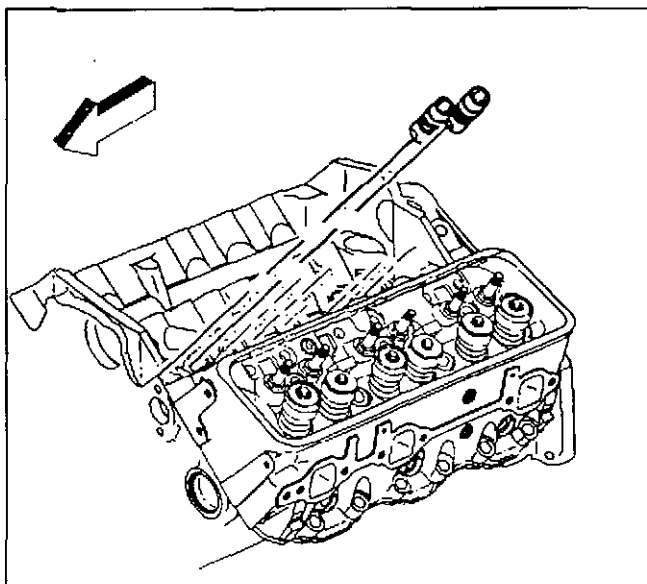
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2. Remove the valve pushrods and the valve rocker arms. Refer to *Valve Rocker Arm and Push Rod Replacement*.



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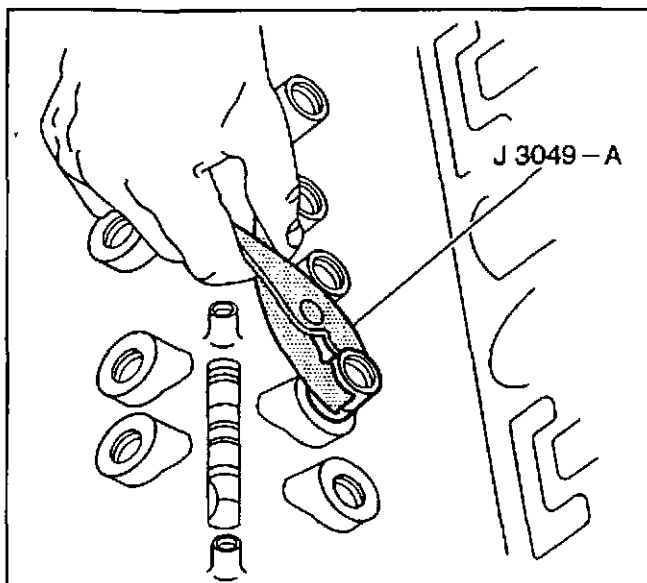
3. Remove the valve lifter pushrod guide and the bolts.



4578

4. Remove the valve lifters from the engine block. Refer to *Valve Lifter Removal*.

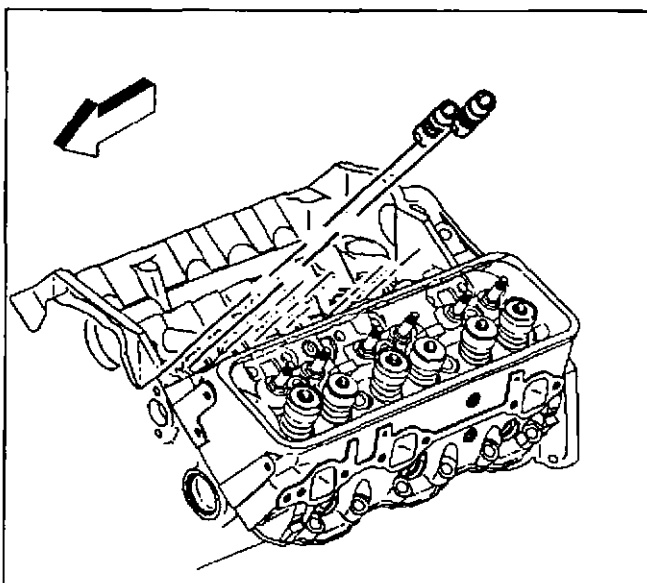
5. Use the J 3049-A in order to remove stuck lifters.



31350

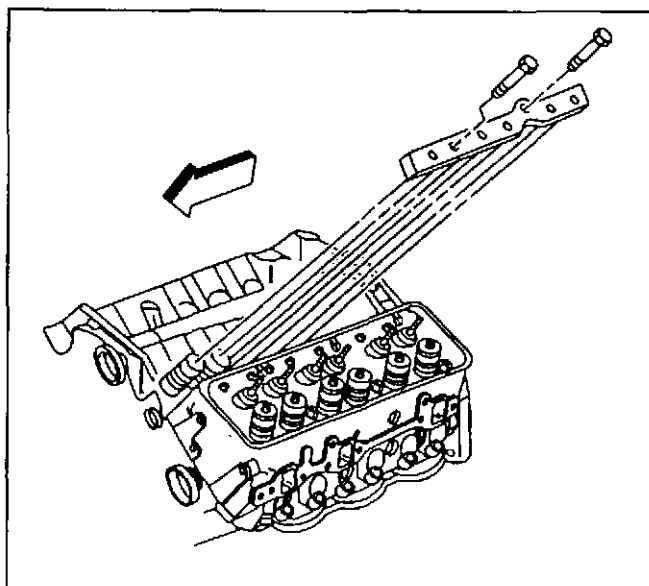
Installation Procedure

1. Install the valve lifters to the engine block. Refer to *Valve Lifter Installation*.

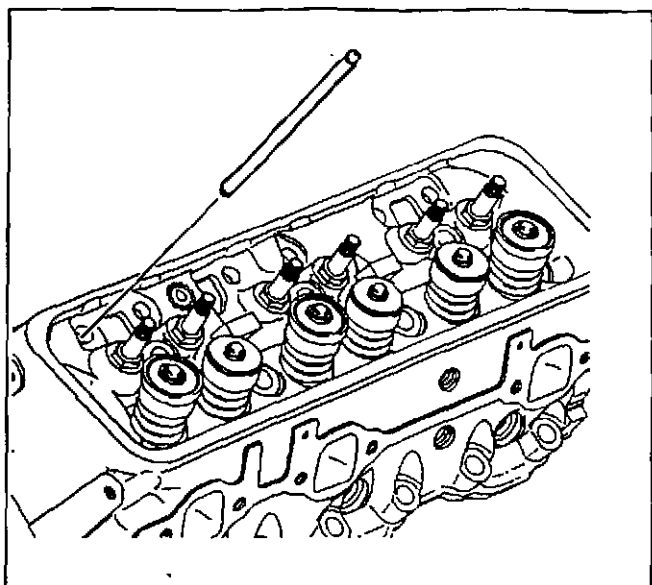


4576

2. Install the valve lifter pushrod guide. Refer to *Valve Lifter Installation*.

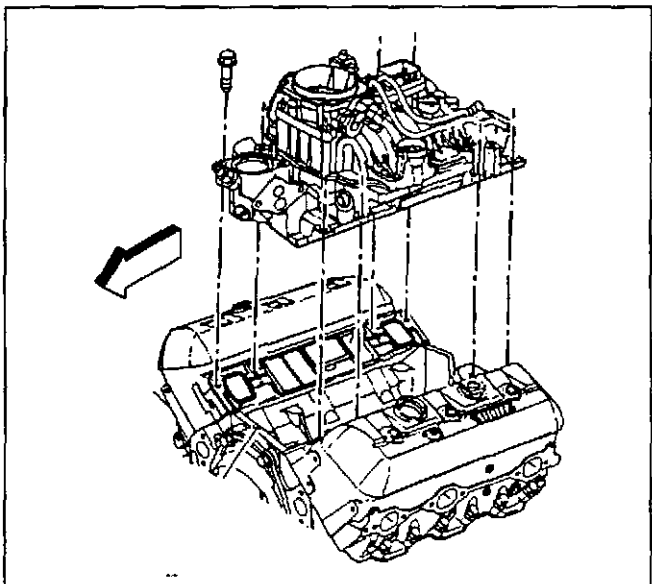


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3. Install the valve pushrods and valve rocker arms. Refer to *Valve Rocker Arm and Push Rod Replacement*.

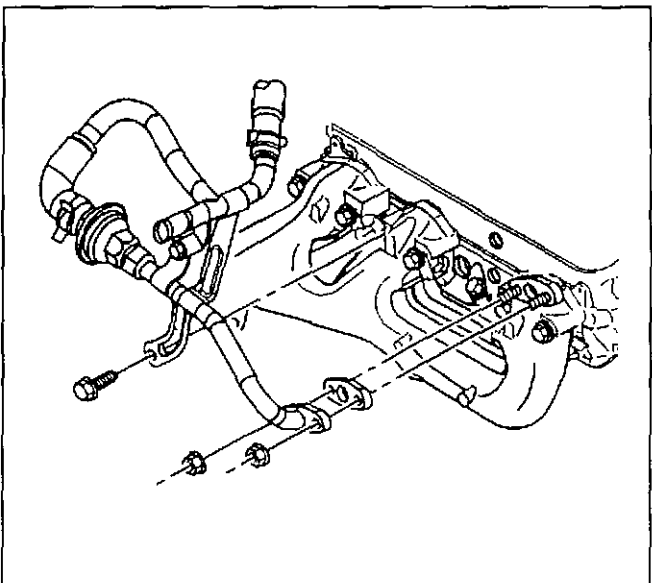


31510

4. Install the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.

Important

It is normal for NEW lifters to make a slight ticking noise when the engine is first started. Increasing the engine RPMs slightly to raise oil pressure should stop the noise.



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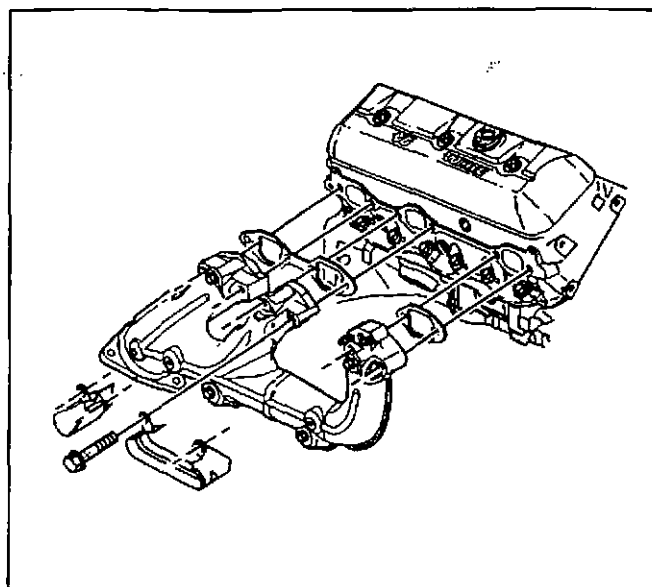
SIE-ID - 329737

Exhaust Manifold Replacement (Right)

Removal Procedure

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Disconnect the exhaust pipe from the exhaust manifold. Refer to *Catalytic Converter Replacement (System A 4.3L, 4.8L, and 5.3L)* in Engine Exhaust.
3. Lower the vehicle.
4. Remove the secondary air injection (AIR) pipe assembly, if equipped from the exhaust manifold. Refer to *AIR Check Valve/Pipe Replacement - Bank 2* in Engine Controls.
5. Disconnect the spark plug wires from the spark plugs. Refer to *Spark Plug Wire Harness Replacement (4.3L)* in Engine Electrical.

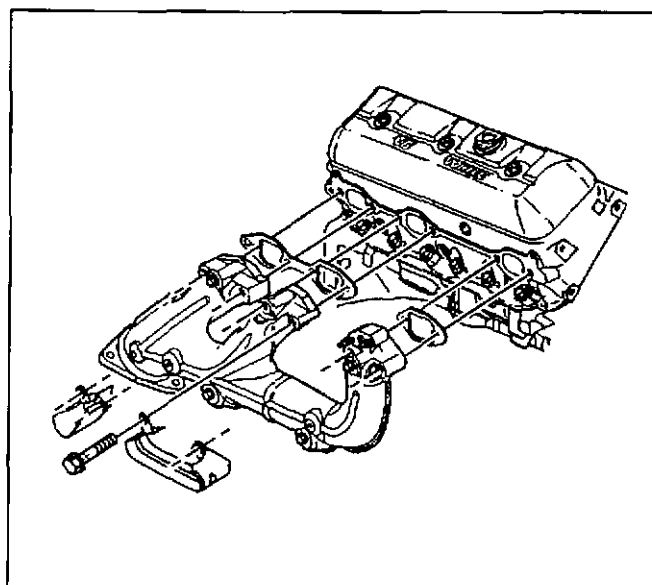
6. Remove the exhaust manifold bolts.
7. Remove the exhaust manifold and the spark plug wire shields from the engine.
8. Clean all gasket surfaces. Refer to *Exhaust Manifold Clean and Inspect*.
9. Remove the heat shield from the exhaust manifold, if necessary.



332371

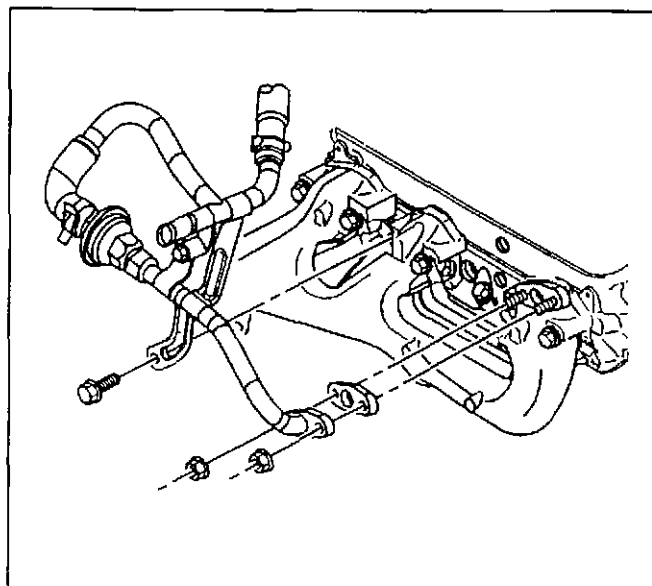
Installation Procedure

1. Install the heat shield to the exhaust manifold, if removed.
Notice: Refer to *Fastener Notice* in Cautions and Notices.
2. Install the heat shield bolts.
Tighten
Tighten the heat shield bolts to 9 N.m (80 lb in).
3. Sub-assemble the bolts, spark plug wire shields, and NEW gaskets to the exhaust manifold.
4. Install the exhaust manifold. Refer to *Exhaust Manifold Installation (Right)*.

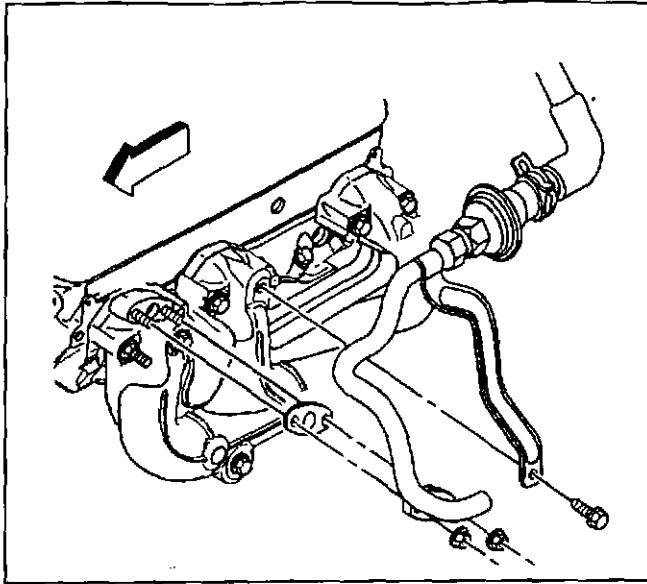


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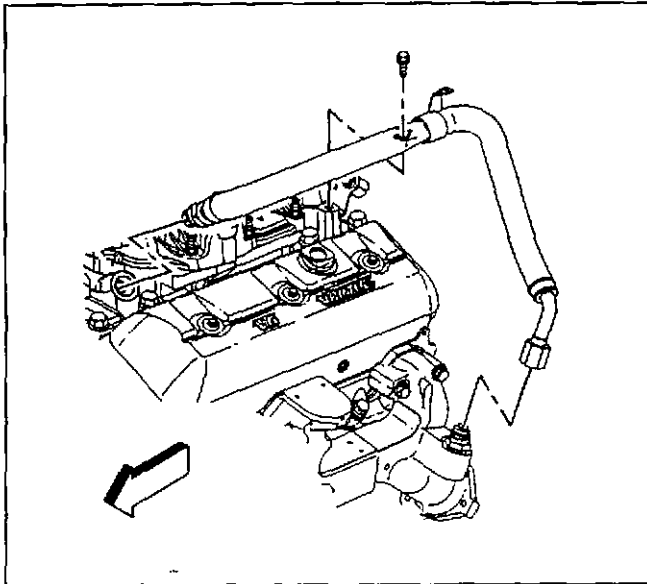
5. Install the AIR pipe assembly, if equipped to the exhaust manifold. Refer to *AIR Check Valve/Pipe Replacement - Bank 2* in Engine Controls.
6. Connect the spark plug wires to the spark plugs. Refer to *Spark Plug Wire Harness Replacement (4.3L)* in Engine Electrical.
7. Raise the vehicle.
8. Connect the exhaust pipe to the exhaust manifold. Refer to *Catalytic Converter Replacement (System A 4.3L, 4.8L, and 5.3L)* in Engine Exhaust.
9. Lower the vehicle.



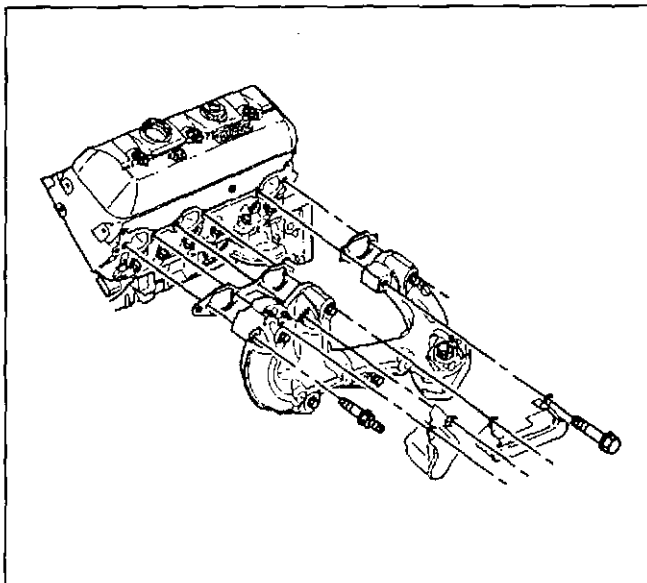
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Exhaust Manifold Replacement (Left)

Removal Procedure

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle*.
2. Disconnect the exhaust pipe from the exhaust manifold. Refer to *Catalytic Converter Replacement (System A 4.3L, 4.8L, and 5.3L)* in Engine Exhaust.
3. Lower the vehicle.
4. Remove the secondary air injection (AIR) pipe assembly, if equipped from the exhaust manifold. Refer to *AIR Check Valve/Pipe Replacement - Bank 1* in Engine Controls.
5. Disconnect the spark plug wires from the spark plugs. Refer to *Spark Plug Wire Harness Replacement (4.3L)* in Engine Electrical.
6. Disconnect the exhaust gas recirculation (EGR) valve inlet pipe from the exhaust manifold.
7. Disconnect the engine coolant temperature (ECT) gauge sensor electrical connector.
8. Remove the exhaust manifold bolts and the stud.
9. Remove the exhaust manifold and the spark plug wire shields from the engine.
10. Clean all gasket surfaces. Refer to *Exhaust Manifold Clean and Inspect*.
11. Remove the heat shield from the exhaust manifold, if necessary.

Installation Procedure

1. Install the heat shield to the exhaust manifold, if removed.

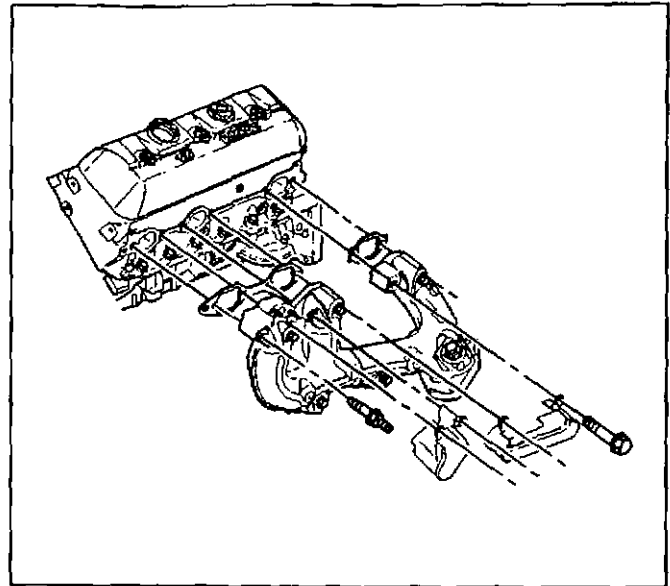
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the heat shield bolts.

Tighten

Tighten the heat shield bolts to 9 N.m (80 lb in).

3. Sub-assemble the bolts, spark plug wire shields, and NEW gaskets to exhaust manifold.
4. Install the exhaust manifold. Refer to *Exhaust Manifold Installation (Left)*.



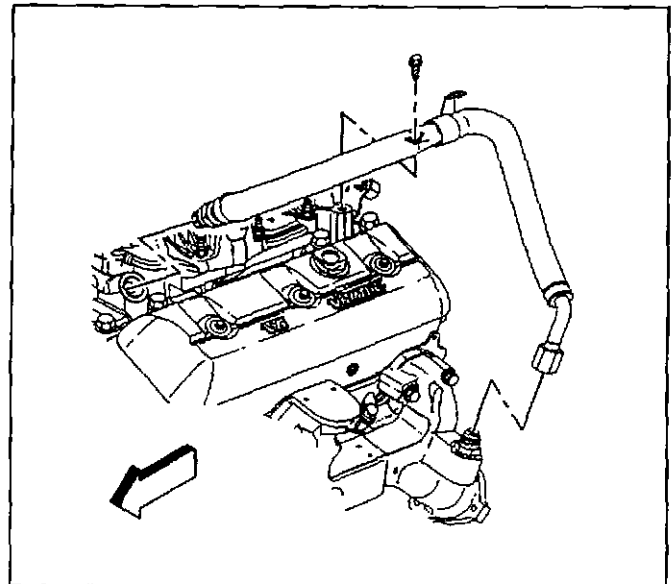
332373

5. Connect the EGR valve inlet pipe to the exhaust manifold.

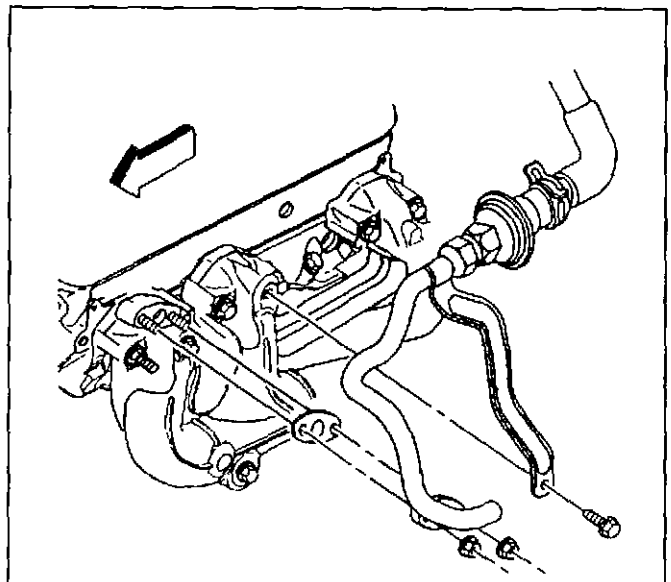
Tighten

Tighten the EGR valve inlet pipe nut to 30 N.m (22 lb ft).

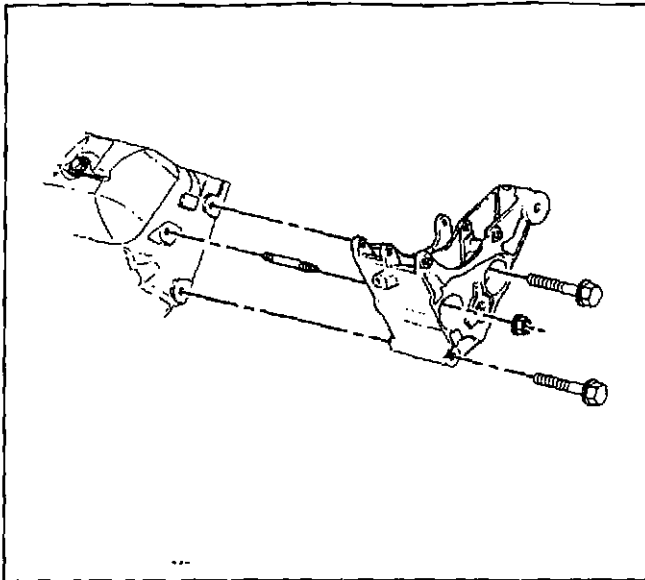
6. Connect the (ECT) gauge sensor electrical connector.
7. Connect the spark plug wires to the spark plugs. Refer to *Spark Plug Wire Harness Replacement (4.3L)* in Engine Electrical.
8. Install the AIR pipe assembly to the exhaust manifold. Refer to *AIR Check Valve/Pipe Replacement - Bank 1* in Engine Controls.
9. Raise the vehicle.
10. Connect the exhaust pipe to the exhaust manifold. Refer to *Catalytic Converter Replacement (System A 4.3L, 4.8L, and 5.3L)* in Engine Exhaust.
11. Lower the vehicle.



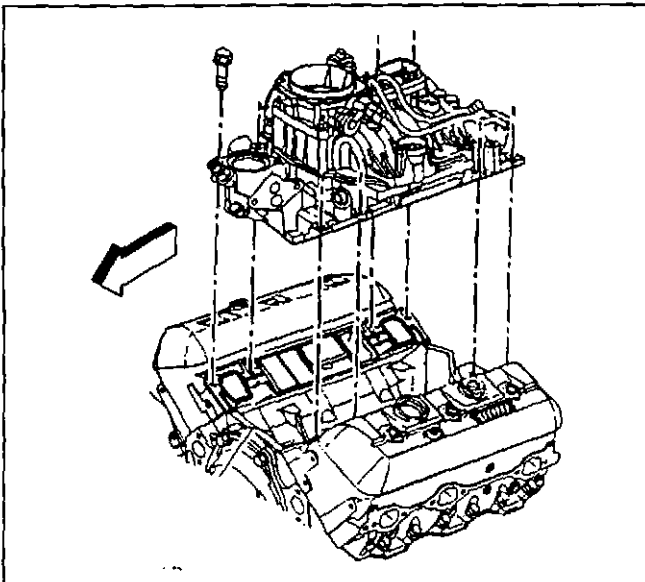
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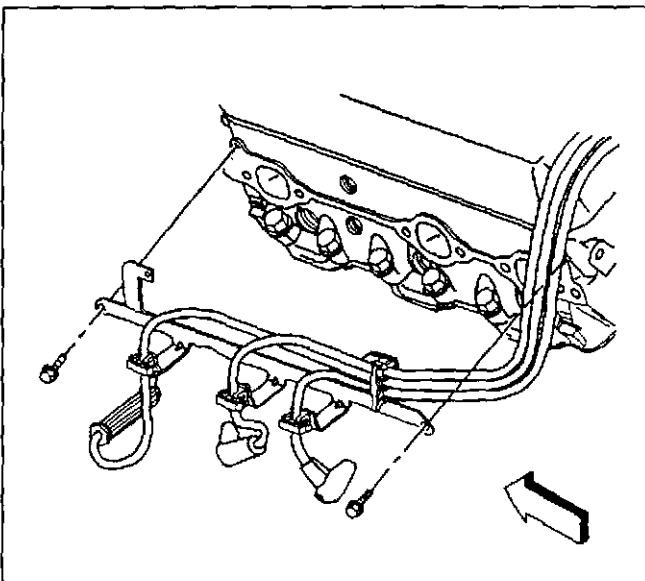
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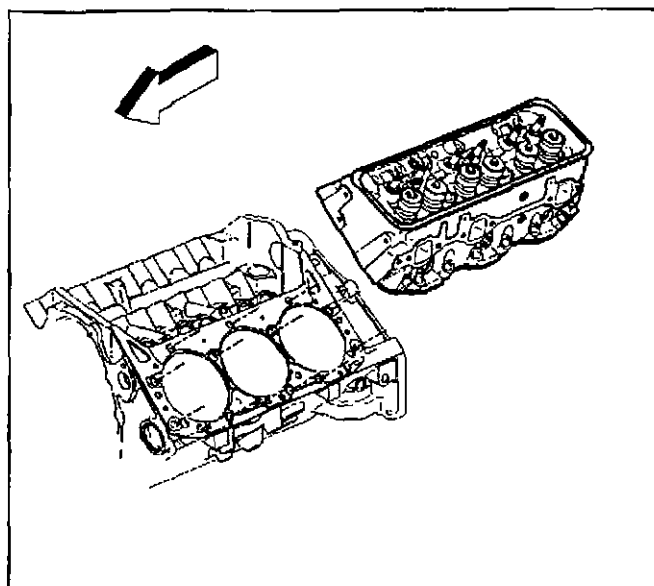
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Cylinder Head Replacement (Right)

Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.
2. Drain the engine coolant. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Remove the engine cooling fan assembly. Refer to *Fan Clutch Replacement* in Engine Cooling.
4. Remove the generator mounting bracket. Refer to *Accessory Mounting Brackets Replacement (Generator Mounting Bracket)*.
5. Remove the generator mounting bracket stud from the cylinder head.
6. Remove the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
7. Remove the exhaust manifold. Refer to *Exhaust Manifold Replacement (Right)*.
8. Remove the spark plug wire harness and spark plug wire support.
9. Remove the valve pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.

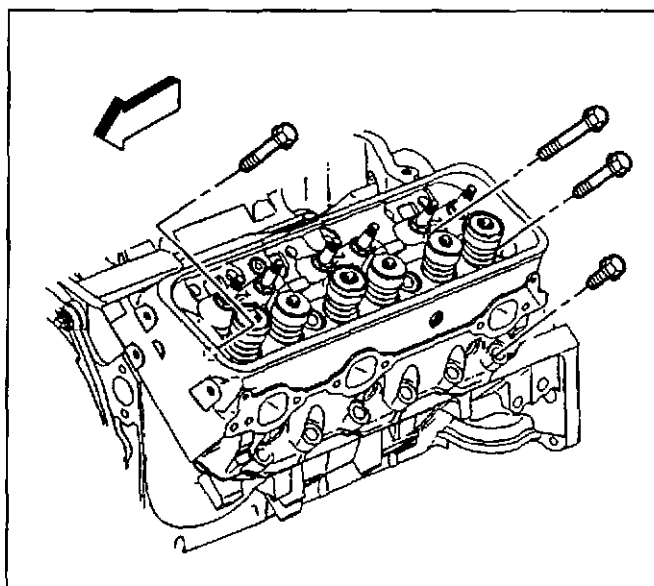
10. Remove the cylinder head bolts.
11. Remove the cylinder head.
12. Clean all sealing surfaces. Refer to *Cylinder Head Clean and Inspect*.



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Installation Procedure

1. Install the cylinder head. Refer to *Cylinder Head Installation (Right)*.
2. Install the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.



5129

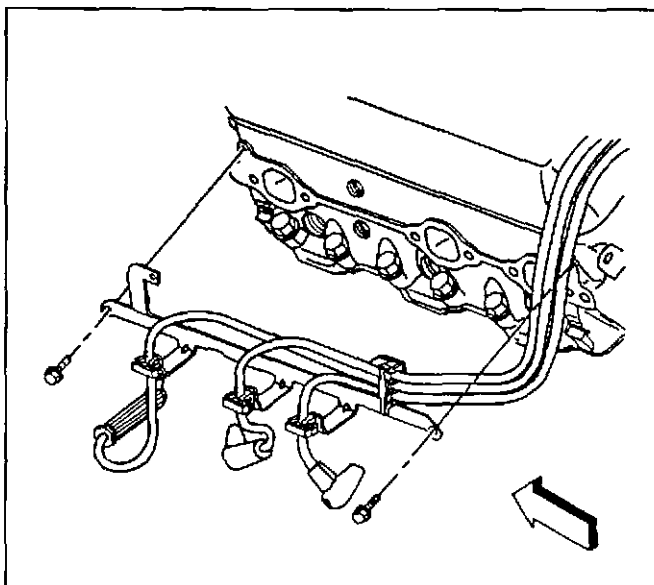
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the spark plug wire harness and the spark plug wire support.

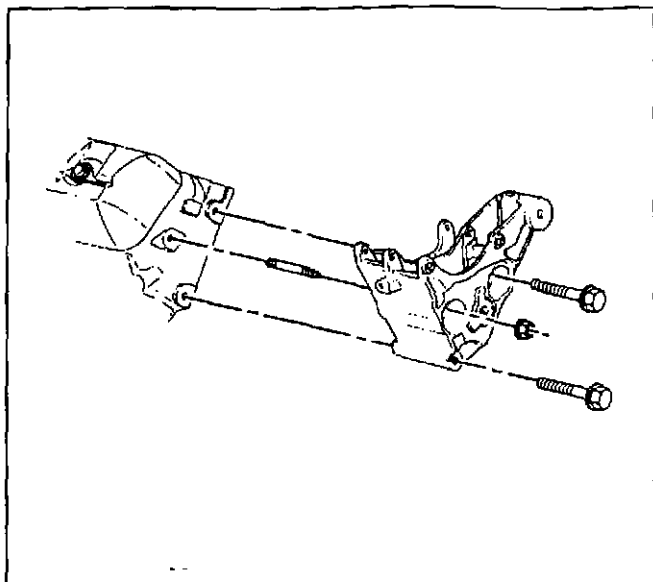
Tighten

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

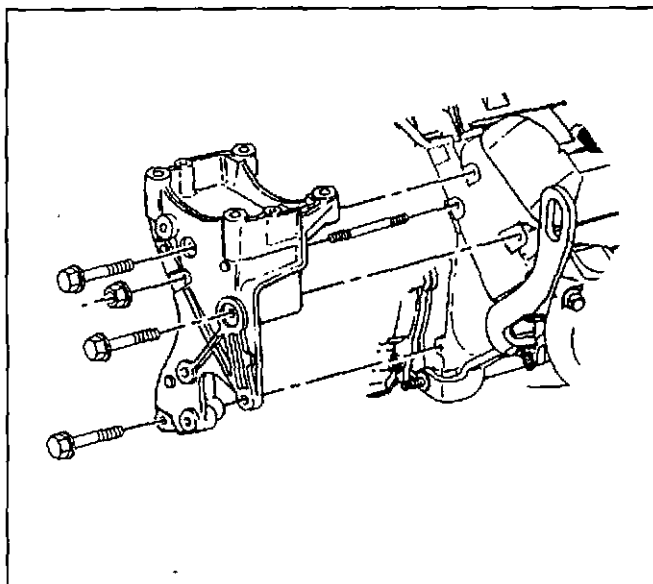
4. Install the exhaust manifold. Refer to *Exhaust Manifold Replacement (Right)*.



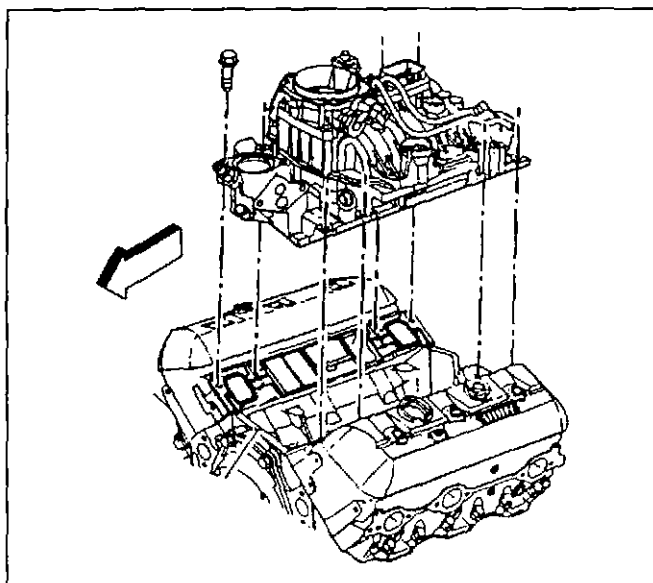
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5. Install the stud for the generator mounting bracket.

Tighten

Tighten the generator mounting bracket stud to 20 N·m (15 lb ft).

6. Install the generator mounting bracket. Refer to *Accessory Mounting Brackets Replacement (Generator Mounting Bracket)*.
7. Install the engine cooling fan assembly. Refer to *Fan Clutch Replacement* in Engine Cooling.
8. Fill the engine coolant system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
9. Connect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.

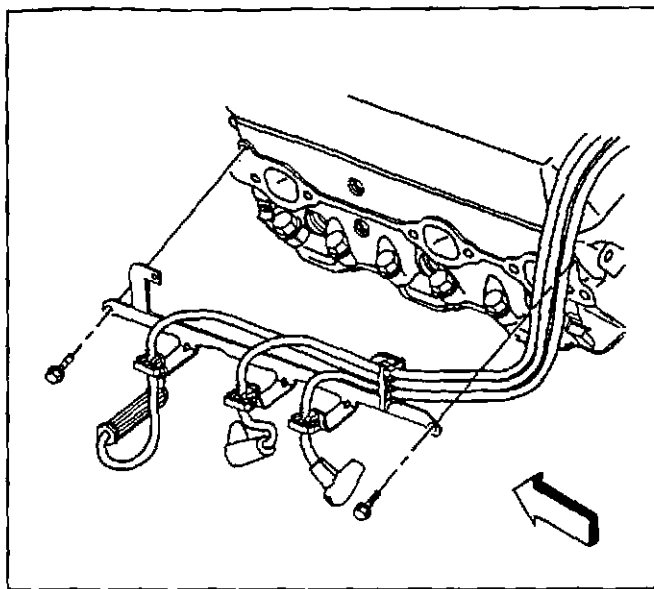
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Cylinder Head Replacement (Left)

Removal Procedure

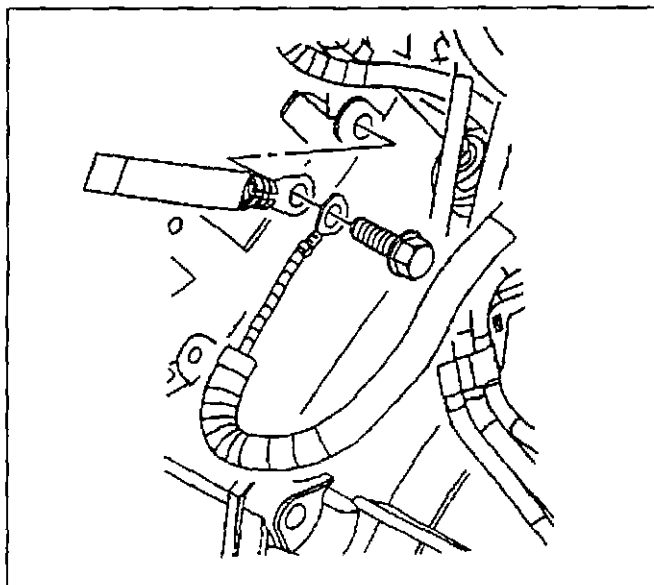
1. Disconnect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.
2. Drain the engine coolant. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Remove the engine cooling fan assembly. Refer to *Fan Clutch Replacement* in Engine Cooling.
4. Remove the power steering pump mounting bracket. Refer to *Accessory Mounting Brackets Replacement (P/S Pump Mounting Bracket)*.
5. Remove the power steering pump mounting bracket stud from the cylinder head.
6. Remove the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
7. Remove the exhaust manifold. Refer to *Exhaust Manifold Replacement (Left)*.

8. Remove the spark plug wire harness and the spark plug wire support.
9. Remove the valve pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.



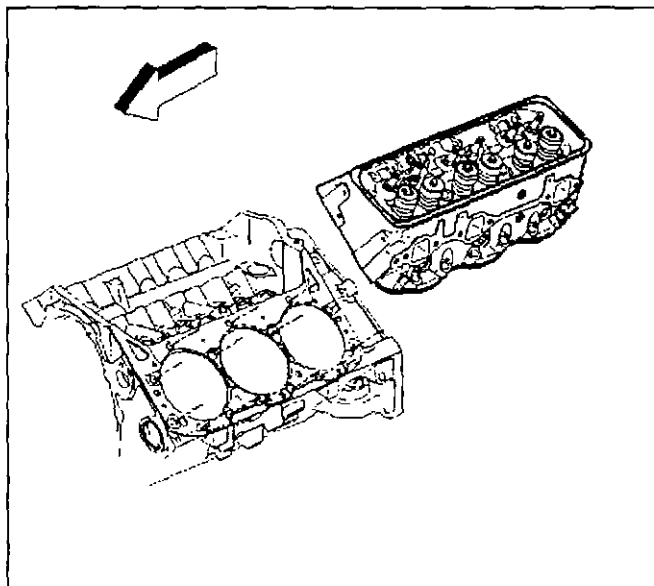
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10. Remove the ground strap and ground wire bolt from the rear of the cylinder head.

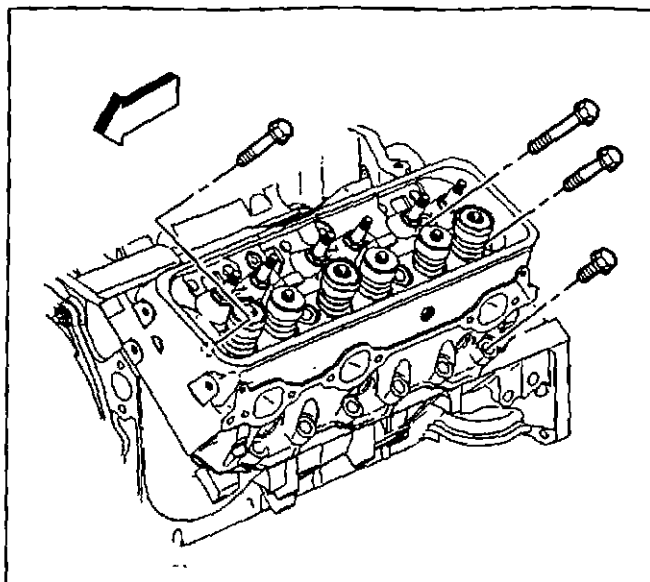


310256

11. Remove the cylinder head bolts.
12. Remove the cylinder head.
13. Clean all sealing surfaces. Refer to *Cylinder Head Clean and Inspect*.



5130



5129

Installation Procedure

1. Install the cylinder head. Refer to *Cylinder Head Installation (Left)*.

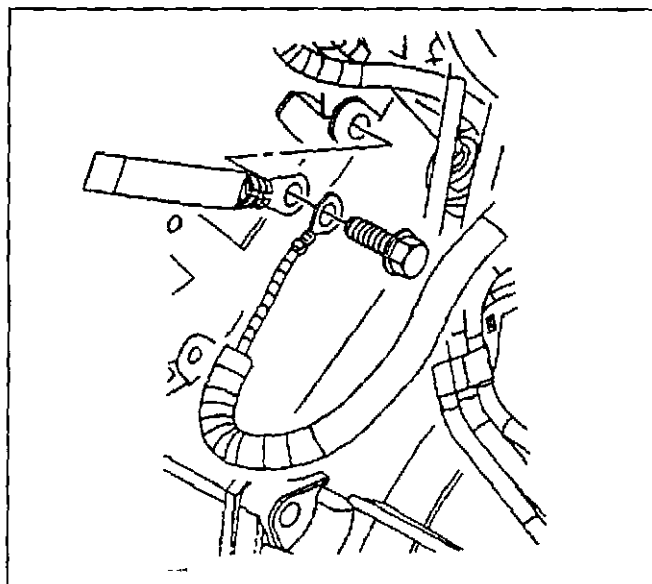
Notice: Refer to *Fastener Notice* in Cautions and Notices.

2. Install the ground strap and the ground wire bolt.

Tighten

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

3. Install the valve pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
4. Install the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
5. Install the exhaust manifold. Refer to *Exhaust Manifold Replacement (Left)*.

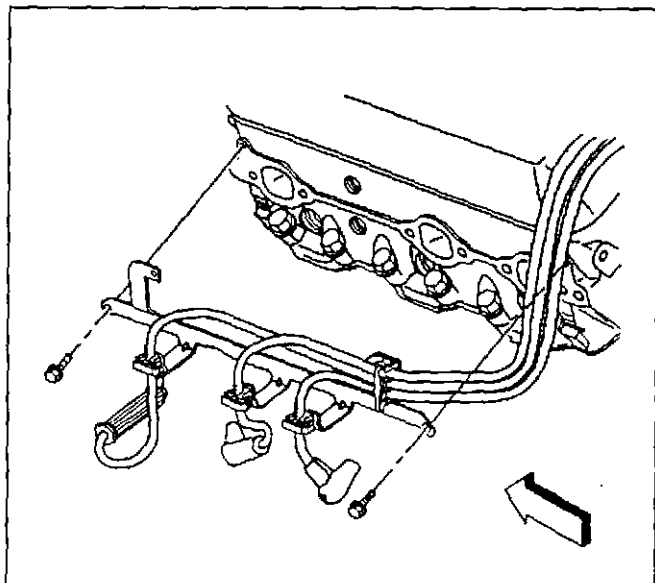


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6. Install the spark plug wire harness and spark plug wire support.

Tighten

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



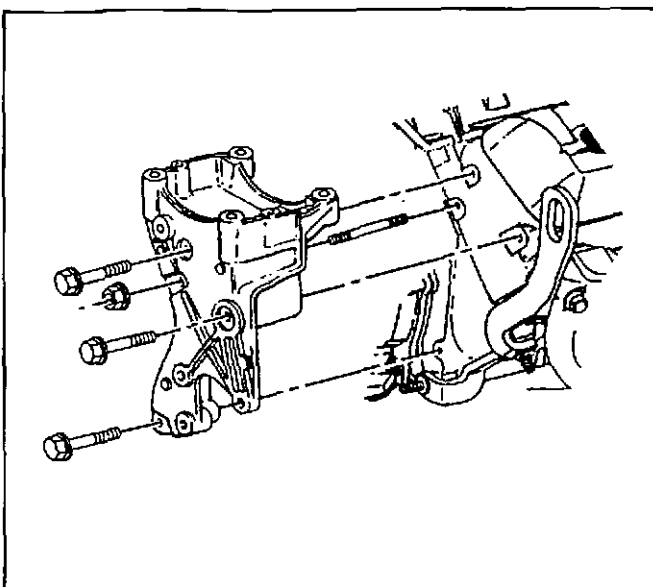
317450

7. Install the stud for the power steering pump mounting bracket to the cylinder head.

Tighten

Tighten the power steering pump mounting bracket stud to 20 N.m (15 lb ft).

8. Install the power steering pump mounting bracket. Refer to *Accessory Mounting Brackets Replacement (P/S Pump Mounting Bracket)*.
9. Install the engine cooling fan assembly. Refer to *Fan Clutch Replacement* in Engine Cooling.
10. Fill the engine coolant system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
11. Connect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.



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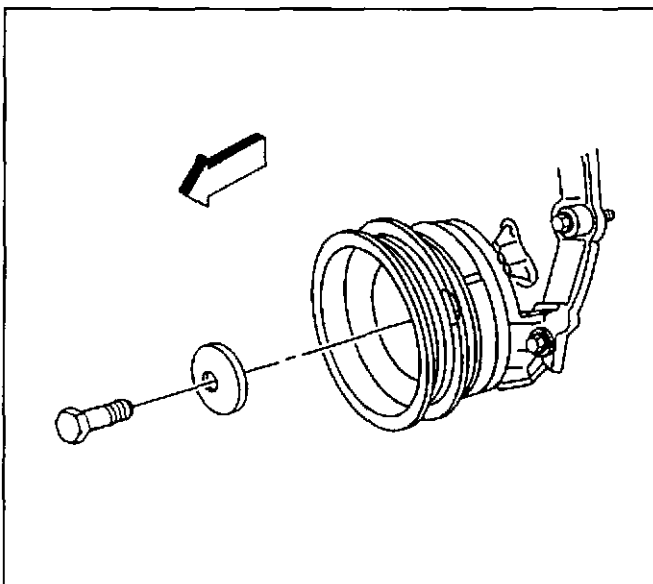
Crankshaft Balancer Replacement

Removal Procedure

Tools Required

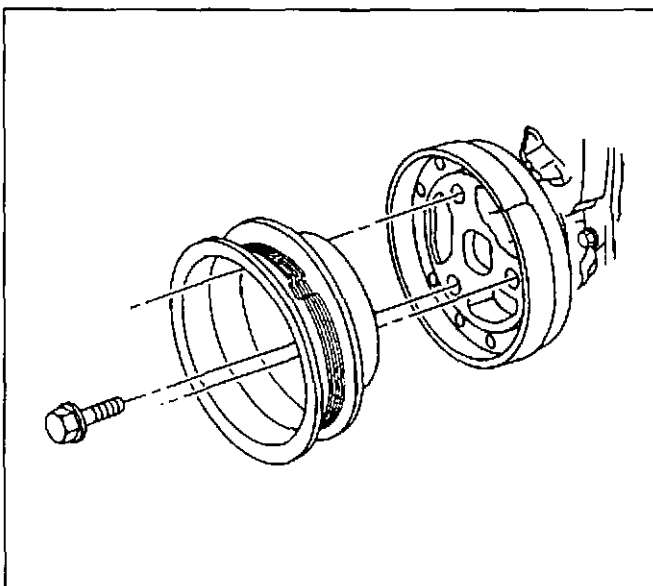
J 23523-F Balancer Remover and Installer

1. Disconnect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.
2. Remove the fan shroud assembly. Refer to *Fan Shroud Replacement* in Engine Cooling.
3. Remove the drive belt. Refer to *Drive Belt Replacement*.
4. Remove the crankshaft balancer bolt.

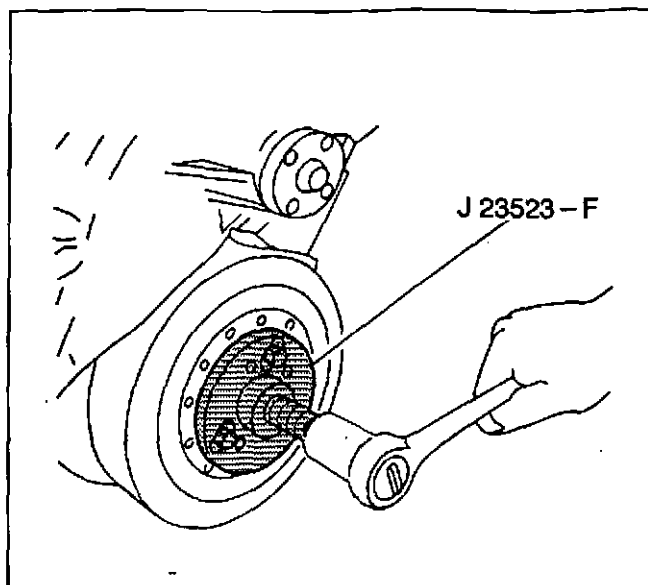


173172

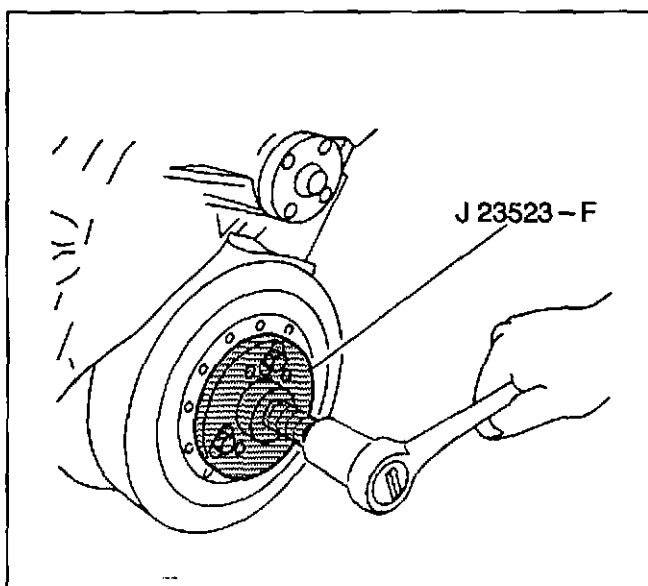
5. Remove the crankshaft pulley bolts.
6. Remove the crankshaft pulley.



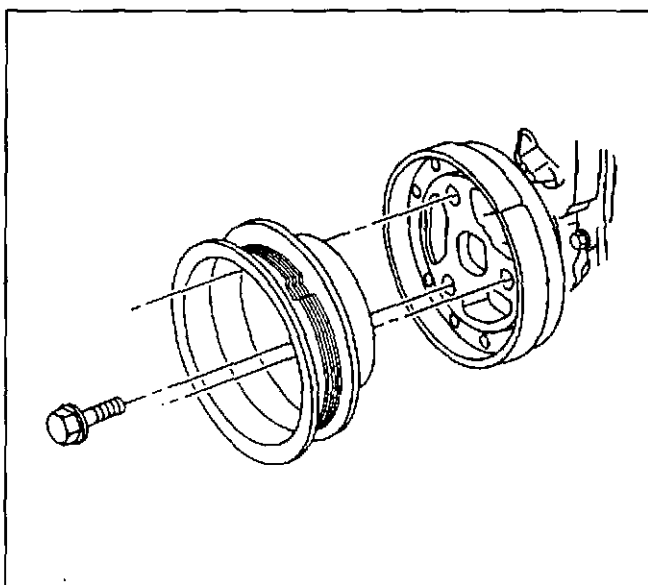
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Notice: SIO-10 - 301560 To prevent damage to the end of the crankshaft when using a crankshaft balancer removal tool install a bolt in the crankshaft. Use a shorter bolt with the same threads as the crankshaft balancer bolt. This bolt will allow a place for the tool to push against. The shorter bolt is to keep from going past the threads in the crankshaft and damaging the crankshaft threads.

7. Use J 23523-F to remove the crankshaft balancer. Refer to *Crankshaft Balancer Removal*.
8. Clean and inspect all parts. Refer to *Crankshaft Balancer Clean and Inspect*.

Installation Procedure

Tools Required

J 23523-F Balancer Remover and Installer

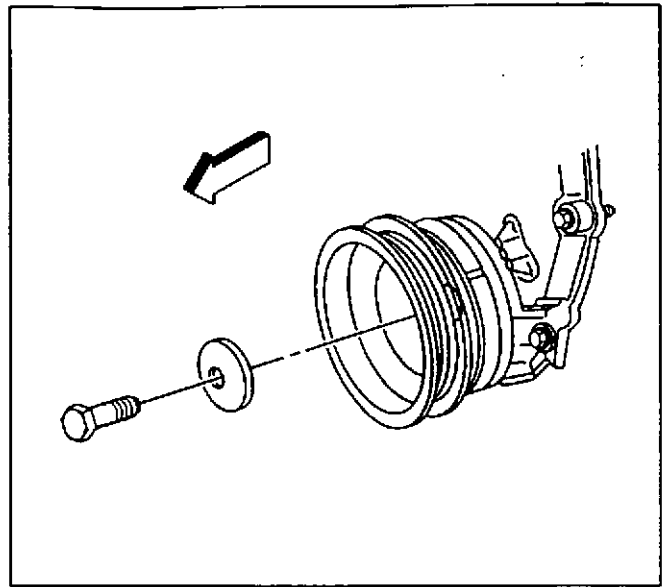
1. Use J 23523-F to install the crankshaft balancer. Refer to *Crankshaft Balancer Installation*.
2. Install the crankshaft pulley.
3. Loosely install the crankshaft pulley bolts.

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

4. Install the crankshaft balancer bolt.

Tighten

- 4.1. Tighten the crankshaft balancer bolt to 95 N.m (70 lb ft).
- 4.2. Tighten the crankshaft pulley bolts to 58 N.m (43 lb ft)
5. Install the drive belt. Refer to *Drive Belt Replacement*.
6. Install the fan shroud assembly. Refer to *Fan Shroud Replacement* in Engine Cooling.
7. Connect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.



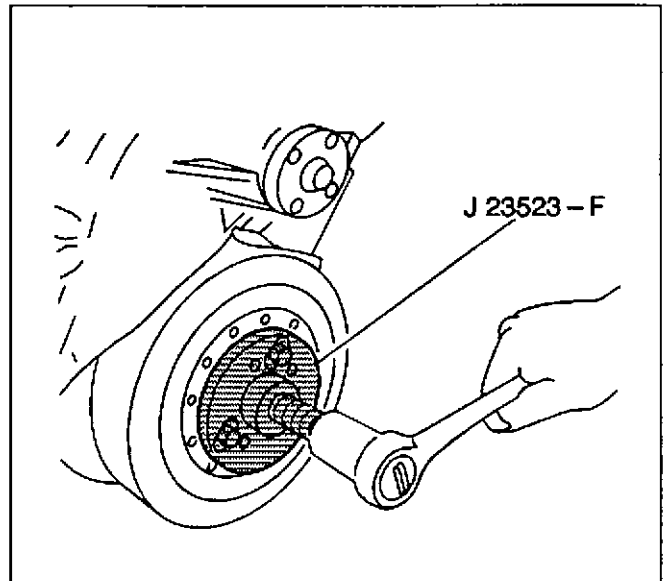
173172

SIE-ID = 377446

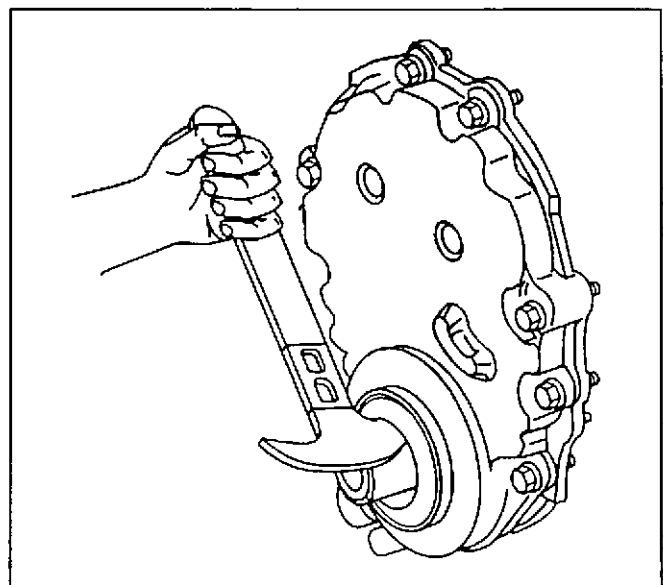
Crankshaft Front Cover Oil Seal Replacement

Removal Procedure

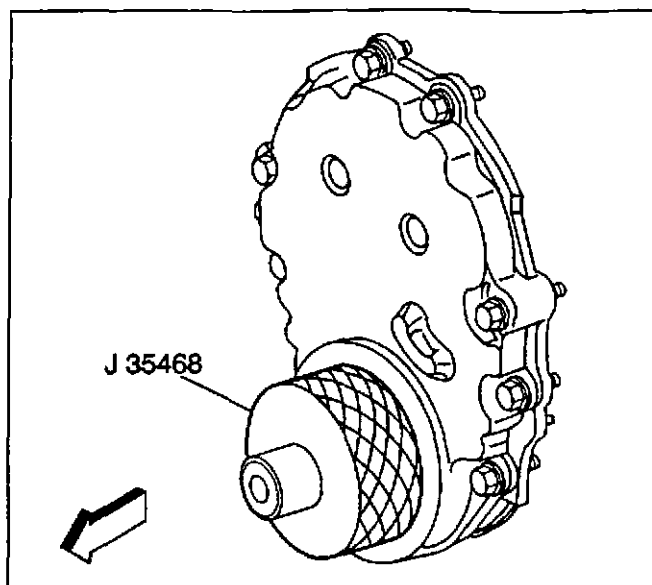
1. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
2. Use a suitable prying tool to remove the crankshaft front oil seal.
3. Inspect the engine front cover seal bore area for damage.
4. Inspect the crankshaft balancer seal area. Refer to *Crankshaft Balancer Clean and Inspect*.



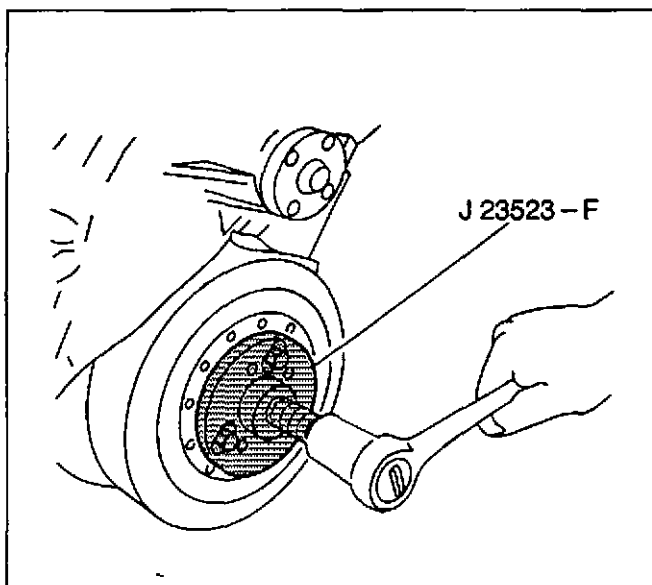
4059



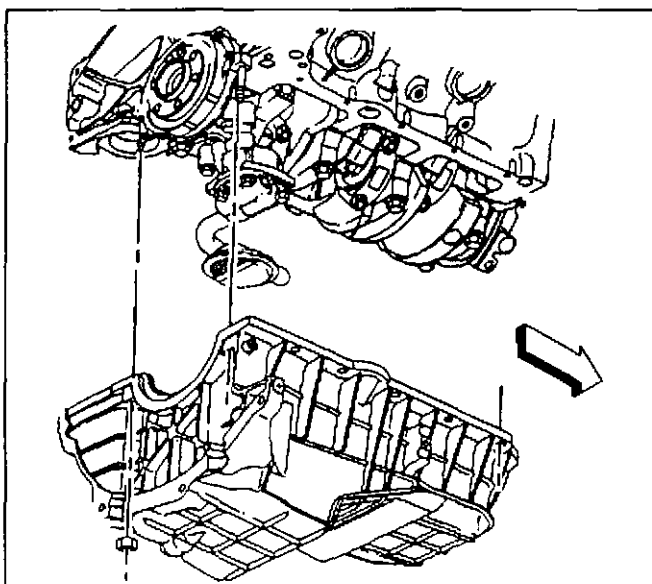
357563



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31739

Installation Procedure

Tools Required

J 35468 Cover Aligner/Seal Installer

Important: The engine front cover is a plastic composition.

1. Lubricate the exterior of the seal with clean engine oil.
2. Use the J 35468 with a hammer in order to install the crankshaft front oil seal.
3. Inspect to ensure the crankshaft front oil seal is flush and square to the engine front cover.

4. Install the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.

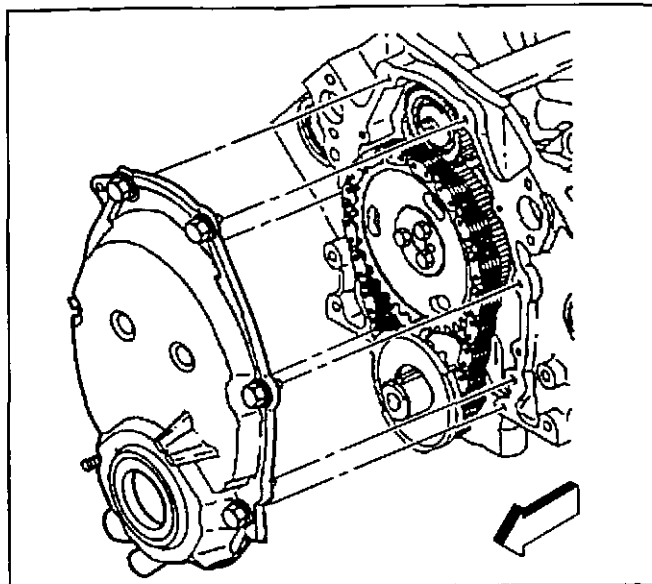
SIE-ID = 329749

Engine Front Cover Replacement

Removal Procedure

1. Remove the engine oil pan. Refer to *Oil Pan Replacement*.
2. Disconnect the crankshaft position (CKP) sensor electrical connector.
3. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
4. Remove the water pump. Refer to *Water Pump Replacement (4.3L)* in Engine Cooling.
5. Remove the CKP sensor. Refer to *Camshaft Position Sensor Replacement* in Engine Controls.

6. Remove the engine front cover. Refer to *Engine Front Cover Removal*.

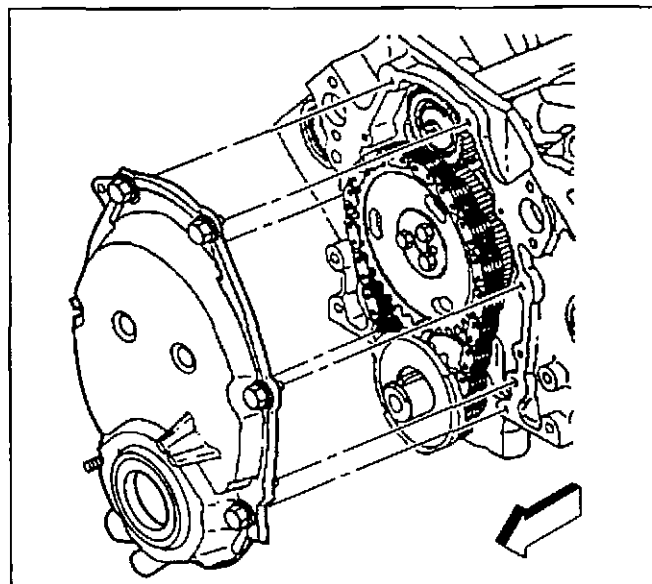


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Installation Procedure

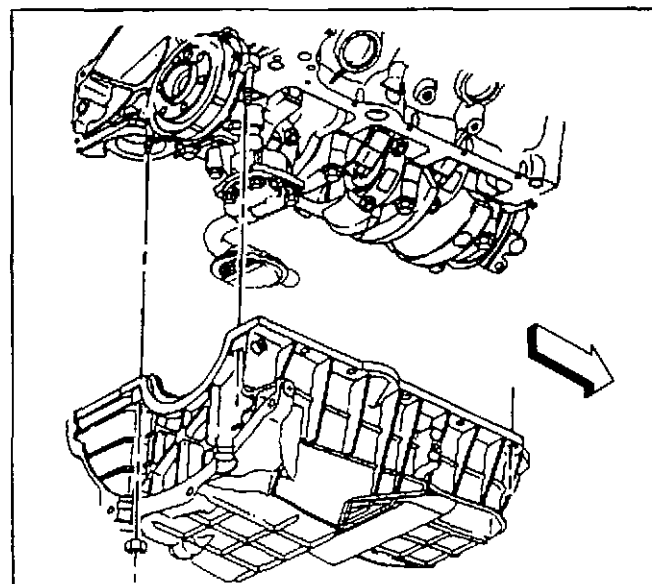
Notice: DO NOT reuse the engine front cover. Oil leaks may result. Do not reuse the original seal (O-ring) when installing the crankshaft position (CKP) to the engine front cover. Erratic engine operation may result.

1. Install the engine front cover. Refer to *Engine Front Cover Installation*.
2. Install the CKP sensor with a NEW seal (O-ring). Refer to *Camshaft Position Sensor Replacement* in Engine Controls.

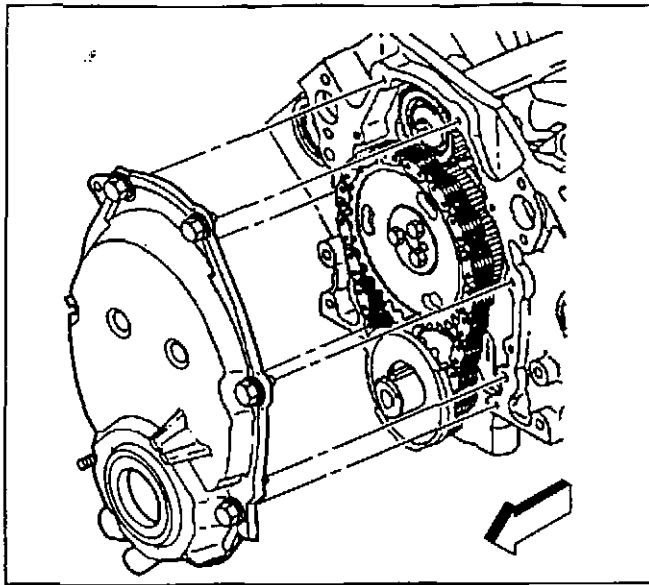


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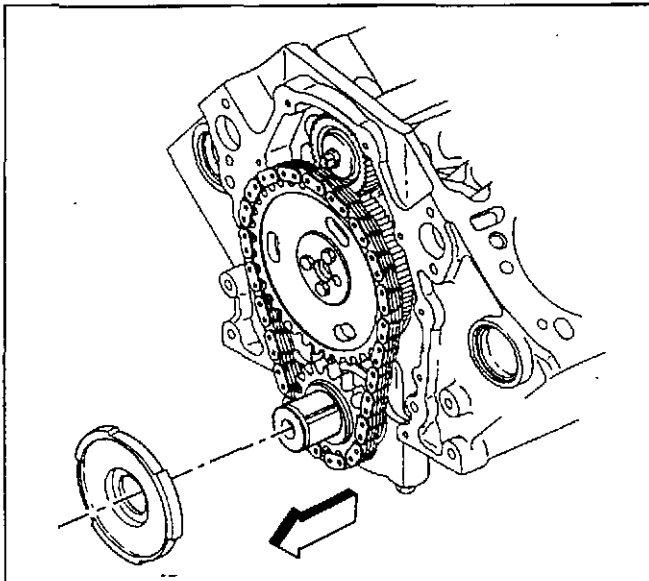
3. Install the engine oil pan. Refer to *Oil Pan Replacement*.
4. Connect the crankshaft position (CKP) sensor electrical connector.
5. Install the water pump. Refer to *Water Pump Replacement (4.3L)* in Engine Cooling.
6. Install the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.



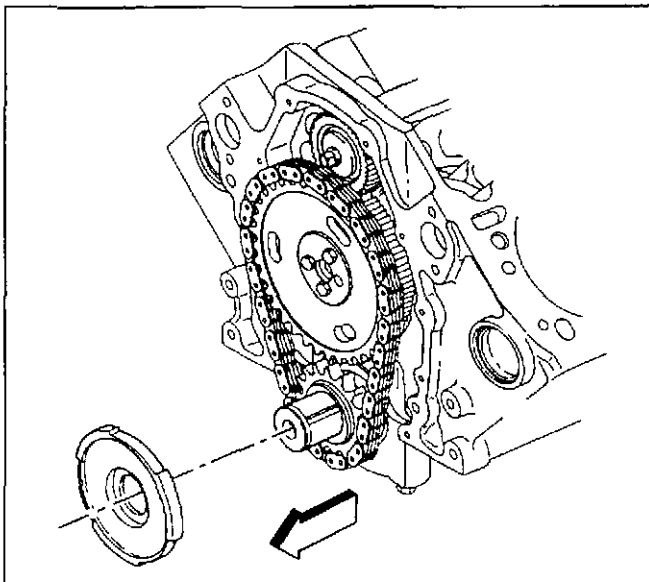
31739



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45986



45986

SIE-ID = 329753

Crankshaft Position Reluctor Ring Replacement

Removal Procedure

1. Remove the engine front cover.
Refer to *Engine Front Cover Replacement*.

2. Remove the crankshaft position sensor reluctor ring.

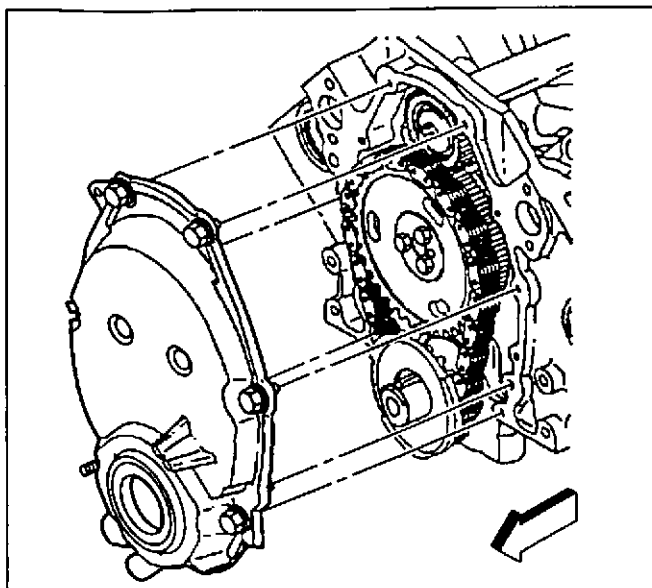
Installation Procedure

Notice: SIO-ID = 23526 Failure to properly align the crankshaft position sensor reluctor ring may result in component damage and effect OBD II system performance.

Important: The reluctor ring is shaped like a dish. The dish must face the engine front cover. Failure to do so will damage the front cover and the reluctor ring.

1. Install the crankshaft position sensor reluctor ring.

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



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SIE-ID - 329755

Timing Chain and Sprockets Replacement

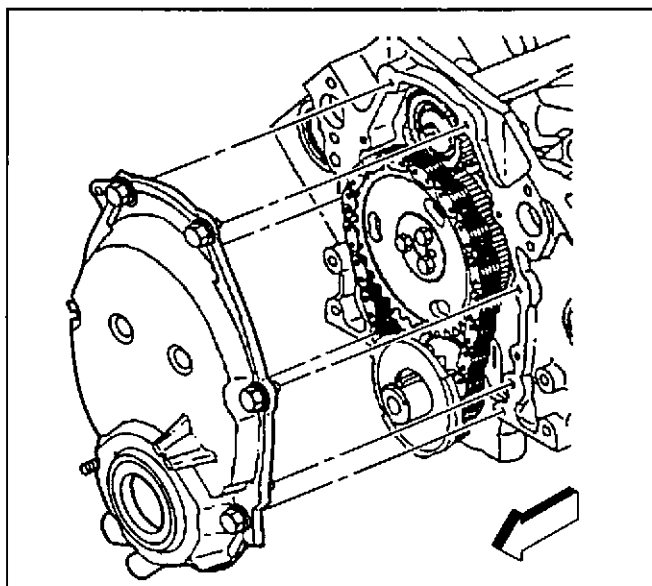
Removal Procedure

Tools Required

- J 23523-F Balancer Remover and Installer
- J 5825-A Crankshaft Gear Remover

Important: Once the composite engine front cover is removed, DO NOT reinstall the engine front cover. Always install a NEW engine front cover.

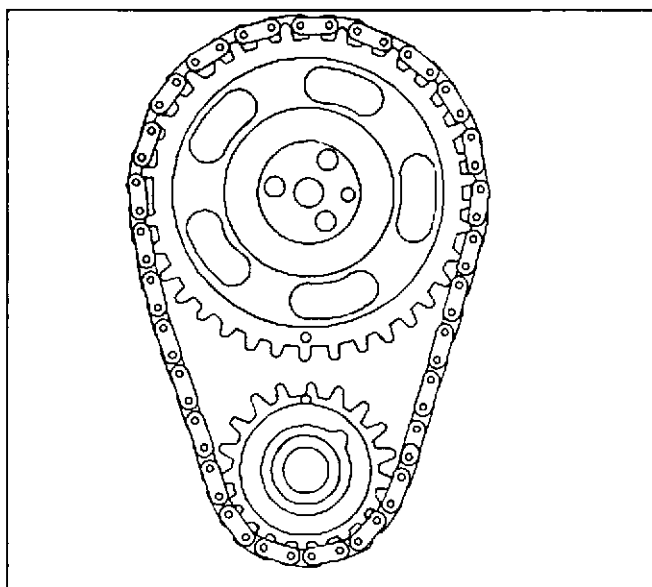
1. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.
2. Remove the crankshaft position sensor reluctor ring.



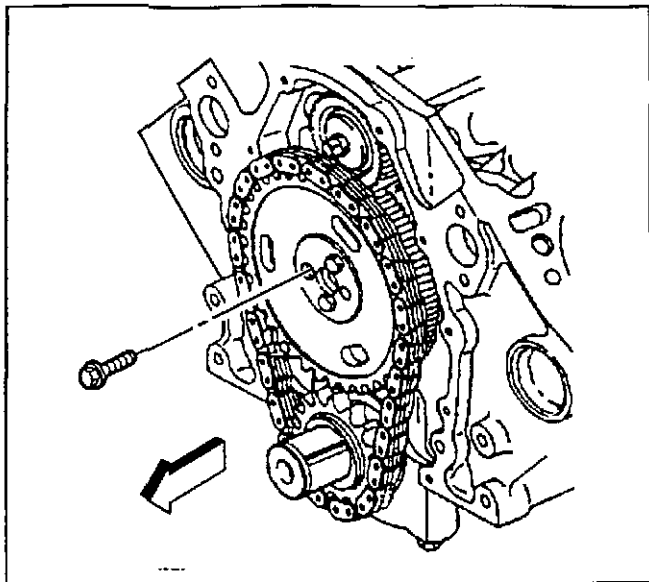
188000

Notice: In order to rotate the crankshaft, in the end of the crankshaft install a short bolt with the same threads or use the crankshaft balancer bolt with sufficient spacers to keep from damaging the threads of the bolt.

3. Check the timing chain free play. Refer to *Timing Chain and Sprockets Removal*.
4. Rotate the crankshaft until:
 - 4.1. The timing marks on both sprockets line up.
 - 4.2. The number four cylinder is at top dead center (TDC) of the compression stroke.

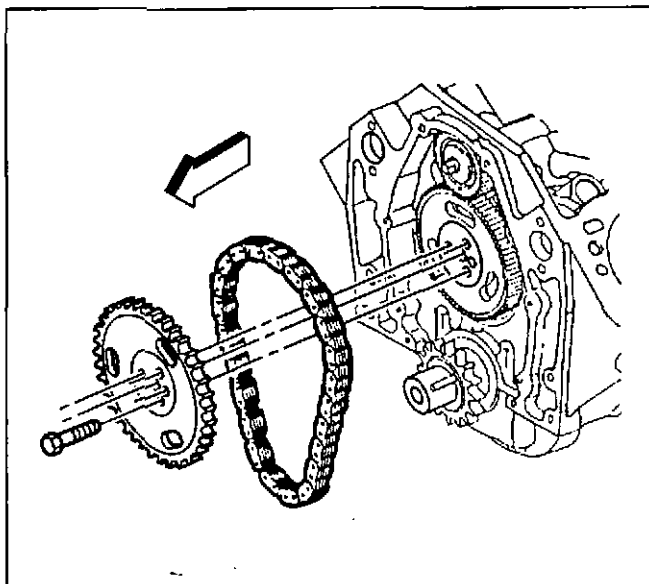


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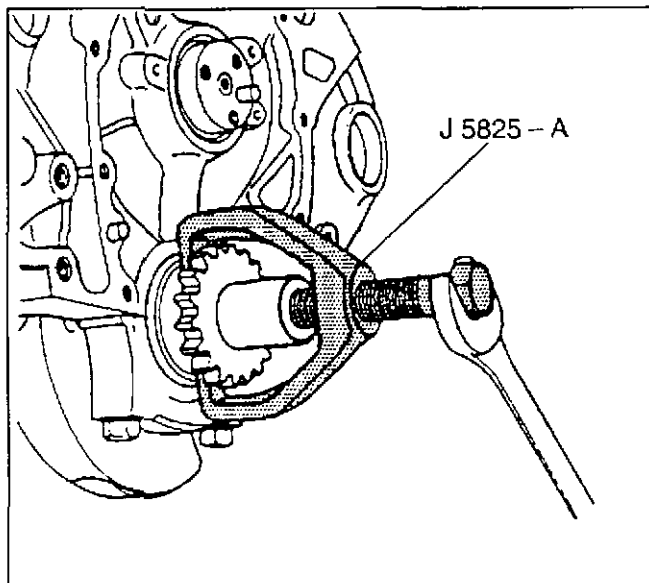
5. Remove the camshaft sprocket bolts.



188122

6. Remove the camshaft sprocket.

7. Remove the camshaft timing chain.



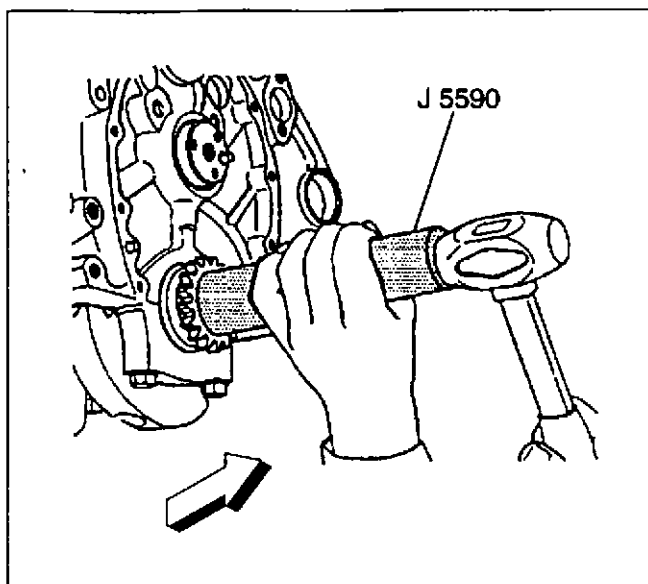
11506

8. Use the *J 5825-A* in order to remove the crankshaft sprocket.

9. If necessary, remove the crankshaft balancer key.

Installation Procedure**Tools Required**

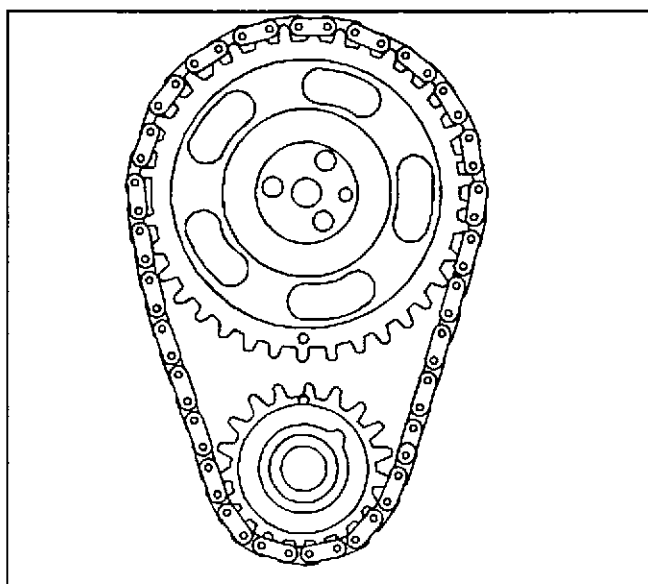
- J 23523-F Balancer Remover and Installer
 - J 5590 Installer
1. Install the crankshaft balancer key into the keyway in the crankshaft (if removed).
The crankshaft balancer key should be parallel to the crankshaft or with the front of the key slightly lower.
 2. Align the keyway of the crankshaft sprocket with the crankshaft balancer key.
 3. Use the J 5590 and a hammer in order to install the crankshaft sprocket.



32066

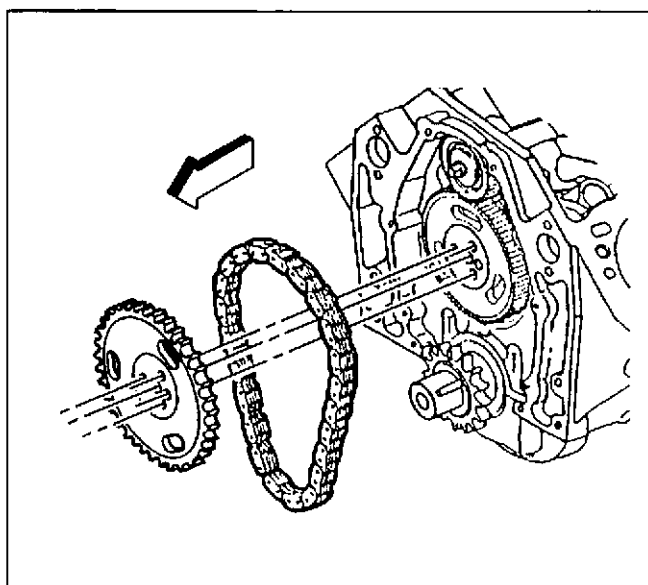
Important: Be sure to align the camshaft and the crankshaft sprocket alignment marks.

4. Align the camshaft and the crankshaft sprockets timing marks.
5. Look to ensure that the crankshaft sprocket is aligned at the 12 o'clock position and the camshaft sprocket is aligned at the 6 o'clock position.

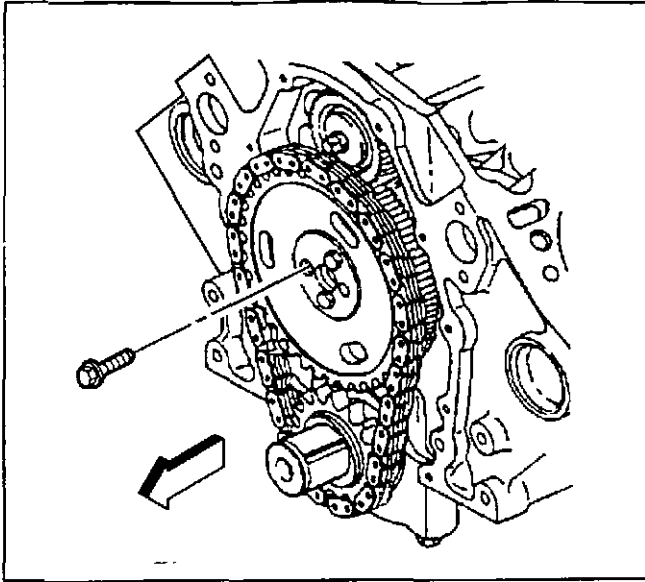


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6. Install the camshaft sprocket and the camshaft timing chain.



330584



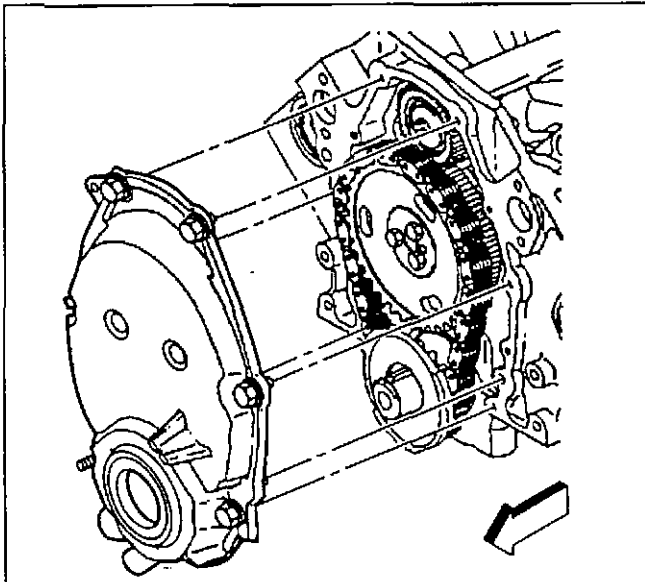
330581

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

7. Install the camshaft sprocket bolts.

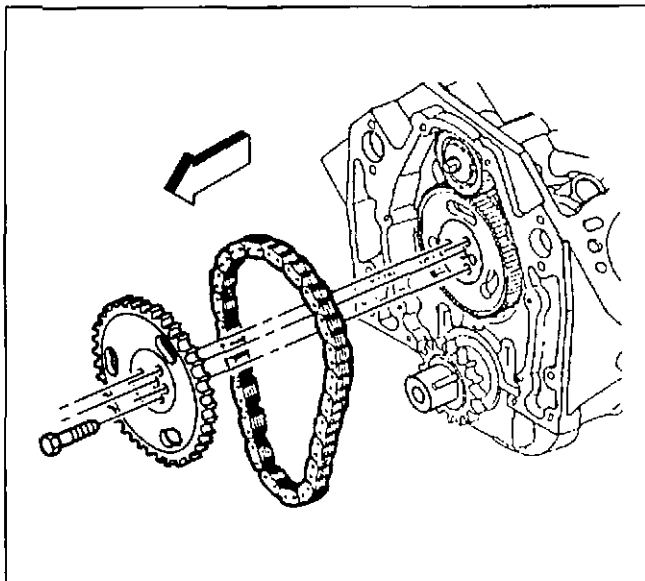
Tighten

Tighten the camshaft sprocket bolts to 25 N·m (18 lb ft).



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8. Install the crankshaft position sensor reluctor ring. Refer to *Crankshaft Position Reluctor Ring Replacement*.
9. Install the engine front cover. Refer to *Engine Front Cover Replacement*.



186122

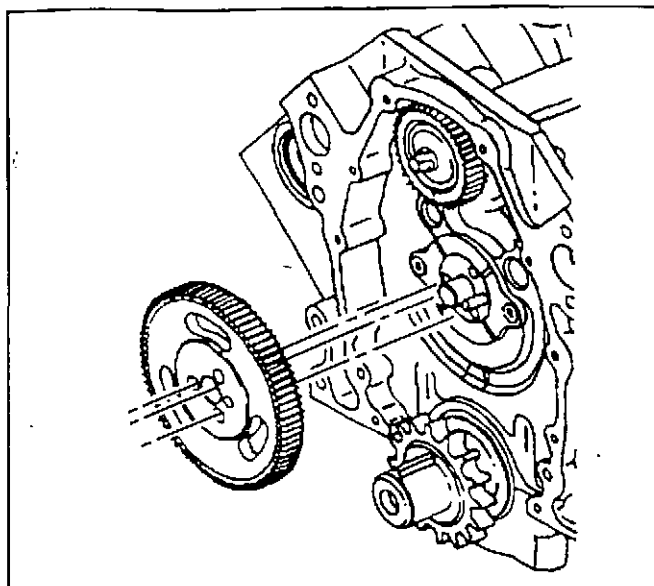
SIE-ID - 329759

Balance Shaft Replacement

Removal Procedure

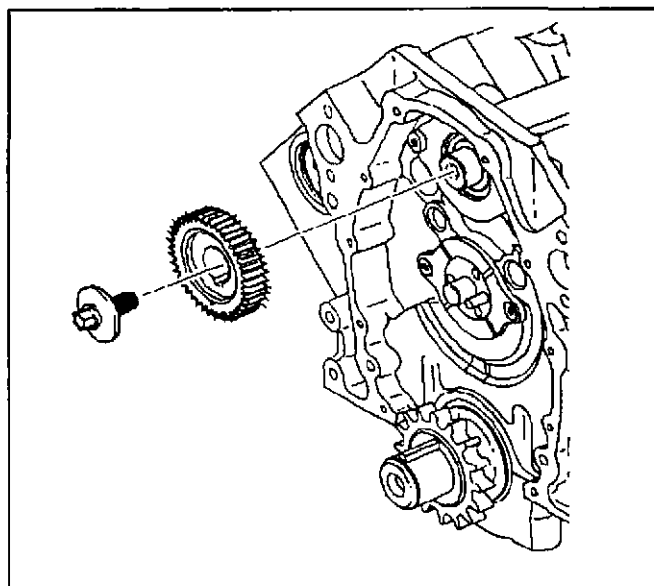
1. Remove the radiator. Refer to *Radiator Replacement* in *Engine Cooling*.
2. Remove the A/C condenser, if equipped. Refer to *Condenser Replacement* in *HVAC Systems with A/C - Manual*.
3. Remove the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
4. Remove the valve lifter pushrod guide. Refer to *Valve Lifter Replacement*.
5. Remove the timing chain and sprockets. Refer to *Timing Chain and Sprockets Replacement*.

6. Remove the balance shaft drive gear.



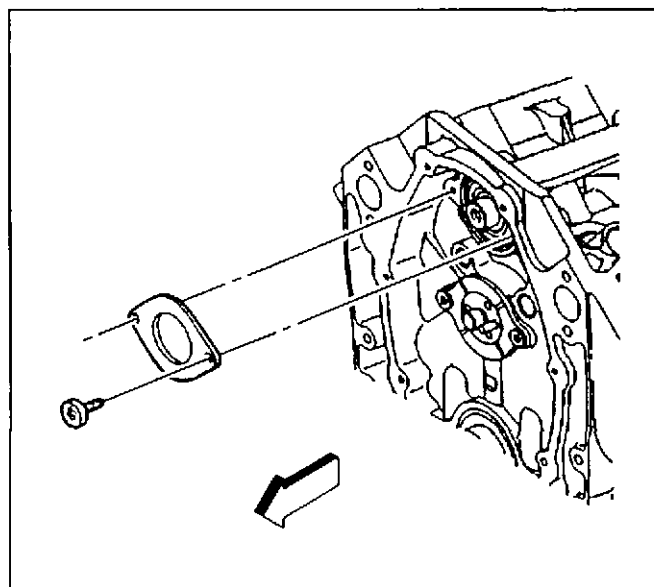
9847

7. Remove the bolt holding the balance shaft driven gear.
8. Remove the balance shaft driven gear.

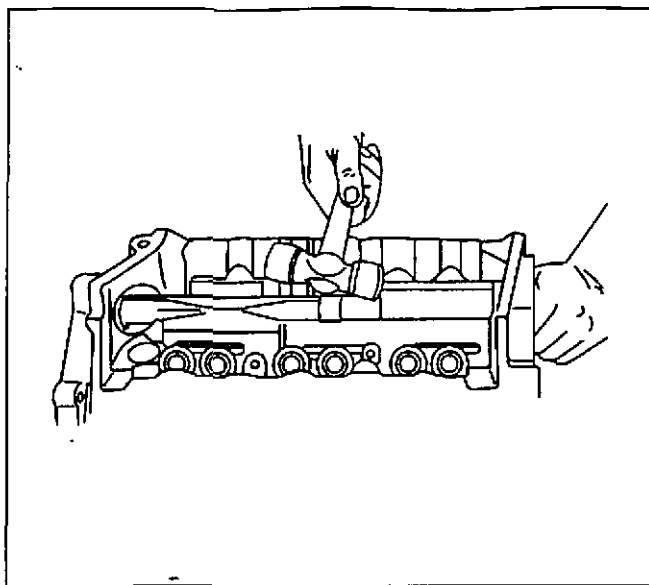


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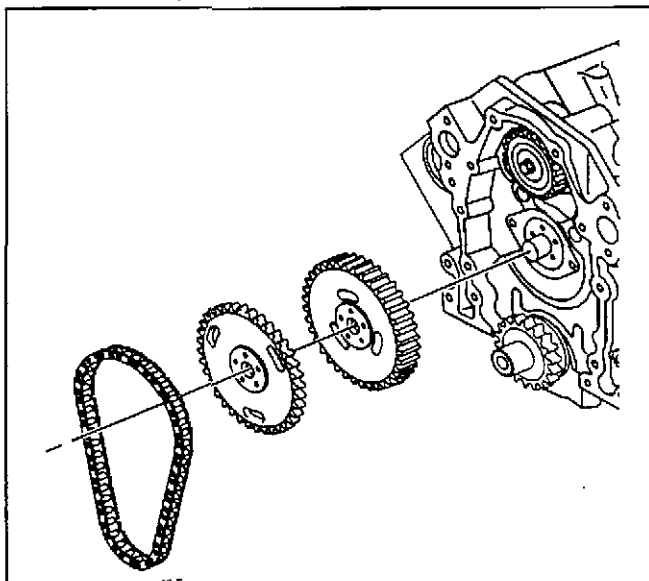
9. Remove the bolts and the balance shaft retainer.



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Important: The balance shaft and the front bearing are serviced only as a package. Do not remove the bearing from the balance shaft.

10. Tap on the balance shaft using a soft-faced hammer in order to remove the balance shaft. Refer to *Balance Shaft Removal*.
11. Clean all sealing surfaces. Refer to *Balance Shaft Clean and Inspect*.

Installation Procedure

1. Install the balance shaft. Refer to *Balance Shaft Installation*.
2. Install the timing chain and the camshaft sprocket. Refer to *Timing Chain and Sprockets Replacement*.
3. Install the crankshaft position reluctor ring and the front cover. Refer to *Crankshaft Position Reluctor Ring Replacement*.
4. Install the valve lifter pushrod guide. Refer to *Valve Lifter Replacement*.

Important: When the timing marks on the camshaft and the crankshaft sprocket are aligned the engine is at top dead center for cylinder number four. In order to install the distributor align the crankshaft balancer marks with the front cover marks for top dead center cylinder number one.

5. Install the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
6. Install the A/C condenser, if equipped. Refer to *Condenser Replacement* in HVAC Systems with A/C - Manual.
7. Install the radiator. Refer to *Radiator Replacement* in Engine Cooling.

SIE-ID - 329763

Balance Shaft Bearing and/or Bushing Replacement

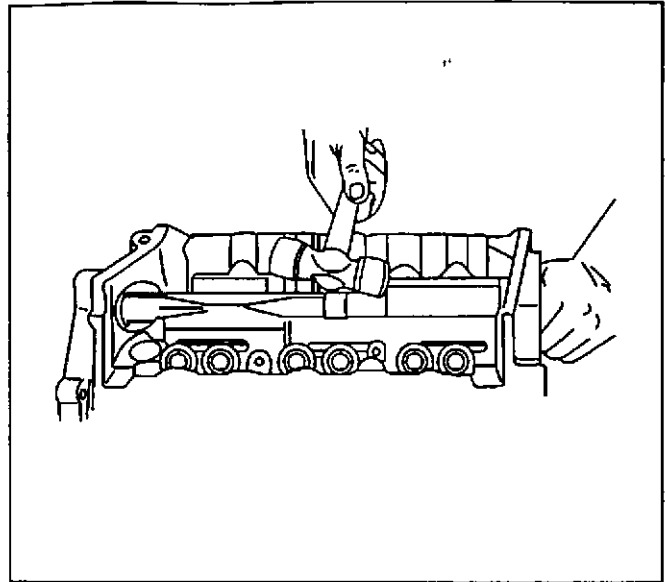
Removal Procedure

Tools Required

- J 26941 Bushing/Bearing Remover.
- J 38834 Balance Shaft Service Kit.

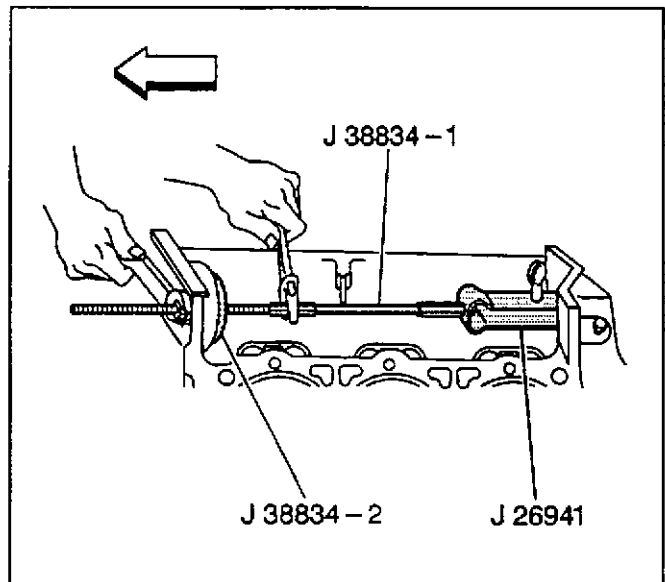
Important: The balance shaft and the front bearing are serviced only as a package. Do not remove the bearing from the balance shaft.

1. Remove the balance shaft. Refer to *Balance Shaft Replacement*.



5139

2. Use the J 38834 and the J 26941 in order to remove the balance shaft rear bearing.
 - 2.1. Install the J 26941 legs behind the balance shaft rear bearing and secure.
 - 2.2. Install the J 38834-1 with the short threaded end through the front of the engine block.
 - 2.3. Install the J 38834-1 into the J 26941.
 - 2.4. Slide the J 38834-2 onto the J 38834-1 and into the balance shaft bore of the engine block.
 - 2.5. Install the bearing, washer, and nut on the J 38834-1.
 - 2.6. Hold the J 38834-1 and turn the nut clockwise until the bearing is removed.
3. Discard the balance shaft rear bearing.



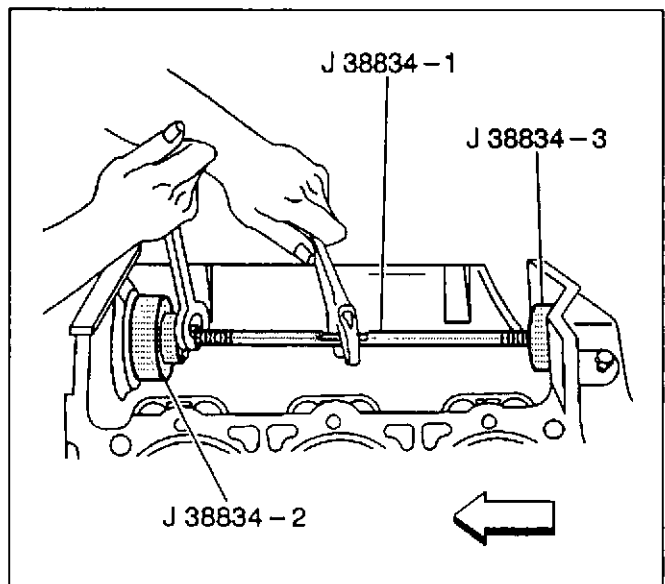
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Installation Procedure

Tools Required

J 38834 Balance Shaft Service Kit

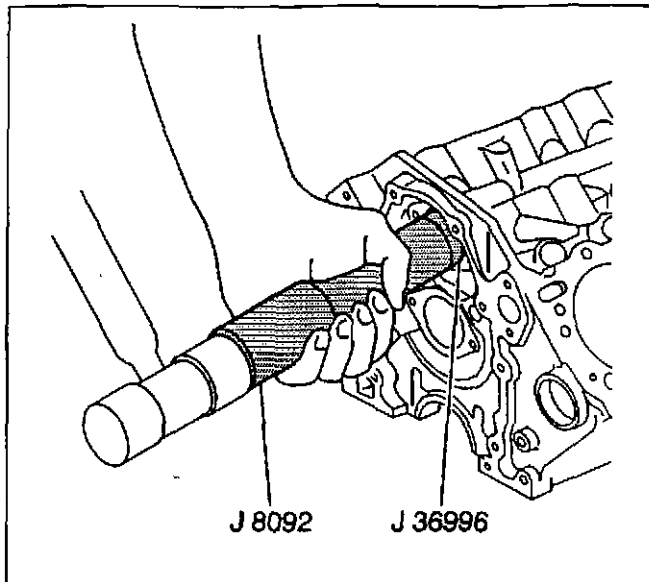
1. Dip the balance shaft rear bearing in clean engine oil before installation.
2. Use the J 38834 in order to install the balance shaft rear bearing.
 - 2.1. Install the J 38834-3 onto the short threaded end of the J 38834-1.
 - 2.2. Install the nut, washer, and bearing on the long threaded end the J 38834-1.
 - 2.3. Install the J 38834-2 so that the smaller diameter will be facing the front, onto the J 38834-1.
 - 2.4. Install the J 38834-2 on the inside of the balance shaft front bearing bore.
 - 2.5. Install the balance shaft rear bearing on the J 38834-1.
 - 2.6. Position the bearing.



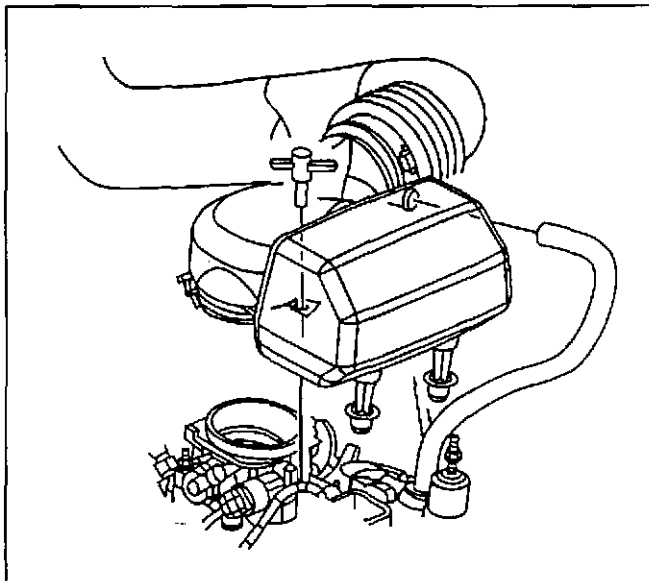
340085

- 2.7. Hold the J 38834-1 with a wrench and turn the nut clockwise until the bearing is installed.

3. Install the balance shaft. Refer to *Balance Shaft Replacement*.



5141



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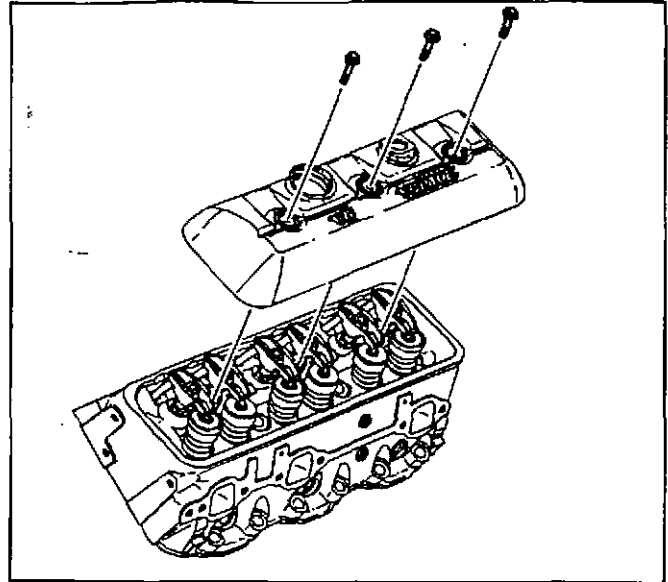
SIE-ID - 330888

Camshaft Replacement

Removal Procedure

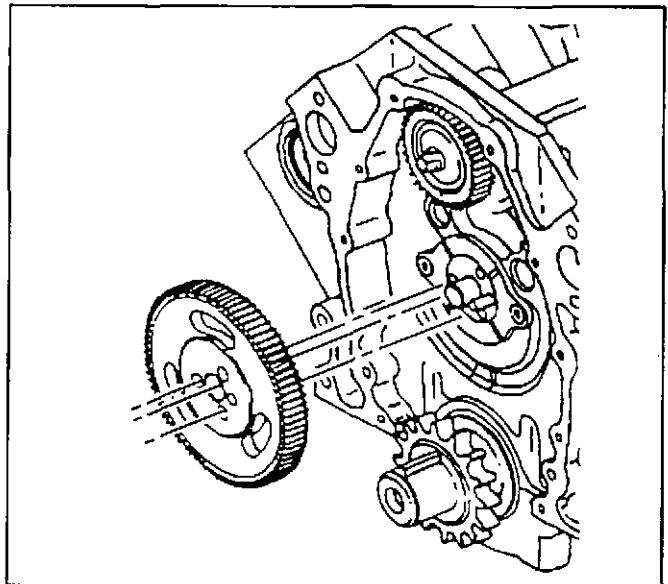
1. Disconnect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)*
2. Disconnect the PCV hose from the air inlet duct.
3. Remove the air inlet duct from the throttle body and the MAF sensor.
4. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
5. Discharge the air condition system, if equipped. Refer to *Refrigerant Recovery and Recharging* in HVAC Systems with A/C - Manual.
6. Remove the radiator. Refer to *Radiator Replacement* in Engine Cooling.
7. Remove the A/C condenser, if equipped. Refer to *Condenser Replacement* in HVAC Systems with A/C - Manual.

