

GENERAC[®]
POWER SYSTEMS, INC.

4.3 LITER

**GM
GAS
ENGINE**

***SERVICE
MANUAL***

FOREWORD

This manual has been published by GENERAC® POWER SYSTEMS, INC. to aid our dealers' mechanics, company service personnel and general consumers when servicing the products described herein.

It is assumed that these personnel are familiar with the servicing procedures for these products, or like or similar products, manufactured and marketed by GENERAC® POWER SYSTEMS, INC. It is also assumed that they have been trained in the recommended servicing procedures for these products, which includes the use of mechanics hand tools and any special tools that might be required.

Proper service and repair is important to the safe, economical and reliable operation of the products described herein. The troubleshooting, testing, service and repair procedures recommended by GENERAC® POWER SYSTEMS, INC. and described in this manual are effective methods of performing such operations. Some of these operations or procedures may require the use of specialized equipment. Such equipment should be used when and as recommended.

We could not possibly know of and advise the service trade of all conceivable procedures or methods by which a service might be performed, nor of any possible hazards and/or results of each procedure or method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a procedure or method not recommended by the manufacturer must first satisfy himself that neither his safety, nor the product's safety, will be endangered by the service or operating procedure selected.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. However, GENERAC® POWER SYSTEMS, INC. reserves the right to change, alter or otherwise improve the product at any time without prior notice.

Some components or assemblies of the product described in this manual may not be considered repairable. Disassembly, repair and reassembly of such components may not be included in this manual.

The engines described herein may be used to power a wide variety of products. Service and repair instructions relating to any such products are not covered in this manual. For information pertaining to use of these engines with other products, refer to any owner's or service manuals pertaining to said products.

SERVICE RECOMMENDATIONS	A_2
EXPLODED VIEWS	
ENGINE COMMON PARTS (LEFT SIDE)	A_4
ENGINE COMMON PARTS (RIGHT SIDE)	A_6
CARBURETOR SETUP (TYPICAL)	A_8
TORQUE SPECIFICATIONS	6-1 THRU 6-3
ENGINE MECHANICAL SPECIFICATIONS	6-3 THRU 6-6
DIAGNOSTIC INFORMATION AND PROCEDURES	6-11 THRU 6-26
VISUAL IDENTIFICATION	6-27 THRU 6-32
REPAIR INSTRUCTIONS	6-33 THRU 6-264
DESCRIPTION AND OPERATION	6-265 THRU 6-266
ENGINE IDENTIFICATION.....	6-267
LUBRICATION	6-268
CLEANLINESS AND CARE.....	6-268
REPLACING ENGINE GASKETS	6-269
USE OF RTV AND ANAEROBIC SEALER.....	6-269
SPECIAL TOOLS AND EQUIPMENT	6-272 THRU 6-275

The 4.3 Liter Gas Engine has been engineered for use in Generac Power Systems products. The contents of this manual have been reprinted from the original manufacturer's service and repair manual. The exploded view section at the front of this manual is for reference only.

4.3 Liter Gas Engine Service Recommendations

◆ ENGINE OIL RECOMMENDATIONS

The unit has been filled with "break in" engine oil at the factory. Use a high-quality detergent oil classified "For Service CC, SD, SE or SF." Detergent oils keep the engine cleaner and reduce carbon deposits. Use oil having the following SAE viscosity rating, based on the ambient temperature range anticipated before the next oil change:

Engine Lubrication System:

Type of Oil Pump Gear
Oil Filter Full Flow, Cartridge
Crankcase Oil Capacity 4.25 L (4.5 U.S. qts.) ◆

Temperature	Oil Grade (Recommended)
Above 86° F (30° C)	SAE 40 or 15W-40
32° to 86° F (0° to 30° C)	SAE 30 or 15W-40
Below 32° F (0° C)	SAE 20W or 15W-40
All Seasons	SAE 15W-40

COOLANT

Use a mixture of half low silicate, ethylene glycol base antifreeze and half soft water. Use only soft water and only low silicate antifreeze. If desired, you may add a high quality rust inhibitor to the recommended coolant mixture. When adding coolant, always add the recommended 50-50 mixture.

Cooling System:

Type Pressurized, Closed Recovery
Coolant Capacity
System SG035/045/075 17 L (4.5 U.S. gals.)
System SG060 19 L (5 U.S. gals.)

⚠ DANGER ⚠

⚠ Do not remove the radiator pressure cap while the engine is hot or serious burns from boiling liquid or steam could result.

⚠ Ethylene glycol base antifreeze is poisonous. Do not use your mouth to siphon coolant from the radiator, recovery bottle or any container. Wash your hands thoroughly after handling. Never store used antifreeze in an open container because animals are attracted to the smell and taste of antifreeze even though it is poisonous to them.

⚠ CAUTION ⚠

⚠ Do not use any chromate base rust inhibitor with ethylene glycol base antifreeze, or chromium hydroxide ("green slime") will form and cause overheating. Engines that have been operated with a chromate base rust inhibitor must be chemically cleaned before adding ethylene glycol base antifreeze. Using any high silicate antifreeze boosters or additives also will cause overheating. We also recommend that you DO NOT use any soluble oil inhibitor for this equipment.

PERIODIC MAINTENANCE SCHEDULE:

◆ AUTHORIZED OPERATOR MAINTENANCE FUNCTIONS

Every Month or 100 Hours

(whichever comes first)

- Test standby generator system.
- Inspect battery and cables.
- Check engine oil level.
- Check gearbox oil level (if so equipped).
- Check engine coolant level.
- Check generator ground connections.
- Test/inspect starting aids.

Every Three Months or Every 120 Hours

(whichever comes first)

- Inspect and test fuel system and connections.
- Inspect exhaust system.
- Inspect/test fuel supply system.

◆ AUTHORIZED SERVICE TECHNICIAN MAINTENANCE FUNCTIONS

After First 30 Hours of Operation

- Inspect wiring.
- Change engine crankcase oil and oil filter.
- Inspect engine fan belts.
- Inspect battery and cables.

Every Six Months or Every 200 Hours

(whichever comes first)

- Change engine oil and filter.
- Lubricate engine controls.
- Service engine air cleaner.
- Service engine fuel filter.
- Inspect AC generator.
- Test engine safety controls.
- Inspect fan belts.
- Check engine coolant level.
- Inspect engine cooling system hoses.
- Check optional starting aids.
- Check battery.
- Check engine compression.
- Check electrical connections.
- Check/test annunciator panel.
- Perform operational test.

Annually or Every 600 Hours

(whichever comes first)

- Inspect spark plugs, replace if necessary.
- Inspect all wiring.
- Test engine starter operation.
- Retorque fan bolts.
- Drain and refill gearbox (if so equipped)
- Check ignition timing.

Every Two Years

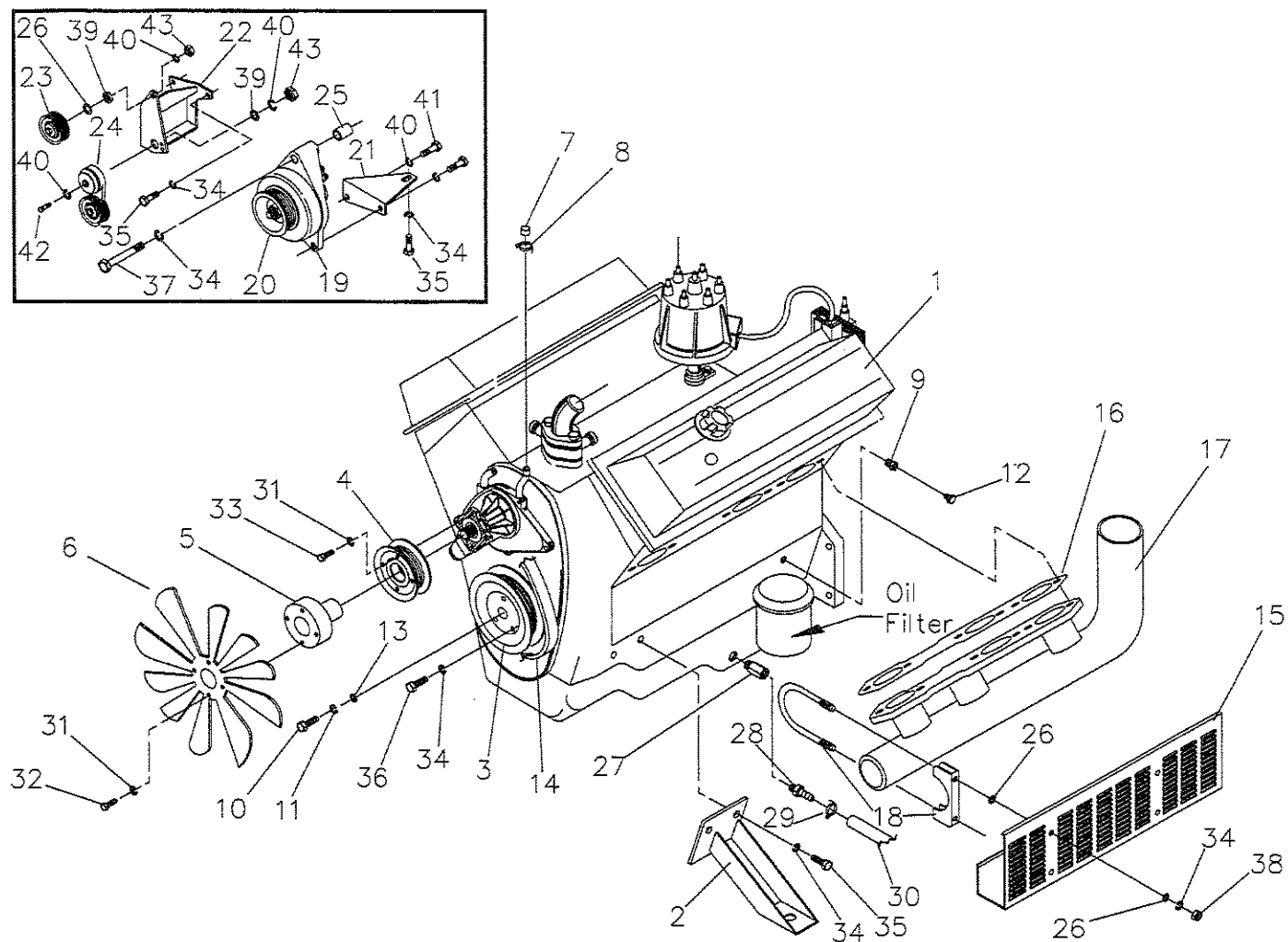
- Replace all rubber hoses.
- Replace engine fan belts.
- Inspect the Standby Generator System.
- Drain, flush, refill cooling system.

Every 1,000 Operating Hours

- Replace spark plugs.
- Inspect engine DC alternator.
- Inspect engine starter.
- Retorque engine mounting brackets.
- Remove/test cooling system thermostat.
- Inspect complete ignition system.

4.3 Liter Gas Engine Common Parts (Left Side)

Exploded View

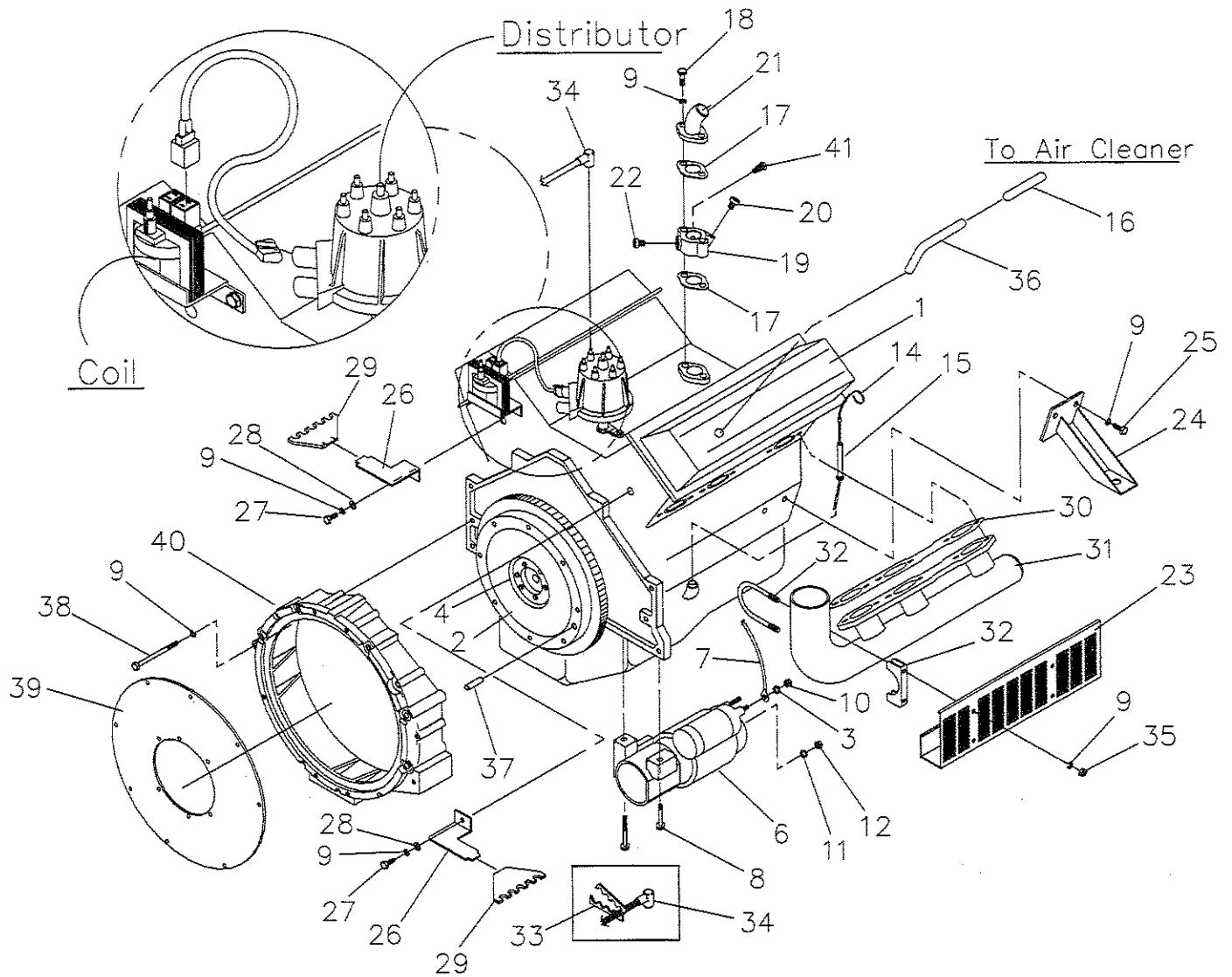


4.3 Liter Gas Engine Common Parts (Left Side)

ITEM	DESCRIPTION	QTY
1	ENGINE, 4.3L VORTEC	1
2	ENGINE MOUNT	1
3	PULLEY, CRANKSHAFT	1
4	PULLEY, WATERPUMP	1
5	FAN SPACER, 35KW UNITS ONLY	1
	FAN SPACER, 45KW UNITS ONLY	1
6	FAN, 15"-35KW UNITS ONLY	1
	FAN, 17"-45KW UNITS ONLY	1
7	CAP, ANTI-FREEZE	1
8	CLAMP, HOSE #10	1
9	REDUCER, 1/4" NPT-1/8" NPT	1
10	CAPSCR.,-HEX HD.-7/16"-20 X 2-1/4"	1
11	LOCK WASHER-7/16"	1
12	SWITCH, OIL PRESSURE	1
13	SPACER,- .50-1.50	1
14	SERPENTINE BELT,72-1/2"	1
15	HEAT SHIELD, LEFT	1
16	GASKET, EXHAUST	1
17	MANIFOLD-LEFT EXHAUST	1
18	U-BOLT & SADDLE	2
19	DC ALTERNATOR	1
20	PULLEY, ALTERNATOR	1
21	BRACKET, ALTERNATOR SUPPORT	1
22	BRACKET, ALTERNATOR MOUNTING	1
23	PULLEY, IDLER	1
24	PULLEY, TENSIONER	1
25	SPACER	1
26	FLAT WASHER, 3/8"-M10	9
27	ADAPTOR, M12-1.75 - 3/8" NPT	1
28	BARB, 3/8 "NPT-5/8 BARB	1
29	CLAMP, HOSE #10	1
30	HOSE, 5/8"-12" LONG	1
31	LOCK WASHER, 5/16"	8
	LOCK WASHER-M6 (35KW)	4
32	HEX HD. CAPSCR.-5/16"-18 X 3/4" (45KW)	4
	HEX HD. CAPSCR.-M6-1.0 X 16 (35KW)	4
33	HEX HD. CAPSCR.-5/16"-24 X 3/4"	4
34	LOCK WASHER, 3/8"	15
35	HEX HD. CAPSCR.-3/8"-16 X 1	7
36	HEX HD. CAPSCR.-3/8"-24 X 1	3
37	HEX HD. CAPSCR.-3/8"-16 X 4	1
38	HEX NUT, 3/8"-16	4
39	FLAT WASHER, M10 HEAVY	2
40	LOCK WASHER, M10	5
41	HEX HD. CAPSCR.-M10-1.5 X 25	2
42	HEX HD. CAPSCR.-M10-1.5 X 70	1
43	HEX NUT, M10	2

4.3 Liter Gas Engine Common Parts (Right Side)

Exploded View

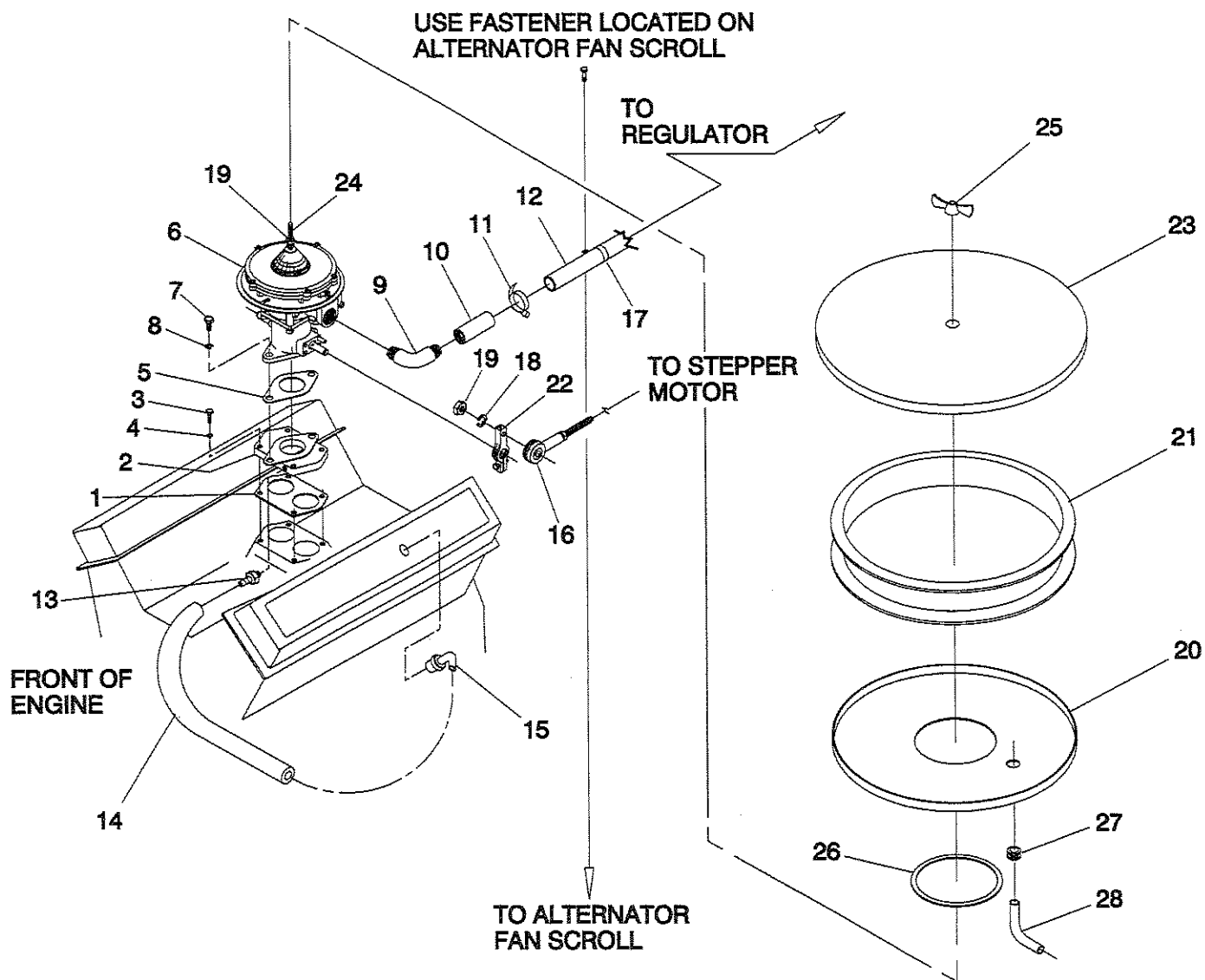


4.3 Liter Gas Engine Common Parts (Right Side)

ITEM	DESCRIPTION	QTY
1	ENGINE-4.3 LITER V6	1
2	FLYWHEEL	1
3	XWASHER, LOCK-EXTERNAL M12	1
4	BOLT (FLYWHEEL)	6
6	STARTER	1
7	CABLE, BATTERY (RED)-15" LONG	1
8	BOLT, STARTER	2
9	WASHER, LOCK-3/8"	17
10	NUT, HEX-M10-1.50	1
11	WASHER, LOCK-M5	1
12	NUT, HEX-M5-0.80	1
13	CONNECTOR, COIL DISTRIBUTOR	1
14	DIPSTICK, OIL LEVEL	1
15	TUBE, OIL DIPSTICK	1
16	TUBING, 3/4" I.D. X 10" LONG	1
17	GASKET, THERMOSET	2
18	CAPSCREW, HEX HD.-3/8"-16 X 2-3/4"	2
19	HOUSING, SENSOR/THERMOSTAT	1
20	SENDER, TEMPERATURE	1
21	HOUSING, THERMOSTAT/WATER INLET	1
22	SWITCH, HIGH COOLANT	1
23	HEATSHIELD	1
24	ENGINE MOUNT	1
25	CAPSCR., HEX HD.-3/8"-16 X 1"	3
26	SUPPORT, SPARK PLUG WIRE	2
27	CAPSCR., HEX HD.-3/8"-16 X 3/4"	2
28	WASHER, FLAT-3/8"	2
29	GROMMET, SPARK PLUG WIRE	2
30	GASKET, EXHAUST	1
31	MANIFOLD, EXHAUST	1
32	HEAT SHIELD SPACER	2
33	RETAINER, SPARK PLUG WIRES	2
34	SET-SPARK PLUG WIRE	1
35	NUT, HEX 3/8"-16	4
36	CONNECTOR	1
37	DOWEL PIN-M10 X 24	2
38	CAPSCR., HEX HD.-3/8"-16 X 3.5"	6
39	FLEX PLATE	3
40	ADAPTER CASTING, SAE3	1
41	WATER LEVEL SENSOR	1

4.3 Liter Gas Engine Carburetor Setup (Typical)

Exploded View



4.3 Liter Gas Engine Carburetor Setup (Typical)

ITEM	DESCRIPTION	QTY
1	GASKET	1
2	ADAPTOR, CARBURETOR	1
3	CAPSCREW, HEX HD. 5/16"-18 X 1-1/4"	4
4	WASHER, LOCK 5/16"	4
5	GASKET	1
6	CARBURETOR (NATURAL GAS + VAPOR)	1
	CARBURETOR (LPG LIQUID)	1
7	CAPSCREW, HEX HD. 3/8"-16 X 1"	2
8	WASHER, LOCK 3/8"	2
9	ELBOW, STREET 3/4" NPT	1
10	NIPPLE, PIPE (THREADED ONE END) 3/4" NPT X 2" LONG	1
11	CLAMP, HOSE #16	1
12	HOSE, 1" I.D. X 44" LONG (NATURAL GAS + VAPOR)	1
	HOSE, 1" I.D. X 12" LONG (LPG LIQUID)	1
13	BARB 1/8" NPT-3/8"	1
14	HOSE, 3/8" X 9" LONG	1
15	PVC VALVE	1
16	BALL JOINT	1
17	CLAMP, VINYL 1-5/16" X 13/32"	1
18	WASHER, LOCK 1/4"	1
19	NUT, HEX 1/4"-28	2
20	BOTTOM, AIR CLEANER	1
21	ELEMENT, AIR CLEANER	1
22	ARM, THROTTLE	1
23	COVER, AIR CLEANER	1
24	STUD 1/4"-20 X 3" LONG	1
25	NUT, WING 1/4"-20	1
26	GASKET	1
27	GROMMET	1
28	CONNECTOR	1

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Engine Mechanical - 4.3L

Specifications

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Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Control Cable Bracket Nut to Stud	12 N·m	106 lb in
Accelerator Control Cable Bracket Nut to Throttle Body	9 N·m	80 lb in
Accelerator Control Cable Bracket Stud to Intake Manifold	6 N·m	53 lb in
Accelerator Control Cable Bracket Stud to Throttle Body	12 N·m	106 lb in
Air Cleaner Adapter Stud	8 N·m	71 lb in
Balance Shaft Driven Gear Bolt		
First Pass	20 N·m	15 lb ft
Final Pass	35 degrees	
Balance Shaft Retainer Bolt	12 N·m	106 lb in
Battery Cable Bracket Bolt to Oil Pan	12 N·m	106 lb in
Battery Negative Cable Bolt to Engine	25 N·m	18 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	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 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
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

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
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	75 N·m	55 lb ft
Engine Mount Frame Side Mount Bolt	65 N·m	50 lb ft
Engine Oil Level Sensor	13 N·m	115 lb in
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	9 N·m	80 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	9 N·m	80 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	89 lb in
Exhaust Manifold Bolt/Stud		
First Pass	15 N·m	11 lb ft
Final Pass	30 N·m	22 lb ft
Exhaust Manifold Heat Shield Bolt	9 N·m	80 lb in
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	89 lb in
Fuel Pipe Bracket Bolt	6 N·m	53 lb in
Fuel Pipe Retainer Nut	3 N·m	27 lb in
Fuel Supply Pipe Nut (Fuel Tank Side)	30 N·m	22 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		

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
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 Fitting	55 N·m	41 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 (Rear Bracket 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	89 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 Wiring Harness/Transmission Cooler Pipe Bracket to Oil Pan Bolt	9 N·m	80 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		
First Pass	5 N·m	44 lb in
Final Pass	9 N·m	80 lb in
Valve Lifter Pushrod Guide Bolt	16 N·m	12 lb ft
Valve Rocker Arm Bolt	30 N·m	22 lb ft
Valve Rocker Arm Cover Bolt	12 N·m	106 lb in
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 L35 VIN Code W		
Displacement	4.3 L	262 CID
Bore	101.60 mm	4.012 in

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
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) at Normal Operating Temperature	42 kPa at 1,000 RPM	6 psig at 1,000 RPM
	125 kPa at 2,000 RPM	18 psig at 2,000 RPM
	166 kPa at 4,000 RPM	24 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	0.0010–0.0090 in
Journal Diameter	47.440–47.490 mm	1.8677–1.8696 in
Journal Diameter Out-of-Round	0.025 mm (Maximum)	0.0010 in (Maximum)
Lobe Lift (Exhaust)	7.20–7.30 mm	0.283–0.287 in
Lobe Lift (Intake)	6.97–7.07 mm	0.274–0.278 in
Runout	0.065 mm	0.0026 in
Connecting Rod		
Connecting Rod Bearing Clearance (Production)	0.038–0.078 mm	0.0015–0.0031 in
Connecting Rod Bearing Clearance (Service)	0.025–0.063 mm	0.0010–0.0025 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)	0.00030 in (Maximum)
Connecting Rod Journal Taper (Service)	0.025 mm (Maximum)	0.0010 in (Maximum)
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)	0.0010 in (Maximum)
Crankshaft		
Crankshaft Bearing Clearance (Journal #1–Production)	0.02–0.508 mm	0.0008–0.0020 in
Crankshaft Bearing Clearance (Journal #2, #3, and #4–Production)	0.028–0.058 mm	0.0011–0.0023 in
Crankshaft Bearing Clearance (Journal #1–Service)	0.0254–0.05 mm	0.0010–0.0020 in
Crankshaft Bearing Clearance (Journal #2, #3, and #4–Service)	0.025–0.063 mm	0.0010–0.0250 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 (Journal #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)	0.0010 in (Maximum)
Crankshaft Journal Taper (Production)	0.007 mm (Maximum)	0.0003 in (Maximum)
Crankshaft Runout	0.025 mm (Maximum)	0.0010 in (Maximum)
Cylinder Bore		
Diameter	101.618–101.643 mm	4.0007–4.0017 in
Out-of-Round (Production)	0.0127 mm (Maximum)	0.00050 in (Maximum)
Out-of-Round (Service)	0.05 mm (Maximum)	0.002 in (Maximum)
Taper (Production Relief Side)	0.025 mm (Maximum)	0.0010 in (Maximum)
Taper (Production Thrust Side)	0.012 mm (Maximum)	0.0005 in (Maximum)
Taper (Service)	0.025 mm (Maximum)	0.0010 in (Maximum)
Cylinder Head		

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Surface Flatness	0.10 mm (Maximum)	0.004 in (Maximum)
Exhaust Manifold		
Surface Flatness (Flange to Flange)	0.25 mm (Maximum)	0.010 in (Maximum)
Surface Flatness (Individual Flange)	0.05 mm (Maximum)	0.002 in (Maximum)
Intake Manifold		
Surface Flatness	0.10 mm (Maximum)	0.004 in (Maximum)
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 in (Maximum)
Piston Pin		
Clearance in Piston (Production)	0.013–0.023 mm	0.0005–0.0009 in
Clearance in Piston (Service)	0.025 mm (Maximum)	0.0010 in (Maximum)
Diameter	23.545–23.548 mm	0.9270–0.9271 in
Fit in Connecting Rod	0.021–0.040 mm (Interference)	0.0008– 0.0016 in (Interference)
Piston Rings (End Gap Measured in Cylinder Bore)		
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 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 Oil Ring Gap (Production)	0.25–0.76 mm	0.010–0.029 in
Piston Oil Ring Gap (Service)	0.90 mm (Maximum)	0.035 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)
Valve System		
Valve Face Angle	45 degrees	
Valve Head Edge Margin	0.79 mm (Minimum)	0.031 in (Minimum)
Valve Lash	Net Lash—No Adjustment	
Valve Lift (Exhaust)	10.879 mm	0.4280 in
Valve Lift (Intake)	10.527 mm	0.4140 in
Valve Lifter	Hydraulic Roller Type	
Valve Rocker Arm	Roller Pivot Type	
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)	1.651–2.489 mm	0.065–0.098 in
Valve Seat Width (Intake)	1.016–1.651 mm	0.040–0.065 in
Valve Spring Free Length	51.3 mm	2.02 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 Spring Pressure (Closed)	338–374 N at 43.2 mm	76–84 lb at 1.70 in

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Valve Spring Pressure (Open)	832–903 N at 32.3 mm	187–203 lb at 1.27 in
Valve Stem Clearance (Exhaust–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–Production)	0.025–0.069 mm	0.0010–0.0027 in
Valve Stem Clearance (Intake–Service)	0.025–0.094 mm	0.0010–0.0037 in
Valve Stem Oil Seal Installed Height (Measured from the Top of the Large Diameter Valve Guide Bevel to the Bottom of the Valve Stem Oil Seal)	1–2 mm	0.03937–0.07874 in

SIE-ID = 571049

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
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

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
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
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

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
Oil Fill Tube	1.745
Oil Fill Tube (Lower) Bracket	1.750
Oil Filter	1.836
Oil Filter Bypass Valve	1.837
Oil Filter Fitting	1.855
Oil Level Indicator	1.516
Oil Level Indicator Tube	1.516
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
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

GM SPO Group Numbers (cont'd)

Application	GM SPO Group Number
Valve Lifter Pushrod Guide	0.439
Valve Pushrod	0.426
Valve Rocker Arm Assembly	0.333
Valve Rocker Arm Cover	0.386
Valve Rocker Arm Cover Bolt Grommet	0.423
Valve Rocker Arm Cover Gasket	0.423
Valve Rocker Arm Support	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

SIE-JD - 506836

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number
Balancer Shaft Driven Gear Bolt	Threadlock	12345382
Camshaft Retainer Bolt	Threadlock	12345382
Crankshaft Balancer Keyway	Adhesive	12346141
Cylinder Head Bolt	Sealant	12346004
Engine Block to the Crankshaft Rear Oil Seal Housing Junction at the Oil Pan Sealing Surfaces	Adhesive	12346141
Engine Block to the 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	Sealant	12346004
Engine Block Core Hole Plug	Threadlock	12345382
Engine Block Oil Gallery Plug	Sealant	12346004
Engine Coolant Temperature (ECT) Sensor	Sealant	12346004
Engine Coolant Temperature (ECT) Gauge Sensor	Sealant	12346004
Engine Oil	SAE 5W-30 Oil	12345610
Engine Oil Pressure Sensor	Sealant	12346004
Engine Oil Pressure Sensor Fitting	Sealant	12346004
Engine Oil Supplement	Lubricant	1052367
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Stud	Threadlock	12345382
Exhaust Manifold Bolt/Stud	Threadlock	12345493
Expansion Cup Plug (Balance Shaft Rear Bearing Hole)	Sealant	12346004
Expansion Cup Plug (Camshaft Rear Bearing Hole)	Sealant	12346004
Fuel Meter Body Bracket Bolt	Threadlock	12345382
Fuel Pipe Bolt	Threadlock	12345382
Lower Intake Manifold Bolt	Threadlock	12345382
Oil Level Indicator Tube	Sealant	12346004
Oil Pump Screen Tube	Sealant	12346004
Throttle Body Stud	Threadlock	12345382

Sealers, Adhesives, and Lubricants (cont'd)

Application	Type of Material	GM Part Number
Upper Intake Manifold Stud	Threadlock	12345382
Valve Train Component Prelube	Lubricant	12345501
Water Pump Bolt	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. If the knock is timed to the crankshaft speed, inspect the following: • Worn crankshaft or connecting rod bearings • Piston or cylinder damage • Worn piston or piston pin • Faulty connecting rod • Excessive carbon build-up on the top of the piston
No Abnormal Internal Engine Noise	1. Inspect for a worn or improperly installed camshaft timing chain and/or sprockets. 2. Remove the valve rocker arm cover on the side of the engine with the cylinder that is misfiring. 3. Inspect for the following: • Loose valve rocker arm studs • Bent valve push rods • Faulty valve springs • Faulty valve lifters (bleeding down) • Worn or improperly seated valves • Worn engine camshaft lobes

Engine Compression Test

SIE-ID - 201715

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 x 70% = 725) (150 x 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.

9. Install the removed parts.

10. Connect the disconnected components.

SIE-ID - 349121

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

Engine Noise Diagnosis (cont'd)

Symptom	Cause
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
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

Valve Train Diagnosis

SIE-ID - 532838

General Information

Symptom	Cause
• A light tapping noise at ½ 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</i> and <i>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
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

Diagnostic Table (cont'd)

Step	Action	Value(s)	Yes	No
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	—

Oil Consumption Diagnosis

SIE-ID • 69356

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, damaged, 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.

Oil Pressure Diagnosis and Testing

SIE-ID • 23360

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.
6. Start the engine and then allow the engine to reach normal operation temperature.
7. Measure the engine oil pressure at the following RPM:

Specification

- 7.1. 42 kPa (6 psig) (minimum) at 1,000 RPM
- 7.2. 125 kPa (18 psig) (minimum) at 2,000 RPM
- 7.3. 166 kPa (24 psig) (minimum) at 4,000 RPM
- 8. If the engine oil pressure is below minimum specifications, inspect the engine for one or more of the following:
 - Oil pump worn or dirty
 - Malfunctioning oil pump pressure relief valve

SIE-ID = 204344

- 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

Oil Leak Diagnosis

Step	Action	Value(s)	Yes	No
Important: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.				
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait (15 minutes). 4. Check for drippings. Are drippings present?	—	Go to Step 2	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 3
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 4
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait (15 minutes). 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 5
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 6

Oil Leak Diagnosis (cont'd)

Step	Action	Value(s)	Yes	No
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 7
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 8
8	Use J 28428-E, Dye and Light Kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	Go to Step 9
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	—	Go to Step 10	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	—	Go to Step 11	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	—	Go to Step 1	—

Symptoms - Drive Belt

SIE-ID - 575798

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

Visual/Physical Inspection

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

Intermittent

- Drive belt symptoms may be from intermittent failure of an accessory drive component.
- Drive belt symptoms may occur from changes in load of the accessory drive components.

Drive Belt Chirping Diagnosis

SIE-ID - 575801

Diagnostic Aids

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

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

Test Description

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

- The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
- The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt(s) the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
- Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.

- Ambient temperatures, moisture, or engine operating temperature can affect the drive belt operation.

Symptom List

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

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

- Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misalign pulley using a straight edge in the pulley grooves across two or three pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
- Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
- Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
- Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • It usually occurs on cold damp mornings.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt

Drive Belt Chirping Diagnosis (cont'd)

Step	Action	Yes	No
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to Engine Noise Diagnosis	Go to Step 4
4	Inspect for severe pilling exceeding 1/3 of the belt groove depth. Does the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 15	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 15	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 15	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	Tighten any loose fasteners. Replace any improper or missing fasteners. Refer to <i>Fastener Tightening Specifications</i> . Did you complete the repair?	Go to Step 15	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 13	Go to Step 14
13	Replace the bent pulley. Did you complete the repair?	Go to Step 15	Go to Step 14
14	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the repair?	Go to Step 15	Go to Diagnostic Aids
15	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

Drive Belt Squeal Diagnosis

SIE-ID - 575804

Diagnostic Aids

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

If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.

Test Description

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

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table

3. The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify the squeal noise is the drive belt(s) or an accessory drive component. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. This test is to verify that an accessory drive component does not have a seized bearing. With the belt remove test the bearings in the accessory drive components for turning smoothly. Also test the accessory drive components with the engine operating by varying the load on the components to verify that the components operate properly.

5. This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.
6. This test is to verify that the drive belt(s) is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.
7. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory

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

8. This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.

Drive Belt Squeal Diagnosis

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

Drive Belt Whine Diagnosis

SIE-ID - 575807

Diagnostic Aids

The drive belt(s) will not cause the whine noise.

If the whine noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. Such items but not limited to may be an A/C system overcharged, the power steering system restricted or the wrong fluid, or the generator failing.

Test Description

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

3. This test is to verify that the noise is being caused by the drive belt(s) or the accessory drive components. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4. The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belt(s) may have to be installed and the accessory drive components

operated separately by varying their loads. Refer to the suspected accessory drive component for the proper inspection and replacement procedure.

Drive Belt Whine Diagnosis

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

Drive Belt Rumbling Diagnosis

SIE-ID = 575812

Diagnostic Aids

Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise.

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

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

Test Description

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

- This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.

- This test is to verify that the drive belt(s) is causing the rumbling noise. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
- Inspecting the drive belt(s) is to ensure that it is not causing a the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt our felt as a lump in the belt.
- Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: - A low pitch tapping, knocking, or thumping noise heard at or just above idle. - Heard once per revolution of the drive belt or a pulley. - Rumbling may be caused from: - Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove - The separation of the drive belt - A damaged drive belt			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt

Drive Belt Rumbling Diagnosis (cont'd)

Step	Action	Yes	No
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to Engine Noise Diagnosis	Go to Step 4
4	Inspect the drive belt(s) for damage, separation, or sections of missing ribs. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt. Refer to <i>Drive Belt Replacement</i> Did you complete the repair?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Refer to <i>Drive Belt Replacement</i> Did you complete the replacement?	Go to Step 8	—
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Diagnostic Aids

Drive Belt Vibration Diagnosis

SIE-ID - 575813

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Such as but not limited to the A/C system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

Test Description

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

- This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom such as the exhaust system, or the drivetrain.
- This test is to verify that the drive belt(s) or accessory drive components may be causing the vibration. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

- The drive belt(s) may cause a vibration. While the drive belt(s) is removed this is the best time to inspect the condition of the belt.
- Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
- This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smoothness, ease of turning. Inspect for a bent fan shaft or bent mounting flange.
- This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smoothness and excessive play. Compare the water pump with a known good water pump.
- Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: The following items are indications of drive belt vibration: - The vibration is engine-speed related. - The vibration may be sensitive to accessory load.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to Step 3	Go to Diagnostic Aids

Drive Belt Vibration Diagnosis (cont'd)

Step	Action	Yes	No
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to <i>Engine Related Vibration</i> in Vibration and Diagnosis	Go to <i>Step 4</i>
4	Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions?	Go to <i>Step 5</i>	Go to <i>Step 6</i>
5	Install a new drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the replacement?	Go to <i>Step 11</i>	—
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to <i>Step 7</i>	Go to <i>Step 8</i>
7	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to <i>Fastener Tightening Specifications</i> . Did you complete the repair?	Go to <i>Step 11</i>	—
8	Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Refer to <i>Fan Clutch Replacement</i> in Engine Cooling. Did you find and correct the condition?	Go to <i>Step 11</i>	Go to <i>Step 9</i>
9	Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to <i>Water Pump Replacement (4.3L Engine)</i> in Engine Cooling. Did you find and correct the condition?	Go to <i>Step 11</i>	Go to <i>Step 10</i>
10	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to <i>Step 11</i>	Go to Diagnostic Aids
11	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to <i>Step 3</i>

Drive Belt Falls Off Diagnosis

SIE-ID - 575816

Diagnostic Aids

If the drive belt(s) repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

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

If the drive belt(s) is the incorrect length, the drive belt tensioner may not keep the proper tension on the drive belt.

Test Description

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

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

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

- Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
- Accessory drive component brackets that are bent or cracked will let the drive belt fall off.
- Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed. Missing, loose, or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

Drive Belt Falls Off Diagnosis

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

Drive Belt Excessive Wear Diagnosis

SIE-ID - 575817

Diagnostic Aids

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

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

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt(s) fall off.

Test Description

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

- The inspection is to verify the drive belt(s) is correctly installed on all of the drive belt pulleys. Wear on the drive belt(s) may be caused by mis-positioning the drive belt(s) by one groove on a pulley.
- The installation of a drive belt that is too wide or too narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.
- This inspection is to verify the drive belt(s) is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt(s) should not come in contact with an engine or a body component when snapping the throttle.

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
Notice: Refer to <i>Belt Dressing Notice</i> in Cautions and Notices. DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			

Drive Belt Excessive Wear Diagnosis (cont'd)

Step	Action	Yes	No
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Drive Belt
2	Inspect the drive belt(s) for the proper installation. Refer to <i>Drive Belt Replacement</i> . Did you find this condition?	Go to Step 5	Go to Step 3
3	Inspect for the proper drive belt. Did you find this condition?	Go to Step 5	Go to Step 4
4	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to Step 6	Go to Diagnostic Aids
5	Replace the drive belt. Refer to <i>Drive Belt Replacement</i> . Did you complete the replacement?	Go to Step 6	—
6	Operate the system in order to verify the repair. Did you correct the condition?	System OK	—

Drive Belt Tensioner Diagnosis

SIE-ID = 476309

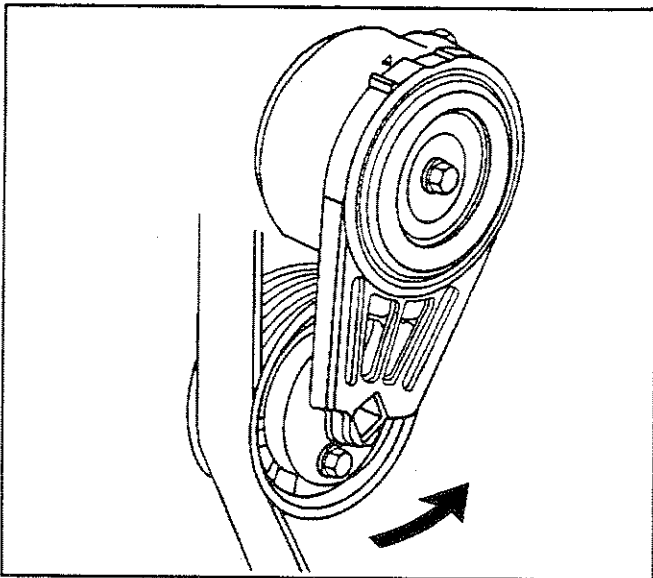
Inspection Procedure

Important

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

- 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*.



374176

Notice: SIO-ID = 3753 Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

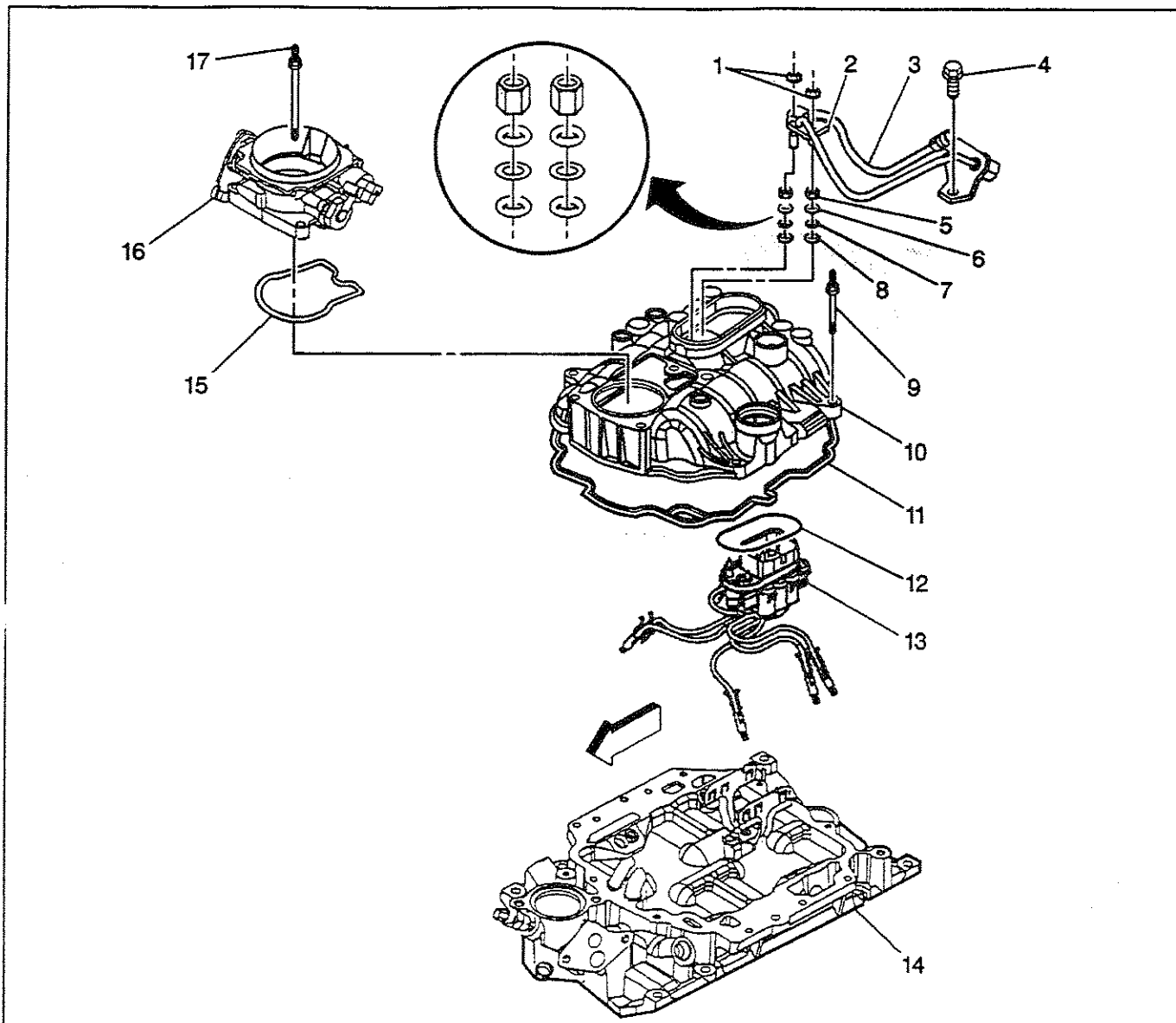
1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Position a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise.
3. Move the drive belt tensioner through its full travel.
 - The movement should feel smooth
 - There should be no binding

Visual Identification

Disassembled Views

SIE-ID = 532491

Upper and Lower Intake Manifold View SIO-ID = 356346

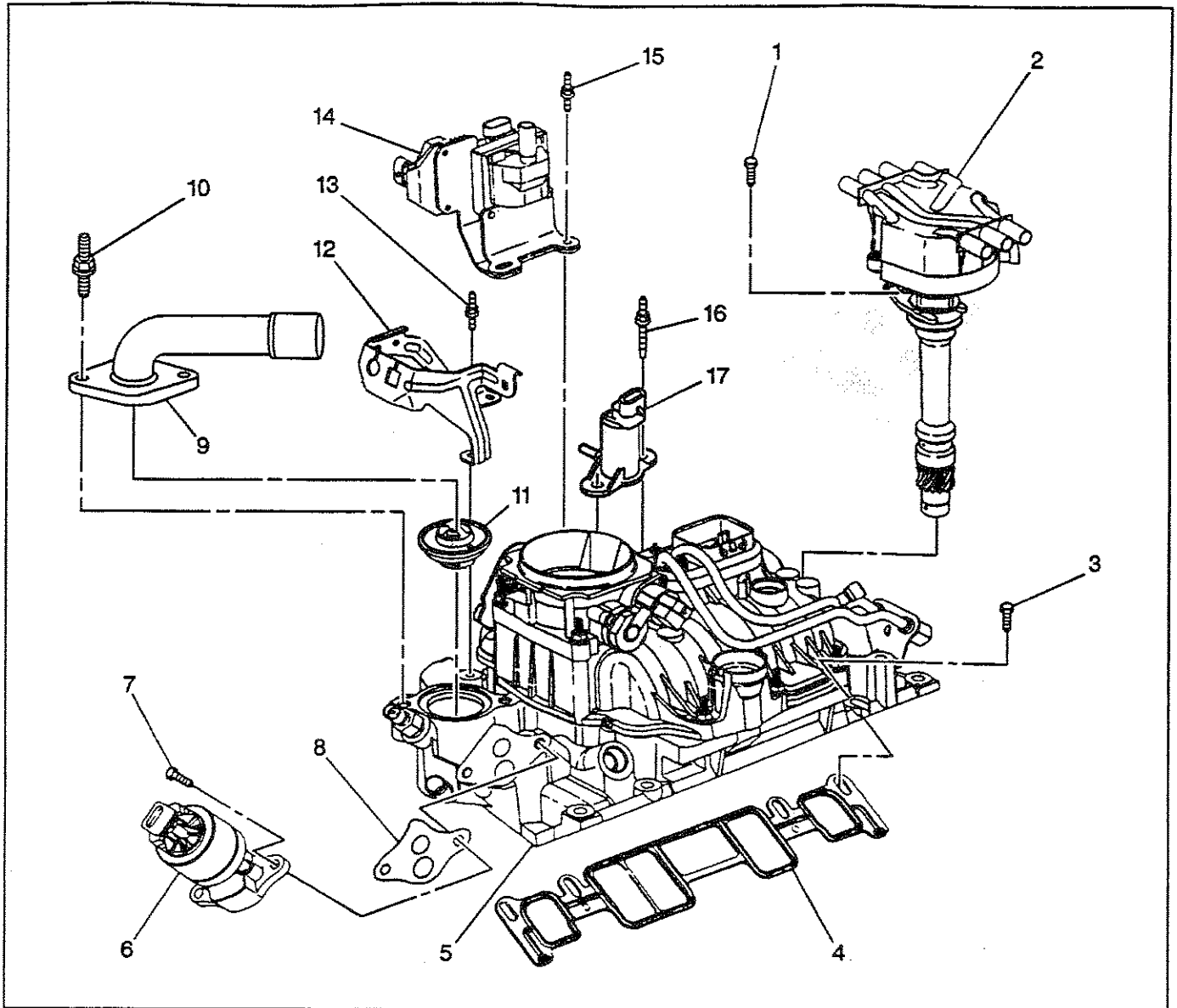


334238

Legend

- | | |
|-------------------------------------|--|
| (1) Fuel Pipe Retainer Bracket Nut | (11) Upper Intake to Lower Intake Manifold Gasket |
| (2) Fuel Pipe Retainer | (12) Fuel Meter Body Seal (O-ring) |
| (3) Fuel Pipe | (13) Fuel Meter Body |
| (4) Fuel Pipe Bolt | (14) Intake Manifold |
| (5) Fuel Seal Retainer | (15) Throttle Body to Upper Intake Manifold Gasket |
| (6) Upper Fuel Seal (Yellow O-ring) | (16) Throttle Body |
| (7) Spacer Ring (Metal Flat Washer) | (17) Throttle Body Attaching Stud |
| (8) Lower Fuel Seal (Black O-ring) | |
| (9) Upper Manifold Attaching Stud | |
| (10) Upper Intake Manifold | |

Upper Engine View 1 SIO-ID = 502230

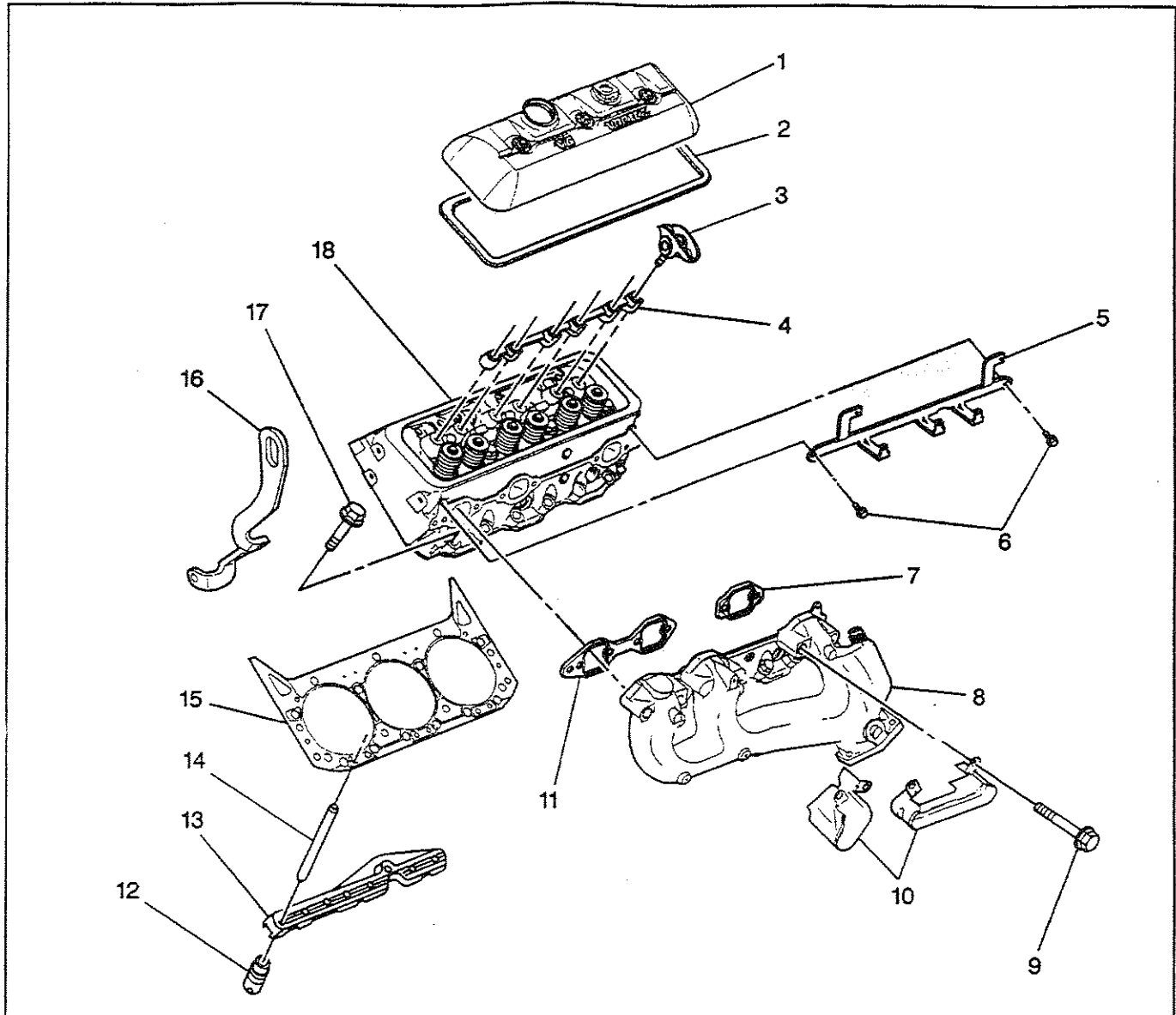


480498

Legend

- | | |
|------------------------------------|--|
| (1) Distributor Bolt | (10) Water Outlet Stud |
| (2) Distributor | (11) Engine Coolant Thermostat |
| (3) Intake Manifold Bolt (Lower) | (12) Accelerator Control Cable Bracket |
| (4) Intake Manifold Gasket (Lower) | (13) Accelerator Control Cable Bracket Stud |
| (5) Intake Manifold Assembly | (14) Ignition Coil |
| (6) EGR Valve | (15) Ignition Coil Stud |
| (7) EGR Valve Bolt | (16) EVAP Canister Purge Solenoid Valve Stud |
| (8) EGR Valve Gasket | (17) EVAP Canister Purge Solenoid Valve |
| (9) Water Outlet | |

Upper Engine View 2 SIO-ID = 519807

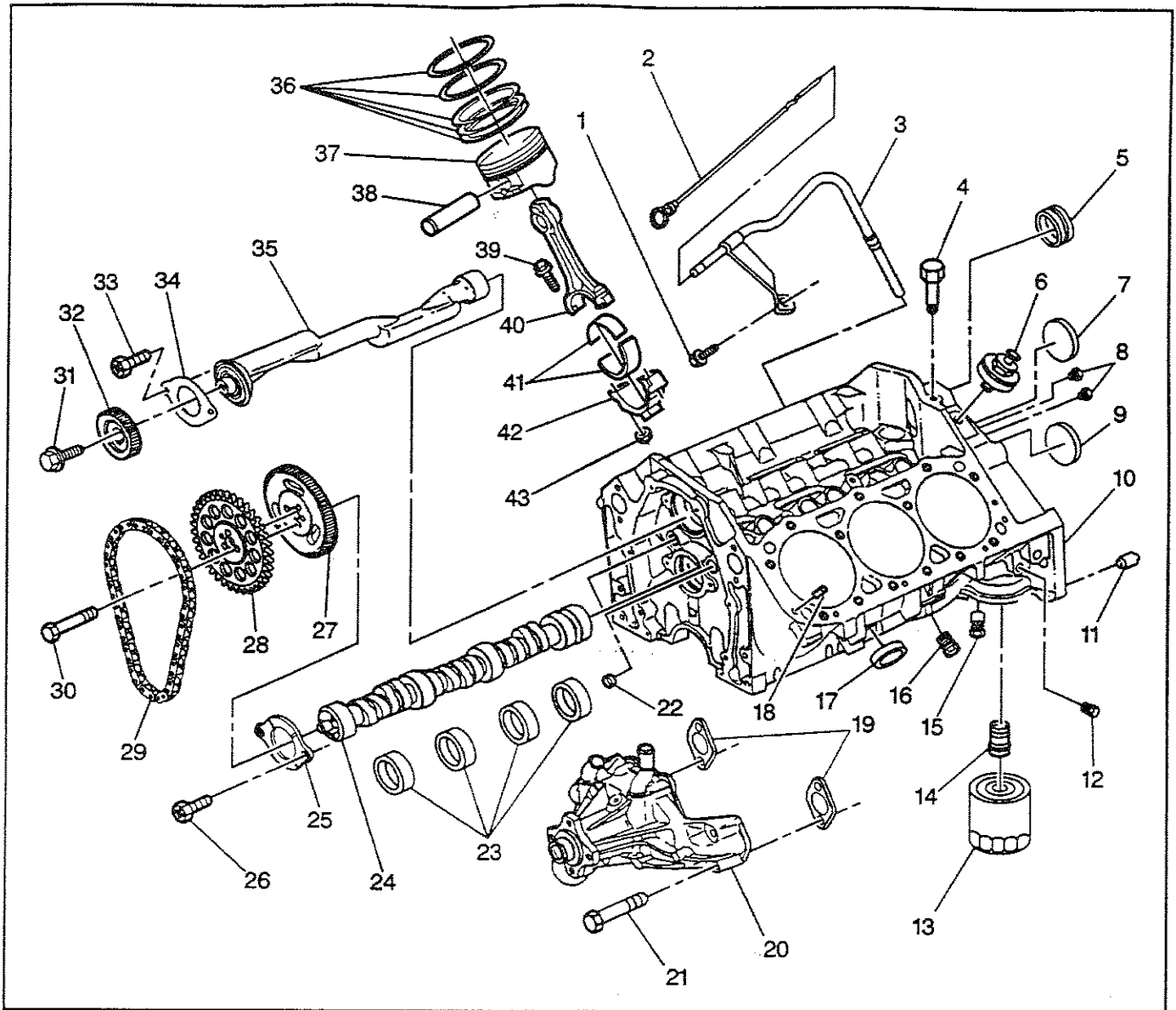


480513

Legend

- | | |
|-----------------------------------|---------------------------------|
| (1) Valve Rocker Arm Cover | (10) Spark Plug Wire Shields |
| (2) Valve Rocker Arm Cover Gasket | (11) Exhaust Manifold Gasket |
| (3) Valve Rocker Arm Assembly | (12) Valve Lifter |
| (4) Valve Rocker Arm Support | (13) Valve Lifter Pushrod Guide |
| (5) Spark Plug Wire Support | (14) Valve Pushrod |
| (6) Spark Plug Wire Support Bolt | (15) Cylinder Head Gasket |
| (7) Exhaust Manifold Gasket | (16) Engine Lift Front Bracket |
| (8) Exhaust Manifold | (17) Cylinder Head Bolt |
| (9) Exhaust Manifold Bolt | (18) Cylinder Head |

Lower Engine View 1 SIO-ID = 570634



569262

Legend

- | | |
|--|--|
| (1) Oil Level Indicator Tube Bolt | (15) Oil Filter Bypass Valve |
| (2) Oil Level Indicator | (16) Engine Coolant Drain Hole Plug |
| (3) Oil Level Indicator Tube | (17) Engine Block Core Hole Plug |
| (4) Engine Oil Pressure Sensor Fitting | (18) Dowel Pin (Cylinder Head Locator) |
| (5) Balance Shaft Bearing (Rear) | (19) Water Pump Gasket |
| (6) Knock Sensor | (20) Water Pump |
| (7) Expansion Cup Plug (Balance Shaft Rear Bearing Hole) | (21) Water Pump Bolt |
| (8) Engine Block Rear Oil Gallery Plug | (22) Front Oil Gallery Plug |
| (9) Expansion Cup Plug (Camshaft Rear Bearing Hole) | (23) Camshaft Bearings |
| (10) Engine Block | (24) Engine Camshaft |
| (11) Dowel Straight Pin (Transmission Locator) | (25) Camshaft Retainer |
| (12) Left Side Oil Gallery Plug | (26) Camshaft Retainer Bolt |
| (13) Oil Filter | (27) Balance Shaft Drive Gear |
| (14) Oil Filter Fitting | (28) Camshaft Sprocket |
| | (29) Camshaft Timing Chain |
| | (30) Camshaft Sprocket Bolt |

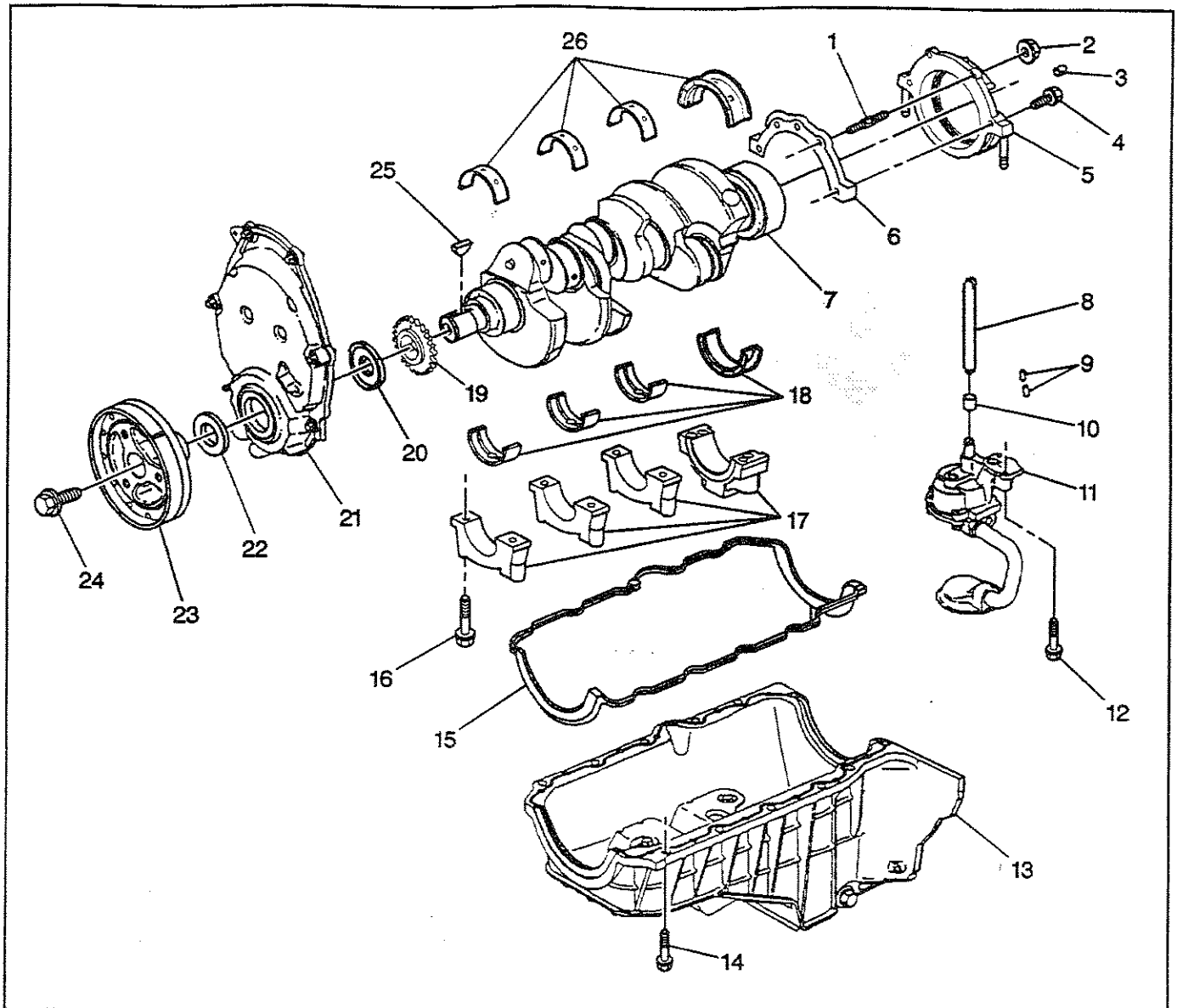
Engine

Engine Mechanical - 4.3L 6-31

- (31) Balance Shaft Gear Bolt
- (32) Balance Shaft Driven Gear
- (33) Balance Shaft Retainer Bolt
- (34) Balance Shaft Retainer
- (35) Balance Shaft
- (36) Piston Ring Set
- (37) Piston

- (38) Piston Pin
- (39) Connecting Rod Bolt
- (40) Connecting Rod
- (41) Connecting Rod Bearings
- (42) Connecting Rod Cap
- (43) Hex Nut

Lower Engine View 2 SIO-ID = 502239



480518

Legend

- | | |
|--|---|
| (1) Crankshaft Rear Oil Seal Housing Retainer Stud | (14) Oil Pan Bolt |
| (2) Crankshaft Rear Oil Seal Housing Nut | (15) Oil Pan Gasket |
| (3) Flywheel Locator Pin | (16) Crankshaft Bearing Cap Bolt |
| (4) Crankshaft Rear Oil Seal Housing Bolt | (17) Crankshaft Bearing Cap |
| (5) Crankshaft Rear Oil Seal Housing | (18) Crankshaft Bearings (Lower) |
| (6) Crankshaft Rear Oil Seal Housing Gasket | (19) Crankshaft Sprocket |
| (7) Crankshaft | (20) Crankshaft Position Sensor Reluctor Ring |
| (8) Oil Pump Drive Shaft | (21) Engine Front Cover |
| (9) Oil Pump Locator Pin | (22) Crankshaft Front Oil Seal |
| (10) Oil Pump Drive Shaft Retainer | (23) Crankshaft Balancer |
| (11) Oil Pump | (24) Crankshaft Balancer Bolt |
| (12) Oil Pump Bolt | (25) Crankshaft Balancer Key |
| (13) Oil Pan | (26) Crankshaft Bearings (Upper) |

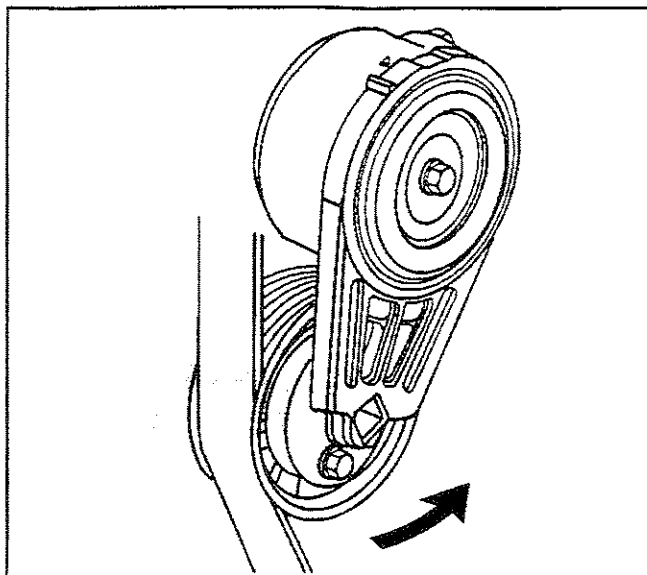
Repair Instructions

Drive Belt Replacement

SIE-ID = 475310

Removal Procedure

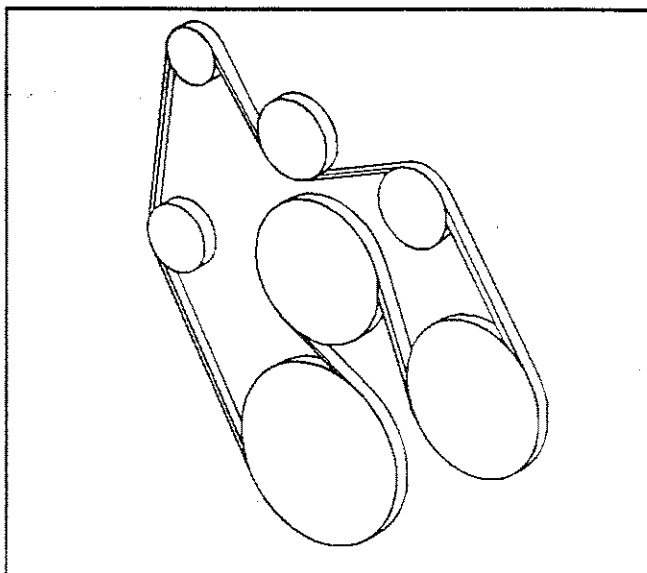
1. Install a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise.
2. Remove the drive belt.
3. Slowly release the tension on the drive belt tensioner arm.



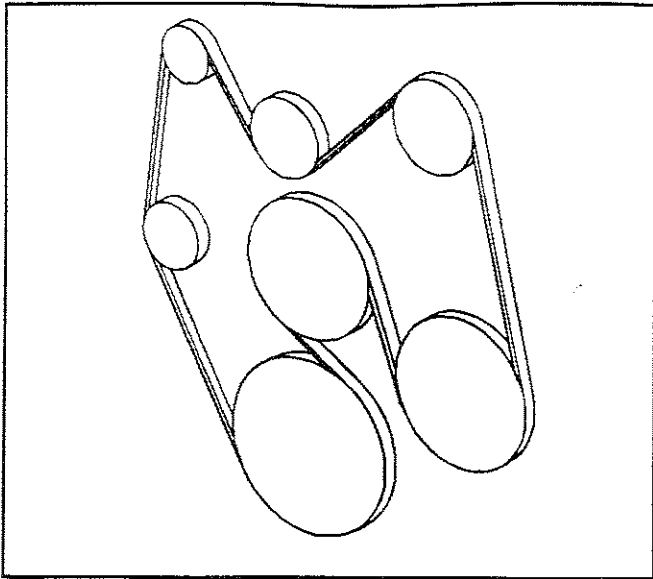
374176

Installation Procedure

1. Route the drive belt over all the pulleys except the drive belt tensioner pulley.
2. Observe the drive belt routing for the vehicles without air conditioning.

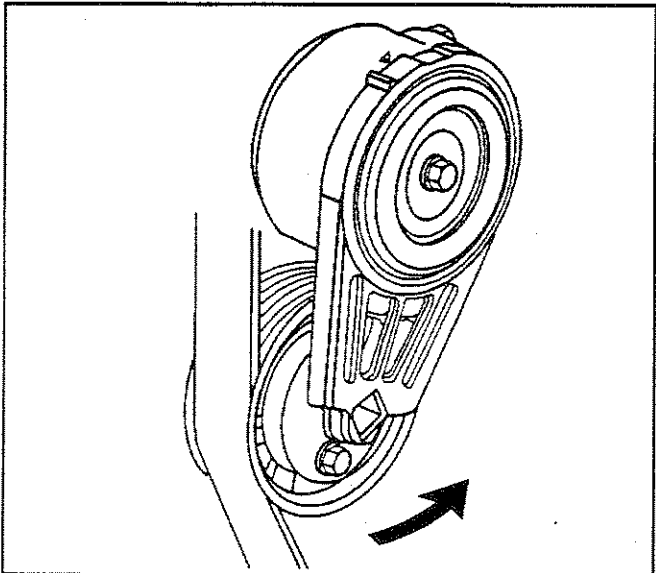


43858



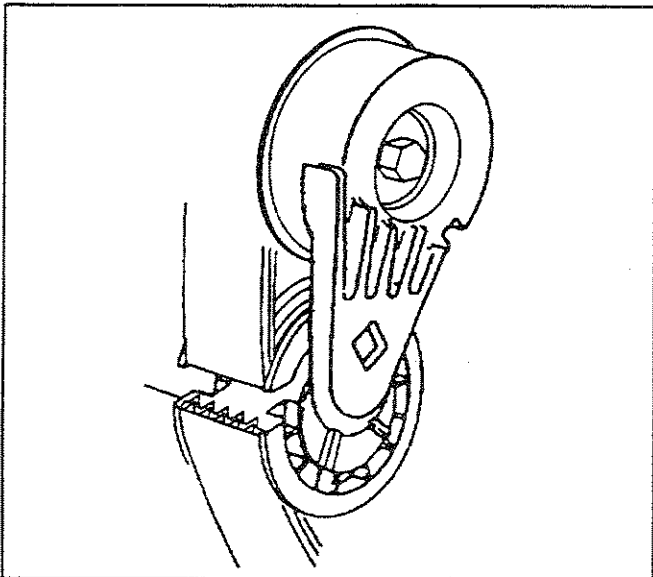
43859

3. Observe the drive belt routing for the vehicles with air conditioning.



374176

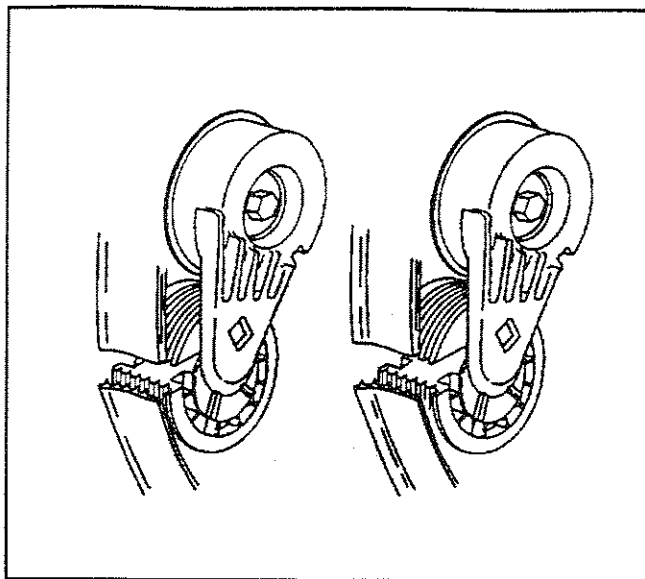
4. Install a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise.
5. Install the drive belt over the drive belt tensioner pulley.
6. Slowly release the tension on the drive belt tensioner arm.



172992

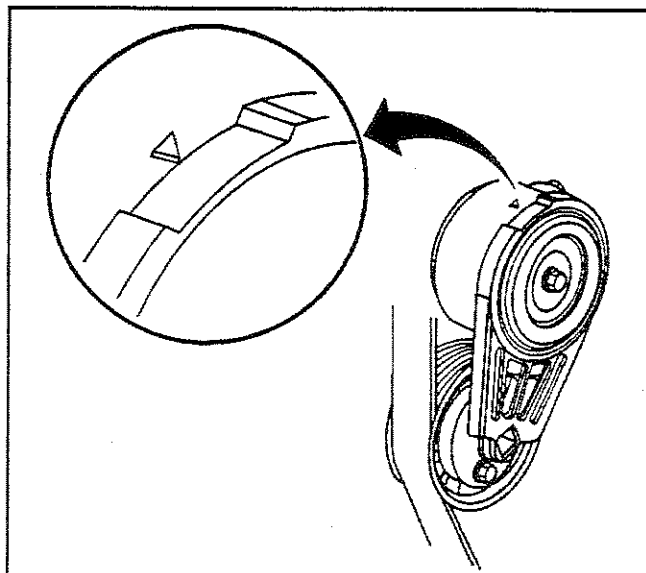
7. Inspect for the drive belt being properly installed on the pulleys.

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



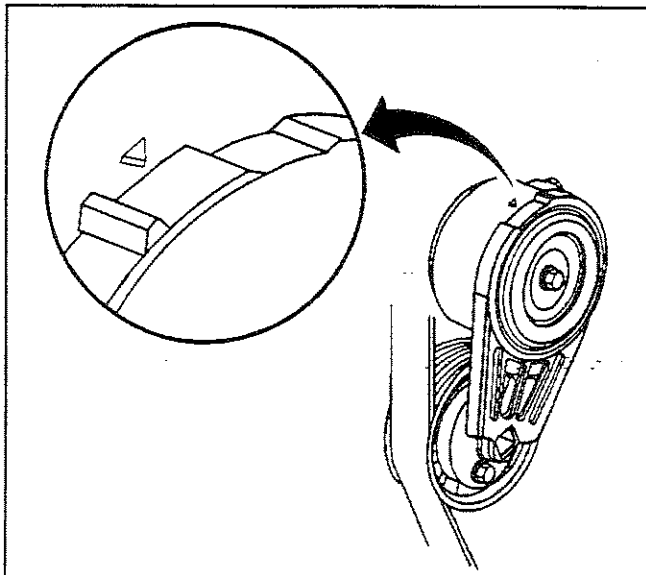
172993

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.

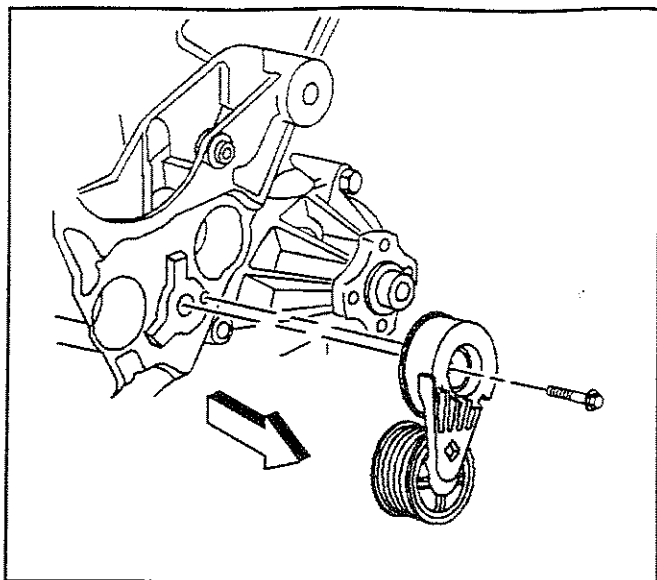


331327

10. With a used drive belt installed the fix pointer should not align past the index mark.



369211



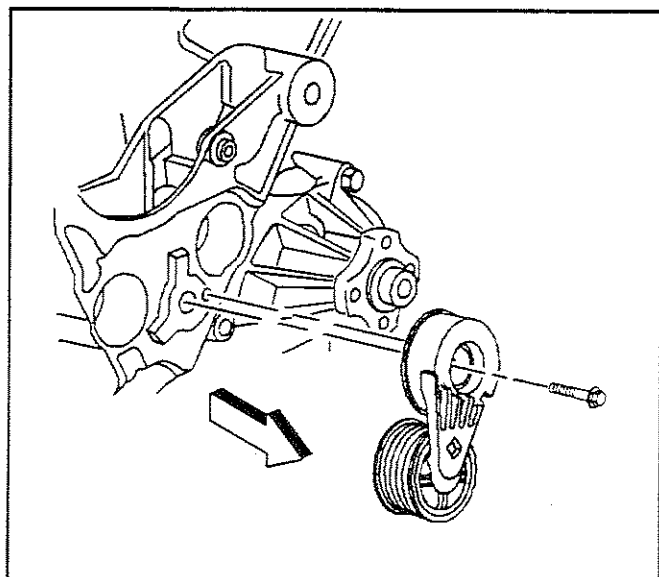
43854

Drive Belt Tensioner Replacement

SIE-ID - 475311

Removal Procedure

1. Remove the drive belt. Refer to *Drive Belt Replacement*.
2. Remove the bolt.
3. Remove the drive belt tensioner.



43854

Installation Procedure

1. Install the drive belt tensioner assembly.

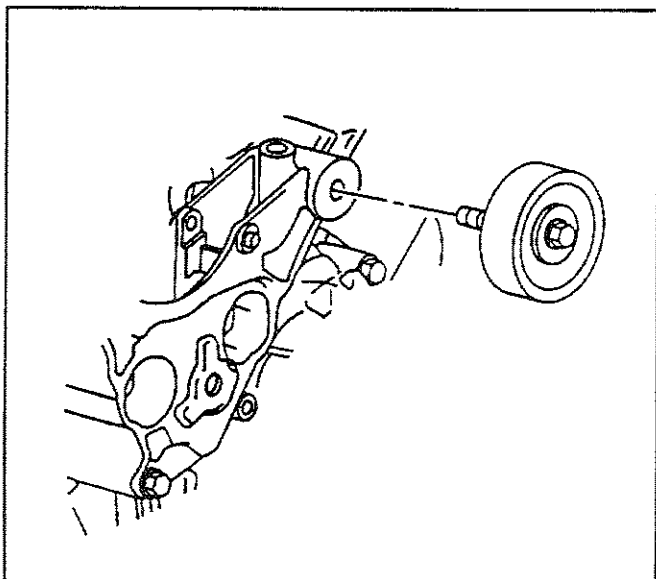
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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*.



310229

Drive Belt Idler Pulley Replacement (Right Side)

SIE-ID - 475313

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.

Installation Procedure

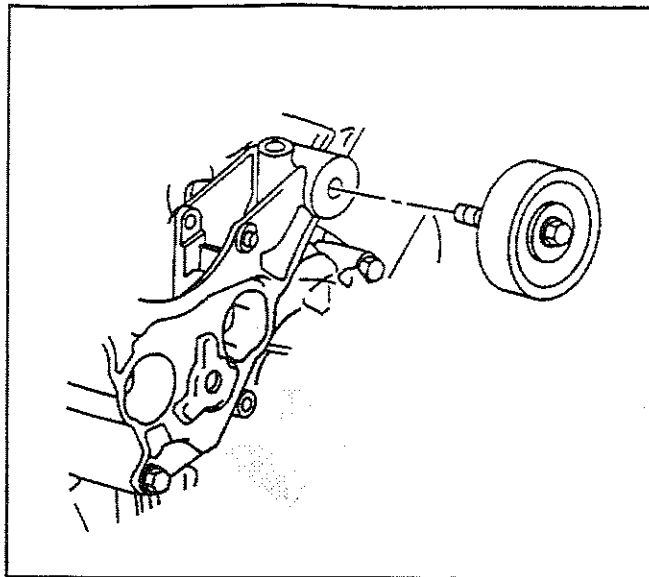
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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*.



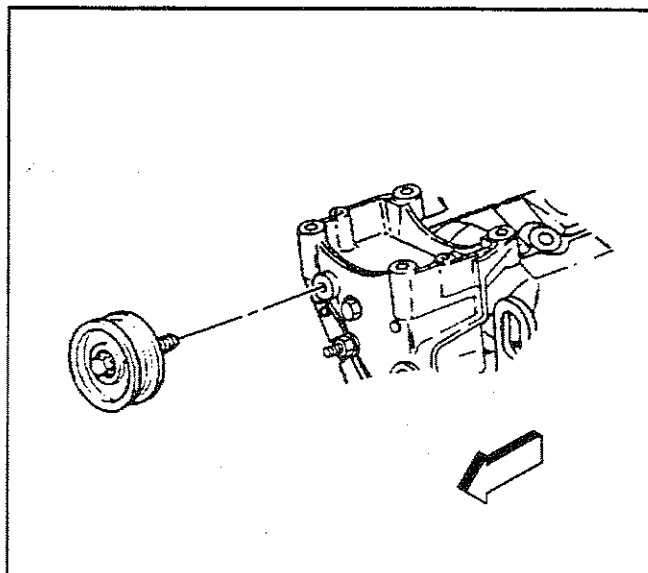
310229

Drive Belt Idler Pulley Replacement (Without A/C)

SIE-ID = 478516

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.



338506

Installation Procedure

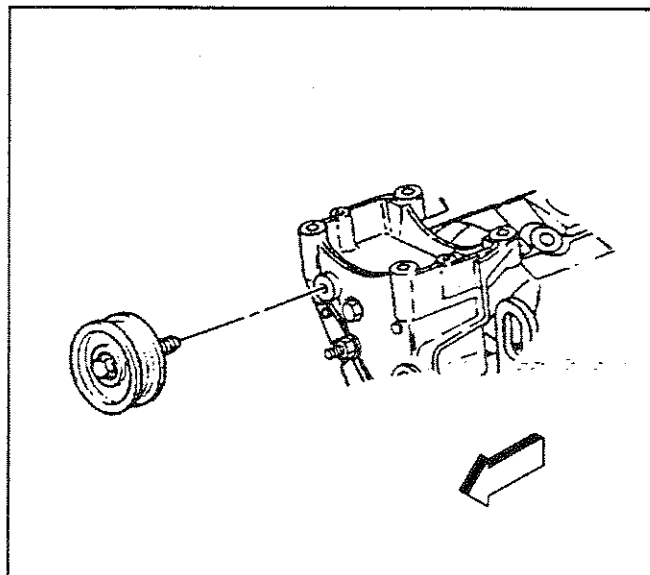
Notice: Refer to *Fastener Notice* in Cautions and Notices.

1. Install the belt idler pulley and the bolt to the power steering pump mounting bracket.

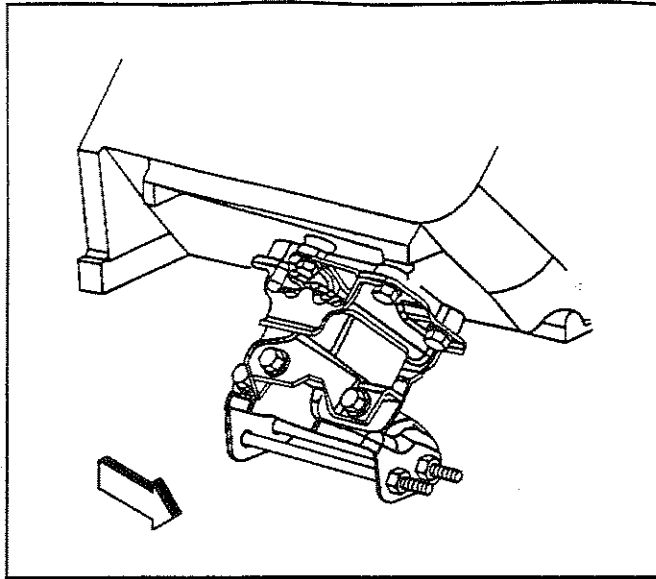
Tighten

Tighten the bolt to 50 N·m 37 lb ft).

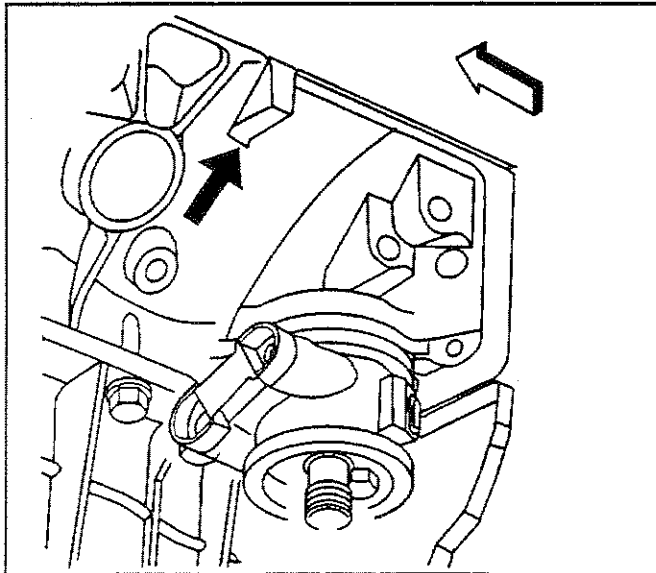
2. Install the drive belt. Refer to *Drive Belt Replacement*.



338506



315378



374320

Engine Mount Inspection

SIE-ID = 478517

Notice: SIO-ID = 5167 Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

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: 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. In order to access the square tab on the right side of the engine remove the starter. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.
5. Using a jack on the square tab at the rear of the engine block (left side shown) 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.
6. 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.
7. Replace the starter, if removed. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.
8. Lower the vehicle.

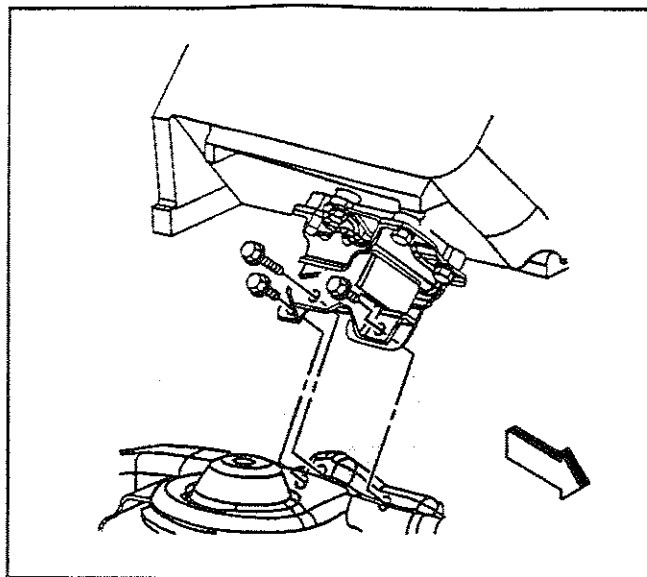
Engine Mount Replacement

SIE-ID = 478518

Removal Procedure

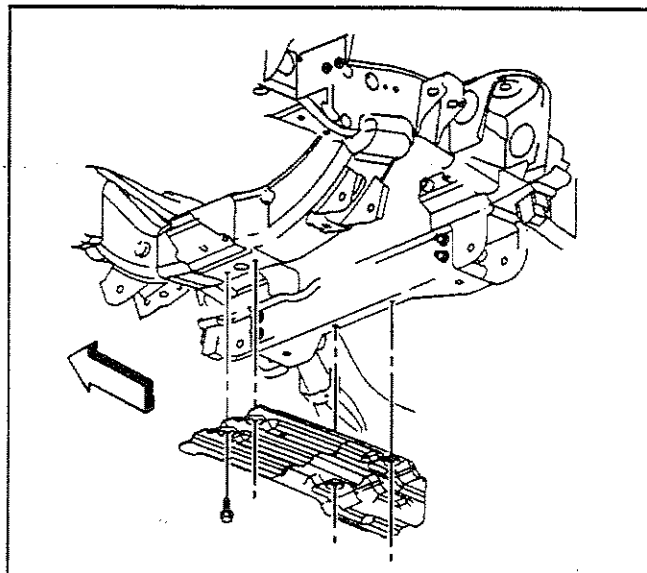
Notice: SIO-ID = 5167 Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

1. From under the hood, remove the three bolts holding the engine mount to the engine mount frame bracket.



310259

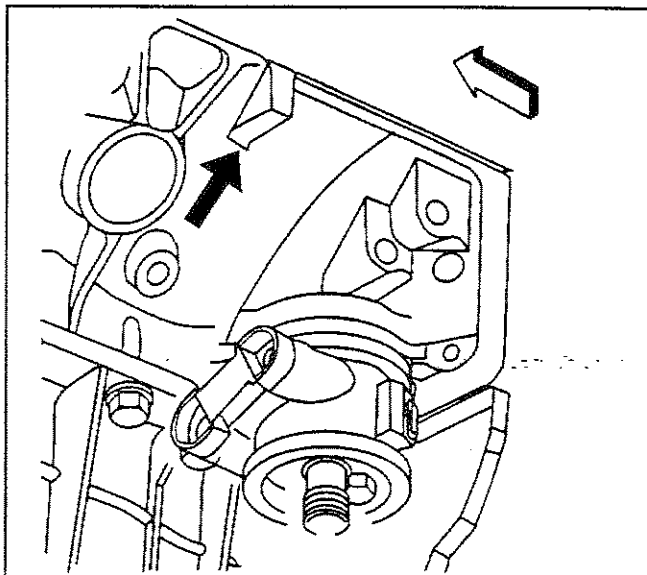
2. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the oil pan skid plate.



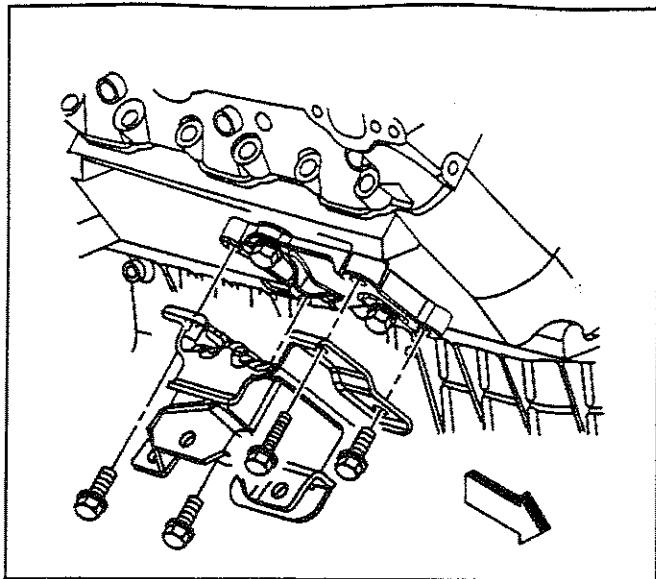
309158

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. Using a jack on the square tab (left side shown) at the rear of the engine block, raise the engine.
5. In order to access the square tab on the right side of the engine, remove the starter. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.

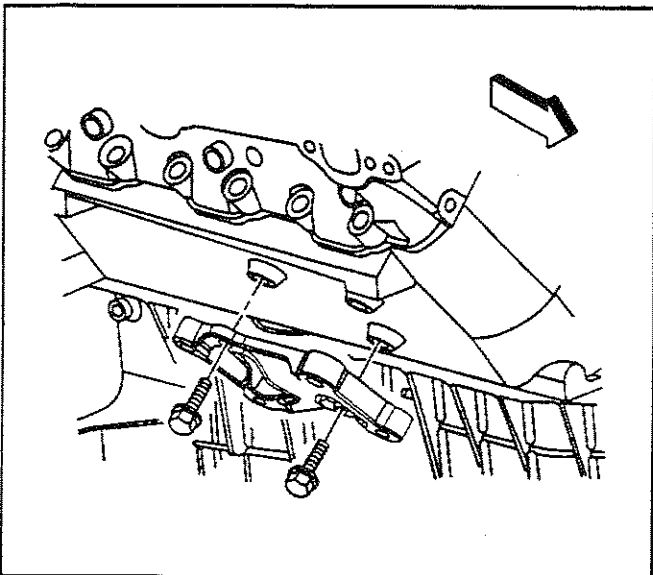


374320



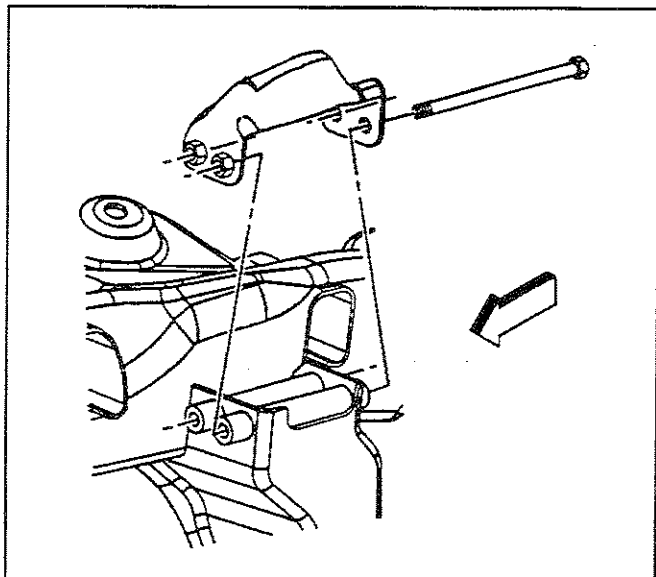
310267

6. Remove the bolts holding the engine mount to the engine mount bracket and the engine.
7. Remove the engine mount.



310262

8. Remove the engine mount bracket to the engine, if necessary.



310271

9. In order to replace the engine mount frame bracket, remove the two through-bolts.
10. Remove the engine mount frame bracket.

Installation Procedure

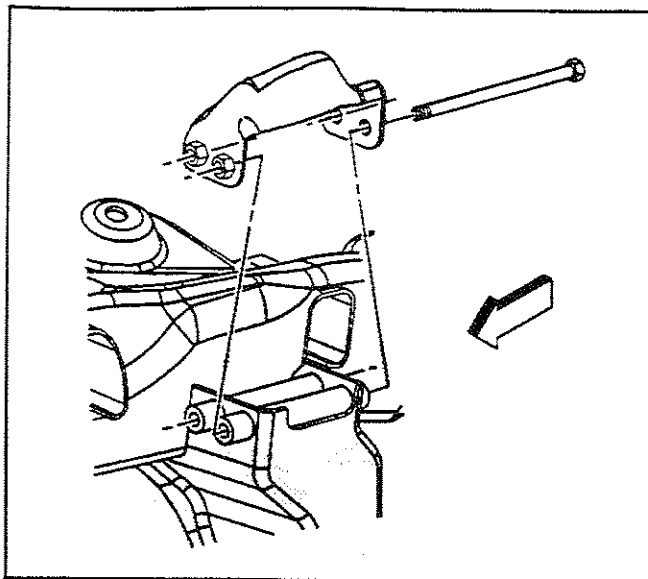
1. Position the engine mount frame bracket on the frame.

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

2. Install the two through-bolts.

Tighten

Tighten the through-bolts to 75 N·m (55 lb ft).

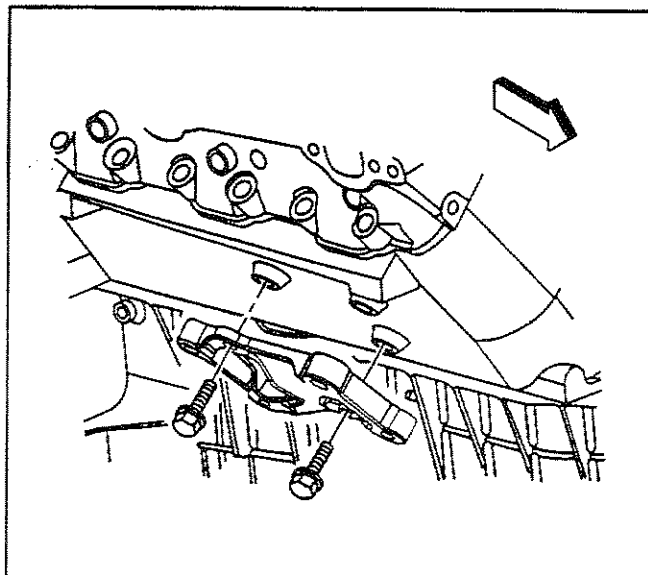


310271

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).



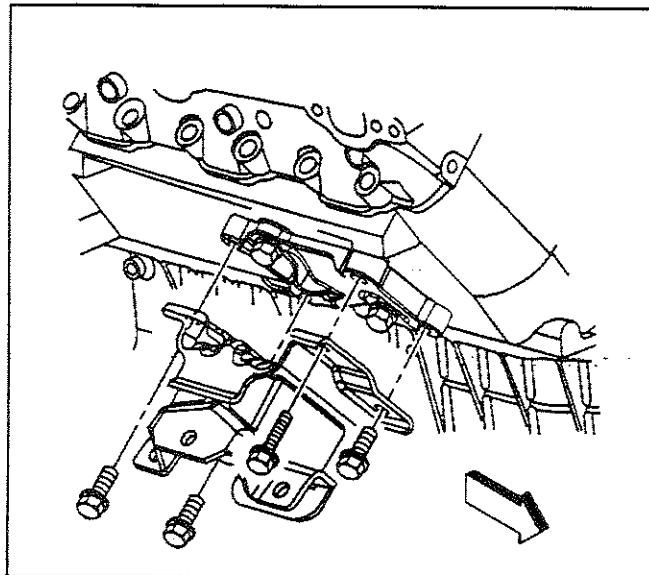
310262

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.

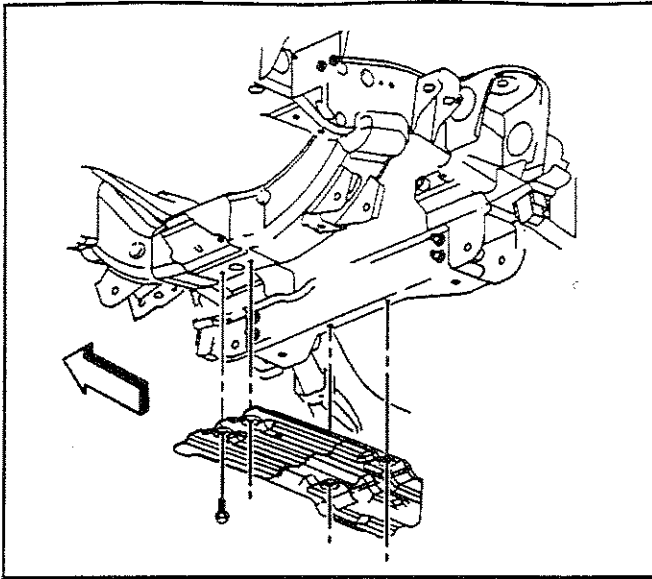
Tighten

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

8. Lower the engine.
9. Install the starter, if removed. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.



310267



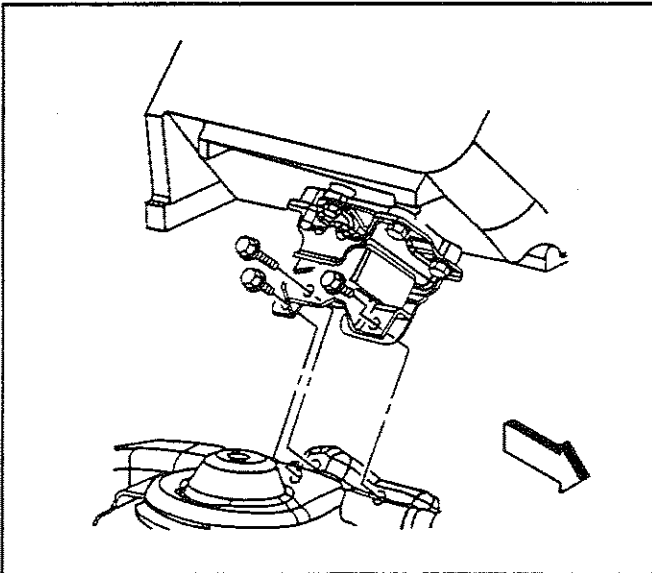
309158

10. Install the oil pan skid plate.

Tighten

Tighten the bolts to 20 N·m (15 lb ft).

11. Lower the vehicle.

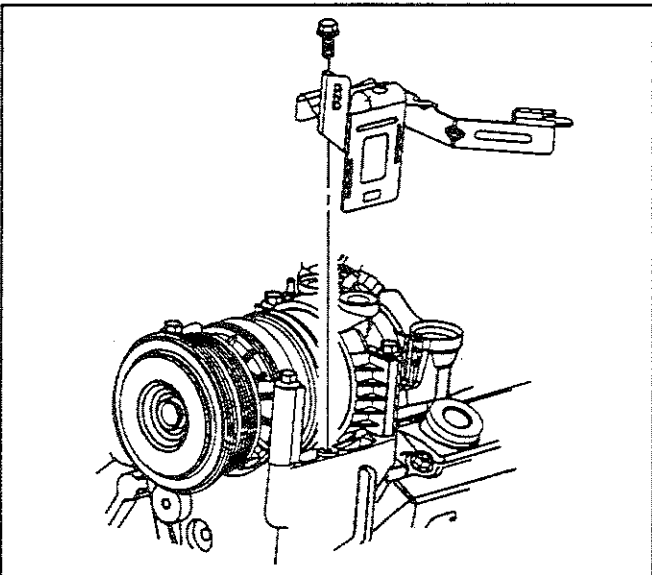


310259

12. 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 65 N·m (50 lb ft).



394403

Accessory Mounting Brackets Replacement (P/S Pump)

SIE-ID - 478525

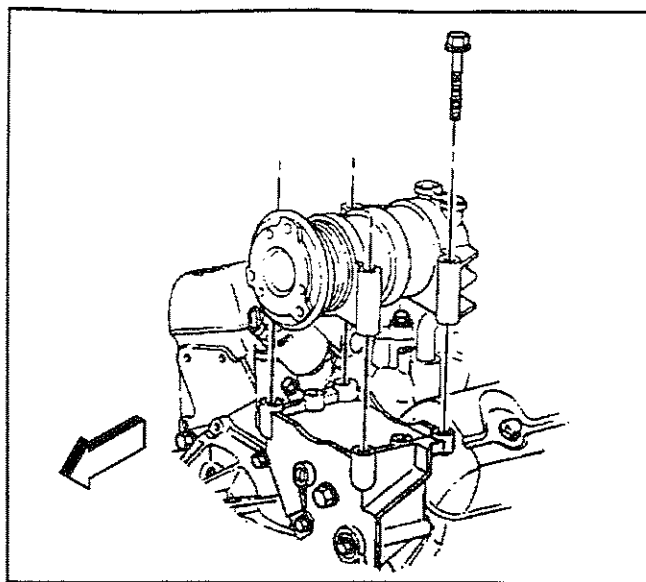
Removal Procedure

1. Remove the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.
2. Remove the drive belt. Refer to *Drive Belt Replacement*.
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.

Important: Do not evacuate the air conditioning system.

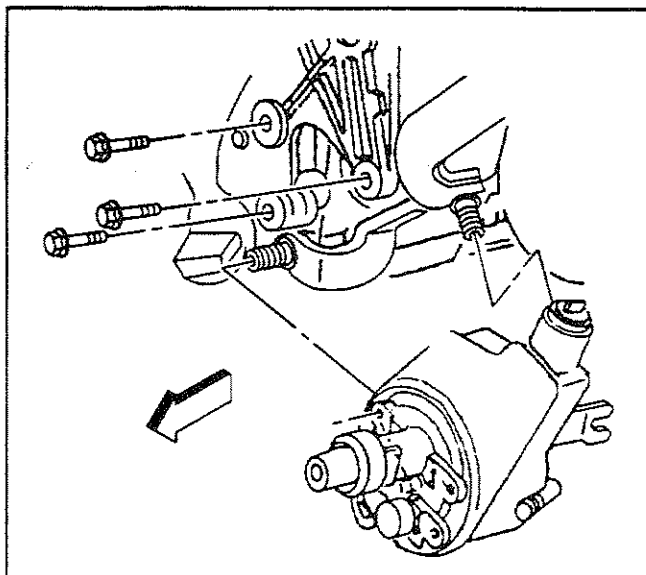
Remove the mounting bolts for the air conditioning (A/C) compressor, if equipped.

5. Move the A/C compressor aside and support.
6. Remove the drive belt idler pulley if not equipped with A/C. Refer to *Drive Belt Idler Pulley Replacement (Without A/C)*.
7. Remove the power steering pump pulley. Refer to *Power Steering Pump Replacement (4.3L)* in *Power Steering Systems*.



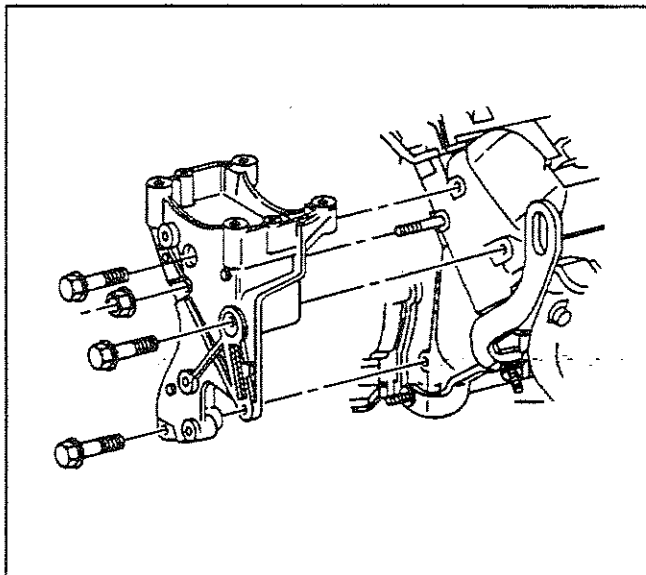
281151

8. 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.

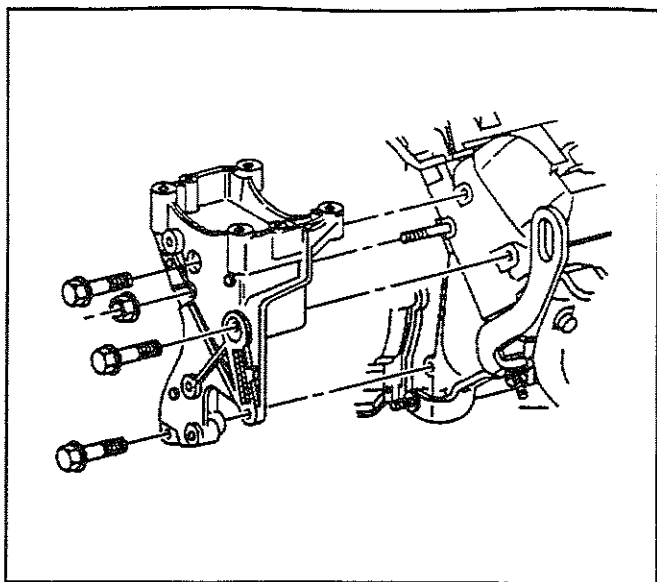


288829

9. Remove the three bolts and nut holding the power steering pump mounting bracket to the engine.
10. Slide the power steering pump mounting bracket off the stud and the power steering pump.



188295



188295

Installation Procedure

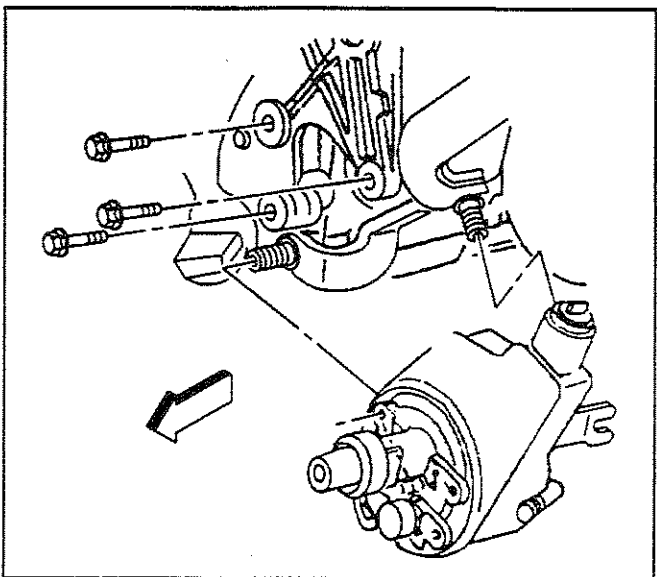
1. Slide the power steering pump mounting bracket on the stud and the power steering pump.

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).