8. Remove the valve rocker arm covers.
 - Refer to *Valve Rocker Arm Cover Replacement (Left)*.
 - Refer to *Valve Rocker Arm Cover Replacement (Right)*.
9. Remove the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
10. Remove the valve lifters and the valve pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.



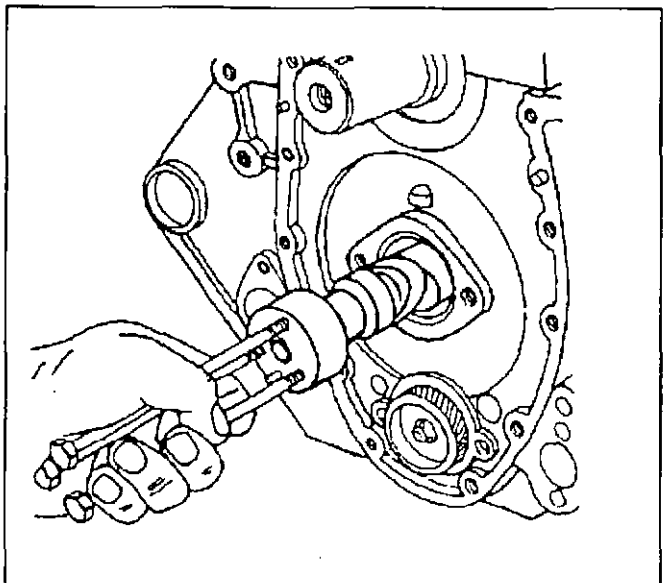
4041

11. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.
12. Remove the crankshaft position sensor reluctor ring. Refer to *Crankshaft Position Reluctor Ring Replacement*.
13. Remove the timing chain and camshaft sprocket. Refer to *Timing Chain and Sprockets Replacement*.
14. Remove the balance shaft drive gear.

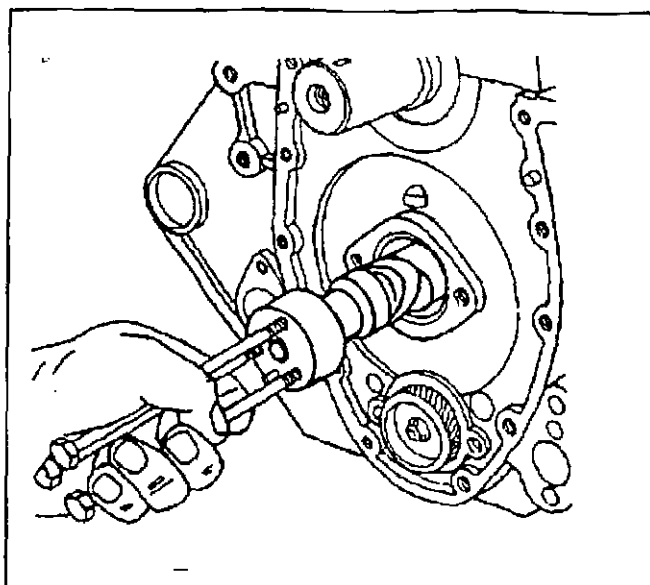


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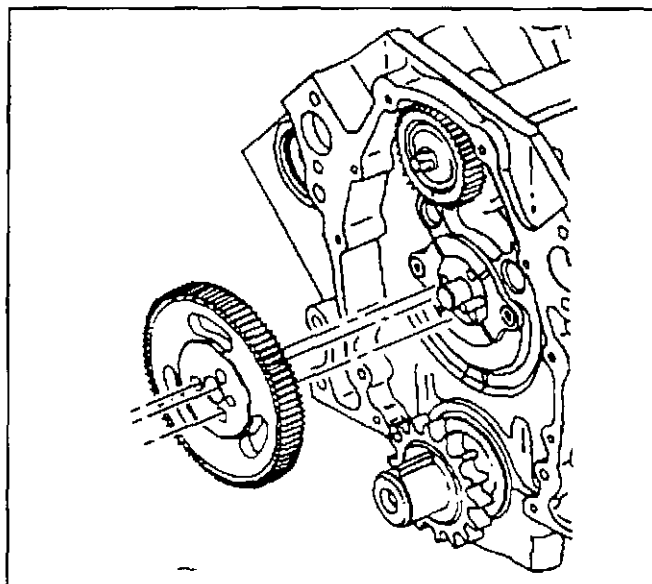
15. Remove the camshaft. Refer to *Camshaft Removal*.



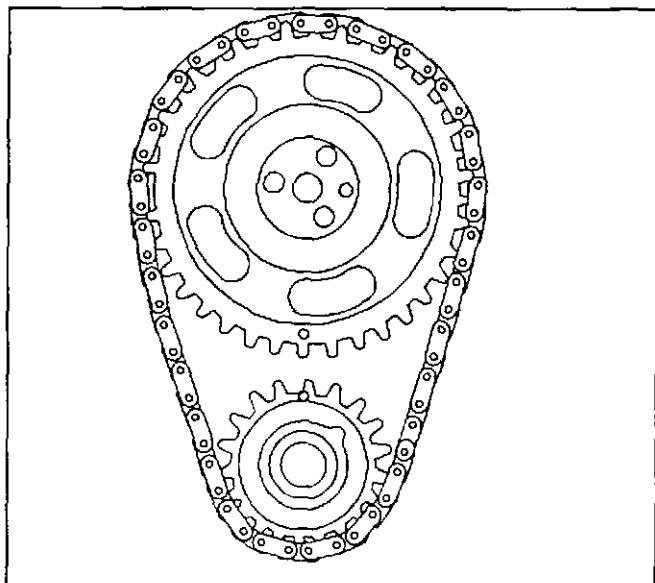
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Installation Procedure

Important: Whenever a new camshaft is installed, do the following procedures:

- Change the engine oil.
- Change the engine oil filter.
- Add GM Engine Oil Supplement GM P/N 1052367 or the equivalent to the engine oil.

1. Install the camshaft into the engine block. Refer to *Camshaft Installation*.

2. Install the balance shaft drive gear. Refer to *Balance Shaft Installation* for alignment of the balance shaft drive gear and the driven gear.

3. Line up the timing marks on the camshaft sprocket and the crankshaft sprocket dot to dot. When these dots are lined up dot to dot, the number four cylinder is at the top dead center of its compression stroke.

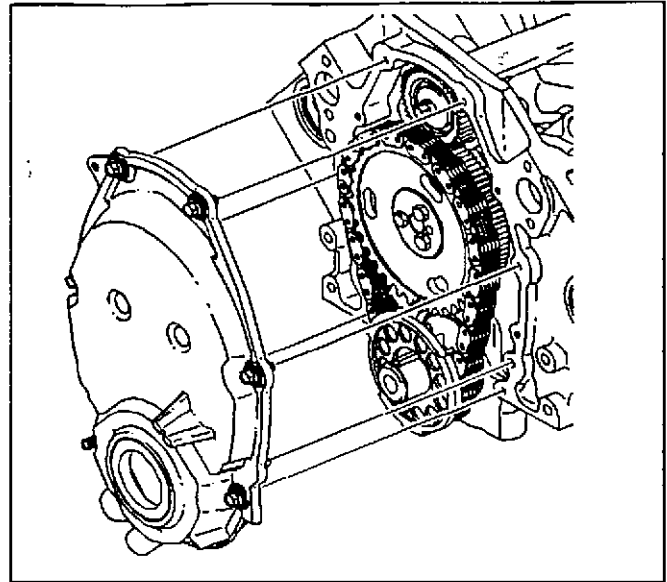
4. Install the camshaft timing chain and camshaft sprocket. Refer to *Timing Chain and Sprockets Replacement*.

Notice: S10-ID - 23526 Failure to properly align the crankshaft position sensor reluctor ring may result in component damage and effect OBD II system performance.

5. Install the crankshaft position sensor reluctor ring. Refer to *Crankshaft Position Reluctor Ring Replacement*.

6. Install the valve lifters and the valve pushrods. Refer to *Valve Lifter Replacement*.

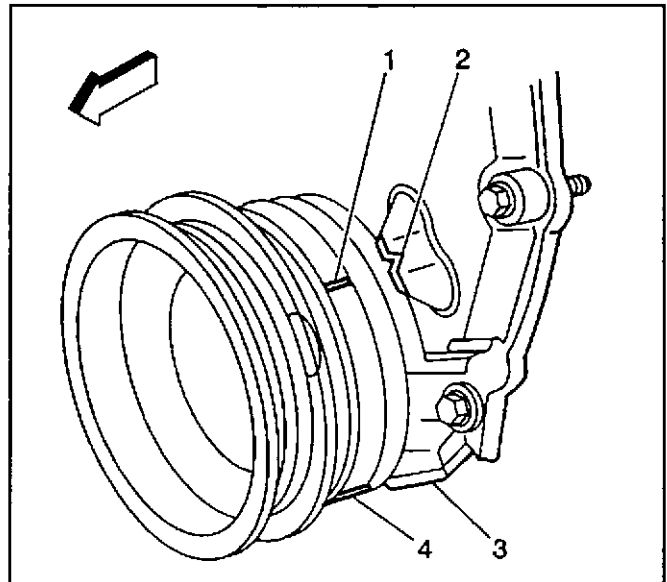
7. Install the engine front cover. Refer to *Engine Front Cover Replacement*.
8. Install the intake manifold. Refer to *Intake Manifold Replacement (Lower)*.



4068

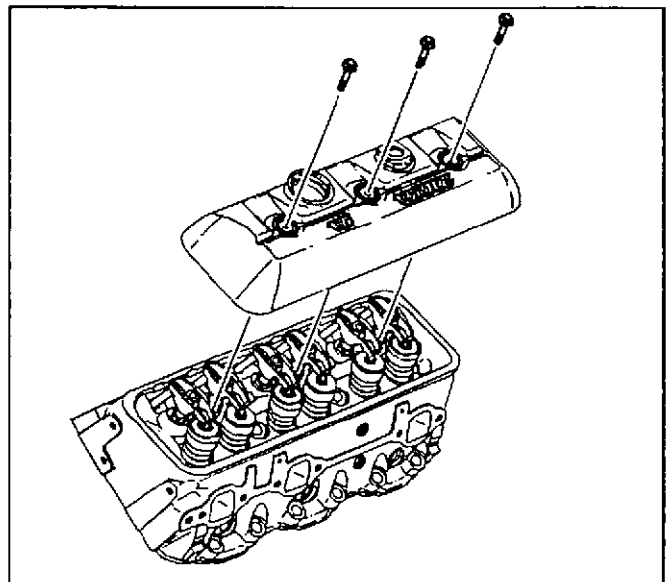
Important: When the alignment marks on the camshaft sprocket and the crankshaft sprocket are aligned the engine is at cylinder number four top dead center.

9. Rotate the engine to align the crankshaft balancer marks (1) and (4) with the front cover marks (2) and (3) for cylinder number one top dead center.
10. Install the distributor. Refer to *Distributor Installation* in Engine Electrical.

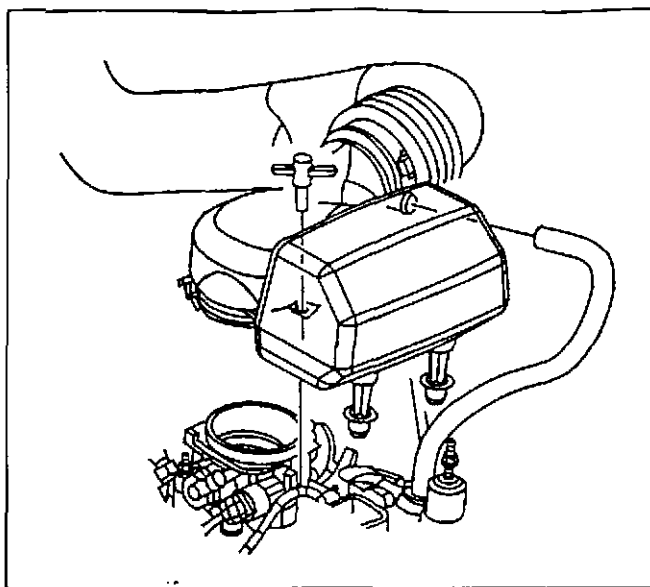


334551

11. Install the valve rocker arm covers.
 - Refer to *Valve Rocker Arm Cover Replacement (Left)*.
 - Refer to *Valve Rocker Arm Cover Replacement (Right)*.
12. Install the A/C condenser, if equipped. Refer to *Condenser Replacement* in HVAC Systems with A/C - Manual.
13. Install the radiator. Refer to *Radiator Replacement* in Engine Cooling.
14. Fill the cooling system with the proper grade and quantity of engine coolant. Refer to *Draining and Filling Cooling System* in Engine Cooling.
15. Recharge the air conditioning system, if equipped. Refer to *Refrigerant Recovery and Recharging* in HVAC Systems with A/C - Manual.

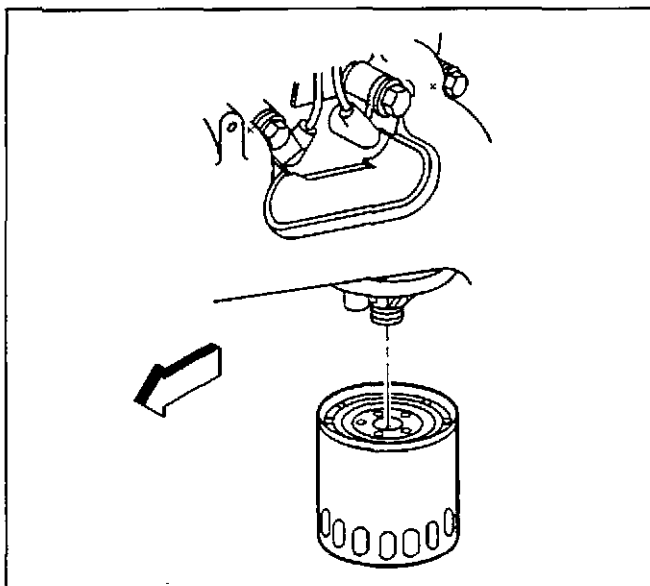


4041



310234

16. Install the air inlet duct to the throttle body and the MAF sensor.
17. Connect the PCV hose to the air inlet duct.
18. Connect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.



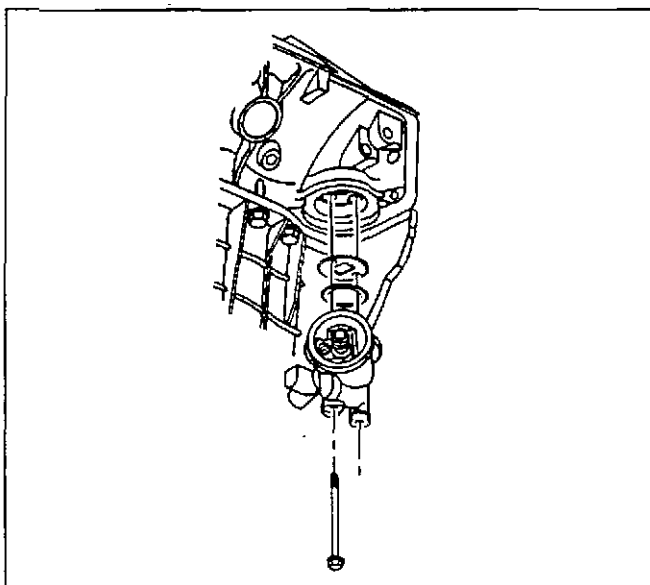
316766

SIE-ID - 333834

Oil Filter Adapter and Valve Assembly Replacement

Removal Procedure

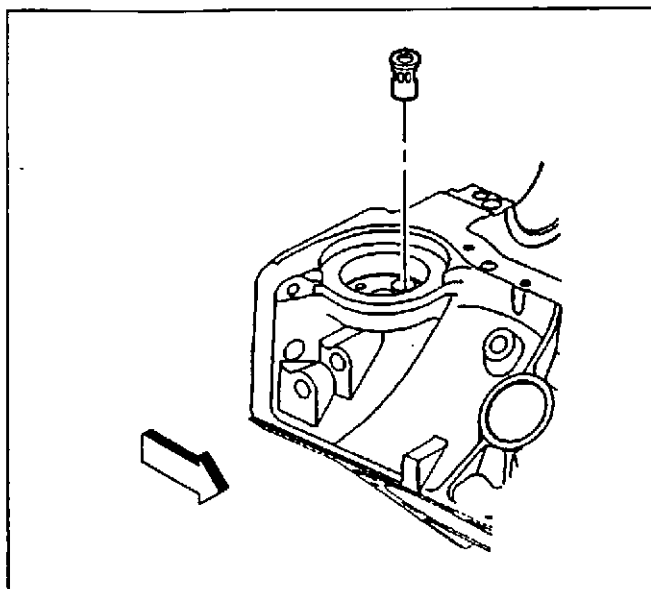
1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the oil filter. Refer to *Engine Oil and Oil Filter Replacement*



391869

3. Use the following procedure to remove the oil filter adapter for a Four Wheel Drive vehicle:
 - 3.1. Remove the oil filter adapter bolts.
 - 3.2. Remove the oil filter adapter and gasket.
 - 3.3. Remove the seal (O-ring) from the adapter.

4. Remove the oil filter bypass valve.
5. Clean and inspect valve bore for damage.

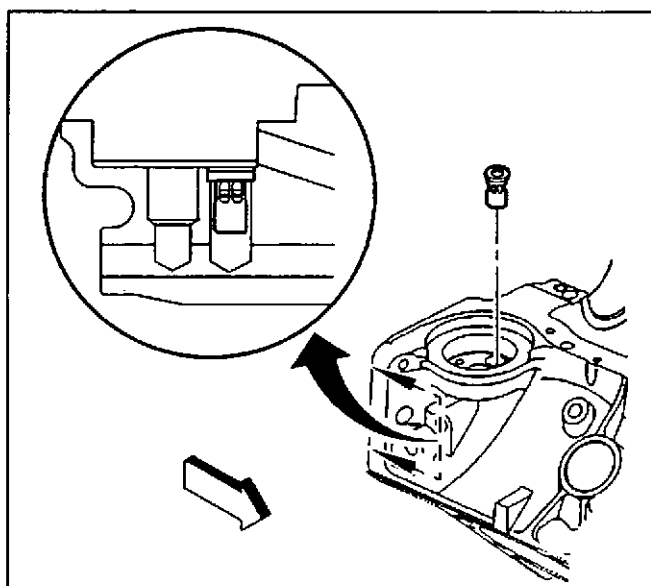


188026

Installation Procedure

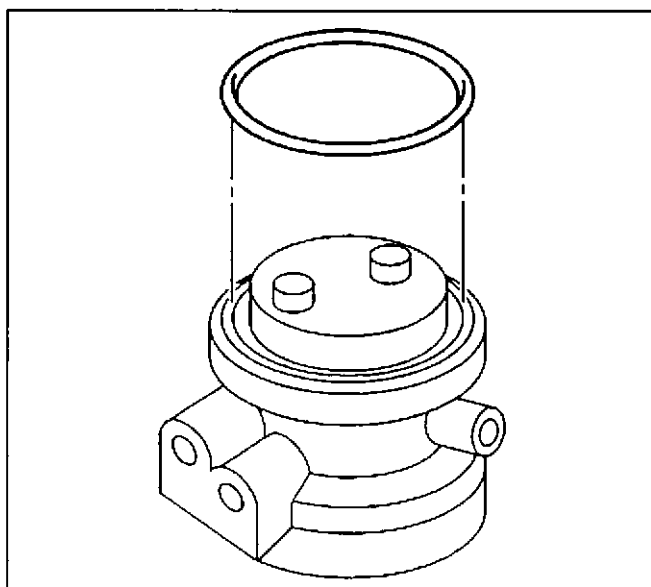
Caution: SIO-ID # 5011 *Wear safety glasses in order to avoid eye damage.*

1. Install a NEW oil filter bypass valve.
 - 1.1. Install the bypass valve into the oil gallery bore until slightly below flush with the surface of the engine block.
 - 1.2. Using a pointed punch, stake the block area around the oil filter bypass valve. Stake in three locations 120 degrees apart.

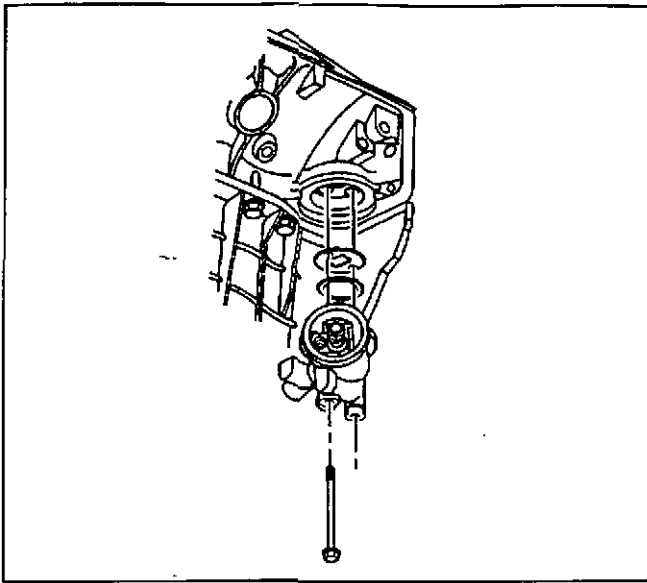


188023

2. Install a NEW seal (O-ring) into the groove in the oil filter adapter, Four Wheel Drive vehicles only.



4556



391869

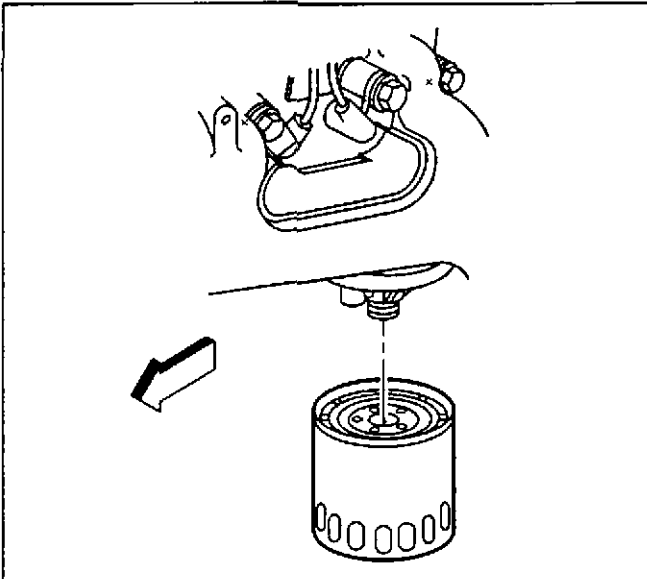
3. Install the oil filter adapter and NEW gasket to the engine, Four Wheel Drive vehicles only.

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

4. Install the oil filter adapter bolts.

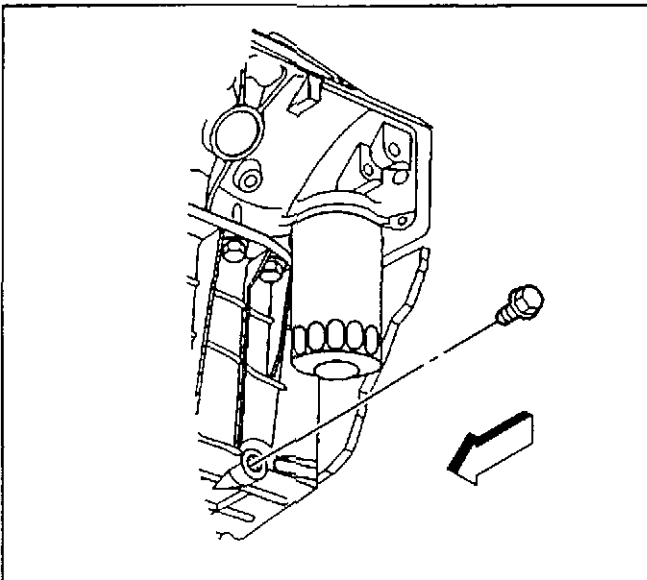
Tighten

Tighten the oil filter adapter bolts to 21 N.m (15 lb ft).



316766

5. Install the oil filter. Refer to *Engine Oil and Oil Filter Replacement*
6. Lower the vehicle.



188048

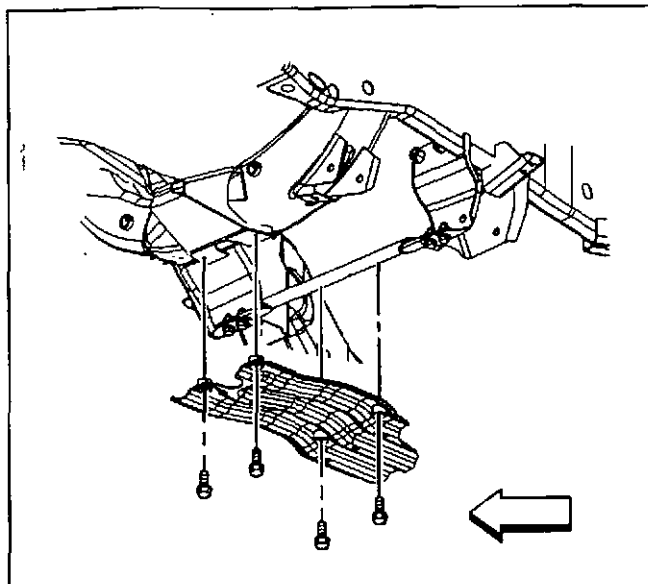
SIE-ID = 331099

Oil Pan Replacement

Removal Procedure

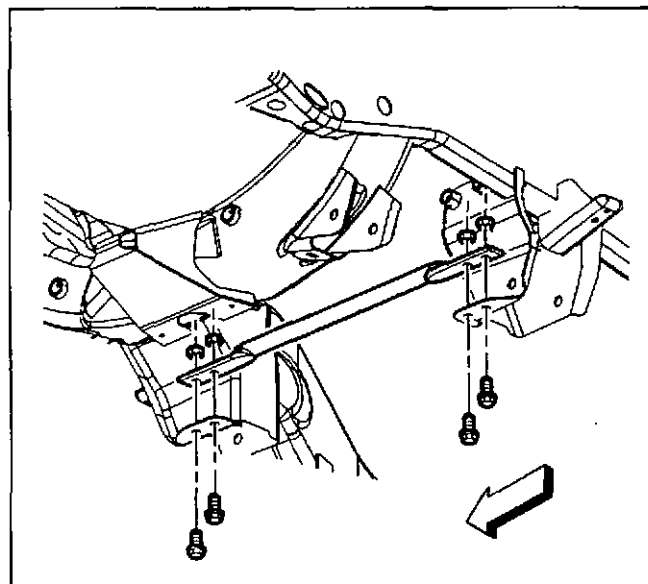
1. Disconnect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.
2. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the oil pan drain plug and drain the engine oil into a suitable container.
4. Remove the oil filter.

5. Remove the oil pan skid plate.



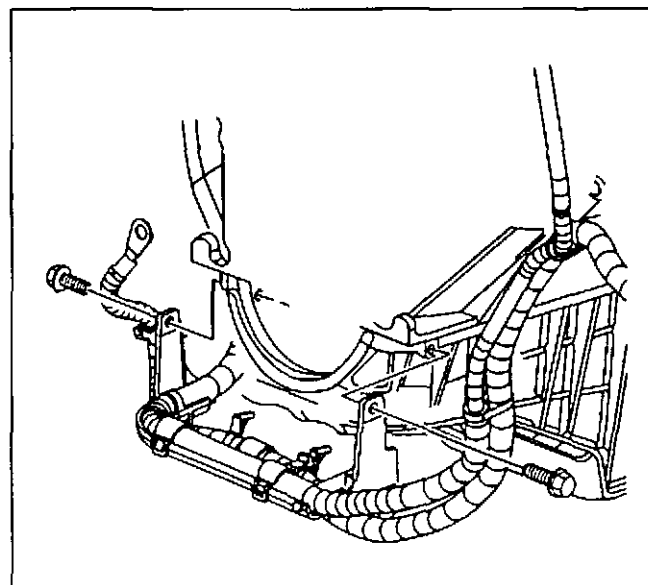
309158

6. Remove the crossbar.

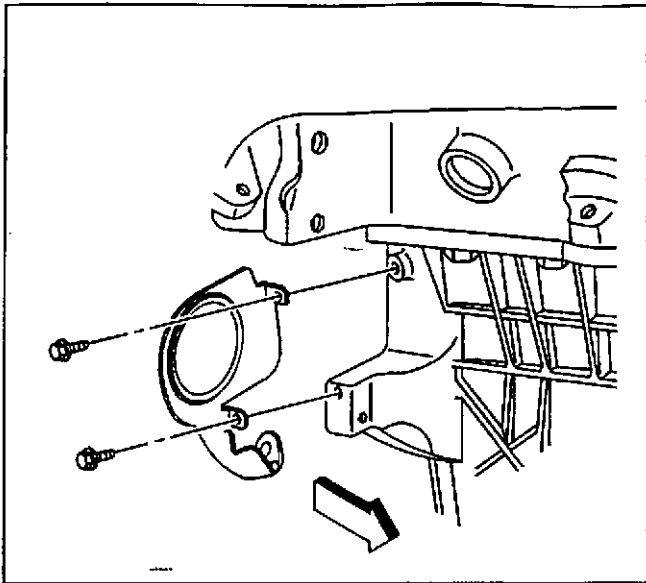


328107

7. Remove the bolts holding the battery cable brackets to the oil pan.
8. Remove the starter and move aside. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.

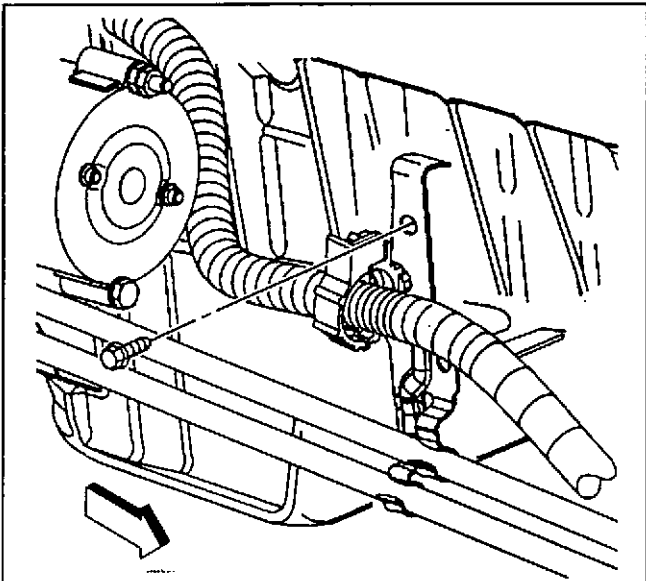


310250



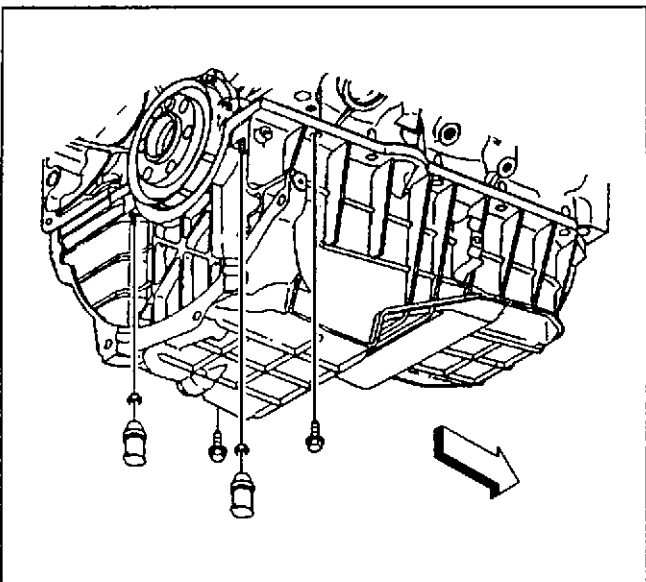
391868

9. Remove the transmission cover.



327996

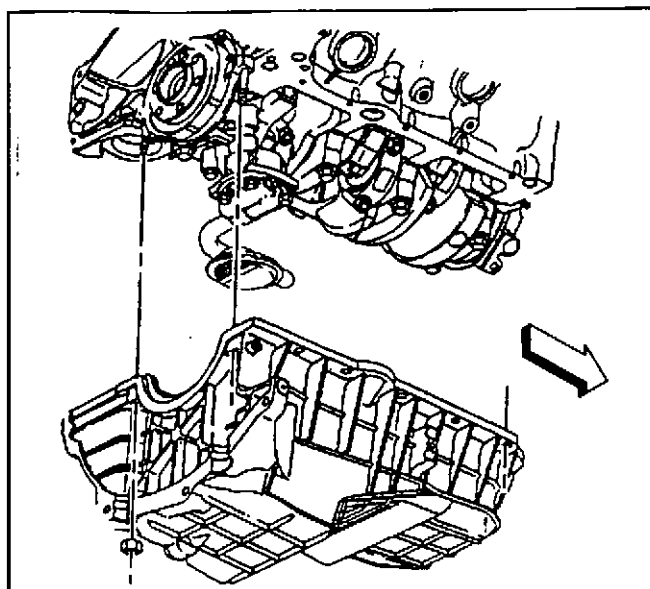
- 10. Remove the bracket for the starter positive cable and the transmission cooler lines from the side of the oil pan.
- 11. Disconnect the low oil level sensor electrical connector.



331034

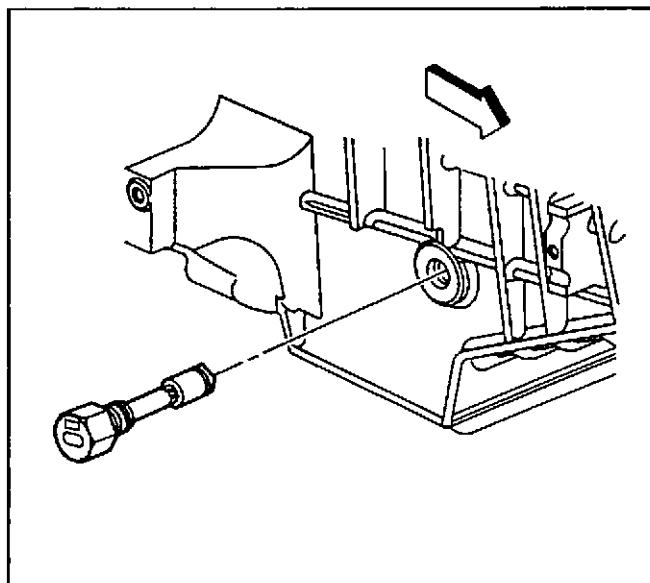
- 12. Remove the access plugs for the oil pan rear nuts.
- 13. Remove the nuts at the rear of the oil pan.

14. Remove the following oil pan fasteners:
 - 14.1. Remove the oil pan bolts.
 - 14.2. Remove the two nuts at the crankshaft rear oil seal housing.
 - 14.3. Remove the transmission to oil pan bolts.
15. Remove the oil pan and the gasket. Refer to *Oil Pan Removal*.



31739

16. Remove the low oil level sensor, if required.
17. Clean all sealing surfaces on the engine and the oil pan. Refer to *Oil Pan Clean and Inspect*.



387460

Installation Procedure

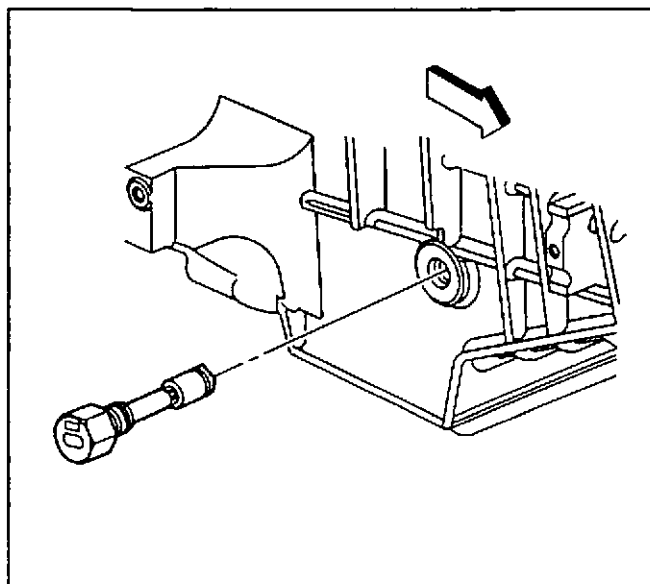
1. Apply sealant GM P/N 12346004 to the threads on the low oil level sensor, if removed.

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

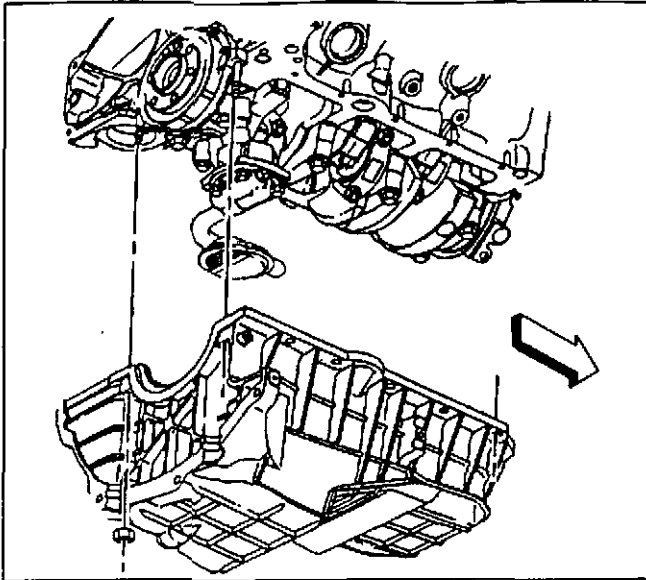
2. Install the low oil level sensor.

Tighten

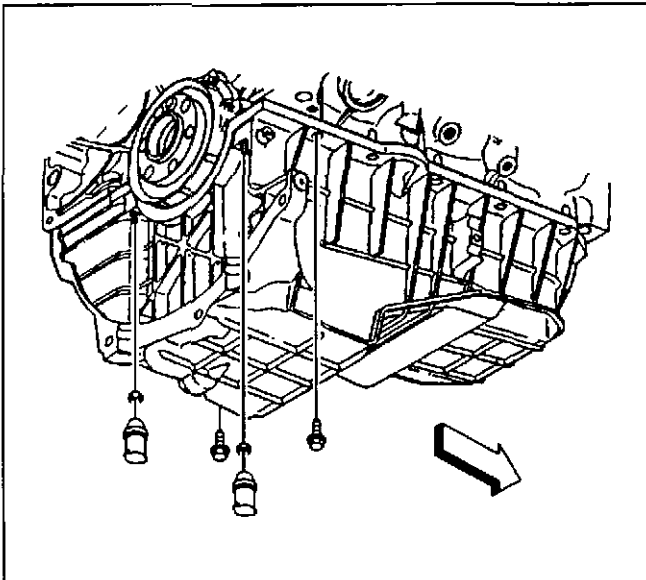
Tighten the sensor to 20 N·m (15 lb ft).



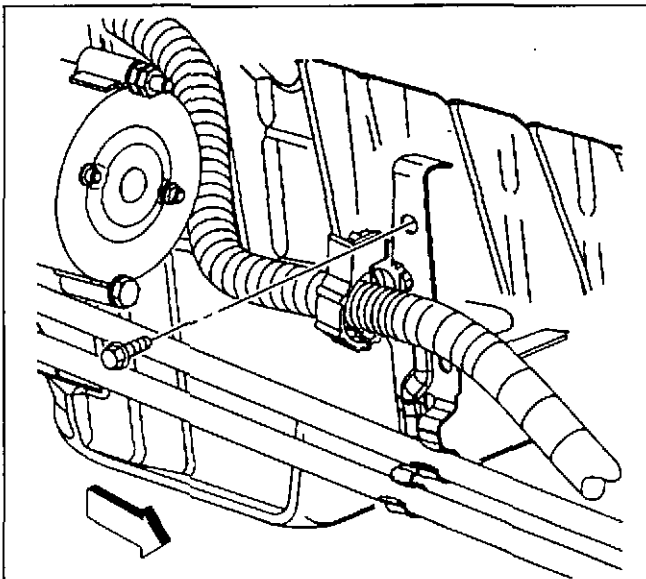
387460



31739



331034



327996

Notice: Any time the transmission and the engine oil pan are off of the engine at the same time, install the transmission before the oil pan. This is to allow for the proper measurement of the oil pan tolerance. Failure to achieve the correct clearance can result in premature transmission failure.

3. Install the oil pan. Refer to *Oil Pan Installation*.
4. Install the transmission to oil pan bolts and nuts.

Tighten

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

5. Install the access plugs for the oil pan rear nuts,

6. Install the bracket for the starter positive cable and the transmission cooler lines to the side of the oil pan.

Tighten

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

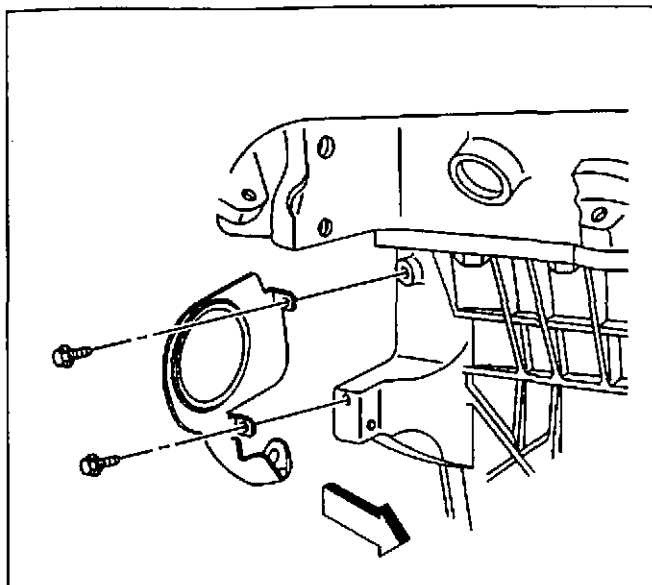
7. Connect the low oil level sensor electrical connector.

8. Install the transmission cover.

Tighten

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

9. Install the starter. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.

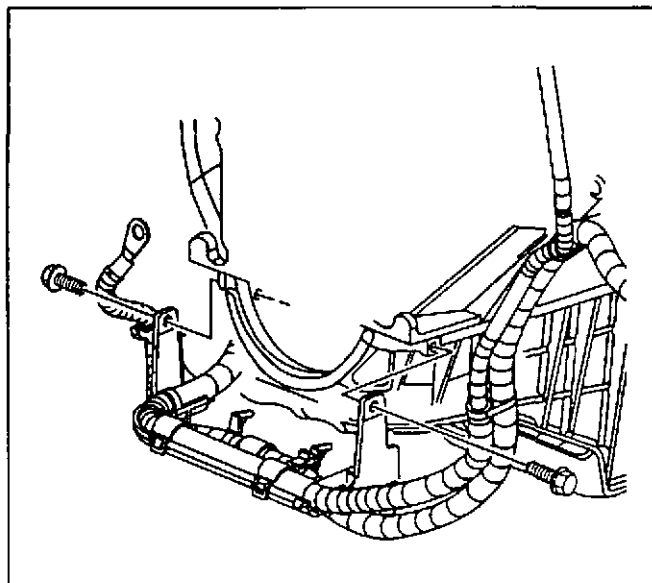


391858

10. Install the bolts holding the battery cable brackets to the oil pan.

Tighten

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

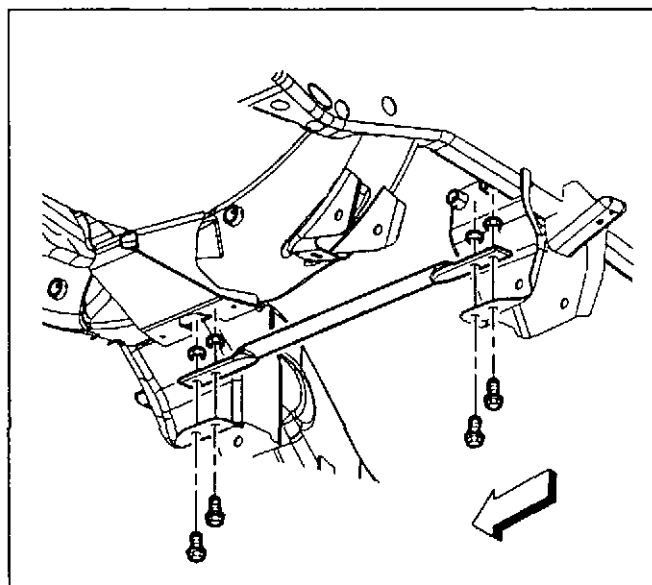


310250

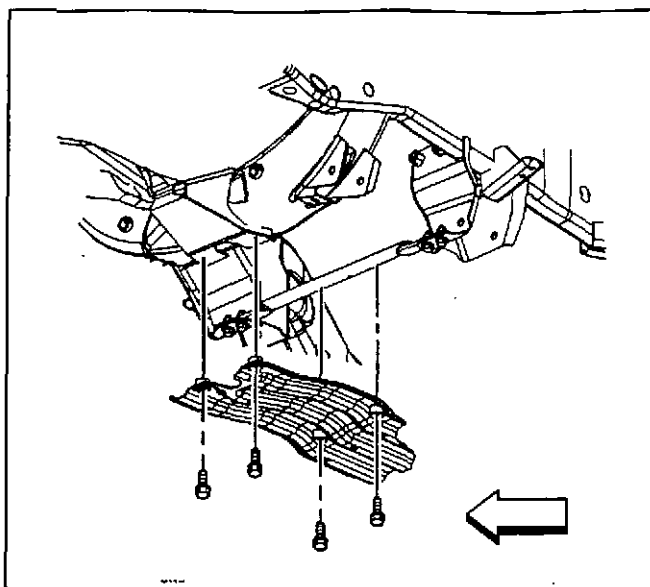
11. Install the crossbar.

Tighten

Tighten the bolts to 100 N.m (74 lb ft).



328107

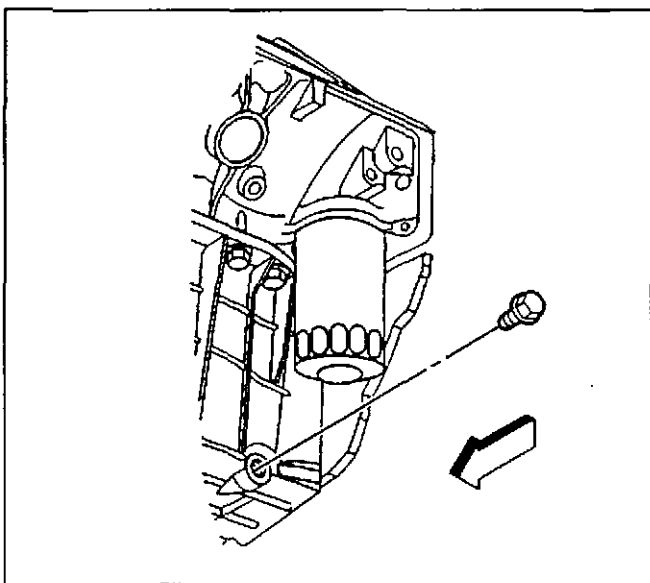


309158

12. Install the oil pan skid plate.

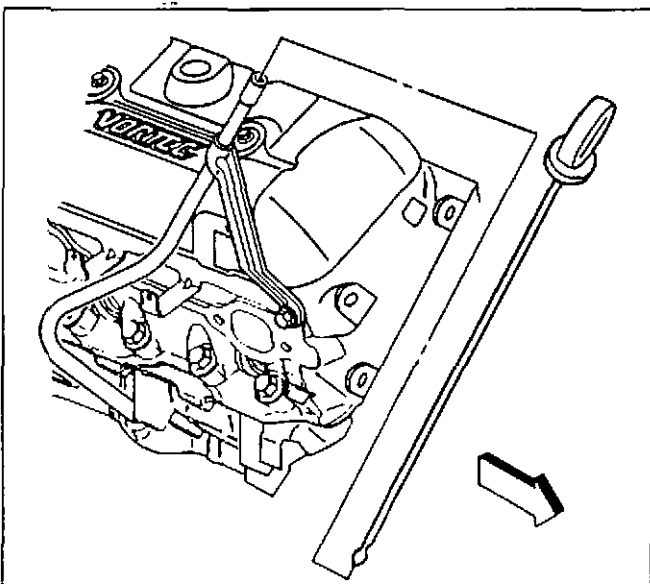
Tighten

Tighten the bolts to 20 N·m (15 lb ft).



188048

13. Install the oil filter and the oil pan drain plug. Refer to *Engine Oil and Oil Filter Replacement*
14. Lower the vehicle.
15. Fill the engine with oil. Refer to *Engine Oil and Oil Filter Replacement*
16. Connect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.



330580

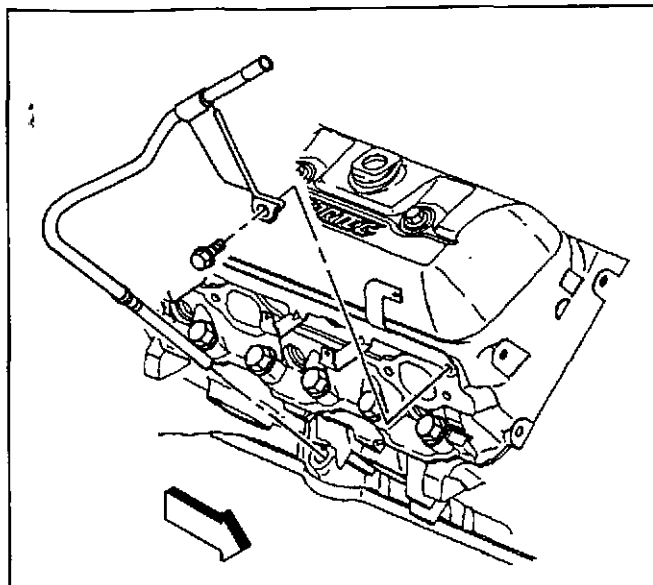
SIE-ID = 331110

Oil Level Indicator and Tube Replacement

Removal Procedure

1. Remove the oil level indicator.
2. Remove the right exhaust manifold. Refer to *Exhaust Manifold Replacement (Right)*.

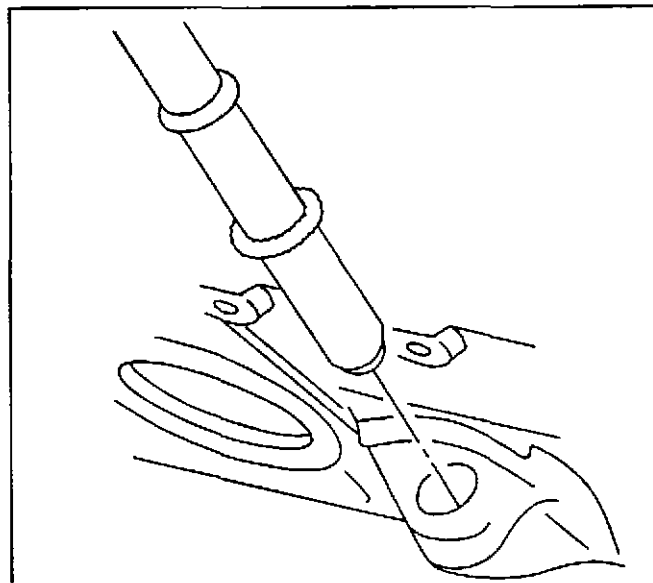
3. Remove the oil level indicator tube bolt.
4. Remove the oil level indicator tube from the engine using a twisting motion.
5. Clean the old sealer from the oil level indicator tube and the engine block.



172977

Installation Procedure

1. Apply sealer, GM P/N 12346004 or equivalent, to the indicator tube on the area where it fits into the engine.
2. Install the oil level indicator tube to the engine. Refer to *Oil Level Indicator and Tube Installation*.



176058

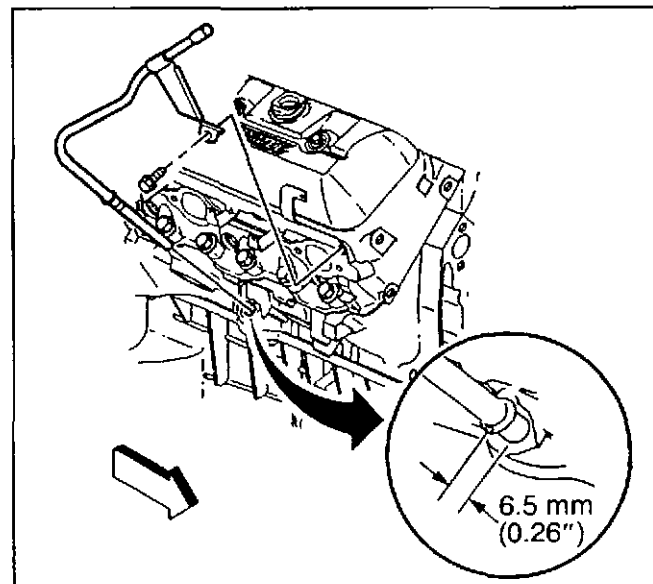
3. Line up the indicator tube with the spark plug wire support bolt hole.

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

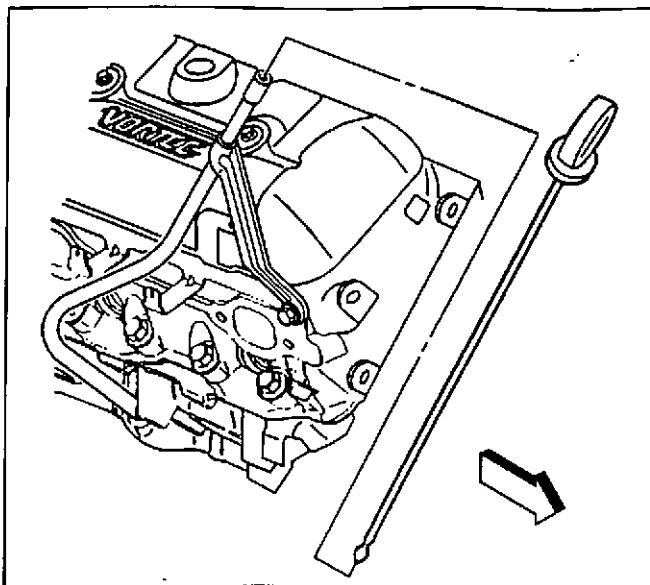
4. Install the bolt.

Tighten

Tighten the oil level indicator tube bolt to 12 N·m (106 lb in).

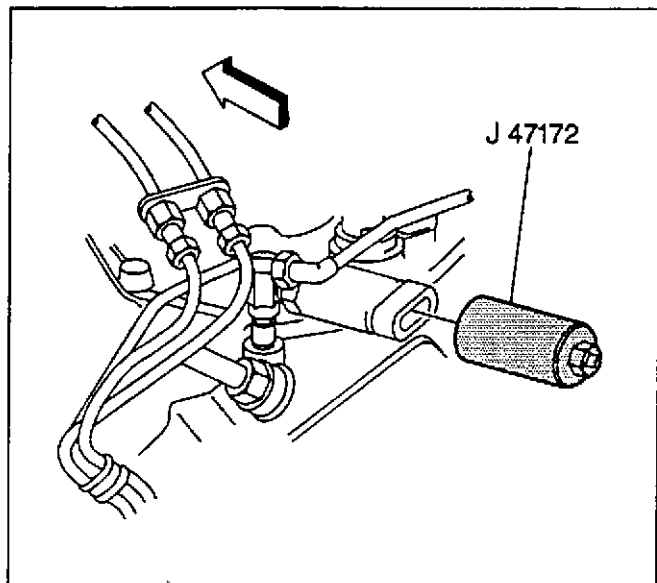


188009



330580

5. Install the right exhaust manifold. Refer to *Exhaust Manifold Replacement (Right)*
6. Install the oil level indicator.



348085

SIE-ID = 348137

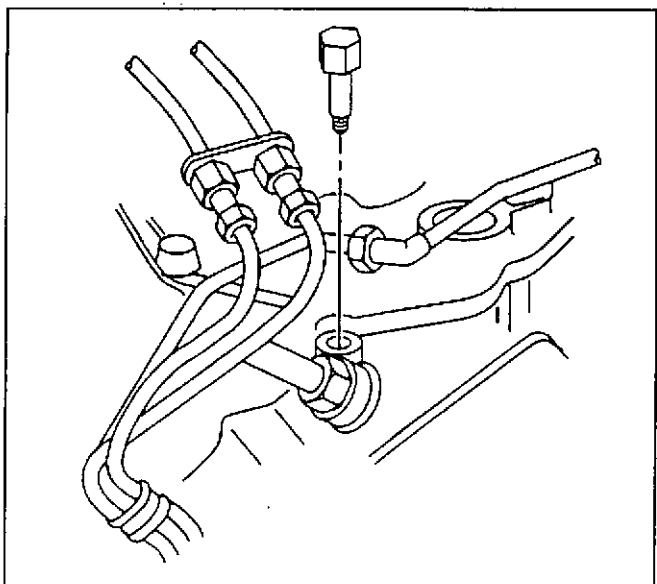
Engine Oil Pressure Sensor/Switch Replacement

Removal Procedure

Tools Required

J 47172 Oil Pressure Switch Socket.

1. Remove the distributor. Refer to *Distributor Replacement (HVS Systems)* in Engine Electrical.
2. Disconnect the engine oil pressure gauge sensor electrical connector.
3. Hold the engine oil pressure gauge sensor fitting with a wrench.
4. Remove the engine oil pressure gauge sensor using the J 47172.



348087

Important: Note the alignment of the engine oil pressure gauge sensor fitting prior to removal.

5. Remove the engine oil pressure gauge sensor fitting, if necessary.

Installation Procedure**Tools Required**

J 41712 Oil Pressure Switch Socket.

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

Important: Do not loosen the sensor fitting. Do not tighten the sensor fitting more than one turn.

1. Install the engine oil pressure gauge sensor fitting, if removed.

Tighten

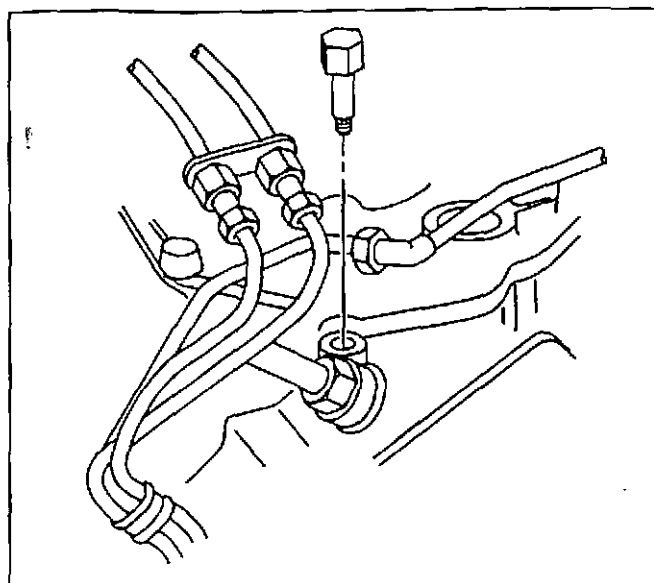
- 1.1. Tighten the engine oil pressure gauge sensor fitting to 15 N·m (11 lb ft).
- 1.2. Tighten the sensor fitting until properly align.

2. Install the engine oil pressure gauge sensor.
3. Hold the engine oil pressure gauge sensor fitting with a wrench to prevent from turning.

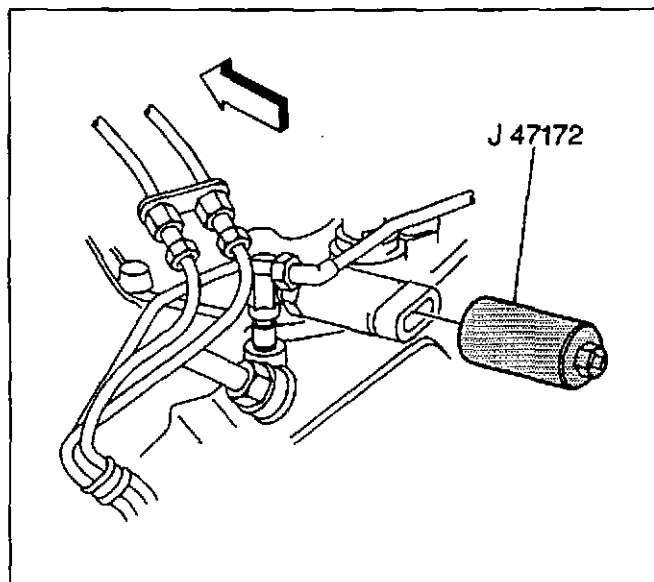
Tighten

Using the J 41712 tighten the engine oil pressure gauge sensor to 30 N·m (22 lb ft).

4. Connect the engine oil pressure gauge sensor electrical connector.
5. Install the distributor. Refer to *Distributor Replacement (HVS Systems)* in Engine Electrical.



348087

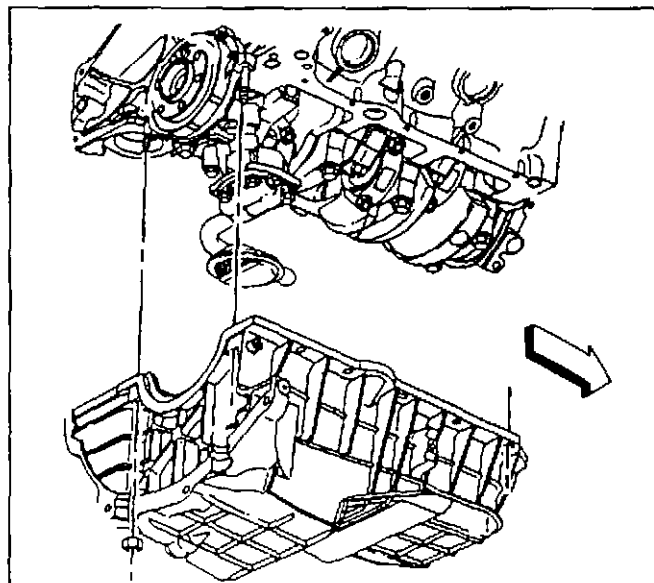


348085

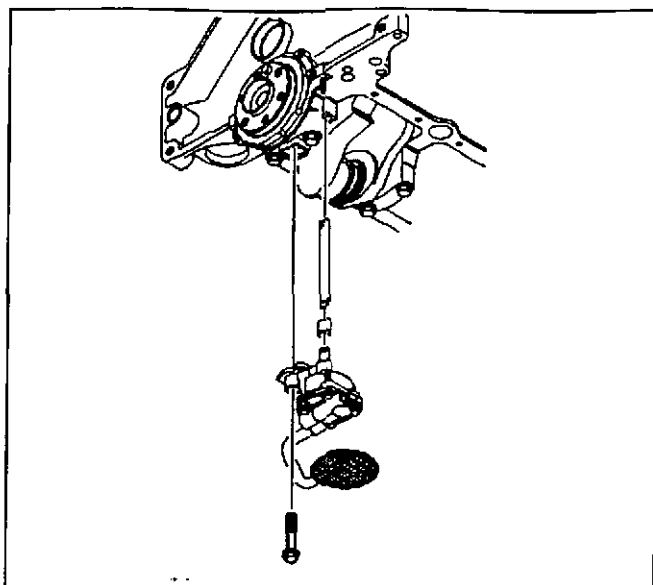
SIE-ID - 331114

Oil Pump Replacement**Removal Procedure**

1. Remove the oil pan. Refer to *Oil Pan Replacement*.

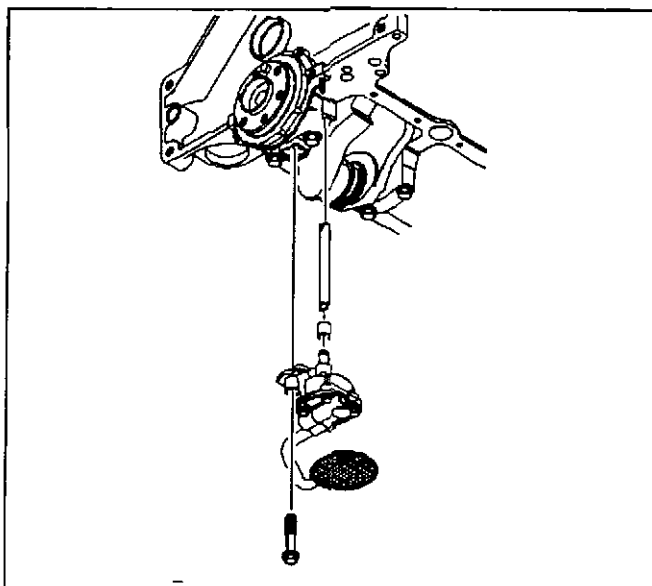


31739



4548

2. Remove the oil pump. Refer to *Oil Pump Removal*.
3. Clean and inspect all parts. Refer to *Oil Pump Clean and Inspect*.

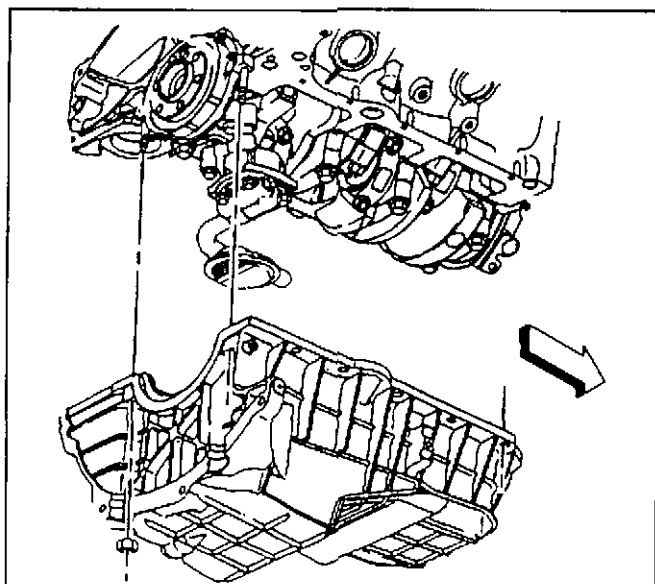


4548

Installation Procedure

Important: Use a NEW oil pump driveshaft retainer.

1. Install the oil pump. Refer to *Oil Pump Installation*.



31739

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

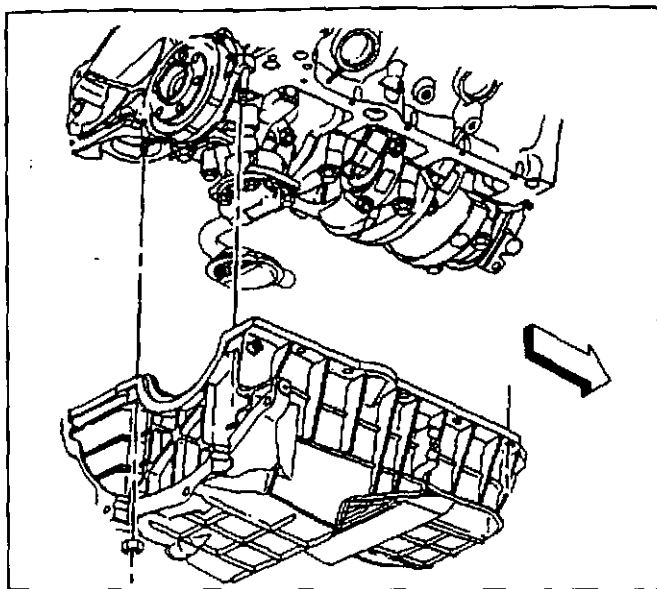
SIE-ID - 331121

Crankshaft Rear Oil Seal and Housing Replacement (Housing)

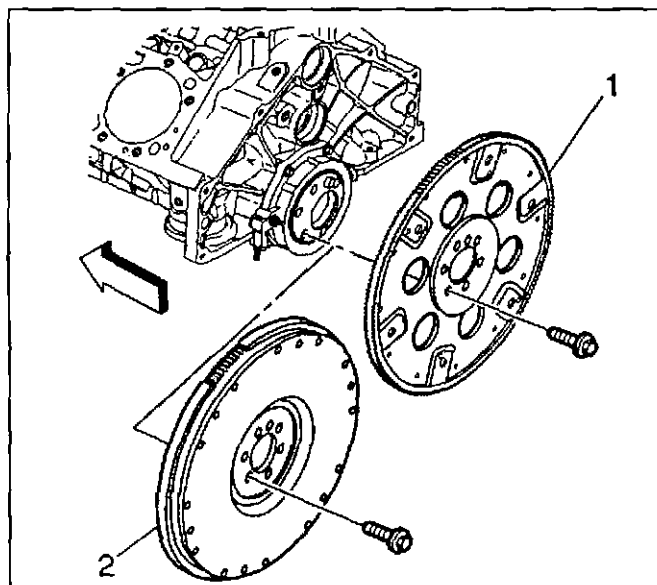
Removal Procedure

Important: Do not remove the crankshaft rear oil seal housing if only replacing the crankshaft rear oil seal.

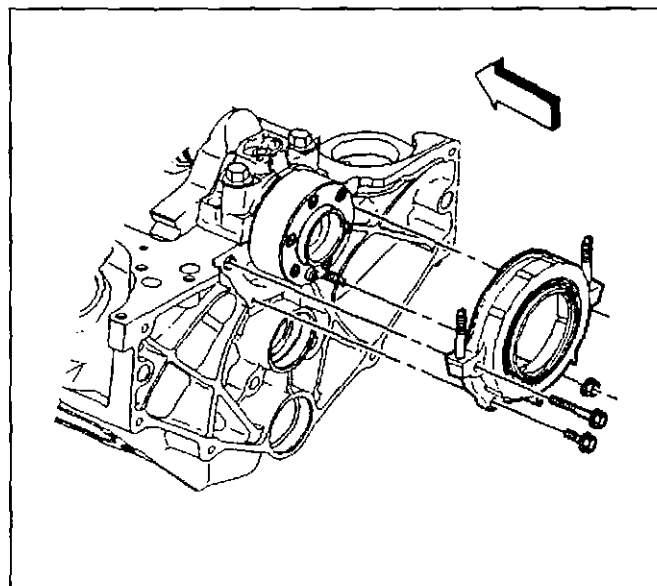
1. Remove the oil pan. Refer to *Oil Pan Replacement*.
2. Remove the transmission assembly.
 - Refer to *Transmission Replacement in Automatic Transmission - 4L60-E*.
 - Refer to *Transmission Replacement in Manual Transmission - NV3500*.
3. Remove the engine flywheel (1) or (2).
 - Refer to *Engine Flywheel Replacement (Automatic Transmission)*.
 - Refer to *Engine Flywheel Replacement (Manual Transmission)*.
4. Remove the three bolts and the one nut holding the crankshaft rear oil seal housing to the engine.
5. Remove the crankshaft rear oil seal housing.



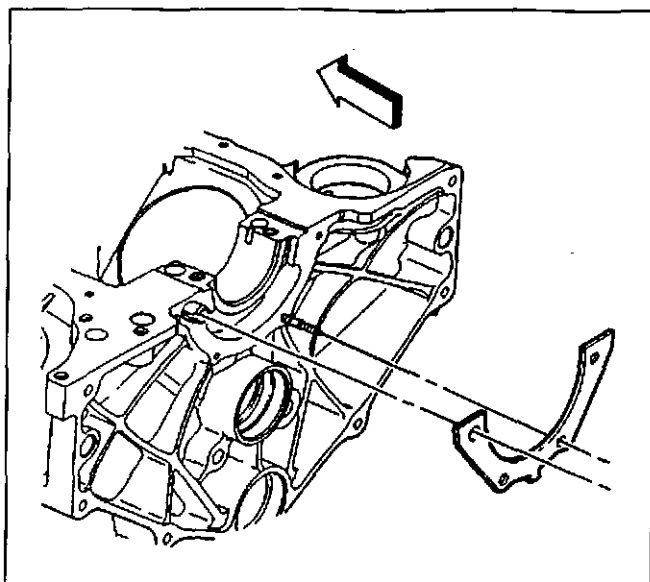
31739



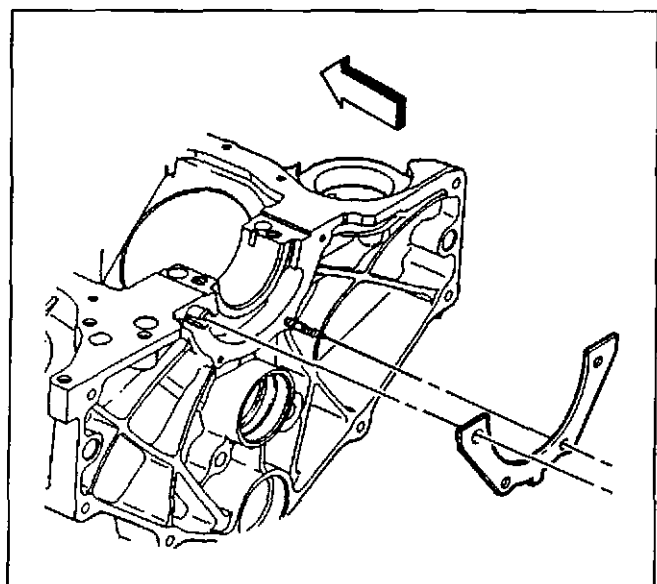
188129



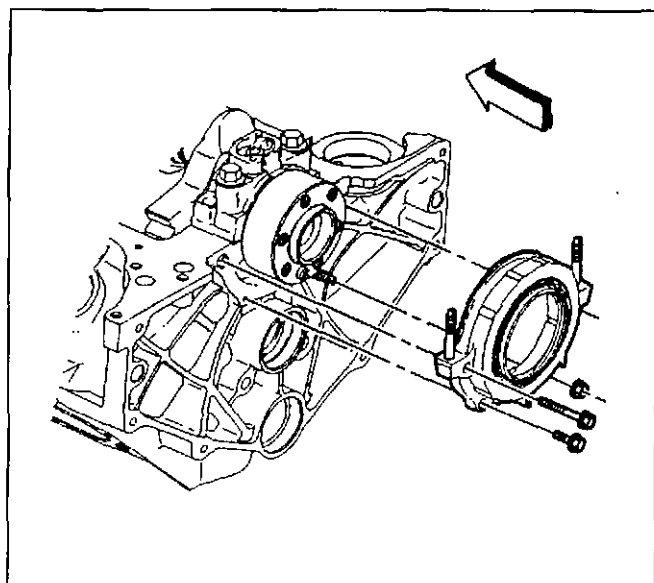
334317



334319



334319



334317

6. Remove and discard the crankshaft rear oil seal housing gasket.
7. Clean all sealing surfaces.
8. Inspect the crankshaft rear oil seal housing for warping, cracks, wear, or damage.

Installation Procedure

1. Install a NEW crankshaft rear oil seal housing gasket.

Important: When installing the NEW crankshaft rear oil seal housing the seal will come with the housing. Use the following procedure for installing a new housing. Refer to *Crankshaft Rear Oil Seal and Housing Replacement (Seal)* if reusing the housing.

Important: Do not oil or grease the seal lip.

2. Install the NEW crankshaft rear oil seal housing with seal to the engine block using the following procedure:
 - 2.1. Leave the sleeve in the crankshaft rear oil seal and use the sleeve as a guide to ease the seal lip over the end of the crankshaft.
 - 2.2. Push the crankshaft rear oil seal housing with the seal, fully on to the crankshaft until the housing is against the gasket and the engine.

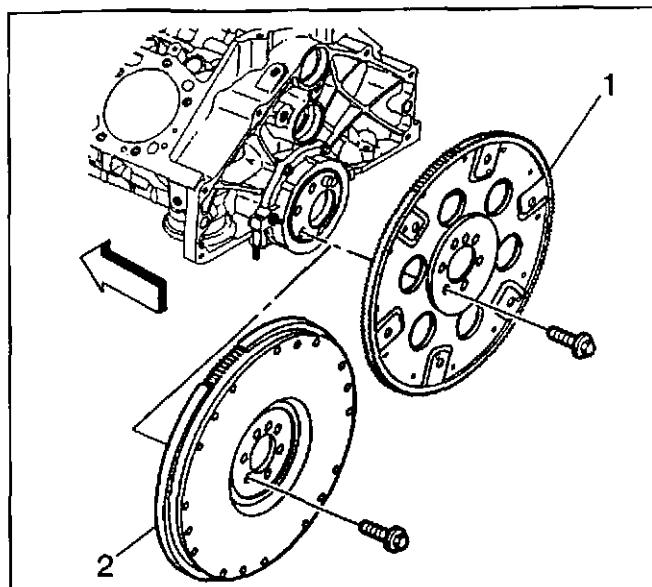
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the three bolts and the one nut to the crankshaft rear oil seal housing.

Tighten

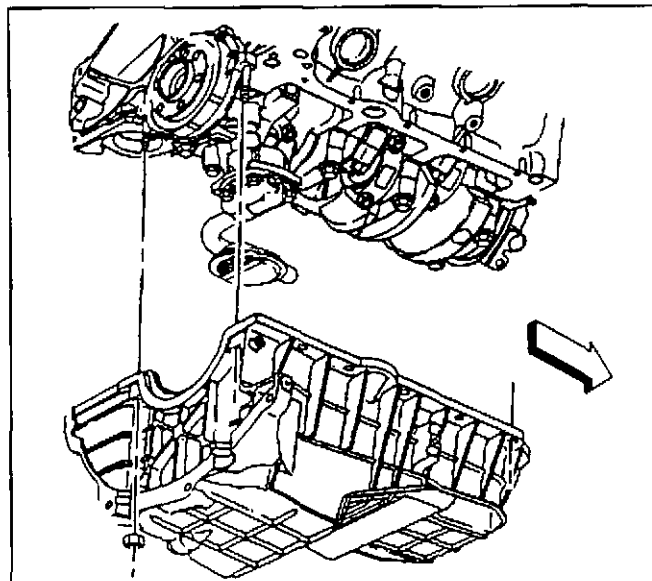
Tighten the crankshaft rear oil seal housing bolts and nut to 12 N.m (106 lb in).

4. Install the engine flywheel (1) or (2).
- Refer to *Engine Flywheel Replacement (Automatic Transmission)*.
 - Refer to *Engine Flywheel Replacement (Manual Transmission)*.
5. Install the transmission assembly.
- Refer to *Transmission Replacement in Automatic Transmission - 4L60-E*.
 - Refer to *Transmission Replacement in Manual Transmission - NV3500*.

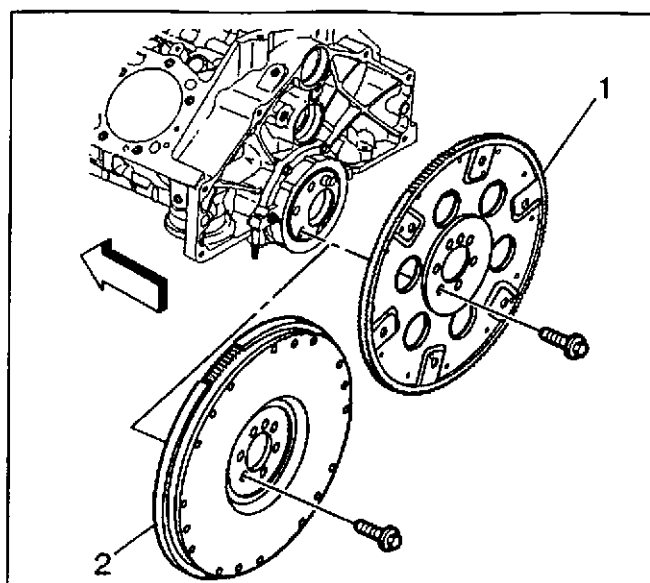


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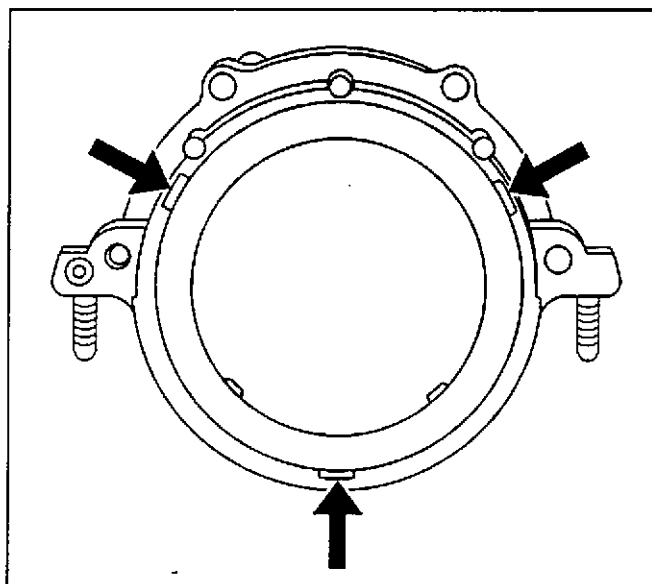
6. Install the oil pan. Refer to *Oil Pan Replacement*.



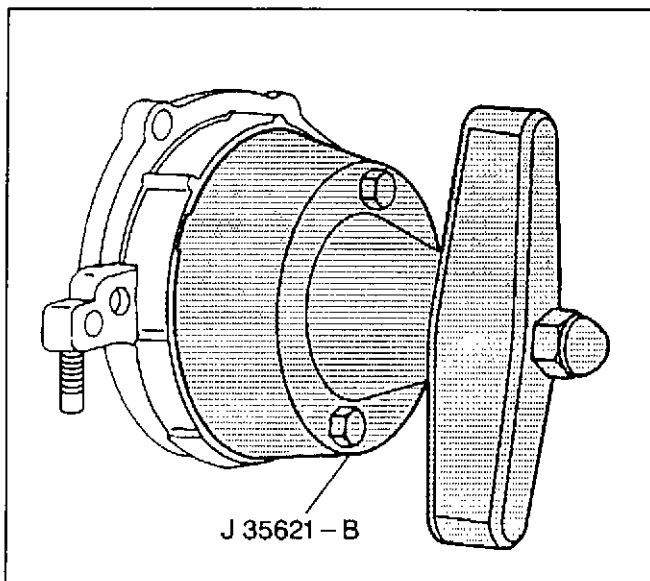
31739



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SIE-ID - 331123

Crankshaft Rear Oil Seal and Housing Replacement (Seal)

Removal Procedure

1. Remove the transmission assembly.
 - Refer to *Transmission Replacement* in Automatic Transmission - 4L60-E.
 - Refer to *Transmission Replacement* in Manual Transmission - NV3500.
2. Remove the engine flywheel (1) or (2).
 - Refer to *Engine Flywheel Replacement (Automatic Transmission)*.
 - Refer to *Engine Flywheel Replacement (Manual Transmission)*.
3. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.

Insert a suitable tool into the access notches and then carefully pry the crankshaft rear oil seal from the crankshaft rear oil seal housing.
4. Discard the crankshaft rear oil seal.
5. Clean off any dirt or rust in the area.

Installation Procedure

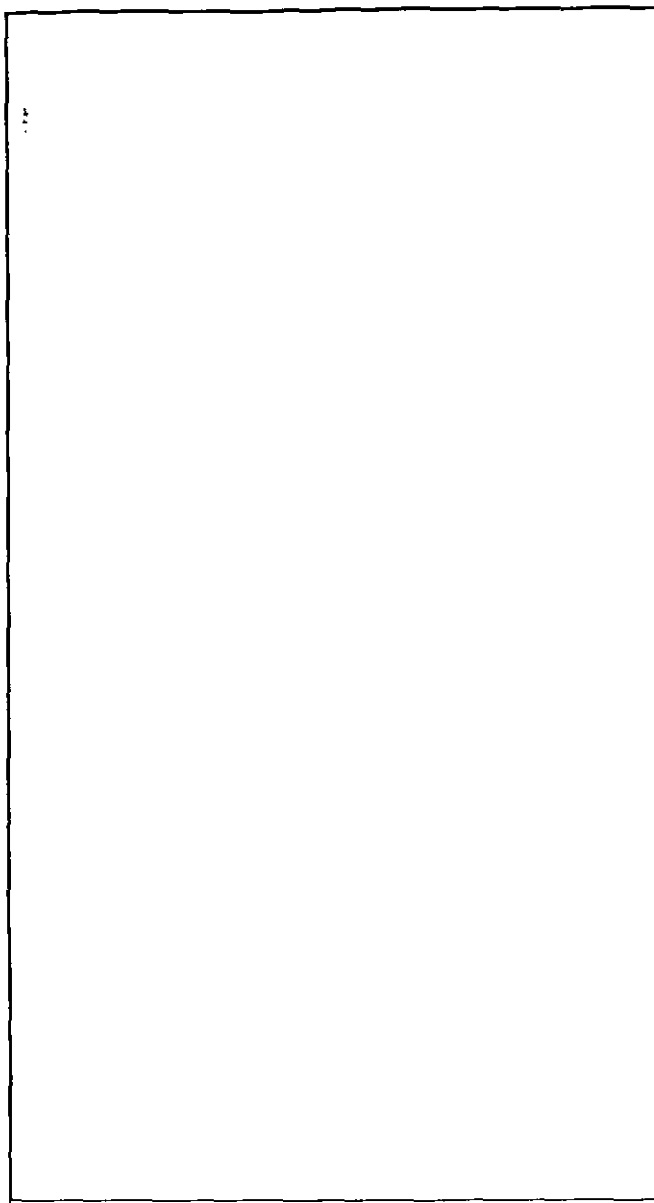
Tools Required

J 35621-B Rear Main Seal Installer

Important: Do not oil or grease the seal lip.

1. Use the J 35621-B in order to install the NEW oil seal. Refer to *Crankshaft Rear Oil Seal and Housing Installation*.

2. Install the engine flywheel (1) or (2).
 - Refer to *Engine Flywheel Replacement (Automatic Transmission)*.
 - Refer to *Engine Flywheel Replacement (Manual Transmission)*.
3. Install the transmission assembly.
 - Refer to *Transmission Replacement in Automatic Transmission - 4L60-E*.
 - Refer to *Transmission Replacement in Manual Transmission - NV3500*.



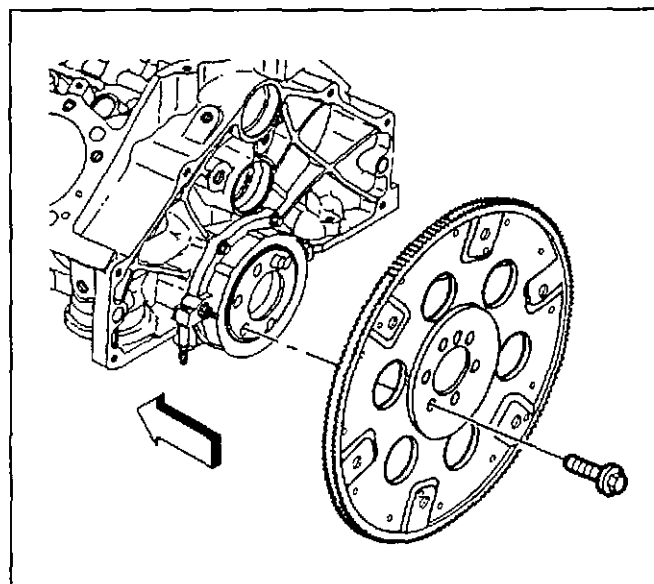
188189

SIE-ID = 331124

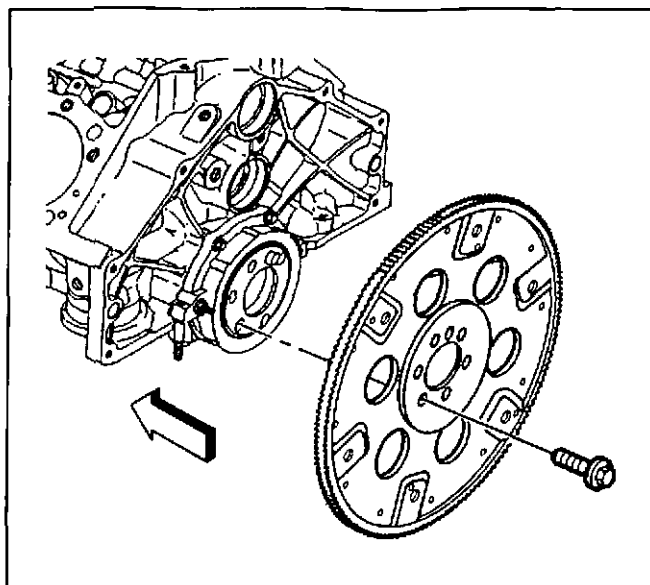
Engine Flywheel Replacement (Automatic Transmission)

Removal Procedure

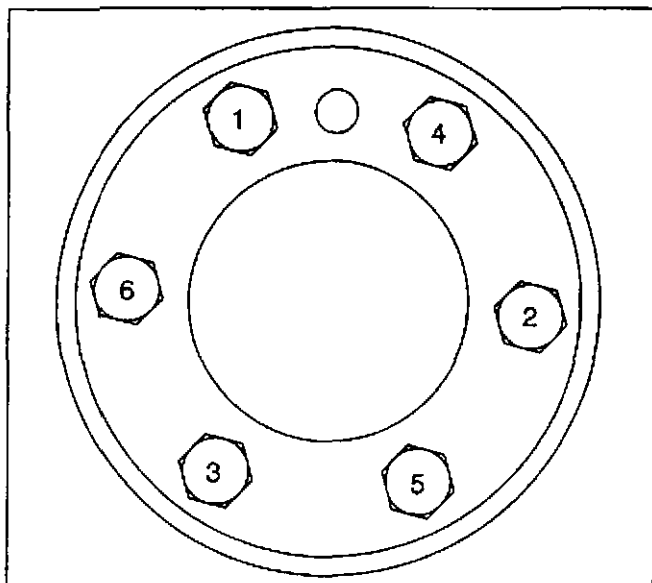
1. Remove the transmission assembly. Refer to *Transmission Replacement in Automatic Transmission - 4L60-E*.
2. Remove the bolts and the engine flywheel.
3. Clean and inspect all parts. Refer to *Engine Flywheel Clean and Inspect*.



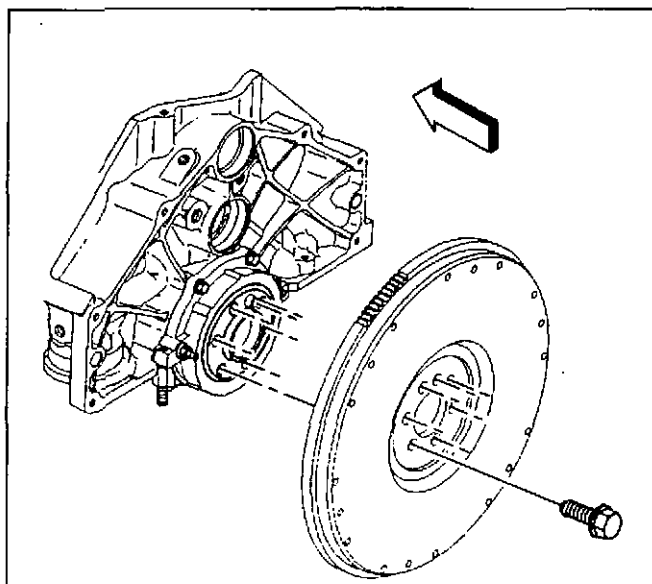
188130



188130



63174



345944

Installation Procedure

1. Install the engine flywheel.
2. Align the locator hole to the pin.

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

3. Install the engine flywheel bolts.

Tighten

Tighten the engine flywheel bolts in sequence to 100 N.m (74 lb ft).

4. Install the transmission assembly. Refer to *Transmission Replacement* in Automatic Transmission - 4L60-E.

SIE-10 = 412145

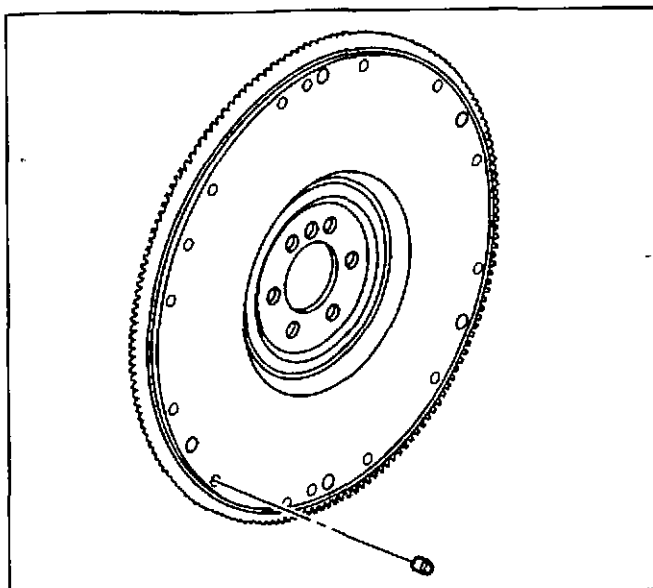
Engine Flywheel Replacement (Manual Transmission)

Removal Procedure

1. Remove the transmission. Refer to *Transmission Replacement* in Manual Transmission - NV3500.
2. Remove the clutch assembly. Refer to *Clutch Assembly Replacement* in Clutch.
3. Remove the bolts and the engine flywheel.

Important: If replacing the manual transmission engine flywheel, NEW balance weights must be installed into the NEW engine flywheel in the same location as the old engine flywheel.

4. Note the position of any manual transmission engine flywheel balance weights for assembly (if applicable).
5. Clean and inspect all parts. Refer to *Engine Flywheel Clean and Inspect*.



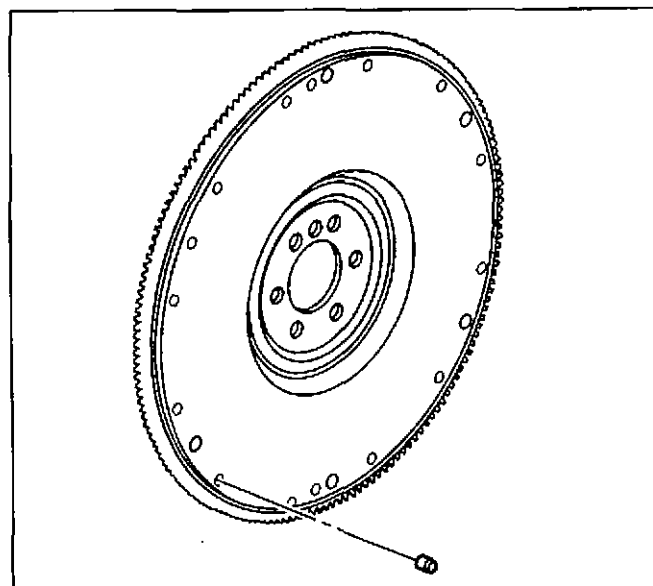
64126

Installation Procedure

Important: If replacing the engine flywheel note the position of the original balance weights (if applicable). Balance weights must be installed into the new engine flywheel in the same location.

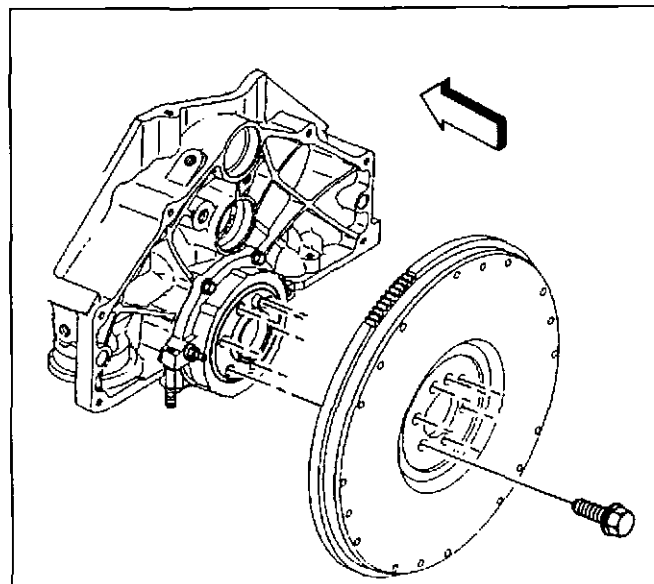
1. Note the position of the engine flywheel balance weights and install the engine flywheel balance weights as required.

A properly installed engine flywheel balance weight will be flush or slightly below flush with the face of the engine flywheel.

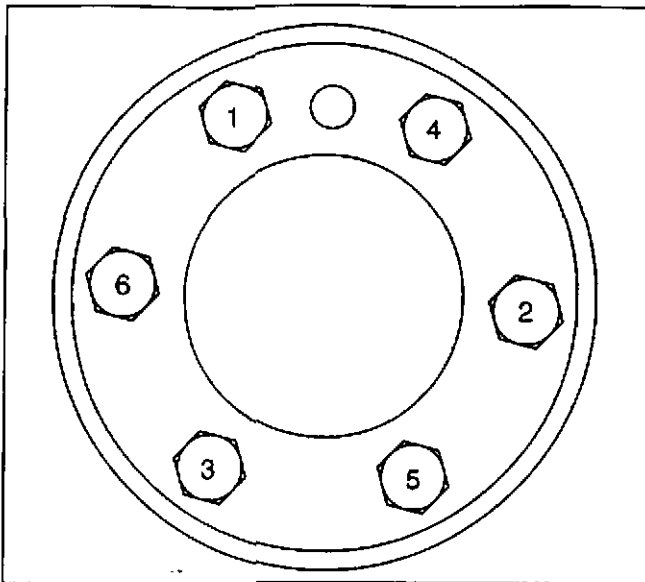


64126

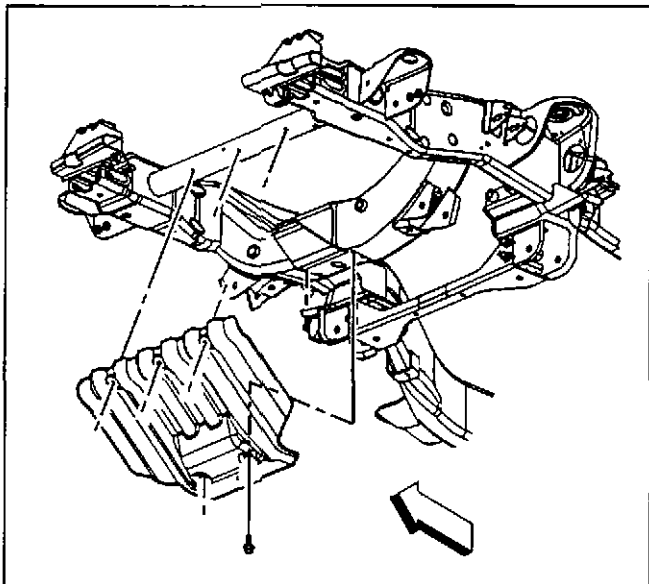
2. Install the engine flywheel to the crankshaft.
3. Align the locator hole to the pin.



345944



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310119

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

4. Install the engine flywheel bolts.

Tighten

Tighten the engine flywheel bolts in sequence to 100 N.m (74 lb ft).

5. Install the clutch assembly. Refer to *Clutch Assembly Replacement* in Clutch.
6. Install the transmission. Refer to *Transmission Replacement* in Manual Transmission - NV3500.

SIE-ID = 331132

Engine Replacement

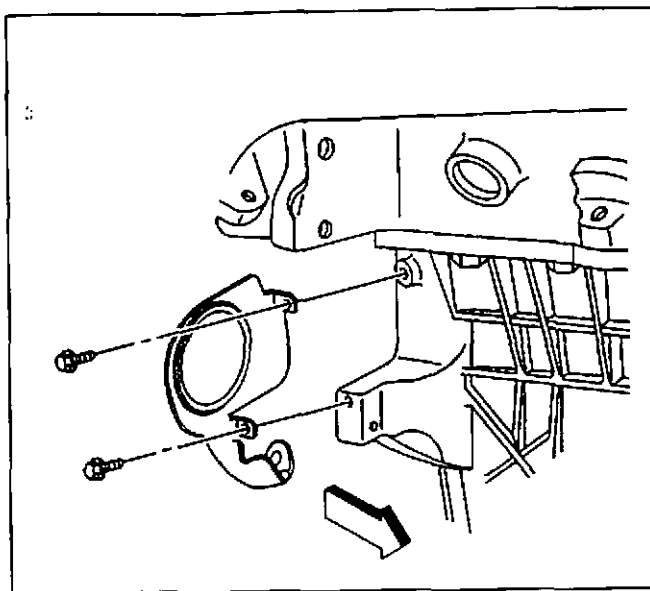
Removal Procedure

Tools Required

J 41427 Engine Lift Brackets

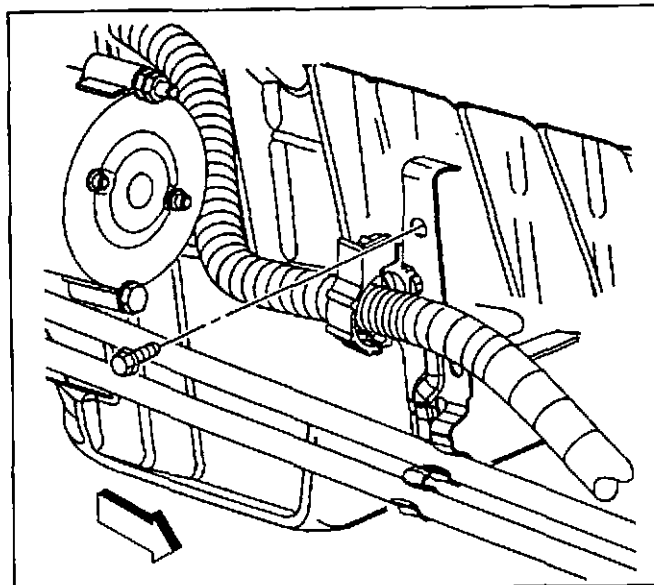
1. Disconnect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.
2. Drain the engine coolant. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Evacuate and recover the A/C refrigerant, if equipped. Refer to *Refrigerant Recovery and Recharging* in HVAC Systems with A/C - Manual.
4. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
5. Remove the oil pan skid plate.
6. Remove the engine protection shield, if equipped. Refer to *Engine Protection Shield Replacement* in Frame and Underbody.
7. Remove the starter. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.

8. Remove the transmission cover.



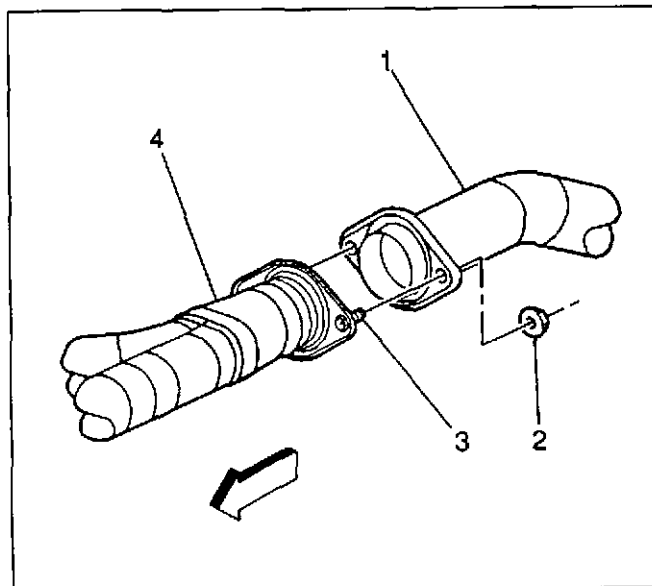
391868

9. Remove the bolt holding the bracket for the starter cables and transmission cooler lines, if equipped.

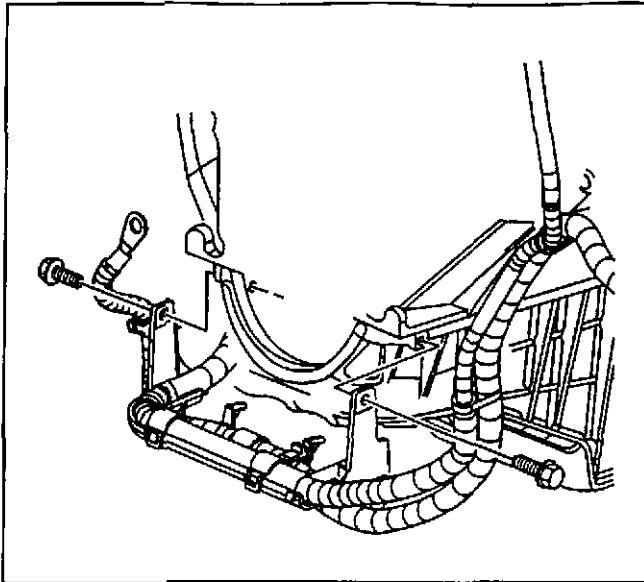


327996

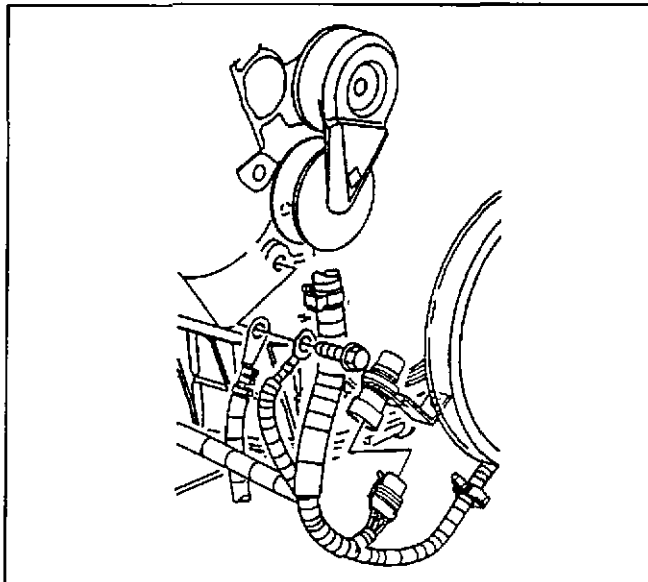
10. Loosen the nuts (2) at the catalytic converter pipe.
11. Remove the exhaust pipes from the exhaust manifolds. Refer to *Catalytic Converter Replacement (System A 4.3L, 4.8L, and 5.3L)* in Engine Exhaust.