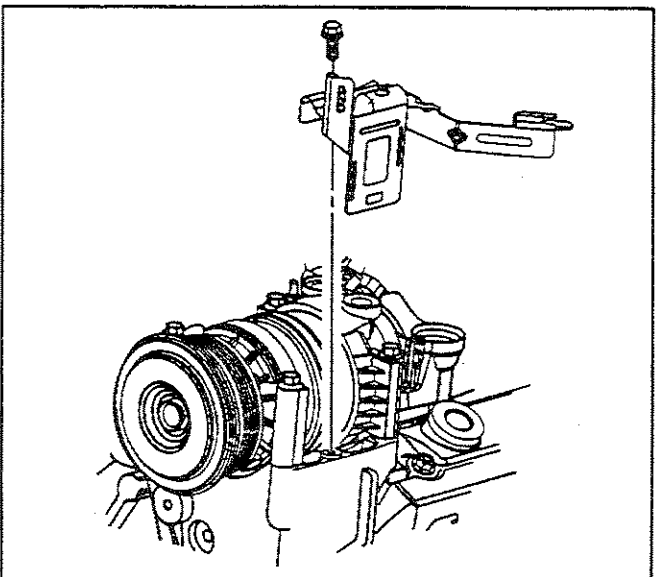
288829

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 Heating Ventilation and Air Conditioning.



394403

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).

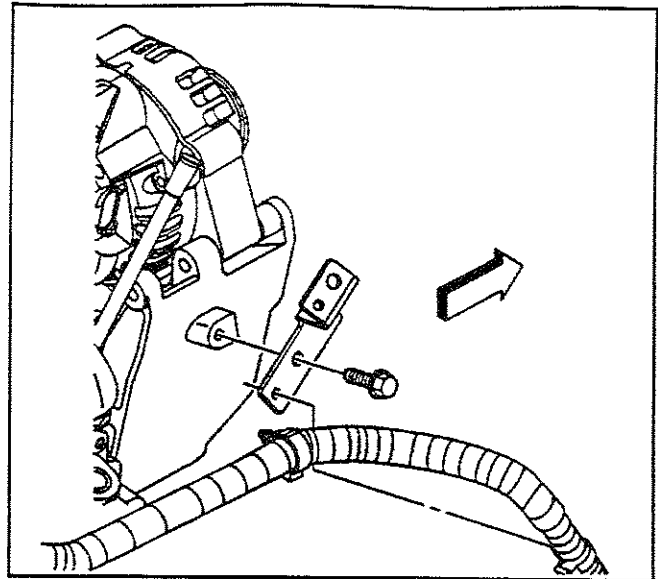
8. Install the drive belt idler pulley if not equipped with A/C. Refer to *Drive Belt Idler Pulley Replacement (Without A/C)*.
9. Install the drive belt. Refer to *Drive Belt Replacement*.
10. Install the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.

Accessory Mounting Brackets Replacement (Generator)

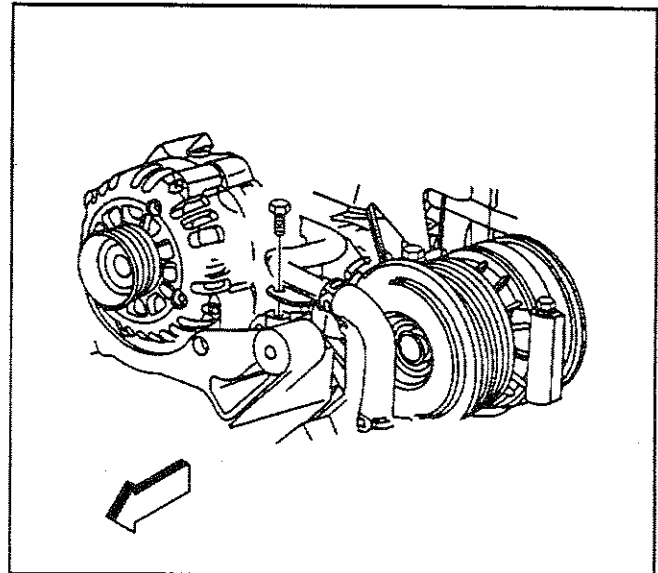
SIE-ID - 478528

Removal Procedure

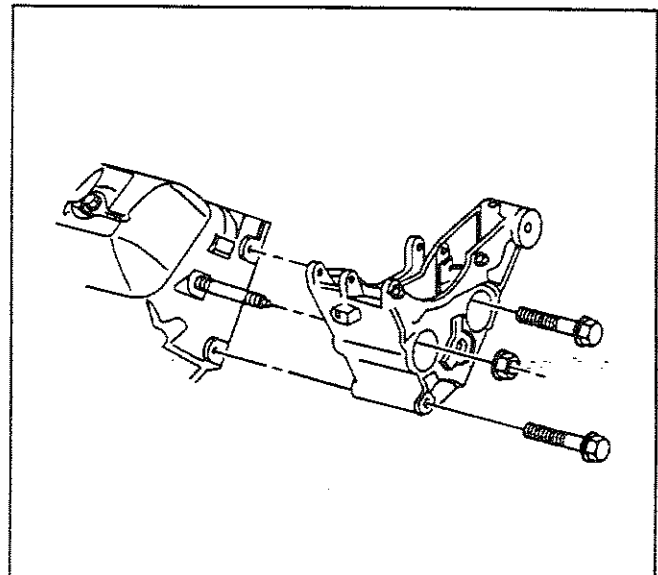
1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.
2. Remove the air cleaner outlet duct from the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
3. Remove the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.
4. Remove the drive belt. Refer to *Drive Belt Replacement*.
5. Remove the bolt holding the bracket for the wiring harness and the A/C hose, if equipped, from the generator mounting bracket.
6. Remove the bolt holding the heater hose bracket to the generator mounting bracket.
7. Remove the generator. Refer to *Generator Replacement (4.3L)* in Engine Electrical.
8. Remove the drive belt tensioner. Refer to *Drive Belt Tensioner Replacement*.
9. Remove the drive belt idler pulley. Refer to *Drive Belt Idler Pulley Replacement (Right Side)*.
10. Remove the two bolts and the nut holding the generator mounting bracket to the engine.
11. Slide the generator mounting bracket off of the stud.



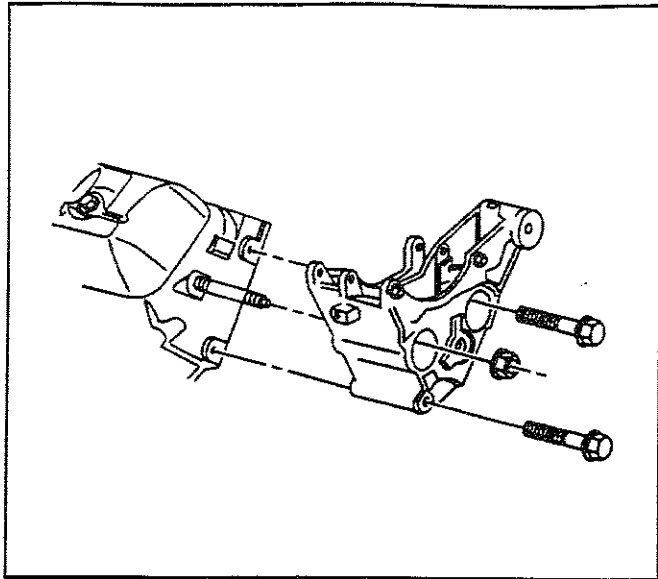
334162



316440



196643



196643

Installation Procedure

1. Slide the generator mounting bracket on the stud.

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

2. Install the two bolts and the nut.

Tighten

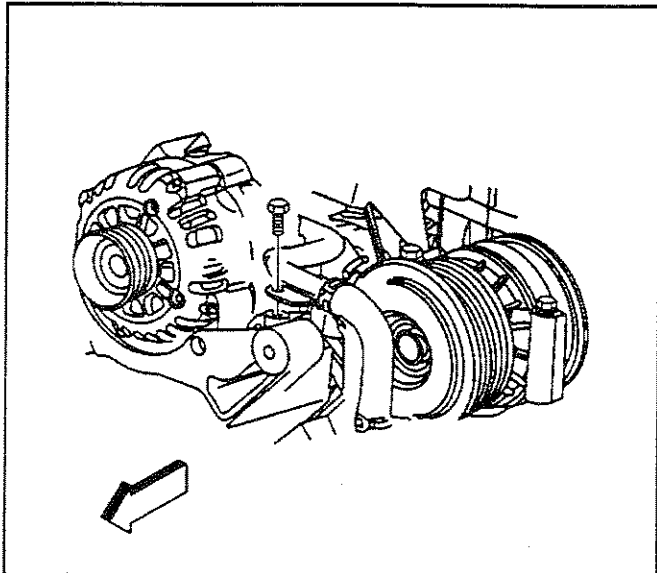
Tighten the generator mounting bracket bolts and nut to 41 N·m (30 lb ft).

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*.
5. Install the generator. Refer to *Generator Replacement (4.3L)* in Engine Electrical.

6. 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).



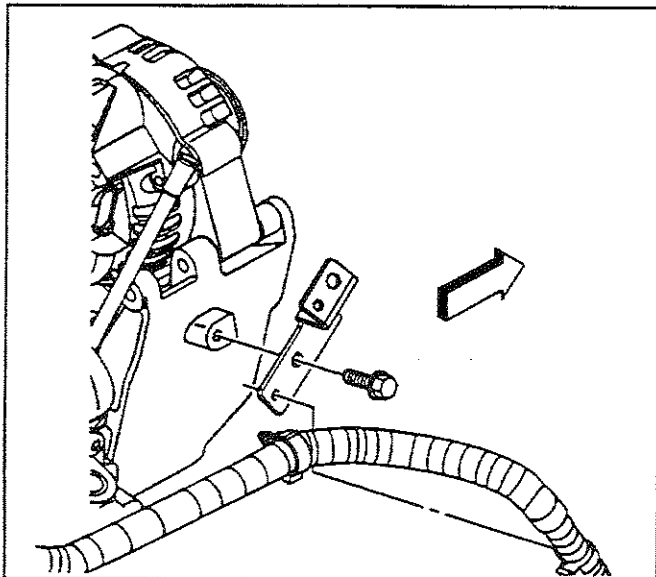
316440

7. Install the bolt holding the bracket for the 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).

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. Install the air cleaner outlet duct to the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
11. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.



334162

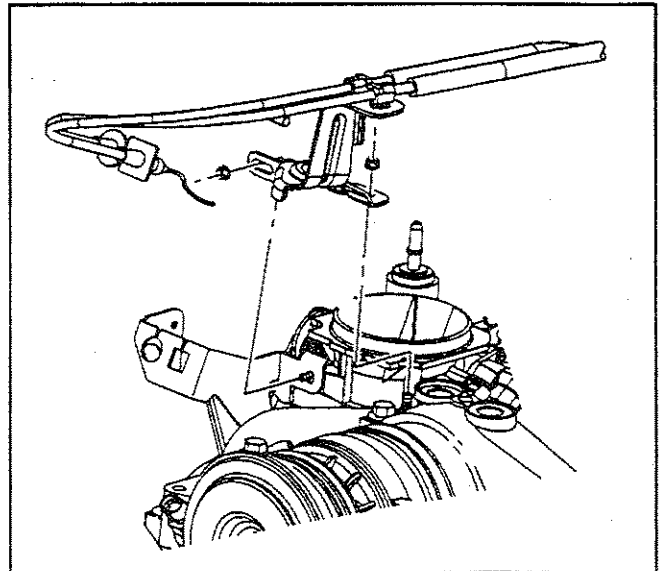
Intake Manifold Replacement (Upper)

SIE-ID - 478531

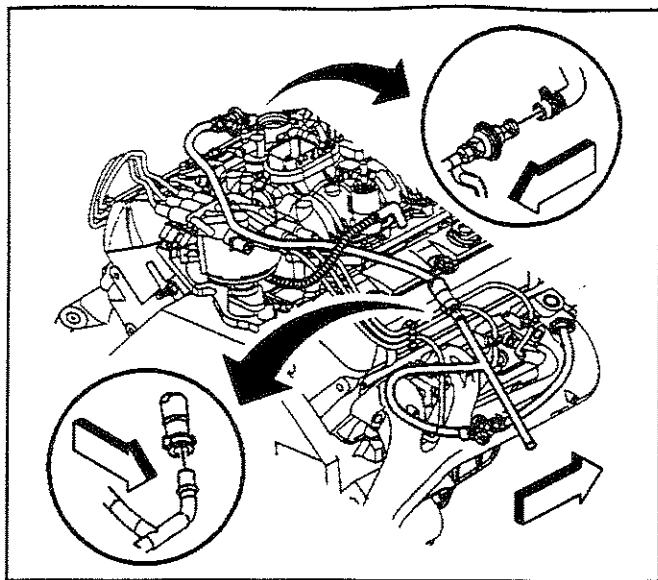
Removal Procedure

Important: It is not necessary to remove the upper intake manifold in order to remove the lower intake manifold.

1. Disconnect the PCV hose from the air cleaner outlet duct.
2. Remove the air cleaner outlet duct from the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
3. Disconnect the accelerator control cable from the throttle shaft and the accelerator cable bracket at the side of the throttle body. Refer to *Accelerator Controls Cable Replacement* in Engine Controls - 4.3L.
4. Disconnect the cruise control cable, if equipped from the throttle shaft and the accelerator cable bracket at the side of the throttle body. Refer to *Cruise Control Cable Replacement (V8)* in Cruise Control.
5. Remove the engine wiring harness clip from the accelerator control cable bracket.
6. Remove the accelerator control cable bracket with the accelerator control cable and the cruise control cable from the throttle body.
7. Move and secure the accelerator control cable and the cruise control cable out of the way.

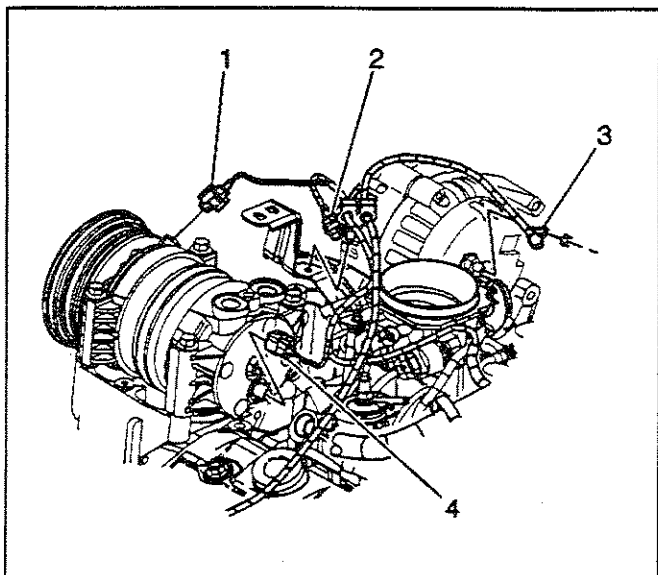


398030



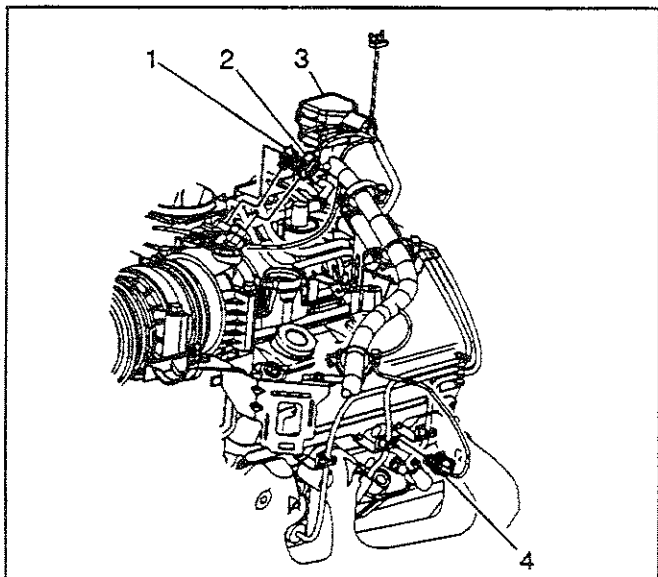
398868

8. Disconnect the secondary air injection (AIR) crossover pipe from the AIR pipe assemblies, if equipped.
9. Remove the AIR crossover pipe, if equipped.



491821

10. Disconnect the following electrical connections:
 - The A/C compressor clutch (1), if equipped
 - The A/C pressure switch (4), if equipped
 - The EGR valve (2)

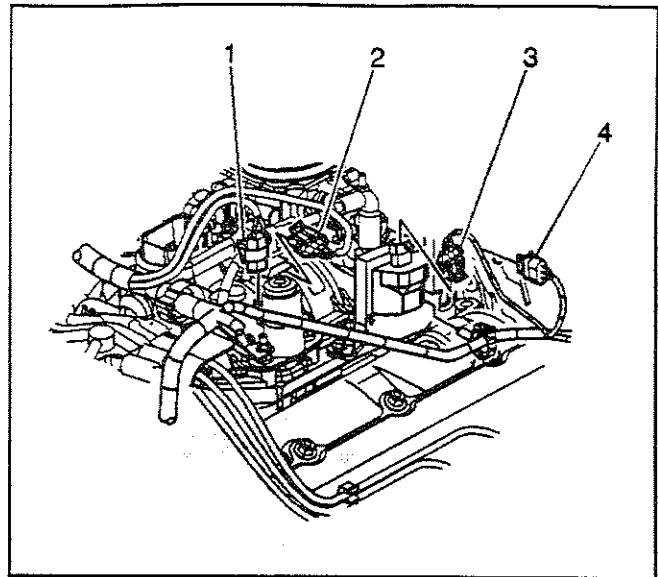


491817

11. Disconnect the following electrical connections:
 - The throttle position (TP) sensor (1)
 - The idle air control (IAC) motor (2)
 - The fuel meter body assembly connector (3)

12. Disconnect the following electrical connections:

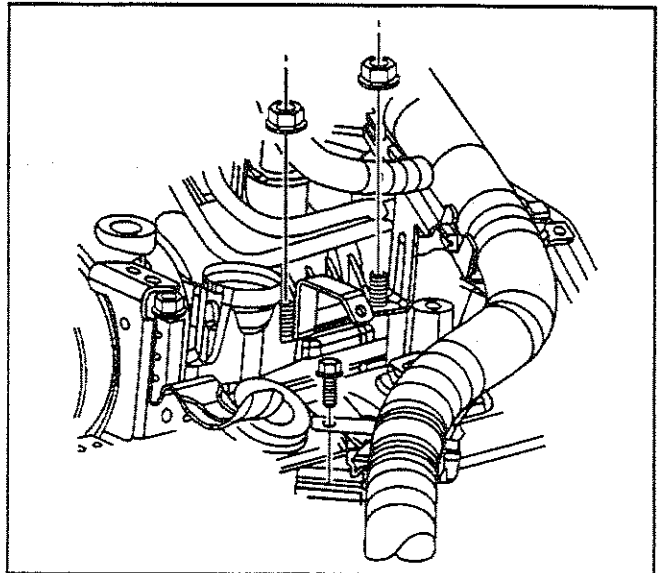
- The manifold absolute pressure (MAP) sensor (2)
- The EVAP canister purge solenoid valve (1)



491816

13. Remove the two nuts holding the engine wiring harness bracket to the upper intake manifold studs.

14. Remove the engine wiring harness bracket from the studs.



310241

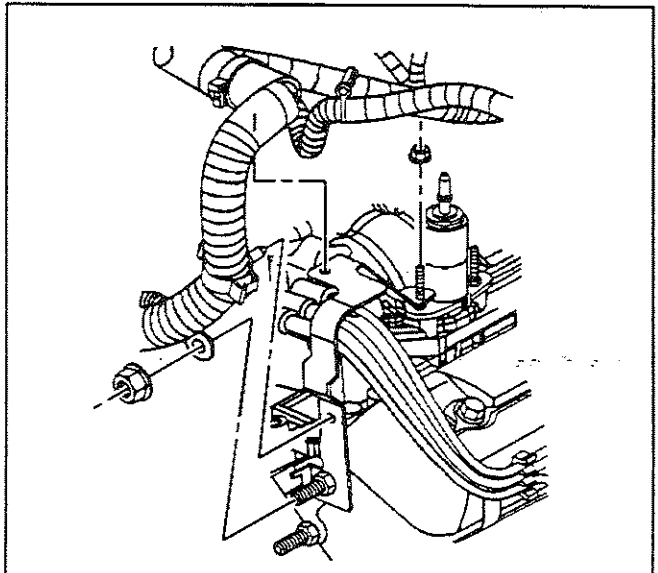
15. Remove the nut holding the engine wiring harness bracket to the stud at the EVAP canister purge solenoid valve.

16. Remove the nut and the ground wire from the engine wiring harness bracket stud at the rear of the right cylinder head.

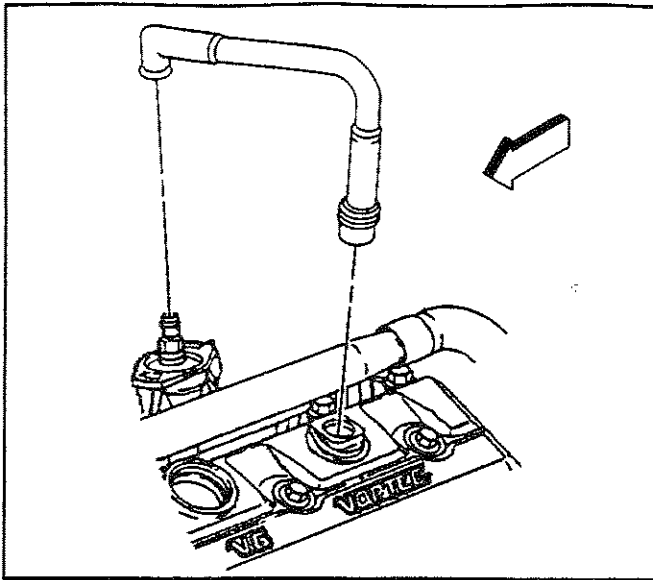
17. Remove the stud holding the engine wiring harness bracket.

18. Move the engine wiring harness and the engine wiring harness brackets aside.

19. Remove the EVAP canister purge solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls - 4.3L.

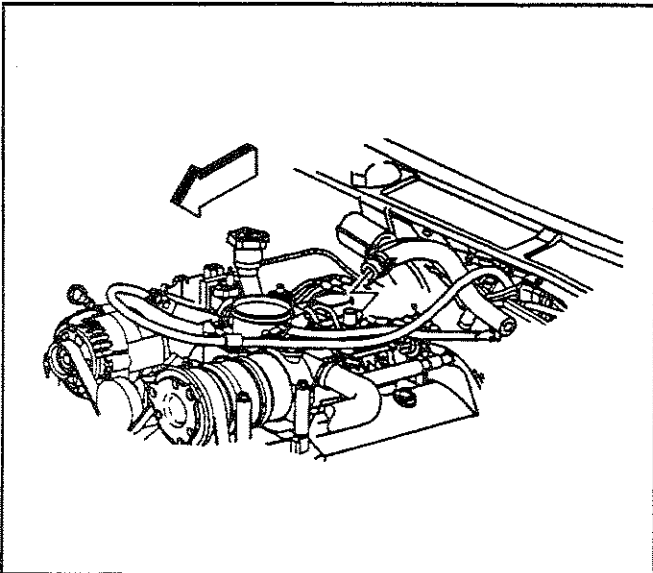


310243



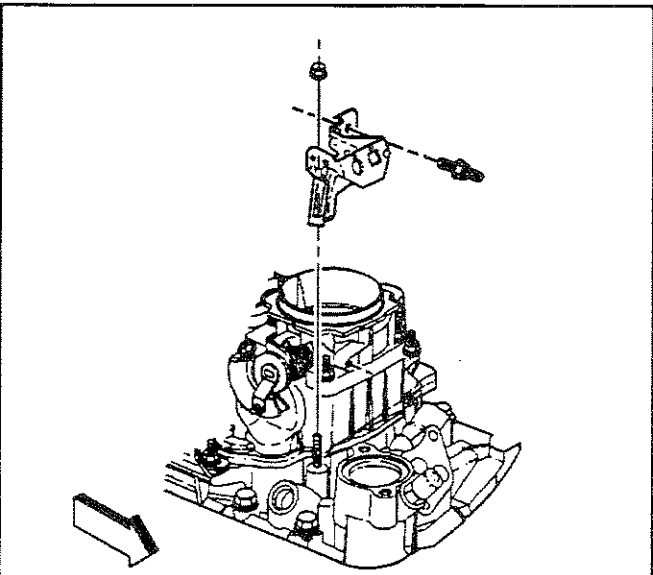
172995

20. Remove the PCV valve hose assembly from the intake manifold and the valve rocker arm cover.



346148

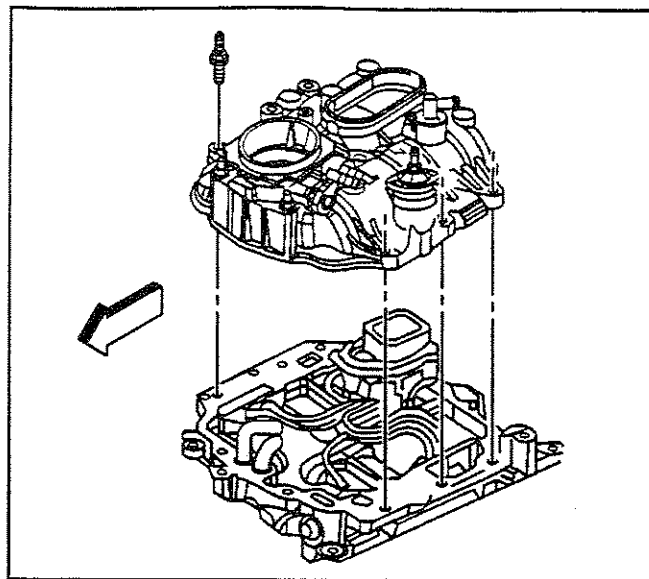
21. Disconnect the power brake booster vacuum hose from the intake manifold.



398033

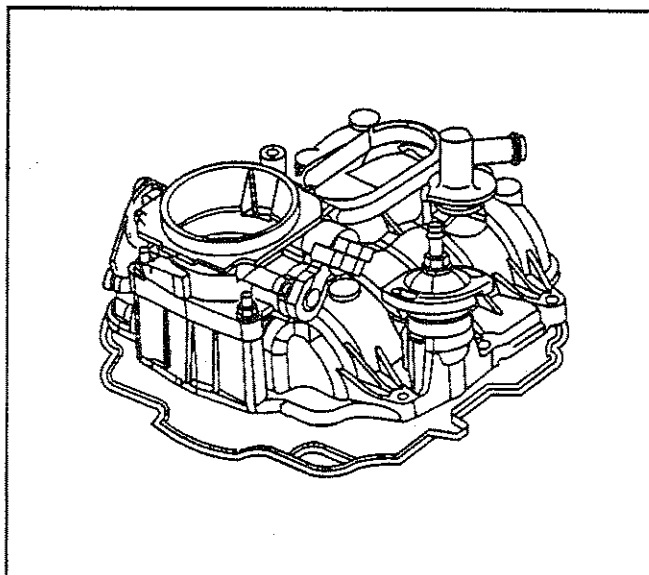
22. Remove the accelerator control cable bracket from the intake manifold and the throttle body.
23. Remove the fuel lines from the fuel meter body assembly. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls - 4.3L.

24. Remove the studs for the upper intake manifold.
25. Remove the upper intake manifold.



516794

26. Remove the upper intake manifold gasket from the groove.
27. Discard the gasket.



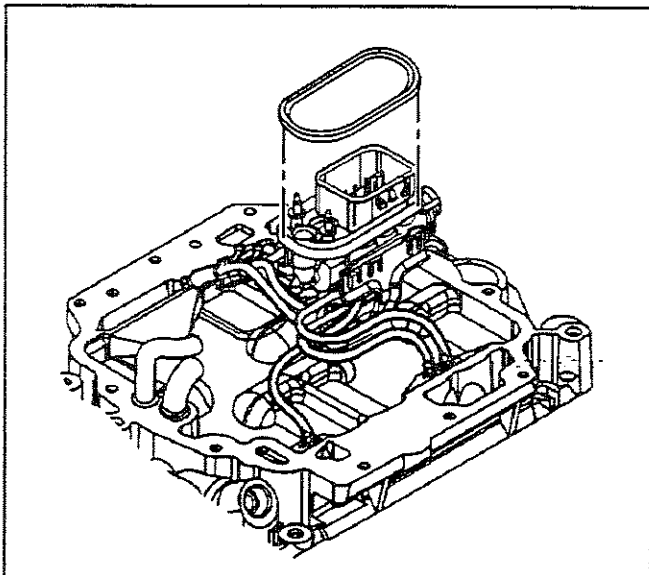
516790

28. Remove the seal (O-ring) from the fuel meter body assembly.
29. Discard the seal.

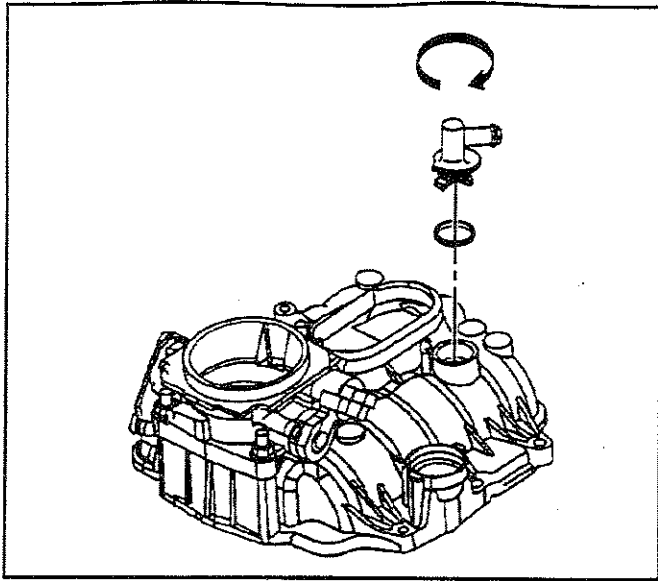
Important: Do not immerse the assembled upper intake manifold in cleaning solvent.

Clean all sealing surfaces and the inside of the upper intake manifold with a shop towel and cleaning solvent.

30. Inspect the upper intake manifold for the following:
 - Cracks or other damage to the exterior
 - Cracking or damage to the gasket grooves
 - Loose or damaged bolt hole thread inserts

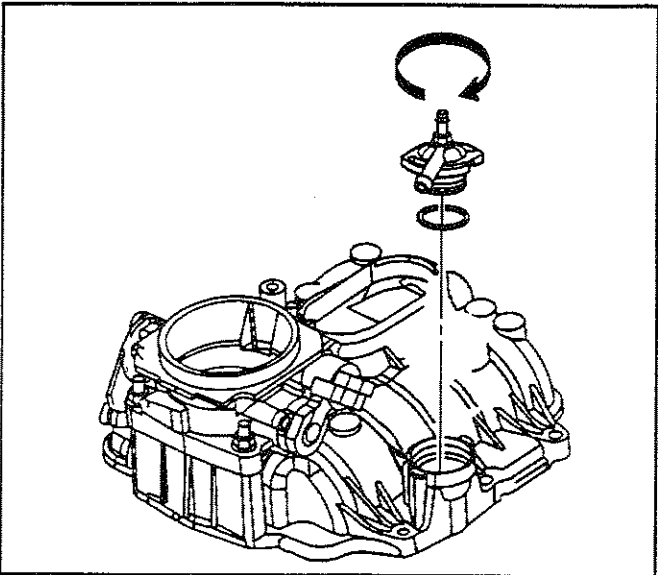


516773



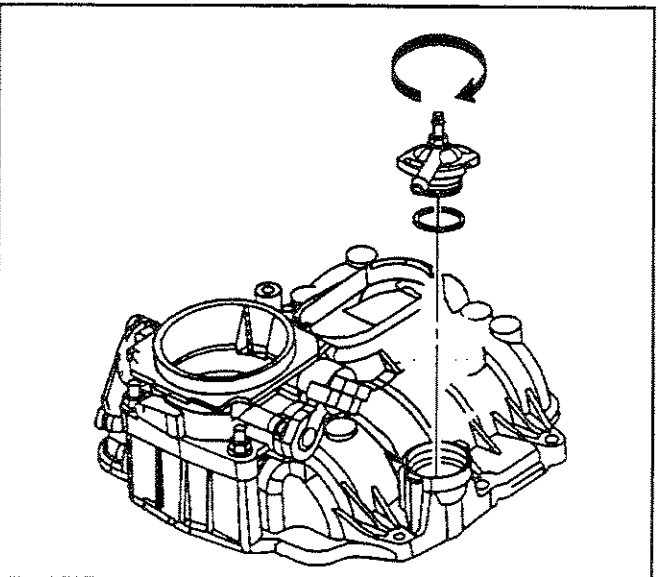
516797

31. If replacing the upper intake manifold, turn and remove the power brake booster vacuum tube fitting from the upper intake manifold.
32. Remove and discard the seal (O-ring).



516804

33. If replacing the upper intake manifold, turn and remove the PCV valve cover from the upper intake manifold.
34. Remove and discard the seal (O-ring).
35. Remove the throttle body if replacing the upper intake manifold. Refer to *Throttle Body Assembly Replacement*.
36. Remove the MAP sensor if replacing the upper intake manifold. Refer to *MAP Sensor Replacement* in Engine Controls - 4.3L.

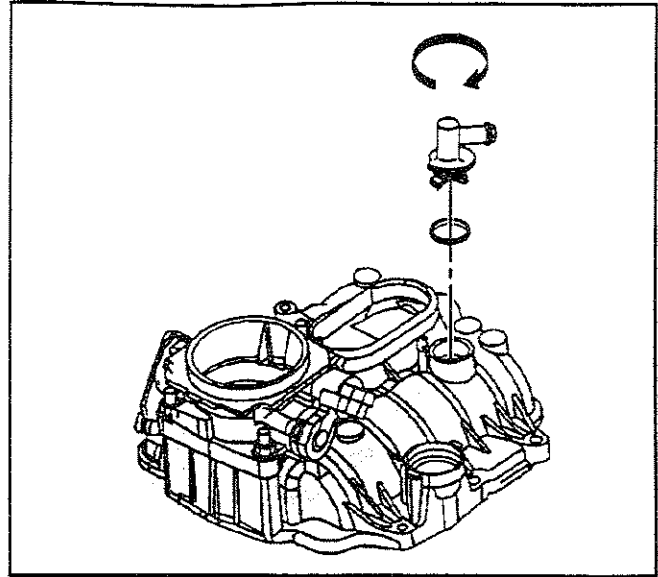


516804

Installation Procedure

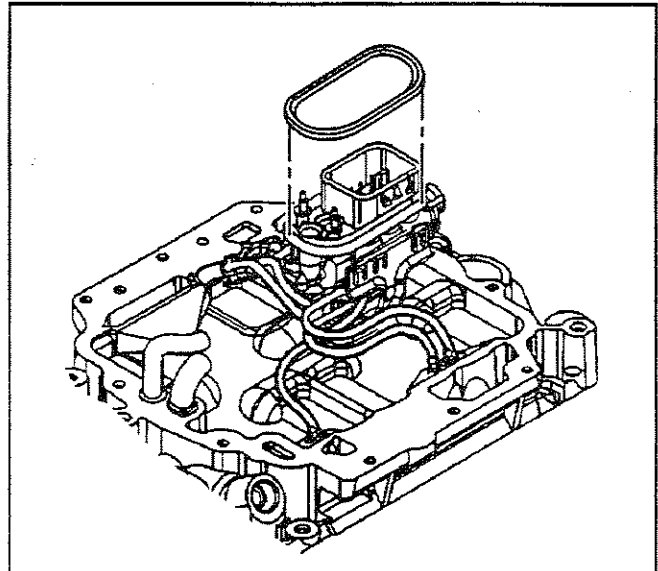
1. Install the throttle body, if removed. Refer to *Throttle Body Assembly Replacement*.
2. Install the MAP sensor, if removed. Refer to *MAP Sensor Replacement* in Engine Controls - 4.3L.
3. Install the PCV valve cover, if removed, using the following procedure:
 - 3.1. Install a NEW seal (O-ring) on the PCV valve cover.
 - 3.2. Lubricate the seal with clean engine oil.
 - 3.3. Install the PCV valve cover in the upper intake manifold.
 - 3.4. Turn and lock the PCV valve cover in position.

4. Install the power brake booster vacuum tube fitting, if removed, using the following procedure:
 - 4.1. Install a NEW seal (O-ring) on the power brake booster vacuum tube fitting.
 - 4.2. Lubricate the seal with clean engine oil.
 - 4.3. Install the power brake booster vacuum tube fitting in the upper intake manifold.
 - 4.4. Turn and lock the power brake booster vacuum tube fitting in position.



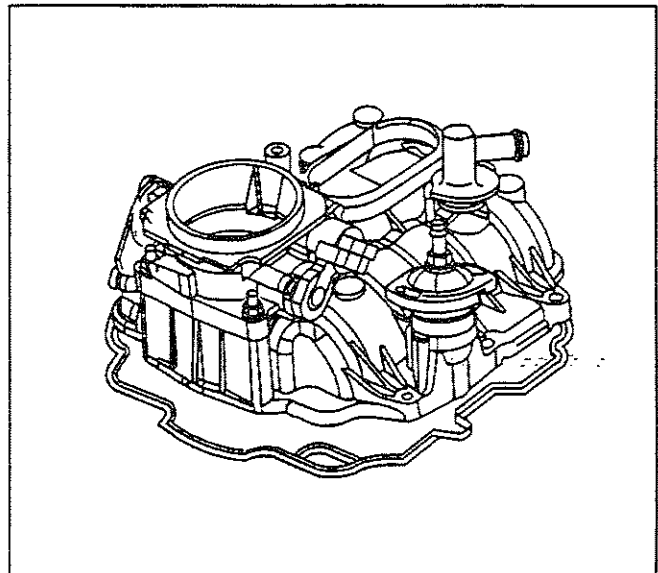
516797

5. Install a NEW seal on the fuel meter body assembly.
6. Lubricate the seal with clean engine oil.

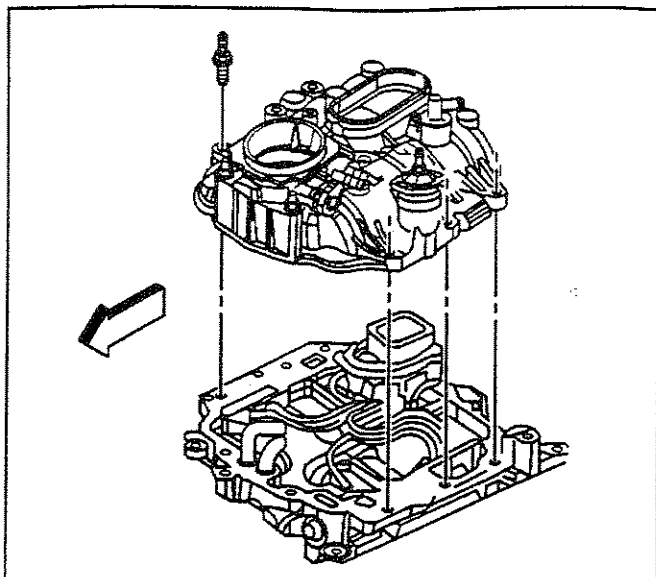


516773

7. Install a NEW upper intake manifold to lower intake manifold gasket in the groove of the upper intake manifold.



516790



516794

8. Install the upper intake manifold onto the lower intake manifold.
9. If reusing the fasteners, apply threadlock GM P/N 12345382 or equivalent to the threads of the upper intake manifold attaching bolts.

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

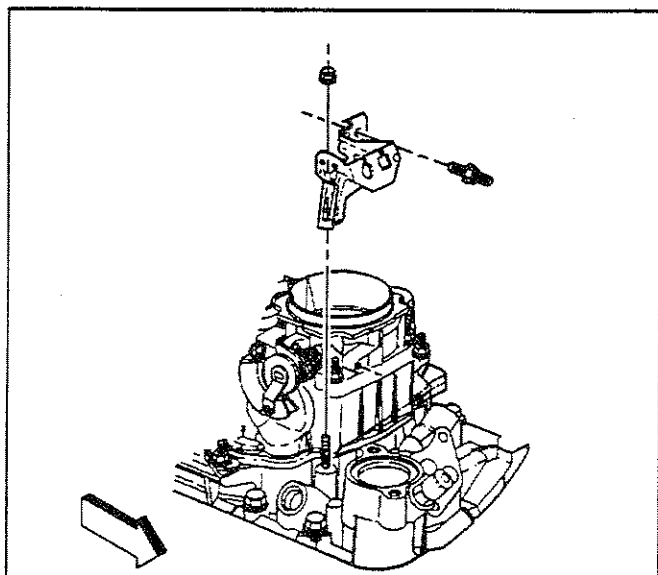
10. Install the upper intake manifold attaching studs.

Tighten

- 10.1. Tighten the upper intake manifold attaching studs on the first pass to 5 N·m (44 lb in).
- 10.2. Tighten the upper intake manifold attaching studs on the final pass to 9 N·m (80 lb in).
11. Install the fuel lines to the fuel meter body assembly. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls - 4.3L.
12. Install the EVAP canister purge solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls - 4.3L.
13. Install the accelerator control cable bracket to the throttle body and the intake manifold.

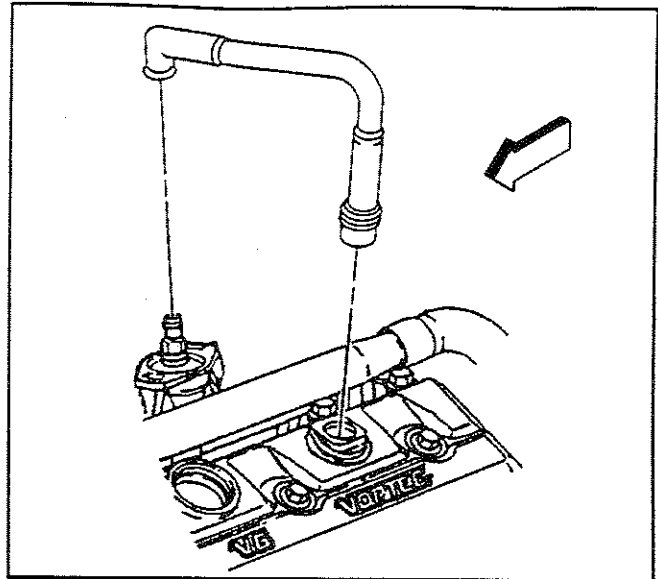
Tighten

Tighten the accelerator control cable bracket studs and nuts to 12 N·m (106 lb in).



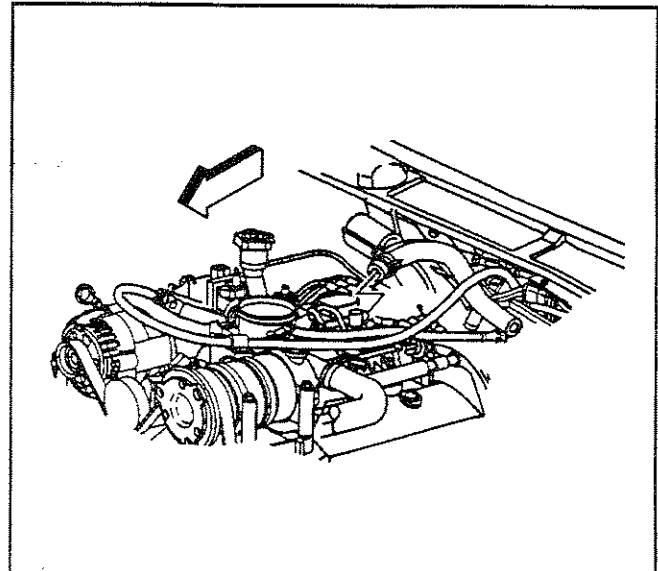
398033

14. Connect the PCV valve hose assembly to the intake manifold and the valve rocker arm cover.



172995

15. Connect the power brake booster vacuum hose to the intake manifold.



346148

16. Position the engine wiring harness and engine wiring harness brackets.
17. Install the stud holding the engine wiring harness bracket to the rear of the right cylinder head.

Tighten

Tighten the engine wiring harness bracket stud to 25 N·m (18 lb ft).

18. Install the nut holding the engine wiring harness bracket to the stud at the EVAP canister purge solenoid valve.

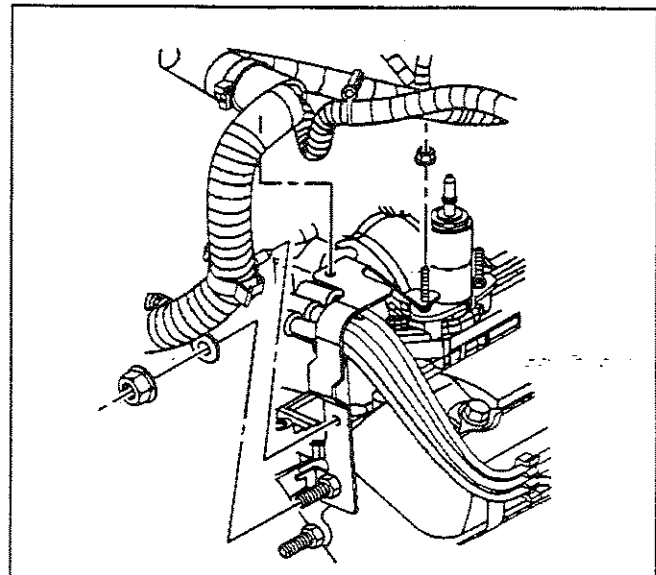
Tighten

Tighten the engine wiring harness bracket nut to 9 N·m (80 lb in).

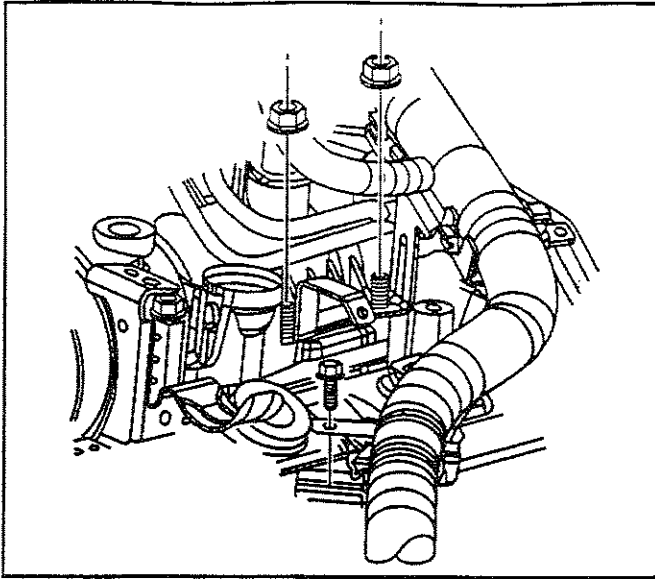
19. Install the nut and the ground wire on the engine wiring harness bracket stud at the rear of the right cylinder head.

Tighten

Tighten the ground wire nut to 16 N·m (12 lb ft).



310243

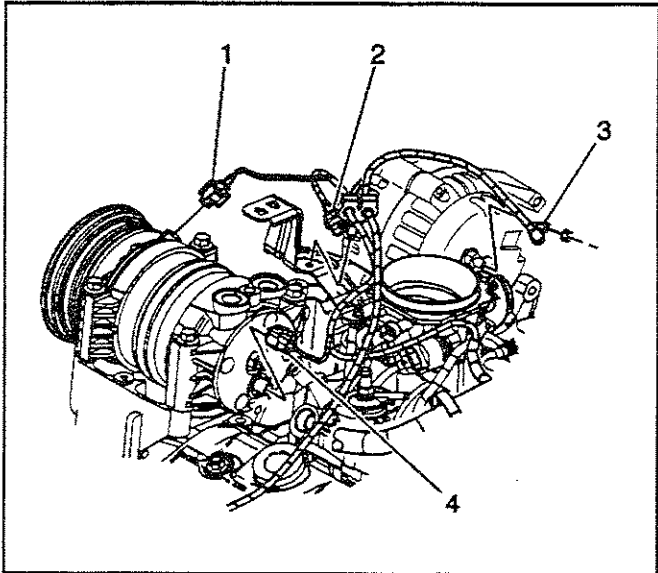


310241

20. Install the engine wiring harness bracket on the upper intake manifold studs.
21. Install the engine wiring harness bracket nuts.

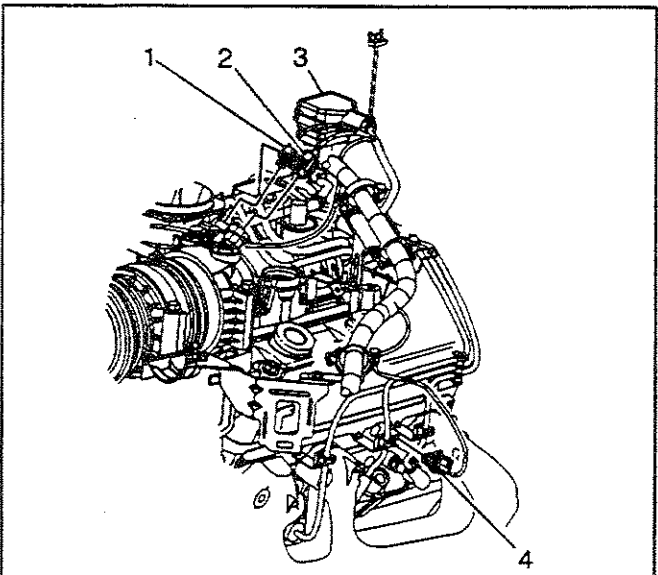
Tighten

Tighten the engine wiring harness bracket nuts to 12 N·m (106 lb in).



491821

22. Connect the following electrical connections:
 - The A/C compressor clutch (1), if equipped
 - The A/C pressure switch (4), if equipped
 - The EGR valve (2)

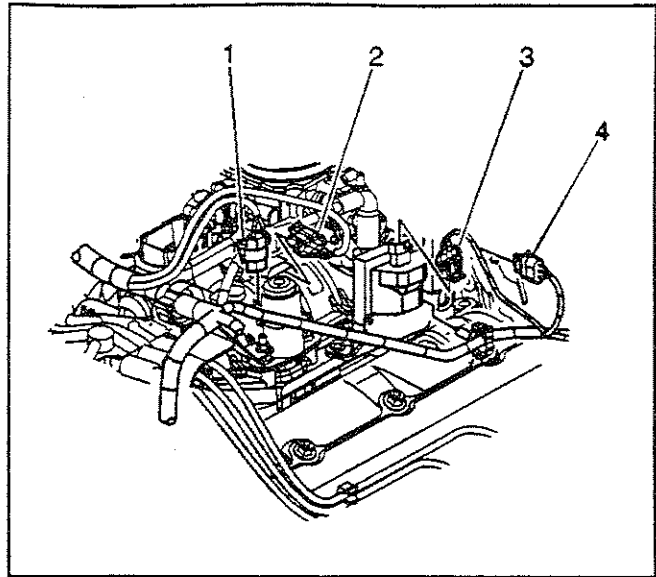


491817

23. Connect the following electrical connections:
 - The throttle position (TP) sensor (1)
 - The idle air control (IAC) motor (2)
 - The fuel meter body assembly connector (3)

24. Connect the following electrical connections:

- The manifold absolute pressure (MAP) sensor (2)
- The EVAP canister purge solenoid valve (1)



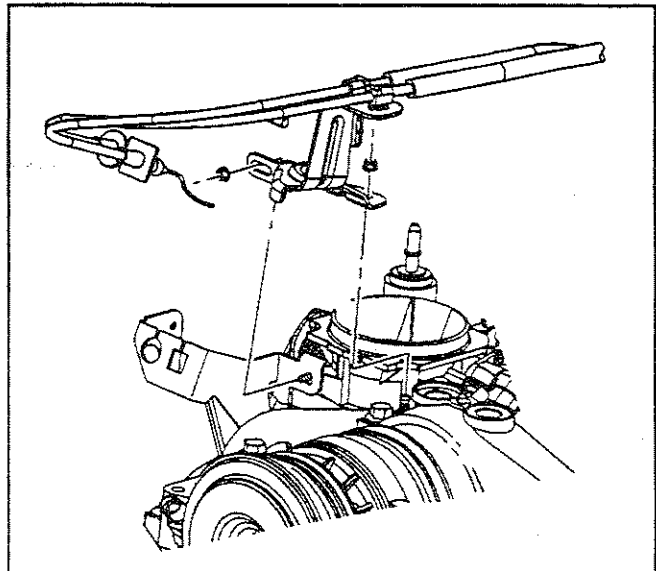
491816

25. Install the accelerator control cable bracket with the accelerator control cable and the cruise control cable and the nuts to the throttle body.

Tighten

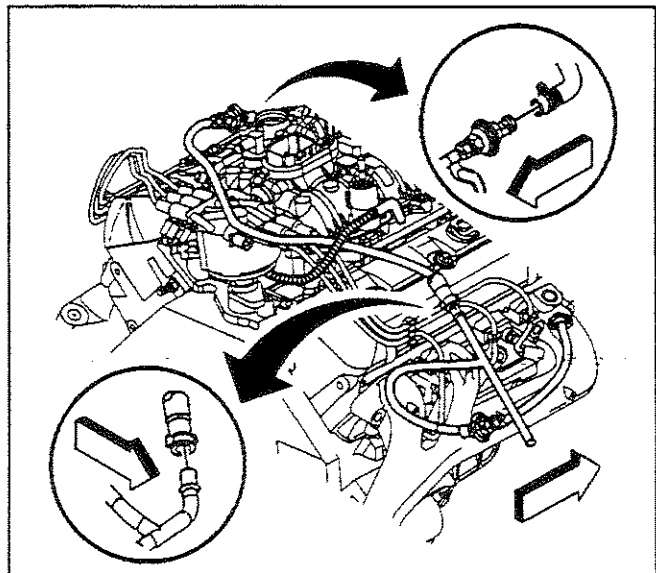
Tighten the accelerator control cable bracket nuts to 9 N·m (80 lb in).

26. Install the engine wiring harness clip to the accelerator control cable bracket.
27. Install the cruise control cable, if equipped to the throttle shaft and the accelerator control cable bracket. Refer to *Cruise Control Cable Replacement (V8)* in Cruise Control.
28. Install the accelerator control cable to the throttle shaft and the accelerator control cable bracket. Refer to *Accelerator Controls Cable Replacement* in Engine Controls - 4.3L.



398030

29. Connect the AIR crossover pipe to the AIR pipe assemblies.
30. Install the air cleaner outlet duct to the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
31. Connect the PCV hose to the air cleaner outlet duct.



398868

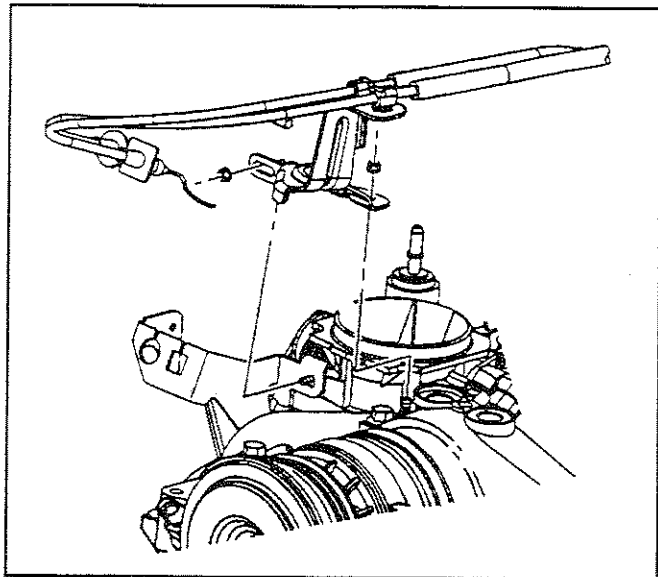
Intake Manifold Replacement (Lower)

SIE-ID - 478532

Removal Procedure

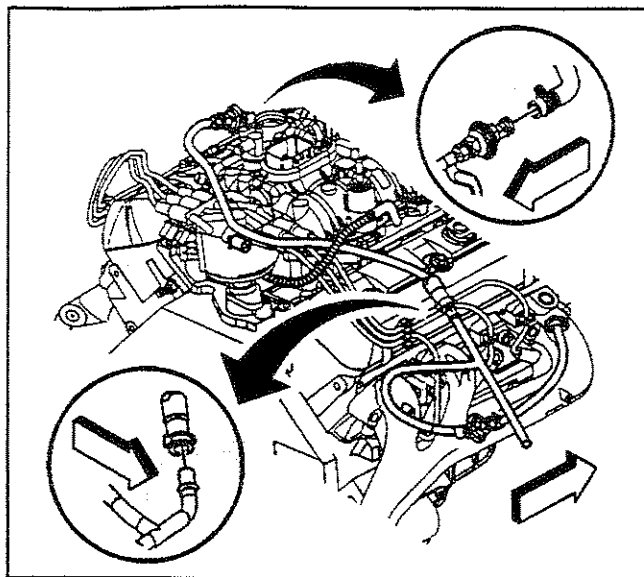
Important: You do not have to remove the upper intake manifold in order to remove the lower intake manifold.

1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* 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 cleaner outlet duct.
4. Remove the air cleaner outlet duct from the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
5. Remove the accelerator control cable from the throttle shaft and the accelerator control cable bracket at the side of the throttle body. Refer to *Accelerator Controls Cable Replacement* in Engine Controls - 4.3L.
6. Disconnect the cruise control cable, if equipped from the throttle shaft and the accelerator control cable bracket at the side of the throttle body. Refer to *Cruise Control Cable Replacement (V8)* in Cruise Control.
7. Remove the engine wiring harness and clip from the accelerator control cable bracket.
8. Remove the accelerator control cable bracket with the accelerator control cable and the cruise control cable from the throttle body.
9. Move and secure the accelerator control cable bracket with the cables out of the way.



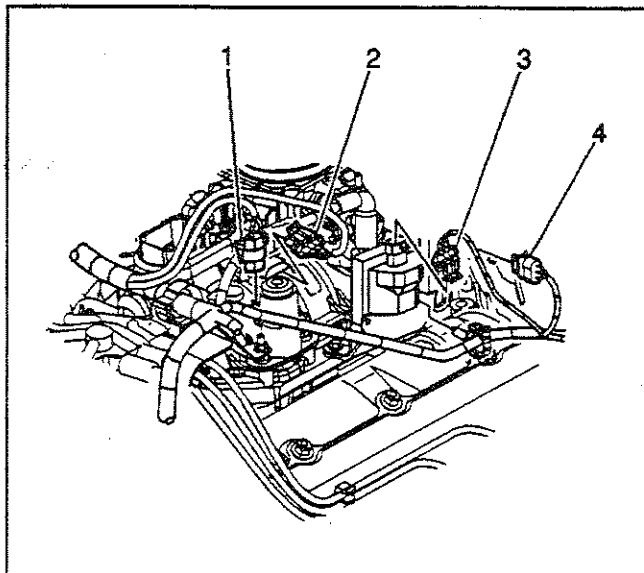
398030

10. Disconnect the secondary air injection (AIR) crossover pipe from the AIR pipe assemblies, if equipped.
11. Remove the AIR crossover pipe.



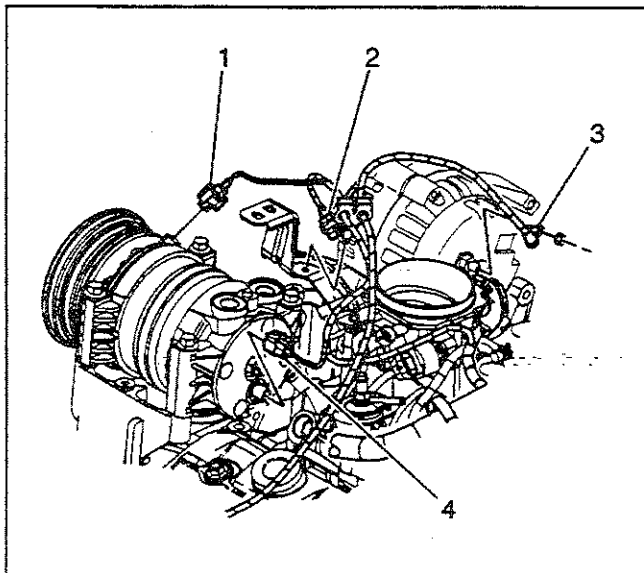
398868

12. Disconnect the following electrical connectors:
 - The EVAP canister purge solenoid valve (1)
 - The manifold absolute pressure (MAP) sensor (2)
 - The ignition control module (ICM) (4)
 - The ignition coil (3)

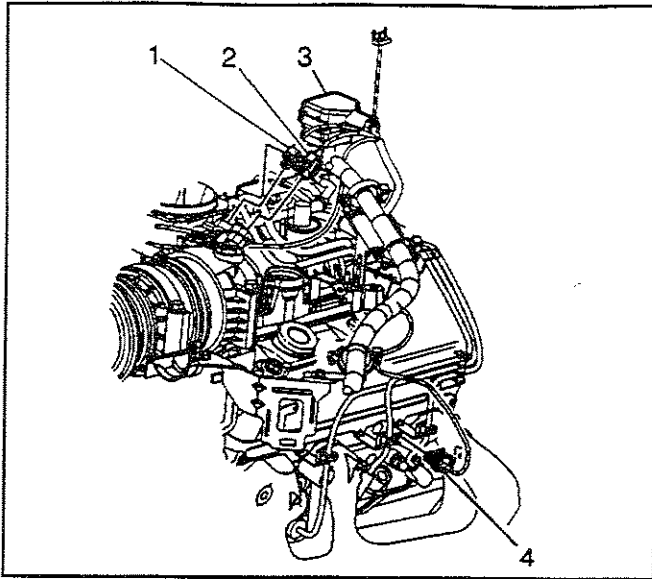


491816

13. Disconnect the following electrical connectors:
 - The A/C pressure switch (4), if equipped
 - The A/C compressor clutch (1), if equipped
 - The exhaust gas recirculation (EGR) valve (2)
 - The generator battery positive cable (3)

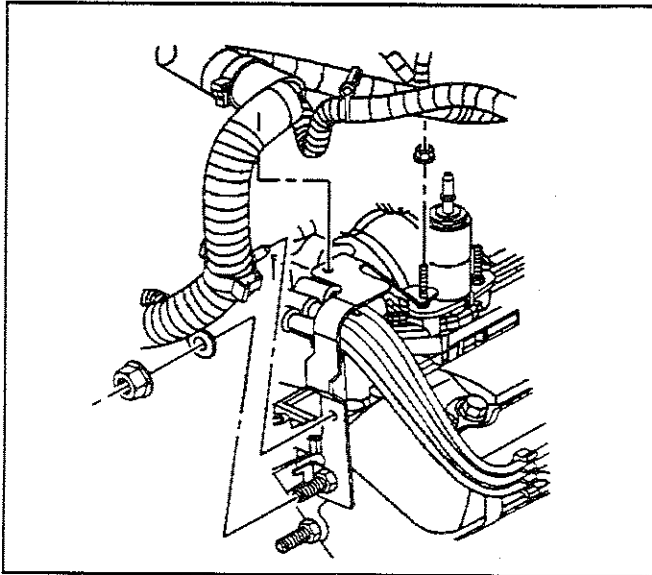


491821



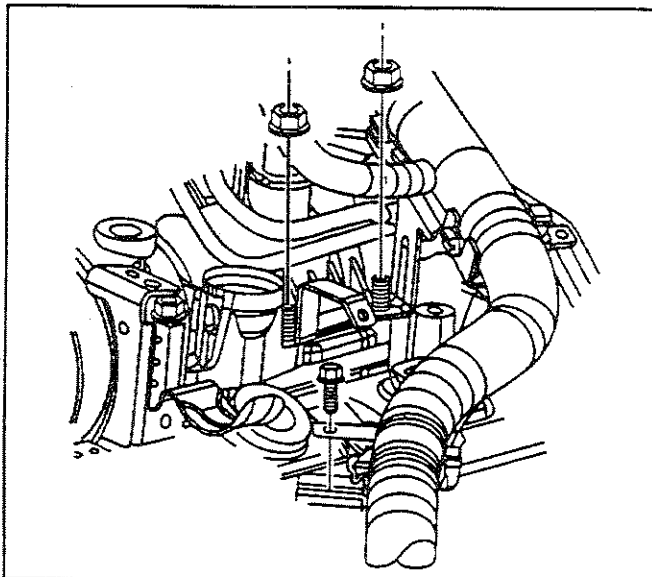
491817

14. Disconnect the following electrical connectors:
- The fuel meter body assembly (3)
 - The throttle position (TP) sensor (1)
 - The idle air control (IAC) motor (2)
 - The engine coolant temperature (ECT) sensor (4)



310243

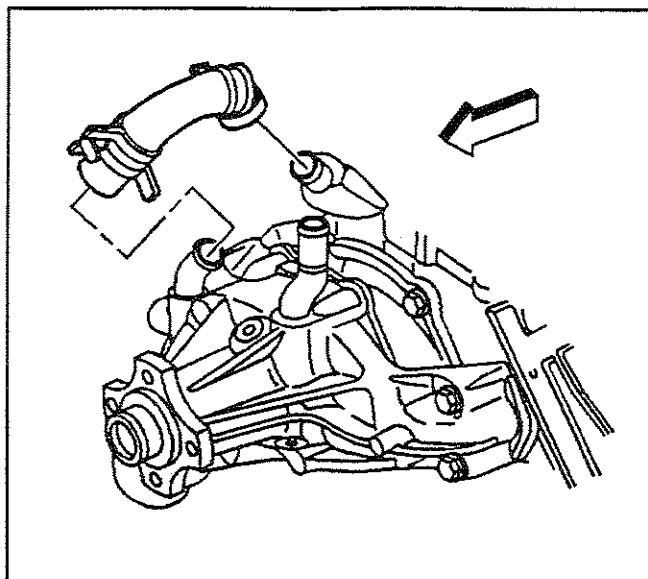
15. Remove the nut holding the engine wiring harness bracket to the EVAP purge solenoid valve stud.
16. Remove the nut holding the ground wire to the engine wiring harness bracket stud at the rear of the right cylinder head.
17. Remove the stud holding the engine wiring harness bracket.



310241

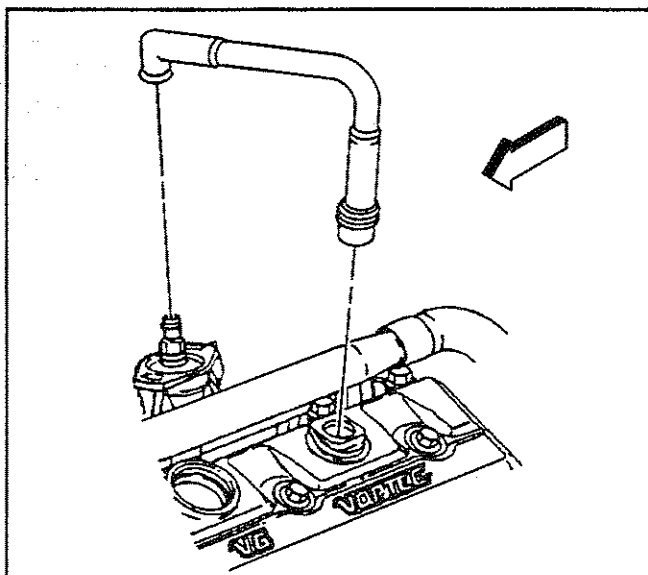
18. Remove the two nuts holding the engine wiring harness bracket to the upper intake manifold studs.
19. Remove the engine wiring harness bracket from the studs.
20. Move the engine wiring harness with the brackets aside.

21. Remove the radiator inlet hose at the water outlet. Refer to *Radiator Hose Replacement - Inlet (4.3L Engine)* in Engine Cooling..
22. Remove the water pump inlet hose from the intake manifold.
23. Remove the heater hoses from the engine. Refer to *Heater Hoses Replacement (4.3L)* in Heating Ventilation and Air Conditioning.
24. Remove the distributor. Refer to *Distributor Replacement* 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 - 4.3L.



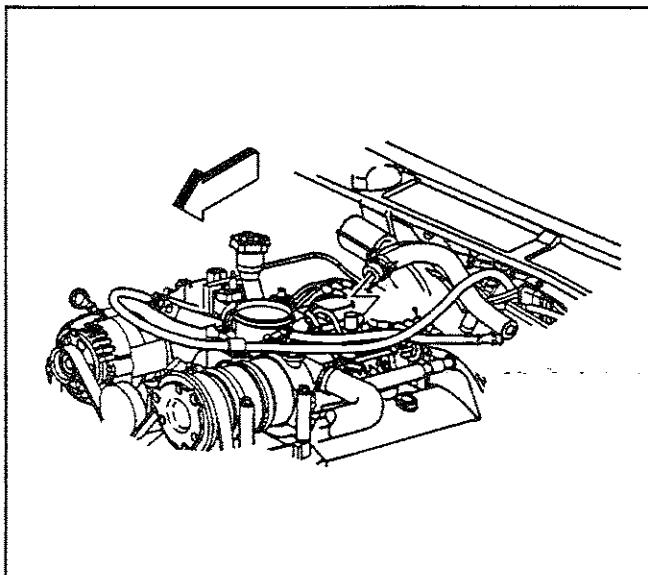
182853

26. Disconnect PCV valve hose assembly from the intake manifold and the valve rocker arm cover.

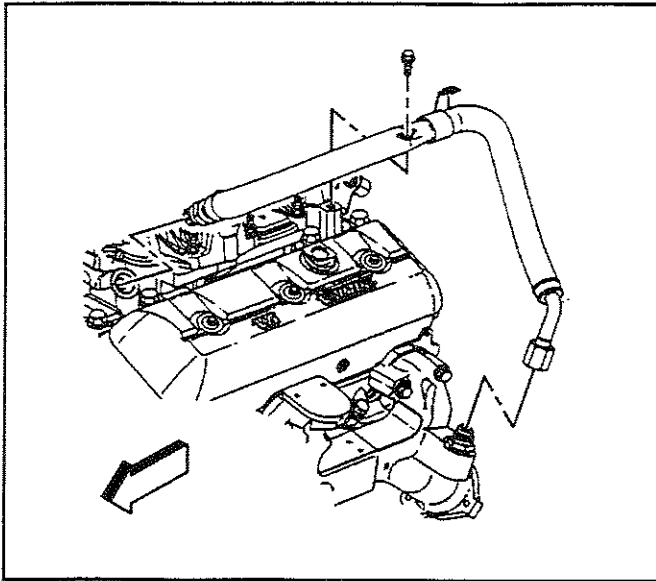


172995

27. Disconnect the power brake booster vacuum hose from the intake manifold.
28. Disconnect the hose to the EVAP canister purge solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls - 4.3L.

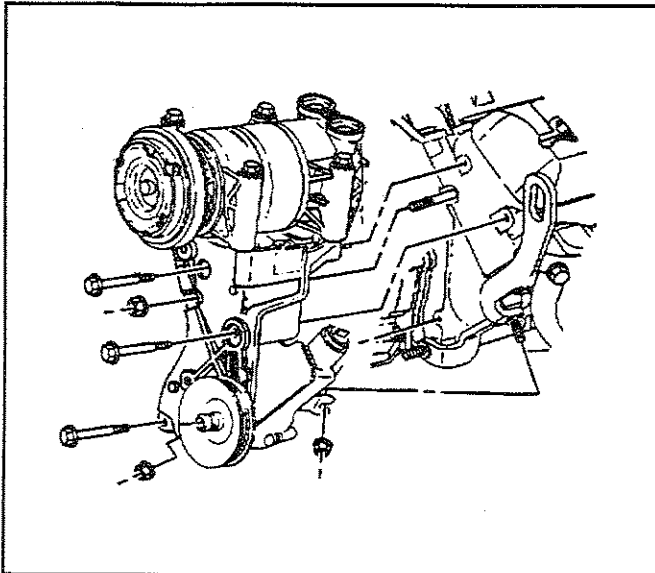


346148



172982

29. Remove the spark plug wire harness retainer from the exhaust gas recirculation (EGR) valve inlet pipe.
30. Remove the clamp bolt for the EGR valve inlet pipe.
31. Remove the EGR valve inlet pipe from the intake and the exhaust manifolds.



340090

32. In order to remove the front intake manifold bolt, perform the following:
 - 32.1. Remove the drive belt. Refer to *Drive Belt Replacement*.
 - 32.2. Loosen the power steering pump rear bracket side nut.
 - 32.3. Remove the power steering pump rear bracket front nut.
 - 32.4. Remove the bolts and the nut for the power steering pump mounting bracket.
 - 32.5. Leave the A/C compressor, if equipped, and the power steering pump on the bracket.
 - 32.6. Slide the power steering pump mounting bracket forward to access the bolt at the front of the intake manifold.
33. Remove the lower intake manifold. Refer to *Intake Manifold Removal*.

Important: Do not immerse the assembled intake manifold in cleaning solvent.

Clean all sealing surfaces and the intake manifold. Refer to *Intake Manifold Disassemble*.

34. If the intake manifold requires replacement refer to *Intake Manifold Disassemble* and *Intake Manifold Assemble*.

Installation Procedure

1. Install the lower intake manifold. Refer to *Intake Manifold Installation*.
2. Position the power steering pump mounting bracket.
3. Install the three bolts and the nut.

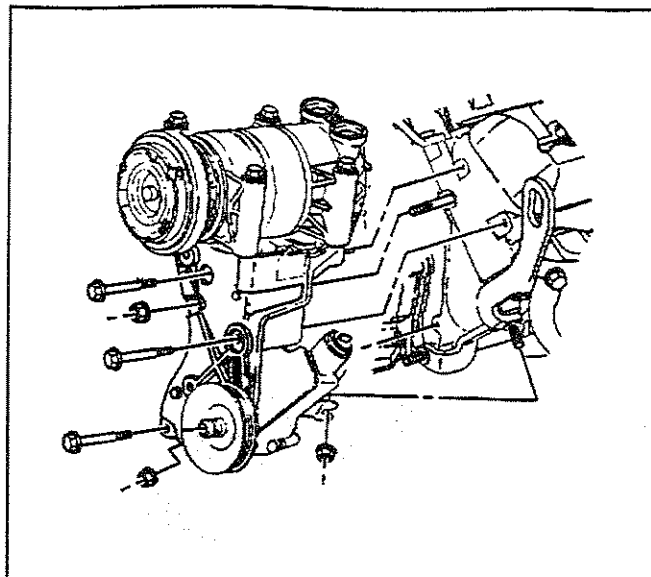
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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 nuts to 41 N·m (30 lb ft).

5. Install the drive belt. Refer to *Drive Belt Replacement*.



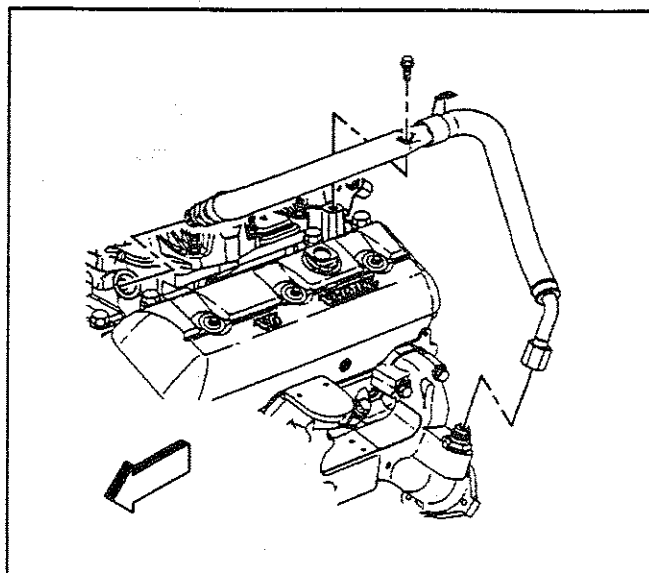
340090

6. Install the EGR valve inlet pipe to the intake manifold and the exhaust manifold.

Tighten

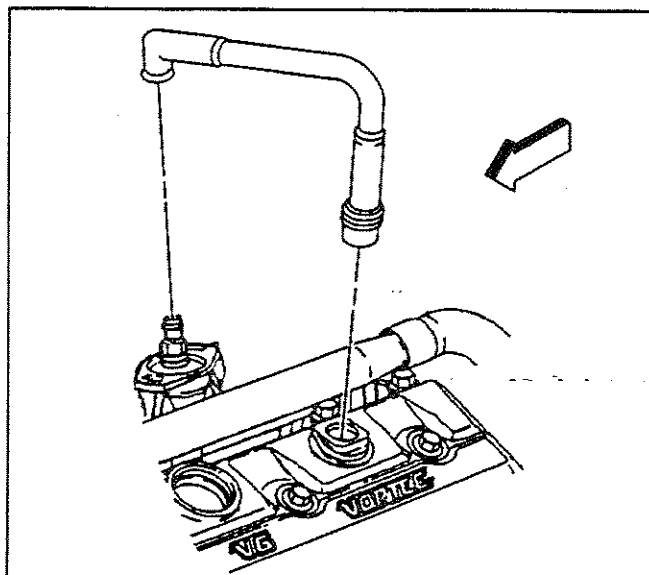
- 6.1. Tighten the EGR valve inlet pipe intake manifold nut to 25 N·m (18 lb ft).
- 6.2. Tighten the EGR valve inlet pipe exhaust manifold nut to 30 N·m (22 lb ft).
- 6.3. Tighten the EGR valve inlet pipe clamp bolt 25 N·m (18 lb ft).

7. Install the spark plug wire harness retainer on the EGR valve inlet pipe.

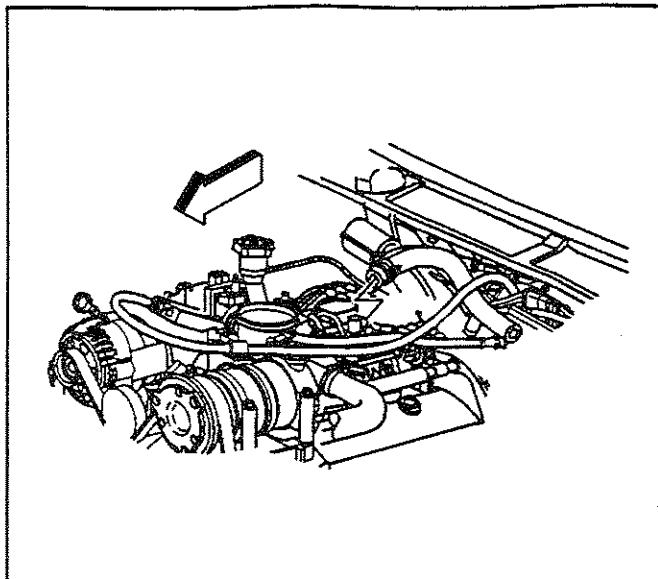


172982

8. Install the PCV valve hose assembly to the intake manifold and the valve rocker arm cover.

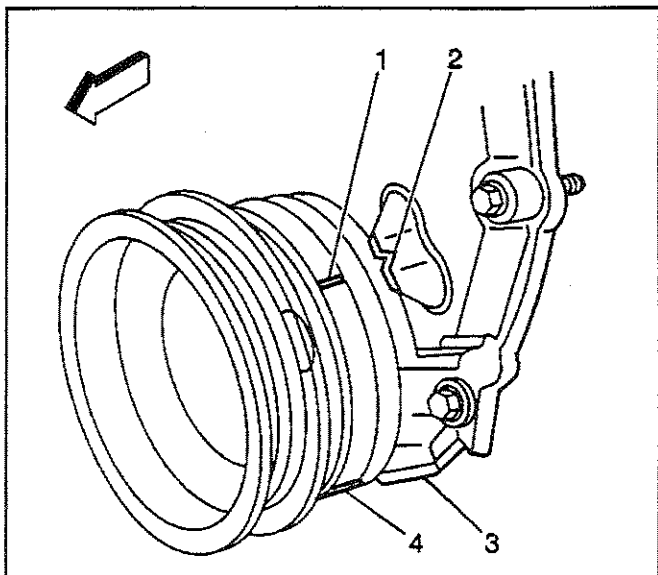


172995



346148

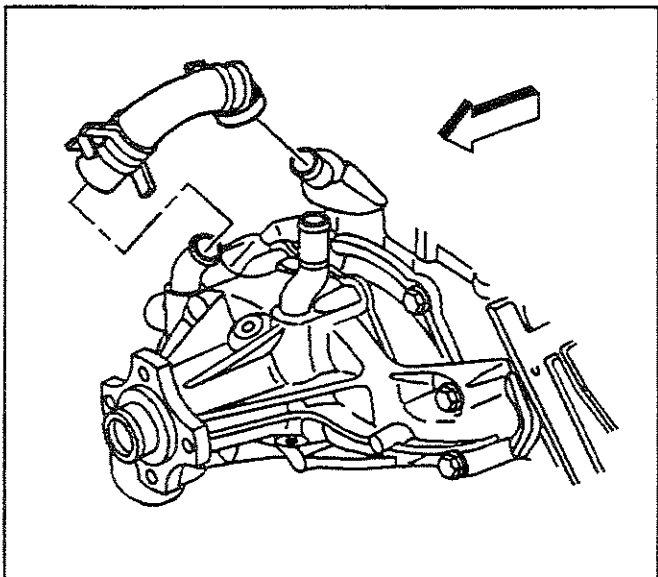
9. Install the power brake booster vacuum hose to the intake manifold.
10. Install the EVAP canister purge solenoid valve hose. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls - 4.3L.
11. Install the fuel supply and return pipes to the rear of the intake manifold. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls - 4.3L.



334551

Important: In order to install the distributor for the correct engine timing, position the engine to number one cylinder top dead center.

- 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* in Engine Electrical.
15. Install the distributor. Refer to *Distributor Replacement* in Engine Electrical.
16. Install the water pump inlet hose to the intake manifold.
17. Install the heater hoses to the engine. Refer to *Heater Hoses Replacement (4.3L)* in Heating Ventilation and Air Conditioning.
18. Install the radiator inlet hose to the water outlet. Refer to *Radiator Hose Replacement - Inlet (4.3L Engine)* in Engine Cooling.
19. Refill the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.



182853

20. Position the engine wiring harness and the engine wiring harness brackets.
21. Install the stud at the rear of the right cylinder head for the engine wiring harness bracket.

Tighten

Tighten the engine wiring harness bracket stud to 25 N·m (18 lb ft).

22. Install the nut holding the engine wiring harness bracket to the EVAP purge canister solenoid stud.

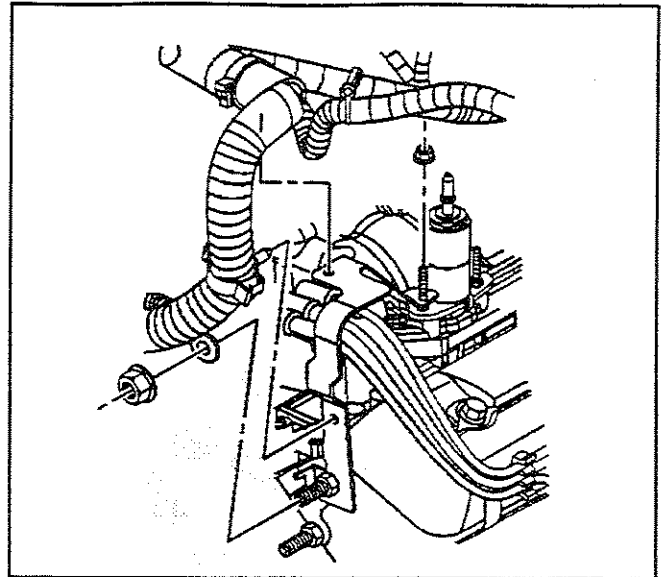
Tighten

Tighten the engine wiring harness bracket nut to 9 N·m (80 lb in).

23. Install the nut and the ground wire to engine wiring harness bracket stud at the rear of the right cylinder head.

Tighten

Tighten the ground wire nut to 16 N·m (12 lb ft).

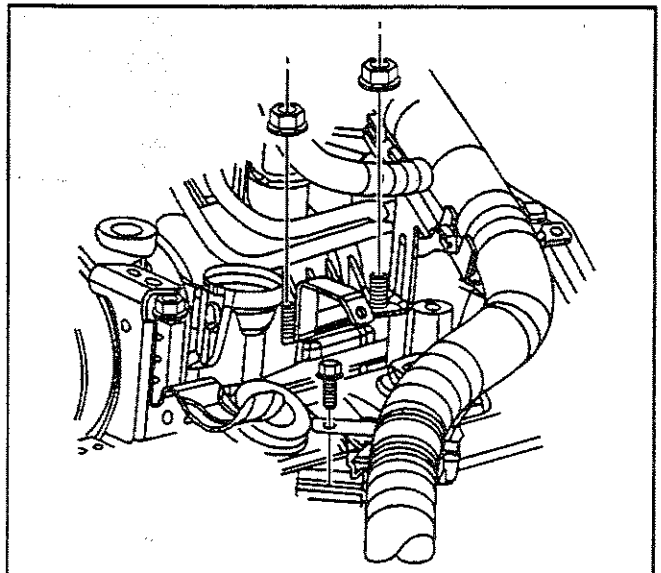


310243

24. Install the nuts and the engine wiring harness bracket to the upper intake manifold studs.

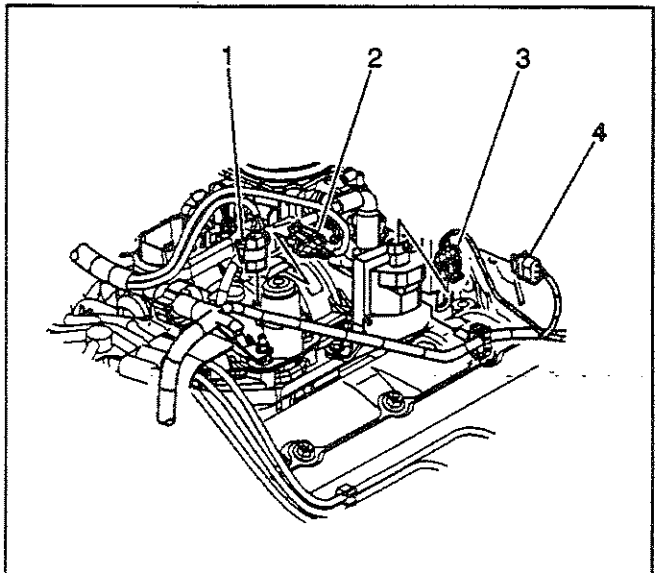
Tighten

Tighten the engine wiring harness bracket nuts 12 N·m (106 lb in).

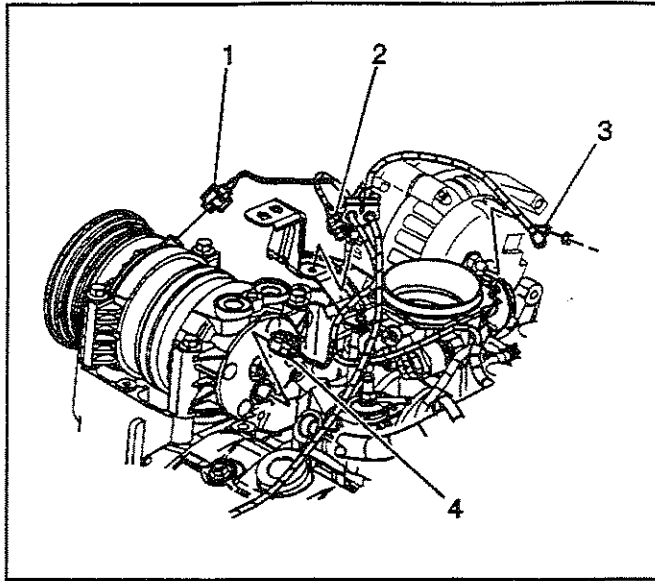


310241

25. Connect the following electrical connectors:
 - The EVAP canister purge solenoid valve (1)
 - The manifold absolute pressure (MAP) sensor (2)
 - The ignition control module (ICM) (4)
 - The ignition coil (3)

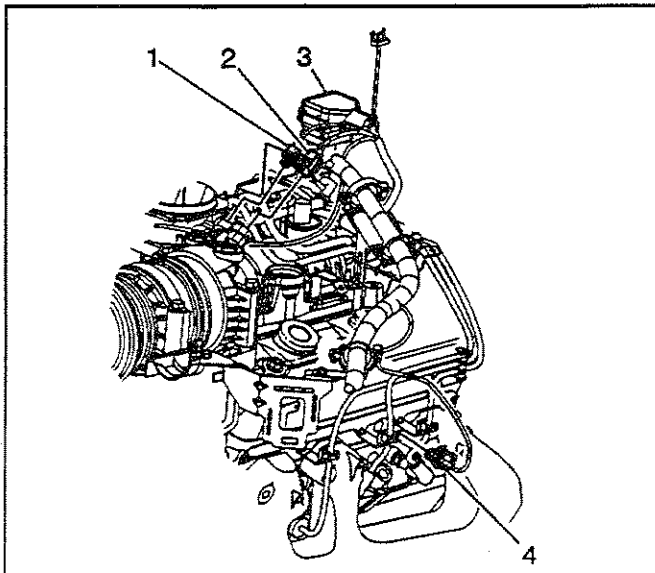


491816



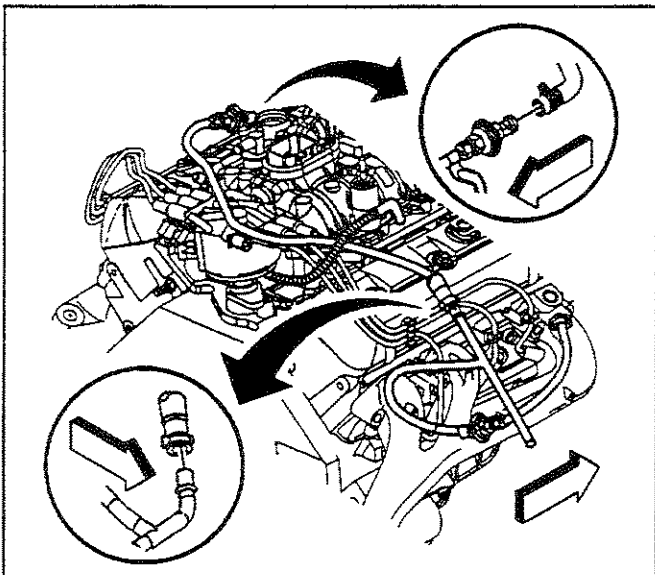
491821

26. Connect the following electrical connectors:
- The A/C pressure switch (4), if equipped
 - The A/C compressor clutch (1), if equipped
 - The exhaust gas recirculation (EGR) valve (2)
 - The generator battery positive cable (3)



491817

27. Connect the following electrical connectors:
- The fuel meter body assembly (3)
 - The throttle position (TP) sensor (1)
 - The idle air control (IAC) motor (2)
 - The engine coolant temperature (ECT) sensor (4)



398868

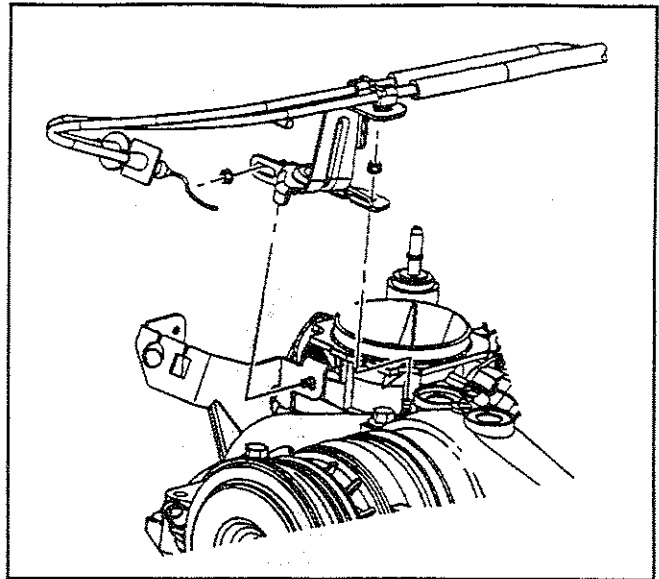
28. Connect the AIR crossover pipe to the AIR pipe assemblies.

29. Install the accelerator control cable bracket with the accelerator control cable and the cruise control cable and the nuts to the throttle body.

Tighten

Tighten the nuts to 9 N·m (80 lb in).

30. Install the accelerator cable to the throttle shaft the accelerator control cable bracket. Refer to *Accelerator Controls Cable Replacement* in Engine Controls - 4.3L.
31. Install the cruise control cable, if equipped to the throttle shaft the accelerator control cable bracket. Refer to *Cruise Control Cable Replacement (V8)* in Cruise Control.
32. Install the engine wiring harness and clip to the accelerator control cable bracket.
33. Install the air cleaner outlet duct to the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
34. Connect the PCV hose to the air cleaner outlet duct.
35. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.



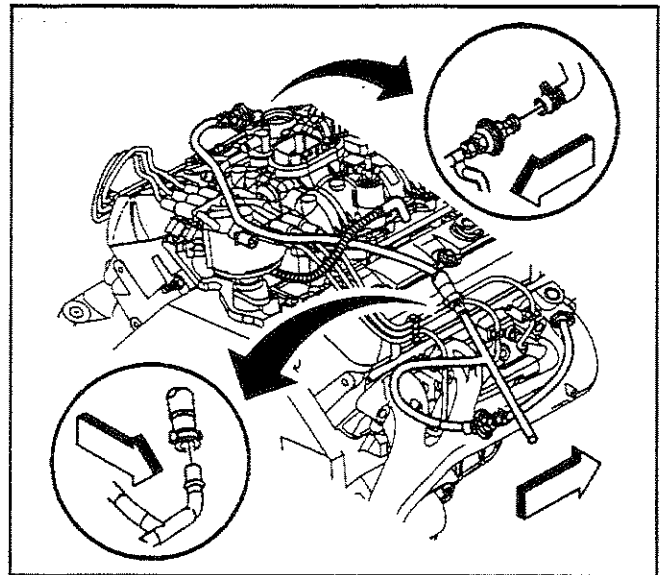
398030

Valve Rocker Arm Cover Replacement (Left)

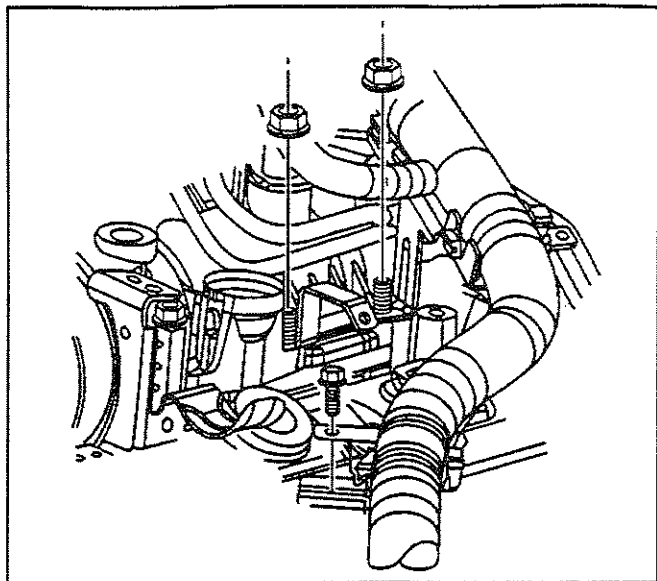
SIE-ID = 478535

Removal Procedure

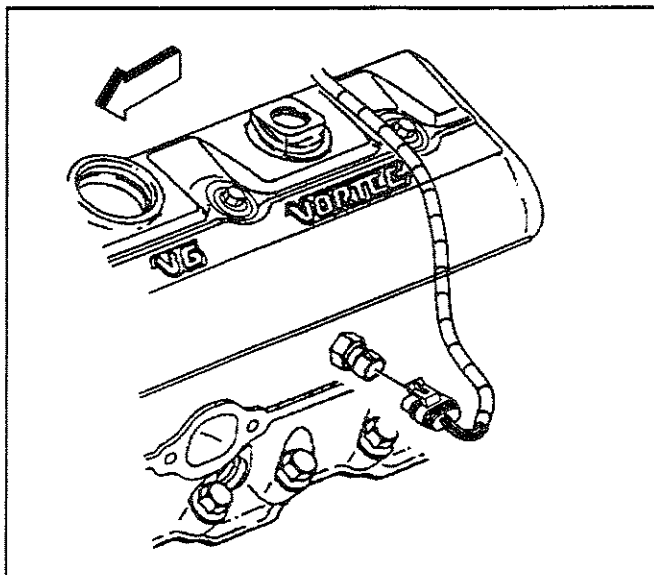
1. Remove the AIR crossover pipe, if equipped.



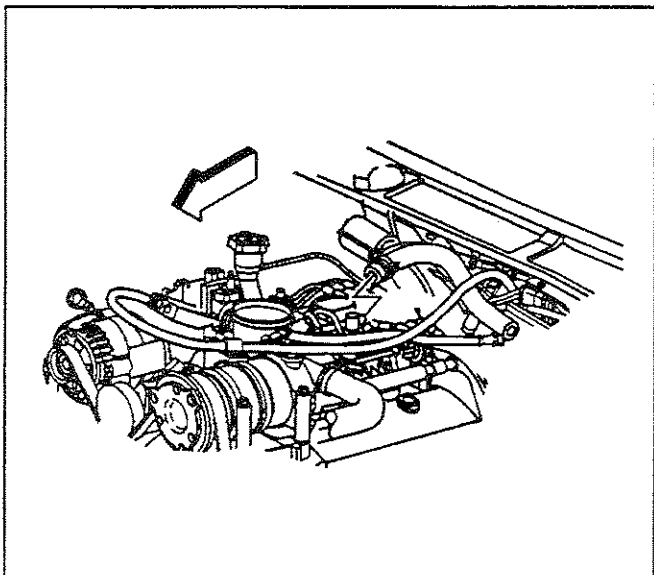
398868



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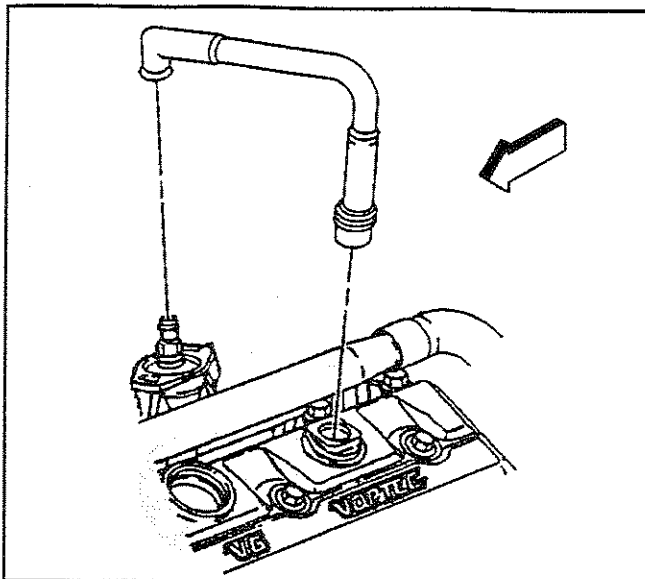
246797



346148

2. Remove the secondary air injection (AIR) pipe assembly from the exhaust manifold, if equipped. Refer to *AIR Check Valve/Pipe Replacement - Bank 1* in Engine Controls - 4.3L.
3. Remove the nuts and the engine wiring harness bracket from the upper intake manifold studs.
4. Remove the bolt holding the engine wiring harness clip to the positive battery cable junction block bracket.
5. Disconnect the engine coolant temperature (ECT) sensor electrical connector.
6. Move and secure the engine wiring harness with the engine wiring harness bracket aside.
7. Disconnect the power brake booster vacuum hose from the intake manifold and the vacuum brake booster.

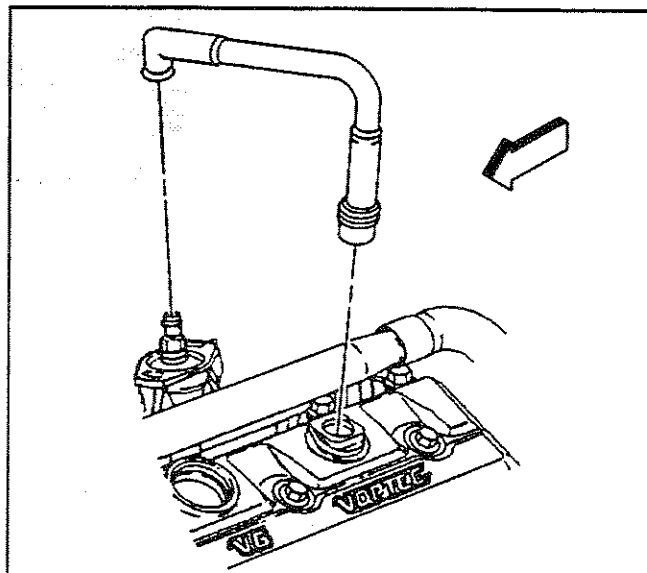
8. Remove the PCV valve hose assembly from the intake manifold and the valve rocker arm cover.
9. Remove the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Removal (Left)*.
10. Clean all sealing surfaces and the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Clean and Inspect*.



172995

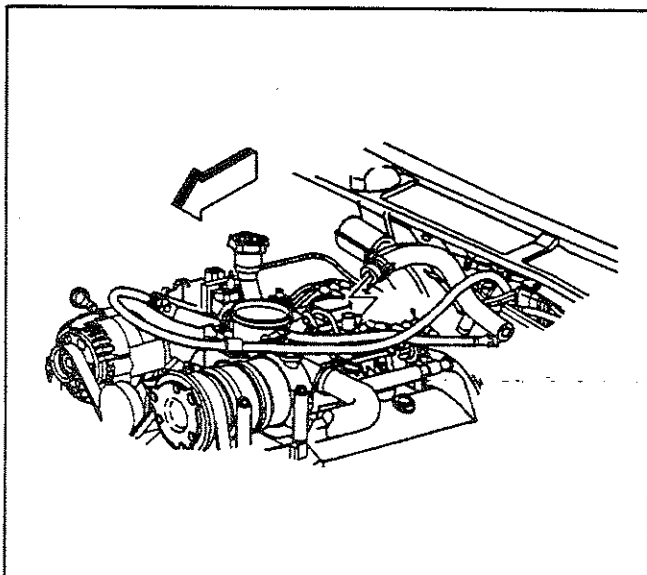
Installation Procedure

1. Install the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Installation (Left)*.
2. Install the PCV valve hose assembly to the intake manifold and the valve rocker arm cover.

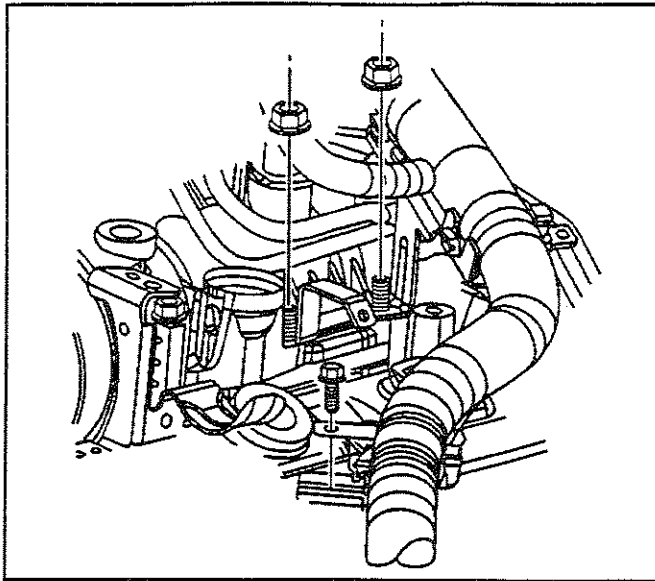


172995

3. Connect the power brake booster vacuum hose to the intake manifold and the vacuum brake booster.



346148



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4. Reposition the engine wiring harness.

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

5. Install the engine wiring harness bracket and the nuts to the lower intake manifold studs.

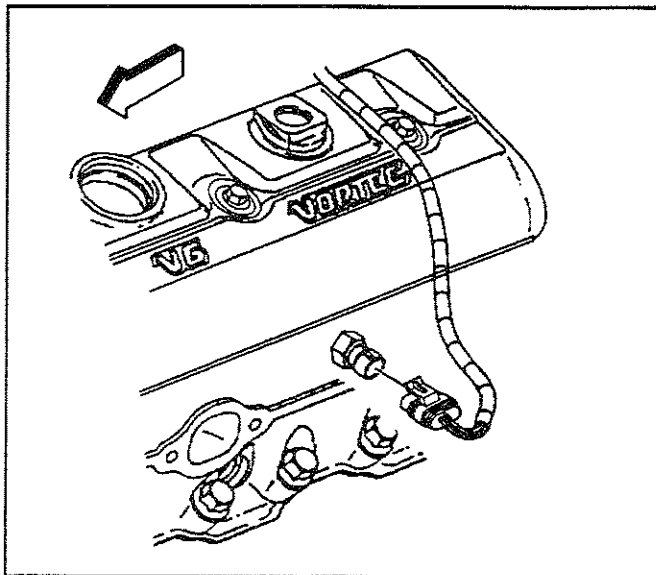
Tighten

Tighten the engine wiring harness bracket nuts to 12 N·m (106 lb in).

6. Install the bolt for the engine wiring harness clip to the positive battery cable junction block bracket.

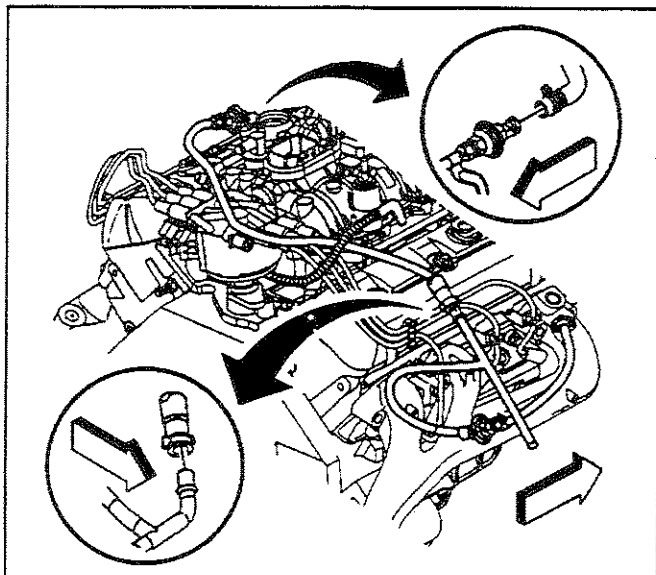
Tighten

Tighten the engine wiring harness clip nut to 9 N·m (80 lb in).



246797

7. Connect the ECT sensor electrical connector.



398868

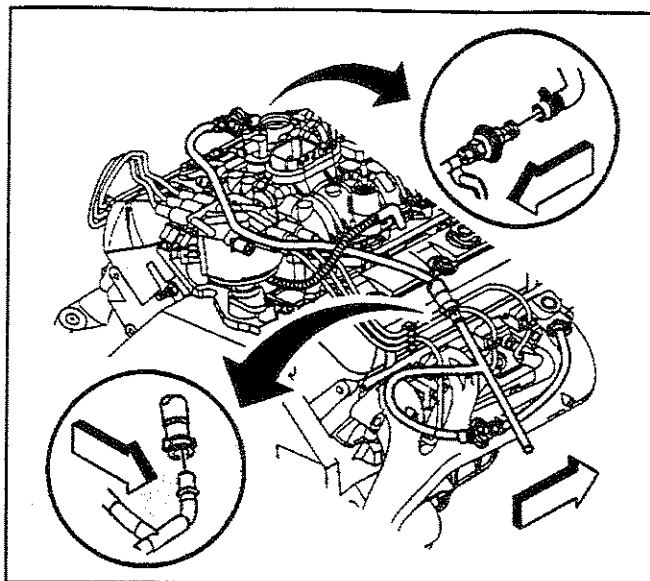
8. Install the AIR pipe assembly to the exhaust manifold, if equipped. Refer to *AIR Check Valve/Pipe Replacement - Bank 1* in Engine Controls - 4.3L.
9. Install the AIR crossover pipe, if equipped.

Valve Rocker Arm Cover Replacement (Right)

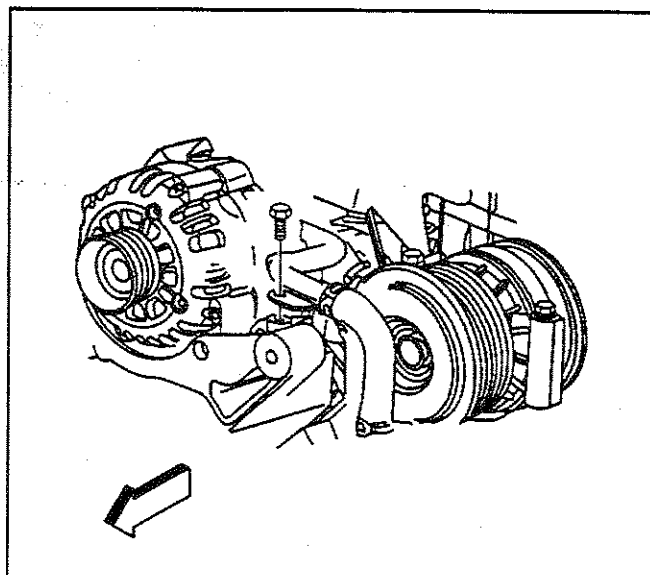
SIE-ID = 478536

Removal Procedure

1. Disconnect the PCV hose from the air cleaner outlet duct.
2. Remove the air cleaner outlet duct from the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
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. Refer to *AIR Check Valve/Pipe Replacement - Bank 2* in Engine Controls - 4.3L.
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.
8. Remove the right valve rocker arm cover. Refer to *Valve Rocker Arm Cover Removal (Right)*.
9. Clean all sealing surfaces and the valve rocker arm cover. Refer to *Valve Rocker Arm Cover Clean and Inspect*.



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316440

Installation Procedure

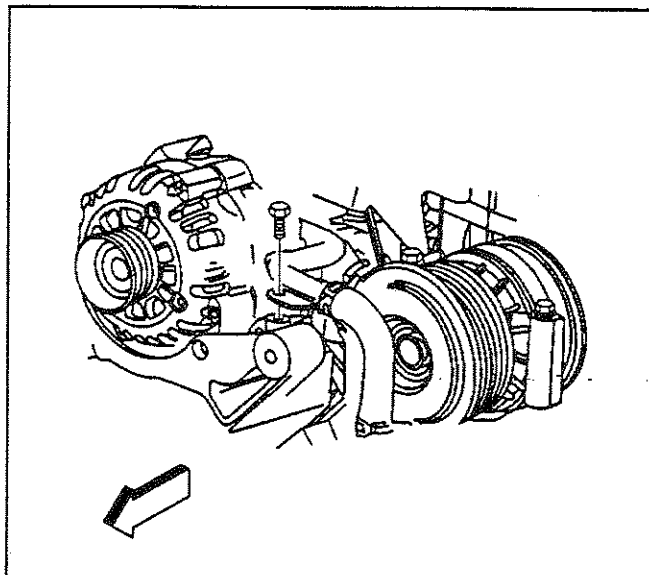
1. Install the right valve rocker arm cover and bolts. Refer to *Valve Rocker Arm Cover Installation (Right)*.
2. Reposition the engine wiring harness.
3. Reposition the heater hoses.

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

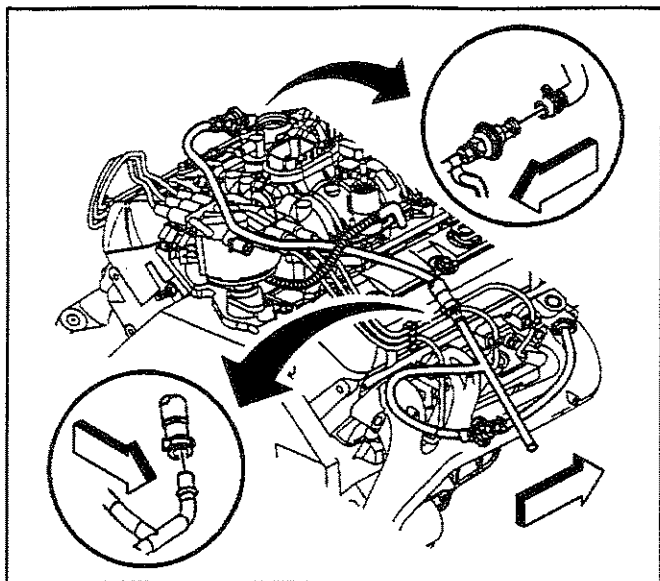
4. Install the heater hose bracket bolt.

Tighten

Tighten the bracket bolt to 25 N·m (18 lb ft).



316440



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5. Install the AIR pipe assembly to the exhaust manifold. Refer to *AIR Check Valve/Pipe Replacement - Bank 2* in Engine Controls - 4.3L.
6. Connect the AIR pipe assembly to the AIR pump and the AIR crossover pipe.
7. Install the air cleaner outlet duct to the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
8. Install the PCV hose to the air cleaner outlet duct.

Valve Rocker Arm and Push Rod Replacement

SIE-ID - 478538

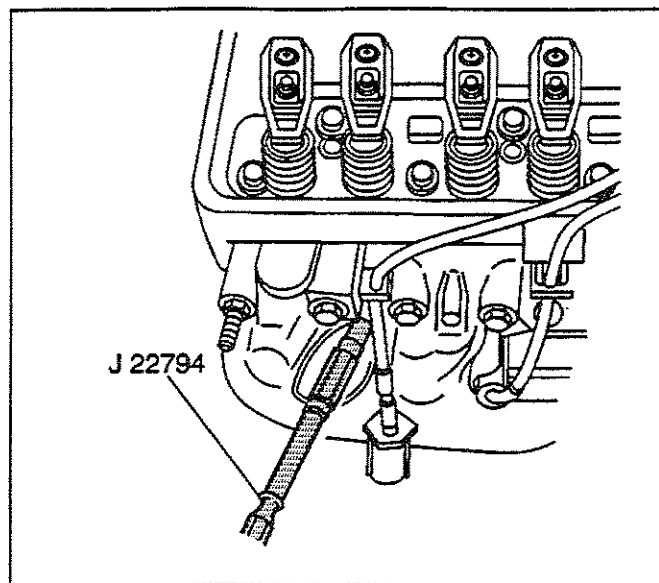
Removal Procedure

1. Remove the valve rocker arm cover. Refer to:
 - *Valve Rocker Arm Cover Replacement (Left).*
 - *Valve Rocker Arm Cover Replacement (Right).*
2. Remove the valve rocker arm and the valve pushrod. Refer to *Valve Rocker Arm and Push Rod Removal.*

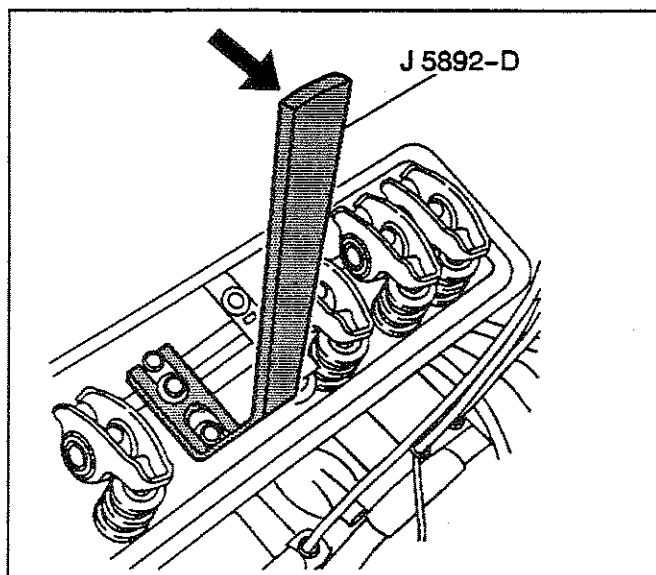
3. Clean and inspect the valve rocker arm and the valve pushrod. Refer to *Valve Rocker Arm and Push Rods Clean and Inspect.*

Installation Procedure

1. Install the valve rocker arm and the valve pushrod. Refer to *Valve Rocker Arm and Push Rod Installation.*
2. Install the valve rocker arm cover. Refer to:
 - *Valve Rocker Arm Cover Replacement (Left).*
 - *Valve Rocker Arm Cover Replacement (Right).*



476770



476767

Valve Stem Oil Seal and Valve Spring Replacement

SIE-ID = 478540

Removal Procedure

Tools Required

- J 22794 Spark Plug Port Adapter
- J 38606 Valve Spring Compressor
- J 5892-D Valve Spring Compressor

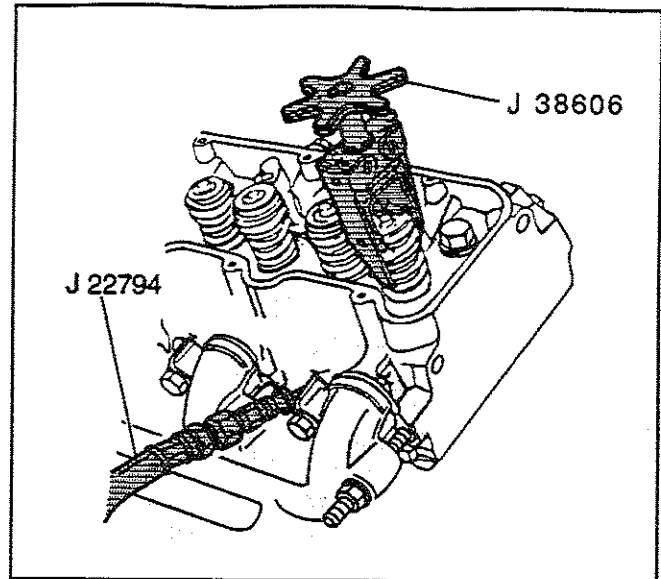
1. Remove the valve rocker arm cover.
 - Refer to *Valve Rocker Arm Cover Replacement (Left)*.
 - Refer to *Valve Rocker Arm Cover Replacement (Right)*.
2. Remove the required valve rocker arms. Refer to *Valve Rocker Arm and Push Rod Removal*.
3. Remove the required spark plugs. Refer to *Spark Plug Replacement* in Engine Electrical.
4. Install the J 22794 into the spark plug hole.
5. Connect a shop air supply hose and apply compressed air in order to hold the valves in place.
6. Remove a bolt from a valve rocker arm.
7. Install a flat washer on the bolt.
8. Install the bolt in the valve rocker arm bolt hole for the valve spring requiring removal.

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 5892-D in order to compress the valve spring.
 - 9.1. Hook the slotted end of J 5892-D under the washer on the valve rocker arm bolt.
 - 9.2. Apply steady pressure on the valve spring cap until the valve keys are accessible.

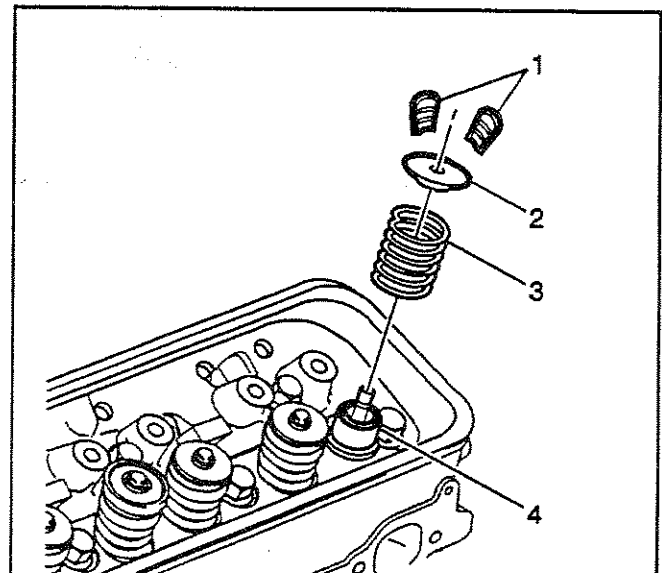
Notice: SIO-ID = 524974 Completely engage the J 38606 jaws on the valve spring. The J 38606 may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratch.

10. Use J 38606 when J 5892-D will not fit.



218211

11. Remove the valve keys (1).
12. Carefully release the valve spring tension.
13. Remove the J 5892-D or the J 38606.
14. Remove the valve spring cap (2) and valve spring (3).
15. Remove the valve stem oil seal (4).



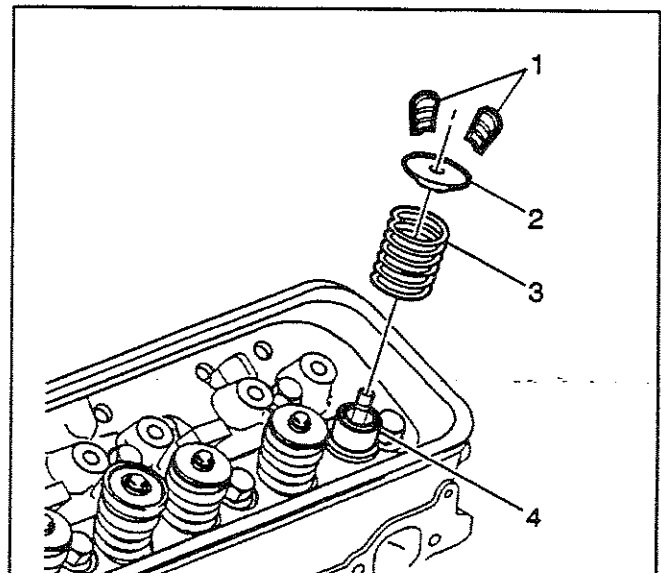
480555

Installation Procedure

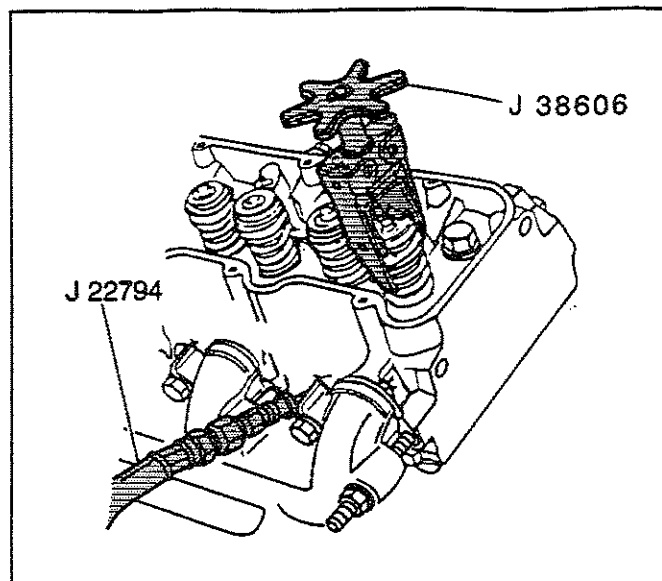
1. Install the valve seals (4). Refer to *Cylinder Head Assemble*.
2. Install the valve spring (3).
3. Install the valve spring cap (2) on the valve stem.

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.**

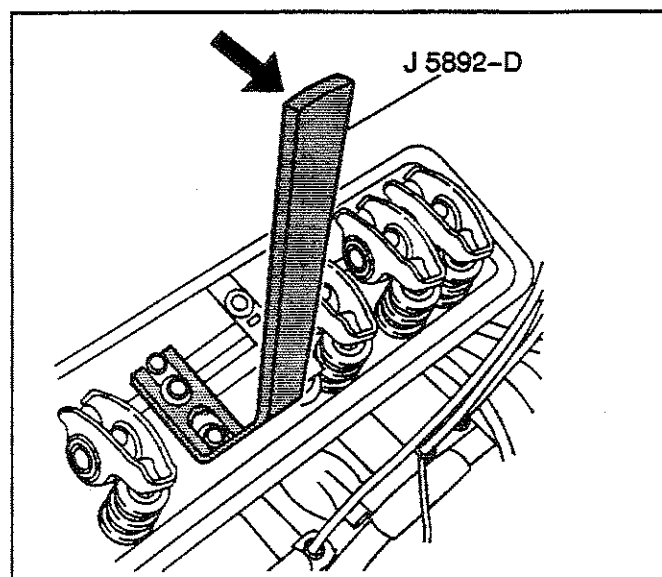
4. To compress the valve spring (3) use the J 5892-D.



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Notice: SIO-ID = 524974 Completely engage the J 38606 jaws on the valve spring. The J 38606 may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratch.

5. Use the J 38606 if the clearance does not permit use of the J 5892-D.
6. Install the valve stem keys.
Use grease in order to hold the valve stem keys in place.

7. Carefully release the valve spring pressure, making sure the valve stem keys stay in place.

Notice: SIO-ID = 524975 The valve stem keys must correctly seat in the valve spring cap. Engine damage may occur by not installing properly.

8. Remove the J 5892-D or the J 38606.
 - 8.1. Look to ensure that the valve stem keys seat properly in the upper groove of the valve stem.
 - 8.2. Tap the end of the valve stem with a plastic faced hammer in order to seat the valve stem keys, if necessary.
9. Remove the J 22794.
10. Install the spark plugs. Refer to *Spark Plug Replacement* in Engine Electrical.
11. Install the valve rocker arms to the cylinder head. Refer to *Valve Rocker Arm and Push Rod Installation*.
12. Install the valve rocker arm cover.
 - Refer to *Valve Rocker Arm Cover Replacement (Left)*.
 - Refer to *Valve Rocker Arm Cover Replacement (Right)*.

Valve Lifter Replacement

SIE-ID - 478541

Removal Procedure

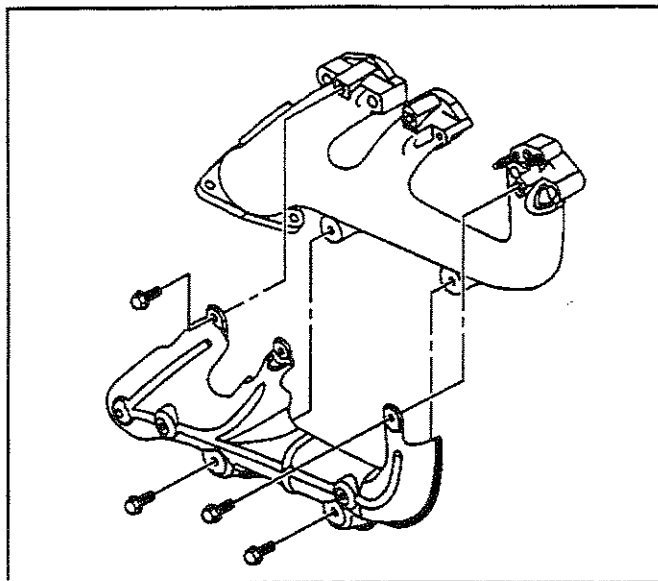
1. Remove the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
2. Remove the valve rocker arms and the valve pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
3. Remove the valve lifters. Refer to *Valve Lifter Removal*.
4. Use a cleaning solvent and a shop towel to clean any varnish from the valve lifter bores.
5. Inspect the valve lifter bores for excessive wear or scoring. Replace the engine block if there is excessive wear or deep scoring.
6. Inspect the camshaft for wear or damage. If the wear is questionable remove the camshaft and inspect. Refer to *Camshaft and Bearings Clean and Inspect*.

7. Clean and inspect the valve lifters and the valve pushrod guide. Refer to *Valve Lifters and Guides Clean and Inspect*.

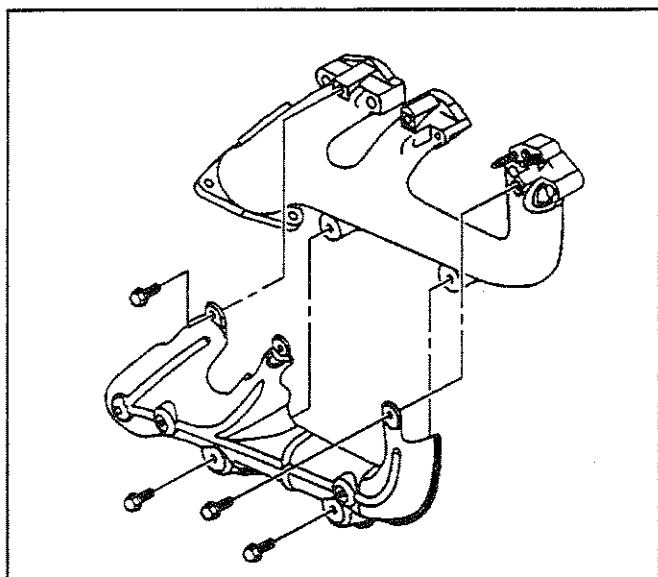
Installation Procedure

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.

1. Install the valve lifters. Refer to *Valve Lifter Installation*.
2. Install the valve rocker arms and pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
3. Install the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.



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Exhaust Manifold Replacement (Right)

SIE-ID - 478545

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 (Light Duty-4.3L, 4.8L, 5.3L)* in Engine Exhaust.
3. Lower the vehicle.
4. Remove the air cleaner outlet duct from the air cleaner assembly and the throttle body. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
5. 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 - 4.3L.
6. Disconnect the spark plug wires from the spark plugs. Refer to *Spark Plug Wire Harness Replacement (4.3 L)* in Engine Electrical.
7. Remove the exhaust manifold. Refer to *Exhaust Manifold Removal (Right)*.
8. Clean all gasket surfaces. Refer to *Exhaust Manifold Clean and Inspect*.
9. Remove the bolts and 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.

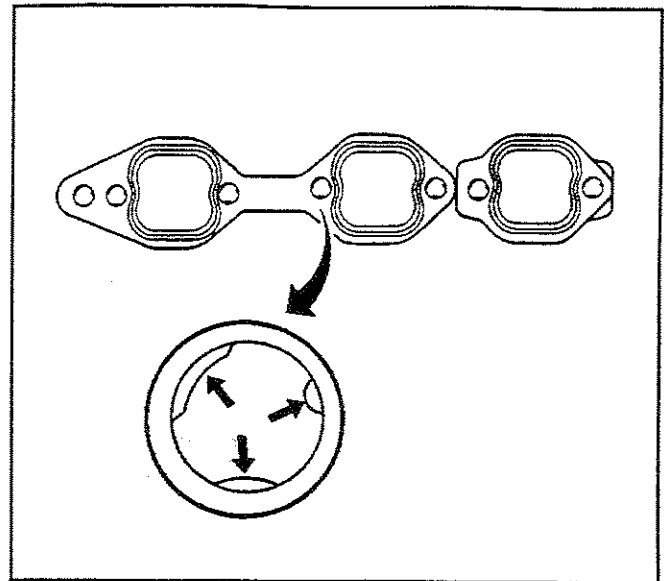
Tighten

Tighten the heat shield bolts to 9 N·m (80 lb in).

Important: To assist in installing the exhaust manifold to the engine, the tabs at the bolt holes on a NEW exhaust manifold gasket will hold the bolts and the gaskets in place.

Sub-assemble the bolts, spark plug wire shields, and NEW gaskets to the exhaust manifold.

3. Ensure that the exhaust manifold bolts are held in place by the tabs on the exhaust manifold gaskets.
4. Install the exhaust manifold. Refer to *Exhaust Manifold Installation (Right)*.
5. Install the AIR pipe assembly, if equipped to the exhaust manifold. Refer to *AIR Check Valve/Pipe Replacement - Bank 2* in Engine Controls - 4.3L.
6. Connect the spark plug wires to the spark plugs. Refer to *Spark Plug Wire Harness Replacement (4.3 L)* in Engine Electrical.
7. Raise the vehicle.
8. Connect the exhaust pipe to the exhaust manifold. Refer to *Catalytic Converter Replacement (Light Duty-4.3L, 4.8L, 5.3L)* in Engine Exhaust.
9. Lower the vehicle.
10. Install the air cleaner outlet duct to the air cleaner assembly and the throttle body. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.



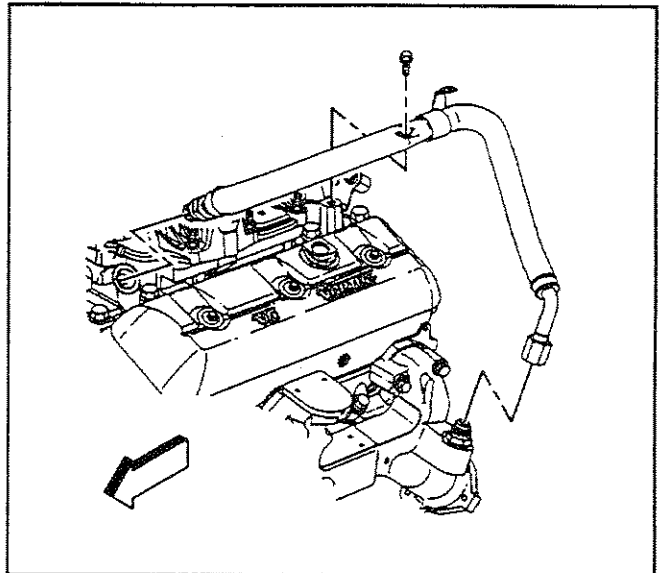
476818

Exhaust Manifold Replacement (Left)

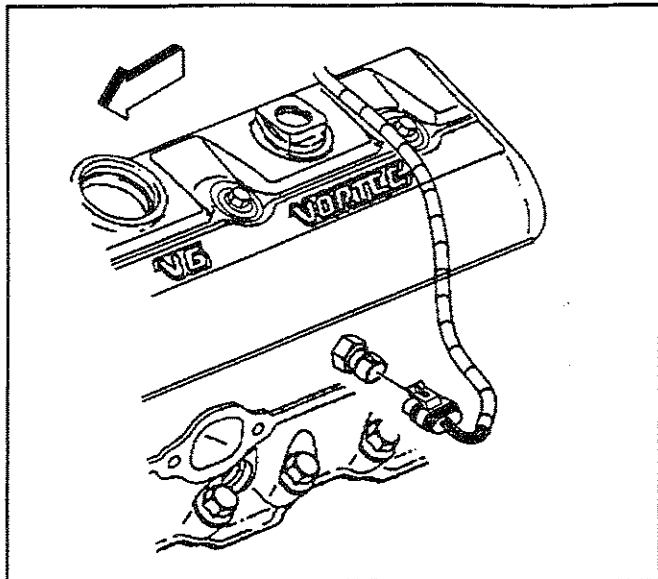
SIE-ID - 478547

Removal Procedure

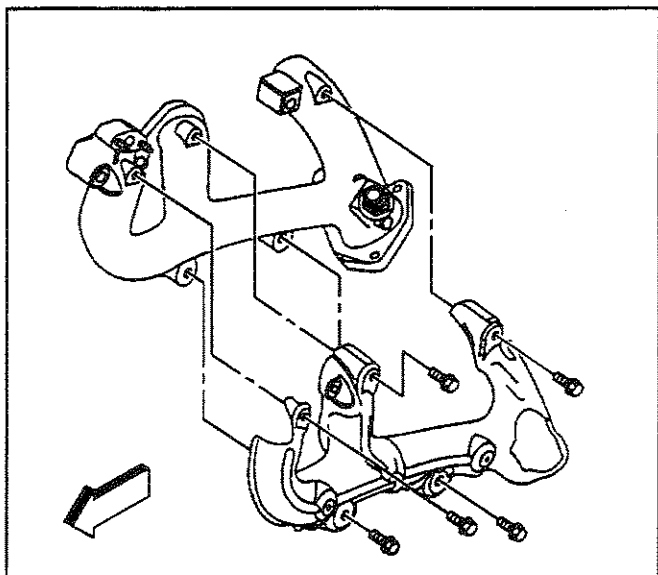
1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle*.
2. Disconnect the exhaust pipe from the exhaust manifold. Refer to *Catalytic Converter Replacement (Light Duty-4.3L, 4.8L, 5.3L)* in Engine Exhaust.
3. Lower the vehicle.
4. Remove the secondary air injection (AIR) pipe assembly, if equipped from the exhaust manifold. Refer to *AIR Check Valve/Pipe Replacement - Bank 1* in Engine Controls - 4.3L.
5. Disconnect the spark plug wires from the spark plugs. Refer to *Spark Plug Wire Harness Replacement (4.3 L)* in Engine Electrical.
6. Disconnect the exhaust gas recirculation (EGR) valve inlet pipe from the exhaust manifold.



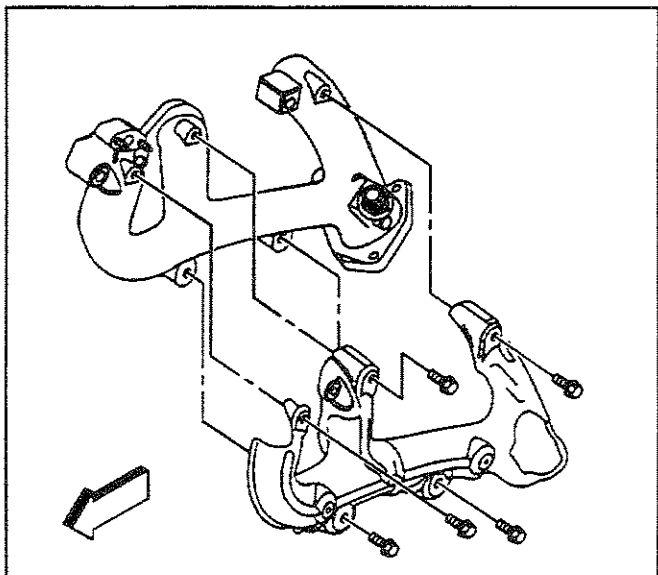
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7. Disconnect the engine coolant temperature (ECT) sensor electrical connector.
8. Remove the exhaust manifold. Refer to *Exhaust Manifold Removal (Left)*.
9. Clean all gasket surfaces. Refer to *Exhaust Manifold Clean and Inspect*.

10. Remove the bolts and 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.

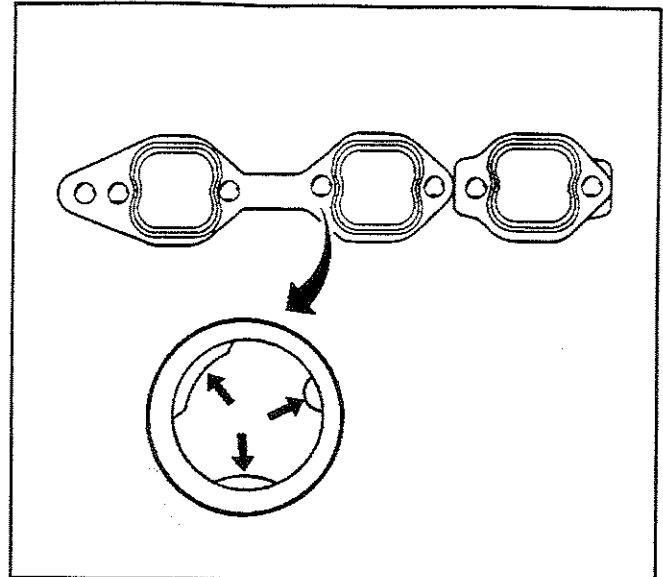
Tighten

Tighten the heat shield bolts to 9 N·m (80 lb in).

Important: To assist in installing the exhaust manifold to the engine, the tabs on a NEW exhaust manifold gasket will hold the gasket and bolts in place.

Sub-assemble the bolts, spark plug wire shields, and NEW gaskets to the exhaust manifold.

3. Ensure that the exhaust manifold bolts are held in place by the tabs on the exhaust manifold gaskets.
4. Install the exhaust manifold. Refer to *Exhaust Manifold Installation (Left)*.

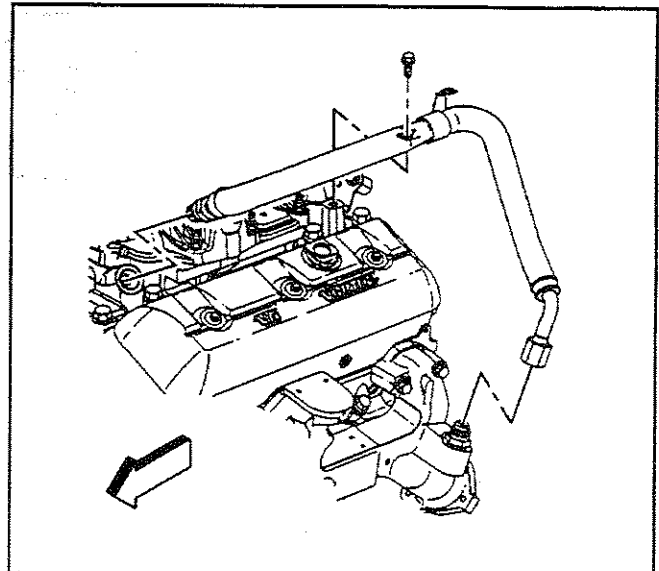


476818

5. Connect the EGR valve inlet pipe to the exhaust manifold.

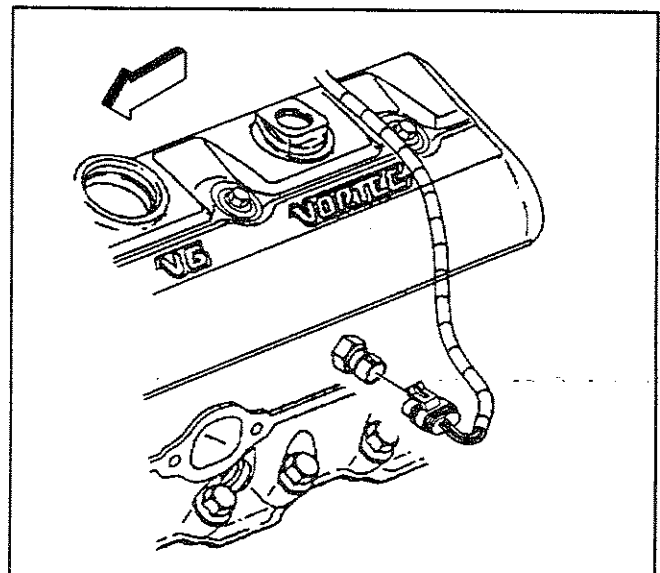
Tighten

Tighten the EGR valve inlet pipe nut to 30 N·m (22 lb ft).

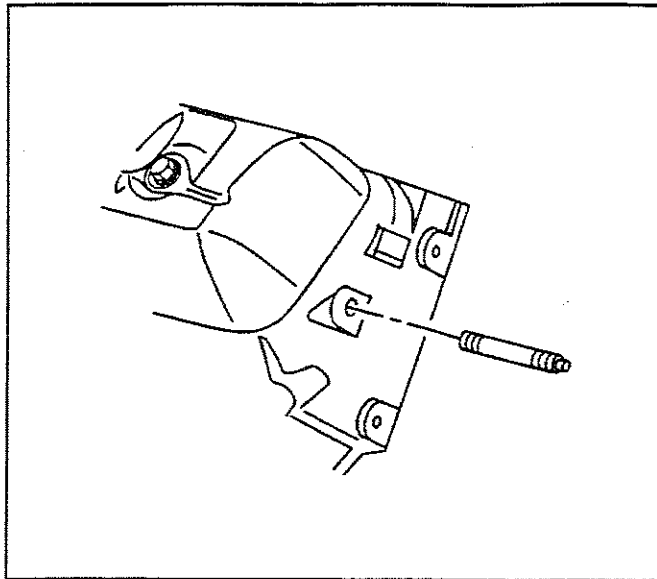


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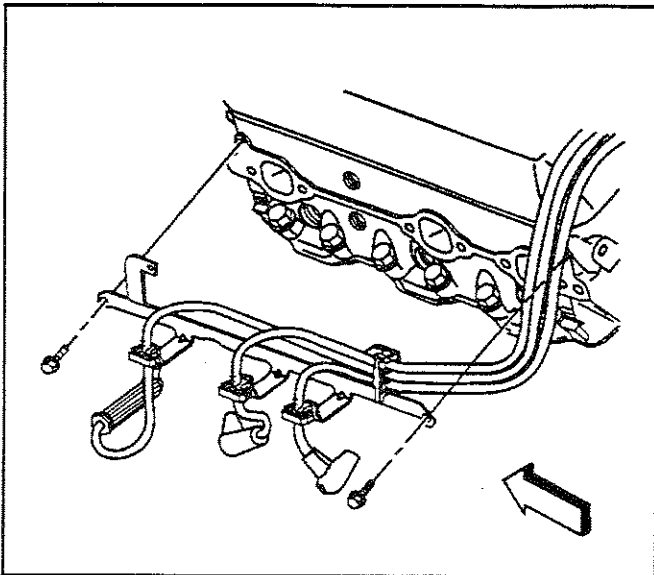
6. Connect the ECT sensor electrical connector.
7. Connect the spark plug wires to the spark plugs. Refer to *Spark Plug Wire Harness Replacement (4.3 L)* in Engine Electrical.
8. Install the AIR pipe assembly to the exhaust manifold. Refer to *AIR Check Valve/Pipe Replacement - Bank 1* in Engine Controls - 4.3L.
9. Raise the vehicle.
10. Connect the exhaust pipe to the exhaust manifold. Refer to *Catalytic Converter Replacement (Light Duty-4.3L, 4.8L, 5.3L)* in Engine Exhaust.
11. Lower the vehicle.



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Cylinder Head Replacement (Right)

SIE-ID = 478559

Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* 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)*.
5. Remove the generator mounting bracket stud from the cylinder head.
6. Remove the lower 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 and the gasket. Refer to *Cylinder Head Removal (Right)*.
11. Clean the engine block and the cylinder head sealing surfaces.

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.

12. Clean the cylinder head bolts and the engine block bolt holes.
13. For further service to the cylinder head refer to the following:
 - Refer to *Cylinder Head Disassemble*.
 - Refer to *Cylinder Head Clean and Inspect*.
 - Refer to *Valve Guide Reaming/Valve and Seat Grinding*.
 - Refer to *Cylinder Head Assemble*.

Installation Procedure

1. Install the cylinder head. Refer to *Cylinder Head Installation (Right)*.
2. Install the valve pushrods. Refer to *Valve Rocker Arm and Push Rod Replacement*.
3. Install the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.

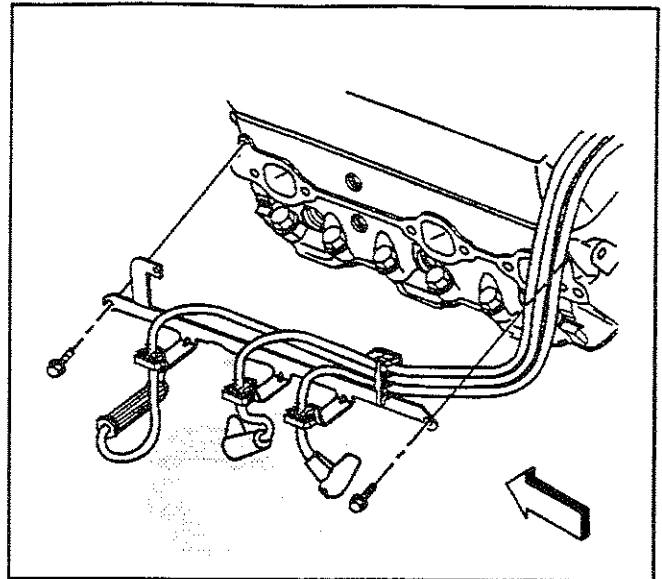
Notice: Refer to *Fastener Notice* in Cautions and Notices.

4. Install the spark plug wire harness and the spark plug wire support.

Tighten

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

5. Install the exhaust manifold. Refer to *Exhaust Manifold Replacement (Right)*.



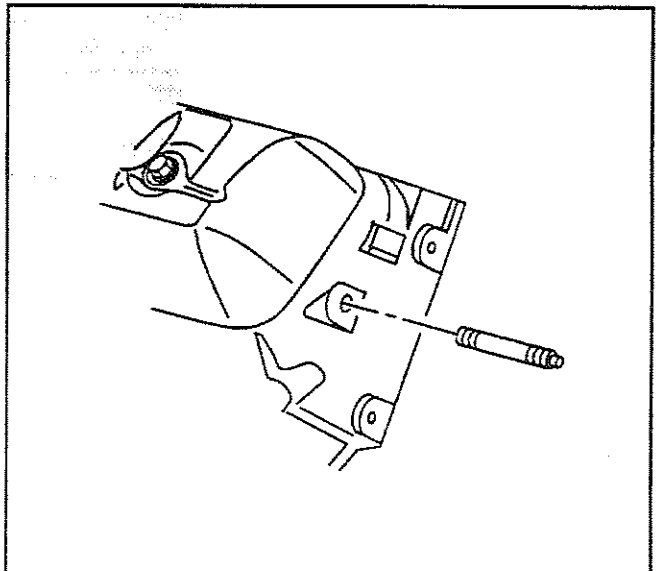
317450

6. Install the stud for the generator mounting bracket.

Tighten

Tighten the generator mounting bracket stud to 20 N·m (15 lb ft).

7. Install the generator mounting bracket. Refer to *Accessory Mounting Brackets Replacement (Generator)*.
8. Install the engine cooling fan assembly. Refer to *Fan Clutch Replacement* in Engine Cooling.
9. Fill the engine coolant system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
10. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.



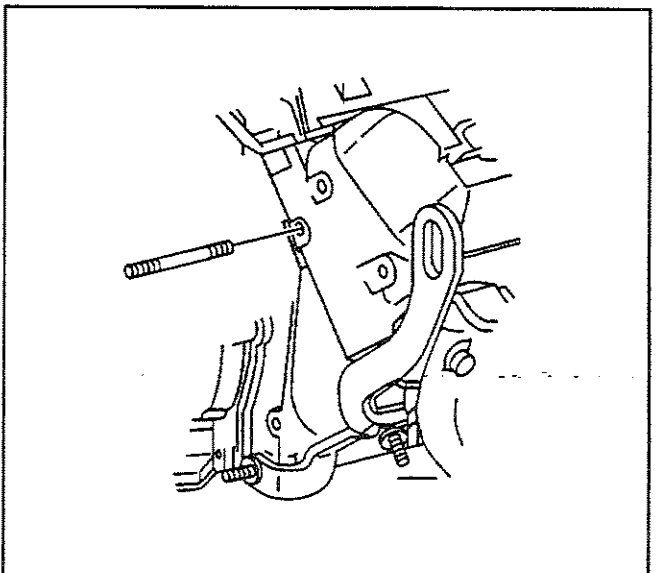
475837

Cylinder Head Replacement (Left)

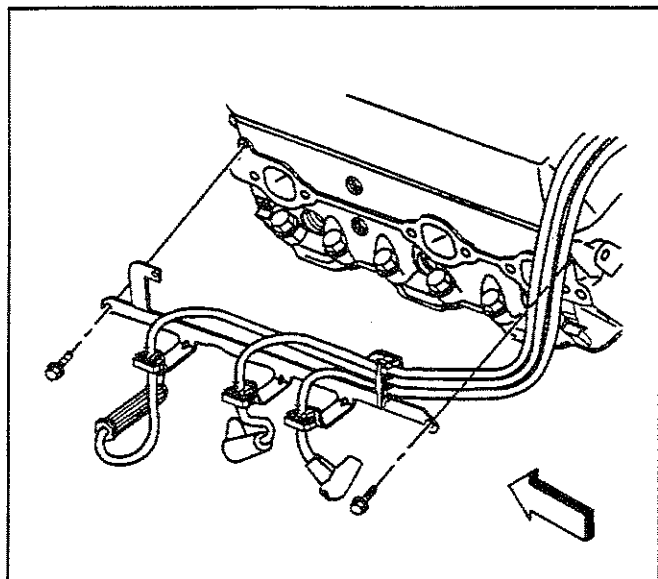
SIE-ID - 478562

Removal Procedure

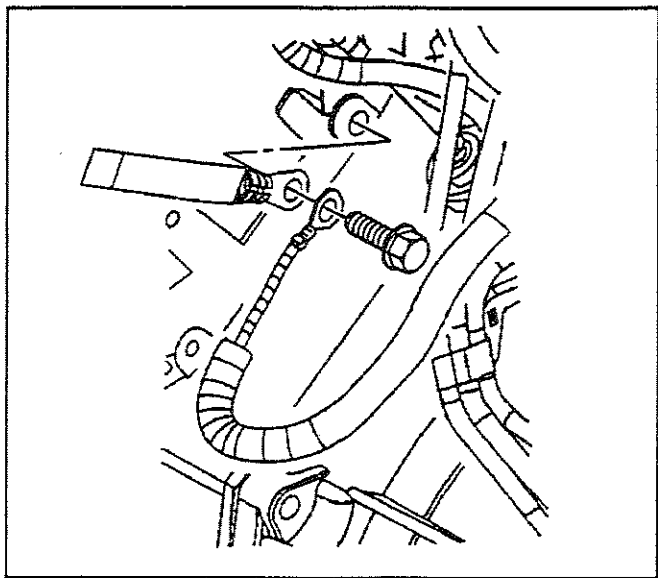
1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.
2. Drain the engine coolant. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Remove the engine cooling fan assembly. Refer to *Fan Clutch Replacement* in Engine Cooling.
4. Remove the power steering pump mounting bracket. Refer to *Accessory Mounting Brackets Replacement (P/S Pump)*.
5. Remove the power steering pump mounting bracket stud from the cylinder head.
6. Remove the lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.



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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*.

10. Remove the ground strap and ground wire bolt from the rear of the cylinder head.
11. Remove the cylinder head and the gasket. Refer to *Cylinder Head Removal (Left)*.
12. Clean the engine block and the cylinder head sealing surfaces.

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.

13. Clean the cylinder head bolts and the engine block bolt holes.
14. For further service to the cylinder head refer to the following:
 - Refer to *Cylinder Head Disassemble*.
 - Refer to *Cylinder Head Clean and Inspect*.
 - Refer to *Valve Guide Reaming/Valve and Seat Grinding*.
 - Refer to *Cylinder Head Assemble*.

Installation Procedure

1. Install the cylinder head. Refer to *Cylinder Head Installation (Left)*.

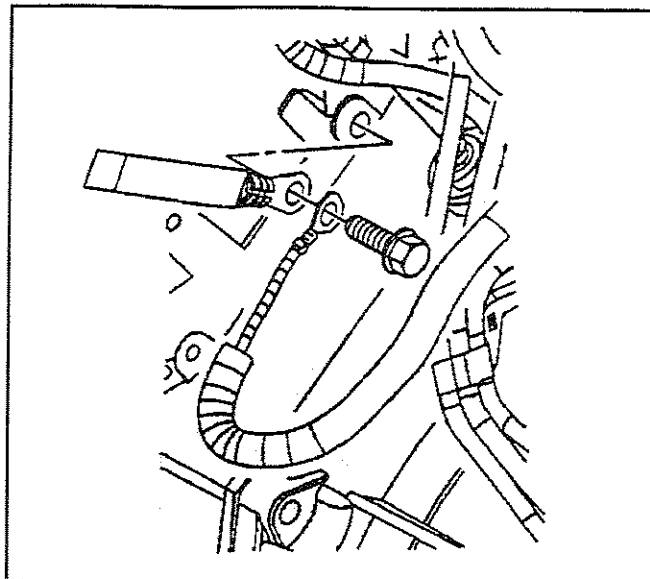
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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 lower intake manifold. Refer to *Intake Manifold Replacement (Lower)*.
5. Install the exhaust manifold. Refer to *Exhaust Manifold Replacement (Left)*.

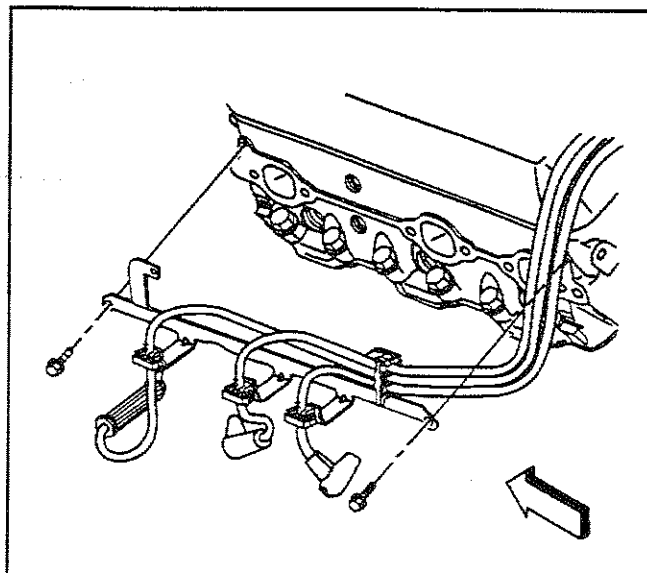


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6. Install the spark plug wire harness and spark plug wire support.

Tighten

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



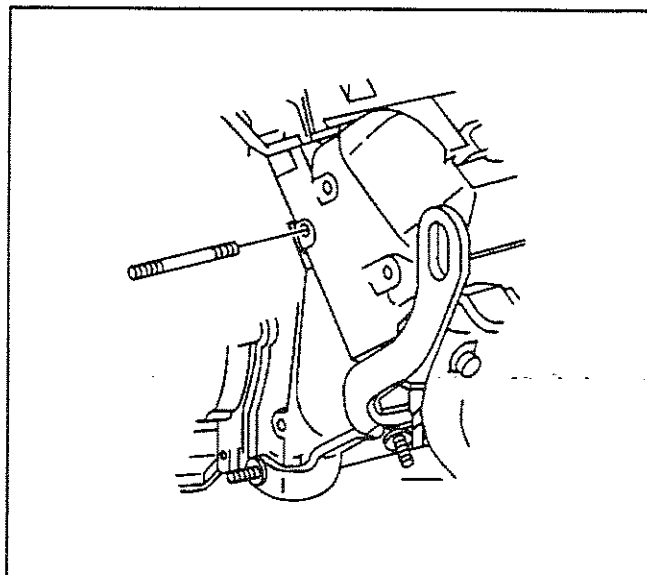
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7. Install the stud for the power steering pump mounting bracket to the cylinder head.

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)*.
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 Negative Cable Disconnect/Connect Procedure* in Engine Electrical.



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Crankshaft Balancer Replacement

SIE-ID = 478567

Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* 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*.

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.

4. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Removal*.
5. Clean and inspect all parts. Refer to *Crankshaft Balancer Clean and Inspect*.

Installation Procedure

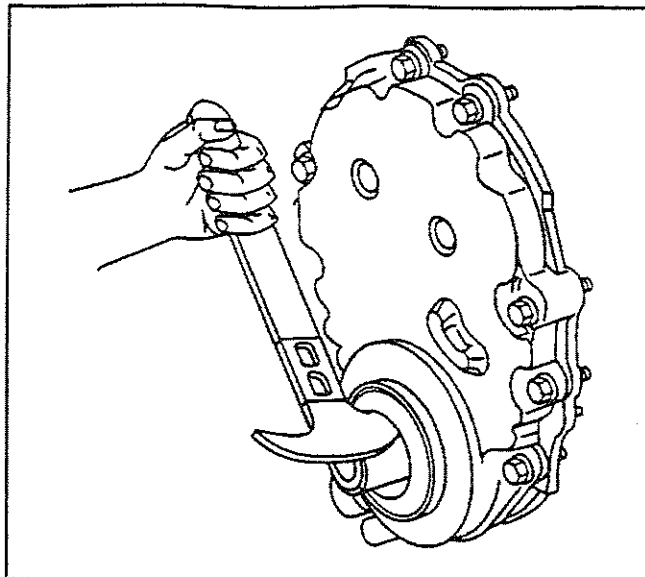
1. Apply a small amount of grease to the crankshaft front cover oil seal sealing surface if reusing the seal.
2. Install the crankshaft balancer. Refer to *Crankshaft Balancer Installation*.
3. Install the drive belt. Refer to *Drive Belt Replacement*.
4. Install the fan shroud assembly. Refer to *Fan Shroud Replacement* in Engine Cooling.
5. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.

Crankshaft Front Cover Oil Seal Replacement

SIE-ID - 478569

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*.



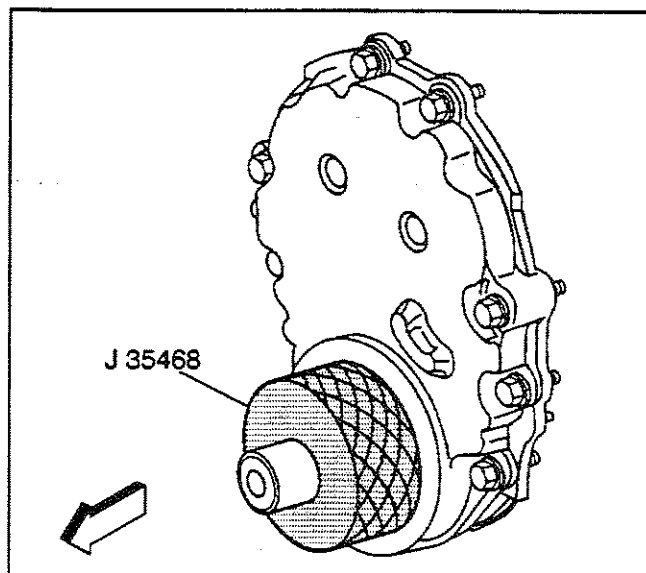
357563

Installation Procedure

Tools Required

J 35468 Cover Aligner/Seal Installer

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*.



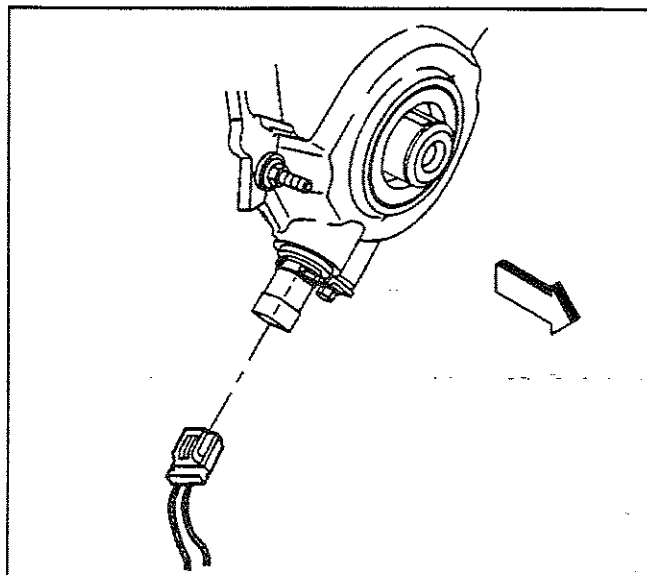
357566

Engine Front Cover Replacement

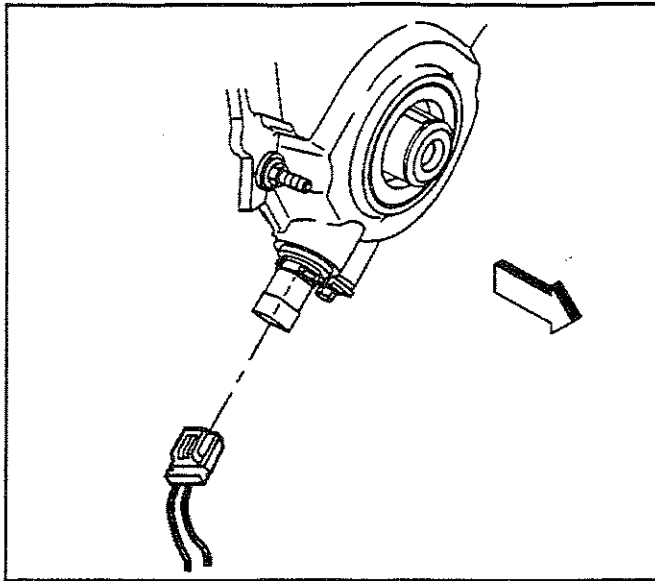
SIE-ID - 478571

Removal Procedure

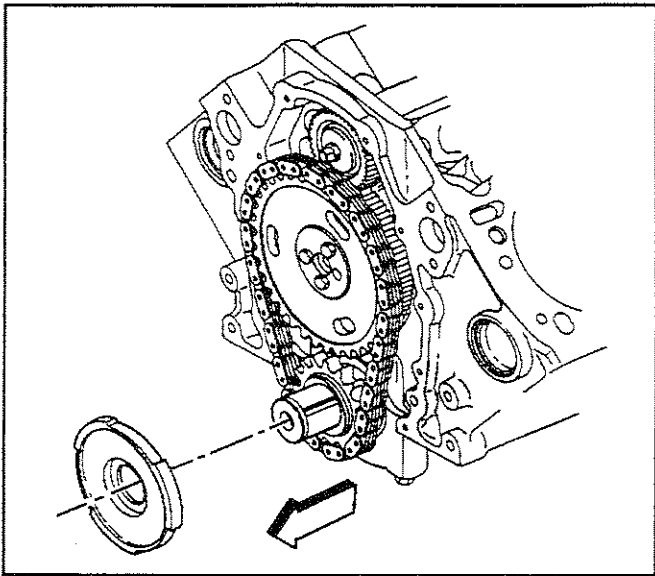
1. Remove the engine oil pan. Refer to *Oil Pan Replacement*.
2. Disconnect the crankshaft position (CKP) sensor electrical connector.
3. Remove the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.
4. Remove the water pump. Refer to *Water Pump Replacement (4.3L Engine)* in Engine Cooling.
5. Remove the CKP sensor. Refer to *Crankshaft Position Sensor (CKP) Replacement* in Engine Controls - 4.3L.
6. Remove the engine front cover. Refer to *Engine Front Cover Removal*.
7. Discard the engine front cover.



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8. Clean all sealing surfaces.

Installation Procedure

Notice: SIO-ID = 529908 Do not reuse the engine front cover. Oil leaks may result.

1. Install the NEW engine front cover. Refer to *Engine Front Cover Installation*.

Important: Do not reuse the original seal (O-ring) when installing the crankshaft position (CKP) sensor to the engine front cover. Erratic engine operation may result.

Install the CKP sensor with a NEW seal (O-ring). Refer to *Crankshaft Position Sensor (CKP) Replacement* in Engine Controls - 4.3L.

2. Install the engine oil pan. Refer to *Oil Pan Replacement*.
3. Connect the CKP sensor electrical connector.
4. Install the water pump. Refer to *Water Pump Replacement (4.3L Engine)* in Engine Cooling.
5. Install the crankshaft balancer. Refer to *Crankshaft Balancer Replacement*.

Crankshaft Position (CKP) Reluctor Ring Replacement

SIE-ID = 478573

Removal Procedure

1. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.
2. Remove the crankshaft position sensor reluctor ring.

Installation Procedure

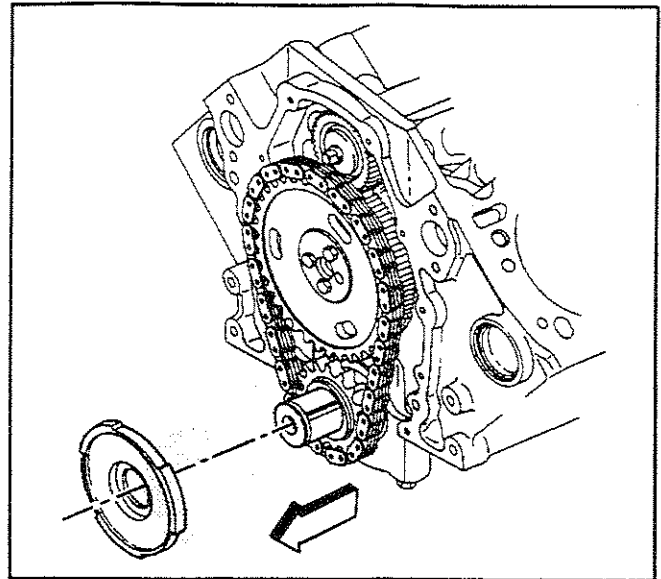
Notice: SIO-ID = 23526 Failure to properly align the crankshaft position sensor reluctor ring may result in component damage and effect OBD II system performance.

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.

Install the crankshaft position sensor reluctor ring.

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



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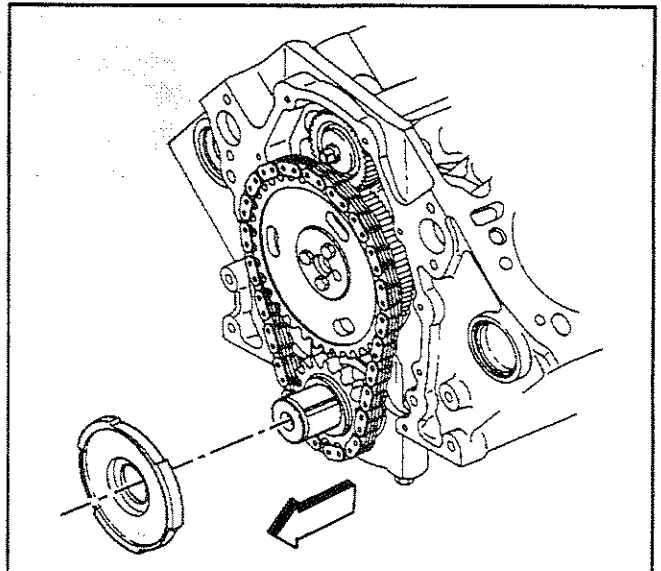
Timing Chain and Sprockets Replacement

SIE-ID = 478575

Removal Procedure

Notice: SIO-ID = 529908 Do not reuse the engine front cover. Oil leaks may result.

1. Remove the engine front cover. Refer to *Engine Front Cover Replacement*.
2. Remove the crankshaft position sensor reluctor ring.



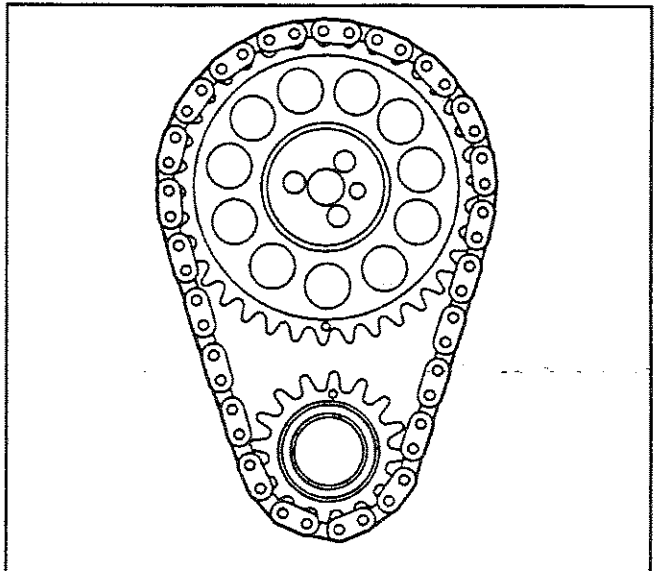
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Notice: SIO-ID = 529904 In order to rotate the engine install a bolt with the same threads as the crankshaft, but do not use the crankshaft balancer bolt or a bolt longer than 1 inch, in the crankshaft. Failing to do so will cause damage to the bolt threads and the crankshaft threaded hole when removing the bolt.

3. Install a 7/16-20 x 1 inch bolt into the end of the crankshaft.

Notice: SIO-ID = 529913 Align the timing marks before removing the timing chain. If it is necessary to turn either the camshaft or the crankshaft with the timing chain removed, loosen or remove the valve rocker arms. Turning either the crankshaft or camshaft with the timing chain removed may cause the pistons to contact the valves, resulting in damage.

4. Rotate the crankshaft until:
 - 4.1. The timing marks on both sprockets line up.



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- 4.2. The number four cylinder is at top dead center (TDC) of the compression stroke.
5. Remove the timing chain and sprockets. Refer to *Timing Chain and Sprockets Removal*.
6. Clean and inspect the timing chains and sprockets. Refer to *Timing Chain and Sprockets Clean and Inspect*.

Installation Procedure

1. Install the timing chain and sprockets. Refer to *Timing Chain and Sprockets Installation*.
2. Remove the bolt that was installed in the end of the crankshaft.
3. Install the engine front cover. Refer to *Engine Front Cover Replacement*.

Balance Shaft Replacement

SIE-ID = 478577

Removal Procedure

1. Remove the radiator. Refer to *Radiator Replacement* in Engine Cooling.
2. Remove the A/C condenser. Refer to *Condenser Replacement* in Heating Ventilation and Air Conditioning.
3. Remove the valve lifter pushrod guide. Refer to *Valve Lifter Replacement*.
4. Remove the timing chain and camshaft sprockets. Refer to *Timing Chain and Sprockets Replacement*.
5. Remove the balance shaft. Refer to *Balance Shaft Removal*.
6. Clean and inspect the balance shaft. 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 Installation*.
3. Install the crankshaft position reluctor ring and the front cover. Refer to *Crankshaft Position (CKP) Reluctor Ring Replacement*

4. Install the valve lifter pushrod guide. Refer to *Valve Lifter Replacement*.
5. Install the A/C condenser. Refer to *Condenser Replacement* in Heating Ventilation and Air Conditioning.
6. Install the radiator. Refer to *Radiator Replacement* in Engine Cooling.

Balance Shaft Bearing and/or Bushing Replacement

SIE-ID = 478590

Removal Procedure

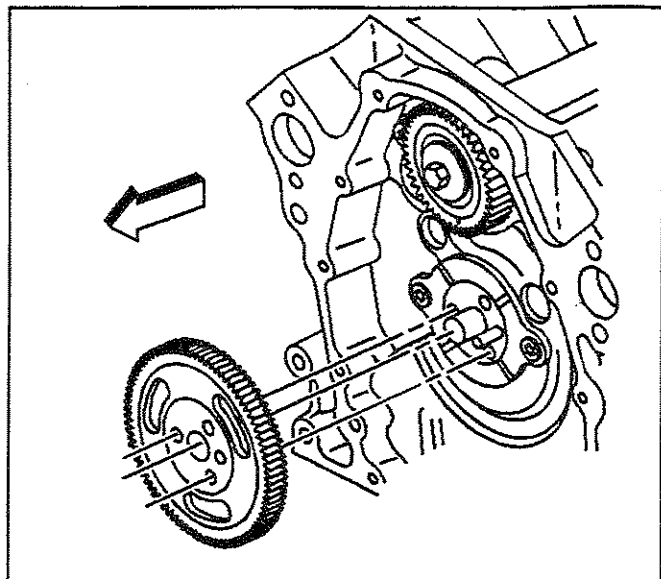
Important: The balance shaft and the front bearing are serviced only as a package. Do not remove the bearing from the balance shaft.

Remove the balance shaft. Refer to *Balance Shaft Replacement*.

1. Remove the balance shaft rear bearing. Refer to *Balance Shaft Bearing and/or Bushing Removal*.

Installation Procedure

1. Install the balance shaft rear bearing. Refer to *Balance Shaft Bearing and/or Bushing Installation*.
2. Install the balance shaft. Refer to *Balance Shaft Replacement*.



9847

Camshaft Replacement

SIE-ID - 478593

Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.
2. Drain the cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Remove the radiator. Refer to *Radiator Replacement* in Engine Cooling.
4. Remove the A/C condenser. Refer to *Condenser Replacement* in Heating Ventilation and Air Conditioning.
5. Remove the valve lifters. Refer to *Valve Lifter Replacement*.
6. Remove the timing chain and the camshaft sprocket. Refer to *Timing Chain and Sprockets Replacement*.
7. Remove the balance shaft drive gear.
8. Remove the camshaft. Refer to *Camshaft Removal*.
9. Clean and inspect the camshaft and the bearings. Refer to *Camshaft and Bearings Clean and Inspect*.

Installation Procedure

Important: Whenever a new camshaft is installed, do the following procedures:

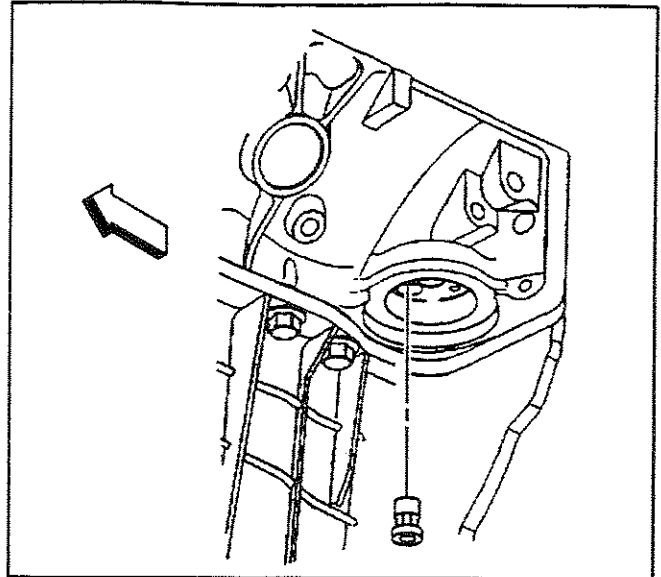
- Change the engine oil.
 - Change the engine oil filter.
 - Add GM Engine Oil Supplement GM P/N 1052367 or the equivalent to the engine oil.
- Install the camshaft into the engine block. Refer to *Camshaft Installation*.
1. Install the balance shaft drive gear. Refer to *Balance Shaft Installation* for alignment of the balance shaft drive gear and the driven gear.
 2. Install the timing chain and camshaft sprocket. Refer to *Timing Chain and Sprockets Replacement*.
 3. Install the valve lifters. Refer to *Valve Lifter Replacement*.
 4. Install the A/C condenser. Refer to *Condenser Replacement* in Heating Ventilation and Air Conditioning.
 5. Install the radiator. Refer to *Radiator Hose Replacement - Inlet (4.3L Engine)* in Engine Cooling.
 6. Fill the engine cooling system. Refer to *Draining and Filling Cooling System* in Engine Cooling.
 7. Recharge the air conditioning system. Refer to *Refrigerant Recovery and Recharging* in Heating Ventilation and Air Conditioning.
 8. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.

Oil Filter Bypass Valve Replacement

SIE-ID = 510974

Removal Procedure

1. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
2. Position a suitable container to catch the engine oil.
3. Remove the oil filter.
4. Using a suitable prying tool remove the oil filter bypass valve.
5. Clean and inspect the valve bore for damage.

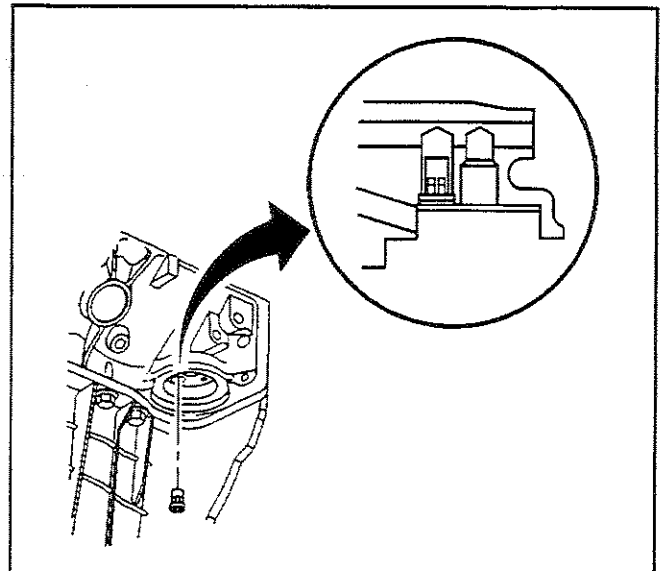


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Installation Procedure

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

1. Install a NEW oil filter bypass valve using the following procedure:
 - 1.1. Use a brass drift that is the same diameter as the outside diameter of the oil filter bypass valve.
 - 1.2. Install the oil filter bypass valve into the oil gallery bore until slightly below flush with the surface of the engine block.
 - 1.3. Using a pointed punch, stake the engine block area around the oil filter bypass valve. Stake in 3 locations 120 degrees apart.
2. Install the oil filter. Refer to *Engine Oil and Oil Filter Replacement*.
3. Lower the vehicle.



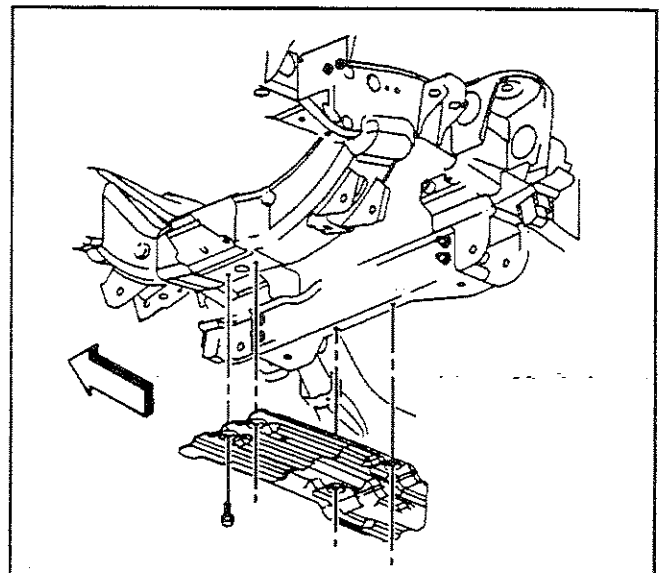
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Oil Pan Replacement

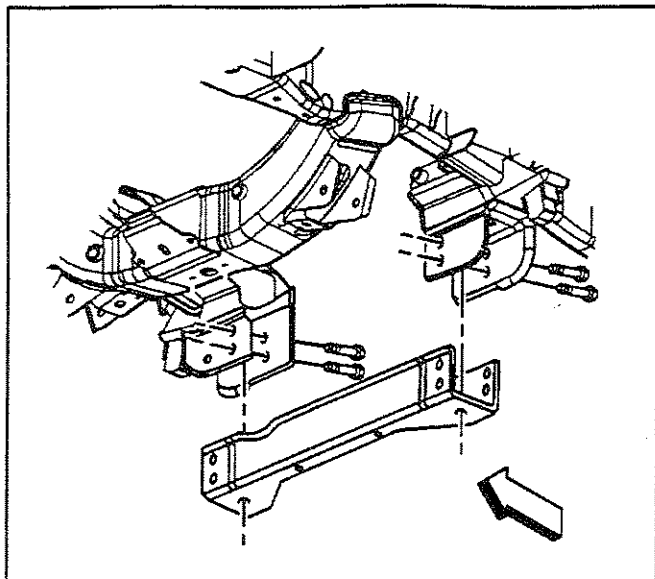
SIE-ID = 478599

Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.
2. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
3. Remove the oil pan skid plate (RWD shown).
4. Remove the oil pan drain plug and drain the engine oil into a suitable container.
5. Remove the oil filter.

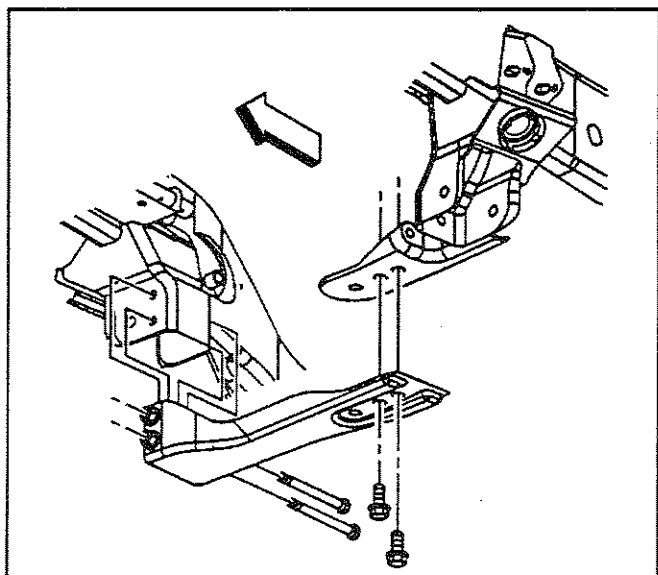


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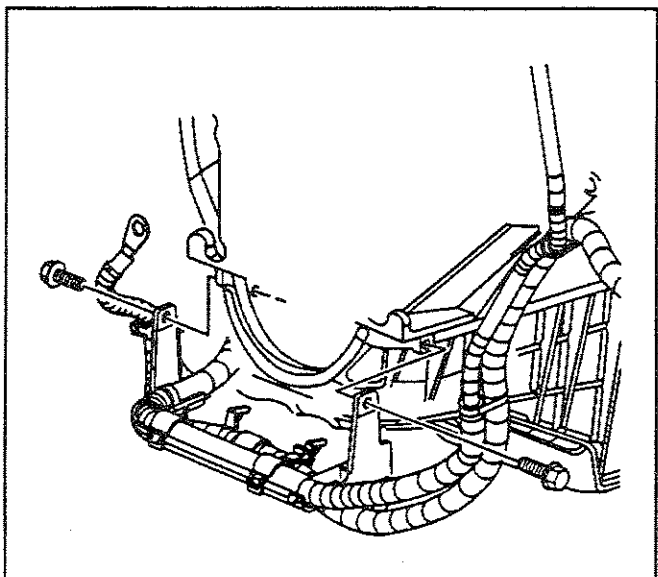
6. Remove the crossbar RWD vehicle.



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7. Remove the crossbar 4WD vehicle.

8. Remove the front differential carrier assembly, if equipped. Refer to *Differential Carrier Assembly Replacement* in Front Axle.

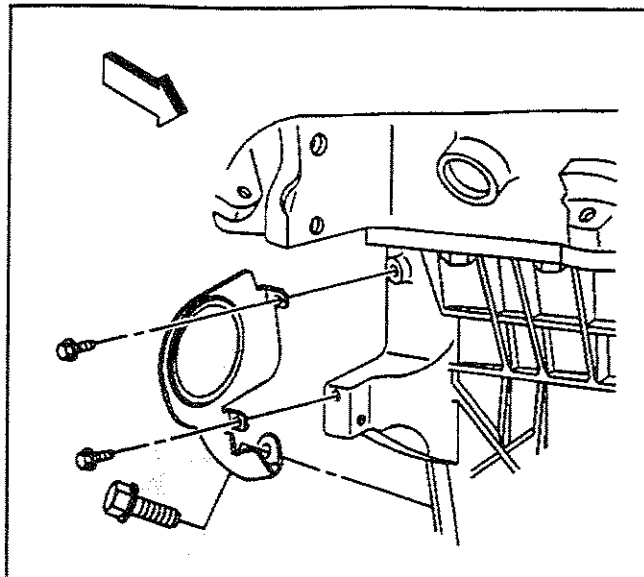


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9. Remove the bolts holding the battery cable brackets to the oil pan.

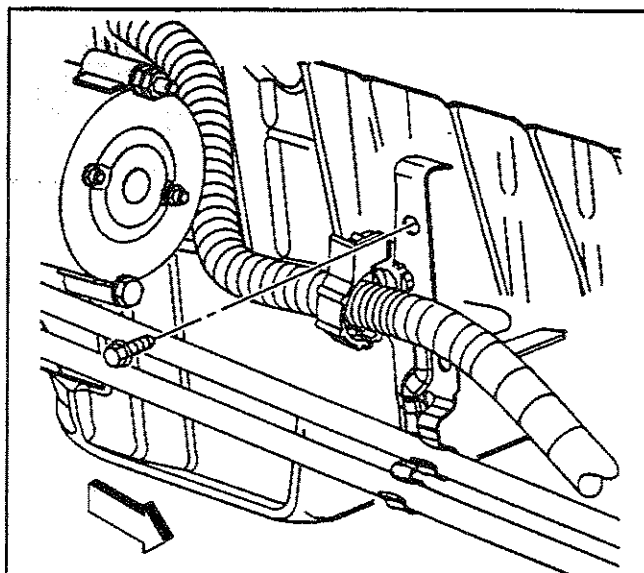
10. Remove the starter and move aside. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.

11. Remove the transmission cover.



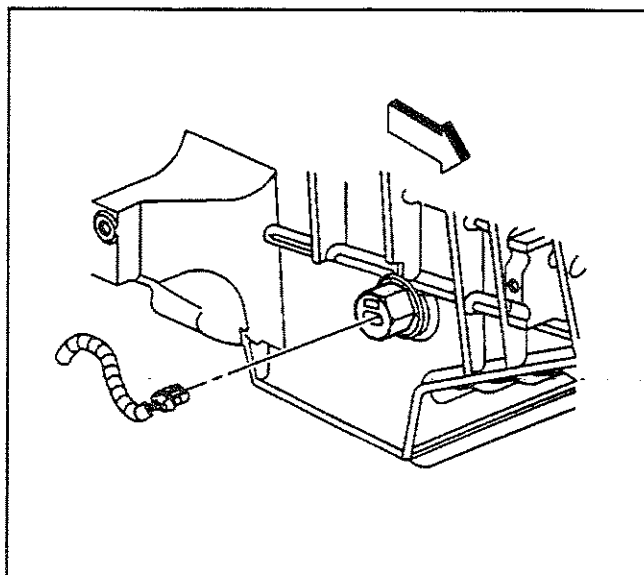
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12. Remove the bracket for the starter positive cable and the transmission cooler lines from the side of the oil pan.

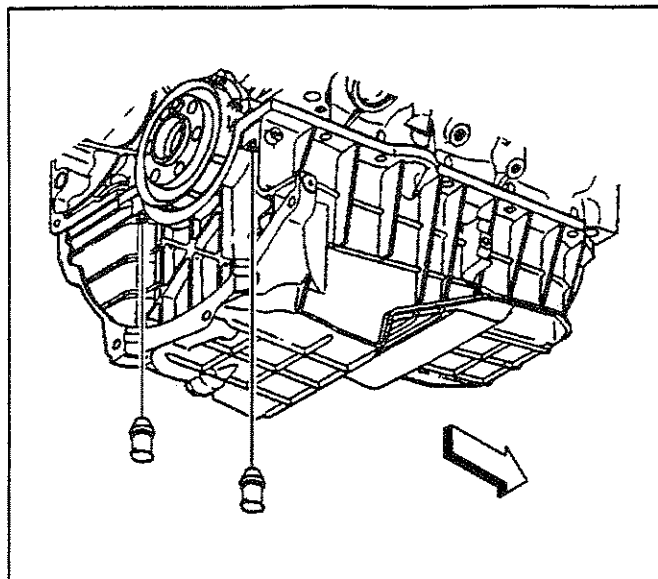


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13. Disconnect the low oil level sensor electrical connector.

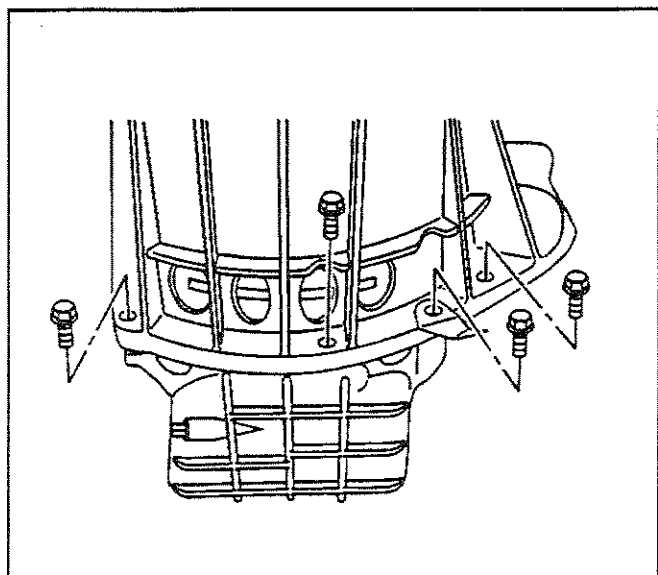


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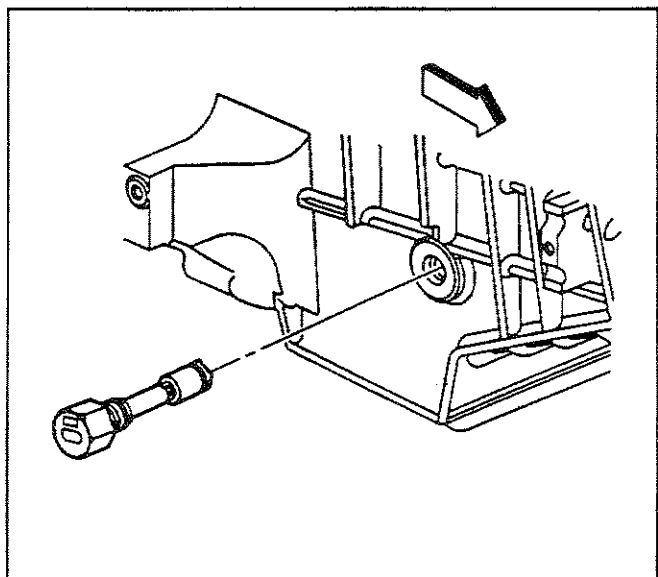
14. Remove the access plugs for the oil pan rear nuts.



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15. Remove the transmission to oil pan bolts (manual transmission shown).

16. Remove the oil pan and the gasket. Refer to *Oil Pan Removal*.



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Important: The low oil level sensor is not reusable. Use a NEW low oil sensor.

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*.

Installation Procedure

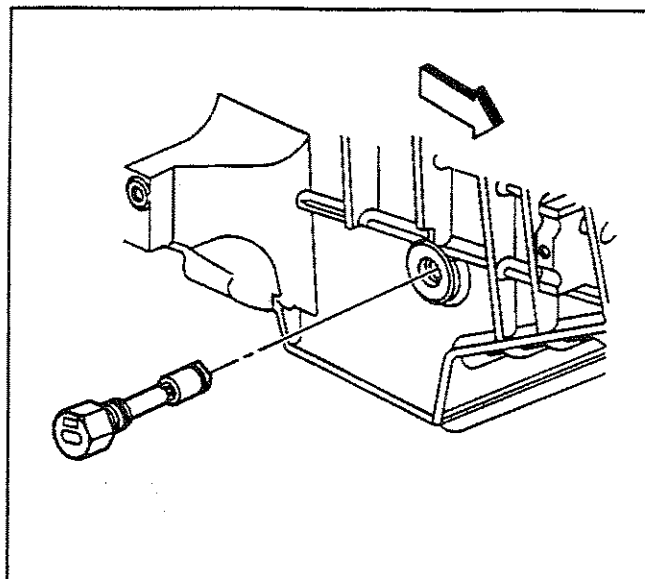
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: The low oil level sensor is not reusable. Use a NEW low oil level sensor.

Install a NEW low oil level sensor, if removed.

Tighten

Tighten the sensor to 13 N·m (115 lb in).



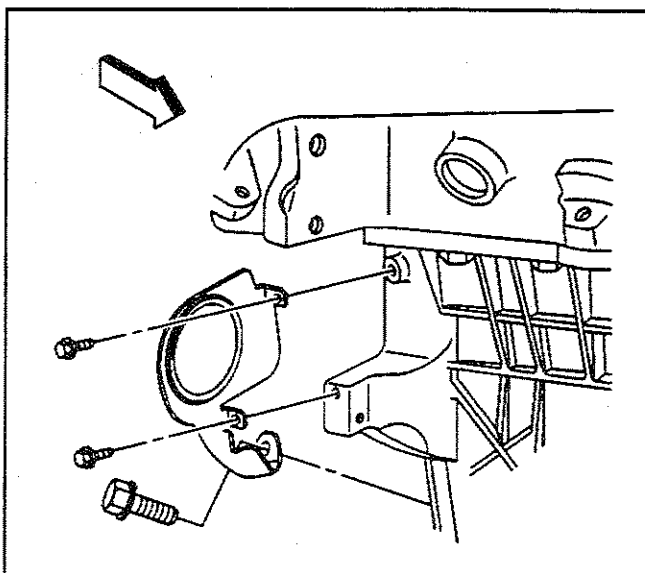
387460

Notice: SIO-ID = 529917 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 oil pan alignment. Failure to achieve the correct oil pan alignment can result in transmission failure.

1. Install the oil pan. Refer to *Oil Pan Installation*.
2. Install the transmission cover.

Tighten

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

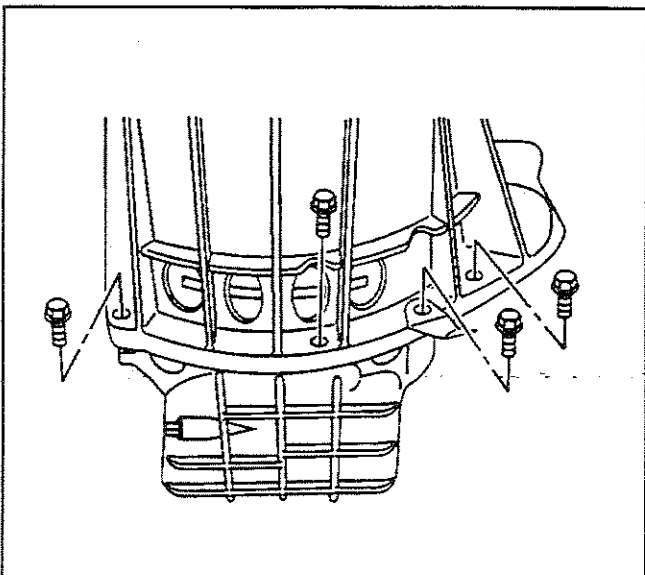


391868

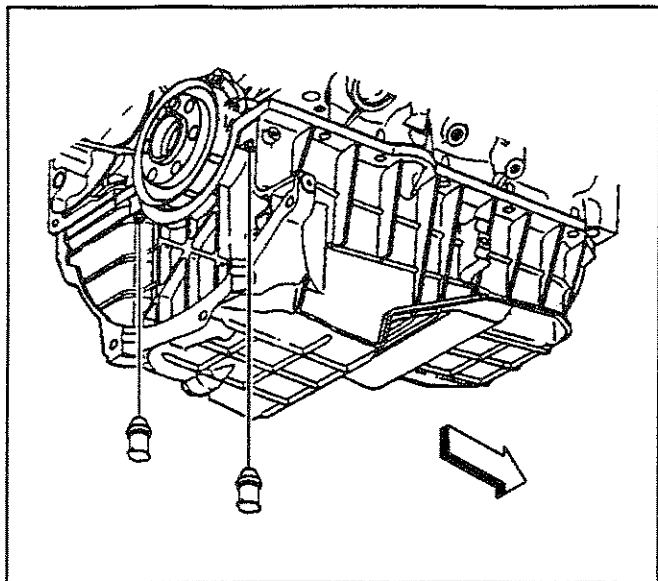
3. Install the transmission to oil pan bolts (manual transmission shown).

Tighten

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

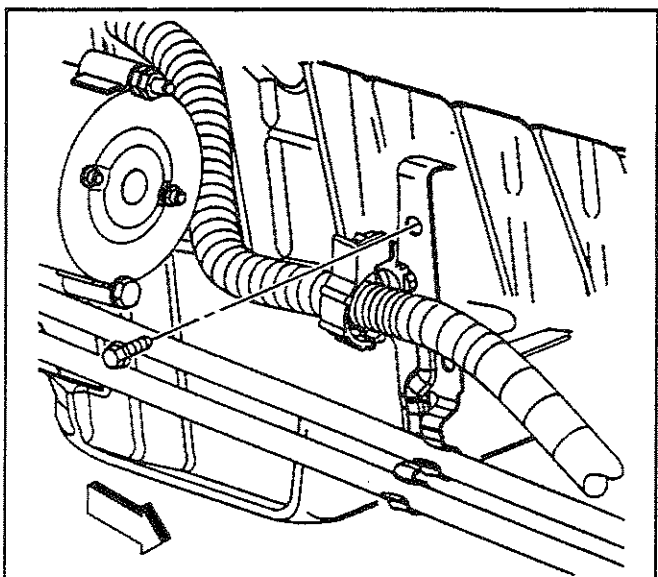


497449



331034

4. Install the access plugs for the oil pan rear nuts,

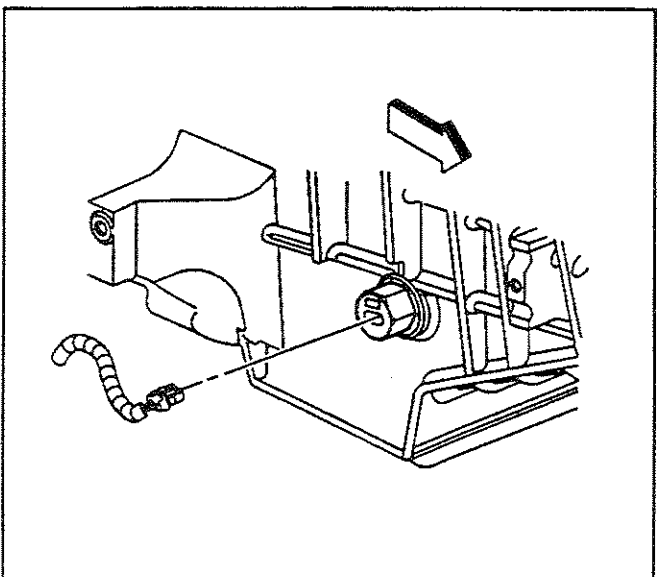


327996

5. 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 9 N·m (80 lb in).



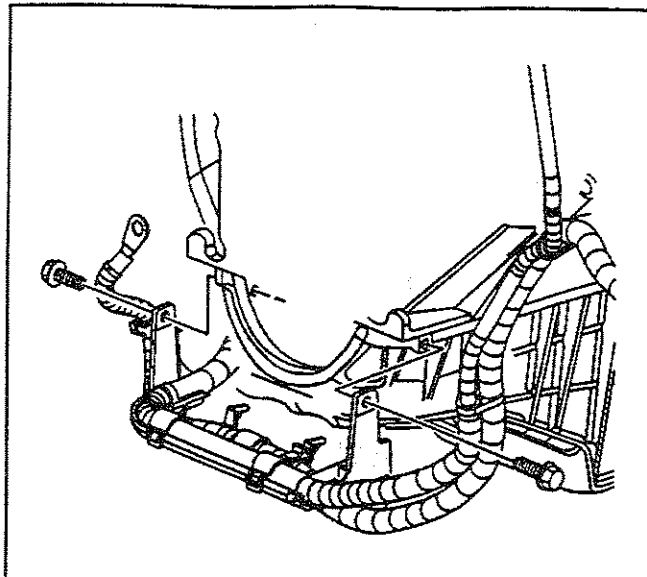
407501

6. Install the starter. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.
7. Connect the low oil level sensor electrical connector.

8. Install the bolts holding the battery cable brackets to the oil pan.

Tighten

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

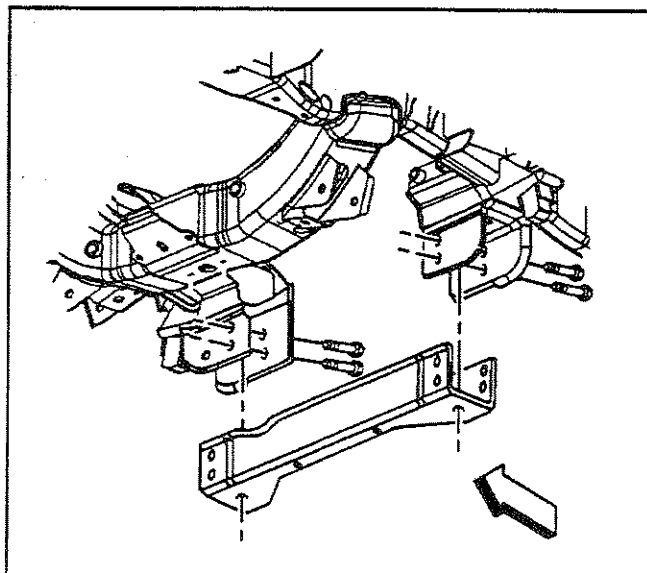


310250

9. Install the crossbar RWD vehicle.

Tighten

Tighten the bolts to 100 N·m (74 lb ft).



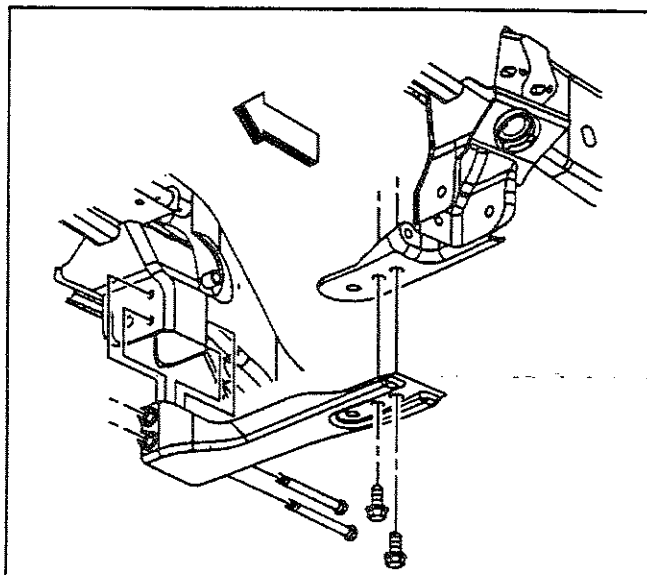
328107

10. Install the front differential carrier assembly, if equipped. Refer to *Differential Carrier Assembly Replacement* in Front Axle.

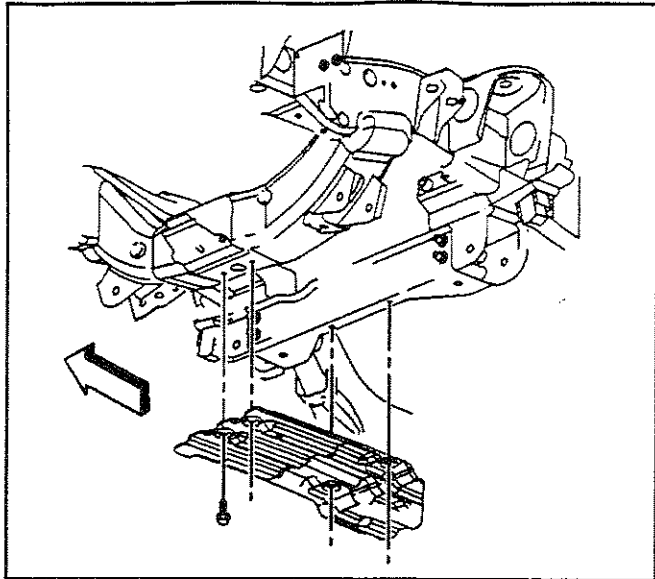
11. Install the crossbar 4WD vehicle.

Tighten

Tighten the bolts to 100 N·m (74 lb ft).

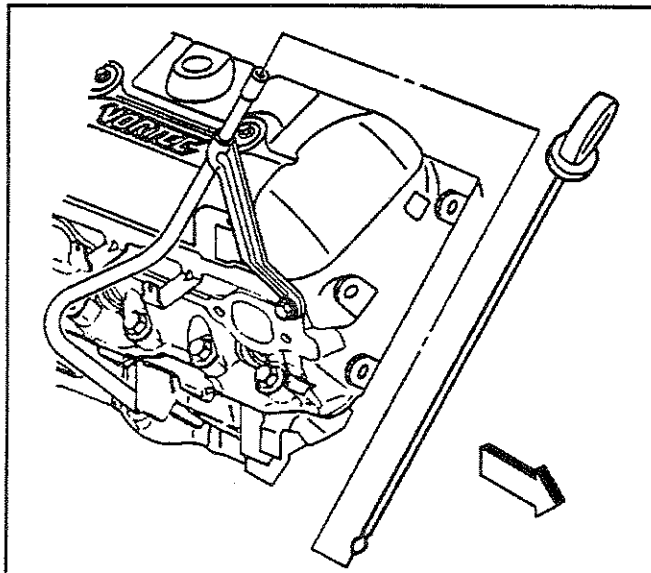


487521



309158

12. Install the oil pan skid plate (RWD shown).
Tighten
Tighten the bolts to 20 N·m (15 lb ft).
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 Negative Cable Disconnect/Connect Procedure* in Engine Electrical.



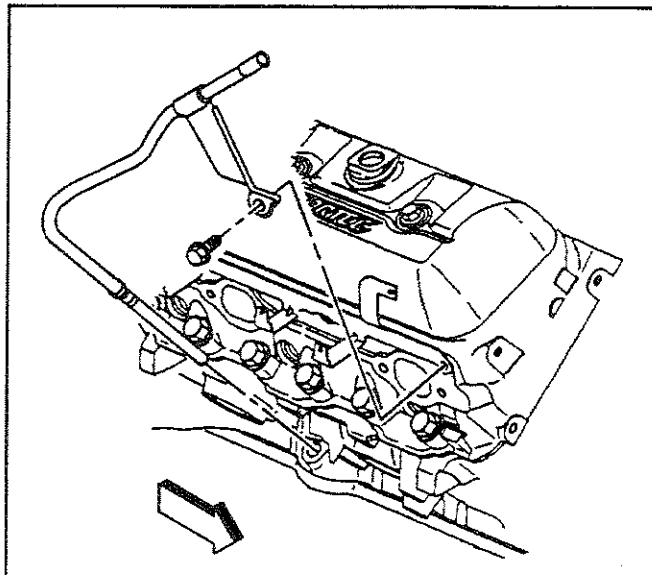
330580

Oil Level Indicator and Tube Replacement

SIE-ID - 478601

Removal Procedure

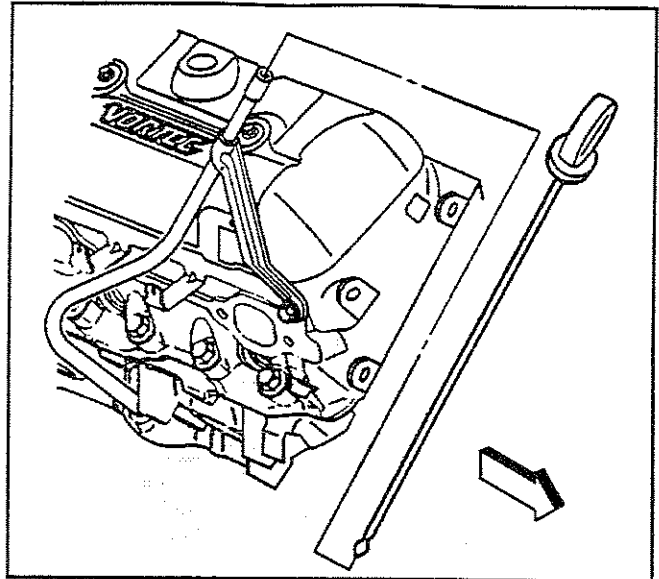
1. Remove the oil level indicator.
2. Remove the right exhaust manifold. Refer to *Exhaust Manifold Replacement (Right)*.
3. Remove the oil level indicator tube bolt.
4. Remove the oil level indicator tube from the engine using a twisting motion.
5. Clean the old sealer from the oil level indicator tube and the engine block.



172977

Installation Procedure

1. Install the oil level indicator tube to the engine. Refer to *Oil Level Indicator and Tube Installation*.
2. Install the right exhaust manifold. Refer to *Exhaust Manifold Replacement (Right)*.
3. Install the oil level indicator.



330580

Engine Oil Pressure Sensor/Switch Replacement

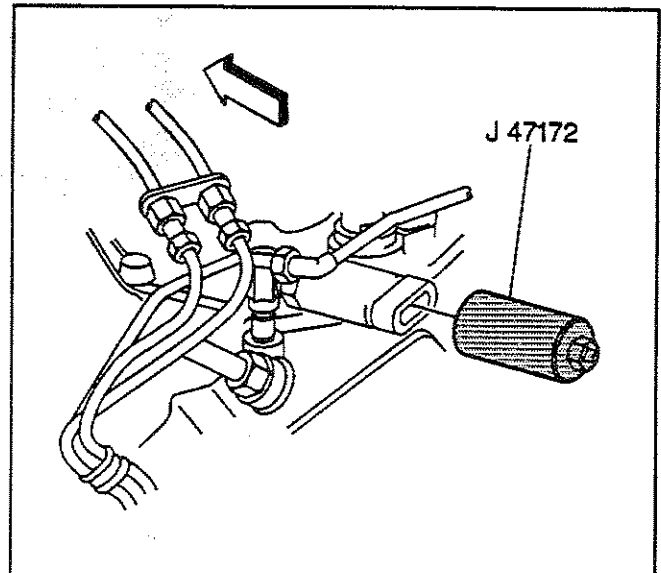
SIE-ID - 478607

Removal Procedure

Tools Required

J 41712 Oil Pressure Switch Socket

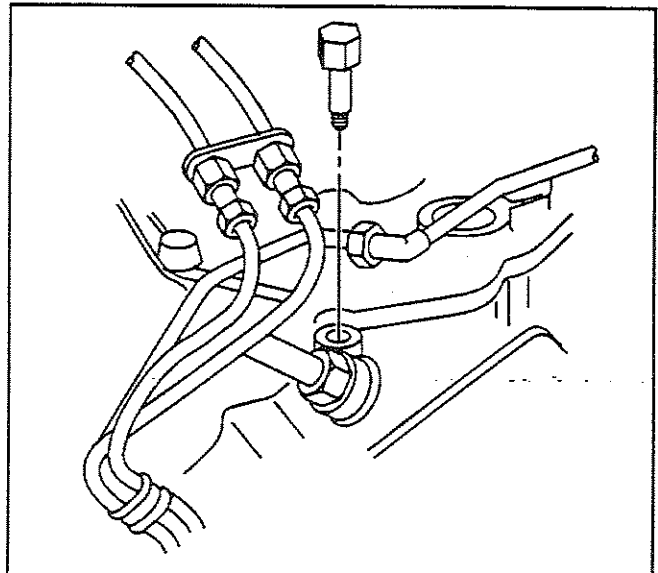
1. Remove the distributor. Refer to *Distributor Replacement* in Engine Electrical.
2. Disconnect the engine oil pressure gauge sensor electrical connector.
3. Hold the engine oil pressure gauge sensor fitting with a wrench.
4. Remove the engine oil pressure gauge sensor using the J 41712.



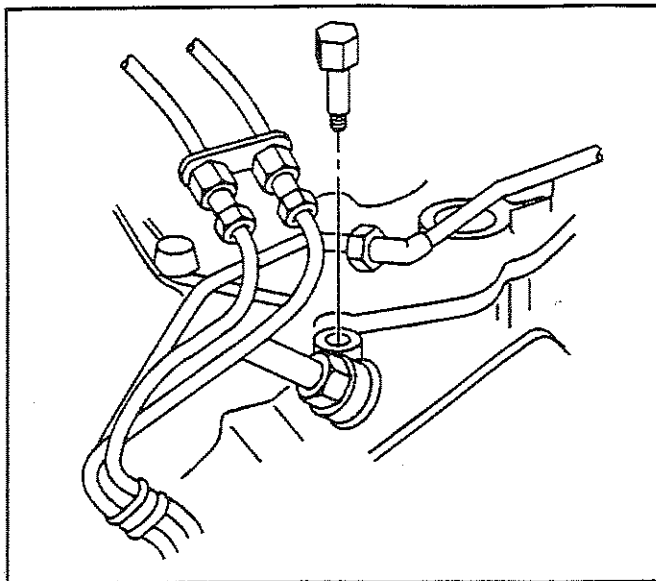
348085

Important: Note the alignment of the engine oil pressure gauge sensor fitting prior to removal.

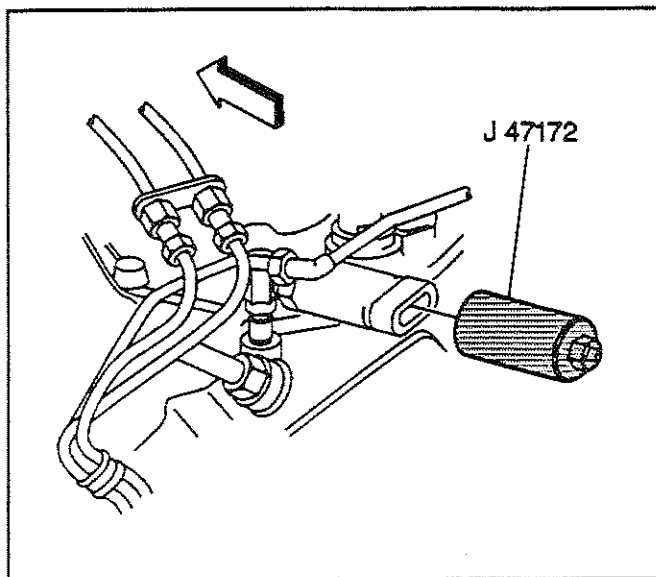
Remove the engine oil pressure gauge sensor fitting, if necessary.



348087



348087



348085

Installation Procedure

Tools Required

J 47172 Oil Pressure Switch Socket

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

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).

Important: Do not loosen the sensor fitting. Do not tighten the sensor fitting more than one turn to align.

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 47172 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* in Engine Electrical.

Oil Pump Replacement

SIE-ID - 478609

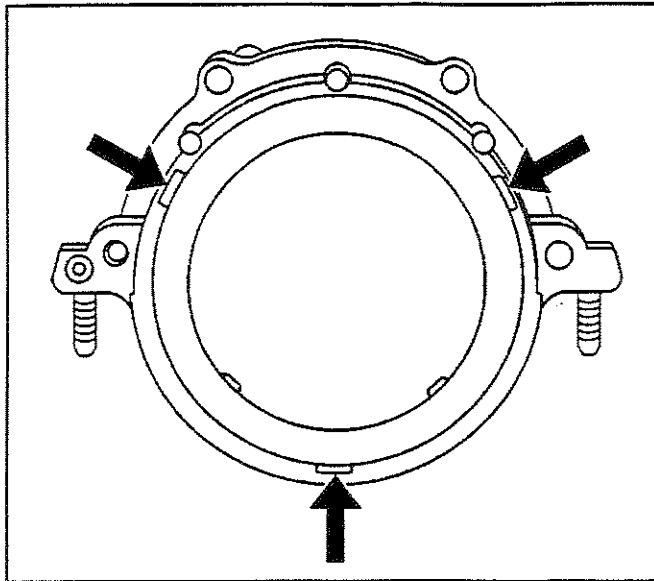
Removal Procedure

1. Remove the oil pan. Refer to *Oil Pan Replacement*.
2. Remove the oil pump. Refer to *Oil Pump Removal*.

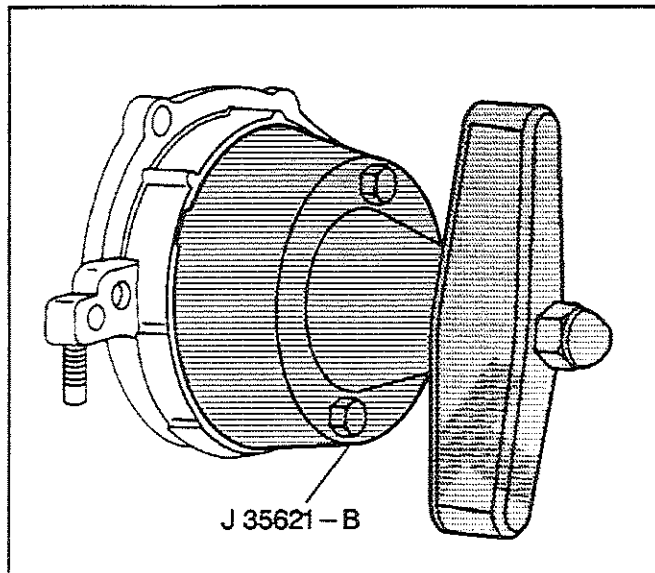
3. Clean and inspect all parts. Refer to *Oil Pump Clean and Inspect*.

Installation Procedure

1. Install the oil pump. Refer to *Oil Pump Installation*.
2. Install the oil pan. Refer to *Oil Pan Replacement*.



31379



334550

Crankshaft Rear Oil Seal Replacement

SIE-ID = 489932

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. Refer to *Engine Flywheel Replacement*.
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

1. Apply a small amount (2 to 3 drops) of clean engine oil to the bore of the crankshaft rear oil seal housing.
2. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the engine flywheel pilot flange.
3. Apply a small amount (1 drop) of clean engine oil to the outside diameter of the flywheel locator pin.
4. Apply a small amount (2 to 3 drops) of clean engine oil to the crankshaft seal surface.
5. 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.

Remove the sleeve from the crankshaft rear oil seal.

6. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the crankshaft rear oil seal.
7. Install the crankshaft rear oil seal onto the J 35621-B.
8. 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.

9. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing.
 - 9.1. 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.
 - 9.2. Turn the *J 35621-B* wing nut counterclockwise to release the *J 35621-B* from the crankshaft rear oil seal.
10. Remove the *J 35621-B* from the crankshaft.
11. Wipe off any excess engine oil with a clean rag.
12. Install the engine flywheel. Refer to *Engine Flywheel Replacement*.
13. Install the transmission assembly.
 - Refer to *Transmission Replacement* in Automatic Transmission - 4L60-E.
 - Refer to *Transmission Replacement* in Manual Transmission - NV3500.

Crankshaft Rear Oil Seal Housing Replacement

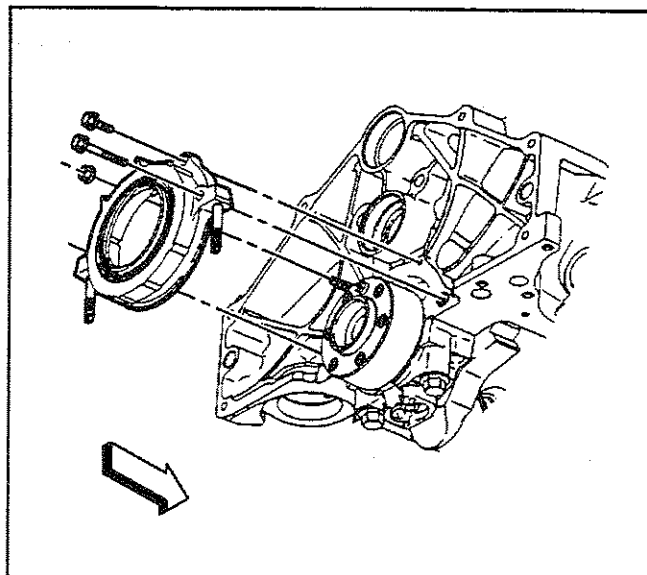
SIE-ID - 489934

Removal Procedure

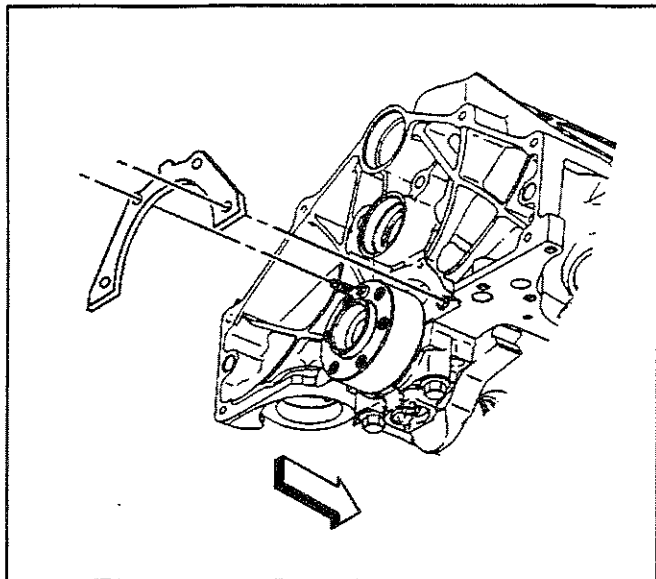
Important: Do not remove the crankshaft rear oil seal housing if only replacing the crankshaft rear oil seal.

Remove the oil pan. Refer to *Oil Pan Replacement*.

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. Refer to *Engine Flywheel Replacement*.
3. Remove the bolts and the nut holding the crankshaft rear oil seal housing to the engine.
4. Remove the crankshaft rear oil seal housing.

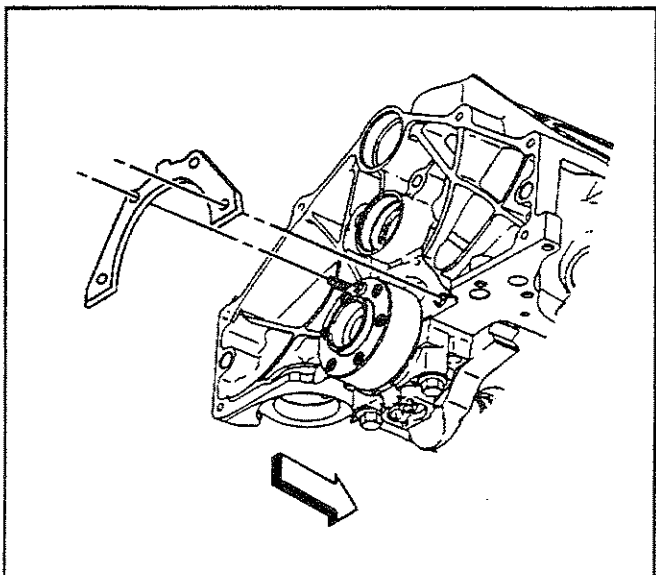


524317



524322

5. Remove and discard the crankshaft rear oil seal housing gasket.
6. Clean all the sealing surfaces.
7. Inspect and replace the crankshaft rear oil seal housing for warping, cracks, wear, or damage.

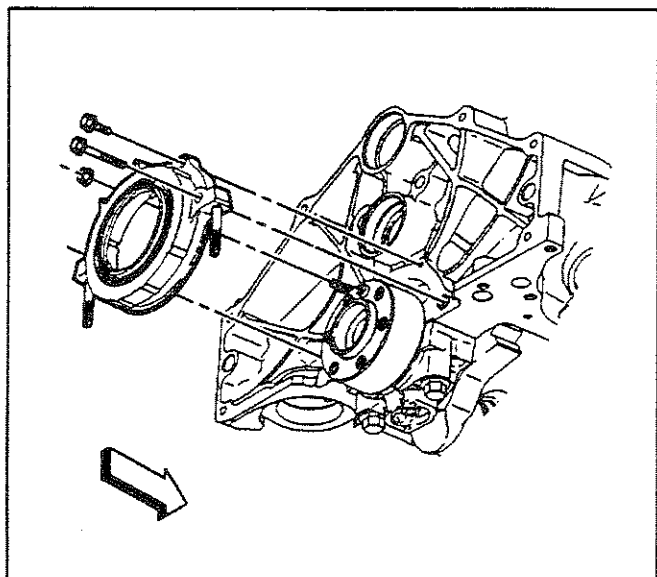


524322

Installation Procedure

Important: When installing a NEW crankshaft rear oil seal housing the crankshaft rear oil seal will come with the housing. If reusing the housing and then installing a NEW seal follow the instructions for installing the housing and then refer to *Crankshaft Rear Oil Seal Replacement* to install the seal.

Install a NEW crankshaft rear oil seal housing gasket.



524317

1. Install the NEW crankshaft rear oil seal housing with the oil seal to the engine block using the following procedure.

Important: Do not oil or grease the seal lip or the crankshaft seal area.

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.

- 1.1. Push the crankshaft rear oil seal housing fully onto the crankshaft until the crankshaft rear oil seal housing is against the crankshaft rear oil seal gasket and the engine.
- 1.2. Remove the sleeve.

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

2. Install the bolts and the 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).

3. Install the engine flywheel. Refer to *Engine Flywheel Replacement*.
4. Install the transmission assembly.
 - Refer to *Transmission Replacement* in Automatic Transmission - 4L60-E.
 - Refer to *Transmission Replacement* in Manual Transmission - NV3500.
5. Install the oil pan. Refer to *Oil Pan Replacement*.