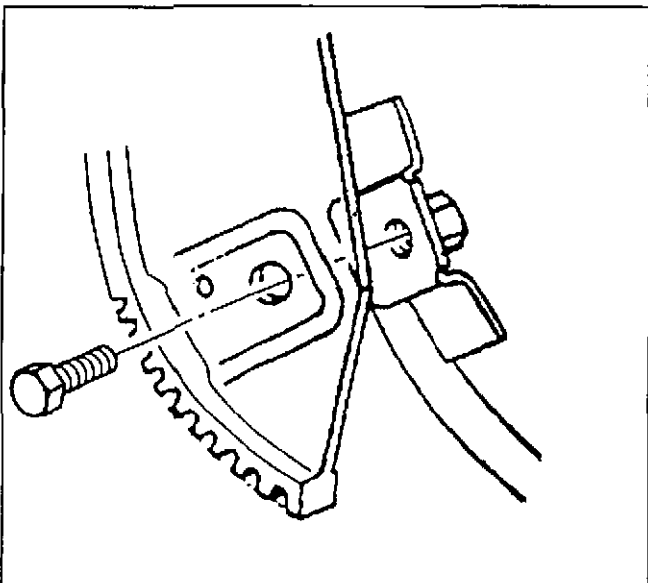
344257



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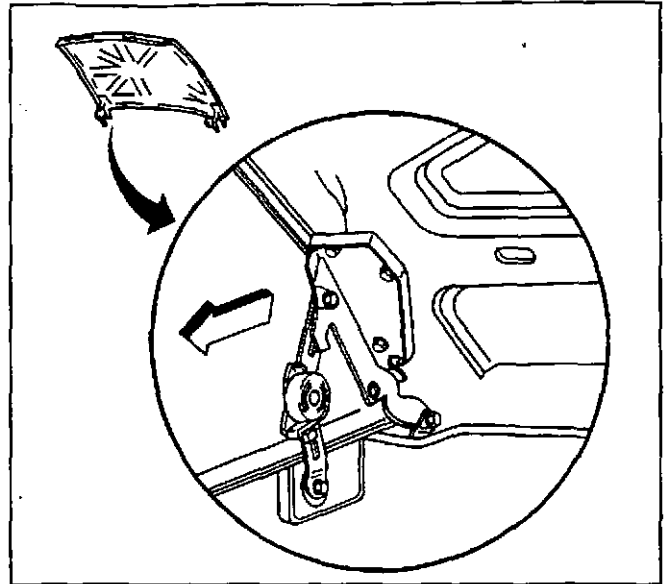
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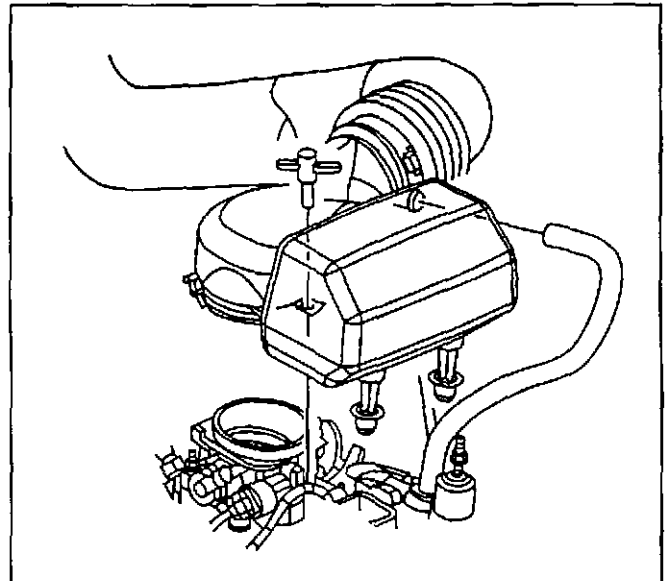
12. Disconnect the low oil level sensor electrical connector.
13. Disconnect the crankshaft position (CKP) sensor and remove the harness from the retainer.
14. Remove the bolts holding the brackets to the oil pan for both battery cables.
15. Remove the bolt holding the battery negative cable and a ground cable to the engine.
16. Remove the torque converter to flywheel bolts, if equipped, through the starter opening.
17. Remove the engine to transmission bolts.
 - Refer to *Transmission Replacement* in Automatic Transmission - 4L60-E.
 - Refer to *Transmission Replacement* in Manual Transmission - NV3500.
18. Lower the vehicle.

19. Move the hood hinge bolts to hold the hood in the service position.



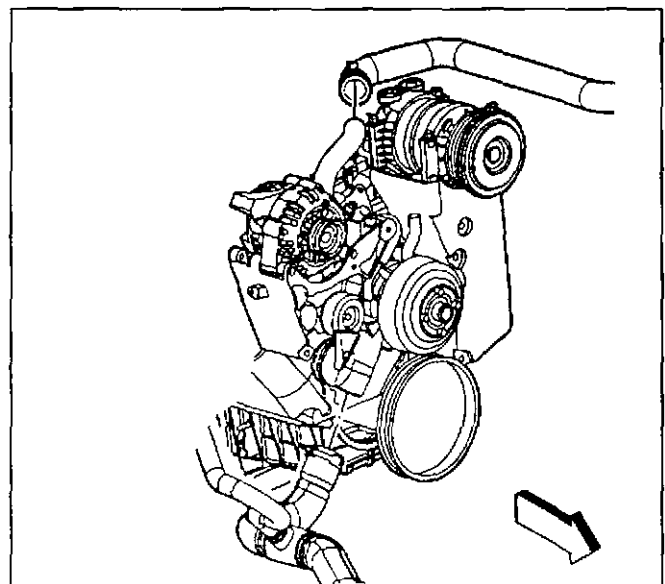
310799

20. Disconnect the PCV hose from the air inlet duct.
21. Remove the air inlet duct from the throttle body and the MAF sensor.
22. Remove the fan shroud. Refer to *Fan Shroud Replacement* in Engine Cooling.
23. Remove the drive belt. Refer to *Drive Belt Replacement*.
24. Remove the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.

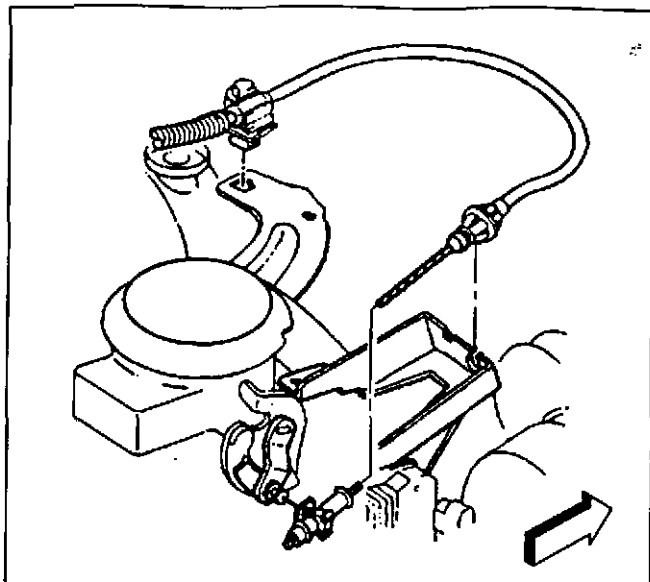


310234

25. Remove the radiator inlet hose from the engine. Refer to *Radiator Hose Replacement - Inlet (4.3L)* in Engine Cooling.
26. Remove the radiator outlet hose from the engine. Refer to *Radiator Hose Replacement - Outlet (4.3L)* in Engine Cooling.
27. Remove the surge tank hose from the engine.



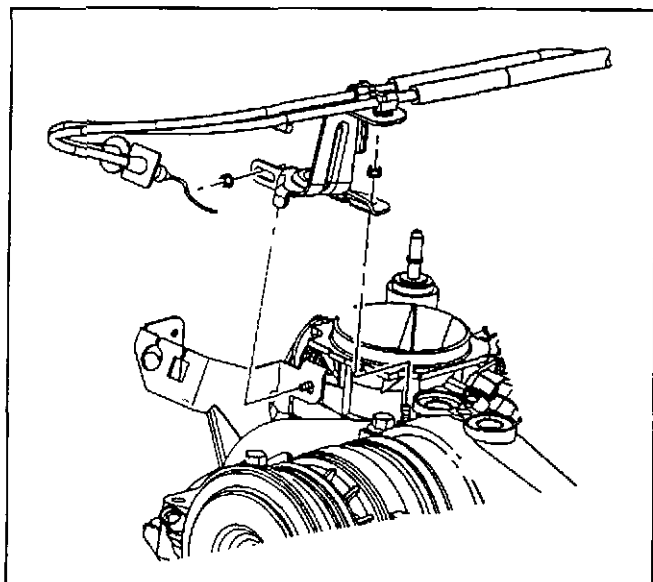
328572



31608

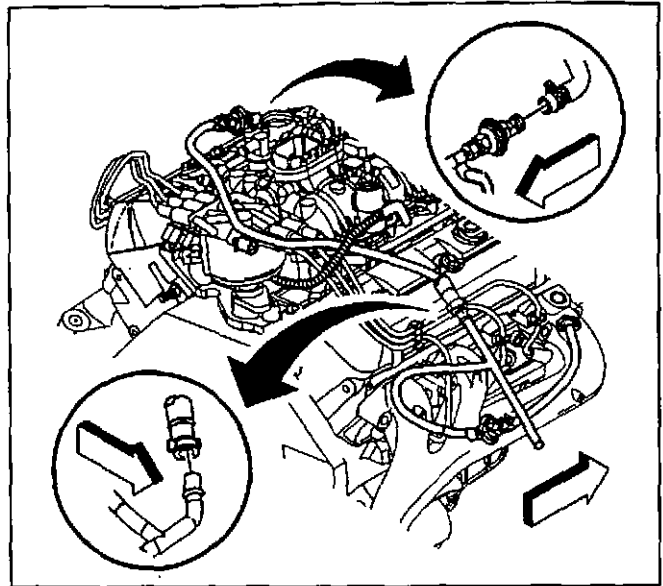
Caution: SIO-ID - 352518 To help avoid potential personal injury or potential damage to the vehicle due to possible cable damage during service, replace the existing accelerator control cable with a NEW cable when removing or replacing the engine. Position the cruise control cable out of the way to ensure it is not damaged while removing or installing the engine. Do not bend the cruise-control cable and cause a kink at the bend. Do not position the cruise control cable where the technician may lean or pry against the cable and cause damage to the cable.

28. Disconnect the accelerator control cable from the throttle body. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.
29. Disconnect the cruise control cable from the throttle body, if equipped. Refer to *Cruise Control Cable Replacement* in Cruise Control.
30. Disconnect the accelerator control cable and the cruise control cable from the bracket on the throttle body and intake manifold.
31. Disconnect the accelerator control cable and the cruise control cable from the bracket on the throttle body.
32. Move the cables aside.
33. Remove the accelerator control cable bracket from the throttle body.
34. Disconnect the A/C hoses from the compressor and the accumulator, if equipped. Refer to *Compressor Hose Assembly Replacement (4.3L)* in HVAC Systems in A/C - Manual.



398030

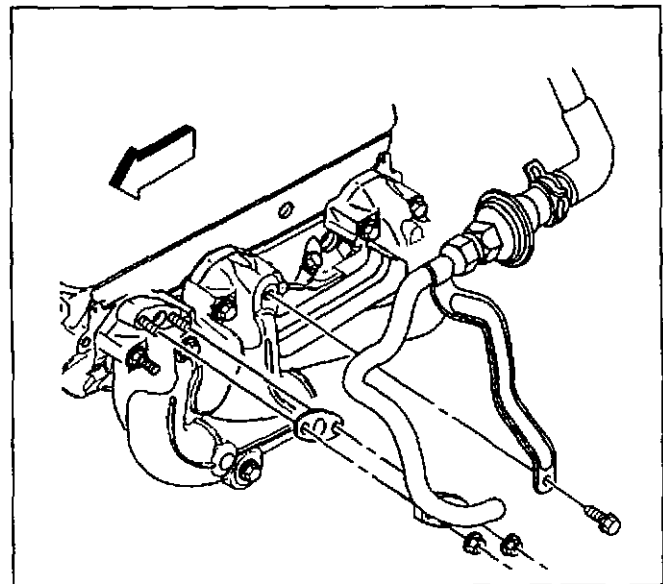
35. Remove the secondary air injection (AIR) crossover pipe from the AIR pipe assemblies.



396868

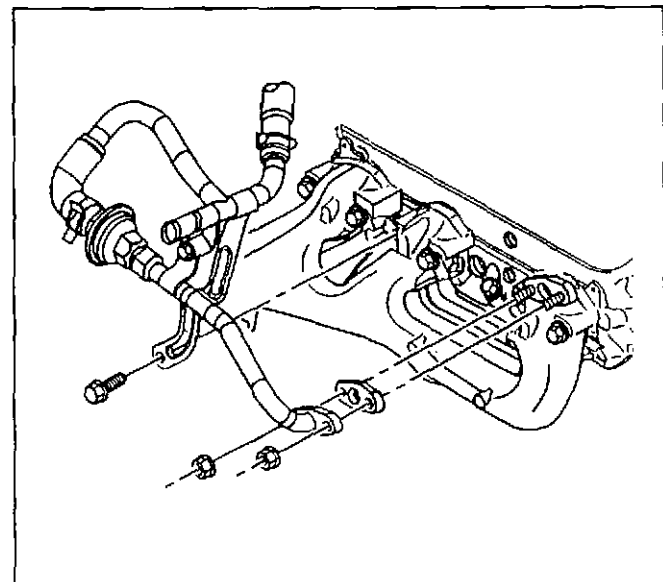
Notice: The AIR pipes can be easily damaged or broken. To prevent from being damaged or broken remove the AIR pipes during engine removal.

36. Remove AIR pipe assemblies from the left exhaust manifold, if equipped.

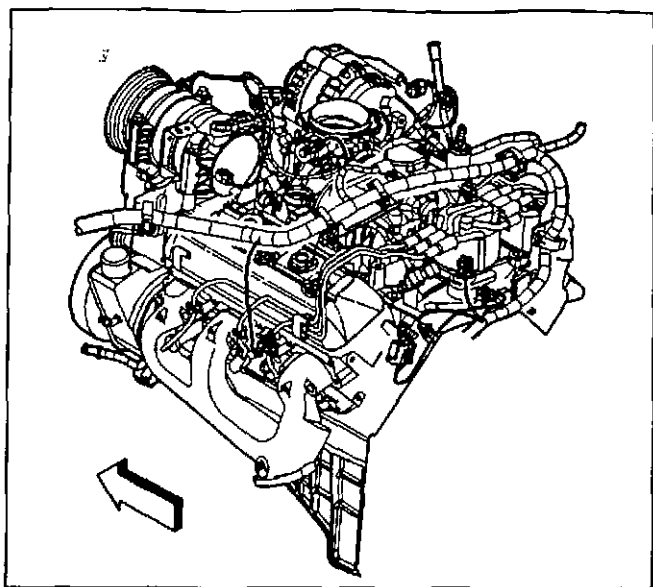


332032

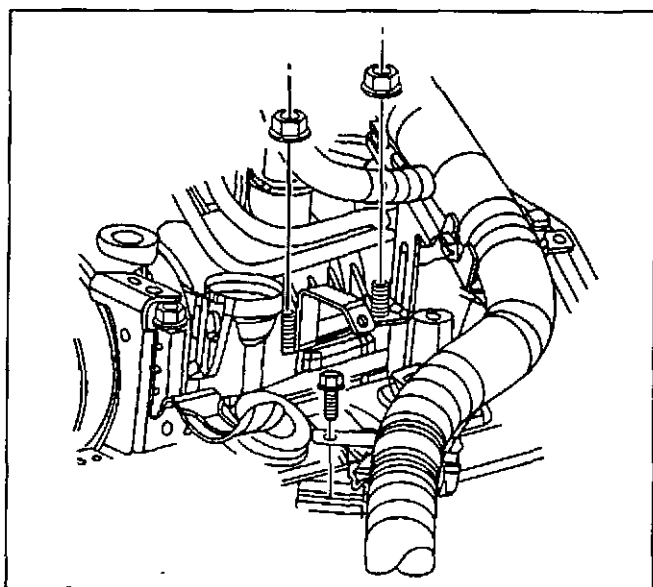
37. Disconnect the AIR pipe assembly from the AIR pump.
38. Remove the AIR pipe assembly from the right exhaust manifold, if equipped.



332026



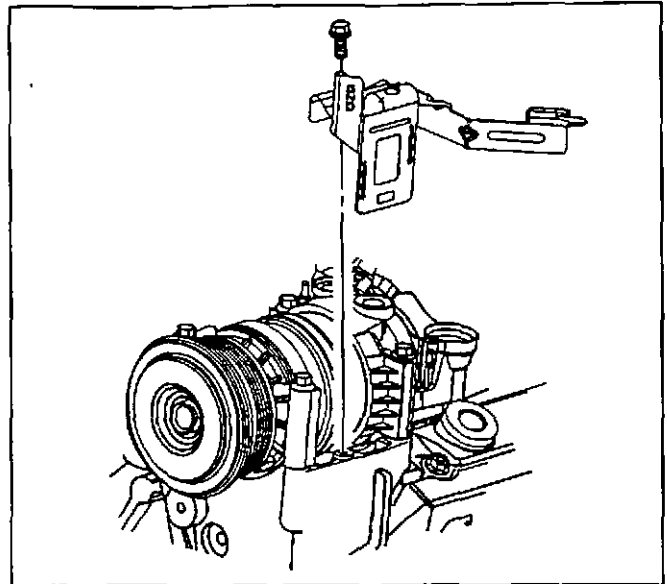
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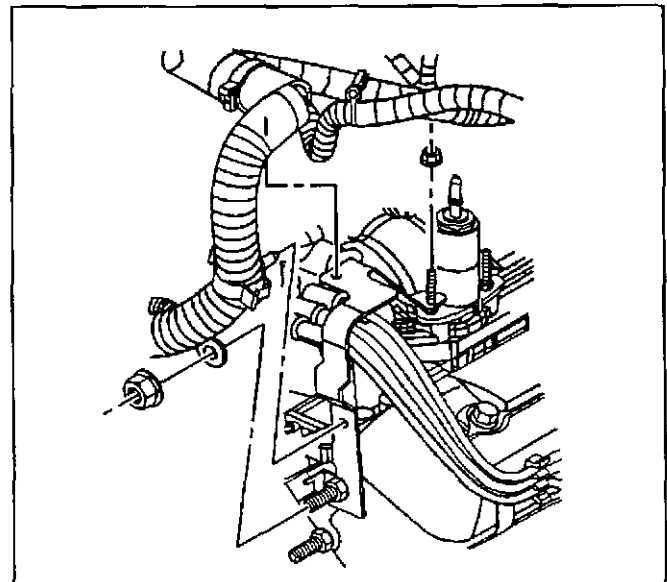
39. Disconnect the following electrical connections from the top of the engine.
- The generator positive cable and connector
 - The fuel meter body assembly
 - The EVAP canister purge solenoid valve
 - The idle air control (IAC) motor
 - The throttle position (TP) sensor
 - The engine coolant temperature (ECT) sensor
 - The A/C compressor high pressure switch, if equipped
 - The A/C clutch switch, if equipped
 - The exhaust gas recirculation (EGR) valve
 - The two ignition control module (ICM)
 - The manifold absolute pressure (MAP) sensor
 - The engine oil pressure gauge sensor
 - The distributor
 - The knock sensor (KS)
40. Remove the nuts holding the brackets for the engine wiring harness to the intake studs.
41. Remove the bolt holding the engine wiring harness to the bracket on the power steering mounting bracket.

42. Remove the bracket for the battery positive cable junction block from the power steering pump mounting bracket.
43. Move the battery positive and negative cables aside.



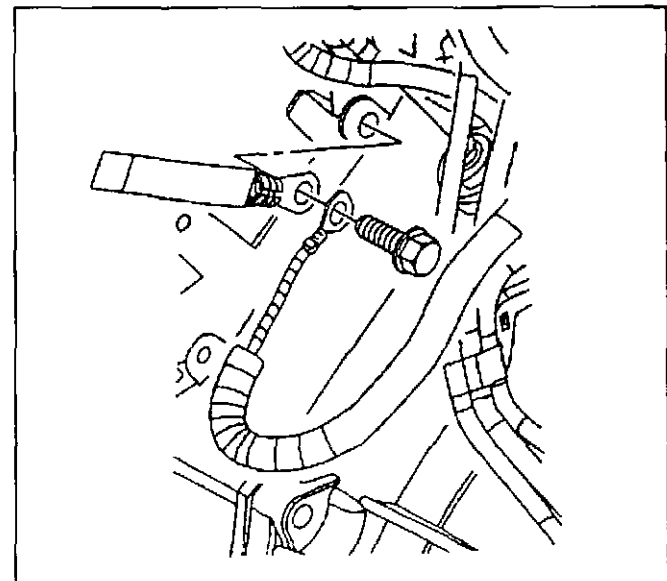
394403

44. Remove the nut holding the ground wire to the stud at the rear of the right cylinder head.
45. Remove the stud holding the engine wiring harness bracket to the rear of the right cylinder head.
46. Remove the nut holding the engine wiring harness bracket to the stud for the EVAP canister purge solenoid valve.

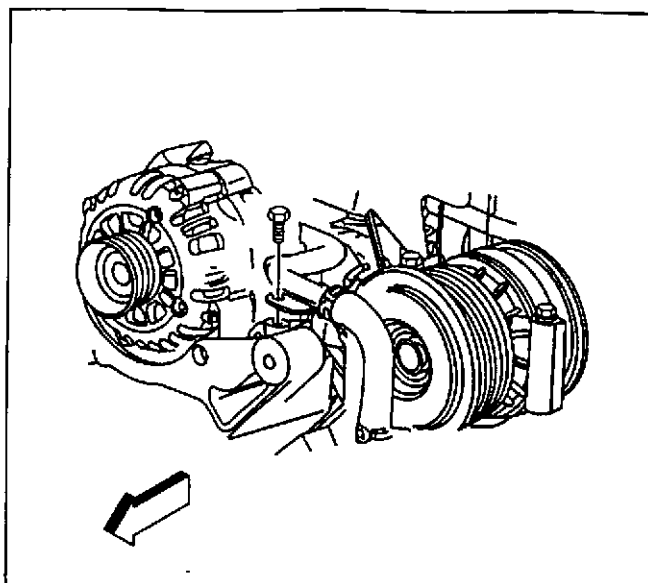


310243

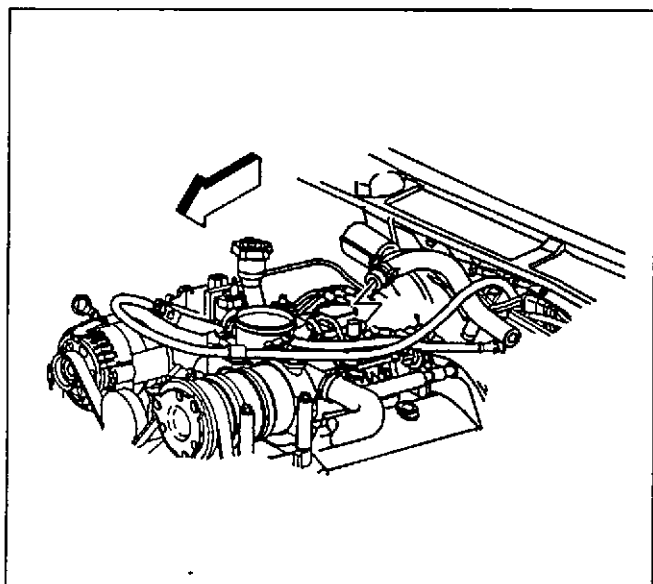
47. Remove the bolt holding the ground strap and the ground wire to the rear of the left cylinder head.
48. Move the engine wiring harness aside.



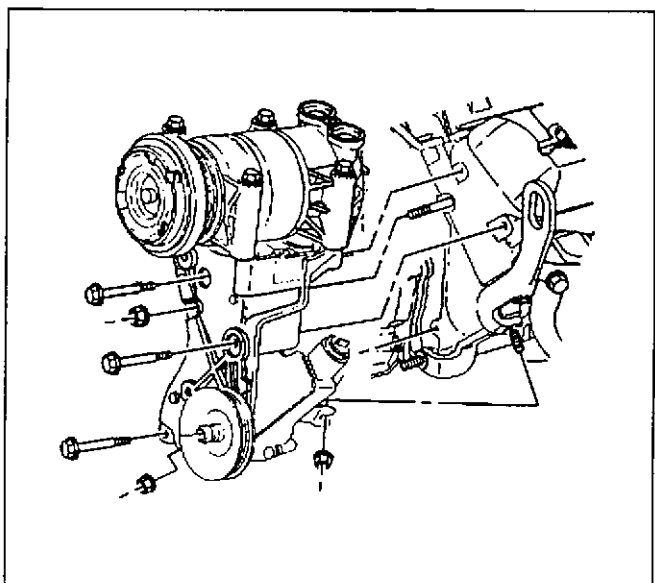
310256



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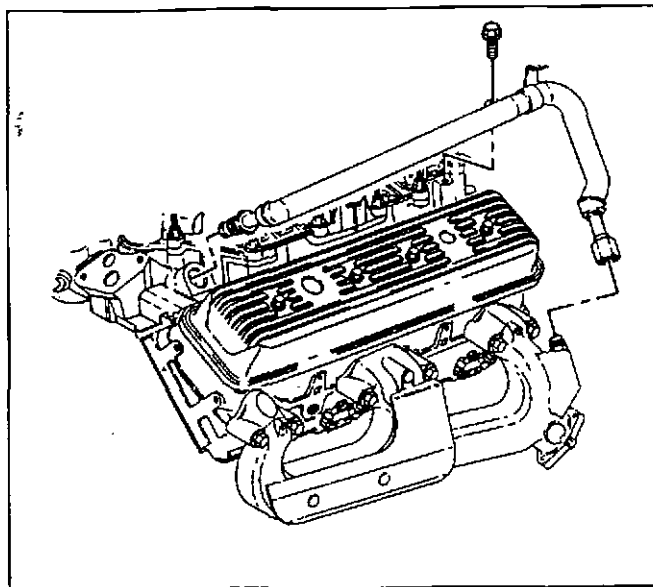
346148



340090

49. Remove both heater hoses from the engine and the cowl.
 - Refer to *Heater Hoses Replacement (4.3L)* in Heating and Ventilation (Non A/C).
 - Refer to *Heater Hoses Replacement (4.3L)* in HVAC Systems with A/C - Manual.
50. Remove the distributor cap. Refer to *Distributor Replacement (HVS Systems)* in Engine Electrical.
51. Disconnect the fuel pipes. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls.
52. Disconnect the hose to the EVAP purge canister solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls.
53. Disconnect the vacuum brake booster hose.
54. Loosen the nut holding the power steering pump rear bracket to the side of the engine.
55. Remove the nut holding the power steering pump rear bracket to the front of the engine.
56. Remove the three bolts and the nut holding the power steering pump mounting bracket to the engine.
57. With the power steering pump and the A/C compressor still attach, slide the power steering pump mount bracket off of the stud and set aside.
58. Remove the water outlet. Refer to *Thermostat Replacement (4.3L)* in Engine Cooling.

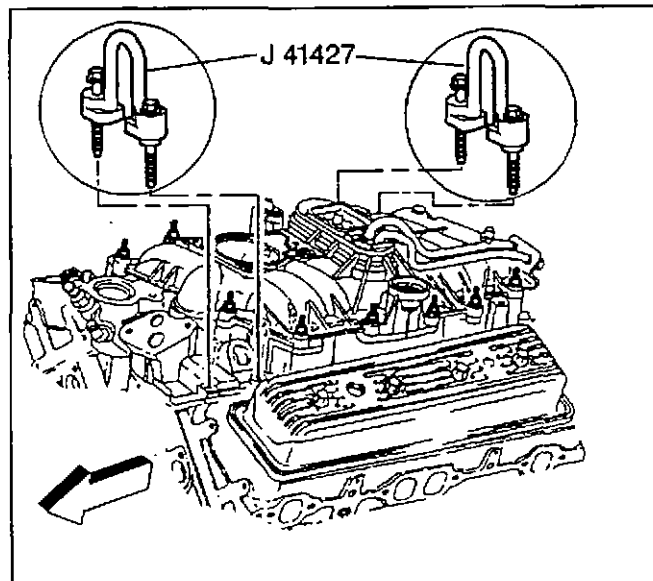
59. Remove the EGR valve inlet pipe from the intake and exhaust manifold.



173206

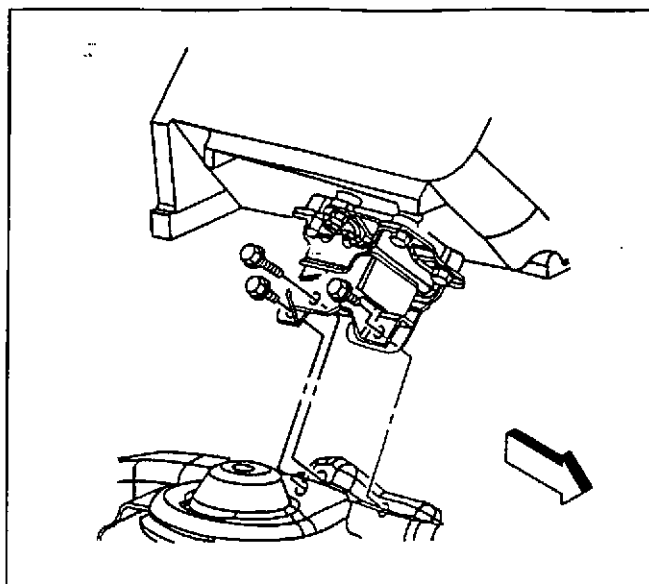
Notice: Refer to *Fastener Notice* in Cautions and Notices.

60. Attach the *J 41427* to the left front and right rear intake manifold mounting bolts, using the following procedure:
- 60.1. Remove the right rear lower intake manifold bolts.
 - 60.2. Install the *J 41427* marked RIGHT REAR.
 - 60.3. Install the retaining bolts.
- Tighten**
- Tighten the bolts to 15 N.m (11 lb ft).
- 60.4. Remove the left front lower intake manifold bolts.
 - 60.5. Install the *J 41427* marked LEFT FRONT with the arrow pointing to the front of the engine.
 - 60.6. Install the retaining bolts.

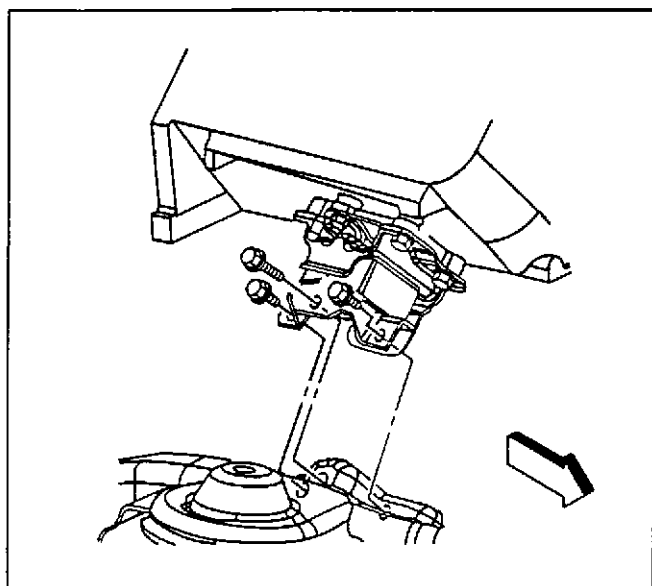


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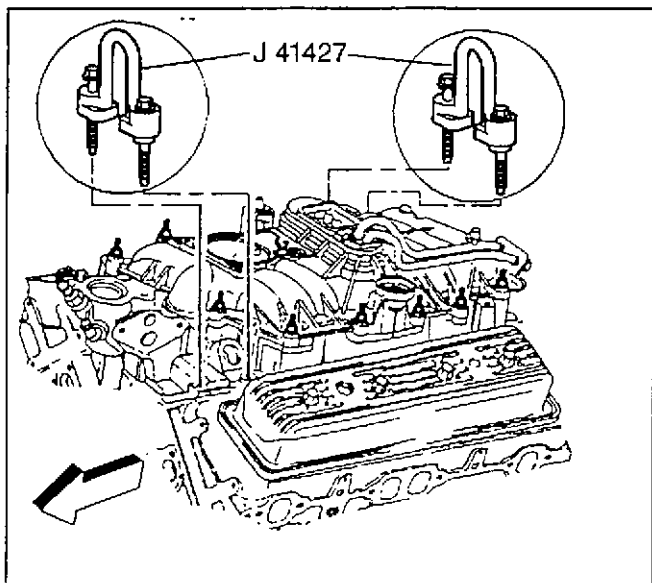
61. Attach a suitable lifting device to the engine lift brackets.



310259



310259



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62. Remove the engine motor mount to frame bracket bolts. Refer to *Engine Mount Replacement*.
63. Support the transmission with a suitable floor jack.
64. Remove the engine.

Installation Procedure

Tools Required

J 41427 Engine Lift Brackets

1. Install the engine to the vehicle.

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

2. Install the engine mount to frame bracket bolts.

Tighten

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

3. Remove the J 41427 and the lifting device.
4. Apply thread lock GM PN 12345382 or equivalent to the threads of the lower intake manifold bolts.
5. Install the intake manifold bolts.

Tighten

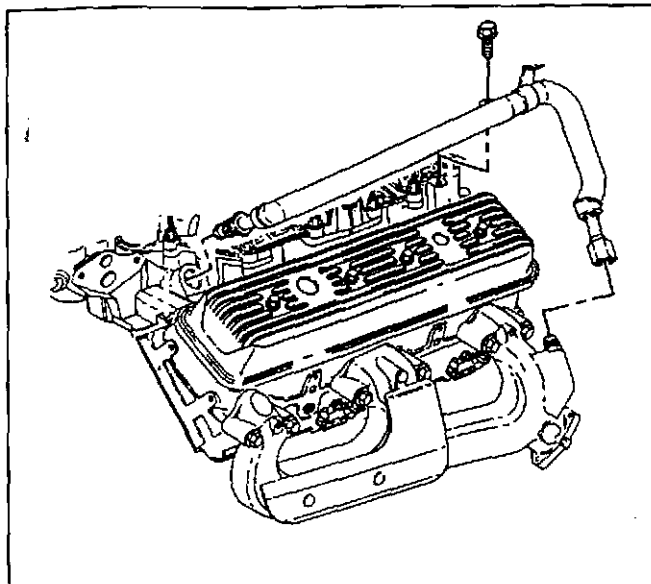
- 5.1. Tighten the bolts the first pass to 3 N·m (27 lb in).
- 5.2. Tighten the bolts the second pass to 12 N·m (106 lb in).
- 5.3. Tighten the bolts the final pass to 15 N·m (11 lb ft).

6. Loosely install one transmission to engine bolt.
7. Remove support jack from under the transmission.

8. Install the EGR valve inlet pipe to the intake and the exhaust manifold.

Tighten

- 8.1. Tighten the EGR valve inlet pipe intake nut to 25 N·m (18 lb ft).
 - 8.2. Tighten the EGR valve inlet pipe exhaust nut to 30 N·m (22 lb ft).
 - 8.3. Tighten the EGR valve inlet pipe clamp bolt to 25 N·m (18 lb ft).
9. Install the water outlet. Refer to *Thermostat Replacement (4.3L)* in Engine Cooling.



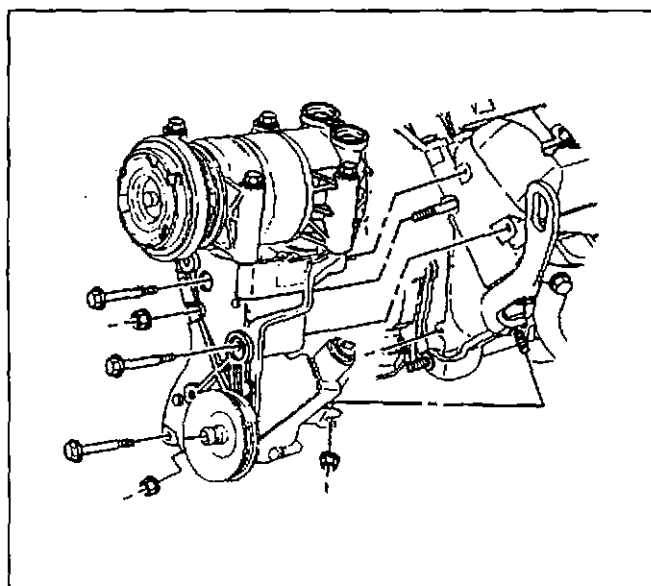
173206

10. Side the power steering pump mounting bracket with the power steering pump and the A/C compressor on the stud.
11. Position the power steering pump rear bracket on the studs.
12. Install the power steering pump mounting bracket three bolts and the nut.
13. Install the nut for the power steering bracket to the front of the engine.

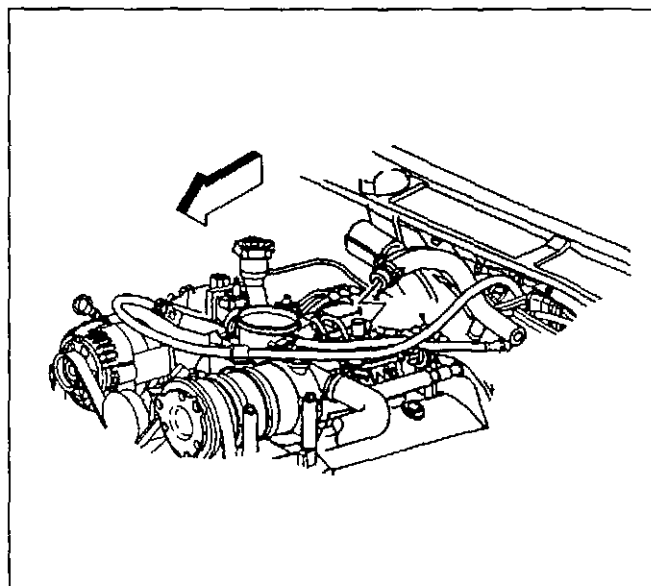
Tighten

Tighten the power steering pump mounting bolts and the nuts to 41 N·m (30 lb ft).

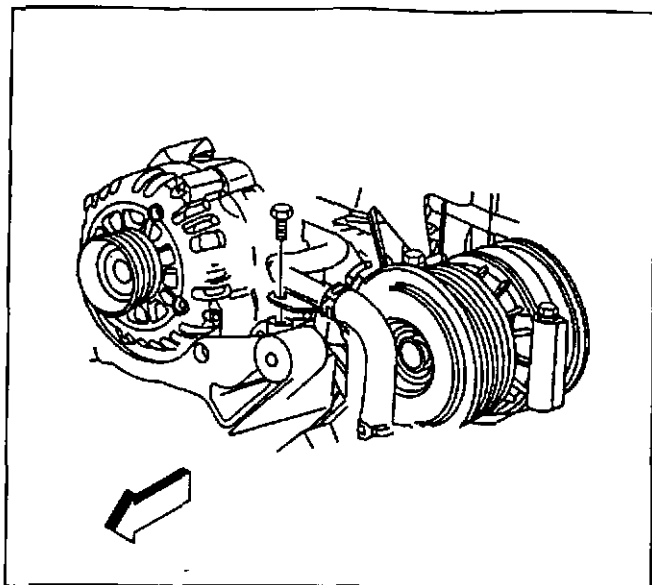
14. Connect the fuel pipes. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls.
15. Connect the hose to the EVAP purge canister solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls.
16. Connect the vacuum brake booster hose.
17. Install the distributor cap. Refer to *Distributor Replacement (HVS Systems)* in Engine Electrical.



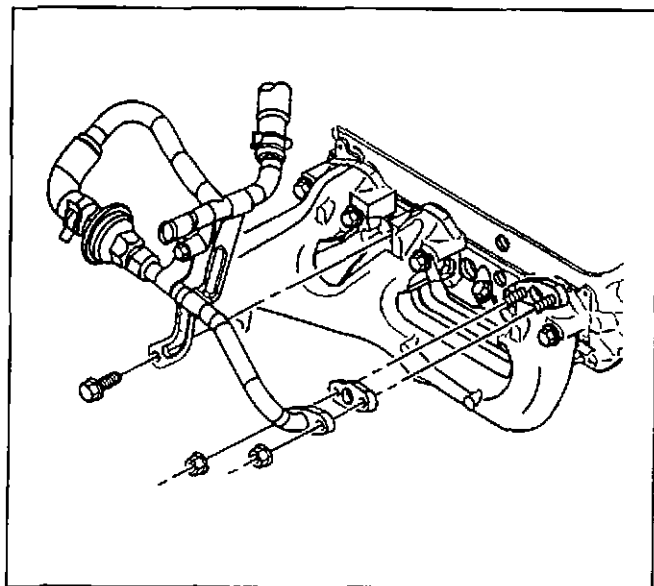
340030



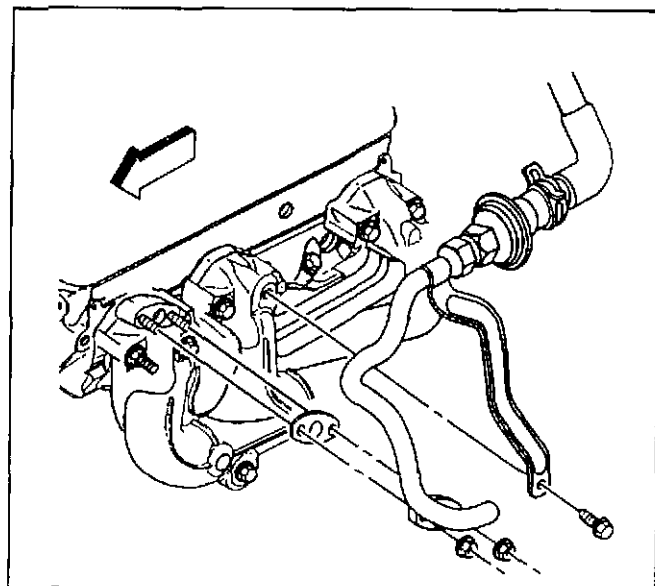
346142



316440



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18. Install both heater hoses to the engine and the cowl.

- Refer to *Heater Hoses Replacement (4.3L)* in Heating and Ventilation (Non A/C).
- Refer to *Heater Hoses Replacement (4.3L)* in HVAC Systems with A/C - Manual.

19. Install the AIR pipe assembly with new gaskets to the exhaust manifold, if equipped.

20. Install the AIR pipe nuts and bracket bolt.

Tighten

20.1. Tighten the AIR nuts to 25 N.m (18 lb ft).

20.2. Tighten the AIR bracket bolt to 10 N.m (88 lb ft).

21. Connect the AIR pipe assembly to the AIR pump.

22. Install the AIR pipe assembly with new gaskets to the exhaust manifold, if equipped.

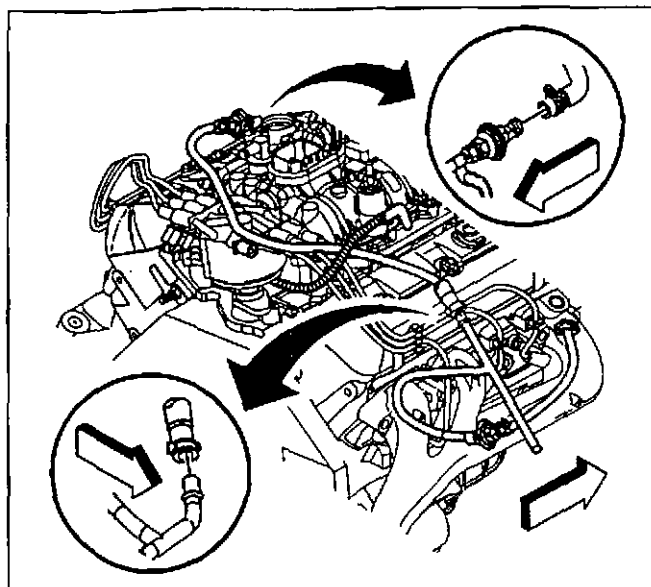
23. Install the AIR pipe nuts and bracket bolt.

Tighten

23.1. Tighten the AIR nuts to 25 N.m (18 lb ft).

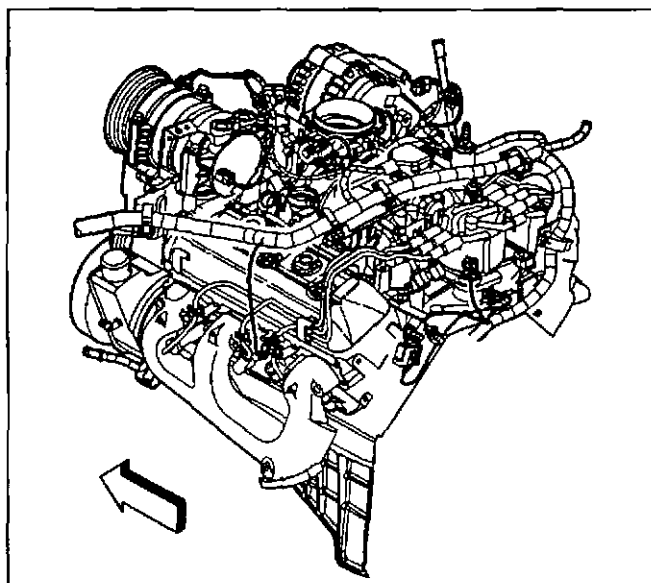
23.2. Tighten the AIR bracket bolt to 10 N.m (88 lb ft).

24. Install the AIR crossover pipe to the AIR pipe assemblies.

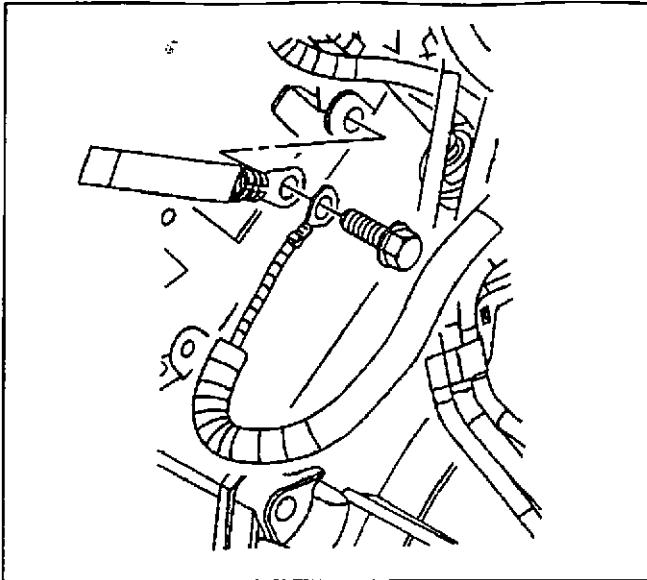


398868

25. Position the engine wiring harness.
26. Connect the following electrical connections to the top of the engine.
- The generator positive cable and connector
 - The ground strap at the rear of the left cylinder head
 - The fuel meter body assembly
 - The EVAP canister purge solenoid valve
 - The idle air control (IAC) motor
 - The throttle position (TP) sensor
 - The engine coolant temperature (ECT) gauge sensor
 - The A/C compressor high pressure switch, if equipped
 - The A/C clutch switch, if equipped
 - The exhaust gas recirculation (EGR) valve
 - The engine coolant temperature (ECT) sensor
 - The two ignition control module (ICM)
 - The manifold absolute pressure (MAP) sensor
 - The engine oil pressure gauge sensor
 - The distributor
 - The knock sensor (KS)



333816

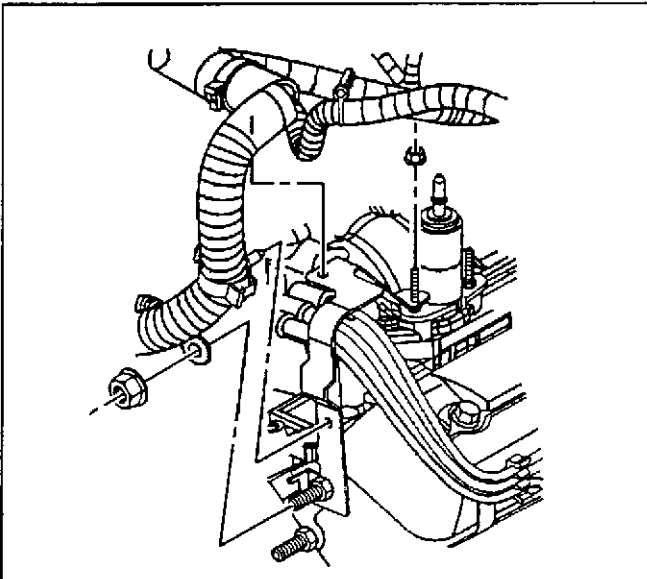


310256

27. Install the bolt holding the ground strap and the ground wire to the rear of the left cylinder head.

Tighten

Tighten the ground strap and wire bolt to 16 N·m (12 lb ft).



310243

28. Position the wiring harness bracket on the EVAP purge canister solenoid valve stud and install the nut.

29. Install the stud holding the wire harness bracket to the rear of the right cylinder head.

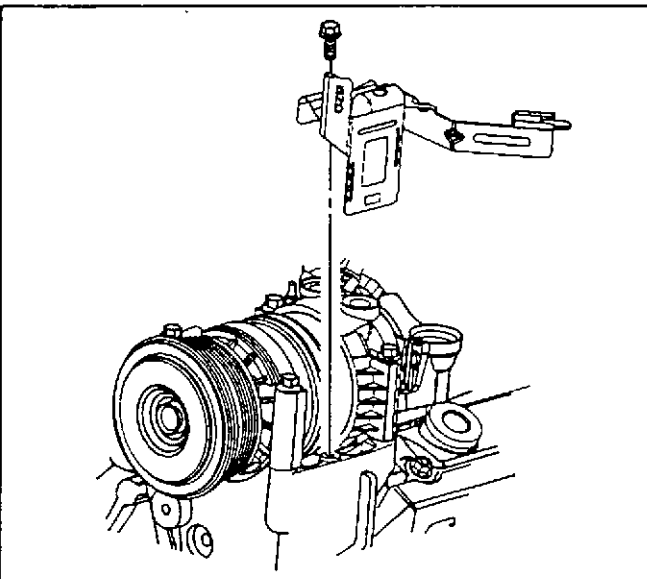
Tighten

- Tighten the nut on the EVAP solenoid to 9 N·m (80 lb in).
- Tighten the stud at rear of the cylinder head to 25 N·m (18 lb ft).

30. Install the nut holding the ground wire on the stud at the rear of the right cylinder head.

Tighten

Tighten the ground wire nut to 16 N·m (12 lb ft).



394403

31. Position the battery positive and negative cables. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)*

32. Install the battery positive cable junction block bracket and bolt to the power steering pump mounting bracket.

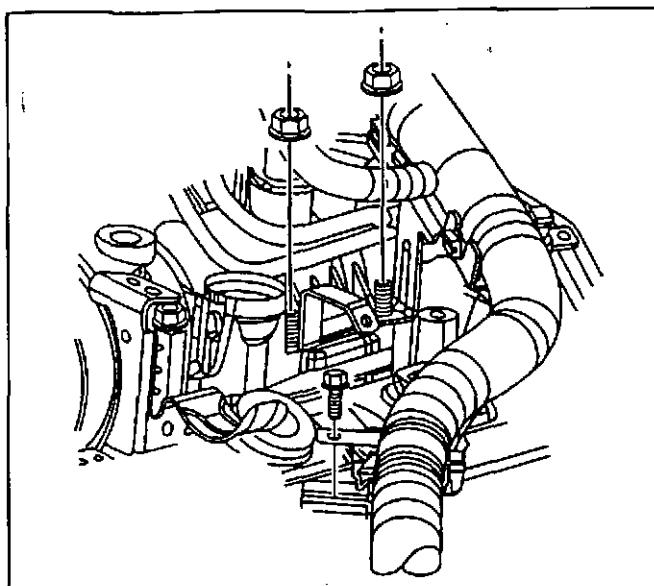
Tighten

Tighten the junction block bracket bolt to 25 N·m (18 lb ft).

33. Install the bolt holding the engine wiring harness bracket to battery positive cable junction block bracket.
34. Install the engine wiring harness bracket on the intake manifold studs and install the nuts.

Tighten

- Tighten the wiring harness bracket nuts to 12 N.m (106 lb in).
 - Tighten the wiring harness bracket bolt to 9 N.m (80 lb ft).
35. Connect the A/C hoses to the A/C compressor and the accumulator. Refer to *Compressor Hose Assembly Replacement (4.3L)* in HVAC Systems with A/C - Manual.

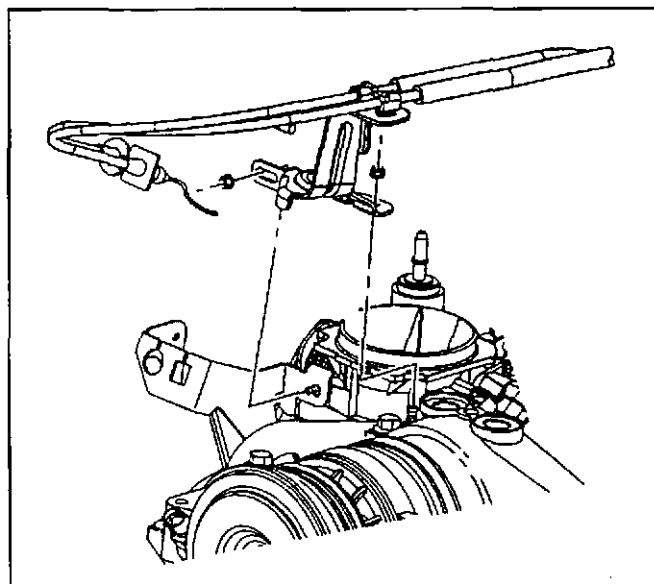


310241

36. Install the accelerator control cable bracket and nuts to the throttle body.

Tighten

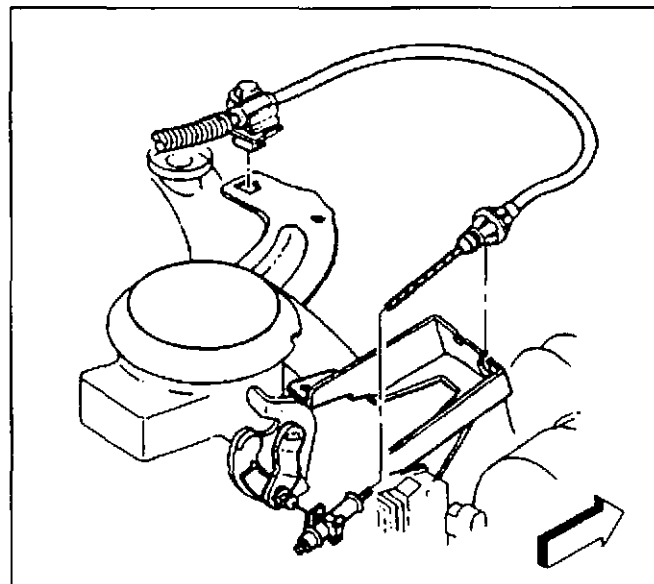
Tighten the nuts to 10 N.m (88 lb in).



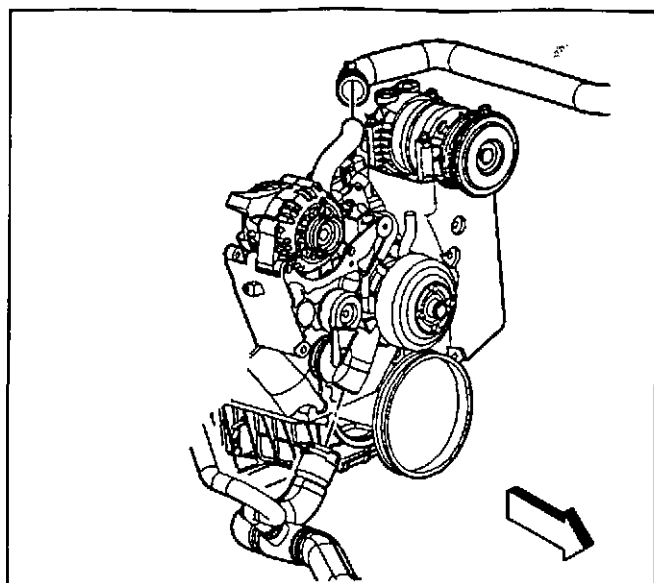
398030

Caution: S10-ID - 352518 To help avoid potential personal injury or potential damage to the vehicle due to possible cable damage during service, replace the existing accelerator control cable with a NEW cable when removing or replacing the engine. Position the cruise control cable out of the way to ensure it is not damaged while removing or installing the engine. Do not bend the cruise control cable and cause a kink at the bend. Do not position the cruise control cable where the technician may lean or pry against the cable and cause damage to the cable.

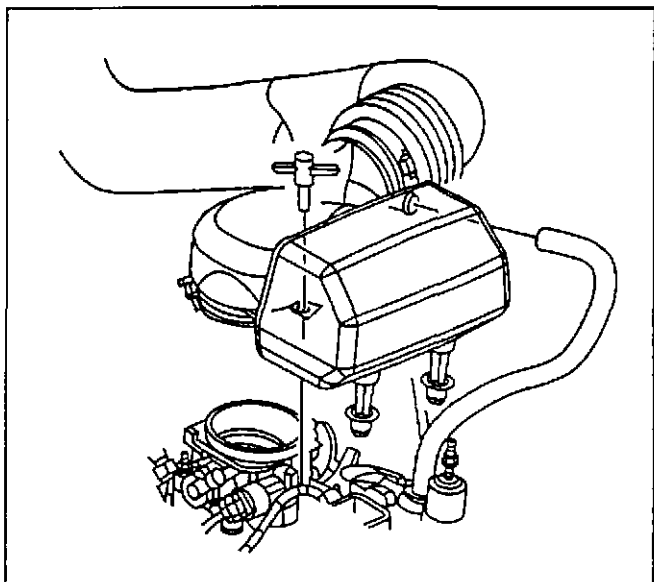
37. Install the NEW accelerator control cable. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.
38. Install the cruise control cable to the accelerator control cable brackets.
39. Connect the cruise control cable to the throttle body, if equipped. Refer to *Cruise Control Cable Replacement* in Cruise Control.



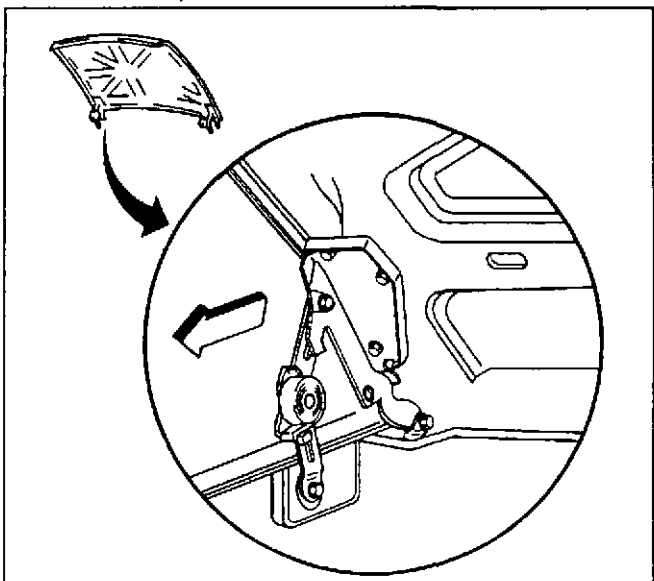
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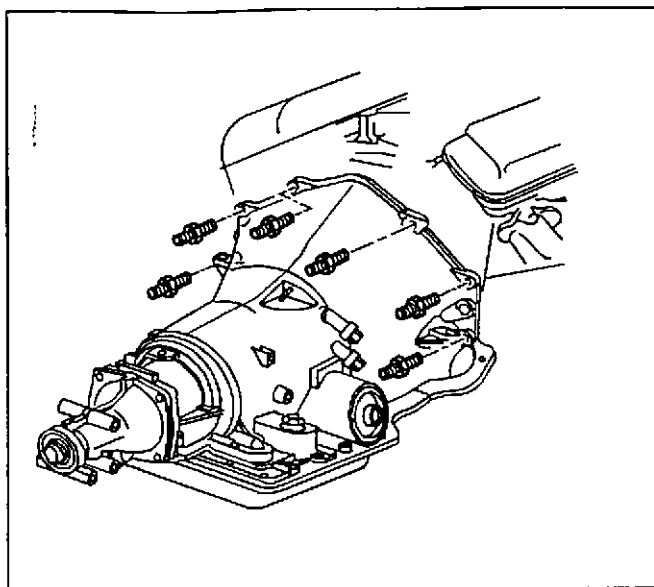
310799

40. Install the radiator inlet hose. Refer to *Radiator Hose Replacement - Inlet (4.3L)* in Engine Cooling.
41. Install the radiator outlet hose. Refer to *Radiator Hose Replacement - Outlet (4.3L)* in Engine Cooling.
42. Install the surge tank hose.
43. Install the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.
44. Install the drive belt. Refer to *Drive Belt Replacement*.
45. Install the upper and lower radiator shroud. Refer *Fan Shroud Replacement* in Engine Cooling.
46. Install the air inlet duct to the throttle body and the MAF sensor.
47. Connect the PCV hose to the air inlet duct.
48. Move the hood hinge bolts to the normal operating location.
49. Raise the vehicle.

50. Install the remaining transmission to engine bolts except for the one where the transmission cover mounts.

- Refer to *Transmission Replacement in Automatic Transmission - 4L60-E*.
- Refer to *Transmission Replacement in Manual Transmission - NV3500*.

51. Install three torque converter to flywheel bolts, if equipped. Refer to *Flywheel to Torque Converter Bolts in Automatic Transmission - 4L60-E*.



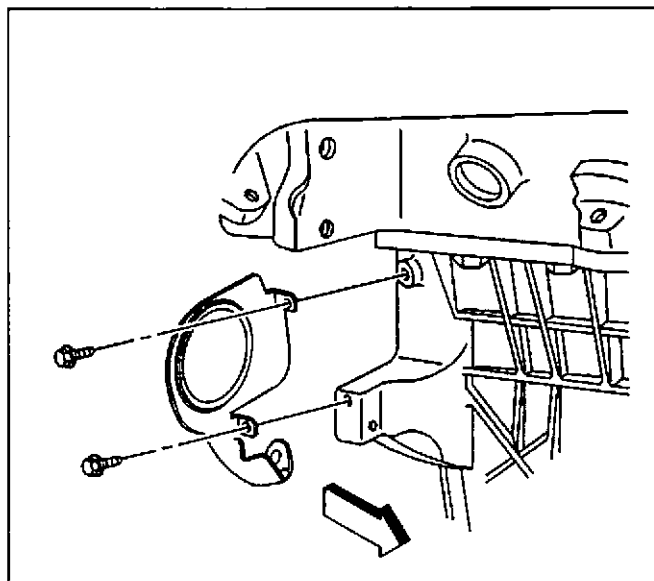
102341

52. Install the transmission cover and bolts.

Tighten

52.1. Tighten the transmission cover to oil pan bolt to 12 N.m (106 lb in).

52.2. Tighten the transmission cover to transmission bolt to 47 N.m (34 lb ft).

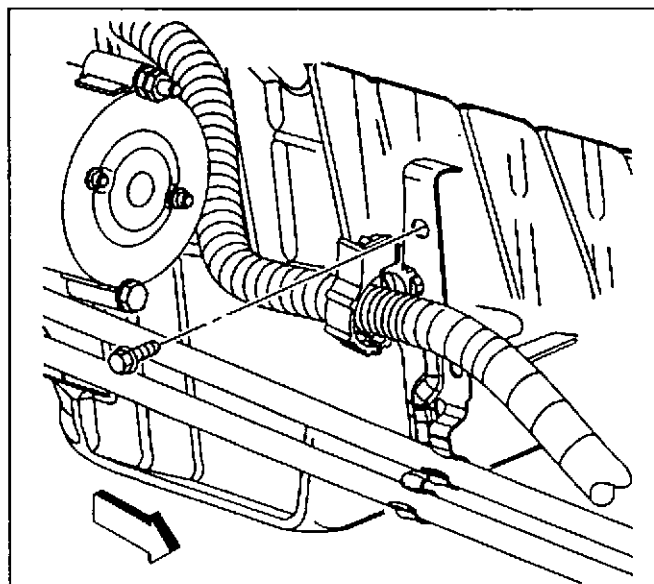


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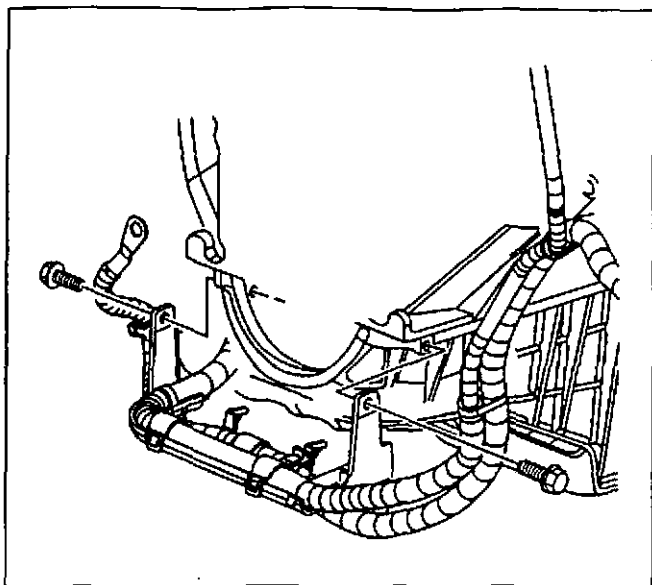
53. Install the bolt holding the bracket for the starter cables and the transmission cooler pipes, if equipped.

Tighten

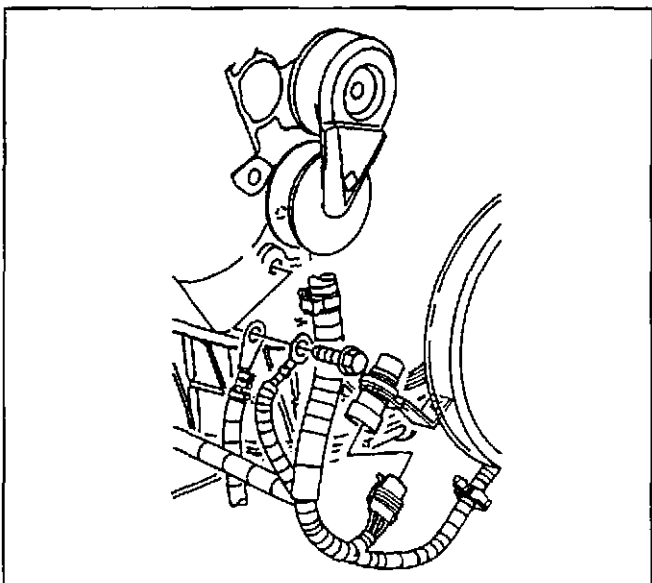
Tighten the bracket bolt to 12 N.m (106 lb in).



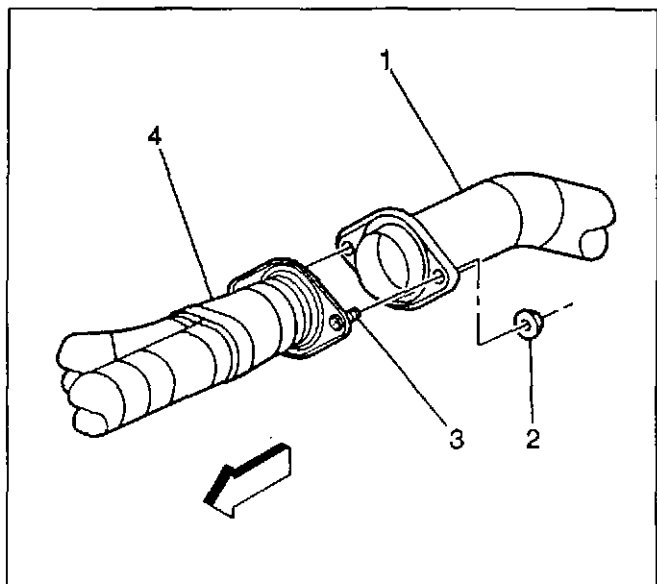
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54. Install the bolts holding the positive and negative battery cable brackets to the oil pan.

Tighten

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

55. Connect the low oil level sensor.
56. Connect the CKP sensor and install the harness in the retainer.

57. Install the bolt for the battery negative cable and ground wire to the front of the engine.

Tighten

Tighten the battery negative cable and ground wire bolt to 16 N.m (12 lb ft).

58. Install the exhaust pipe to the exhaust manifolds. Refer to *Catalytic Converter Replacement (System A 4.3L, 4.8L, and 5.3L)* in Engine Exhaust.
59. Tighten the nuts (2) at the catalytic converter flange. Refer to *Catalytic Converter Replacement (System A 4.3L, 4.8L, and 5.3L)* in Engine Exhaust.
60. Install the starter motor. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.

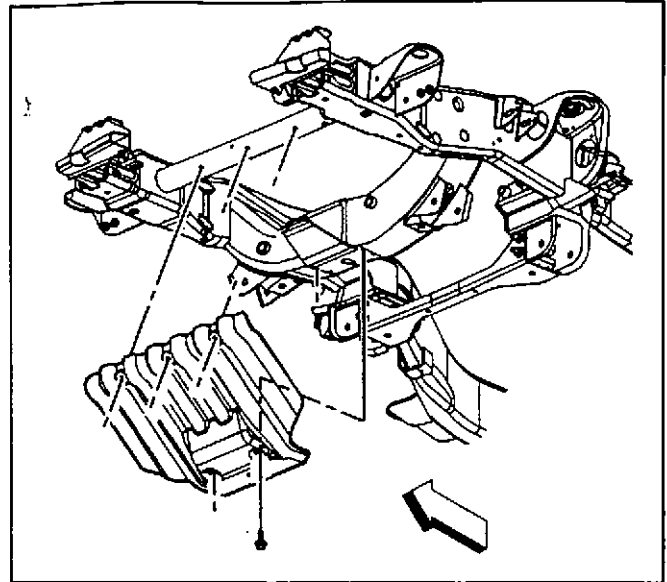
61. Install the oil pan skid plate.
Tighten
Tighten the oil pan skid plate bolt to 20 N.m (15 lb ft).
62. Install the engine protection shield. Refer to *Engine Protection Shield Replacement* in Frame and Underbody.
63. Lower the vehicle.
64. Connect the battery negative cable. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)* in Engine Electrical.
65. Fill the engine with the proper quantity and grade of engine oil. Refer to *Engine Oil and Oil Filter Replacement*.
66. Fill the engine with coolant. Refer to *Draining and Filling Cooling System* in Engine Cooling.
67. Recharge the A/C system. Refer to *Refrigerant Recovery and Recharging* in HVAC Systems with A/C - Manual.
68. Before starting a new engine, or one that has been repaired. Refer to *Engine Set-Up and Testing*.

SIE-ID - 331133

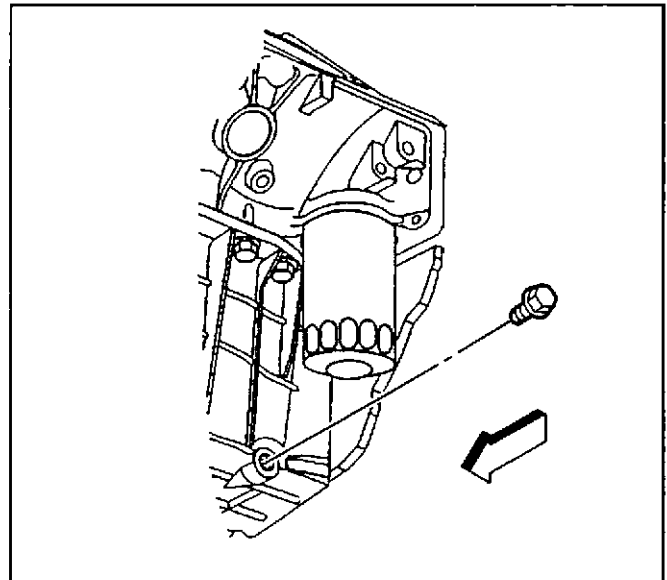
Engine Oil and Oil Filter Replacement

Removal Procedure

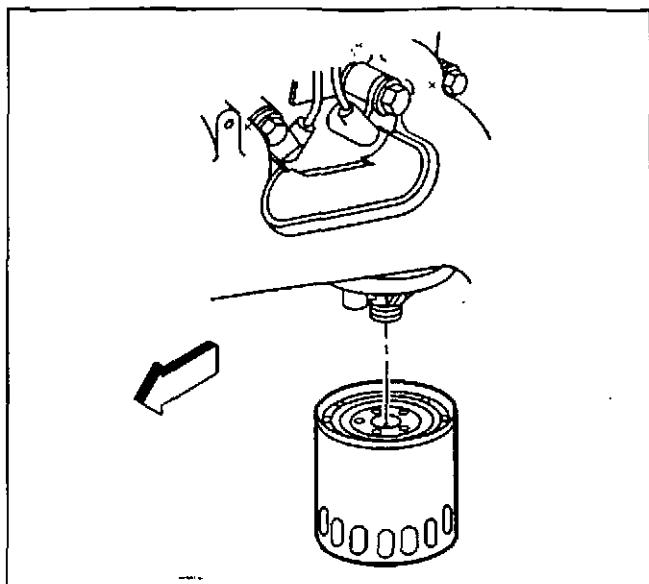
1. Raise the vehicle and support with safety stands. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Remove the oil pan drain plug and drain the engine oil in a suitable container.



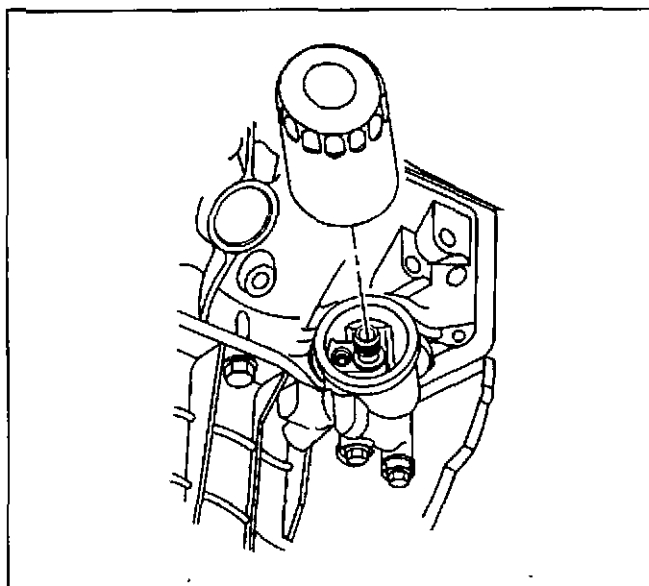
310119



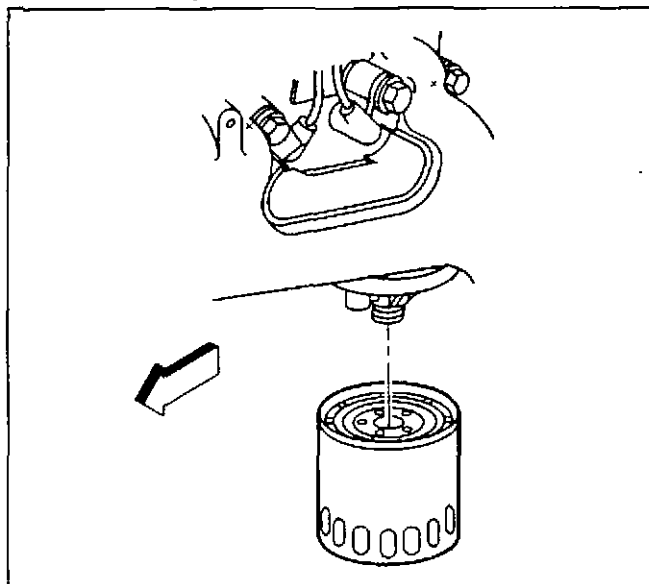
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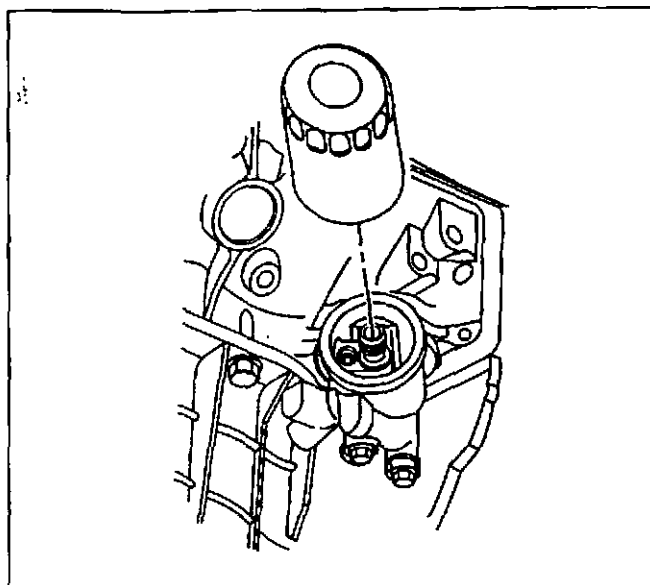
3. Remove the engine oil filter from the engine, RWD vehicle.

4. Remove the engine oil filter from the oil filter adapter, Four Wheel Drive vehicle.
5. Inspect to ensure the engine oil filter gasket is removed.

Installation Procedure

1. Lubricate the engine oil filter gasket with clean engine oil.
2. Install the engine oil filter to the engine, RWD vehicles.

3. Install the engine oil filter to the oil filter adapter, Four Wheel Drive vehicles.
4. Follow the tightening instructions on the oil filter.



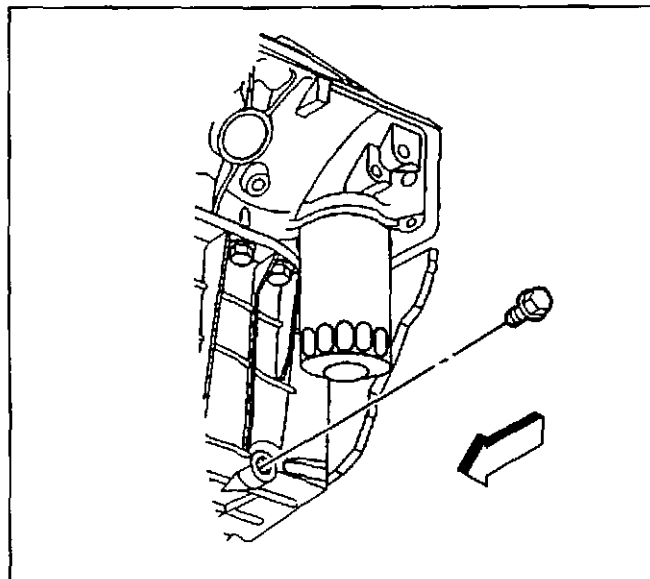
391870

5. Install the oil pan drain plug to the oil pan.

Tighten

Tighten the oil pan drain plug to 25 N·m (18 lb ft).

6. Remove the safety stands and lower the vehicle.
7. Fill the engine with the proper capacity and quality of engine oil.
 - Refer to *Approximate Fluid Capacities* in Maintenance and Lubrication.
 - Refer to *Explanation of Scheduled Services* in Maintenance and Lubrication.
8. Operate the engine, check for leaks, and oil pressure.

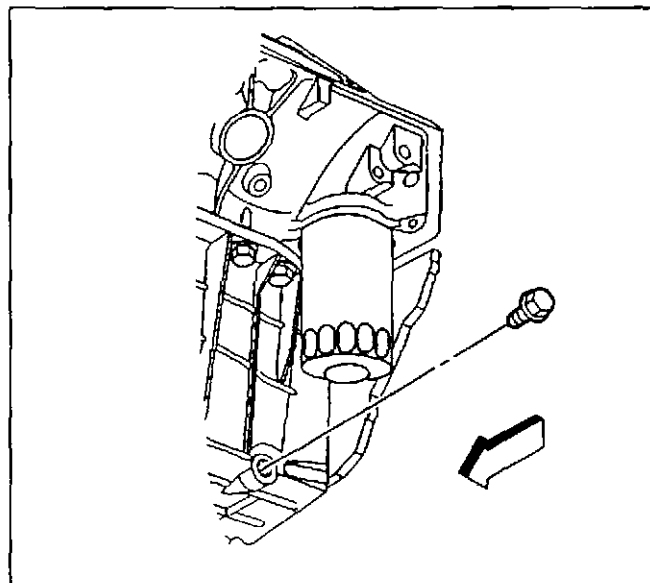


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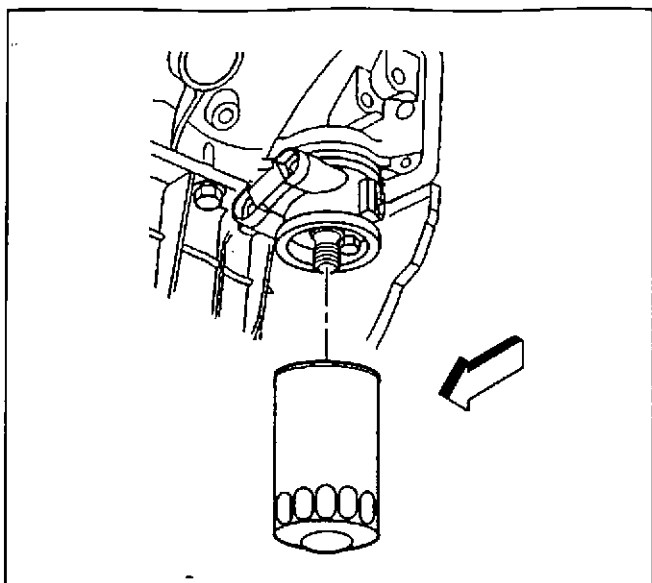
SIE-ID - 43083

Draining Fluids and Oil Filter Removal

1. Remove the oil pan drain plug and allow the engine oil to drain into a suitable container.

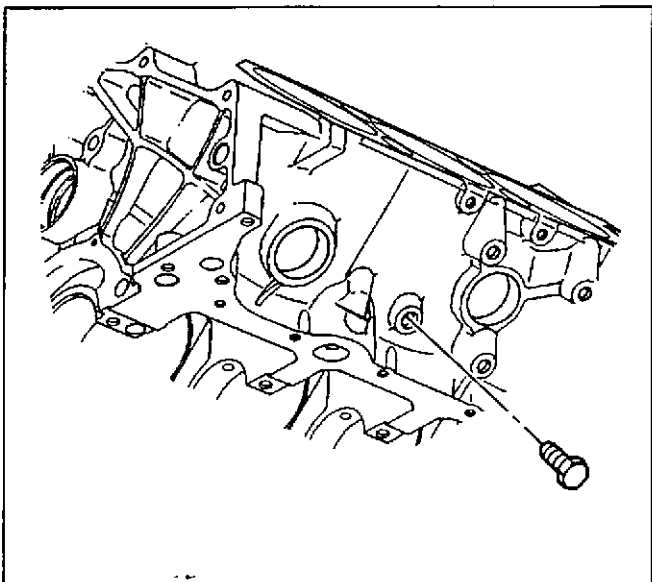


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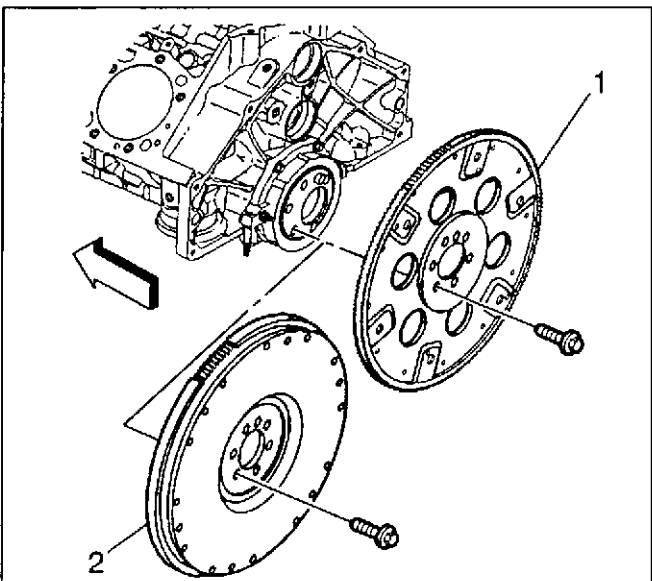
188050

2. Remove the oil filter (if applicable).
3. Discard the oil filter (if applicable).



188052

4. Remove both the engine block coolant drain hole plugs and allow the coolant to drain into a suitable container.



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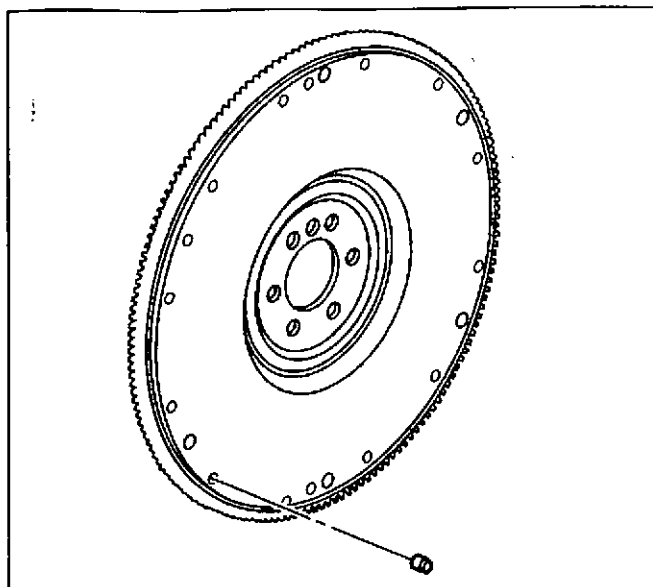
SIE-ID = 43618

Engine Flywheel Removal

1. Remove the engine flywheel bolts.
2. Remove the engine flywheel (automatic transmission) (1), if applicable.
3. Remove the engine flywheel (manual transmission) (2), if applicable.

Important: If replacing the engine flywheel (manual transmission), then NEW flywheel weights must be installed into the NEW engine flywheel in the same location as the old flywheel weights in the old engine flywheel.

4. Note the position of any flywheel weights for assembly (if applicable).



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SIE-ID - 358553

Clutch Pilot Bearing Removal

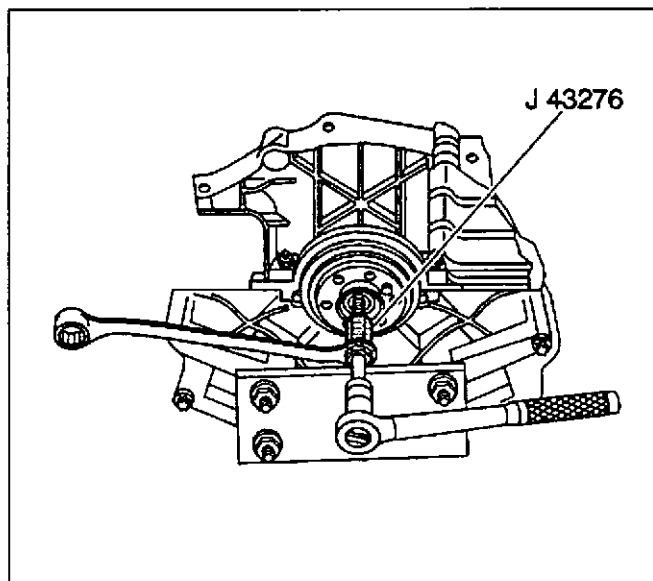
Tools Required

J 43276 Clutch Pilot Bearing Remover

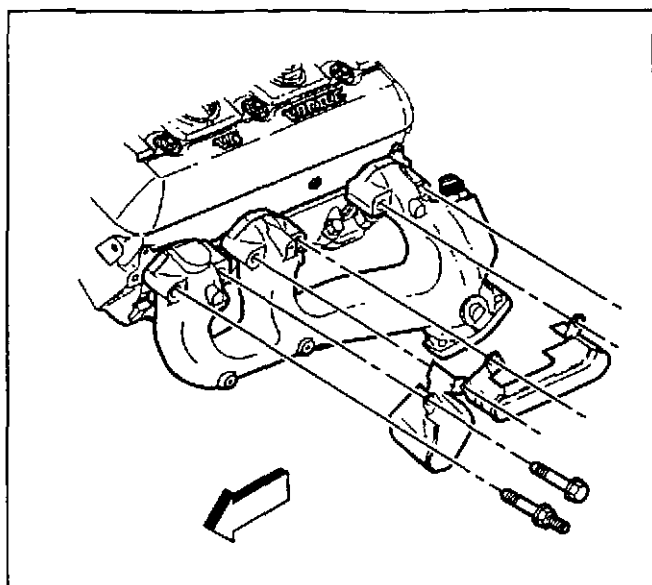
Caution: SIO-ID - 5011 **Wear safety glasses in order to avoid eye damage.**

Notice: SIO-ID - 352829 When using the J 43276 Clutch Pilot Bearing Remover always secure the J 43276-1 Clutch Pilot Bearing Remover tool body using a wrench. Do not allow the J 43276-1 Clutch Pilot Bearing Remover tool body to rotate. Failing to do so will cause damage to the J 43276-1 Clutch Pilot Bearing Remover tool body.

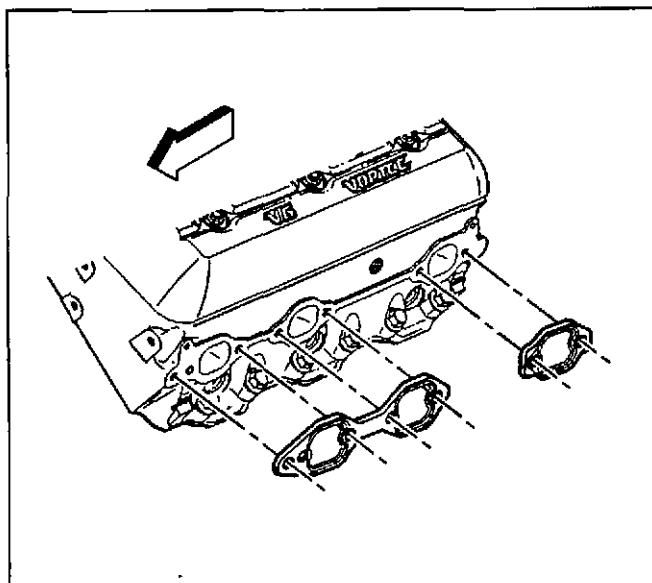
1. Remove the clutch pilot bearing using the J 43276 .
 - 1.1. Install the J 43276-1 tool body into the clutch pilot bearing.
 - 1.2. Using a wrench secure the J 43276-1 tool body.
 - 1.3. Insert the J 43276-2 forcing screw into the J 43276-1 tool body.
 - 1.4. Rotate the J 43276-2 forcing screw clockwise into the J 43276-1 tool body until the clutch pilot bearing is completely removed from the crankshaft.
 - 1.5. Rotate the J 43276-2 forcing screw counterclockwise to remove the J 43276-2 forcing screw from the J 43276-1 tool body.
 - 1.6. Remove the J 43276-1 tool body from the clutch pilot bearing.
2. Discard the clutch pilot bearing.



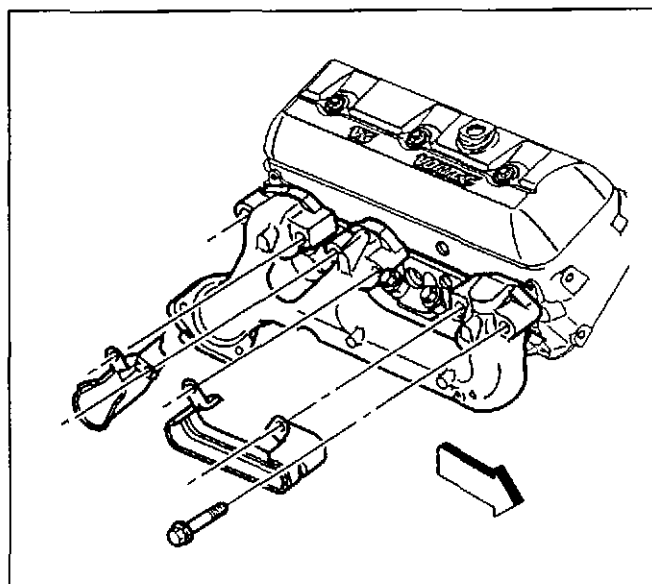
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SIE-ID = 358511

Exhaust Manifold Removal (Left)

Notice: SIO-ID = 2878 Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs.
 - 1.1. Rotate the spark plug wire boot one half turn.
 - 1.2. Pull outward on the spark plug wire boot to release from the spark plug.
2. Remove the spark plug wire retainers from the spark plug wire support.
3. Remove the exhaust manifold bolts and stud.
4. Remove the spark plug wire shields.
5. Remove the exhaust manifold.
6. Remove and discard the exhaust manifold gaskets.

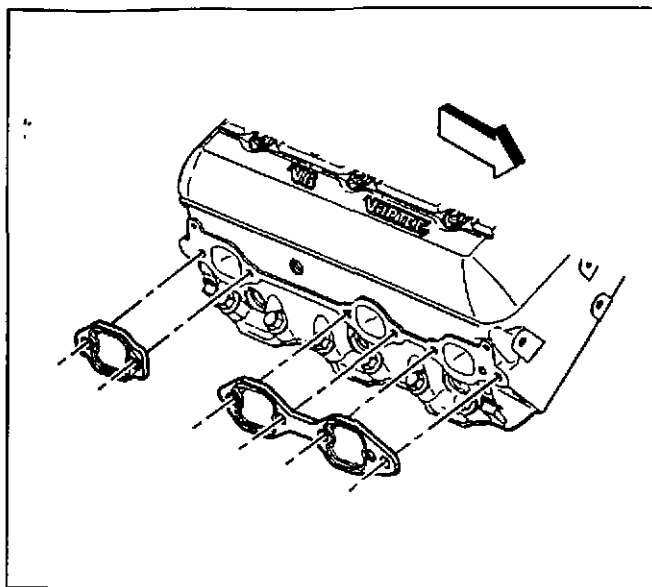
SIE-ID = 358513

Exhaust Manifold Removal (Right)

Notice: SIO-ID = 2878 Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs.
 - 1.1. Rotate the spark plug wire boot one half turn.
 - 1.2. Pull outward on the spark plug wire boot to release from the spark plug.
2. Remove the exhaust manifold bolts.
3. Remove the spark plug wire shields.
4. Remove the exhaust manifold.

5. Remove and discard the exhaust manifold gasket.

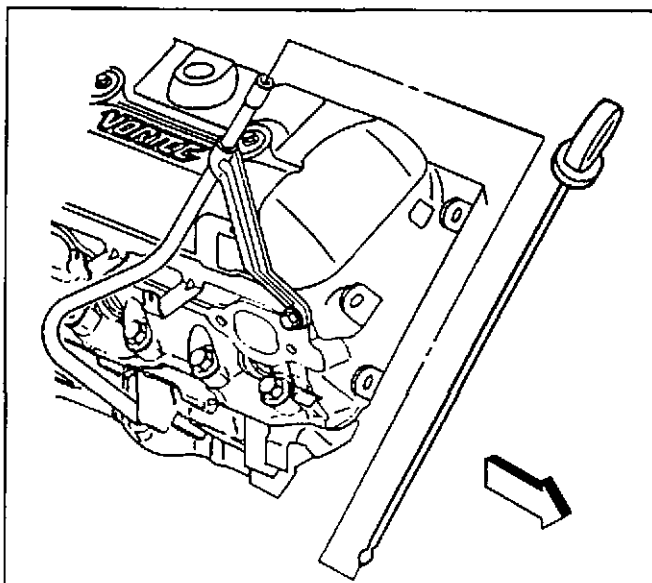


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SIE-ID = 358529

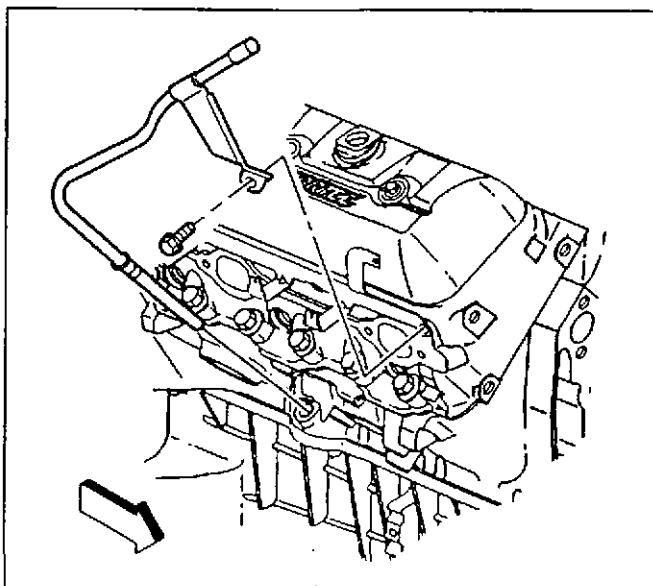
Oil Level Indicator and Tube Removal

1. Remove the oil level indicator from the oil level indicator tube.



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

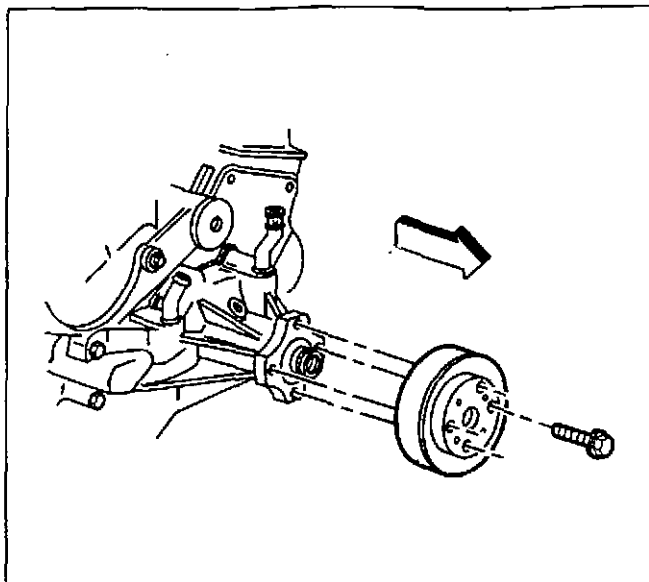


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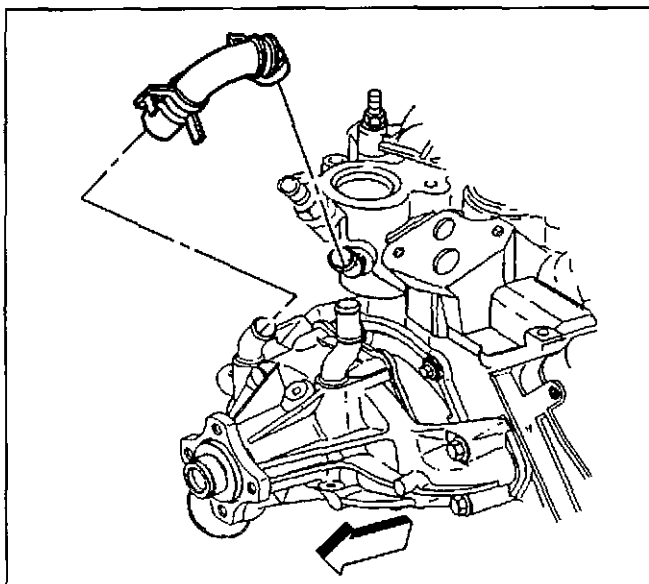
SIE-ID - 358515

Water Pump Removal

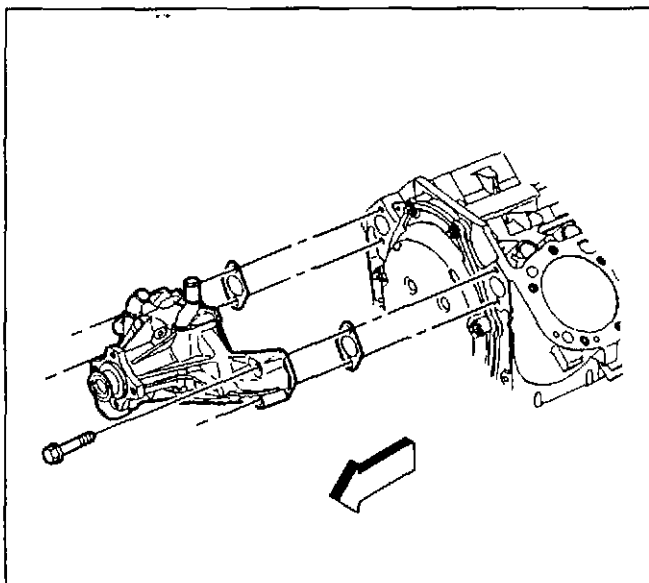
1. Remove the bolts and the fan and water pump pulley.



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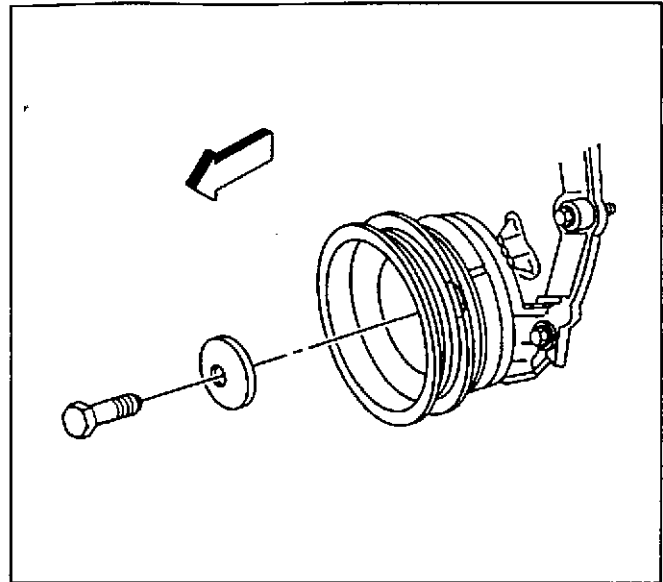
2. Remove the clamps and the water pump inlet hose.

3. Remove the water pump bolts.
4. Remove the water pump.
5. Remove the water pump gaskets.
6. Discard the water pump gaskets.

SIE-ID - 358517

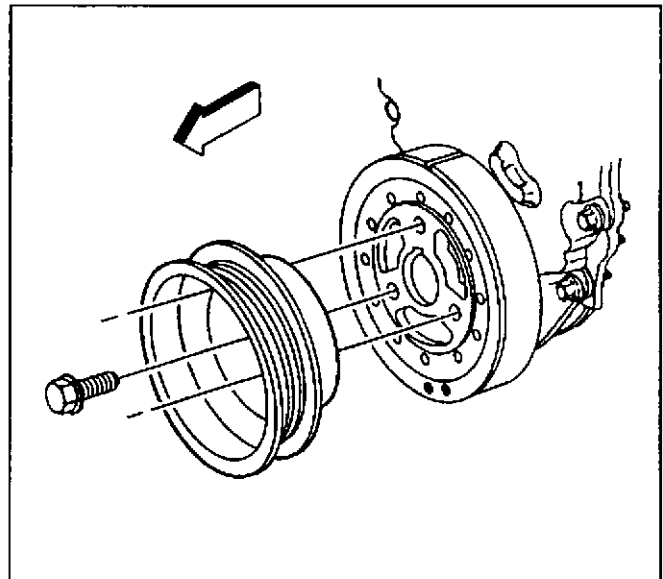
Crankshaft Balancer Removal**Tools Required***J 23523-F* Balancer Remover and Installer

1. Remove the crankshaft balancer bolt and washer.



173172

2. Remove the bolts and the crankshaft pulley.



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Notice: SIO-ID - 301560 To prevent damage to the end of the crankshaft when using a crankshaft balancer removal tool install a bolt in the crankshaft. Use a shorter bolt with the same threads as the crankshaft balancer bolt. This bolt will allow a place for the tool to push against. The shorter bolt is to keep from going past the threads in the crankshaft and damaging the crankshaft threads.

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

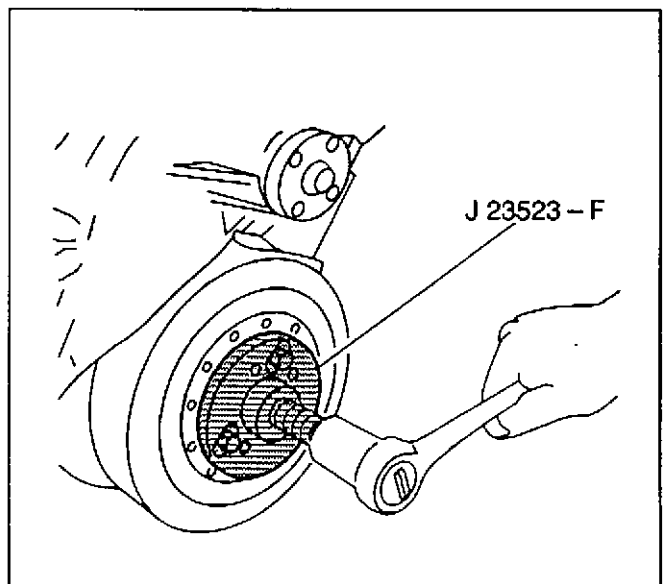
3. Use the *J 23523-F* in order to remove the crankshaft balancer.

- 3.1. Install the *J 23523-F* plate and bolts.

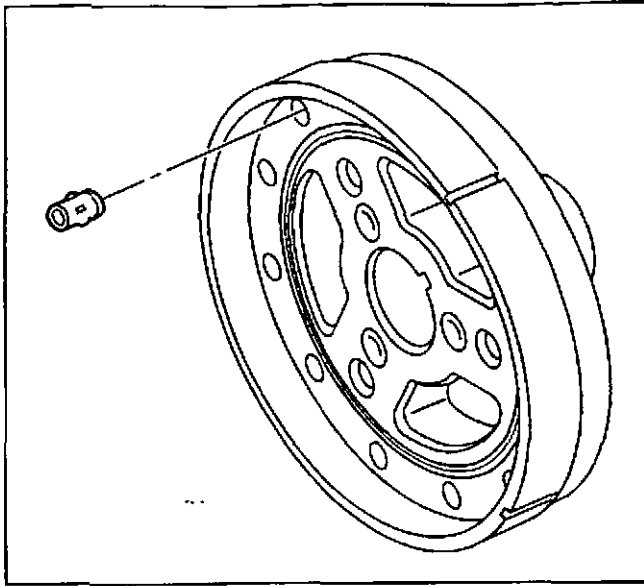
Tighten

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

- 3.2. Install the *J 23523-F* forcing screw.
- 3.3. Rotate the *J 23523-F* forcing screw clockwise in order to remove the crankshaft balancer.