Engine Flywheel Replacement

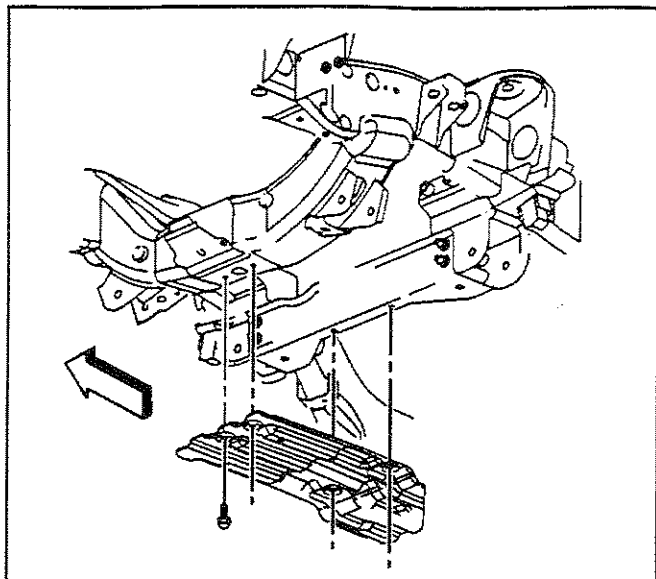
SIE-ID - 478631

Removal Procedure

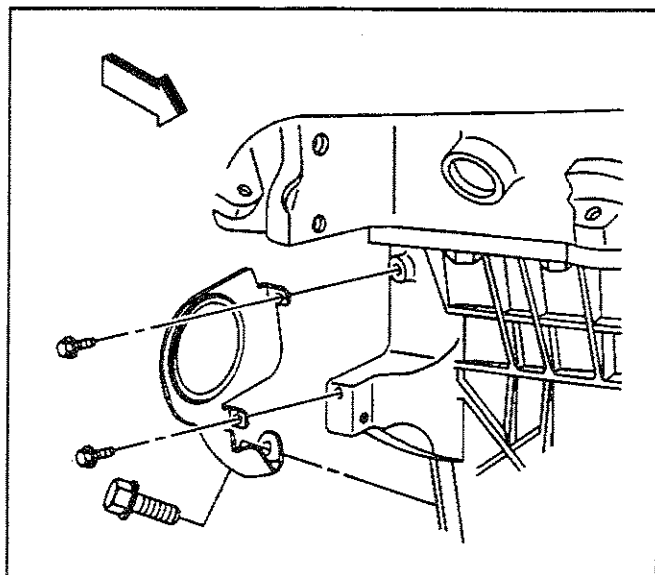
1. Remove the transmission.
 - Refer to *Transmission Replacement* in Automatic Transmission - 4L60-E.
 - Refer to *Transmission Replacement* in Manual Transmission - NV 3500.
2. Remove the clutch assembly, if equipped. Refer to *Clutch Assembly Replacement* in Clutch.
3. Remove the engine flywheel. Refer to *Engine Flywheel Removal*.
4. Clean and inspect all parts. Refer to *Engine Flywheel Clean and Inspect*.

Installation Procedure

1. Install the engine flywheel. Refer to *Engine Flywheel Installation*.
2. Install the clutch assembly, if equipped. Refer to *Clutch Assembly Replacement* in Clutch.
3. Install the transmission.
 - Refer to *Transmission Replacement* in Automatic Transmission - 4L60-E.
 - Refer to *Transmission Replacement* in Manual Transmission - NV 3500.



309158



391868

Engine Replacement

SIE-ID = 478638

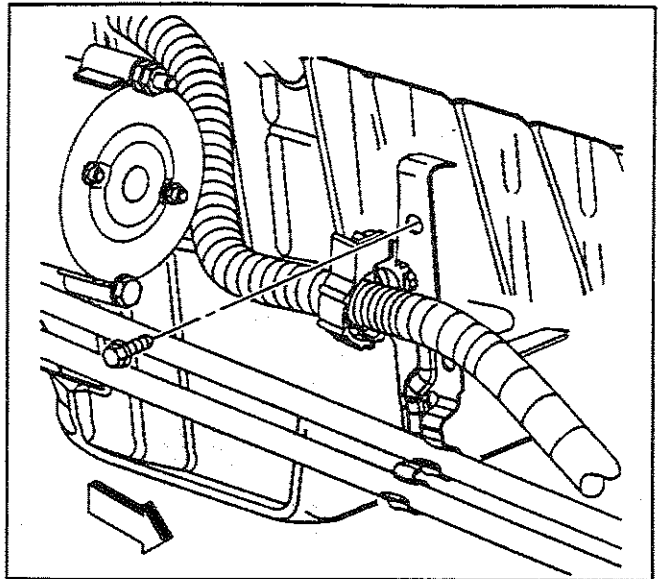
Removal Procedure

Tools Required

J 41427 Engine Lift Brackets

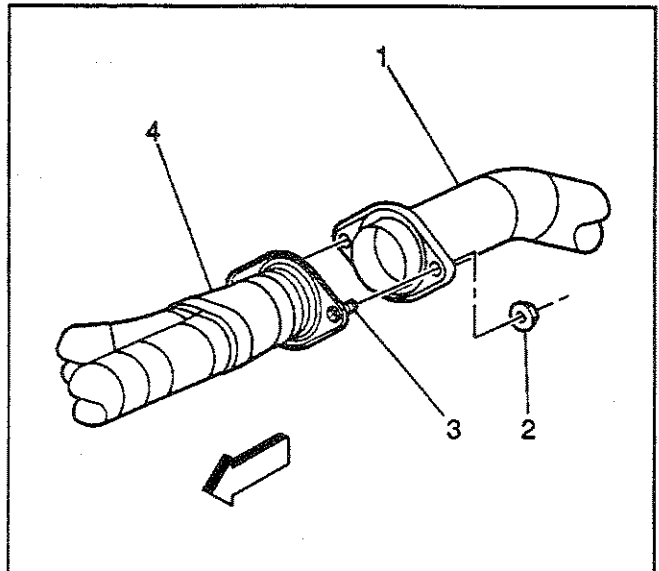
1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.
2. Drain the engine coolant. Refer to *Draining and Filling Cooling System* in Engine Cooling.
3. Evacuate and recover the A/C refrigerant, if equipped. Refer to *Refrigerant Recovery and Recharging* in Heating Ventilation and Air Conditioning.
4. Raise the vehicle. Refer to *Lifting and Jacking the Vehicle* in General Information.
5. Remove the oil pan skid plate (RWD shown).
6. Remove the engine 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.

9. Remove the bolt holding the bracket for the starter cables and transmission cooler lines, if equipped.



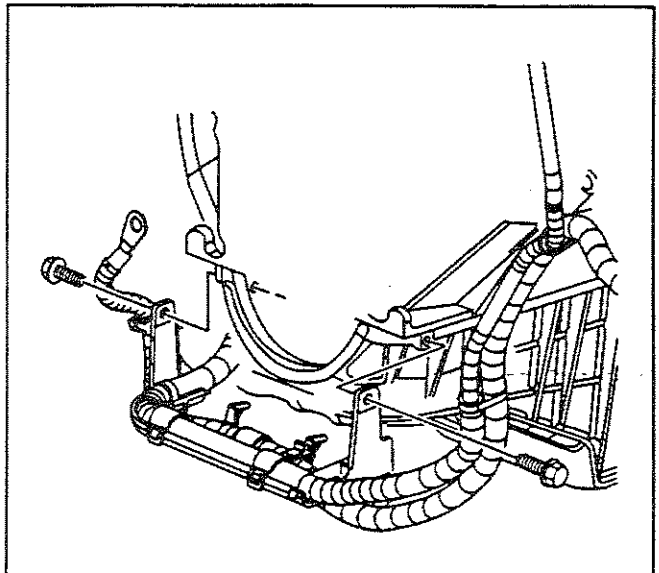
327996

10. Loosen the nuts (2) at the catalytic converter pipe.
11. Remove the exhaust pipes from the exhaust manifolds. Refer to *Catalytic Converter Replacement (Light Duty-4.3L, 4.8L, 5.3L)* in Engine Exhaust.

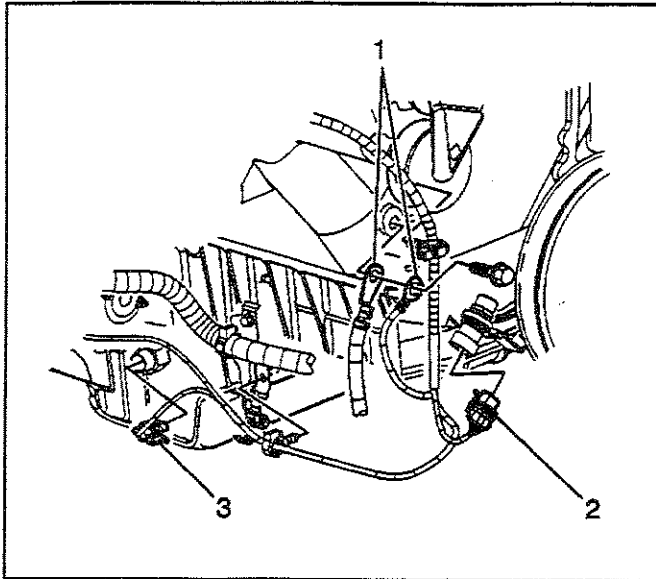


344257

12. Remove the bolts holding the brackets to the oil pan for both battery cables.

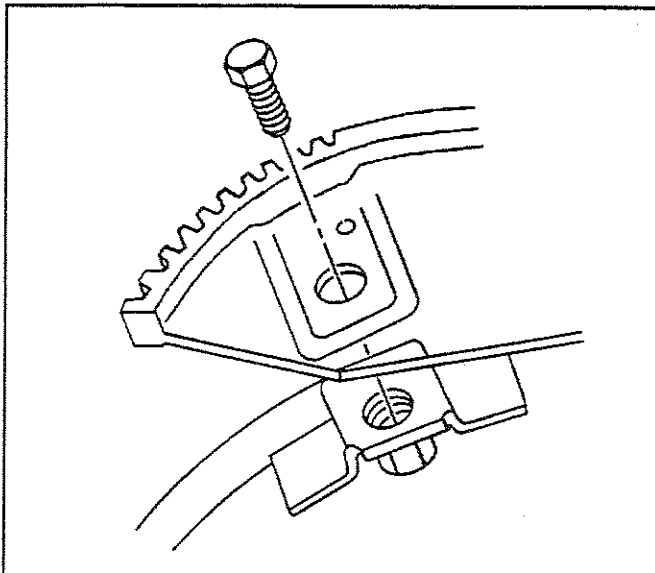


310250



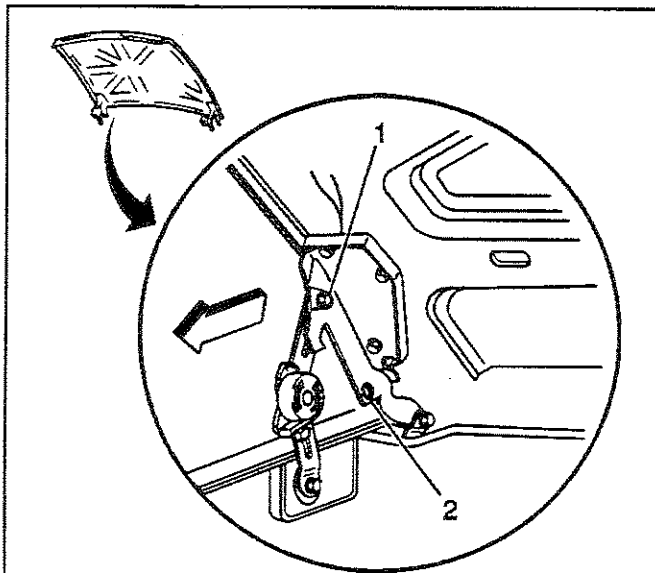
491824

13. Disconnect the crankshaft position (CKP) sensor electrical connector (2) and remove the harness from the retainer.
14. Disconnect the low oil level sensor electrical connector (3) and remove the wire harness from the retainer.
15. Remove the bolt holding the battery negative cable (1) and a ground cable (1) to the engine.



9096

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.



310799

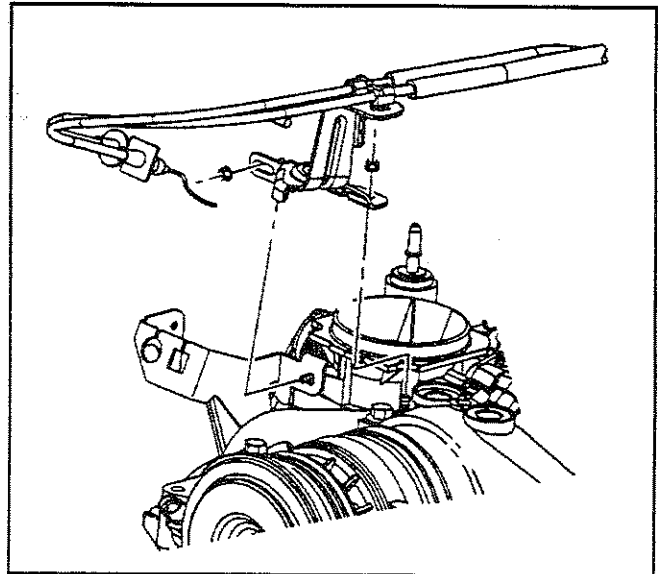
19. Move the hood hinge bolts (1) to hold the hood in the service position (2).
20. Disconnect the PCV hose from the air cleaner outlet duct.
21. Remove the air cleaner outlet duct from the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.
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.
25. Remove the radiator inlet hose from the engine. Refer to *Radiator Hose Replacement - Inlet (4.3L Engine)* in Engine Cooling.

26. Remove the radiator outlet hose from the engine. Refer to *Radiator Hose Replacement - Outlet (4.3L Engine)* in Engine Cooling.

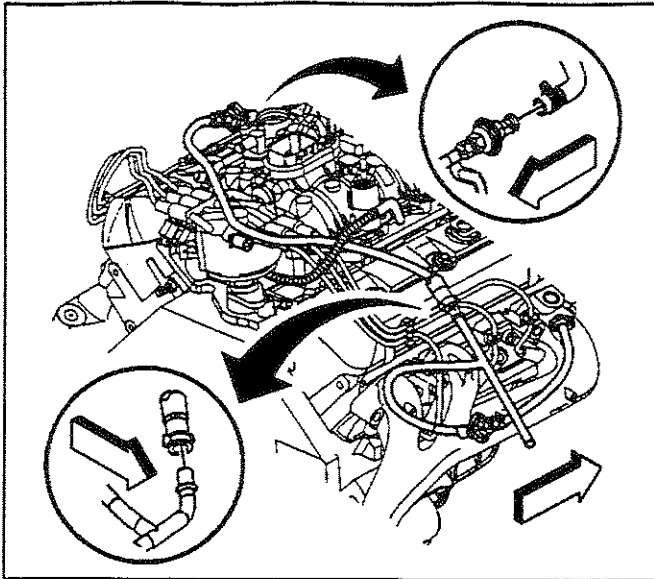
Caution: SIO-ID = 352518 *In order to avoid possible injury or vehicle damage, always replace the accelerator control cable with a NEW cable whenever you remove the engine from the vehicle.*

In order to avoid cruise control cable damage, position the cable out of the way while you remove or install the engine. Do not pry or lean against the cruise control cable and do not kink the cable. You must replace a damaged cable.

27. Remove the accelerator control cable. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.
28. Disconnect the cruise control cable from the throttle body and the bracket on the throttle body and intake manifold, if equipped. Refer to *Cruise Control Cable Replacement (V8)* in Cruise Control.
29. Remove the engine wiring harness and clip from the accelerator control cable bracket.
30. Remove the accelerator control cable bracket from the throttle body.
31. Disconnect the A/C hoses from the compressor and the accumulator, if equipped. Refer to *Compressor Hose Assembly Replacement* in Heating Ventilation and Air Conditioning.

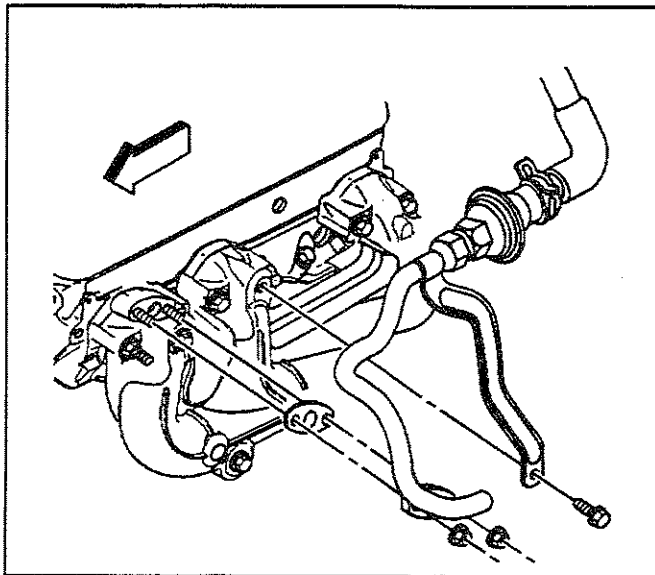


398030



338868

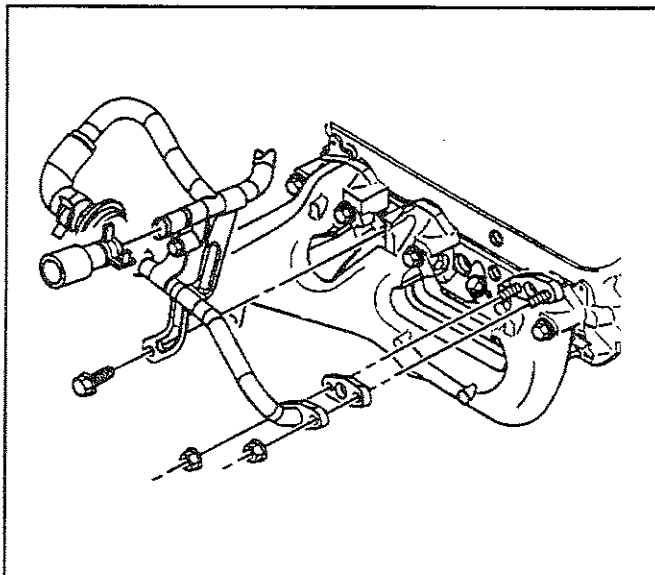
32. Remove the secondary air injection (AIR) crossover pipe from the AIR pipe assemblies.



332032

Notice: SI0-1D = 529899 Remove the AIR pipes before engine removal. The AIR pipes can break or damage easily causing erratic engine operation.

33. Remove AIR pipe assemblies from the left exhaust manifold, if equipped.

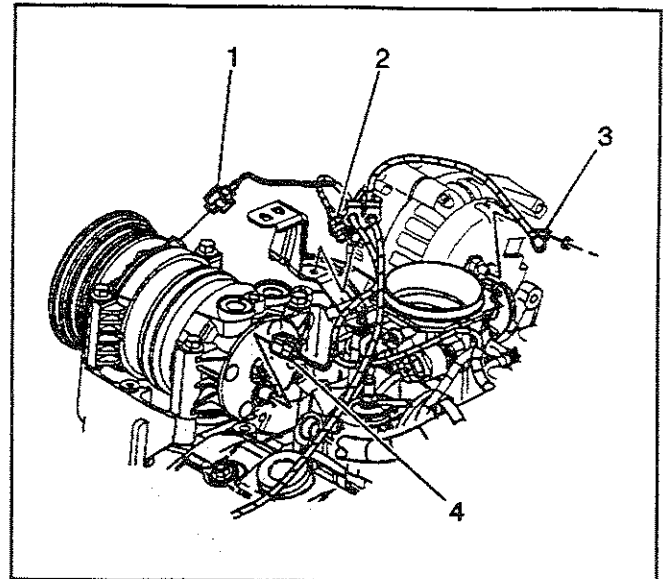


332026

34. Disconnect the AIR pipe assembly from the AIR pump.
35. Remove the AIR pipe assembly from the right exhaust manifold, if equipped.

36. Disconnect the following electrical connectors:

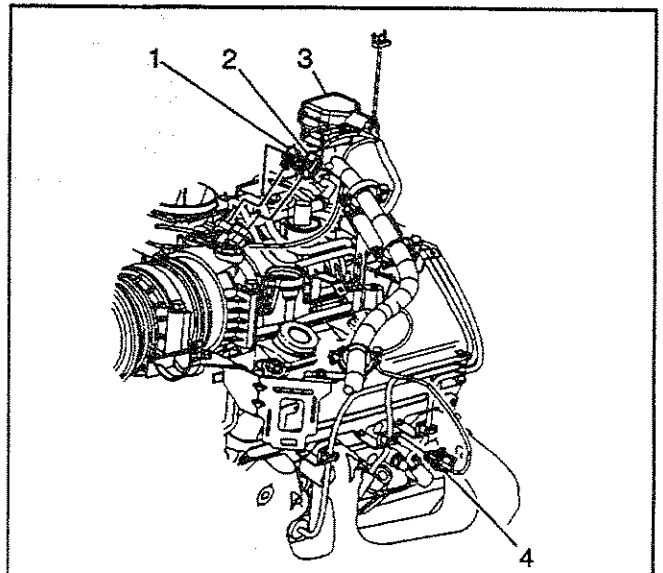
- The A/C pressure switch (4), if equipped
- The A/C compressor clutch (1), if equipped
- The exhaust gas recirculation (EGR) valve (2)
- The generator battery positive cable (3)



491821

37. Disconnect the following electrical connectors:

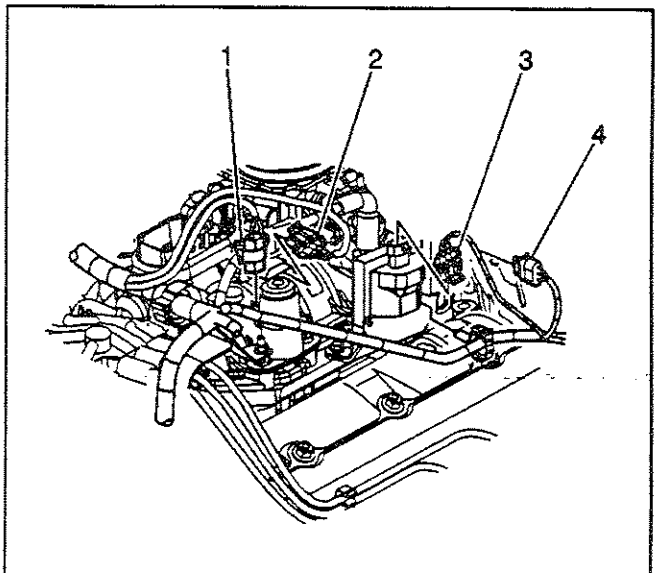
- The fuel meter body assembly (3)
- The idle air control (IAC) motor (2)
- The throttle position (TP) sensor (1)
- The engine coolant temperature (ECT) sensor (4)



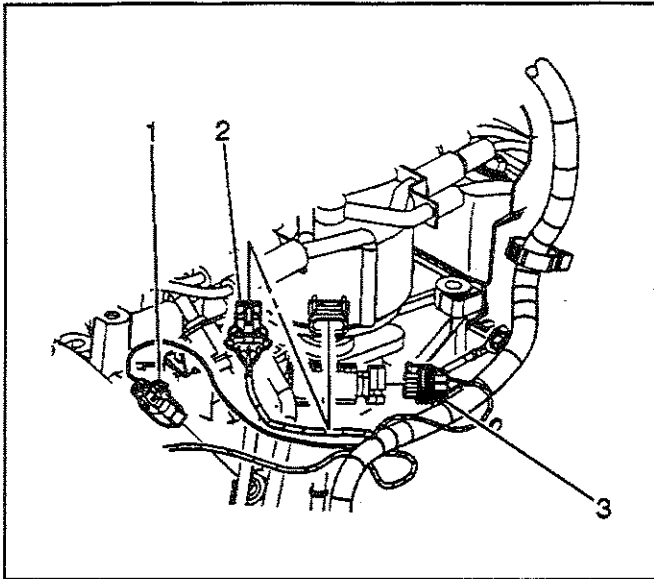
491817

38. Disconnect the following electrical connectors:

- The EVAP canister purge solenoid valve (1)
- The manifold absolute pressure (MAP) sensor (2)
- The ignition control module (ICM) (4)
- The ignition coil (3)



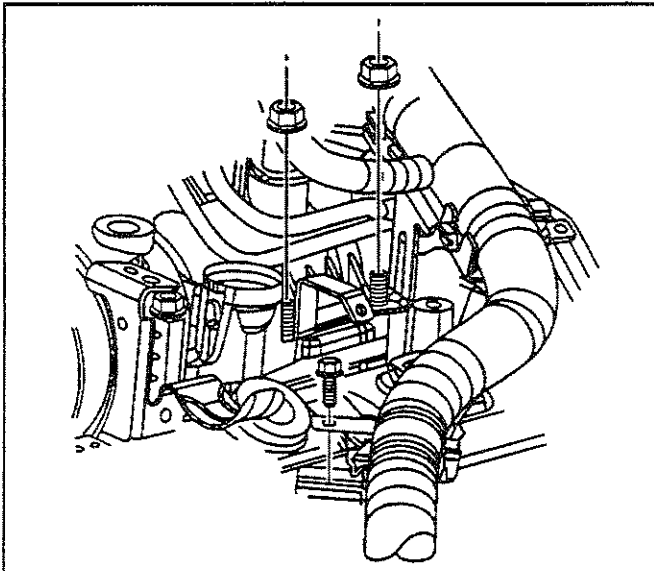
491816



491825

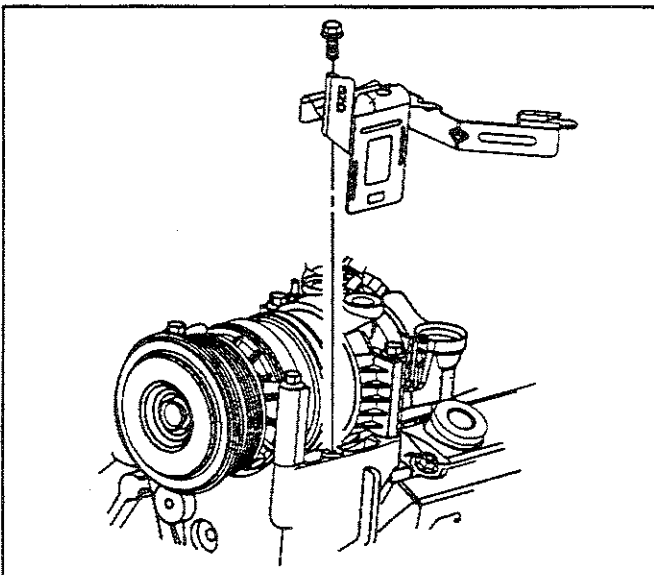
39. Disconnect the following electrical connectors:

- The engine oil pressure gauge sensor (3)
- The distributor (2)
- The knock sensor (KS) (1)



310241

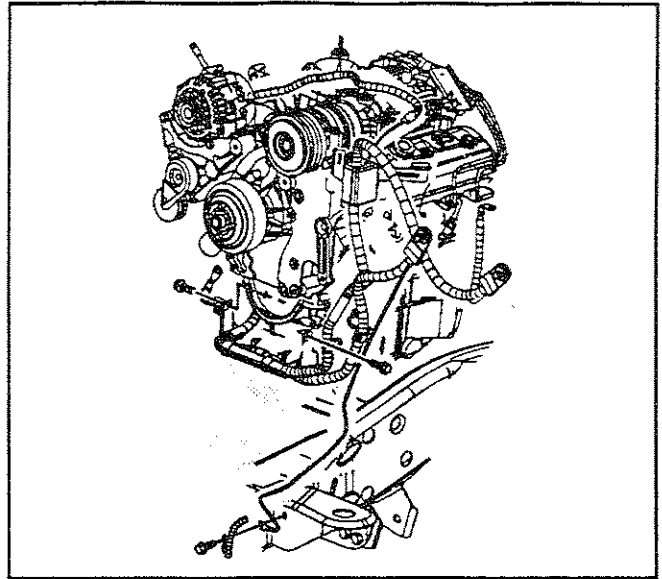
40. Remove the nuts holding the bracket for the engine wiring harness to the intake manifold studs.
41. Remove the bolt holding the engine wiring harness clip to the battery positive cable junction block bracket.



394403

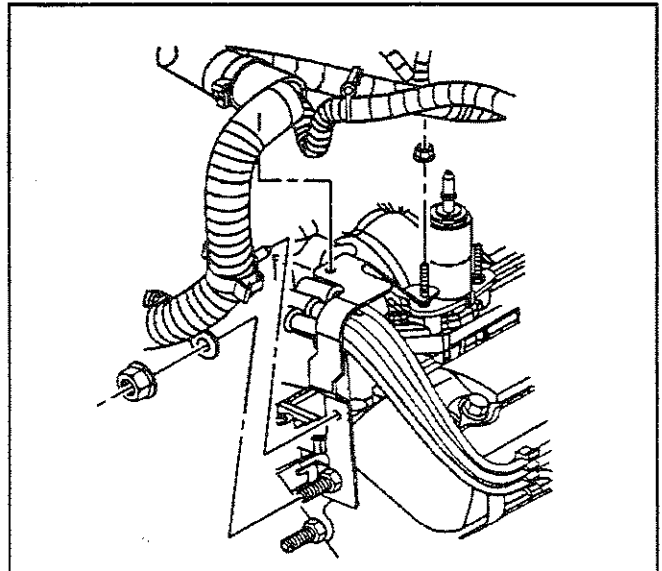
42. Remove the bracket for the battery positive cable junction block from the power steering pump mounting bracket.

43. Move the battery positive and negative cables aside.



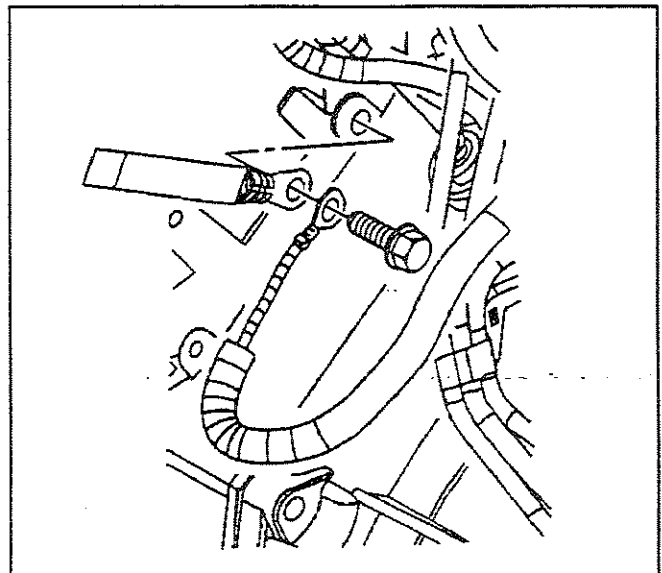
368404

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.

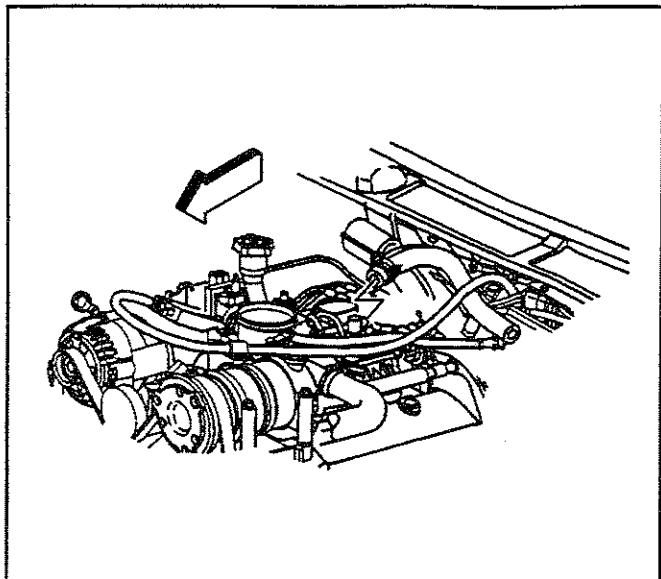


310243

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.
49. Remove both heater hoses from the engine and the cowl. Refer to *Heater Hoses Replacement (4.3L)* in Heating Ventilation and Air Conditioning.
50. Remove the distributor cap. Refer to *Distributor Replacement* in Engine Electrical.
51. Disconnect the fuel pipes at the rear of the engine. Refer to *Fuel Hose/Pipes Replacement (Engine Compartment)* in Engine Controls - 4.3L.
52. Disconnect the hose to the EVAP purge canister solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls - 4.3L.

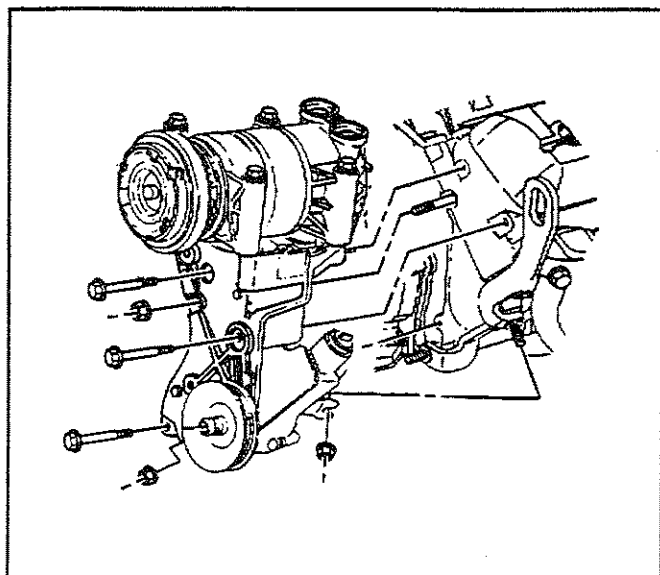


310256



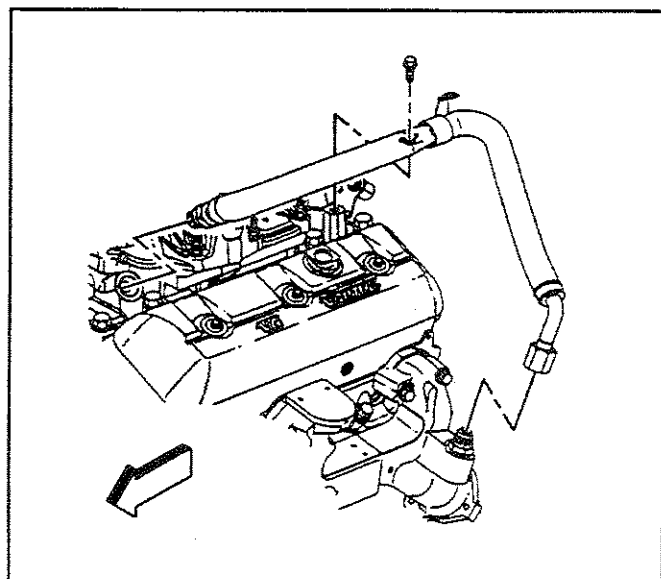
346148

53. Disconnect the power brake booster vacuum hose from the engine and the vacuum brake booster.



340090

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 Engine)* in Engine Cooling.



172982

59. Remove the EGR valve inlet pipe from the intake and exhaust manifold.

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

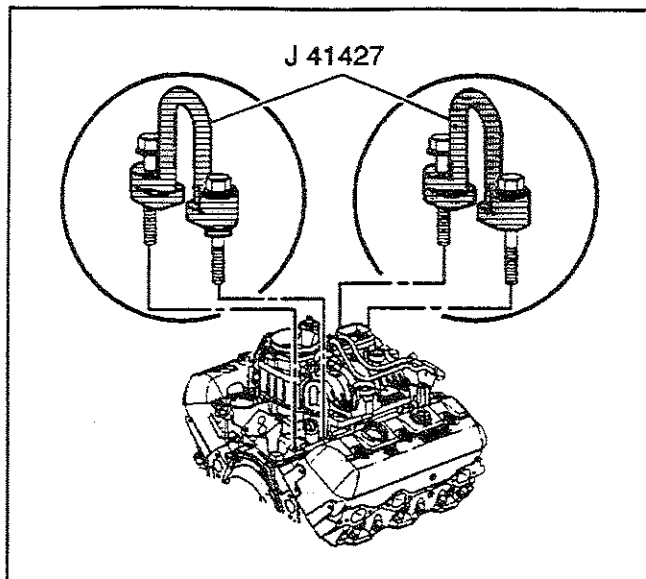
Tighten the bolts to 15 N·m (11 lb ft).

- 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.

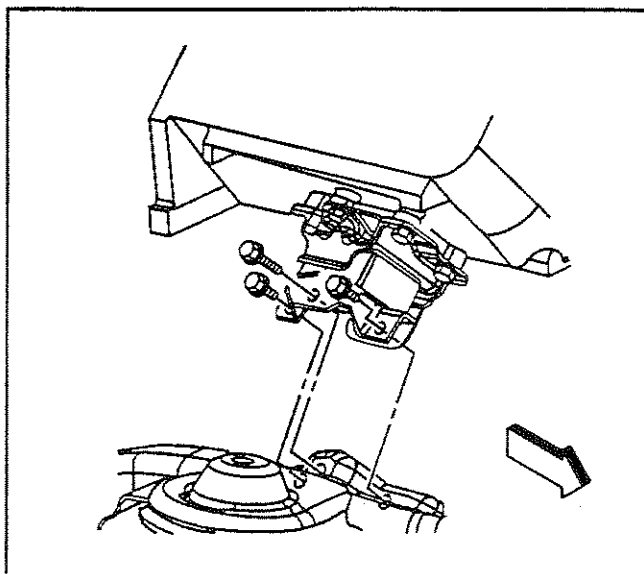
Tighten

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

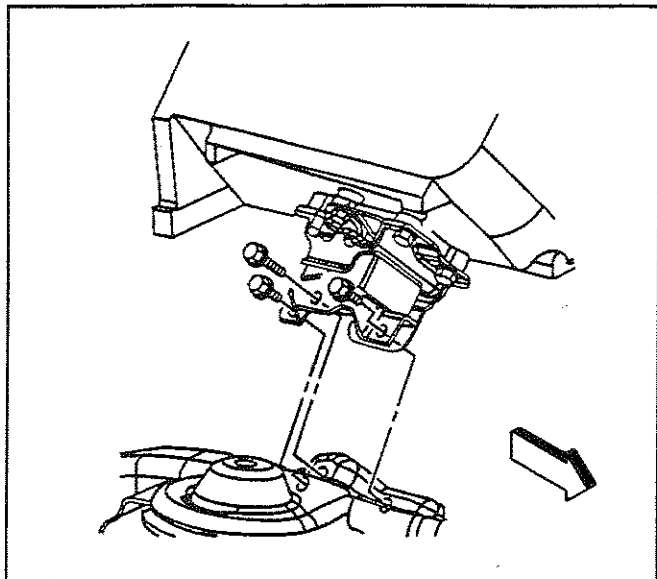
61. Attach a suitable lifting device to the engine lift brackets.
62. Remove the engine motor mount to frame bracket bolts.
63. Support the transmission with a suitable jack.
64. Remove the engine.



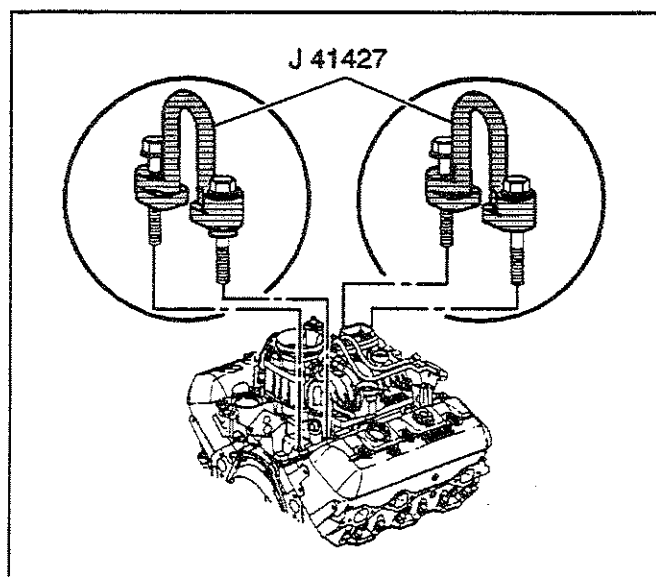
33636



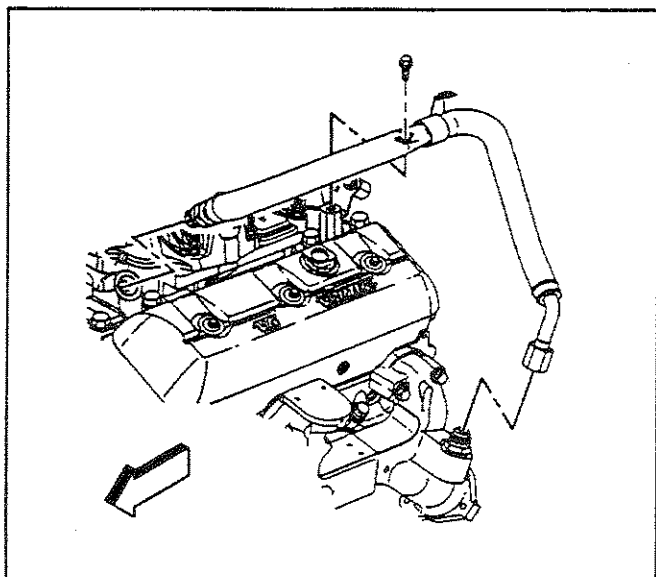
310259



310259



33636



172982

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 65 N·m (50 lb ft).

3. Remove the J 41427 and the lifting device.
4. Apply thread lock GM P/N 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 the support jack from under the transmission.

8. Install the EGR valve inlet pipe to the intake and the exhaust manifold.

Tighten

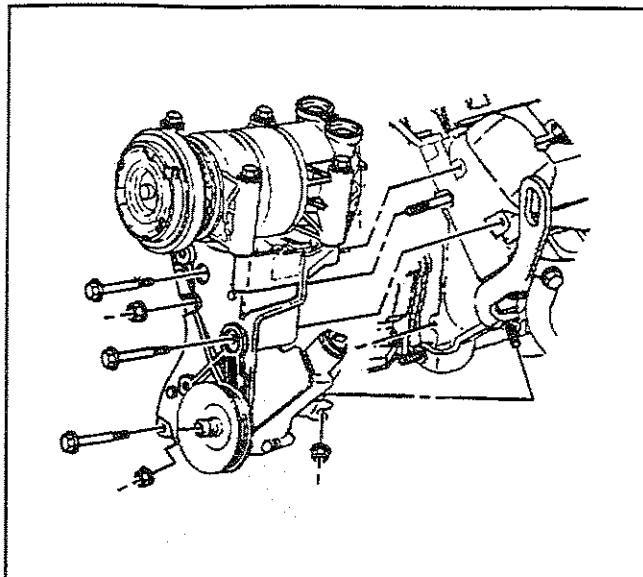
- 8.1. Tighten the EGR valve inlet pipe intake nut to 25 N·m (18 lb ft).
- 8.2. Tighten the EGR valve inlet pipe exhaust nut to 30 N·m (22 lb ft).
- 8.3. Tighten the EGR valve inlet pipe clamp bolt to 25 N·m (18 lb ft).
9. Install the water outlet. Refer to *Thermostat Replacement (4.3L Engine)* in Engine Cooling.

10. Slide 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 pump rear bracket to the front of the engine.

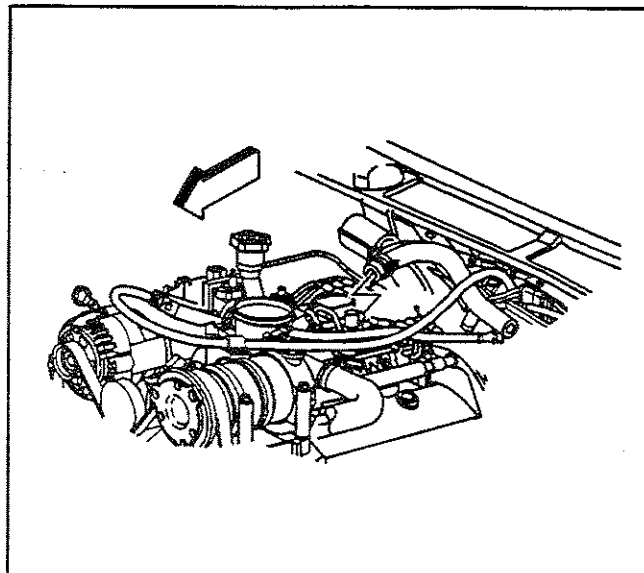
Tighten

Tighten the power steering pump mounting bracket and the power steering pump rear bracket 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 - 4.3L.
15. Connect the hose to the EVAP purge canister solenoid valve. Refer to *EVAP Canister Purge Solenoid Valve Replacement* in Engine Controls - 4.3L.
16. Connect the vacuum brake booster hose to engine and the vacuum brake booster.
17. Install the distributor cap. Refer to *Distributor Replacement* in Engine Electrical.
18. Install both heater hoses to the engine and the cowl. Refer to *Heater Hoses Replacement (4.3L)* in Heating Ventilation and Air Conditioning.



340090



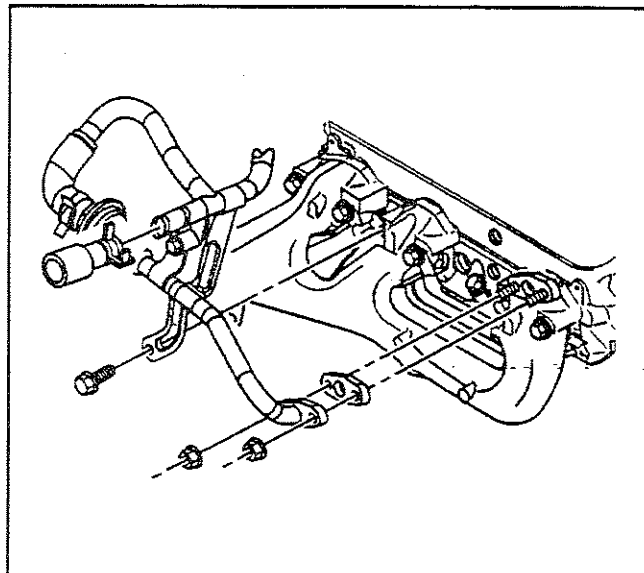
346148

19. Install the AIR pipe assembly with new gaskets to the right exhaust manifold, if equipped.
20. Install the AIR pipe nuts and bracket bolt.

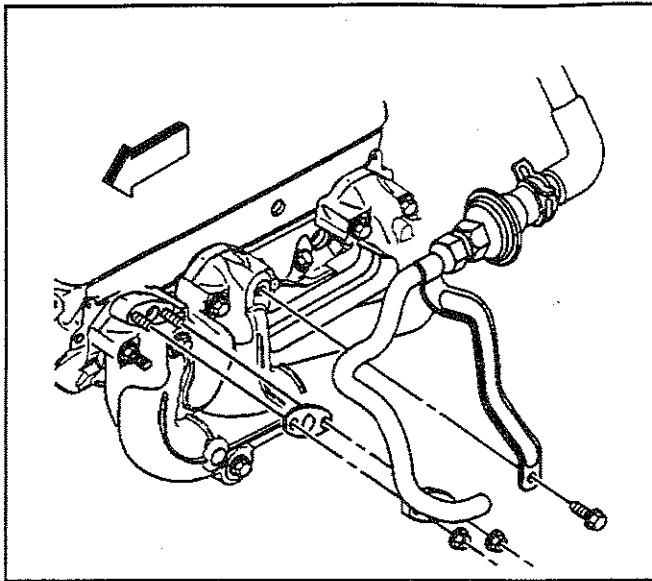
Tighten

- 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.



332026

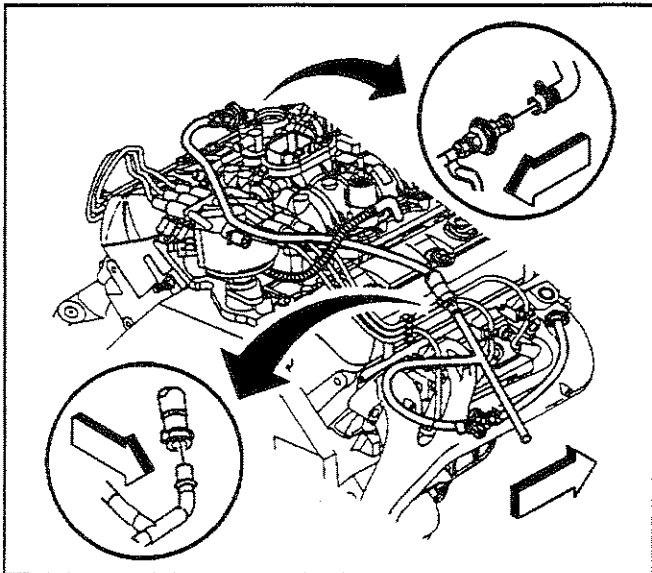


332032

22. Install the AIR pipe assembly with new gaskets to the left exhaust manifold, if equipped.
23. Install the AIR pipe nuts and bracket bolt.

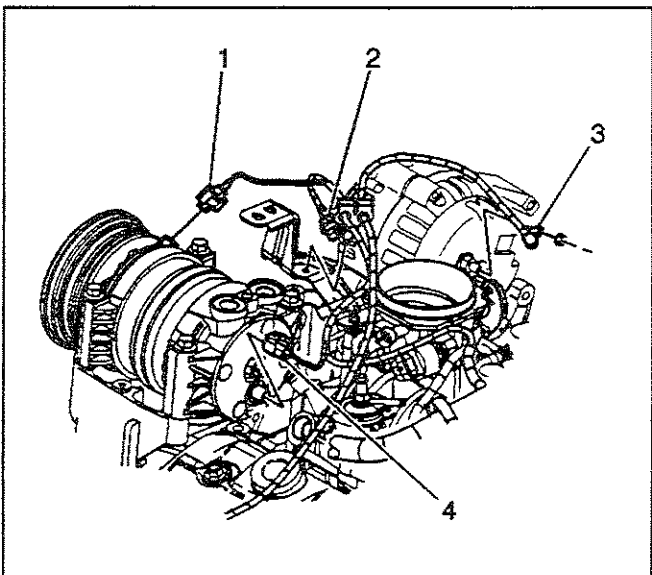
Tighten

- 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).



398868

24. Install the AIR crossover pipe to the AIR pipe assemblies.
25. Position the engine wiring harness.

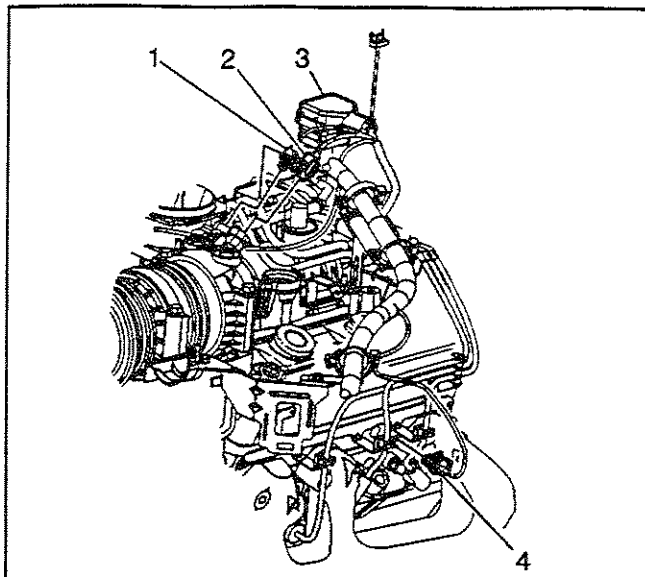


491821

26. Connect the following electrical connectors:
 - The A/C pressure switch (4), if equipped
 - The A/C compressor clutch (1), if equipped
 - The exhaust gas recirculation (EGR) valve (2)
 - The generator battery positive cable (3)

27. Connect the following electrical connectors:

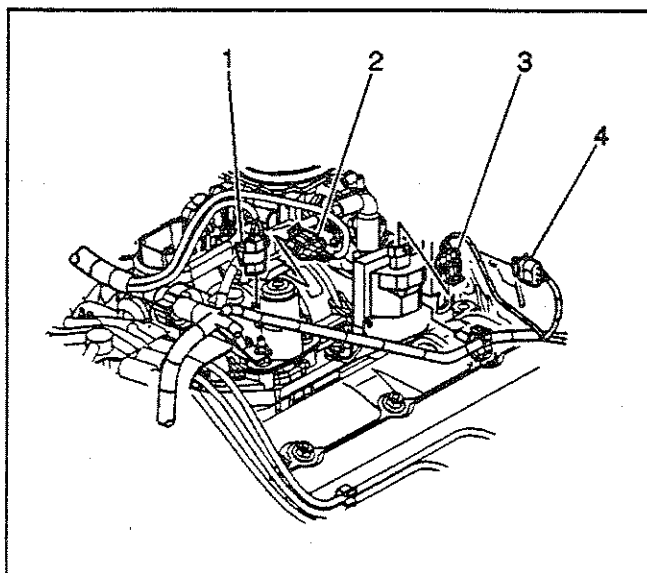
- The fuel meter body assembly (3)
- The idle air control (IAC) motor (2)
- The throttle position (TP) sensor (1)
- The engine coolant temperature (ECT) sensor (4)



491817

28. Connect the following electrical connectors:

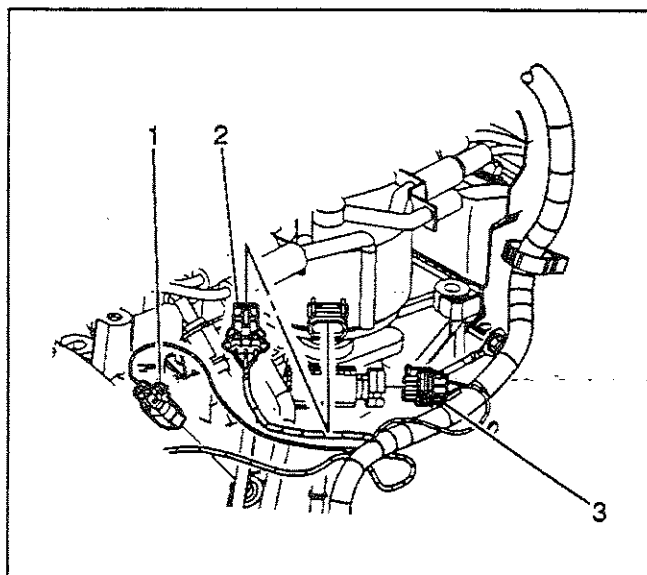
- The EVAP canister purge solenoid valve (1)
- The manifold absolute pressure (MAP) sensor (2)
- The ignition control module (ICM) (4)
- The ignition coil (3)



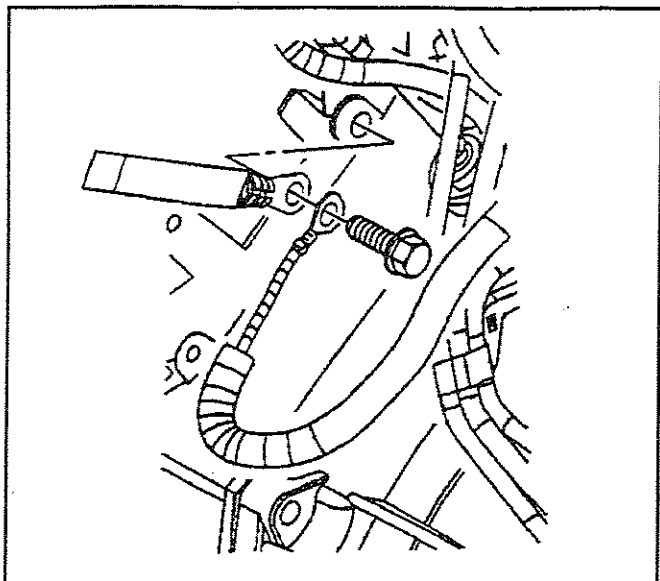
491816

29. Connect the following electrical connectors:

- The engine oil pressure gauge sensor (3)
- The distributor (2)
- The knock sensor (KS) (1)



491825

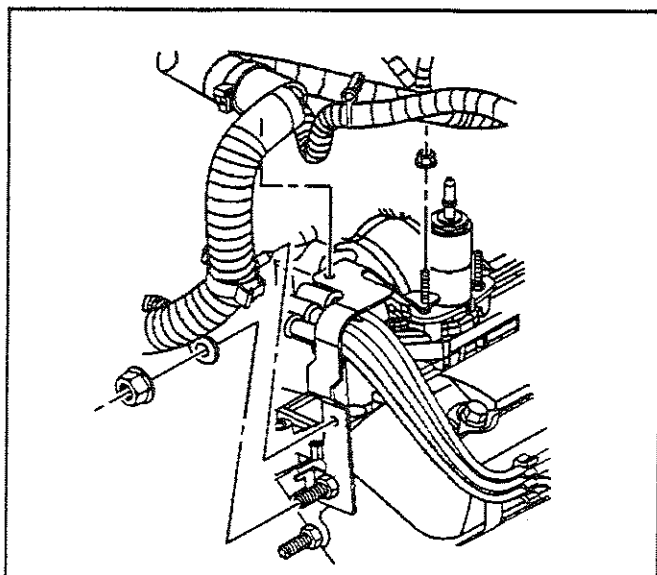


310256

30. 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 ground wire bolt to 16 N·m (12 lb ft).



310243

31. Position the engine wiring harness bracket on the EVAP purge canister solenoid valve stud and install the nut.
32. Install the stud holding the wire harness bracket to the rear of the right cylinder head.

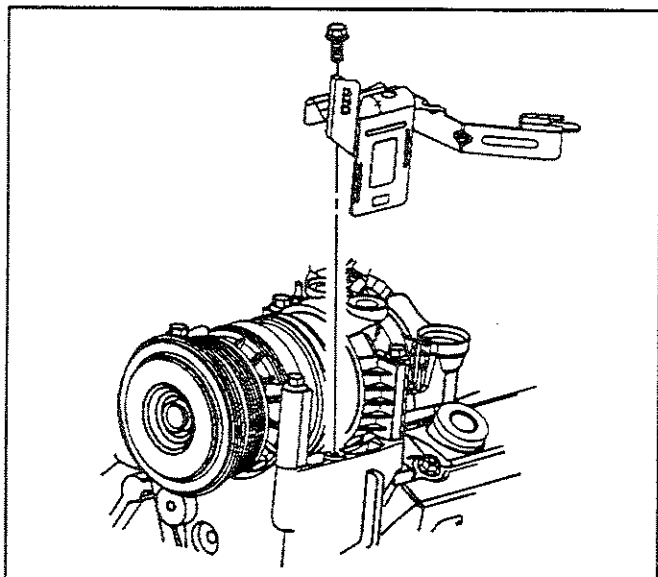
Tighten

- 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).

33. 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

34. Position the battery positive and negative cables. Do not connect the negative battery cable to the battery. Refer to *Battery Cable Replacement (4.3L - Positive/Negative)*
35. Install the battery positive cable junction block bracket and bolt to the power steering pump mounting bracket.

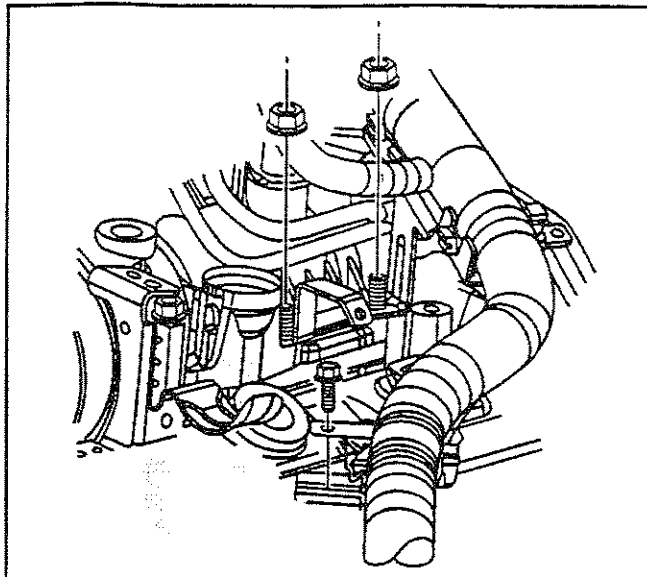
Tighten

Tighten the junction block bracket bolt to 25 N·m (18 lb ft).

36. Install the bolt holding the engine wiring harness bracket to battery positive cable junction block bracket.
37. 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).
38. Connect the A/C hoses to the A/C compressor and the accumulator. Refer to *Compressor Hose Assembly Replacement* in Heating Ventilation and Air Conditioning.



310241

39. Install the accelerator control cable bracket and nuts to the throttle body.

Tighten

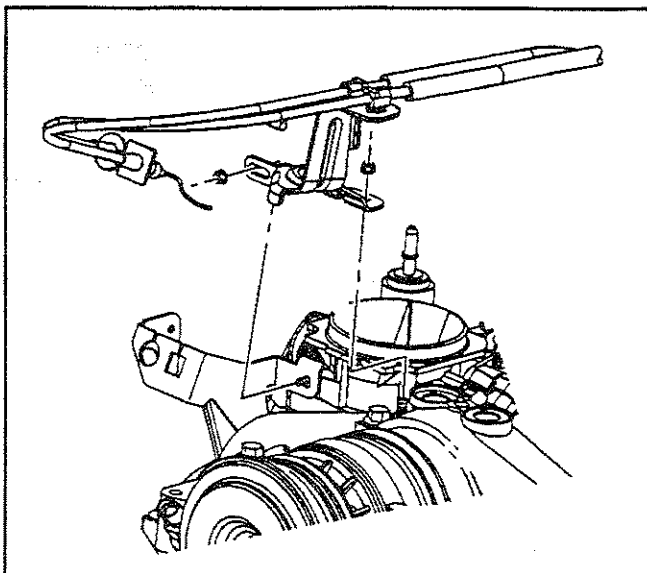
Tighten the nuts to 9 N·m (80 lb in).

40. Install the engine wire harness and clip to the accelerator control cable bracket.

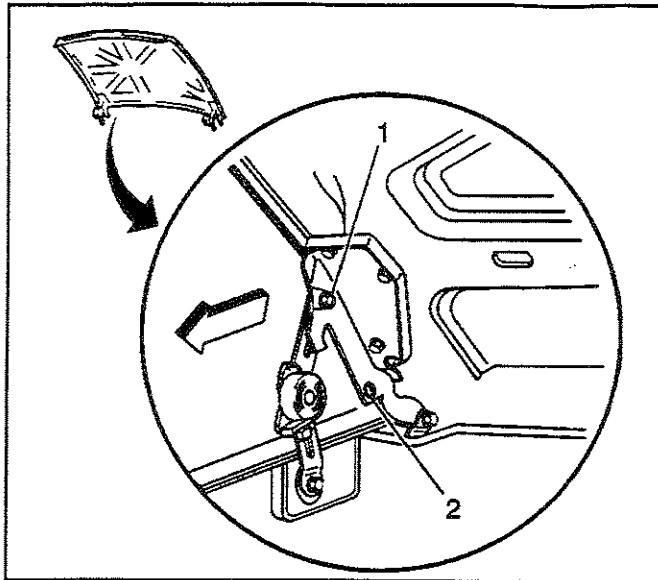
Caution: SIO-ID = 352518 In order to avoid possible injury or vehicle damage, always replace the accelerator control cable with a NEW cable whenever you remove the engine from the vehicle.

In order to avoid cruise control cable damage, position the cable out of the way while you remove or install the engine. Do not pry or lean against the cruise control cable and do not kink the cable. You must replace a damaged cable.

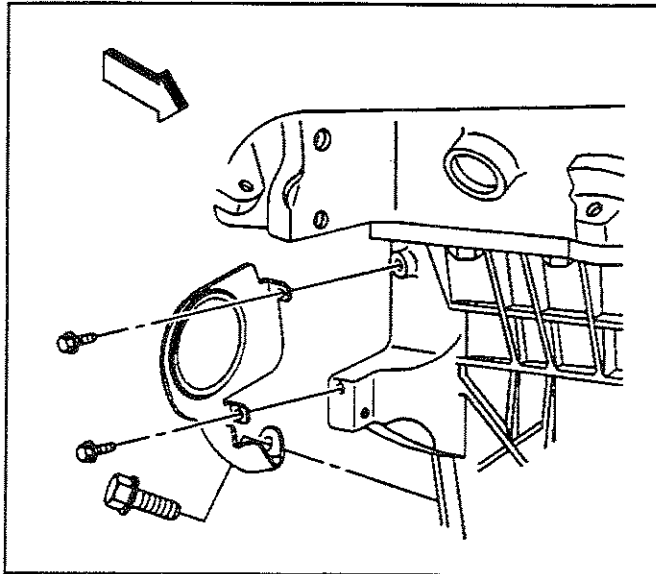
41. Install the NEW accelerator control cable. Refer to *Accelerator Controls Cable Replacement* in Engine Controls.
42. Connect the cruise control cable to the throttle body and the accelerator control cable bracket, if equipped. Refer to *Cruise Control Cable Replacement (V8)* in Cruise Control.
43. Install the radiator inlet hose. Refer to *Radiator Hose Replacement - Inlet (4.3L Engine)* in Engine Cooling.
44. Install the radiator outlet hose. Refer to *Radiator Hose Replacement - Outlet (4.3L Engine)* in Engine Cooling.
45. Install the engine cooling fan. Refer to *Fan Clutch Replacement* in Engine Cooling.
46. Install the drive belt. Refer to *Drive Belt Replacement*.
47. Install the upper and lower radiator shroud. Refer to *Fan Shroud Replacement* in Engine Cooling.
48. Install the air cleaner outlet duct to the throttle body and the air cleaner assembly. Refer to *Air Cleaner Outlet Duct Replacement* in Engine Controls - 4.3L.



398030



310799



391868

49. Connect the PCV hose to the air inlet duct.
50. Move the hood hinge bolts from the service position (2) to the normal operating position (1).
51. Raise the vehicle.
52. 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*.
53. Install three torque converter to flywheel bolts, if equipped. Refer to *Flywheel to Torque Converter Bolts in Automatic Transmission - 4L60-E*.

54. Install the transmission cover and bolts.

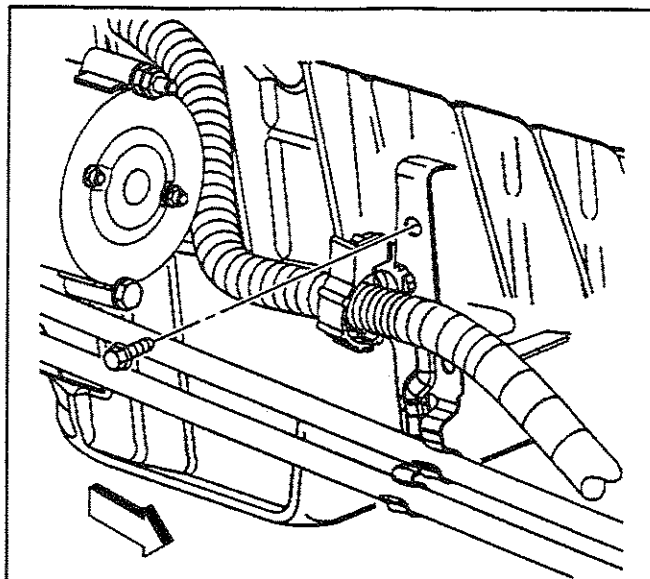
Tighten

- 54.1. Tighten the transmission cover to oil pan bolt to 12 N·m (106 lb in).
- 54.2. Tighten the transmission cover to transmission bolt to 47 N·m (34 lb ft).

55. Install the bolt holding the bracket for the starter cables and the transmission cooler pipes, if equipped.

Tighten

Tighten the bracket bolt to 9 N·m (80 lb in).

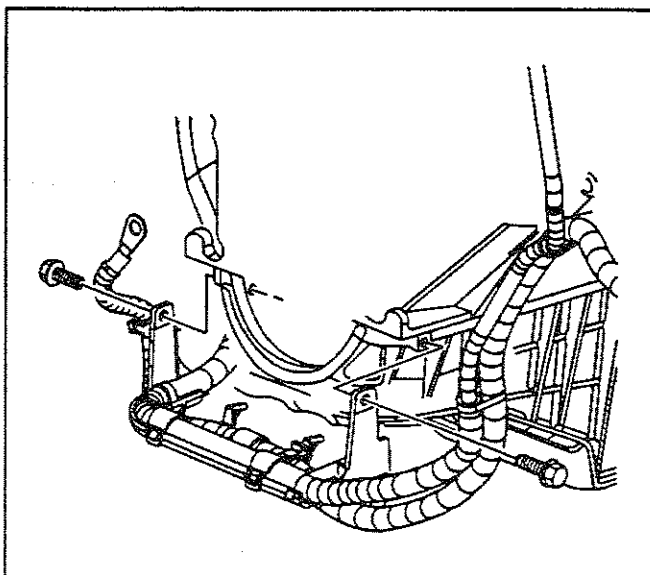


327996

56. 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).



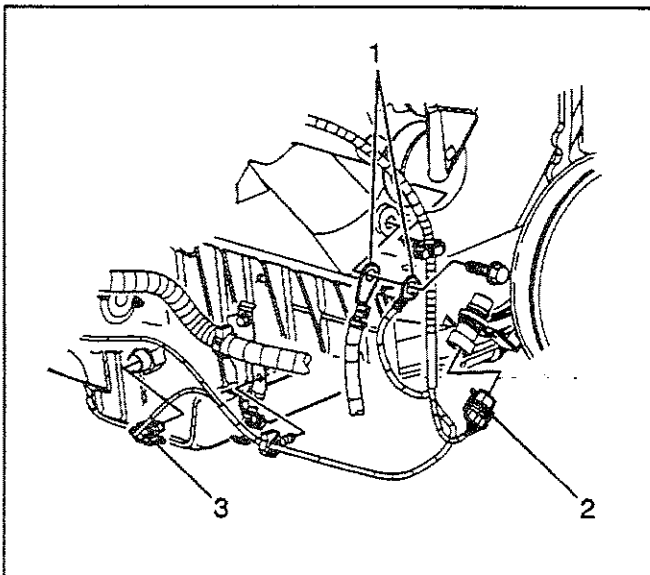
310250

57. Install the bolt for the battery negative cable (1) and ground wire (1) to the front of the engine.

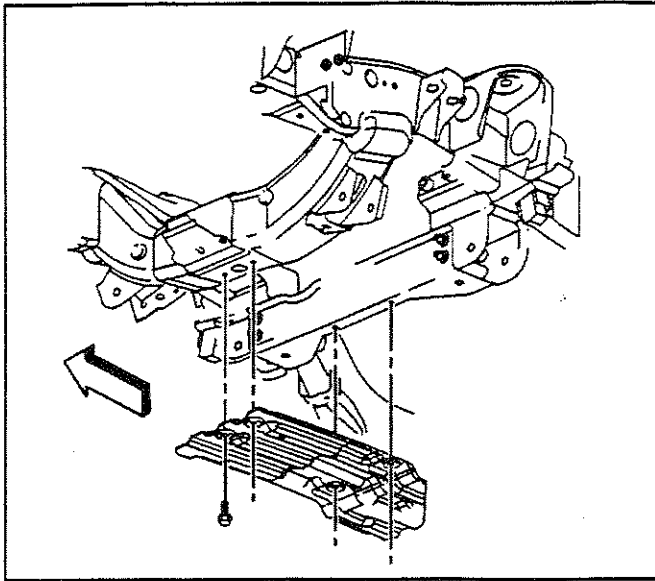
Tighten

Tighten the battery negative cable and ground wire bolt to 25 N·m (18 lb ft).

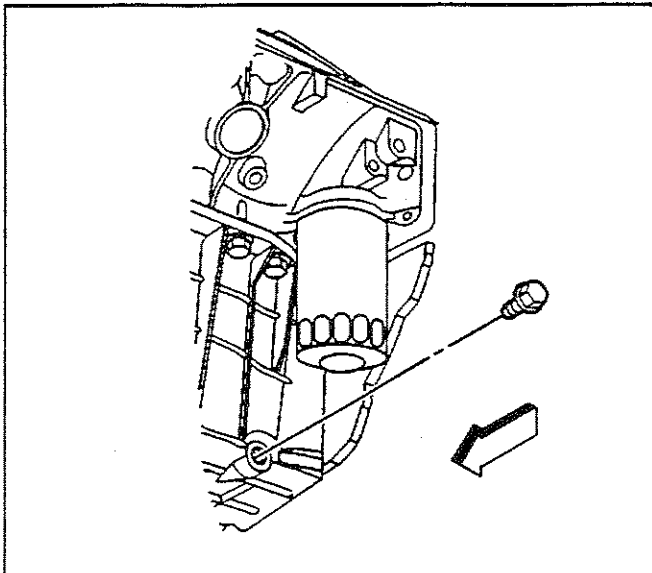
58. Connect the CKP sensor (2) and install the harness in the retainer.
59. Connect the low oil level sensor (3) and install the wire harness in the retainer.
60. Install the exhaust pipe to the exhaust manifolds and tighten the nuts at the catalytic converter flange. Refer to *Catalytic Converter Replacement (Light Duty-4.3L, 4.8L, 5.3L)* in Engine Exhaust.
61. Install the starter motor. Refer to *Starter Motor Replacement (4.3L)* in Engine Electrical.



491824



309158



188048

62. Install the oil pan skid plate (RWD shown).

Tighten

Tighten the oil pan skid plate bolt to 20 N·m (15 lb ft).

63. Install the engine shield. Refer to *Engine Protection Shield Replacement* in Frame and Underbody.
64. Lower the vehicle.
65. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnect/Connect Procedure* in Engine Electrical.
66. Fill the engine with the proper quantity and grade of engine oil. Refer to *Engine Oil and Oil Filter Replacement*.
67. Fill the engine with coolant. Refer to *Draining and Filling Cooling System* in Engine Cooling.
68. Recharge the A/C system. Refer to *Refrigerant Recovery and Recharging* in Heating Ventilation and Air Conditioning.
69. Before starting a new engine, or one that has been repaired. Refer to *Engine Set-Up and Testing*.

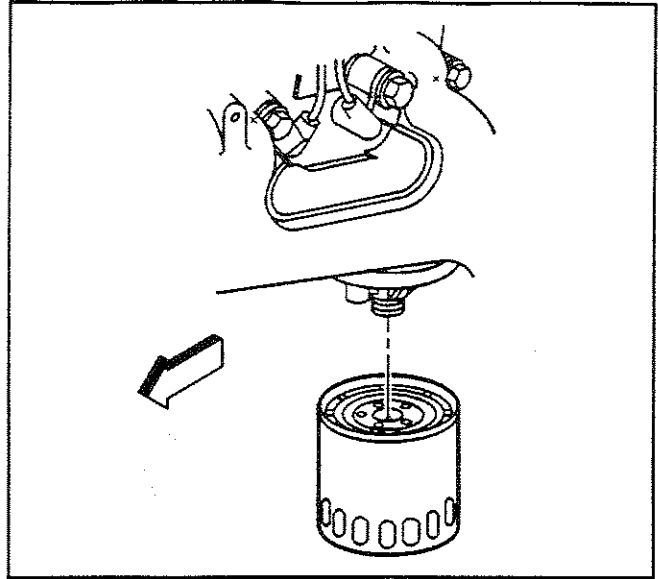
Engine Oil and Oil Filter Replacement

SIE-ID - 478639

Removal Procedure

1. Raise the vehicle. 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.

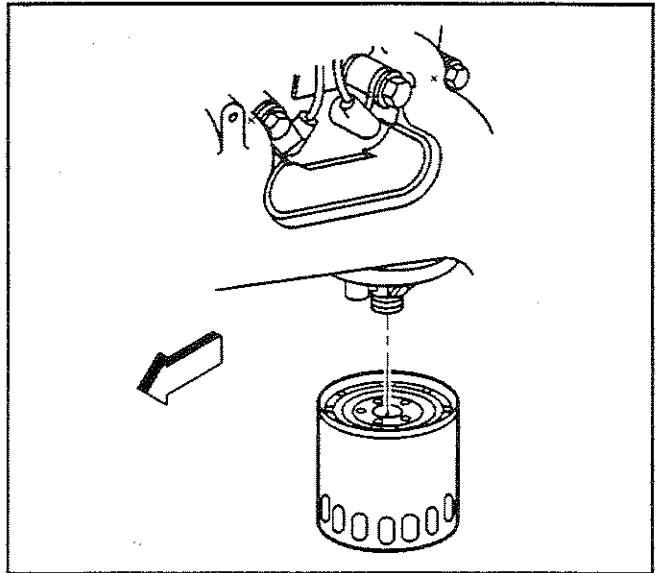
3. Remove the engine oil filter from the engine.
4. Inspect to ensure the engine oil filter gasket is removed.



316766

Installation Procedure

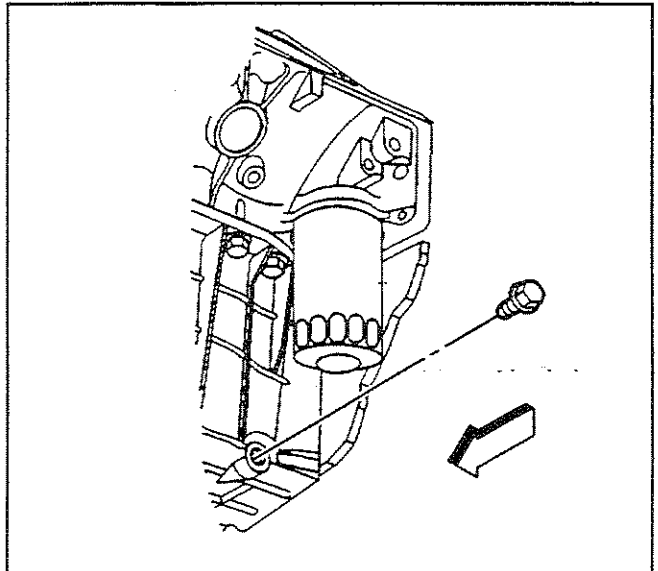
1. Lubricate the engine oil filter gasket with clean engine oil.
2. Install the engine oil filter to the engine.
3. Follow the tightening instructions on the oil filter.



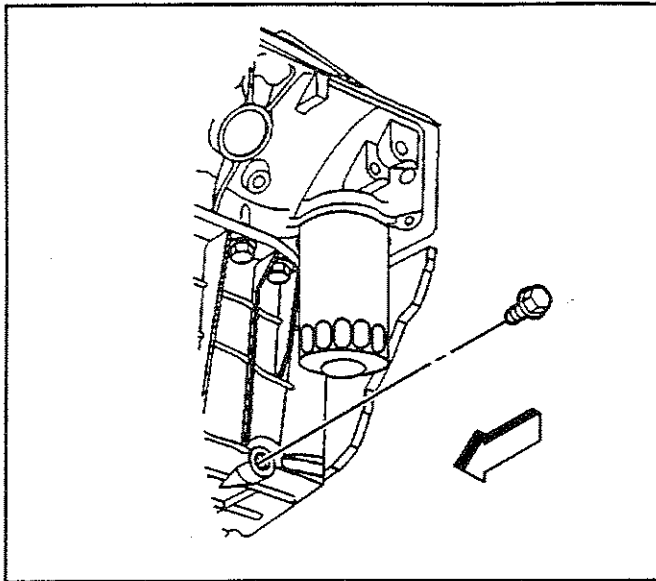
316766

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

4. Install the oil pan drain plug to the oil pan.
Tighten
 Tighten the oil pan drain plug to 25 N·m (18 lb ft).
5. Lower the vehicle.
6. Fill the engine with the proper capacity and quality of engine oil.
 - Refer to *Capacities - Approximate Fluid* in Maintenance and Lubrication.
 - Refer to *Explanation of Scheduled Services* in Maintenance and Lubrication.
7. Operate the engine, check for leaks, and oil pressure.



188048

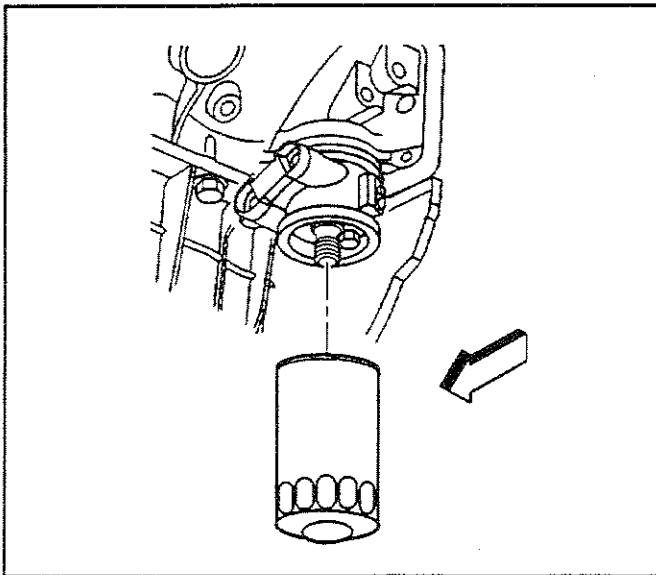


188048

Draining Fluids and Oil Filter Removal

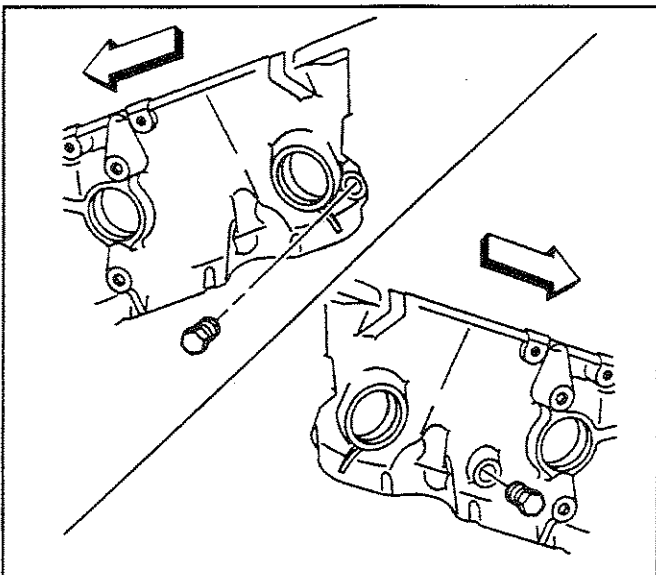
SIE-ID = 43083

1. Remove the oil pan drain plug and allow the engine oil to drain into a suitable container.



188050

2. Remove the oil filter (if applicable).
3. Discard the oil filter (if applicable).



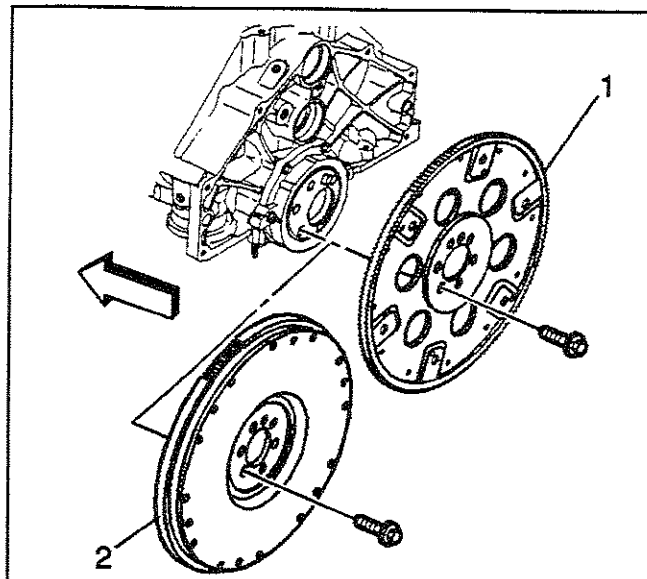
188052

4. Remove both the engine block coolant drain hole plugs and allow the coolant to drain into a suitable container.

Engine Flywheel Removal

SIE-ID = 43618

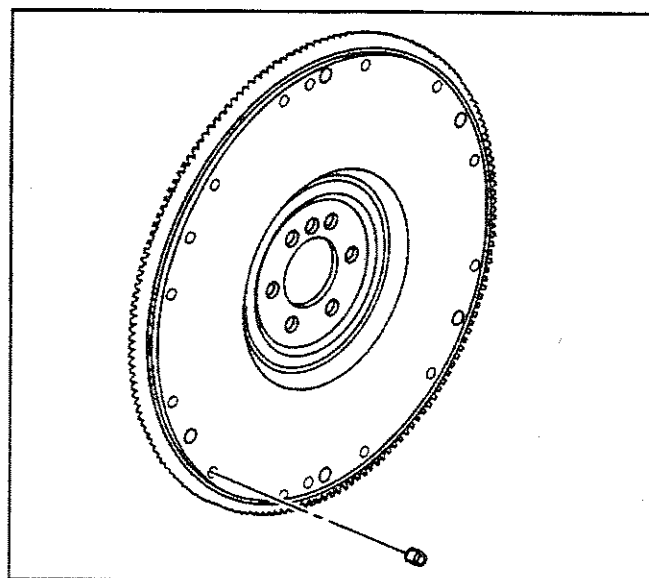
1. Remove the engine flywheel bolts.
2. Remove the engine flywheel (automatic transmission) (1), if applicable.
3. Remove the engine flywheel (manual transmission) (2), if applicable.



188129

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.

Note the position of any flywheel weights for assembly (if applicable).



64126

Clutch Pilot Bearing Removal

SIE-ID = 358553

Tools Required

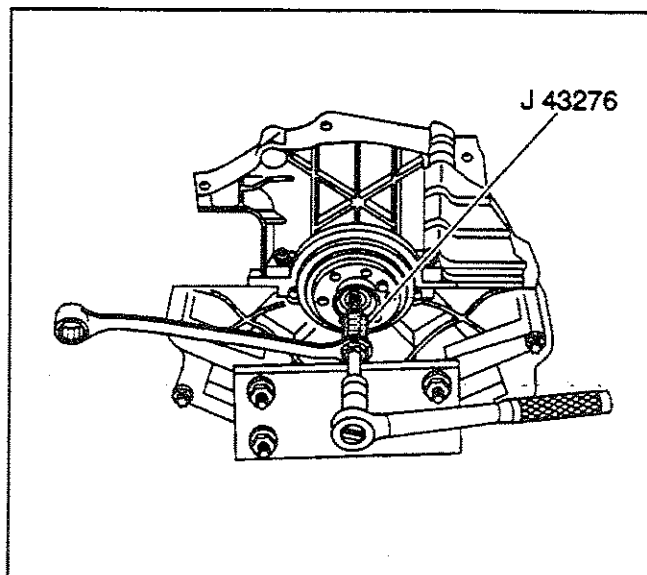
J 43276 Clutch Pilot Bearing Remover

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

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.

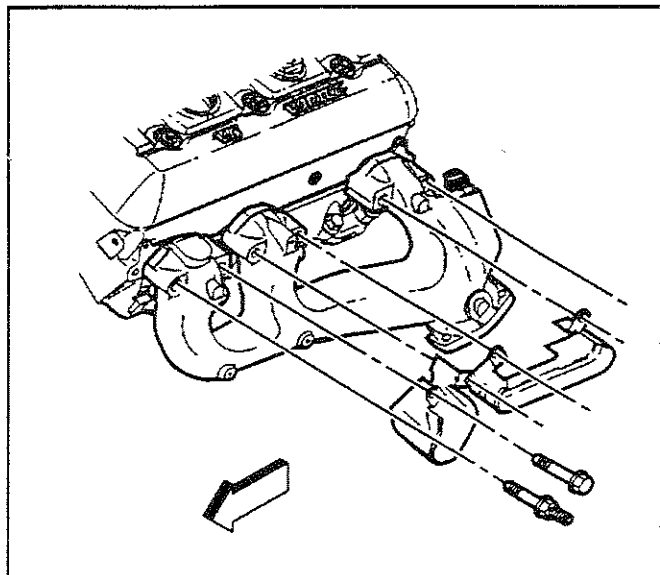
1. Remove the clutch pilot bearing using the J 43276.

- 1.1. Install the J 43276-1 tool body into the clutch pilot bearing.



353275

- 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.



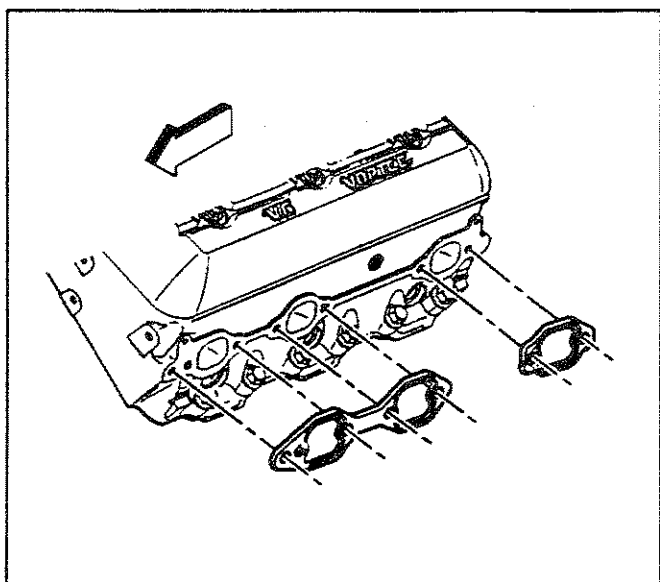
188045

Exhaust Manifold Removal (Left)

SIE-ID = 358511

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 wires from the spark plug wire retainers.
3. Remove the exhaust manifold bolts and the stud.
4. Remove the spark plug wire shields (if applicable) and the exhaust manifold.
5. Remove and discard the exhaust manifold gaskets.



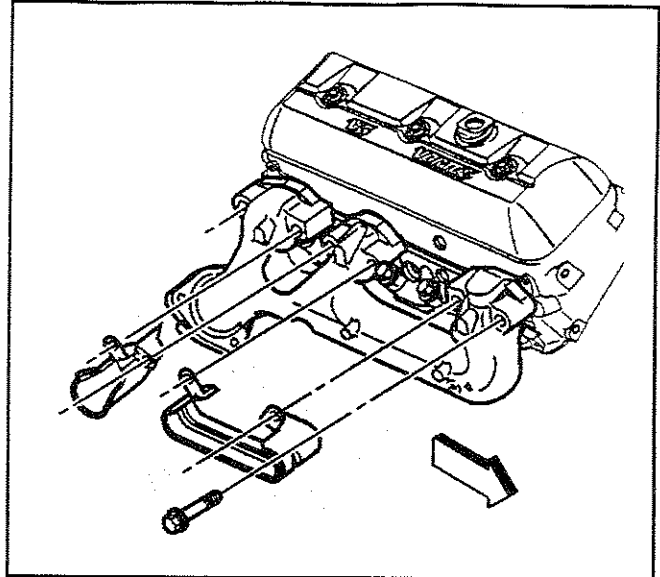
328540

Exhaust Manifold Removal (Right)

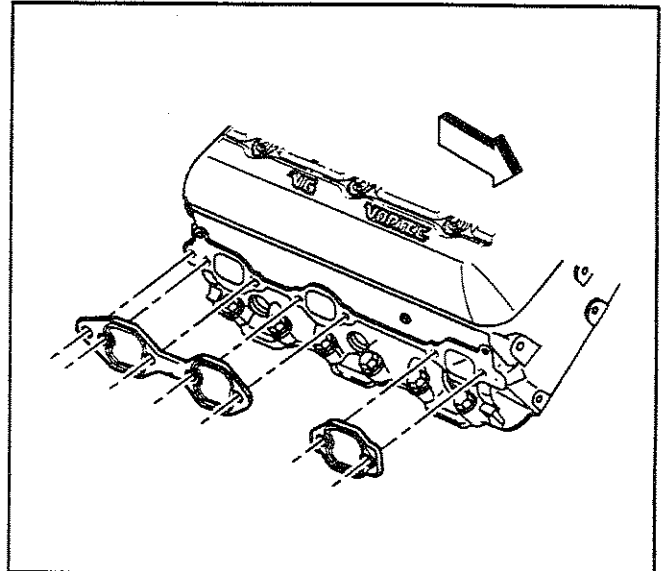
SIE-ID = 358513

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 wires from the spark plug wire retainers.
 3. Remove the exhaust manifold bolts.
 4. Remove the spark plug wire shields and the exhaust manifold.
-
5. Remove and discard the exhaust manifold gaskets.



188121

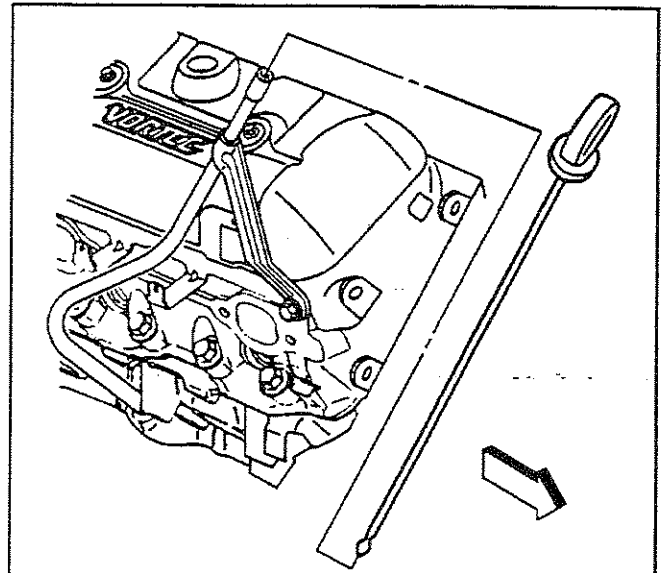


328555

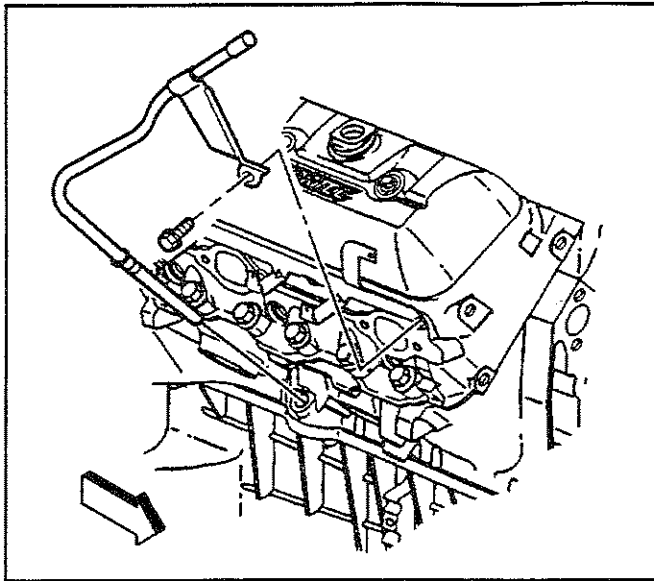
Oil Level Indicator and Tube Removal

SIE-ID = 358529

1. Remove the oil level indicator from the oil level indicator tube, if required.

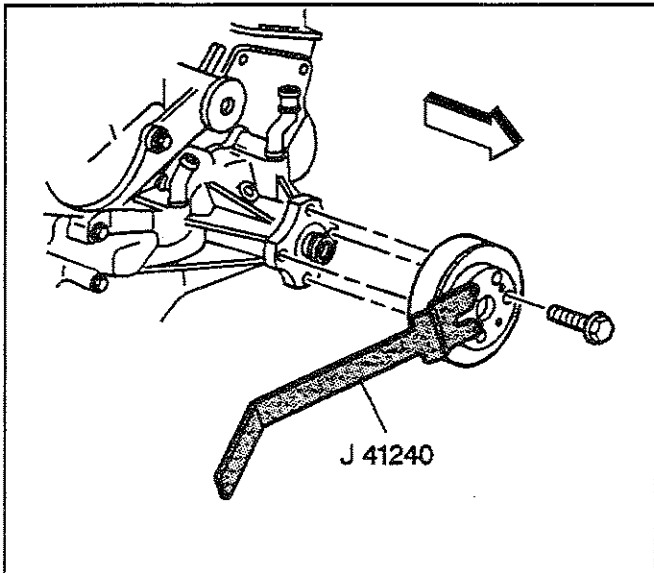


330580



188047

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



317191

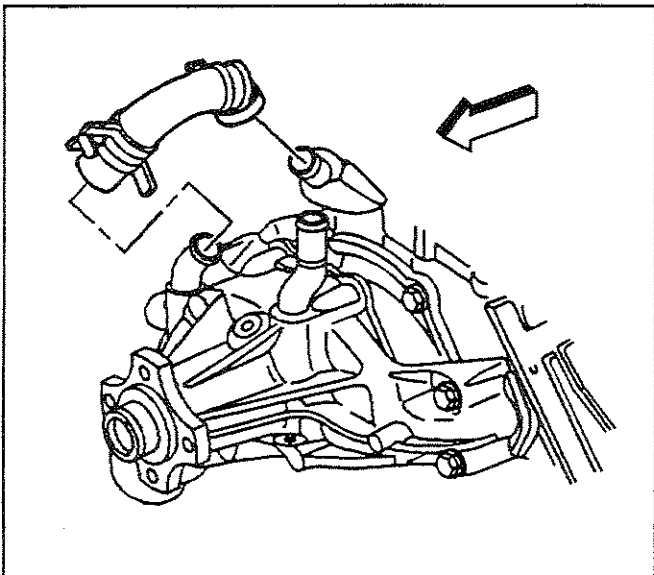
Water Pump Removal

SIE-ID - 358515

Tools Required

J 41240 Fan Clutch Remover and Installer

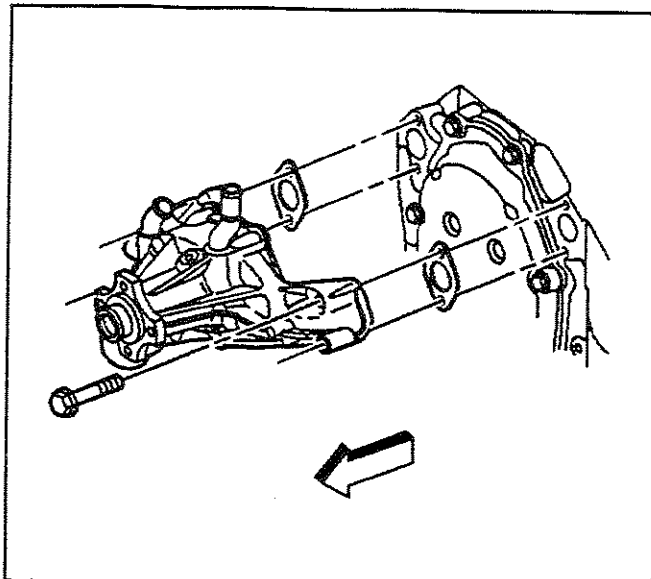
1. Remove the bolts and the fan and water pump pulley using the J 41240.



182853

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.



188054

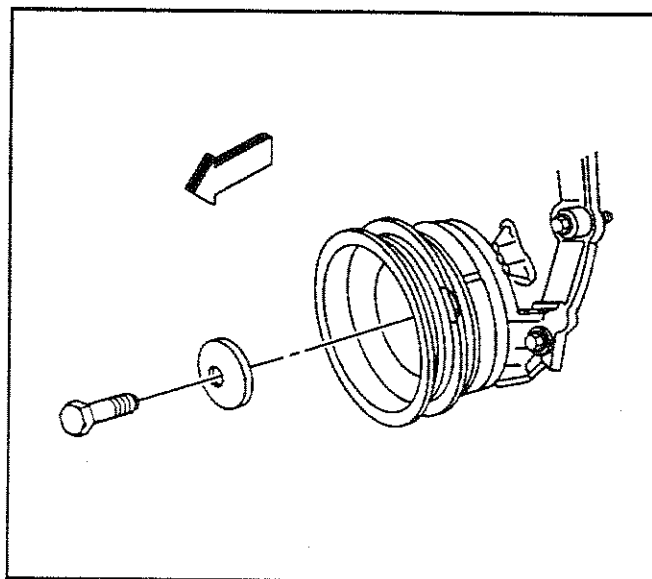
Crankshaft Balancer Removal

SIE-ID - 358517

Tools Required

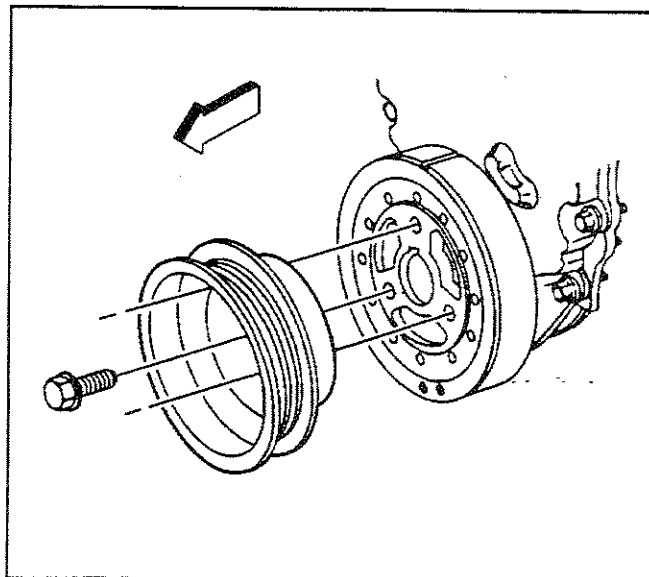
J 23523-F Balancer Remover and Installer

1. Remove the crankshaft balancer bolt and washer.

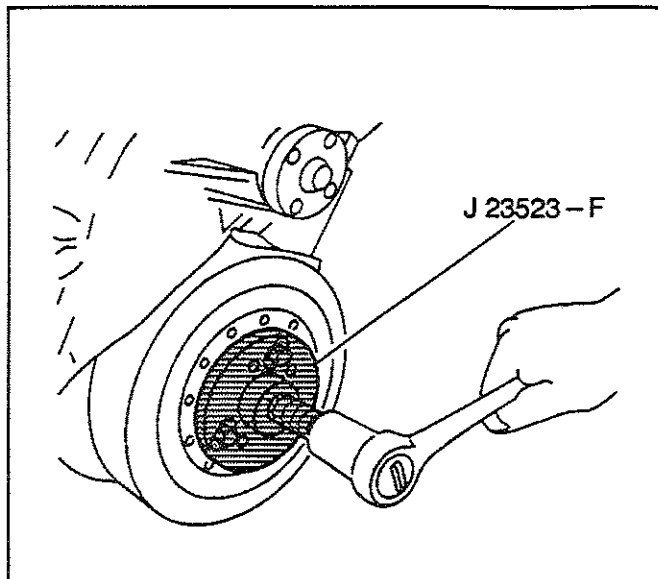


173172

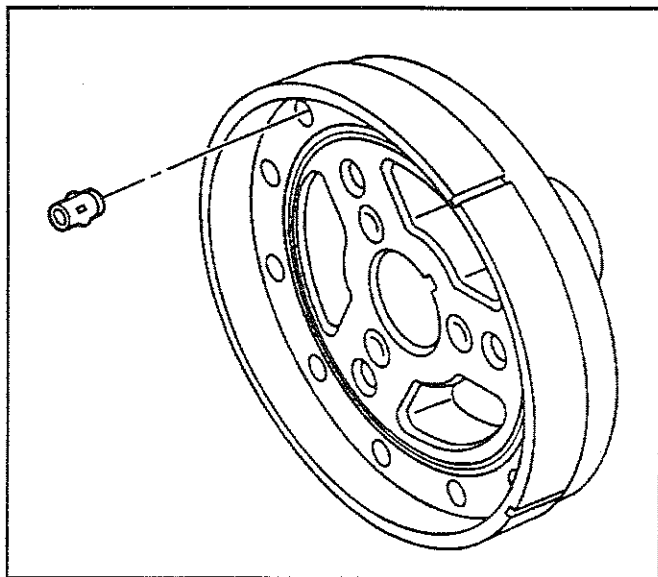
2. Remove the bolts and the crankshaft pulley.



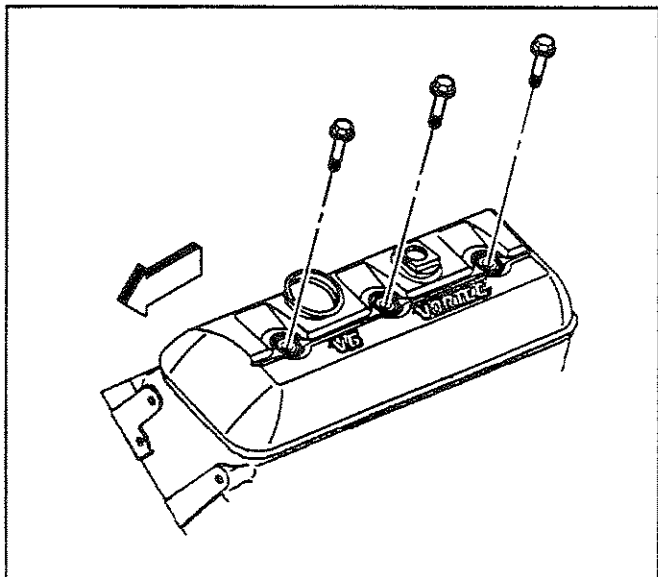
188055



4059



334258



328566

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 onto the crankshaft balancer.

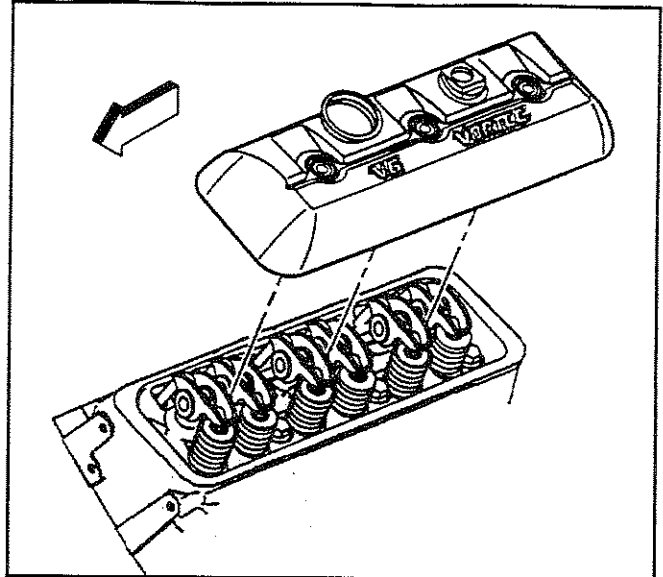
Tighten
Tighten the bolts to 25 N·m (18 lb ft).
 - 3.2. Install the *J 23523-F* forcing screw into the plate.
 - 3.3. Rotate the *J 23523-F* forcing screw clockwise in order to remove the crankshaft balancer.
4. Remove the *J 23523-F* from the crankshaft balancer.
5. Note the position of any front groove pins (crankshaft balancer) (if applicable).

Valve Rocker Arm Cover Removal (Left)

SIE-ID = 506842

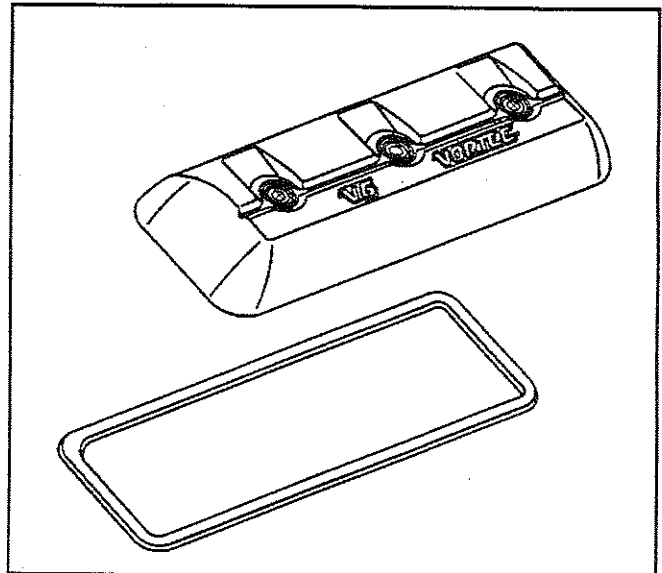
1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover bolt grommets.
3. Discard the valve rocker arm cover bolt grommets.

4. Remove the valve rocker arm cover.



480519

5. Remove the valve rocker arm cover gasket.
6. Discard the valve rocker arm cover gasket.

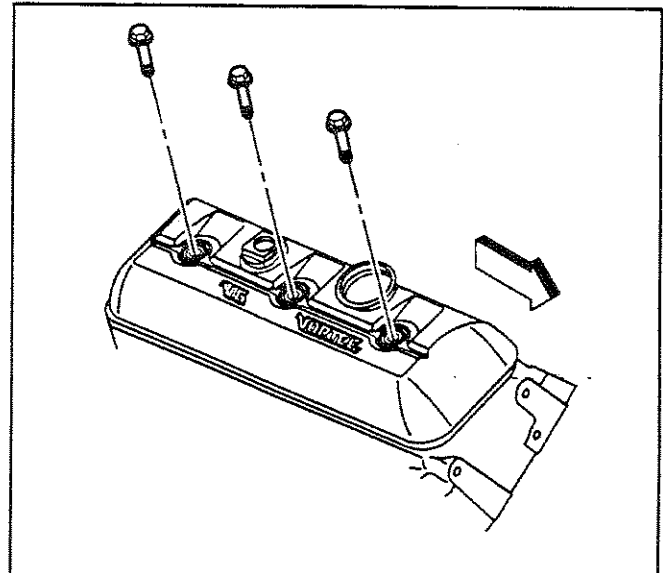


328573

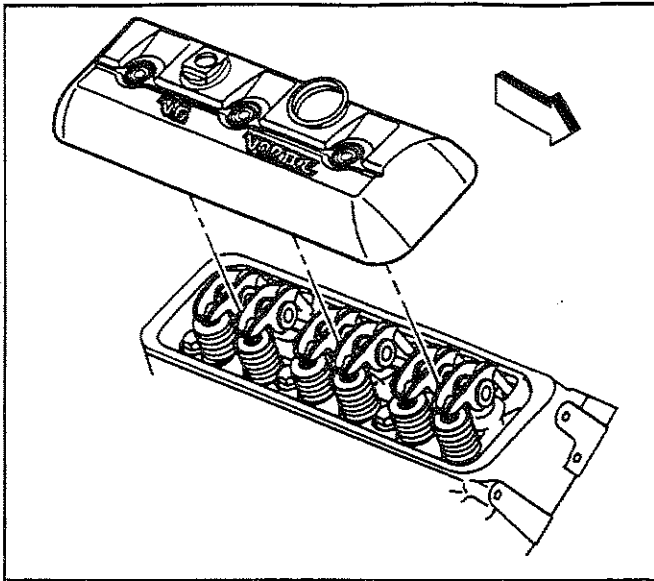
Valve Rocker Arm Cover Removal (Right)

SIE-ID • 506845

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.

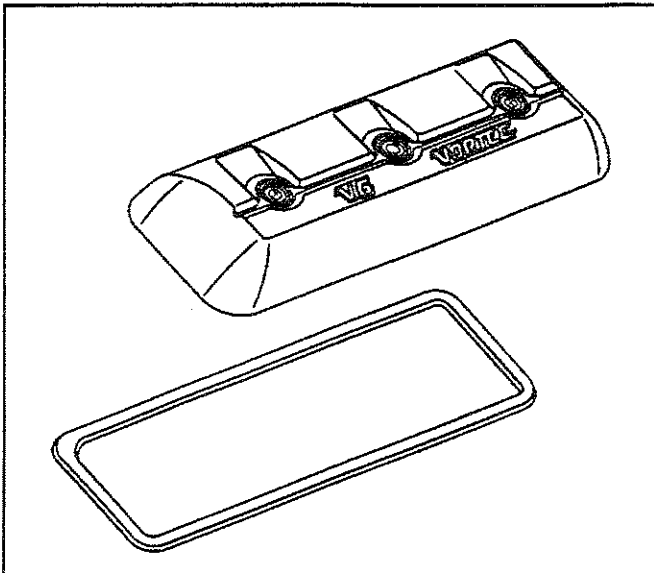


328568



480524

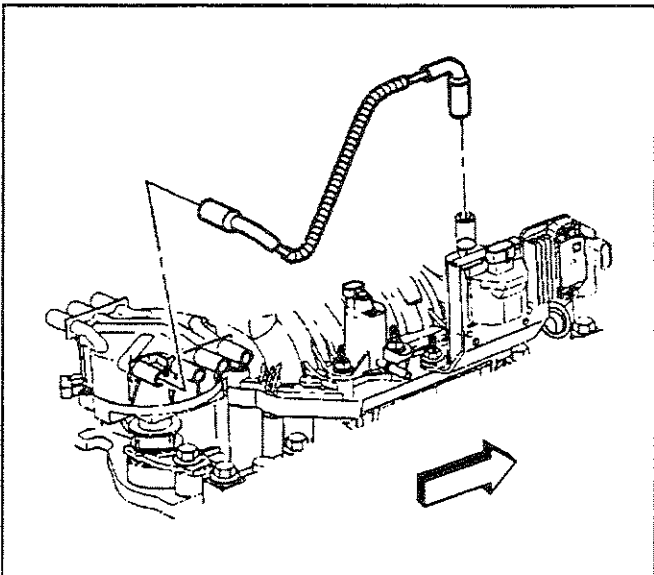
4. Remove the valve rocker arm cover.



328573

5. Remove the valve rocker arm cover gasket.

6. Discard the valve rocker arm cover gasket.



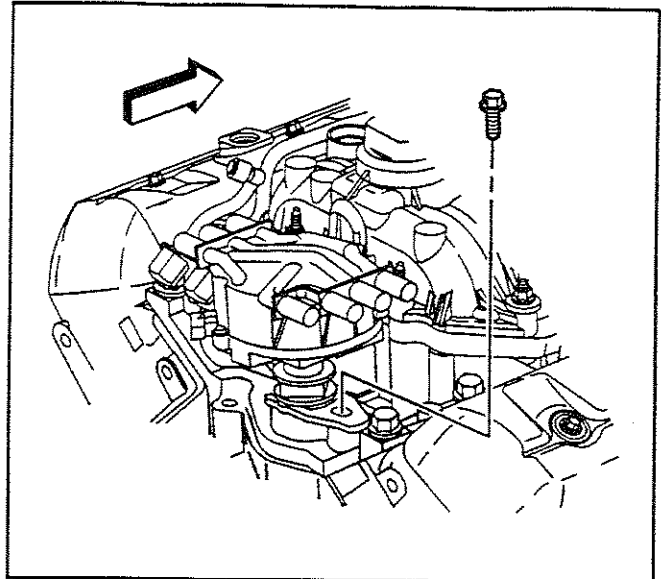
328575

Distributor Removal

S/E-ID - 358521

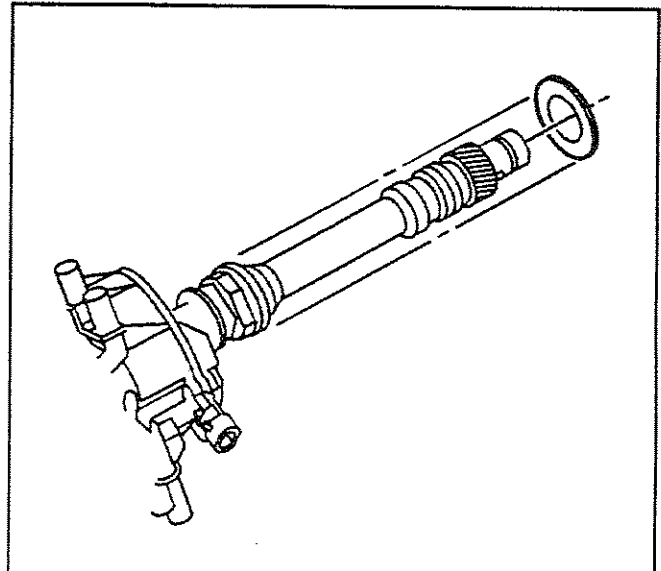
1. Remove the ignition coil wire harness from the ignition coil and distributor cap.

2. Remove the distributor clamp bolt.
3. Remove the distributor and the distributor clamp.



569265

4. Remove the distributor gasket and discard.

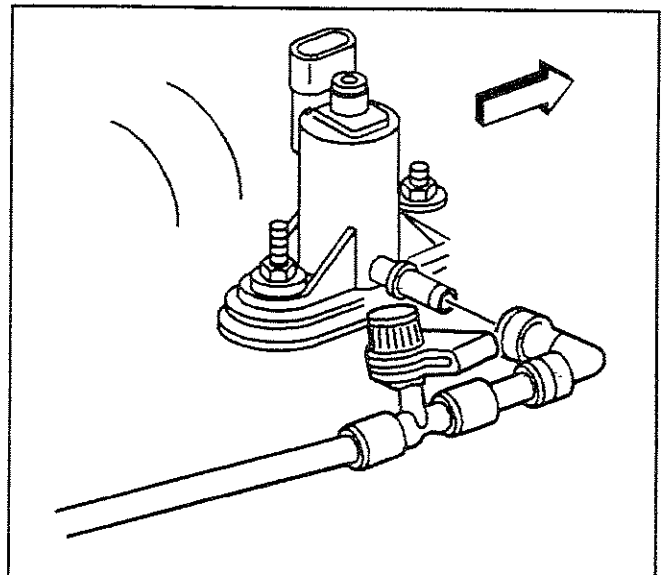


523516

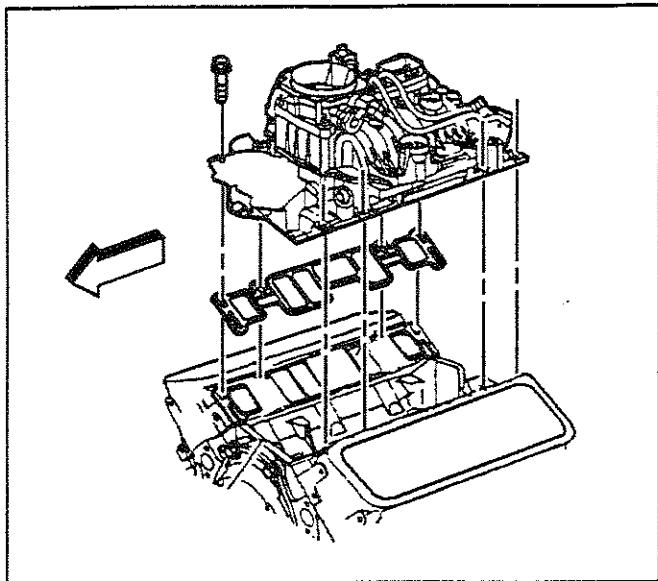
Intake Manifold Removal

SIE-ID # 358523

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.



328579



31510

2. Remove the engine coolant temperature (ECT) sensor wire connector (if equipped) from the engine wiring harness bracket.
3. Remove the lower intake manifold bolts.

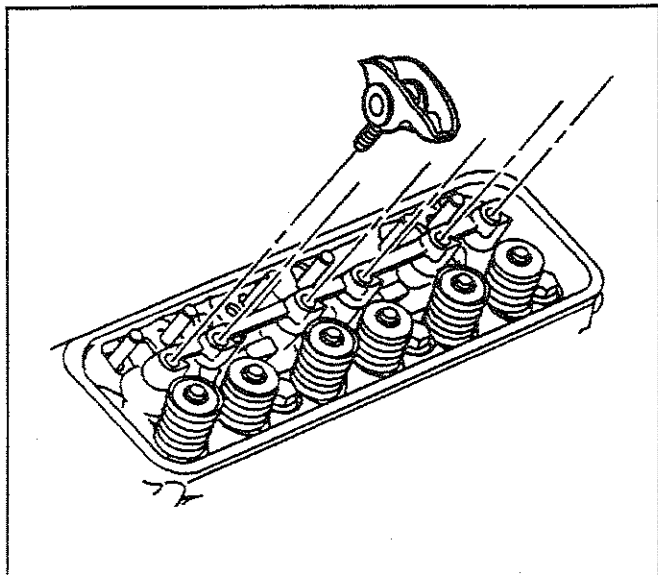
Important: The intake manifold may be removed as an assembly. Do not remove the specific intake manifold components unless component service is required.

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.

Remove the intake manifold assembly.

4. Remove and discard the lower intake manifold gaskets.



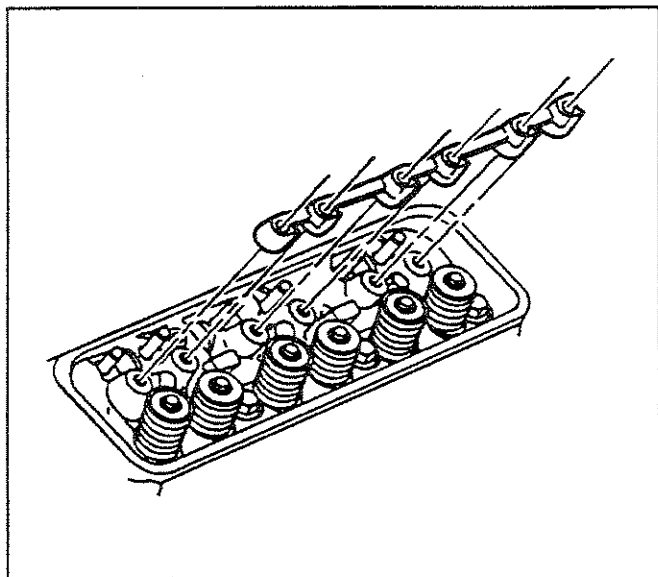
480526

Valve Rocker Arm and Push Rod Removal

SIE-ID - 506855

Important: Mark, sort, and organize all the components for assembly.

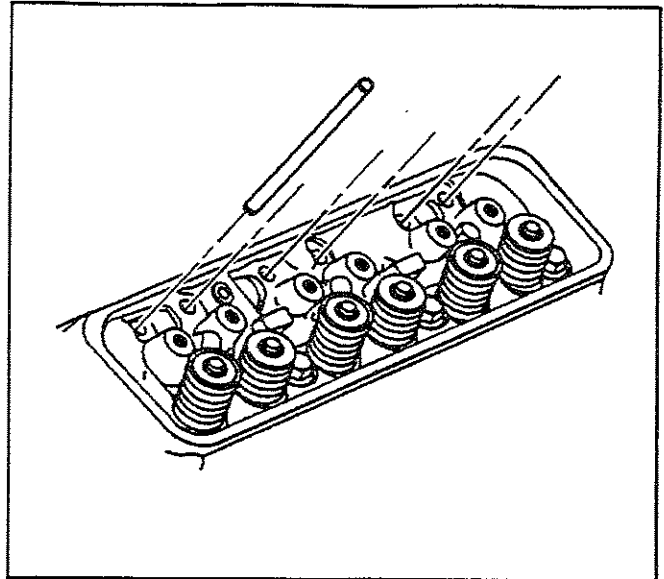
Remove the valve rocker arms.



480527

1. Remove the valve rocker arm supports.

2. Remove the valve pushrods.

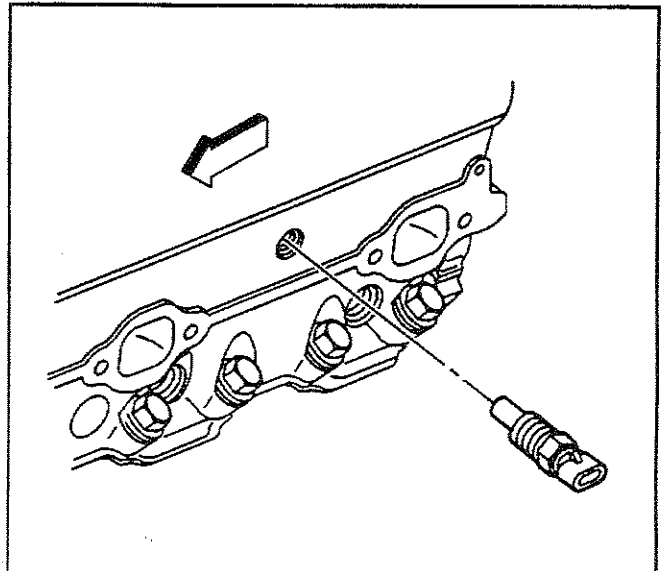


480529

Cylinder Head Removal (Left)

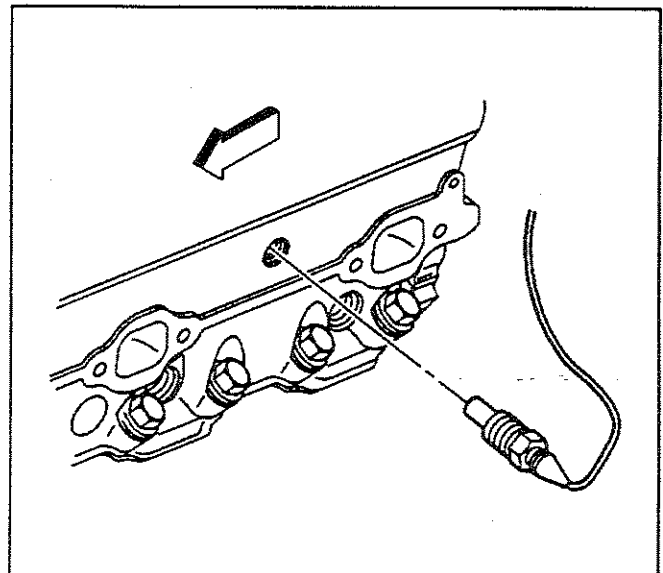
SIE-ID - 506859

1. Remove the engine coolant temperature sensor (if applicable).

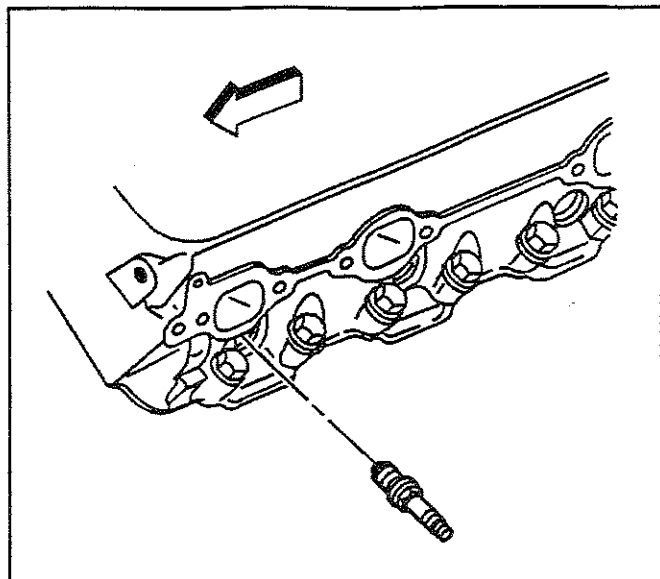


387769

2. Remove the engine coolant temperature gauge sensor (if applicable).

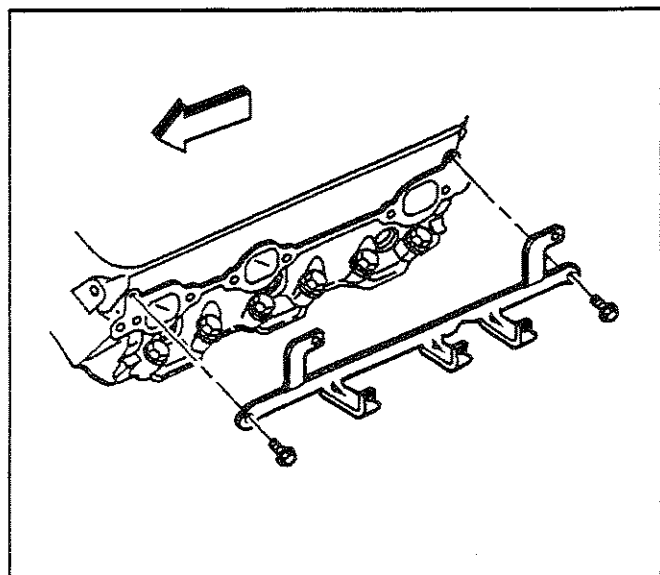


387767



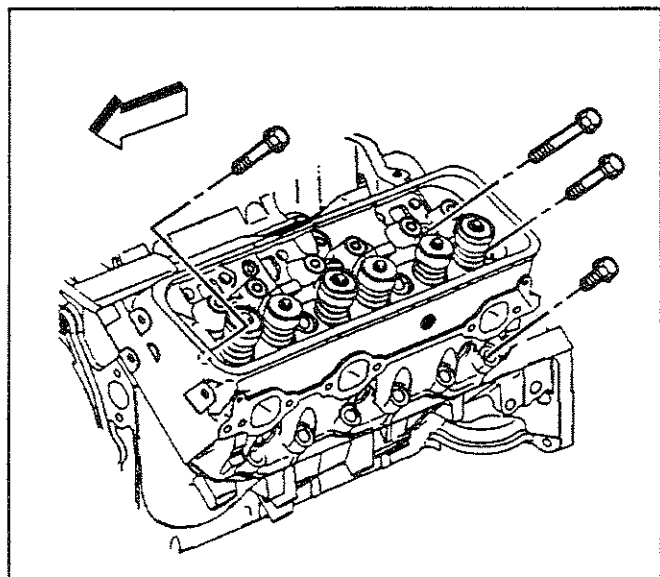
328582

3. Remove the spark plugs.



328588

4. Remove the bolts and the spark plug wire support.

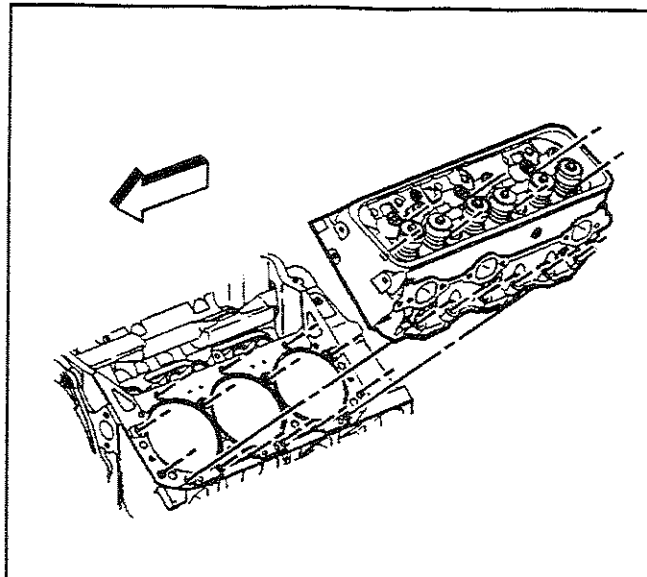


480533

5. Remove the cylinder head bolts.

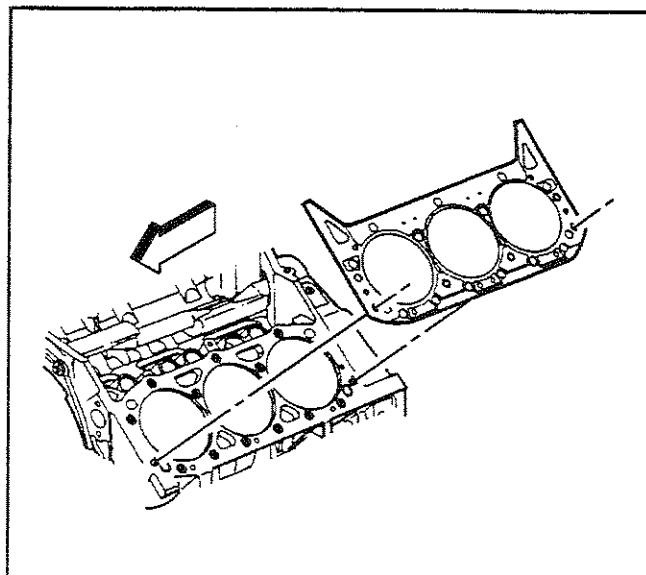
Notice: SIO-ID = 13838 After removal, place the cylinder head on two wood blocks to prevent damage.

6. Remove the cylinder head.



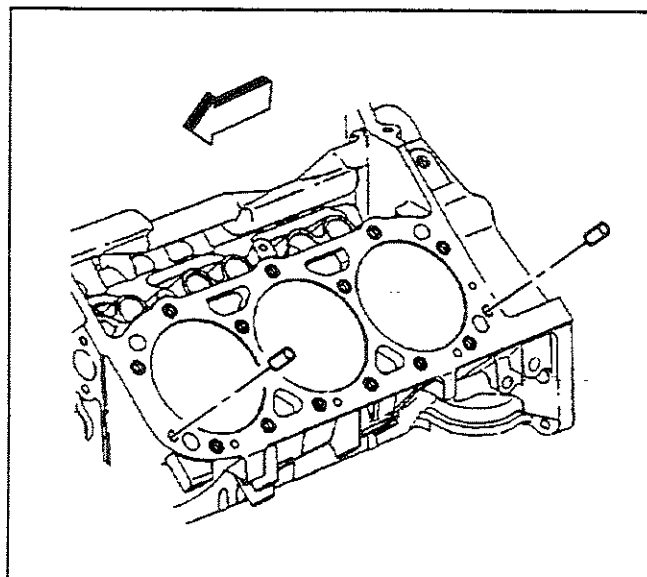
480536

7. Remove and discard the cylinder head gasket.



334299

8. Remove the dowel pins (cylinder head locator) (if required).

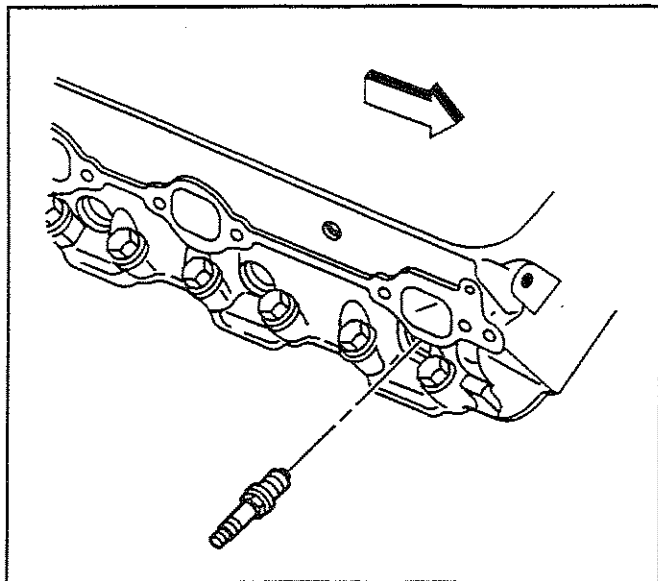


330548

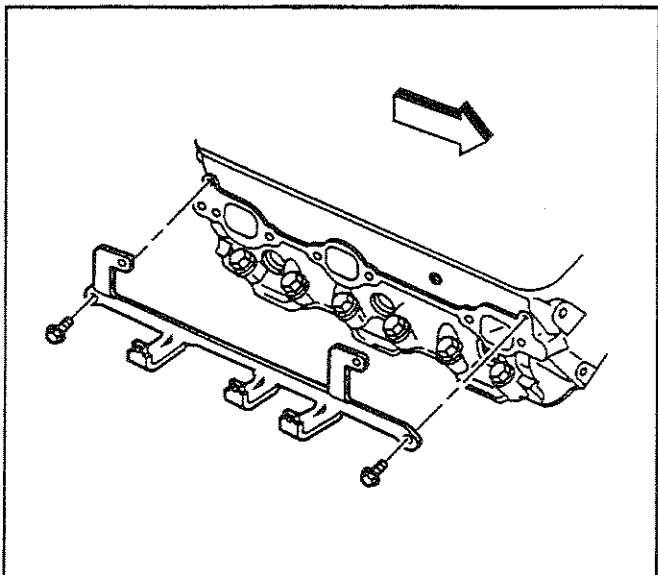
Cylinder Head Removal (Right)

SIE-ID = 506865

1. Remove the spark plugs.

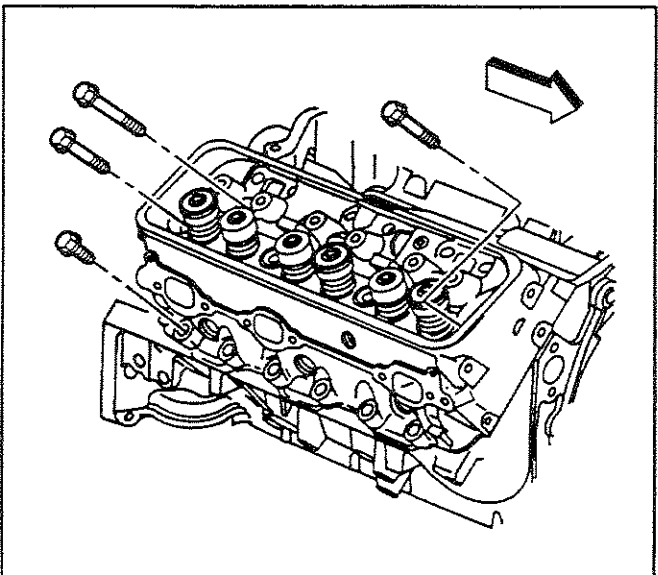


328586



328590

2. Remove the rear bolt and the spark plug wire support.

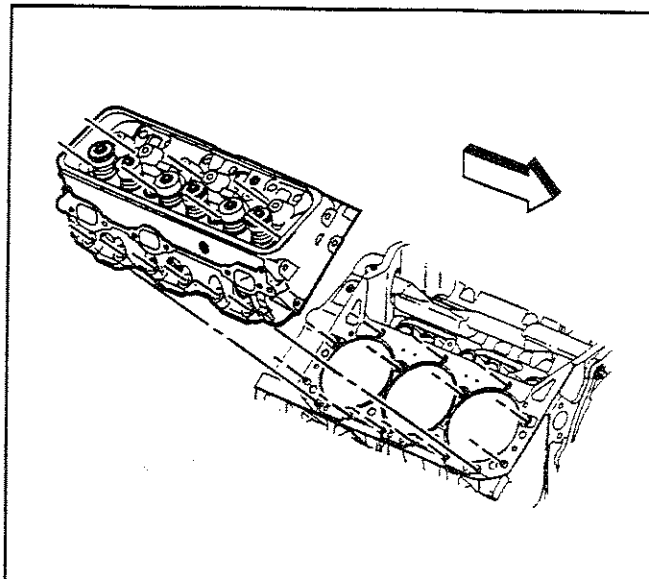


480537

3. Remove the cylinder head bolts.

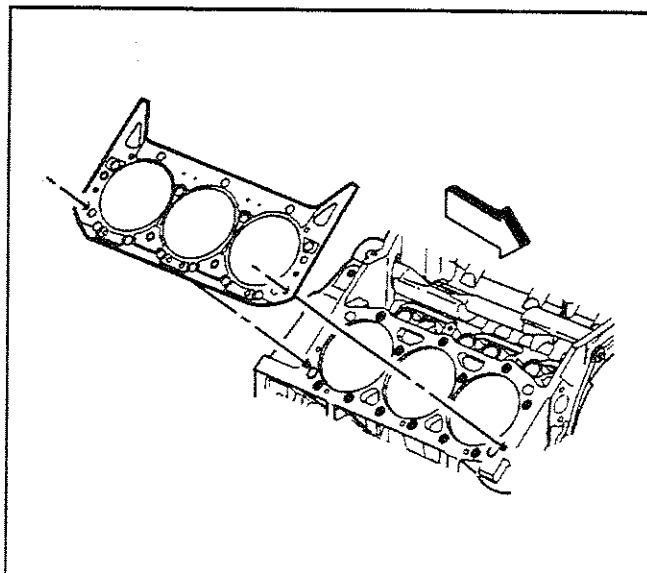
Notice: SIO-ID = 13838 After removal, place the cylinder head on two wood blocks to prevent damage.

4. Remove the cylinder head.



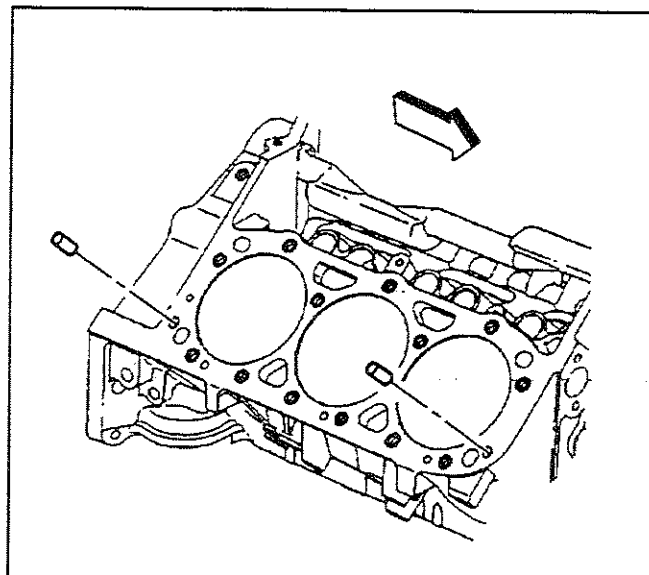
480538

5. Remove and discard the cylinder head gasket.

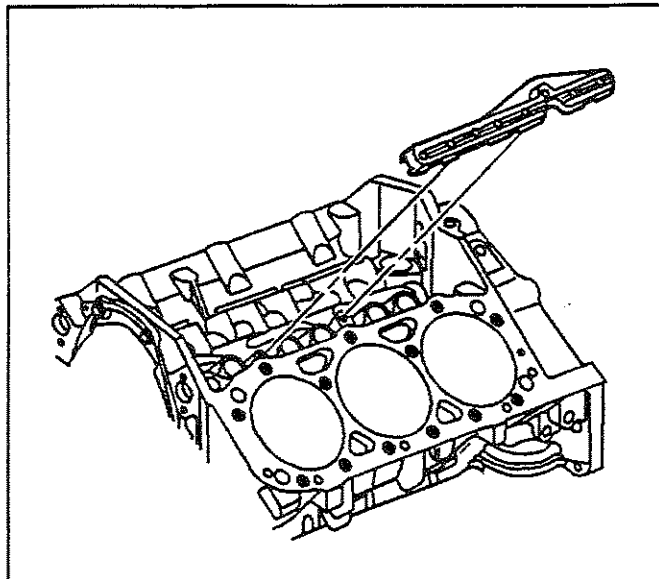


334312

6. Remove the dowel pins (cylinder head locator) (if required).



330553



328592

Valve Lifter Removal

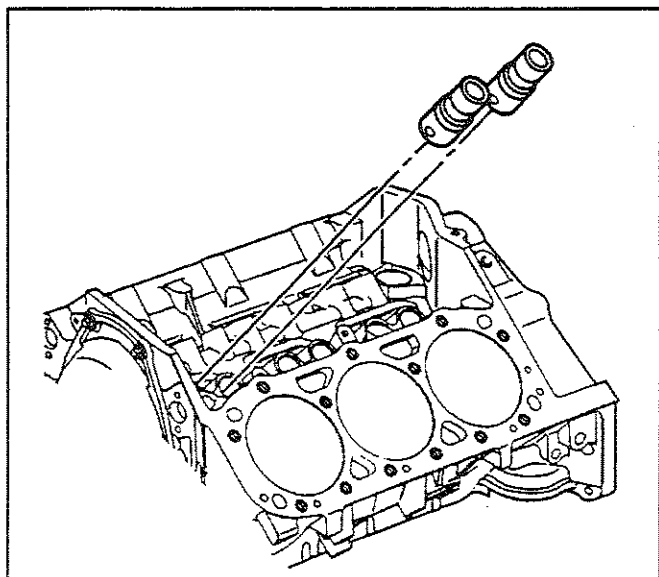
SIE-ID - 358526

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.

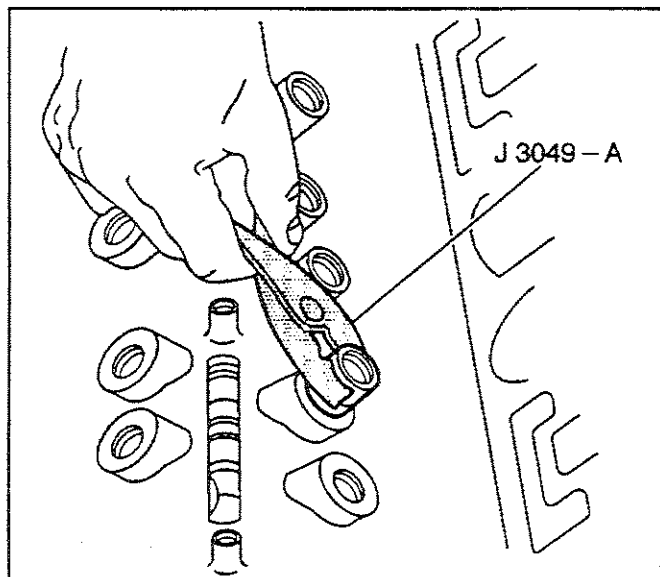
Remove the bolts and valve lifter pushrod guide.



328593

Important: Place the valve lifters in the rack in the upright position in order to maintain the oil inside the valve lifters.

Remove the valve lifters.



31350

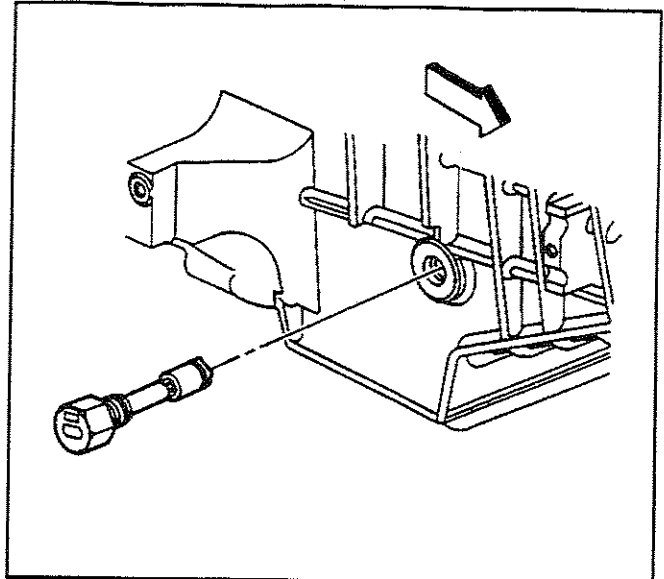
Important: Some valve lifters may be stuck in the valve lifter bores because of gum or varnish deposits and may require the use of J 3049-A for removal.

Use the J 3049-A in order to remove the stuck valve lifters.

Oil Pan Removal

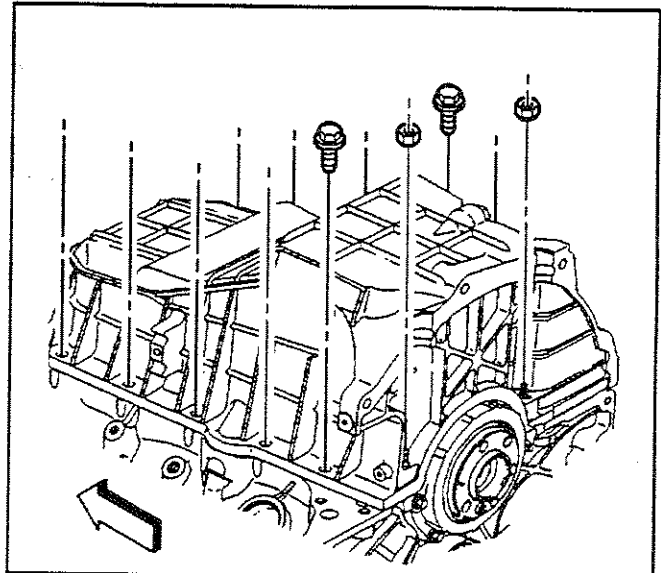
S/E-ID = 358527

1. Remove and discard the engine oil level sensor (if applicable).



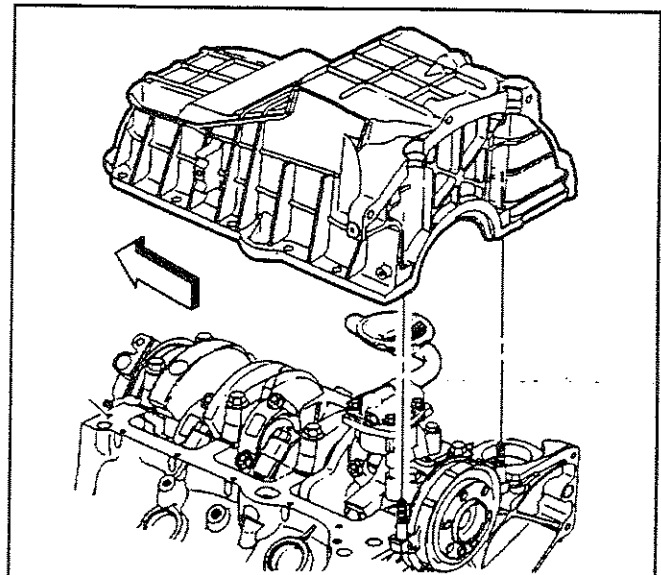
387460

2. Remove the oil pan bolts and nuts.

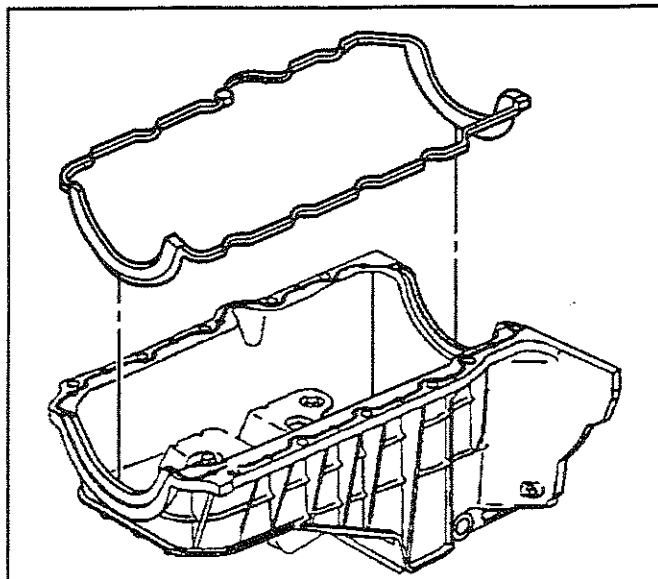


330559

3. Remove the oil pan.

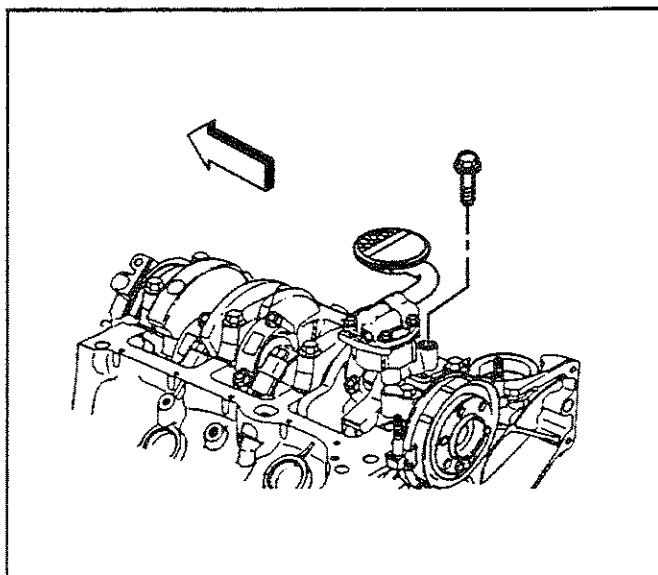


330568



387757

4. Remove the oil pan gasket.
5. Discard the oil pan gasket.

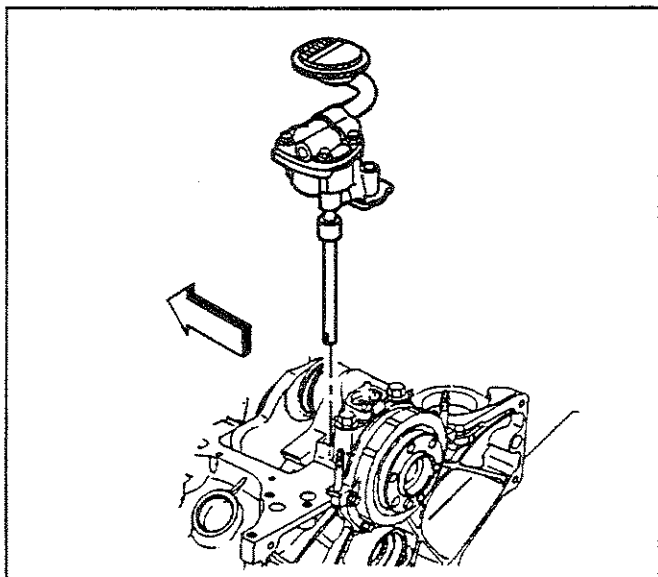


330572

Oil Pump Removal

SIE-ID = 358528

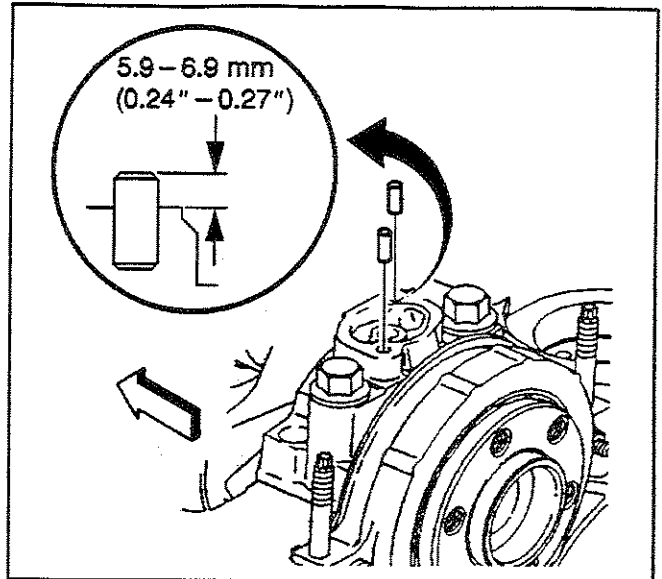
1. Remove the oil pump bolt.



330576

2. Remove the oil pump.

3. Inspect the pins (oil pump locator) for damage, and replace the pins if required.

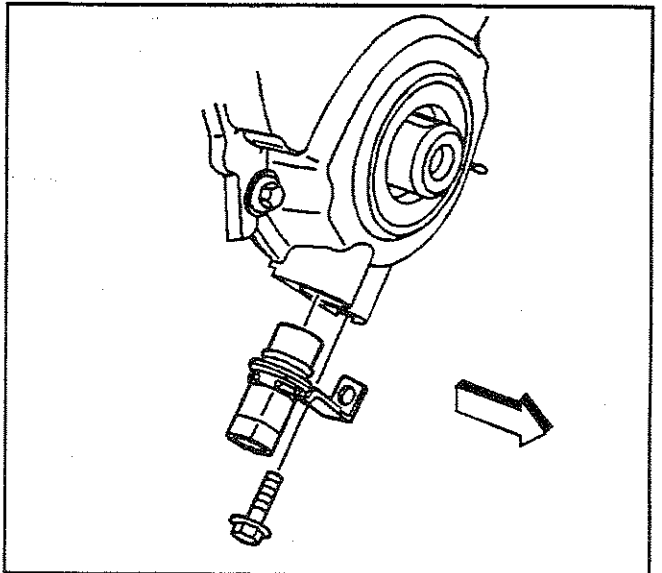


330578

Engine Front Cover Removal

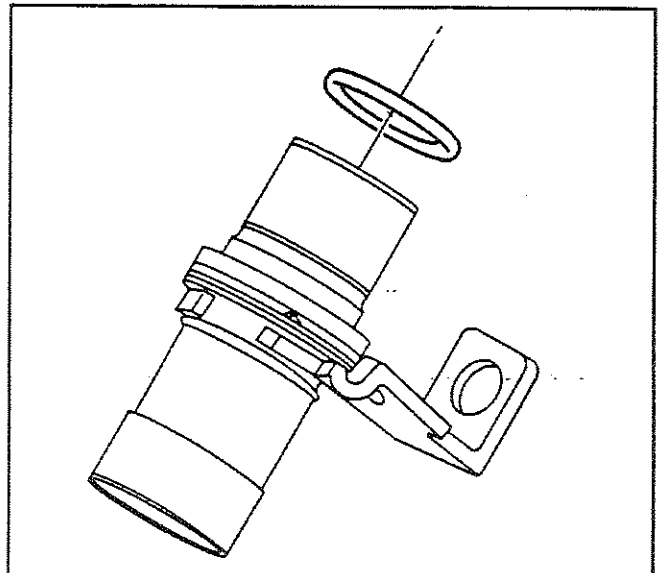
SIE-ID # 506867

1. Remove the crankshaft position sensor bolt.
2. Remove the crankshaft position sensor.

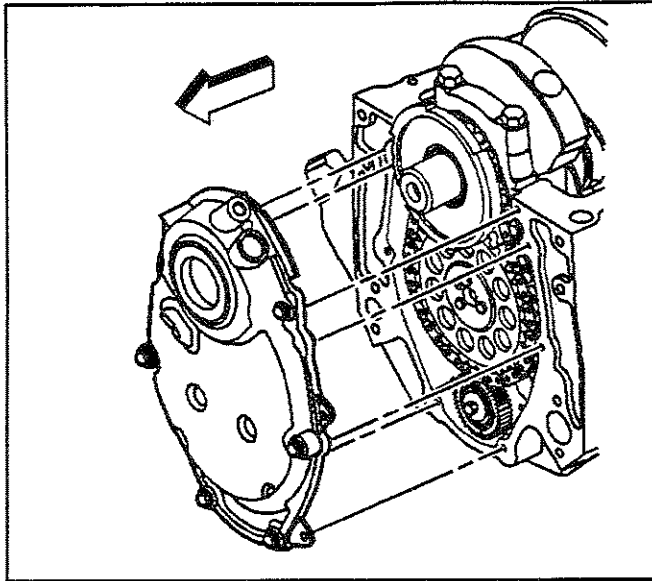


11485

3. Remove the crankshaft position sensor seal (O-ring).
4. Discard the crankshaft position sensor seal (O-ring).



387759



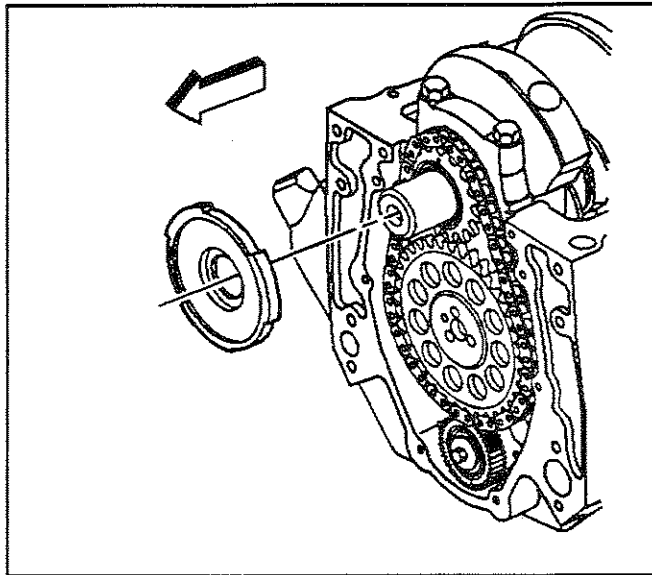
480539

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.

Remove the engine front cover.

6. Discard the engine front cover.



480541

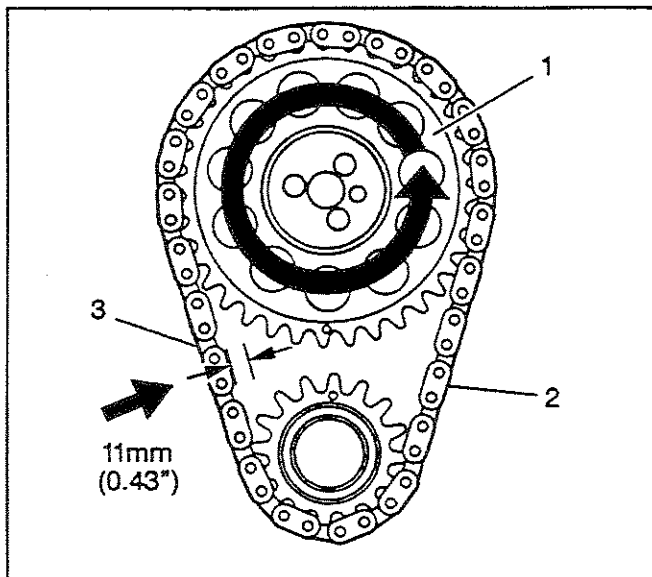
Timing Chain and Sprockets Removal

SIE-ID = 506868

Tools Required

J 5825-A Crankshaft Gear Remover

1. Remove the crankshaft position sensor reluctor ring.

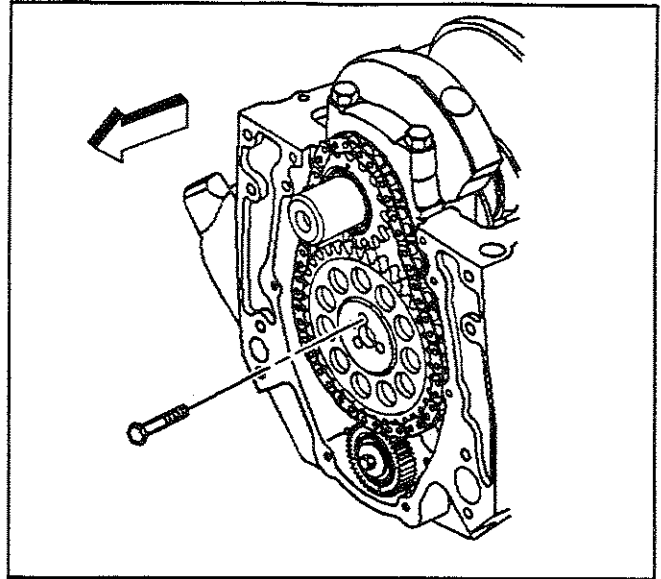


480542

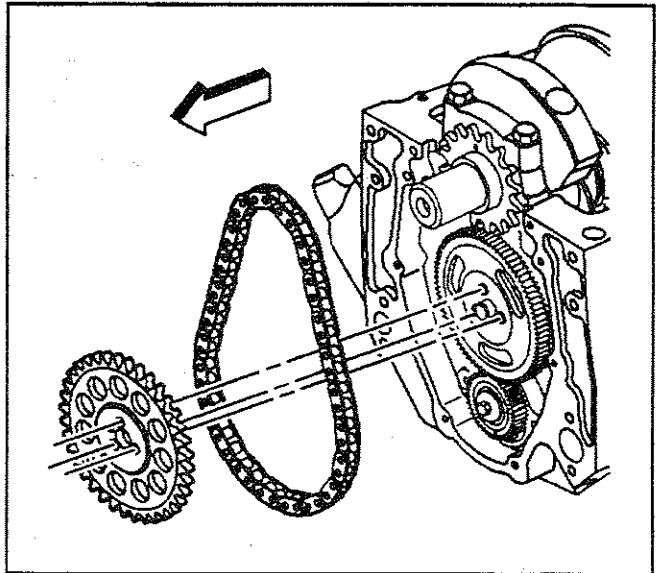
2. Check the camshaft timing chain free play.
 - 2.1. Rotate the camshaft sprocket (1) counterclockwise until all slack is removed from the camshaft timing chain (2).
 - 2.2. Measure the free play on the slack side (3) of the camshaft timing chain.

If the camshaft timing chain can be moved side to side in excess of 11 mm (0.43 in), replacement of the camshaft timing chain and the sprockets is recommended during assembly.

3. Remove the camshaft sprocket bolts.

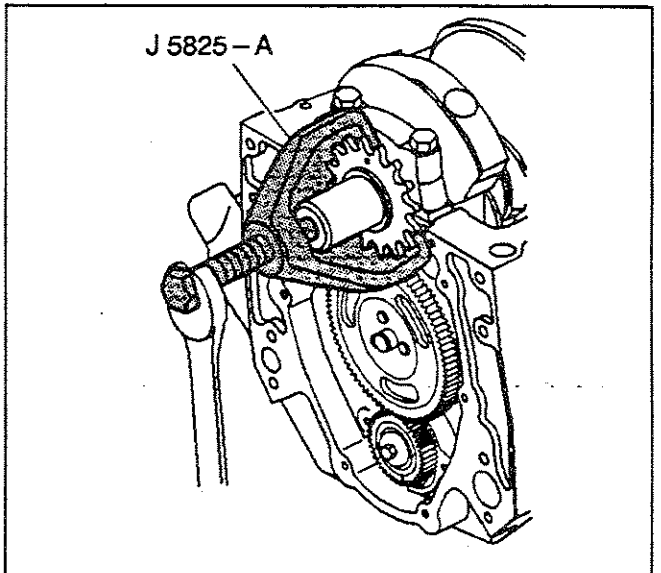


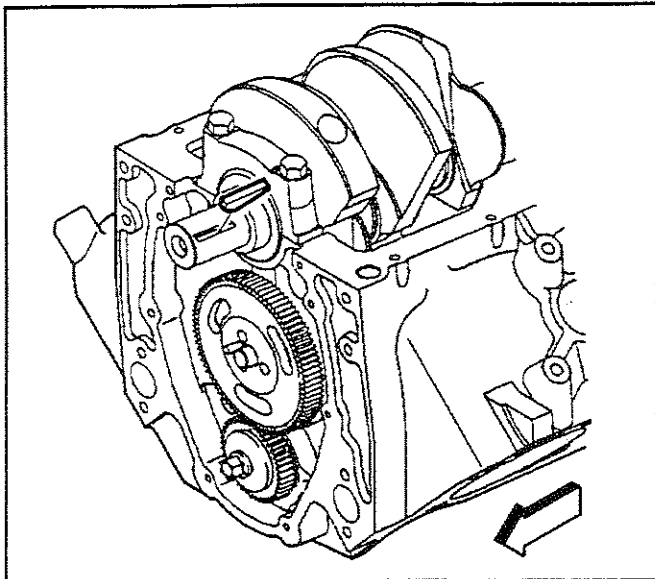
4. Remove the camshaft sprocket and the camshaft timing chain.



Caution: Refer to Safety Glasses Caution in Cautions and Notices.

5. Remove the crankshaft sprocket using the J 5825-A.





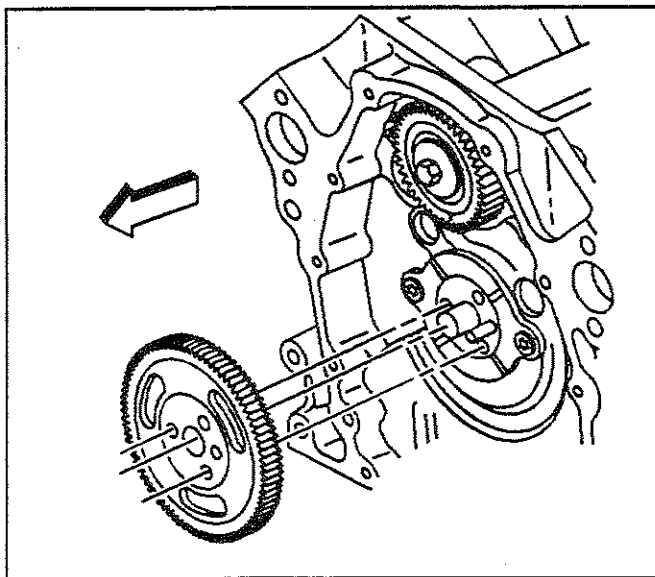
387761

6. Remove the crankshaft balancer key.

Balance Shaft Removal

SIE-ID = 358918

1. Remove the balance shaft drive gear.



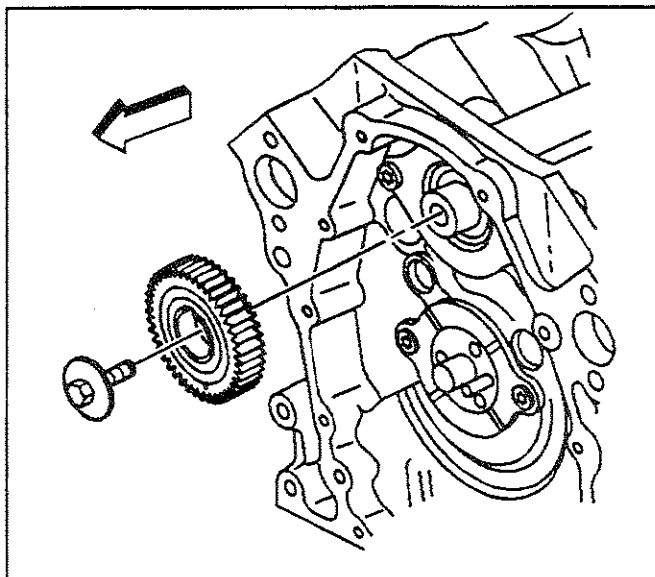
9847

Important: The balance shaft drive and balance shaft driven gears are serviced as a set. The set includes the balance shaft driven gear bolt.

Remove the balance shaft driven gear bolt from the balance shaft.

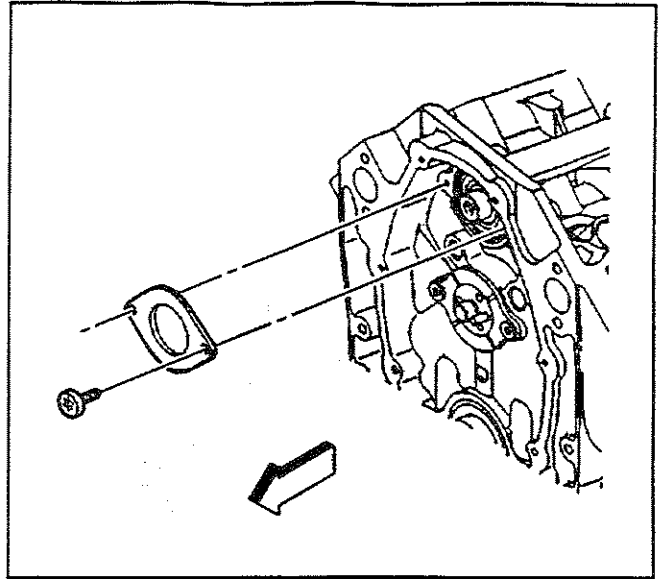
- 1.1. Use a wrench in order to secure the balance shaft.
Place the wrench onto the balance shaft near to the balance shaft front bearing.
- 1.2. Remove the balance shaft bolt.
- 1.3. Remove the wrench from the balance shaft.

2. Remove the balance shaft driven gear from the balance shaft.



5136

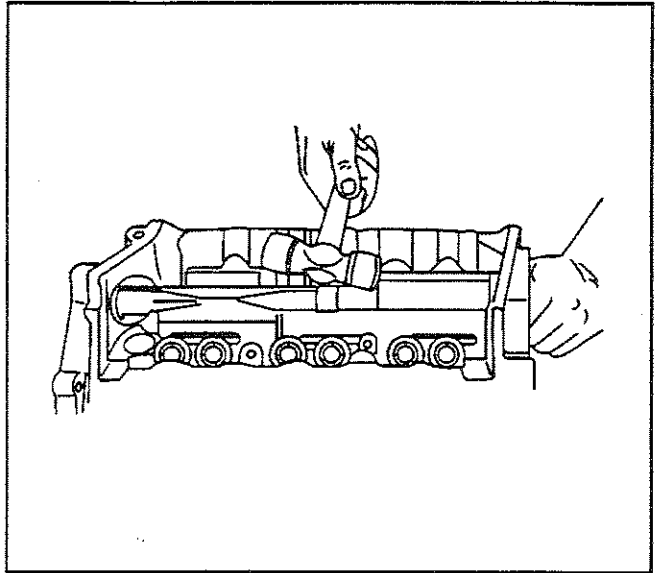
3. Remove the bolts and the balance shaft retainer.



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.

Use a soft-faced hammer in order to remove the balance shaft from the engine block.

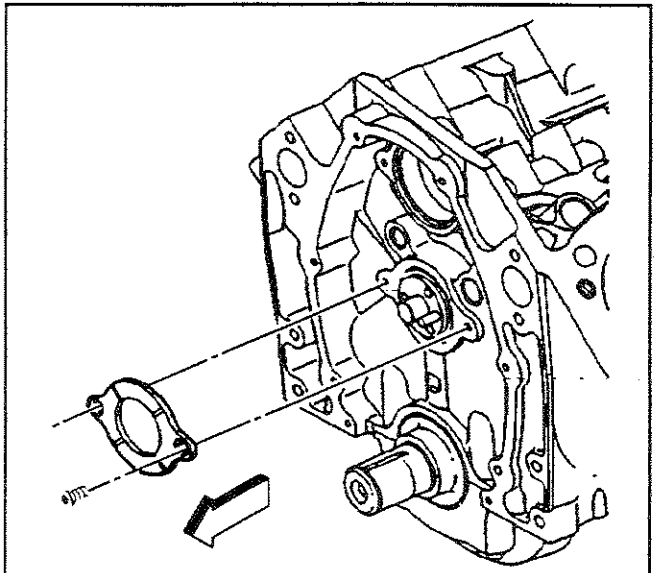


5139

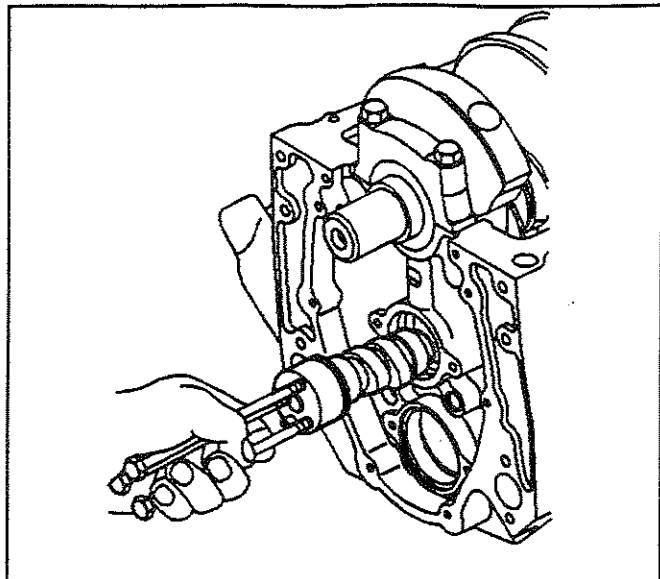
Camshaft Removal

SIE-ID - 42977

1. Remove the camshaft retainer bolts and retainer.



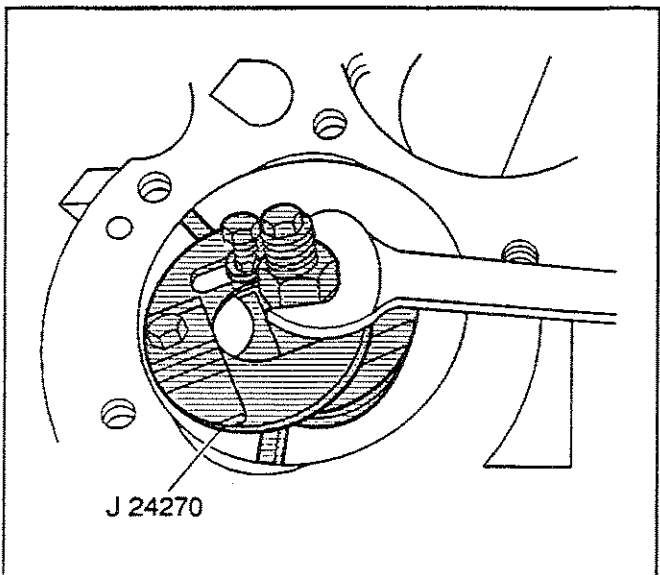
188030



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

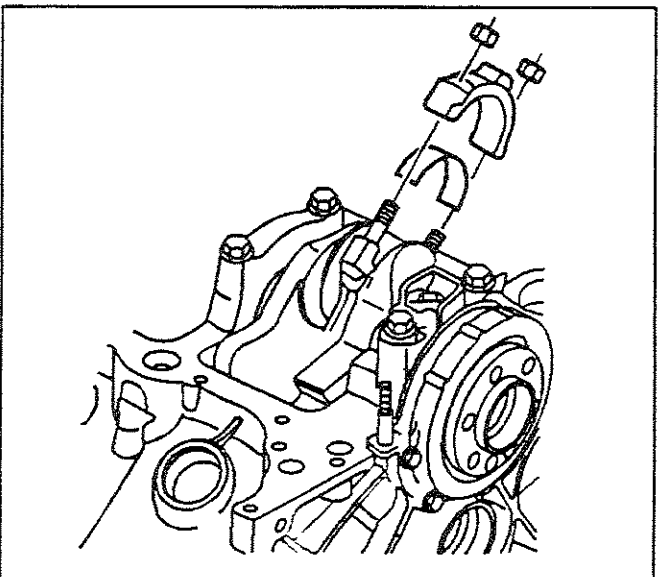
Piston, Connecting Rod, and Bearing Removal

SIE-ID = 42978

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.



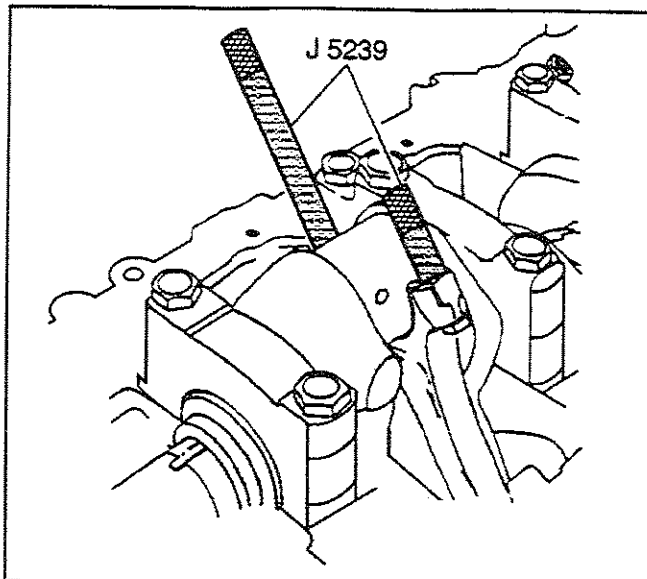
480549

Important: Place matchmarks or numbers on the connecting rods and the connecting rod caps.

Remove the connecting rod nuts.

2. Remove the connecting rod cap.

3. 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.

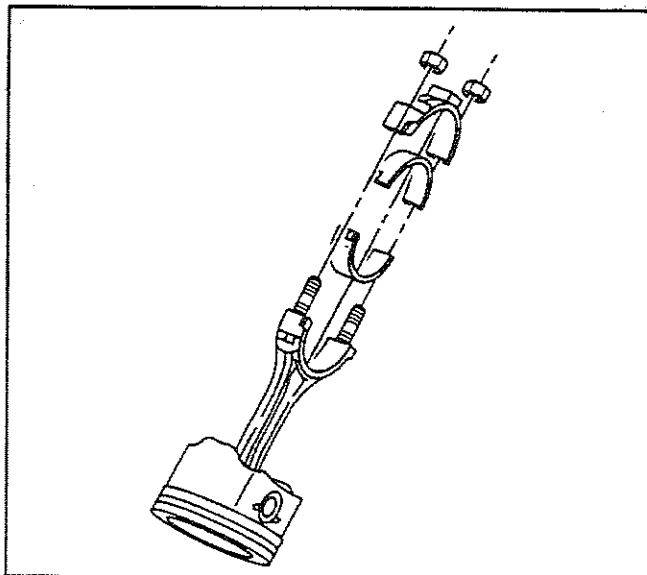


31373

Important: Always assemble the connecting rod caps to the matching connecting rods.

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.

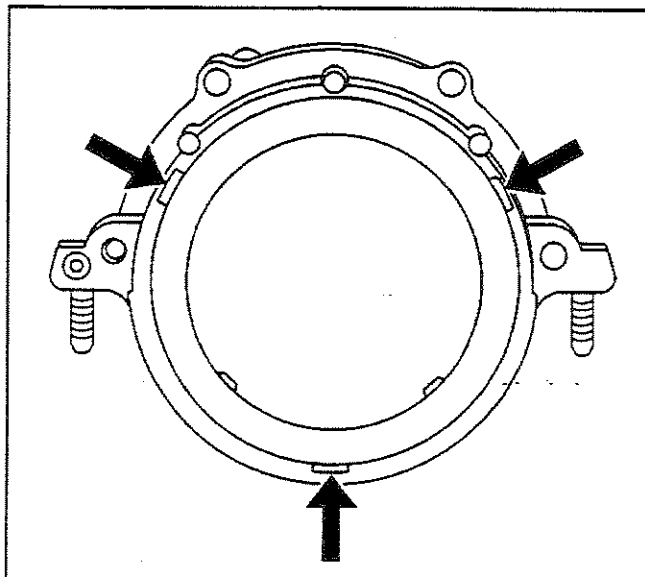


188017

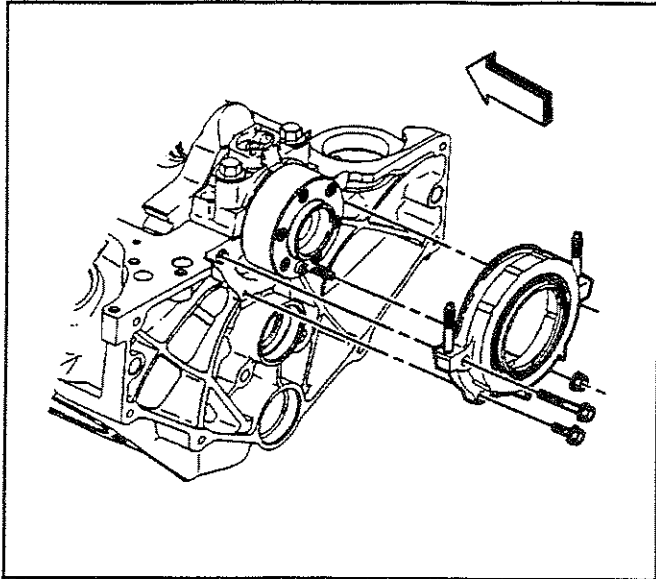
Crankshaft Rear Oil Seal and Housing Removal

SIE-ID = 358535

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.

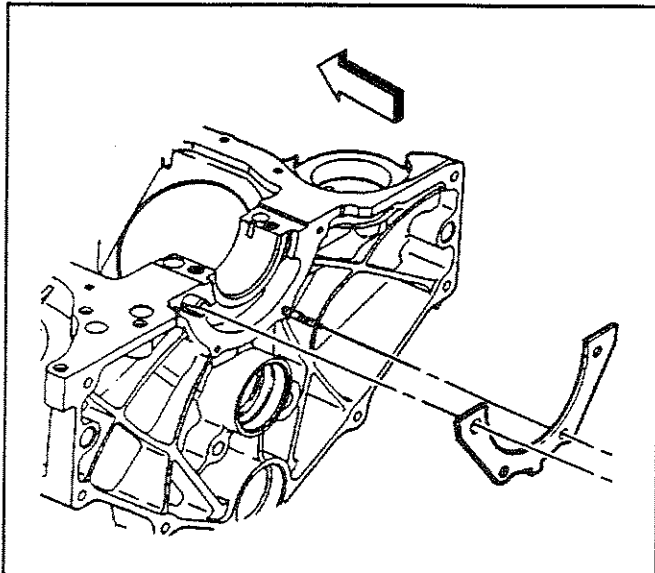


31379



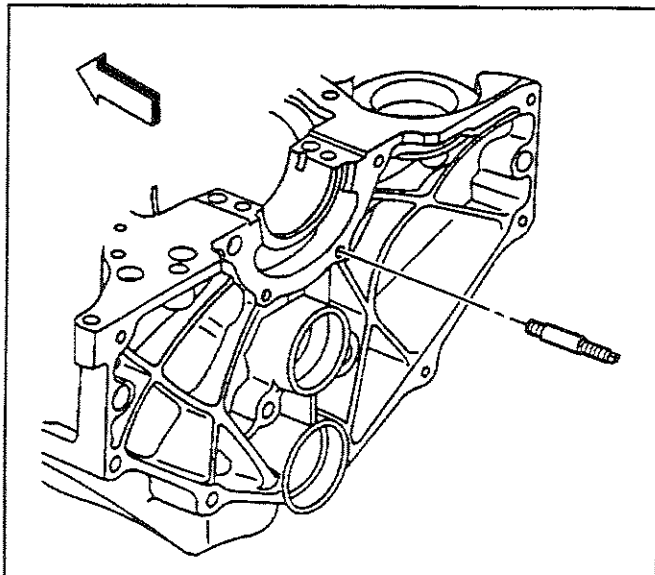
334317

3. Remove the crankshaft rear oil seal housing nut and bolts.
4. Remove the crankshaft rear oil seal housing.



334319

5. Remove the crankshaft rear oil seal housing gasket.
6. Discard the crankshaft rear oil seal housing gasket.



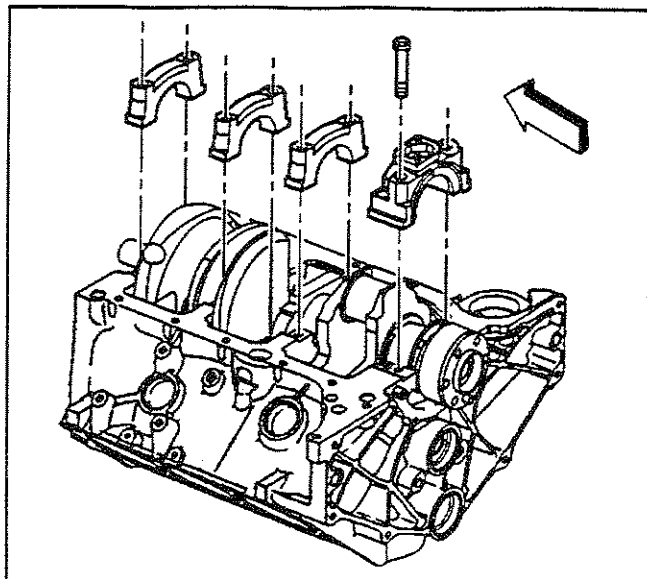
334326

7. Remove the crankshaft rear oil seal housing retainer stud from the engine block.

Crankshaft and Bearings Removal

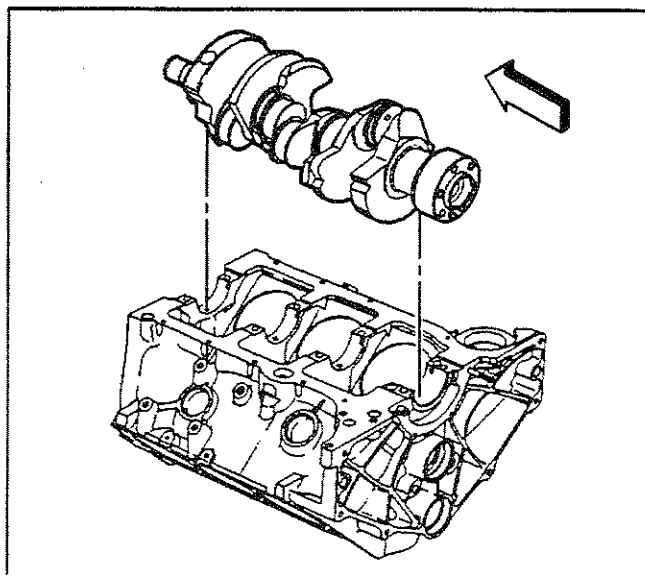
SIE-ID = 358537

1. Mark or identify the crankshaft bearing cap locations, direction, and positions for assembly.
2. Remove the crankshaft bearing cap bolts.
3. Remove the crankshaft bearing caps.



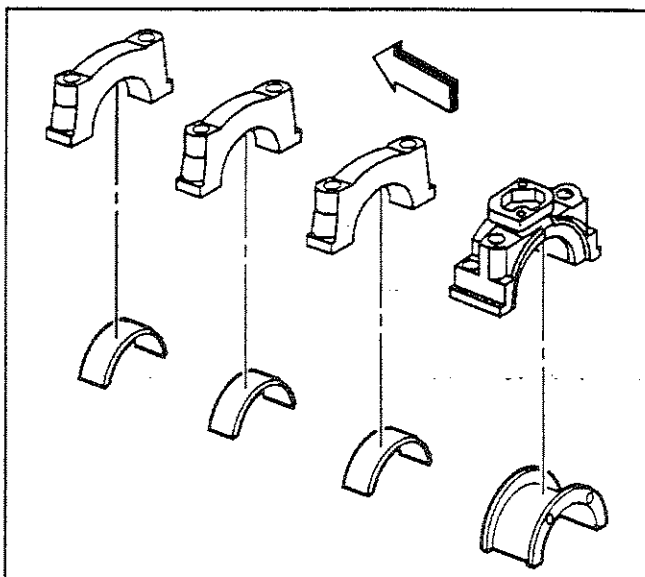
334329

4. Remove the crankshaft.

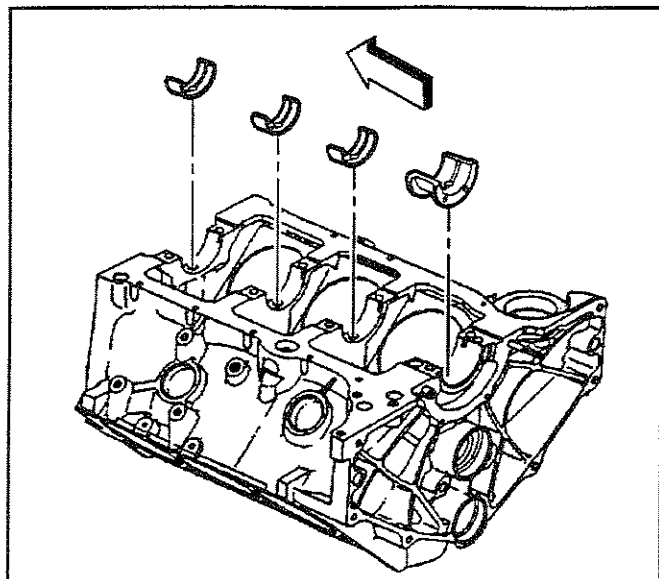


334336

5. Remove the crankshaft bearings from the crankshaft bearing caps.

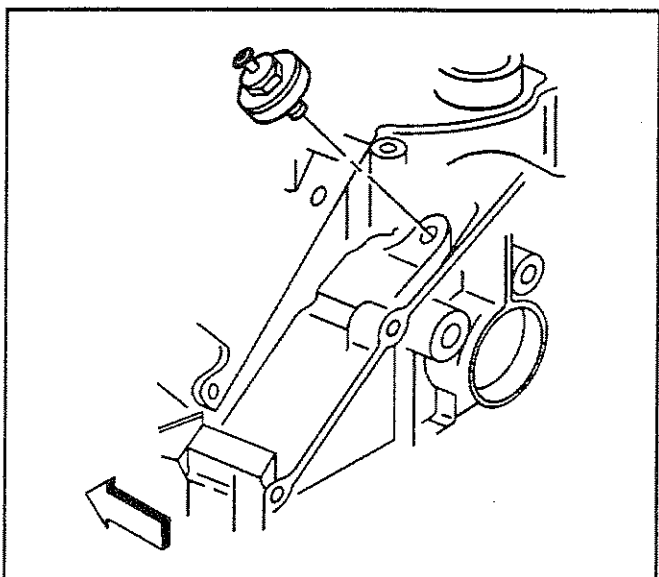


334342



334338

6. Remove the crankshaft bearings from the engine block.



10793

Engine Block Plug Removal

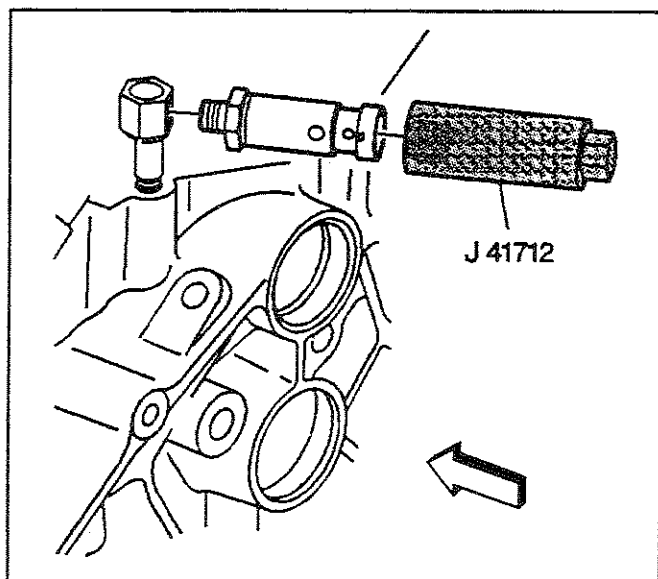
SIE-ID - 358540

Tools Required

J 41712 Oil Pressure Switch Socket

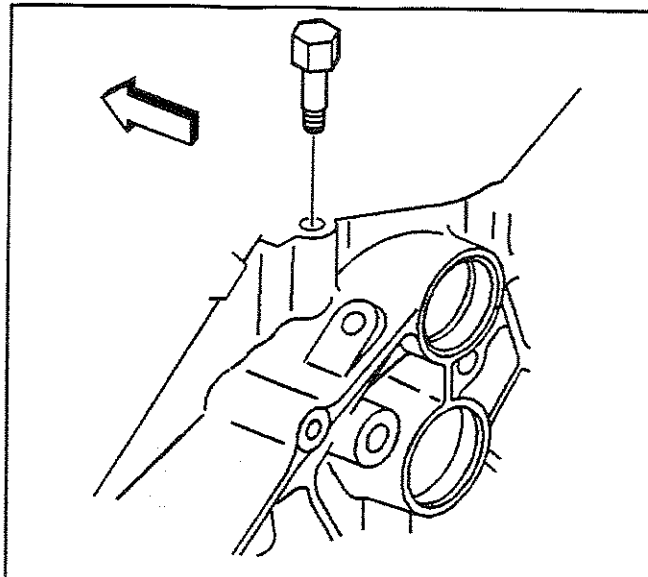
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

1. Remove the knock sensor from the engine block.
2. Remove the engine oil pressure gauge sensor using the J 41712.



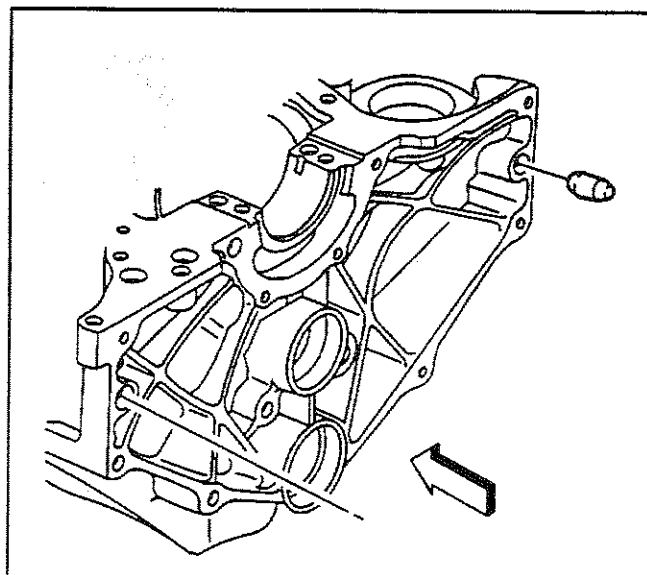
188018

3. Remove the engine oil pressure sensor fitting.



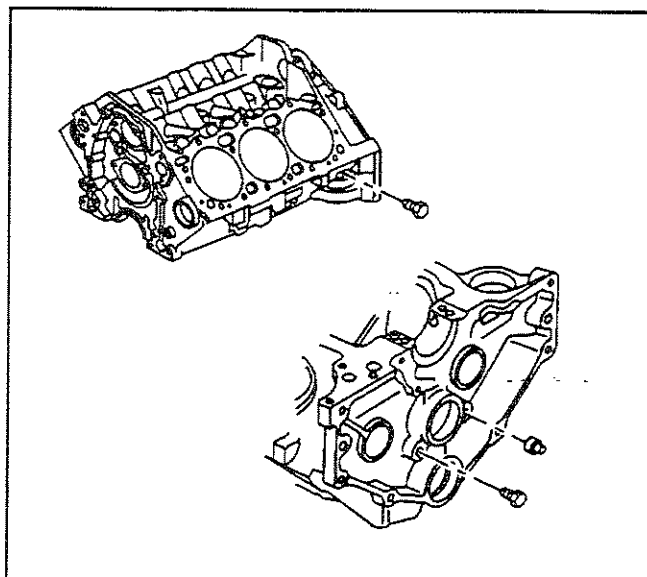
188020

4. Remove the dowel straight pins (transmission locator) (if required).

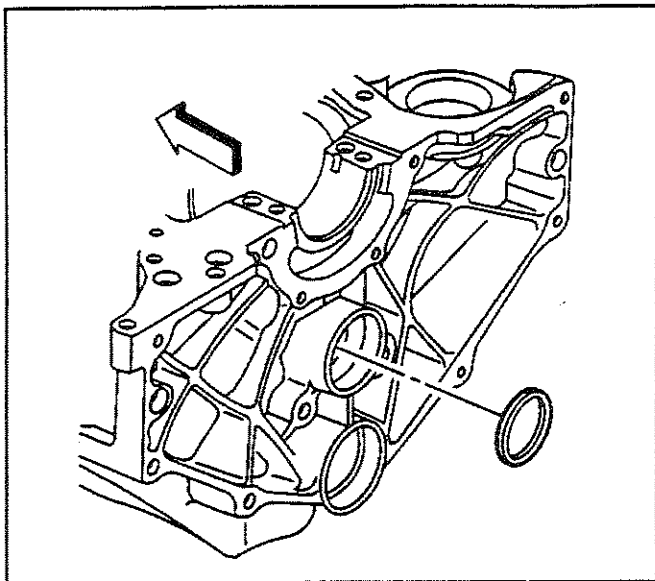


334350

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.

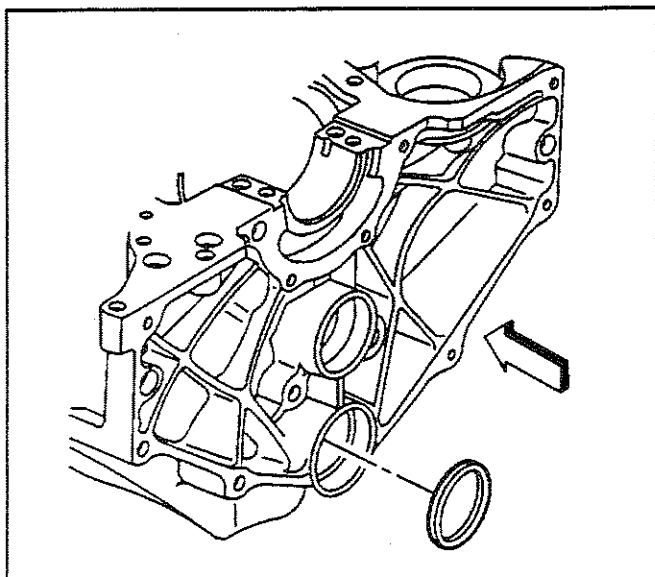


5271



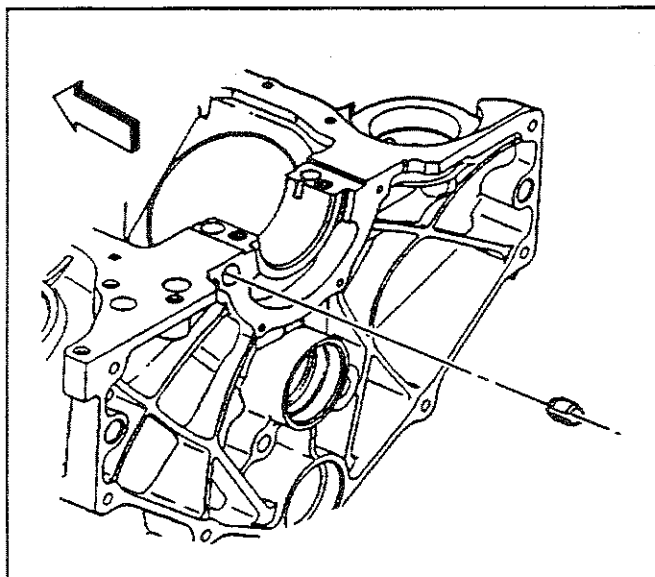
334364

8. Remove the expansion cup plug (camshaft rear bearing hole) and discard.



334366

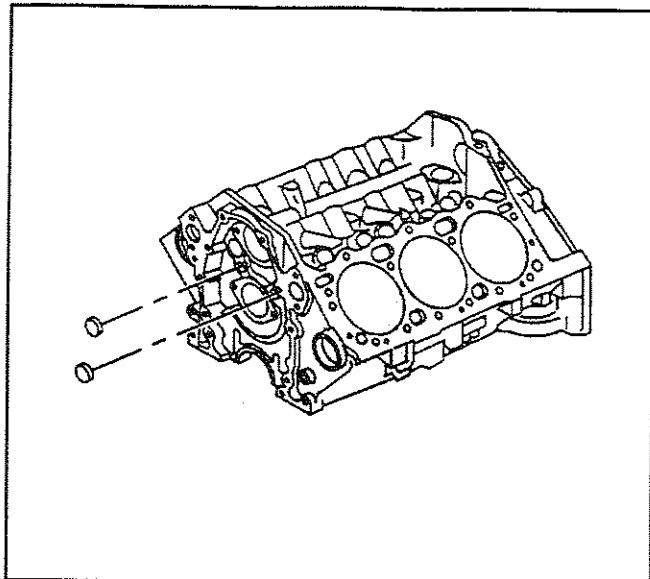
9. Remove the expansion cup plug (balance shaft rear bearing hole) and discard.



334323

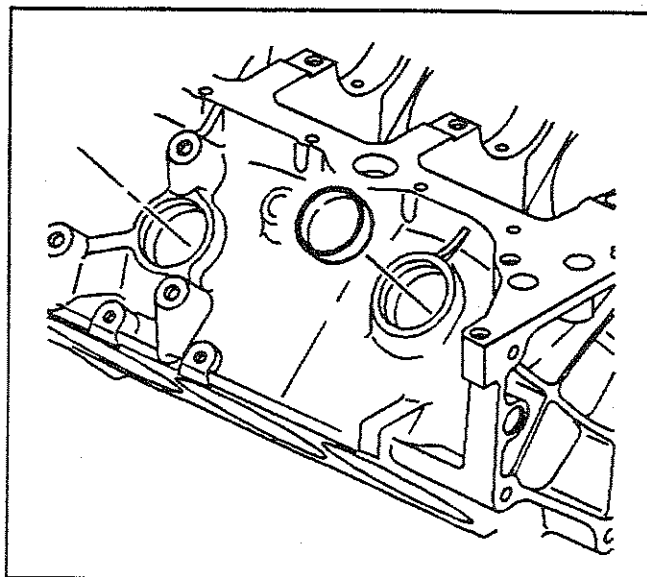
10. Remove the spring type S pin (crankshaft rear oil seal housing locator) (if required).

11. Remove the front oil gallery plugs or balls from the front of the engine block and discard.
Insert a 3/8 x 26 in. rod into the rear oil gallery holes in order to drive out the front oil gallery plugs or balls.



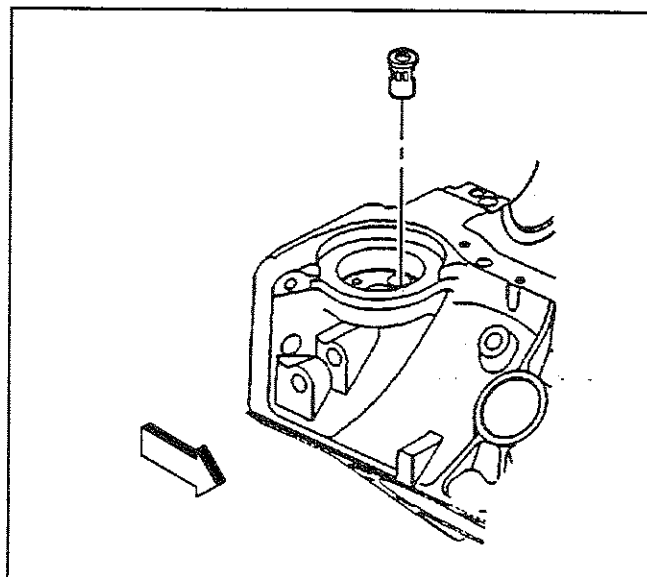
5270

12. Remove the engine block core hole plugs.
- 12.1. Use a suitable tool in order to drive the engine block core hole plugs into the coolant jacket.
 - 12.2. Use a suitable tool in order to pull the engine block core hole plugs from the coolant jacket.
 - 12.3. Discard the engine block core hole plugs.

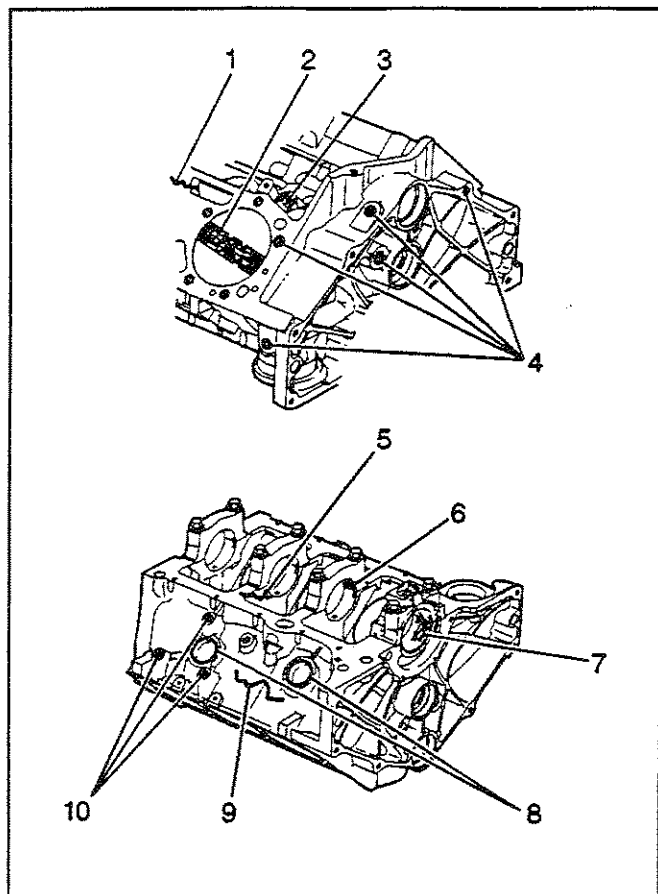


480550

13. Remove the oil filter bypass valve and discard.



188026



33437B

Engine Block Clean and Inspect

SIE-ID = 506873

Tools Required

J 8087 Cylinder Bore Gauge

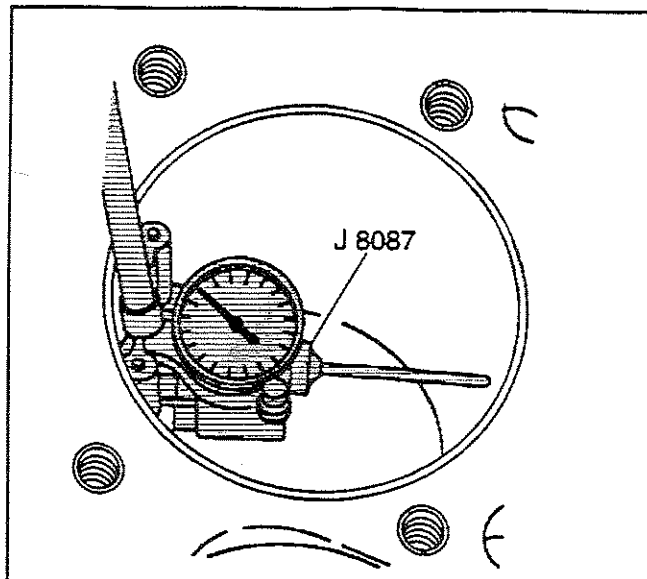
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

1. Clean all the remaining sealing or gasket material from the sealing surfaces.
2. Clean the engine block with cleaning solvent.
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 rebores the engine block crankshaft bearing bores and check for the proper alignment. Finally, check the crankshaft for the proper clearances.
 - Engine block core hole plug bores (8) for damage
 - Engine block (9) for cracks or damage
 - Engine mount bosses (10) for damage

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*.



4972

Cylinder Boring and Honing

SIE-ID - 69045

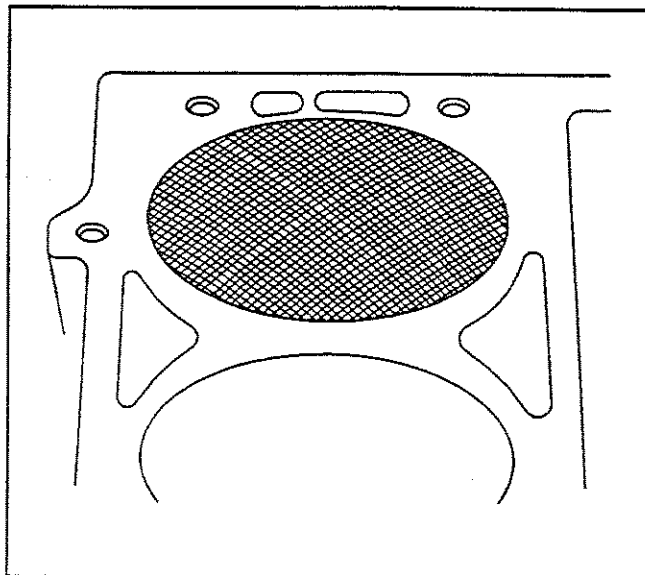
Honing Procedure

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

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.



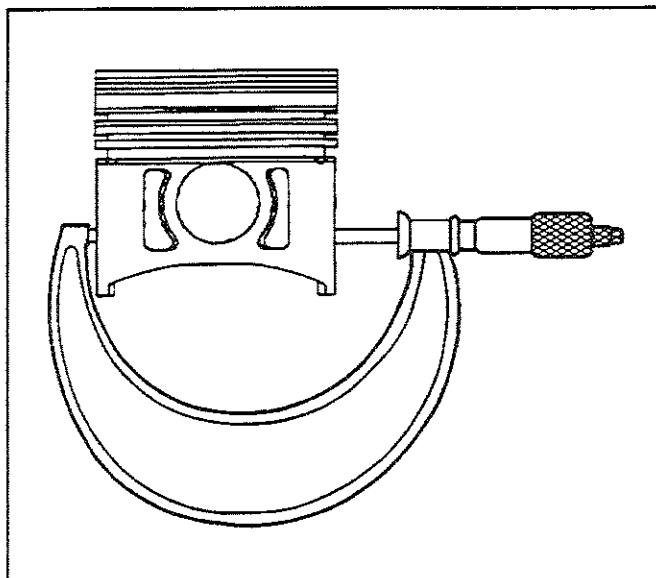
186747

- 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: Refer to Safety Glasses Caution in Cautions and Notices.

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).



188016

Piston and Connecting Rod Disassemble

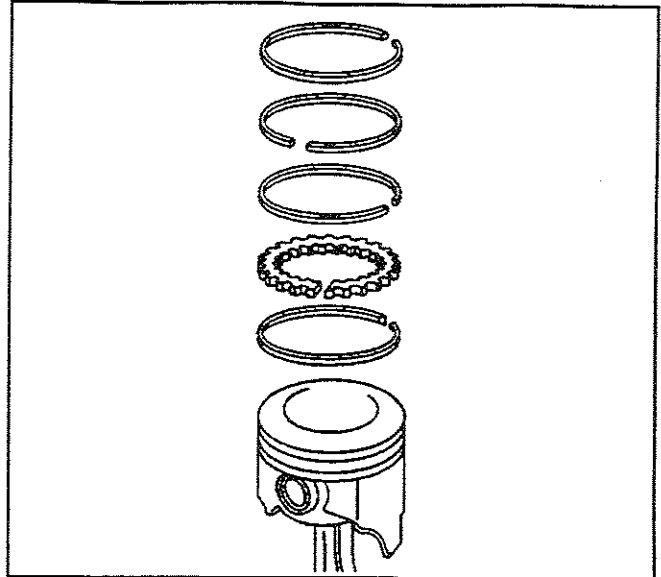
SIE-ID - 195087

Tools Required

J 24086-C Piston Pin Remover/Installer

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

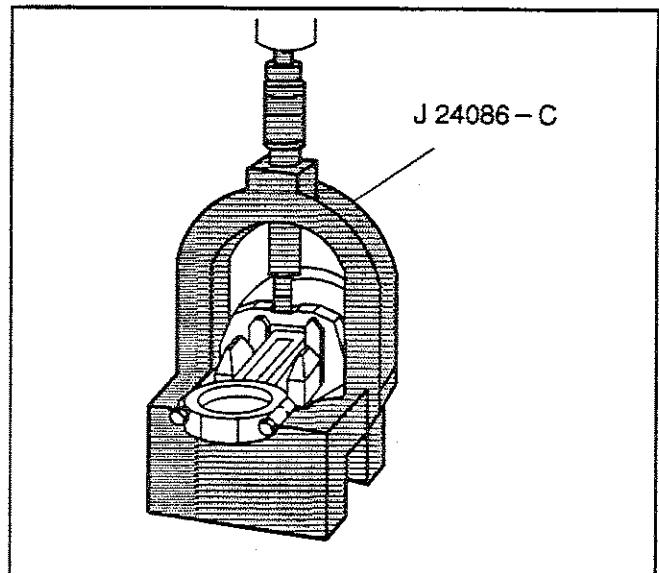
1. Remove the piston rings from the pistons.



4967

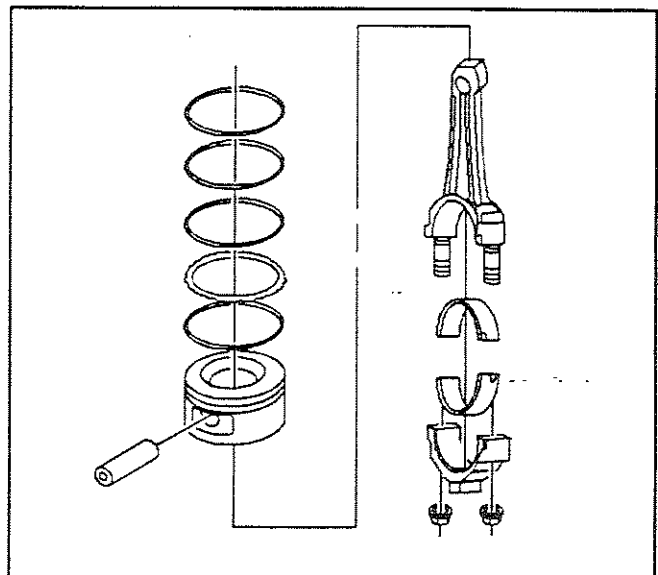
2. Press the piston pin from the connecting rod using the J 24086-C.

The piston pin has an interference fit into the connecting rod, and is full floating in the piston.

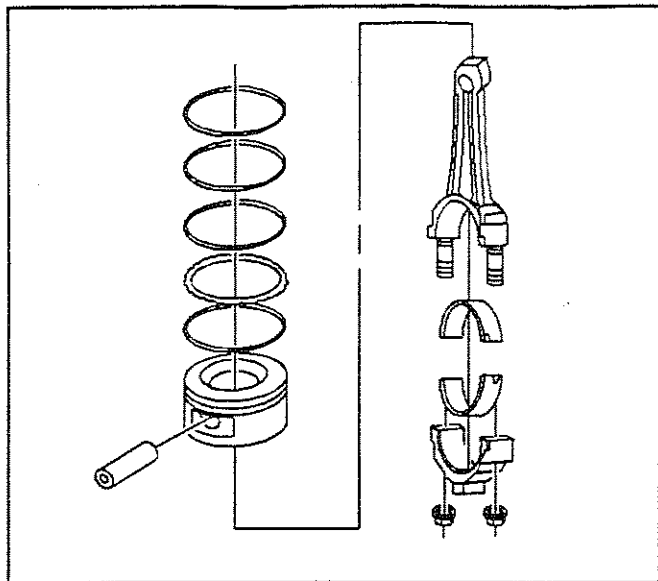


4965

3. Mark, separate, and organize the parts for assembly.



34671



34671

Piston, Connecting Rod and Bearings Clean/Inspect

SIE-ID - 506875

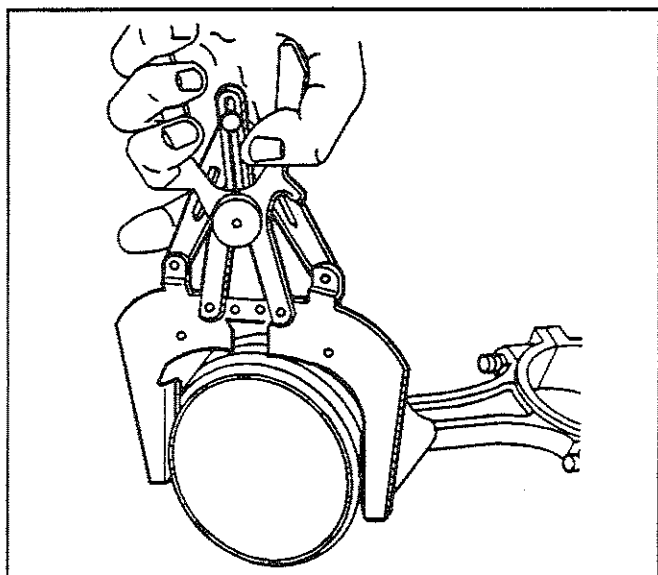
Important: Measurement of all components should be taken with the components at room temperature.

Do not use a wire brush in order to clean any part of the piston.

Clean the piston and connecting rod in solvent.

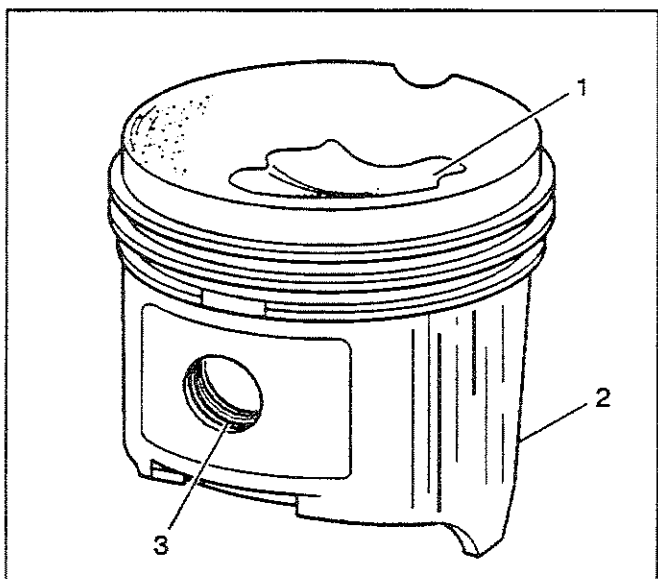
Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

1. Dry the components with compressed air.



4977

2. Clean the piston ring grooves with a suitable ring groove cleaning tool.

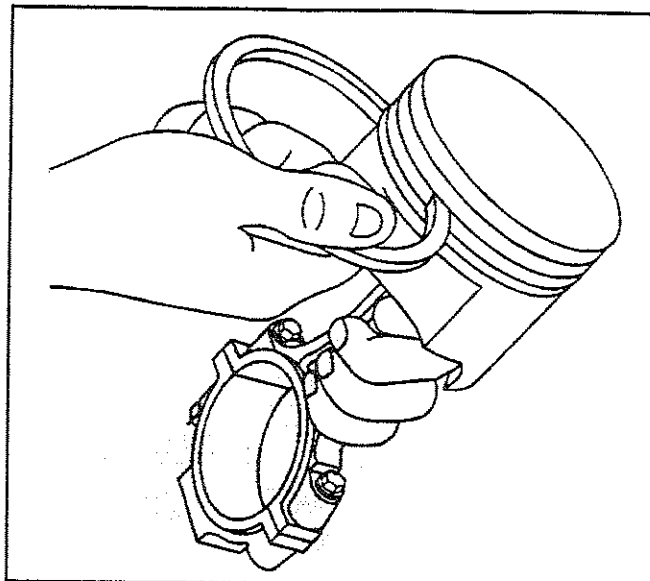


156168

3. Clean the piston oil lubrication holes and slots.
4. 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
5. Inspect the piston pin for scoring, wear or other damage.

6. Measure the piston ring-to-piston ring groove side clearance.

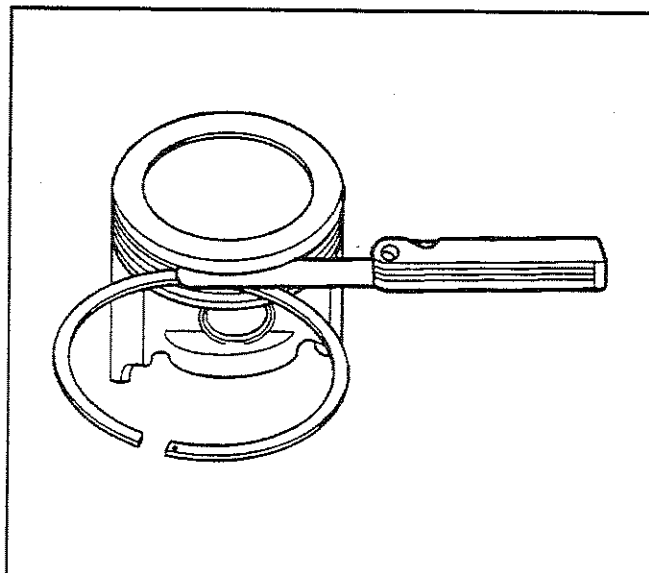
- 6.1. Insert the edge of the piston ring into the piston ring groove.
- 6.2. Roll the piston ring completely around the piston.
 - If binding is caused by a distorted piston ring groove, MINOR imperfections may be removed with a fine file.
 - If binding is caused by a distorted piston ring, replace the piston ring.



4969

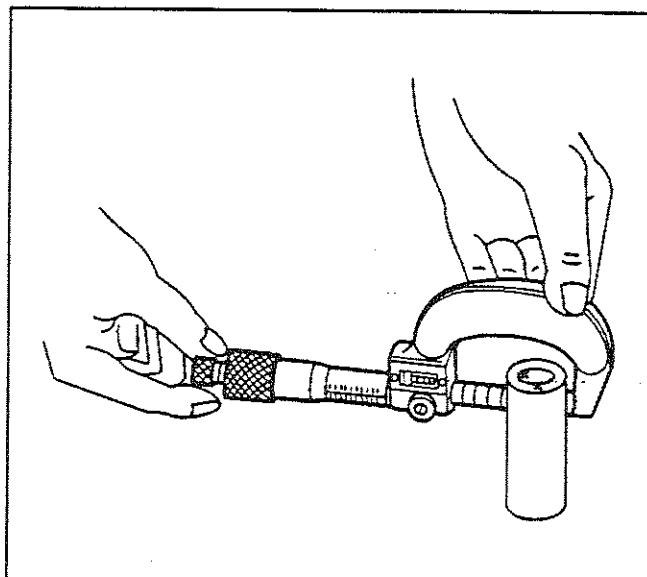
7. Measure the piston ring side clearance with a feeler gauge.

8. If the side clearance is too small, try another piston ring set.
9. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.
10. To determine the proper piston ring side clearance, refer to *Engine Mechanical Specifications*.

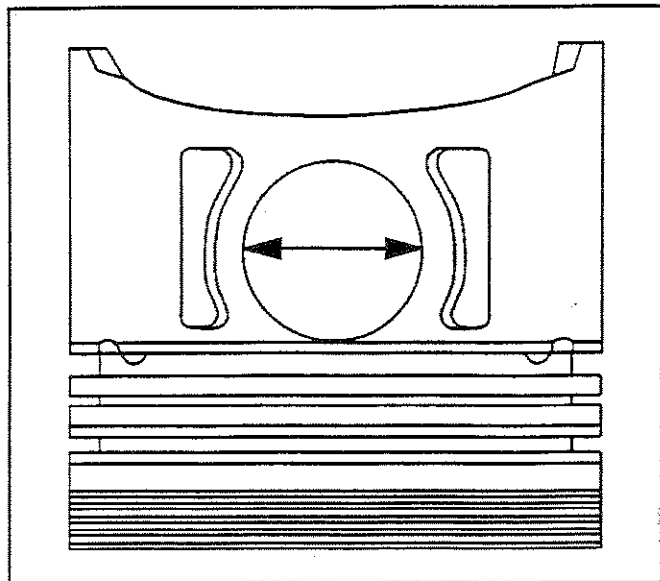


22934

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

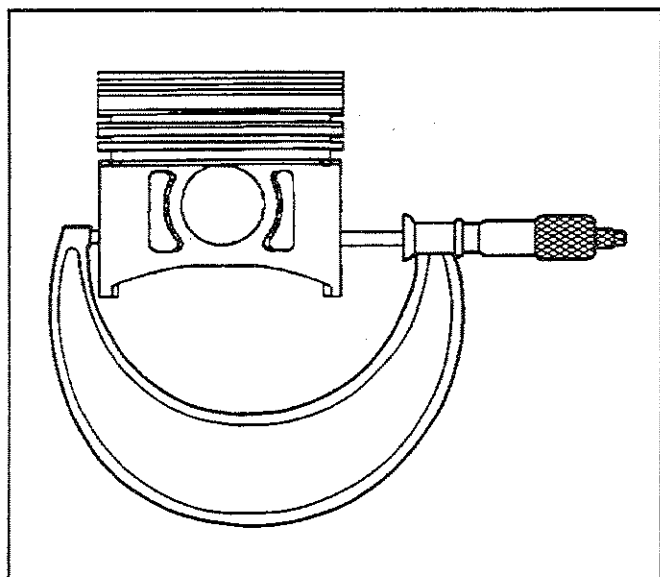


4976



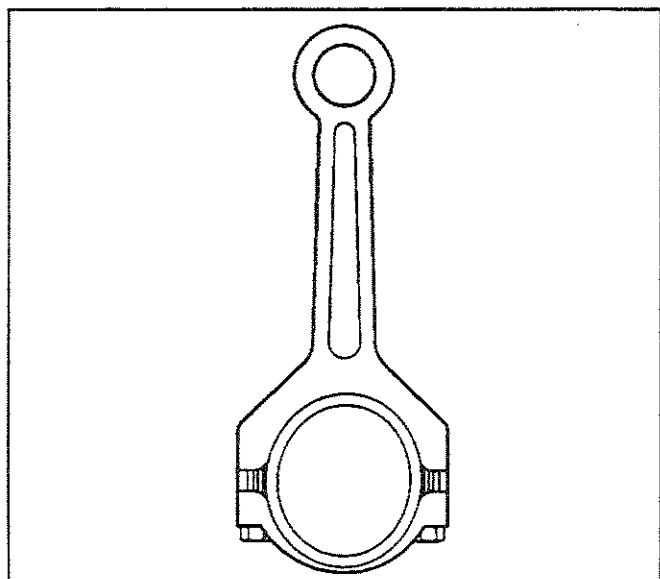
4975

12. To determine piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore.
13. To determine the piston pin-to-bore clearance, subtract the piston pin diameter from the piston pin bore diameter. Refer to *Engine Mechanical Specifications*.