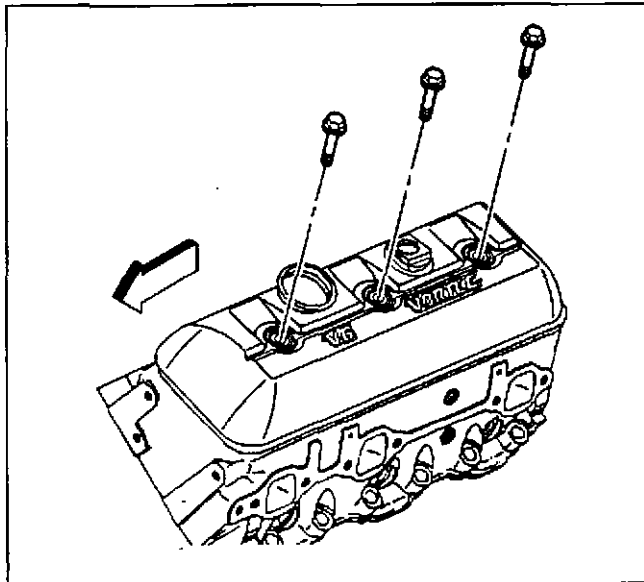


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4. Remove the *J 23523-F* from the crankshaft balancer.
5. Note the position of any front groove pins (crankshaft balancer) (if applicable).



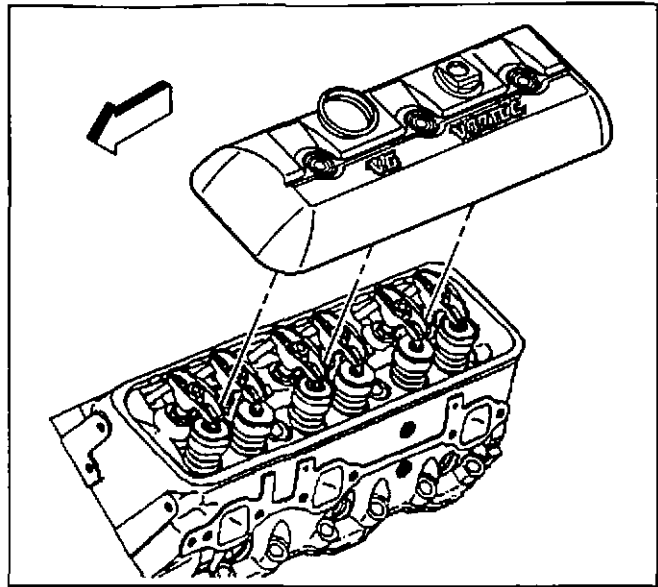
328566

SIE-ID = 358518

Valve Rocker Arm Cover Removal (Left)

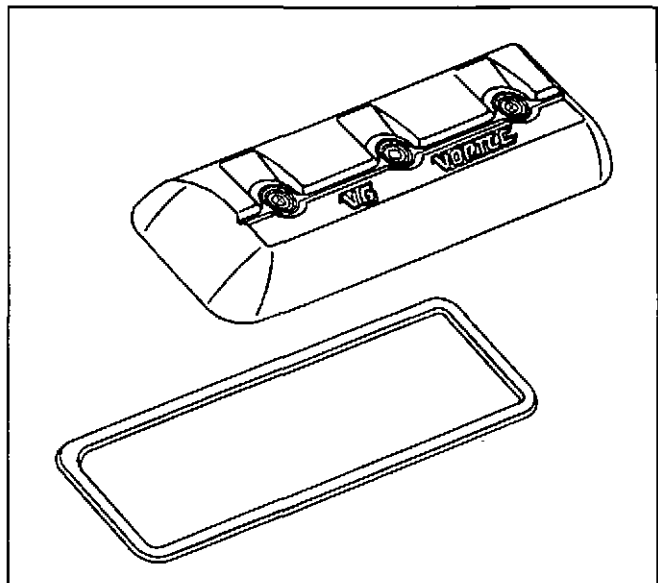
1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover bolt grommets.
3. Discard the valve rocker arm cover bolt grommets.

4. Remove the valve rocker arm cover.



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5. Remove the valve rocker arm cover gasket.
6. Discard the valve rocker arm cover gasket.

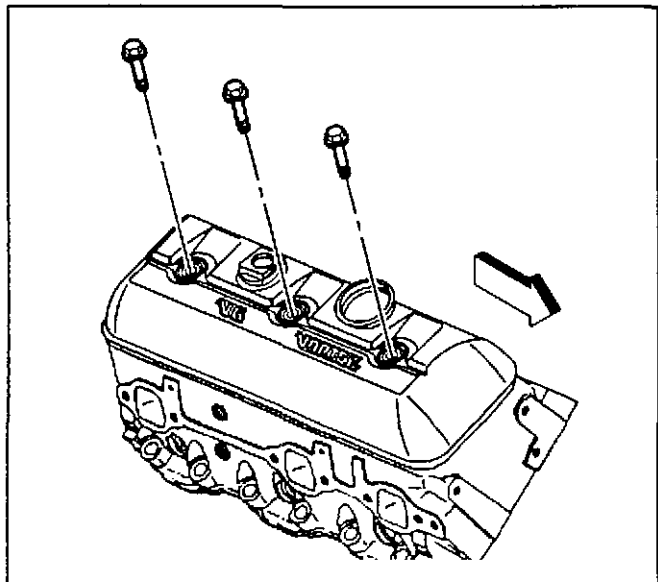


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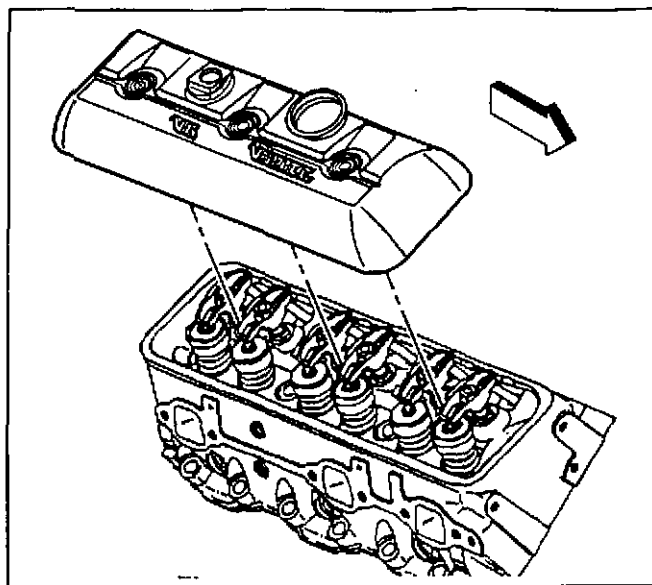
SIE-ID - 358520

Valve Rocker Arm Cover Removal (Right)

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover bolt grommets.
3. Discard the valve rocker arm cover bolt grommets.

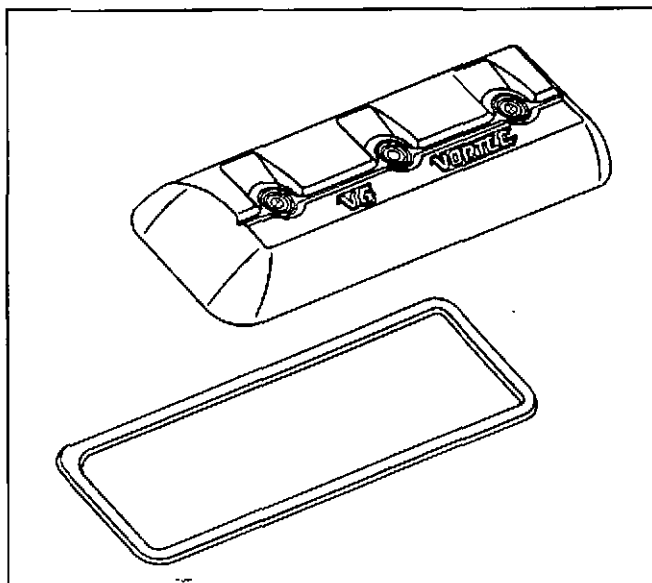


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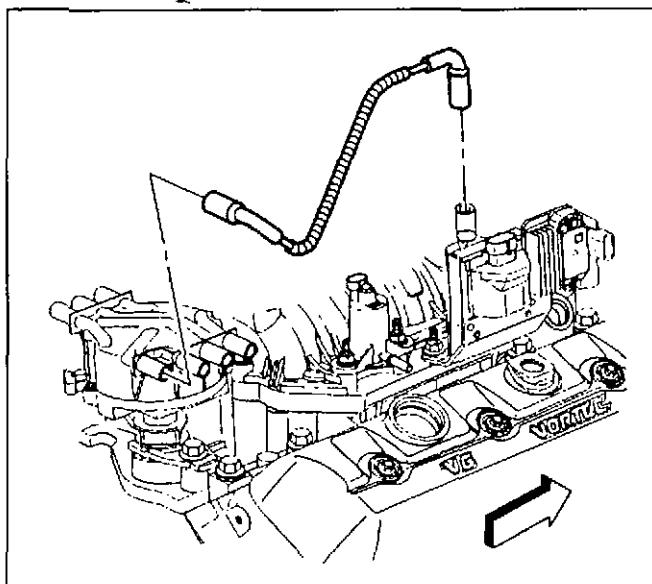
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4. Remove the valve rocker arm cover.



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5. Remove the valve rocker arm cover gasket.
6. Discard the valve rocker arm cover gasket.



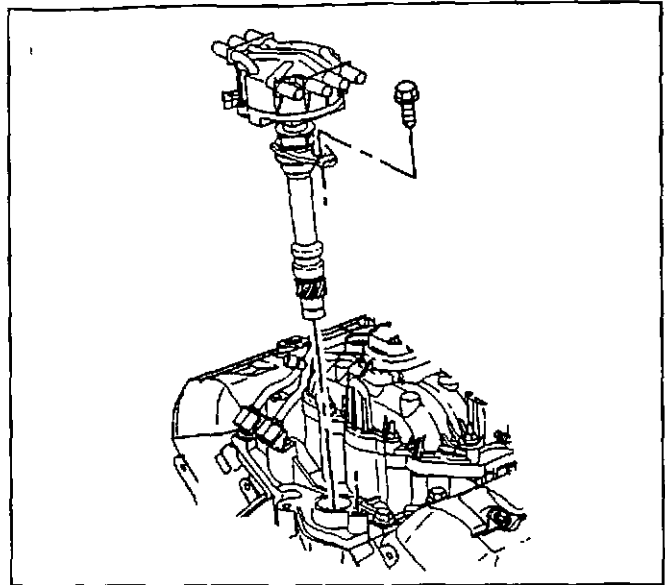
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SIE-ID = 358521

Distributor Removal

1. Remove the ignition coil wire harness from the ignition coil and distributor cap.

2. Remove the distributor clamp bolt.
3. Remove the distributor clamp.
4. Remove the distributor.

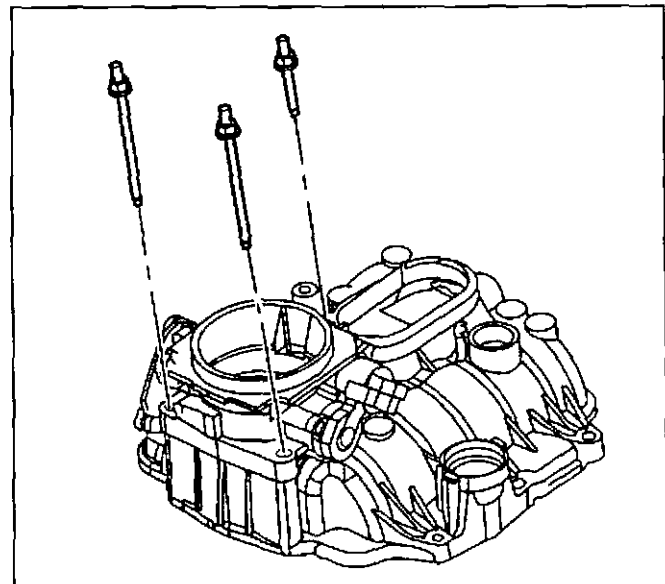


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SIE-ID - 194657

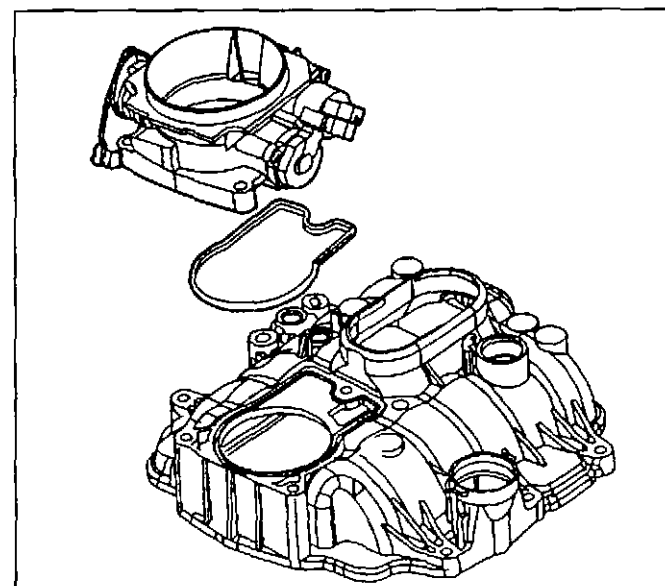
Throttle Body Removal

1. Remove the throttle body attaching studs.

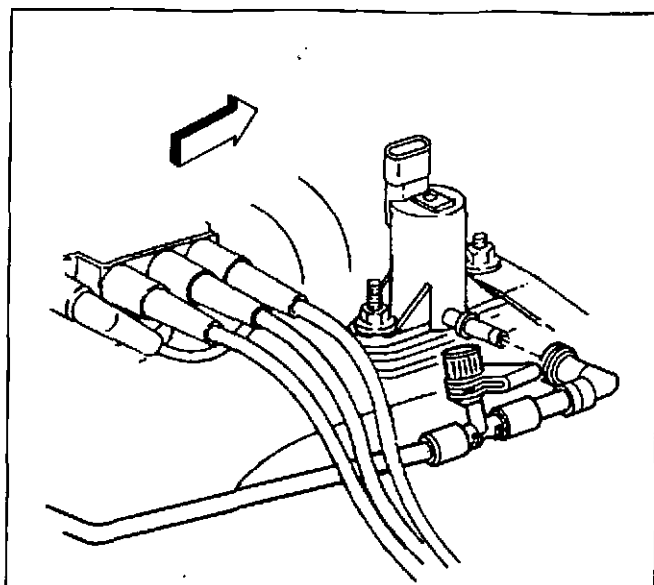


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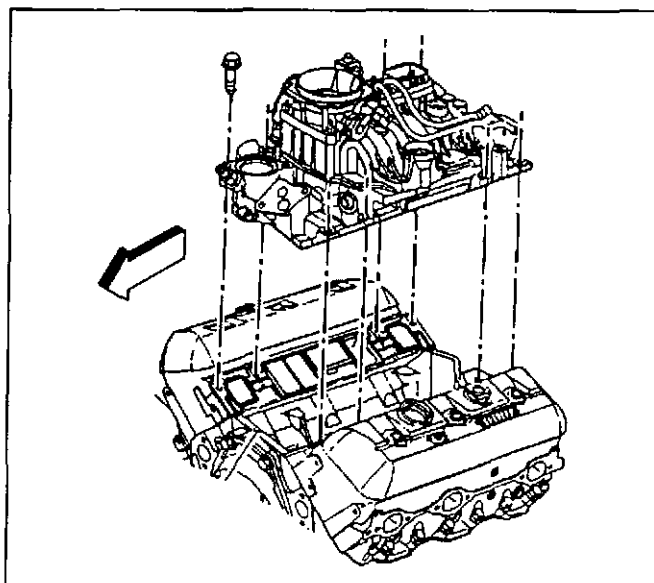
2. Remove the throttle body.
3. Remove the throttle body gasket.
4. Discard the throttle body gasket.



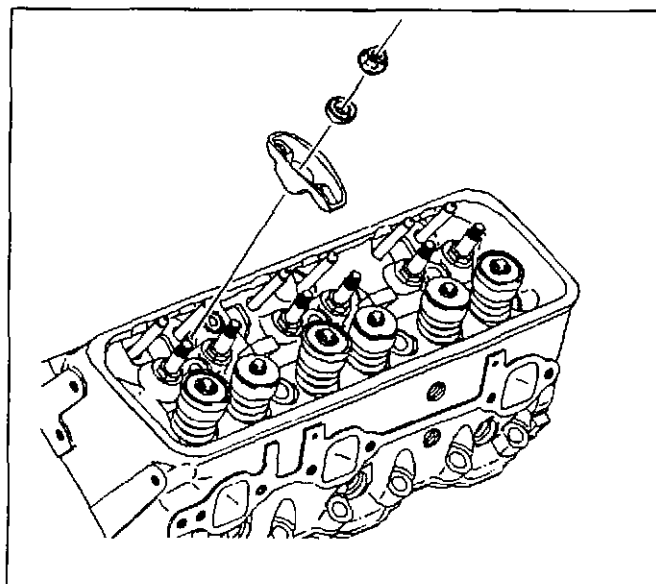
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SIE-ID - 358523

Intake Manifold Removal

1. Remove the evaporative emission (EVAP) canister purge solenoid valve harness.
 - 1.1. Push the quick disconnect clip and hold in place.
 - 1.2. Pull outward on the harness elbow.

2. Remove the lower intake manifold bolts.

Important: The intake manifold may be removed as an assembly. Do not remove the specific intake manifold components unless component service is required.

Do not allow dirt or debris to enter the fuel system. Ensure that the ends of the fuel system are properly sealed.

Do not disassemble the Central Sequential Fuel Injection (SFI) unit, unless service is required.

3. Remove the intake manifold assembly.
4. Remove and discard the lower intake manifold gaskets.

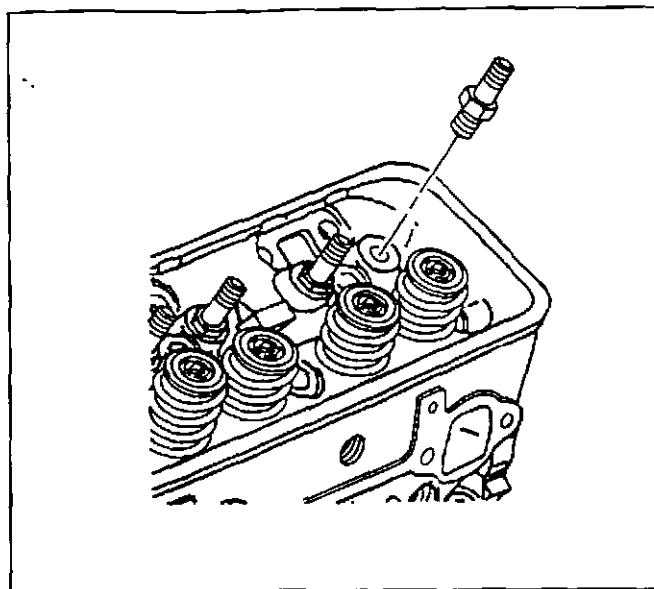
SIE-ID - 42952

Valve Rocker Arm and Push Rod Removal

Important: Mark, sort, and organize all the components for assembly.

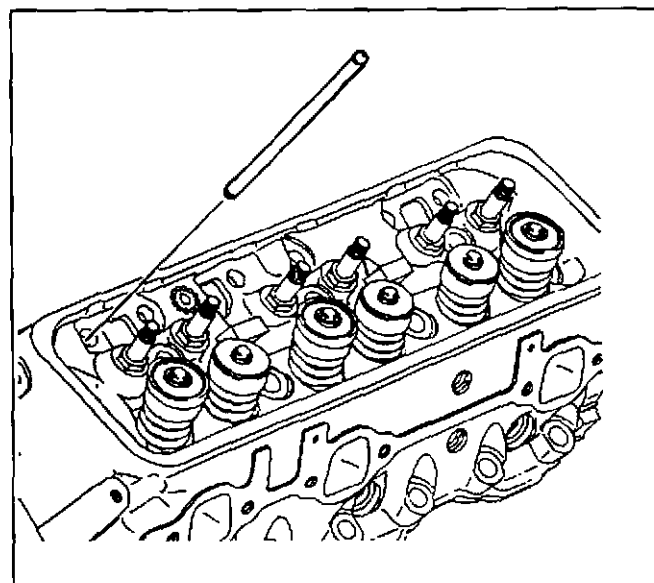
1. Remove the following components from the cylinder head:
 - 1.1. The valve rocker arm nuts
 - 1.2. The valve rocker arm balls
 - 1.3. The valve rocker arms

2. Remove the valve rocker arm studs.



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3. Remove the valve pushrods.

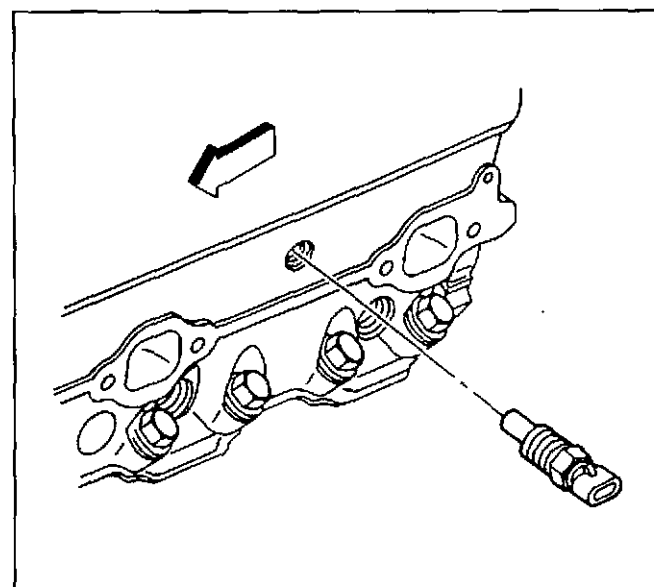


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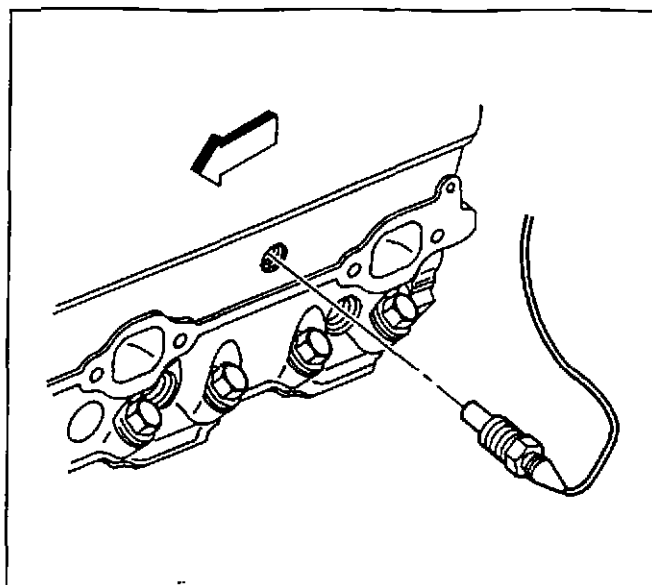
SIE-ID = 358524

Cylinder Head Removal (Left)

1. Remove the engine coolant temperature sensor (if applicable).

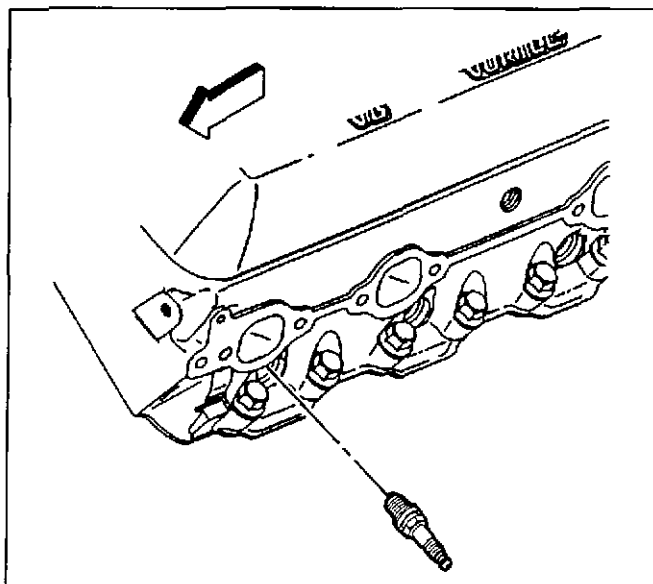


387769



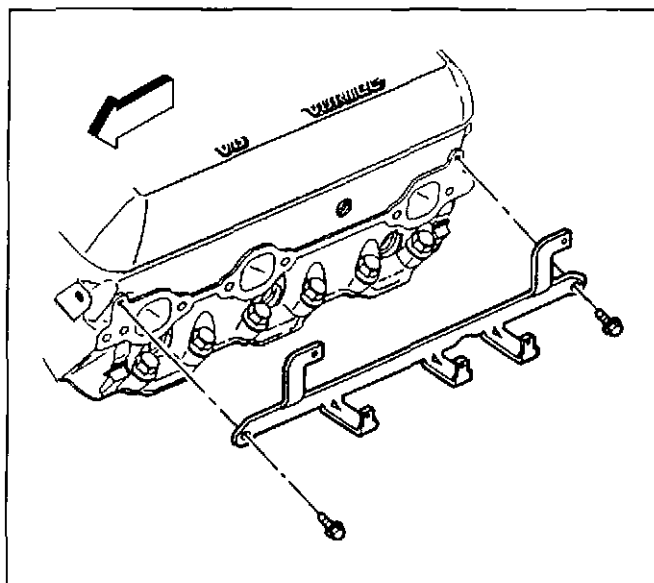
387767

2. Remove the engine coolant temperature gauge sensor (if applicable).



328582

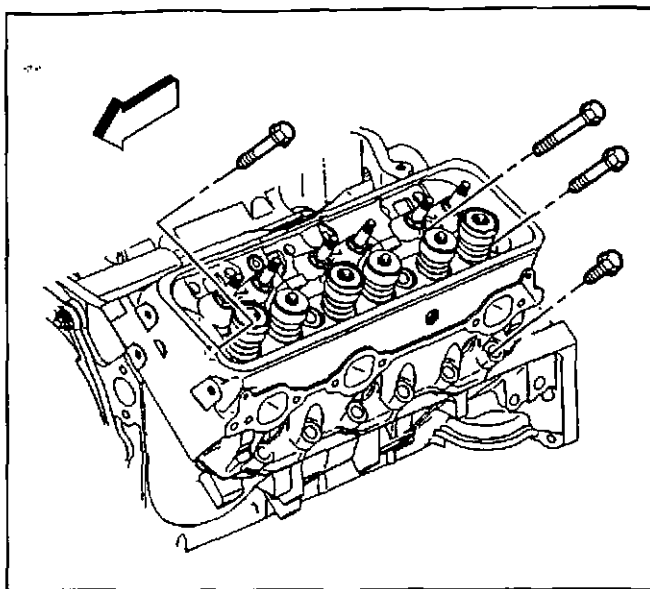
3. Remove the spark plugs.



328588

4. Remove the bolts and the spark plug wire support.

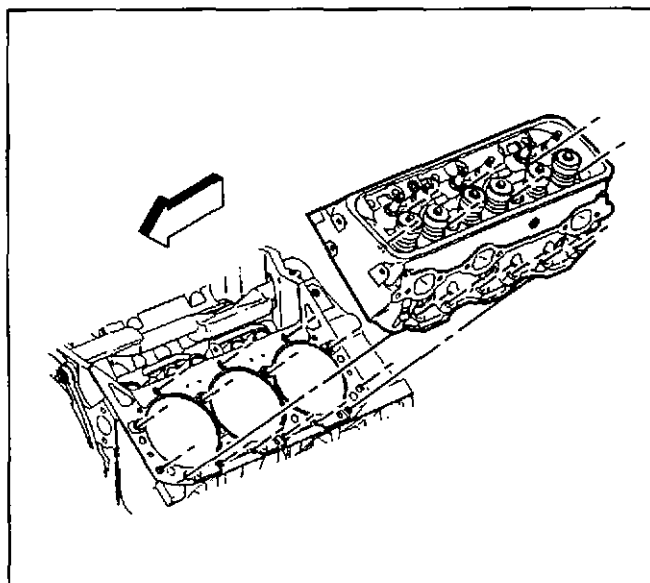
5. Remove the cylinder head bolts.



5129

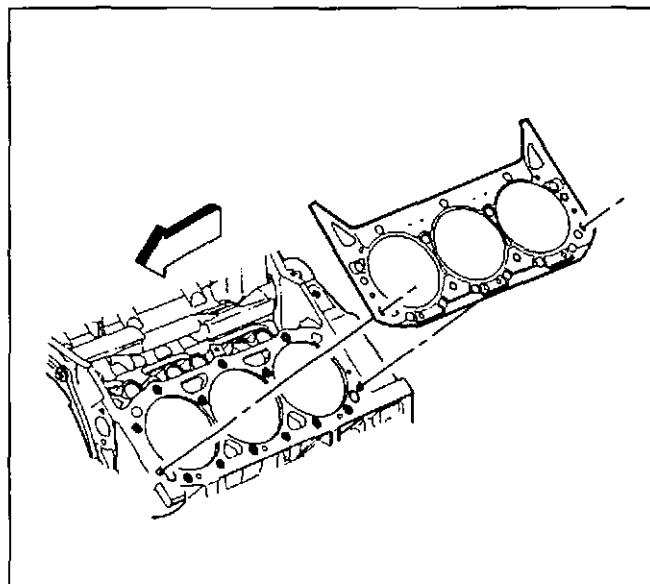
Notice: SIO-ID - 13838 After removal, place the cylinder head on two wood blocks to prevent damage.

6. Remove the cylinder head.

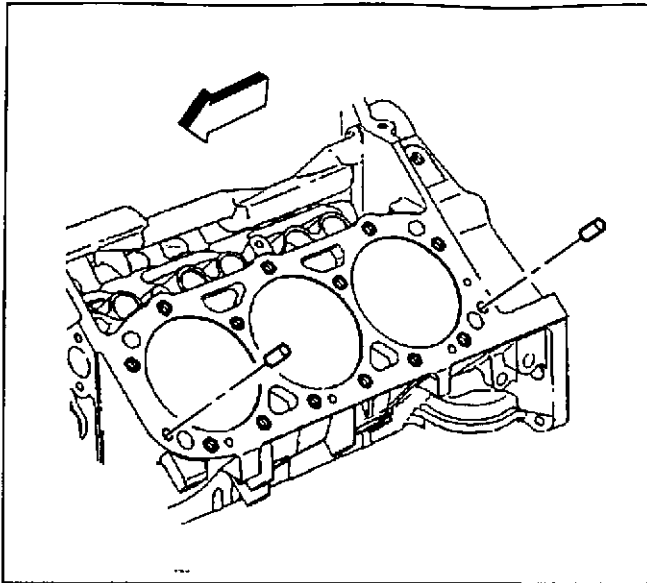


334295

7. Remove and discard the cylinder head gasket.



334299



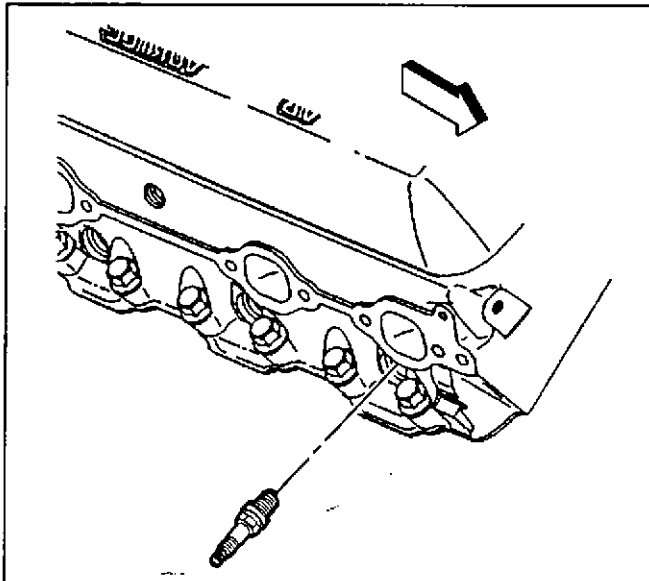
330548

8. Remove the dowel pins (cylinder head locator) (if required).

SIE-ID = 358525

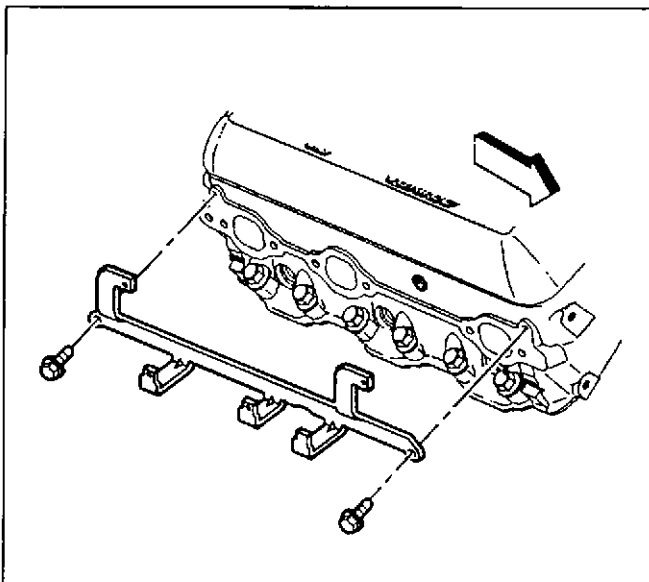
Cylinder Head Removal (Right)

1. Remove the spark plugs.



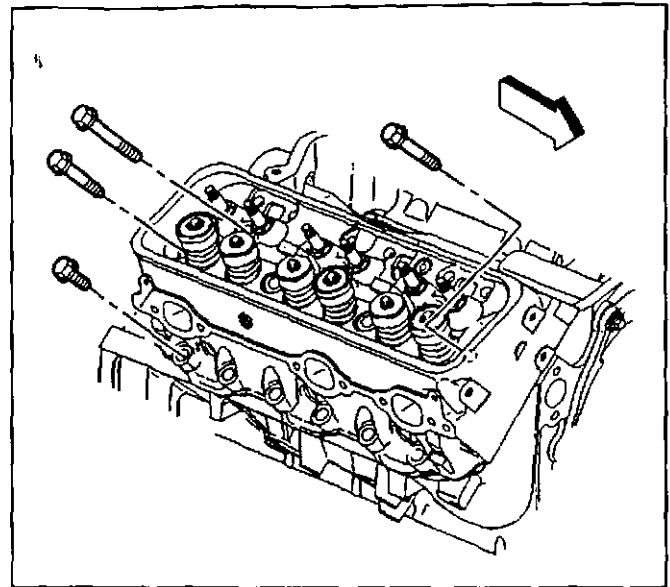
328586

2. Remove the bolts and the spark plug wire support.



328590

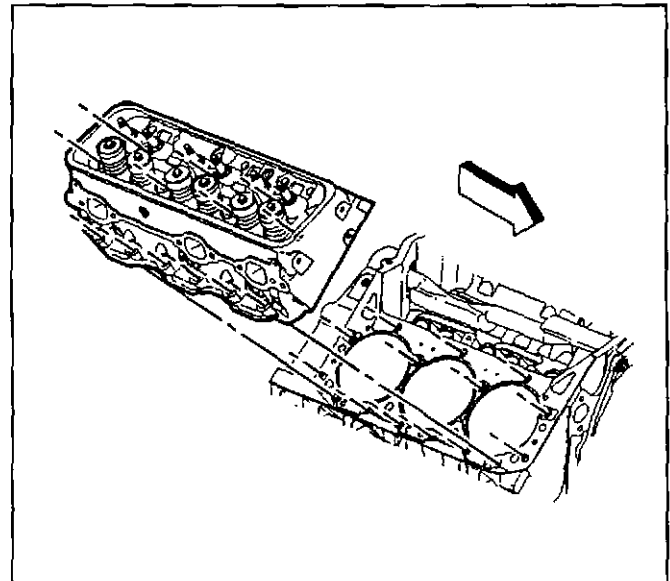
3. Remove the cylinder head bolts.



196132

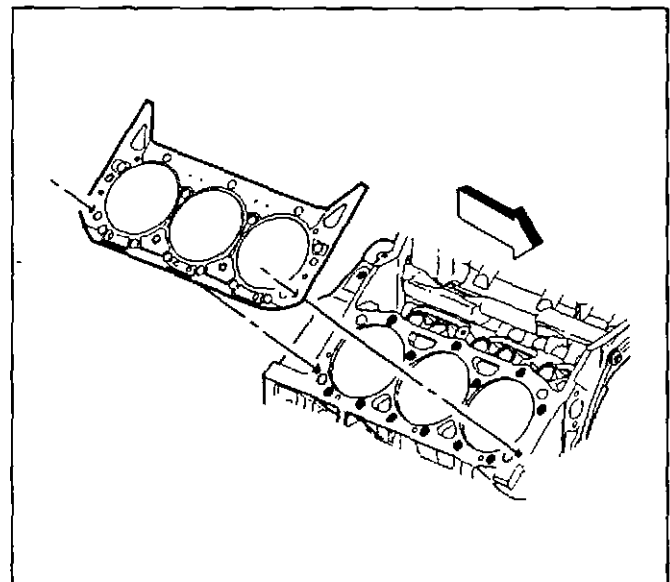
Notice: SIO-ID - 13838 After removal, place the cylinder head on two wood blocks to prevent damage.

4. Remove the cylinder head.

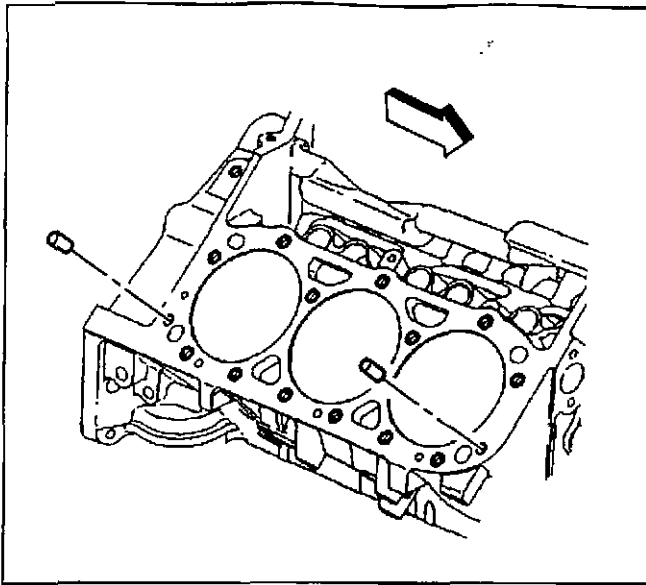


334309

5. Remove and discard the cylinder head gasket.



334312



330553

6. Remove the dowel pins (cylinder head locator) (if required).

SIE-ID = 358526

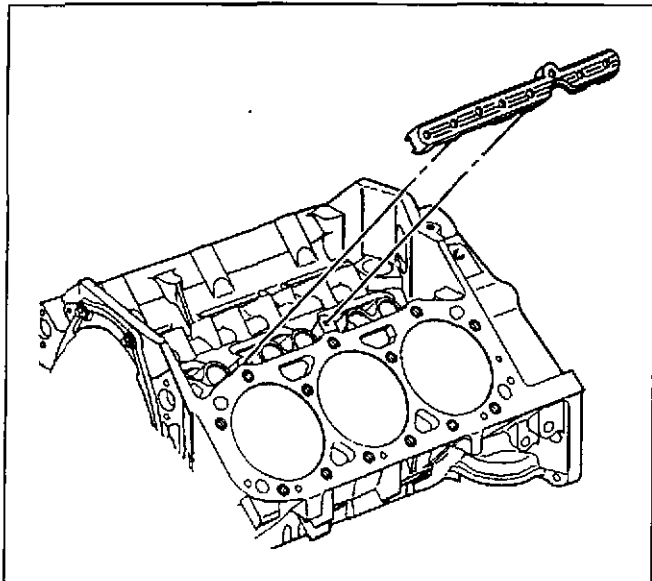
Valve Lifter Removal

Tools Required

J 3049-A Valve Lifter Remover

Important: Place the components in a rack so that the components can be reinstalled to their original location.

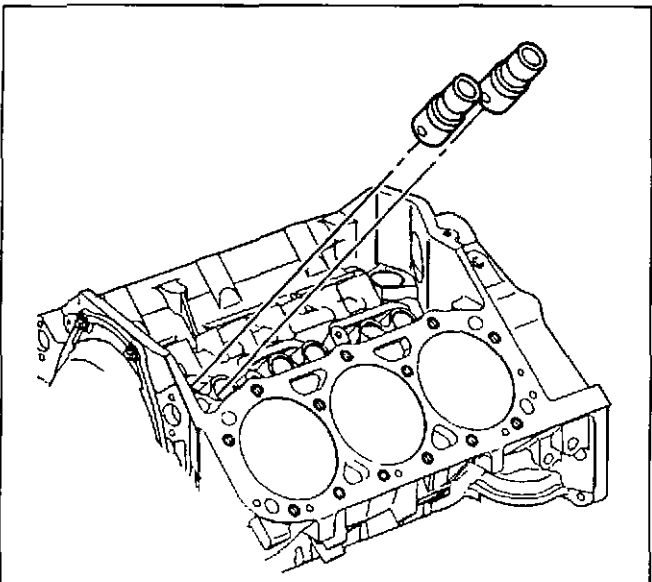
1. Remove the bolts and valve lifter pushrod guide.



328592

Important: Place the valve lifters in the rack in the upright position in order to maintain the oil inside the valve lifters.

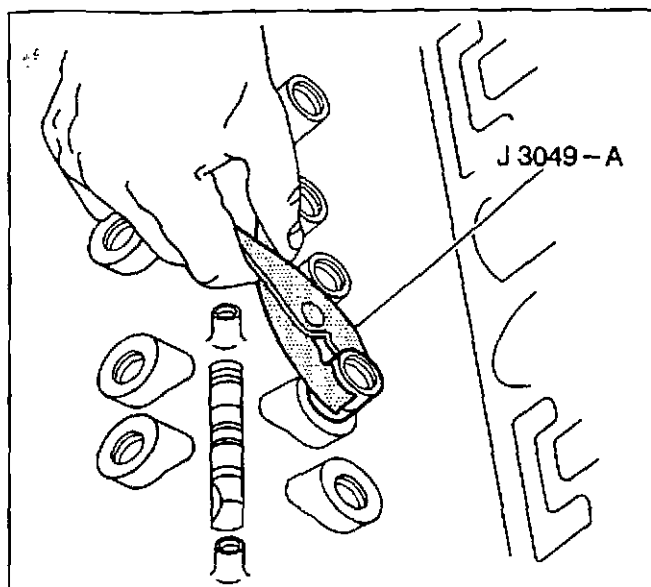
2. Remove the valve lifters.



328593

Important: Some valve lifters may be stuck in the valve lifter bores because of gum or varnish deposits and may require the use of J 3049-A for removal.

3. Use the J 3049-A in order to remove the stuck valve lifters.

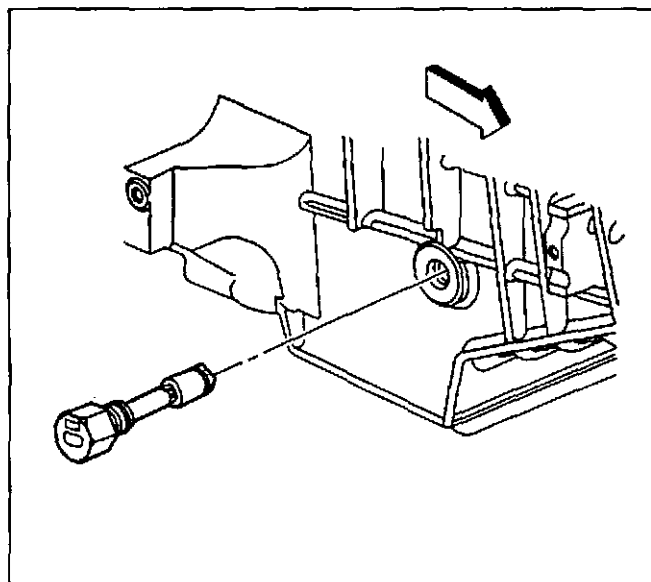


31350

SIE-ID - 358527

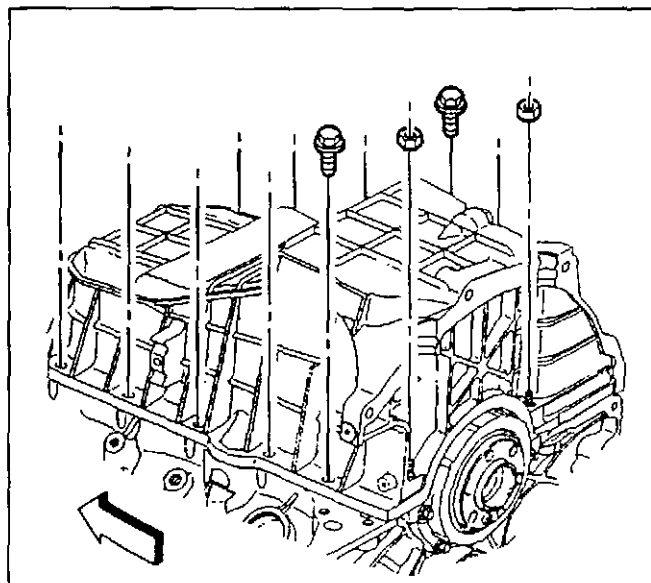
Oil Pan Removal

1. Remove the engine oil level sensor (if applicable).

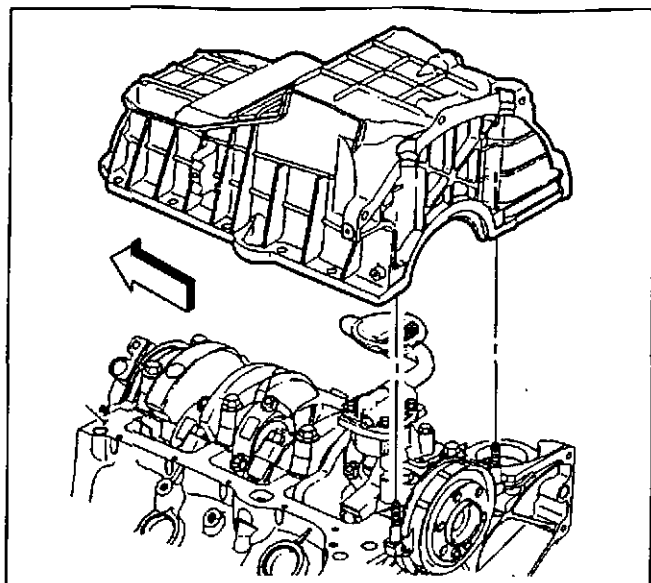


387460

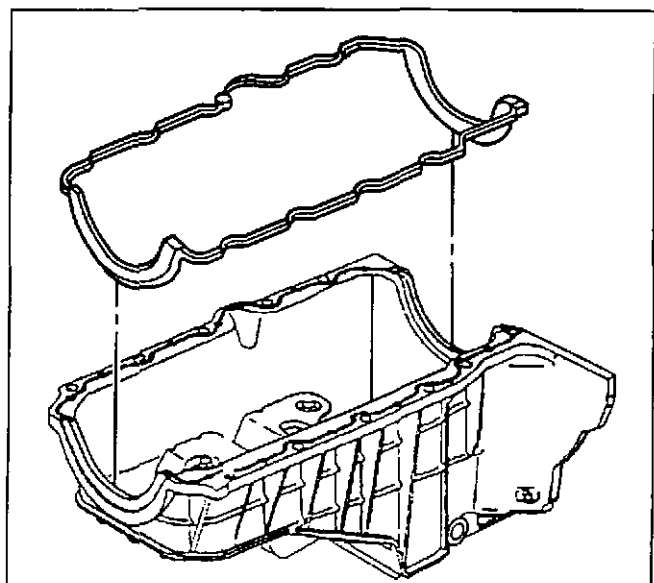
2. Remove the oil pan bolts and nuts.



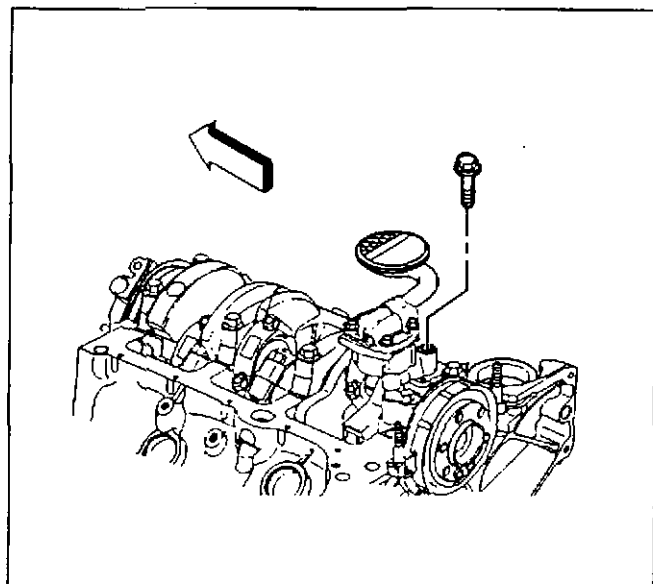
330559



330568



387757



330572

3. Remove the oil pan.

4. Remove the oil pan gasket.

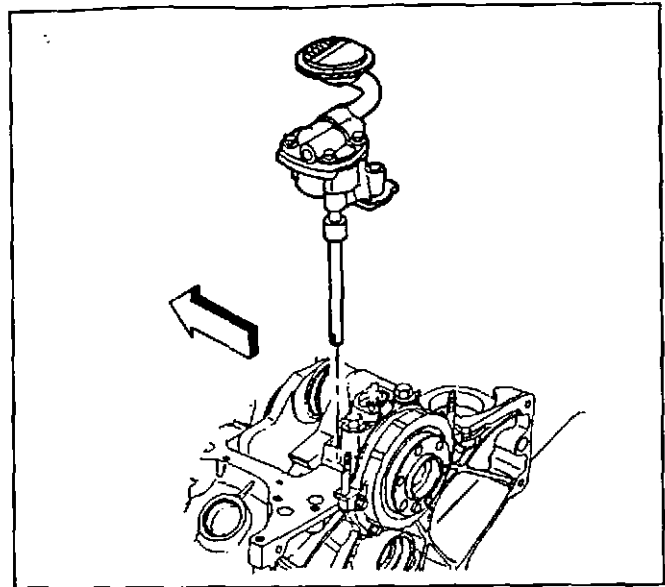
5. Discard the oil pan gasket.

S/E-ID - 358522

Oil Pump Removal

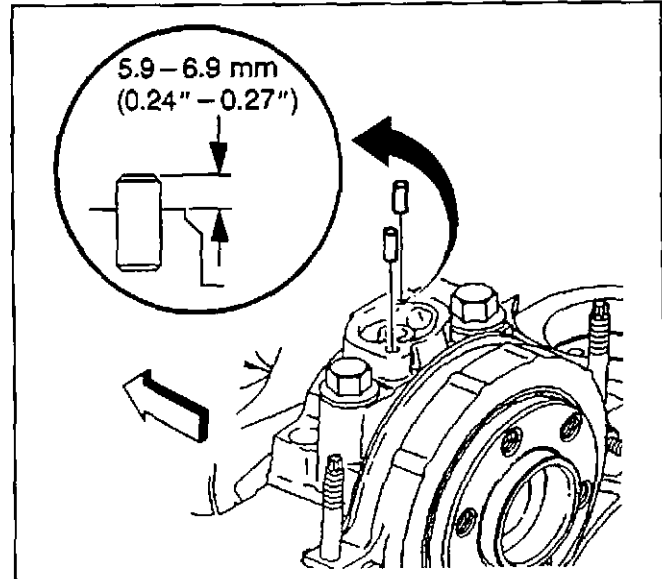
1. Remove the oil pump bolt.

2. Remove the oil pump.



330576

3. Inspect the pins (oil pump locator) for damage, and replace the pins if required.

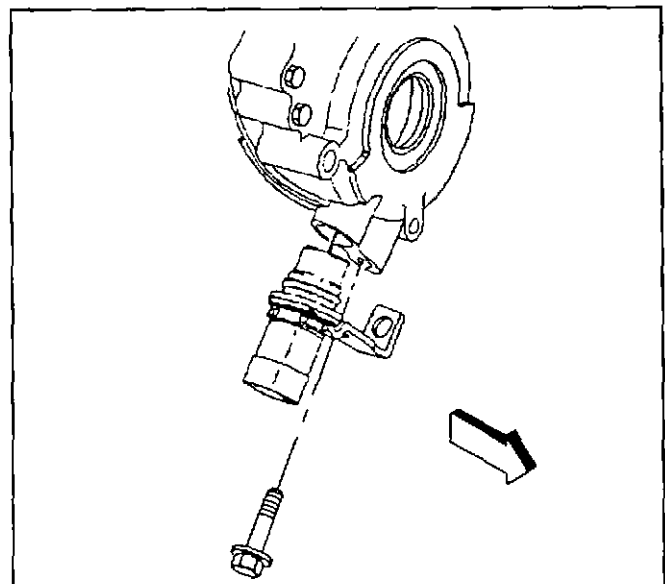


330576

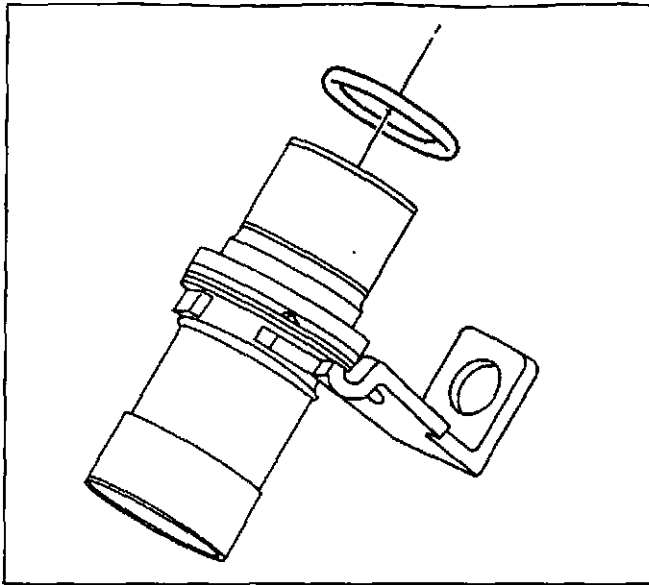
SIE-ID - 42970

Engine Front Cover Removal

1. Remove the crankshaft position sensor bolt.
2. Remove the crankshaft position sensor.

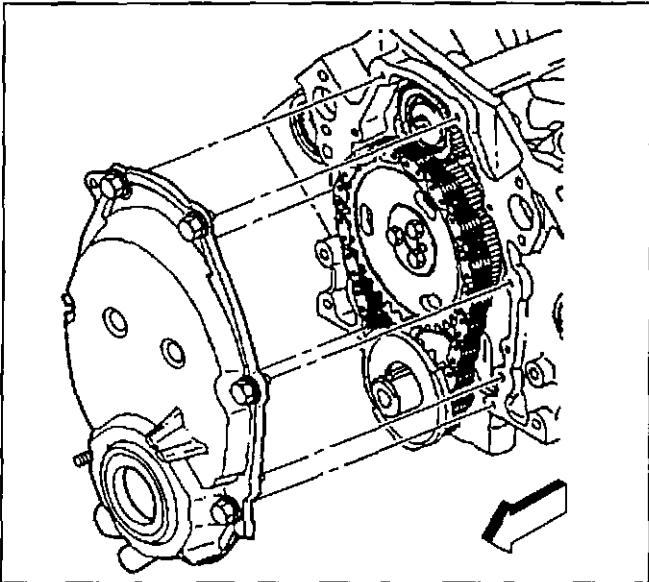


11485



387759

3. Remove the crankshaft position sensor seal (O-ring).
4. Discard the crankshaft position sensor seal (O-ring).

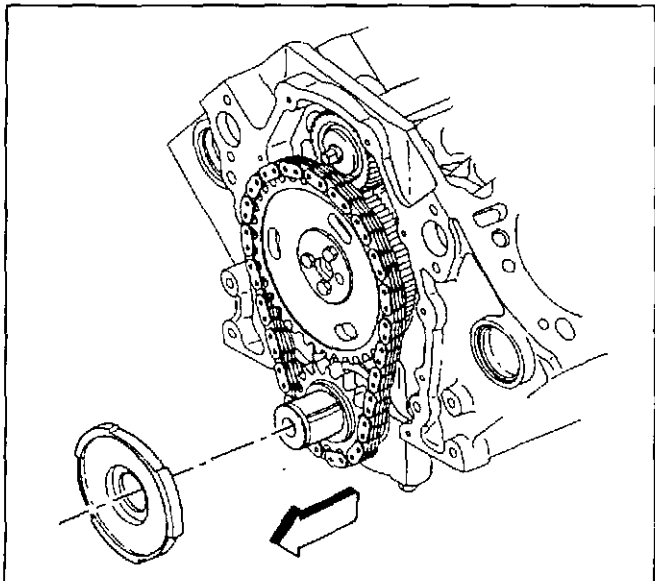


168000

5. Remove the engine front cover bolts.

Important: After the composite engine front cover is removed do not reinstall the engine front cover. Always install a NEW engine front cover.

6. Remove the engine front cover.
7. Discard the engine front cover.



45986

SIE-ID = 358530

Timing Chain and Sprockets Removal

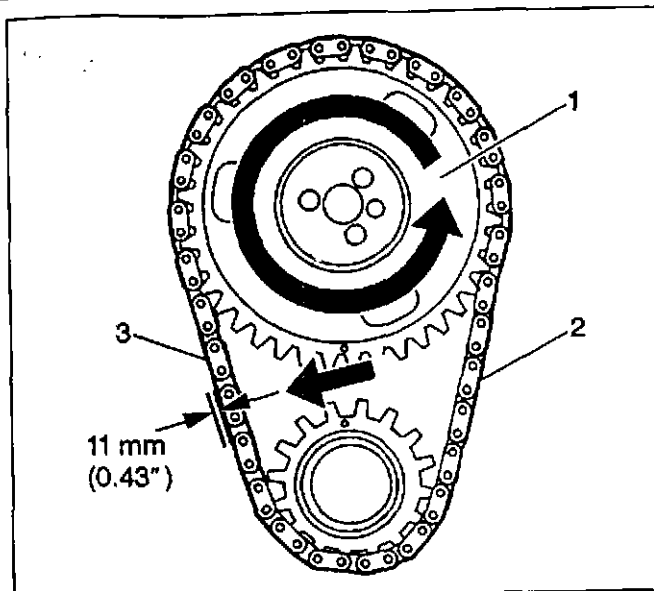
Tools Required

J 5825-A Crankshaft Gear Remover

1. Remove the crankshaft position sensor reluctor ring.

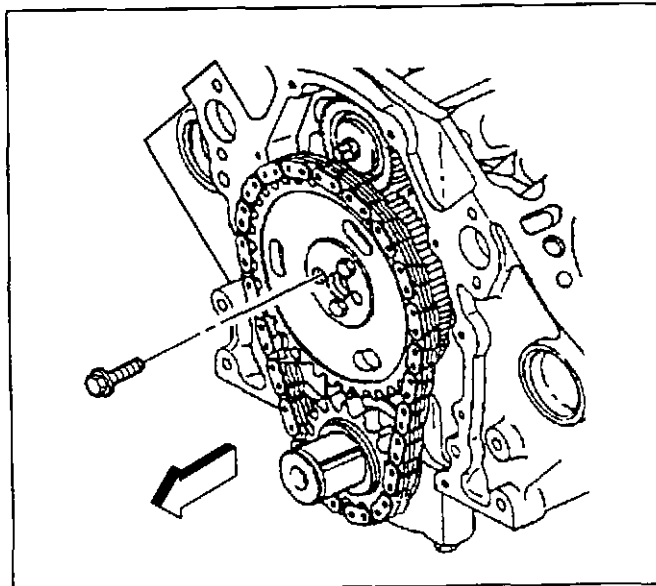
Important: If the camshaft timing chain can be moved in excess of 11 mm (0.43 in), replacement of the camshaft timing chain and the sprockets is recommended during assembly.

2. Check the camshaft timing chain free play.
 - 2.1. Rotate the camshaft sprocket (1) counterclockwise until all slack is removed from the camshaft timing chain (2).
 - 2.2. Measure the free play on the slack side (3) of the camshaft timing chain.



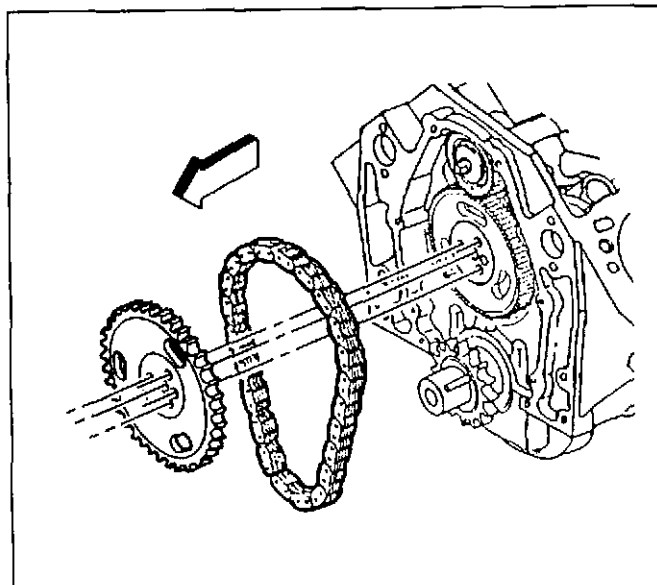
341358

3. Remove the camshaft sprocket bolts.

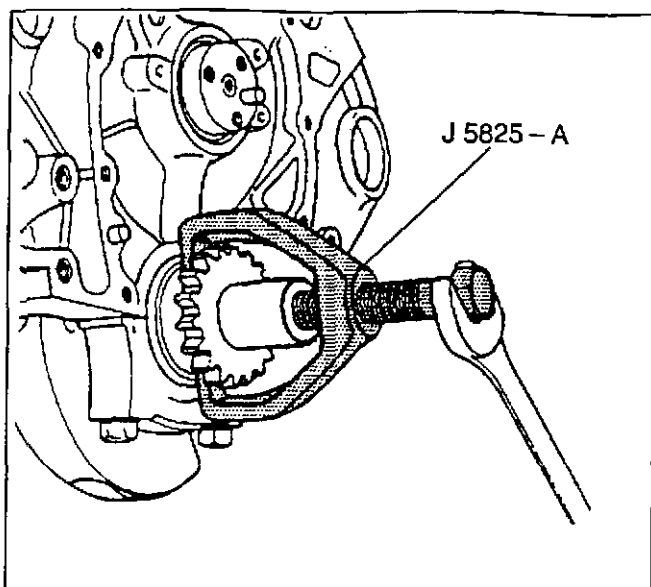


330581

4. Remove the camshaft sprocket and the camshaft timing chain.



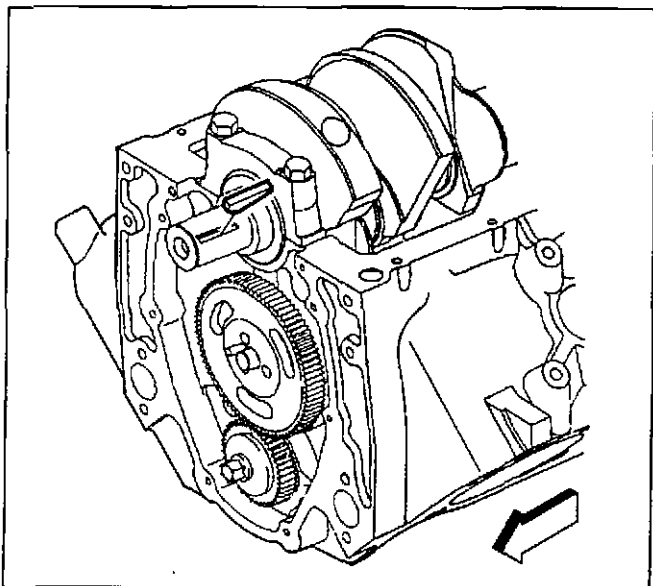
330584



11506

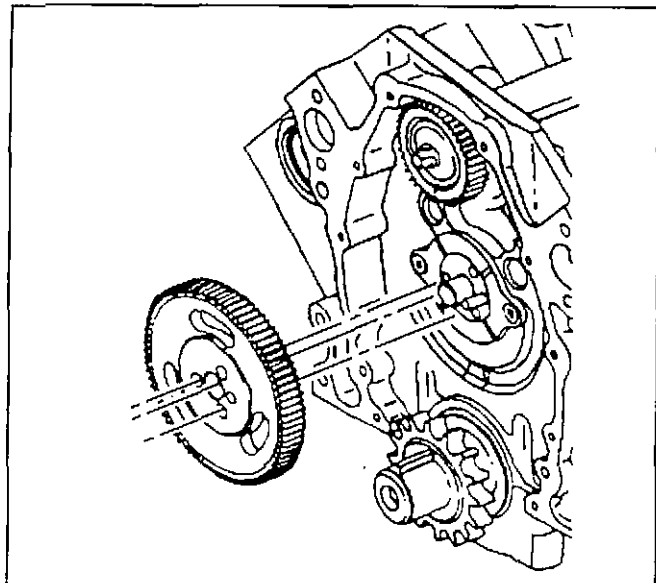
Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

5. Remove the crankshaft sprocket using the J 5825-A.



387761

6. Remove the crankshaft balancer key.



9847

SIE-ID - 358918

Balance Shaft Removal

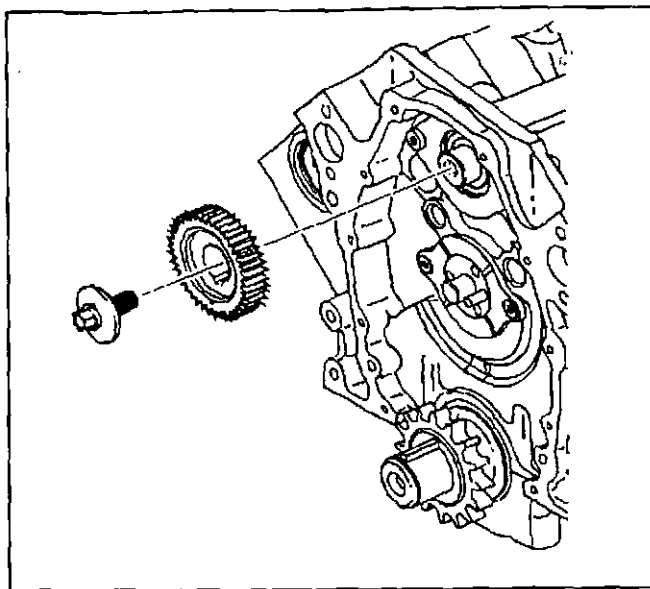
Tools Required

J 38834 Balance Shaft Service Kit

1. Remove the balance shaft drive gear.

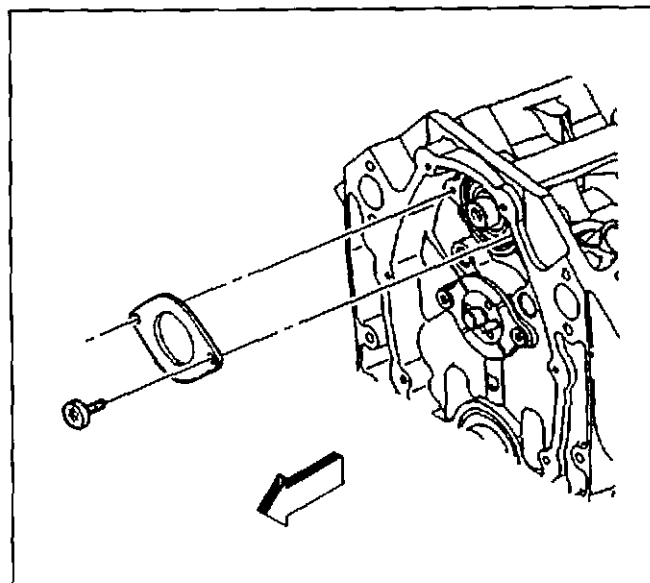
Important: The balance shaft drive and balance shaft driven gears are serviced as a set. The set includes the balance shaft driven gear bolt.

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



5136

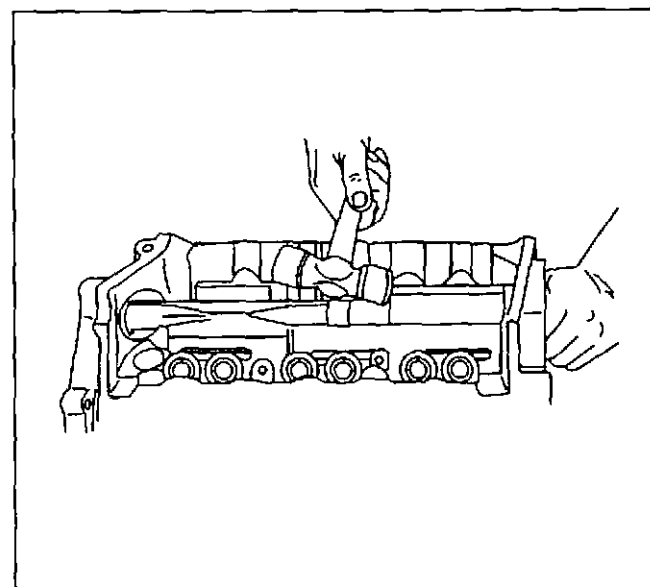
3. Remove the bolts and the balance shaft retainer.



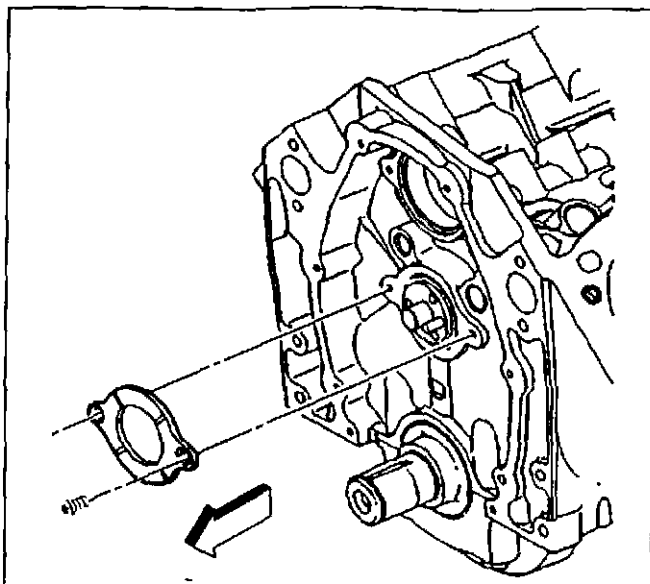
188031

Important: The balance shaft and the balance shaft front bearing are serviced only as a package. Do not remove the balance shaft front bearing from the balance shaft.

4. Use a soft-faced hammer in order to remove the balance shaft and the front bearing from the engine block.



5139

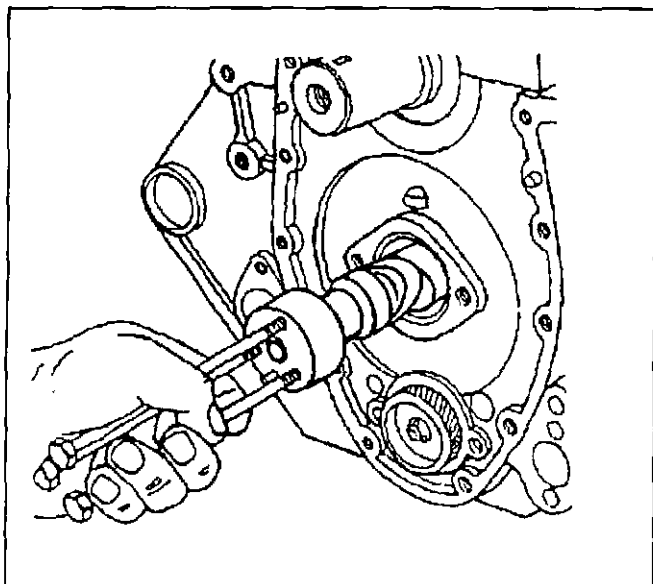


188030

SIE-ID = 42977

Camshaft Removal

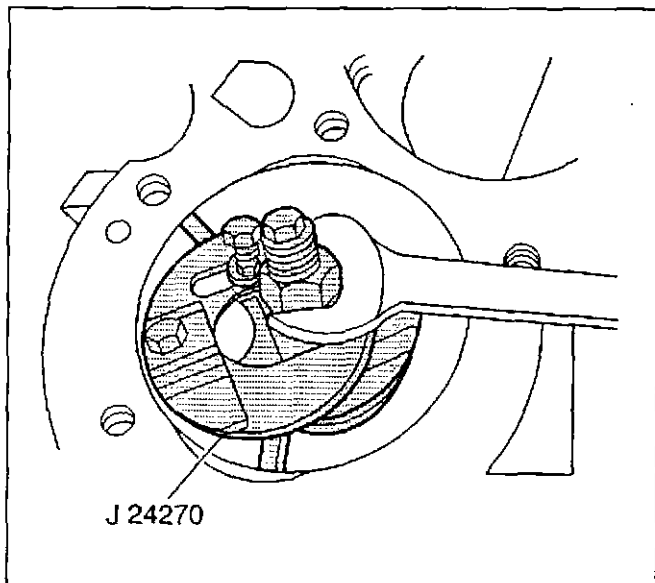
1. Remove the camshaft retainer bolts and retainer.



5147

Notice: SIO-ID = 13833 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.

2. Remove the engine camshaft.
 - 2.1. Install the three 5/16-18 x 4.0 inch bolts into the engine camshaft front bolt holes.
 - 2.2. Using the bolts as a handle, carefully rotate and pull the engine camshaft out of the camshaft bearings.
 - 2.3. Remove the bolts from the front of the engine camshaft.



11497

SIE-ID = 42978

Piston, Connecting Rod, and Bearing Removal

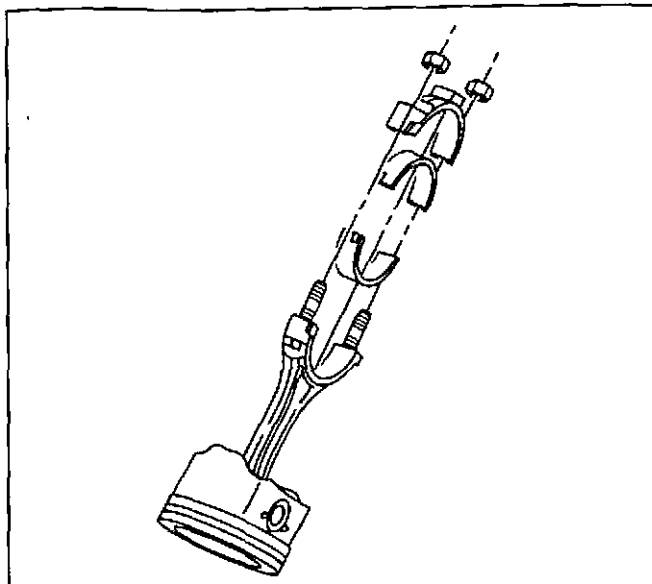
Tools Required

- J 5239 Connecting Rod Bolt Guide Set
- J 24270 Cylinder Bore Ridge Reamer

1. Use the J 24270 in order to remove the cylinder ring ridge.
 - 1.1. Turn the crankshaft until the piston is at the bottom of the stroke.
 - 1.2. Place a cloth on top of the piston.
 - 1.3. Use the J 24270 to remove all of the cylinder ring ridge.
 - 1.4. Turn the crankshaft so the piston is at the top of the stroke.
 - 1.5. Remove the cloth.
 - 1.6. Remove the cutting debris.

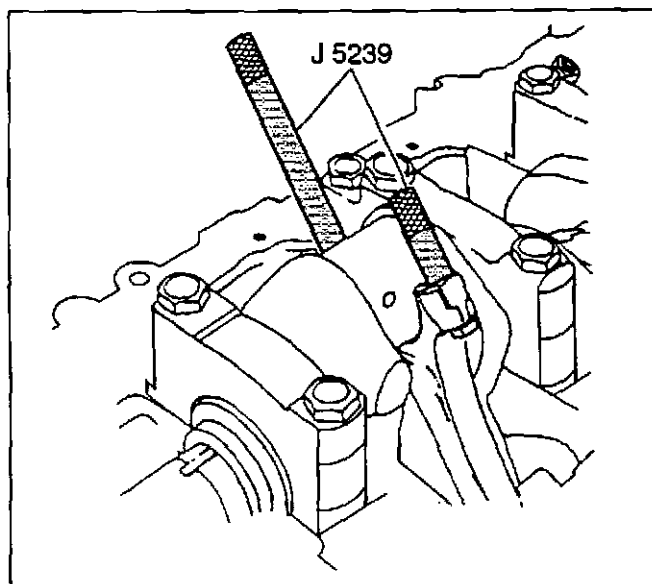
Important: Place matchmarks or numbers on the connecting rods and the connecting rod caps. Assemble the connecting rod caps to the matching connecting rods.

2. Remove the connecting rod nuts.
3. Remove the connecting rod cap.



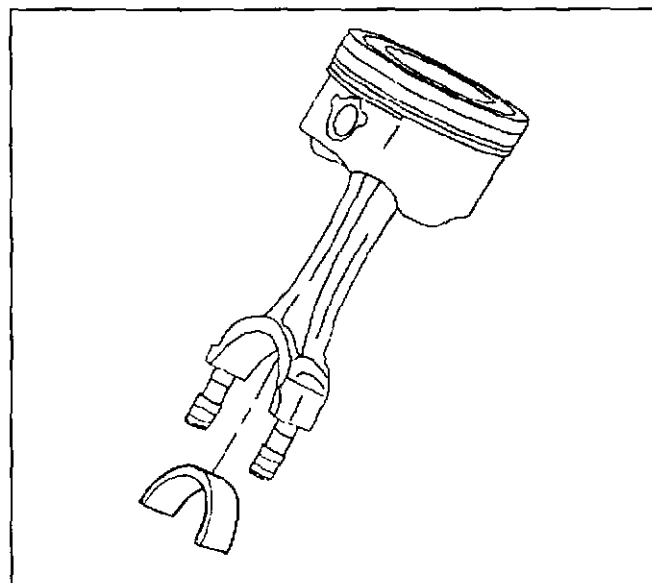
188017

4. Use the J 5239 in order to protect the crankshaft journals and remove the connecting rod and the piston out of the top of the engine block.



31373

5. Remove the connecting rod bearings.
 - Keep the connecting rod bearings with the original connecting rod and connecting rod cap.
 - Wipe the oil from the connecting rod bearings.
 - Wipe the oil from the crankpins.

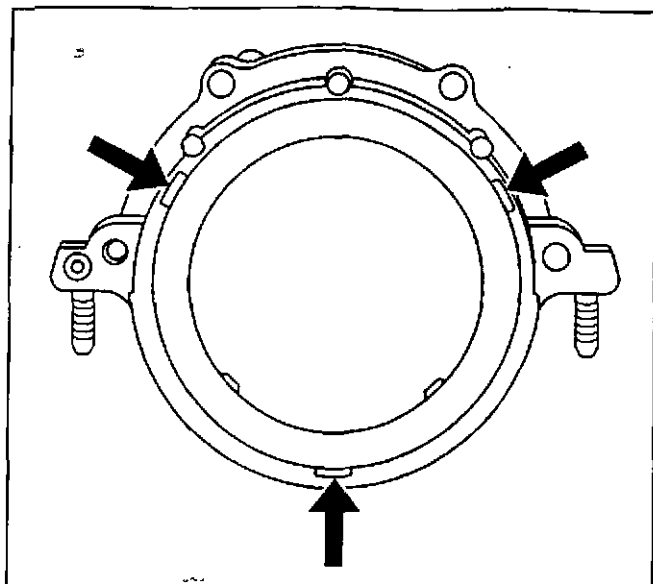


5157

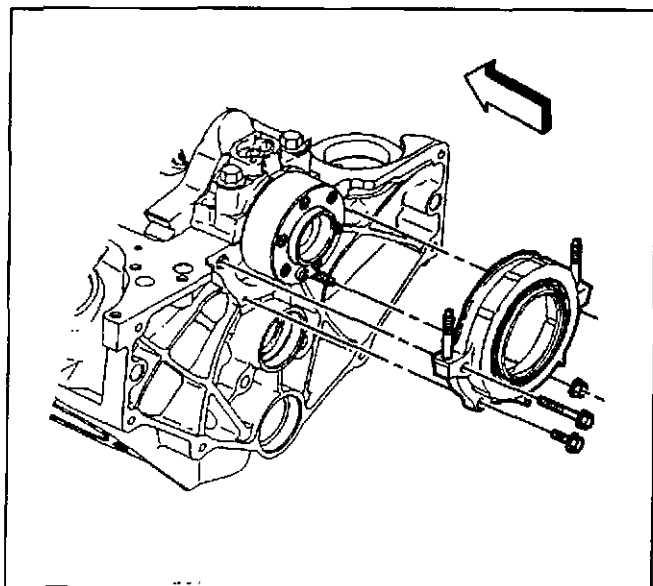
SIE-ID - 358535

Crankshaft Rear Oil Seal and Housing Removal

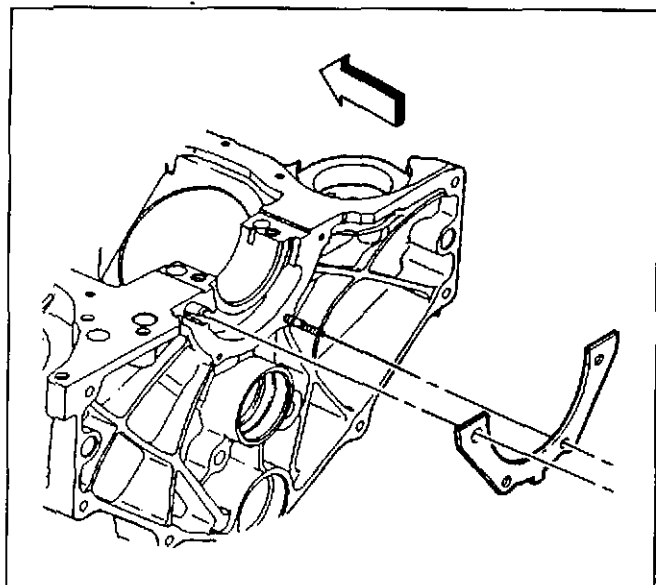
1. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.
Insert a suitable tool into the access notches and then carefully pry the crankshaft rear oil seal from the crankshaft rear oil seal housing.
2. Discard the crankshaft rear oil seal.



31379



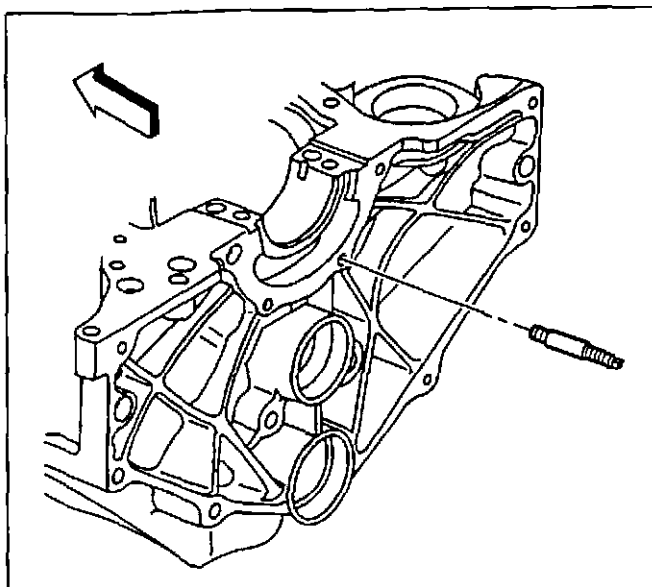
334317



334319

3. Remove the crankshaft rear oil seal housing nut and bolts.
4. Remove the crankshaft rear oil seal housing.
5. Remove the crankshaft rear oil seal housing gasket.
6. Discard the crankshaft rear oil seal housing gasket.

7. Remove the crankshaft rear oil seal housing retainer stud from the engine block.

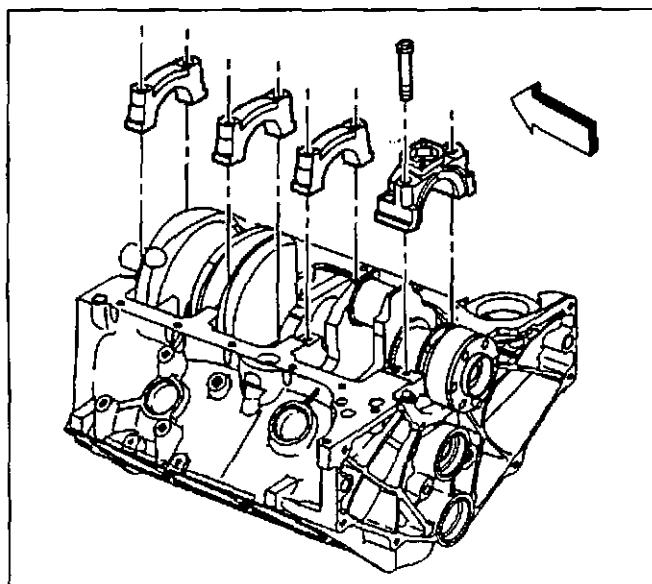


334326

SIE-ID = 358537

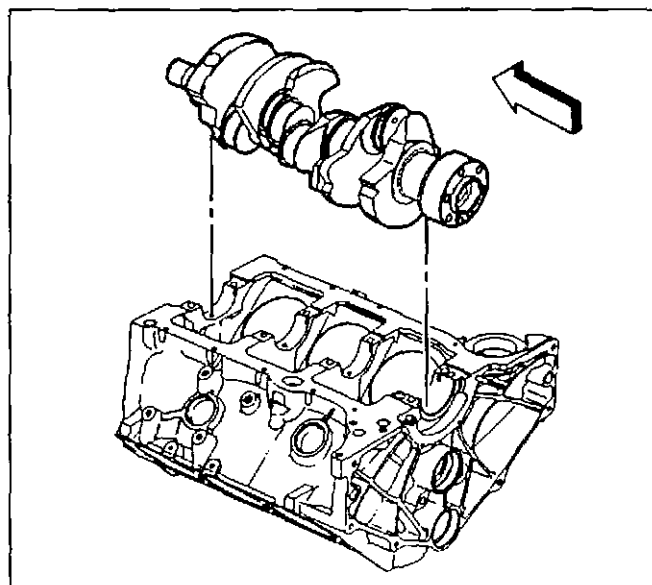
Crankshaft and Bearings Removal

1. Mark or identify the crankshaft bearing cap locations and positions for assembly.
2. Remove the crankshaft bearing cap bolts.
3. Remove the crankshaft bearing caps.

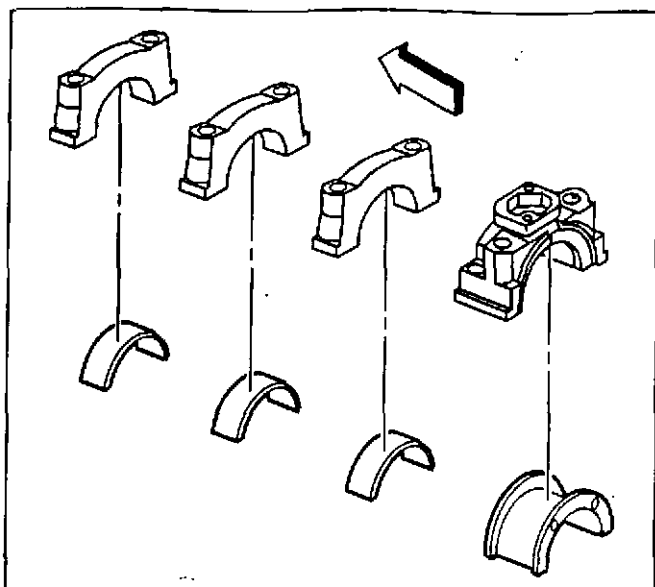


334329

4. Remove the crankshaft.

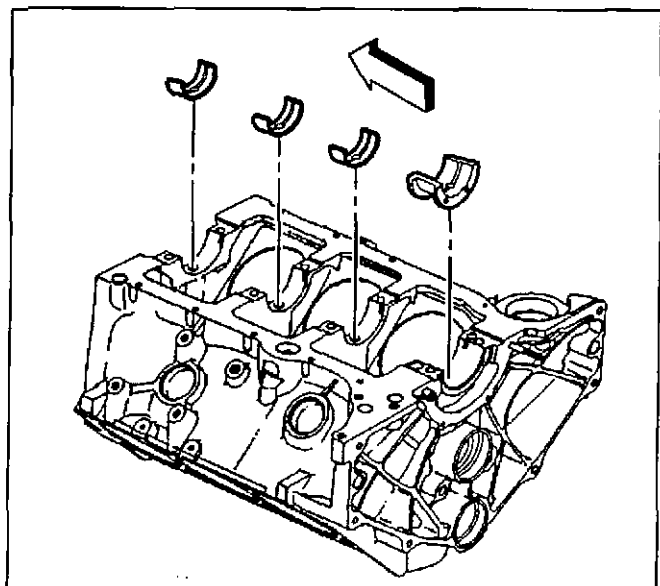


334336



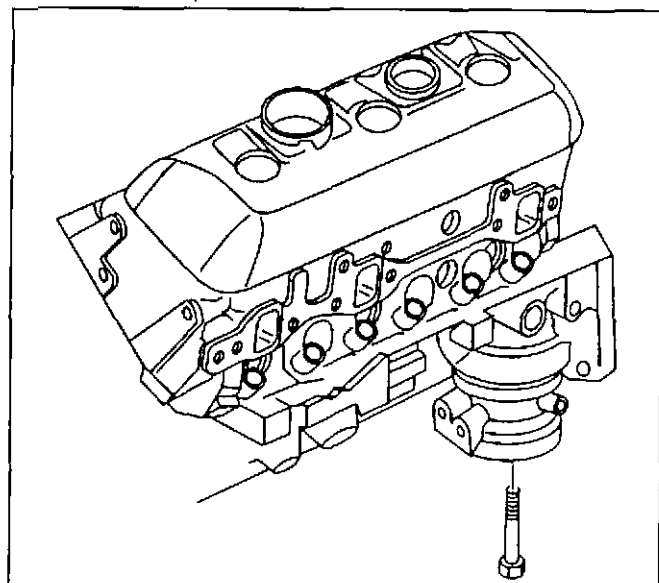
334342

5. Remove the crankshaft bearings from the crankshaft bearing caps.



334338

6. Remove the crankshaft bearings from the engine block.



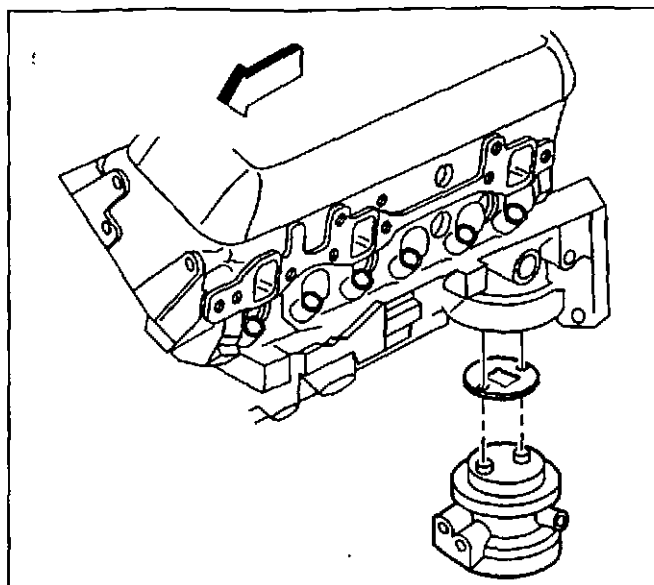
4554

S/E-ID = 42961

Oil Filter Adapter and Valve Assembly Removal

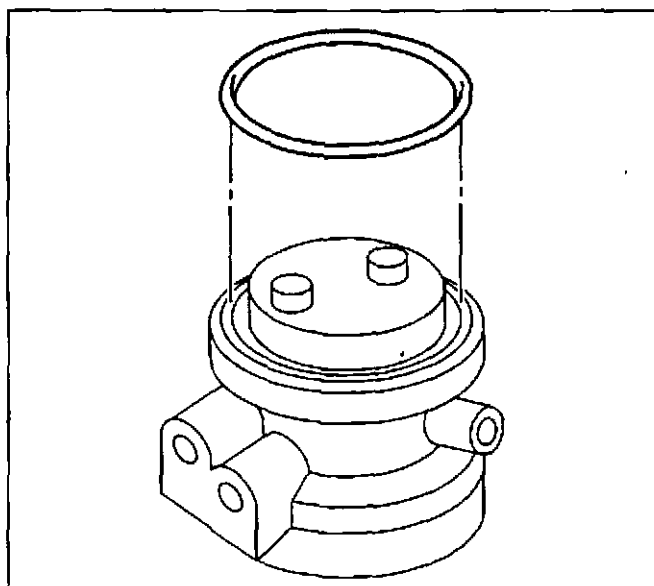
1. Remove the oil filter adapter bolts.

2. Remove the oil filter adapter and the oil filter adapter gasket.
3. Discard the oil filter adapter gasket.



4555

4. Remove the oil filter adapter seal (O-ring).
5. Discard the oil filter adapter seal (O-ring).



4556

SIE-ID = 358540

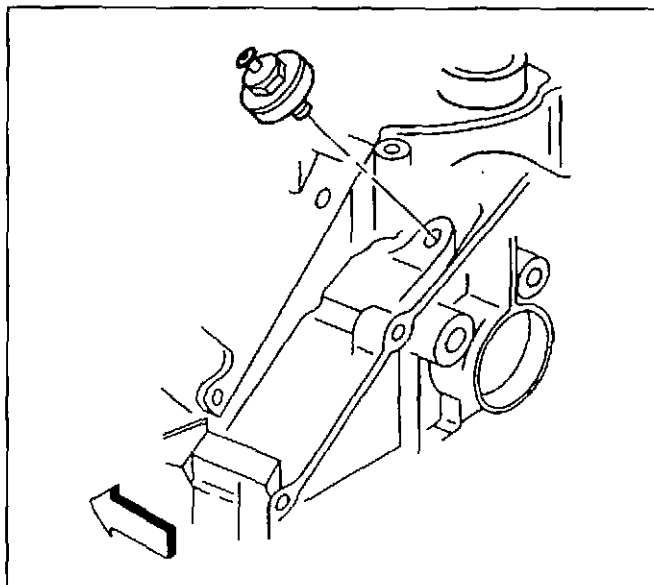
Engine Block Plug Removal

Tools Required

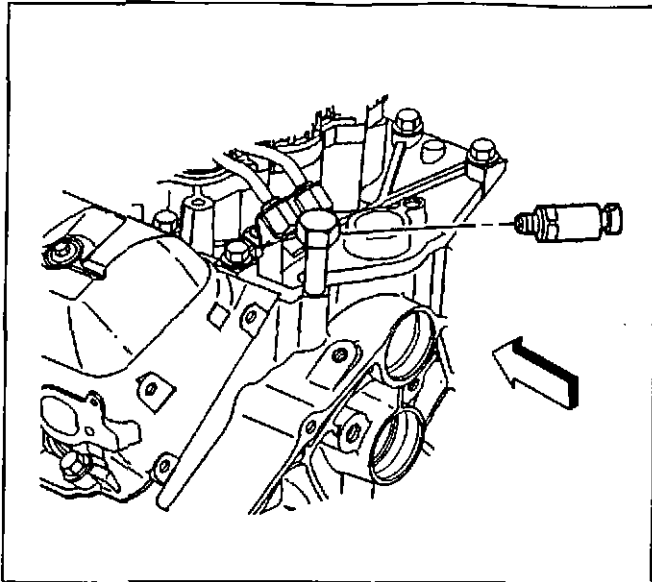
J 41712 Oil Pressure Switch Socket

Caution: SIO-ID = S011 *Wear safety glasses in order to avoid eye damage.*

1. Remove the knock sensor from the engine block.

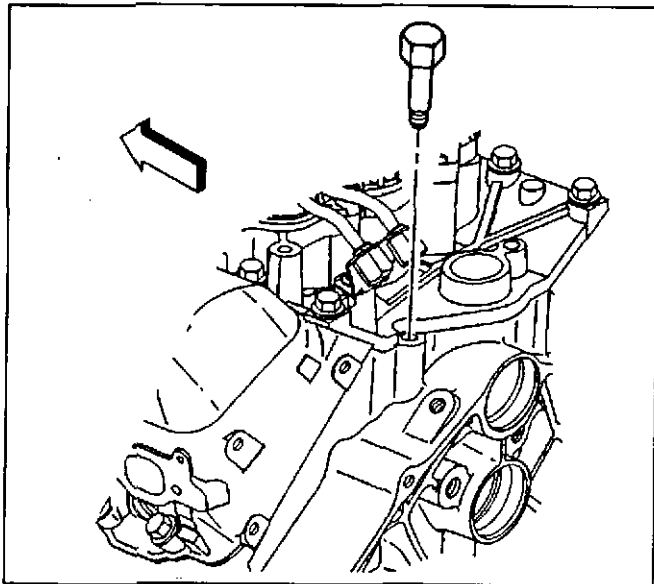


10793



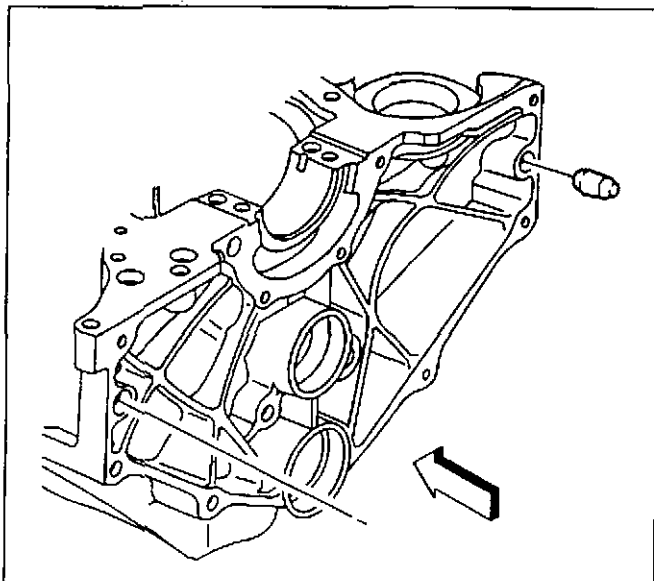
188018

2. Remove the engine oil pressure gauge sensor using the *J 41712*.



188020

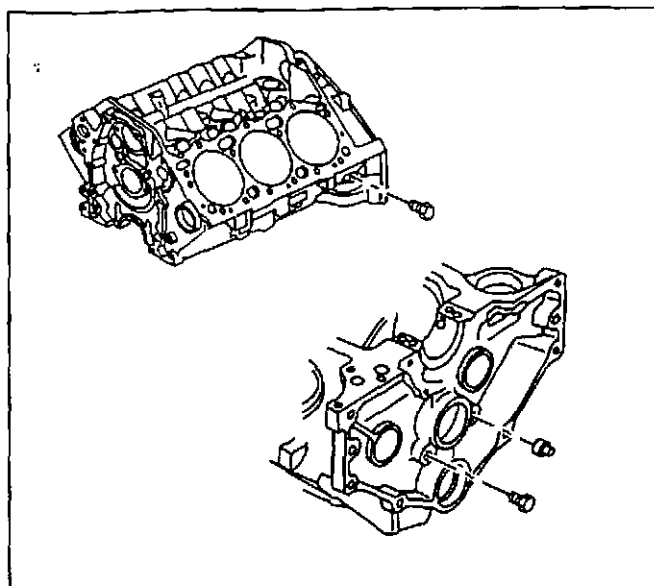
3. Remove the engine oil pressure sensor fitting.



334350

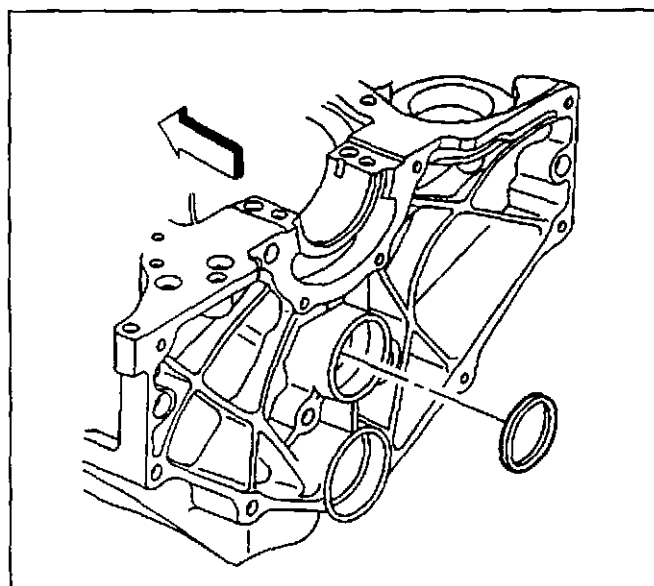
4. Remove the dowel straight pins (transmission locator) (if required).

5. Remove the engine block left side oil gallery plug.
6. Remove the engine block left rear oil gallery plug.
7. Remove the engine block right rear oil gallery plug.



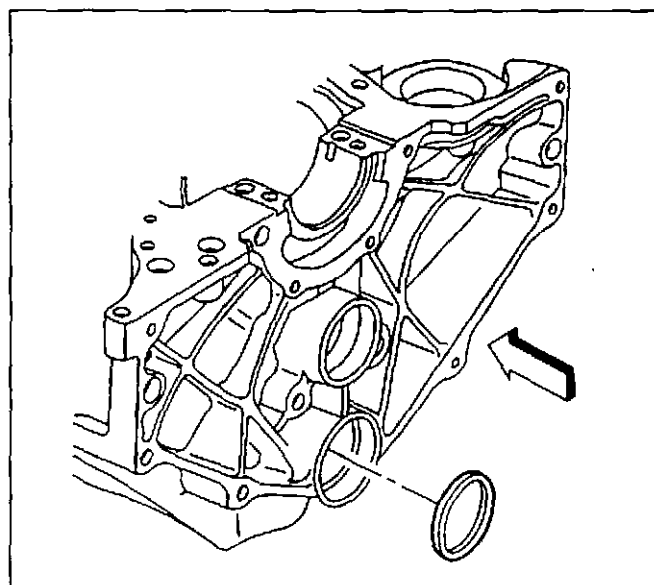
5271

8. Remove the expansion cup plug (camshaft rear bearing hole).

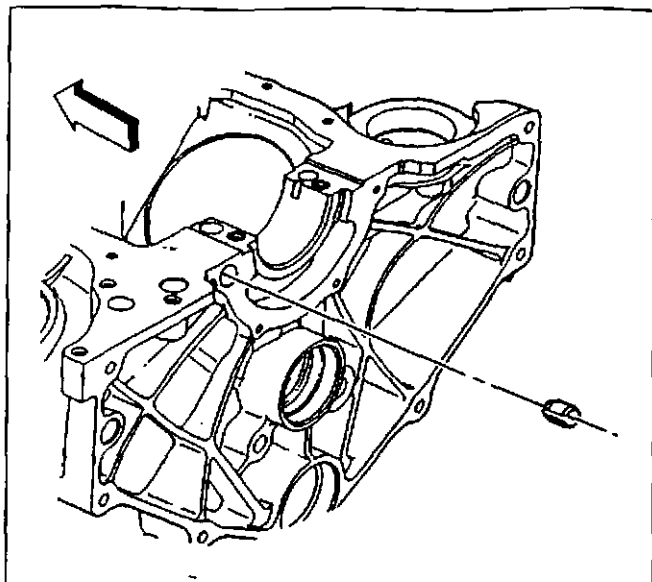


334364

9. Remove the expansion cup plug (balance shaft rear bearing hole).

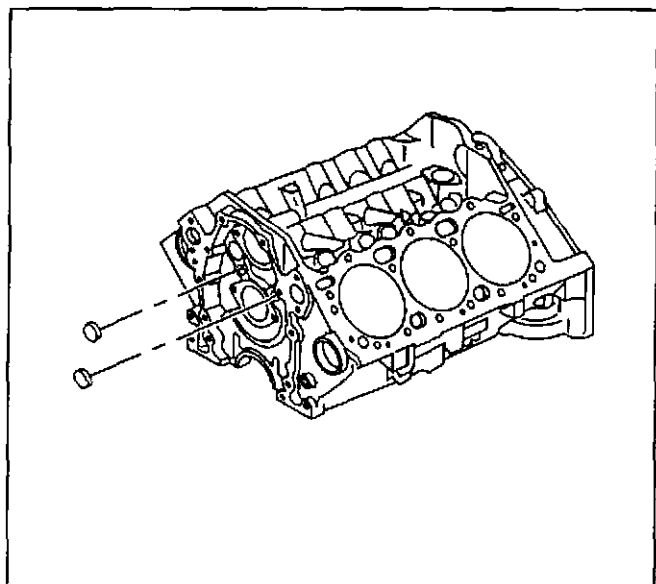


334366



334323

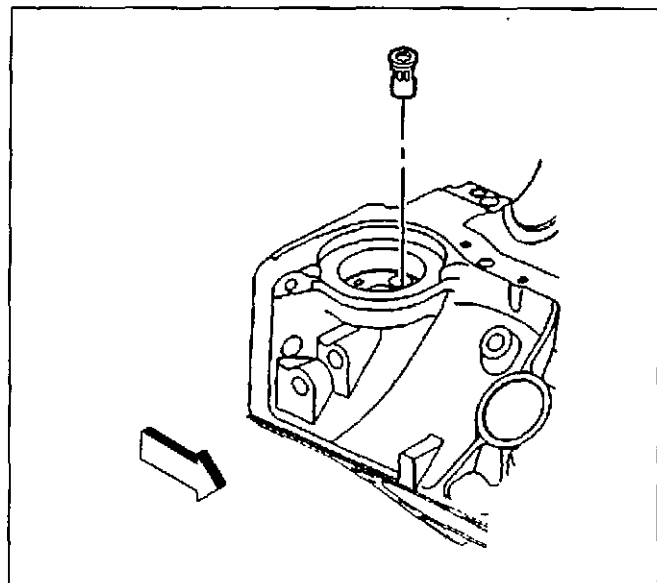
10. Remove the spring type S pin (crankshaft rear oil seal housing locator) (if required).