188016

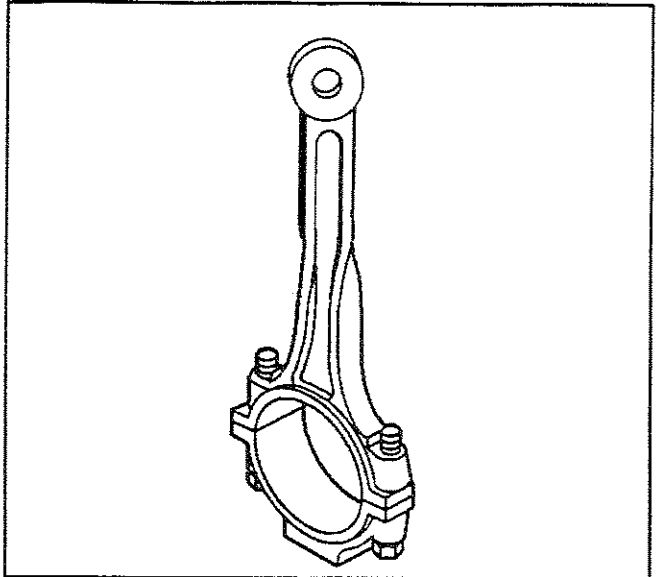
14. Measure the piston with a micrometer at a right angle to the piston pin bore, measure the piston at 11 mm (0.433 in) from the bottom of the skirt. Refer to *Engine Mechanical Specifications*. If the piston is not within specifications, replace the piston and pin as an assembly.



156167

15. Inspect the connecting rod for an out-of-round bearing bore. Refer to *Engine Mechanical Specifications*.

16. Inspect the connecting rod for twisting.
17. Inspect the connecting rod for damage to the bearing cap and bolt threads.



156169

18. Measure the piston compression ring end gap.

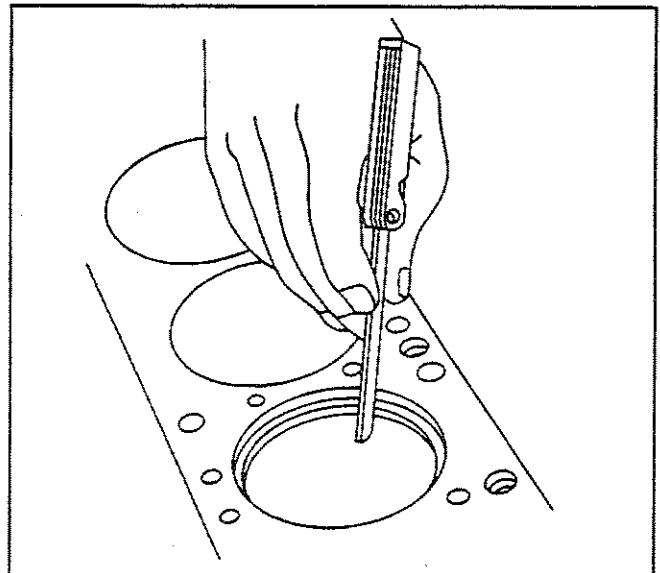
Important: Fit each compression ring to the cylinder in which it will be used.

Place the compression ring into the cylinder bore.

- 18.1. 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.

- 18.2. Use a feeler gage in order to measure the end gap.
- 18.3. Select another size ring set if the end gap exceeds specifications. Refer to *Engine Mechanical Specifications*.



4968

Piston Selection

SIE-ID - 506880

Tools Required

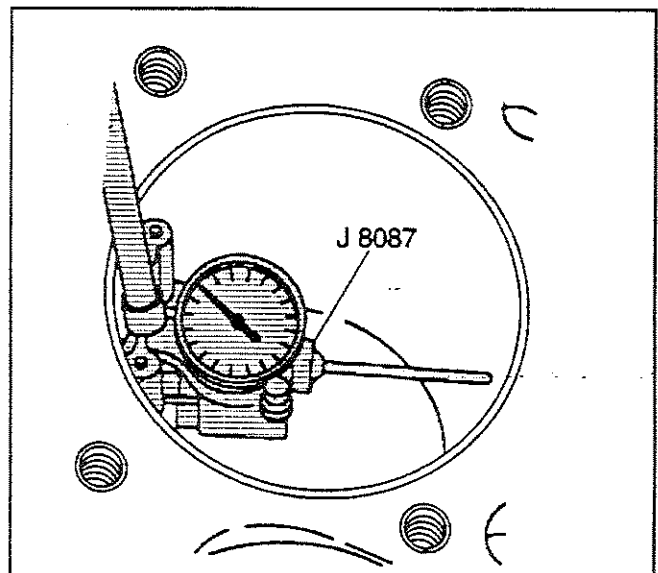
J 8087 Cylinder Bore Gauge

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

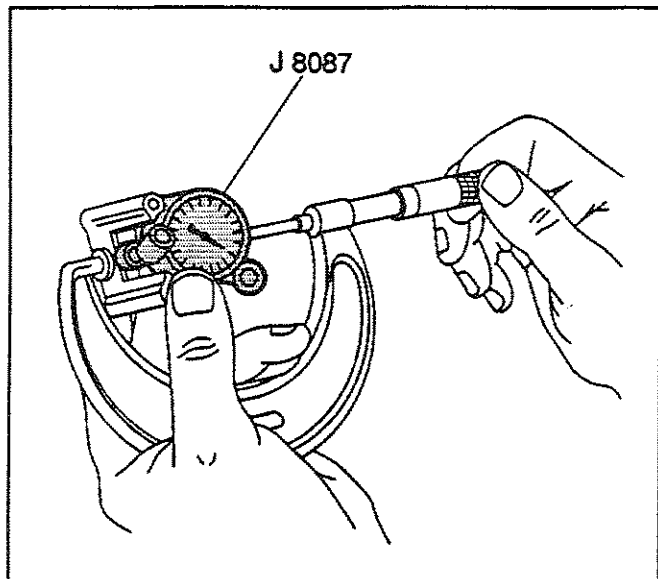
For proper piston fit, the engine block cylinder bores should not have excessive wear or taper.

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

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 bore and 90 degrees to the crankshaft centerline.

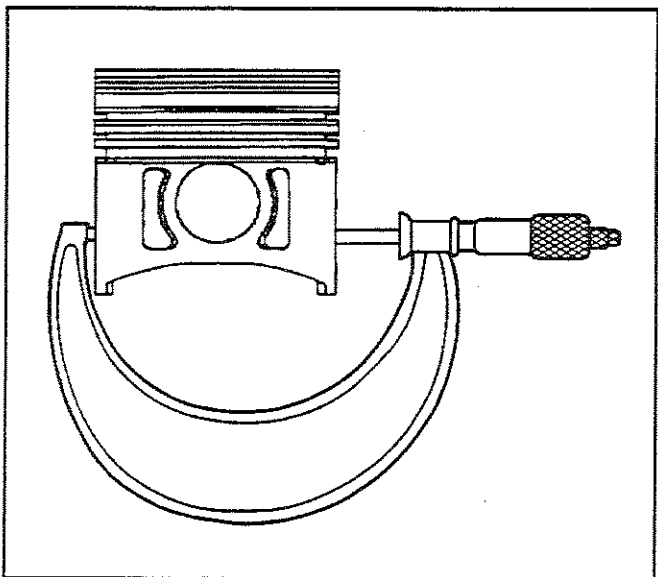


4972



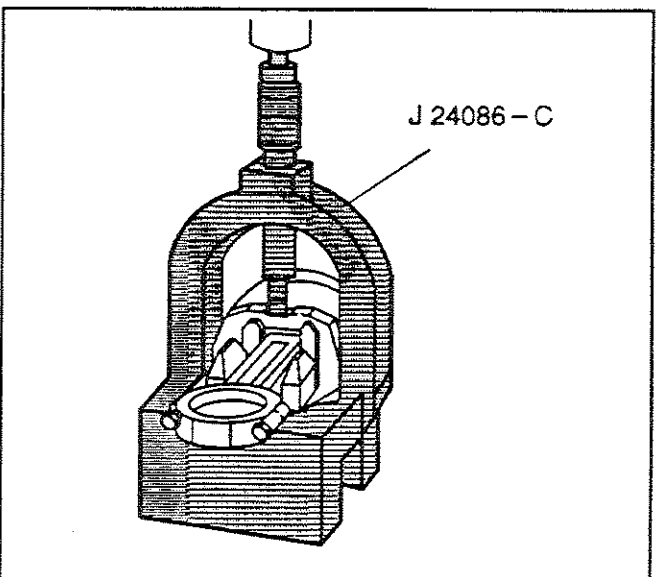
4974

1. Measure the *J 8087* with a micrometer and record the reading.



188016

2. With a micrometer or caliper at a right angle to the piston pin bore, measure the piston 11 mm (0.433 in) from the bottom of the skirt.
3. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance. Refer to *Engine Mechanical Specifications*.
4. 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.
5. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation into the proper cylinder.



4965

Piston and Connecting Rod Assemble

SIE-ID = 195097

Tools Required

J 24086-C Piston Pin Remover/Installer

Caution: SIO-ID = 71607 **Avoid contact with HOT components. Wear safety glasses and protective gloves to avoid personal injury.**

Notice: SIO-ID = 71608 Applying excessive heat to the connecting rod may damage or distort the rod. Rod temperature **SHOULD NOT** exceed 315°C (600°F). At this temperature the end of the connecting rod will turn a straw color upon visual inspection.

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.

Install the piston pin and connecting rod assembly.

1. Lubricate the piston pin bores with clean engine oil.
2. Use a torch and apply MILD heat to the piston pin end of the connecting rod.
3. Use the *J 24086-C* in order to press the piston pin into the piston and connecting rod assembly.
4. Inspect for the proper installation of the piston and piston pin.

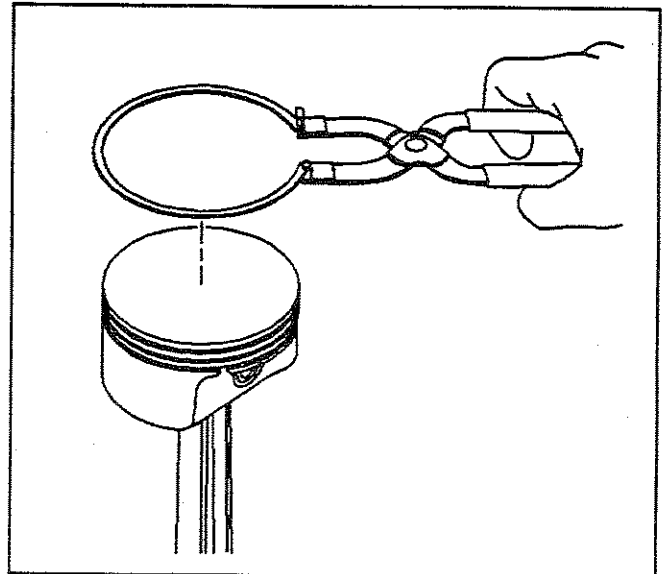
The piston must move freely on the piston pin with no binding or interference.

Notice: SIO-ID = 16608 Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

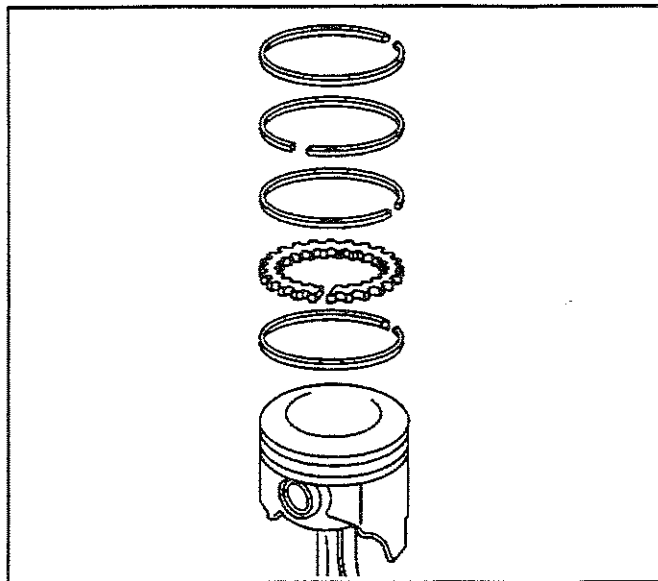
1. Install the piston rings onto the piston.
 - 1.1. Install the oil control piston ring spacer.
 - 1.2. Install the lower oil control piston ring.
 - 1.3. Install the upper oil control piston ring.
 - 1.4. Install the lower compression piston ring.

The mark on the side of the piston ring should face the top of the piston.
 - 1.5. Install the upper compression piston ring.

The mark on the side of the piston ring should face the top of the piston.

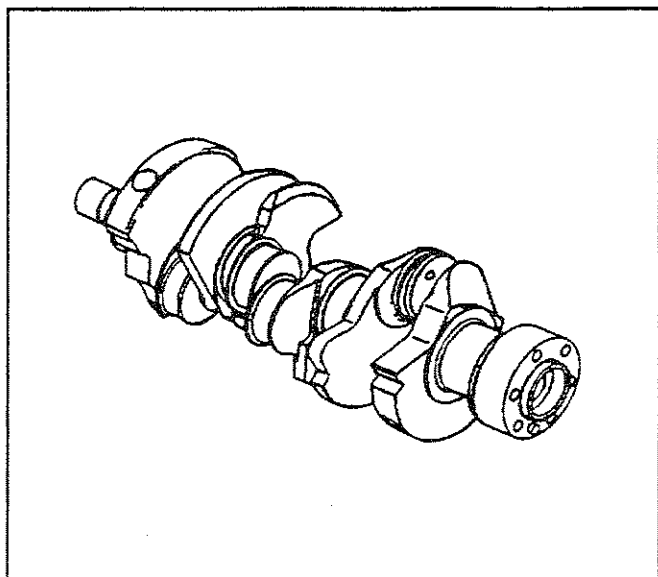


490763



4967

2. Space the compression piston ring end gaps 120 degrees apart.
3. Space the oil control piston ring end gaps a minimum of 90 degrees apart.



334383

Crankshaft and Bearings Clean and Inspect

SIE-ID - 506883

Tools Required

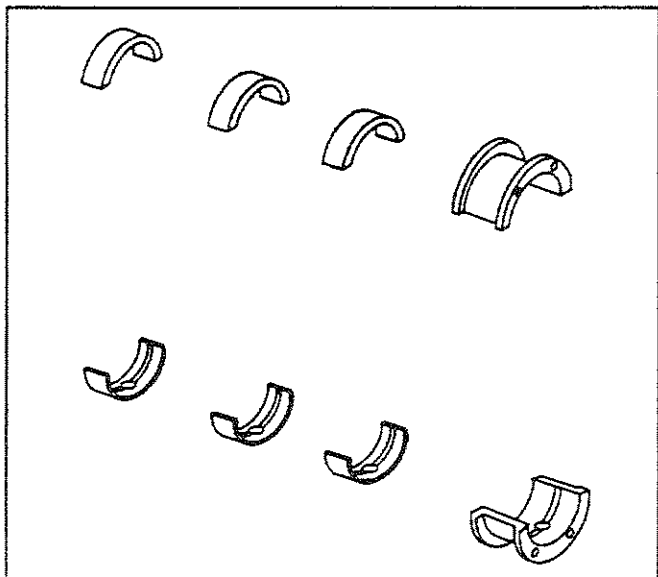
- J 7872 Magnetic Base Dial Indicator
- J 36660 Electronic Torque Angle Meter

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

Important: Use care when handling the crankshaft. Avoid damage to the crankshaft bearing surfaces.

Clean the crankshaft in cleaning solvent.
Remove all sludge or restrictions from the oil passages.

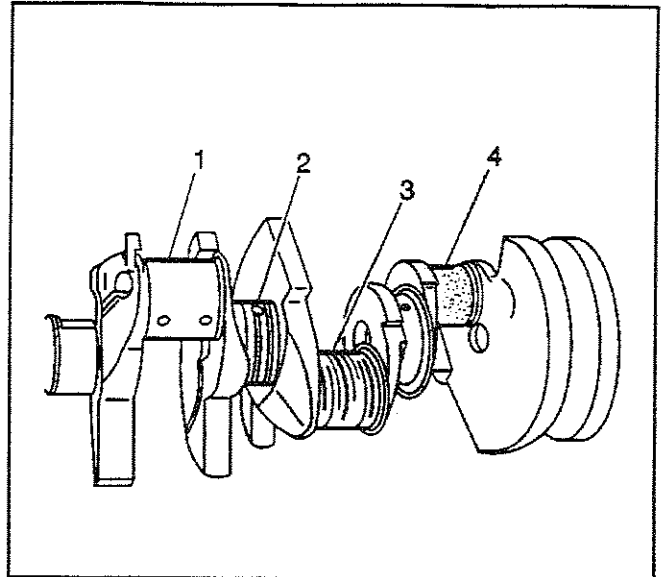
1. Dry the crankshaft with compressed air.
2. Clean the crankshaft bearings in cleaning solvent. Wipe the crankshaft bearings clean with a soft cloth, do not scratch the crankshaft bearing surfaces.
3. Dry the crankshaft bearings with compressed air.



334386

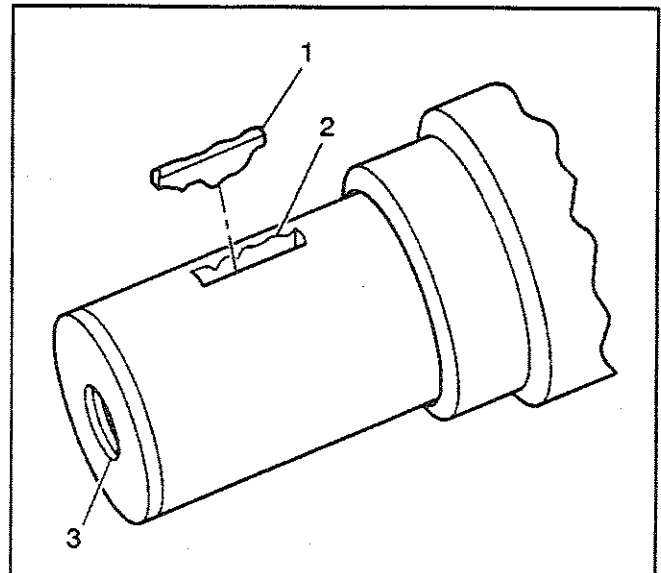
4. Inspect the crankshaft for the following:

- 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 rear seal surface
- Restrictions to the oil passages
- Damage to the threaded bolt holes



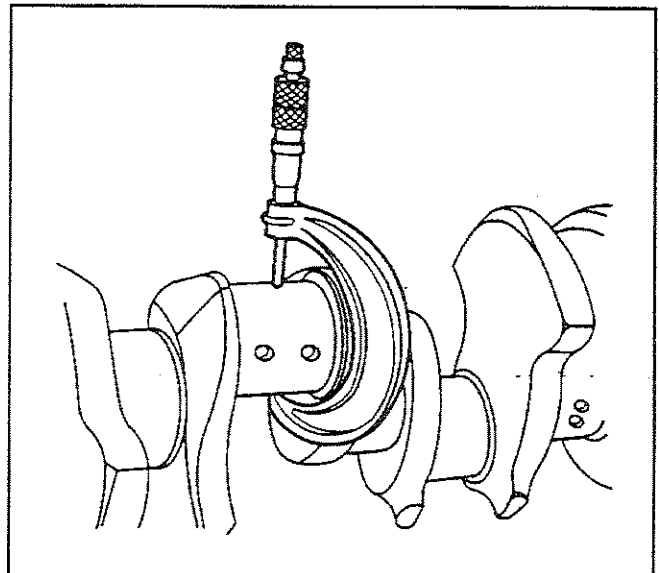
156170

5. Inspect the crankshaft balancer key (1), the keyway (2), and the threaded hole (3) for damage. Repair or replace the crankshaft as necessary.

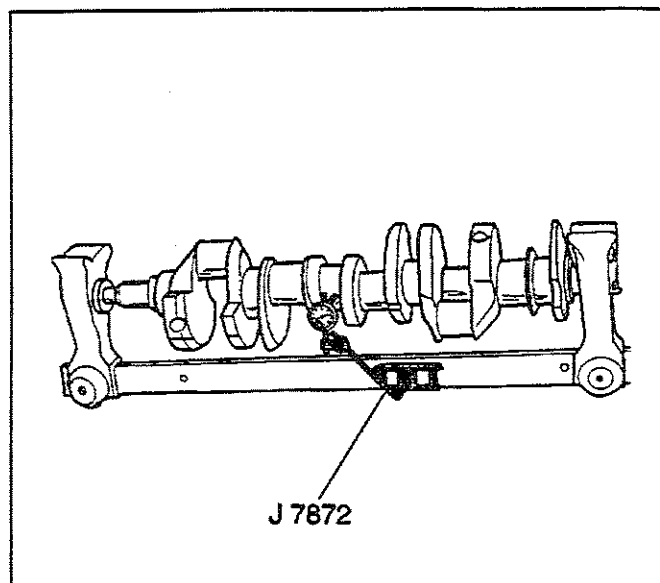


188090

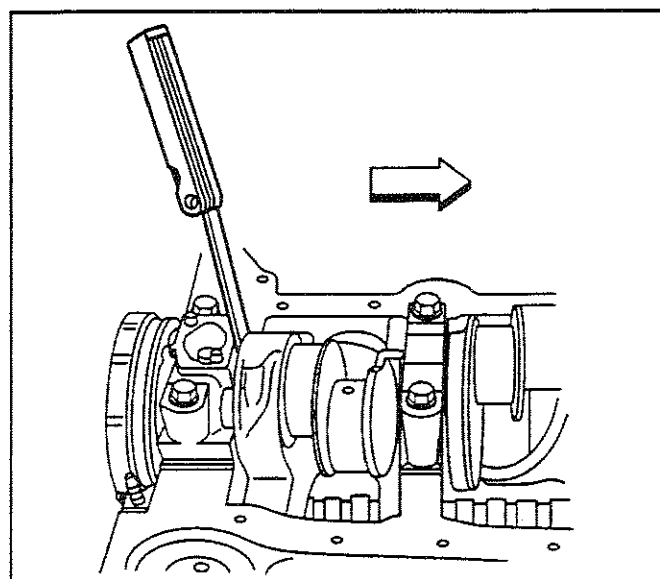
6. Measure the crankpins for out-of-round and taper. Refer to *Engine Mechanical Specifications*.



188015



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7. Use a suitable support to support the crankshaft on the front and rear journals.
8. Use the *J 7872* in order to measure the crankshaft journal runout.

The crankshaft runout should not exceed 0.025 mm (0.0010 in).

9. Measure the crankshaft end play.

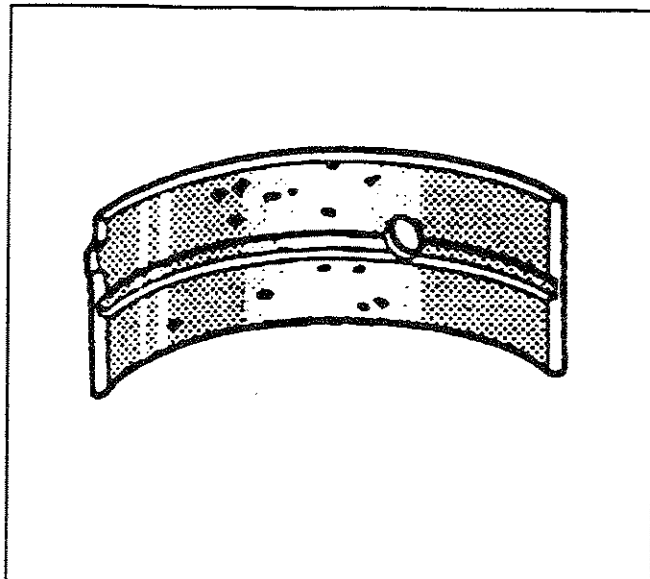
Important: In order to properly measure the crankshaft end play, the crankshaft, the crankshaft bearings, the crankshaft bearing caps, and the crankshaft bearing cap bolts must be installed into the engine block and the bolts tightened to specifications.

Firmly thrust the crankshaft first rearward, then forward. This will align the crankshaft rear bearings and the crankshaft thrust surfaces.

- 9.1. 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*.
- 9.2. If the correct end play cannot be obtained, verify that the correct size crankshaft bearing has been installed. Refer to *Engine Mechanical Specifications*.
- 9.3. 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.

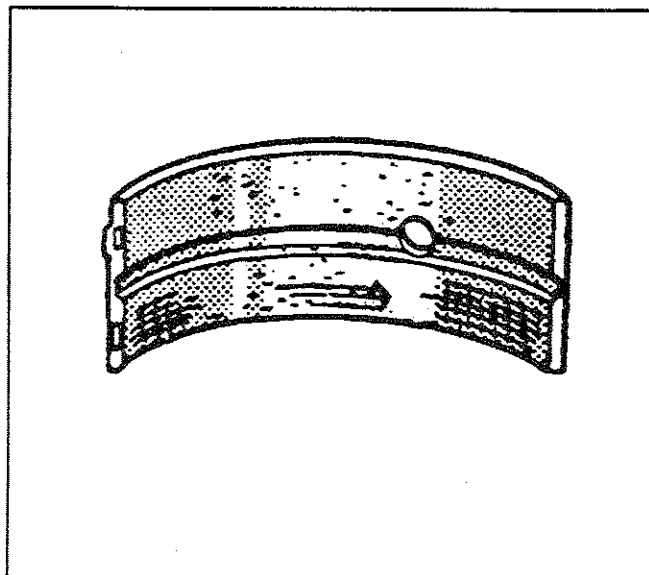
Burrs on the crankshaft bearing cap, foreign matter between the crankshaft bearing and the engine block or the crankshaft bearing cap, or a faulty crankshaft bearing could cause a lack of clearance at the crankshaft bearing.

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



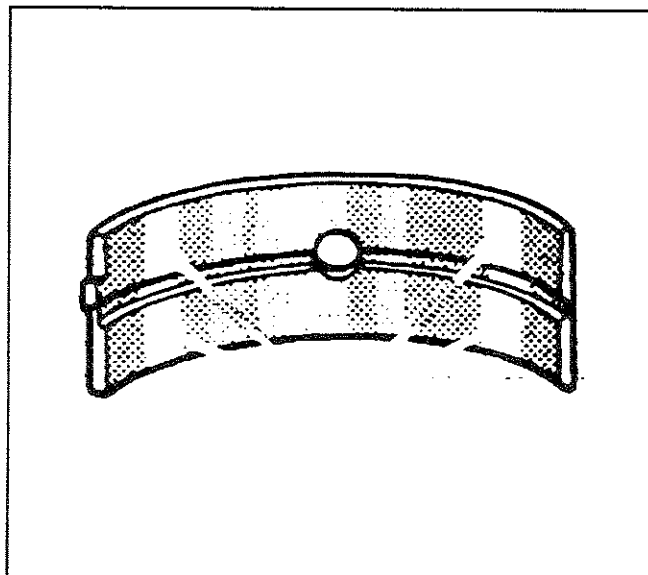
52051

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

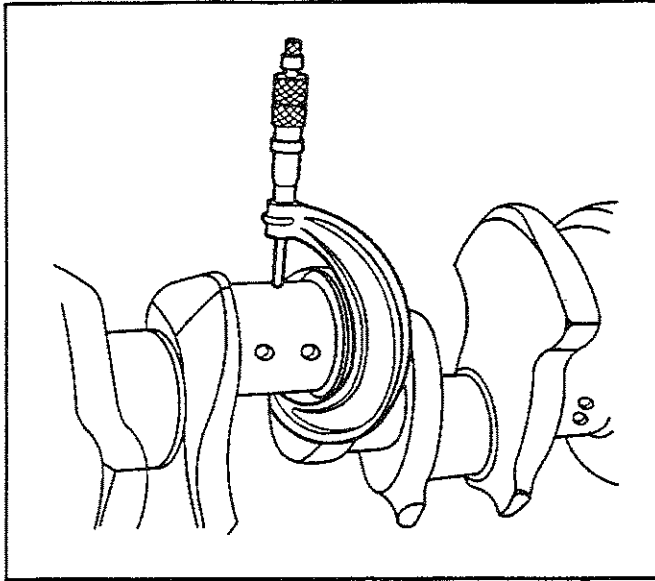


52053

13. 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.



52056



188015

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.

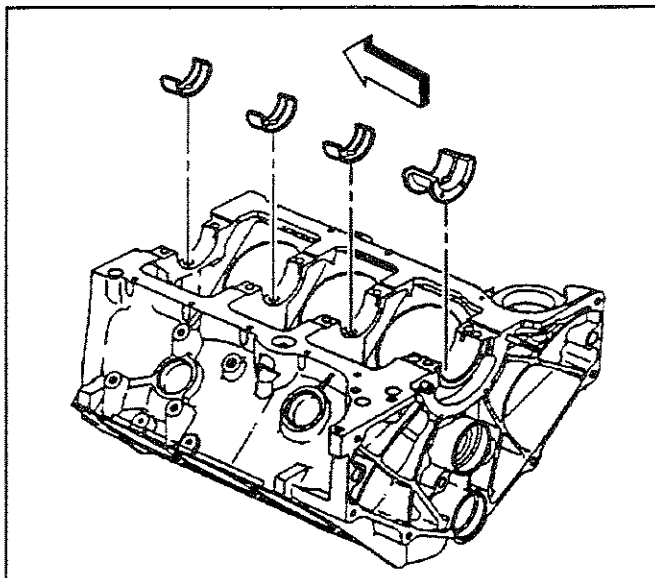
The selective fitting of the crankshaft bearings are necessary in production in order to obtain close tolerances. For this reason, in one journal bore you may use one-half of a standard crankshaft bearing with one-half of a undersize crankshaft bearing.

Important: Do not use the plastic gauge method to measure connecting rod bearing clearances. The plastic gauge method for measuring connecting rod bearing clearances will result in unreliable measurements. Use only the micrometer method to correctly determine the connecting rod bearing clearances.

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.

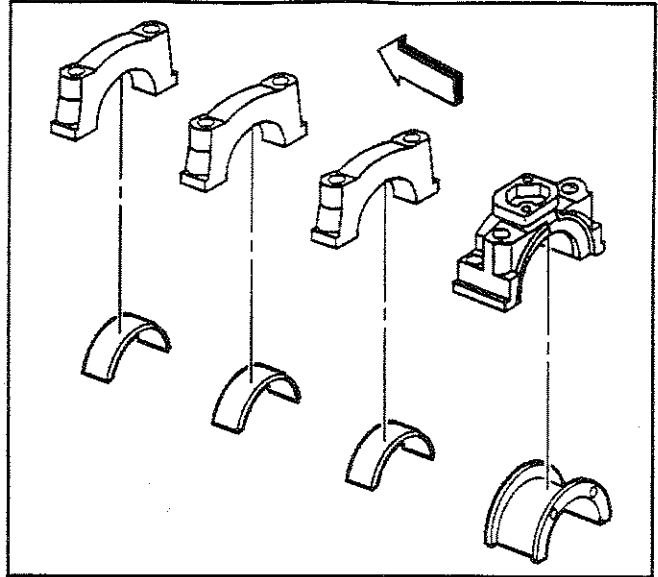
Micrometer Method for Crankshaft Bearings

1. Measure the crankshaft journal diameter with a 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.



334338

4. Install the crankshaft bearings into the crankshaft bearing caps.



334342

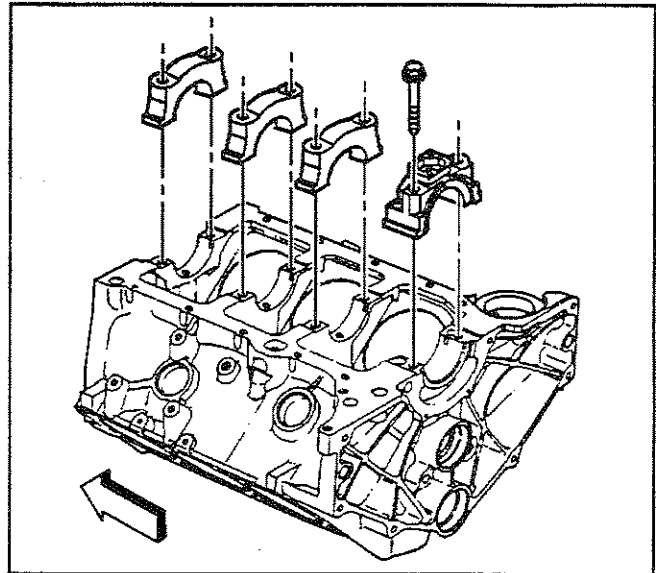
5. Install the crankshaft bearing caps in the original positions and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.

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

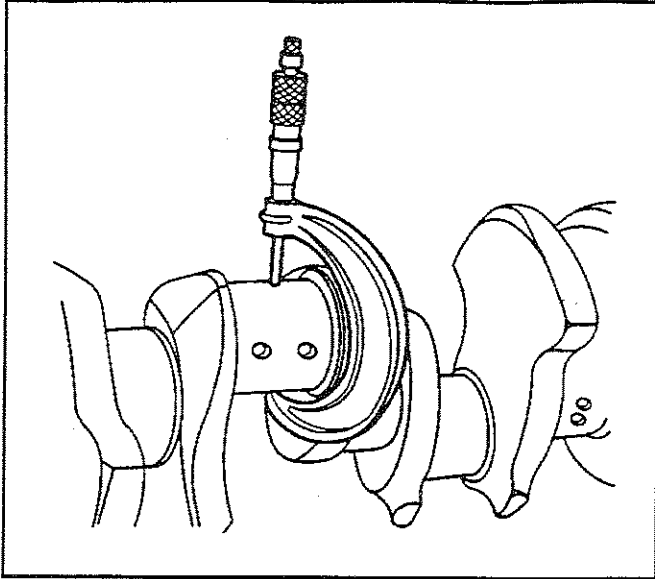
6. Install the crankshaft bearing cap bolts.

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.



353091



188015

Micrometer Method for Connecting Rod Bearings

Notice: SIO-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.

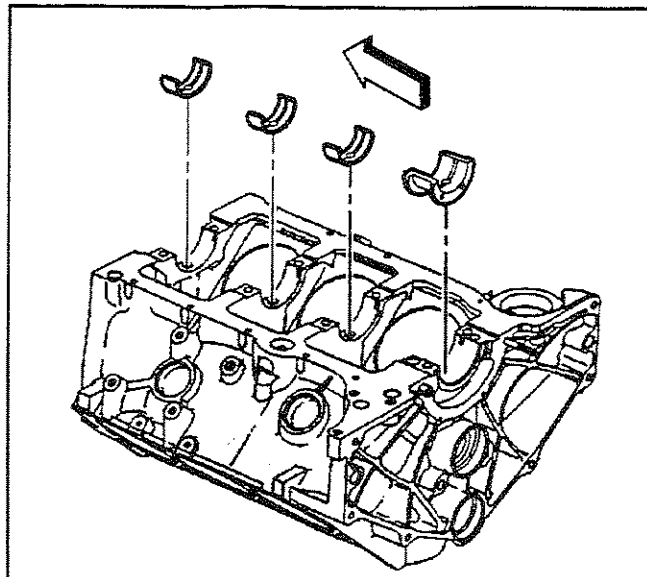
4. Install the connecting rod caps and the nuts.

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 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.

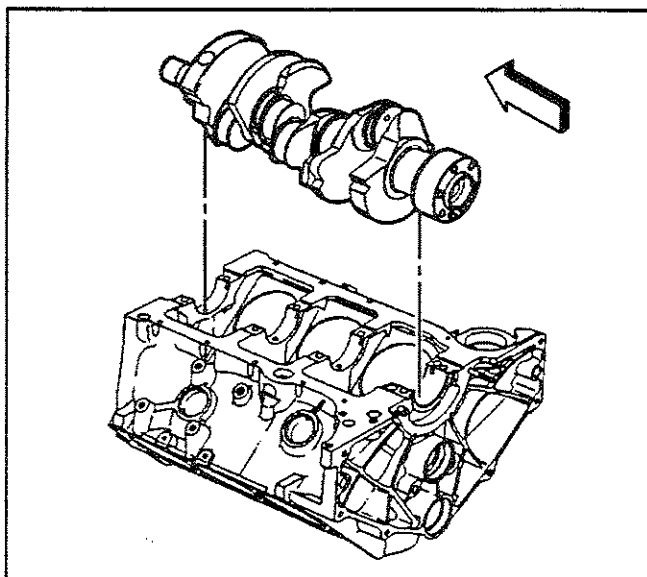
Plastic Gauge Method for Crankshaft Bearings

1. Install the crankshaft bearings into the engine block.



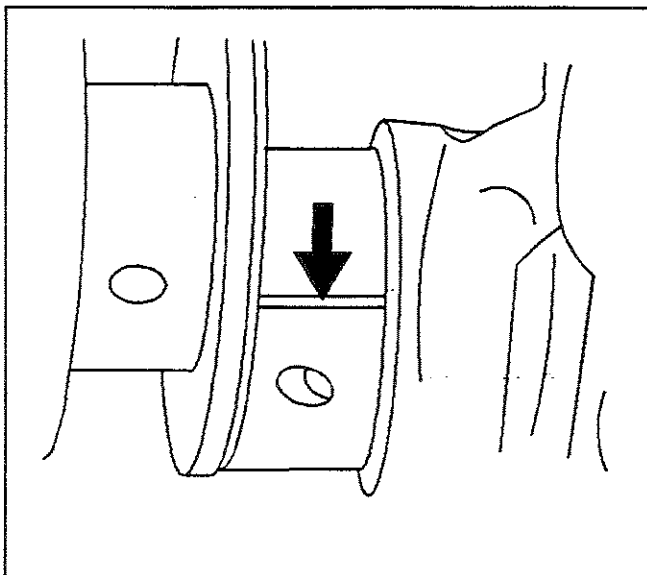
334338

2. Install the crankshaft.

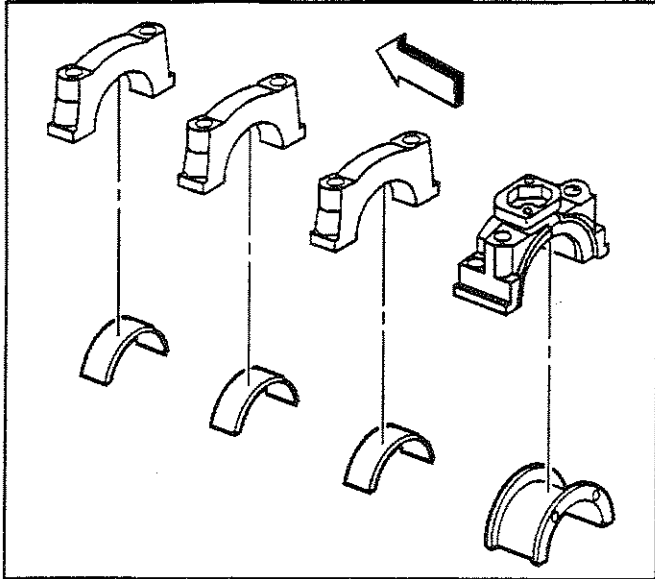


334336

3. Install the gauging plastic the full width of the journal.

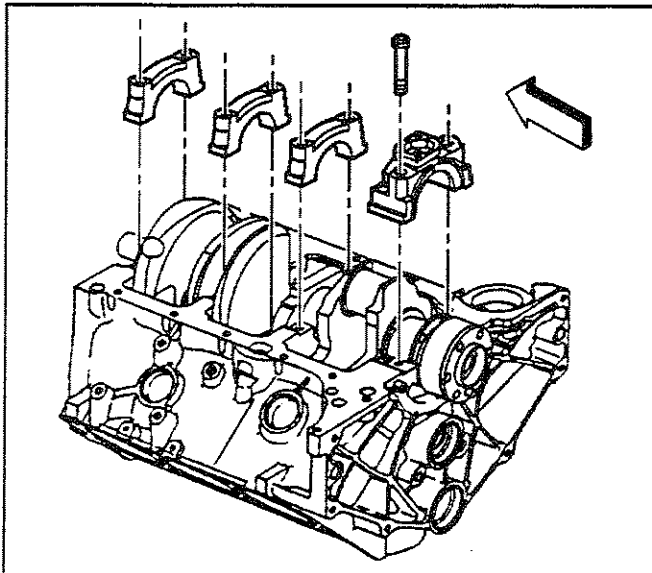


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334342

4. Install the crankshaft bearings into the crankshaft bearing caps.



334329

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.

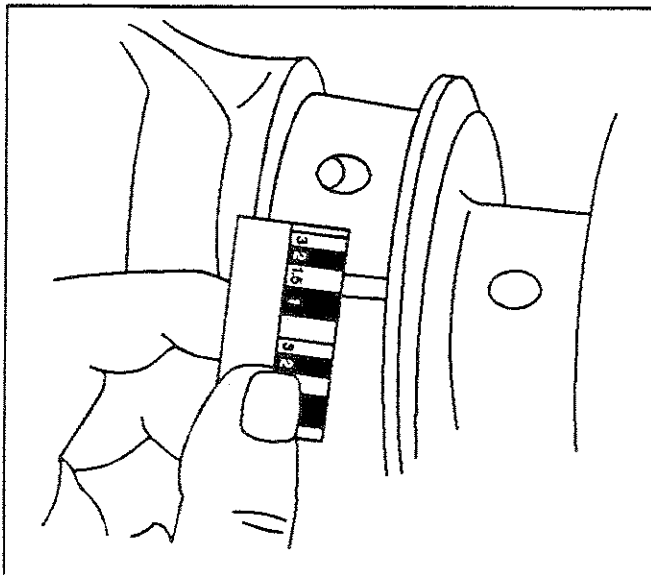
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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. 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.



500656

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 (0.0010 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.

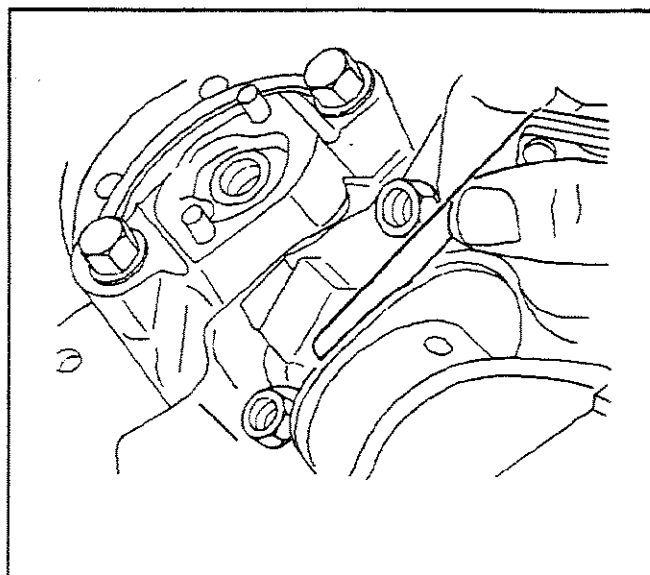
Notice: SIO-ID = 5016 Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

10. Remove the flattened gauging plastic.

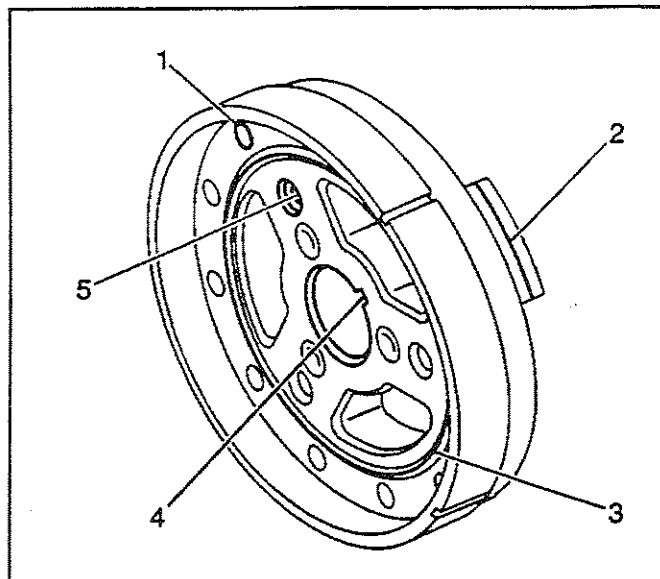
11. Measure the remaining crankshaft bearing journals.

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.



5163



334387

Crankshaft Balancer Clean and Inspect

SIE-ID = 358551

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

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)

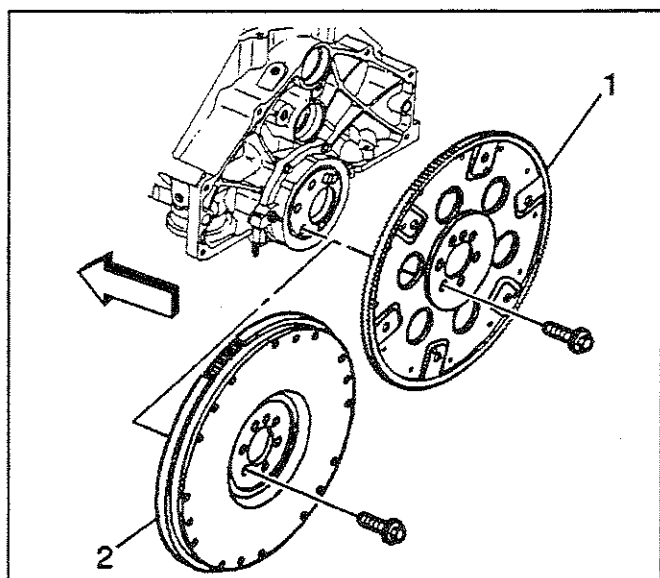
A properly installed front groove pin should be installed until flush or below flush with the face of the crankshaft balancer.

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 the outer ring
- Worn or damaged keyway (4)
- Worn or damaged bolt hole threads (5)



188129

Engine Flywheel Clean and Inspect

SIE-ID = 199436

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

1. Clean the engine flywheel (1) or (2) in cleaning solvent.
2. Dry the engine flywheel with compressed air.

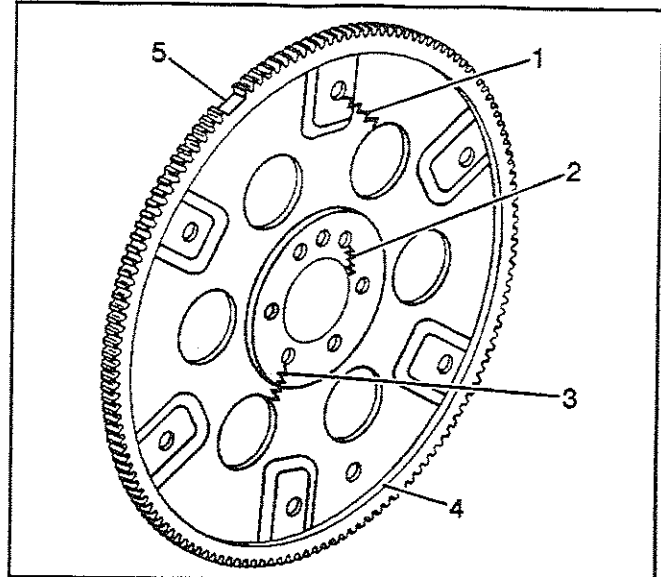
3. Inspect the engine flywheel (automatic transmission) (if equipped) for the following:

- Stress cracks around the engine flywheel-to-torque converter bolt hole locations (1)
- Missing balance weights
- Stress cracks around the engine flywheel-to-crankshaft bolt hole locations (2) or (3)

Important: Do not attempt to repair the welded areas (if present) that retain the ring gear to the engine flywheel plate. Always install a NEW engine flywheel.

Welded areas that retain the ring gear onto the engine flywheel for cracking (4) (if present)

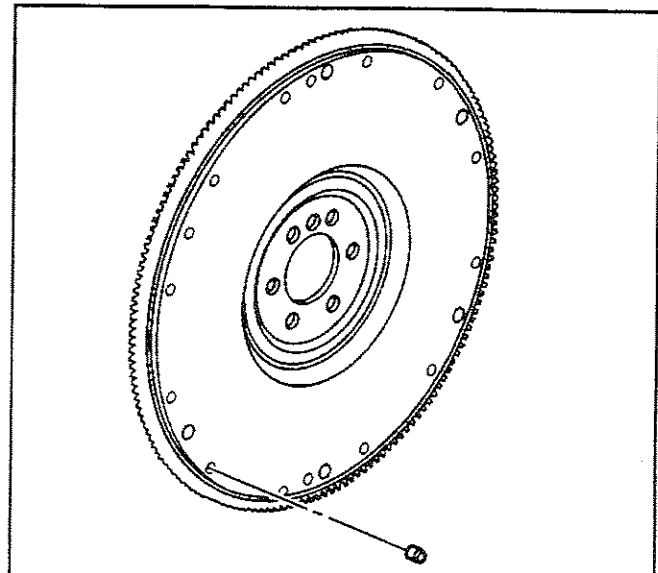
- Damaged ring gear teeth (5)



381965

4. Inspect the engine flywheel (manual transmission) (if equipped) for loose or improperly installed flywheel weights (if applicable).

A properly installed flywheel weight should be installed until flush or below flush with the face of the engine flywheel.

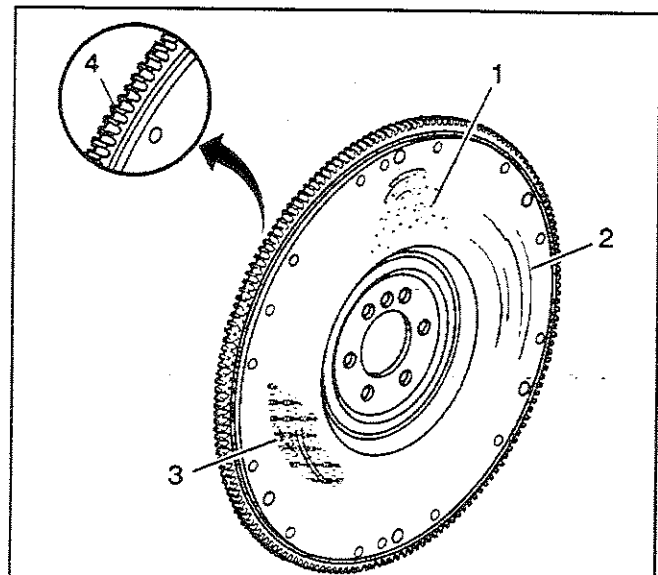


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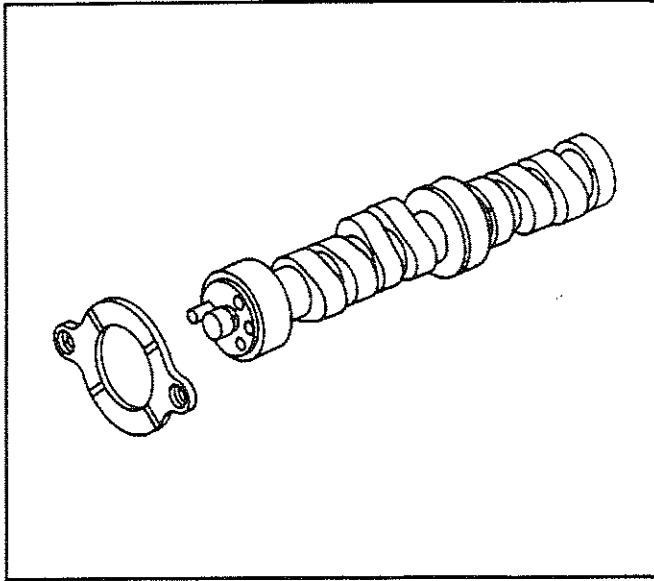
5. Inspect the engine flywheel (manual transmission) (if equipped) for the following:

- Pitted friction surface (1)
- Scoring or grooves (2)
- Rust or other surface damage (3)
- Damaged ring gear teeth (4)
- Loose or improperly positioned ring gear

The ring gear has an interference fit onto the engine flywheel and the ring gear should be positioned completely flat against the flange of the engine flywheel.



188086



334499

Camshaft and Bearings Clean and Inspect

SIE-ID = 506894

Tools Required

J 7872 Magnetic Base Dial Indicator

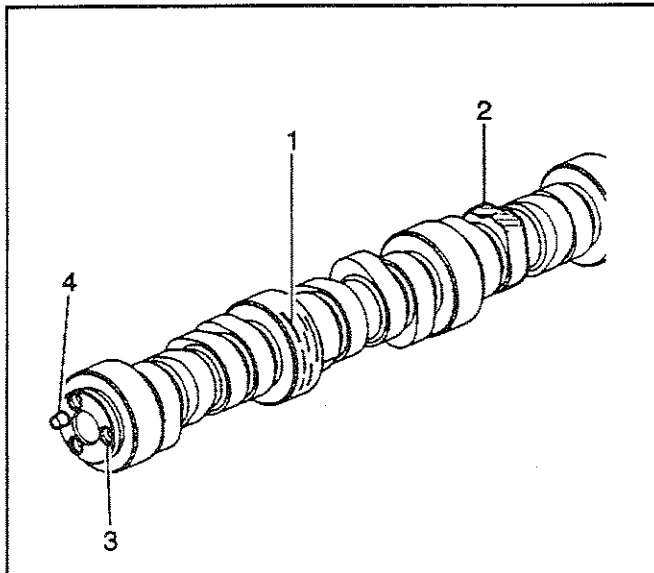
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

1. Clean the engine camshaft in cleaning solvent.
2. Dry the engine camshaft with compressed air.
3. Inspect the camshaft retainer plate for damage.
If the camshaft retainer plate is damaged, replace as necessary.
4. Inspect the camshaft bearings for correct fit into the engine block camshaft bearing bores.
The camshaft bearings have an interference fit to the engine block camshaft bearing bores and must not be loose in the engine block camshaft bearing bores.

Important: If any camshaft bearing is excessively worn or scored, replace all the camshaft bearings.

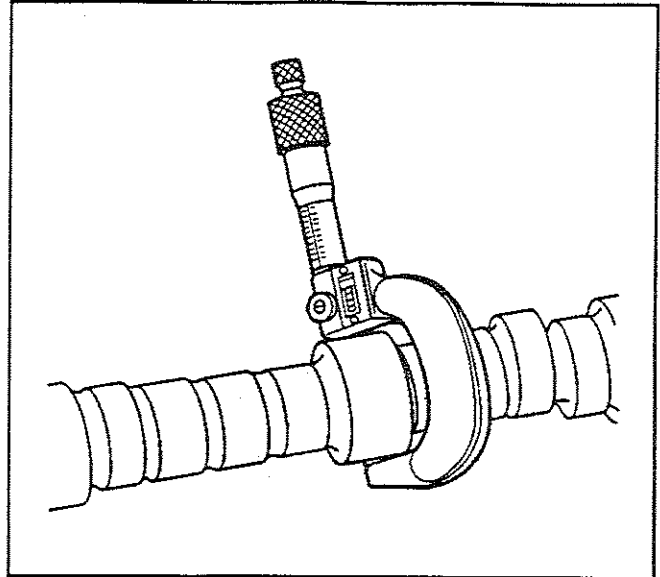
Inspect the camshaft bearings for excessive wear or scoring.

5. 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)



188095

6. 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.



188014

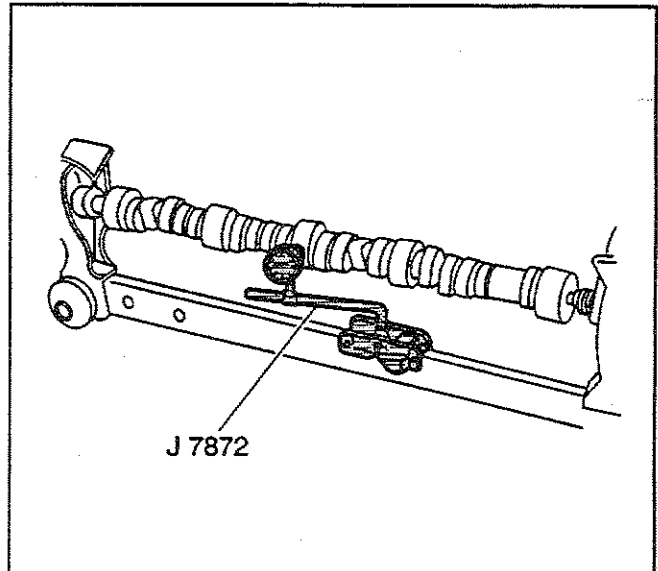
7. Measure for a bent engine camshaft or excessive engine camshaft runout using the J 7872.

- 7.1. Mount the engine camshaft in a suitable stand between centers.
- 7.2. 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 must be replaced.

8. Measure the engine camshaft lobe lift using the J 7872.

- 8.1. Place the engine camshaft on the V-blocks.
- 8.2. Use the J 7872 in order to measure the engine camshaft lobe lift.

9. Replace the engine camshaft if the engine camshaft lobe lift is not within specifications. Refer to *Engine Mechanical Specifications*.



188012

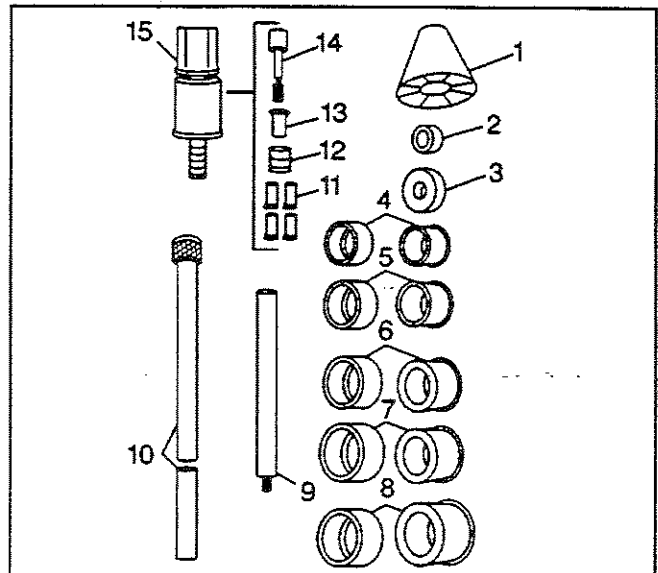
Camshaft Bearing Removal

SIE-ID - 199584

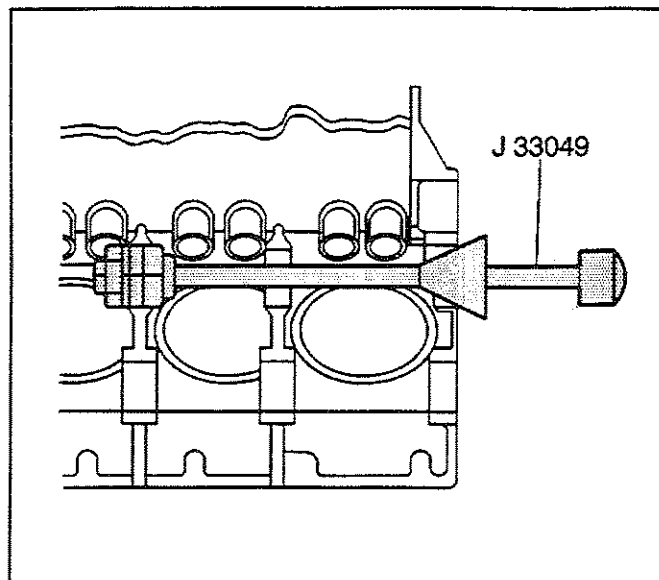
Tools Required

J 33049 Camshaft Bearing Service Kit

1. Select the cone (1), the handle (10), the expanding driver (4-8), the washer (2 or 3), and the expander assembly (15) from the J 33049.
2. Assemble the J 33049.



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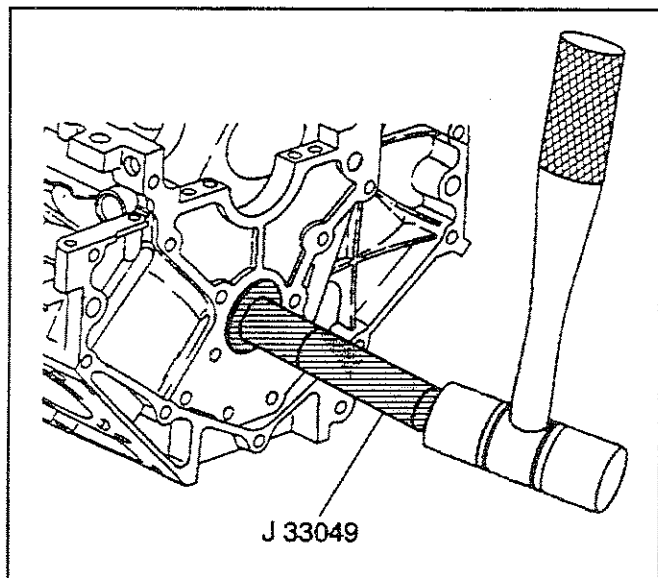
Important: A loose camshaft bearing may be caused by an enlarged, out-of-round, or damaged engine block camshaft bearing bore.

Important: Always remove the camshaft inner bearings #2 and #3 first. The camshaft outer bearings #1 and #4 serve as a guide for the J 33049.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

Remove the camshaft inner bearings #2 and #3.

- 2.1. Insert the J 33049 through the front of the engine block and into the camshaft inner bearing #2.
- 2.2. Tighten the J 33049 expander assembly nut until snug.
- 2.3. Push the J 33049 guide cone into the camshaft front bearing in order to align the J 33049.
- 2.4. Drive the camshaft inner bearing #2 from the camshaft inner bearing bore #2.
- 2.5. Loosen the J 33049 expander assembly nut.
- 2.6. Remove the camshaft inner bearing #2 from the J 33049 expander assembly.
- 2.7. Insert the J 33049 expander assembly into the camshaft inner bearing #3.
- 2.8. Tighten the J 33049 expander assembly nut until snug.
- 2.9. Push the J 33049 guide cone into the camshaft front bearing in order to align the J 33049.
- 2.10. Drive the camshaft inner bearing #3 from the camshaft inner bearing bore #3.
- 2.11. Loosen the J 33049 expander assembly nut.
- 2.12. Remove the camshaft inner bearing #3 from the J 33049 expander assembly.
3. Remove the J 33049 from the engine block.
4. Remove the camshaft outer bearings #1 and #4.
 - 4.1. Insert the J 33049 into the camshaft outer bearing #1.
 - 4.2. Tighten the J 33049 expander assembly nut until snug.
 - 4.3. Drive the camshaft outer bearing #1 from the camshaft outer bearing bore #1.
 - 4.4. Loosen the J 33049 expander assembly nut.
 - 4.5. Remove the camshaft outer bearing #1 from the J 33049 expander assembly.
 - 4.6. Remove the J 33049 from the engine block.
 - 4.7. Insert the J 33049 into the camshaft outer bearing #4.
 - 4.8. Tighten the J 33049 expander assembly nut until snug.
 - 4.9. Drive the camshaft outer bearing #4 from the camshaft outer bearing bore #4.
 - 4.10. Loosen the J 33049 expander assembly nut.
 - 4.11. Remove the camshaft outer bearing #4 from the J 33049 expander assembly.



63219

5. Remove the *J 33049* from the engine block.
6. Discard the camshaft bearings.

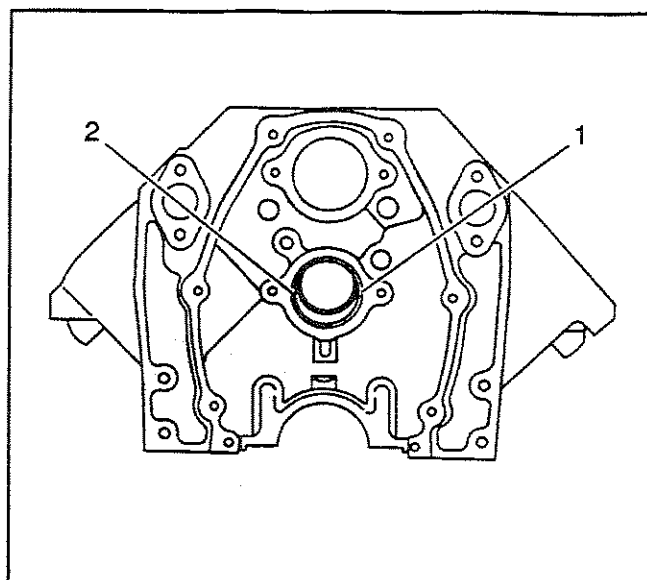
Camshaft Bearing Installation

SIE-ID # 199692

Tools Required

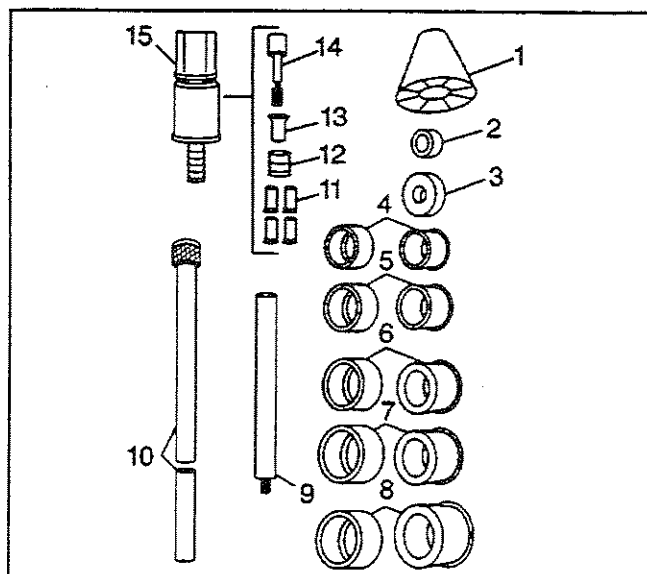
J 33049 Camshaft Bearing Service Kit

Important: When installing the camshaft bearings, always look in order to ensure that the camshaft bearing lubrication hole is located above the 3 o'clock position (1) or the 9 o'clock position (2). The proper positioning of the camshaft bearing lubrication hole is in order to ensure the best lubrication of the engine camshaft journals.

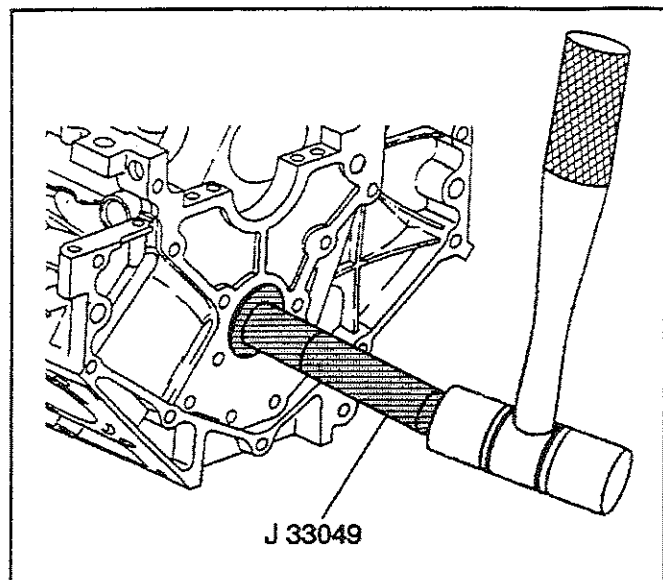


594647

1. Assemble the *J 33049* handle (10), the expanding driver (4–8), the washer (2 or 3), and the expander assembly (15).



66100



63219

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

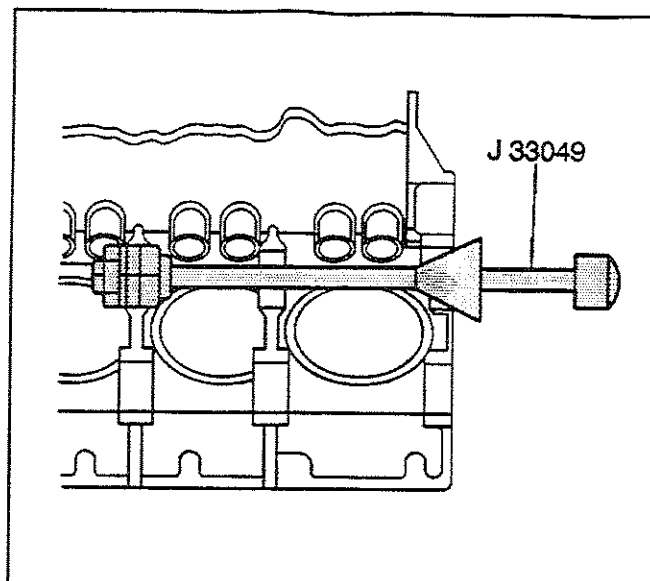
Important: The camshaft bearings vary in size. When ordering the new camshaft bearings, be sure to order the correct camshaft bearings for the application to be serviced.

Always install the camshaft outer bearings #1 and #4 first. The camshaft outer bearings serve as a guide for the J 33049 and help center the camshaft inner bearings during the installation process.

Install the NEW camshaft outer bearings #4 and #1.

- 1.1. Install the NEW camshaft outer bearing #4 onto the J 33049 expander assembly.
- 1.2. Tighten the J 33049 expander assembly nut until snug.
- 1.3. Align the lubrication hole of the camshaft outer bearing #4 above the 3 o'clock position or the 9 o'clock position of the camshaft outer bearing bore #4 at the rear of the engine block.
- 1.4. Drive the camshaft outer bearing #4 into the camshaft outer bearing bore #4 at the rear of the engine block.
- 1.5. Loosen the J 33049 expander assembly nut.
- 1.6. Remove the camshaft outer bearing #4 from the J 33049 expander assembly.
- 1.7. Install the NEW camshaft outer bearing #1 onto the J 33049 expander assembly.
- 1.8. Tighten the J 33049 expander assembly nut until snug.
- 1.9. Align the lubrication hole of the camshaft outer bearing #1 above the 3 o'clock position or the 9 o'clock position of the camshaft outer bearing bore #1 at the front of the engine block.
- 1.10. Drive the camshaft outer bearing #1 into the camshaft outer bearing bore #1 at the front of the engine block.
- 1.11. Loosen the J 33049 expander assembly nut.
- 1.12. Carefully slide the J 33049 into the engine block until the J 33049 expander assembly is positioned between the camshaft inner bearing bores.

2. Install the NEW camshaft inner bearings #3 and #2.
 - 2.1. Install the NEW camshaft inner bearing #3 onto the J 33049 expander assembly.
 - 2.2. Tighten the J 33049 expander assembly nut until snug.
 - 2.3. Align the lubrication hole of the camshaft inner bearing #3 above the 3 o'clock position or the 9 o'clock position of the camshaft inner bearing bore #3 of the engine block.
 - 2.4. Push the J 33049 guide cone into the camshaft front bearing bore #1 in order to align the J 33049.
 - 2.5. Drive the camshaft inner bearing #3 into the camshaft inner bearing bore #3.
 - 2.6. Loosen the J 33049 expander assembly nut.
 - 2.7. Carefully slide the J 33049 until the J 33049 expander assembly is positioned between the camshaft inner bearing bore #2 and the camshaft outer bearing bore #1.
 - 2.8. Install the NEW camshaft inner bearing #2 onto the J 33049 expander assembly.
 - 2.9. Tighten the J 33049 expander assembly nut until snug.
 - 2.10. Align the lubrication hole of the camshaft inner bearing #2 above the 3 o'clock position or the 9 o'clock position of the camshaft inner bearing bore #2 of the engine block.
 - 2.11. Push the J 33049 guide cone into the camshaft front bearing bore #1 in order to align the J 33049.
 - 2.12. Drive the camshaft inner bearing #2 into the camshaft inner bearing bore #2.
 - 2.13. Loosen the J 33049 expander assembly nut.
3. Carefully remove the J 33049 from the engine block.



4985

Balance Shaft Bearing and/or Bushing Removal

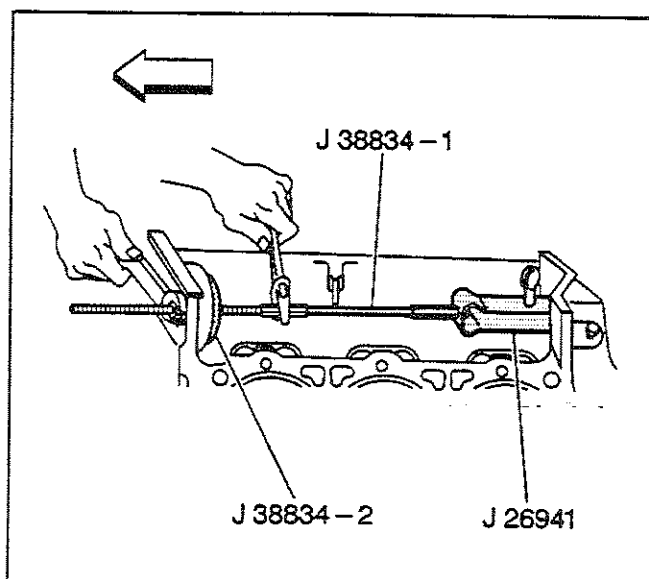
S/E-ID • 358968

Tools Required

- J 26941 Bushing/Bearing Remover
- J 38834 Balance Shaft Service Kit

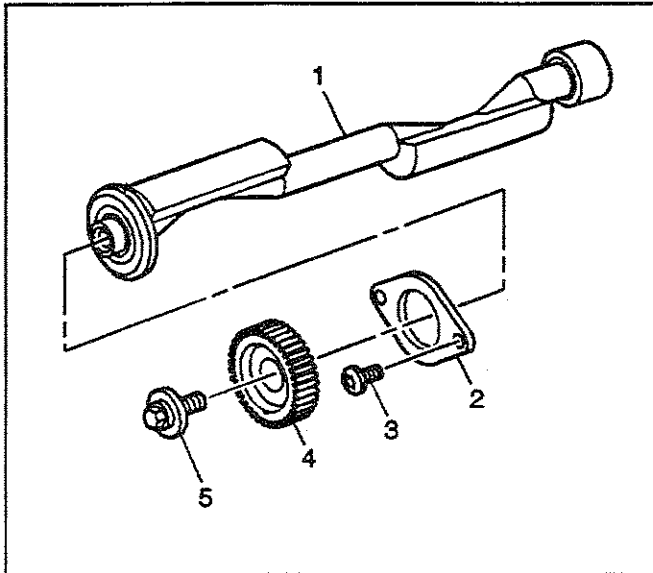
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

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.



340081

- 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.



188106

Balance Shaft Clean and Inspect

SIE-ID - 199440

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

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.

Clean the following components in cleaning solvent:

- The balance shaft (1)
- The balance shaft retainer (2)
- The balance shaft rear bearing
- The balance shaft driven gear (4)
- The balance shaft drive gear

1. Dry the following components with compressed air:

- The balance shaft (1)
- The balance shaft retainer (2)
- The balance shaft rear bearing
- The balance shaft driven gear (4)
- The balance shaft drive gear

2. Inspect the balance shaft bearings for the following:

- Front ball bearing for damage or wear
- Front ball bearing for smoothness of operation
- Rear sleeve bearing for wear, scoring, or other damage

3. Inspect the balance shaft (1) for the following:

- Wear or scoring on the rear bearing journal
- Damaged bolt hole threads
- Damaged to the balance shaft driven gear locator pin

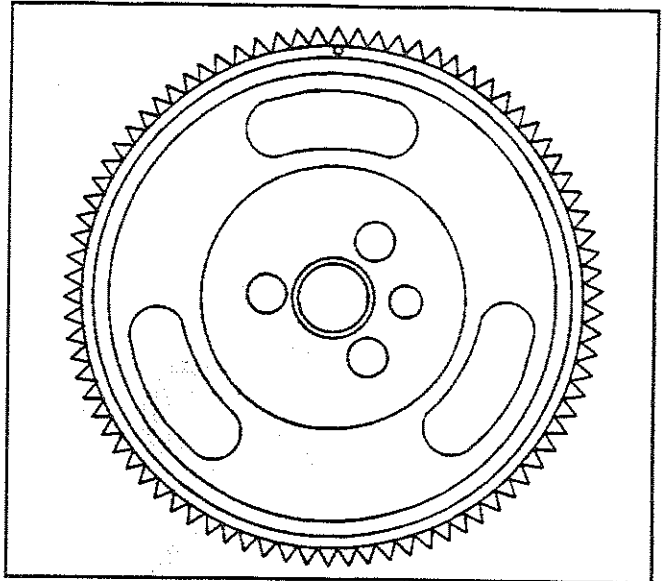
4. Inspect the balance shaft retainer (2) for wear or damage.

5. Inspect the balance shaft retainer bolts (3) for damaged threads.

6. Inspect the driven gear (4) for the following:

- Excessive wear or damage
- Nicks, burrs, or scoring

7. Inspect the driven gear bolt (5) for damaged threads.
8. Inspect the balance shaft drive gear for the following:
 - Excessive wear or damage
 - Nicks, burrs, or scoring



9848

Balance Shaft Bearing and/or Bushing Installation

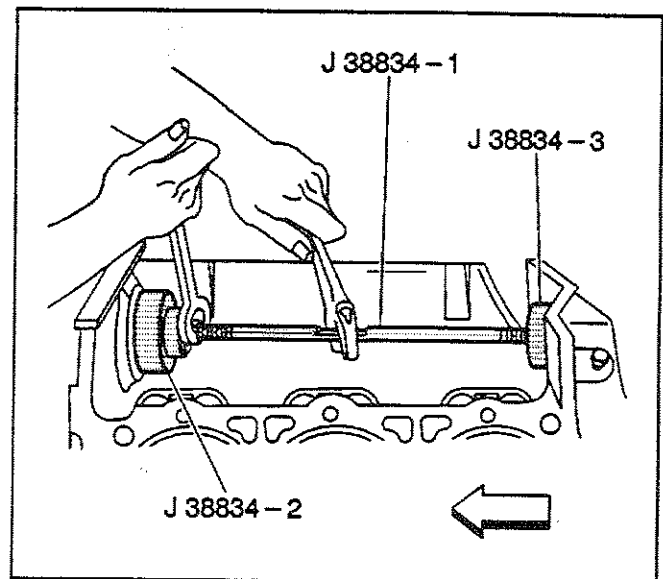
SIE-ID = 359018

Tools Required

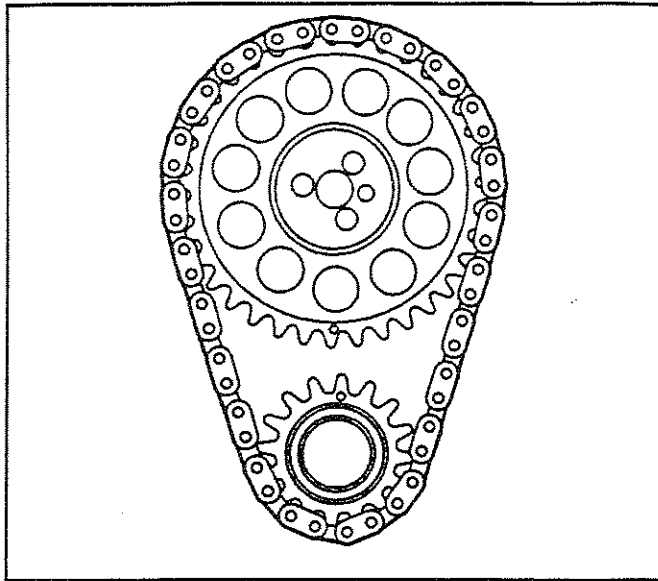
J 38834 Balance Shaft Service Kit

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

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



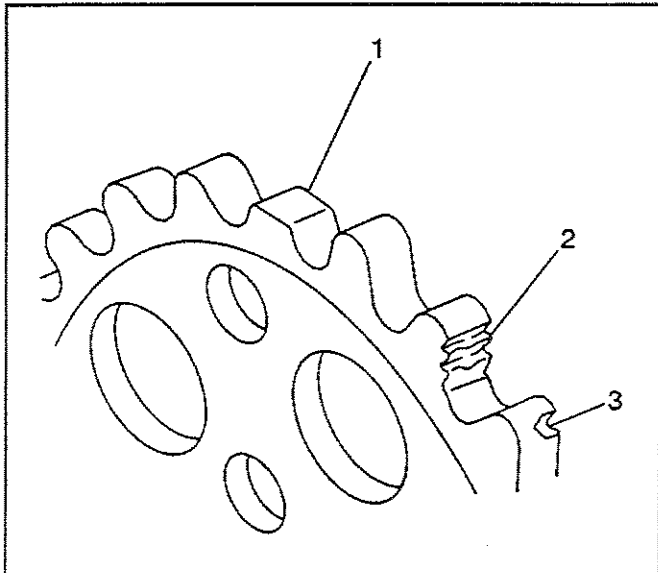
480575

Timing Chain and Sprockets Clean and Inspect

SIE-ID - 507062

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

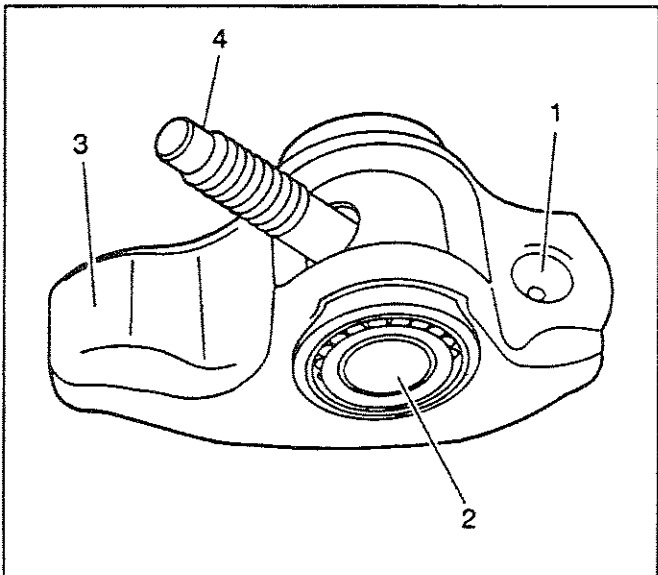
1. Clean the components with cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the camshaft timing chain for binding or wear.



188097

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



480551

Valve Rocker Arm and Push Rods Clean and Inspect

SIE-ID - 507063

Important: Parts that are to be reused must be marked, sorted, and organized for assembly.

Mark, sort, and organize the components for assembly.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

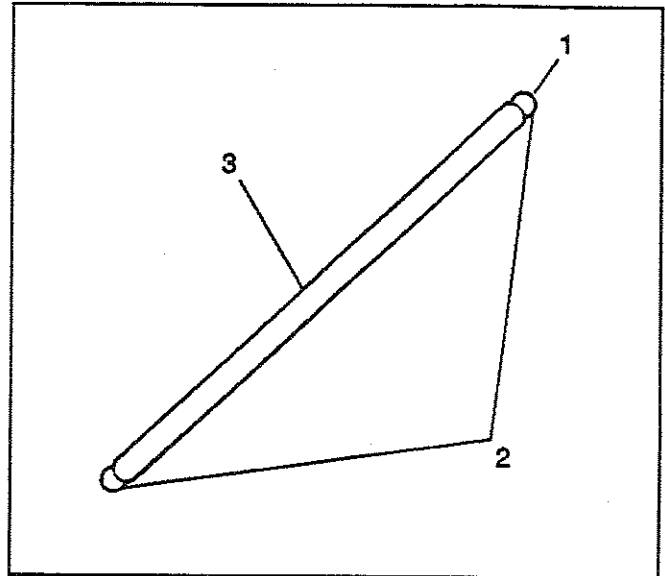
1. Clean the components with cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the valve rocker arm components for the following:
 - Valve rocker arm valve pushrod socket contact surface (1)
 The contact surface must be smooth with no scoring or excessive wear.

- Valve rocker arm roller pivot for binding or damage (2)
- Valve rocker arm valve stem contact surface (3)
The contact surface should be smooth with no scoring or excessive wear.
- Valve rocker arm bolt threads for damage (4)

4. Inspect the valve pushrods for the following:

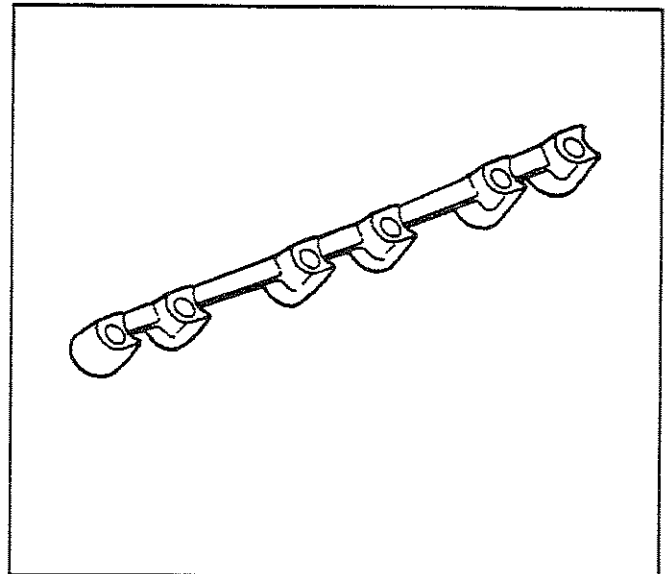
- Restriction of the oil passage (1)
- Wear or scoring of the end contact surfaces (2)
The end contact surfaces must be smooth with no scoring or excessive wear.
- Shaft for bends (3)

Roll the valve pushrod on a flat surface to determine if the valve pushrod is bent.

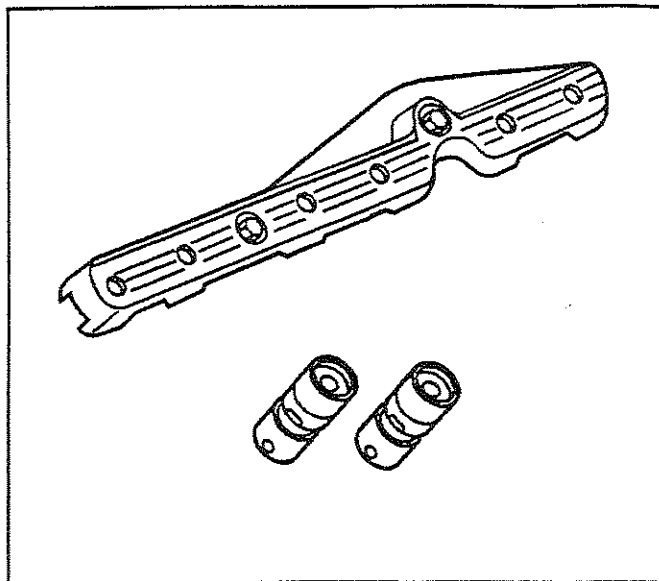


488857

5. Inspect the valve rocker support for excessive wear or damage.



480553



188118

Valve Lifters and Guides Clean and Inspect

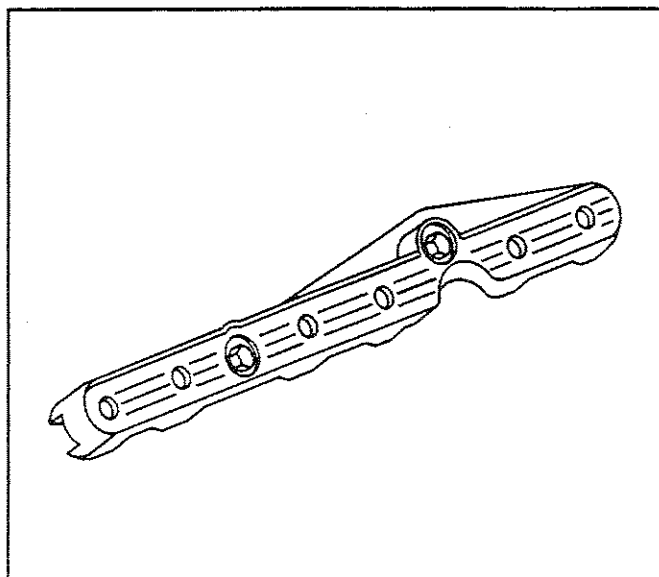
SIE-ID - 199444

Important: Components that are to be reused must be marked, sorted, and organized for assembly.

Mark, sort, and organize the components for assembly.

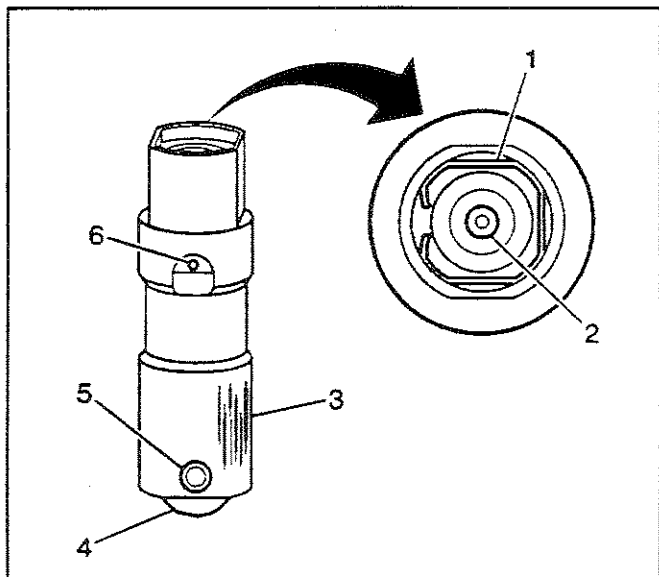
Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

1. Clean the components in cleaning solvent.
2. Dry the components with compressed air.



334500

3. Inspect the valve lifter pushrod guides for excessive wear.
4. Inspect the valve lifter pushrod guides for cracks or damage.



178485

5. Inspect the valve lifter for the following:

- Broken or damaged clip (1)
- Worn pushrod socket (2)
- Scuffed or worn lifter body (3)

If the valve lifter shows scuffing or wear, inspect the engine block valve lifter bores for wear.

- Worn roller (4)
- Loose or damaged pin (5)
- Plugged oil hole (6)

Cylinder Head Disassemble

SIE-ID = 507072

Tools Required

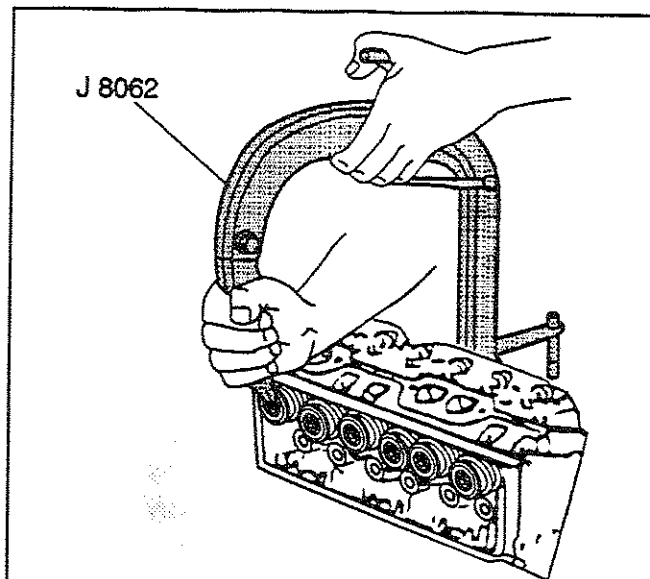
J 8062 Valve Spring Compressor

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.*

Caution: *Failing to use care may cause personal injury.*

Caution: *Refer to Safety Glasses Caution in Cautions and Notices.*

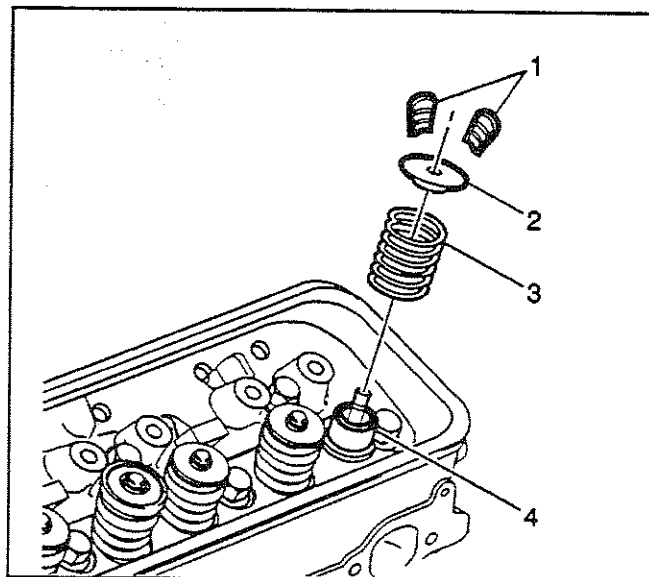
1. Use the J 8062 in order to compress the valve springs.



480554

Important: Mark, sort, and organize the components so that the components can be reinstalled in their original location and position.

- Remove the valve stem keys (1).
- Remove the J 8062 from the cylinder head.
- Remove the valve spring cap (2).
- Remove the valve spring (3).
- Remove the valve stem oil seal (4).
- Discard the valve stem oil seal.
- Remove the valve.



480555

Cylinder Head Clean and Inspect

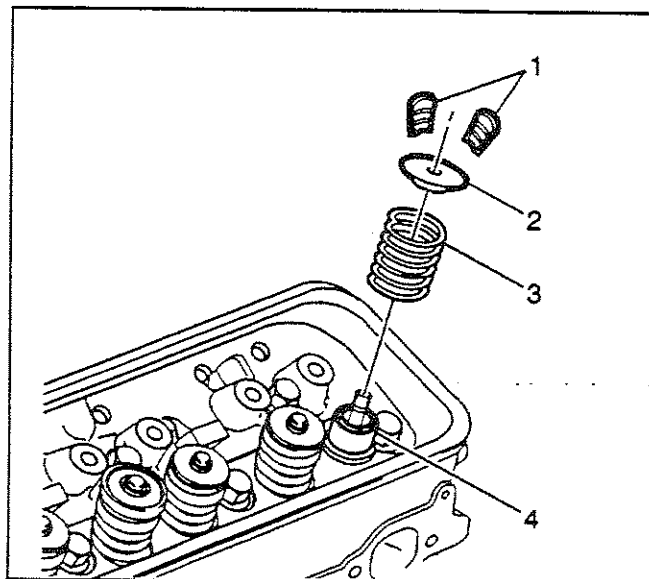
SIE-ID = 507077

Tools Required

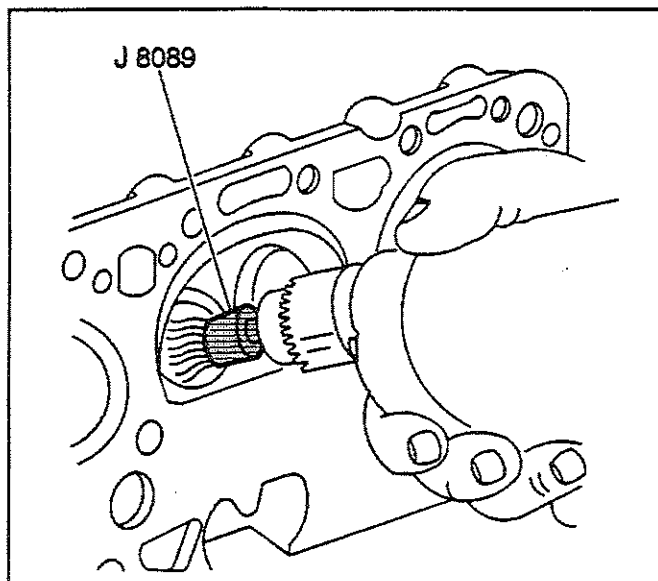
- J 8001 Dial Indicator Set
- J 8089 Carbon Removing Brush
- J 9666 Valve Spring Tester

Caution: *Refer to Safety Glasses Caution in Cautions and Notices.*

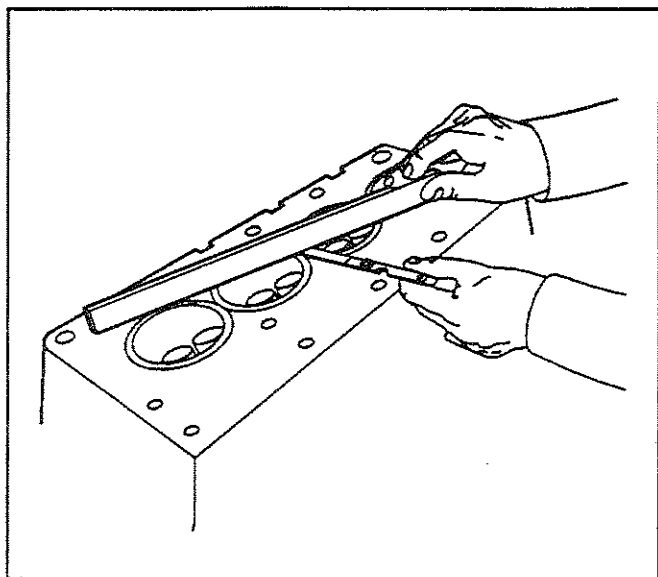
1. Clean the valve stems and cylinder heads on a buffing wheel.
2. Clean the following components in cleaning solvent:
 - Valve stem keys (1)
 - Valve spring cap (2)
 - Valve spring (3)
 - Cylinder head



480555



4957

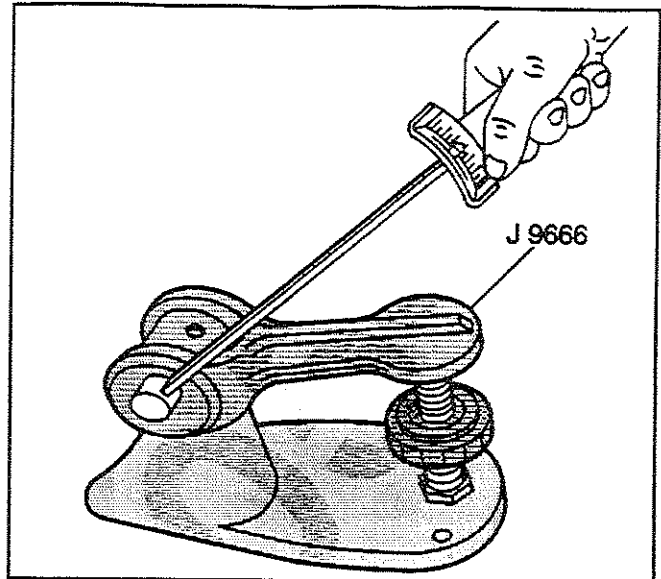


64318

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 0.05 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.

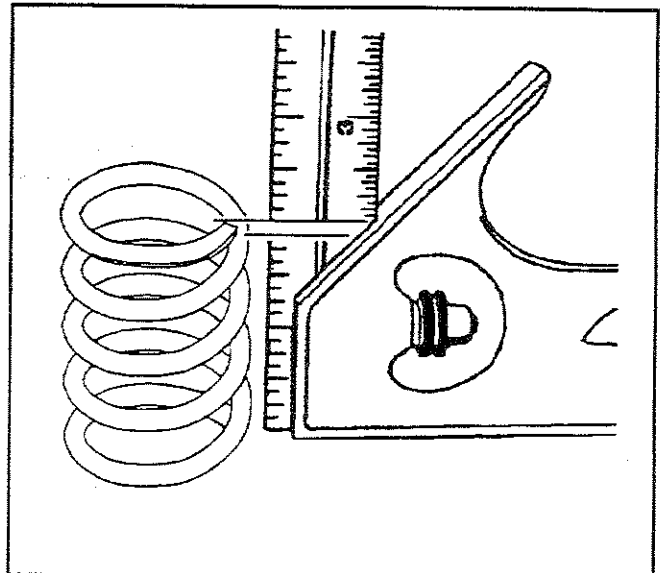
7. Use the J 9666 in order to measure the valve spring.

Replace the valve spring if the valve spring tension is less than 338 N (76 lb) at 43.2 mm (1.70 in).



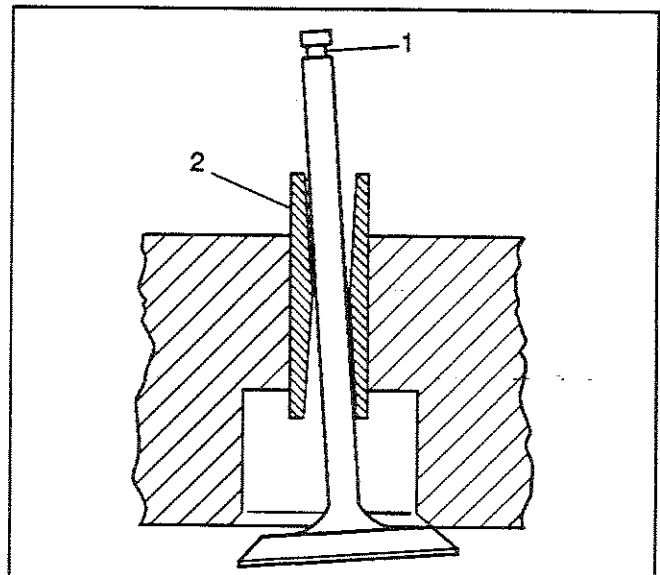
4960

8. Inspect the valve springs for squareness.

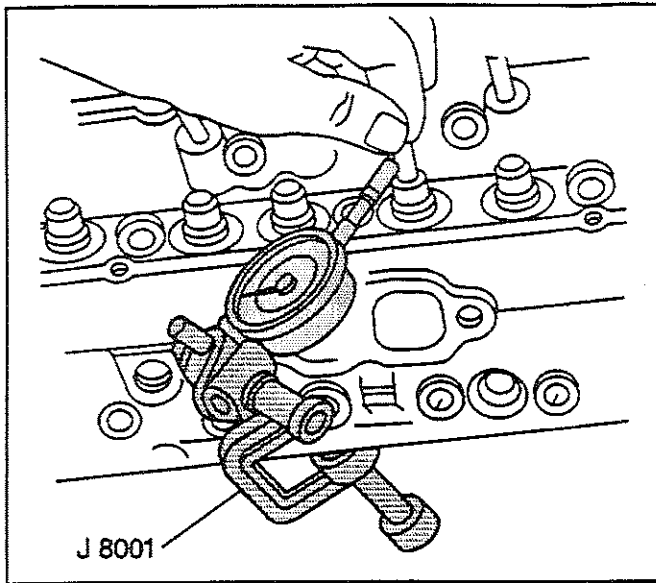


40075

9. Valve stems (1) with excessive valve guide (2) clearance must be repaired or the cylinder head replaced.



156172



35214

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.

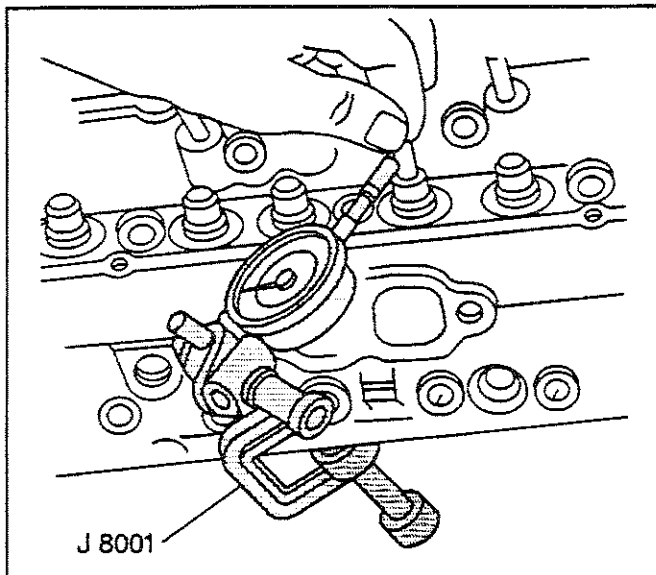
10.1. Clamp the *J 8001* on the exhaust port side of the cylinder head.

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

Valve Guide Reaming/Valve and Seat Grinding

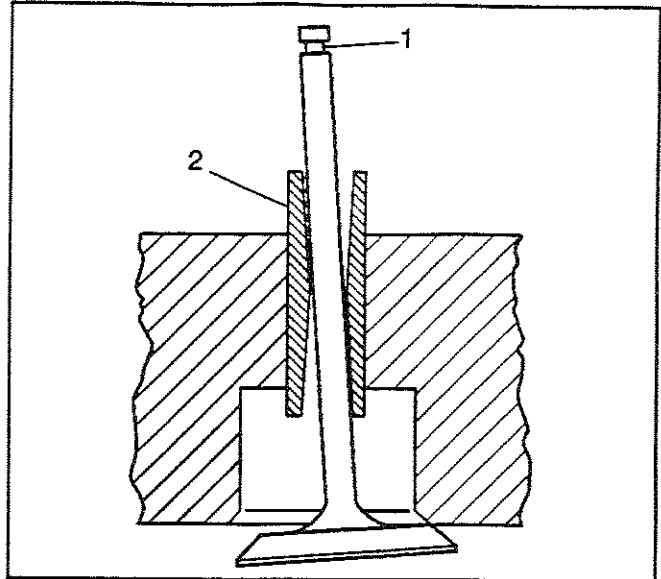
SIE-ID - 507084

Tools Required

- *J 5830-02* Valve Guide Reamer Set
- *J 8001* Dial Indicator Set

1. Measure the valve stem-to-guide clearance. Refer to *Cylinder Head Clean and Inspect*.

2. Improper valve stem (1) to valve guide (2) clearance may cause excessive oil consumption.

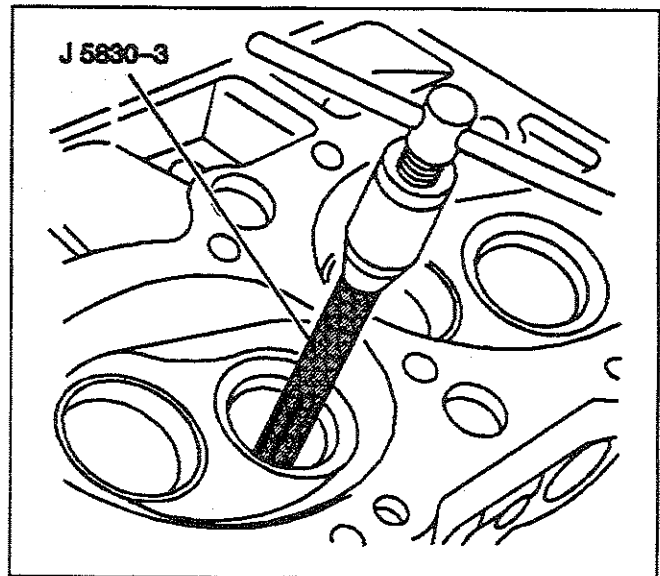


156172

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

Important: Exhaust valves with excessive valve stem-to-guide clearance must be replaced with the available service valve that has an 0.0774 mm (0.0305 in.) oversize valve stem. The intake valves are NOT available with oversize valve stems. Replace the cylinder head if after using a NEW intake valve in order to measure the valve stem-to-guide clearance, the valve stem-to-guide clearance is not within specifications.

Use the J 5830-3 in order to ream the exhaust valve guide in order to achieve the correct valve stem-to-guide clearance.

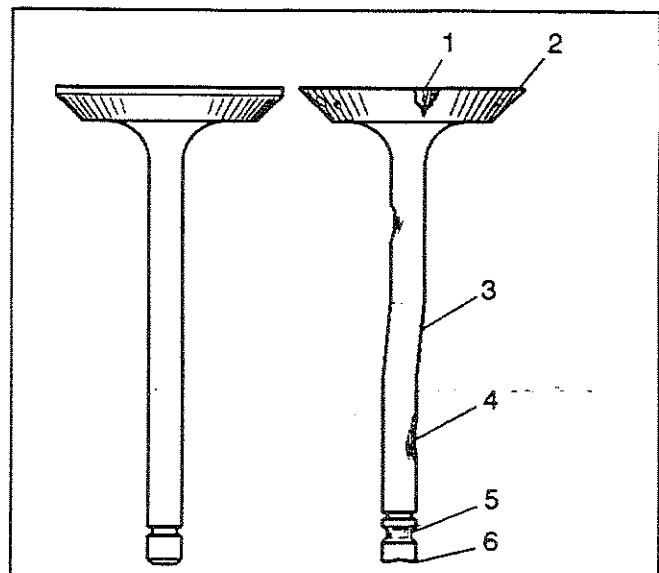


480556

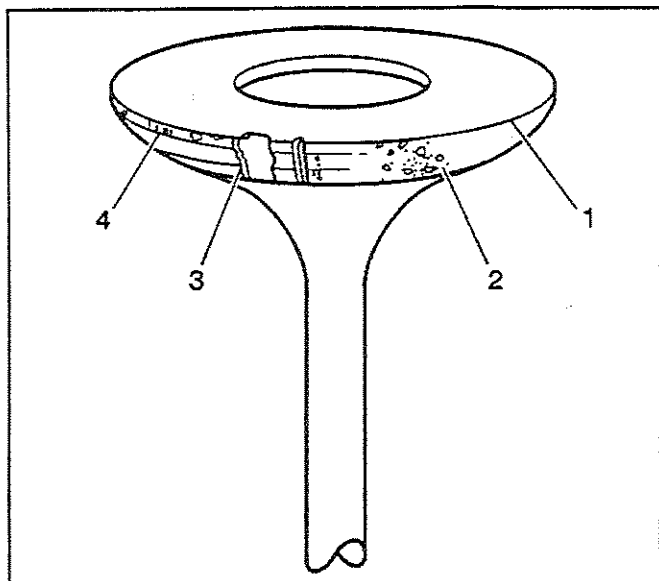
3. Always recondition the exhaust valve seat after reaming the exhaust valve guide bores and installing new exhaust valves.

4. Inspect the valves for the following:

- Burnt or damaged areas (1)
- Undersized margin (2)
- Bent stem (3)
- Scoring or other damage to the stem (4)
- Worn key groove (5)
- Worn stem tip (6)



156174



156173

5. Inspect the valve contact surface for the following:

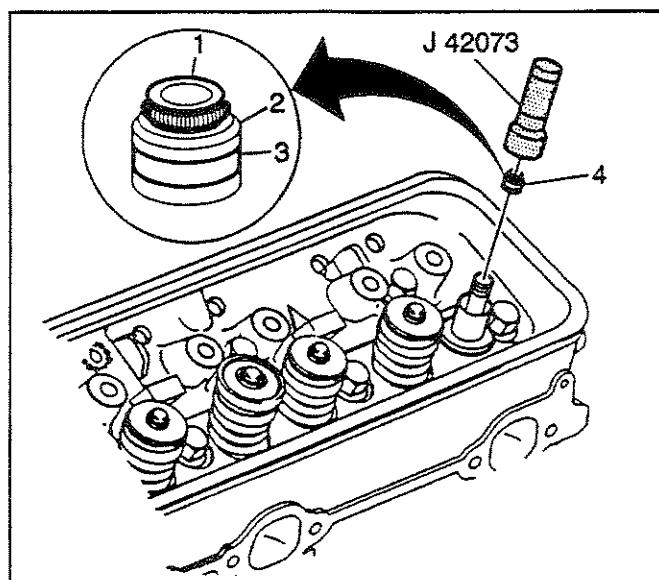
- Undersized margin (1)
- Pitted surface (2)
- Burnt or eroded areas (3)
- Acceptable edge (margin) (4)

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 valve 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 in order to ensure the proper centering of the pilot in the valve guide. The valve seats should be concentric to within 0.05 mm (0.002 in) total indicator reading.
 - Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the valve head and the valve stem.
- Replace the valve if the valve stem is excessively worn or warped.
- Replace the valve if the edge margin (4) 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 equipment manufacturer's recommendations for equipment use to attain the proper results.



480558

Cylinder Head Assemble

SIE-ID - 507090

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 red in color (2) with no paint stripe. The intake valve oil seal is black in color.

Assemble the valve into the proper valve guide.

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 stem.

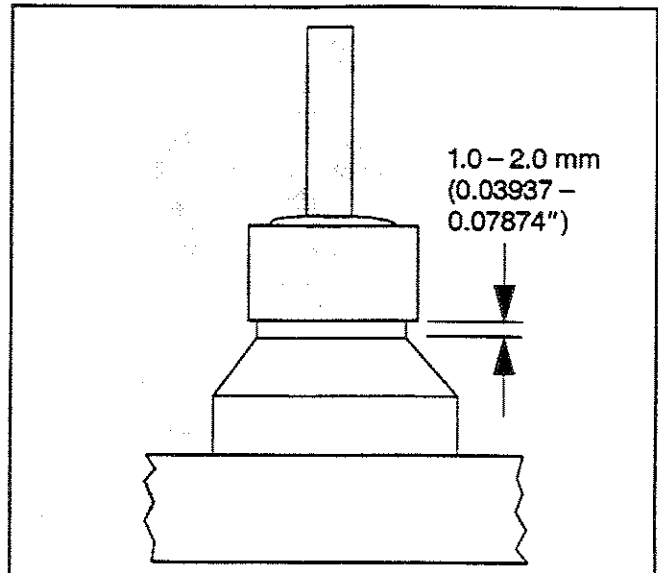
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

4. 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.

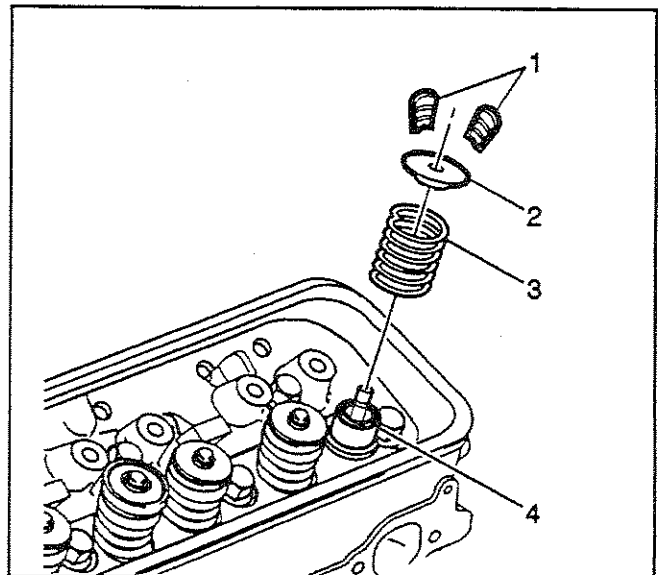
5. Inspect the valve stem oil seal. The valve stem oil seal should not be bottomed against the valve guide.