5270

11. Remove the front oil gallery plugs or balls from the front of the engine block.

Insert a rod into the rear oil gallery holes and drive out the plugs or balls.



188026

12. Remove the oil filter bypass valve.

SIE-ID - 358543

Engine Block Clean and Inspect**Tools Required**

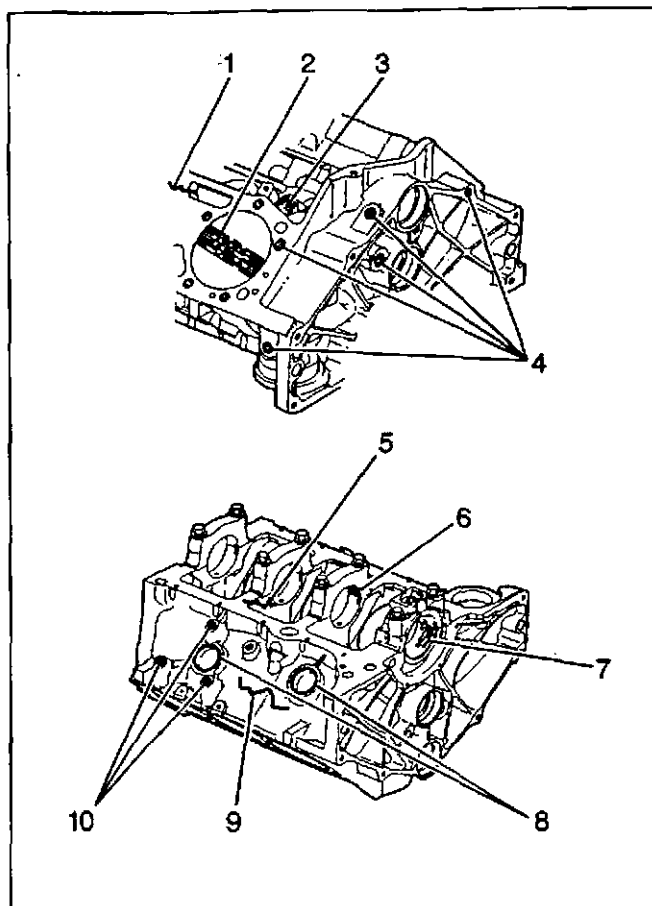
J 8087 Cylinder Bore Gauge

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

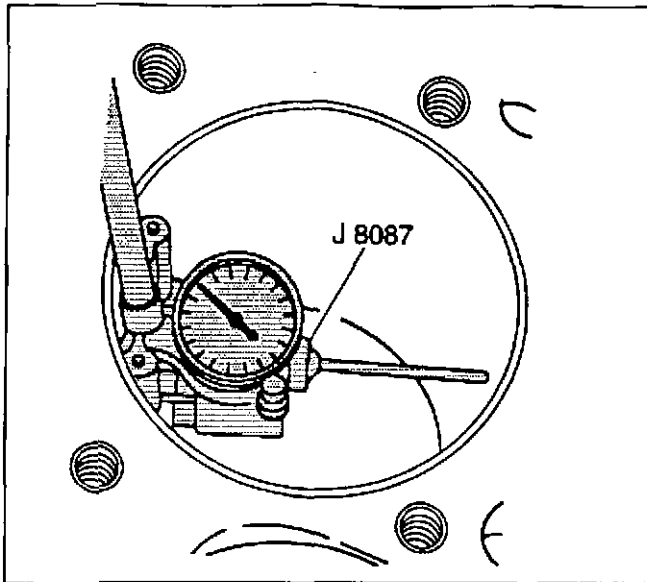
1. Clean all the remaining sealing or gasket material from the sealing surfaces.
2. Boil the engine block in a caustic cleaning solution.
3. Flush the engine block with clean water or steam.
4. Clean the cylinder bores.
5. Clean the oil galleries and the oil passages.
6. Clean the scale and the deposits from the coolant passages.

Notice: SIO-ID - 96999 Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

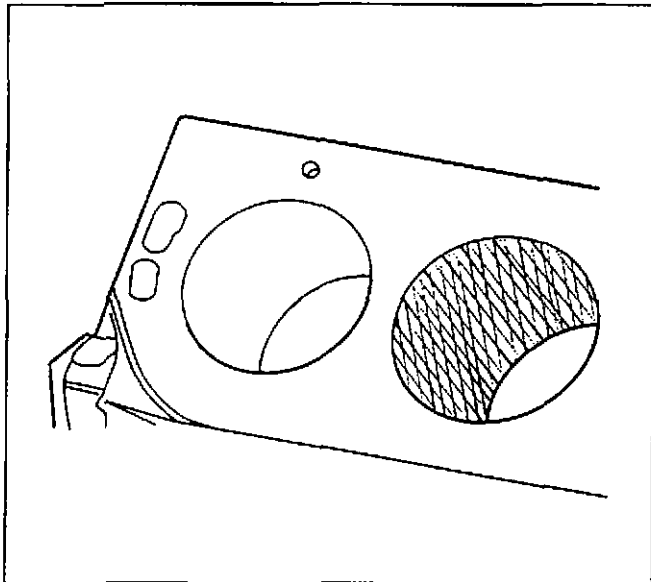
7. Clean the engine block cylinder head bolt holes.
8. After cleaning the engine block, spray or wipe the cylinder bores and the machined surfaces with clean engine oil.
9. Inspect the following areas:
 - Coolant jackets (1) for cracks
 - Cylinder bores (2) for scratches or gouging
 - Valve lifter bores (3) for excessive scoring or wear
 - Threaded holes (4) for damage
 - Crankshaft bearing webs (5) for cracks
 - Crankshaft bearing caps (6) and the crankshaft bearing bores (7) for damage
 - The crankshaft bearing bores should be round and uniform when measuring the inside diameter (ID).
 - The surface where the crankshaft bearings contact the crankshaft bearing bore should be smooth.
 - If a crankshaft bearing cap is damaged and requires replacement, replace the crankshaft bearing cap first, then rebore the engine block crankshaft bearing bores and check for the proper alignment. Finally, check the crankshaft for the proper clearances.
 - Expansion cup plug bores (8) for damage
 - Engine block (9) for cracks or damage
 - Engine mount bosses (10) for damage



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10. Measure the cylinder bores for taper and out-of-round.

10.1. Depress the plunger on the *J 8087* 7 mm (0.275 in) or until the *J 8087* enters the cylinder bore.

10.2. Center the *J 8087* in the cylinder bore and turn the indicator dial to 0.

10.3. Move the *J 8087* up and down the cylinder bore to determine the cylinder bore taper. Refer to *Engine Mechanical Specifications*.

10.4. Turn the *J 8087* to different points around the cylinder bore to determine the cylinder bore out-of-round condition. Refer to *Engine Mechanical Specifications*.

SIE-ID = 69045

Cylinder Boring and Honing

Cylinder Honing

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

1. When honing the cylinder bores, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication.
 - 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.
 - DO NOT hone to a final grade with a coarse or medium-grade stone.
 - Leave sufficient metal so that all the stone marks will be removed with the fine grade stones.
 - Perform the final honing with a fine-grade stone and hone the cylinder bore in a cross hatch pattern at 45–65 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly check the cylinder bore.
 - Repeatedly check the cylinder bore fit with the selected piston.
 - All measurements of the piston or cylinder bore should be made with the components at normal room temperature.
3. When honing to eliminate taper in the cylinder bore, use full strokes the complete length of the cylinder bore.

Repeatedly check the measurement at the top, the middle, and the bottom of the cylinder bore.

 - The finish marks should be clean but not sharp.
 - The finish marks should be free from

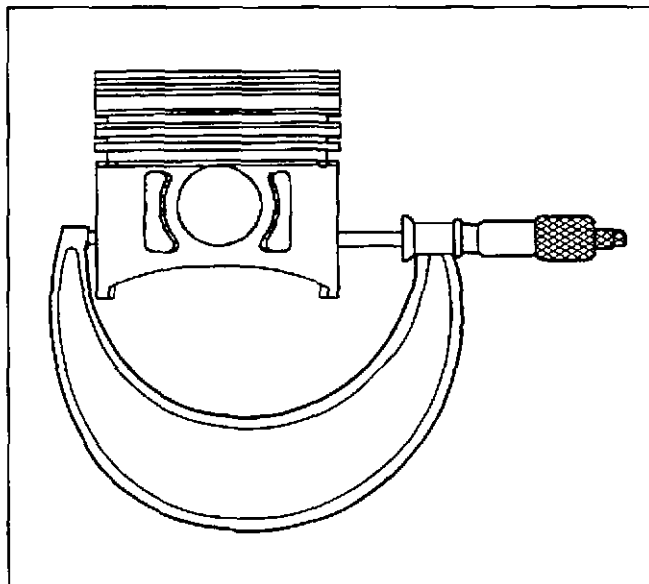
imbedded particles or torn or folded metal.

4. By measuring the selected piston at the sizing point and then by adding the average of the clearance specification, the final cylinder bore honing dimension required can be determined.
5. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.
6. After the final honing and before the piston is checked for fit, clean the cylinder bore with hot water and detergent.
 - 6.1. Scrub the cylinder bores with a stiff bristle brush.
 - 6.2. Rinse the cylinder bores thoroughly with clean hot water.
 - 6.3. Dry the cylinder bores with a clean rag.
 - 6.4. Do not allow any abrasive material to remain in the cylinder bores.
 - Abrasive material may cause premature wear of the new piston rings and the cylinder bores.
 - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
7. Perform final measurements of the piston and the cylinder bore.
8. Permanently mark the top of the piston for the specified cylinder to which it has been fitted.
9. Apply clean engine oil to each cylinder bore in order to prevent rusting.

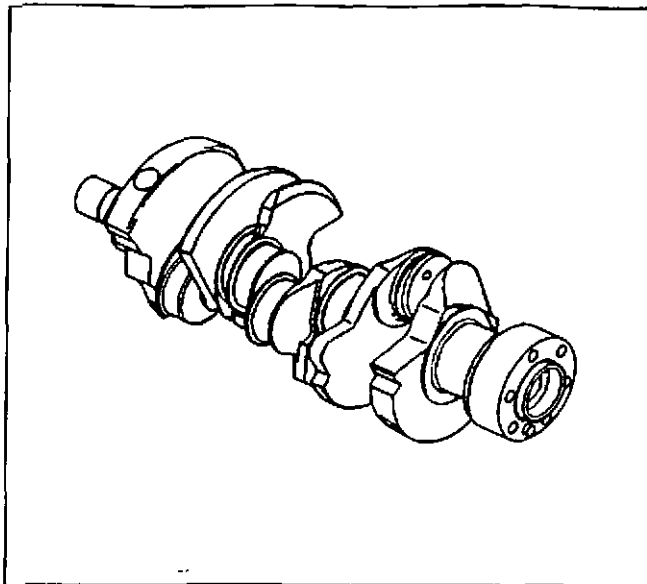
Boring Procedure

Caution: S10-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

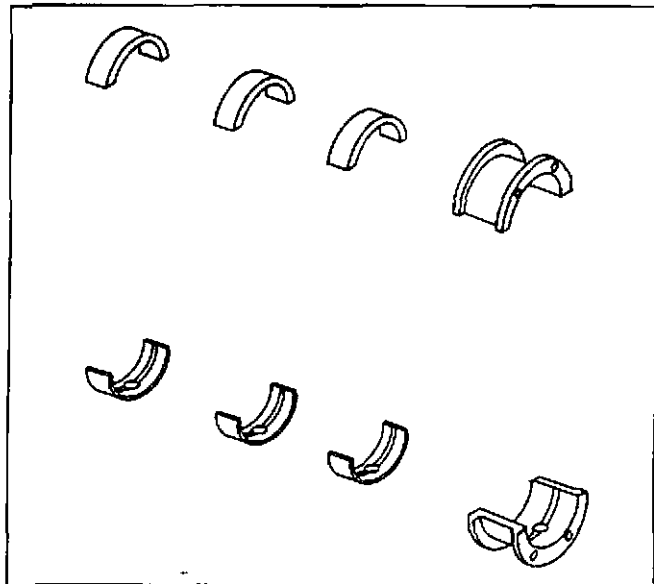
1. Before starting the honing or reboring operation, measure all the new pistons with the micrometer contacting at points exactly 90 degrees from the piston pin centerline.
2. File the top of the cylinder block in order to remove any dirt or burrs before using any type of boring bar.
3. Follow the instructions furnished by the manufacturer regarding use of the boring equipment.
4. When reboring the cylinders, make sure all the crankshaft bearing caps are installed in the original position and direction.
5. Tighten the crankshaft bearing caps to the proper torque specifications in order to avoid distortion of the cylinder bores in the final assembly.
6. When making the final cut with the boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for finish honing. This gives the required position to the cylinder clearance specifications. (Carefully perform the honing and boring operation in order to maintain the specified clearances between the pistons, the piston rings, and the cylinder bores).



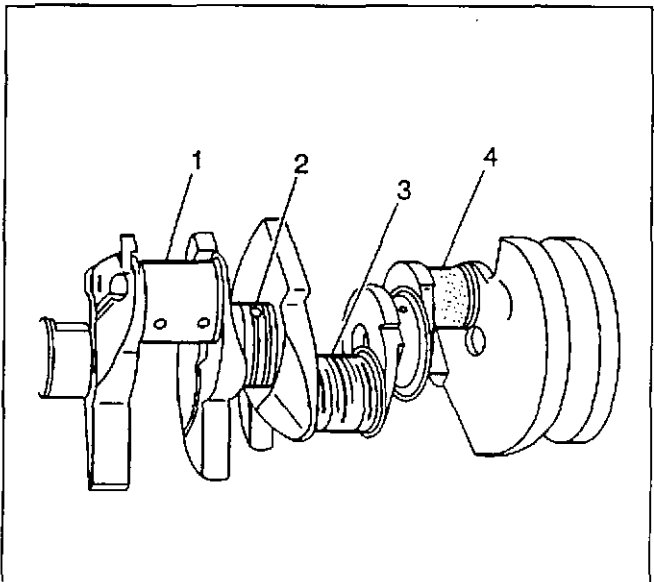
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SIE-ID = 358547

Crankshaft and Bearings Clean and Inspect

Tools Required

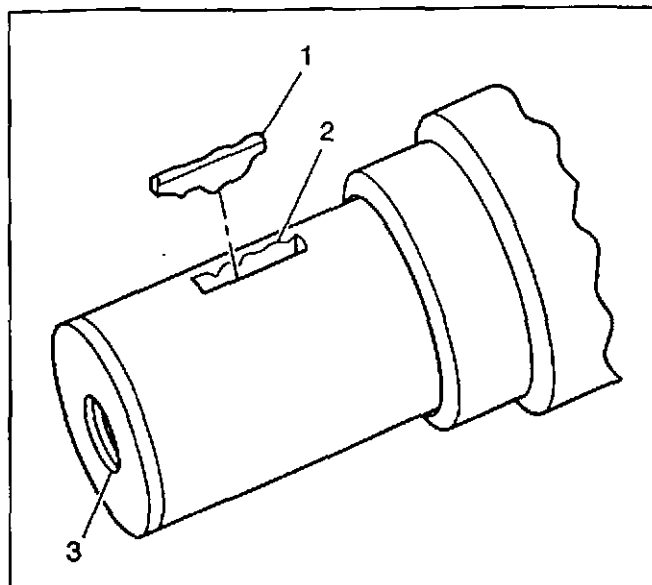
- J 7872 Magnetic Base Dial Indicator
- J 36660 Electronic Torque Angle Meter

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

Important: Use care when handling the crankshaft. Avoid damage to the crankshaft bearing surfaces.

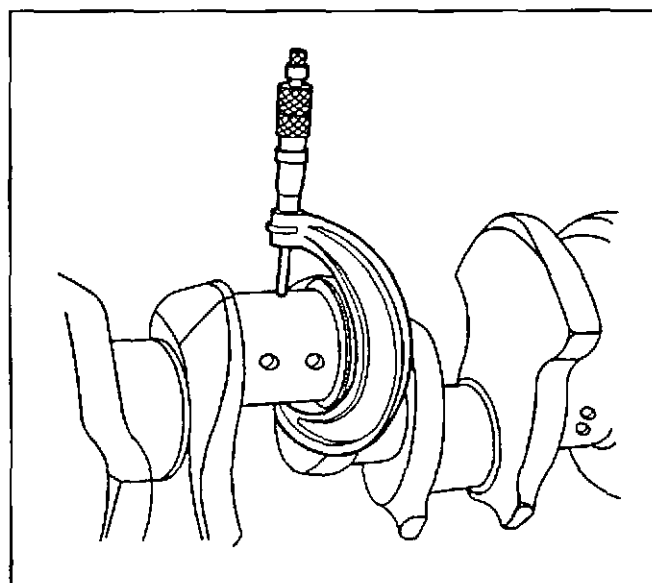
1. Clean the crankshaft in cleaning solvent. Remove all sludge or restrictions from the oil passages.
2. Dry the crankshaft with compressed air.
3. Clean the crankshaft bearings in cleaning solvent. Wipe the crankshaft bearings clean with a soft cloth, do not scratch the crankshaft bearing surfaces.
4. Dry the crankshaft bearings with compressed air.
5. Inspect the crankshaft for the following:
 - Crankshaft journals (1) should be smooth with no evidence of scoring or damage.
 - Deep grooves (2)
 - Scratches or uneven wear (3)
 - Pitted surfaces (4)
 - Wear or damage to the thrust journal surfaces
 - Scoring or damage to the front or rear seal surface
 - Restrictions to the oil passages
 - A loose or damaged rear oil gallery plug
 - Damage to the threaded bolt holes

6. Inspect the crankshaft balancer key (1), the keyway (2), and the threaded hole (3) for damage.



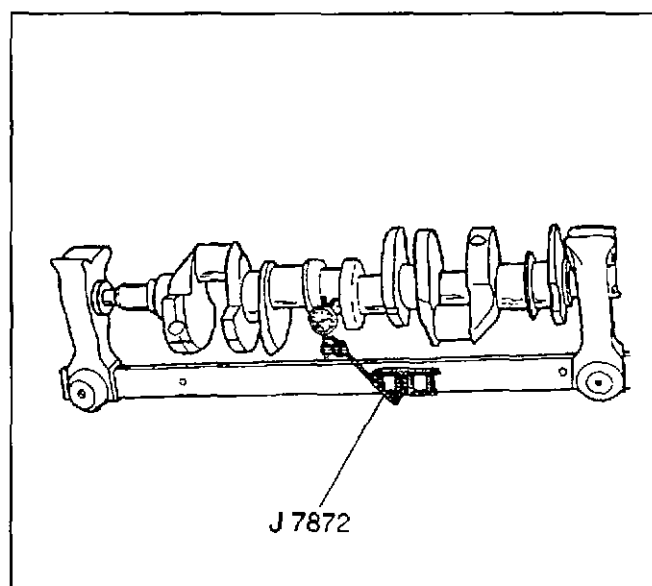
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7. Measure the crankpins for out-of-round and taper.

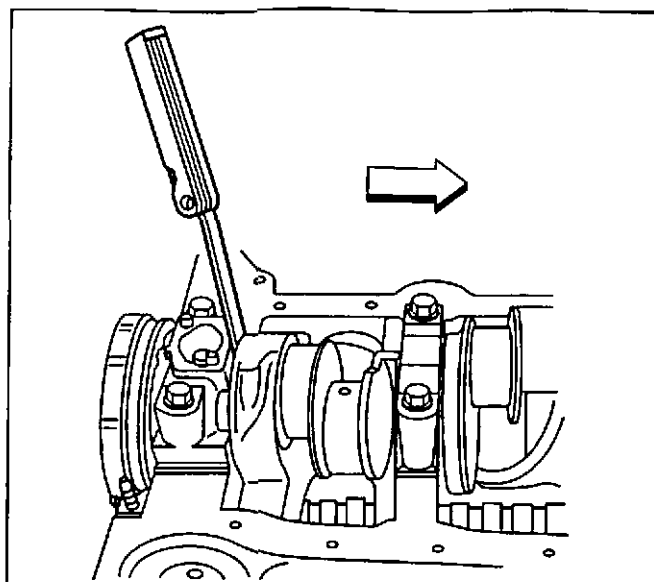


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8. Use a suitable support to support the crankshaft on the front and rear journals.
 9. Use the J 7872 in order to measure the crankshaft journal runout.
- The crankshaft runout should not exceed 0.025 mm (0.001 in).



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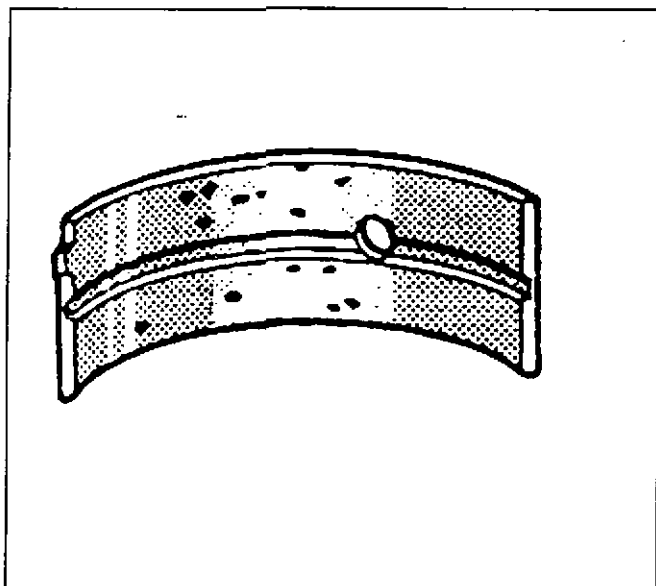


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10. Measure the crankshaft end play.

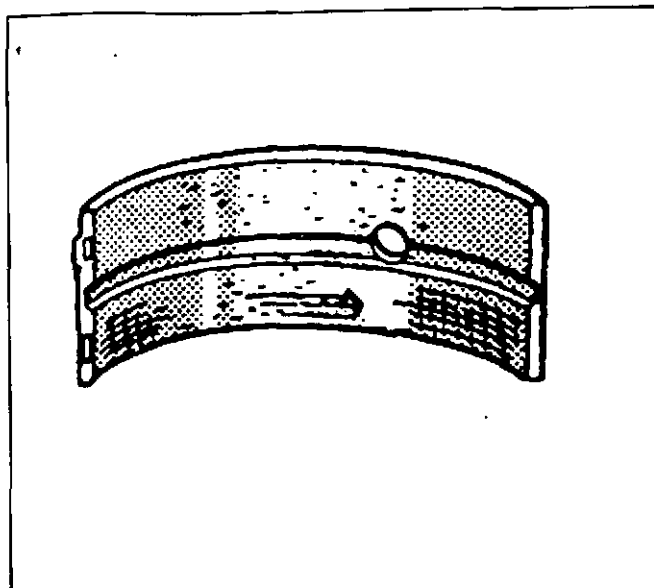
Important: In order to properly measure the crankshaft end play, the crankshaft, the crankshaft bearings, the crankshaft bearing caps, and the crankshaft bearing cap bolts must be installed into the engine block and the bolts tightened to specifications.

- 10.1. Firmly thrust the crankshaft first rearward, then forward. This will align the crankshaft rear bearings and the crankshaft thrust surfaces.
- 10.2. With the crankshaft pushed forward, insert a feeler gauge between the crankshaft and the crankshaft bearing surface and then measure the clearance. Refer to *Engine Mechanical Specifications*.
- 10.3. If the correct end play cannot be obtained, verify that the correct size crankshaft bearing has been installed. Refer to *Engine Mechanical Specifications*.
- 10.4. Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, then loosen the crankshaft bearing cap bolts, one crankshaft bearing cap at a time, until the tight crankshaft bearing is located.
 Burrs on the crankshaft bearing cap, foreign matter between the crankshaft bearing and the engine block or the crankshaft bearing cap, or a faulty crankshaft bearing could cause a lack of clearance at the crankshaft bearing.
11. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the crankshaft bearing halves also indicate fatigue.



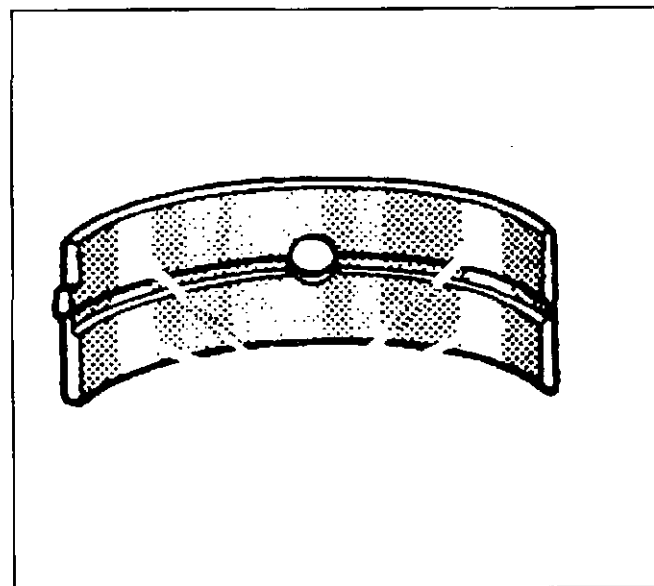
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12. Inspect the crankshaft bearings for excessive scoring or discoloration.
13. Inspect the crankshaft bearings for dirt or debris imbedded into the crankshaft bearing material.



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14. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the crankshaft bearings.
 - If the lower half of the crankshaft bearing is worn or damaged, both the upper and lower halves of the crankshaft bearing should be replaced.
 - Generally, if the lower half of the crankshaft bearing is suitable for use, the upper half of the crankshaft bearing should also be suitable for use.



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Bearing Clearance Measuring Procedures

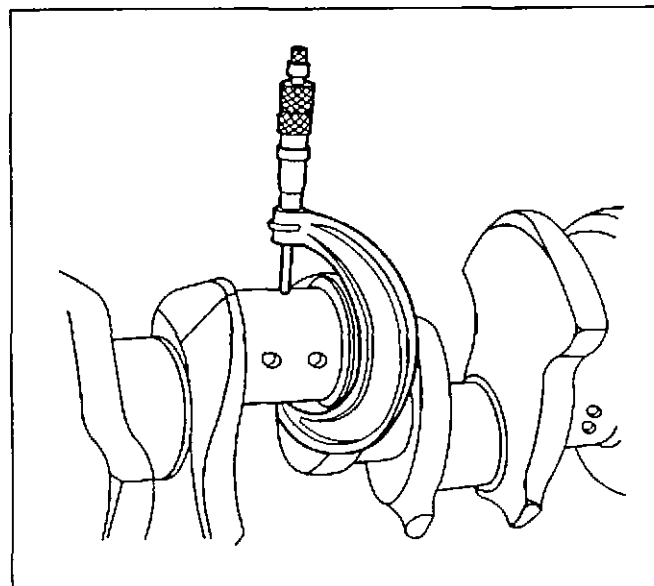
The crankshaft bearings are of the precision insert type and do not use shims for adjustment. If the clearances are excessive, then new upper and lower crankshaft bearings will be required. The service crankshaft bearings are available in the standard size and an undersize.

The selective fitting of the crankshaft bearings are necessary in production in order to obtain close tolerances. For this reason, in one journal bore you may use one-half of a standard crankshaft bearing with one-half of a undersize crankshaft bearing.

In order to determine the correct replacement crankshaft bearing size, the crankshaft bearing clearance must be measured accurately. Either the micrometer or plastic gauge method may be used; however, the micrometer method gives more reliable results and is preferred.

Micrometer-Method for Crankshaft Bearings

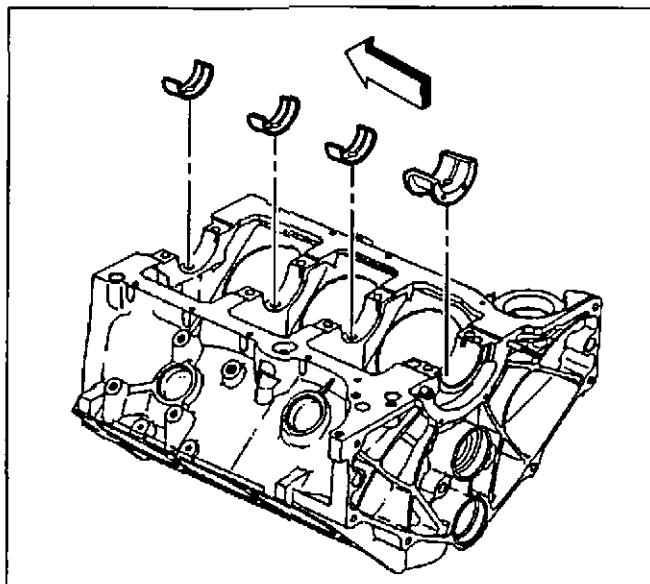
1. Measure the crankshaft journal diameter with a



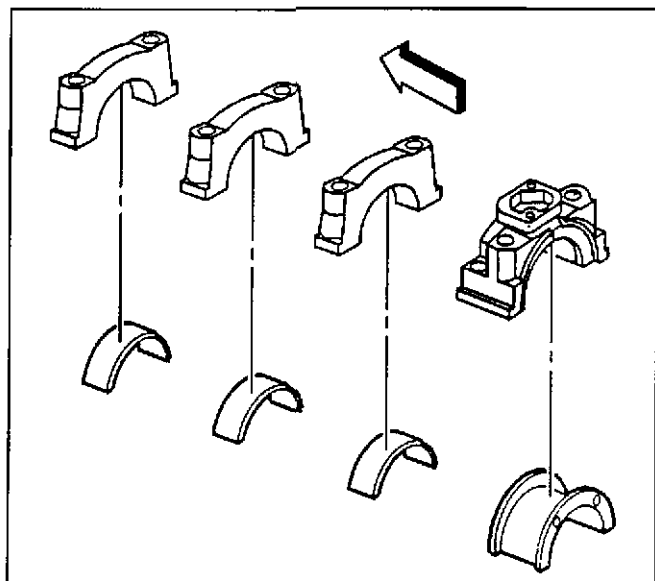
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micrometer in several places, approximately 90 degrees apart, and then average the measurements.

2. Determine the taper and the out-of-round of the crankshaft journal. Refer to *Engine Mechanical Specifications*.
3. Install the crankshaft bearings into the engine block.



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4. Install the crankshaft bearings into the crankshaft bearing caps.

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

5. Install the crankshaft bearing caps in the original positions and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
6. Install the crankshaft bearing cap bolts.

Tighten

- 6.1. Tighten the crankshaft bearing cap bolts on the first pass to 20 N·m (15 lb ft).
- 6.2. Tighten the crankshaft bearing cap bolts on the final pass an additional 73 degrees using the J 36660.
7. Measure the crankshaft bearing inside diameter (ID) at the top and the bottom using an inside micrometer.
8. In order to determine the crankshaft bearing clearance, subtract the journal diameter from the crankshaft bearing ID.
9. Compare the crankshaft bearing clearance to the specifications. Refer to *Engine Mechanical Specifications*.
10. If the crankshaft bearing clearances exceeds specifications, install the new crankshaft bearings as follows:
 - 10.1. Measure the crankshaft bearing inside diameter (ID) at the top and the bottom using an inside micrometer.
 - 10.2. Compare the crankshaft bearing clearance to the specifications. Refer to *Engine Mechanical Specifications*.
11. Replace or repair the crankshaft if the proper clearances cannot be obtained.

Micrometer Method for Connecting Rod Bearings

Notice: S10-ID - 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

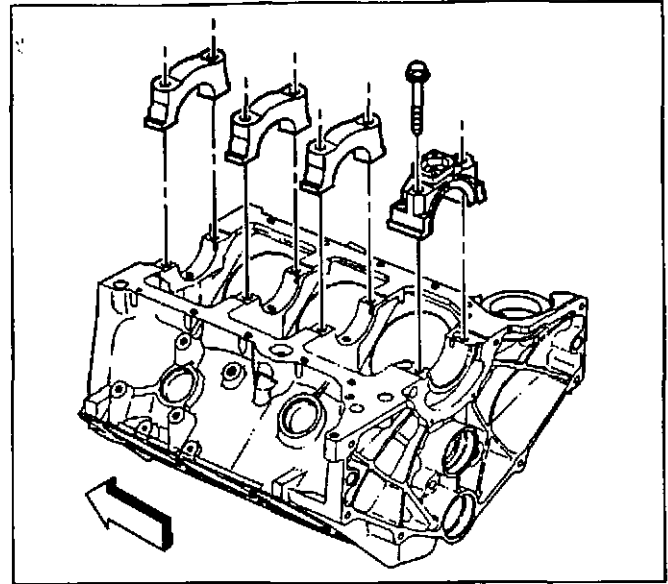
1. Measure the crankpin diameter with a micrometer in several places, approximately 90 degrees apart, and then average the measurements.
2. Determine the taper and the out-of-round. Refer to *Engine Mechanical Specifications*.
3. Install the connecting rod bearings into the connecting rod cap and the connecting rod.

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

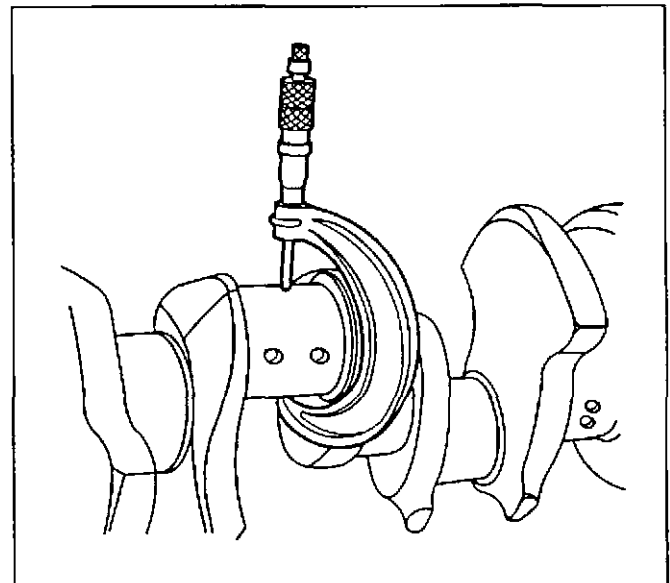
4. Install the connecting rod caps and the nuts.

Tighten

- 4.1. Tighten the connecting rod nuts in the first pass, evenly to 27 N·m (20 lb ft).
- 4.2. Tighten the connecting rod nuts in the final pass an additional 70 degrees using the J 36660.
5. Measure the connecting rod bearing inside diameter (ID) at the top and the bottom using



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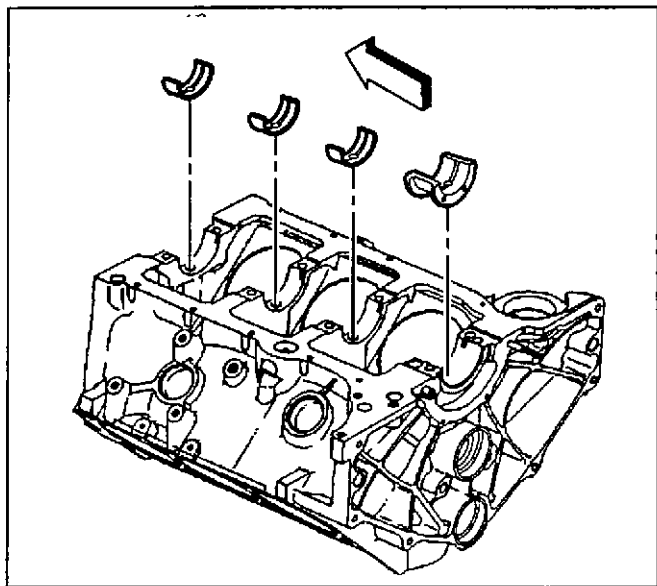
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an inside micrometer.

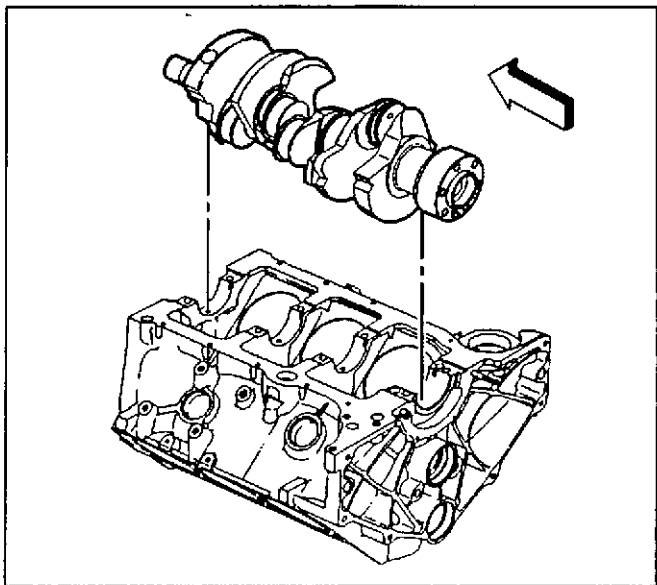
6. Compare the connecting rod bearing clearance to the specifications. Refer to *Engine Mechanical Specifications*.
7. If the connecting rod bearing clearance is within specifications, the connecting rod bearing is satisfactory.
 - Replace the connecting rod bearing if the clearance is not within specifications.
 - Always replace both the upper and the lower connecting rod bearings as an assembly.
8. A standard or undersize connecting rod bearing combination may result in the proper clearance. If the proper connecting rod bearing clearance cannot be achieved using the standard or the undersize connecting rod bearings, it will be necessary to replace or repair the crankshaft.

Plastic Gauge Method for Main or Connecting Rod Bearings

1. Install the crankshaft bearings into the engine block.



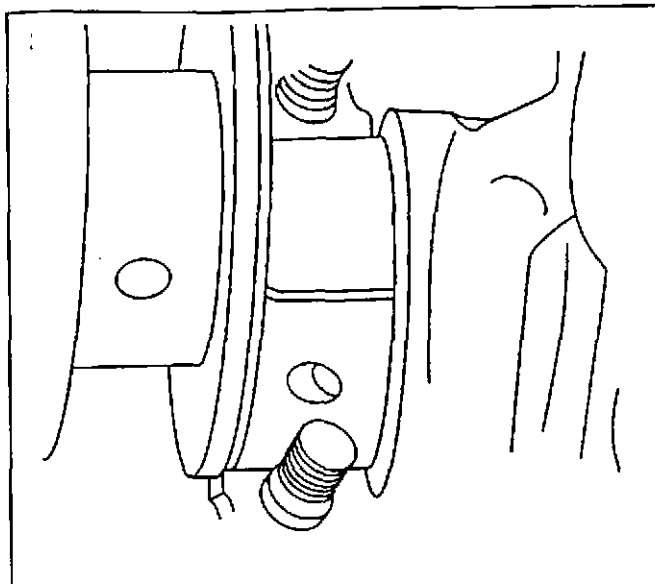
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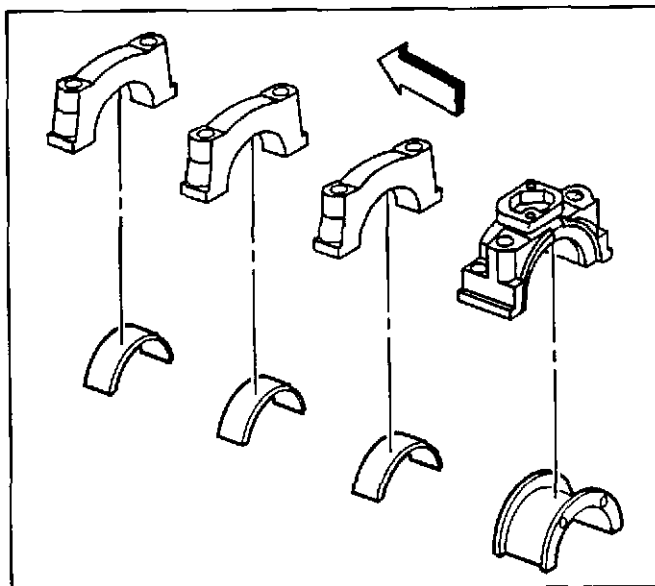
2. Install the crankshaft.

3. Install the gauging plastic the full width of the journal.



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4. Install the crankshaft bearings into the crankshaft bearing caps.



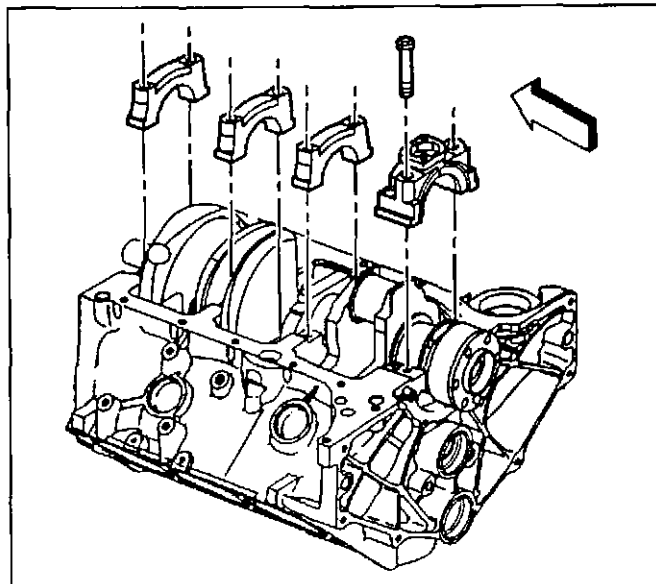
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Notice: Refer to *Fastener Notice* in Cautions and Notices.

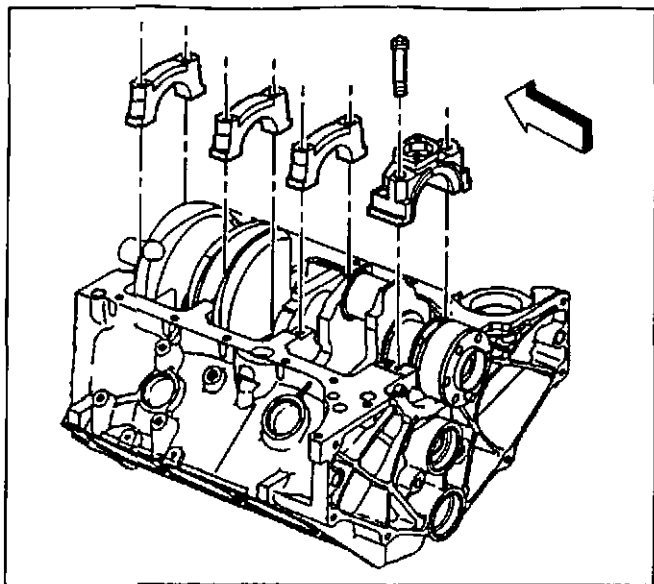
5. Install the crankshaft bearing caps in the original positions and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
6. Install the crankshaft bearing cap bolts.

Tighten

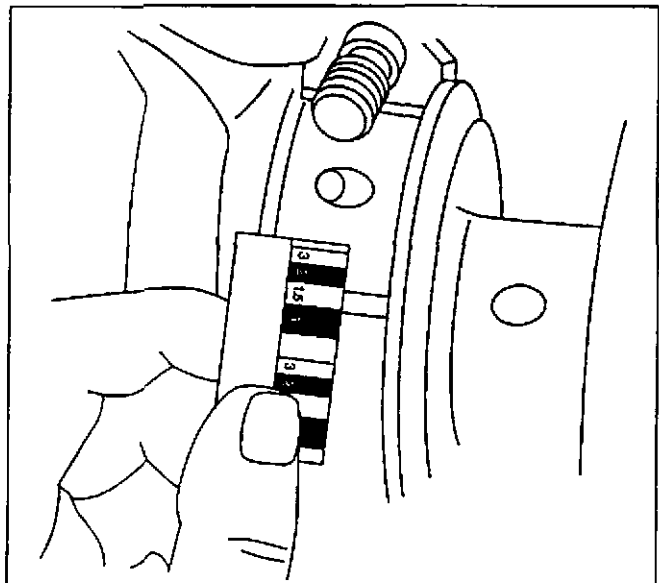
- 6.1. Tighten the crankshaft bearing cap bolts on the first pass to 20 N.m (15 lb ft).
- 6.2. Tighten the crankshaft bearing cap bolts on the final pass an additional 73 degrees using the J 36660.



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7. Remove the crankshaft bearing cap bolts.
8. Remove the crankshaft bearing caps. The gauging plastic may adhere to either the crankshaft bearing journal or the crankshaft bearing surface.

9. Without removing the gauging plastic, measure the compressed width at the widest point using the graduated scale on the edge of the gauging plastic envelope.

If the flattened gauging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft bearing or the crankshaft bearing journal.

- Normally the crankshaft bearing journals wear evenly and are not out-of-round. However, if a crankshaft bearing is being fitted to an out-of-round 0.0254 mm (0.001 in) (maximum) crankshaft bearing journal, be sure to fit to the maximum diameter of the crankshaft bearing journal. If the crankshaft bearing is fitted to the minimum diameter and the crankshaft bearing journal is excessively out-of-round, the interference between the crankshaft bearing and the crankshaft bearing journal will result in rapid crankshaft bearing failure.
- If the crankshaft bearing clearance is within specifications, the crankshaft bearing is satisfactory. If the clearance is not within specifications, replace the crankshaft bearing. Always replace both the upper and lower crankshaft bearings as a unit.
- A standard or undersize crankshaft bearing combination may result in the proper clearance. If the proper crankshaft bearing clearance cannot be achieved using the standard or the undersize crankshaft bearings, it may be necessary to repair or replace the crankshaft.

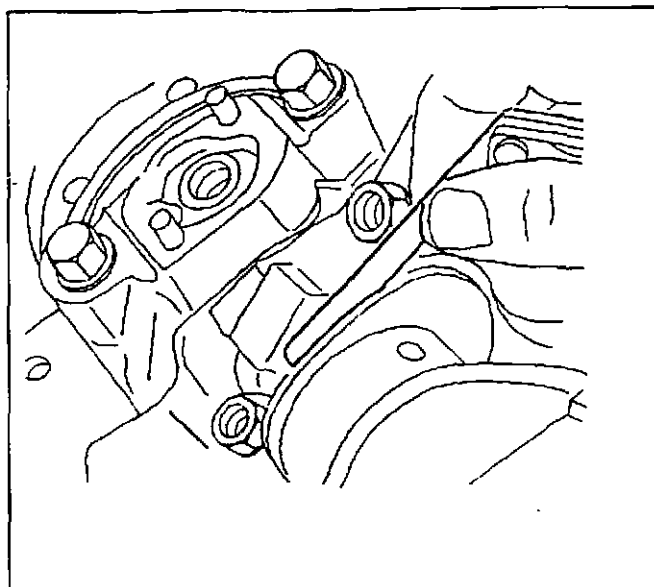
Notice: *S10-10 - 5016* Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

10. Remove the flattened gauging plastic.

11. Measure the remaining crankshaft and connecting rod bearing journals.

Connecting Rod Side Clearance Measuring Procedure

1. Insert a feeler gauge between the connecting rod caps and measure the connecting rod side clearance. Refer to *Engine Mechanical Specifications*.
2. Connecting rod side clearances may also be measured with a dial indicator set.



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SIE-ID = 358551

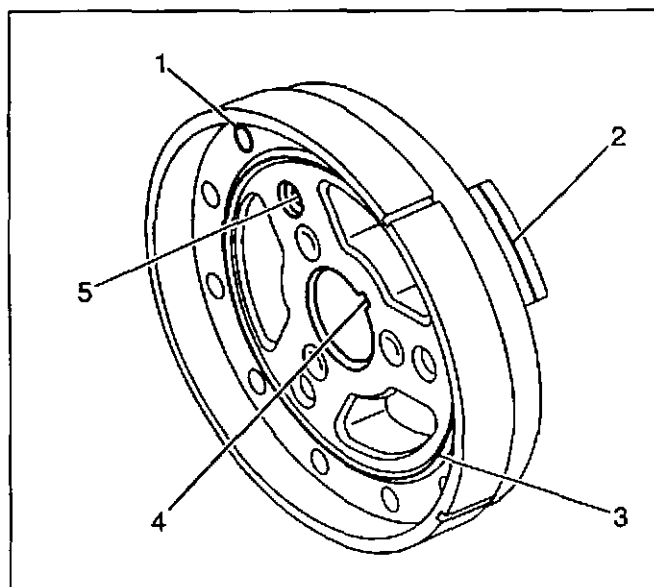
Crankshaft Balancer Clean and Inspect

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

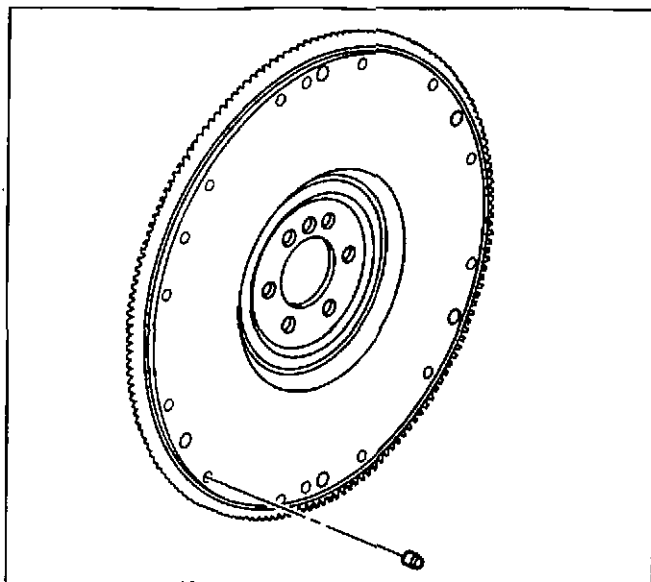
1. Clean the crankshaft balancer in cleaning solvent.
2. Dry the crankshaft balancer with compressed air.
3. Inspect the crankshaft balancer for the following:
 - Loose or improperly installed front groove pin (1) (crankshaft balancer)
A properly installed front groove pin should be installed until flush or below flush with the face of the crankshaft balancer.

Important: A crankshaft front oil sealing surface with excessive scoring, grooves, rust, or other damage must be replaced.

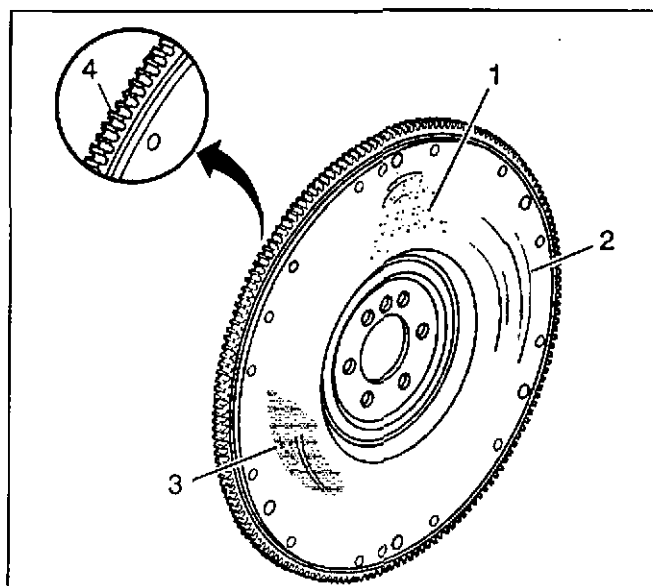
 - Worn, grooved, or damaged crankshaft front oil sealing surface (2)
Minor imperfections on the crankshaft balancer crankshaft front oil seal surface may be removed with a polishing compound or fine grade emery cloth.
 - Worn, chunking, or deteriorated rubber (3) between the hub and pulley
 - Worn or damaged keyway (4)
 - Worn or damaged bolt hole threads (5)



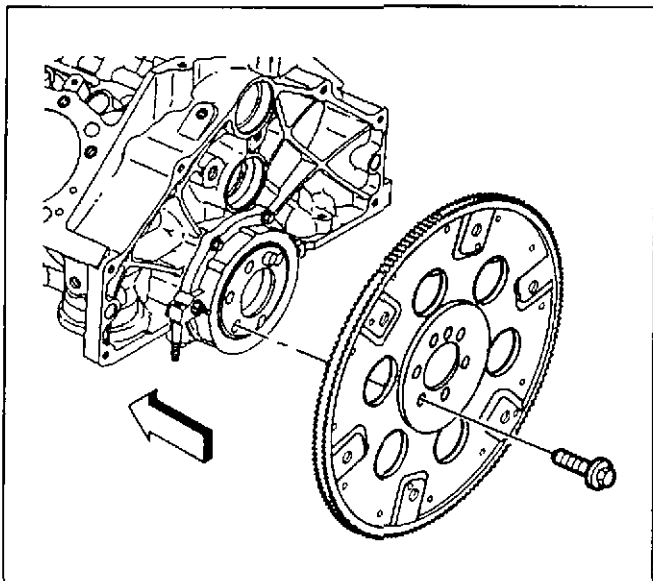
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SIE-ID - 199436

Engine Flywheel Clean and Inspect

1. Clean the engine flywheel in cleaning solvent.

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

2. Dry the engine flywheel with compressed air.
3. Inspect the engine flywheel (manual transmission) for loose or improperly installed flywheel weights.

A properly installed flywheel weight should be installed until flush or below flush with the face of the engine flywheel.

4. Inspect the engine flywheel (manual transmission) for the following:

- Damaged ring gear teeth (4)
- Loose or improperly positioned ring gear
The ring gear has an interference fit onto the engine flywheel and should be positioned completely against the flange of the engine flywheel.
- Pitted friction surface (1)
- Scoring or grooves (2)
- Rust or other damage (3)

5. Inspect the engine flywheel (automatic transmission) for the following:

- Damaged ring gear teeth
- Missing balance weights
- Stress cracks around the flywheel-to-crankshaft bolt hole locations.

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

- Welded areas that retain the ring gear onto the engine flywheel for cracking.

SIE-ID - 195087

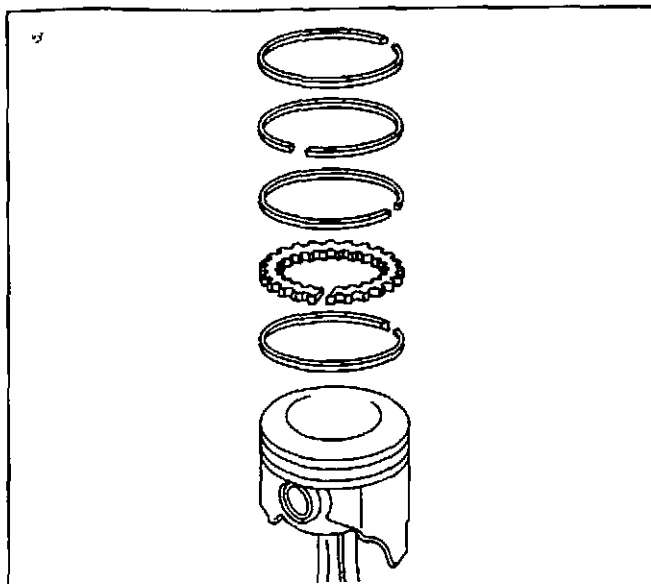
Piston and Connecting Rod Disassemble

Tools Required

J 24086-C Piston Pin Remover/Installer

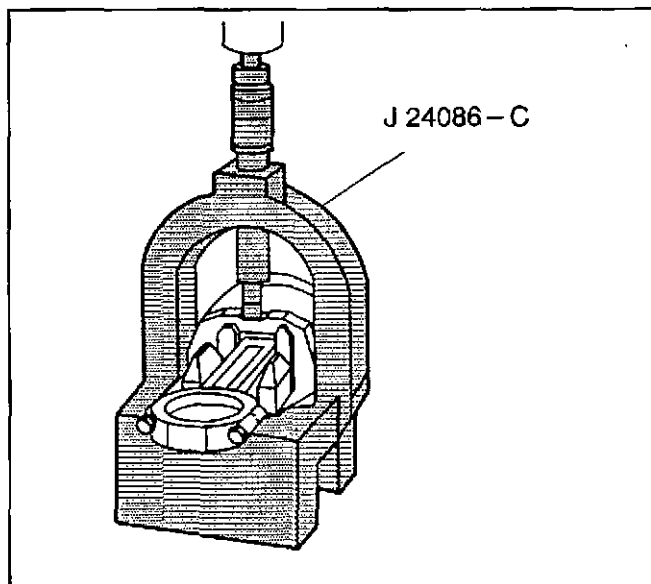
Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Remove the piston rings from the pistons.



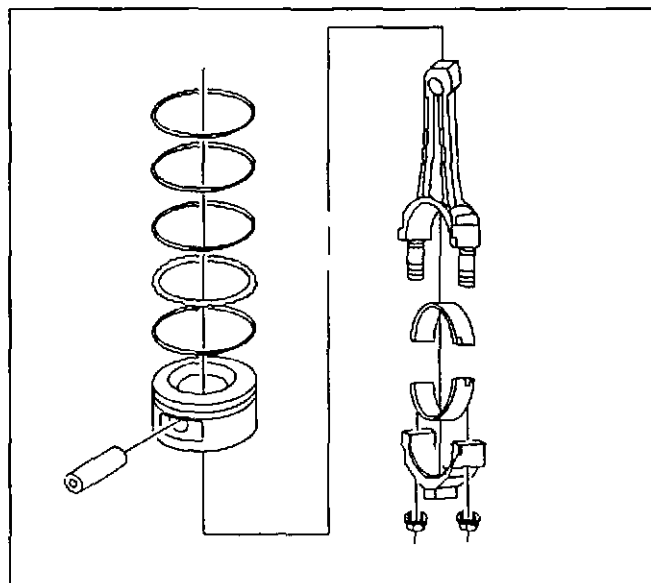
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2. Press the piston pin from the connecting rod using the J 24086-C.
The piston pin has an interference fit into the connecting rod, and is full floating in the piston.

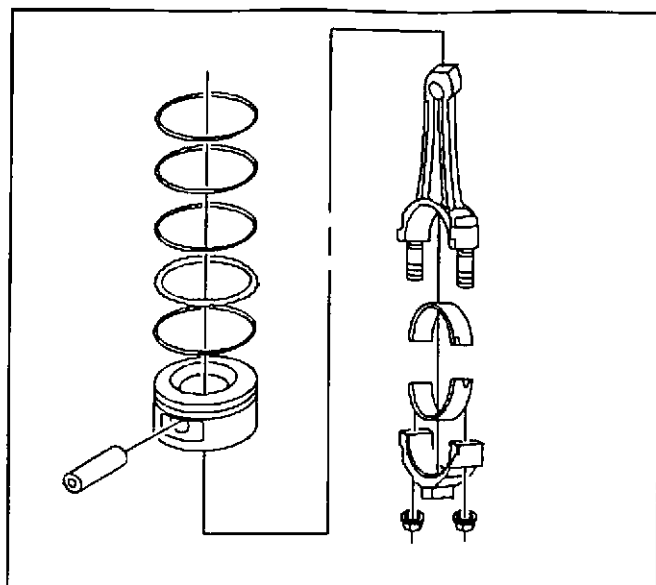


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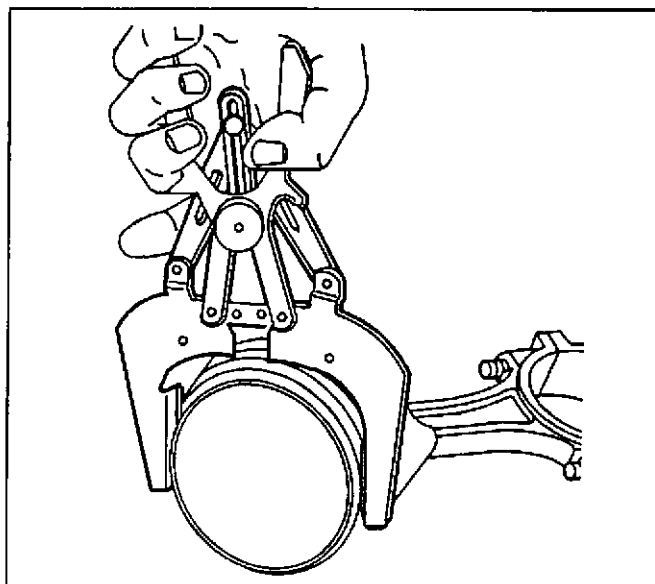
3. Mark, separate, and organize the parts for assembly.



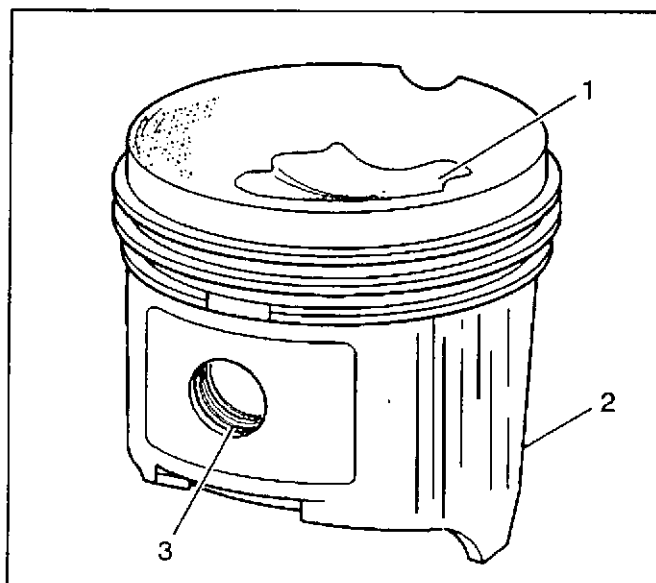
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SIE-ID - 231066

Piston, Connecting Rod and Bearings Clean/Inspect

Important: Measurement of all components should be taken with the components at room temperature. Do not use a wire brush in order to clean any part of the piston.

1. Clean the piston and connecting rod in solvent.

Caution: SIO-ID - 5011 **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.

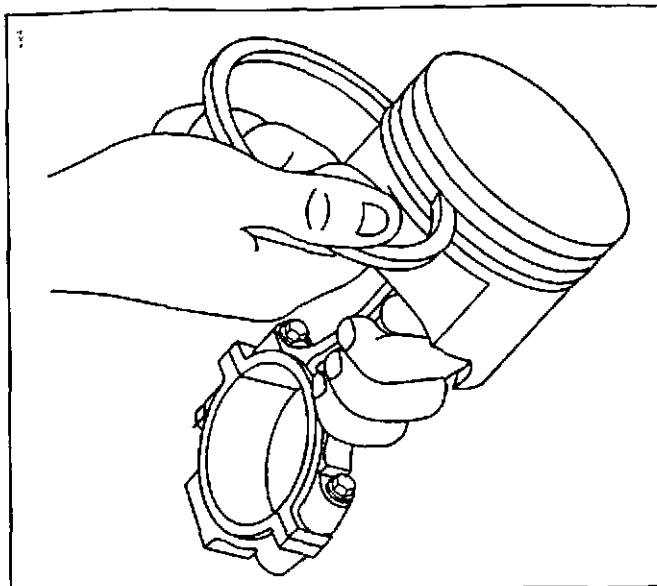
4. Clean the piston oil lubrication holes and slots.

5. Inspect the piston for the following:

- Eroded areas (1) on the 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

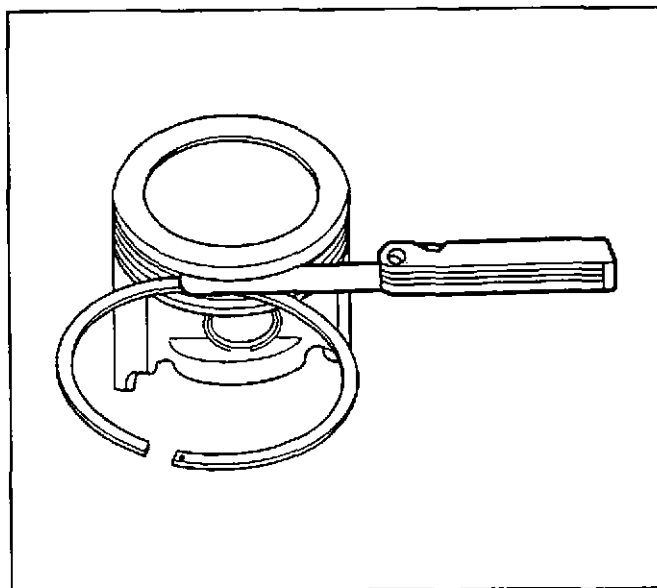
6. Inspect the piston pin for scoring, wear or other damage.

7. Measure the piston ring-to-piston ring groove side clearance.
 - 7.1. Insert the edge of the piston ring into the piston ring groove.
 - 7.2. Roll the piston ring completely around the piston.
 - If binding is caused by a distorted piston ring groove, MINOR imperfections may be removed with a fine file.
 - If binding is caused by a distorted piston ring, replace the piston ring.



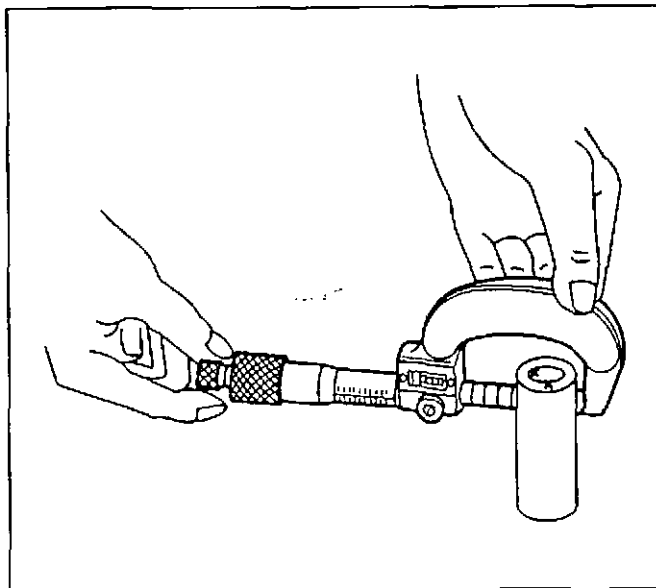
4969

8. Measure the piston ring side clearance with a feeler gauge.
9. If the side clearance is too small, try another piston ring set.
10. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.
11. To determine the proper piston ring side clearance, refer to *Engine Mechanical Specifications*.

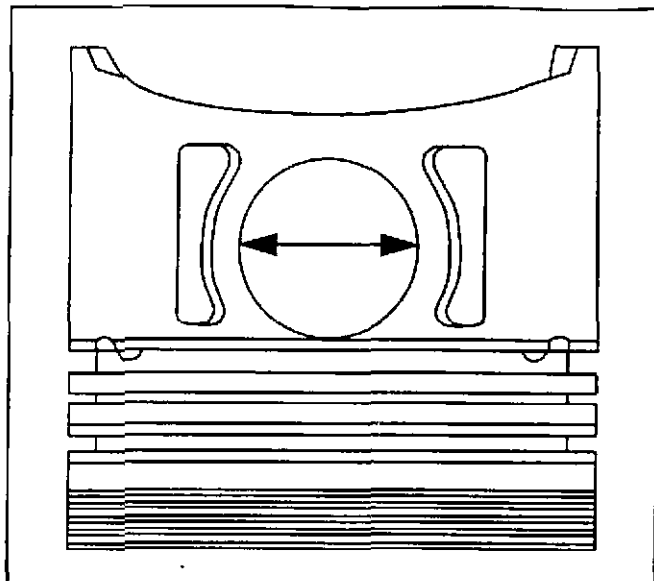


22934

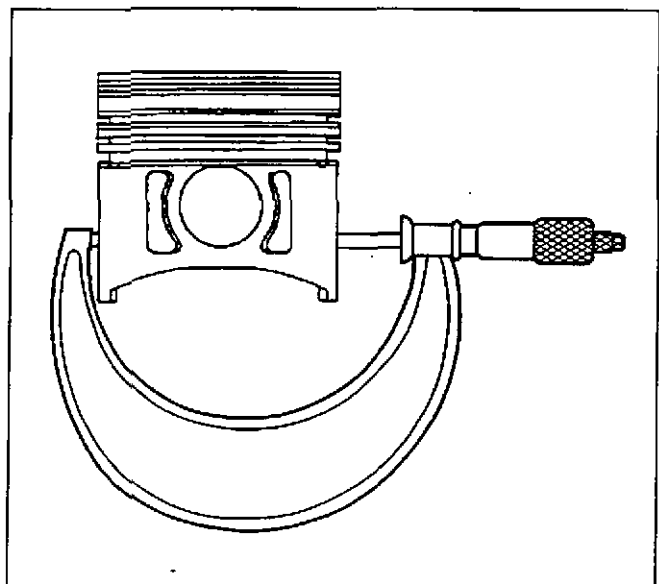
12. To determine piston pin-to-bore clearance use a micrometer and measure the piston pin.



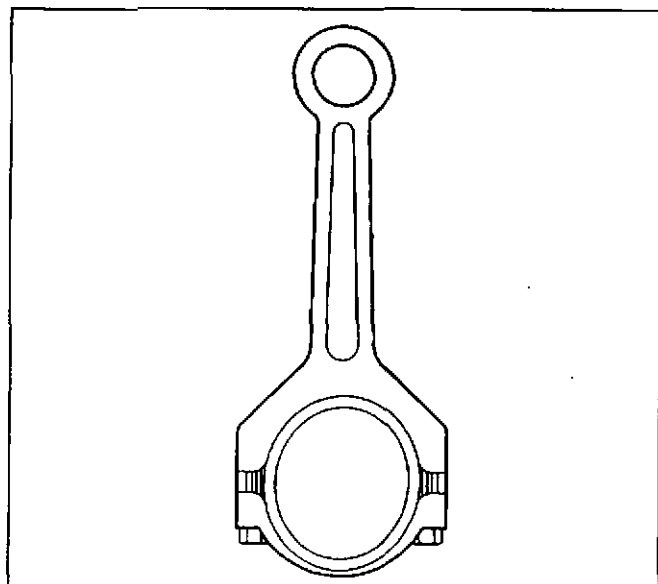
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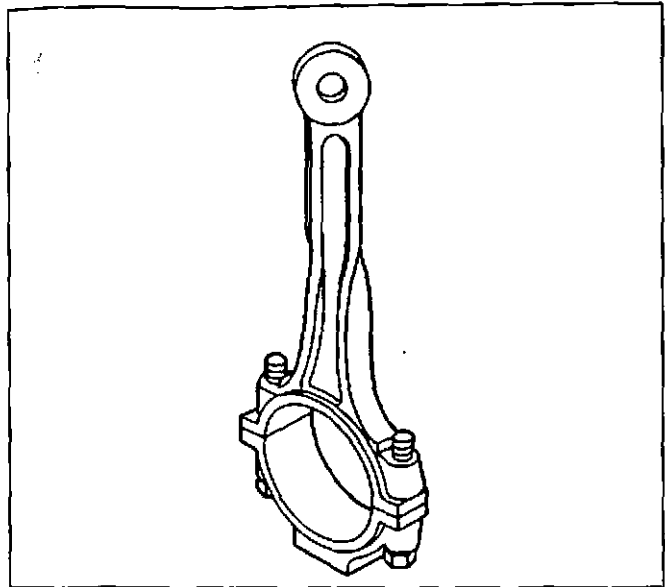
188016



156167

13. To determine piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore.
14. To determine the piston pin-to-bore clearance, subtract the piston pin diameter from the piston pin bore diameter.
15. Measure the piston for out-of-round.
 - 15.1. With a micrometer at a right angle to the piston, measure the piston at 11 mm (0.433 in) from the bottom of the skirt.
 - 15.2. Measure the piston at three different points 120 degrees apart and compare the readings, refer to *Engine Mechanical Specifications*.
 - 15.3. If the clearance is not within specifications, replace the piston and pin as an assembly.
16. Inspect the connecting rod for an out-of-round bearing bore.

17. Inspect the connecting rod for twisting.
18. Inspect the connecting rod for damage to the bearing cap stud threads.

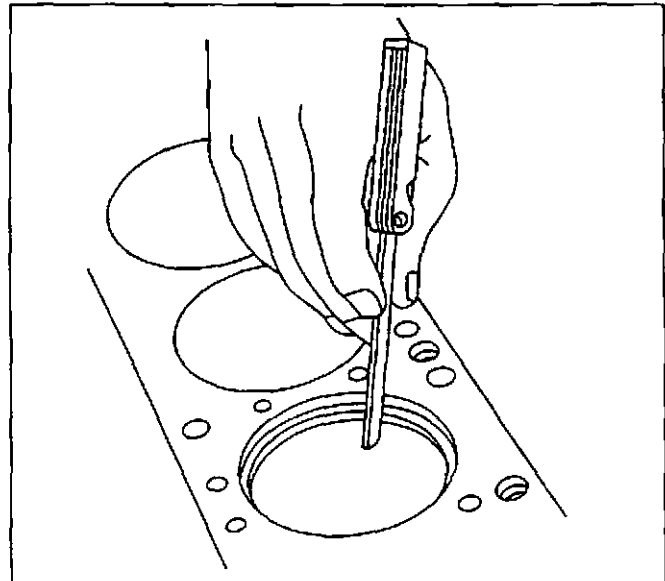


156169

19. Measure the piston compression ring end gap.

Important: Fit each compression ring to the cylinder in which it will be used.

- 19.1. Place the compression ring into the cylinder bore.
- 19.2. Push the compression ring into the cylinder bore to approximately 6.5 mm (0.25 in) above the ring travel. The ring must be square to the cylinder wall.
- 19.3. Use a feeler gage in order to measure the end gap.
- 19.4. Select another size ring set if the end gap exceeds specifications.



4968

SIE-ID - 375213

Piston Selection

Tools Required

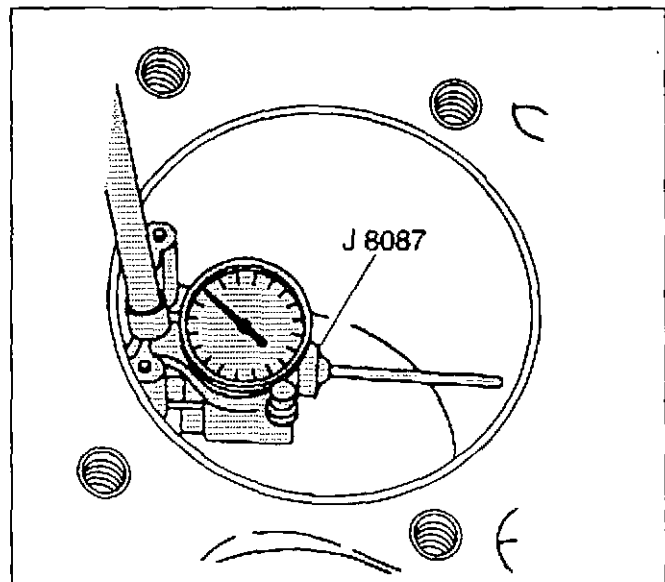
J 8087 Cylinder Bore Gauge

Important: Measurements of all components should be taken with the components at normal room temperature.

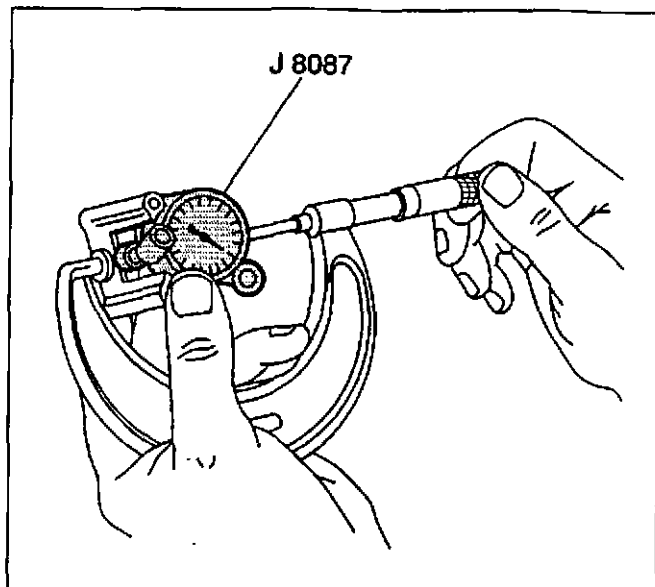
For proper piston fit, the engine block cylinder bores should not have excessive wear or taper.

A used piston and piston pin set may be reinstalled if, after cleaning and inspection, the piston and piston pin are within specifications.

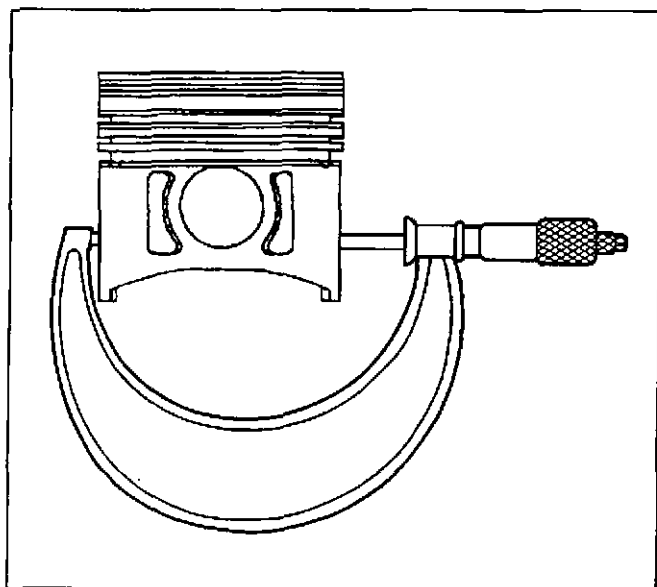
1. Inspect the engine block cylinder bore. Refer to *Engine Block Clean and Inspect*.
2. Inspect the piston and pin. Refer to *Piston, Connecting Rod and Bearings Clean/Inspect*.
3. Use the J 8087 in order to measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder



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bore.

4. Measure the *J 8087* with a micrometer and record the reading.

5. With a micrometer or caliper at a right angle to the piston, measure the piston 11 mm (0.433 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance. Refer to *Engine Mechanical Specifications*.
7. If the proper clearance cannot be obtained, then select another piston and measure the clearances.
If the proper fit cannot be obtained, the cylinder bore may require honing or boring.
8. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation into the proper cylinder.

SIE-ID - 195097

Piston and Connecting Rod Assemble**Tools Required**

J 24086-C Piston Pin Remover/Installer

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

Notice: SIO-ID - 38775 After the J 24086-C installer hub bottoms on the support assembly, DO NOT exceed 35 000 kPa (5,000 psi) or the tool may be damaged.

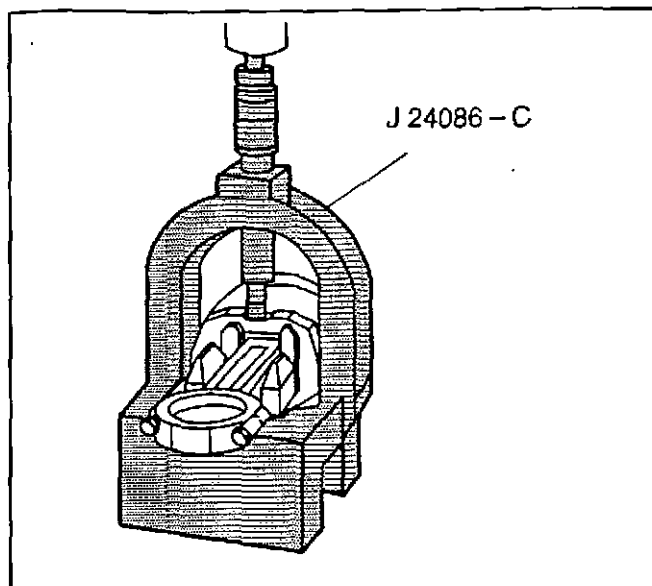
Important: When assembling the piston and connecting rod, the mark on the top of the piston must point to the front of the engine block. The left bank connecting rods should have the flange face toward the front of the engine block. The right bank connecting rods should have the flange face toward the rear of the engine block.

The piston pin has an interference fit into the connecting rod and is full floating in the piston.

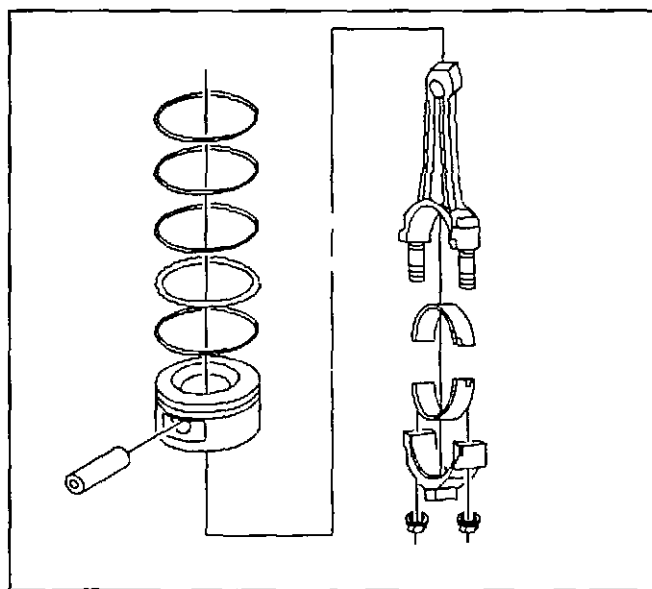
1. Install the piston pin and connecting rod assembly.
 - 1.1. Lubricate the piston and connecting rod pin bores with clean engine oil.
 - 1.2. Press the piston pin into the piston and connecting rod assembly using the J 24086-C.
 - 1.3. Inspect for the proper installation of the piston and piston pin.
The piston should move freely on the piston pin with no binding or interference.

Notice: SIO-ID - 16608 Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

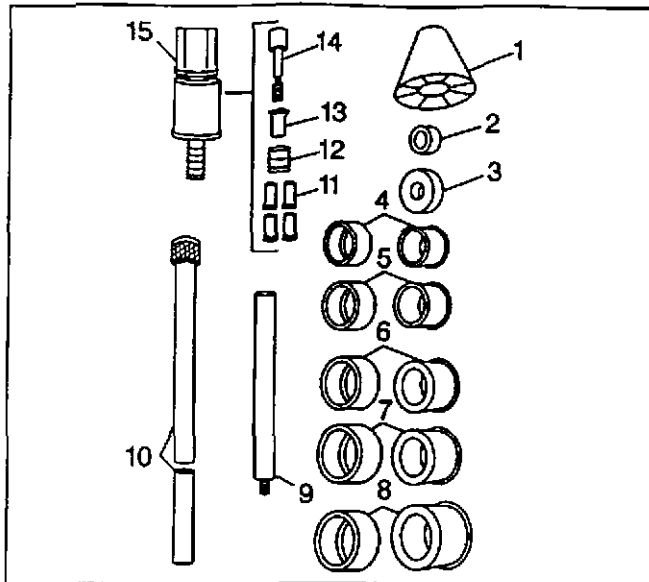
2. Install the piston rings onto the piston.
 - 2.1. Install the oil control ring spacer.
 - 2.2. Install the lower oil control ring.
 - 2.3. Install the upper oil control ring.
 - 2.4. Install the lower compression ring.
The mark on the side of the piston ring should face the top of the piston.
 - 2.5. Install the upper compression ring.
The mark on the side of the piston ring should face the top of the piston.
3. Space the compression ring end gaps 120 degrees apart.
4. Space the oil control ring end gaps a minimum of 90 degrees apart.



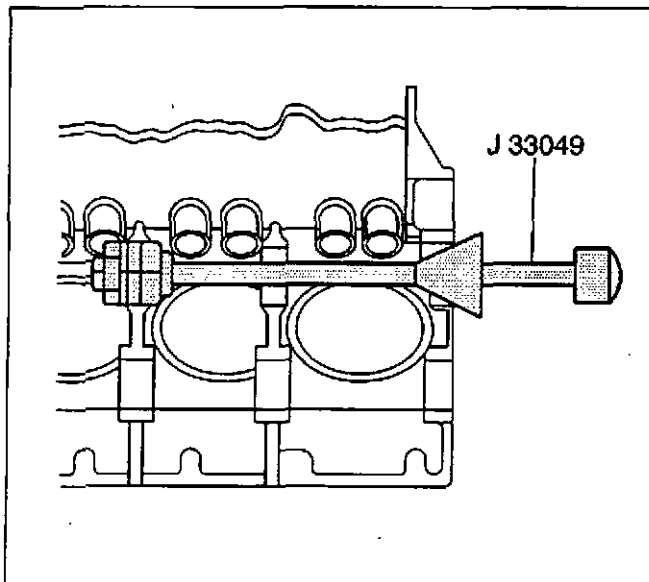
4965



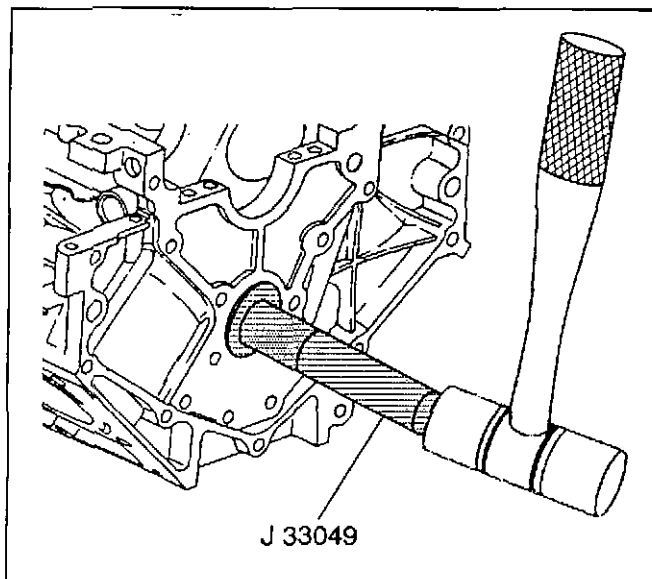
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SIE-ID = 199684

Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Service Kit

1. Select the cone (1), the handle (10), the expanding driver (4-8), and the washer (2 or 3) from the J 33049.
2. Assemble the J 33049.

Important: A loose camshaft bearing may be caused by an enlarged, out-of-round, or damaged engine block camshaft bearing bore.

Important: Remove the inner camshaft bearings #2 and #3 first. The outer camshaft bearings #1 and #4 serve as a guide for the J 33049.

3. Insert the J 33049 through the front of the engine block and into the inner camshaft bearing #2 and #3.
4. Tighten the expander assembly nut until snug.
5. Push the guide cone into the front camshaft bearing to align the tool.
6. Drive the inner camshaft bearings from the inner camshaft bearing bores.
7. Remove the outer camshaft bearings #1 and #4.
 - 7.1. Assemble the tool handle, the expanding driver, and the washer.
 - 7.2. Insert the J 33049 into the engine block front or rear camshaft bearings #1 or #4.
 - 7.3. Drive the camshaft bearings from the camshaft bearing bores.

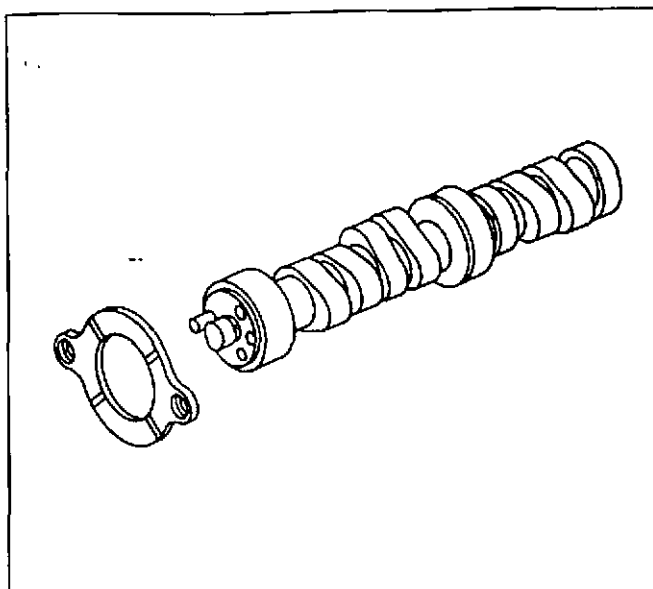
SIE-ID - 32312

Camshaft and Bearings Clean and Inspect**Tools Required**

J 7872 Magnetic Base Dial Indicator

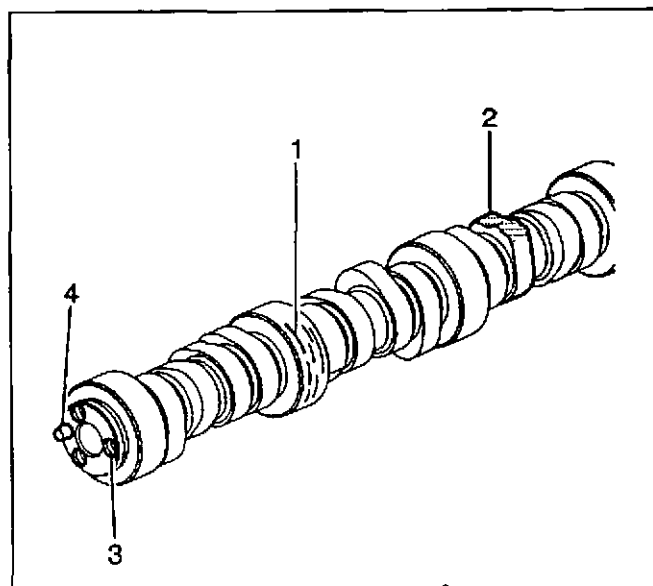
Caution: SIO-ID - 5011 **Wear safety glasses in order to avoid eye damage.**

1. Clean the engine camshaft in cleaning solvent.
2. Dry the engine camshaft with compressed air.
3. Inspect the camshaft retainer plate for damage.



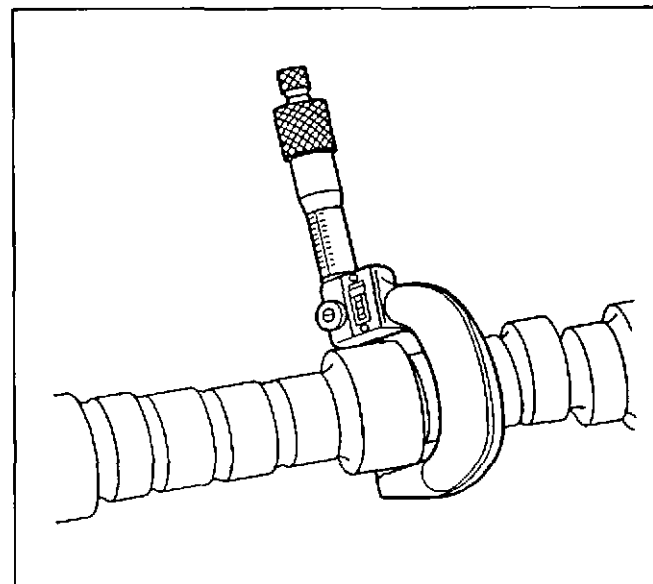
334499

4. Inspect the engine camshaft for the following:
 - Worn, scored, or damaged bearing journals (1)
 - Worn engine camshaft lobes (2)
 - Damaged bolt hole threads (3)
 - Damaged camshaft sprocket locator pin (4)

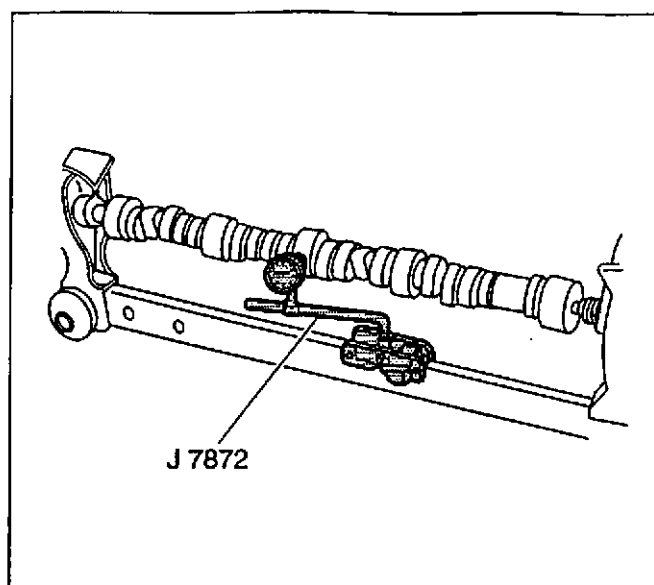


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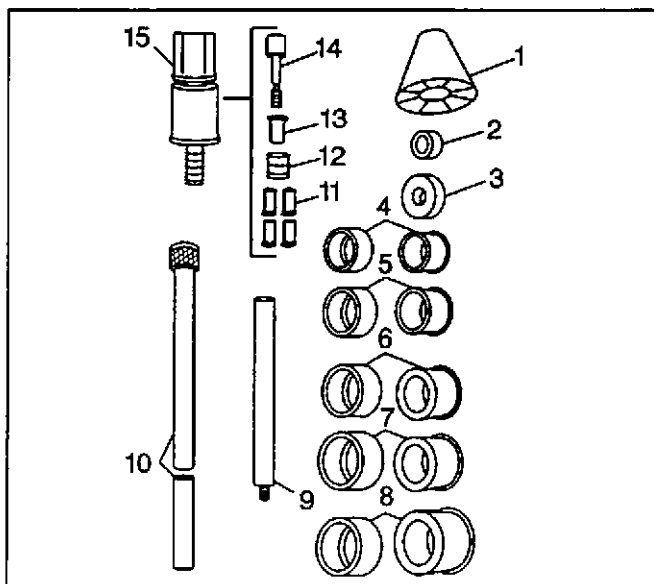
5. Measure the engine camshaft journals with a micrometer.
If the camshaft journals are more than 0.025 mm (0.0010 in) out-of-round, then replace the engine camshaft.



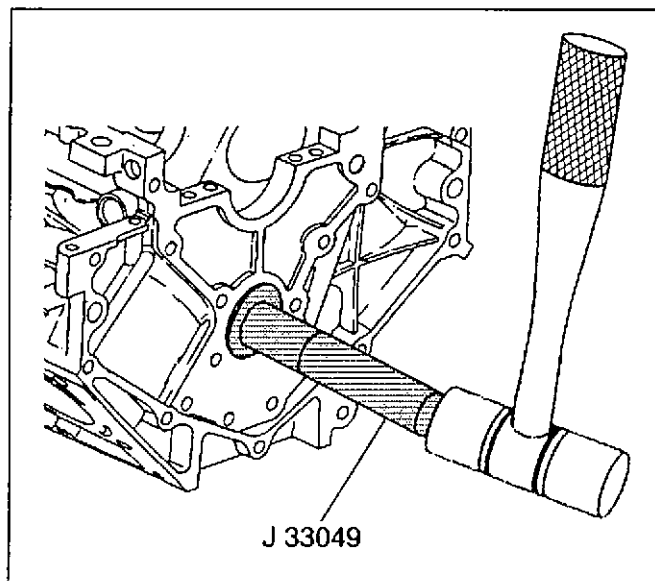
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188012



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6. Measure for a bent engine camshaft or excessive engine camshaft runout using the J 7872.
 - 6.1. Mount the engine camshaft in a suitable stand between centers.
 - 6.2. Use the J 7872 in order to check the intermediate engine camshaft journals.
If the runout exceeds 0.065 mm (0.0026 in), the engine camshaft is bent and should be replaced.
7. Measure the engine camshaft lobe lift using the J 7872.
 - 7.1. Place the engine camshaft on the V-blocks.
 - 7.2. Use the J 7872 in order to measure the engine camshaft lobe lift.
8. Replace the engine camshaft if the engine camshaft lobe lift is not within specifications.

SIE-ID = 199692

Camshaft Bearing Installation

Tools Required

J 33049 Camshaft Bearing Service Kit

Important: The outer camshaft bearings #1 and #4 must be installed first. The outer camshaft bearings serve as guides for the tool and help center the inner camshaft bearings during the installation process.

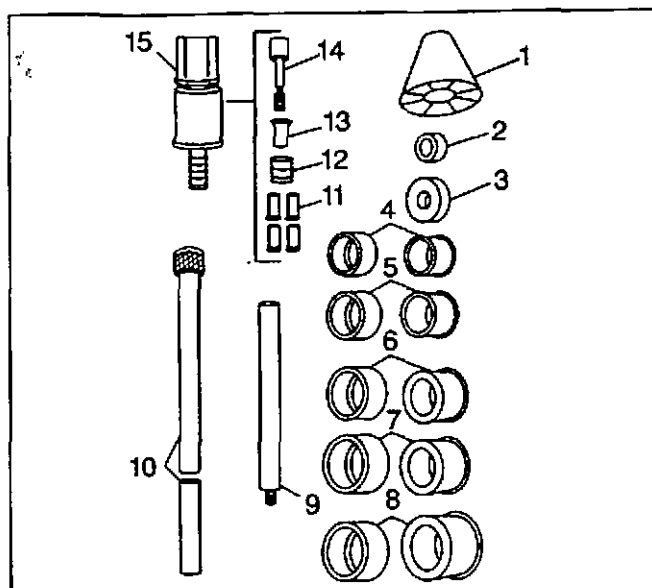
Look to ensure that the camshaft bearing lubrication hole or holes align with the oil gallery hole or holes in the engine block. On some engines, the oil holes may be difficult to see. Verify that the holes are aligned.

1. Assemble the J 33049 handle (10), the expanding driver (4-8), and the washer (2 or 3).
2. Insert the J 33049 into the engine block end camshaft bearings #1 or #4.

Important: The camshaft bearing oil holes must align with the oil galleries in the engine block. After installation of the camshaft bearings, inspect the camshaft bearing oil holes for proper alignment with the oil galleries.

An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the camshaft bearing and the camshaft journal.
3. Drive the end camshaft bearings #1 and #4 into the engine block end camshaft bearing bores.

4. Select the tool handle, the cone, the expanding driver, and the washer from the *J 33049*.
5. Assemble the *J 33049*.



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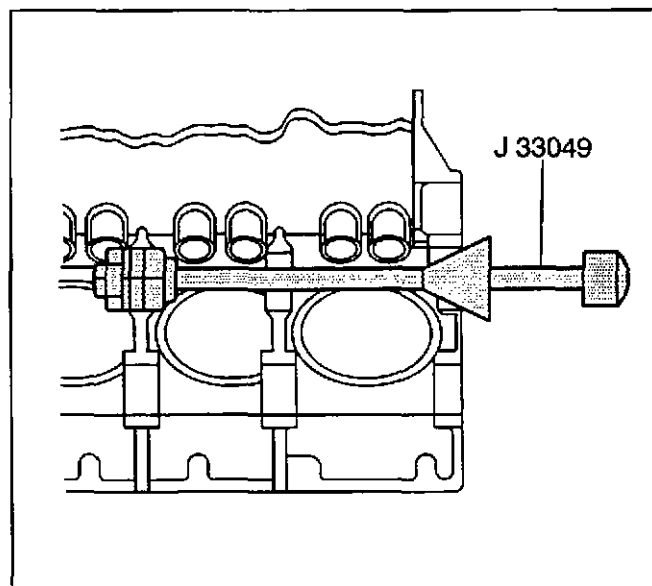
6. Insert the *J 33049* through the front of the engine block and to the inner camshaft bearing bores #2 and #3.
7. Install the camshaft bearing onto the expanding driver.
8. Tighten the expander assembly nut until the *J 33049* is snug in the camshaft bearing.

Important: The camshaft bearing oil holes must align with the oil galleries in the engine block.

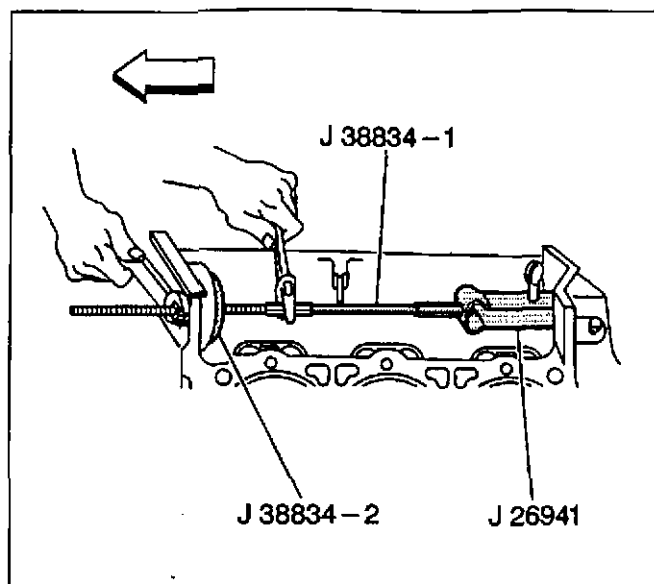
After installation of the camshaft bearings, inspect the camshaft bearing oil holes for proper alignment with the oil galleries.

An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the camshaft bearing and the camshaft journal.

9. Align the oil lubrication hole in the camshaft bearing with the oil galleries in the engine block.
10. Push the guide cone into the front camshaft bearing bore to align the *J 33049*.
11. Drive the camshaft bearing into the camshaft bearing bore.
12. Remove the *J 33049*.



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SIE-ID = 358968

Balance Shaft Bearing and/or Bushing Removal

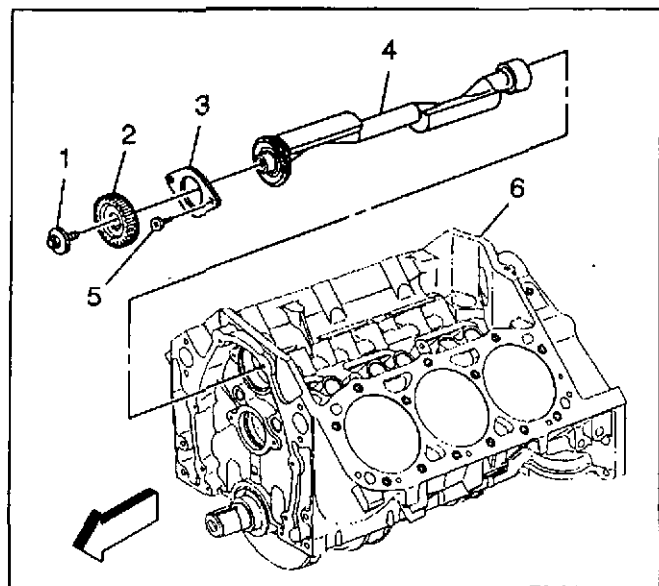
Tools Required

- J 26941 Bushing/Bearing Remover
 - J 38834 Balance Shaft Service Kit
1. Use the J 38834 and the J 26941 in order to remove the balance shaft rear bearing.
 - 1.1. Install J 26941 legs behind the balance shaft rear bearing and secure.
 - 1.2. Install the J 38834-1 with the short threaded end through the balance shaft bore in the front of the engine block.
 - 1.3. Install the J 38834-1 into J 26941.
 - 1.4. Slide the J 38834-2 onto the J 38834-1 and into the balance shaft bore of the engine block.
 - 1.5. Install the J 38834 bearing, washer, and nut onto the J 38834-1.
 - 1.6. Using a wrench secure the J 38834-1 and then rotate the J 38834 nut clockwise until the balance shaft rear bearing is removed from the engine block.
 - 1.7. Remove the J 26941 from the balance shaft rear bearing.
 2. Discard the balance shaft rear bearing.

SIE-ID = 199440

Balance Shaft Clean and Inspect

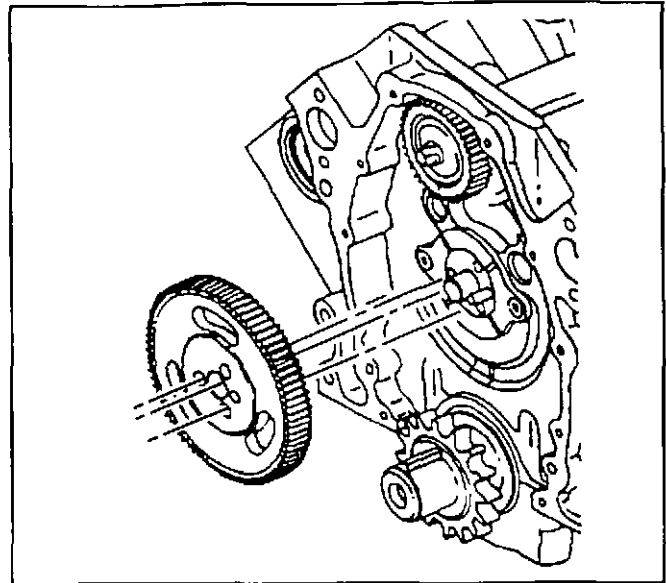
Important: The balance shaft and the front bearing are serviced only as an assembly. Do not remove the front bearing from the balance shaft.



188106

1. Inspect the balance shaft bearings for the following:
 - Front roller bearing for damage or wear
 - Front roller bearing for smoothness of operation
 - Rear sleeve bearing for wear, scoring, or other damage
2. Inspect the balance shaft (4) for the following:
 - Wear or scoring on the rear sleeve bearing end
 - Damaged bolt thread
 - Damaged to the driven gear locating pin
3. Inspect the balance shaft retainer plate (3) for wear or damage.
4. Inspect the driven gear (2) for wear, damage to the teeth or excessive backlash.
5. Inspect the drive gear retaining bolt (1) for damaged threads.