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.

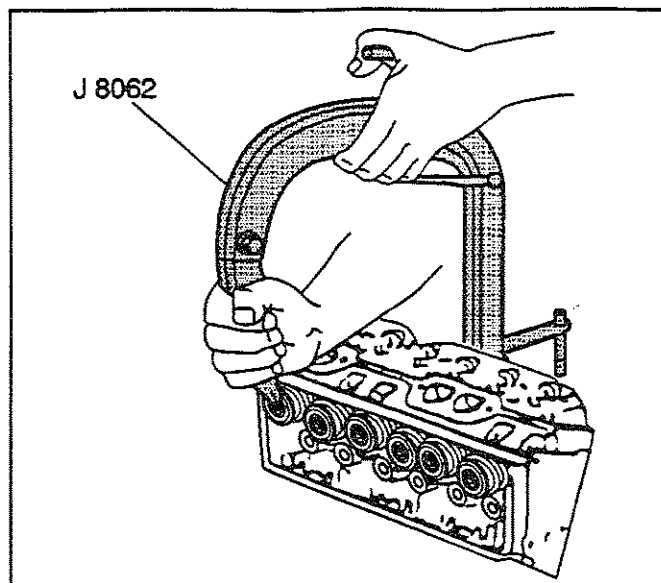


36373

6. Install the valve spring (3).
7. Install the valve spring cap (2) onto the valve spring (3) and over the valve stem.



480555



480554

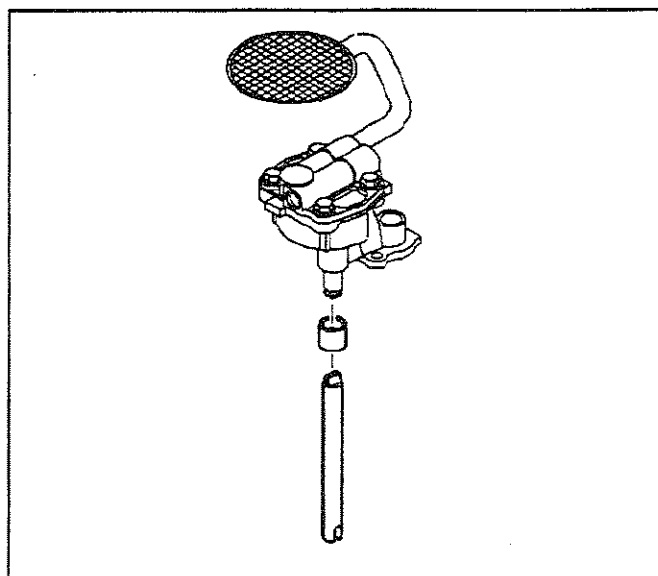
Caution: SIO-ID = 411464 Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing 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.

8. Use the J 8062 in order to compress the valve spring.
9. Install the valve stem keys.
 - 9.1. Use grease in order to hold the valve stem keys in place while disconnecting the J 8062.
 - 9.2. Look to ensure that the valve stem keys seat properly in the upper groove of the valve stem.
 - 9.3. Tap the end of the valve stem with a plastic-faced hammer in order to seat the valve stem keys, if necessary.

Oil Pump Disassemble

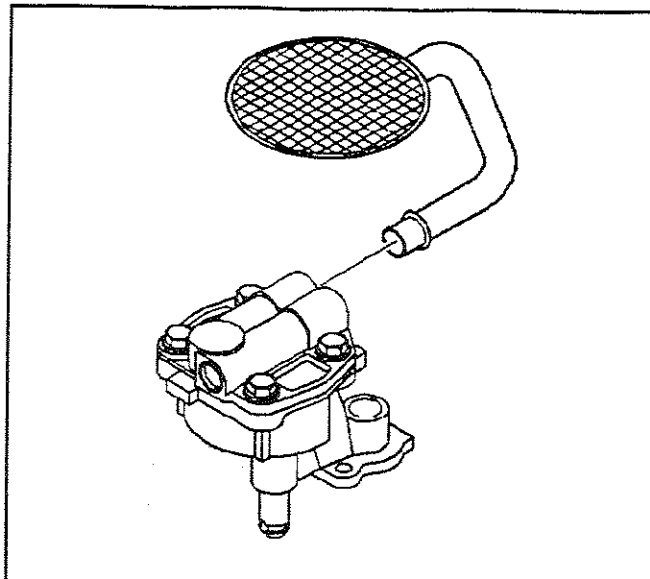
SIE-ID = 195049

1. Remove the oil pump driveshaft and oil pump driveshaft retainer.



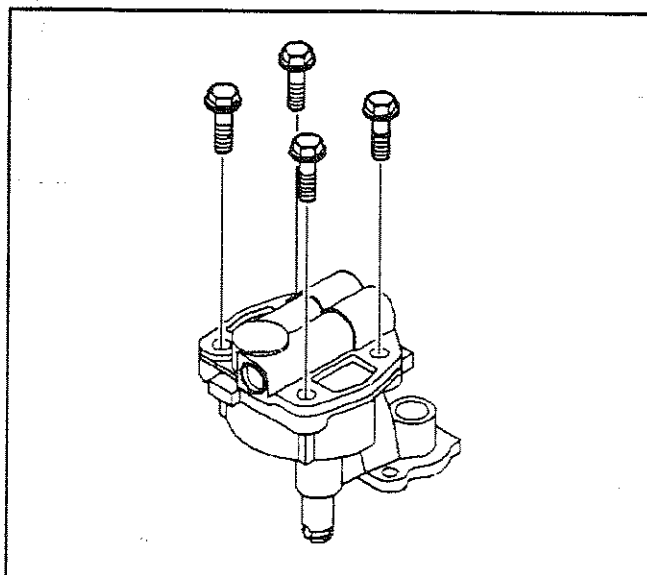
5274

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.



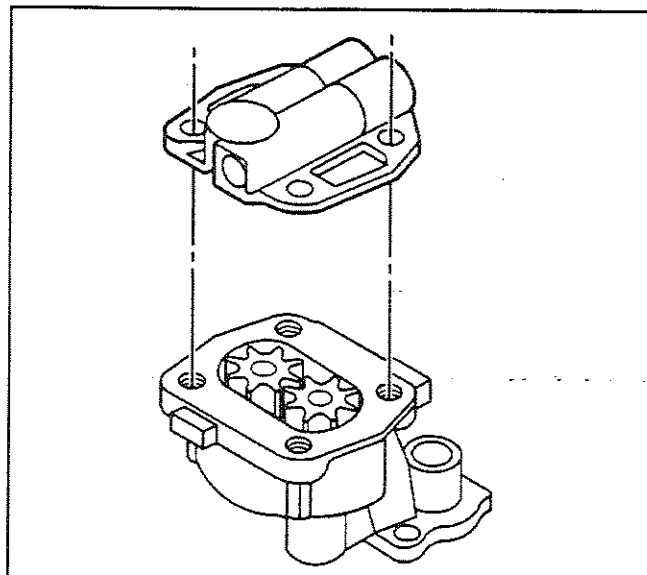
5275

3. Remove the oil pump cover bolts.

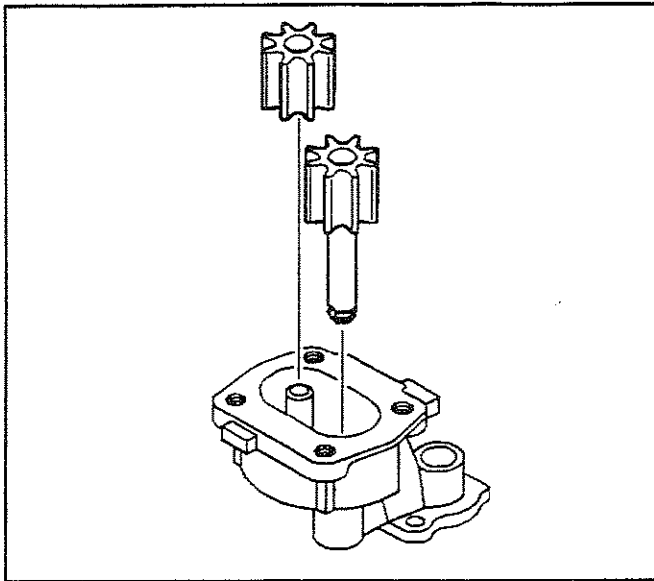


5276

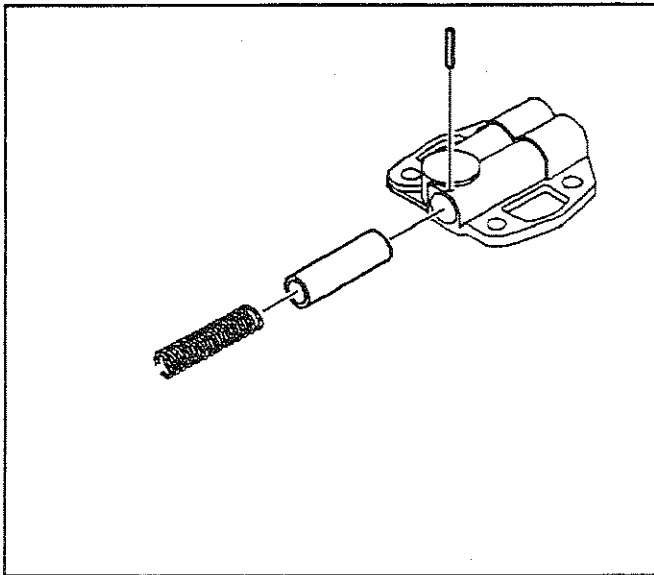
4. Remove the oil pump cover.



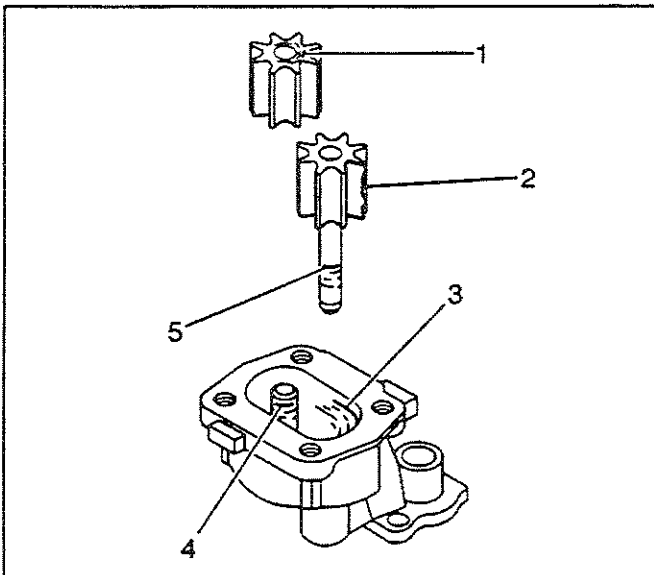
5277



5278



30401



186750

5. Remove the oil pump drive gear and the oil pump driven gear.
6. Matchmark the gear teeth for assembly.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

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

Oil Pump Clean and Inspect

SIE-ID - 35473

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

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 on the top of the gears (1)
 - Damaged gears (2) for the following:
 - Chipping
 - Galling
 - Wear
 - Scoring, damage or casting imperfections to the body (3)
 - Damaged or scored gear shaft (4)
 - Damaged or scored gear shaft (5)

- 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.

Oil Pump Assemble

SIE-ID = 389671

Tools Required

J 21882 Oil Suction Pipe Installer

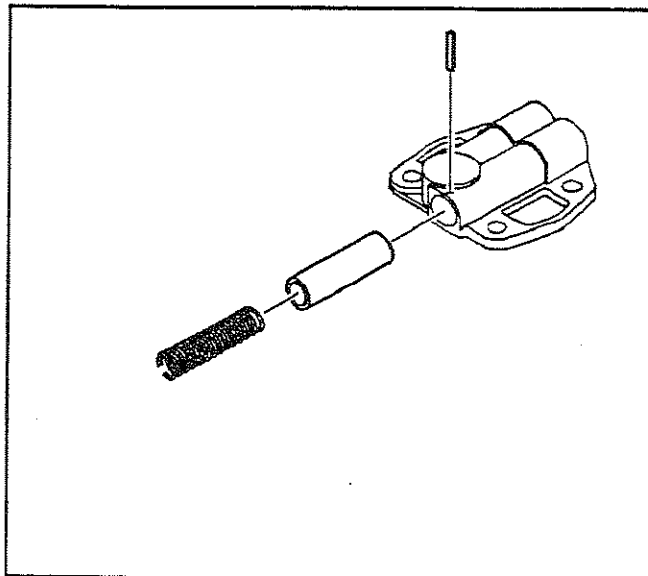
1. Apply clean engine oil GM P/N 12345610 or equivalent to the oil pump pressure relief valve, oil pump pressure relief valve spring, and oil pump body.

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

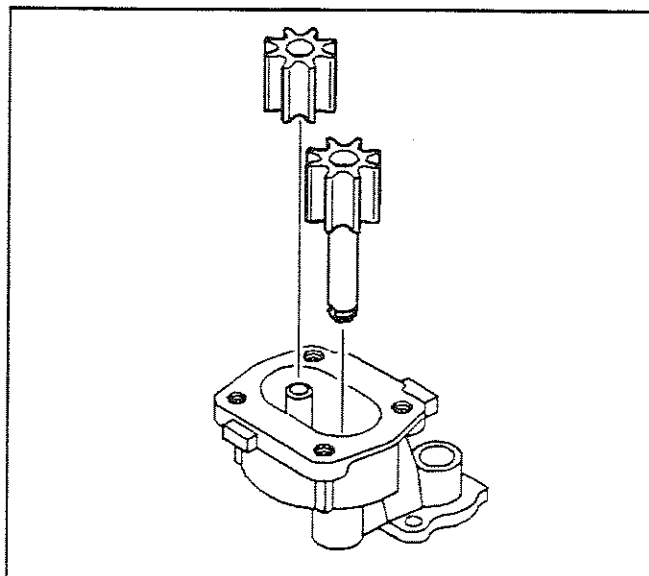
Important: Replace the oil pump pressure relief valve spring when you reuse the oil pump.

Install the following items:

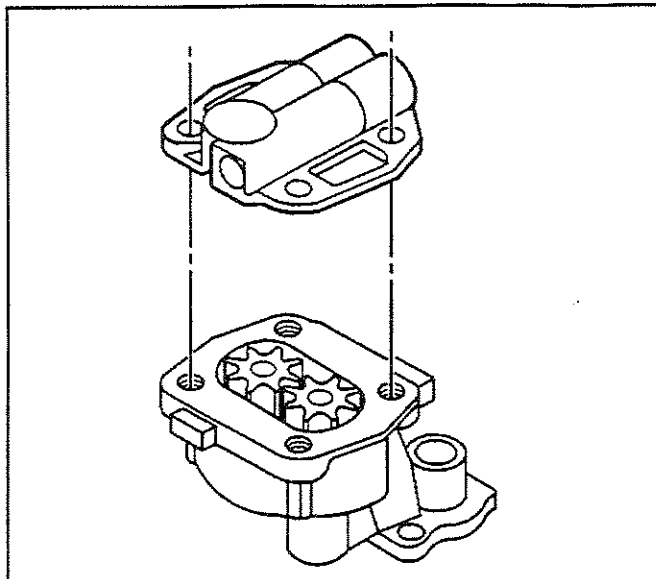
- 1.1. The oil pump pressure relief valve
 - 1.2. The oil pump pressure relief valve spring
 - 1.3. The oil pump pressure relief valve spring straight pin
2. Apply clean engine oil GM P/N 12345610 or equivalent to the oil pump drive gear, the oil pump driven gear, and the oil pump body internal surfaces.
 3. Install the oil pump drive gear and the oil pump driven gear into the oil pump body.
 - 3.1. Align the matchmarks on the oil pump drive and driven gears.
 - 3.2. Install the smooth side of the oil pump drive and driven gears toward the oil pump cover.



30401



5278



5277

4. Install the oil pump cover.

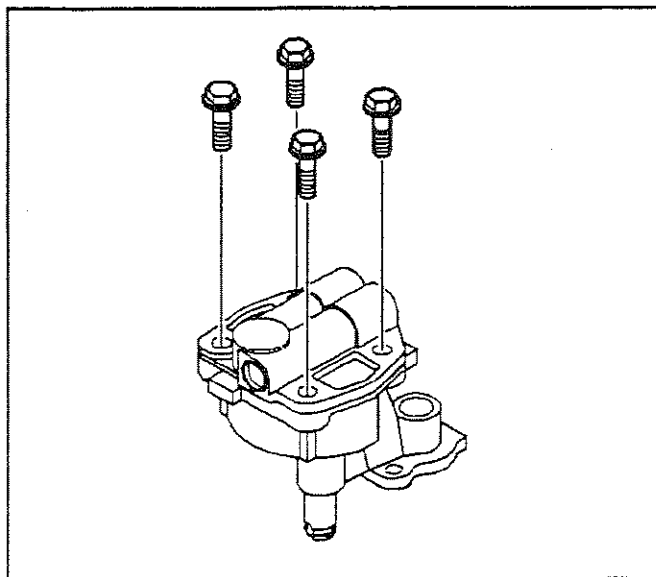
Notice: Refer to *Fastener Notice* in Caution and Notices.

5. Install the oil pump cover bolts.

Tighten

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

6. Inspect the oil pump for smoothness of operation by turning the oil pump driveshaft by hand.



5276

7. Install the oil pump screen.

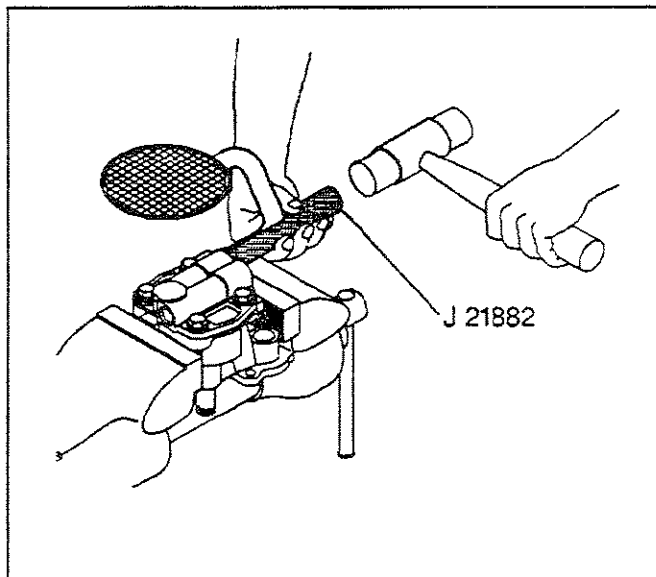
7.1. If removed, replace the oil pump screen. The oil pump screen must have a good press fit into the oil pump body.

7.2. Mount the oil pump in a soft jawed vise.

7.3. Apply sealant GM P/N 12346004 or equivalent to the end of the oil pump screen pipe.

7.4. Use the J 21882 and a soft-faced hammer in order to tap the oil pump screen into the pump body.

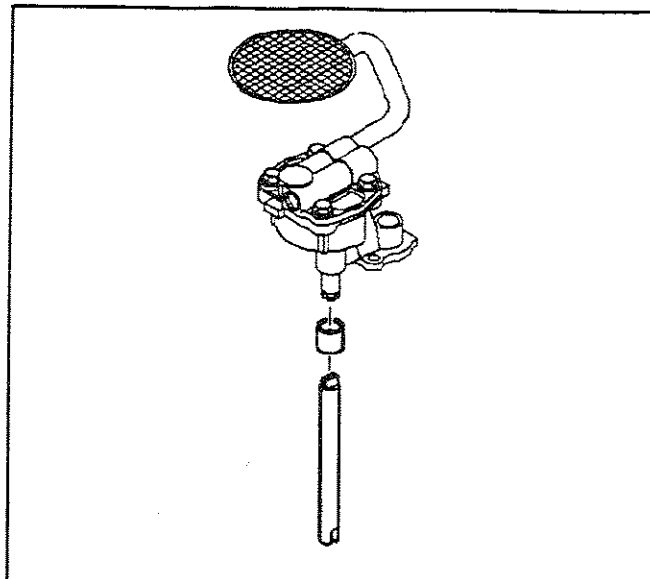
The oil pump screen must align parallel with the bottom of the oil pan when the oil pan is installed.



5280

Important: Install a NEW oil pump driveshaft retainer during assembly.

Install the oil pump driveshaft and the NEW oil pump driveshaft retainer.



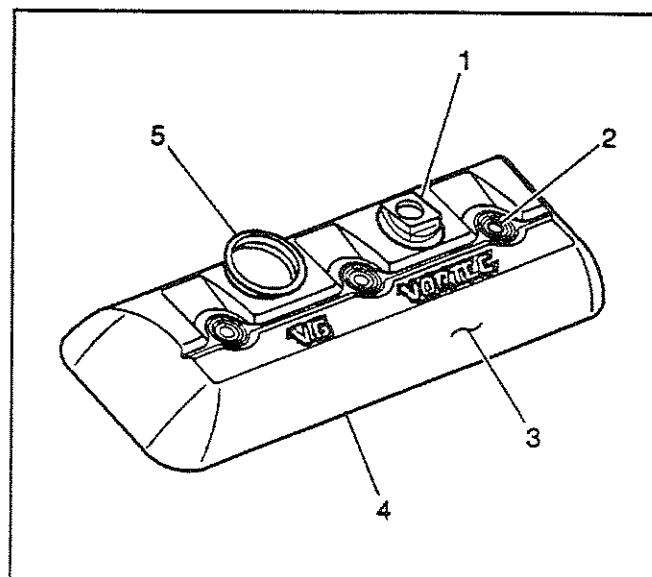
5274

Valve Rocker Arm Cover Clean and Inspect

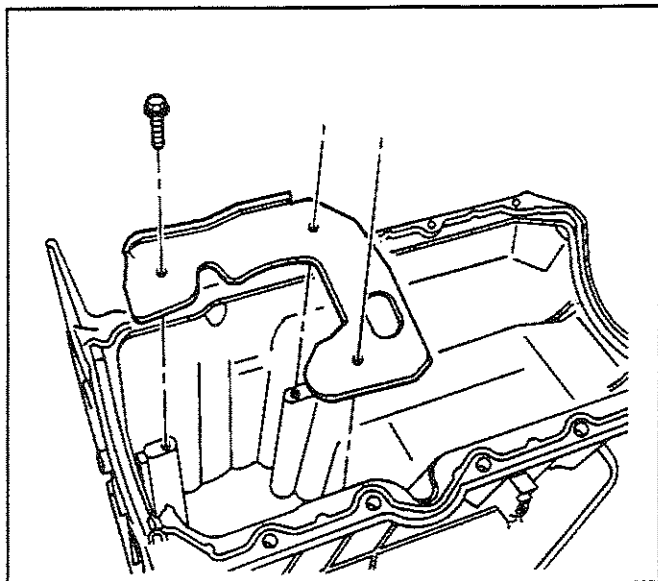
SIE-ID - 358571

Caution: Refer to Safety Glasses Caution in Cautions and Notices.

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

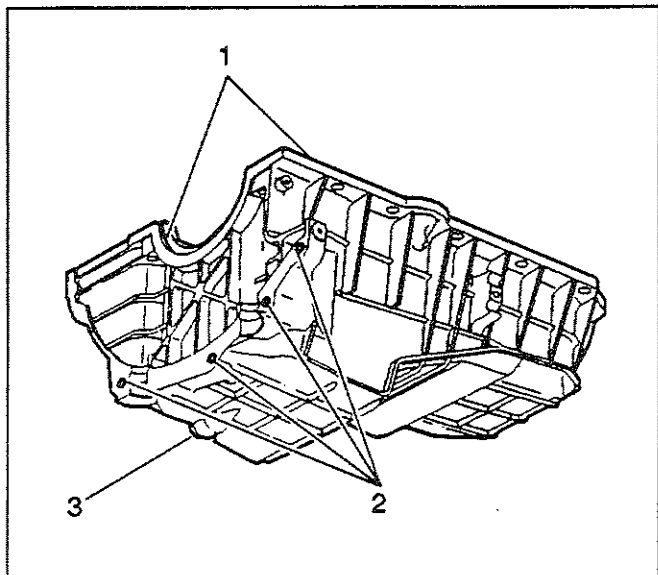


387763

Oil Pan Clean and Inspect

SIE-ID - 358572

1. Remove the oil pan baffle bolts and the oil pan baffle.



334509

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

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

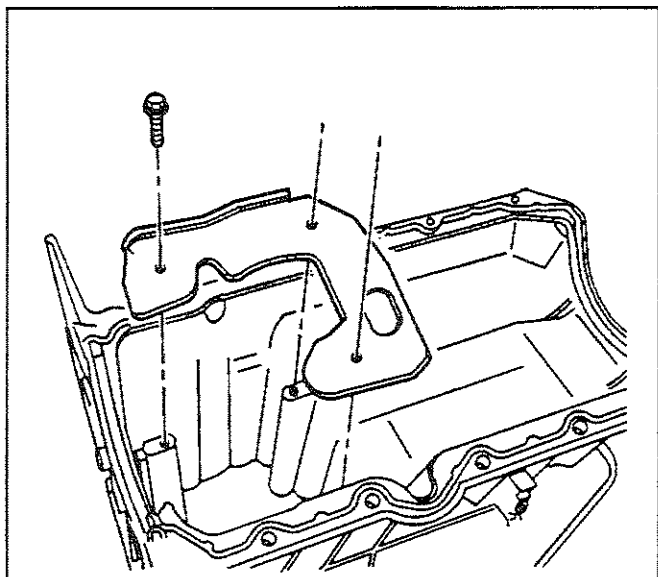
A damaged oil pan may interfere with the proper position of the oil pump screen, or may not distribute oil properly in the oil pan sump area.

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).

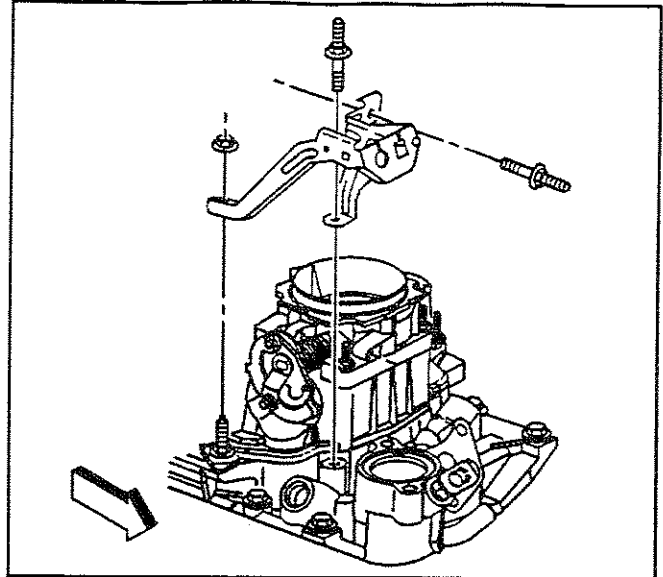


387763

Intake Manifold Disassemble

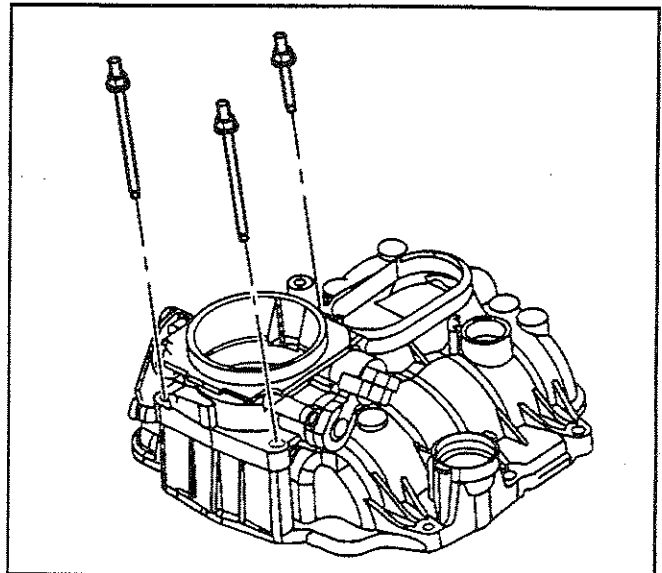
SIE-ID - 507107

1. Remove the nuts, the studs, and the accelerator control cable bracket.



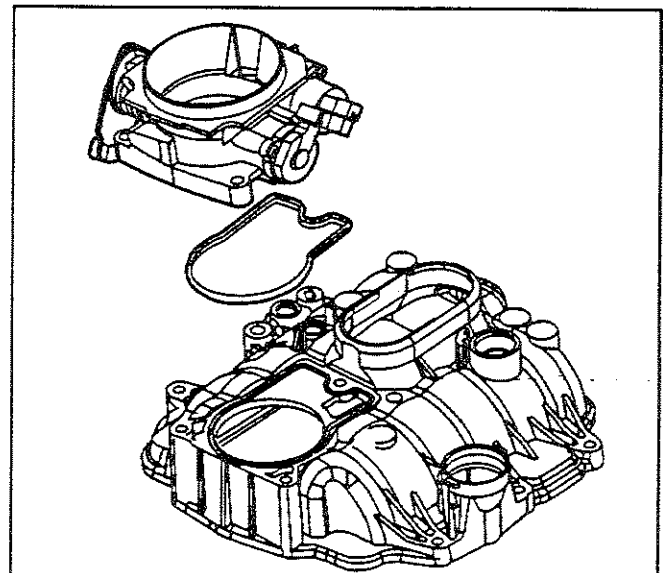
374902

2. Remove the throttle body attaching studs.

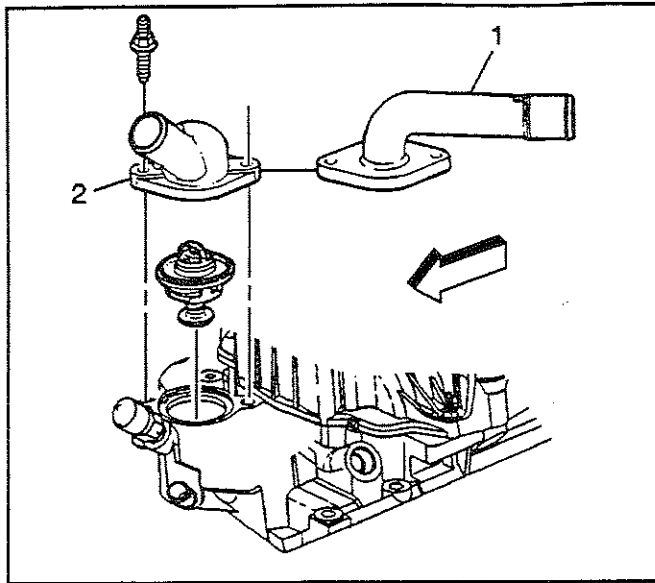


12852

3. Remove the throttle body.
4. Remove the throttle body to upper intake manifold gasket.
5. Discard the throttle body to upper intake manifold gasket.

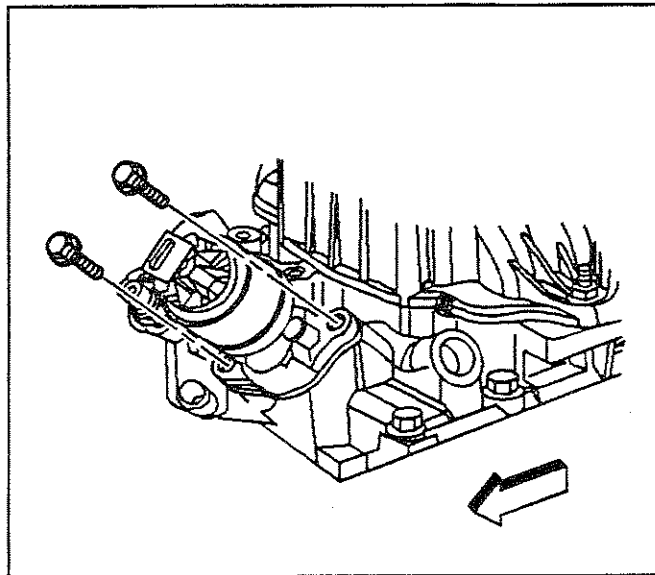


12853



480559

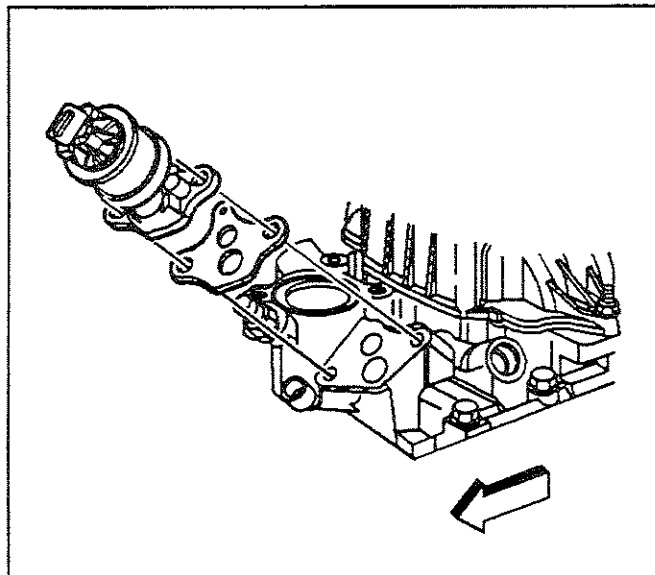
6. Remove the water outlet studs.
7. Remove the water outlet (1) or (2).
8. Remove the engine coolant thermostat.



480563

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.

Remove the exhaust gas recirculation (EGR) valve bolts.

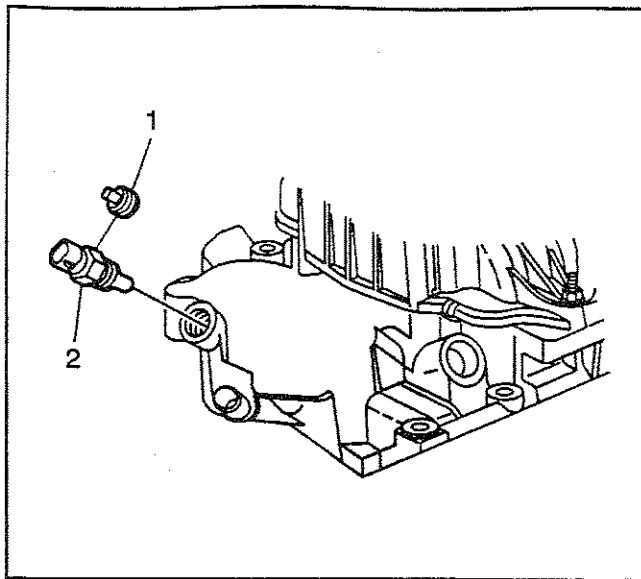


480565

Notice: SIO-ID = 5005 The Linear EGR valve is an electrical component. DO NOT soak in any liquid cleaner or solvent because damage may result.

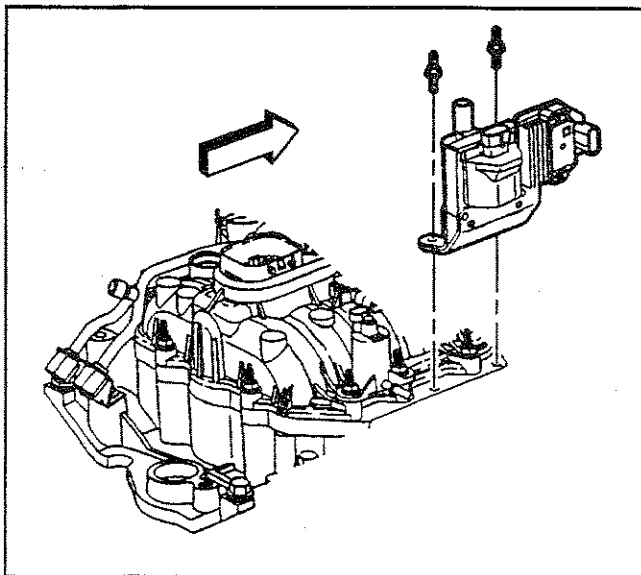
9. Remove the EGR valve and the EGR valve gasket from the lower intake manifold.
10. Discard the EGR valve gasket.

11. Remove the engine coolant temperature (ECT) sensor plug (1) or the ECT sensor (2) from the front of the lower intake manifold (if equipped).



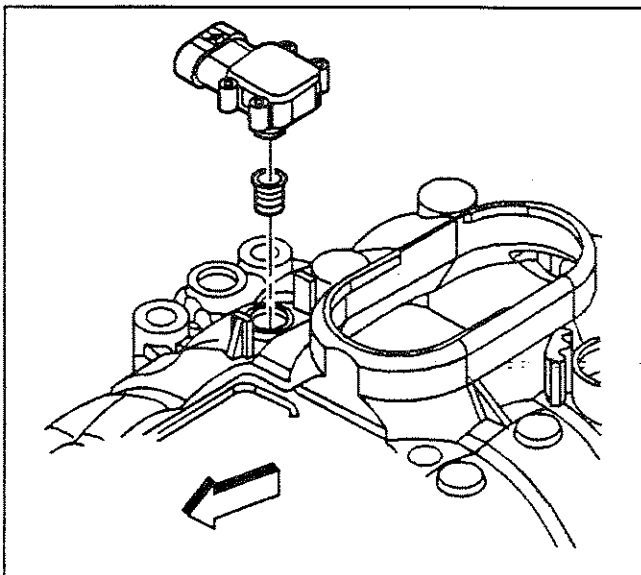
480566

12. Remove the studs and the ignition coil.

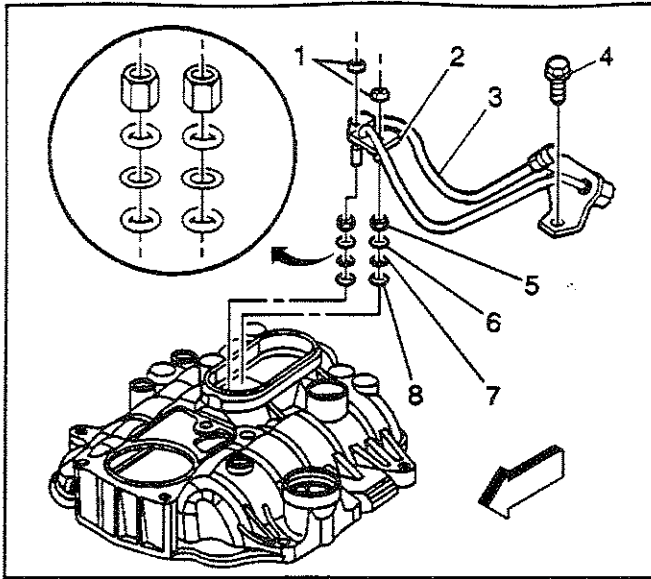


480561

13. Remove the manifold absolute pressure (MAP) sensor.
14. Remove the MAP sensor seal from the MAP sensor.
15. Discard the MAP sensor seal.

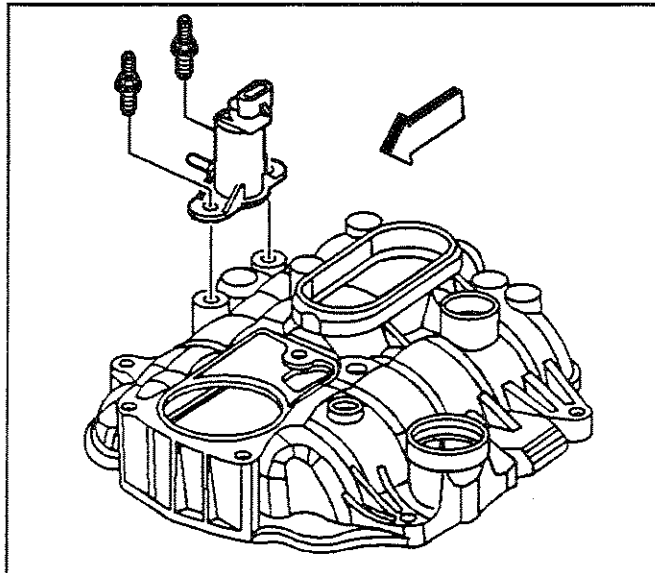


480562



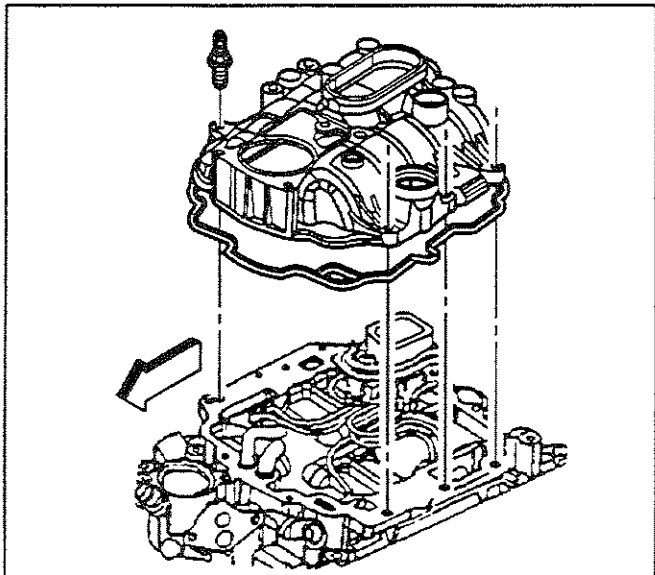
334517

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).



334511

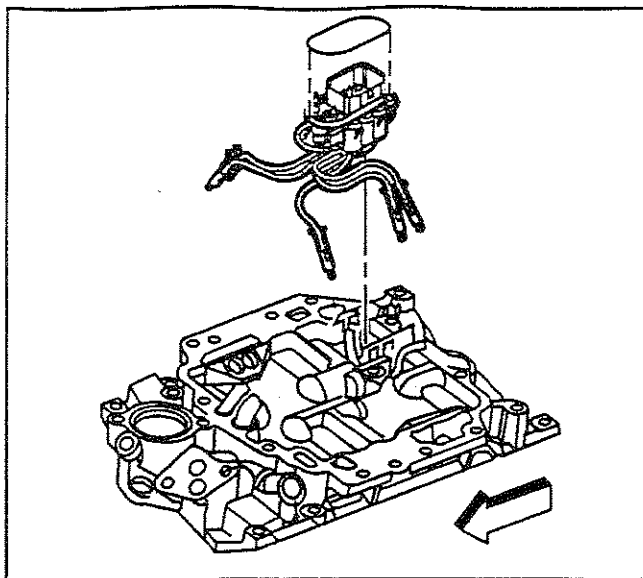
24. Remove the studs and the evaporative emission (EVAP) canister purge solenoid valve.
25. Remove the nut and the engine wiring harness bracket.



334513

26. Remove the upper intake manifold attaching studs.
27. Remove the upper intake manifold.
28. Remove the upper intake manifold to lower intake manifold gasket.
29. Discard the upper intake manifold to lower intake manifold gasket.

30. Remove the fuel meter body seal and discard.
31. Remove the 6 poppet nozzles from the lower intake manifold bores.
32. Remove the fuel meter body.
33. Remove the bolt and the fuel meter body bracket.



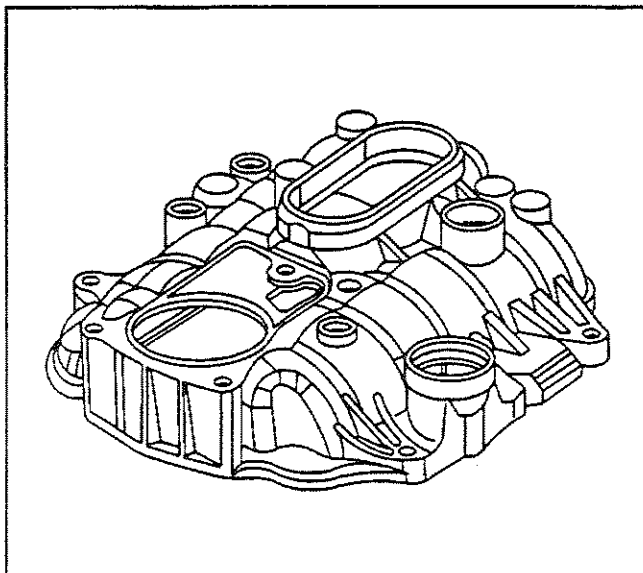
523513

Intake Manifold Clean and Inspect

SIE-ID - 358591

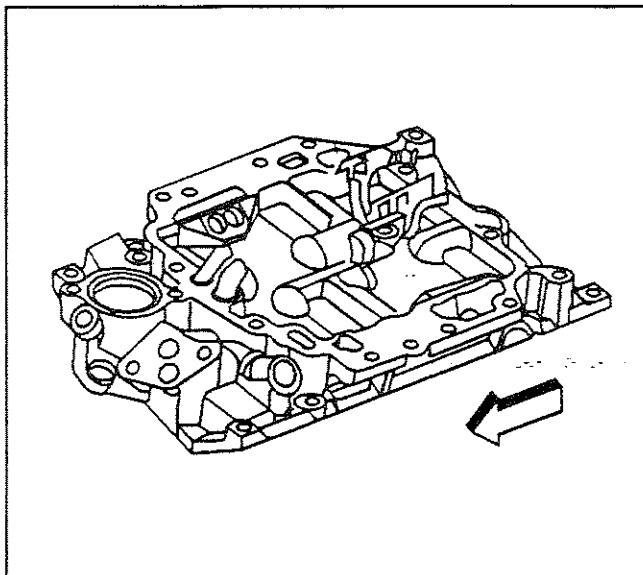
Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

1. Clean the upper intake manifold in cleaning solvent.
2. Dry the upper intake manifold with compressed air.

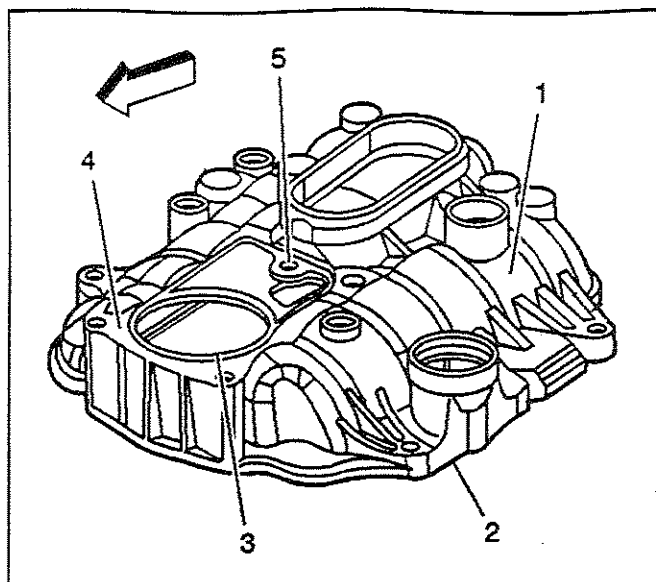


334515

3. Clean the lower intake manifold in cleaning solvent.
4. Dry the lower intake manifold with compressed air.



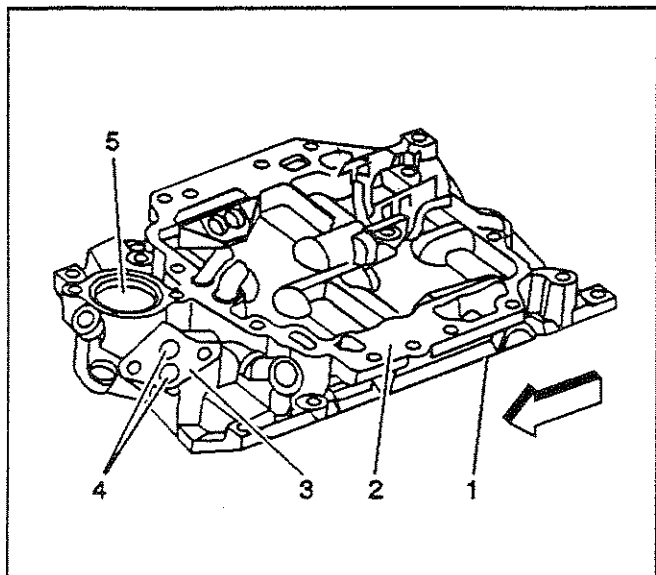
480568



480569

5. Inspect the upper intake manifold for the following:

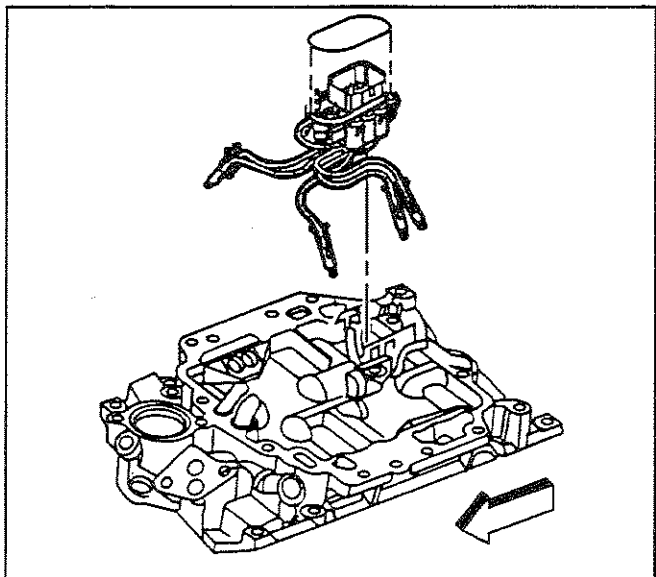
- Cracks or other damage to the exterior (1)
- Cracking or damage in the gasket grooves (2) and (3)
- Damage to the throttle body mounting surface (4)
- Loose or damaged bolt hole thread inserts (5)



480570

6. Inspect the lower intake manifold for the following:

- Damage to the gasket sealing surfaces (1), (2) and (3)
- Restricted exhaust gas recirculation (EGR) system passages (4)
- Restricted cooling system passages (5)
- Cracks or damage
- Damage to the threaded bolt holes



523513

Intake Manifold Assemble

SIE-ID - 507112

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

1. If reusing the fastener, apply threadlock GM P/N 12345382 or equivalent to the threads of the fuel meter body bracket bolt.
2. Install the fuel meter body bracket and bolt.

Tighten

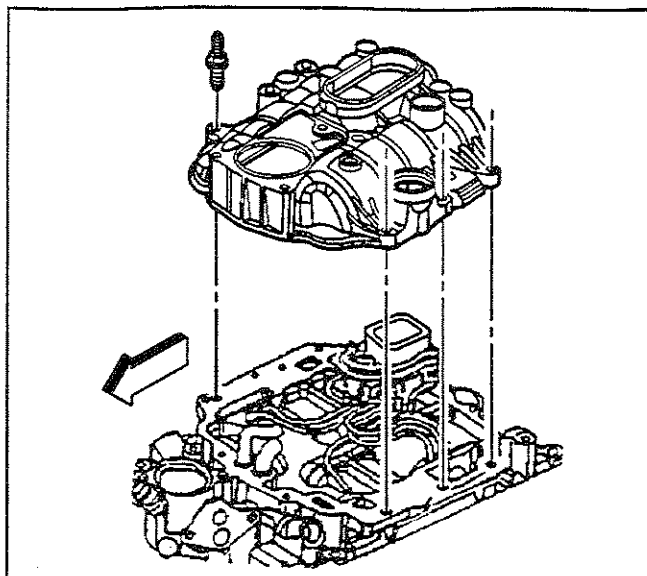
Tighten the fuel meter bracket bolt to 10 N·m (89 lb in).

3. Install the fuel meter body into the fuel meter body bracket.
4. Install the 6 poppet nozzles into the proper lower intake manifold bores.
5. Inspect the poppet nozzles in order to ensure that the poppet nozzles are firmly seated and locked in the lower intake manifold bores.

6. Install a NEW fuel meter body seal into the groove of the fuel meter body.
7. Install a NEW upper intake manifold to lower intake manifold gasket into the groove of the upper intake manifold.
8. Install the upper intake manifold onto the lower intake manifold.
9. If reusing the fasteners, apply threadlock GM P/N 12345382 or equivalent to the threads of the upper intake manifold attaching studs.
10. Install the upper intake manifold attaching studs.

Tighten

- 10.1. Tighten the upper intake manifold attaching studs on the first pass to 5 N·m (44 lb in).
- 10.2. Tighten the upper intake manifold attaching studs on the final pass to 9 N·m (80 lb in).

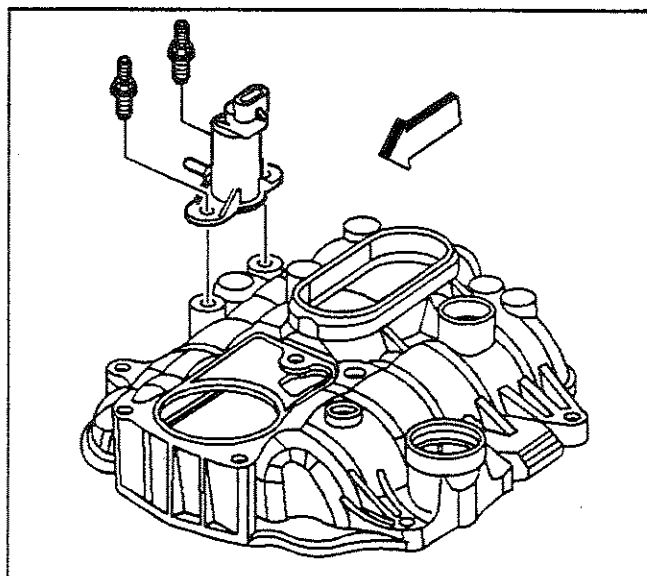


334516

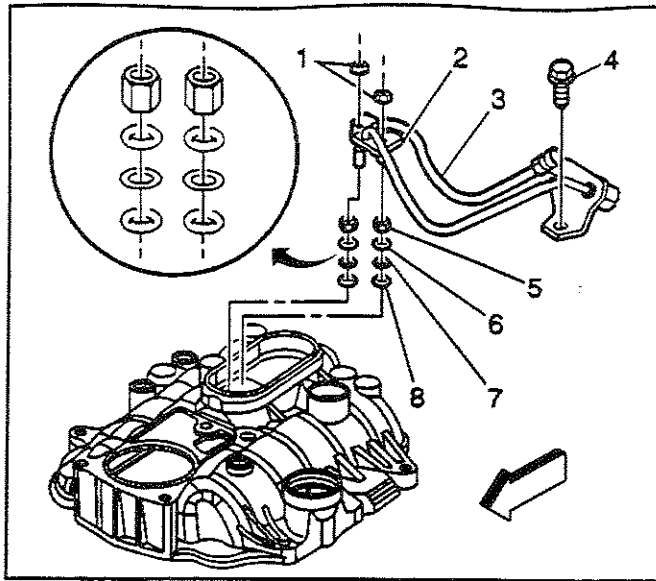
11. If reusing the fasteners, apply threadlock GM P/N 12345382 or equivalent to the threads of the evaporative emission (EVAP) canister purge solenoid valve studs.
12. Install the EVAP canister purge solenoid valve and studs.

Tighten

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



334511



334517

13. Install the engine wiring harness bracket and nut.

Tighten

Tighten the engine wiring harness bracket nut to 12 N·m (106 lb in).

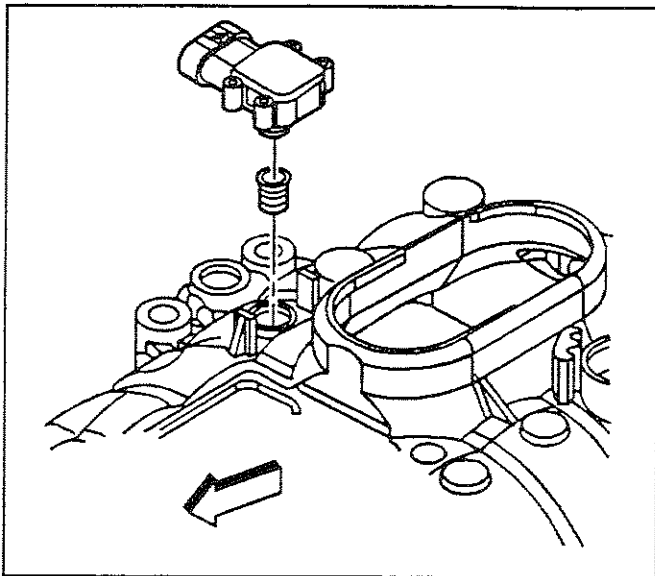
14. Install the NEW fuel seals (8) (black O-rings) into the fuel meter body.
15. Install the NEW spacer rings (7) (flat washers) into the fuel meter body.
16. Install the NEW fuel seals (6) (yellow O-rings) into the fuel meter body.
17. Install the NEW fuel seal retainers (5) into the fuel meter body.
18. Install the fuel pipe (3) into the fuel meter body.
19. Install the fuel pipe retainer bracket (2) onto the fuel pipe.
20. Install the fuel pipe retainer bracket nuts (1).
21. If reusing the fastener, apply threadlock GM P/N 12345382 or equivalent to the threads of the fuel pipe bolt.
22. Install the fuel pipe bolt (4).

Tighten

22.1. Tighten the fuel pipe bracket nuts to 3 N·m (27 lb in).

22.2. Tighten the fuel pipe bolt to 6 N·m (53 lb in).

23. Install a NEW manifold absolute pressure (MAP) sensor seal onto the MAP sensor.
24. Apply a small amount (1 drop) of clean engine oil to the MAP sensor seal.
25. Install the MAP sensor into the upper intake manifold.

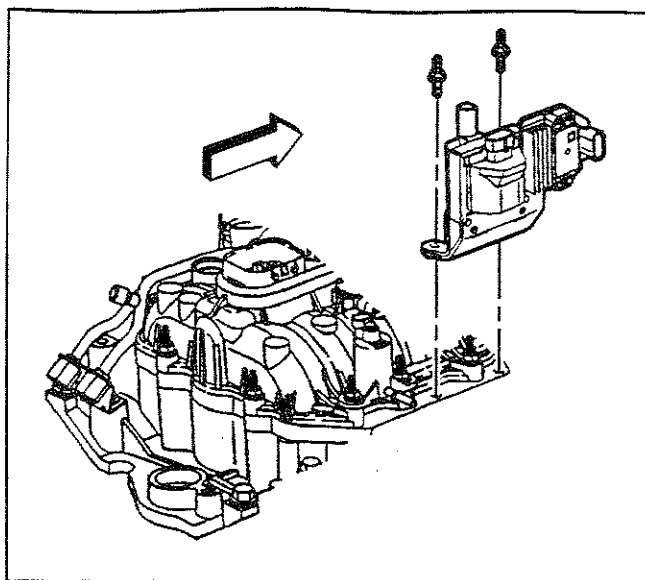


480562

26. Install the ignition coil and studs.

Tighten

Tighten the ignition coil studs to 12 N·m (106 lb in).



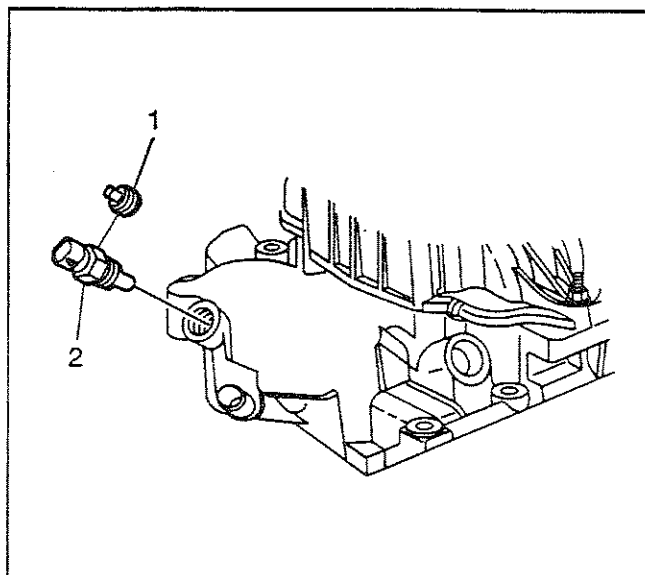
480561

27. If reusing the engine coolant temperature (ECT) sensor plug (1) or the ECT sensor (2) (if equipped), apply sealant GM P/N 12346004 or equivalent to the threads of the ECT sensor plug (1) or the ECT sensor (2).

28. Install the ECT sensor or plug (if equipped) into the front of the lower intake manifold.

Tighten

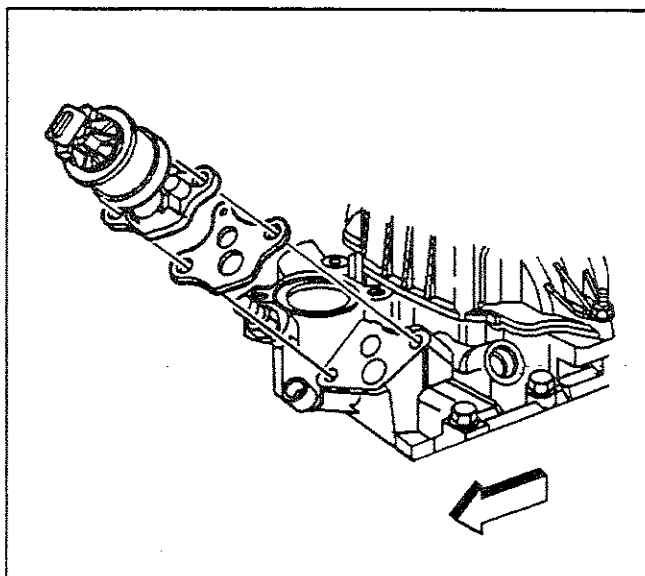
Tighten the ECT sensor or plug to 20 N·m (15 lb ft).



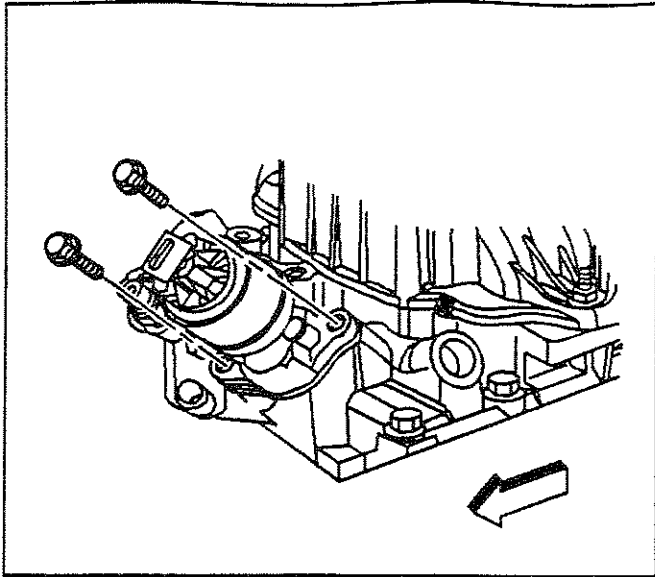
480566

Important: The exhaust gas recirculation (EGR) valve must be installed in the original orientation.

Install a NEW EGR valve gasket and the EGR valve.



480565

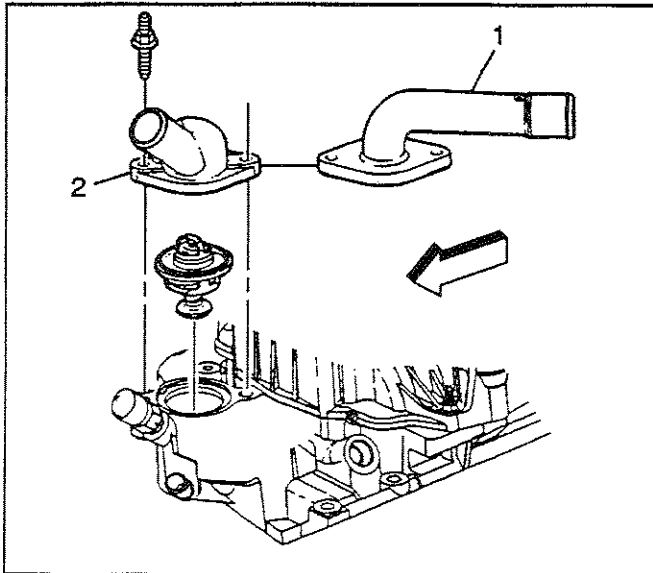


480563

29. Install the EGR valve bolts.

Tighten

- 29.1. Tighten the EGR valve bolts on the first pass to 7 N·m (62 lb in).
 29.2. Tighten the EGR valve bolts on the final pass to 30 N·m (22 lb ft).

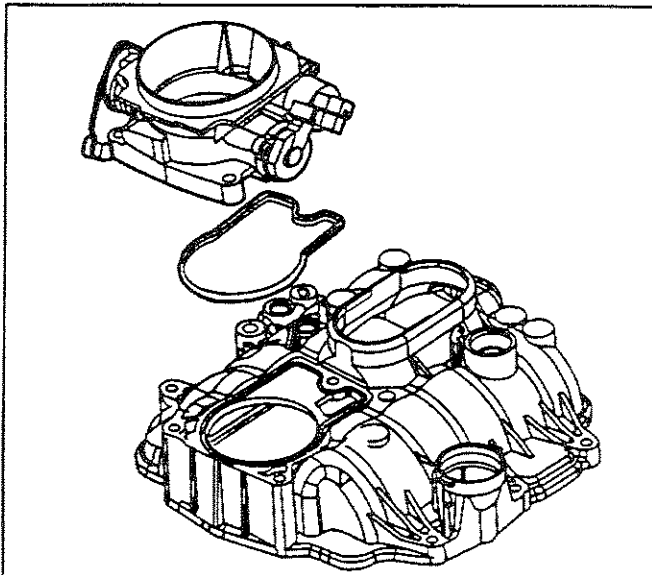


480559

30. Install the engine coolant thermostat.
 31. Install the water outlet (1) or (2).
 32. Install the water outlet studs.

Tighten

Tighten the water outlet studs to 25 N·m (18 lb ft).



12853

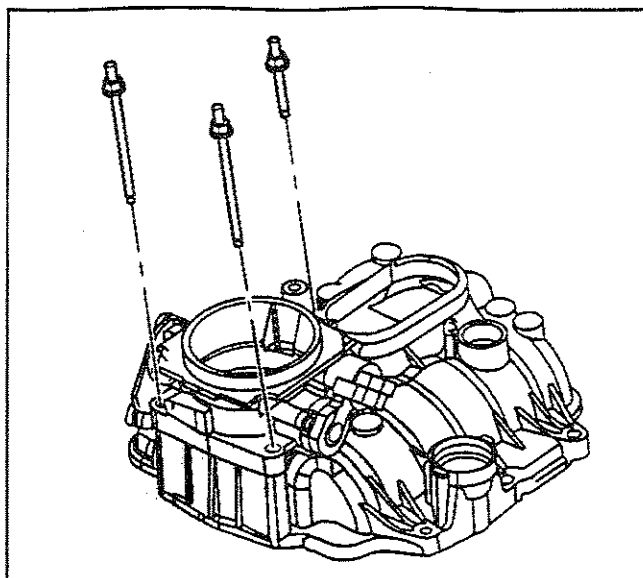
33. Install a NEW throttle body gasket into the groove in the upper intake manifold.
 34. Install the throttle body onto the upper intake manifold.

35. If reusing the fasteners, apply threadlock GM P/N 12345382 or equivalent to the threads of the throttle body attaching studs.

36. Install the throttle body attaching studs.

Tighten

Tighten the throttle body attaching studs to 9 N·m (80 lb in).



12852

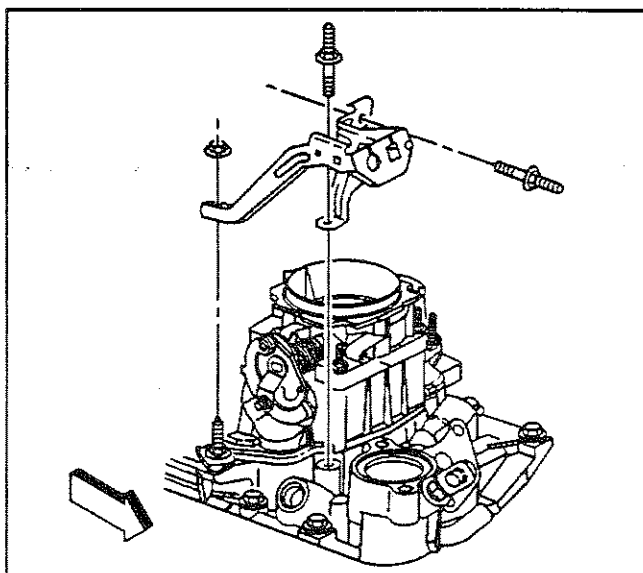
37. Install the accelerator control cable bracket, the studs, and the nuts.

Tighten

- 37.1. Tighten the accelerator control cable bracket stud to the intake manifold to 6 N·m (53 lb in).

- 37.2. Tighten the accelerator control cable bracket nuts to 12 N·m (106 lb in).

- 37.3. Tighten the accelerator control cable bracket stud to the throttle body to 12 N·m (106 lb in).



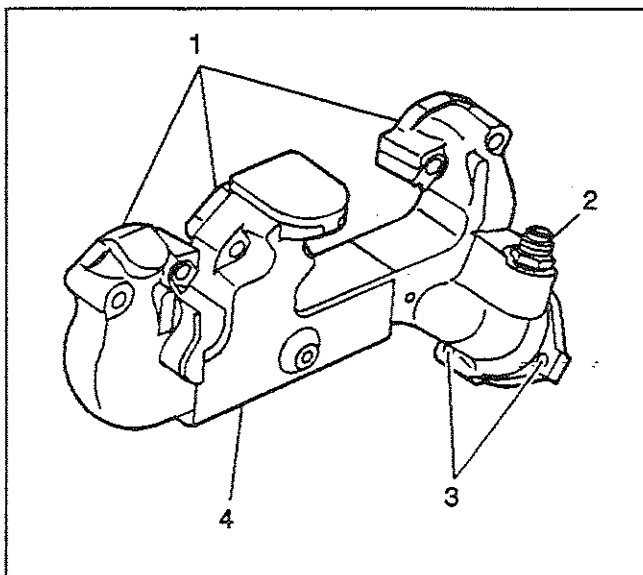
374902

Exhaust Manifold Clean and Inspect

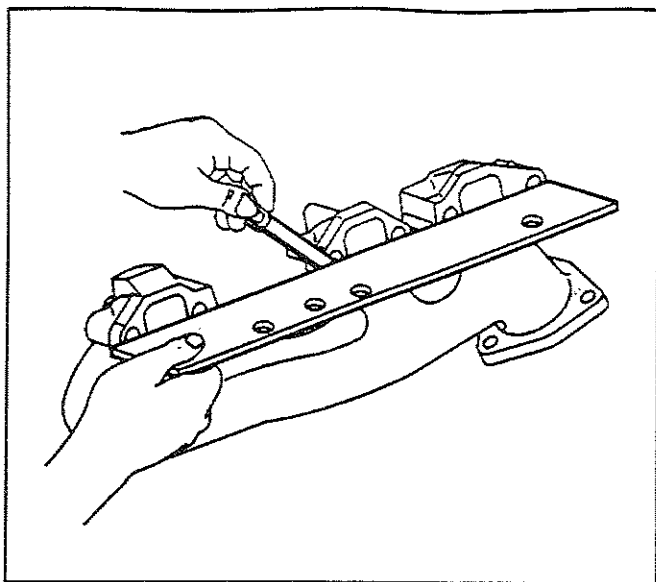
SIE-ID - 507115

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

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 (1)
 - Damage to the exhaust gas recirculation (EGR) pipe fitting (2) (left manifold)
 - Damage to the threaded holes (3)
 - Restrictions within exhaust passages
 - Broken or damaged exhaust manifold heat shields (4) (if applicable)
 - Broken or damaged exhaust manifold



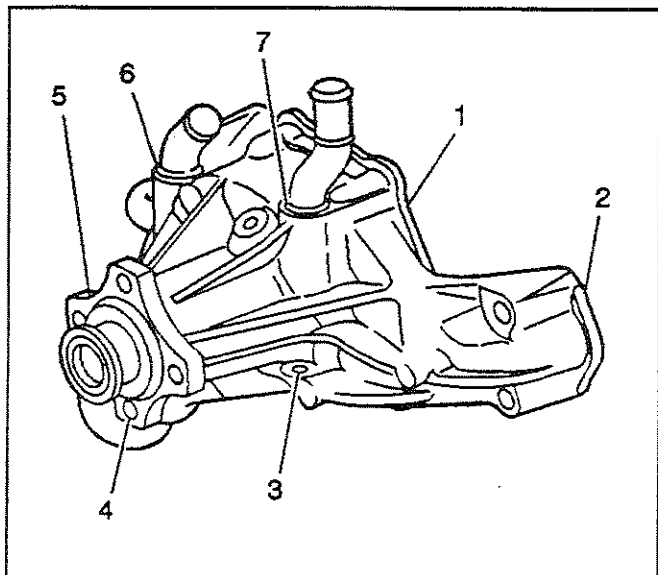
523519



334528

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.



480571

Water Pump Clean and Inspect

SIE-ID = 358600

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all the dirt and any debris from the water pump.
3. Inspect the water pump for the following:
 - Leakage or damage to the housing cover or gasket (1)
 - Excessive scratches or gouging to the gasket sealing surfaces (2)
 - Leakage from the water pump vent hole (3)
A stain around the vent hole is acceptable. If leakage occurred (dripping) with the engine operating and the cooling system pressurized, then replace the water pump.
 - Damaged bolt hole threads (4)
 - Excessive side-to-side movement of the water pump shaft (5)
 - Leakage around the water inlet pipe (6)
 - Leakage around the heater hose pipe (7)
 - Restrictions within the internal coolant passages

Thread Repair

SIE-ID = 43119

General purpose thread repair kits are available commercially.

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

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

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

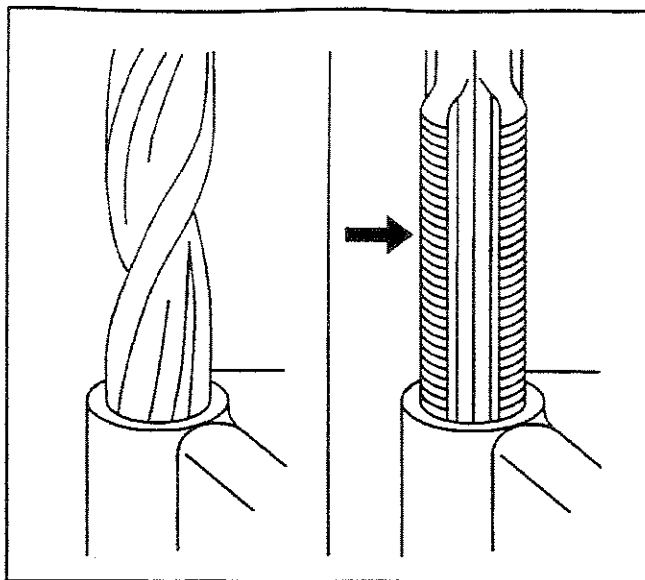
Determine the size, the pitch, and the depth of the damaged thread.

1. Adjust the stop collars on the cutting tool as needed. Tap the stop collars to the required depth.
2. Drill out the damaged thread.
3. Remove the chips.
4. Apply clean engine oil to the top thread.
5. Use the tap in order to cut new thread.
6. Clean the thread.
7. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the thread insert onto the end of the mandrel.

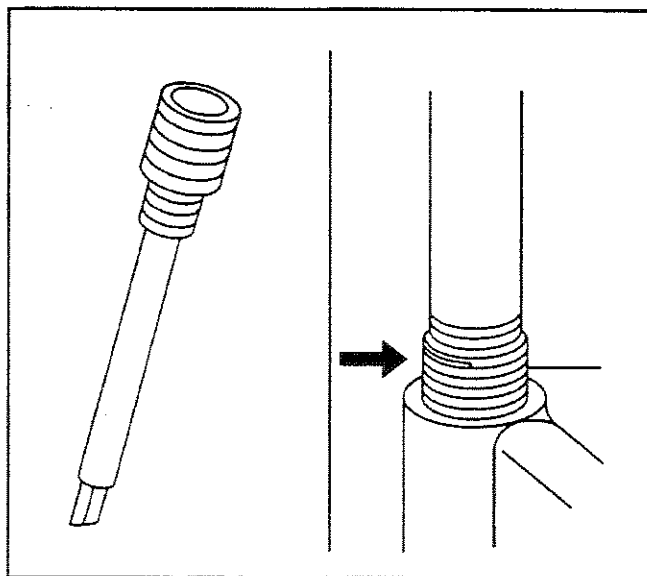
Important: The thread insert should be flush to 1 turn below the surface.

Lubricate the thread insert with clean engine oil (except when installing in aluminum) and install the thread insert.

8. If the tang of the thread insert does not break off when backing out the thread insert installer, break off the tang using a drift punch.



4962



4963

Service Prior to Assembly

SIE-ID = 43122

- 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.

Engine Block Plug Installation

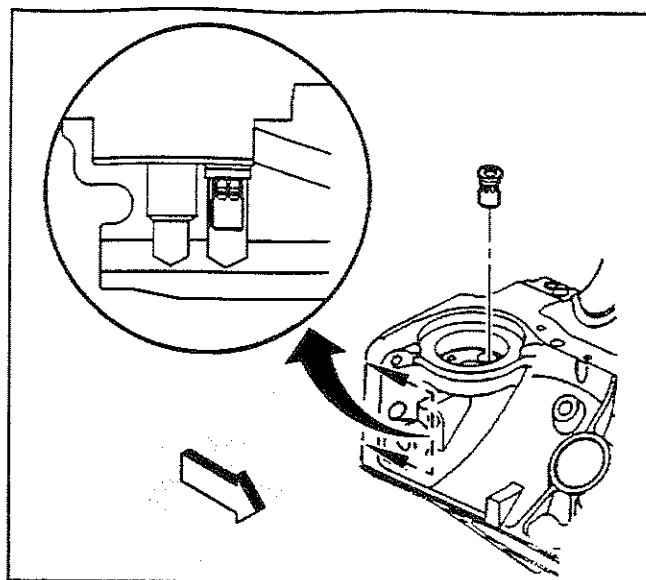
SIE-ID # 358602

Tools Required

J 41712 Oil Pressure Switch Socket

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

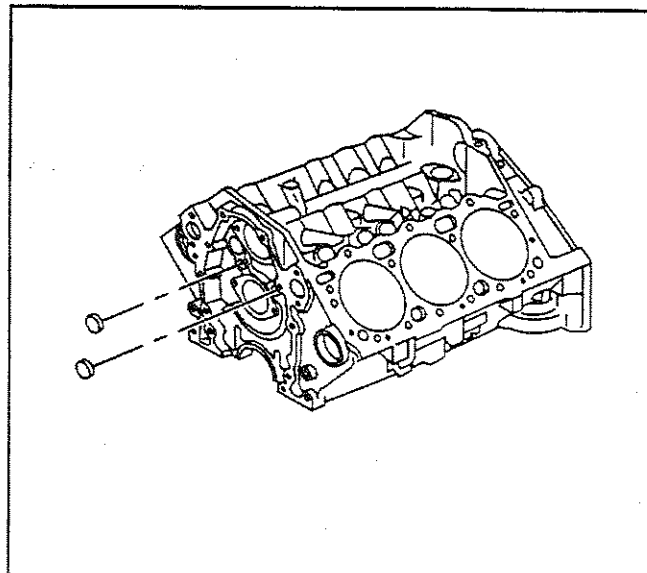
1. Install a NEW oil filter bypass valve.
 - 1.1. Install the oil filter bypass valve into the oil gallery bore until slightly below flush with the surface of the engine block.
 - 1.2. Using a pointed punch, stake the engine block area around the oil filter bypass valve. Stake in 3 locations 120 degrees apart.



188023

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.

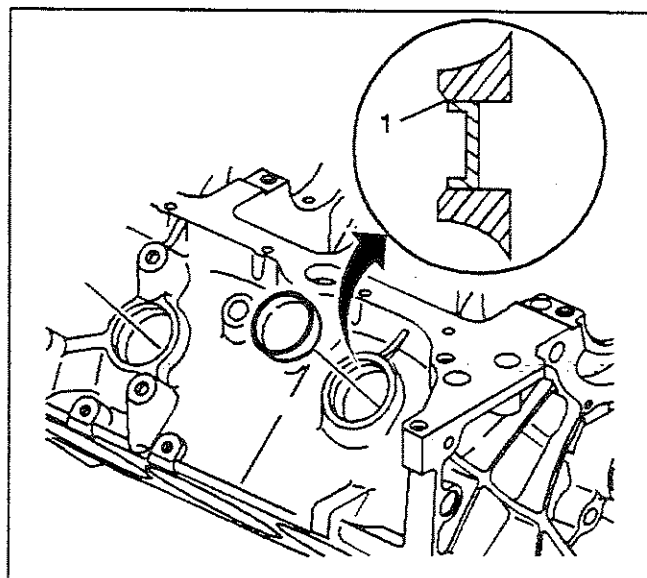
A properly installed front engine oil gallery plug must be installed slightly below flush with the front face of the engine block.



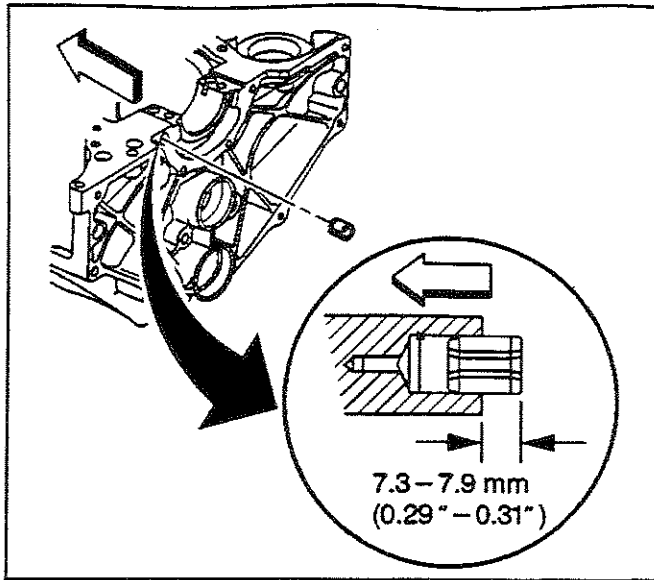
5270

4. Apply threadlock GM P/N 12345382 or equivalent to the outside diameter of the NEW engine block core hole plugs.
5. Install the NEW engine block core hole plugs.

A properly installed engine block core hole plug must be installed flush with the bottom of the chamfer (1) of the engine block core hole.

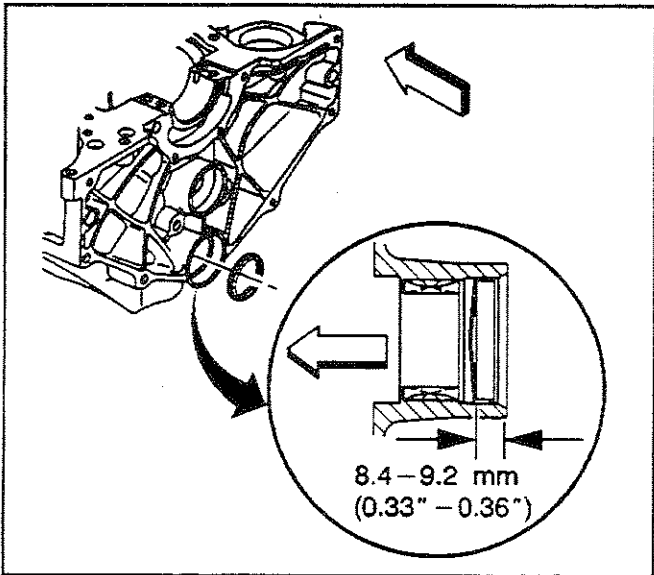


480572



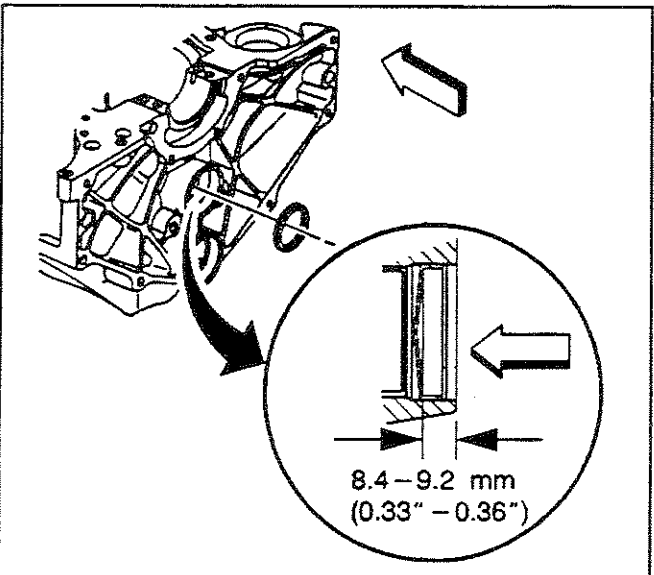
334546

6. Install the spring type S pin (crankshaft rear oil seal housing locator) (if required).



334540

7. Apply sealant GM P/N 12346004 or equivalent to the outside diameter of the NEW expansion cup plug (balance rear bearing hole).
8. Install the NEW expansion cup plug (balance shaft rear bearing hole).



334543

9. Apply sealant GM P/N 12346004 or equivalent to the outside diameter of the NEW expansion cup plug (camshaft rear bearing hole).
10. Install the NEW expansion cup plug (camshaft rear bearing hole).

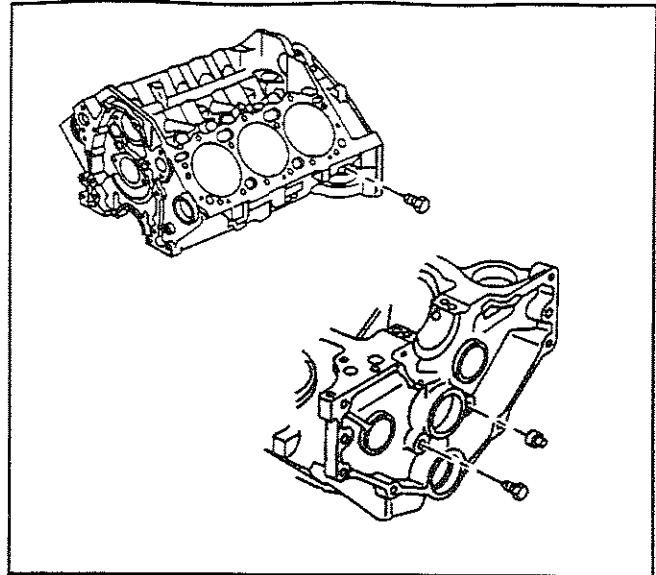
11. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block right rear oil gallery plug, the engine block left rear oil gallery plug, and the engine block left side oil gallery plug.

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

12. 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.

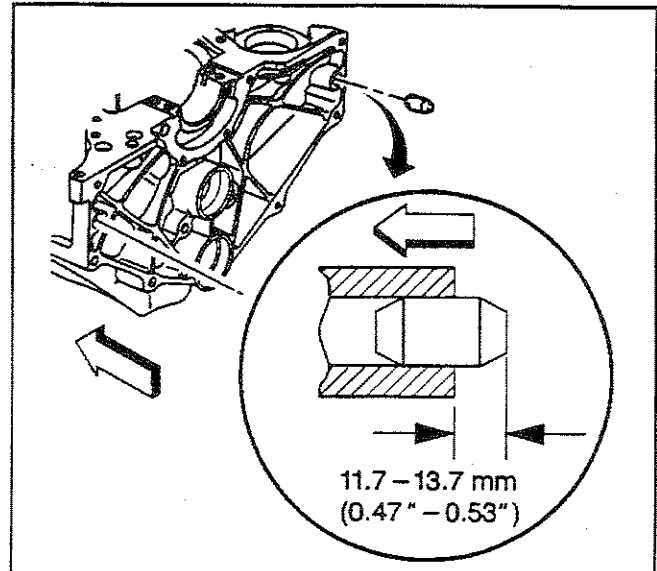
Tighten

- 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).



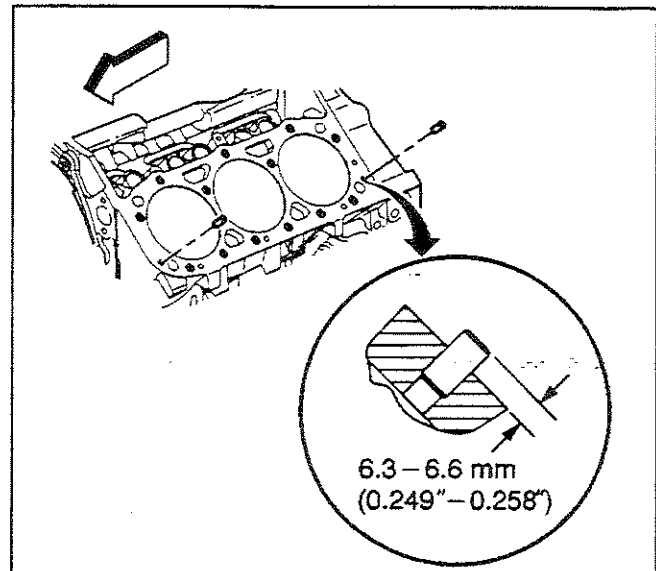
5271

13. Install the dowel straight pins (transmission locator) (if required).

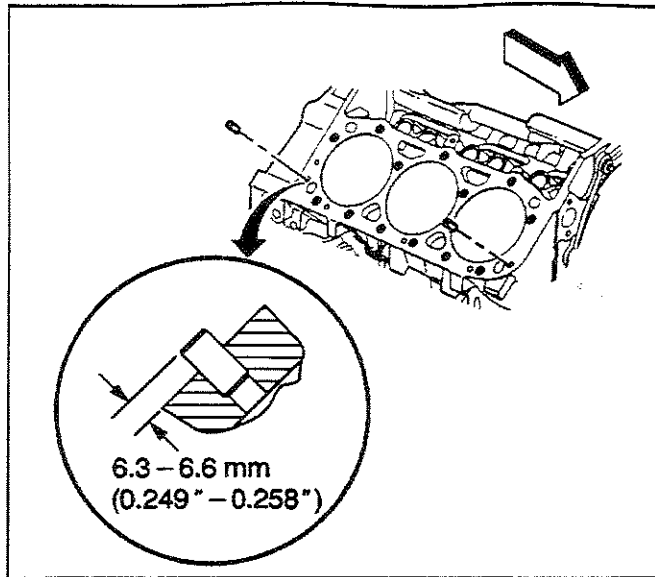


334548

14. Install the left side dowel pins (cylinder head locator) (if required).

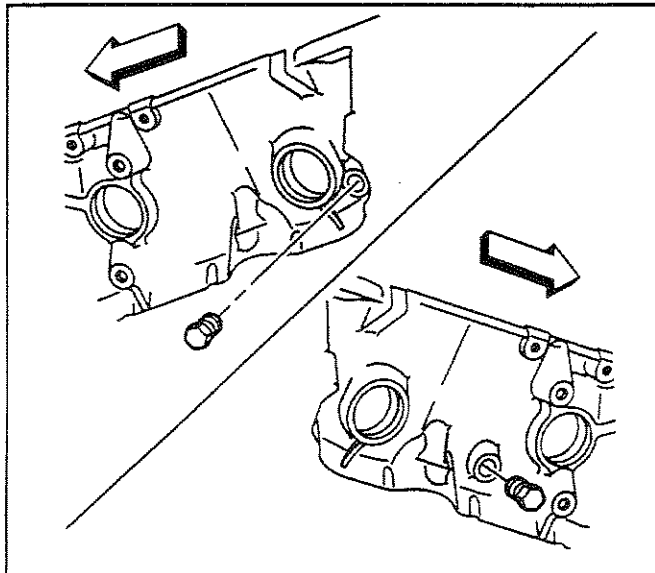


334303



334314

15. Install the right side dowel pins (cylinder head locator) (if required).

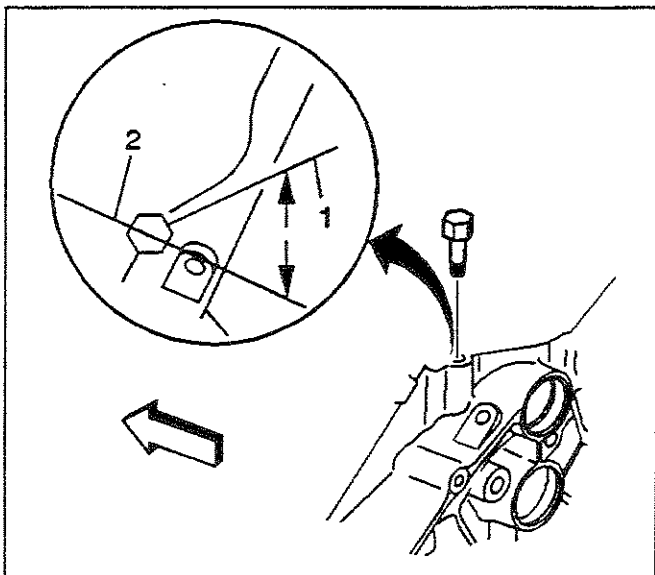


188052

16. Apply sealant GM P/N 12346004 or equivalent to the threads of the engine block coolant drain hole plugs.
17. Install the engine block coolant drain hole plugs.

Tighten

Tighten the engine block coolant hole plugs to 20 N·m (15 lb ft).



334549

18. If reusing the engine oil pressure sensor fitting, 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.

Install the engine oil pressure sensor fitting.

Tighten

Tighten the engine oil pressure sensor fitting to 15 N·m (11 lb ft).

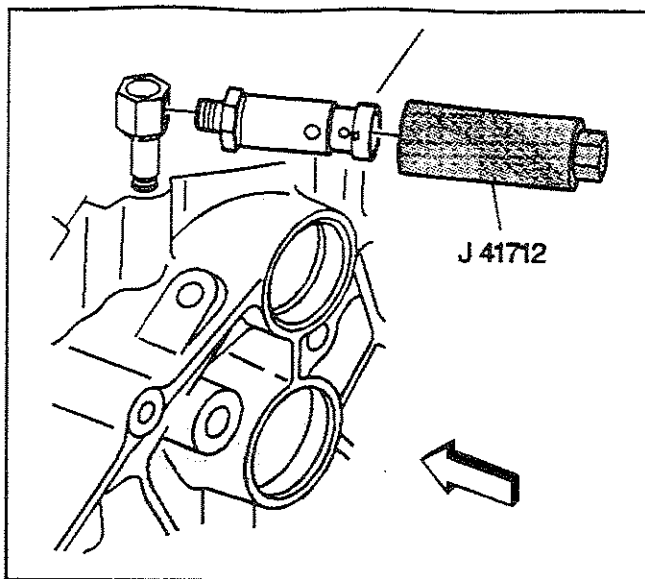
Important: Do not rotate the engine oil pressure fitting clockwise more than 359 degrees after the initial torque has been obtained.

Rotate the engine oil pressure sensor fitting clockwise to the proper position (1), 50 degrees from the centerline (2).

19. If reusing the engine oil pressure gauge sensor, 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).

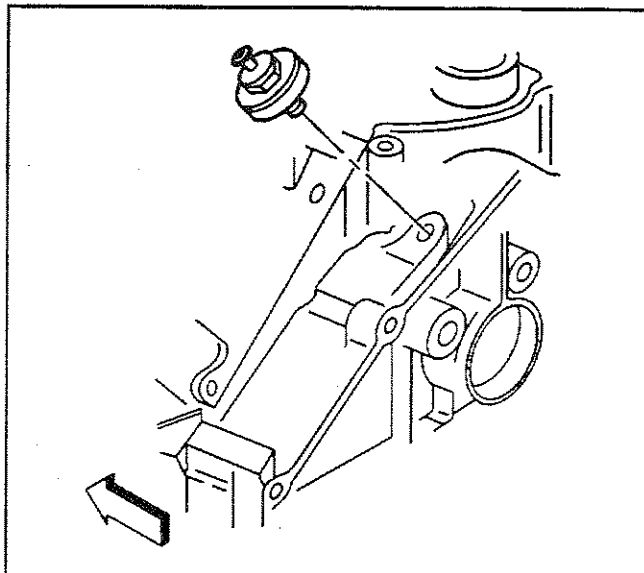


188018

21. Install the knock sensor.

Tighten

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



10793

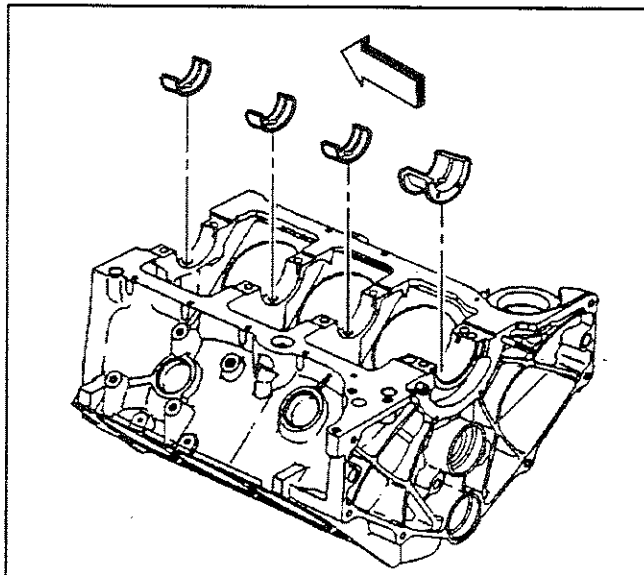
Crankshaft and Bearings Installation

S/E-ID - 358604

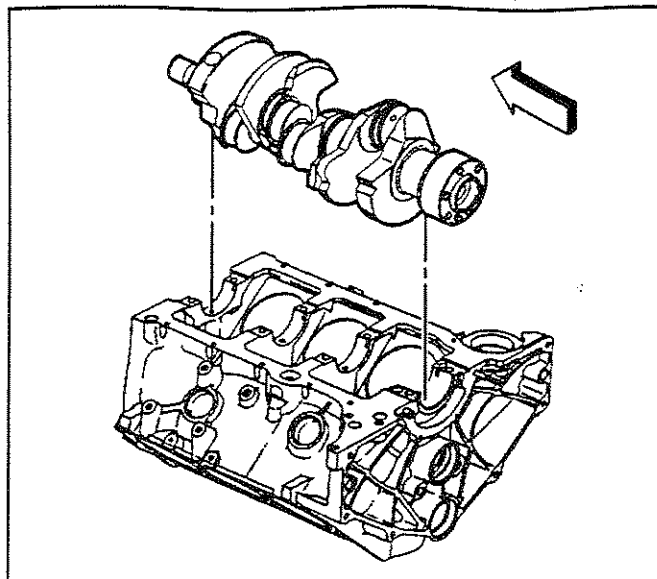
Tools Required

J 36660 Electronic Torque Angle Meter

1. Install the crankshaft bearings into the engine block.
2. Apply clean engine oil to the crankshaft bearings.

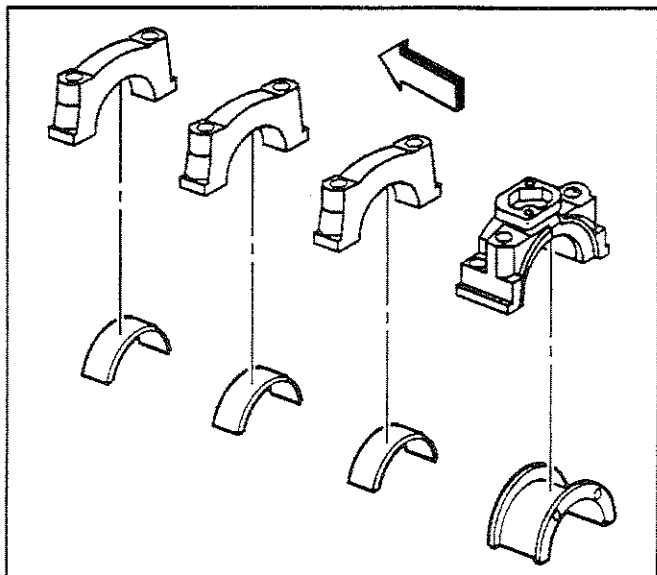


334338



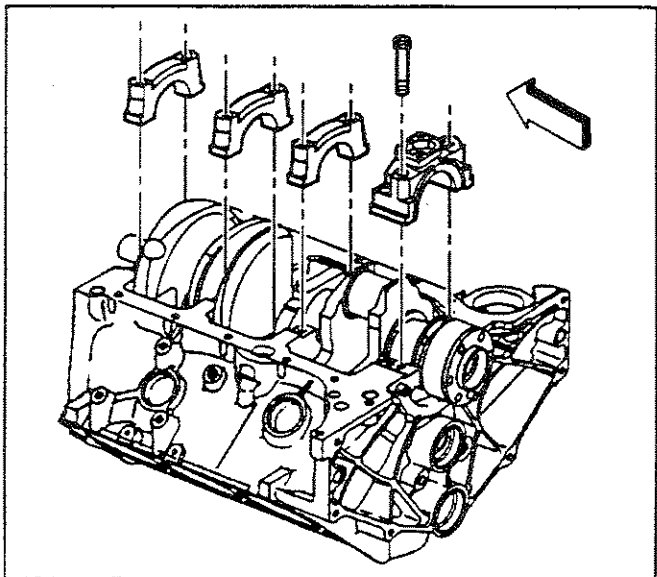
334336

3. Apply clean engine oil to the crankshaft bearing journals.
4. Install the crankshaft.



334342

5. Install the crankshaft bearings into the crankshaft bearing caps.
6. Apply clean engine oil to the crankshaft bearings.



334329

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 until snug.
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.
12. Measure the crankshaft end play.
 - 12.1. Firmly thrust the crankshaft rearward, and then forward.
This will align the crankshaft rear bearing thrust surfaces.
 - 12.2. With the crankshaft pushed forward, insert a feeler gauge between the crankshaft and the crankshaft rear bearing thrust surface to measure the clearance.

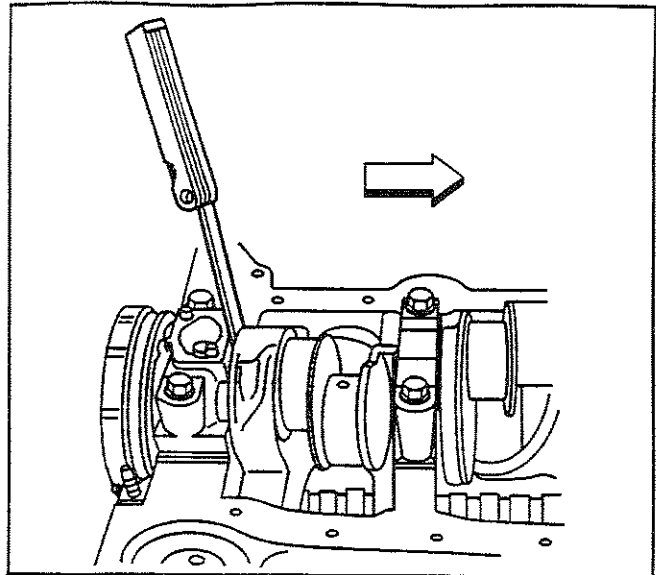
Specification

Crankshaft end play 0.05–0.20 mm (0.002–0.008 in)

13. Rotate the crankshaft in order to check for binding.
A bent crankshaft or lack of proper crankshaft bearing clearance may cause binding.
14. If the crankshaft does not turn freely, loosen the crankshaft bearing cap bolts on 1 crankshaft bearing cap at a time in order to determine the location of the binding.

A lack of proper crankshaft bearing clearance may be caused by the following:

- Burrs on the crankshaft bearing cap
- Foreign material between the crankshaft bearing and the engine block
- Foreign material between the crankshaft bearing and the crankshaft bearing cap
- Damaged crankshaft bearing
- Improper size crankshaft bearing



188467

Crankshaft Rear Oil Seal and Housing Installation

SIE-ID # 358606

Tools Required

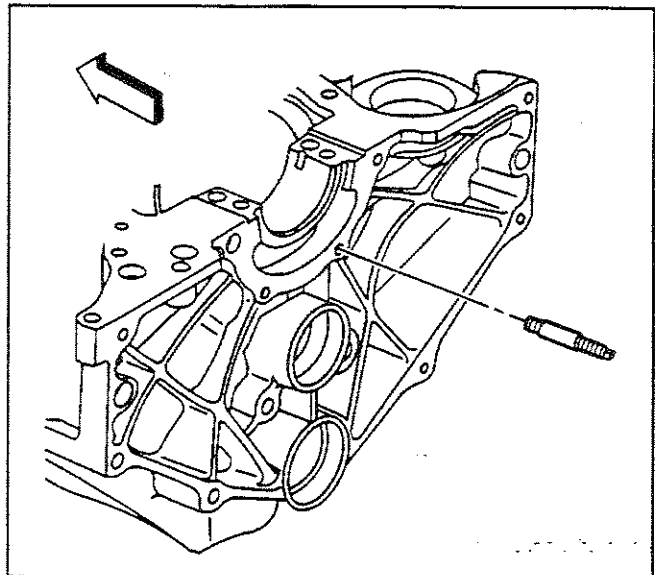
J 35621-B Rear Main Seal Installer

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

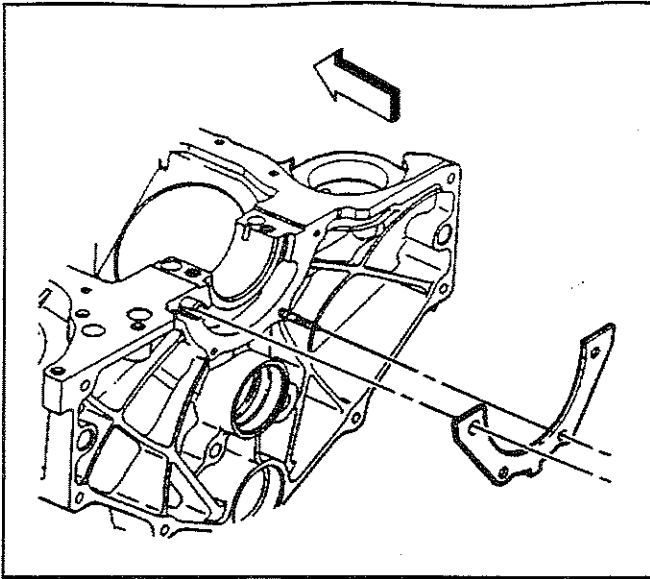
1. Install the crankshaft rear oil seal housing retainer stud.

Tighten

Tighten the crankshaft rear oil seal housing retainer stud to 6 N·m (53 lb in).



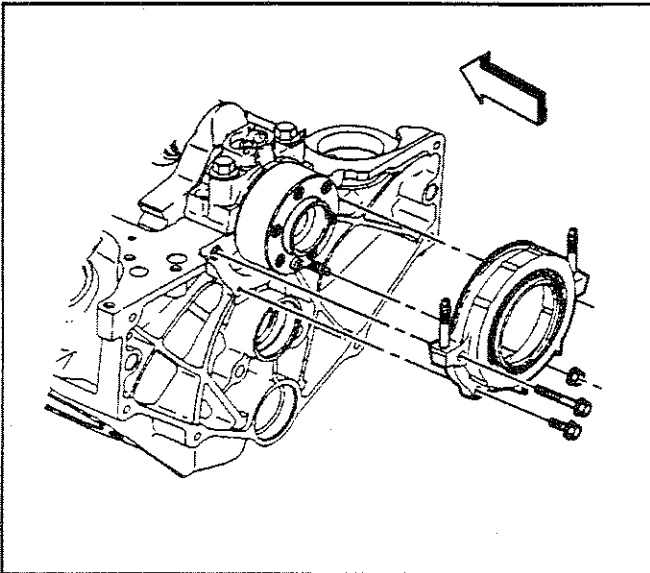
334326



334319

Important: Always use a NEW crankshaft rear oil seal housing gasket when installing the crankshaft rear oil seal housing.

Install the NEW crankshaft rear oil seal housing gasket.

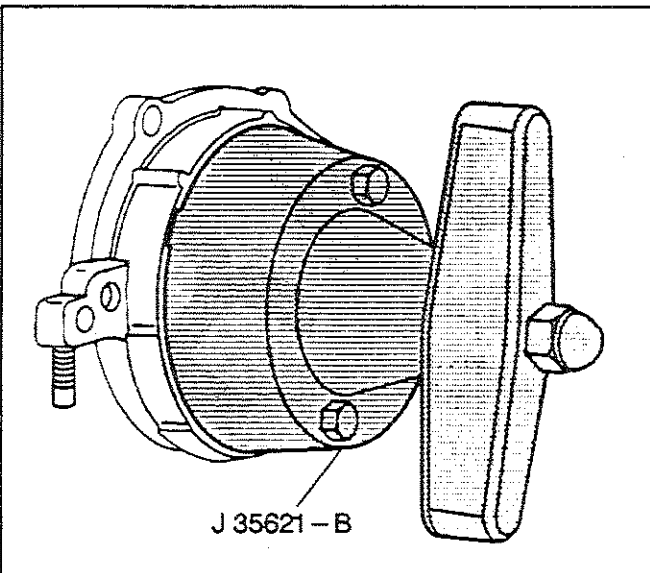


334317

2. Install the crankshaft rear oil housing onto the crankshaft rear oil seal housing retainer stud.
3. 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).



334550

4. Apply a small amount (2 to 3 drops) of clean engine oil to the bore of the crankshaft rear oil seal housing.
5. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the engine flywheel pilot flange.
6. Apply a small amount (1 drop) of clean engine oil to the outside diameter of the flywheel locator pin.
7. Apply a small amount (2 to 3 drops) of clean engine oil to the crankshaft seal surface.
8. 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.

Remove the sleeve from the crankshaft rear oil seal.

9. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the crankshaft rear oil seal.
10. Install the crankshaft rear oil seal onto the *J 35621-B*.
11. 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.

12. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing.
 - 12.1. 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.

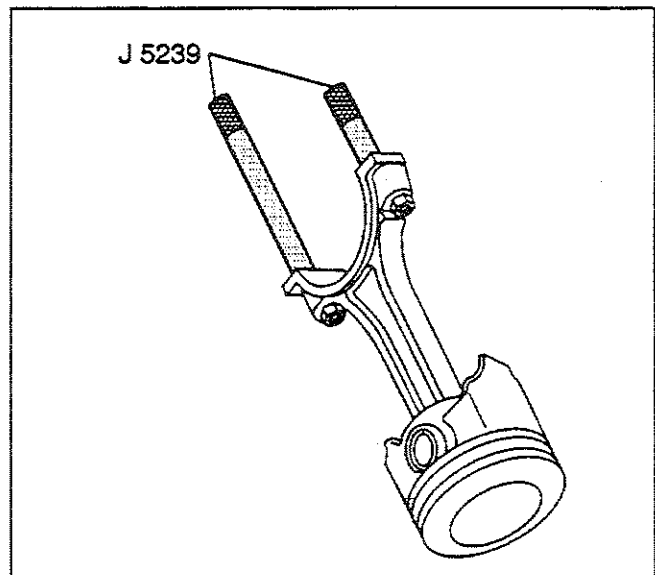
Increased resistance will be felt when the crankshaft rear oil seal has reached the bottom of the crankshaft rear oil seal housing bore.
 - 12.2. Turn the *J 35621-B* wing nut counterclockwise to release the *J 35621-B* from the crankshaft rear oil seal.
13. Remove the *J 35621-B* from the crankshaft.
14. Wipe off any excess engine oil with a clean rag.

Piston, Connecting Rod, and Bearing Installation

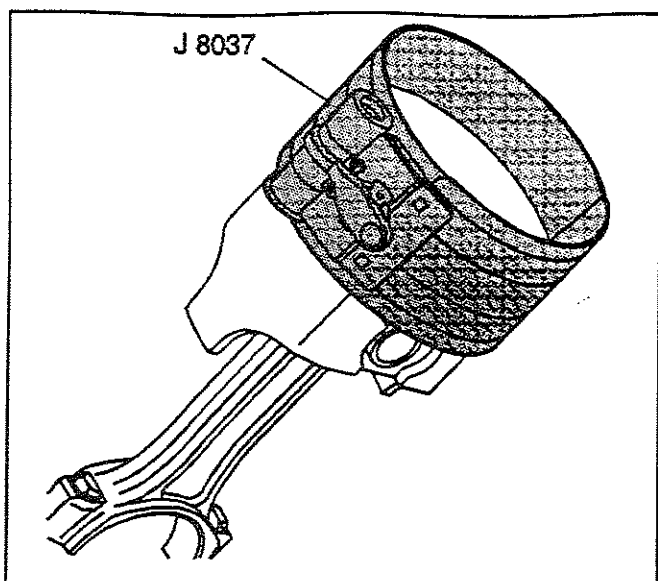
SIE-ID = 24233

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



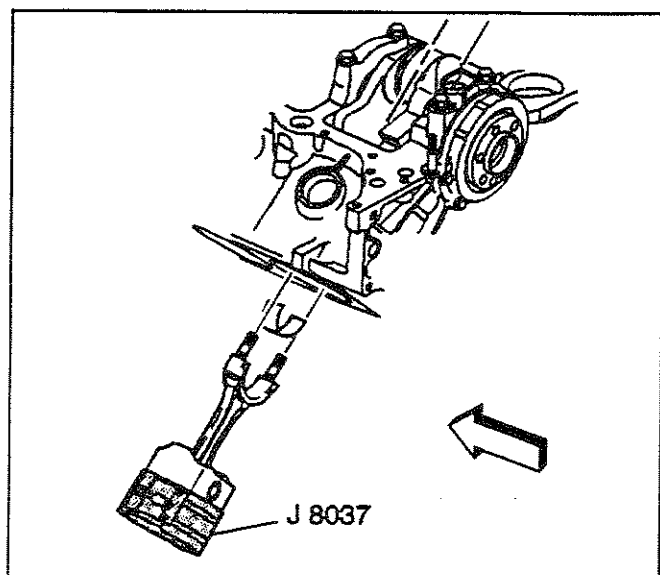
480573

3. Install the *J 8037* onto the piston and compress the piston rings.

Important: 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.