6. Inspect the drive gear for wear and damage to the teeth or excessive backlash.



9847

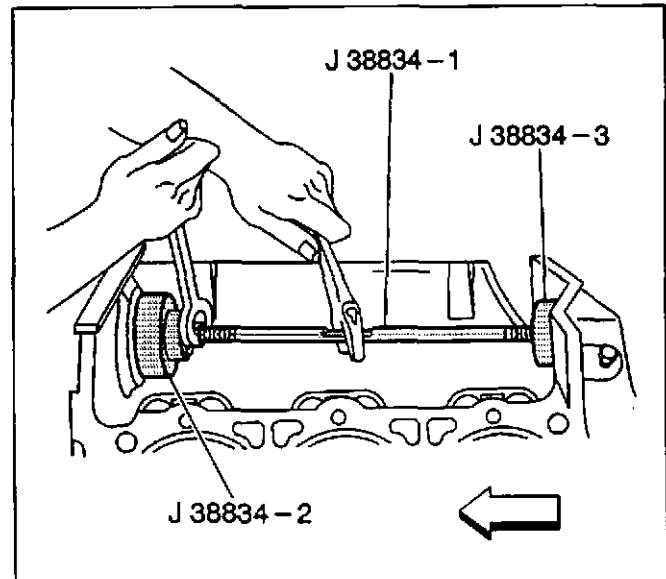
SIE-ID - 359018

Balance Shaft Bearing and/or Bushing Installation

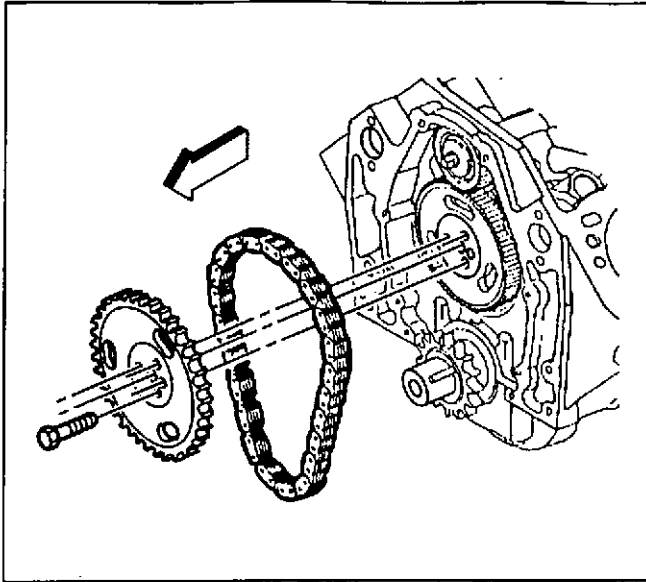
Tools Required

J 38834 Balance Shaft Bearing Service Kit

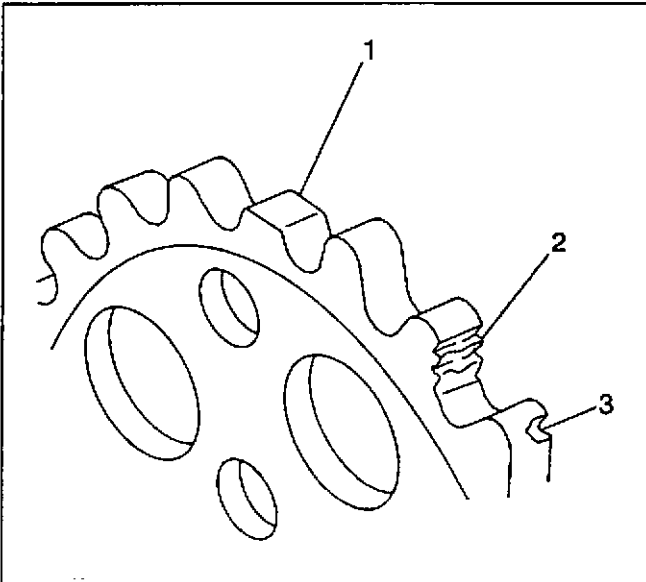
1. Use the J 38834 in order to install the balance shaft rear bearing.
 - 1.1. Install the J 38834-3 onto the short threaded end of the J 38834-1.
 - 1.2. Install the J 38834 nut, the washer, and the bearing on the long threaded end of the J 38834-1.
 - 1.3. Install the J 38834-2 onto the J 38834-1 so that the smaller diameter of the J 38834-2 will be facing the front of the engine block.
 - 1.4. Install the J 38834-2 on the inside of the balance shaft front bearing bore.
 - 1.5. Lubricate the NEW balance shaft rear bearing with clean engine oil.
 - 1.6. Install the balance shaft rear bearing onto the J 38834-2.
 - 1.7. Align the balance shaft rear bearing for installation.
 - 1.8. Using a wrench secure the J 38834-1 into place.
 - 1.9. Rotate the J 38834 nut until the balance shaft rear bearing is properly and completely pushed into the balance shaft rear bearing bore.
2. Remove the J 38834.



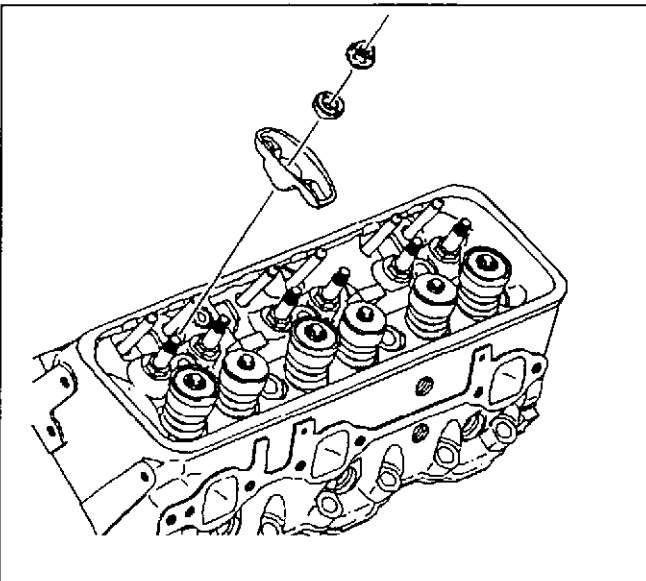
340085



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SIE-ID - 199442

Timing Chain and Sprockets Clean and Inspect

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the components with cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the camshaft timing chain for binding or wear.

4. Inspect the camshaft sprocket and the crankshaft sprocket for:
 - Broken teeth (1)
 - Damaged teeth (2)
 - Chipped teeth (3)
 - Worn teeth
 - Uneven wear on the edge of the teeth
 - Worn valleys between the sprocket teeth
 - Crankshaft sprocket keyway for wear

SIE-ID - 199443

Valve Rocker Arm and Push Rods Clean and Inspect

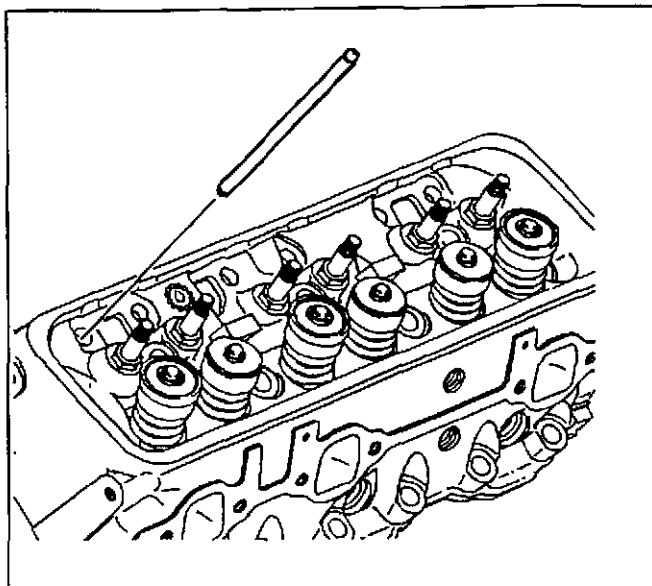
Important: Parts that are to be reused must be marked, sorted, and organized for assembly.

1. Mark, sort, and organize the components for assembly.

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

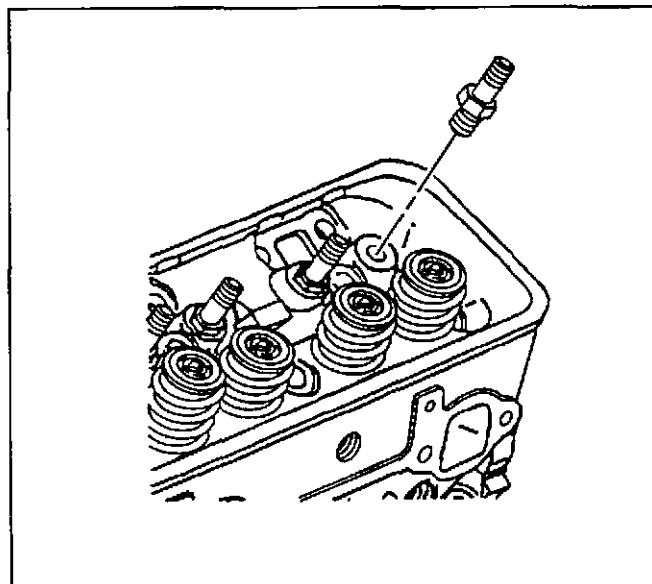
2. Clean the components with cleaning solvent.
3. Dry the components with compressed air.
4. Inspect the valve rocker arms for wear or scoring in the valve rocker arm ball area.
5. Inspect the valve rocker arm pushrod sockets and valve stem contact surfaces. The contact surfaces should be smooth with no scoring or excessive wear.

6. Inspect the valve pushrods for worn or scored ends. The surfaces should be smooth with no scoring or excessive wear.
7. Inspect the valve pushrods for bends.
Roll the valve pushrod on a flat surface to determine if the valve pushrod is bent.
8. Inspect the valve pushrod oil passages for any restrictions.



4047

9. Inspect the valve rocker arm ball studs for unusual wear or damage to the threads.



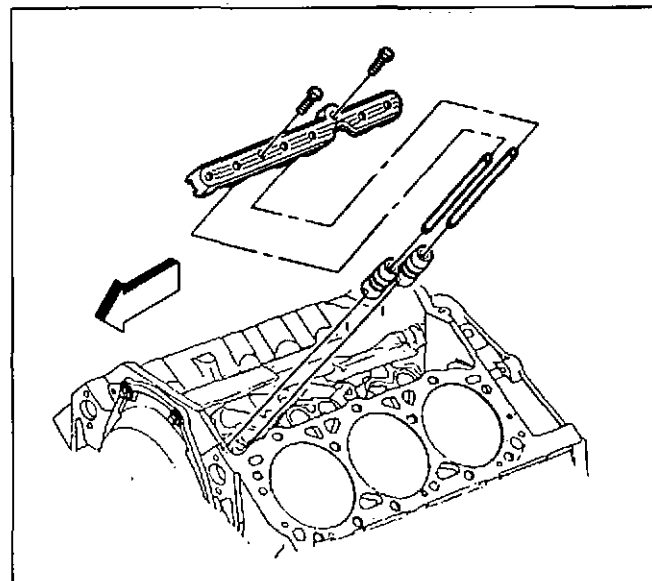
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SIE-ID - 199444

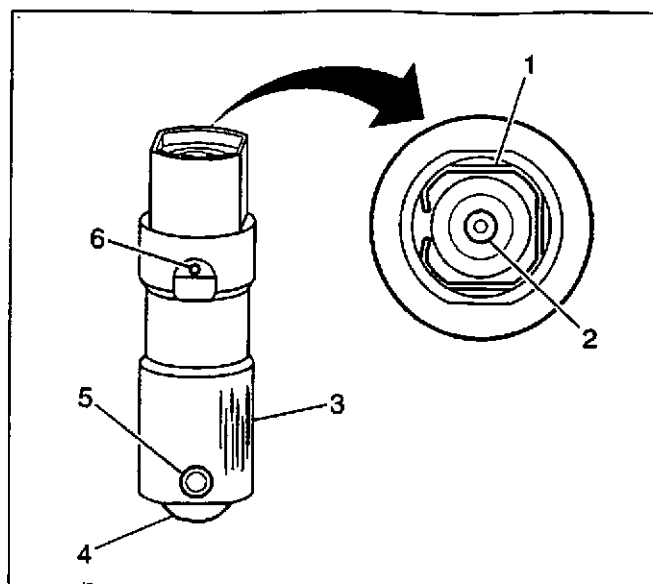
Valve Lifters and Guides Clean and Inspect

Important: Components that are to be reused must be marked, sorted, and organized for assembly.

1. Mark, sort, and organize the components for assembly.
Caution: SIO-ID - 5011 **Wear safety glasses in order to avoid eye damage.**
2. Clean the components in cleaning solvent.
3. Dry the components with compressed air.
4. Inspect the valve lifter pushrod guides for excessive wear.
5. Inspect the valve lifter pushrod guides for cracks or damage.



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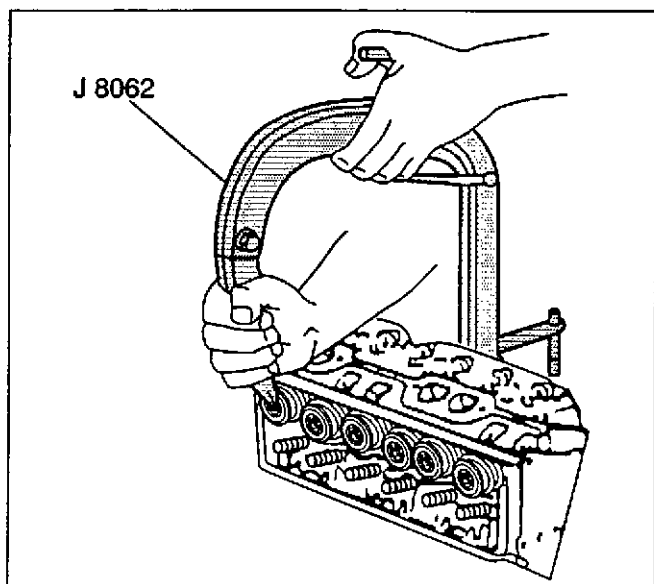


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6. Inspect the valve lifter for the following:

- Broken or damaged clip (1)
- Worn pushrod socket (2)
- Scuffed or worn lifter body (3)
- Worn roller (4)
- Loose or damaged pin (5)
- Plugged oil hole (6)

If the valve lifter shows scuffing or wear, inspect the engine block valve lifter bores for wear.



188473

SIE-ID = 358566

Cylinder Head Disassemble**Tools Required**

J 8062 Valve Spring Compressor

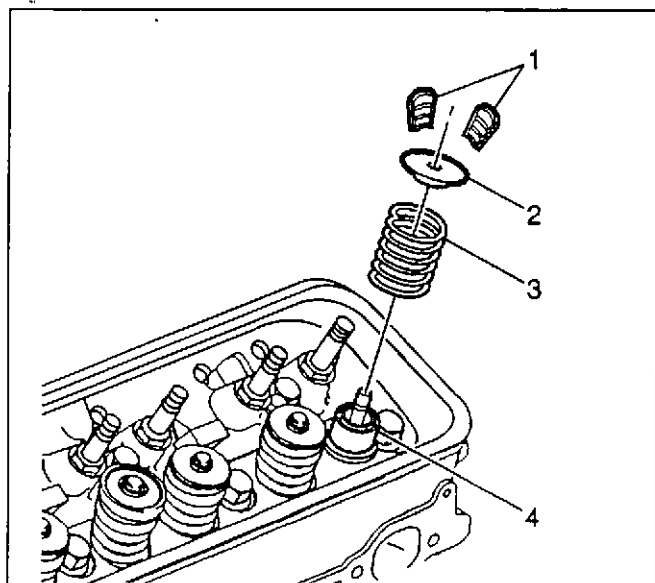
Caution: SIO-ID = 411464 *Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.*

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

1. Use the J 8062 in order to compress the valve springs.

Important: Mark, sort, and organize the components so that the components can be reinstalled in their original location and position.

2. Remove the valve stem keys (1).
3. Remove the J 8062 from the cylinder head.
4. Remove the valve spring cap (2).
5. Remove the valve spring (3).
6. Remove the valve stem oil seal (4).
7. Discard the valve stem oil seal.
8. Remove the valve.



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SIE-ID = 358567

Cylinder Head Clean and Inspect**Tools Required**

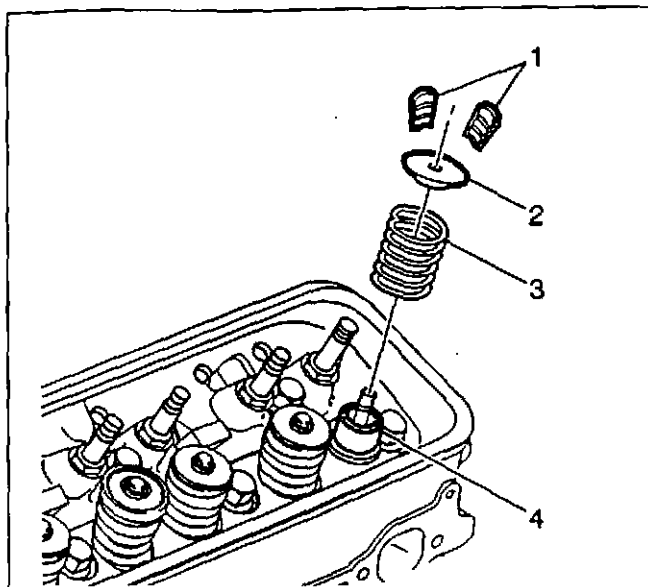
- J 8001 Dial Indicator Set
- J 8089 Carbon Removing Brush
- J 9666 Valve Spring Tester

Caution: SIO-ID = 5011 **Wear safety glasses in order to avoid eye damage.**

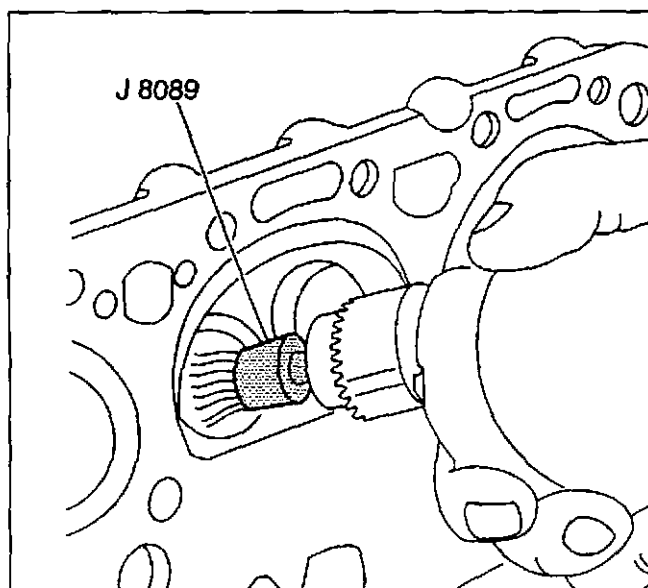
1. Clean the valve stems and cylinder heads on a buffing wheel.
2. Clean the following components in cleaning solvent:
 - Valve stem keys (1)
 - Valve spring cap (2)
 - Valve spring (3)
 - Cylinder head
3. Dry the components with compressed air.
4. Use the J 8089 to clean the carbon from the cylinder head combustion chambers.
Be careful not to scuff the combustion chambers.
5. Inspect the cylinder head for the following:
 - Damage to the gasket surfaces
 - Damage to the threaded bolt holes
 - Burnt or eroded areas in the combustion chamber
 - Cracks in the exhaust ports and combustion chambers
 - External cracks in the water chamber
 - Restrictions in the intake or exhaust passages
 - Restrictions in the cooling system passages
 - Rusted, damaged, or leaking core plugs

6. Measure the cylinder head for warpage with a straight edge and feeler gauge.

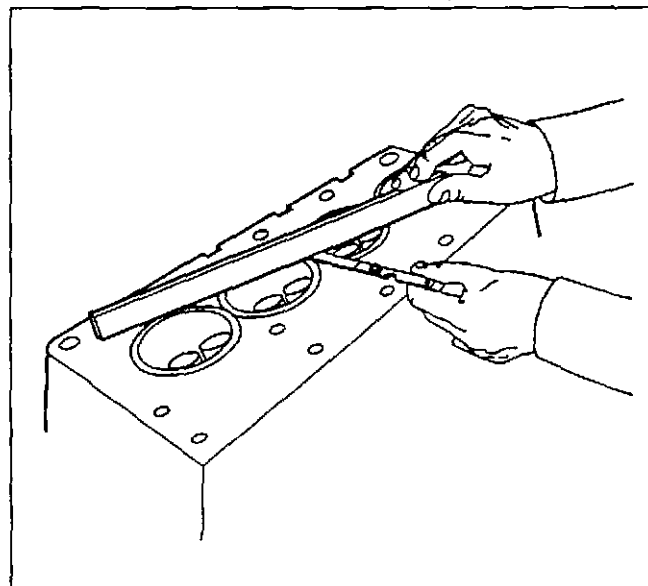
- A cylinder head block deck with warpage in excess of 0.10 mm (0.004 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
- A cylinder head exhaust manifold deck with warpage in excess of 0.5 mm (0.002 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
- A cylinder head intake manifold deck with warpage in excess of 0.10 mm (0.004 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.



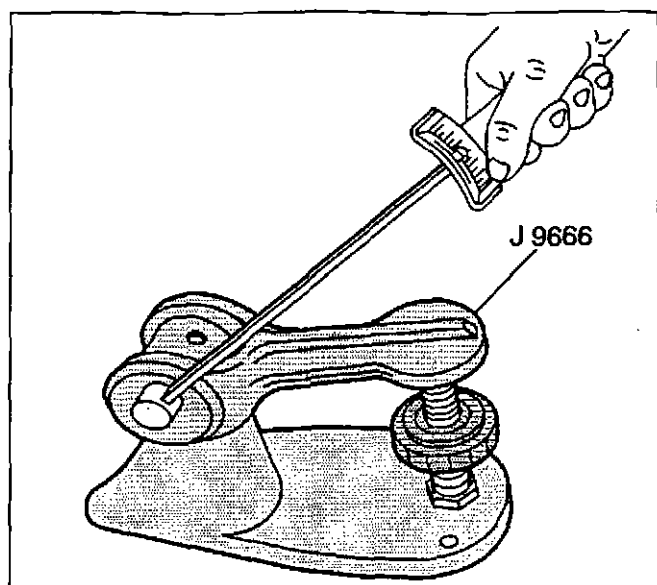
334505



4957



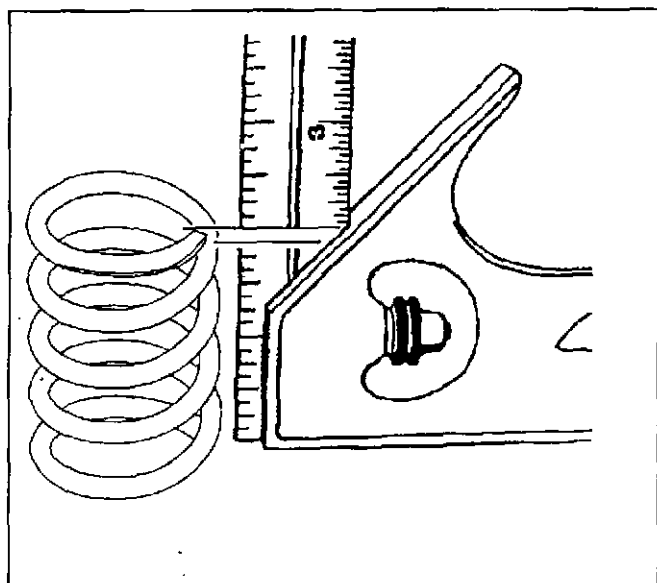
64318



4960

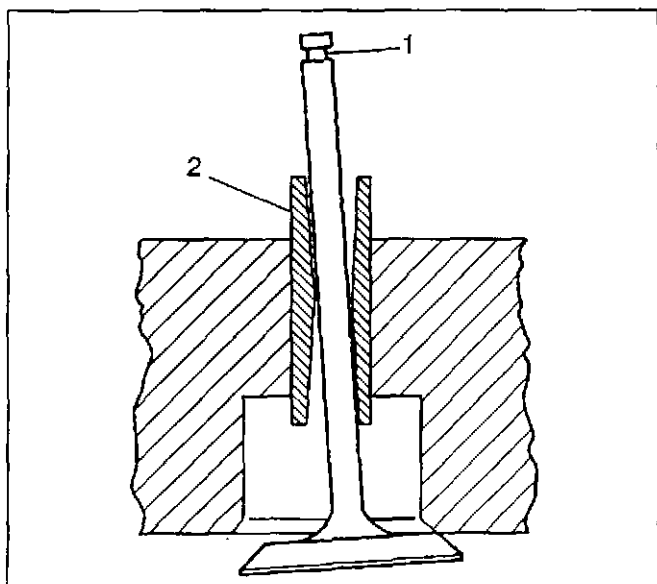
7. Use the J 9666 in order to measure the valve spring.

Replace the valve spring if the valve spring tension is less than 338 N (76 lb) at 43.2 mm (1.70 in).



40075

8. Inspect the valve springs for squareness.



156172

9. Valve stems (1) with excessive valve guide (2) clearance must be repaired or replaced.

10. Measure the valve stem-to-guide clearance.

Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.

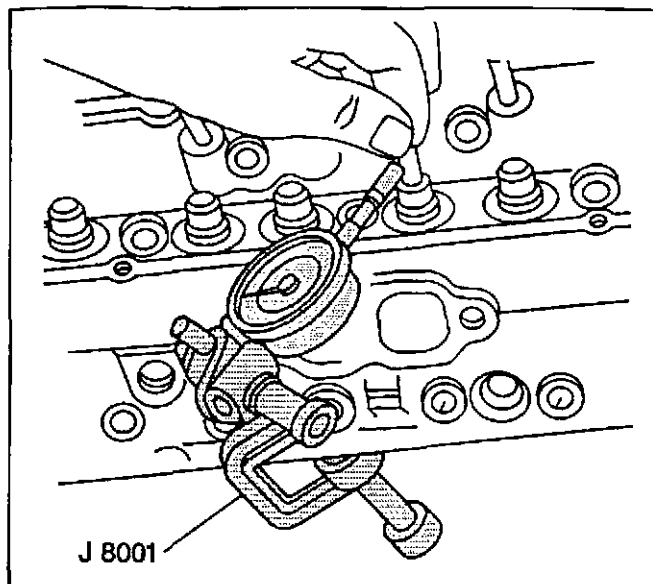
10.1. Clamp the *J 8001* on the exhaust port side of the cylinder head.

10.2. Position the dial indicator so that the movement of the valve stem from side to side (crosswise to the cylinder head) will cause a direct movement of the dial indicator stem.

The dial indicator stem must contact the side of the valve stem just above the valve guide.

10.3. Drop the valve head about 1.6 mm (0.063 in) off the valve seat.

10.4. Use light pressure and move the valve stem from side to side in order to obtain a valve stem-to-guide clearance reading. Refer to *Engine Mechanical Specifications*.



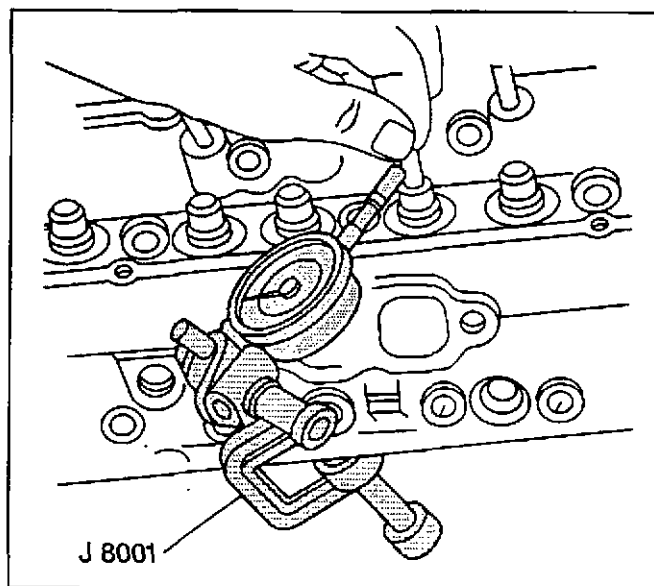
35214

SIE-ID - 375217

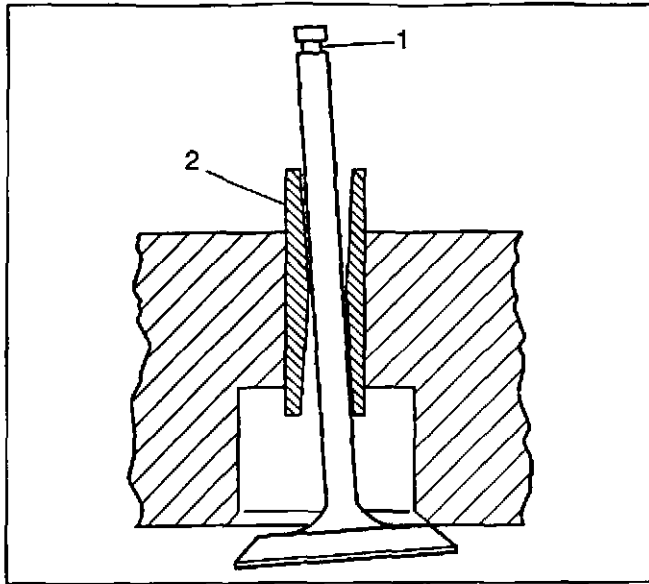
Valve Guide Reaming/Valve and Seat Grinding**Tools Required**

J 8001 Dial Indicator Set

1. Use the *J 8001* to measure the valve stem-to-guide clearance. Refer to *Cylinder Head Clean and Inspect*.

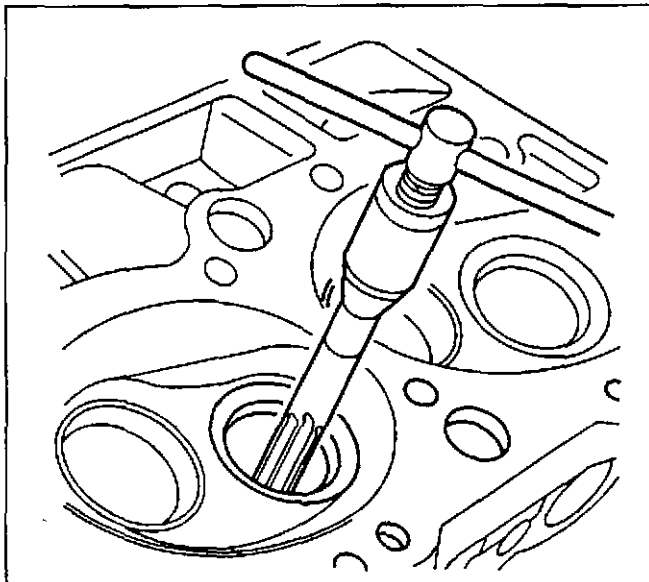


35214



156172

2. Improper valve stem (1) to valve guide (2) clearance may cause excessive oil consumption.

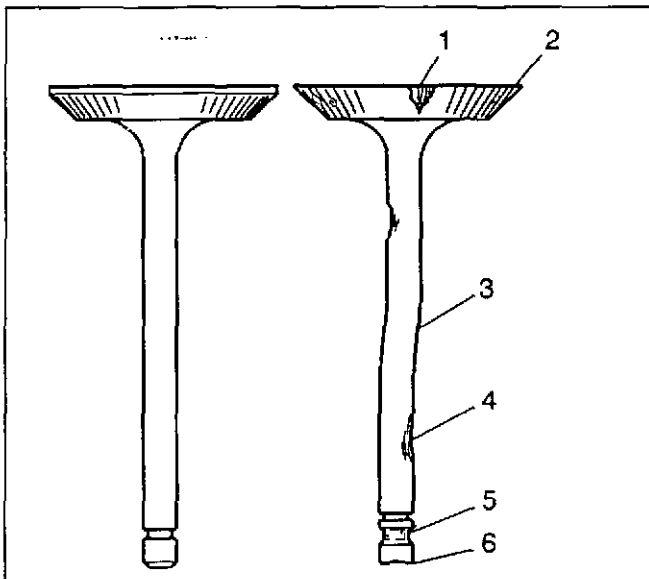


4956

3. Ream the valve guide as necessary to achieve proper valve stem-to-guide clearance.

- 3.1. Ream the valve guide oversize to accept a valve guide sleeve.
- 3.2. Insert the valve guide sleeve into the guide bore.
- 3.3. Ream the sleeve to achieve proper valve stem-to-guide clearance.

Always recondition the valve and valve seat after reaming the valve guide bores or installing new valves.



156174

4. Inspect the valves for the following:

- Burnt or damaged areas (1)
- Undersized valve margin (2)
- Bent stem (3)
- Scoring or other damage to the stem (4)
- Worn key groove (5)
- Worn stem tip (6)

5. Inspect the valve contact surface for the following:

- Undersized margin (1)
- Pitted surface (2)
- Burnt or eroded areas (3)
- Acceptable edge (margin) (4)

Valves with excessive damage must be replaced.

Minor imperfections of the valve or valve seat may be repaired.

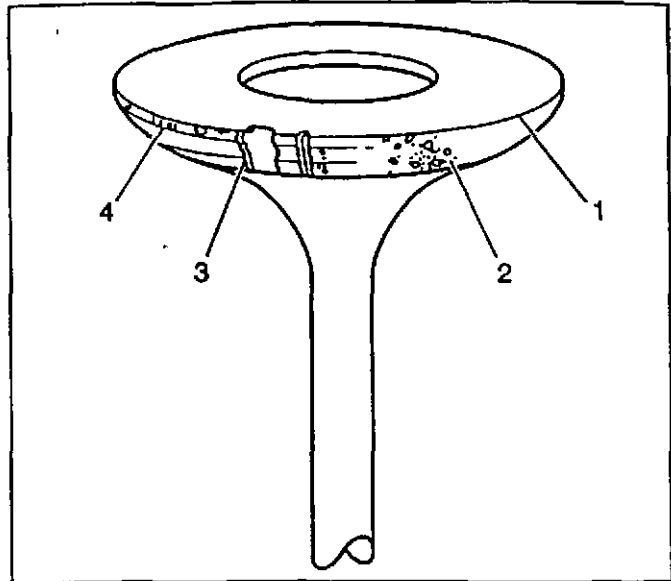
6. Reconditioning of the valves and valve seats:

- The valves must seat perfectly for the engine to deliver optimum power and performance.
- Cooling the valve heads is another important factor. Good contact between each valve and its seat in the cylinder head is necessary to insure that the heat in the valve head is properly carried away.

- Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the valve guide.

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

- Reface pitted valves on a valve refacing machine in order to insure the correct relationship between the head and the stem.
- Replace the valve stems that show excessive wear or are warped.
- Replace the valve if the edge of the valve head is less than 0.79 mm (0.031 in) thick after grinding.
- Several different types of equipment are available for reconditioning valves and valve seats. Follow the manufacturer's recommendations for equipment use to attain the proper results.



156173

SIE-10 - 358570

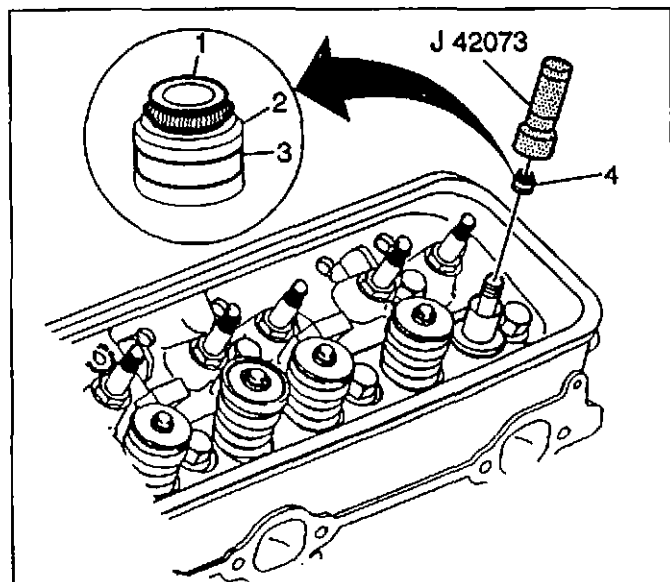
Cylinder Head Assemble

Tools Required

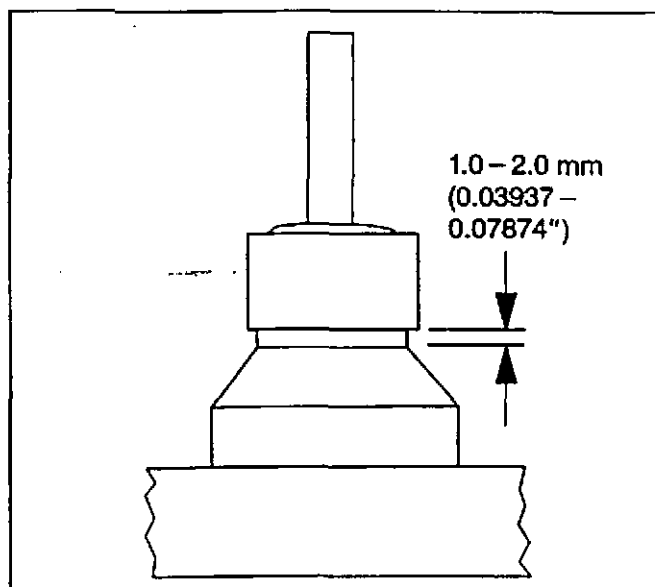
- J 8062 Valve Spring Compressor
- J 42073 Valve Stem Seal Installer

Important: The exhaust valve oil stem seal has the letters EX (1) molded into the top of the seal. The exhaust valve oil stem seal material is brown in color (2) with a white stripe (3) painted onto the outside diameter of the seal, or the material may be off-white in color (2) with no paint stripe. The intake valve oil seal is black in color.

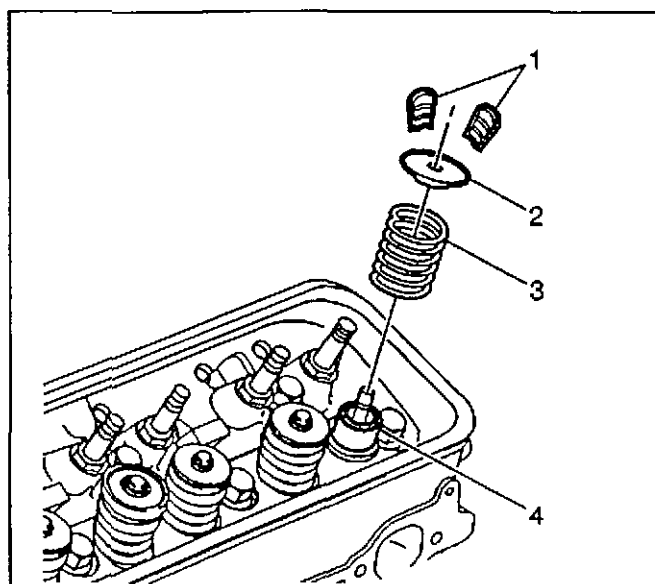
1. Assemble the valve into the proper valve guide.
2. Select the proper valve stem oil seal for the specific valve guide.
3. Lubricate the valve stem oil seal and the outside diameter of the valve guide with clean engine oil.



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4. Assemble the valve stem oil seal onto the valve stem.

Caution: S10-10 - 5011 *Wear safety glasses in order to avoid eye damage.*

5. Install the valve stem oil seal onto the valve guide using the J 42073 .

Tap the valve stem oil seal onto the valve guide until the J 42073 bottoms against the valve spring seat.

6. Inspect the valve stem oil seal. The valve stem oil seal should not be bottomed against the valve guide.

There should be a 1–2 mm (0.03937–0.07874 in) gap between the bottom edge of the valve stem oil seal and the valve guide.

7. Install the valve spring (3).
8. Install the valve spring cap (2) onto the valve spring (3) and over the valve stem.

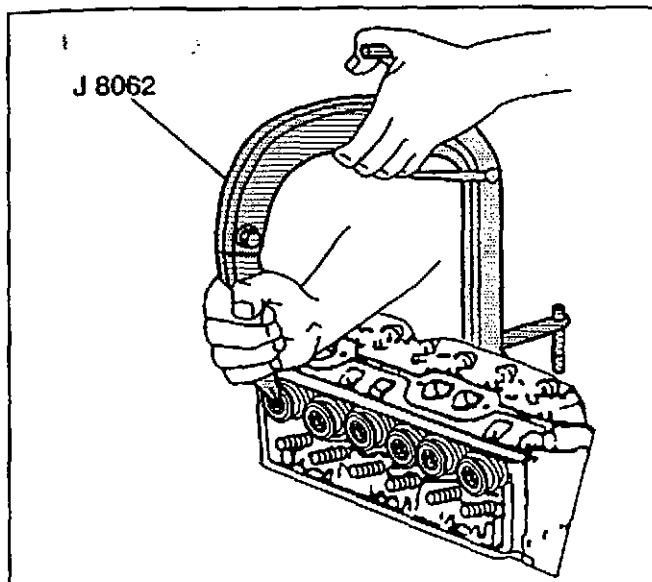
Caution: SIO-ID - 411464 *Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.*

9. Use the J 8062 in order to compress the valve spring.
10. Install the valve stem keys.
 - 10.1. Use grease in order to hold the valve stem keys in place while disconnecting the J 8062.
 - 10.2. Look to ensure that the valve stem keys seat properly in the upper groove of the valve stem.
 - 10.3. Tap the end of the valve stem with a plastic-faced hammer in order to seat the valve stem keys, if necessary.

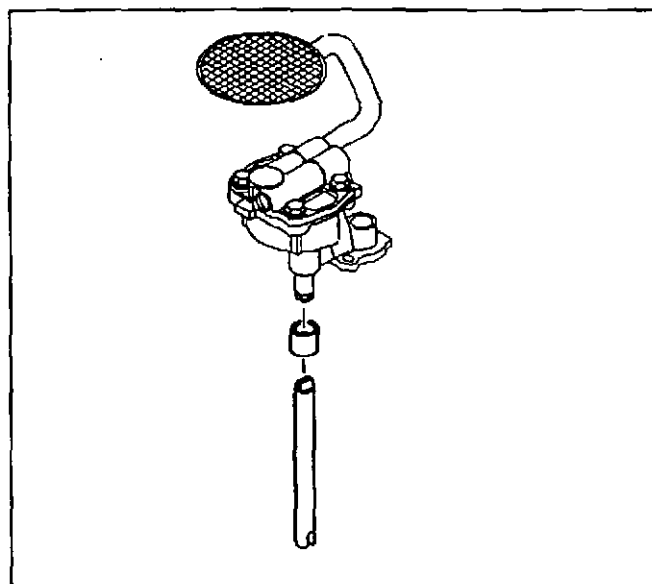
SIE-ID - 195049

Oil Pump Disassemble

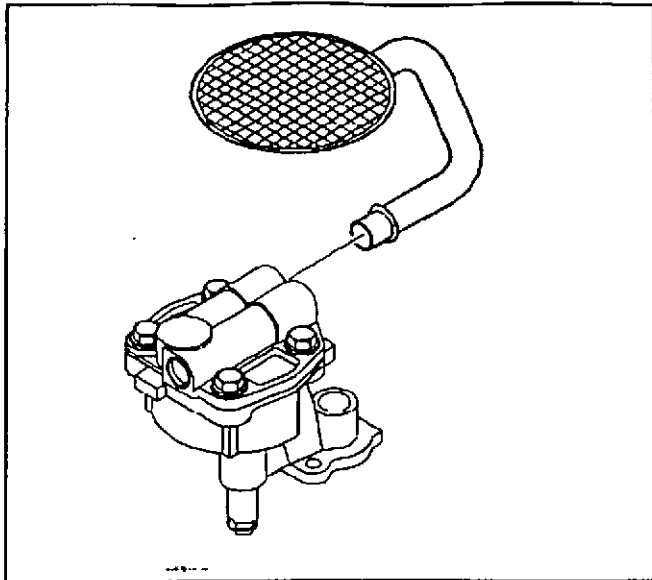
1. Remove the oil pump driveshaft and oil pump driveshaft retainer.



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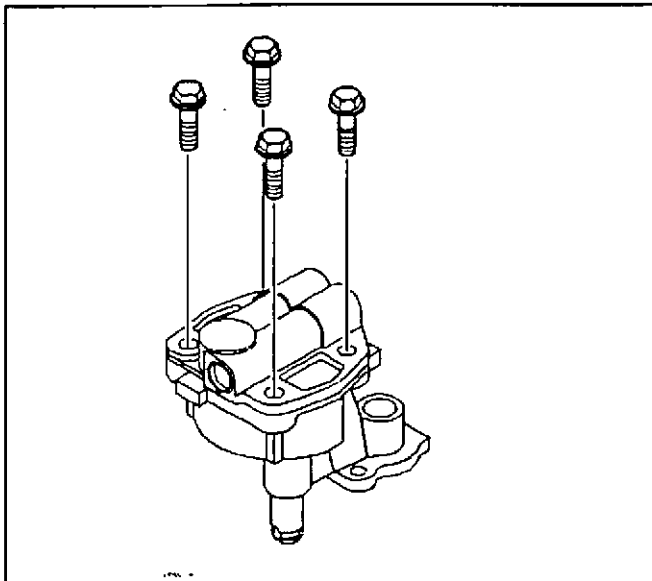


5274



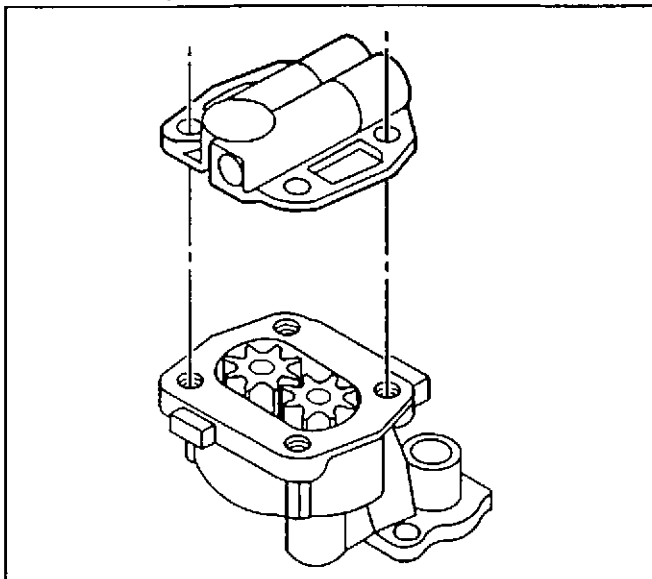
5275

2. Remove the oil pump screen (If necessary).
 - The oil pump screen has a press fit into the oil pump cover.
 - DO NOT remove the oil pump screen from the pipe. The pipe and oil pump screen are serviced as a complete assembly.



5276

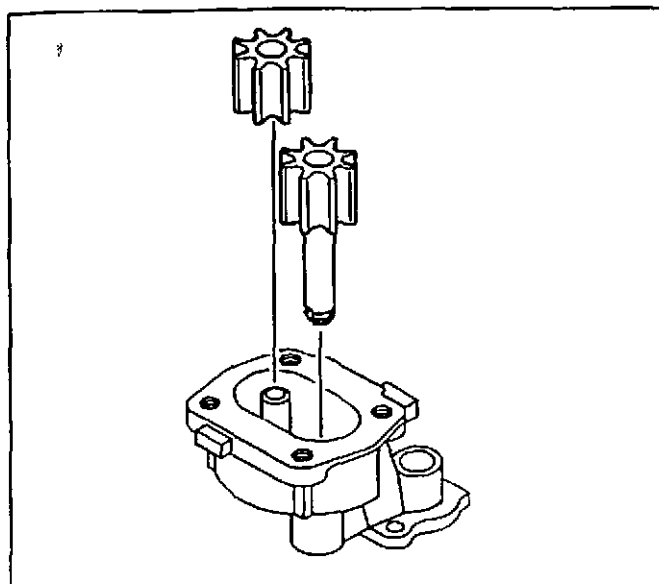
3. Remove the oil pump cover bolts.



5277

4. Remove the oil pump cover.

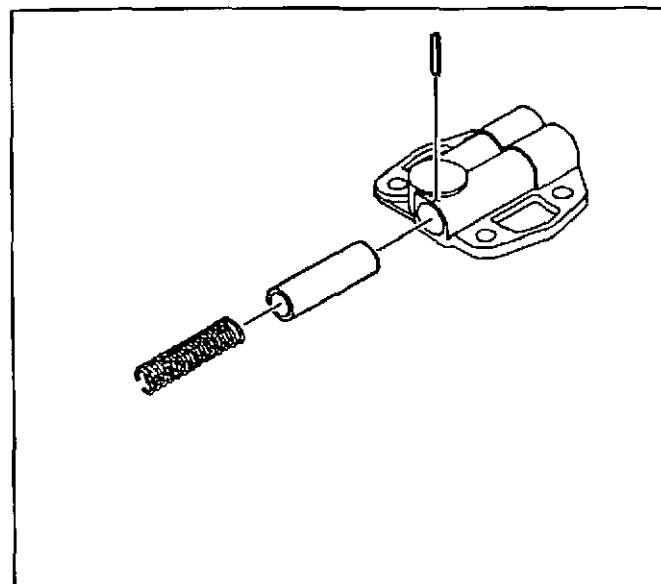
5. Remove the oil pump drive gear and the oil pump driven gear.
6. Matchmark the gear teeth for assembly.



5278

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

7. Remove the following items:
 - 7.1. The oil pump pressure relief valve spring straight pin
 - 7.2. The oil pump pressure relief spring
 - 7.3. The oil pump pressure relief valve



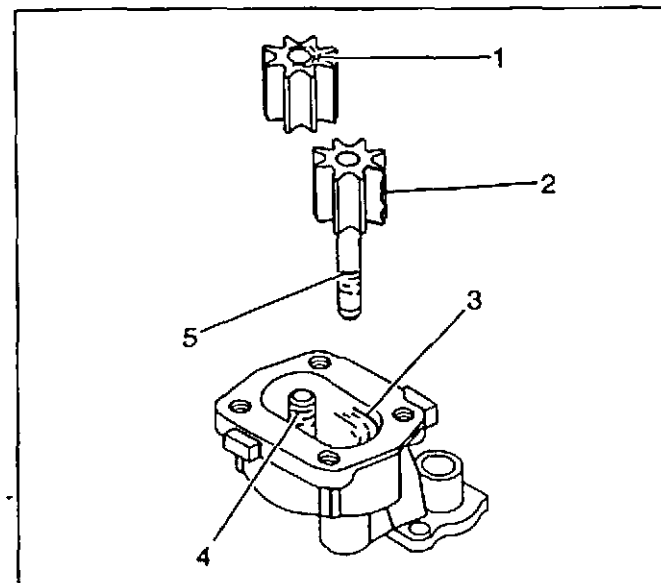
30401

SIE-ID - 35473

Oil Pump Clean and Inspect

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the oil pump components in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the oil pump for the following conditions:
 - Scoring, damage or casting imperfections to the body (3)
 - Damaged gears (2) for
 - Chipping
 - Galling
 - Wear
 - Scoring on the top of the gears (1)
 - Damaged or scored gear shaft (5)



186750

- Damaged bolt hole threads
 - Worn oil pump driveshaft bore
 - Damaged or sticking oil pump pressure relief valve (minor imperfections may be removed with a fine oil stone).
 - Collapsed or broken oil pump pressure relief valve spring
4. If the oil pump is to be reused, install a NEW oil pump pressure relief valve spring.
 5. During oil pump installation, install a NEW oil pump driveshaft retainer.

SIE-ID - 389671

Oil Pump Assemble

Tools Required

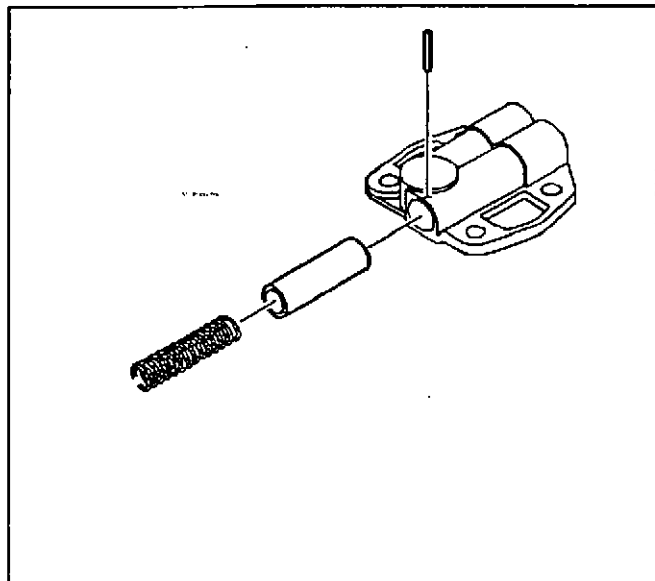
J 21882 Oil Suction Pipe Installer

1. Apply clean engine oil GM P/N 12345610 or equivalent to the oil pump pressure relief valve, oil pump pressure relief valve spring, and oil pump body.

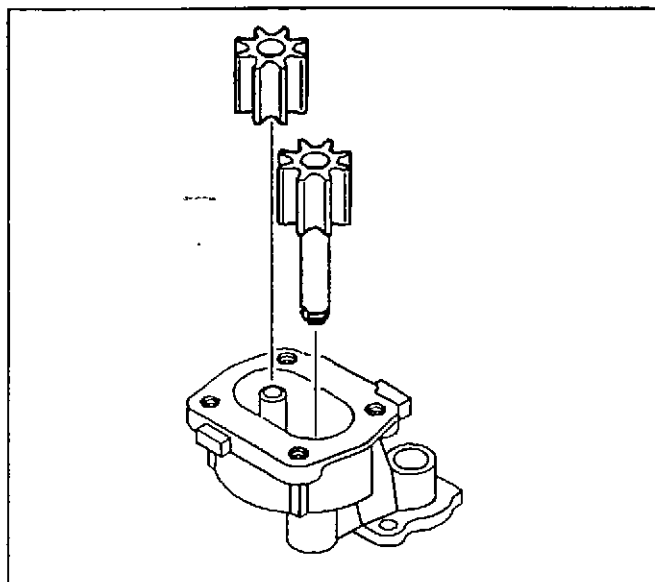
Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

Important: Replace the oil pump pressure relief valve spring when you reuse the oil pump.

2. Install the following items:
 - 2.1. The oil pump pressure relief valve
 - 2.2. The oil pump pressure relief valve spring
 - 2.3. The oil pump pressure relief valve spring straight pin
3. Apply clean engine oil GM P/N 12345610 or equivalent to the oil pump drive gear, the oil pump driven gear, and the oil pump body internal surfaces.
4. Install the oil pump drive gear and the oil pump driven gear into the oil pump body.
 - 4.1. Align the matchmarks on the oil pump drive and driven gears.
 - 4.2. Install the smooth side of the oil pump drive and driven gears toward the oil pump cover.

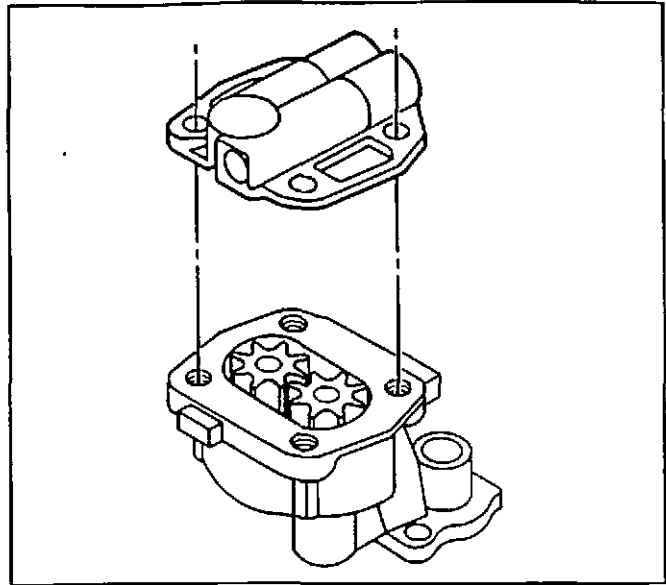


30401



5278

5. Install the oil pump cover.



5277

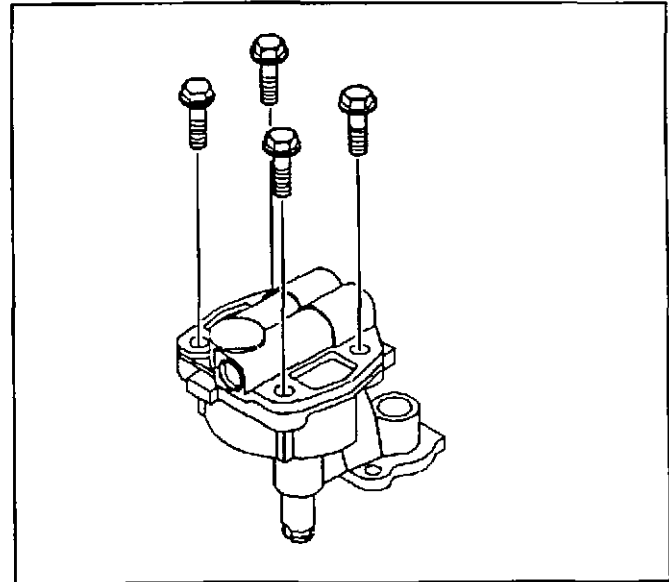
Notice: Refer to *Fastener Notice* in Caution and Notices.

6. Install the oil pump cover bolts.

Tighten

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

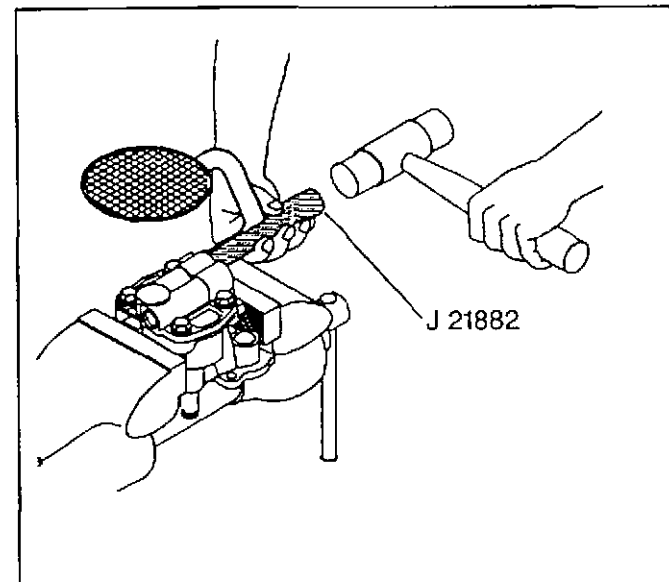
7. Inspect the oil pump for smoothness of operation by turning the oil pump driveshaft by hand.



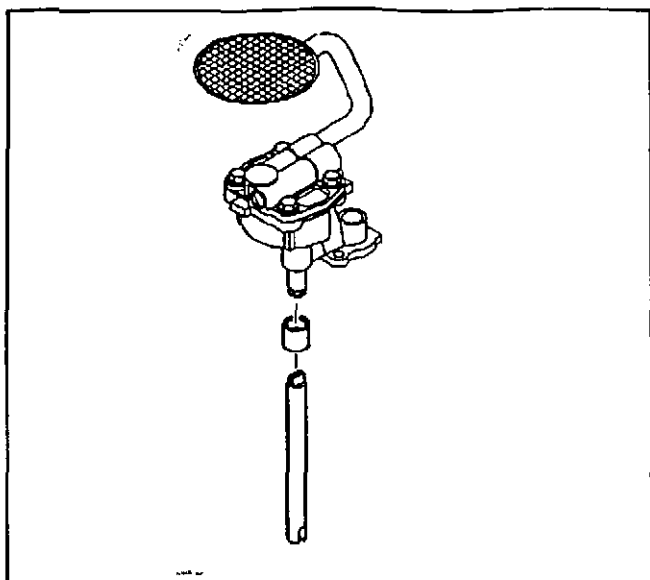
5276

8. Install the oil pump screen.

- 8.1. If removed, replace the oil pump screen. The oil pump screen must have a good press fit into the oil pump body.
- 8.2. Mount the oil pump in a soft jawed vise.
- 8.3. Apply sealant GM P/N 12346004 or equivalent to the end of the oil pump screen pipe.
- 8.4. Use the J 21882 and a soft-faced hammer in order to tap the oil pump screen into the pump body.
The oil pump screen must align parallel with the bottom of the oil pan when the oil pan is installed.



5280



5274

Important: Install a NEW oil pump driveshaft retainer during assembly.

9. Install the oil pump driveshaft and the NEW oil pump driveshaft retainer.

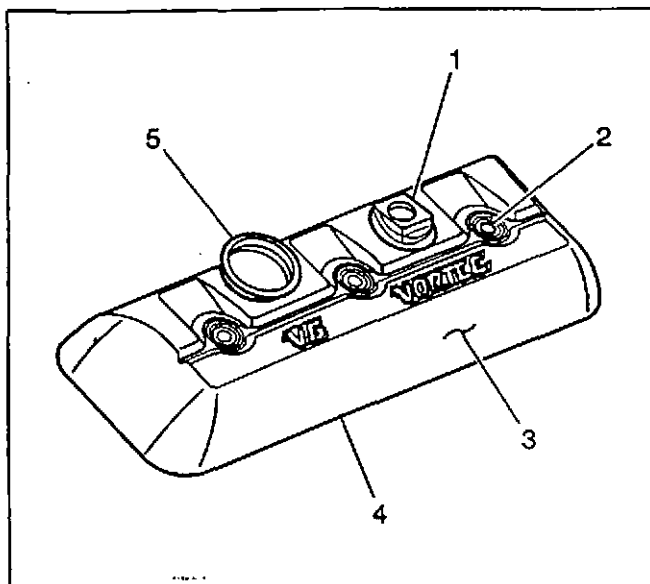
SIE-ID = 358571

Valve Rocker Arm Cover Clean and Inspect

Caution: SIO-ID = 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the valve rocker arm cover in cleaning solvent.
2. Dry the valve rocker arm cover with compressed air.
3. Inspect the valve rocker arm cover for the following:

- Damage to the PCV valve grommet (1)
- Damage to the bolt holes (2)
- A damaged valve rocker arm cover may interfere with the valve rocker arms.
- Damage to the exterior of the valve rocker arm cover (3)
- Gouges or damage to the sealing surface (4)
- Damage to the oil fill tube grommet (5)
- Restrictions to the ventilation system passages

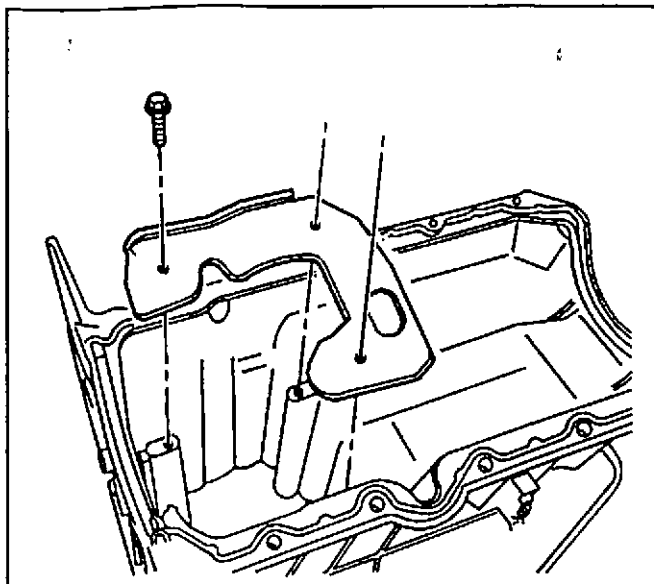


334508

SIE-ID - 358572

Oil Pan Clean and Inspect

1. Remove the oil pan baffle bolts and the oil pan baffle.

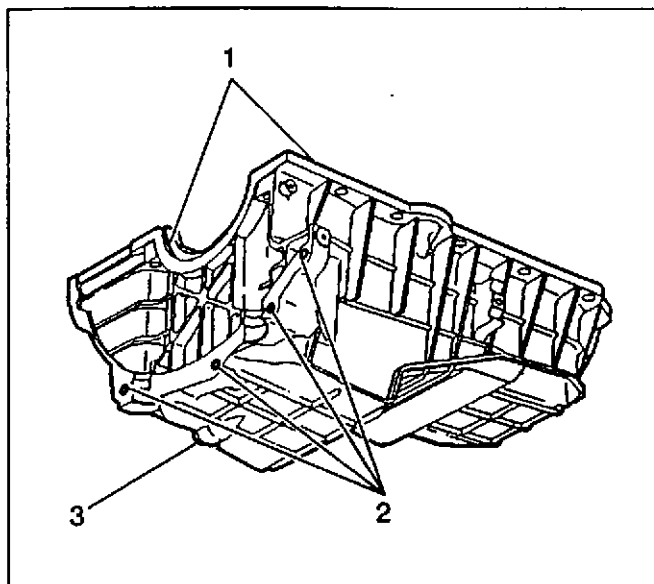


387763

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

2. Clean the oil pan and oil pan baffle in cleaning solvent.
3. Dry the oil pan and oil pan baffle with compressed air.
4. Inspect the oil pan for the following:
 - Gouges or damage to the oil pan sealing surfaces (1)
 - Damage to the threaded holes (2)
 - Damaged oil pan drain hole threads (3)
 - Damage to the oil pan baffle
 - Damage to the exterior of the oil pan

A damaged oil pan may interfere with the proper position of the oil pump screen, or may not distribute oil properly in the oil pan sump area.



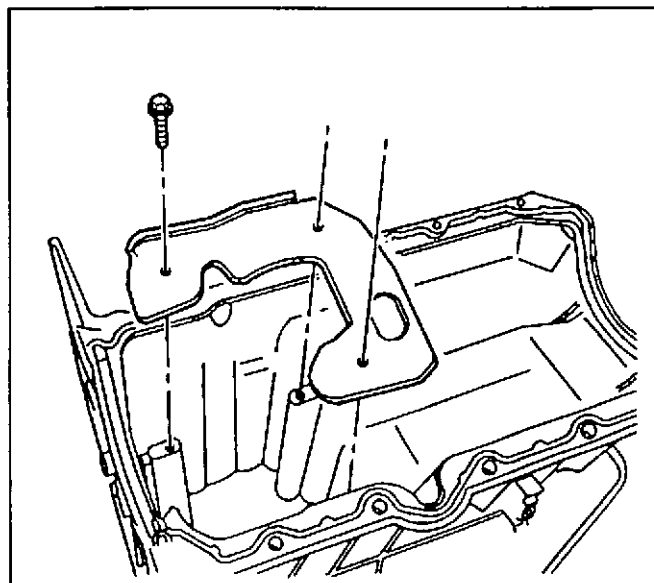
334509

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

5. Install the oil pan baffle and the bolts.

Tighten

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

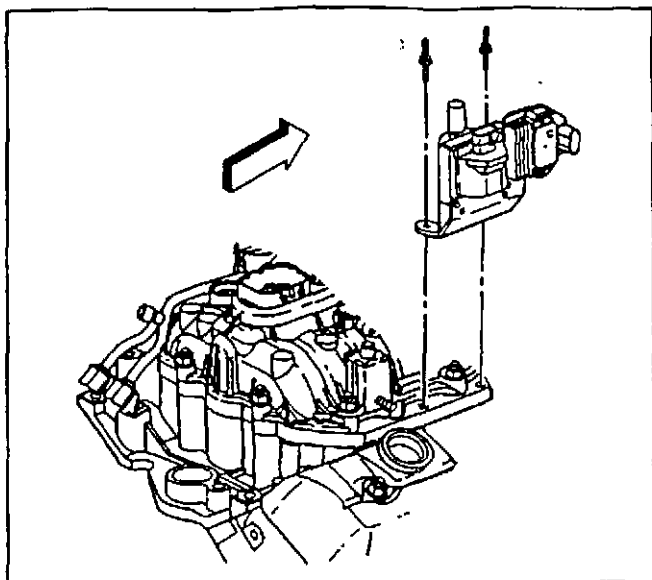


387763

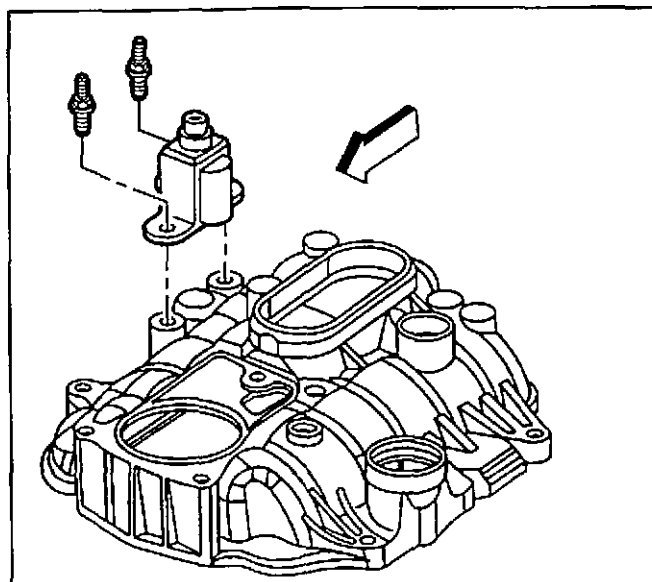
SIE-ID - 358878

Intake Manifold Disassemble

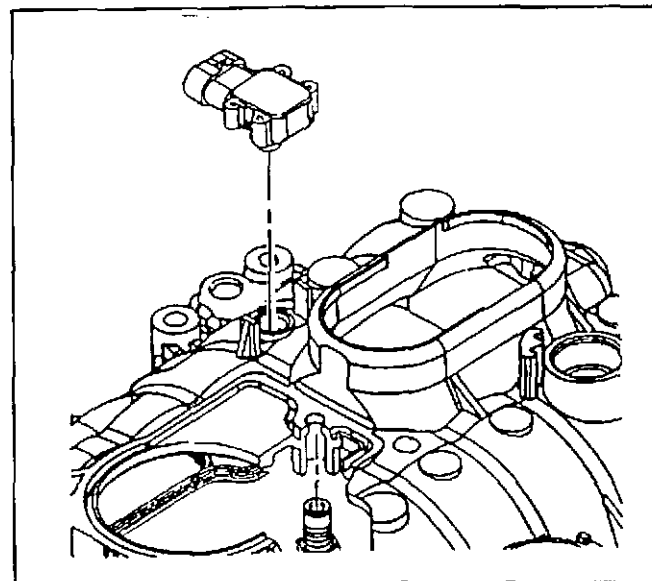
1. Remove the studs and the ignition coil.



31466



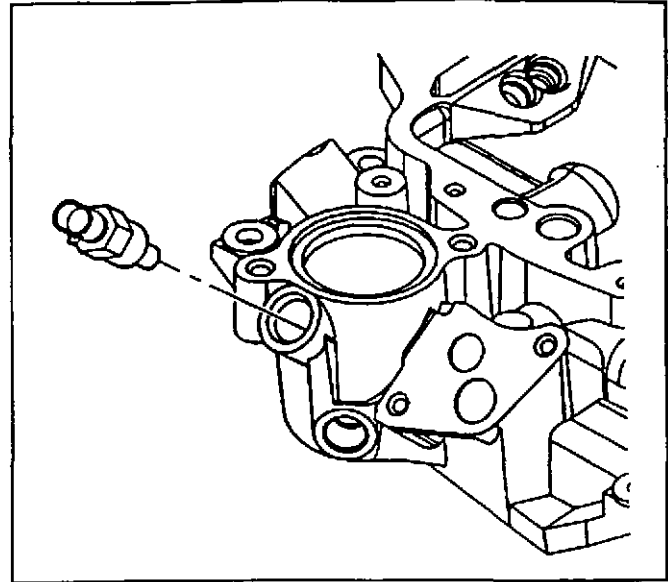
334511



31753

3. Remove the manifold absolute pressure (MAP) sensor.
4. Remove the MAP sensor seal (O-ring) from the MAP sensor and discard.

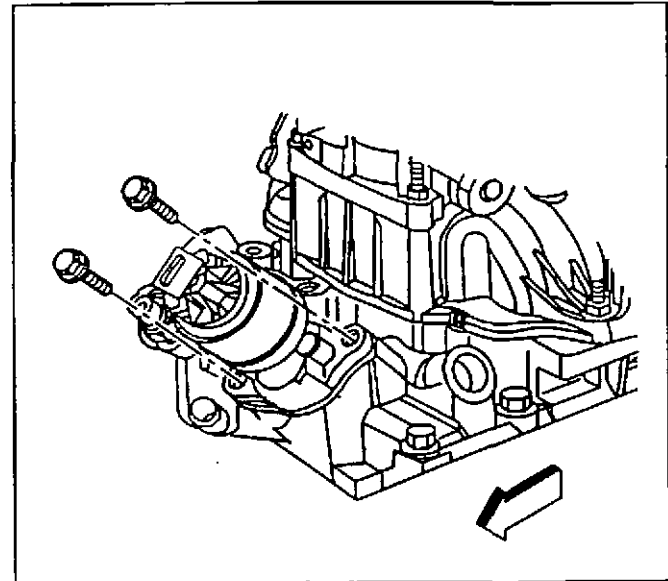
5. Remove the engine coolant temperature (ECT) sensor from the front of the lower intake manifold (if equipped).



10932

Important: Note the position and direction of the exhaust gas recirculation (EGR) valve before removal. It is possible to improperly install the EGR valve 180 degrees from the original position.

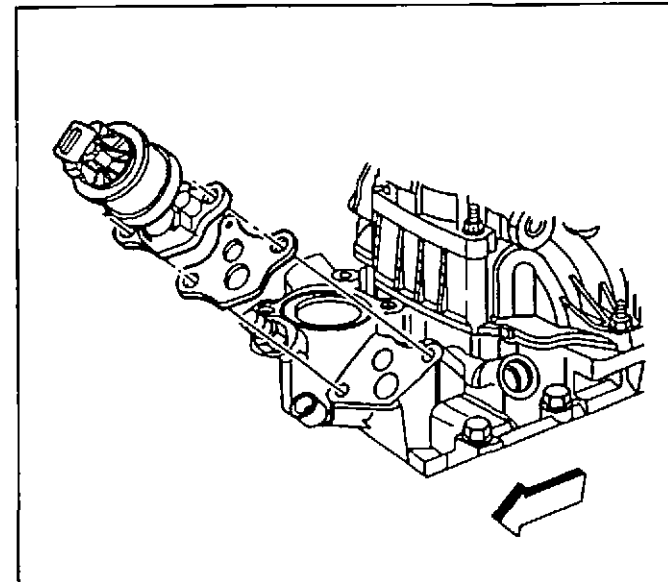
6. Remove the exhaust gas recirculation (EGR) valve bolts.



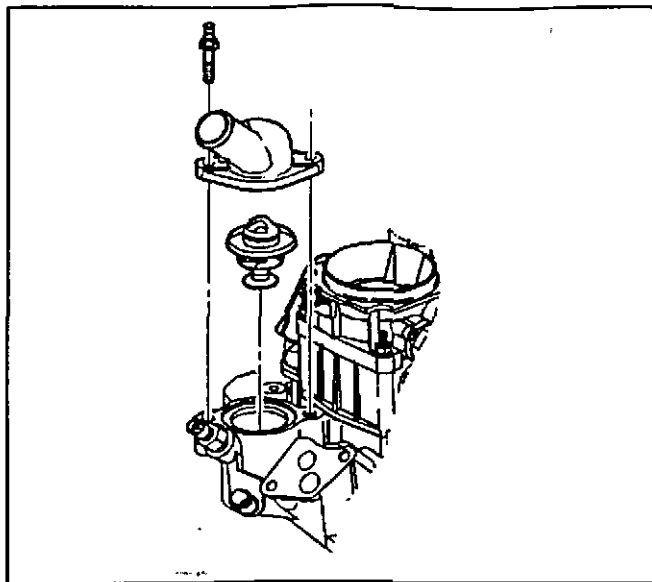
22075

Notice: S10-ID - 5005 The Linear EGR valve is an electrical component. DO NOT soak in any liquid cleaner or solvent because damage may result.

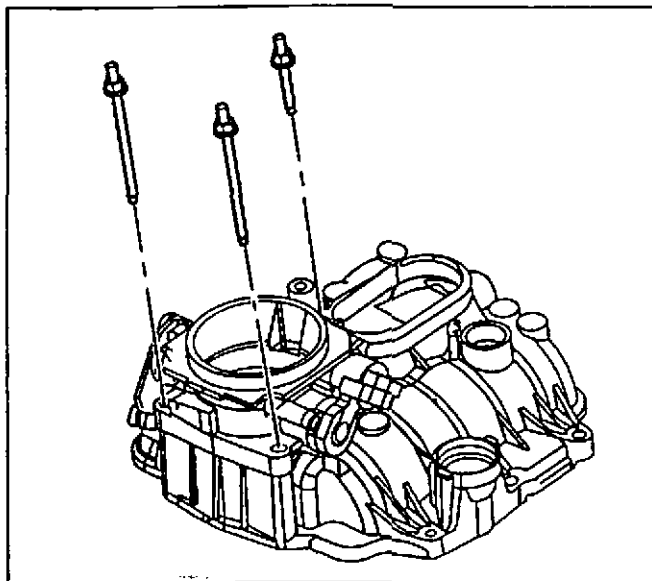
7. Remove the EGR valve and the EGR valve gasket from the lower intake manifold.
8. Discard the EGR valve gasket.



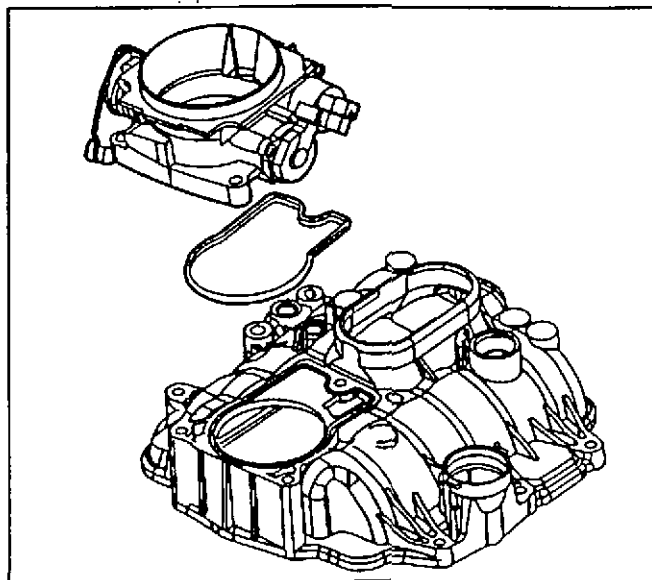
22078



9. Remove the water outlet studs.
10. Remove the water outlet.
11. Remove the engine coolant thermostat.

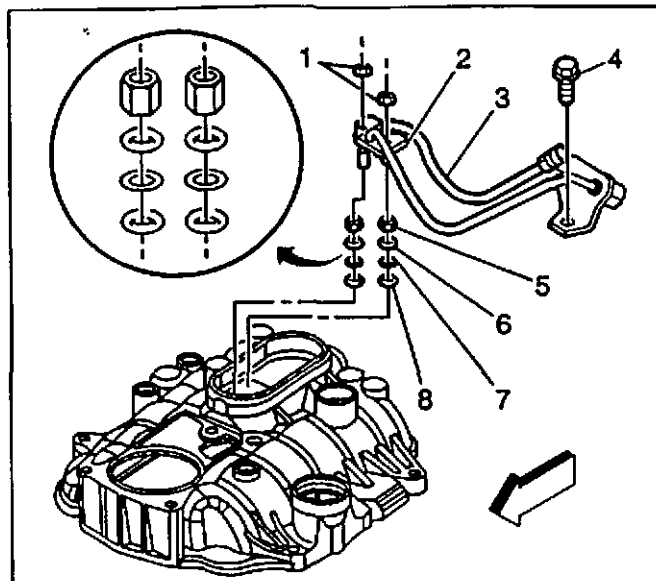


12. Remove the throttle body attaching studs.



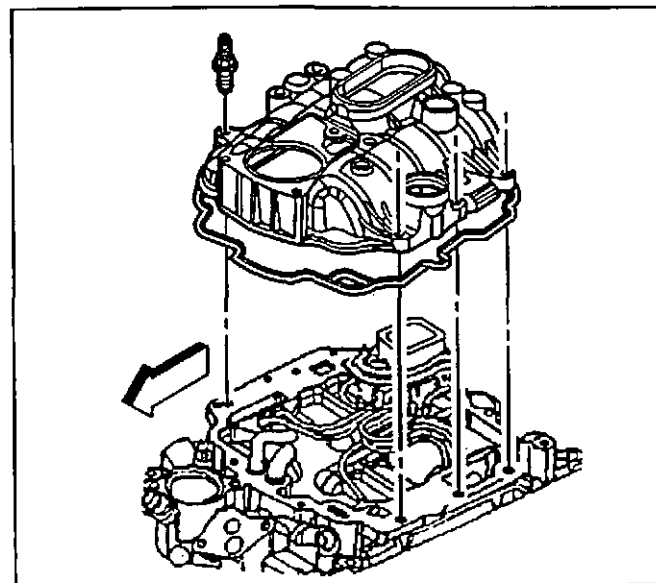
13. Remove the throttle body.
14. Remove the throttle body to upper intake manifold gasket.
15. Discard the throttle body to upper intake manifold gasket.

16. Remove the fuel pipe bolt (4).
17. Remove the fuel pipe retainer nuts (1).
18. Remove the fuel pipe retainer (2).
19. Remove the fuel pipe (3).
20. Remove and discard the fuel seal retainers (5).
21. Remove and discard the fuel seals (6) (yellow O-rings).
22. Remove and discard the spacer rings (7) (flat washers).
23. Remove and discard the fuel seals (8) (black O-rings).



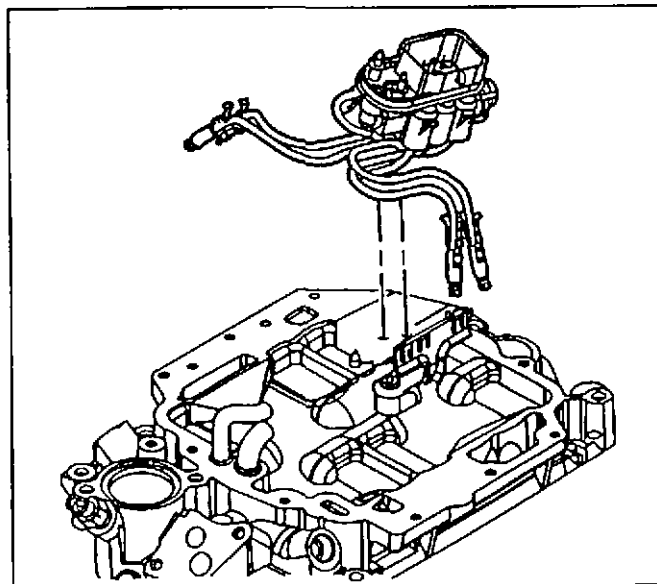
334517

24. Remove the upper intake manifold attaching studs.
25. Remove the upper intake manifold.
26. Remove the upper intake manifold to lower intake manifold gasket.
27. Discard the upper intake manifold to lower intake manifold gasket.

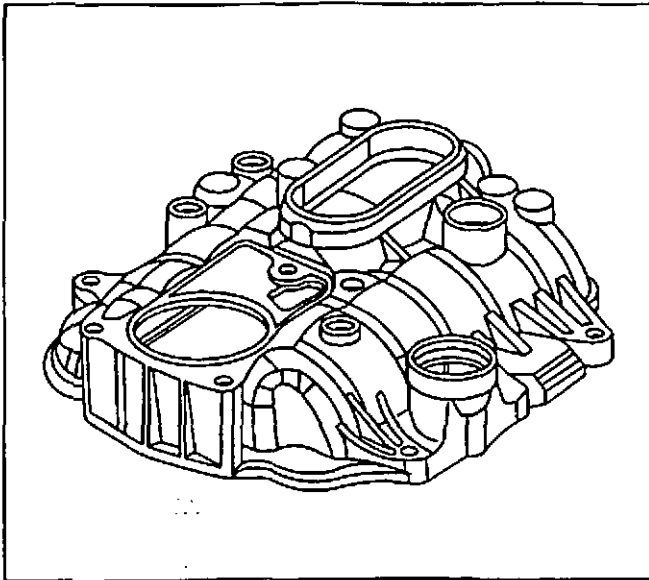


334513

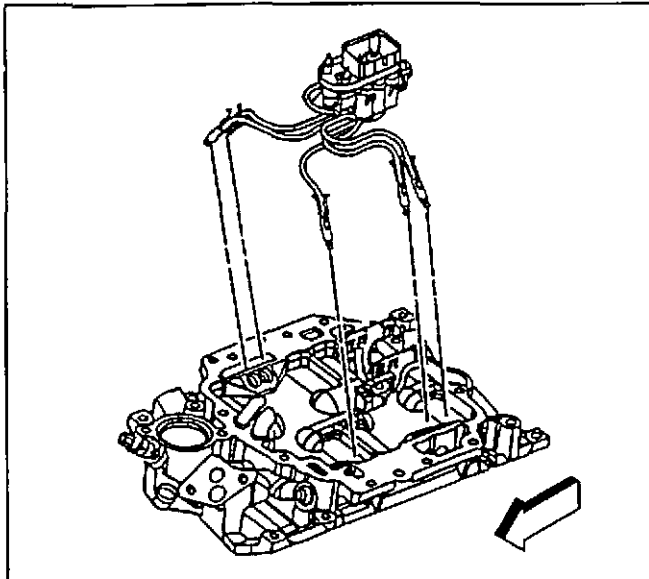
28. Remove the TBI fuel meter body seal and discard.
29. Remove the 6 poppet nozzles from the lower intake manifold bores.
30. Remove the TBI fuel meter body.
31. Remove the bolt and the TBI fuel meter body bracket.



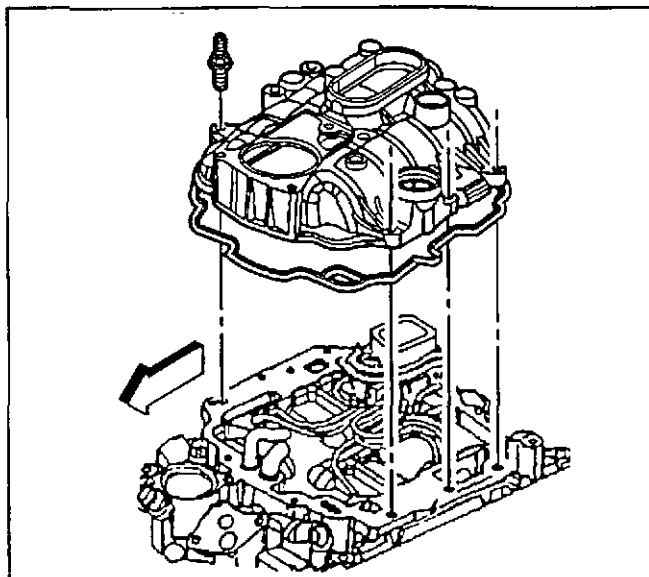
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31800



334513

SIE-ID - 358591

Intake Manifold Clean and Inspect

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the upper intake manifold in cleaning solvent.
2. Dry the upper intake manifold with compressed air.

3. Clean the lower intake manifold in cleaning solvent.
4. Dry the lower intake manifold with compressed air.

5. Inspect the upper intake manifold for the following:
 - Cracks or other damage to the exterior
 - Cracking or damage in the gasket grooves
 - Loose or damaged bolt hole thread inserts
 - Damage to the throttle body mounting surface
6. Inspect the lower intake manifold for the following:
 - Cracks or damage
 - Damage to the gasket sealing surfaces
 - Damage to the threaded bolt holes
 - Restricted exhaust gas recirculation (EGR) system passages
 - Restricted cooling system passages

SIE-ID - 358595

Intake Manifold Assemble

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

1. Install the TBI fuel meter body bracket and bolt.
Tighten

Tighten the TBI fuel meter bracket bolt to 10 N.m (88 lb in).

2. Install the TBI fuel meter body into the TBI fuel meter body bracket.
3. Install the 6 poppet nozzles into the proper lower intake manifold bores.
4. Inspect the poppet nozzles in order to ensure that the poppet nozzles are firmly seated and locked in the lower intake manifold bores.
5. Install a NEW TBI fuel meter body seal into the groove of the TBI fuel meter body.

6. Install a NEW upper intake manifold to lower intake manifold gasket into the groove of the upper intake manifold.
7. Install the upper intake manifold onto the lower intake manifold.
8. Install the upper intake manifold attaching studs.

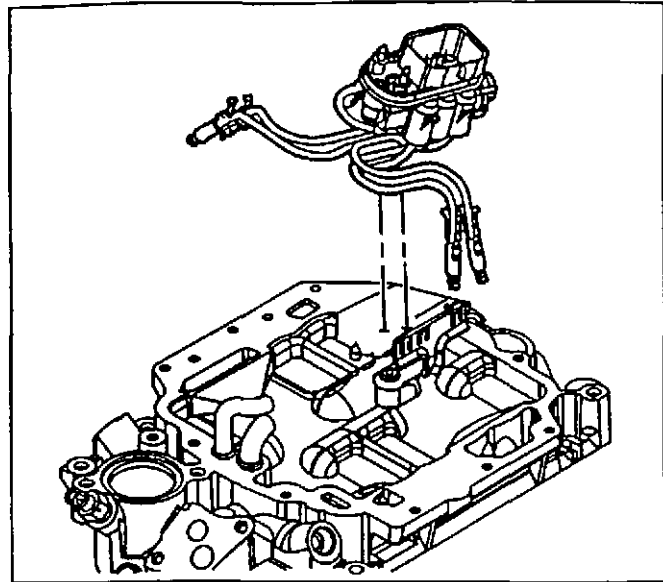
Tighten

- 8.1. Tighten the upper intake manifold attaching studs on the first pass to 5 N.m (44 lb in).
- 8.2. Tighten the upper intake manifold attaching studs on the final pass to 9 N.m (80 lb in).

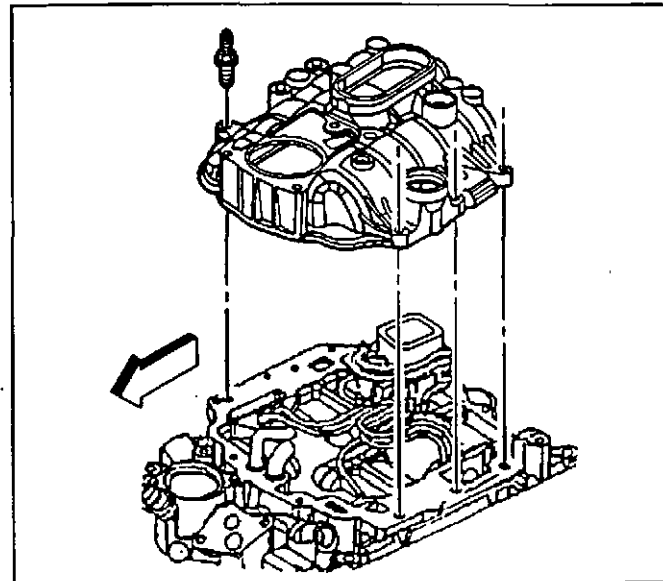
9. Install the NEW the fuel seals (8) (black O-rings) into the TBI fuel meter body.
10. Install the NEW spacer rings (7) (flat washers) into the TBI fuel meter body.
11. Install the NEW the fuel seals (6) (yellow O-rings) onto the fuel pipe (3). into the TBI fuel meter body.
12. Install the NEW fuel seal retainers (5) into the TBI fuel meter body.
13. Install the fuel pipe (3) into the TBI fuel meter body.
14. Install the fuel pipe retainer bracket (2) onto the fuel pipe.
15. Install the fuel pipe retainer bracket nuts (1).
16. Install the fuel pipe bolt (4).

Tighten

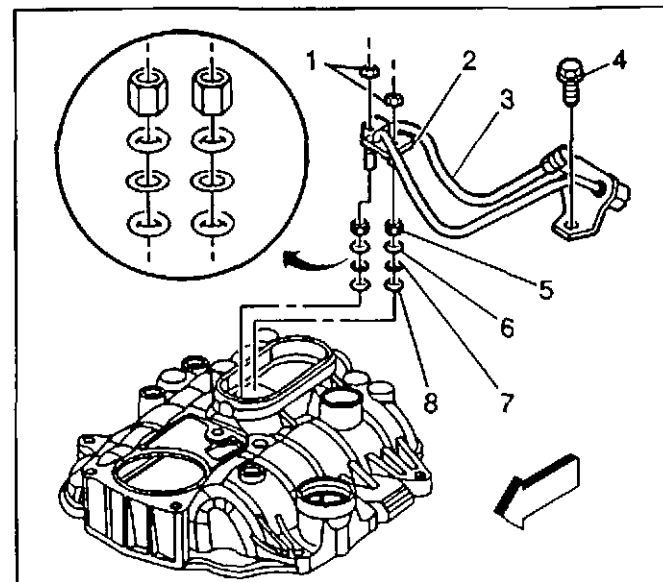
- 16.1. Tighten the fuel pipe bracket nuts to 3 N.m (27 lb in).
- 16.2. Tighten the fuel pipe bolt to 6 N.m



12867



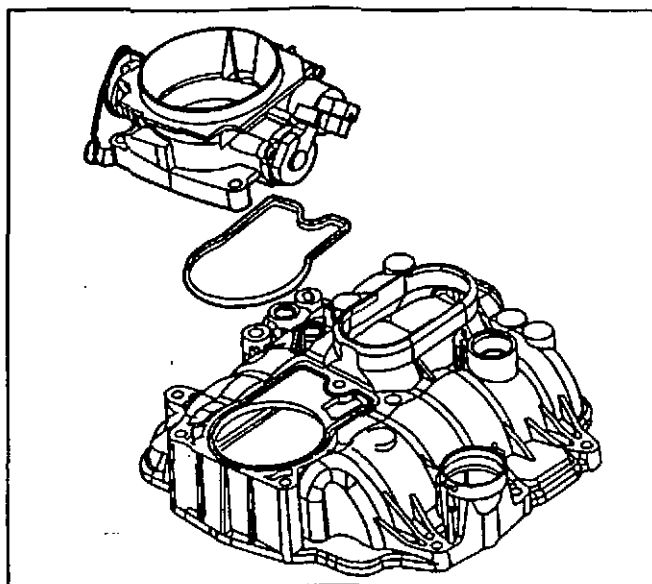
334516



334517

(53 lb in).

17. Install a NEW throttle body gasket into the groove in the upper intake manifold.
18. Install the throttle body onto the upper intake manifold.

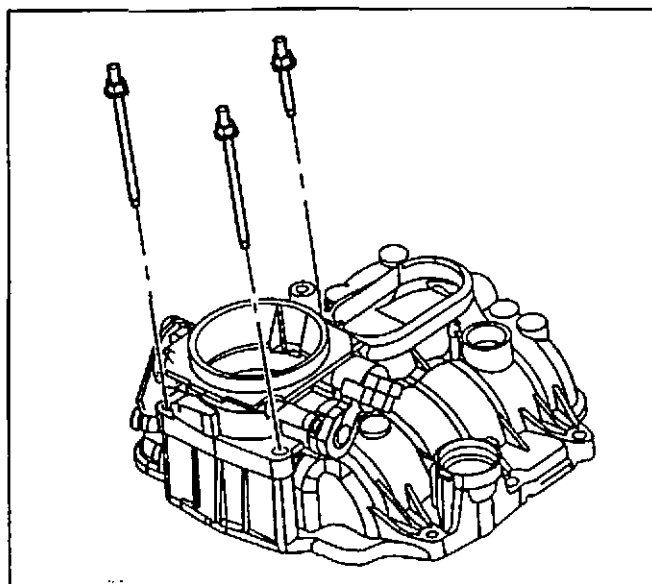


12853

19. Install the throttle body attaching studs.

Tighten

Tighten the throttle body attaching studs to 9 N·m (80 lb in).

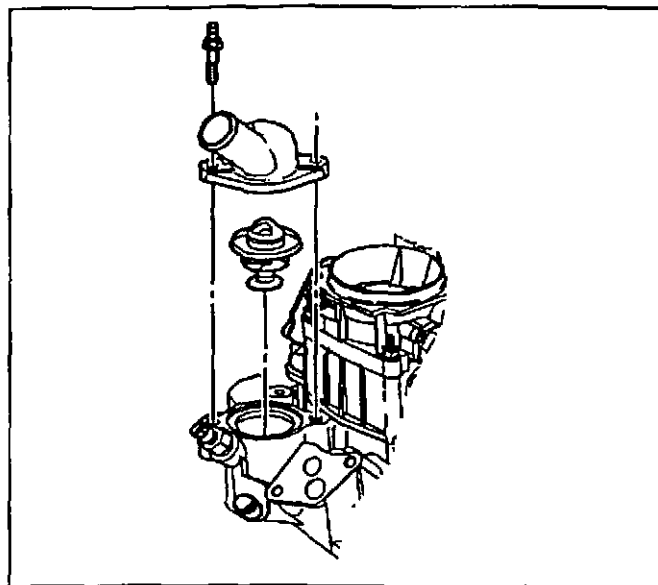


12852

20. Install the engine coolant thermostat.
21. Install the water outlet.
22. Install the water outlet studs.

Tighten

Tighten the water outlet studs to 25 N·m (18 lb ft).



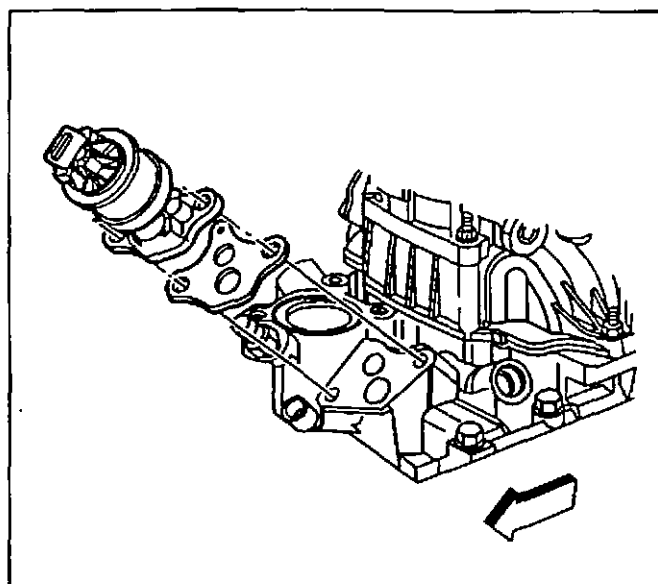
48323

Important: The EGR valve must be installed in the original orientation.

23. Install a NEW EGR valve gasket and the EGR valve.
24. Install the EGR valve bolts.

Tighten

- 24.1. Tighten the EGR valve bolts on the first pass to 7 N·m (62 lb in).
- 24.2. Tighten the EGR valve bolts on the final pass to 30 N·m (22 lb ft).

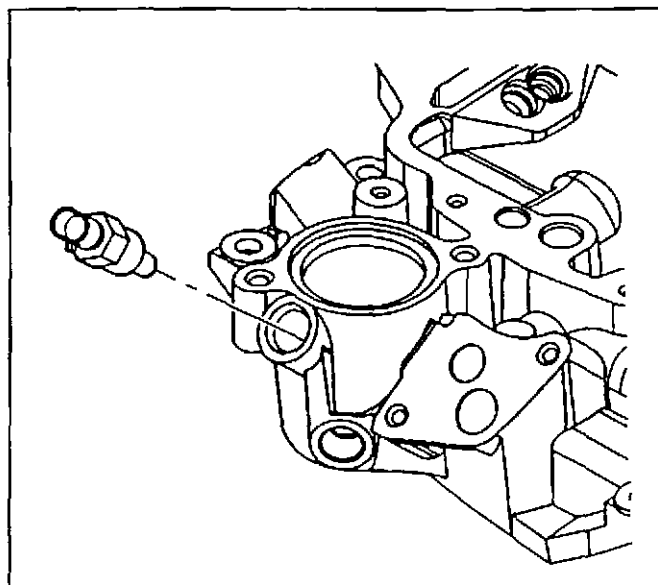


22078

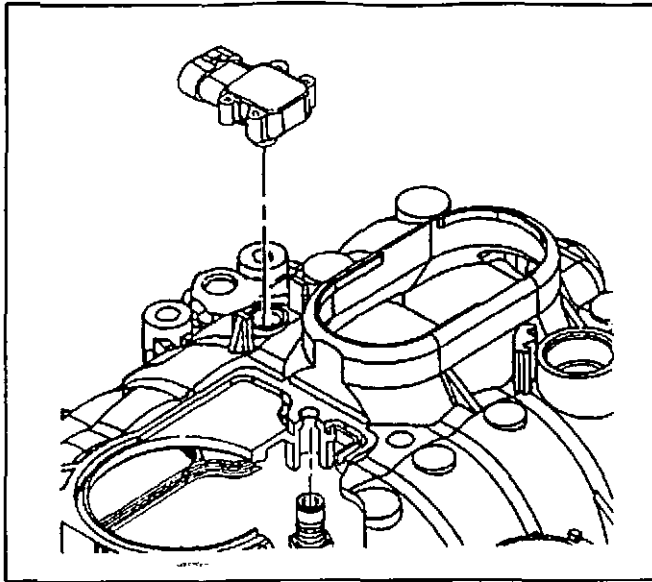
25. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine coolant temperature (ECT) sensor (if applicable).
26. Install the ECT sensor into the front for the lower intake manifold (if applicable).

Tighten

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

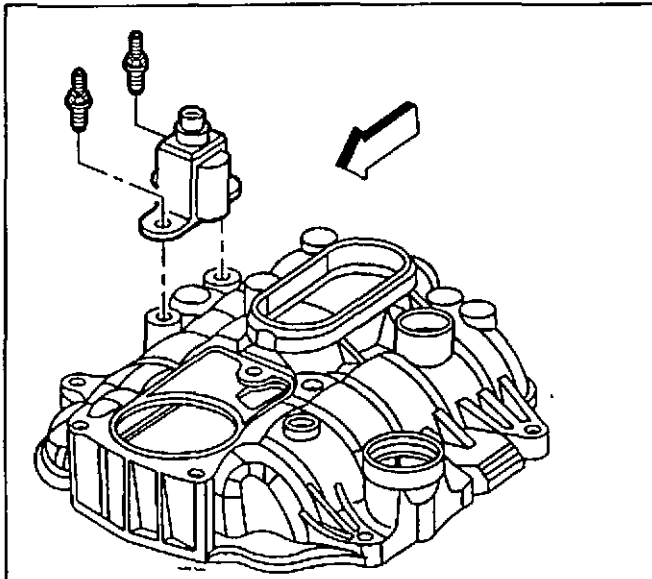


10932



31753

27. Install a NEW MAP sensor seal onto the MAP sensor.
28. Apply a small amount (1 drop) of clean engine oil to the MAP sensor seal.
29. Install the MAP sensor.

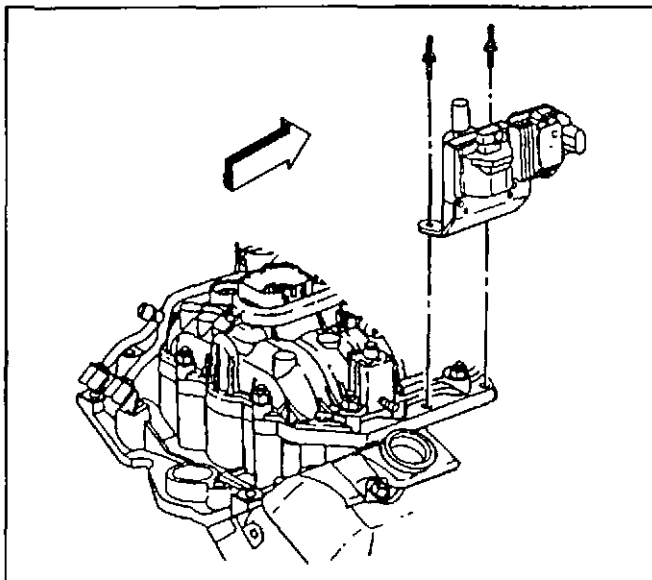


334511

30. Install the evaporative emission (EVAP) canister purge solenoid valve and studs.

Tighten

Tighten the EVAP canister purge solenoid valve studs to 12 N·m (106 lb in).



31466

31. Install the ignition coil and studs.

Tighten

Tighten the ignition coil studs to 12 N·m (106 lb in).

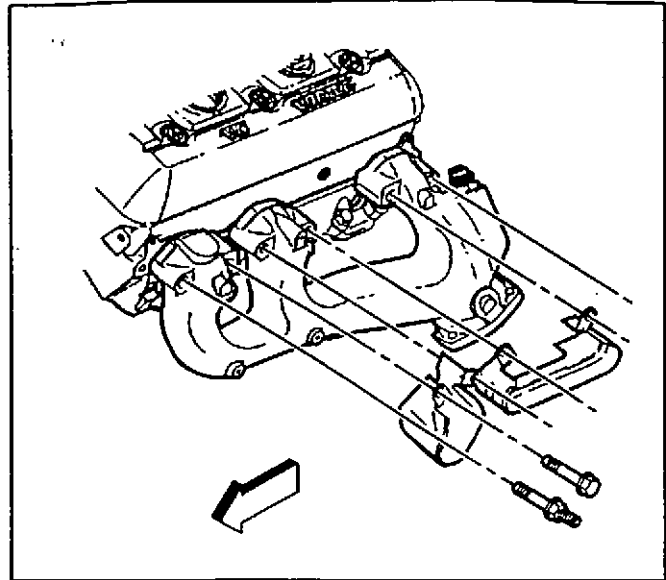
SIE-ID - 358598

Exhaust Manifold Clean and Inspect

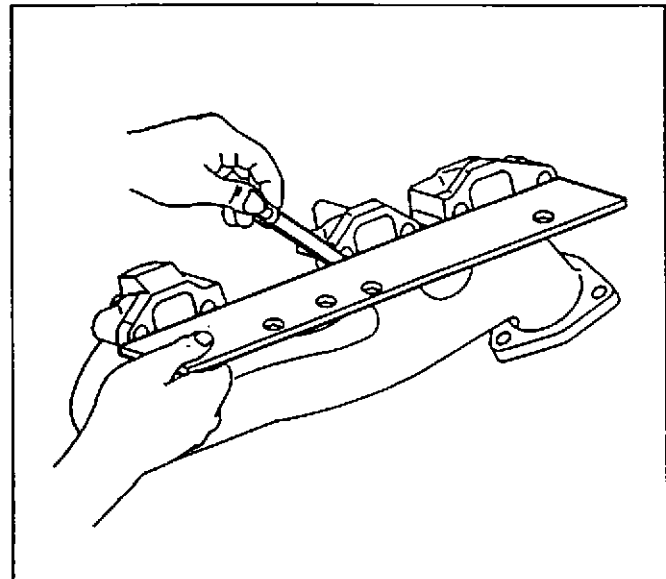
Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Clean the exhaust manifolds in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the exhaust manifolds for the following:
 - Damage to the gasket sealing surfaces
 - Damage to the exhaust gas recirculation (EGR) pipe fitting (left manifold)
 - Damage to the take down studs
 - Restrictions within exhaust passages
 - Broken or damaged exhaust manifold heat shields (if applicable)
 - Broken or damaged exhaust manifold
4. Measure the alignment or surface flatness of the exhaust manifold flanges using a straight edge and a feeler gauge. Refer to *Engine Mechanical Specifications*.

If the surface flatness is not within the specifications, the exhaust manifold is warped and must be replaced.



188045



334528

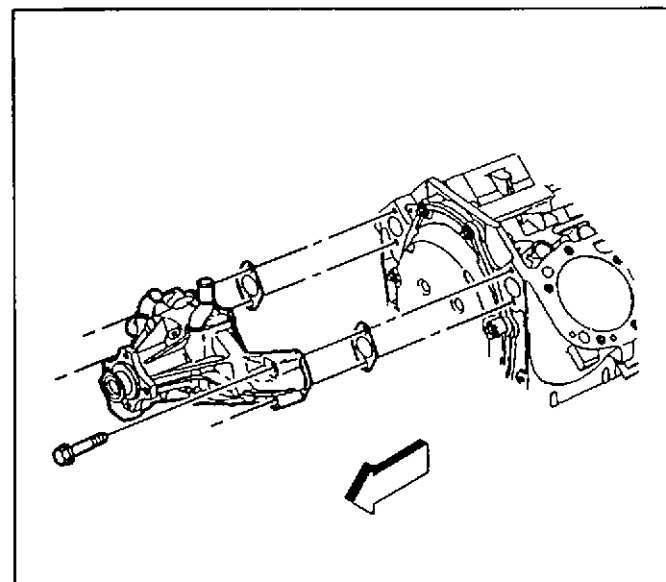
SIE-ID - 358600

Water Pump Clean and Inspect

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump for the following:
 - Gasket sealing surfaces for excessive scratches or gouging
 - Restrictions within the internal coolant passages
 - Excessive side-to-side play in the pulley shaft
 - Leakage at the water inlet pipe or housing rear cover gasket
 - Leakage at the water pump-vent hole

A stain around the vent hole is acceptable. If



188054

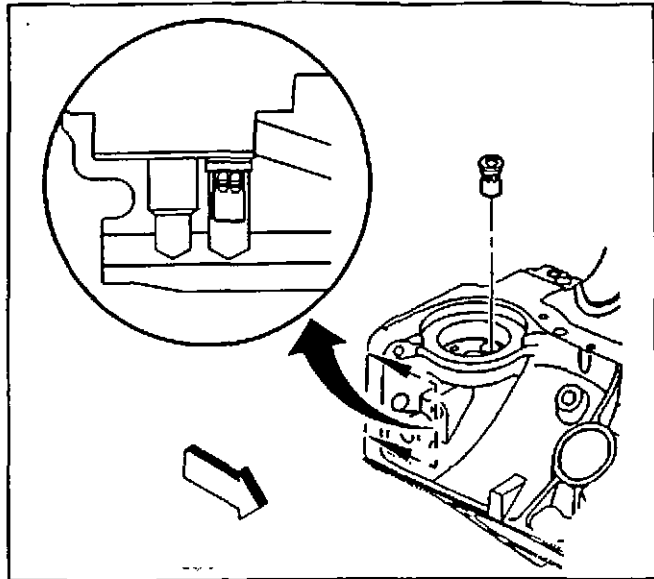
leakage occurred (dripping) with the engine operating and the cooling system pressurized, then replace the water pump.

- Damaged bolt hole threads

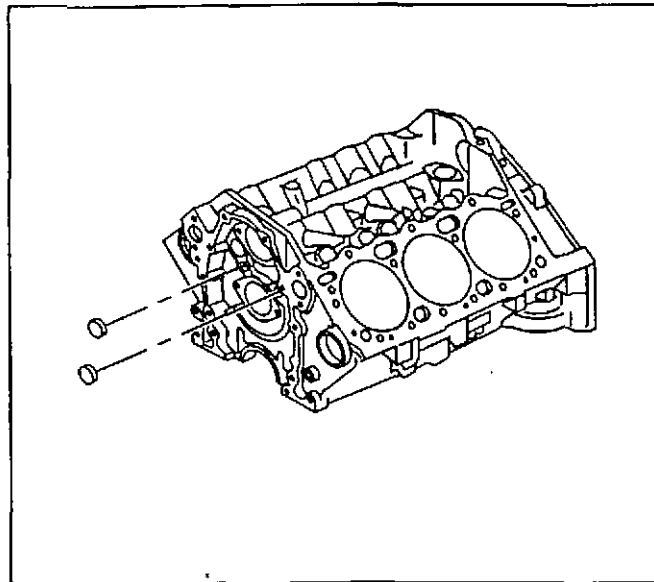
SIE-ID - 43122

Service Prior to Assembly

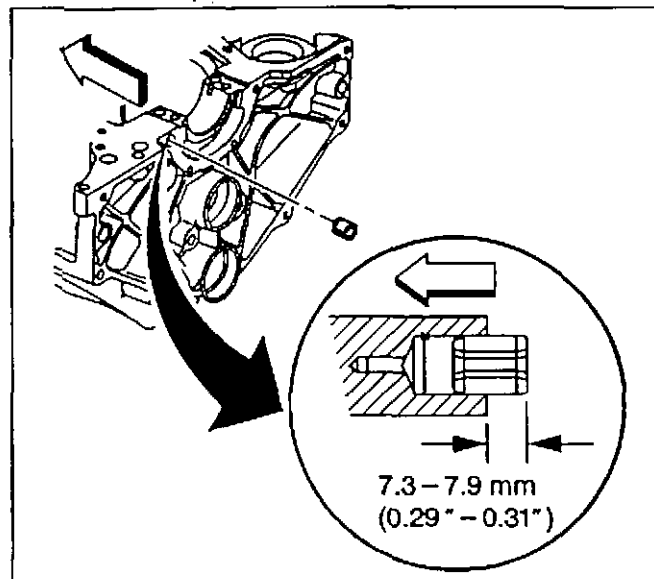
- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are re-installed into an engine,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



188023



5270



334546

SIE-ID - 358602

Engine Block Plug Installation**Tools Required**

J 41712 Oil Pressure Switch Socket

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

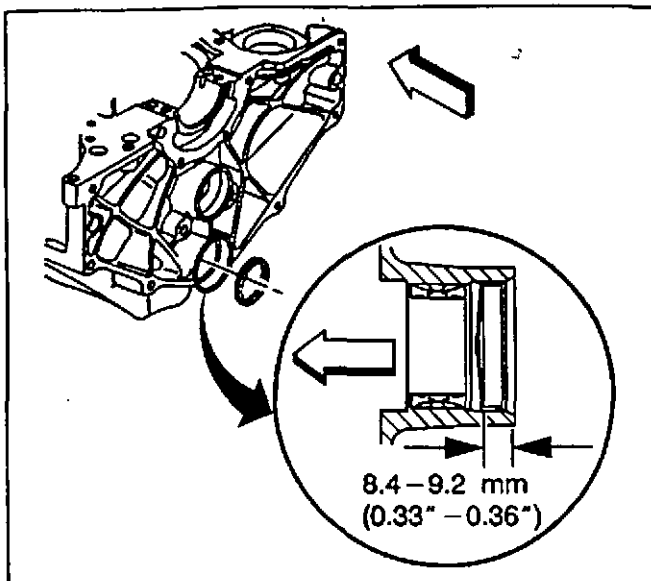
1. Install a NEW oil filter bypass valve.
 - 1.1. Install the oil filter bypass valve into the oil gallery bore until slightly below flush with the surface of the engine block.
 - 1.2. Using a pointed punch, stake the engine block area around the oil filter bypass valve.
Stake in 3 locations 120 degrees apart.

2. Apply sealant GM P/N 12346004 or equivalent to the outside diameter of the NEW front engine oil gallery plugs.
3. Install the NEW front engine block oil gallery plugs.

A properly installed front engine oil gallery plug must be installed slightly below flush with the front face of the engine block.

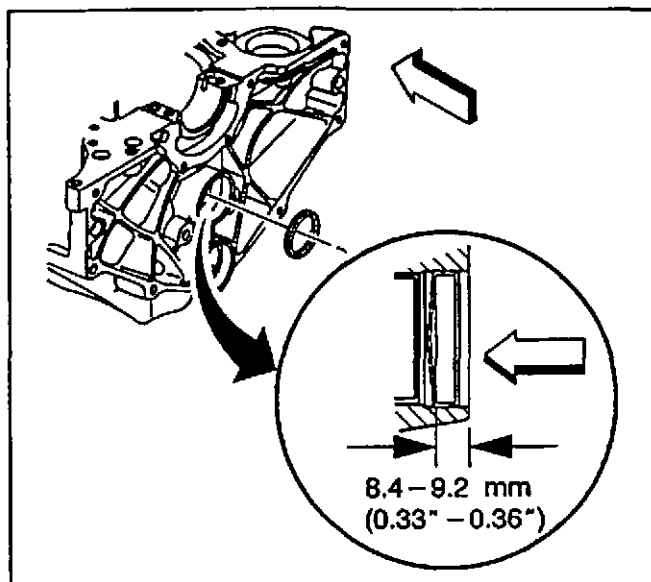
4. Install the spring type S pin (crankshaft rear oil seal housing locator) (if required).

5. Apply sealant GM P/N 12346004 or equivalent to the outside diameter of the NEW expansion cup plug (balance rear bearing hole).
6. Install the NEW expansion cup plug (balance shaft rear bearing hole).



334540

7. Apply sealant GM P/N 12346004 or equivalent to the outside diameter of the NEW expansion cup plug (camshaft rear bearing hole).
8. Install the NEW expansion cup plug (camshaft rear bearing hole).



334543

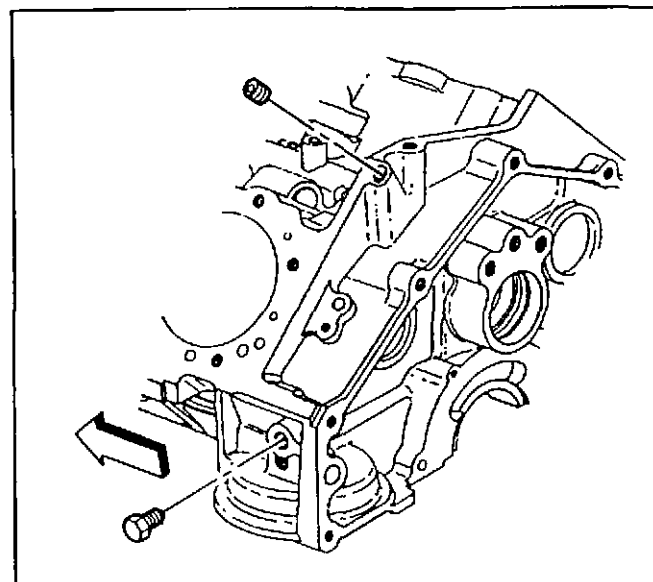
9. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block right rear oil gallery plug, the engine block left rear oil gallery plug, and the engine block left side oil gallery plug.

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

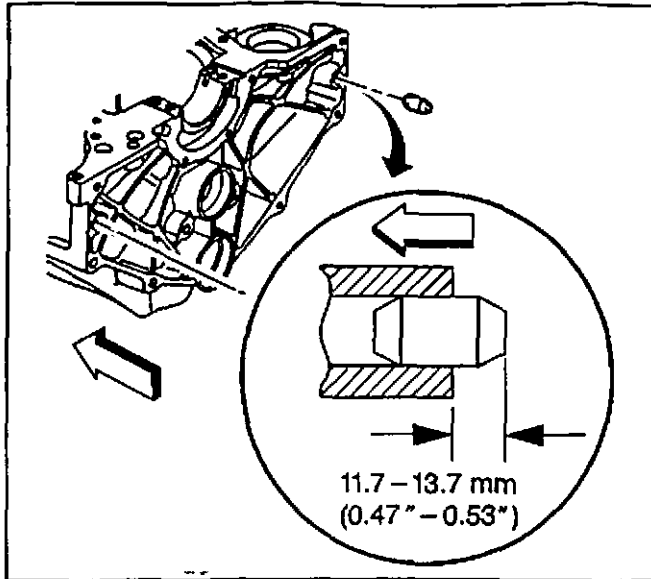
10. Install the engine block right rear oil gallery plug, the engine block left rear oil gallery plug, and the engine block left side oil gallery plug.

Tighten

- Tighten the engine block left side oil gallery plug and the engine block right rear oil gallery plug to 20 N.m (15 lb ft).
- Tighten the engine block left rear oil gallery plug 30 N.m (22 lb ft).

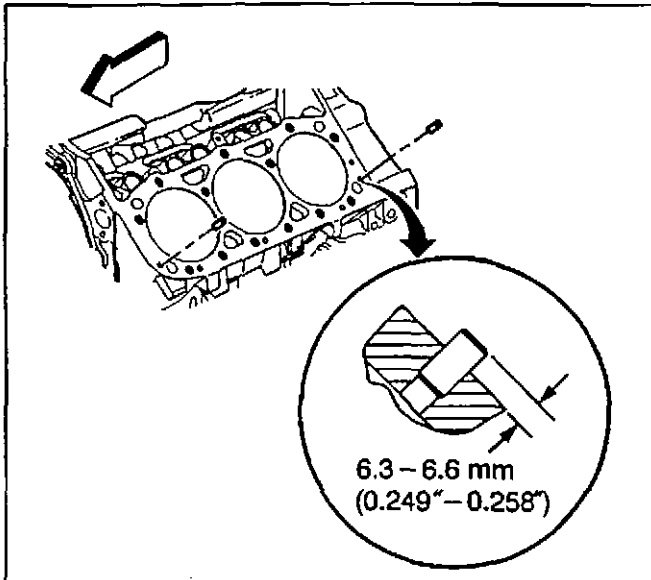


182841



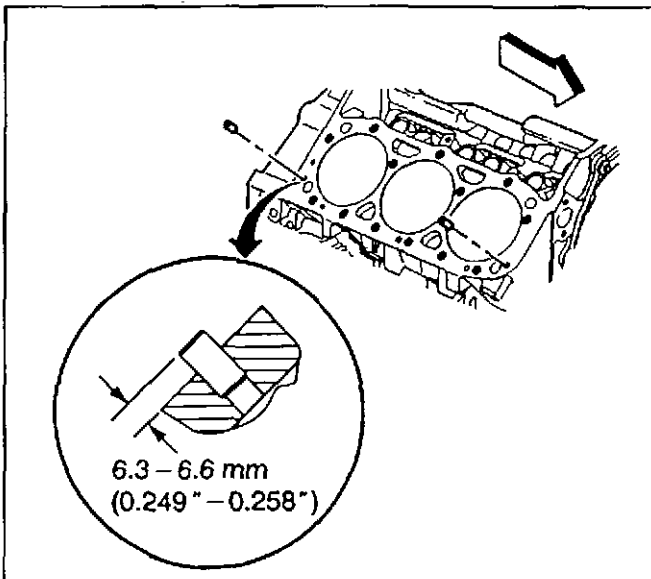
334548

11. Install the dowel straight pins (transmission locator) (if required).



334303

12. Install the left side dowel pins (cylinder head locator) (if required).



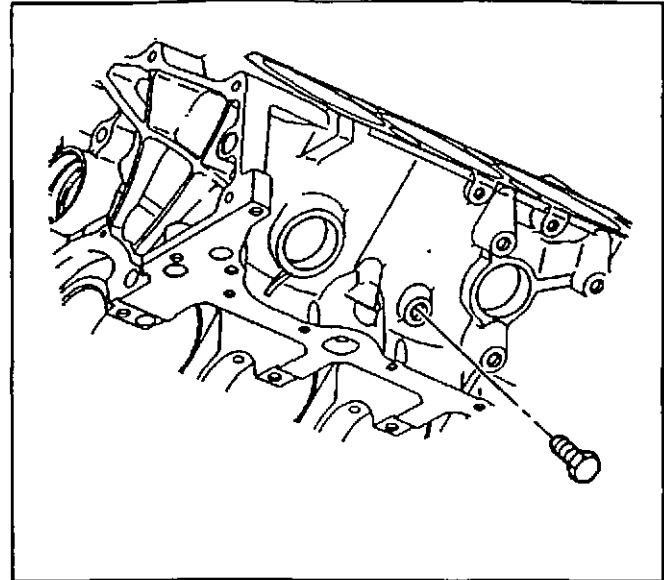
334314

13. Install the right side dowel pins (cylinder head locator) (if required).

14. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block coolant drain hole plug.

15. Install the engine block coolant drain hole plug.
Tighten

Tighten the engine block coolant hole plug to 20 N.m (15 lb ft).



188052

16. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine oil pressure sensor fitting.

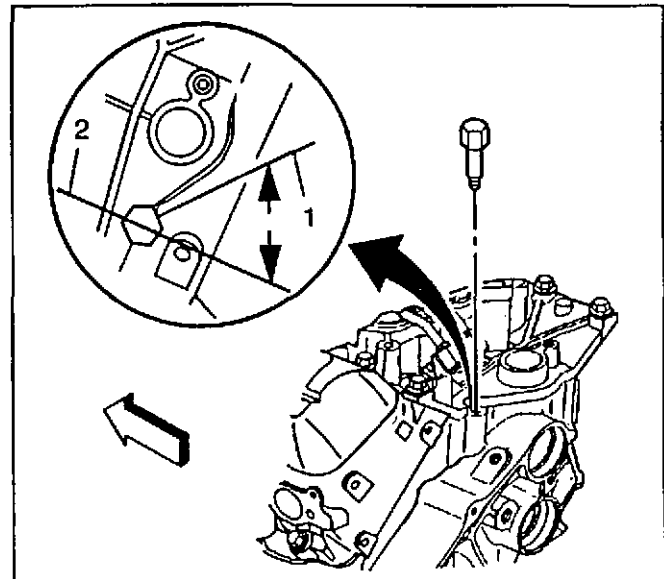
Important: Do not loosen the engine oil pressure fitting after the initial torque has been obtained.

17. Install the engine oil pressure sensor fitting.
Tighten

Tighten the engine oil pressure sensor fitting to 15 N.m (11 lb ft).

Important: Do not rotate the engine oil pressure fitting clockwise more than 359 degrees after the initial torque has been obtained.

18. Rotate the engine oil pressure sensor fitting clockwise to the proper position (1), 50 degrees from the centerline (2).



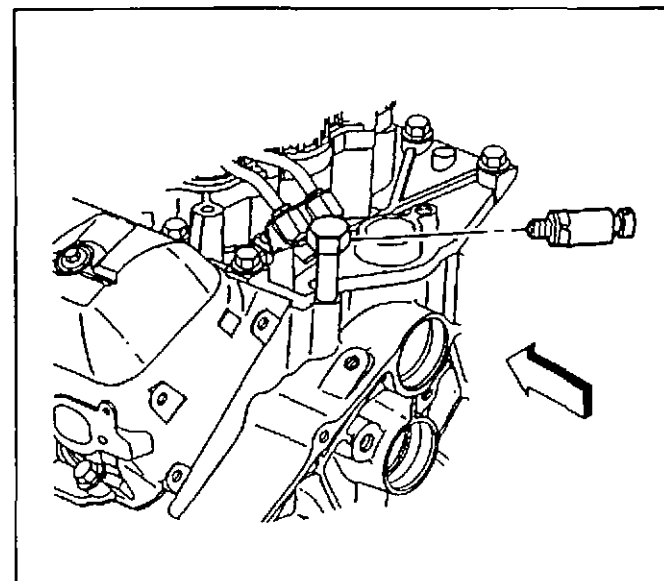
334549

19. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine oil pressure gauge sensor.

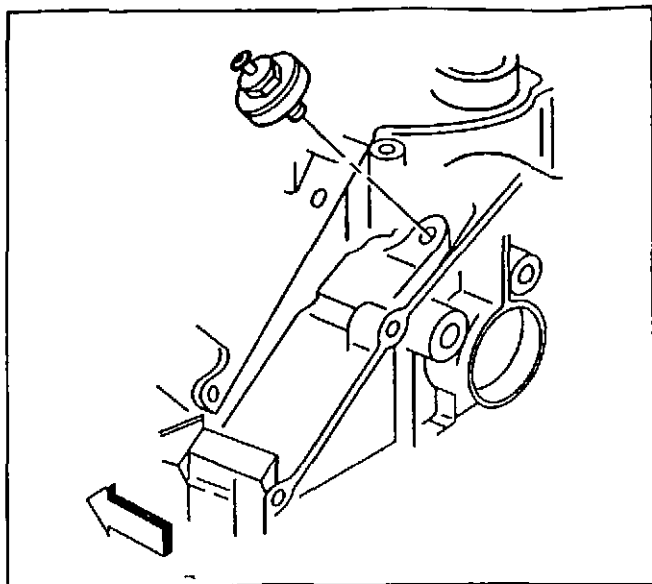
20. Install the engine oil pressure gauge sensor using the J 41712.

Tighten

Tighten the engine oil pressure gauge sensor to 30 N.m (22 lb ft).



188018



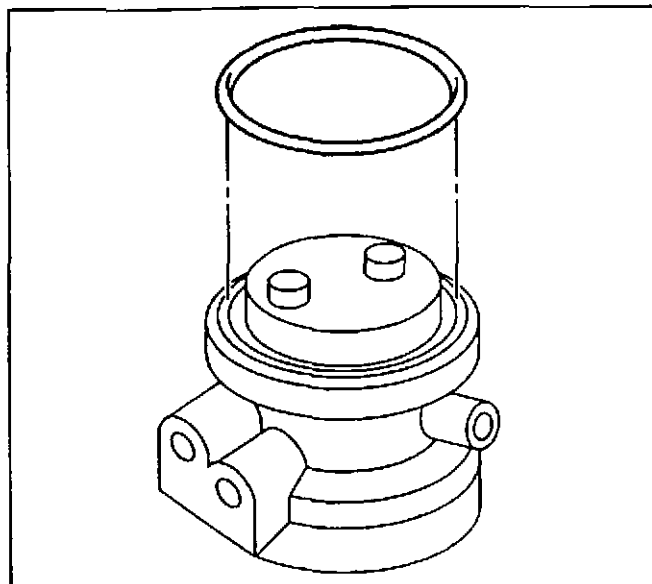
10793

21. Apply sealant GM P/N 12346004 or equivalent to the threads of the knock sensor.

22. Install the knock sensor.

Tighten

Tighten the knock sensor to 20 N.m (15 lb ft).

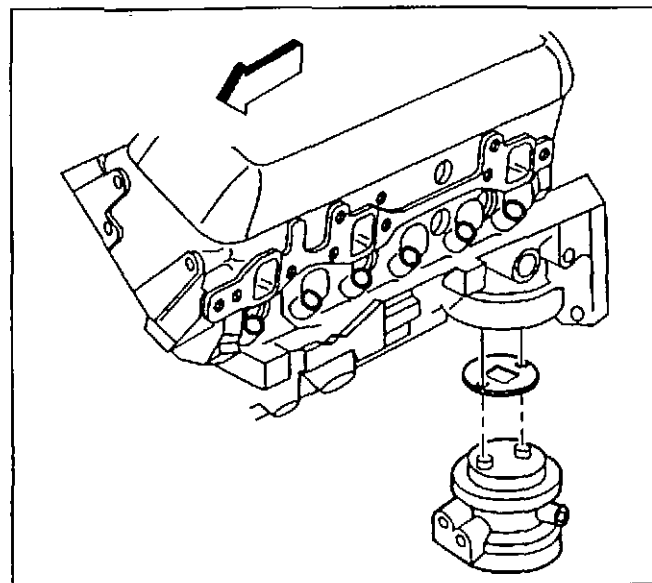


4556

SIE-ID - 42963

Oil Filter Adapter and Valve Assembly Installation

1. Install the NEW oil filter adapter seal (O-ring) into the groove in the oil filter adapter.



4555

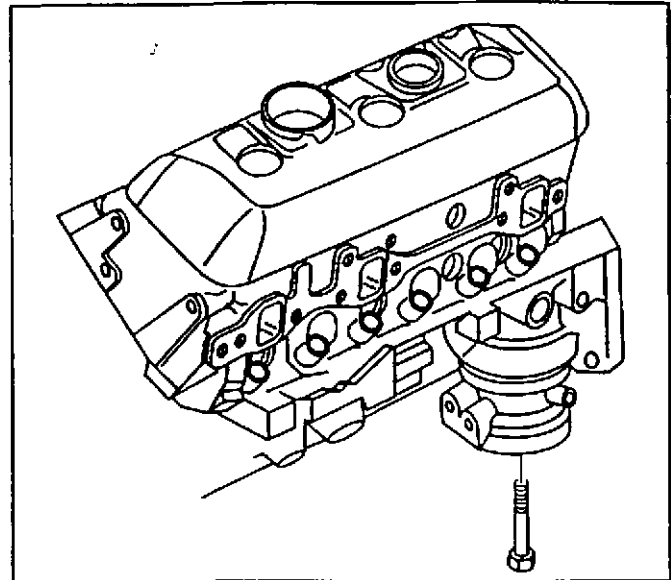
2. Install the oil filter adapter and NEW oil filter adapter gasket.

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

3. Install the oil filter adapter bolts.

Tighten

Tighten the oil filter adapter bolts to 21 N.m (15 lb ft).



4554

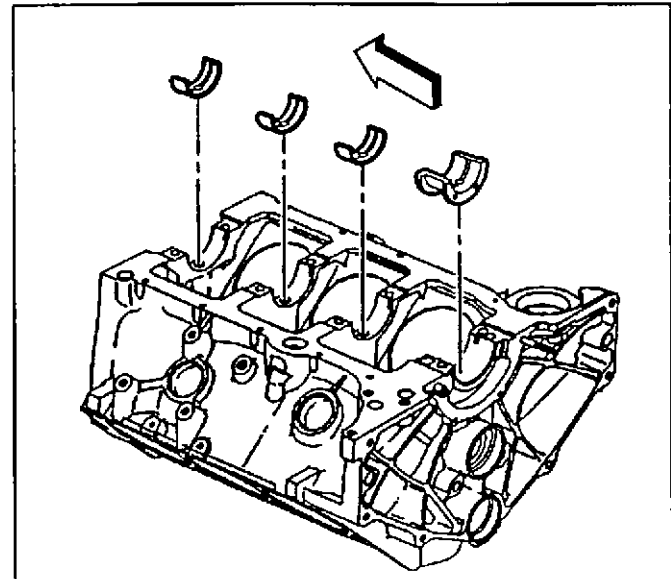
SIE-ID - 358604

Crankshaft and Bearings Installation

Tools Required

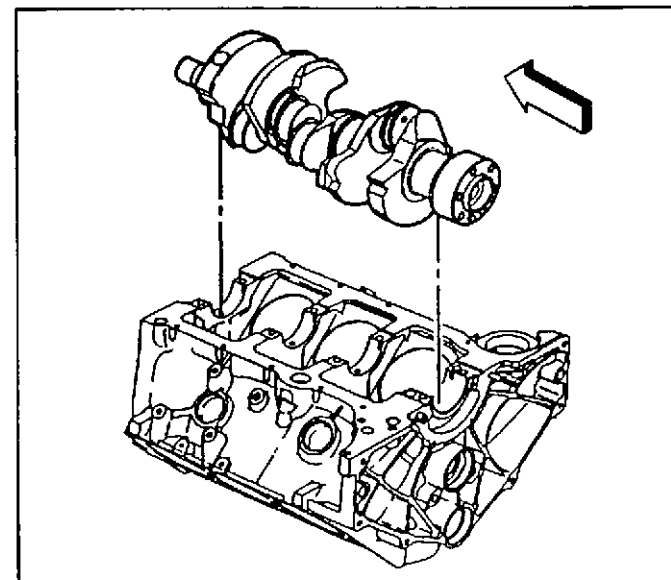
J 36660 Electronic Torque Angle Meter

1. Install the crankshaft bearings into the engine block.
2. Apply clean engine oil to the crankshaft bearings.

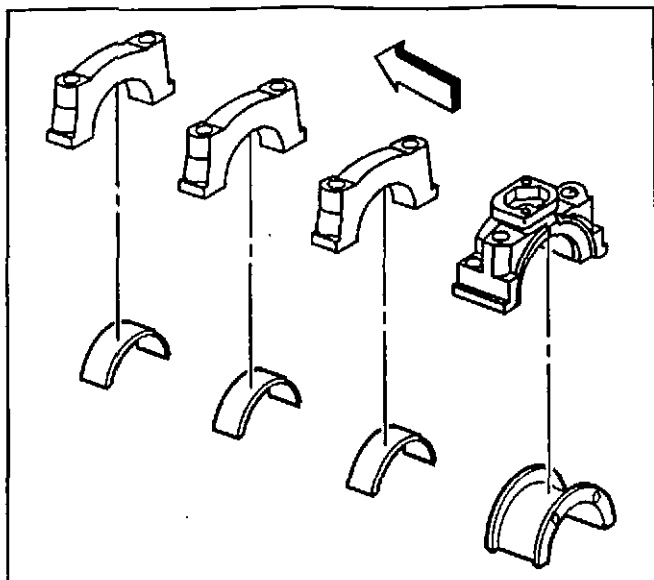


334336

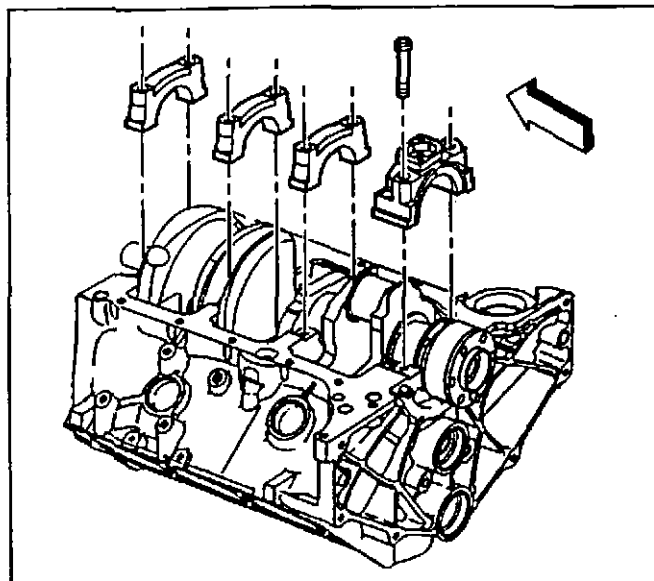
3. Apply clean engine oil to the crankshaft bearing journals.
4. Install the crankshaft.



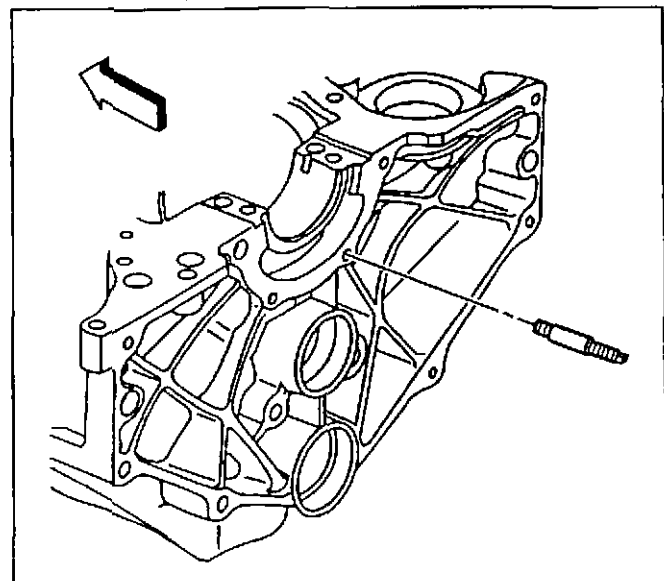
334336



334342



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334326

5. Install the crankshaft bearings into the crankshaft bearing caps.
6. Apply clean engine oil to the crankshaft bearings.

7. Install the crankshaft bearing caps in the original position and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.

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

8. Install the crankshaft bearing cap bolts.
9. Thrust the crankshaft rearward in order to set and align the crankshaft thrust bearings and the crankshaft bearing caps.
10. Thrust the crankshaft forward in order to align the rear faces of the crankshaft thrust bearings.
11. Tighten the crankshaft bearing cap bolts.

Tighten

- 11.1. Tighten the crankshaft bearing cap bolts on the first pass to 20 N·m (15 lb ft).
- 11.2. Tighten the crankshaft bearing cap bolts on the final pass an additional 73 degrees using the J 36660.

SIE-ID - 358606

Crankshaft Rear Oil Seal and Housing Installation

Tools Required

J 35621-B Rear Main Seal Installer

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

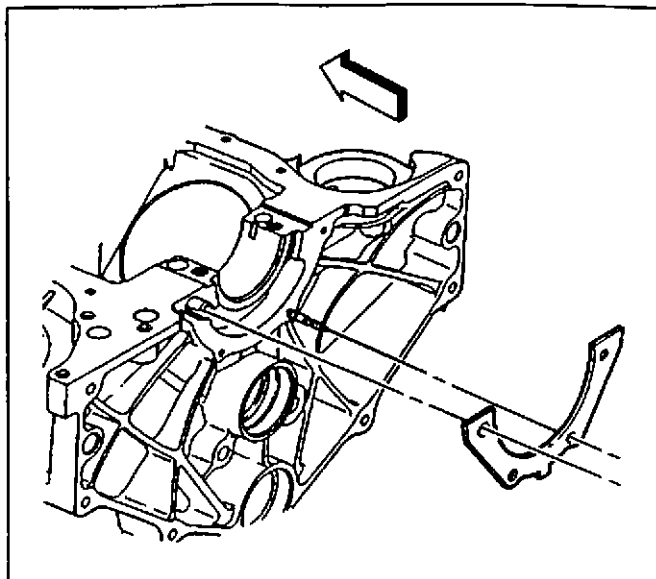
1. Install the crankshaft rear oil seal housing retainer stud.

Tighten

Tighten the crankshaft rear oil seal housing retainer stud to 6 N·m (53 lb in).

Important: Always use a NEW crankshaft rear oil seal housing gasket when installing the crankshaft rear oil seal housing.

2. Install the NEW crankshaft rear oil seal housing gasket.

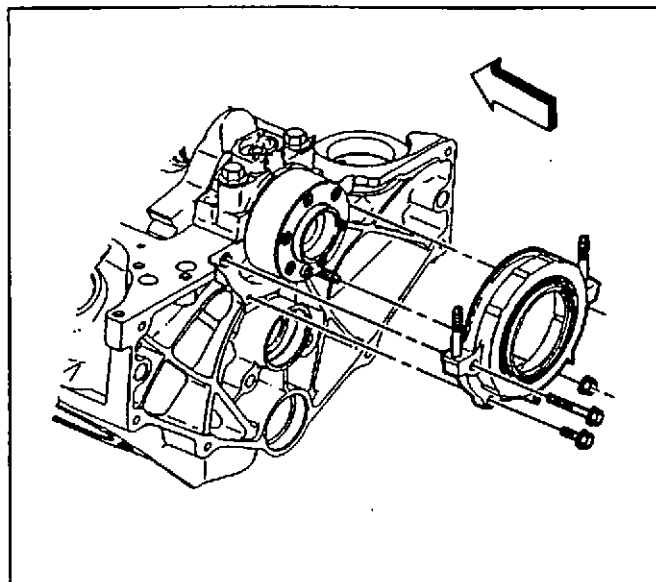


334319

3. Install the crankshaft rear oil housing onto the crankshaft rear oil seal housing retainer stud.
4. Install the crankshaft rear oil seal housing nut and bolts.

Tighten

Tighten the crankshaft rear oil seal housing nut and bolts to 12 N·m (106 lb in).

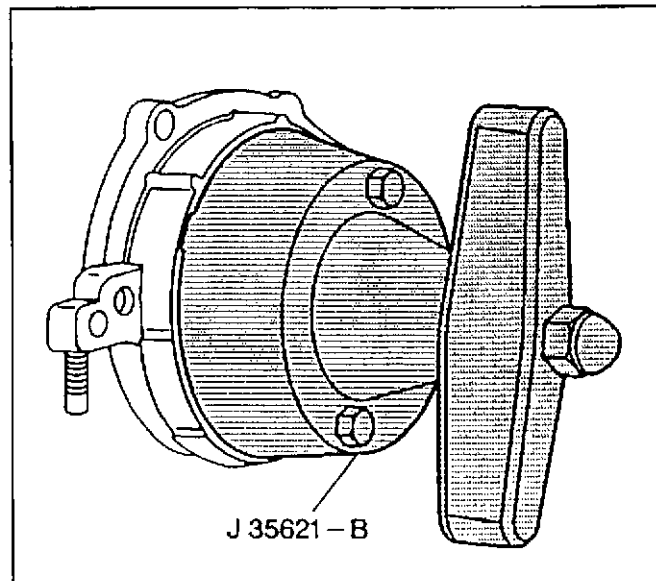


334317

5. Apply a small amount (2 to 3 drops) of clean engine oil to the bore of the crankshaft rear oil seal housing.
6. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the engine flywheel pilot flange.
7. Apply a small amount (1 drop) of clean engine oil to the outside diameter of the flywheel locator pin.
8. Apply a small amount (2 to 3 drops) of clean engine oil to the crankshaft seal surface.
9. Inspect the J 35621-B flange for imperfections that may damage the crankshaft rear oil seal. Minor imperfections may be removed with a fine grade emery cloth.

Important: DO NOT allow oil or any other lubricants to contact the seal lip surface of the crankshaft rear oil seal.

10. Remove the sleeve from the crankshaft rear oil



334550

seal.

11. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the crankshaft rear oil seal.
12. Install the crankshaft rear oil seal onto the *J 35621-B*.
13. Install the *J 35621-B* onto the rear of the crankshaft and hand tighten the tool bolts until snug.

Notice: *SIO-ID - 348112* Proper alignment of the crankshaft rear oil seal is critical. Install the crankshaft rear oil seal near to flush and square to the crankshaft rear oil seal housing. Failing to do so may cause the crankshaft rear oil seal or the crankshaft rear oil seal installation tool to fail.

14. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing.
 - 14.1. Turn the *J 35621-B* wing nut clockwise until the crankshaft rear oil seal is installed near to flush and square to the crankshaft rear oil seal housing.
Increased resistance will be felt when the crankshaft rear oil seal has reached the bottom of the crankshaft rear oil seal housing bore.
 - 14.2. Turn the *J 35621-B* wing nut counterclockwise to release the *J 35621-B* from the crankshaft rear oil seal.
15. Remove the *J 35621-B* from the crankshaft.
16. Wipe off any excess engine oil with a clean rag.

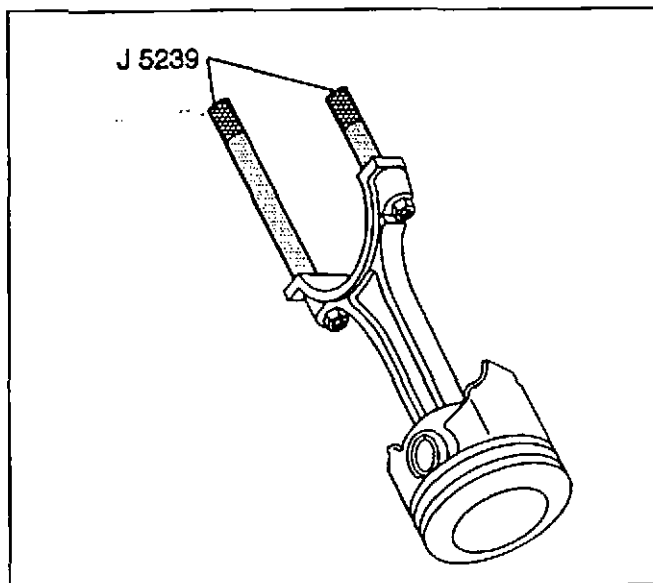
SIE-ID - 24233

Piston, Connecting Rod, and Bearing Installation

Tools Required

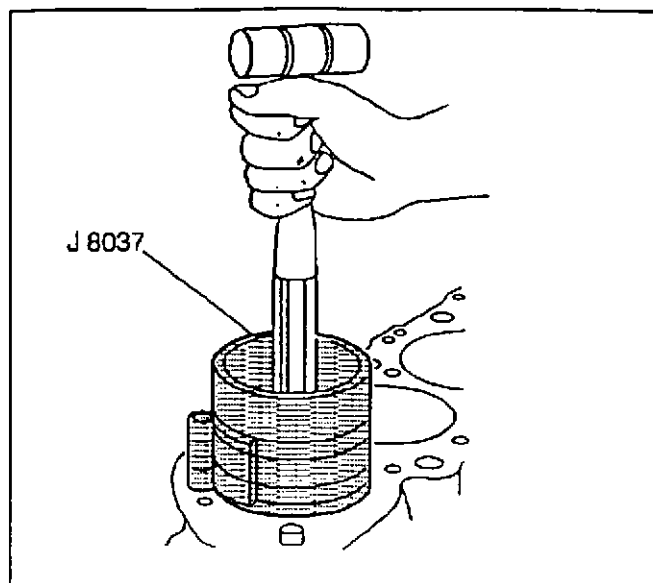
- *J 5239* Connecting Rod Bolt Guide Set
- *J 8037* Ring Compressor
- *J 36660* Electronic Torque Angle Meter

1. Apply clean engine oil to the following components:
 - The piston
 - The piston rings
 - The cylinder bore
 - The bearing surfaces
2. Install the *J 5239* onto the connecting rod bolts.



387765

3. Install the *J 8037* onto the piston and compress the piston rings.



5159

4. Install the piston and connecting rod assembly into the proper cylinder.

- The mark on the top of the piston must face the front of the engine block.
- When assembled, the flanges on the connecting rod and connecting rod cap should face to the front of the engine block on the left bank, and to the rear of the engine block on the right bank.

5. Use the *J 8037* and the *J 5239* and lightly tap the top of the piston with a wooden hammer handle.

- Hold the *J 8037* firmly against the engine block until all of the piston rings have entered the cylinder bore.
- Use the *J 5239* in order to guide the connecting rod onto the crankshaft journal.

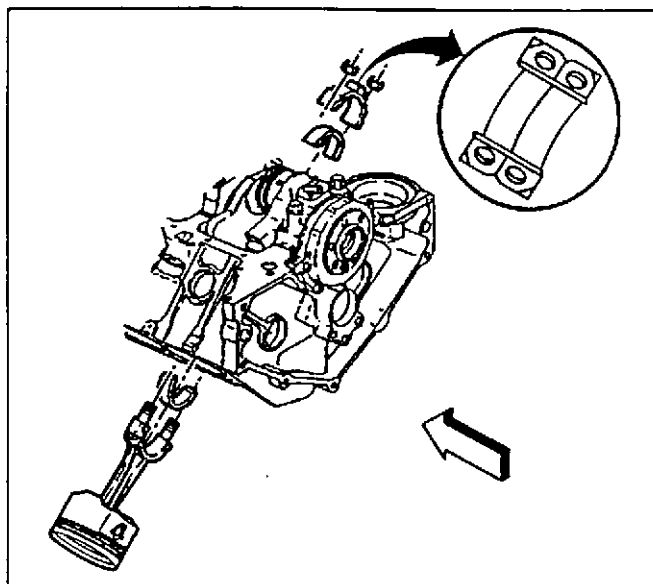
6. Remove the *J 5239*.

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

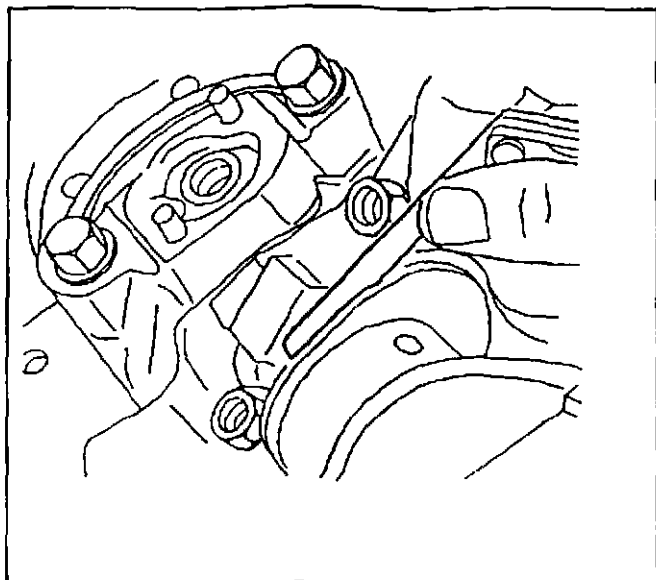
7. Install the connecting rod cap and nuts.

Tighten

- 7.1. Tighten the nuts evenly on the first pass to 27 N.m (20 lb ft).
- 7.2. Use the *J 36660* in order to tighten the nuts on the final pass an additional 70 degrees.

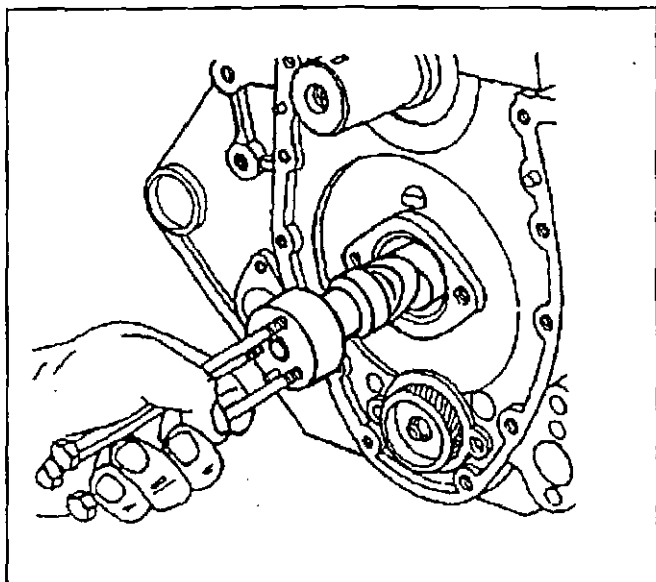


39124



5163

8. After the piston and connecting rod assemblies have been installed, then lightly tap each connecting rod assembly (parallel to the crankpin) in order to ensure that the connecting rods have side clearance.
9. Use a feeler gauge or a dial indicator to measure the connecting rod side clearance between the connecting rod caps. The connecting rod side clearance should be 0.15–0.44 mm (0.006–0.017 in).



5147

S1E-ID - 389625

Camshaft Installation

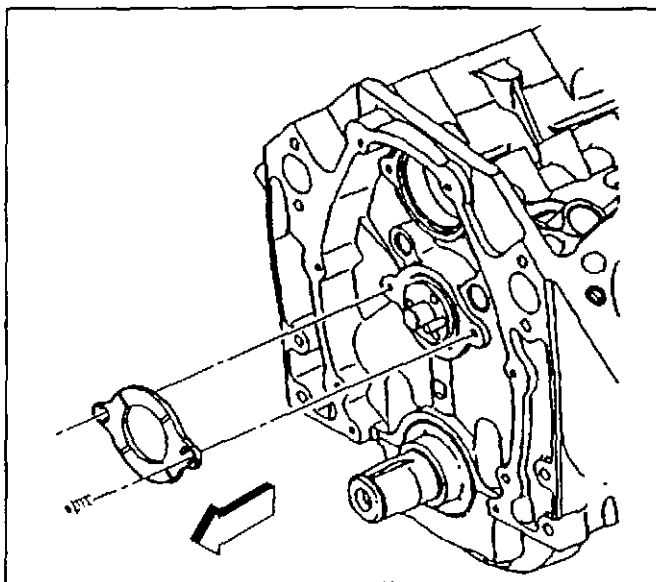
1. Apply clean engine oil GM P/N 12345610 or equivalent, or engine oil supplement GM P/N 1052367 or equivalent to the following components:
 - The engine camshaft lobes
 - The camshaft bearing journals
 - The camshaft bearings
 2. Install the three 5/16–18 x 4.0 in. bolts into the engine camshaft front bolt holes.
- Notice:** S1O-ID - 13833 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.
3. Use the bolts as a handle in order to install the engine camshaft.
 4. Remove the three bolts from the front of the engine camshaft.

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

5. Install the camshaft retainer and bolts.

Tighten

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



188030

SIE-ID - 386494

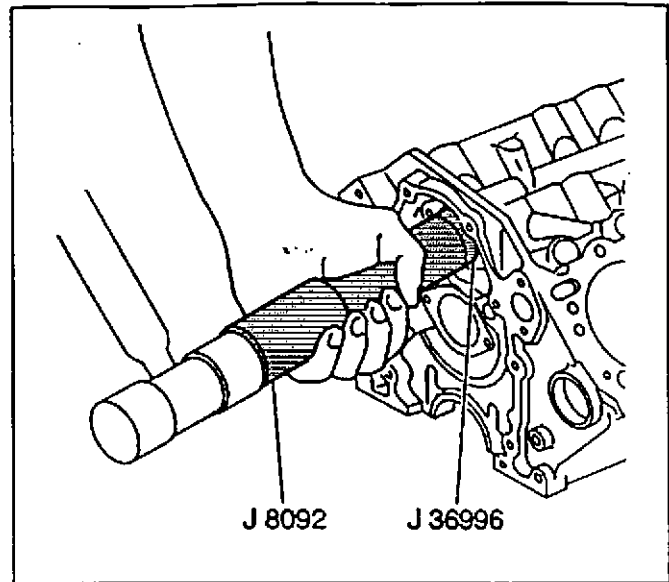
Balance Shaft Installation

Tools Required

- J 8092 Universal Driver Handle
- J 36660 Electronic Torque Angle Meter
- J 36996 Balance Shaft Installer

Important: The balance shaft and the balance shaft front bearing are serviced only as an assembly. Do not remove the balance shaft front bearing from the balance shaft.

1. Apply clean engine oil GM P/N 12345610 or equivalent to the balance shaft front bearing.
2. Use the J 36996 and the J 8092 in order to install the balance shaft.



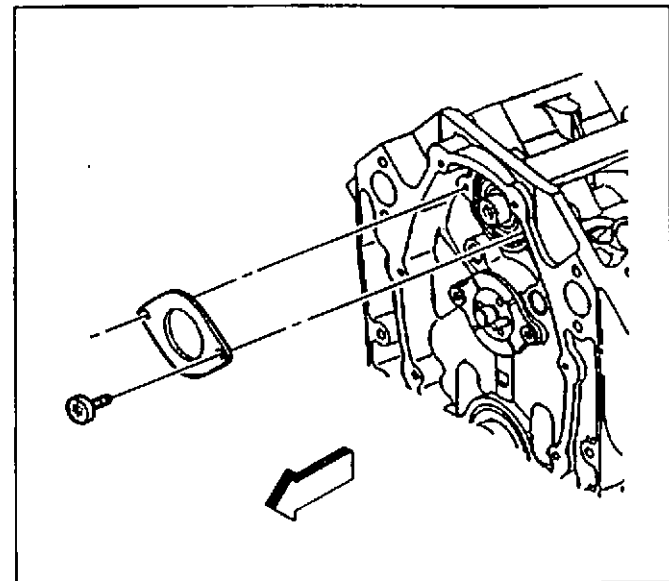
5141

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

3. Install the balance shaft retainer and bolts.

Tighten

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

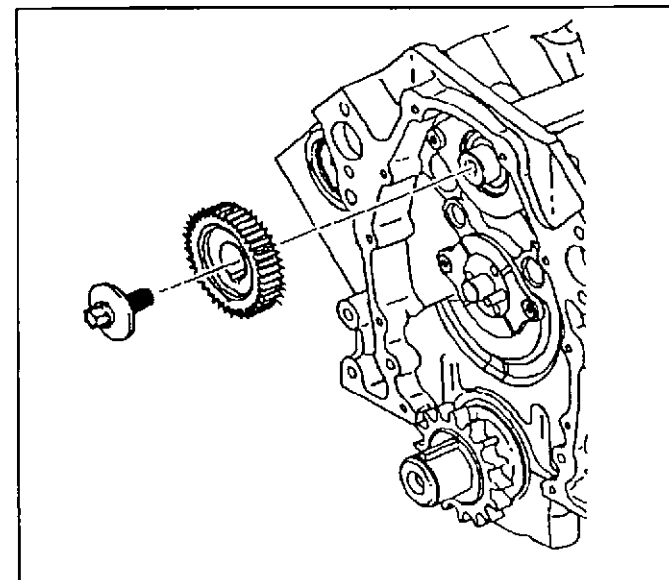


188031

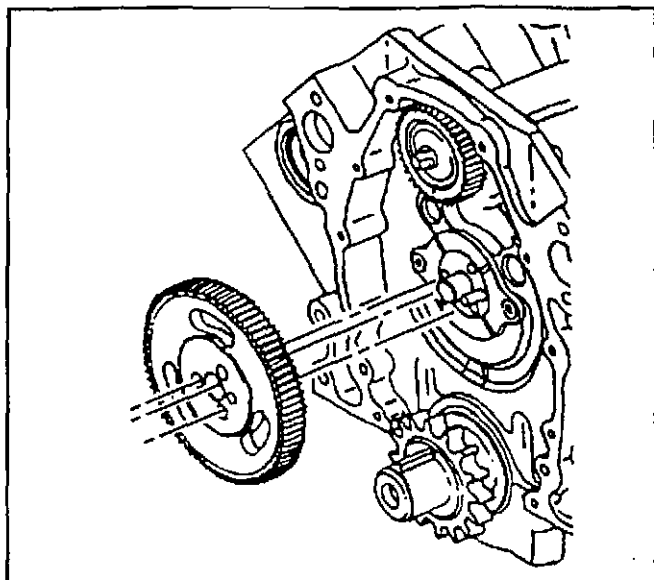
4. Apply threadlock GM P/N 12345382 or equivalent to the threads of the balance shaft driven gear bolt.
5. Install the balance shaft driven gear and bolt.

Tighten

- 5.1. Tighten the balance shaft driven gear bolt on the first pass to 20 N.m (15 lb ft).
- 5.2. Tighten the balance shaft driven gear bolt on the final pass using the J 36660 an additional 35 degrees.
6. Rotate the balance shaft by hand in order to ensure that there is clearance between the balance shaft and the valve lifter pushrod guide. If the balance shaft does not rotate freely, check to ensure that the retaining ring on the balance shaft front bearing is seated on the case.

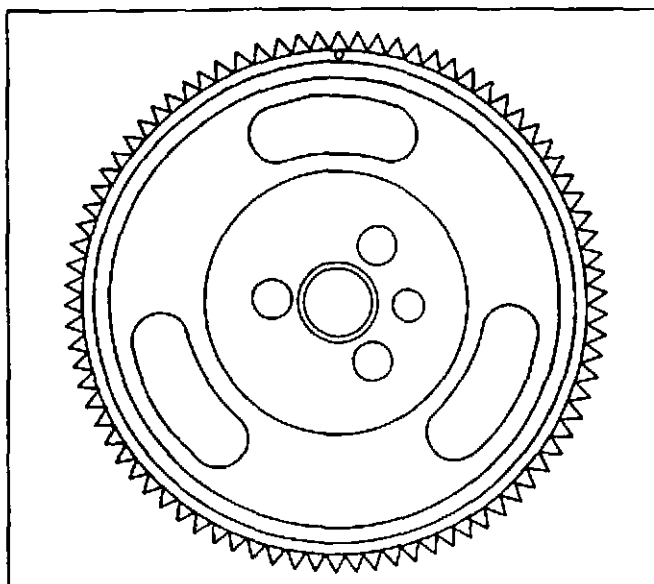


5136



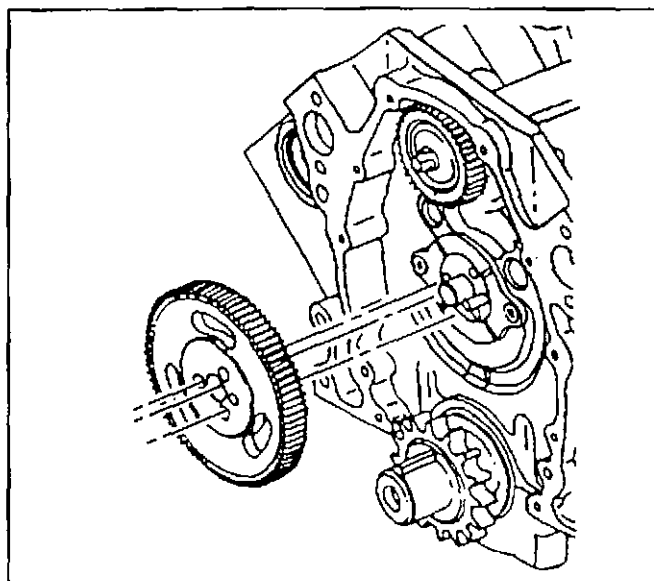
9847

7. Install the balance shaft drive gear. DO NOT install the camshaft sprocket bolts at this time.



9848

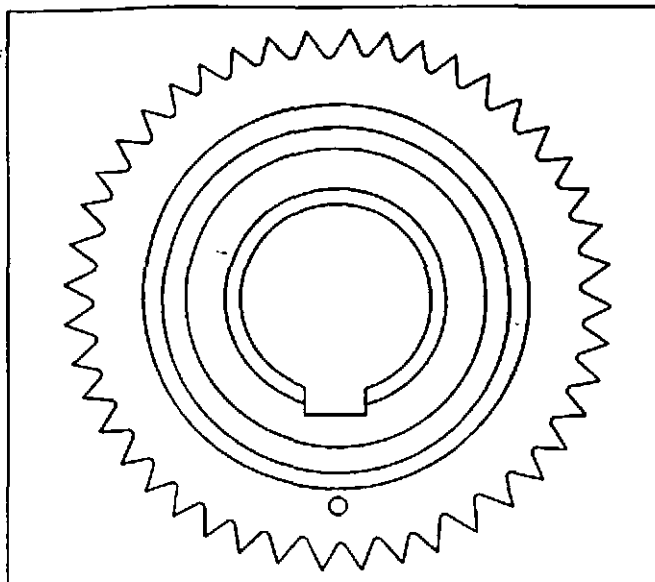
8. Rotate the engine camshaft so that the timing mark on the balance shaft drive gear is in the 12 o'clock position.



9847

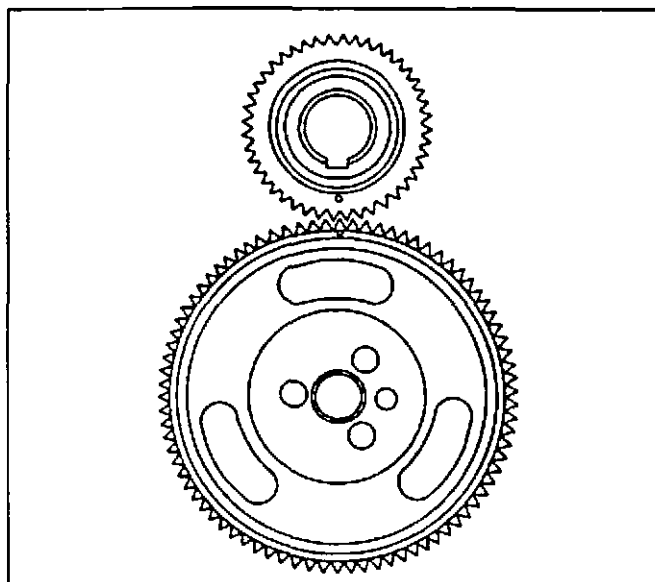
9. Remove the balance shaft drive gear.

10. Rotate the balance shaft so that the timing mark on the balance shaft driven gear is in the 6 o'clock position.



9849

11. Position the balance shaft drive gear onto the engine camshaft.
12. Look to ensure that the balance shaft drive gear and the balance shaft driven gear timing marks are aligned.



5144

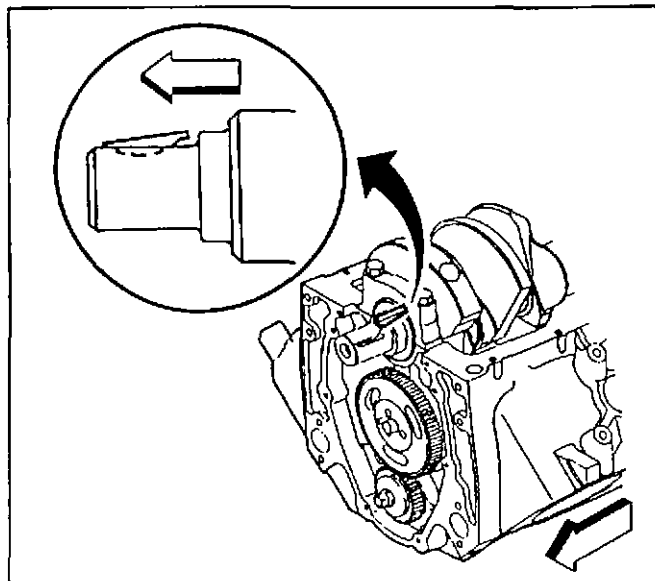
SIE-ID = 358611

Timing Chain and Sprockets Installation

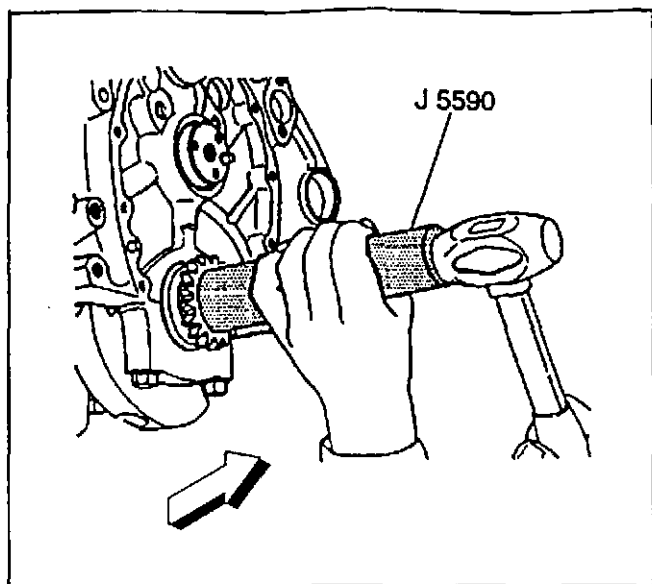
Tools Required

J 5590 Installer

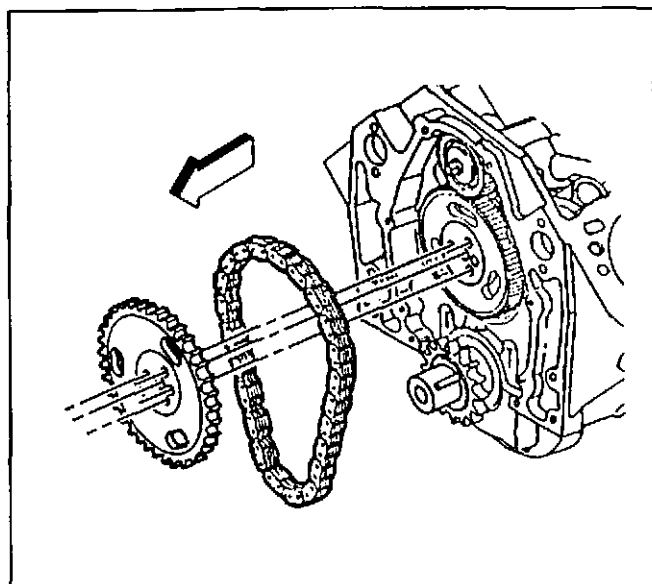
1. Install the crankshaft balancer key into the crankshaft keyway.
The crankshaft balancer key should be parallel to the crankshaft or with a slight incline.



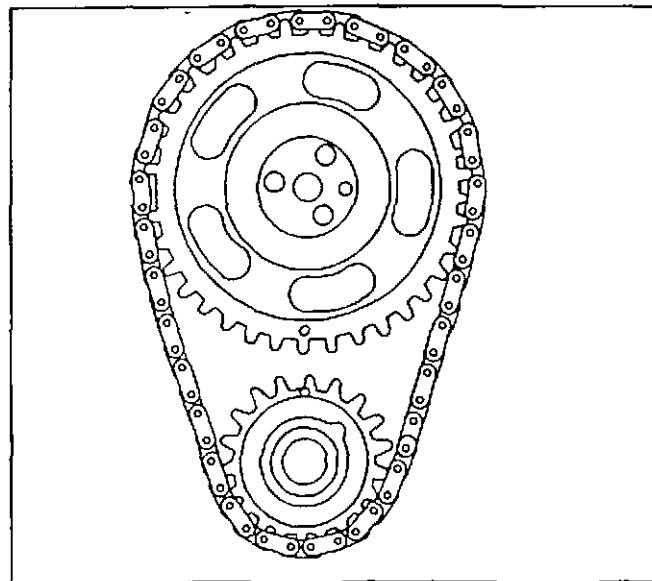
387766



32066



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11503

2. Align the keyway of the crankshaft sprocket with the crankshaft balancer key.

Caution: S10-10 - 5011 *Wear safety glasses in order to avoid eye damage.*

3. Use the J 5590 in order to install the crankshaft sprocket.

4. Rotate the crankshaft until the crankshaft sprocket alignment mark is at the 12 o'clock position.

Important: Install the camshaft sprocket with the alignment mark at the 6 o'clock position.

5. Install the camshaft sprocket and the camshaft timing chain.

6. Look to ensure that the crankshaft sprocket is aligned at the 12 o'clock position and camshaft sprocket is aligned at the 6 o'clock position.

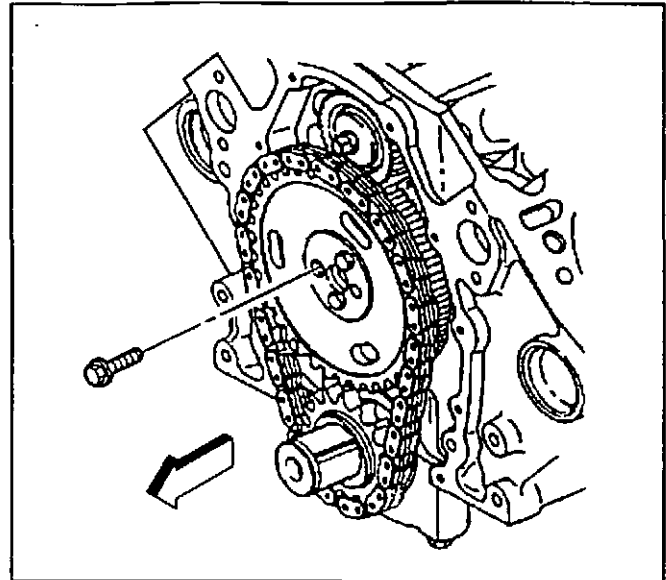
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: Do not use a hammer to install the camshaft sprocket onto the camshaft. To do so may dislodge the expansion cup plug (camshaft rear bearing hole).

7. Install camshaft sprocket bolts.

Tighten

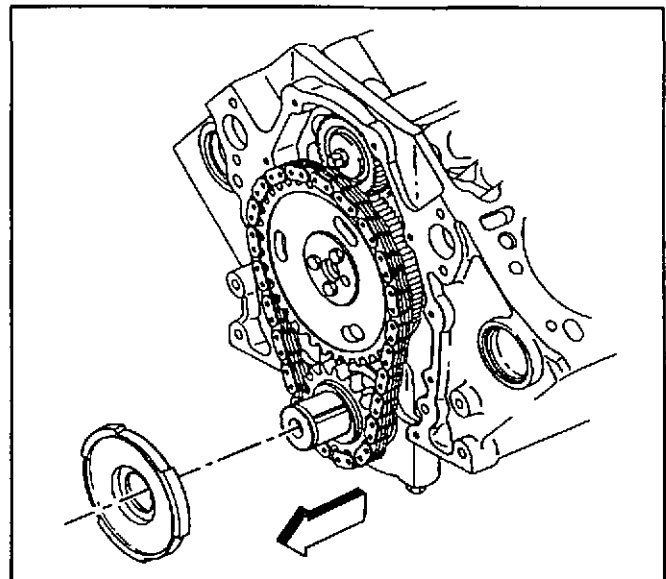
Tighten the camshaft sprocket bolts to 25 N.m (18 lb ft).



330581

8. Install the crankshaft position sensor reluctor ring.

- 8.1. Align the keyway on the crankshaft position sensor reluctor ring with the crankshaft balancer key in the crankshaft.
- 8.2. Use the *J 5590* in order to push the crankshaft position sensor reluctor ring onto the crankshaft until completely seated against the crankshaft sprocket.



45986

SIE-ID - 63224

Engine Front Cover Installation

Important: Once the composite engine front cover is removed DO NOT reinstall the engine front cover. Always install a NEW engine front cover.

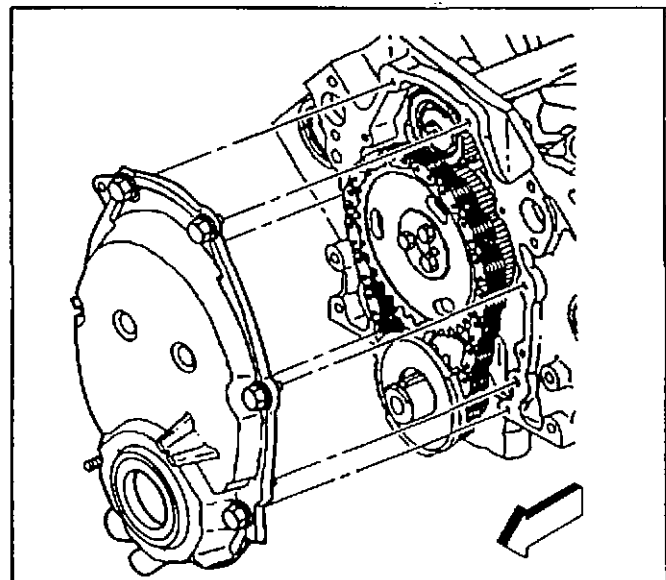
1. Install the NEW engine front cover.

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

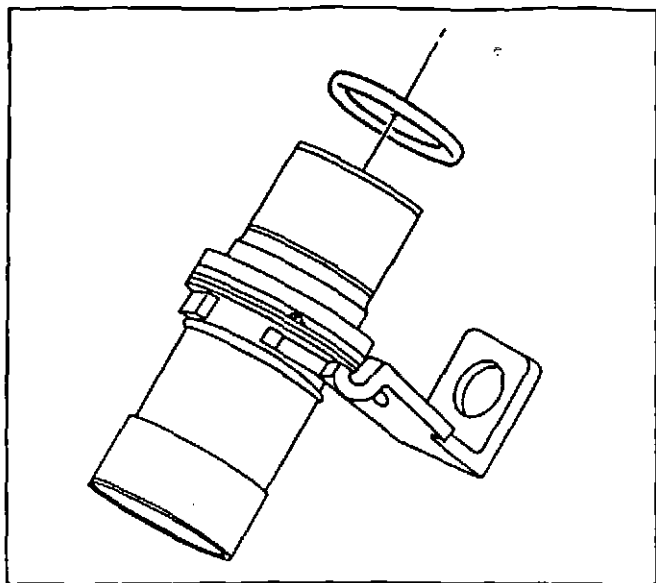
2. Install the engine front cover bolts.

Tighten

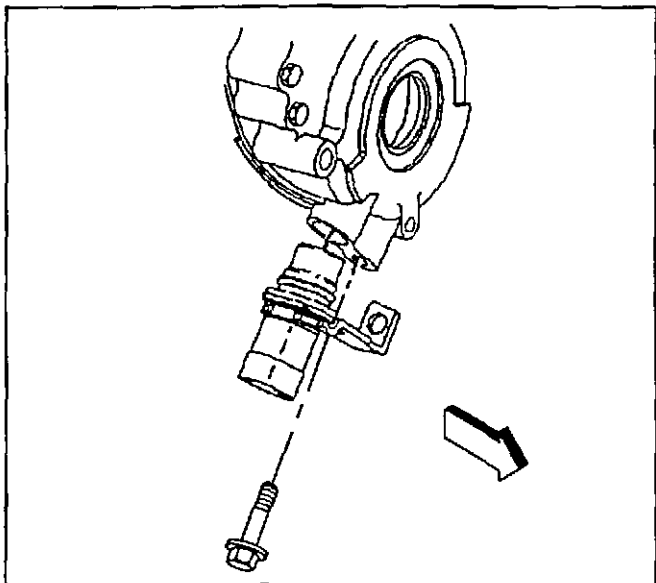
Tighten the bolts to 12 N.m (106 lb in).



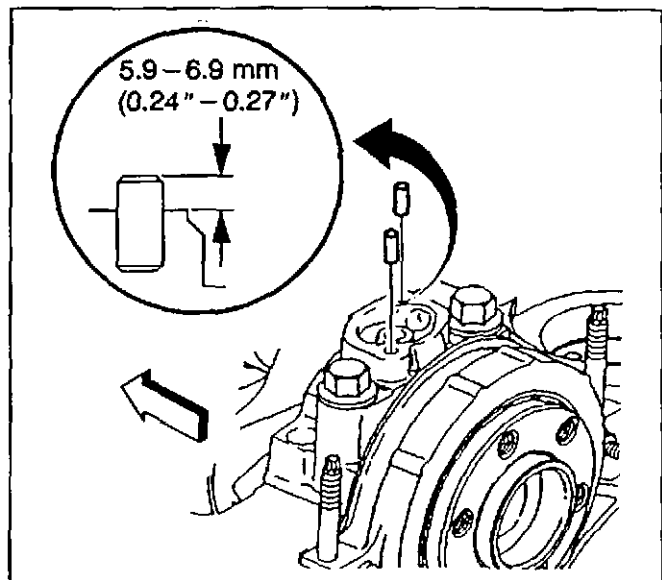
188000



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Important: DO NOT reuse the original crankshaft position sensor seal (O-ring). When installing the crankshaft position sensor be sure the crankshaft position sensor is fully seated and held stationary in the engine front cover crankshaft position sensor bore. A crankshaft position sensor that is not completely seated will cock in the engine front cover and may result in erratic engine operation.

3. Lubricate the NEW crankshaft position sensor seal (O-ring) with clean engine oil.
4. Install the NEW crankshaft position sensor seal (O-ring) onto the crankshaft position sensor.

5. Install crankshaft position sensor.
6. Install crankshaft position sensor bolt.

Tighten

Tighten the crankshaft position sensor bolt to 8 N.m (71 lb in).

SIE-ID - 358623

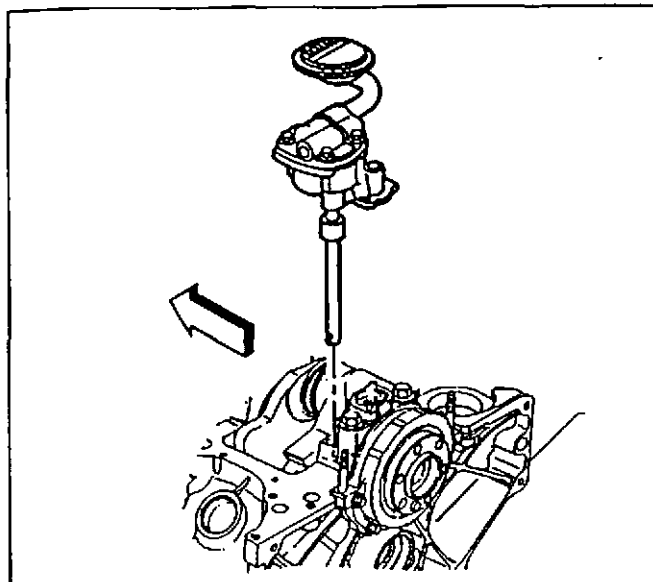
Oil Pump Installation

1. Inspect for properly installed pins (oil pump locator).

Important: Do not reuse the oil pump driveshaft retainer.

During assembly, install a NEW oil pump driveshaft retainer.

2. Install the oil pump.
3. Position the oil pump onto the pins.



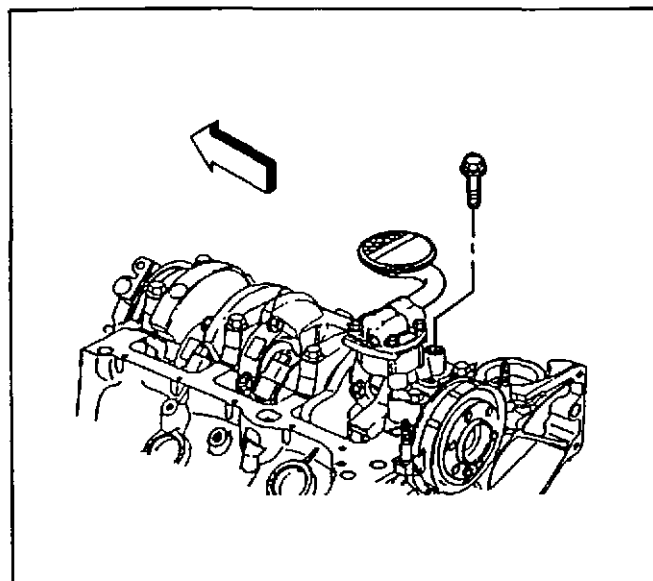
330576

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

4. Install the oil pump bolt attaching the oil pump to the rear crankshaft bearing cap.

Tighten

Tighten the oil pump bolt to 90 N·m (66 lb ft).

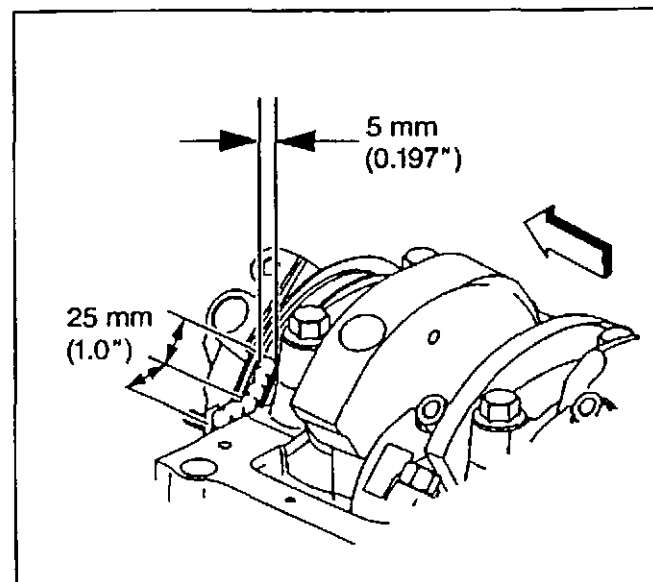


330572

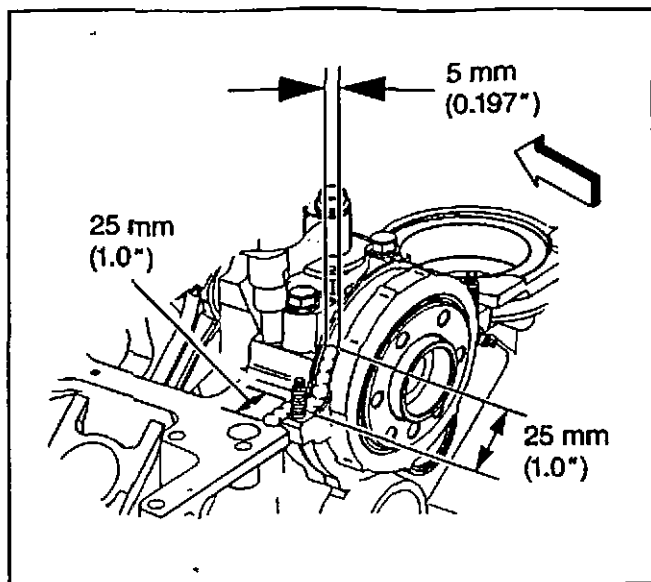
SIE-ID - 358625

Oil Pan Installation

1. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive GM P/N 12346141 or equivalent to the engine front cover to engine block junction at the oil pan sealing surfaces.

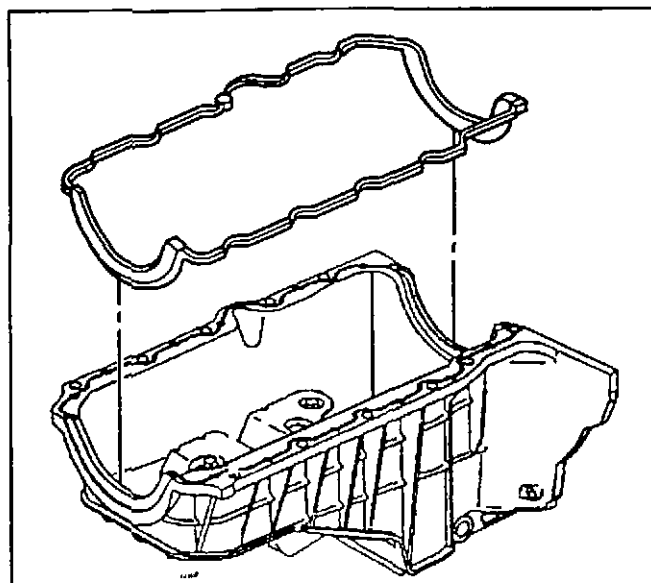


317310



317313

2. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive GM P/N 12346141 or equivalent to the crankshaft rear oil seal housing to engine block junction at the oil pan sealing surfaces.

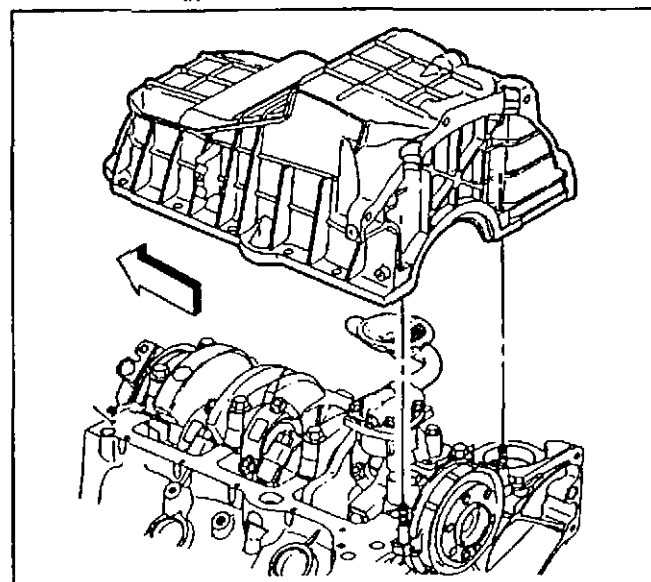


387757

Important: Always install a NEW oil pan gasket.

The oil pan gasket and oil pan must be installed and the fasteners tightened while the adhesive is still wet to the touch.

3. Install the NEW oil pan gasket into the groove in the oil pan.



330568

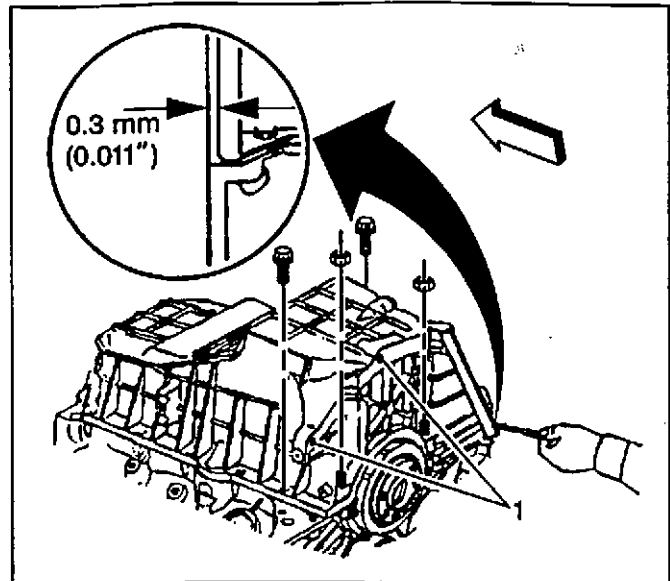
Important: The oil pan alignment must always be flush or forward no more than 0.3 mm (0.011 in) from the rear face of the engine block.

4. Install the oil pan onto the engine block.
Press the oil pan gasket into the grooves of the engine front cover and crankshaft rear oil seal housing.
5. Slide the oil pan back against a suitable straight edge.

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

Important: Use a feeler gauge to check the clearance between the oil pan-to-transmission housing measurement points. If the clearance exceeds 0.3 mm (0.011 in) at any of the 3 oil pan-to-transmission housing measurement points (1), then repeat the step until the oil pan-to-transmission housing clearance is within the specification. The oil pan must always be forward of the rear face of the engine block.

6. Install the oil pan bolts and nuts, but do not tighten.
7. Measure the pan-to-transmission housing clearance using a feeler gauge and a straight edge.



38496

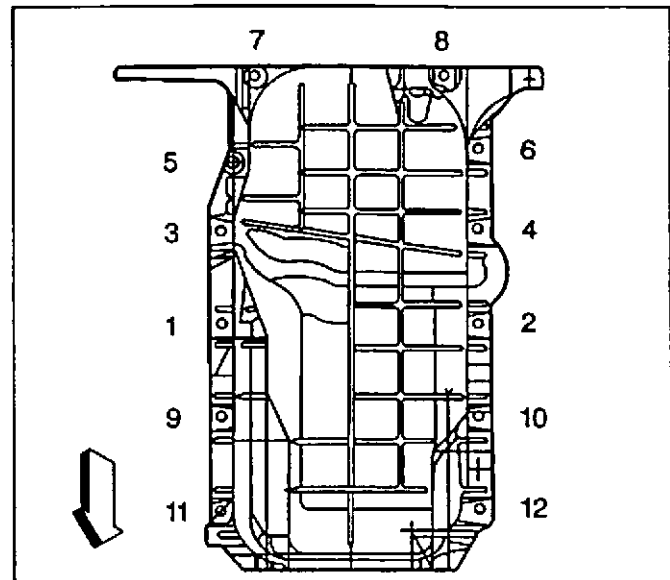
Notice: *S10-ID - 41424* If the clearance is more than 0.3 mm (0.011 in), powertrain durability may be impacted.

8. Tighten the oil pan bolts and nuts in sequence (1-12).

Tighten

Tighten the oil pan bolts to 25 N·m (18 lb ft).

9. Measure the clearance between the 3 oil pan-to-transmission housing measurement points in order to ensure proper alignment.

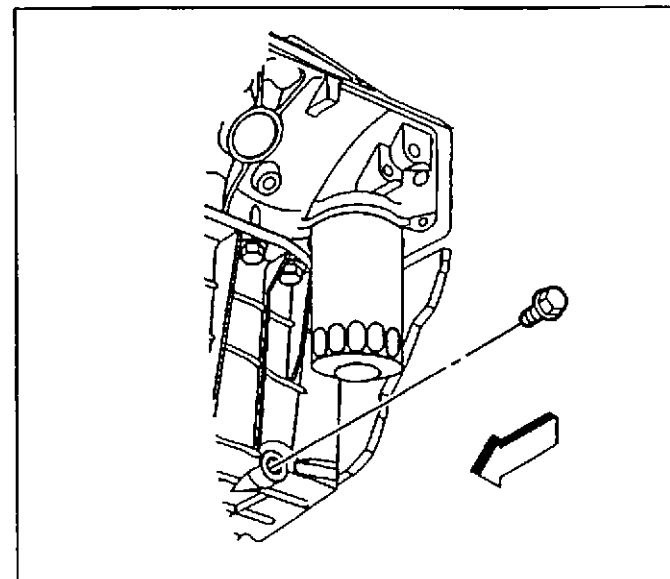


38481

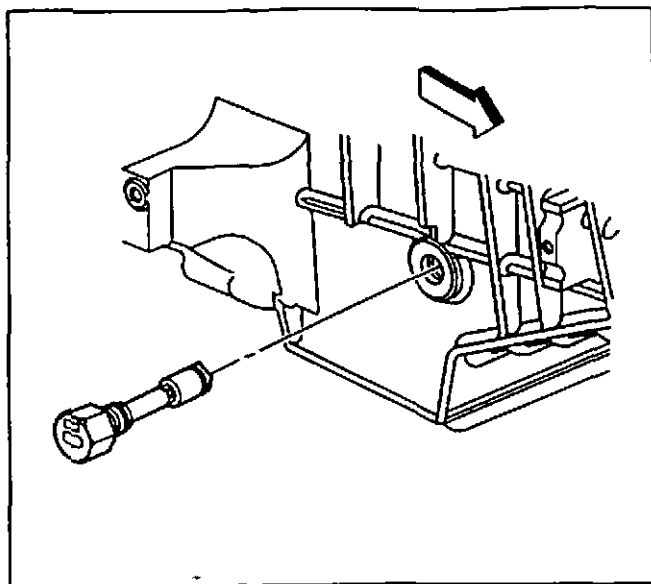
10. Install a NEW oil pan drain plug seal (O-ring) onto the oil pan drain plug.
11. Install the oil pan drain plug into the oil pan.

Tighten

Tighten the oil pan drain plug to 25 N·m (18 lb ft).



188048



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12. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine oil level sensor (if applicable).
13. Install the engine oil level sensor (if applicable).
Tighten
Tighten the engine oil level sensor to 20 N·m (15 lb ft).

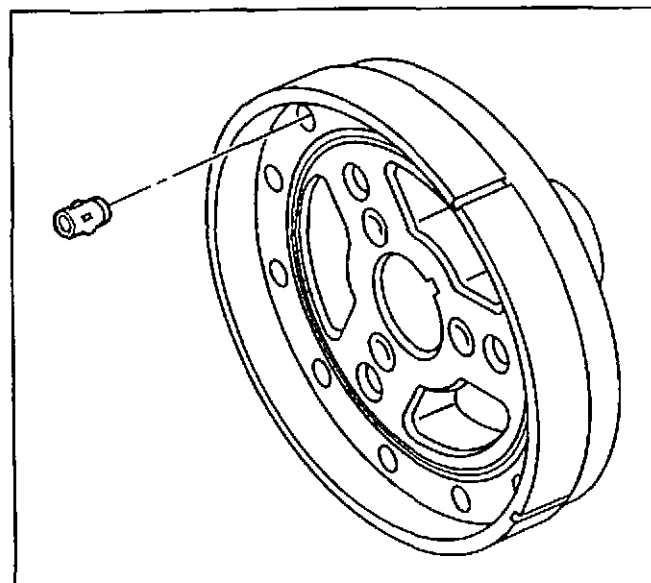
SIE-ID = 358626

Crankshaft Balancer Installation

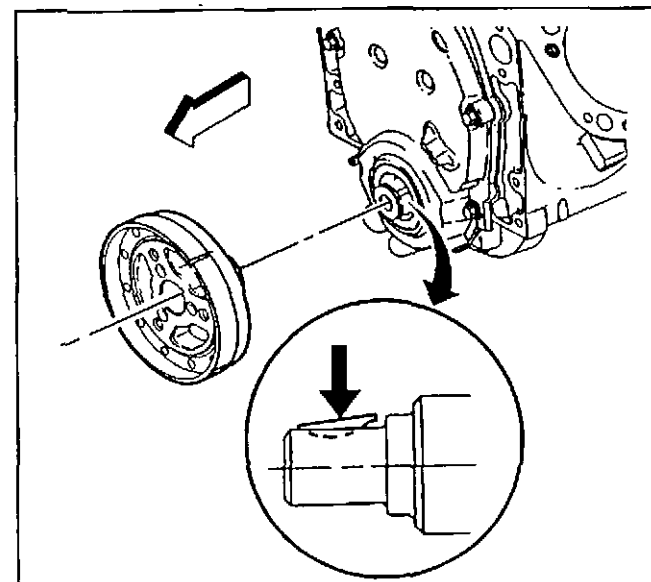
Tools Required

J 23523-F Balancer Remover and Installer

1. Look to ensure that the front groove pin (crankshaft balancer) is installed in the proper location (if applicable).



334258

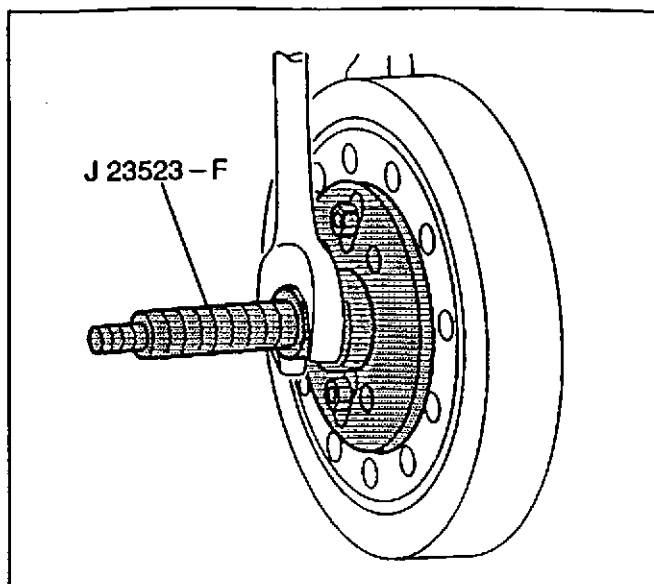


186059

Notice: SIO-ID = 18580 The inertial weight section of the crankshaft balancer is assembled to the hub with a rubber type material. The correct installation procedures (with the proper tool) must be followed or movement of the inertial weight section of the hub will destroy the tuning of the crankshaft balancer.

2. Apply a small amount of adhesive GM P/N 12346141 or equivalent onto the crankshaft balancer keyway in order to seal the crankshaft balancer keyway and crankshaft joint.
3. Align the keyway of the crankshaft balancer with the crankshaft balancer key.
4. Install the crankshaft balancer onto the end of the crankshaft.

5. Use the *J 23523-F* in order to press the crankshaft balancer onto the crankshaft.
 - 5.1. Install the *J 23523-F* into the front of the crankshaft.
 - 5.2. Rotate the *J 23523-F* nut until the nut, washer, and the bearing are firmly against the crankshaft balancer.
 - 5.3. Use one wrench to hold the *J 23523-F* forcing screw.
 - 5.4. Use a second wrench and rotate the *J 23523-F* nut clockwise until the crankshaft balancer hub is completely seated against the crankshaft position sensor reluctor ring.
 - 5.5. Remove the *J 23523-F*.



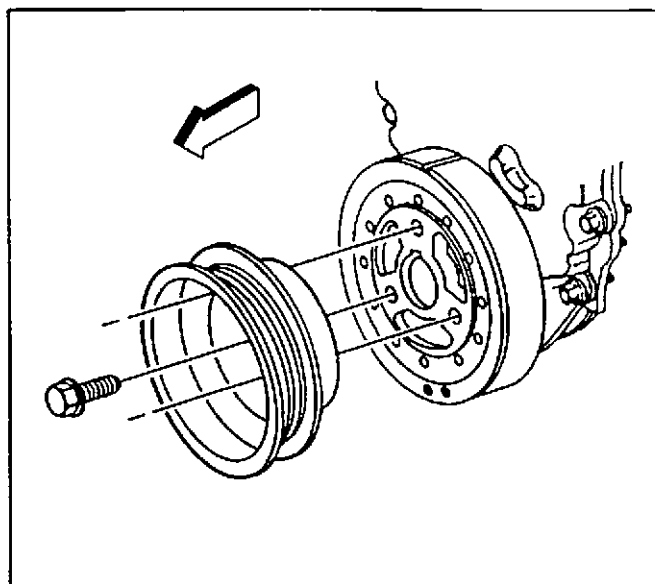
4065

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

6. Install the crankshaft pulley and bolts.

Tighten

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

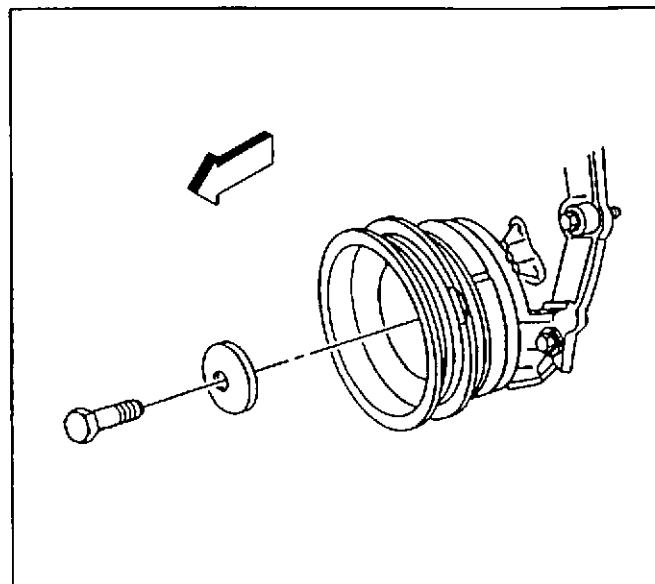


188055

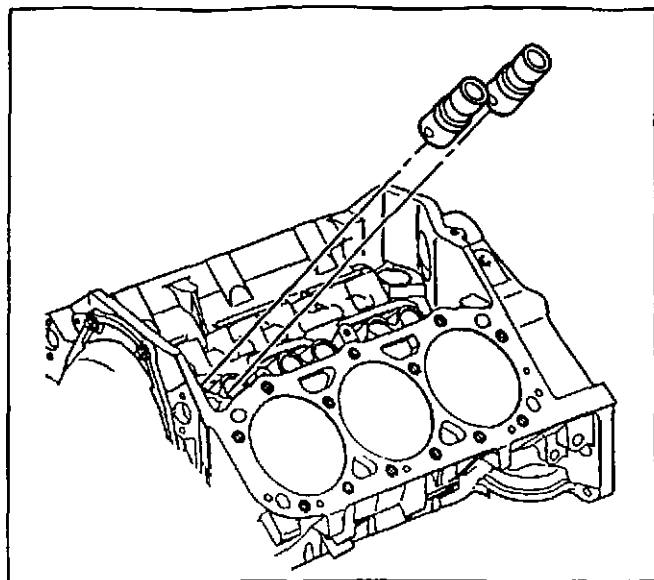
7. Install the crankshaft balancer washer and the bolt.

Tighten

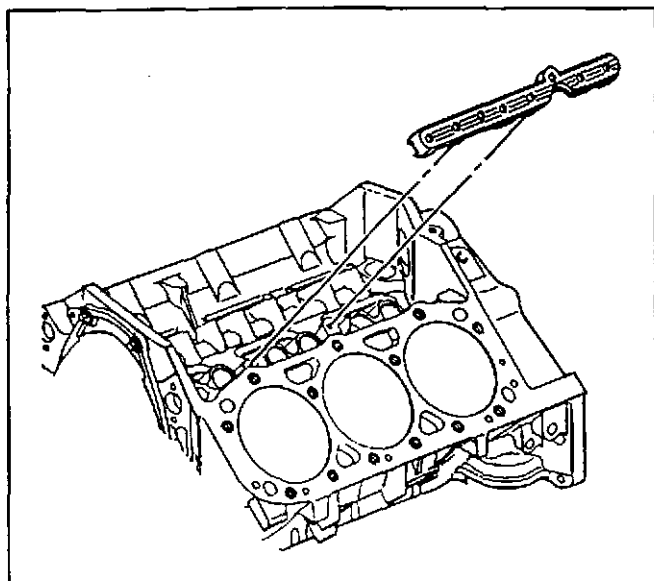
Tighten the crankshaft balancer bolt to 95 N.m (70 lb ft).



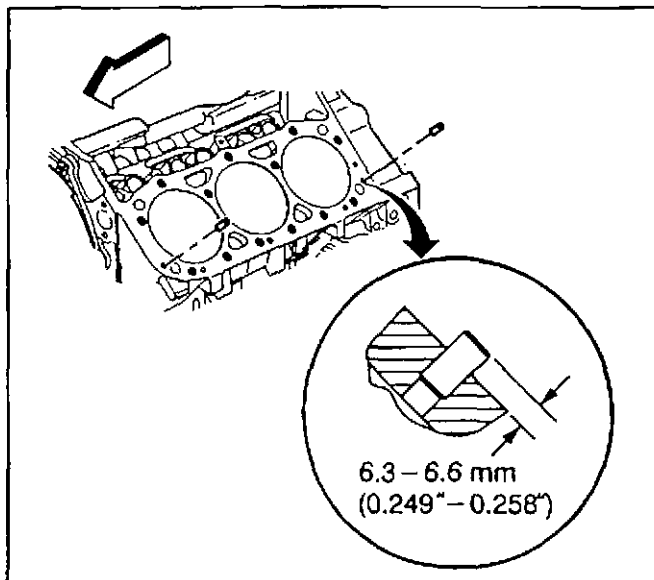
173172



328593



328592



334303

SIE-ID - 358627

Valve Lifter Installation

1. Apply lubricant GM P/N 12345501 or equivalent to the valve lifter rollers.

Important: If reusing the valve lifters, install the valve lifters in the original positions.

2. Install the valve lifters.

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

3. Install the valve lifter pushrod guides.

Tighten

Tighten the valve lifter pushrod guide bolts to 16 N.m (12 lb ft).

SIE-ID - 358632

Cylinder Head Installation (Left)

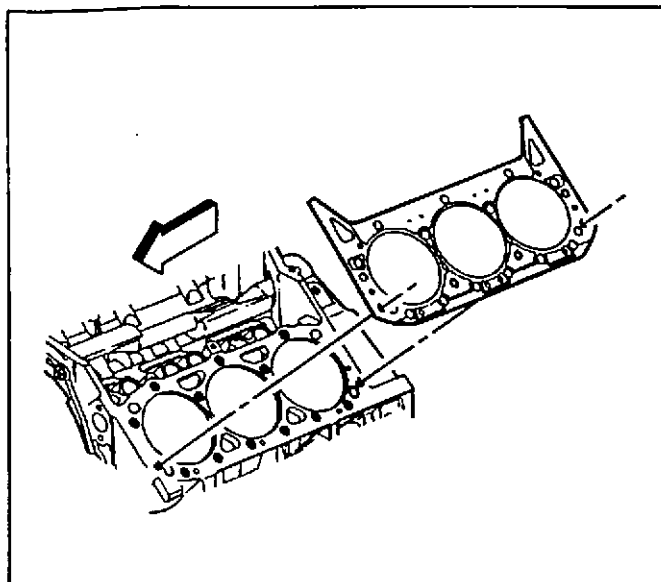
Tools Required

J 36660 Electronic Torque Angle Meter

1. Clean the cylinder head gasket surfaces on the engine block.
2. Inspect the dowel pins (cylinder head locator) for proper installation.
3. Clean the cylinder head gasket surfaces on the cylinder head.

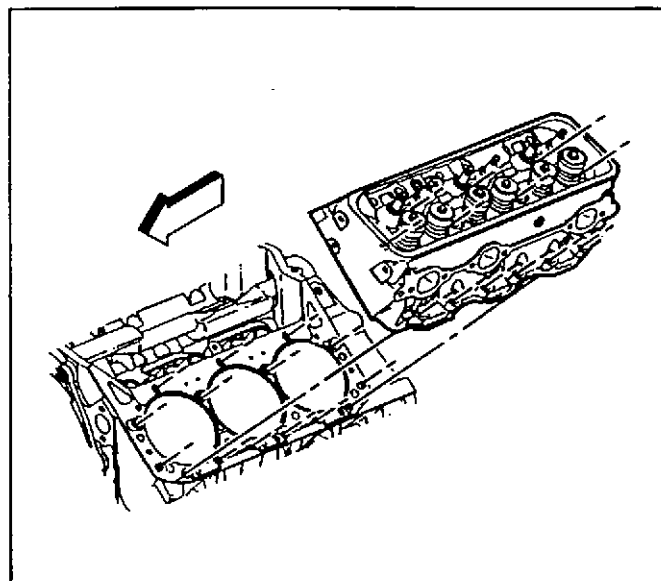
Important: Do not use any type sealer on the cylinder head gasket (unless specified).

4. Install the NEW cylinder head gasket in position over the dowel pins (cylinder head locator).



334299

5. Install the cylinder head onto the engine block. Guide the cylinder head carefully into place over the dowel pins and the cylinder head gasket.

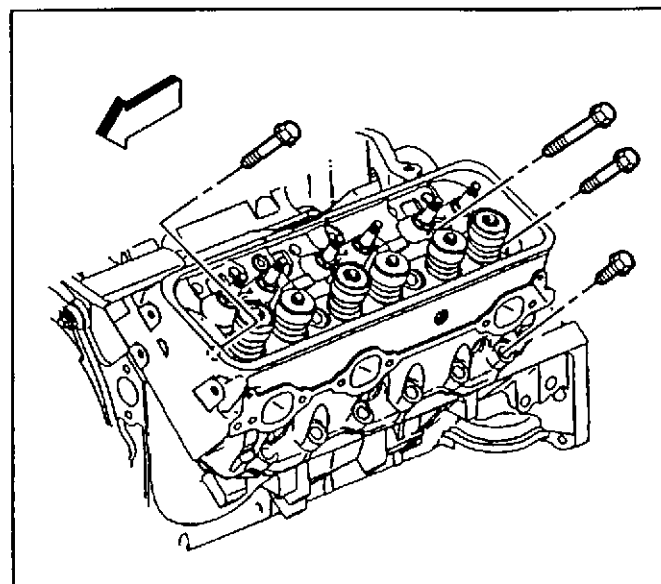


334295

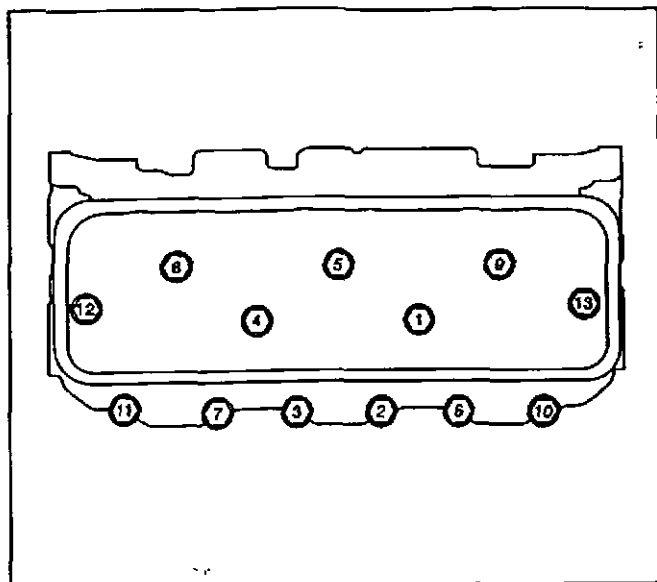
6. Apply sealant GM P/N 12346004 or equivalent to the threads of the cylinder head bolts.

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

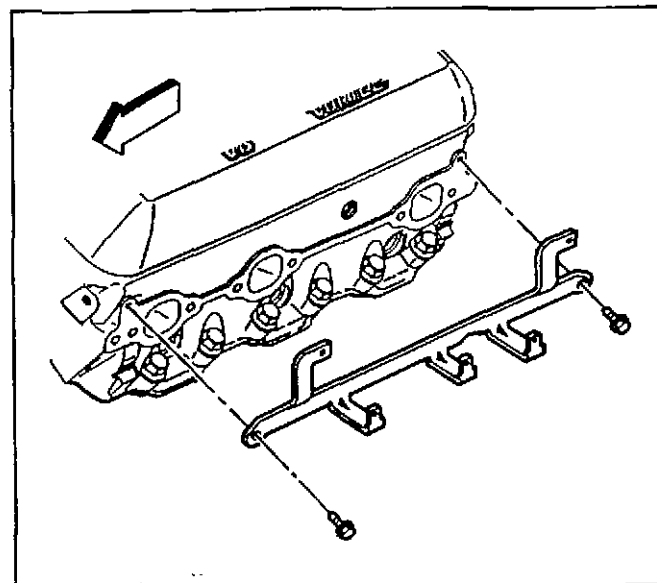
7. Install the cylinder head bolts finger tight.



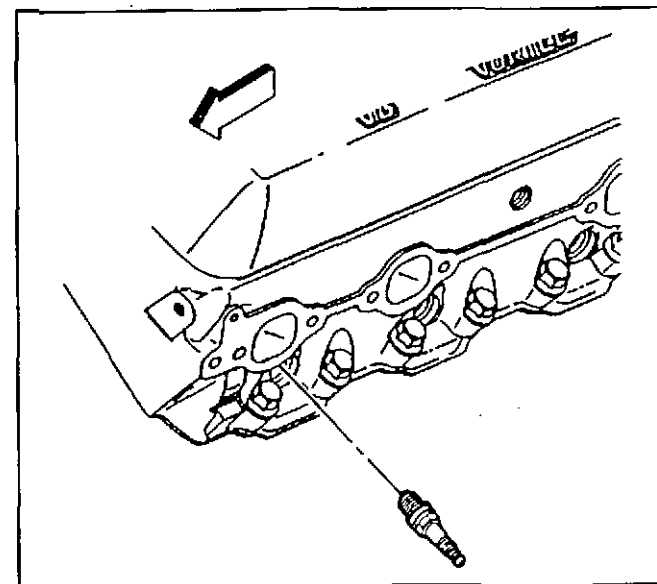
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328582

8. Tighten the cylinder head bolts in sequence on the first pass.

Tighten

Tighten the bolts in sequence on the first pass to 30 N.m (22 lb ft).

9. Use the J 36660 in order to tighten the cylinder head bolts in sequence on the final pass.

Tighten

- Tighten the long bolts (1, 4, 5, 8, and 9) on the final pass in sequence to 75 degrees.
- Tighten the medium bolts (12 and 13) on the final pass in sequence to 65 degrees.
- Tighten the short bolts (2, 3, 6, 7, 10, and 11) on the final pass in sequence to 55 degrees.

10. Install the spark plug wire support and bolts.

Tighten

Tighten the spark plug wire support bolts to 12 N.m (106 lb in).

11. Measure the NEW spark plugs for the proper gap.

Adjust the spark plug gap if necessary.

Specification

Spark plug gap to 1.52 mm (0.060 in).

12. Install the spark plugs.

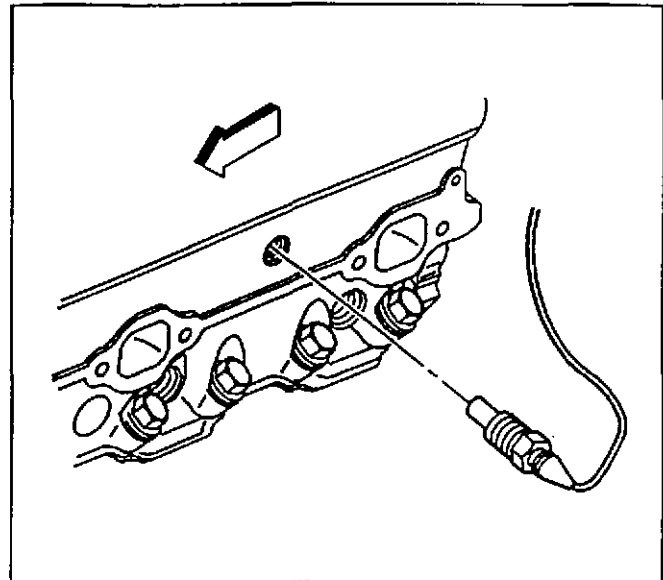
Tighten

- Tighten the spark plugs for a USED cylinder head to 15 N.m (11 lb ft).
- Tighten the spark plugs for the initial installation of a NEW cylinder head to 30 N.m (22 lb ft).

13. Install the engine coolant temperature gauge sensor (if applicable).

Tighten

Tighten the engine coolant temperature gauge sensor to 20 N·m (15 lb ft).

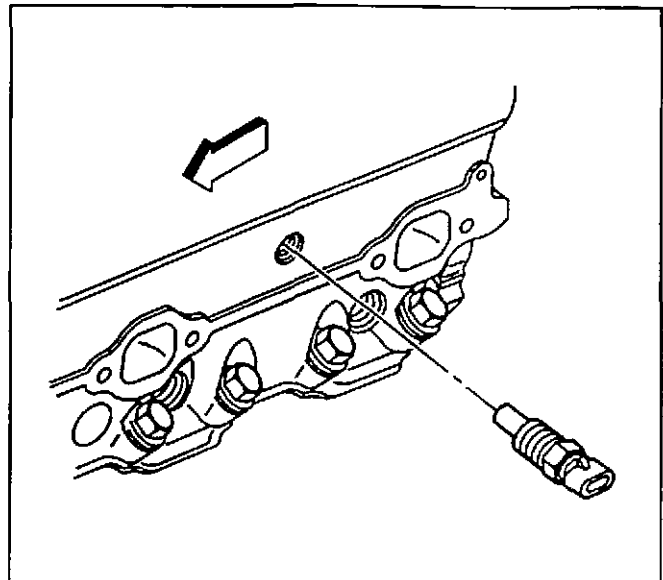


387767

14. Install the engine coolant temperature sensor (if applicable).

Tighten

Tighten the engine coolant temperature sensor to 20 N·m (15 lb ft).



387769

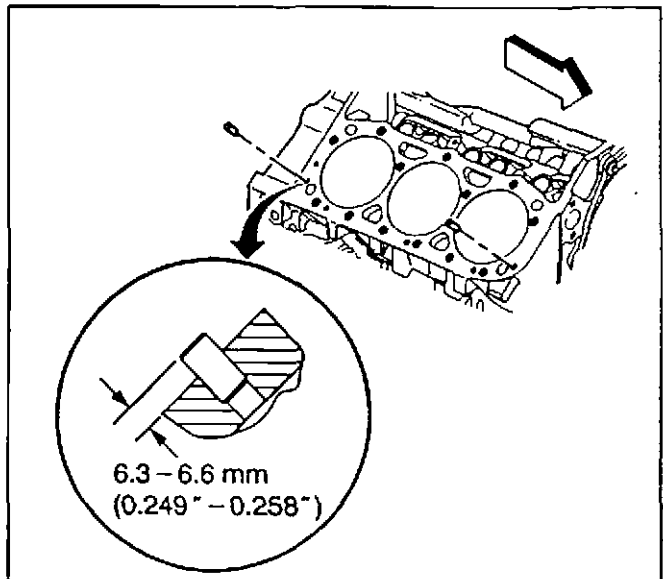
SIE-ID - 358634

Cylinder Head Installation (Right)

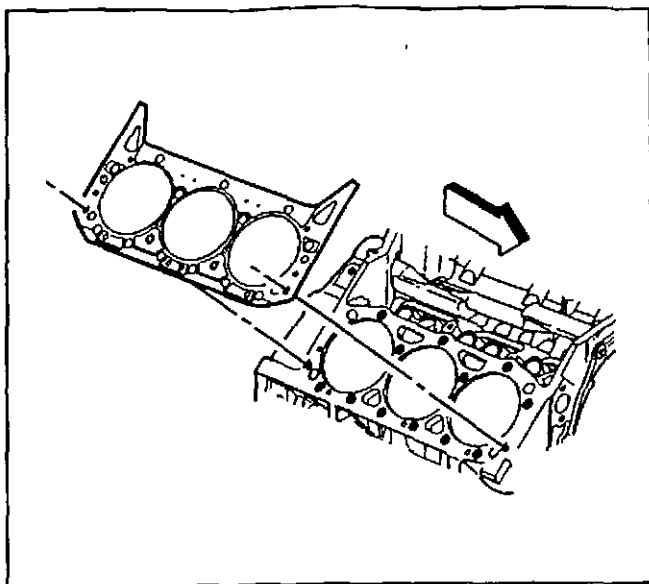
Tools Required

J 36660 Electronic Torque Angle Meter

1. Clean the cylinder head gasket surfaces on the engine block.
2. Inspect the dowel pins (cylinder head locator) for proper installation.
3. Clean the cylinder head gasket surfaces on the cylinder head.



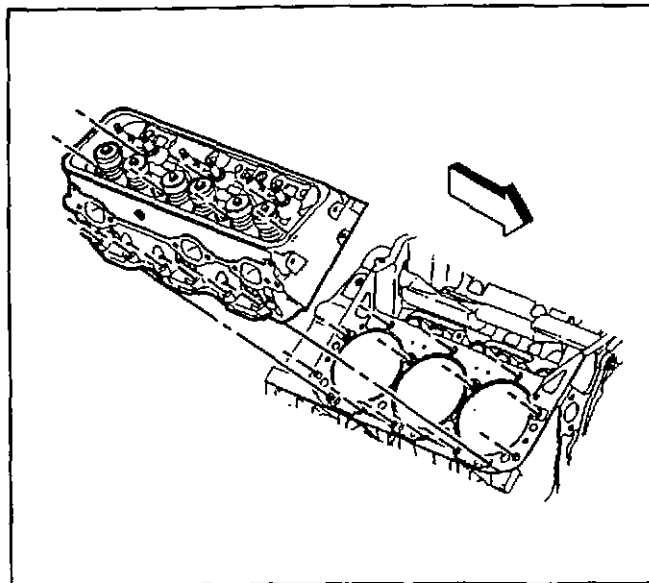
334314



334312

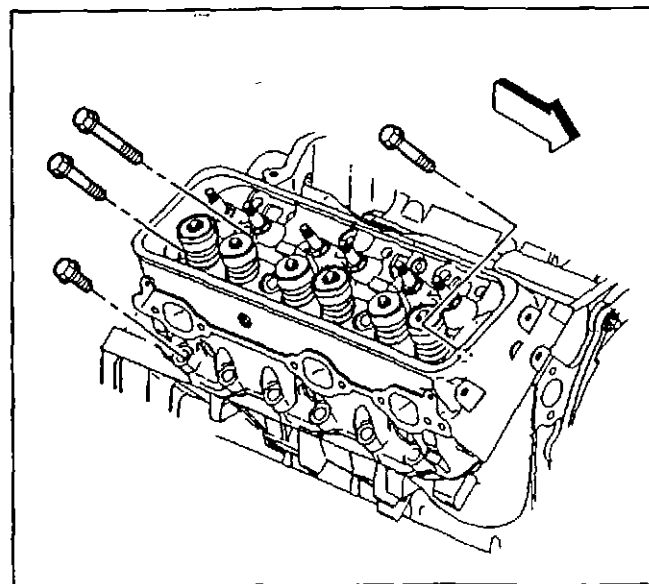
Important: Do not use any type sealer on the cylinder head gasket (unless specified).

4. Install the NEW cylinder head gasket in position over the dowel pins (cylinder head locator).



334309

5. Install the cylinder head onto the engine block. Guide the cylinder head carefully into place over the dowel pins and the cylinder head gasket.



196132

6. Apply sealant GM P/N 12346004 or equivalent to the threads of the cylinder head bolts.

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

7. Install the cylinder head bolts finger tight.

8. Tighten the cylinder head bolts in sequence on the first pass.

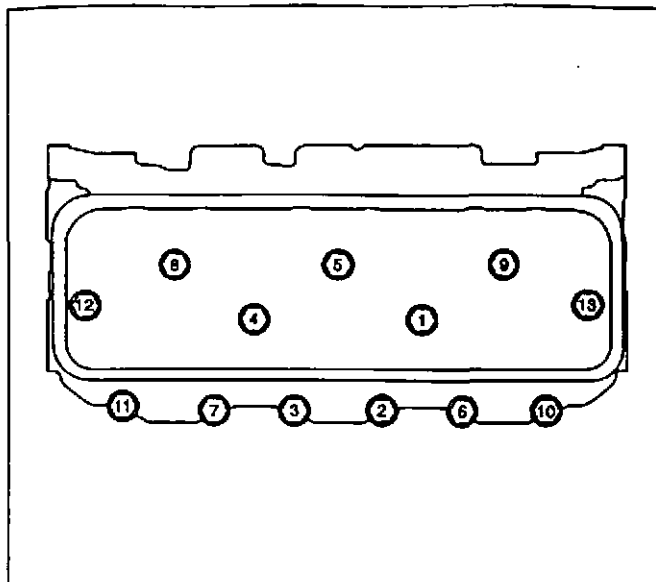
Tighten

Tighten the bolts in sequence on the first pass to 30 N.m (22 lb ft).

9. Use the J 36660 in order to tighten the cylinder head bolts in sequence on the final pass.

Tighten

- Tighten the long bolts (1, 4, 5, 8, and 9) on the final pass in sequence to 75 degrees.
- Tighten the medium bolts (12 and 13) on the final pass in sequence to 65 degrees.
- Tighten the short bolts (2, 3, 6, 7, 10, and 11) on the final pass in sequence to 55 degrees.

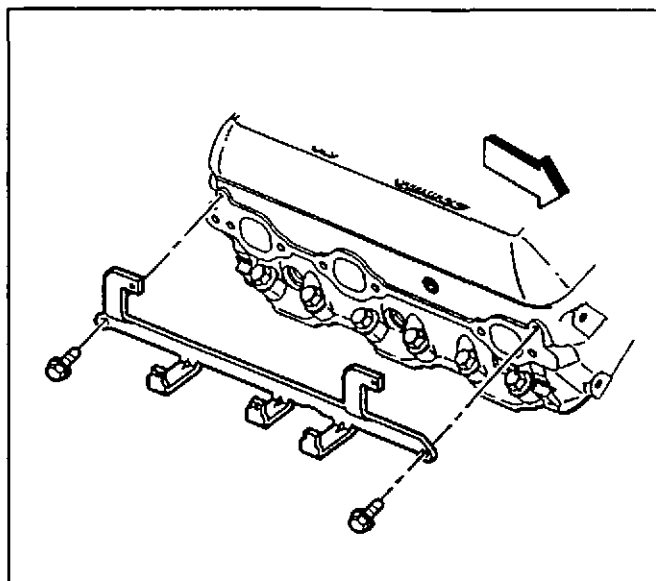


5132

10. Install the spark plug wire support and bolts.

Tighten

Tighten the spark plug wire support bolts to 12 N.m (106 lb in).



328590

11. Measure the NEW spark plugs for the proper gap.

Adjust the spark plug gap if necessary.

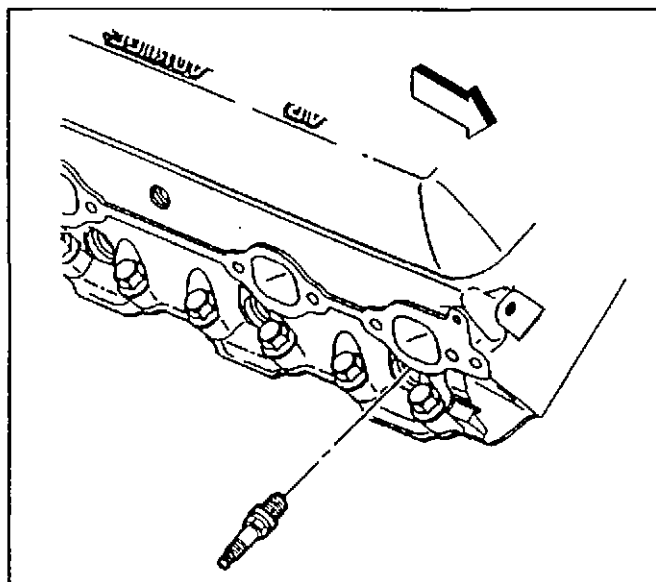
Specification

Spark plug gap to 1.52 mm (0.060 in).

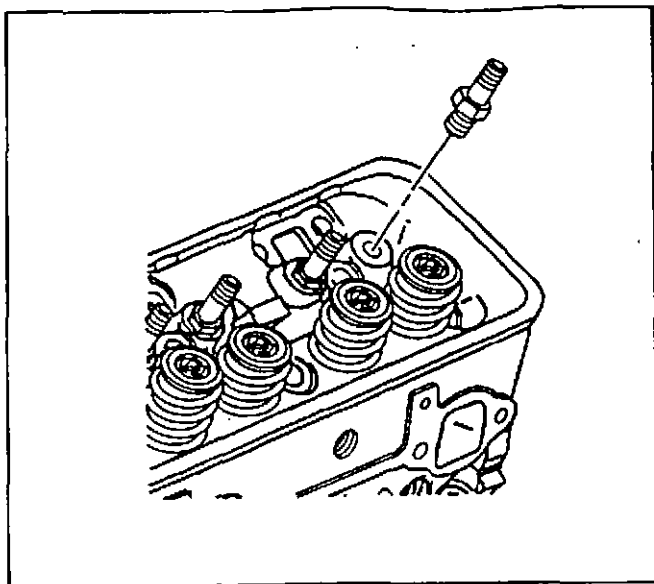
12. Install the spark plugs.

Tighten

- Tighten the spark plugs for a USED cylinder head to 15 N.m (11 lb ft).
- Tighten the spark plugs for the initial installation of a NEW cylinder head to 30 N.m (22 lb ft).



328586



4081

SIE-ID - 358884

Valve Rocker Arm and Push Rod Installation

1. Apply threadlock GM P/N 12345493 or equivalent to the threads of the valve rocker arm ball stud.

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

Important: Be sure to keep parts in order. Parts must be reinstalled into their original location and position.

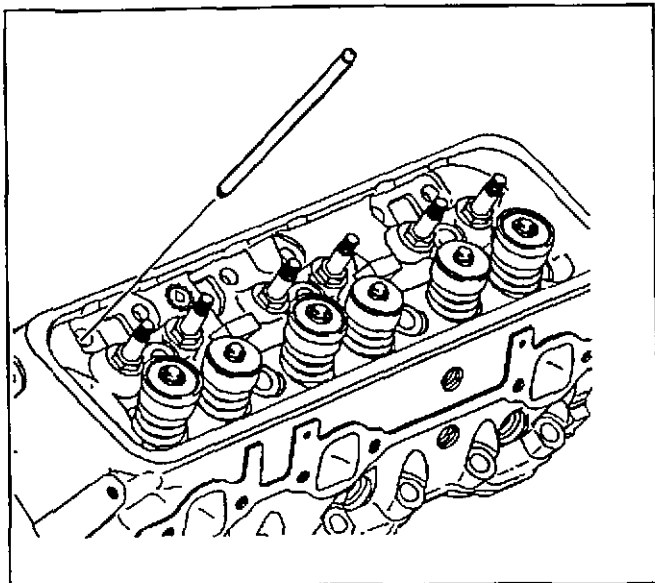
2. Install the valve rocker arm ball stud.

Tighten

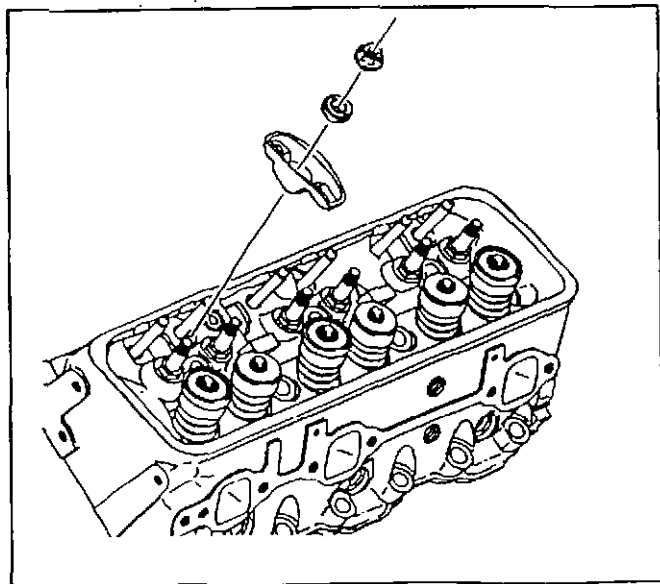
Tighten the valve rocker arm ball stud to 47 N.m (35 lb ft).

Important: Be sure that the valve pushrods seat in the valve lifter sockets.

3. Install the valve pushrods.



4047



4045

4. Apply prelube GM P/N 12345501 or equivalent to the valve rocker arm and valve rocker arm ball bearing surfaces.
5. Install the valve rocker arms.
6. Install the valve rocker arm balls.

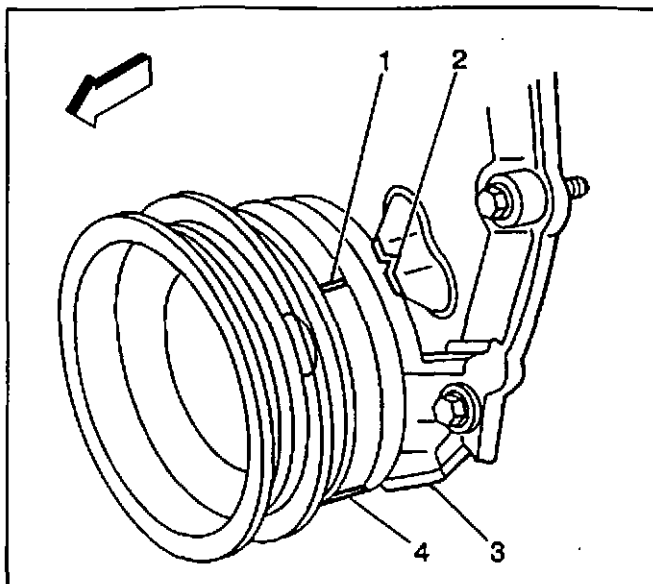
Important: Once the valve rocker arm nuts are installed and properly torqued, no additional valve lash adjustment is required.

7. Install the valve rocker arm nuts.

8. Rotate the crankshaft balancer to position the crankshaft balancer alignment mark (1) 57–63 degrees clockwise or counterclockwise from the engine front cover alignment tab (2).
9. Tighten the valve rocker arm nuts.

Tighten

Tighten valve rocker arm nuts to 25 N.m (18 lb ft).



334551

SIE-ID - 358637

Intake Manifold Installation

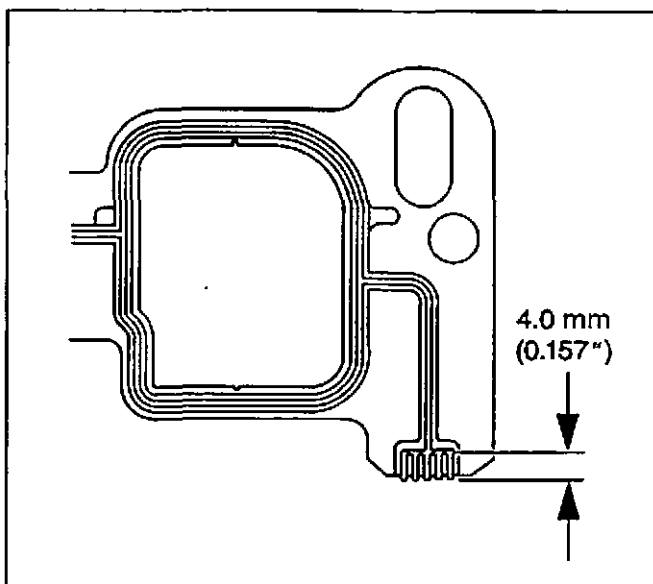
Notice: SIO-ID - 16302 Applying excessive amounts of sealant may prohibit the intake gasket from sealing properly.

1. Apply a 4.0 mm (0.157 in) patch of adhesive GM P/N 12346141 or equivalent to the cylinder head side of the lower intake manifold gasket at each end.

Important: The lower intake manifold gasket must be installed while the adhesive is still wet to the touch.

2. Install the lower intake manifold gasket onto the cylinder head.

Use the gasket locator pins in order to properly seat the lower intake manifold gasket on the cylinder head.

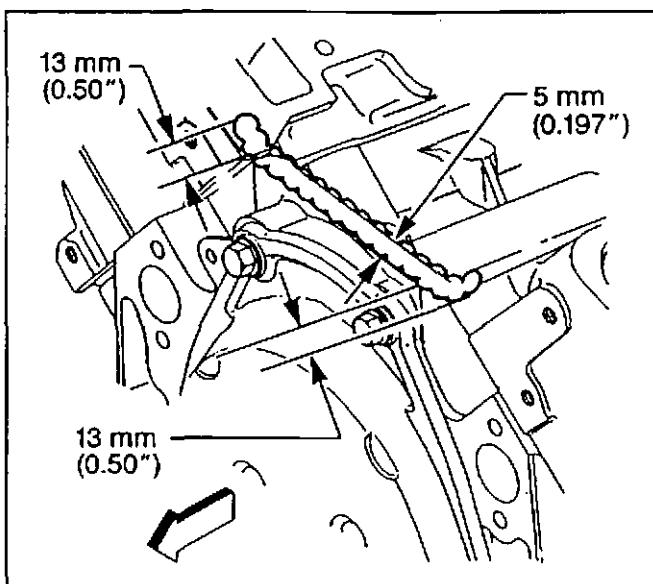


38512

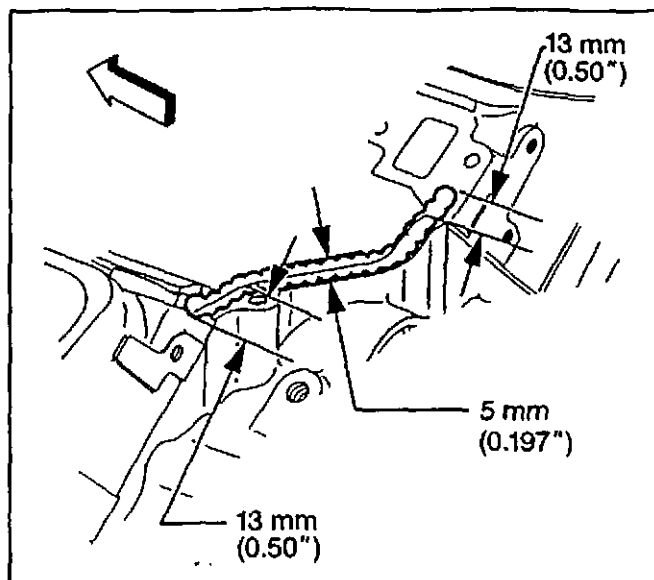
Notice: SIO-ID - 41431 Care must be used to apply the correct amount of sealant onto the gaskets. Applying excessive amounts of sealant may prohibit the intake gaskets from sealing properly.

Important: The lower intake manifold must be installed and the fasteners tightened while the adhesive is still wet to the touch.

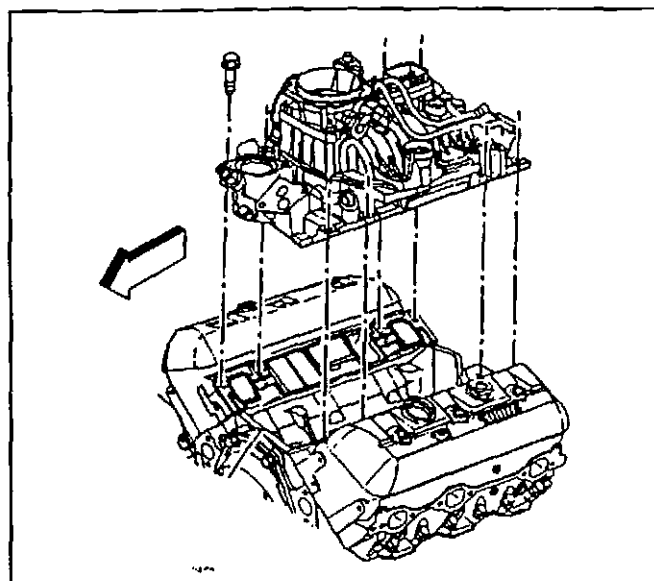
3. Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 or equivalent to the front top of the engine block.
4. Extend the adhesive bead 13 mm (0.50 in) onto the each lower intake manifold gasket.



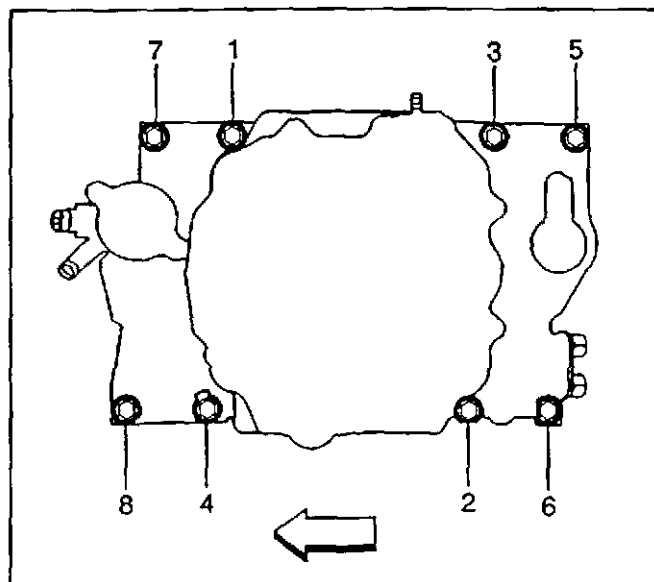
26744



26743



31510



188150

5. Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 or equivalent to the rear top of the engine block.
6. Extend the adhesive bead 13 mm (0.50 in) onto each lower intake manifold gasket.

7. Install the lower intake manifold onto the engine block.
8. Apply threadlock GM P/N 12345382 or equivalent to the threads of the lower intake manifold bolts.

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

9. Install the lower intake manifold bolts.

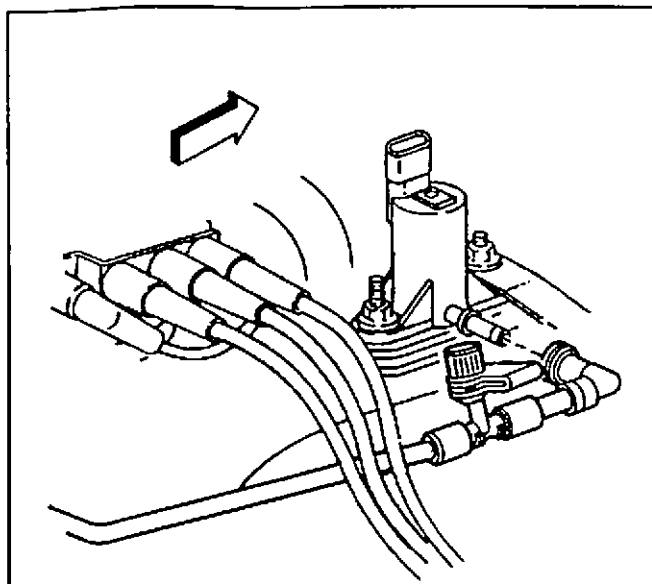
Notice: *S10-10 - 382467* Proper lower intake manifold fastener tightening sequence and torque is critical. Always follow the tightening sequence, and torque the intake manifold bolts using the 3 step method. Failing to do so may distort the crankshaft bearing bore alignment and cause damage to the crankshaft bearings.

10. Tighten the lower intake manifold bolts.

Tighten

- 10.1. Tighten the bolts on the first pass in sequence (1-8) to 3 N.m (27 lb in).
- 10.2. Tighten the bolts on the second pass in sequence (1-8) to 12 N.m (106 lb in).
- 10.3. Tighten the bolts on the final pass in sequence (1-8) to 15 N.m (11 lb ft).

11. Connect the evaporative emission (EVAP) canister solenoid valve harness.

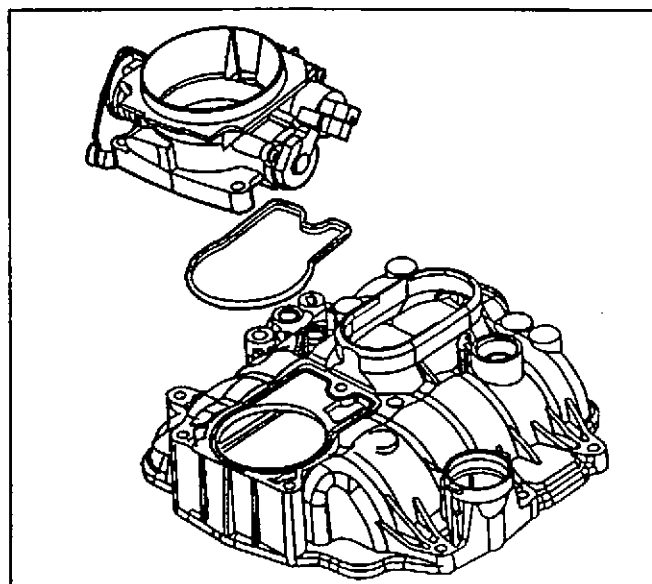


328579

SIE-ID - 194662

Throttle Body Installation

1. Install a NEW throttle body gasket into the groove of the upper intake manifold.
2. Install the throttle body onto the upper intake manifold.



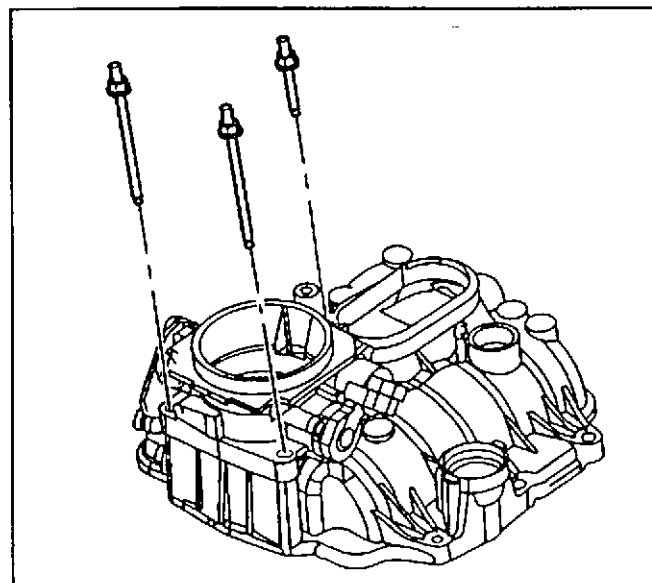
12853

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

3. Install the throttle body attaching studs.

Tighten

Tighten the throttle body attaching studs to 9 N.m (80 lb in).



12852

SIE-ID - 358641

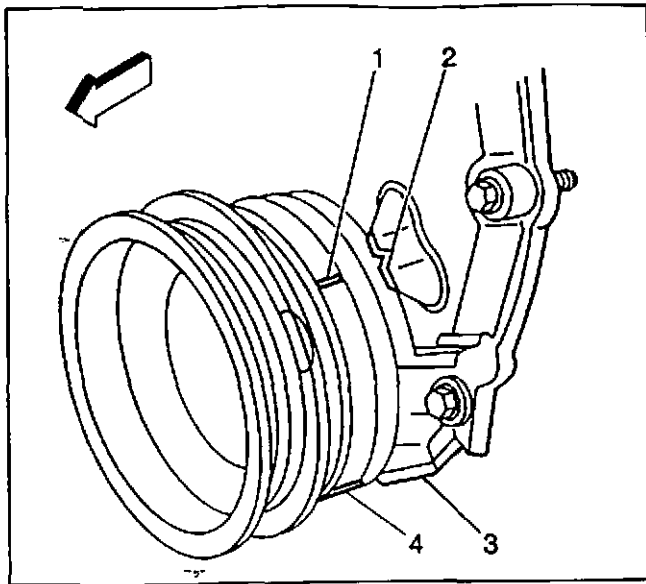
Distributor Installation

Important: The engine front cover has 2 alignment tabs and the crankshaft balancer has 2 alignment marks (spaced 90 degrees apart) which are used for positioning number 1 piston at top dead center (TDC). With the piston on the compression stroke and at top dead center, the crankshaft balancer alignment mark (1) must align with the engine front cover tab (2) and the crankshaft balancer alignment mark (4) must align with the engine front cover tab (3).

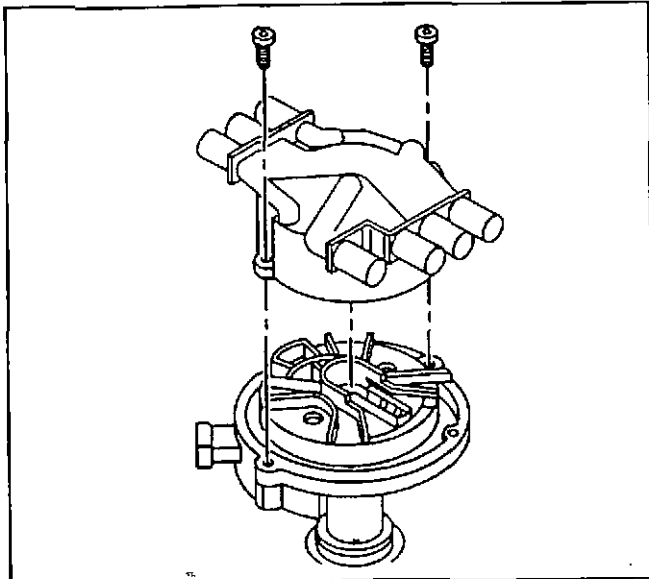
1. Rotate the crankshaft balancer clockwise until the alignment marks on the crankshaft balancer are aligned with the tabs on the engine front cover and the number 1 piston is at top dead center of the compression stroke.

2. Remove the distributor cap bolts and discard.
3. Remove the distributor cap.

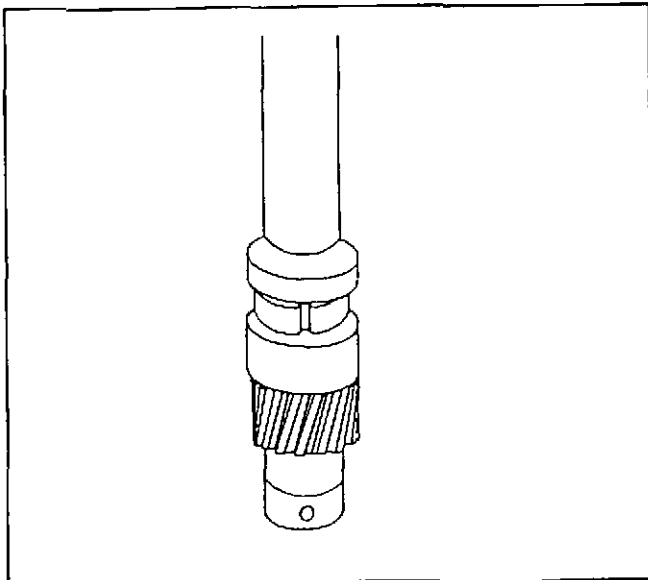
4. Align the indent hole on the driven gear with the paint mark on the distributor housing.



334551

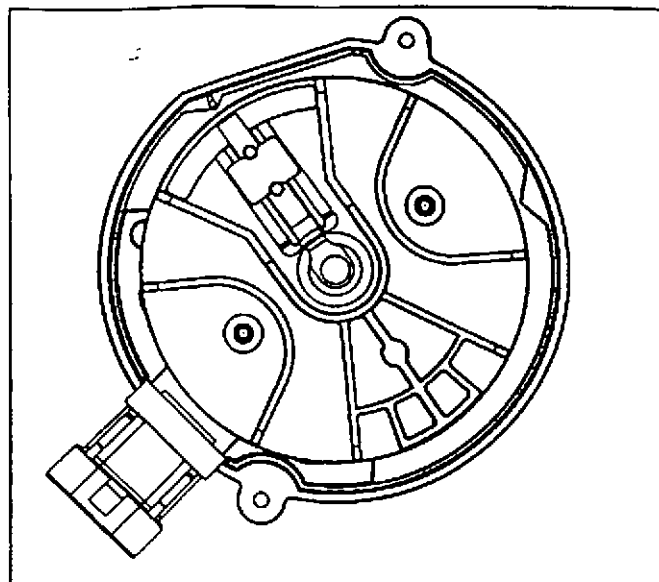


301393



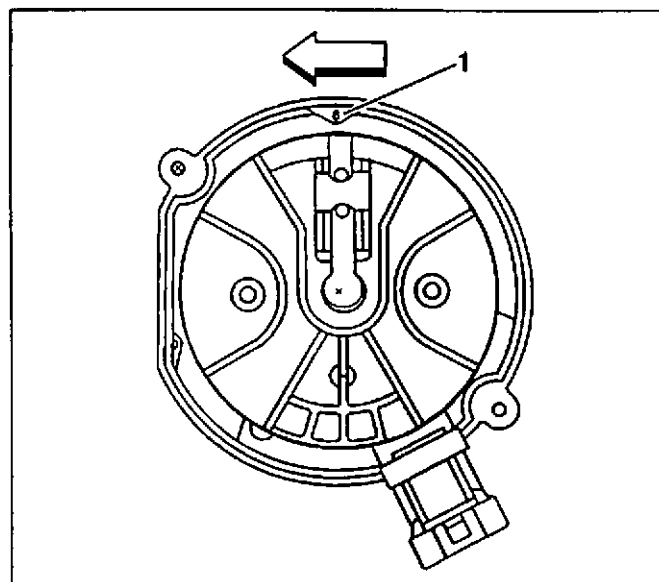
43756

5. Ensure that the distributor rotor segment points to the cap hold area.
6. Align the slotted tang in the oil pump driveshaft with the distributor driveshaft. Rotate the oil pump driveshaft with a screwdriver if necessary.
7. Install the distributor and NEW distributor gasket. The flat in the distributor housing must point toward the front of the engine.



68505

8. Once the distributor is fully seated, align the distributor rotor segment with the number 6 pointer (1) that is cast into the distributor base.
9. If the distributor rotor segment does not come within a few degrees of the number 6 pointer (1), the gear mesh between the distributor and camshaft may be off a tooth or more. Repeat the procedure again in order to achieve proper alignment.



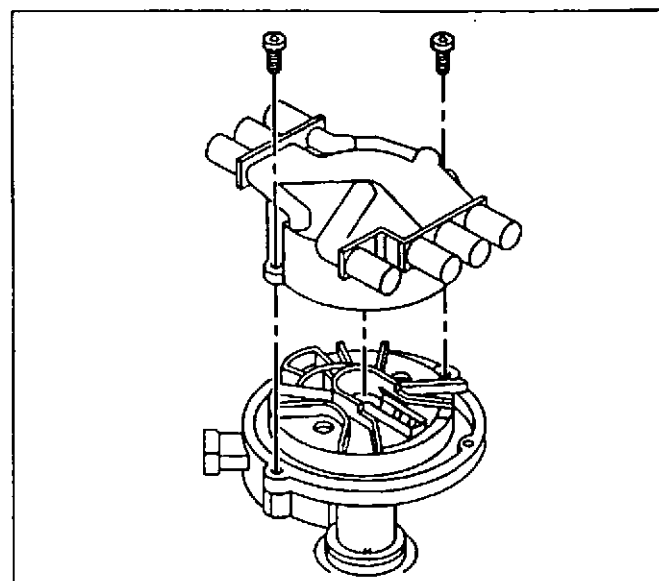
334555

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

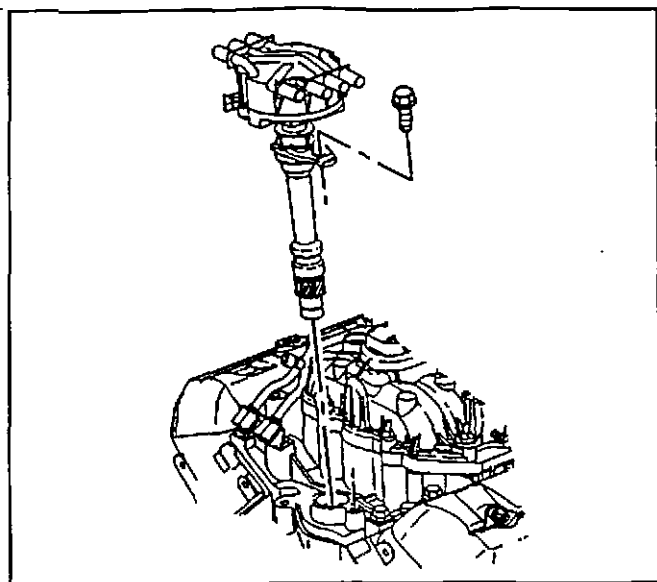
10. Install the distributor cap and NEW distributor cap bolts.

Tighten

Tighten the distributor cap bolts to 2.4 N.m (21 lb in).



301393

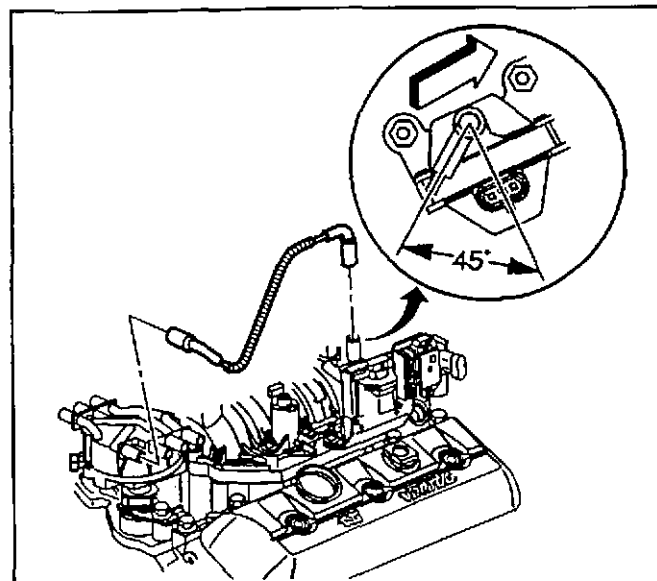


34403

11. Install the distributor clamp and bolt.

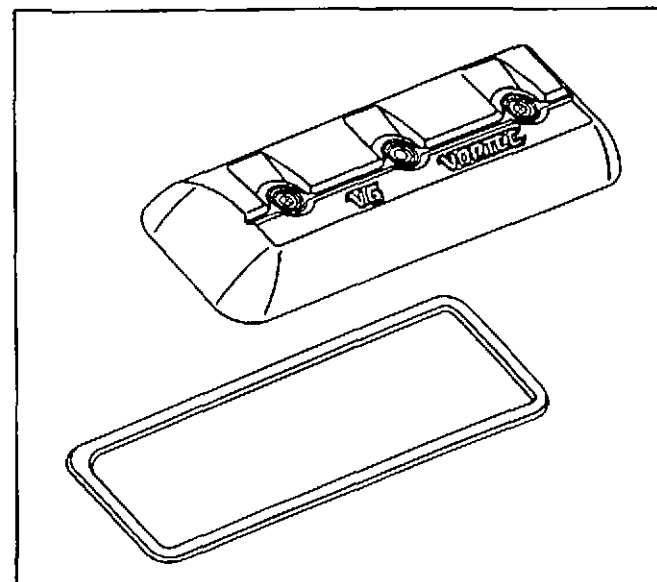
Tighten

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



387772

12. Install the ignition coil wire harness.



328573

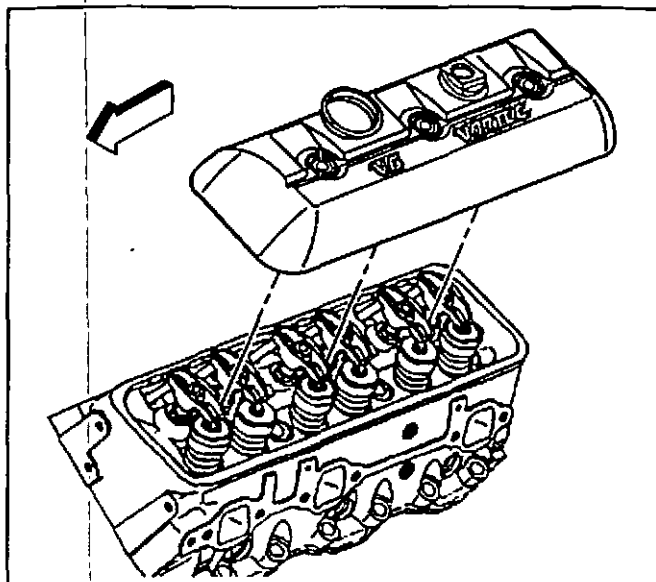
SIE-ID - 358644

Valve Rocker Arm Cover Installation (Left)

Important: Do not reuse the valve cover gasket or the valve rocker arm cover bolt grommets.

1. Install the NEW valve rocker arm cover gasket into the groove of the valve rocker arm cover.
2. Install the NEW valve rocker arm cover bolt grommets into the valve rocker arm cover.

3. Install the valve rocker arm cover onto the cylinder head.



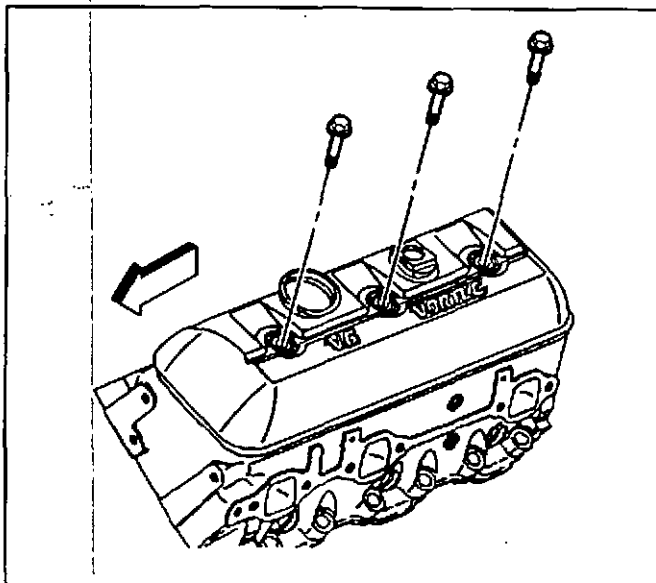
328569

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

4. Install the valve rocker arm cover bolts.

Tighten

Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).



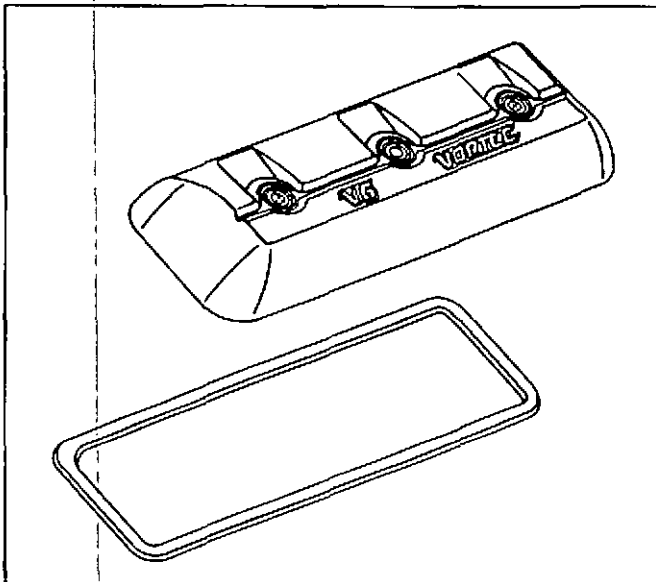
328566

SIE-10 - 358645

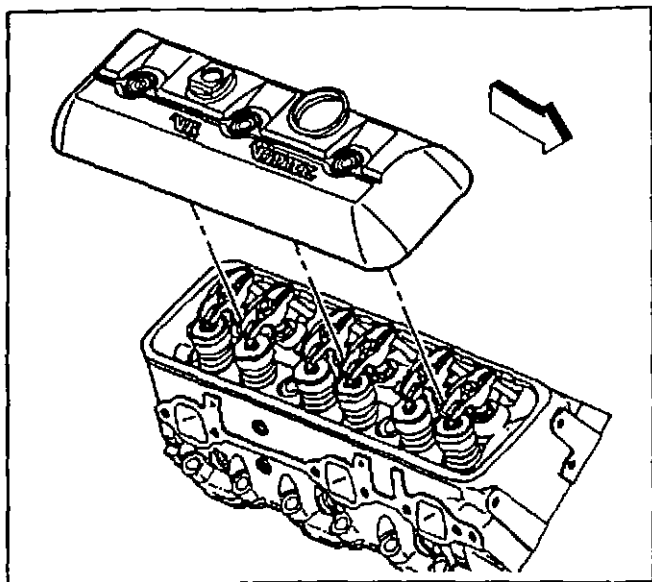
Valve Rocker Arm Cover Installation (Right)

Important: Do not reuse the valve cover gasket or the valve rocker arm cover bolt grommets.

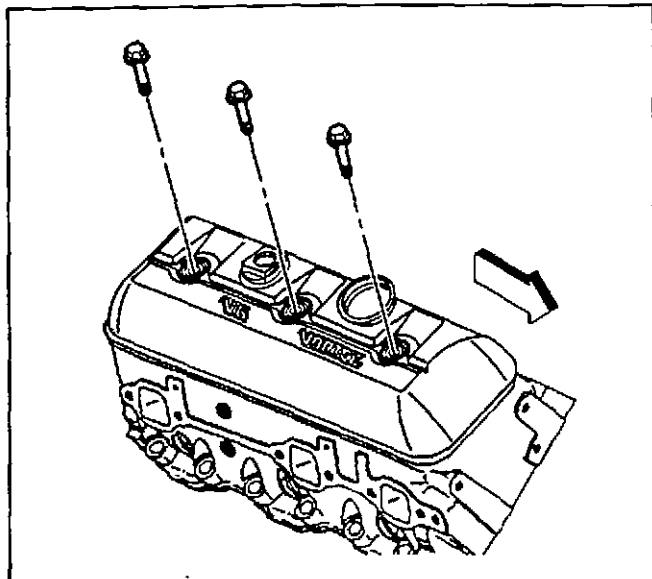
1. Install the NEW valve rocker arm cover gasket into the groove of the valve rocker arm cover.
2. Install the NEW valve rocker arm cover bolt grommets into the valve rocker arm cover.



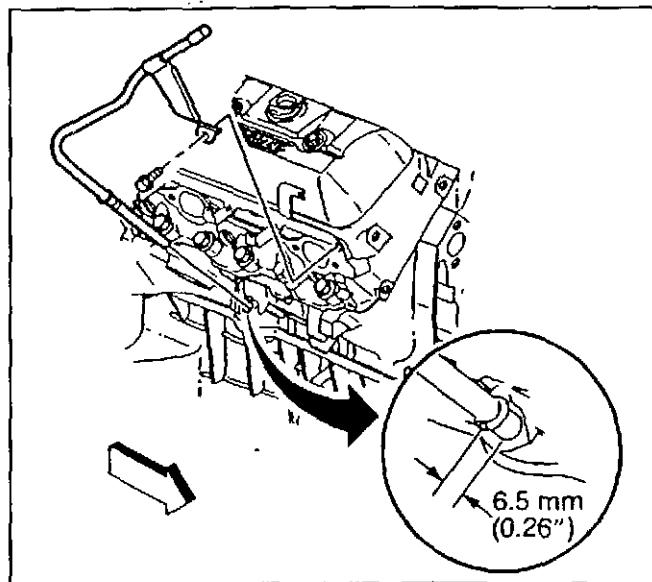
328573



328571



328568



188009

3. Install the valve rocker arm cover onto the cylinder head.

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

4. Install the valve rocker arm cover bolts.

Tighten

Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

SIE-ID - 358621

Oil Level Indicator and Tube Installation

1. Apply sealant GM P/N 12346004 or equivalent around the oil level indicator tube 13 mm (0.5 in) below the tube bead.
2. Install the oil level indicator tube into the engine block. Rotate the oil level indicator tube into position.

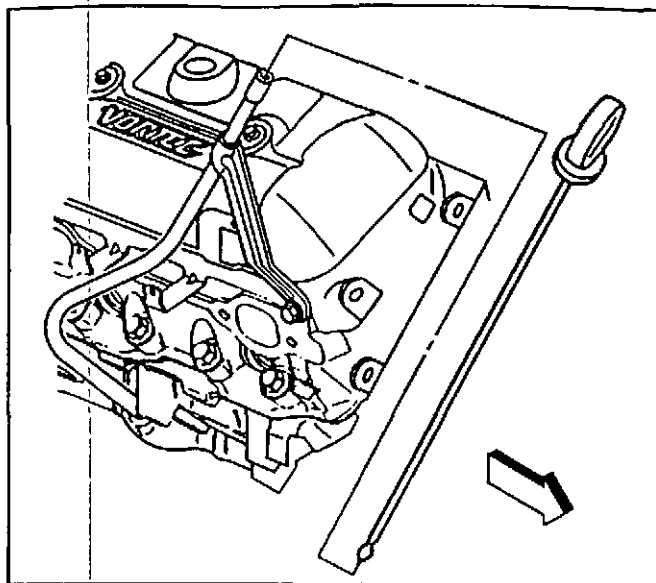
Notice: Refer to *Fastener Notice* in Cautions and Notices.

3. Install the oil level indicator tube bolt.

Tighten

Tighten the oil level indicator tube bolt to 12 N.m (106 lb in).

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



330580

SIE-ID - 358646

Water Pump Installation

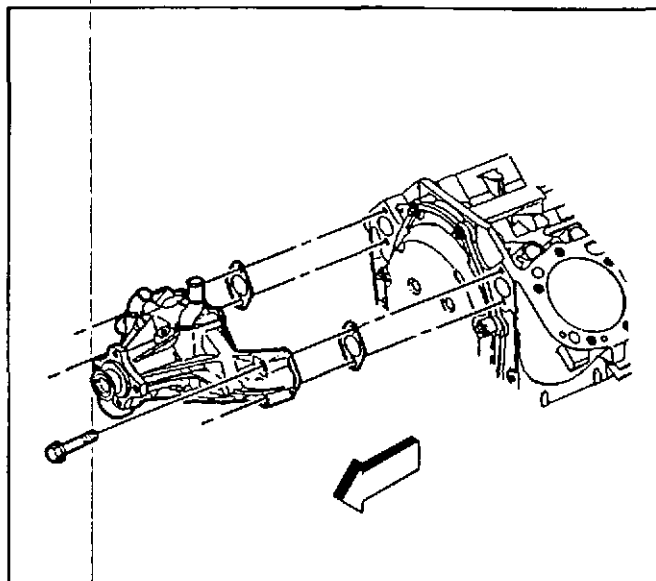
1. Apply sealant GM P/N 12346004 or equivalent to the threads of the water pump bolts.
2. Install the water pump and the NEW water pump gaskets.

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

3. Install the water pump bolts.

Tighten

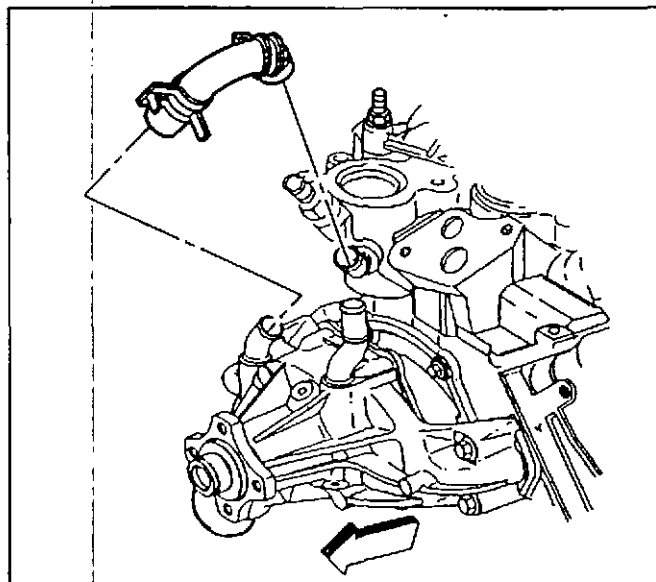
Tighten the water pump bolts to 45 N.m (33 lb ft).



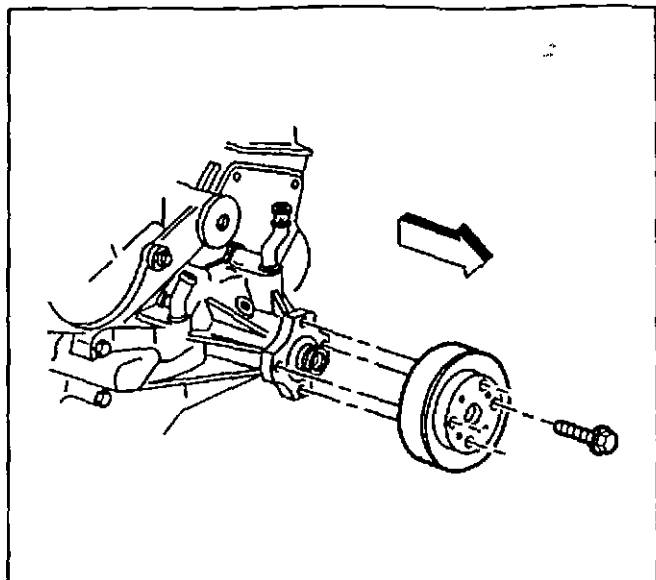
188054

Important: After final assembly, the water pump inlet hose clamp tangs (water pump end) must point forward and the upper tang should be level with the outside diameter of the water pump inlet hose.

4. Install the water pump inlet hose and the water pump inlet hose clamps.



182853



317191

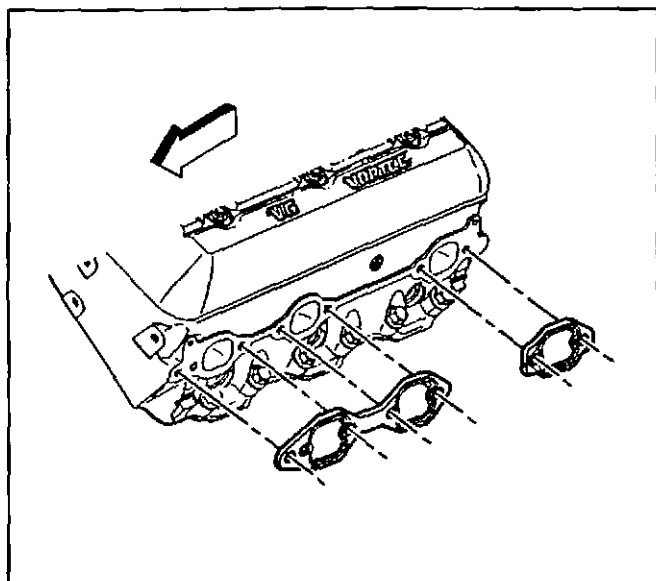
5. Install the fan and water pump pulley and bolts.
Tighten

Tighten the fan and water pump pulley bolts to 25 N.m (18 lb ft).

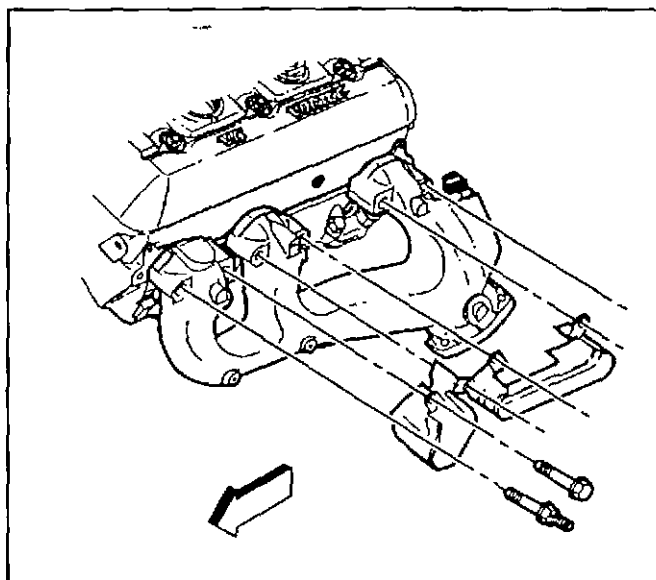
SIE-ID - 358655

Exhaust Manifold Installation (Left)

1. Install the NEW exhaust manifold gasket.



328540



188045

2. Install the exhaust manifold.
3. Install the spark plug wire shields.
4. Apply threadlock GM P/N 12345493 or equivalent to the threads of the exhaust manifold bolts.

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

5. Install the exhaust manifold bolts.

Tighten

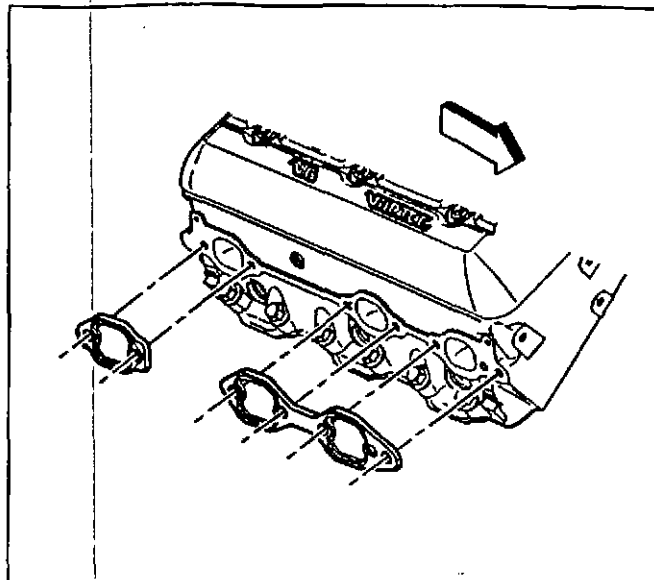
- 5.1. Tighten the exhaust manifold bolts on the first pass to 15 N.m (11 lb ft).
- 5.2. Tighten the exhaust manifold bolts on the final pass to 30 N.m (22 lb ft).

6. Install the spark plug wire retainers onto the spark plug wire support.
7. Install the spark plug wires onto the spark plugs.

SIE-ID - 358657

Exhaust Manifold Installation (Right)

1. Install the NEW exhaust manifold gasket.



328555

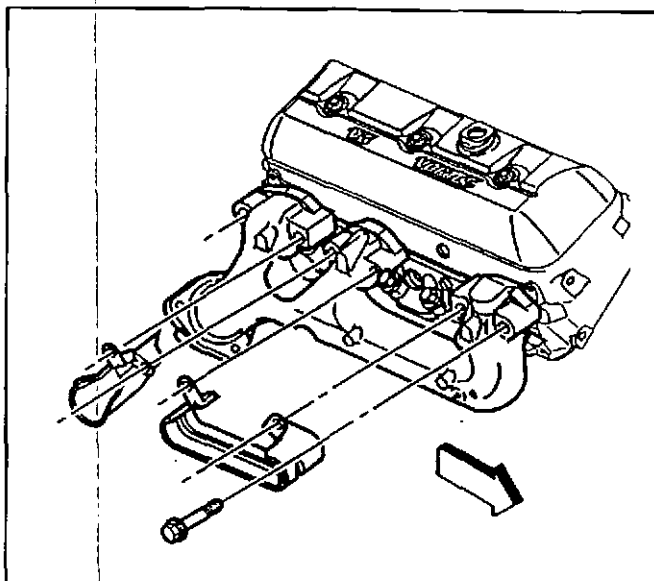
2. Install the exhaust manifold.
3. Install the spark plug heat shields.
4. Apply threadlock GM P/N 12345493 or equivalent to the threads of the exhaust manifold bolts.

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

5. Install the exhaust manifold bolts.
6. Tighten the exhaust manifold bolts.

Tighten

- 6.1. Tighten the bolts on the first pass to 15 N·m (11 lb ft).
- 6.2. Tighten the bolts on the final pass to 30 N·m (22 lb ft).
7. Install the spark plug wire retainers onto the spark plug wire support.
8. Install the spark plug wires onto the spark plugs.



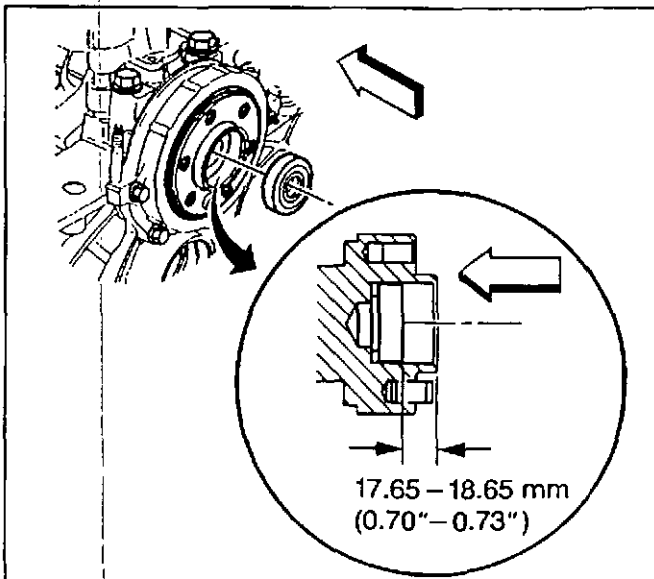
188121

SIE-ID - 358659

Clutch Pilot Bearing Installation

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

1. Install the NEW clutch pilot bearing.
2. Measure to ensure the proper installation depth is obtained.



334385

SIE-ID - 43080

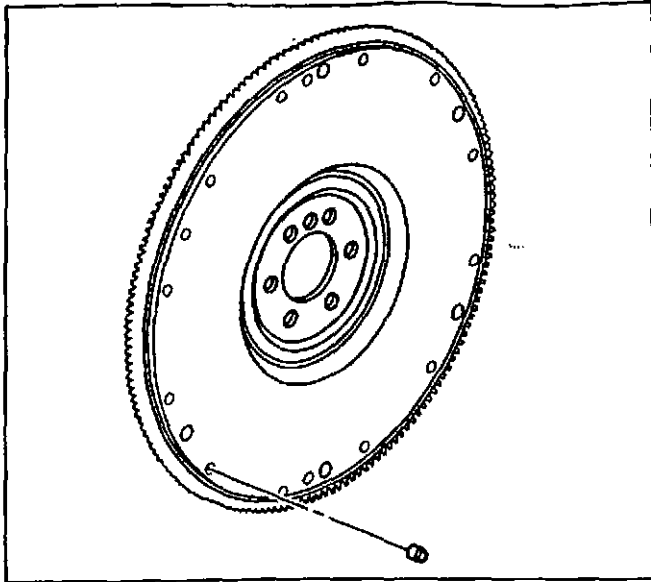
Engine Flywheel Installation

Important: If replacing the engine flywheel (manual transmission), note the position of the original flywheel weights (if applicable). Flywheel weights must be installed into the new engine flywheel in the same location as the old flywheel weights were in the old engine flywheel.

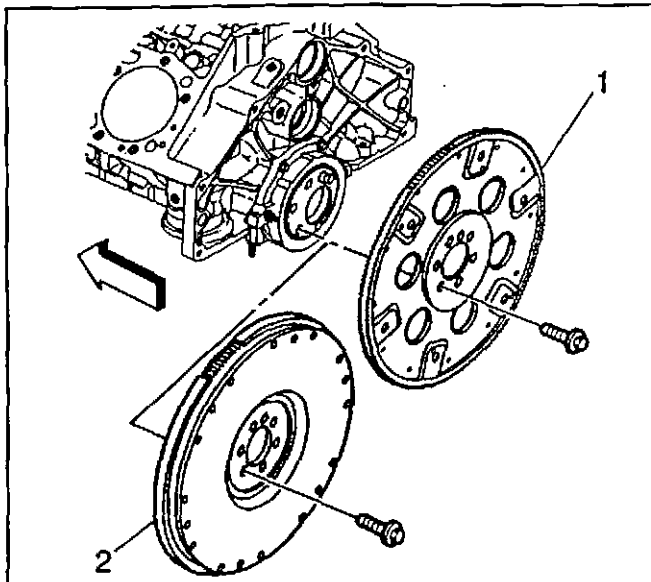
1. Note the position of the flywheel weights and install the NEW flywheel weights as required.
A properly installed flywheel weight will be flush or slightly below flush with the face of the engine flywheel.

2. Install the engine flywheel (1) or (2) to the crankshaft.

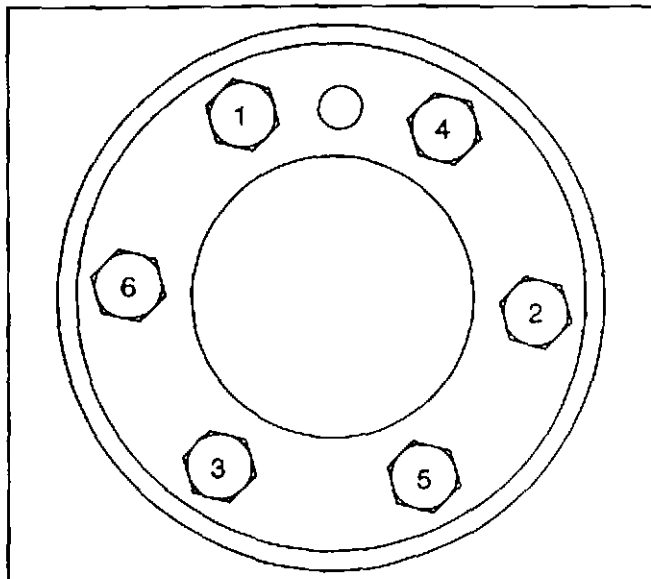
Align the engine flywheel locator hole to the flywheel locator pin.



64126



188129



63174

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

3. Install the engine flywheel bolts.

Tighten

Tighten the engine flywheel bolts in sequence (1-6) to 100 N.m (74 lb ft).

SIE-10 - 223034

Engine Set-Up and Testing

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

1. Fill the crankcase with the proper quantity and grade of oil.
2. Add engine oil supplement GM P/N 1052367 or equivalent to the engine oil.
3. Fill the cooling system with the proper quantity and grade of coolant.
 - Whenever the cooling system is serviced or drained for service procedures, two cooling system sealing pellets GM P/N 3634621 or equivalent, must be added to the cooling system.
 - Cooling system sealing pellets must be crushed prior to installation. The cooling system sealing pellets must be added to the radiator or the pressurized coolant reservoir.
 - Do not place the cooling system sealing pellets into a non-pressurized coolant recovery reservoir. On these systems, the pellets must be added to the radiator.
 - The sealant pellets may leave a film on the sides of the pressurized and non-pressurized coolant recovery reservoirs. This film is normal.
4. With the ignition OFF or disconnected, crank the engine several times. Listen for any unusual noises or evidence that any of the parts are binding.
5. Start the engine and listen for unusual noises.
6. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.

If necessary, install an oil pressure gauge and measure the engine oil pressure.
7. Run the engine at about 1000 RPM until the engine has reached normal operating temperature.
8. Listen for improperly adjusted or sticking valves, sticking lifters, or other unusual noises.
9. Inspect for oil and/or coolant leaks while the engine is running.
10. Verify that the distributor is properly positioned.
11. Perform a final inspection for the proper engine oil and coolant levels.

Description and Operation

SIE-ID - 43117

Engine Component Description

Balance Shaft

The cast iron balance shaft is mounted in the crankcase above and in-line with the camshaft. A camshaft gear drives the gear attached to the balance shaft. The front end of the balance shaft is supported by a ball-type bearing. The rear end of the balance shaft uses a sleeve-type bearing.

Camshaft

The steel camshaft is supported by four bearings pressed into the engine block. The camshaft timing chain sprocket mounted to the front of the camshaft is driven by the crankshaft sprocket through a camshaft timing chain.

Crankshaft

The cast nodular iron crankshaft is supported by four crankshaft bearings. The number four bearing at the rear of the engine is the end thrust bearing. The bearings are retained by bearing caps that are machined with the block for proper alignment and clearances. The reluctor ring has three lugs used for crankshaft timing and is constructed of powdered metal. The reluctor ring has a slight interference fit onto the crankshaft and an internal keyway for correct positioning.

Cylinder Heads

The cast iron cylinder heads have one intake and one exhaust valve for each cylinder. A spark plug is located between the valves in the side of the cylinder head. The valve guides and seats are integral to the cylinder head. The valve rocker arms are positioned on studs and retained by a specific locking nut.

Engine Block

The cast iron engine block has six cylinders arranged in a V shape with three cylinders in each bank. Starting at the front side of the engine block, the cylinders in the left bank are numbered 1-3-5 and cylinders in the right bank are numbered 2-4-6 (when viewed from the rear). The firing order of the cylinders is 1-6-5-4-3-2. The cylinders are encircled by coolant jackets.

Exhaust Manifolds

The cast iron exhaust manifolds direct exhaust gases from the combustion chambers to the exhaust system. The left side exhaust manifold has a port for the EGR valve inlet pipe.

Intake Manifold

The intake manifold is a two-piece design. The upper portion is made from a composite material and the lower portion is cast aluminum. The throttle body attaches to the upper manifold. The lower manifold has an exhaust gas recirculation (EGR) port cast into the manifold for mixture. The (EGR) valve bolts into

the lower intake manifold. The Central Sequential Multiport Fuel Injection system uses multiple injectors to meter and distribute fuel to each engine cylinder. The Central (SFI) is retained by a bracket bolted to the lower intake manifold. The fuel meter body also houses the pressure regulator. Metal inlet and outlet fuel lines and nylon delivery tubes connect to the Central (SFI) unit. The delivery tubes independently distribute fuel to each cylinder through nozzles located at the port entrance of each manifold runner where the fuel is atomized.

Piston and Connecting Rod Assemblies

The cast aluminum pistons use two compression rings and one oil control assembly. The piston is a low friction, lightweight design with a flat top and barrel shaped skirt. The piston pins are offset 0.9 mm (0.0354 in) toward the major thrust side (right side) to reduce piston slap as the connecting rod travels from one side of the piston to the other side after a stroke. They have a floating fit in the piston and are retained by a press fit in the connecting rod. The connecting rods are forged steel. The connecting rods are machined with the rod cap installed for proper clearances and alignments.

Valve Train

The valve train is a ball-pivot type. Motion is transmitted from the camshaft through the hydraulic roller valve lifters and the tubular valve pushrods to the valve rocker arms. The valve rocker arm pivots on a ball in order to open the valve. The hydraulic valve lifters keep all the parts of the valve train in constant contact. Each lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment.

SIE-ID - 357205

New Product Information

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

Changes may include one or more of the following items:

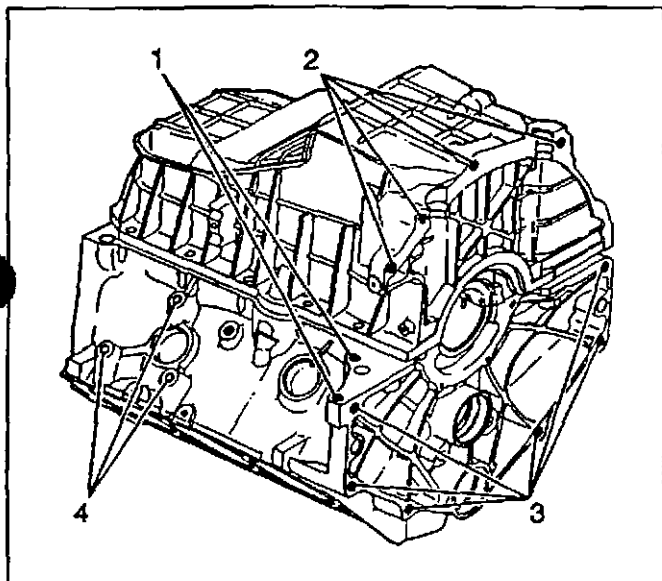
- A component comparison from the previous year
- Fastener changes
- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools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

Component Comparison

- New engine block M10 X 1.5 metric attachments for the engine mounts, the starter, and the transmission

- New oil pan M10 X 1.5 metric attachment for the transmission
- New crankshaft with a unique crankshaft clutch pilot bearing hole and 3 mm shortened engine flywheel mounting flange
- New clutch pilot bearing (ball type)
- Revised crankshaft rear oil seal and crankshaft rear oil seal housing for the shortened crankshaft engine flywheel mounting flange
- New engine flywheels (automatic and manual) for shortened crankshaft engine flywheel mounting flange
- Eliminated the fuel pump switch from the engine oil pressure gauge sensor
- Revised the water pump seal
- Revised the engine coolant thermostat

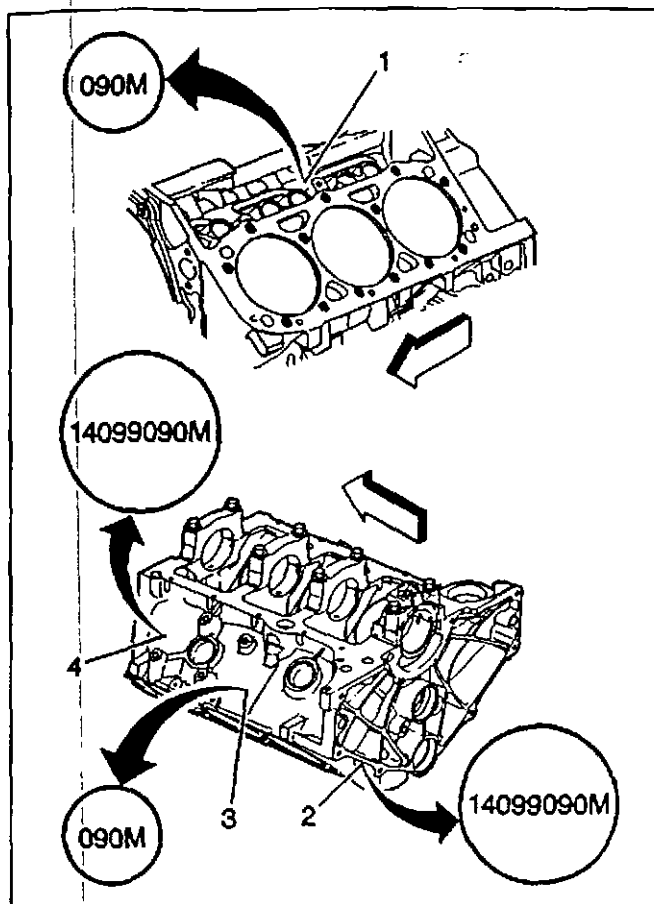
Engine Block and Oil Pan Partial Metricification



334564

- The engine block has been changed to M10 X 1.5 metric fasteners for the starter (1), the transmission (3), and the engine mount attachments (4).
- The oil pan has been changed to M10 X 1.5 metric fasteners for the transmission attachments (2).

Partial Metric Engine Block Identification



334566

- Engine blocks manufactured at the Saginaw casting plant are cast with 090M (1) and 14099090M (4) casting numbers for partial metric engine block identification.
- Engine blocks manufactured at the Defiance casting plant are cast with 090M (3) and 14099090M (2) casting numbers for partial metric engine block identification.

Torque Values and/or Fastener Tightening Strategies

- Cylinder head bolts, the crankshaft bearing cap bolts, and the connecting rod bolts apply a torque angle strategy.
In an on-vehicle situation where a torque angle meter may not fit into the vehicle packaging, a three step tightening process may be followed using a torque wrench.
- Certain fasteners should not be reused. Bolts, studs, or other fasteners that must be replaced will be called out in the specific service procedure.

Changed Engine Specifications

Engine mechanical specifications remain the same as the 1998 products.

New Sealants and/or Adhesives

Additional applications have been added to the table including:

- Balance shaft driven gear bolt

- Expansion cup plug (camshaft rear bearing hole)
- Expansion cup plug (balance shaft rear bearing hole)

Refer to sealers, adhesives, and lubricants.

Disassembly and Assembly Procedure Revisions or Additions

- A revised design Teflon® rear crankshaft oil seal
- A new design clutch pilot bearing (ball type)
- Engine block plug information has been enhanced to include the dowel pins (cylinder head locator) and dowel straight pins (transmission locator).
- Crankshaft Rear Oil Seal and Housing has been enhanced to include the spring type S pin (crankshaft rear oil seal housing locator).
- Intake Manifold Assemble information includes enhanced fuel seal installation detail.
- Discard all used gaskets, seals, or O-ring seals unless otherwise indicated.

Gaskets, seals, or O-ring seals that can be reused will be identified in the specific service procedure.

Engine Mechanical Diagnostic Procedure Revisions

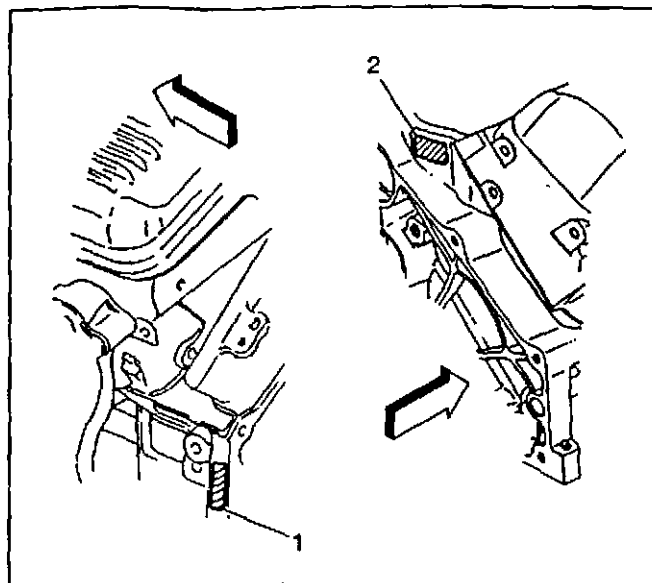
- Valve Train diagnostic information is now provided in table form.
Potential or probable causes are supplied for each specific concern.
- Engine Noise diagnostic information is now provided in table form.
Potential or probable causes are supplied for each specific concern.

New Special Tools Required

- Tool J 35621-B is a revision of the J 35621-A, and can be used to service All the crankshaft rear oil seal installation applications.
- Tool J 41712 has been added for removal and installation of the engine oil pressure gauge sensor.
- Tool J 43276 has been added for the removal of the clutch pilot bearing. Refer to *Special Tools*.

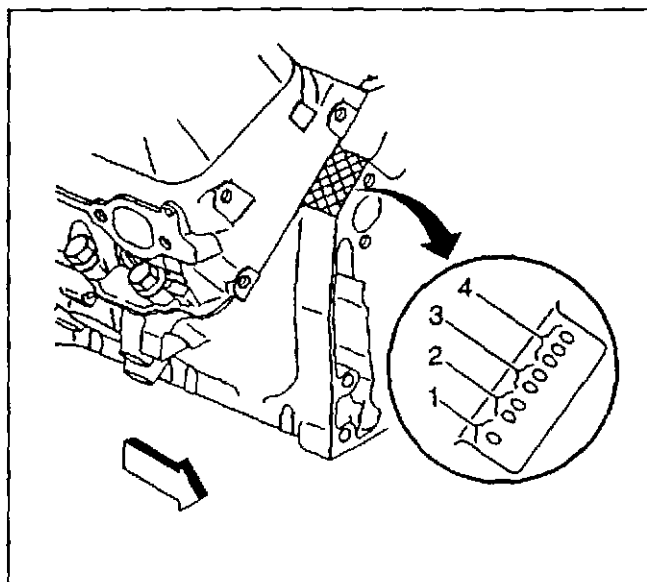
SIE-ID - 199882

Engine Identification



174107

- The Vehicle Identification Number (VIN) Derivative is located on the left side rear of the engine block (1) or on the right side rear (2) and typically is a nine digit number stamped or laser etched onto the engine at the vehicle assembly plant.
 - The first digit identifies the division.
 - The second digit identifies the model year.
 - The third digit identifies the assembly plant.
 - The fourth through ninth digits are the last six digits of the Vehicle Identification Number (VIN).

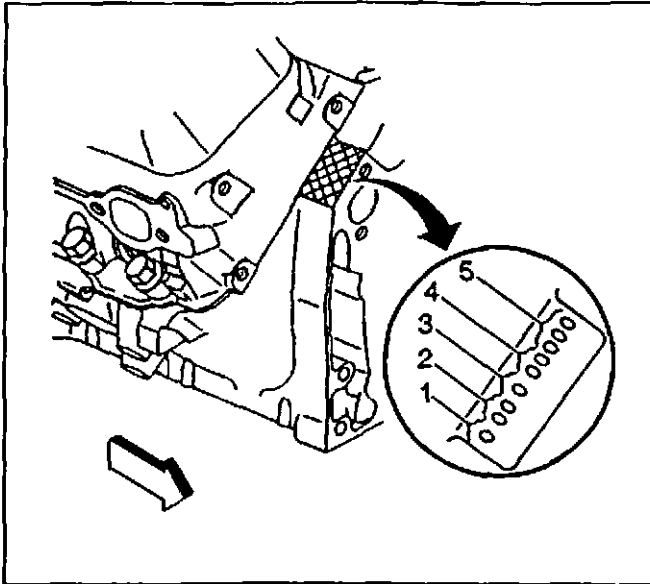


195338

- Engines built at the Tonawanda engine plant have the engine identification number located at the right front top of the engine block.
 - The first digit (1) is the source code.
 - The second and third digits (2) are the month of build.
 - The fourth and fifth digits (3) are the date of

build.

- The sixth, seventh, and eighth digits (4) are the broadcast code.



195339

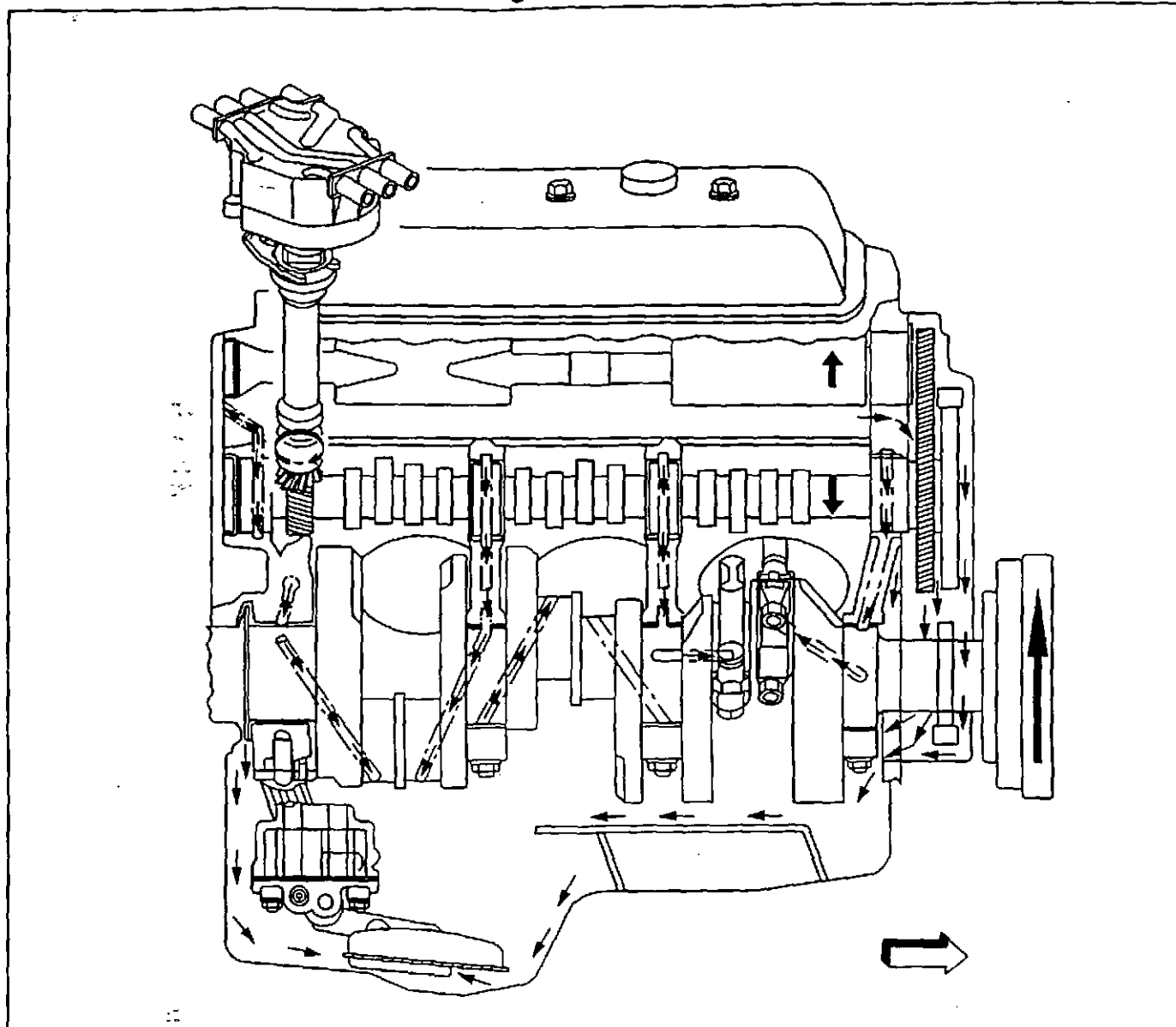
- Engines built at the Romulus engine plant have the engine identification number located at the right front top of the engine block.
 - The first digit (1) is the source code.
 - The second and third digits (2) are the month of build.
 - The fourth digit (3) is the hour of the build.
 - The fifth and sixth digits (4) are the date of build.
 - The seventh, eighth, and ninth digits (5) are the broadcast code.

SIE-ID - 43423

Lubrication

SIO-ID - 41430

Engine Lubrication



44610

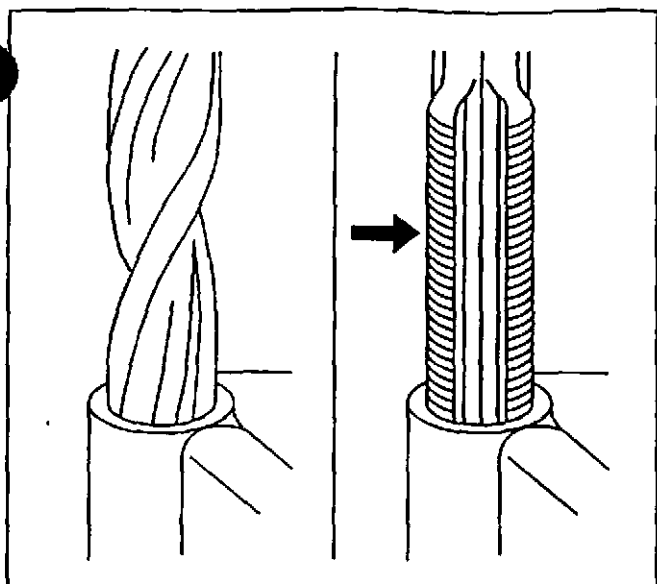
Full pressure lubrication, through a full-flow oil filter is supplied by a gear-type oil pump. Oil is drawn up through the oil pump screen and passes through the pump to the oil filter. The oil filter is a full-flow paper element unit with an anti-drain back valve. An oil filter bypass valve is used to ensure adequate oil supply, in the event the filter becomes plugged or develops excessive pressure drop. Filtered oil flows into the main gallery and then to the camshaft, the balance shaft, the rear bearing, and the crankshaft bearings. The valve lifter oil gallery supplies oil to the valve lifters. Oil flows from the valve lifters through the hollow valve pushrods to the valve rocker arms. Oil drains back to the crankcase through the oil drain holes in the cylinder head. The camshaft timing chain is drip fed from the front camshaft bearing. The pistons and piston pins are lubricated by oil splash.

SIE-ID - 43119

Tools Required

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

Thread Repair



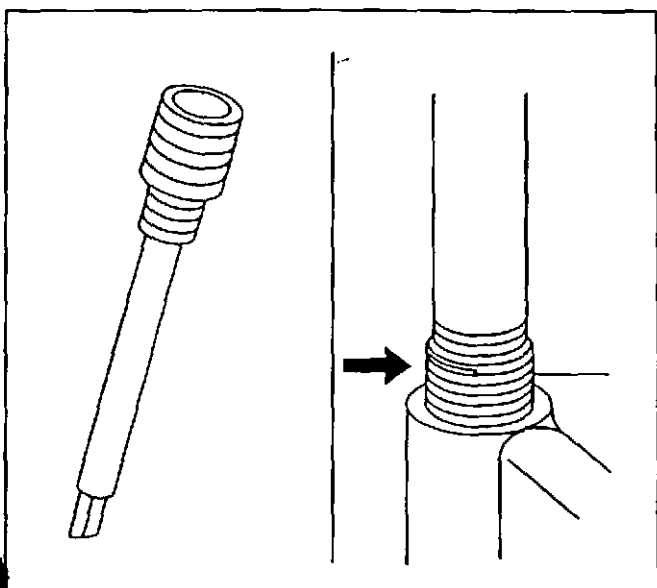
4962

Caution: SIO-ID - 5011 *Wear safety glasses in order to avoid eye damage.*

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

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

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



4963

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

Important: The insert should be flush to 1 turn

below the surface.

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

SIE-ID - 19007

Cleanliness and Care

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, the components should be marked, organized or retained in a specific order for re-assembly.
- At the time of installation, the components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. The surfaces should be protected to avoid component damage.
- Apply a liberal amount of clean engine oil to friction areas during assembly.
- Proper lubrication will protect and lubricate friction areas during initial operation.

SIE-ID - 66654

Replacing Engine Gaskets

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion of the components.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components. Do not use any other method or technique to

remove the sealant or the gasket material from a part.

- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.
 - Abrasive pads also produce a fine grit that the oil filter cannot remove from the engine oil.

This fine grit is an abrasive and can cause internal engine damage.

Assembling Components

- Assemble components using only the sealant (or equivalent) that is specified in the service procedure.
- Sealing surfaces must be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.
- Tighten fasteners to the proper specifications. DO NOT overtighten the fasteners.

SIE-ID - 411537

Use of RTV and Anaerobic Sealer

Sealant Types

Important: The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant (or equivalent) as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

- Aerobic sealant (Room Temperature Vulcanizing (RTV))
- Anaerobic sealant, which include the following:
 - Gasket eliminator
 - Pipe
 - Threadlock

Aerobic Type Room Temperature Vulcanizing (RTV) Sealant

Aerobic type Room Temperature Vulcanizing (RTV) sealant cures when exposed to air. This type of sealant is used where 2 components (such as the intake manifold and the engine block) are assembled together.

Use the following information when using RTV

sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

Important: Do not allow the RTV sealant to enter any blind threaded holes, as it may prevent the fasteners from clamping properly or cause damage when the fastener is tightened.

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.
- Assemble the components while the RTV sealant is still wet to the touch (within 3 minutes). Do not wait for the RTV sealant to skin over.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Gasket Eliminator Sealant

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

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.

The surfaces to be sealed must be clean and dry.

Important: Do not allow the gasket eliminator sealant to enter any blind threaded holes, as the gasket eliminator sealant may prevent the fasteners from clamping properly, seating properly, or cause damage when the fastener is tightened.

- Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.

Important: Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than five minutes, may result in incorrect shimming and sealing of the joint.

- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.
- After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

Important: Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than five minutes, may result in incorrect clamp load of assembled components.

- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

Important: Do not allow the pipe sealant to enter any of the blind threaded holes, as the pipe sealant may prevent the fastener from

clamping properly, or cause component damage when the fastener is tightened.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to 1 sealing surface.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

SIE-ID - 194497

Separating Parts

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

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

Mark or identify the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the specific cylinder bore
- Connecting rod to the crankshaft journal
- Connecting rod to connecting rod cap
- Crankshaft bearings and connecting rod bearings
- Engine camshaft and valve lifters
- Valve lifters and valve rocker arms
- Valve to the valve guide
- Valve spring to cylinder head location
- Engine block bearing cap location and direction
- Oil pump drive and driven gears

SIE-ID - 73997

Tools and Equipment

SIO-ID - 70760

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well-lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools

6-286 Engine Mechanical - 4.3L

- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

Special Tools and Equipment

SIE-ID = 356712

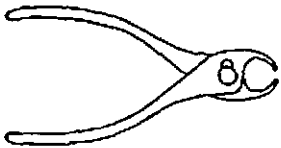
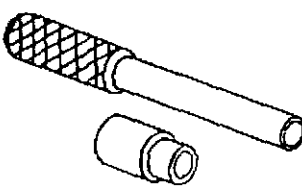
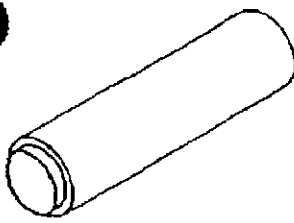
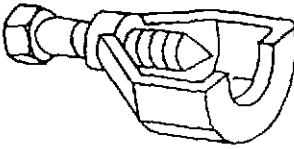
Illustration	Tool Number/ Description
 14487	J 3049-A Valve Lifter Remover
 3404	J 5239 Connecting Rod Bolt Guide Set
 3407	J 5590 Installer
 3406	J 5825-A Crankshaft Gear Remover

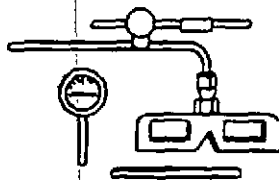
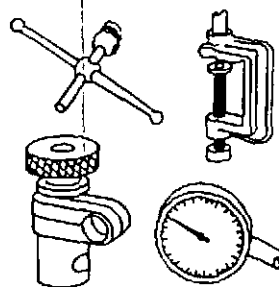
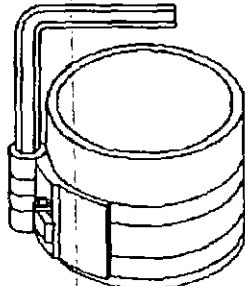
Illustration	Tool Number/ Description
 3399	J 5892-D Valve Spring Compressor
 35463	J 7872 Magnetic Base Dial Indicator
 2014	J 8001 Dial Indicator Set
 3403	J 8037 Ring Compressor

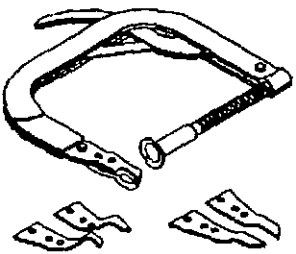
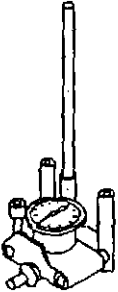
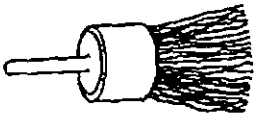
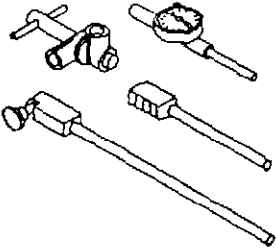
Illustration	Tool Number/ Description
 3414	J 8062 Valve Spring Compressor
 5110	J 8087 Cylinder Bore Gauge
 35464	J 8089 Carbon Removing Brush
 2015	J 8092 Universal Driver Handle
 3408	J 8520 Cam Lobe Lift Indicator

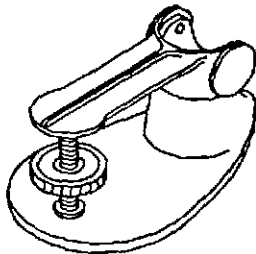
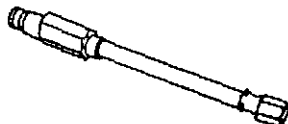
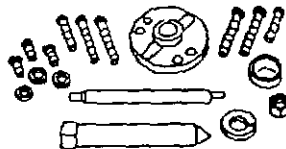
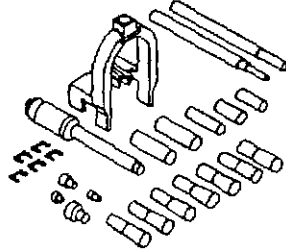
Illustration	Tool Number/ Description
 5112	J 9666 Valve Spring Tester
 3416	J 21882 Oil Suction Pipe Installer
 26998	J 22794 Spark Plug Port Adapter
 66168	J 23523-F Balancer Remover and Installer
 14495	J 24086-C Piston Pin Remover/Installer

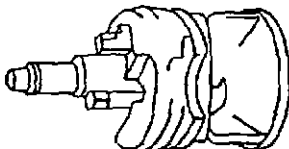
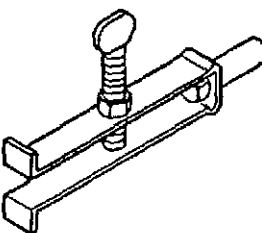
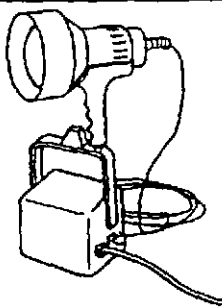
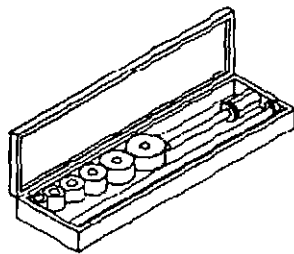
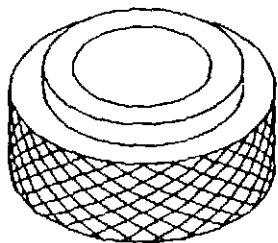
Illustration	Tool Number/ Description
 3412	J 24270 Cylinder Bore Ridge Reamer
 4862	J 26941 Bushing/Bearing Remover
 62292	J 28428-E High Intensity Black Light Kit
 5118	J 33049 Camshaft Bearing Service Kit
 3401	J 35468 Cover Aligner/Seal Installer

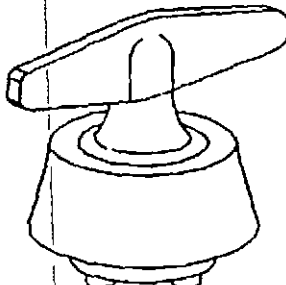
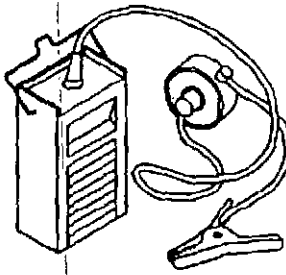
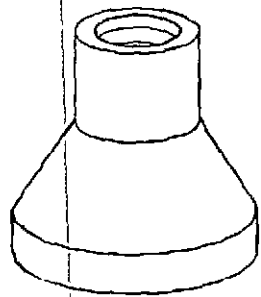
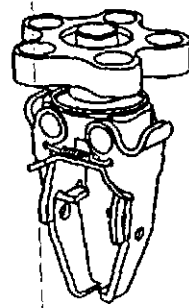
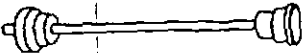
Illustration	Tool Number/ Description
 350498	J 35621-B Rear Main Seal Installer
 3413	J 36660 Electronic Torque Angle Meter
 3411	J 36996 Balance Shaft Installer
 33658	J 38606 Valve Spring Compressor
 3410	J 38834 Balance Shaft Service Kit

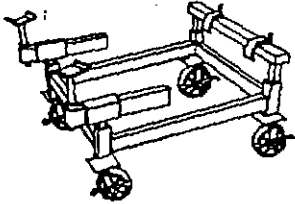
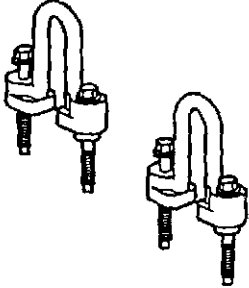
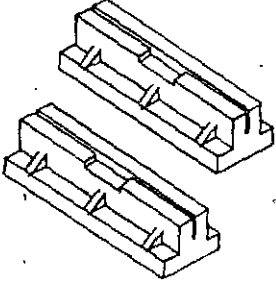
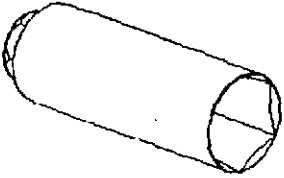
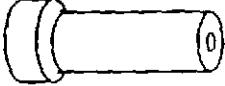
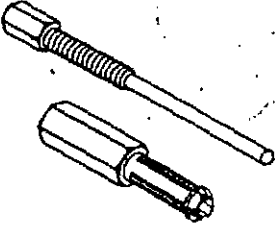
Illustration	Tool Number/ Description
 52122	 J 39580 Engine Support Table
 66511	 J 41427 Engine Lift Bracket
 43739	 J 41602 Body Protection Hoist Adapter Set
 67136	 J 41712 Oil Pressure Switch Socket
 38509	 J 42073 Valve Stem Seal Installer

Illustration	Tool Number/ Description
 355040	 J 43276 Clutch Pilot Bearing Remover