Install the piston and connecting rod assembly, and the *J 8037* into the proper cylinder bore.

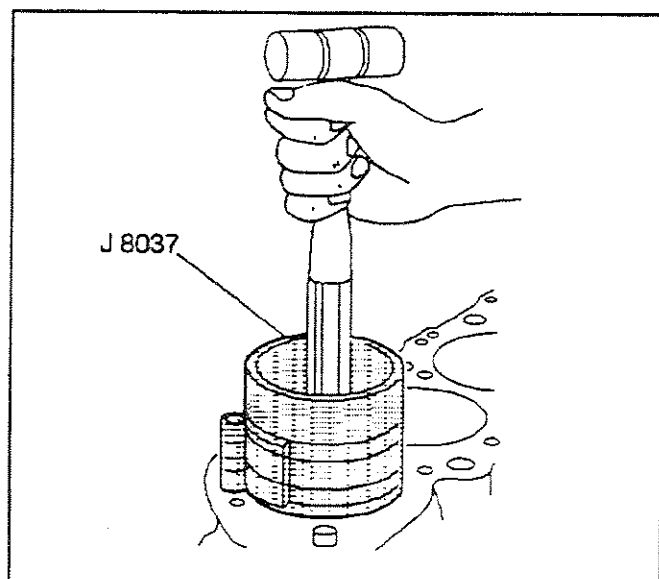


492144

4. Use the *J 8037* and the *J 5239* and lightly tap the top of the piston with a wooden hammer handle.

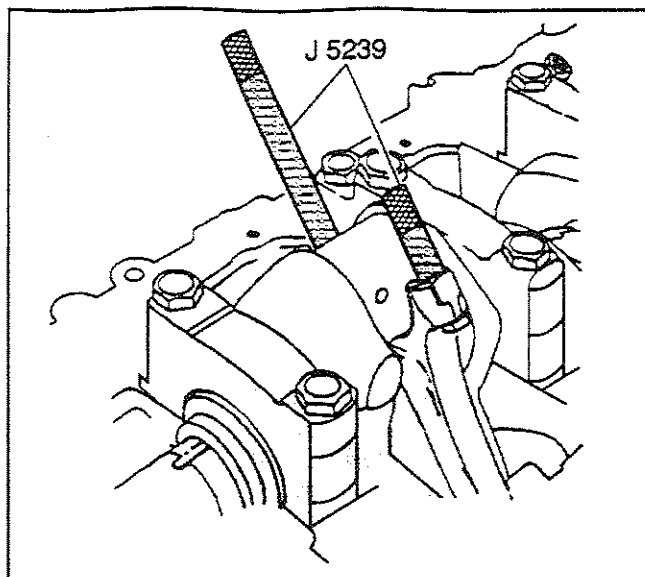
- 4.1. Hold the *J 8037* firmly against the engine block until all of the piston rings have entered the cylinder bore.

- 4.2. Use the *J 5239* in order to guide the connecting rod onto the crankshaft journal.



5159

5. Remove the *J 5239*.



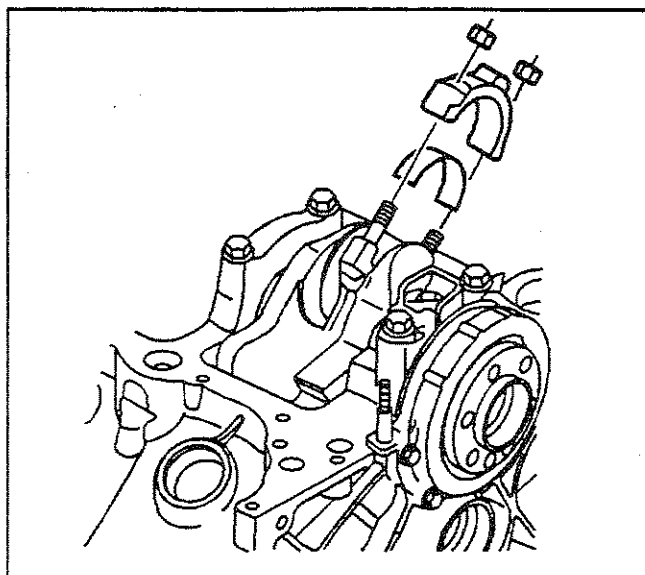
31373

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

6. Install the connecting rod caps, bearings, and nuts.

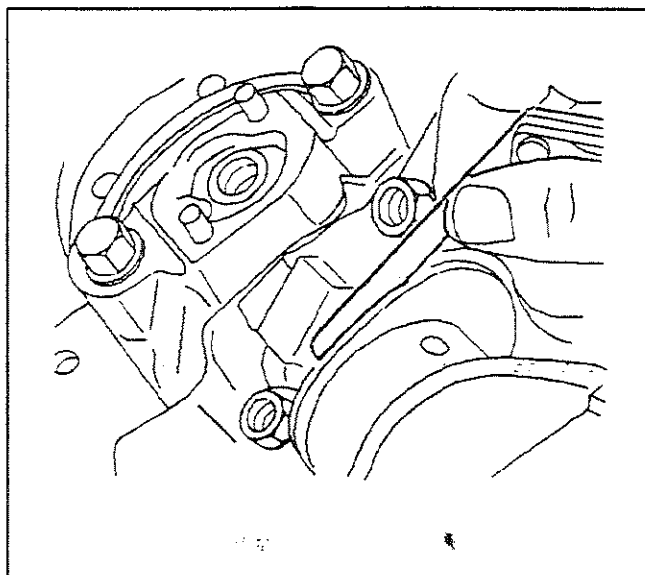
Tighten

- 6.1. Tighten the nuts evenly on the first pass to 27 N·m (20 lb ft).
- 6.2. Use the *J 36660* in order to tighten the nuts on the final pass an additional 70 degrees.

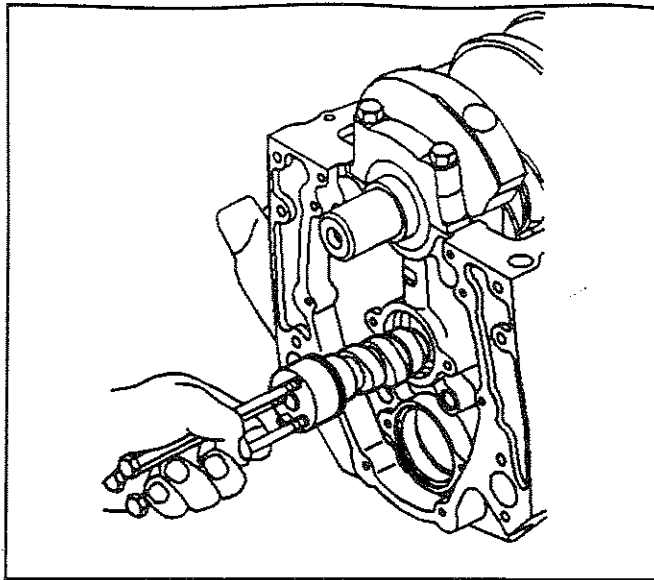


480549

7. 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.
8. 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).



5163



5147

Camshaft Installation

SIE-ID = 389625

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 three 5/16-18 x 4.0 in. bolts into the engine camshaft front bolt holes.

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.

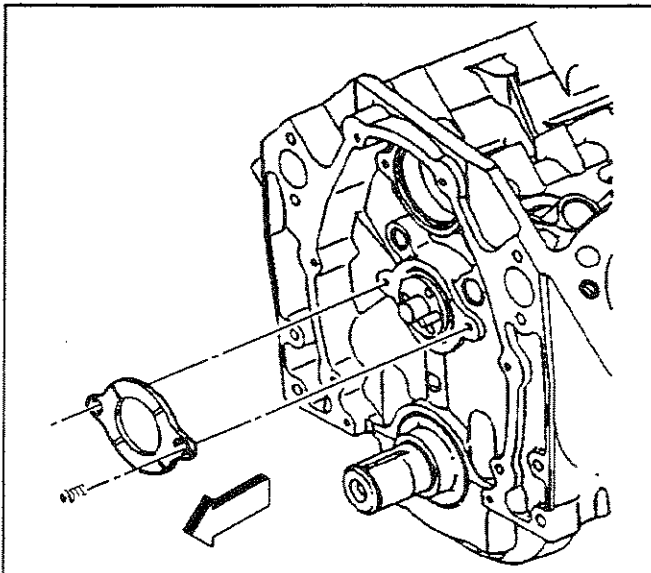
3. Use the bolts as a handle in order to install the engine camshaft.
4. Remove the 3 bolts from the front of the engine camshaft.

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

5. If reusing the fasteners, apply threadlock GM P/N 12345382 or equivalent to the threads of the camshaft retainer bolts.
6. Install the camshaft retainer and bolts.

Tighten

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



188030

Balance Shaft Installation

SIE-ID = 386494

Tools Required

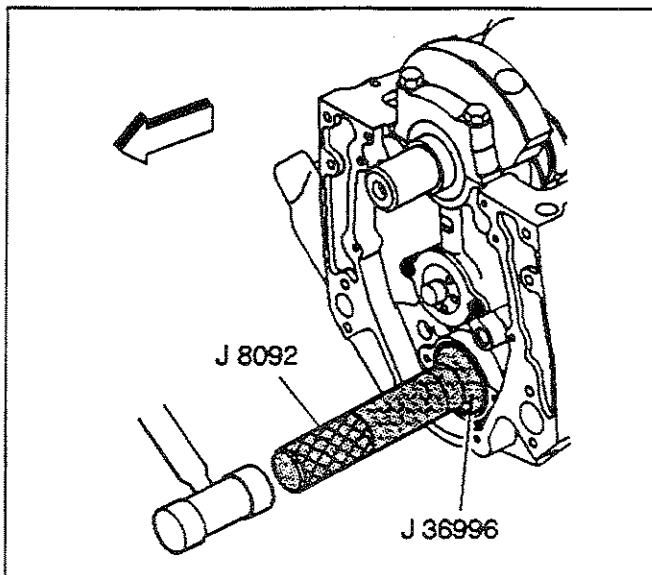
- J 8092 Universal Driver Handle
- J 36660 Electronic Torque Angle Meter
- J 36996 Balance Shaft Installer

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.

Apply clean engine oil GM P/N 12345610 or equivalent to the balance shaft front bearing.

Caution: Refer to *Safety Glasses Caution* in Cautions and Notices.

1. Use the J 36996 and the J 8092 in order to install the balance shaft.



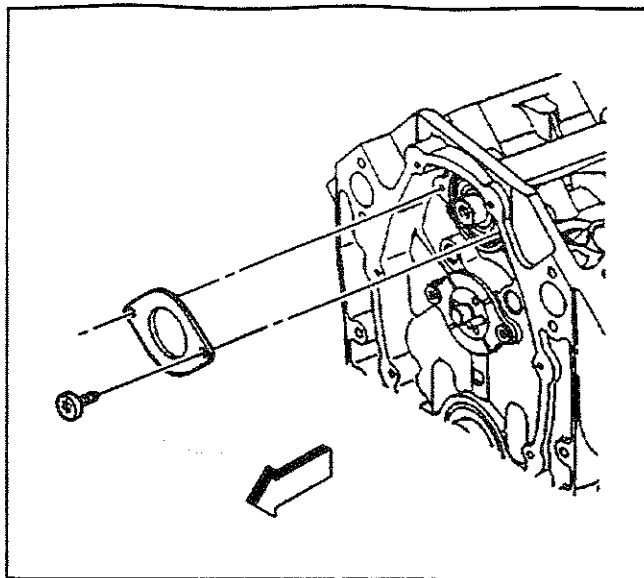
5141

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

2. Install the balance shaft retainer and bolts.

Tighten

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



188031

3. Install the balance shaft driven onto the balance shaft.
4. If reusing the fastener, 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 bolt.

- 5.1. Use a wrench to secure the balance shaft.

Place the wrench onto the balance shaft near to the balance shaft front bearing.

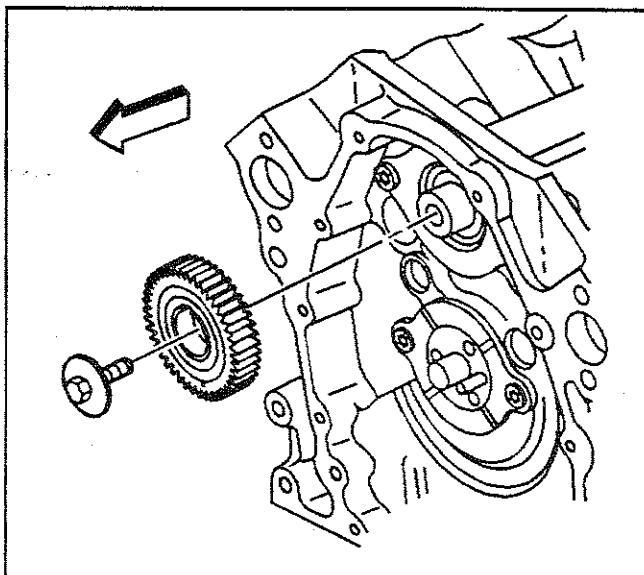
- 5.2. Install the balance shaft driven gear bolt.

Tighten

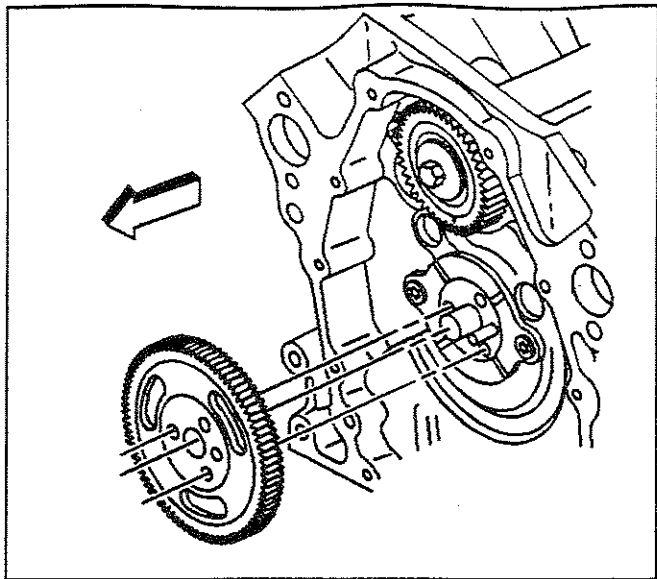
- 5.2.1. Tighten the balance shaft driven gear bolt on the first pass to 20 N·m (15 lb ft).

- 5.2.2. Tighten the balance shaft driven gear bolt on the final pass using the J 36660 an additional 35 degrees.

6. Remove the wrench from the balance shaft.
7. 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.

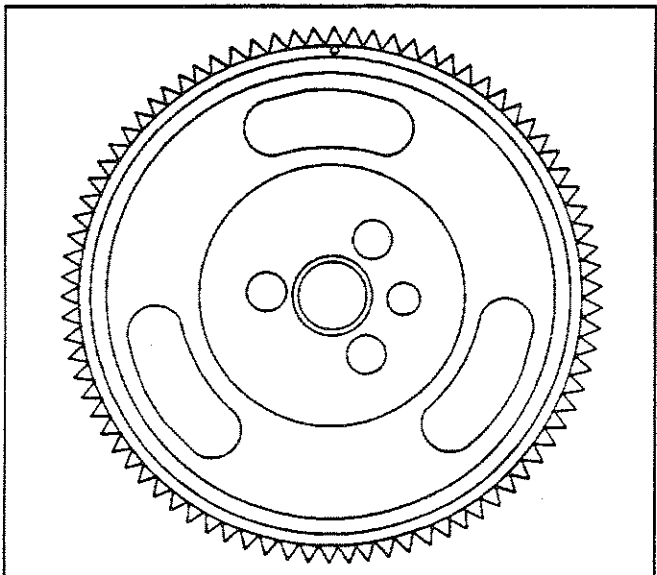


5136



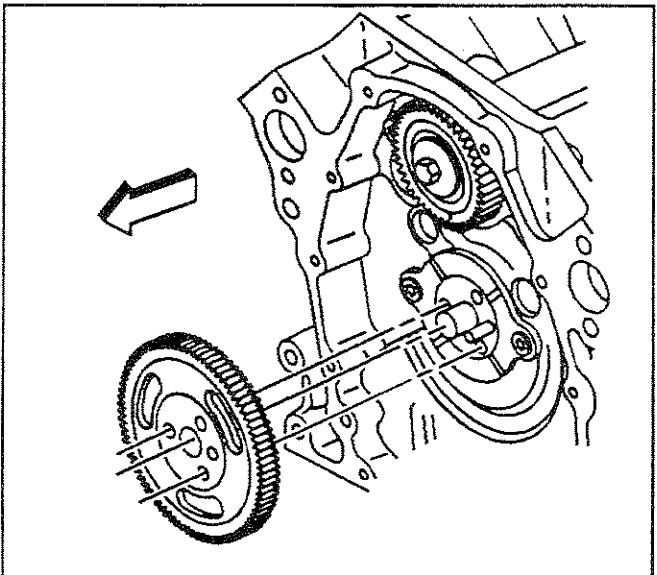
9847

8. Install the balance shaft drive gear. DO NOT install the camshaft sprocket bolts at this time.



9848

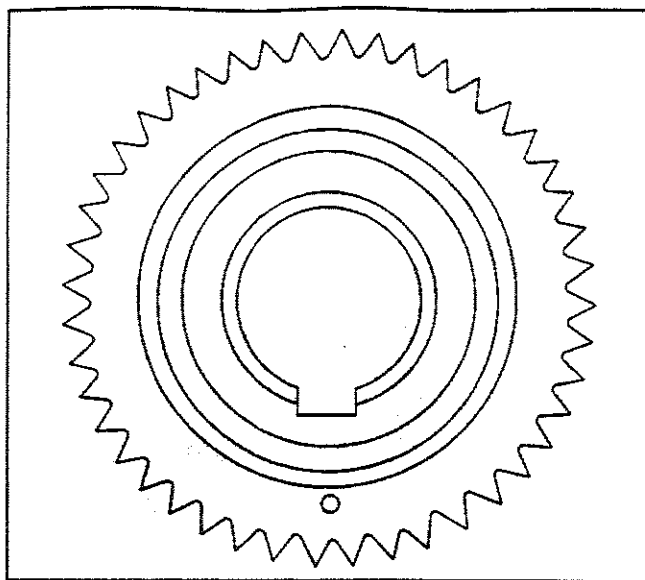
9. Rotate the engine camshaft so that the timing mark on the balance shaft drive gear is in the 12 o'clock position.



9847

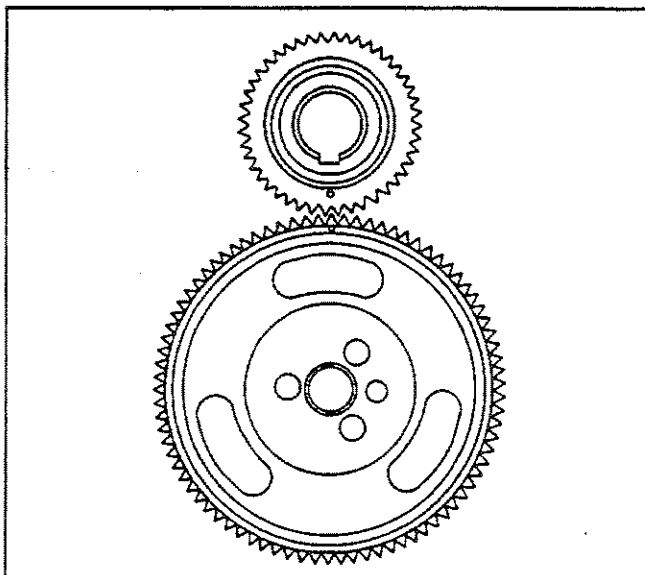
10. Remove the balance shaft drive gear.

11. Rotate the balance shaft so that the timing mark on the balance shaft driven gear is in the 6 o'clock position.



9849

12. Position the balance shaft drive gear onto the engine camshaft.
13. Look to ensure that the balance shaft drive gear and the balance shaft driven gear timing marks are aligned.



5144

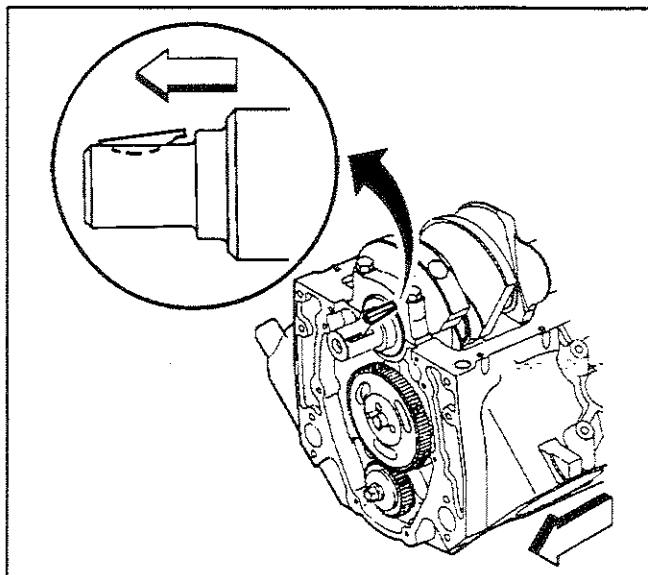
Timing Chain and Sprockets Installation

SIE-ID - 507123

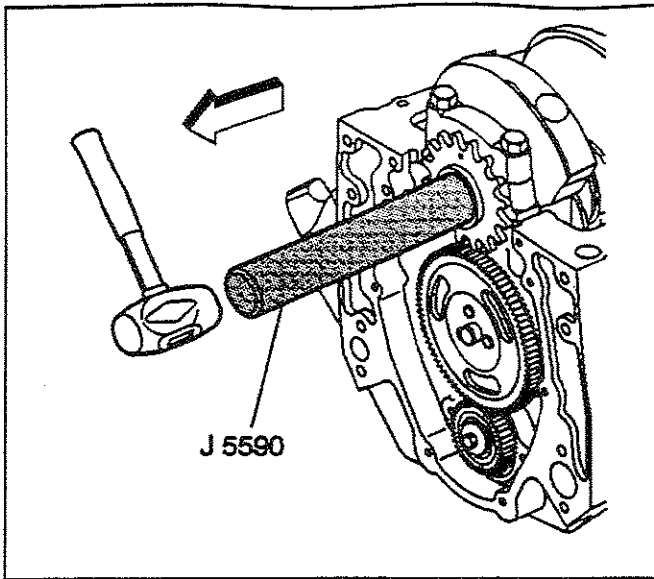
Tools Required

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

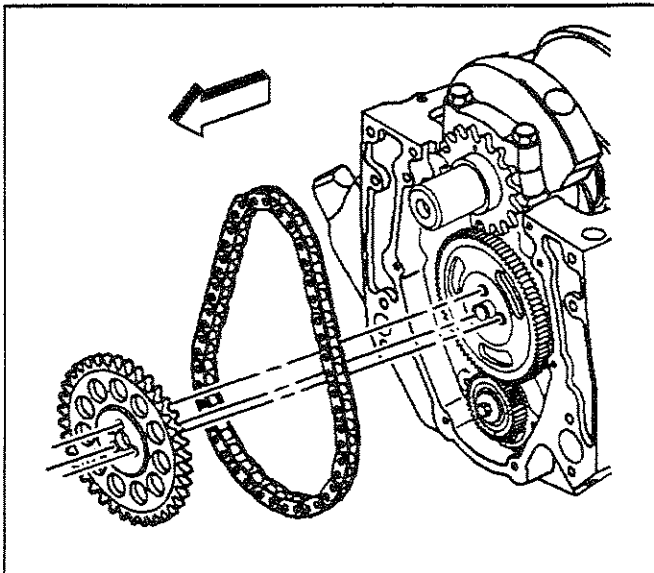


480574

2. Align the keyway of the crankshaft sprocket with the crankshaft balancer key.

Caution: Refer to *Safety Glasses Caution in Cautions and Notices*.

3. Use the J 5590 in order to install the crankshaft sprocket.

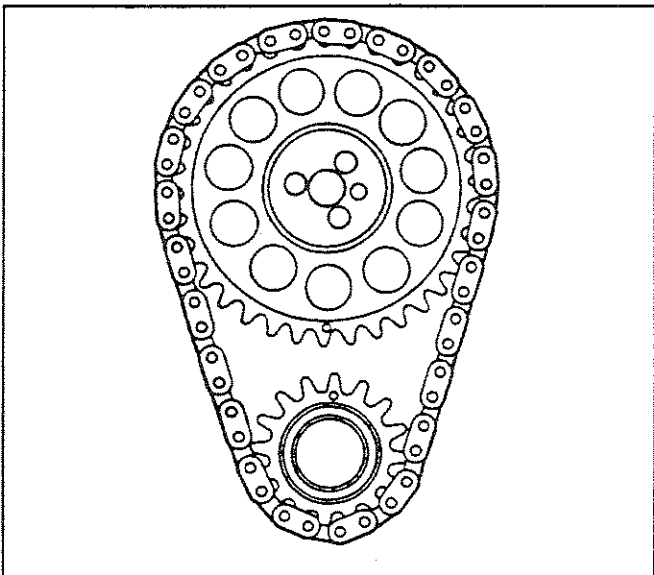


480546

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.

Install the camshaft sprocket and the camshaft timing chain.



480575

5. 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.

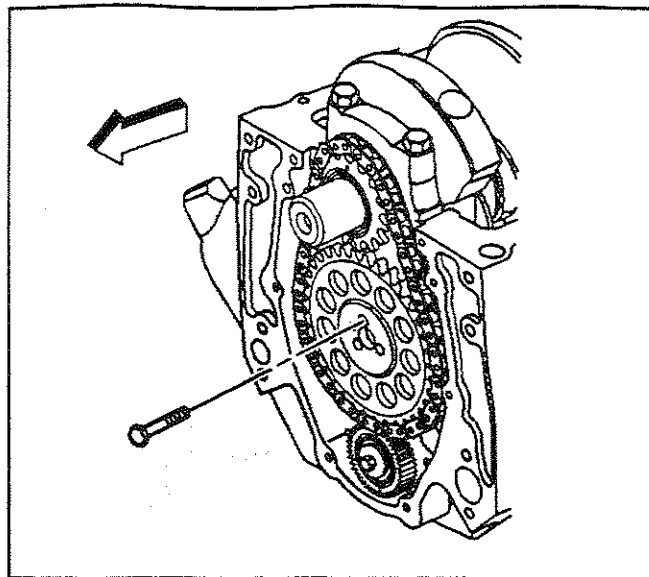
Notice: Refer to *Fastener Notice* in Cautions and Notices.

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).

Install camshaft sprocket bolts.

Tighten

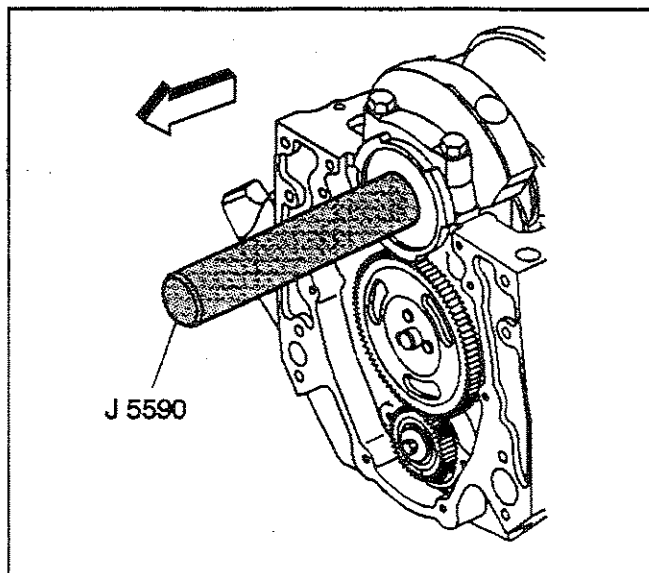
Tighten the camshaft sprocket bolts to 25 N·m (18 lb ft).



480544

6. Install the crankshaft position sensor reluctor ring.

- 6.1. Align the keyway on the crankshaft position sensor reluctor ring with the crankshaft balancer key in the crankshaft.
- 6.2. Use the *J 5590* in order to push the crankshaft position sensor reluctor ring onto the crankshaft until completely seated against the crankshaft sprocket.



480576

Engine Front Cover Installation

SIE-ID = 507165

Important: Once the composite engine front cover is removed DO NOT reinstall the engine front cover. Always install a NEW engine front cover.

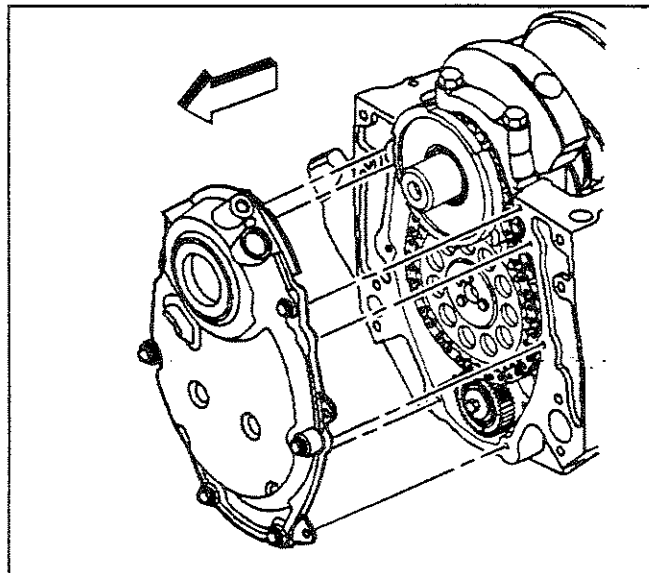
Install the NEW engine front cover.

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

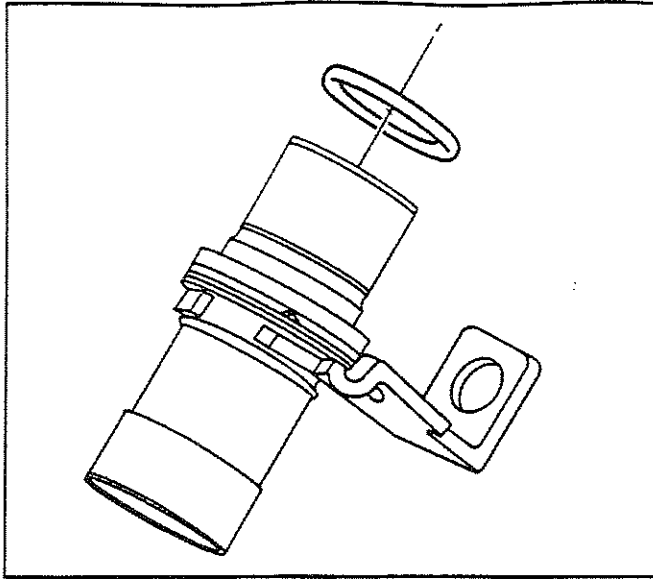
1. Install the engine front cover bolts.

Tighten

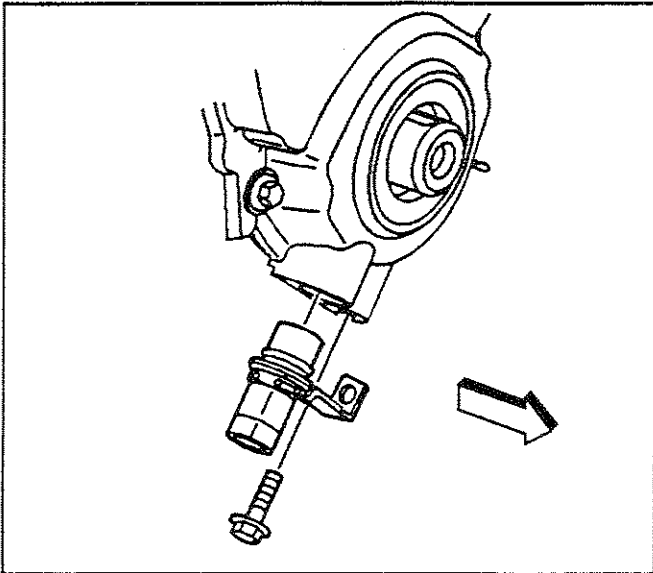
Tighten the bolts to 12 N·m (106 lb in).



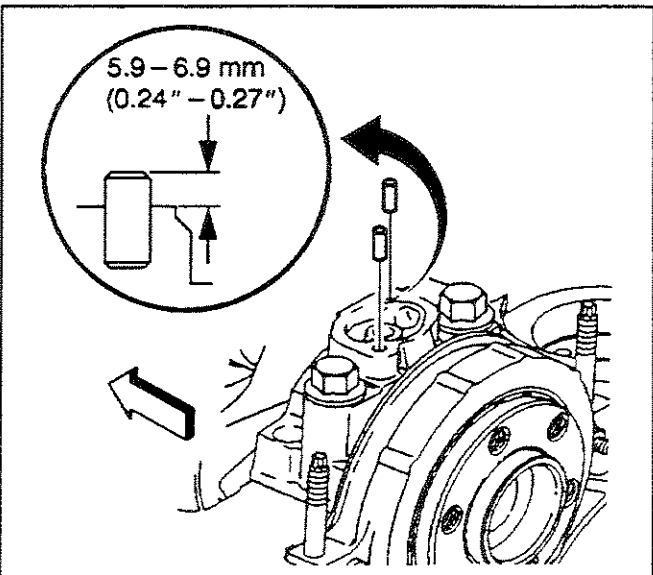
480539



387759



11485



330578

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.

Lubricate the NEW crankshaft position sensor seal (O-ring) with clean engine oil.

2. Install the NEW crankshaft position sensor seal (O-ring) onto the crankshaft position sensor.

3. Install crankshaft position sensor until fully seated into the engine front cover.
4. Install crankshaft position sensor bolt.

Tighten

Tighten the crankshaft position sensor bolt to 8 N·m (71 lb in).

Oil Pump Installation

SIE-ID = 358623

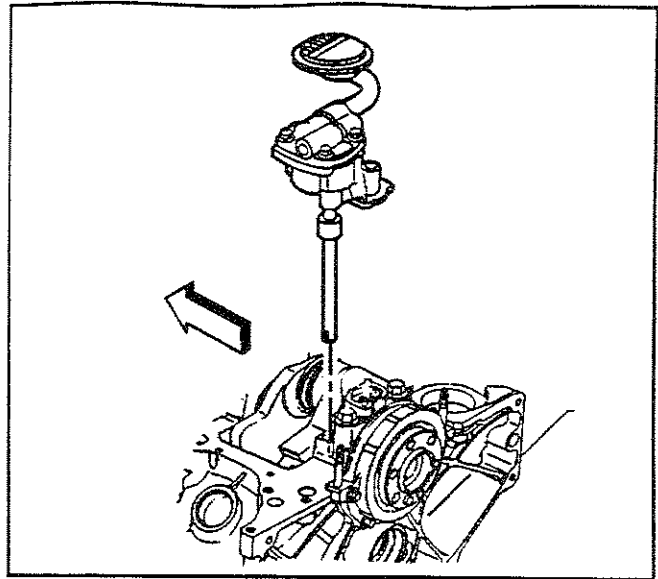
1. Inspect for properly installed pins (oil pump locator).

Important: Do not reuse the oil pump driveshaft retainer.

During assembly, install a NEW oil pump driveshaft retainer.

Install the oil pump.

2. Position the oil pump onto the pins.



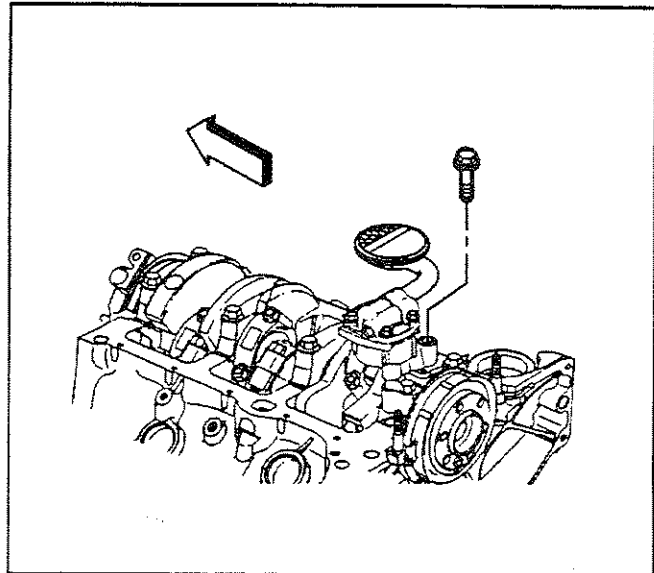
330576

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

3. 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).

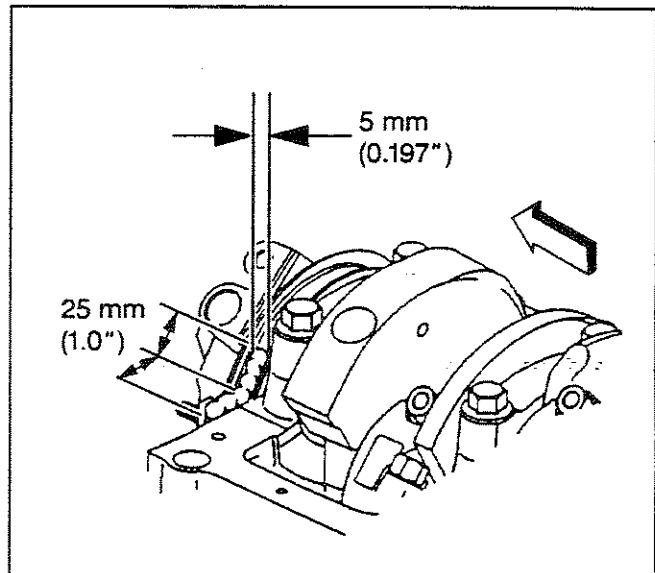


330572

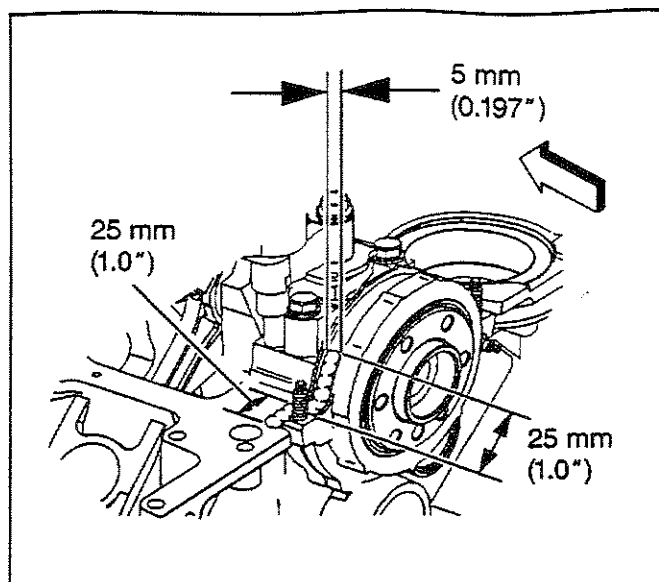
Oil Pan Installation

SIE-ID # 358625

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 both the right and left sides of the engine front cover to engine block junction at the oil pan sealing surfaces.

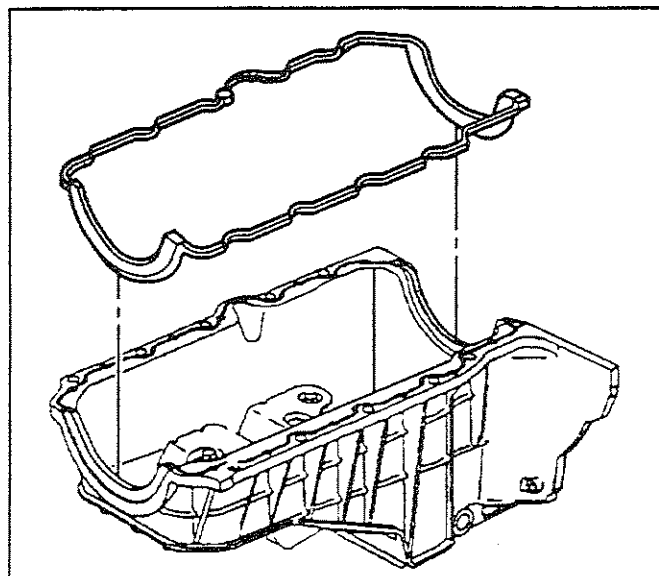


317310



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 both the right and left sides of the crankshaft rear oil seal housing to engine block junction at the oil pan sealing surfaces.

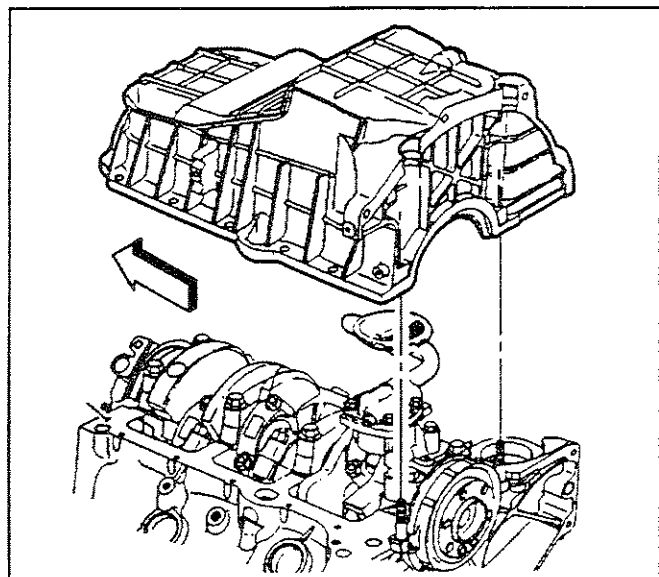


387757

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.

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.

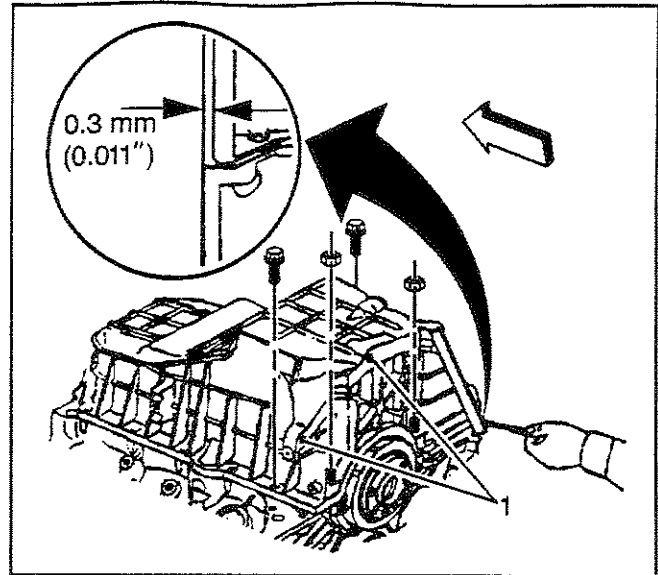
Install the oil pan onto the engine block.

Press the oil pan gasket into the grooves of the engine front cover and crankshaft rear oil seal housing.

3. Slide the oil pan back against a suitable straight edge.

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

4. Install the oil pan bolts and nuts, but do not tighten.
5. Measure the pan-to-transmission housing clearance using a feeler gauge and a straight edge.
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.



38496

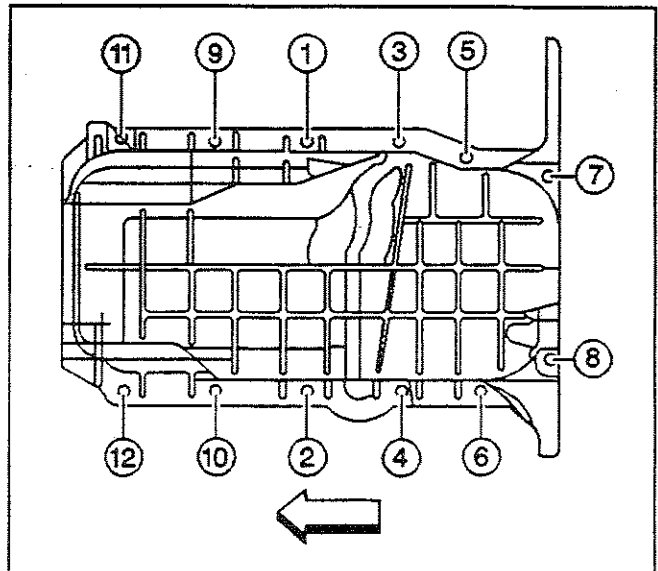
Notice: SIO-ID = 41424 If the clearance is more than 0.3 mm (0.011 in), powertrain durability may be reduced.

6. Tighten the oil pan bolts and nuts in sequence (1–12).

Tighten

Tighten the oil pan bolts to 25 N·m (18 lb ft).

7. Measure the clearance between the 3 oil pan-to-transmission housing measurement points in order to ensure proper alignment.

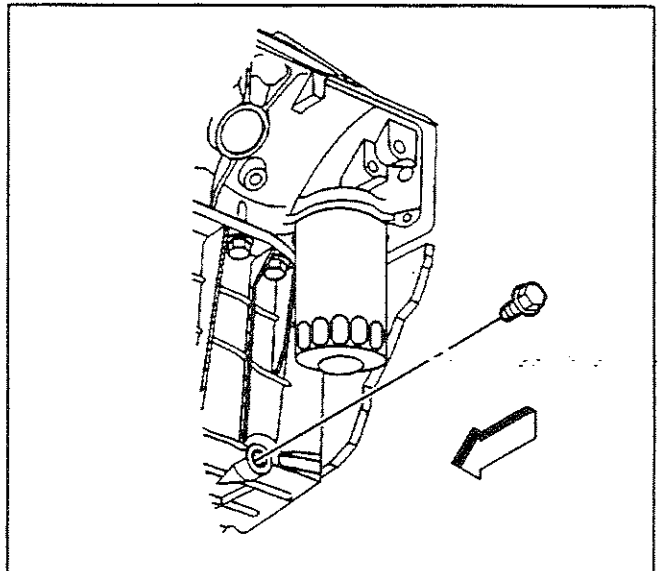


38481

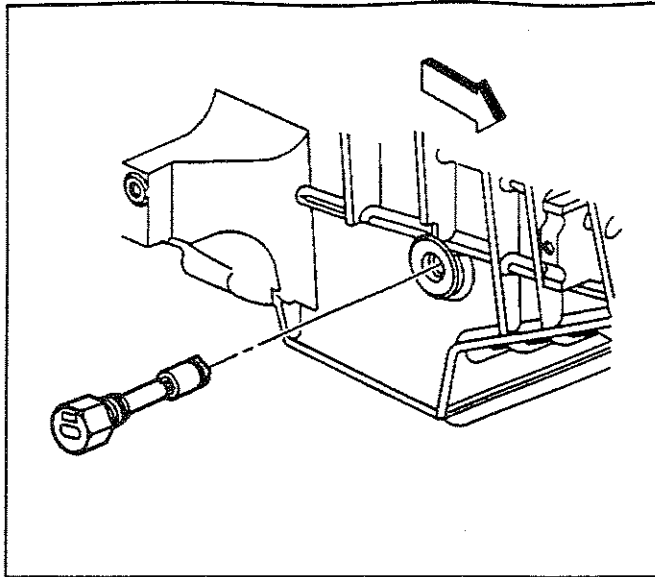
8. Install a NEW oil pan drain plug seal (O-ring) onto the oil pan drain plug.
9. Install the oil pan drain plug into the oil pan.

Tighten

Tighten the oil pan drain plug to 25 N·m (18 lb ft).



188048

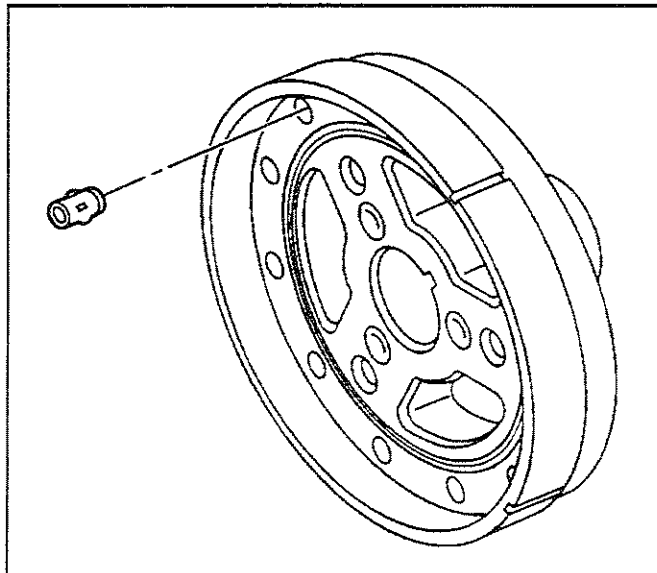


387460

10. Install the NEW engine oil level sensor (if applicable).

Tighten

Tighten the engine oil level sensor to 13 N·m (115 lb in).



334258

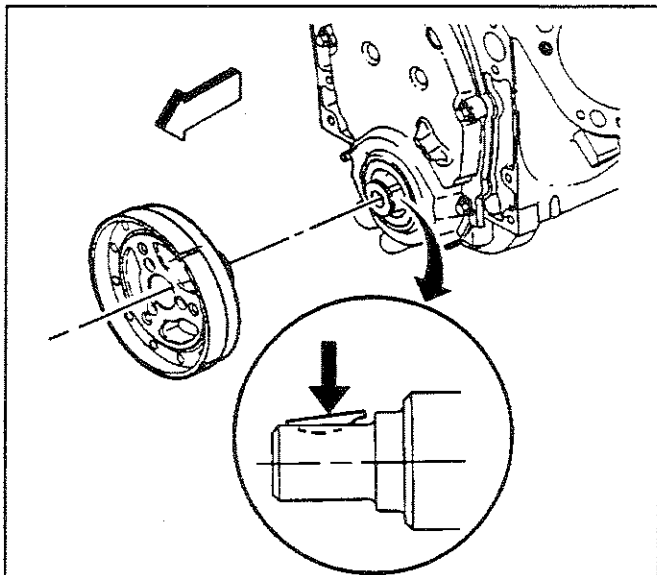
Crankshaft Balancer Installation

SIE-ID = 358626

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).



188059

Notice: SIO-ID = 16580 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.

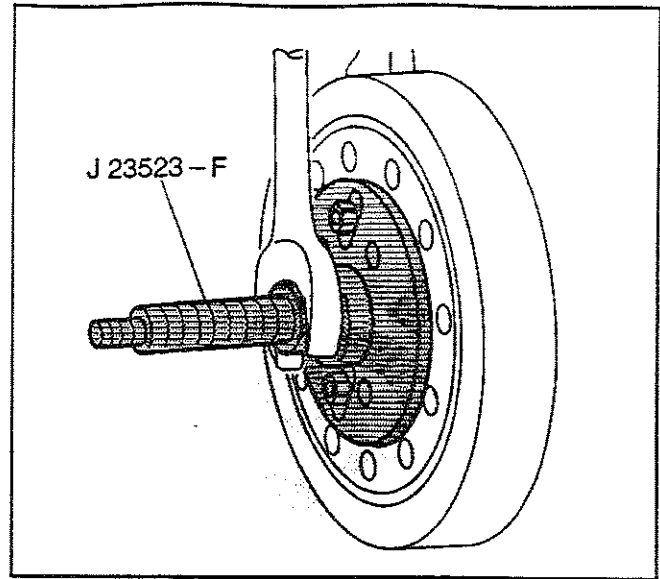
5. Use the *J 23523-F* in order to press the crankshaft balancer onto the crankshaft.

- 5.1. Install the *J 23523-F* plate and bolts onto the front of the crankshaft balancer.

Tighten

Tighten the *J 23523-F* plate bolts to 25 N·m (18 lb ft).

- 5.2. Install the *J 23523-F* screw into the end for the crankshaft.
 - 5.3. Install the *J 23523-F* bearing, the washer, and the nut onto the *J 23523-F* screw.
 - 5.4. Rotate the *J 23523-F* nut clockwise until the crankshaft balancer hub is completely seated against the crankshaft position sensor reluctor ring.
6. Remove the *J 23523-F*.



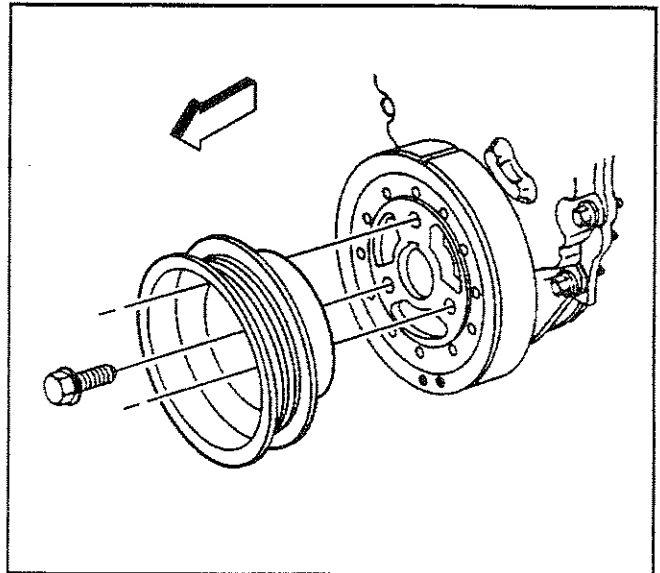
4065

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

7. Install the crankshaft pulley and bolts.

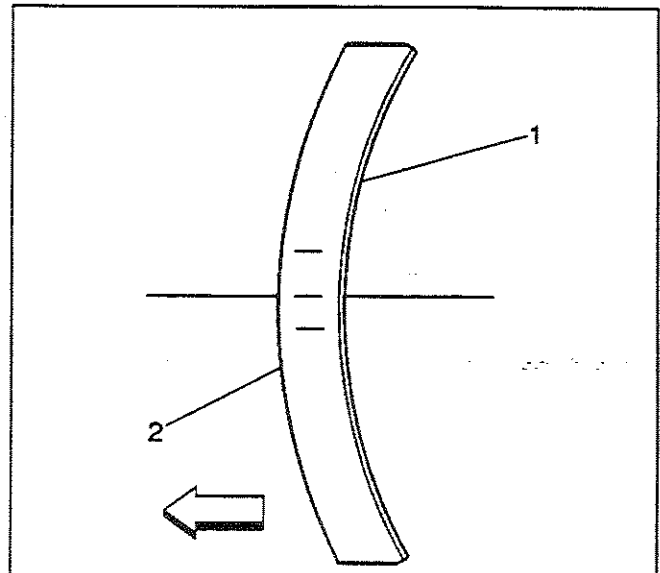
Tighten

Tighten the crankshaft pulley bolts to 58 N·m (43 lb ft).

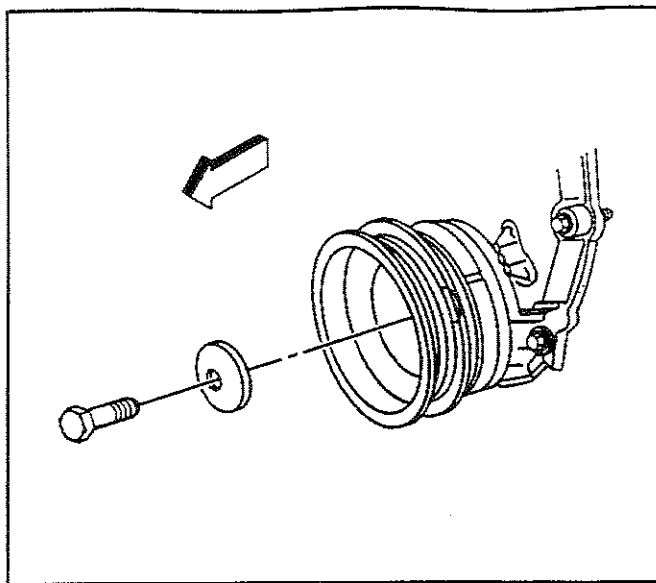


188055

8. Ensure that the crown of the crankshaft balancer washer (2) is faced away from the engine.



342203

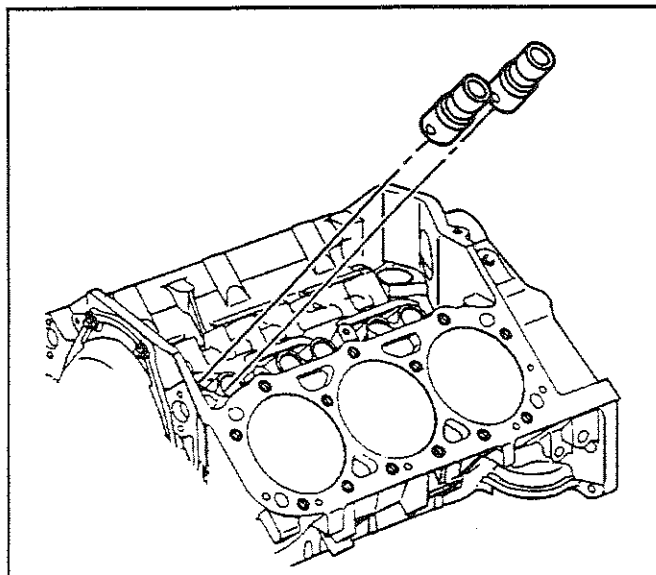


173172

9. Install the crankshaft balancer washer and the bolt.

Tighten

Tighten the crankshaft balancer bolt to 95 N·m (70 lb ft).



328593

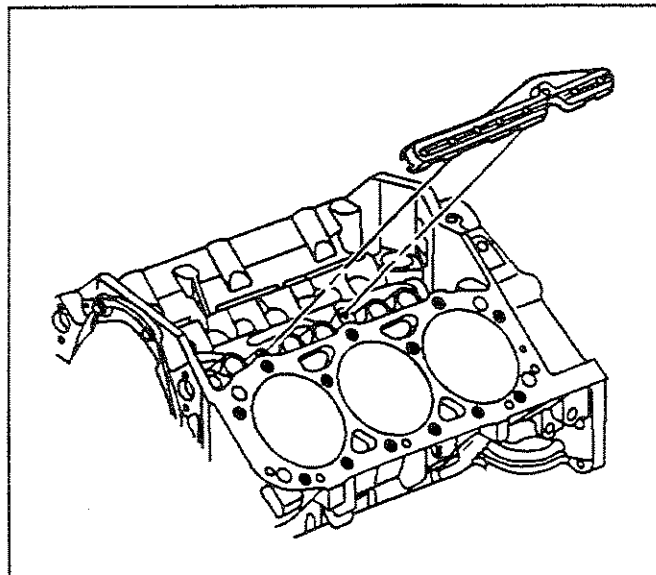
Valve Lifter Installation

SIE-ID = 359627

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.

Install the valve lifters.



328592

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

2. Install the valve lifter pushrod guides.

Tighten

Tighten the valve lifter pushrod guide bolts to 16 N·m (12 lb ft).

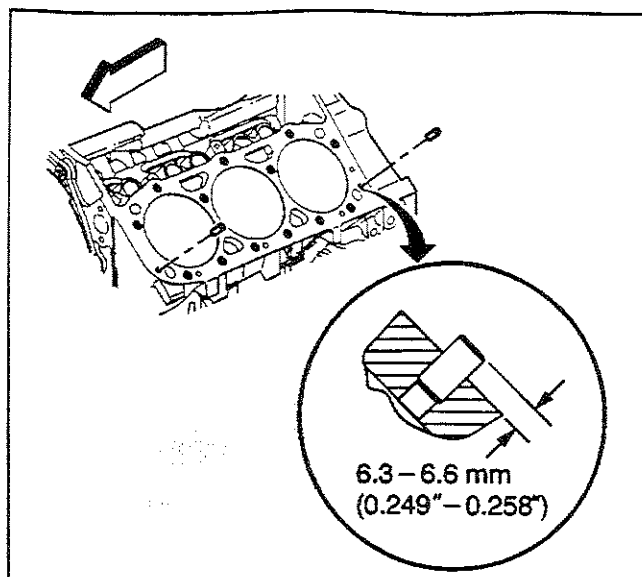
Cylinder Head Installation (Left)

SIE-ID - 507172

Tools Required

J 36660 Electronic Torque Angle Meter

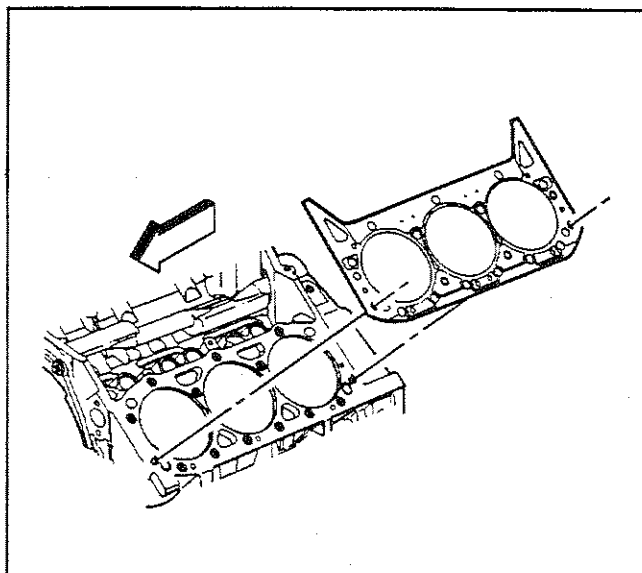
1. Clean the cylinder head gasket surfaces on the engine block.
2. Inspect the dowel pins (cylinder head locator) for proper installation.
3. Clean the cylinder head gasket surfaces on the cylinder head.



334303

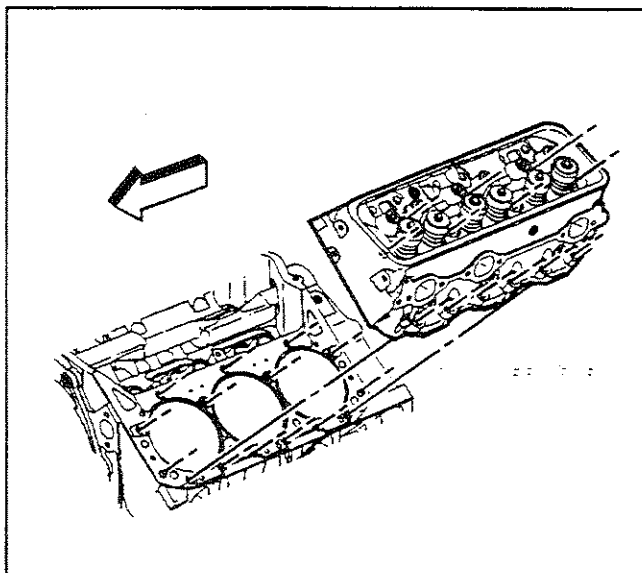
Important: Do not use any type sealer on the cylinder head gasket (unless specified).

Install the NEW cylinder head gasket in position over the dowel pins (cylinder head locator).

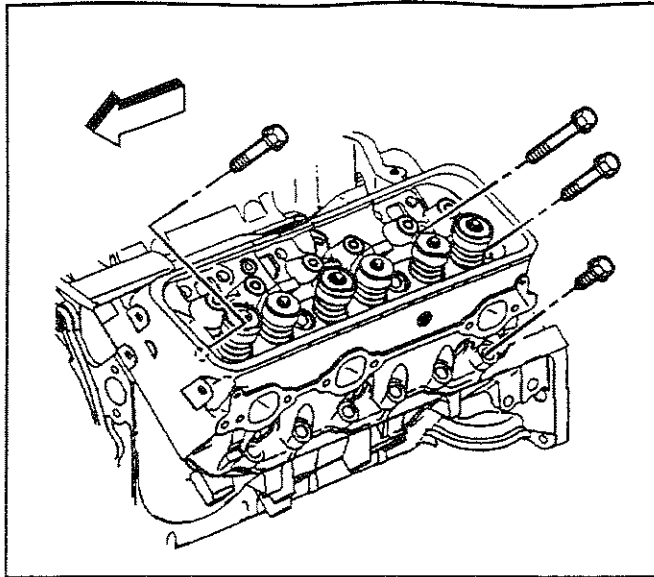


334299

4. Install the cylinder head onto the engine block.
Guide the cylinder head carefully into place over the dowel pins and the cylinder head gasket.



480536

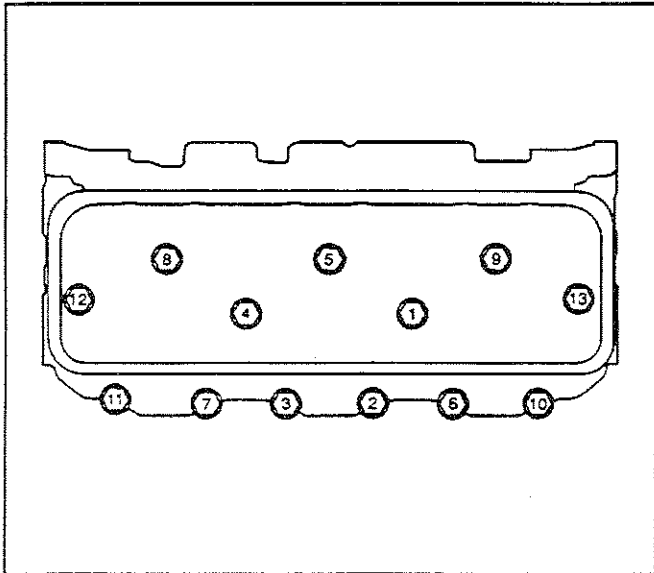


480533

5. 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.

6. Install the cylinder head bolts finger tight.



5132

7. Tighten the cylinder head bolts in sequence on the first pass.

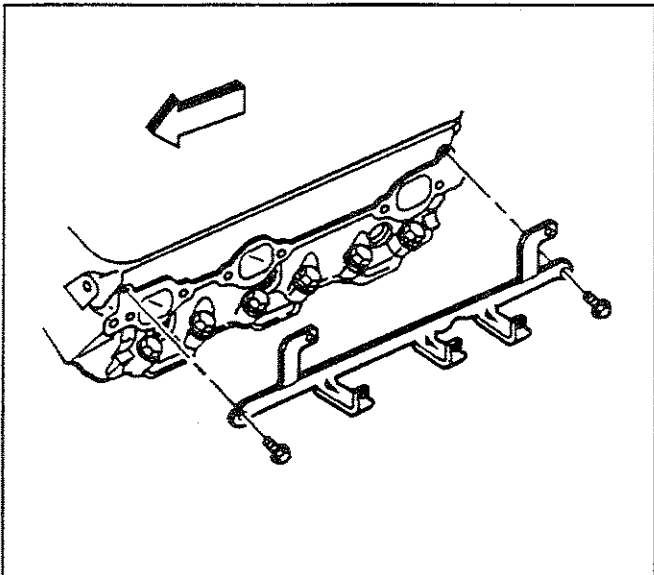
Tighten

Tighten the bolts in sequence on the first pass to 30 N·m (22 lb ft).

8. 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.



328588

9. Install the spark plug wire support and bolts.

Tighten

Tighten the spark plug wire support bolts to 12 N·m (106 lb in).

10. Measure the NEW spark plugs for the proper gap.
Adjust the spark plug gap if necessary.

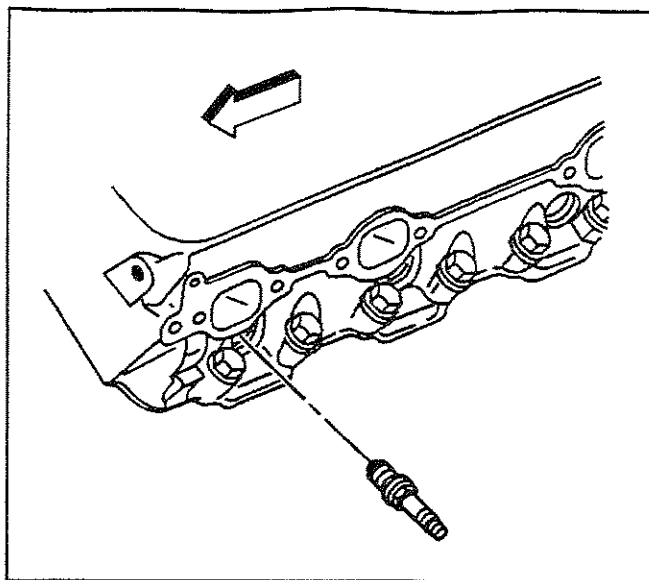
Specification

Spark plug gap to 1.52 mm (0.060 in).

11. 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).

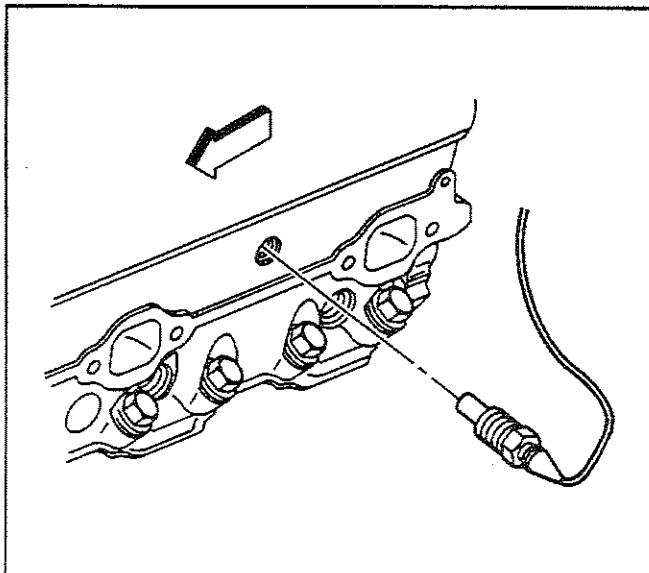


328582

12. If reusing the engine coolant temperature gauge sensor (if applicable), apply sealant GM P/N 12346004 or equivalent to the threads of the engine coolant temperature gauge sensor.
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).

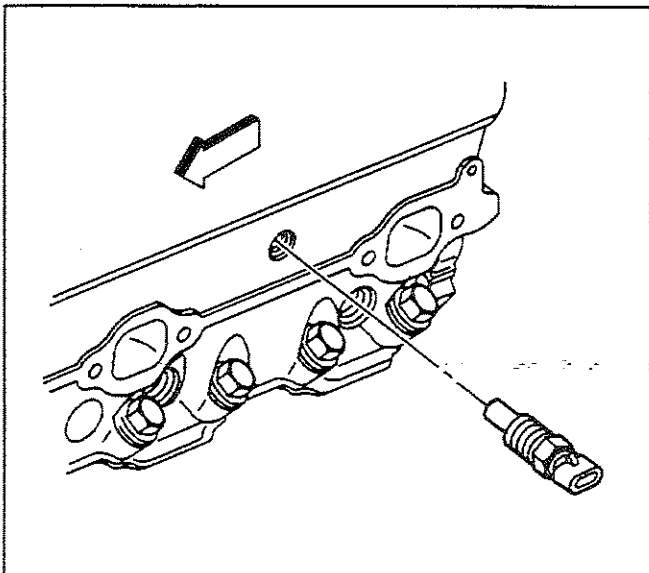


387767

14. If reusing the engine coolant temperature sensor (if applicable), apply sealant GM P/N 12346004 or equivalent to the threads of the engine coolant temperature gauge sensor.
15. Install the engine coolant temperature sensor (if applicable).

Tighten

Tighten the engine coolant temperature sensor to 20 N·m (15 lb ft).



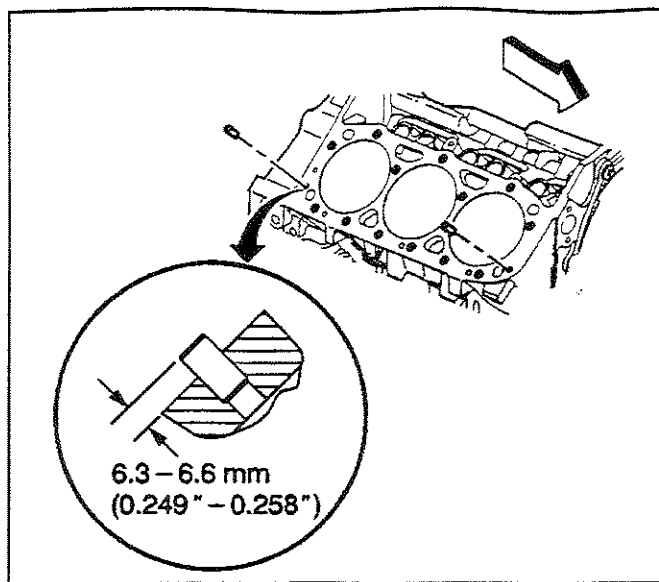
387769

Cylinder Head Installation (Right)

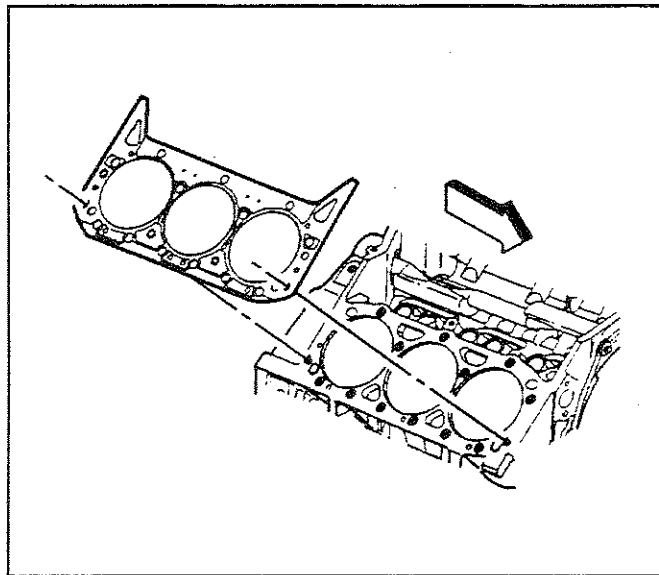
SIE-ID # 507177

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.



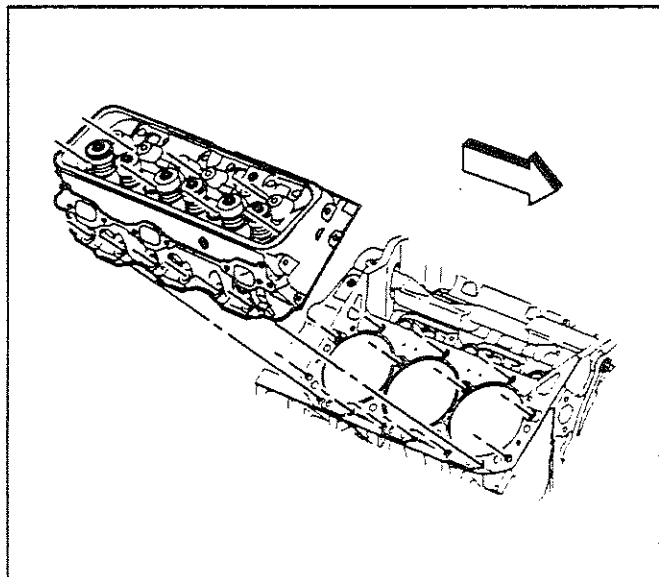
334314



334312

Important: Do not use any type sealer on the cylinder head gasket (unless specified).

Install the NEW cylinder head gasket in position over the dowel pins (cylinder head locator).



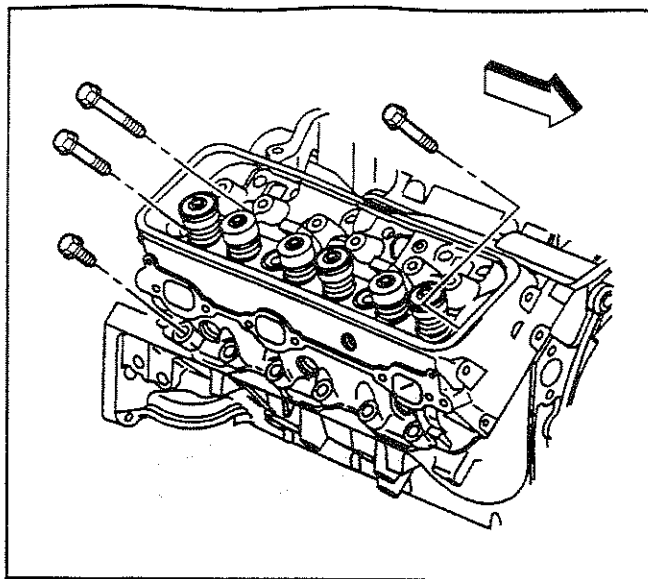
480538

4. Install the cylinder head onto the engine block. Guide the cylinder head carefully into place over the dowel pins and the cylinder head gasket.

5. 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.

6. Install the cylinder head bolts finger tight.



480537

7. Tighten the cylinder head bolts in sequence on the first pass.

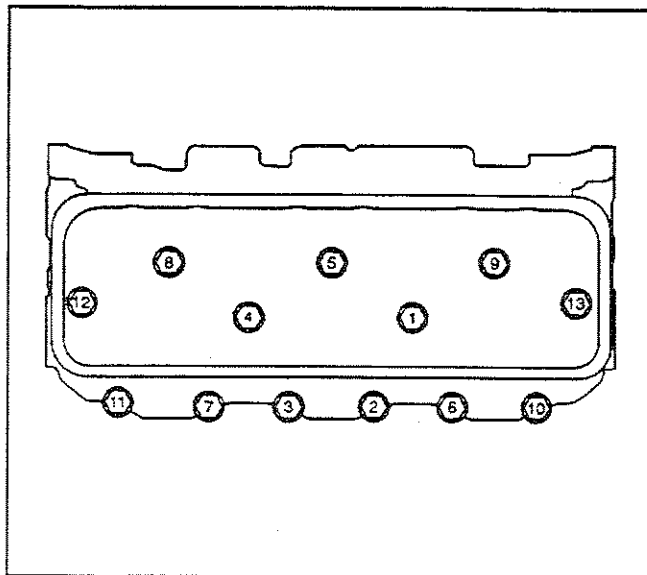
Tighten

Tighten the bolts in sequence on the first pass to 30 N·m (22 lb ft).

8. 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

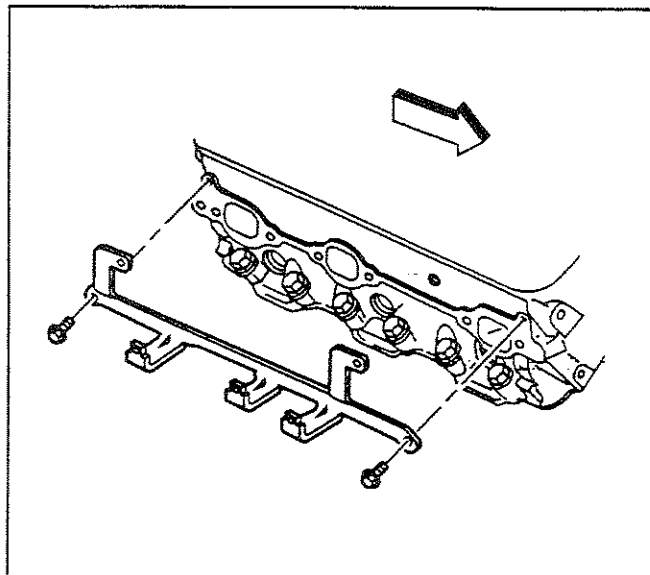
9. Install the spark plug wire support and bolts.

Tighten

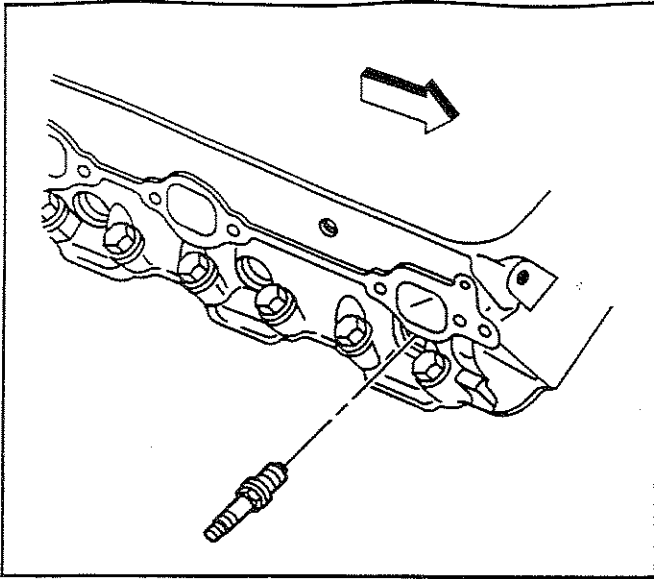
Tighten only the rear spark plug wire support bolt to 12 N·m (106 lb in).

10. Remove the front spark plug wire support bolt.

The front spark plug wire support bolt is used to fasten the oil level indicator tube, and will be installed within the oil level indicator tube installation procedure.



328590



328586

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

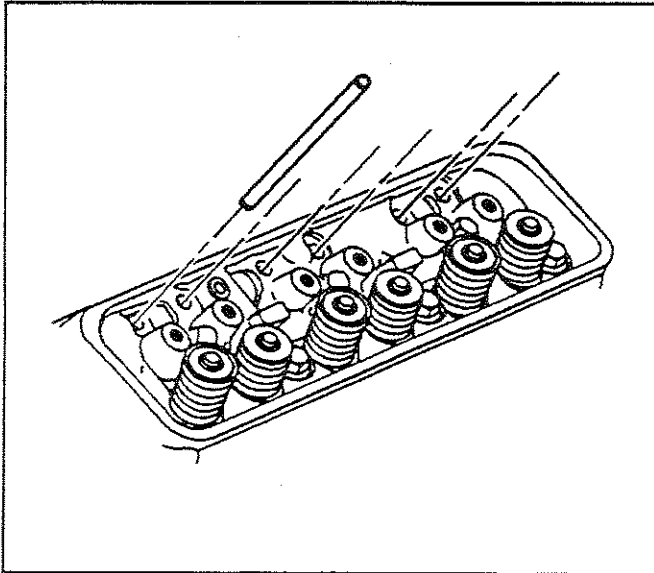
- Tighten the spark plugs for a USED cylinder head to 15 N·m (11 lb ft).
- Tighten the spark plugs for the initial installation of a NEW cylinder head to 30 N·m (22 lb ft).

Valve Rocker Arm and Push Rod Installation

SIE-ID = 507181

Important: Be sure to keep parts in order. Parts must be reinstalled into the original location and position.

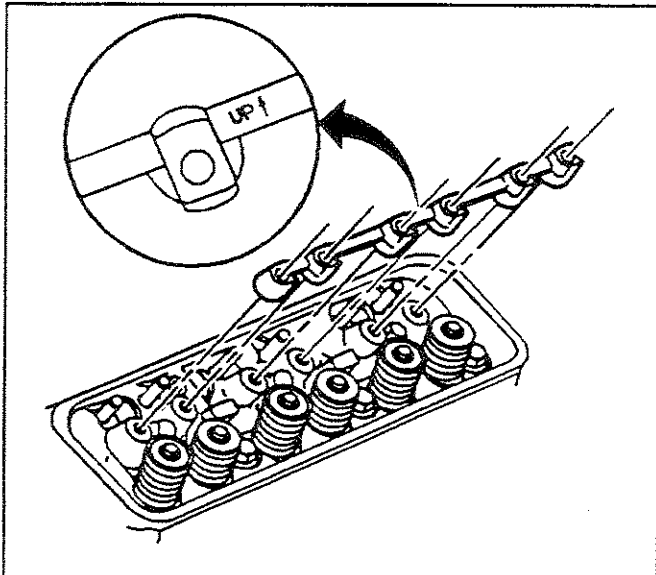
Install the valve pushrods.



480529

Important: Be sure that the arrow on the valve rocker arm support is in the up position.

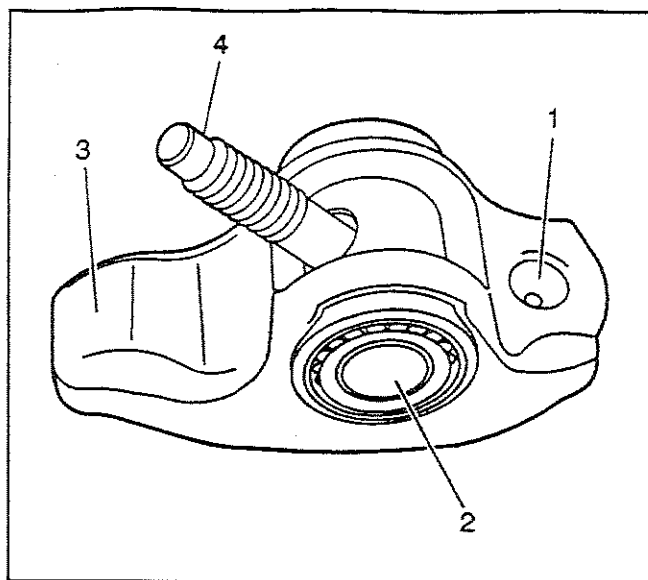
Install the valve rocker arm supports.



480578

1. Apply prelube GM P/N 12345501 or equivalent to the following valve rocker arm contact surfaces:

- Valve pushrod socket (1)
- Roller pivot (2)
- Valve stem tip (3)

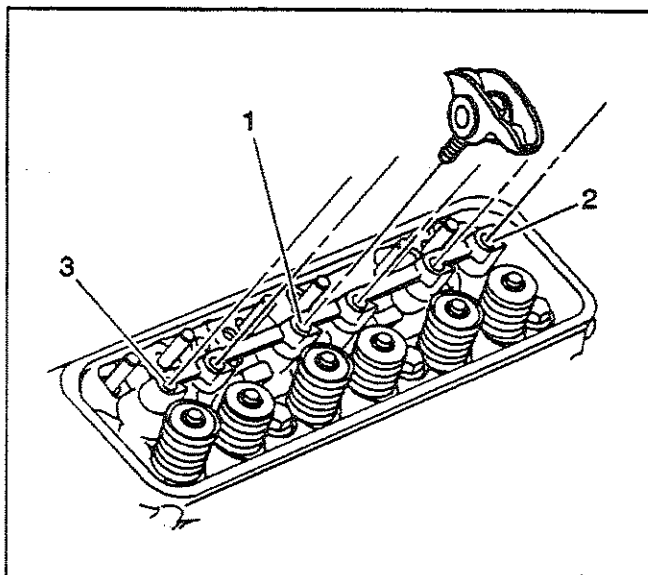


480551

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

2. Install the valve rocker arm assemblies as follows:

- 2.1. Finger start the bolt at location (1)
- 2.2. Finger start the bolt at location (2)
- 2.3. Finger start the bolt at location (3)
- 2.4. Finger start the remaining valve rocker arm bolts



480580

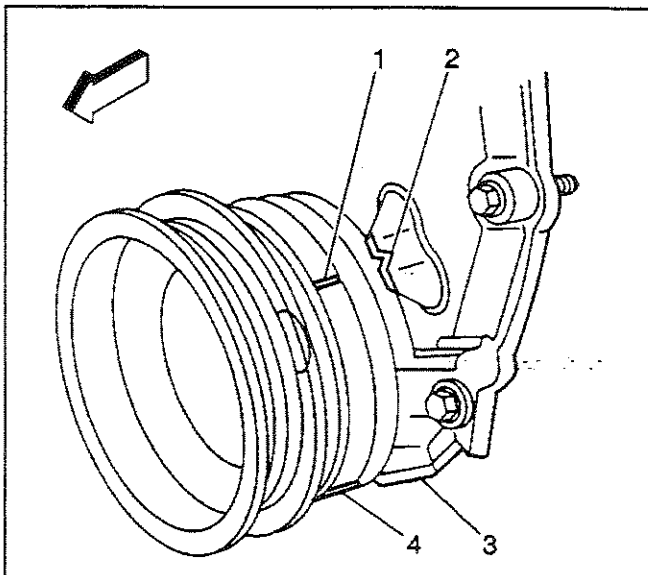
3. Rotate the crankshaft balancer to position the crankshaft balancer alignment mark (1) 57–63 degrees clockwise or counterclockwise from the engine front cover alignment tab (2).

Important: Once the valve rocker arm assemblies are installed and properly torqued, no additional valve lash adjustment is required.

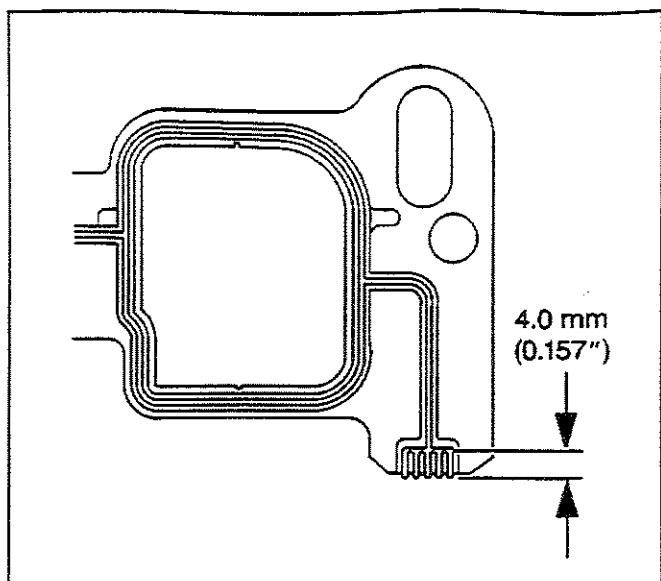
Tighten the valve rocker arm bolts.

Tighten

Tighten valve rocker arm bolts to 30 N·m (22 lb ft).



334551



38512

Intake Manifold Installation

SIE-ID = 358637

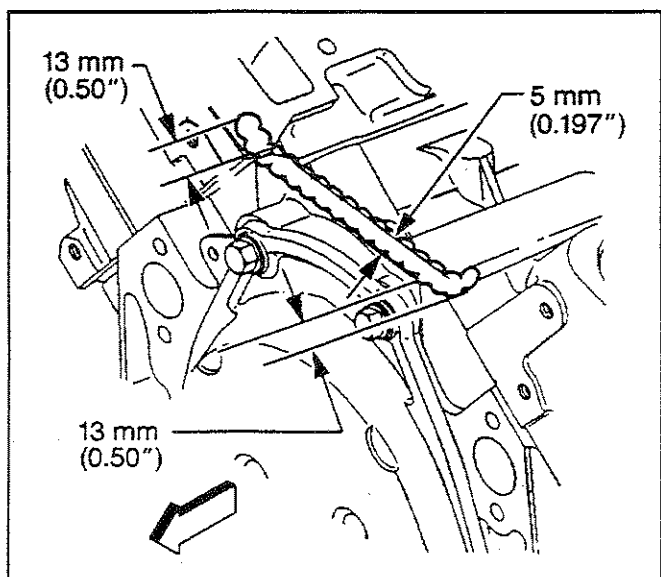
Notice: SIO-ID = 16302 Applying excessive amounts of sealant may prohibit the intake gasket from sealing properly.

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.

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.



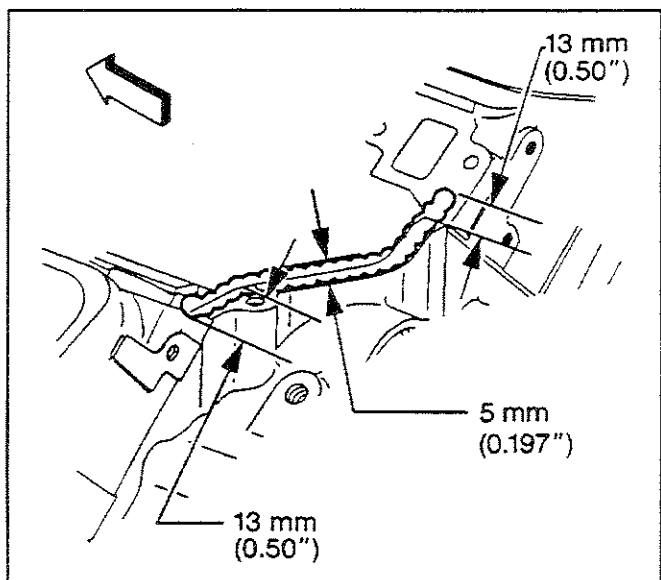
26744

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.

Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 or equivalent to the front top of the engine block.

2. Extend the adhesive bead 13 mm (0.50 in) onto each lower intake manifold gasket.



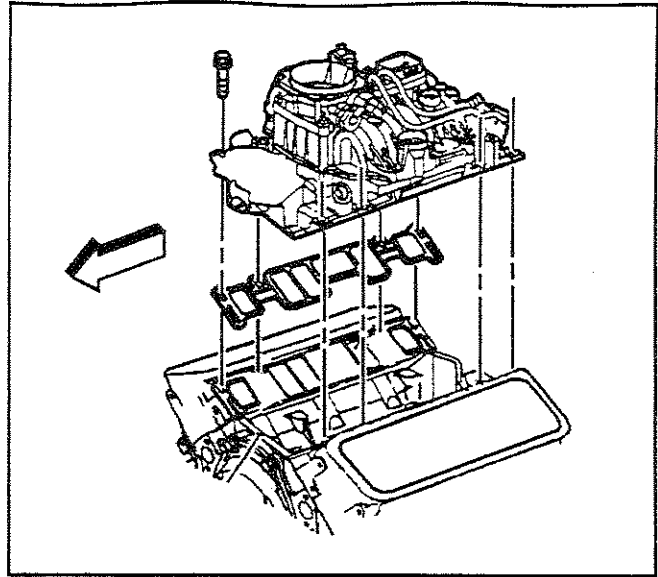
26743

3. Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 or equivalent to the rear top of the engine block.
4. Extend the adhesive bead 13 mm (0.50 in) onto each lower intake manifold gasket.

5. Install the lower intake manifold onto the engine block.

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

6. If reusing the fasteners, apply threadlock GM P/N 12345382 or equivalent to the threads of the lower intake manifold bolts.
7. Install the lower intake manifold bolts.



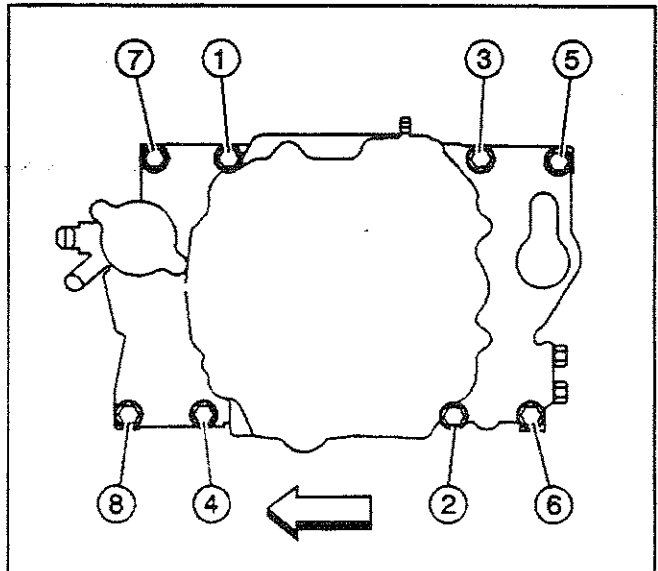
31510

Notice: SIO-ID = 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.

8. Tighten the lower intake manifold bolts.

Tighten

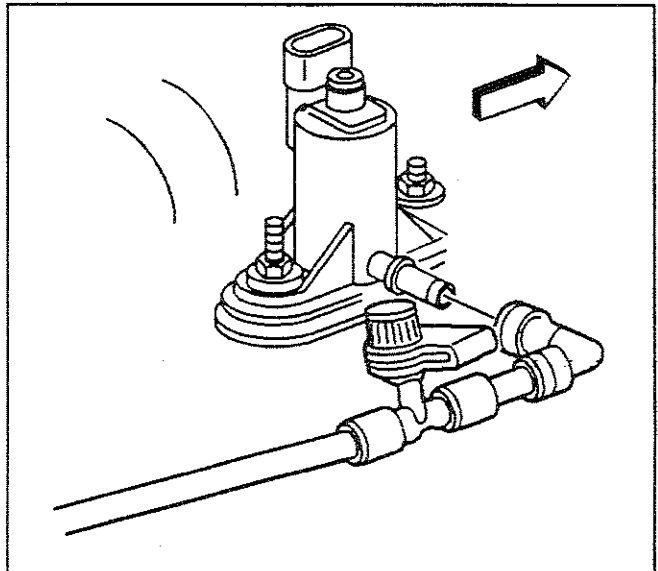
- 8.1. Tighten the bolts on the first pass in sequence (1–8) to 3 N·m (27 lb in).
- 8.2. Tighten the bolts on the second pass in sequence (1–8) to 12 N·m (106 lb in).
- 8.3. Tighten the bolts on the final pass in sequence (1–8) to 15 N·m (11 lb ft).



188150

9. Connect the evaporative emission (EVAP) canister solenoid valve harness.

- 9.1. Push the elbow inward until the quick connect snaps into place.
- 9.2. Pull the elbow outward in order to ensure proper connection.



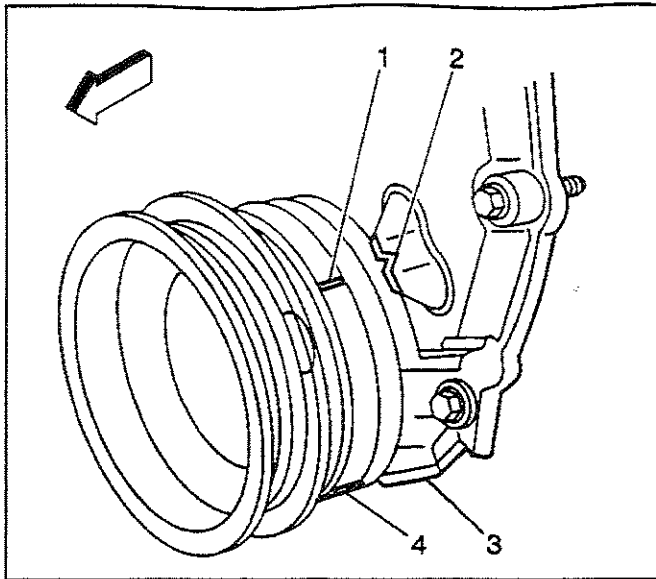
328579

Distributor Installation

SIE-ID = 358641

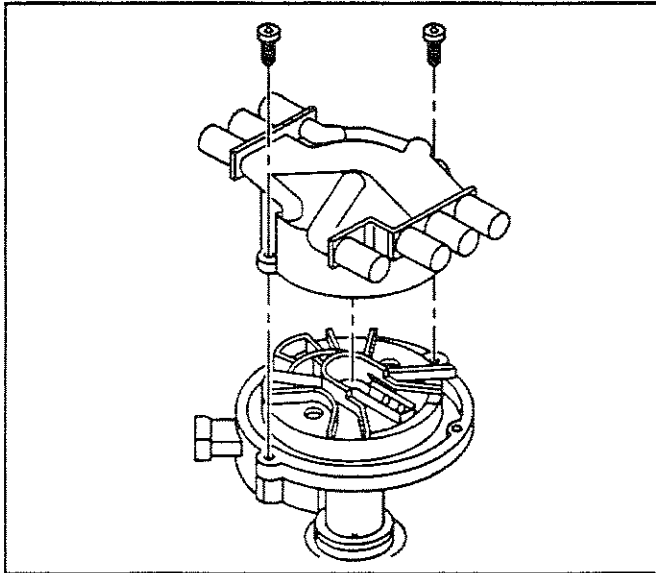
Important: The engine front cover has 2 alignment tabs and the crankshaft balancer has 2 alignment marks (spaced 90 degrees apart) which are used for positioning number 1 piston at top dead center (TDC). With the piston on the compression stroke and at top dead center, the crankshaft balancer alignment 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).

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.



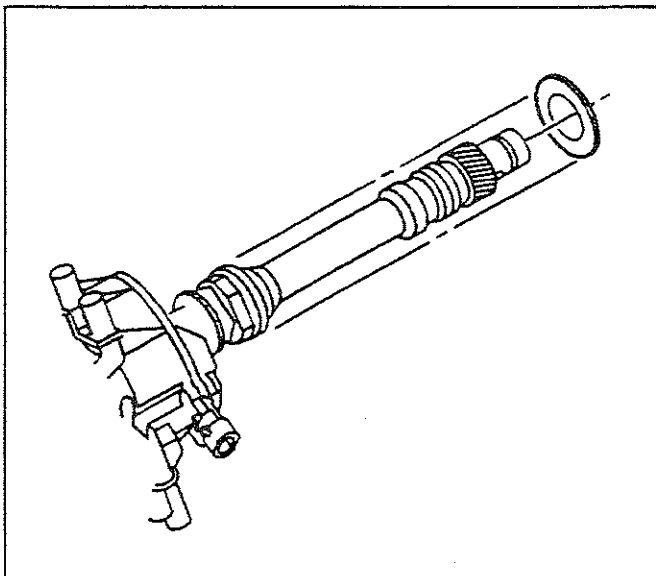
334551

1. Remove the distributor cap bolts and discard.
2. Remove the distributor cap.



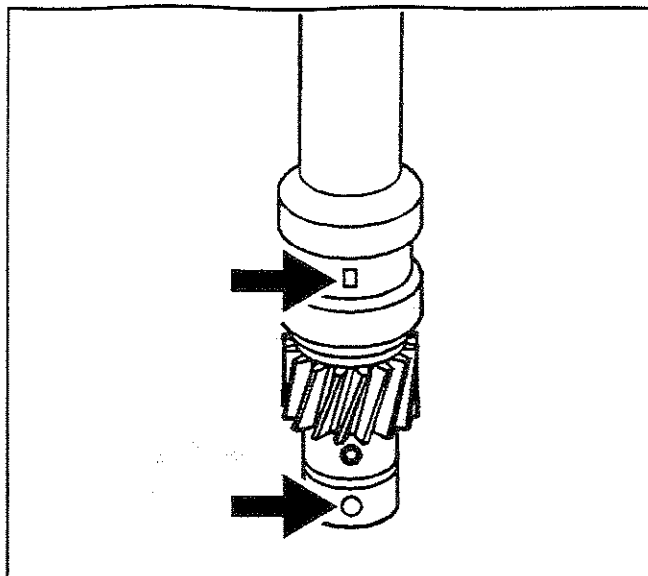
301393

3. Install a NEW distributor gasket onto the distributor.



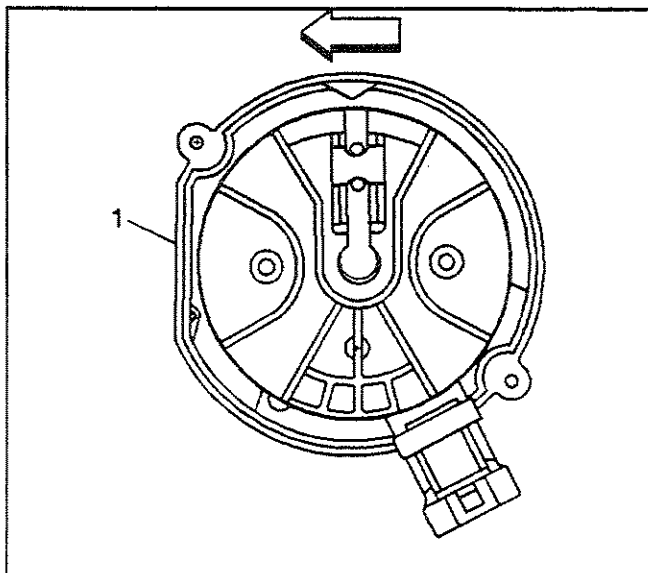
523516

4. Align the indent hole on the driven gear with the paint mark on the distributor housing.
5. Ensure that the distributor rotor segment points to the cap hold area.



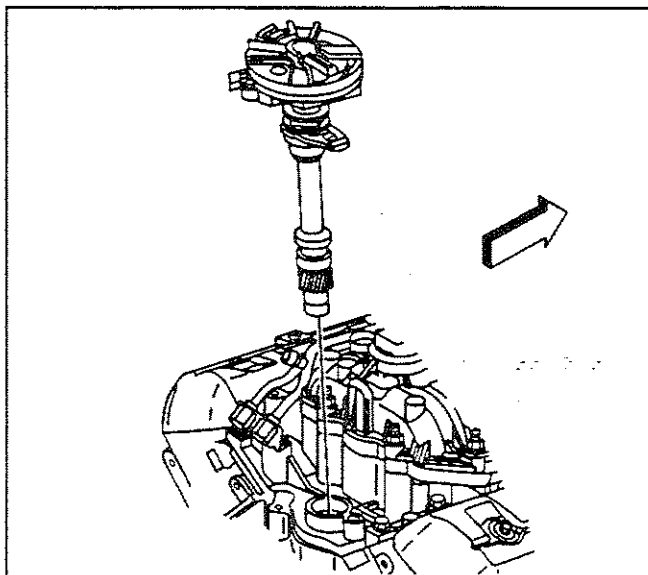
492137

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. Align the flat (1) in the distributor housing toward the front of the engine.

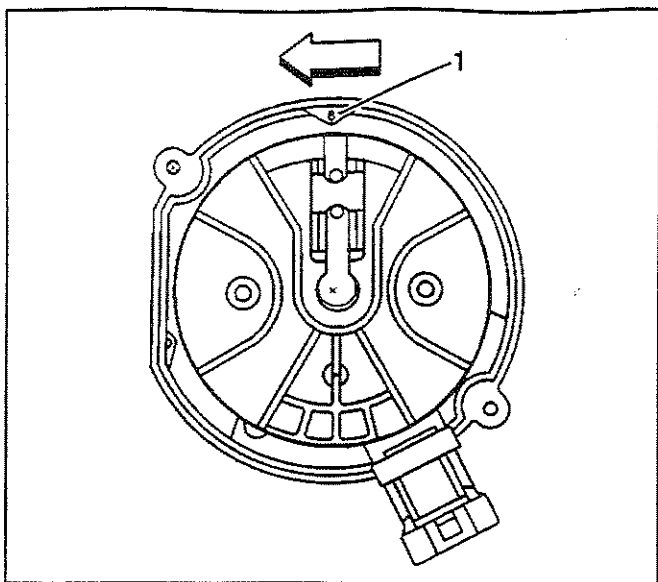


523746

8. Install the distributor and distributor clamp.
The flat in the distributor housing must point toward the front of the engine.



310298



334555

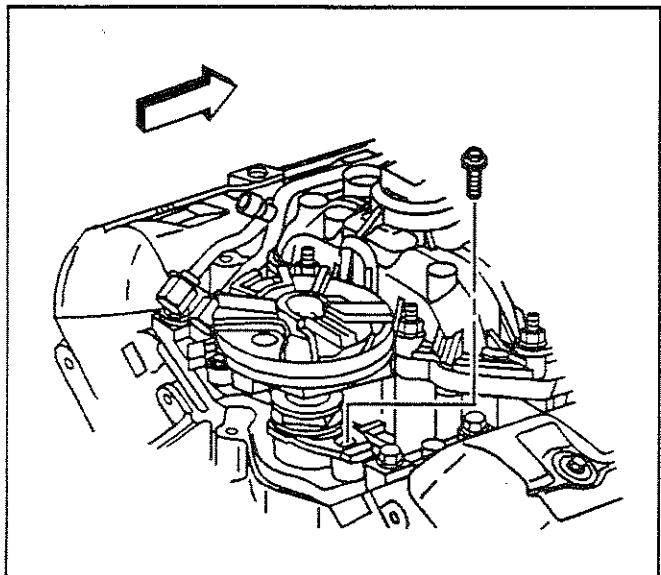
9. Once the distributor is fully seated, align the distributor rotor segment with the number 6 pointer (1) that is cast into the distributor base. If the distributor rotor segment does not come within a few degrees of the number 6 pointer (1), the gear mesh between the distributor and camshaft may be off a tooth or more. Repeat the procedure again in order to achieve proper alignment.

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

10. Install the distributor clamp bolt.

Tighten

Tighten the distributor clamp bolt to 25 N·m (18 lb ft).

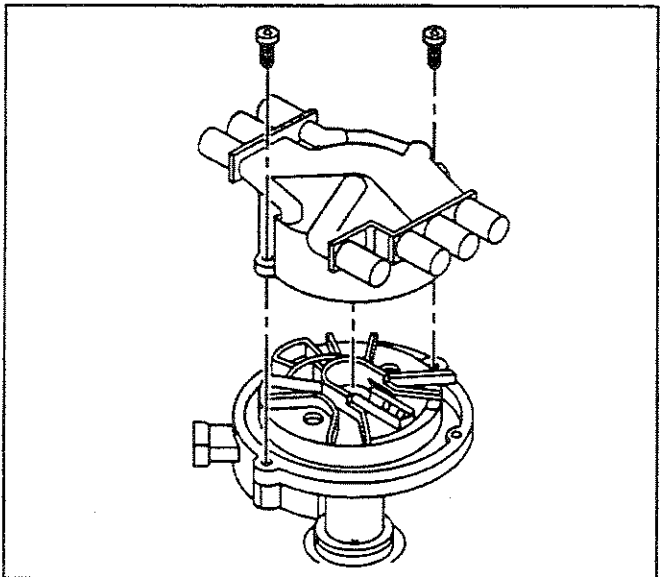


34403

11. Install the distributor cap and NEW distributor cap bolts.

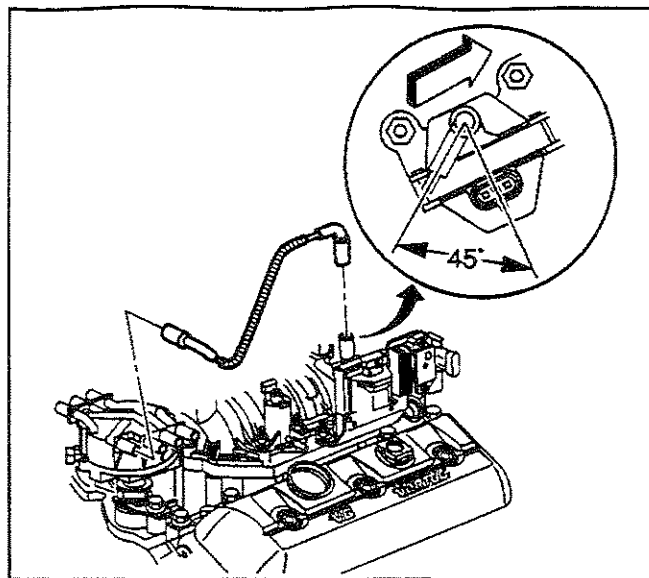
Tighten

Tighten the distributor cap bolts to 2.4 N·m (21 lb in).



301393

12. Install the ignition coil wire harness.



387772

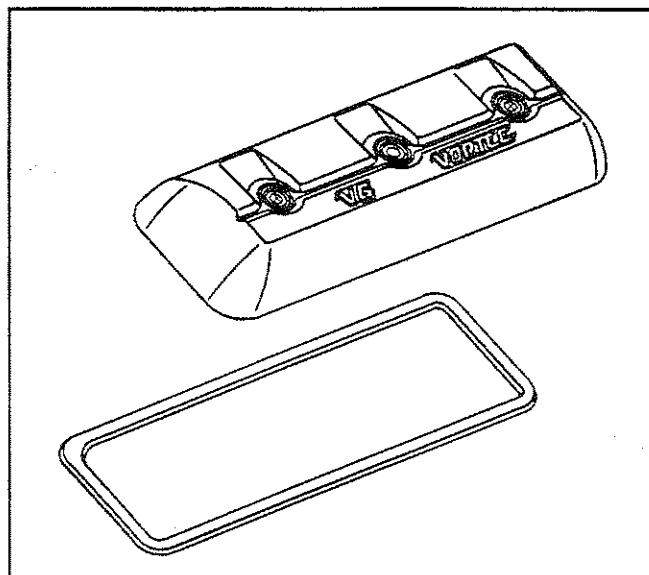
Valve Rocker Arm Cover Installation (Left)

SIE-ID = 507185

Important: Do not reuse the valve cover gasket or the valve rocker arm cover bolt grommets.

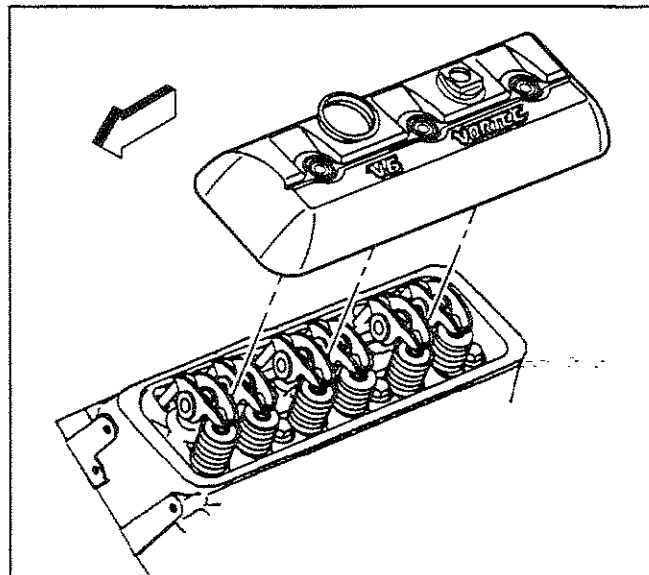
Install the NEW valve rocker arm cover gasket into the groove of the valve rocker arm cover.

1. Install the NEW valve rocker arm cover bolt grommets into the valve rocker arm cover.

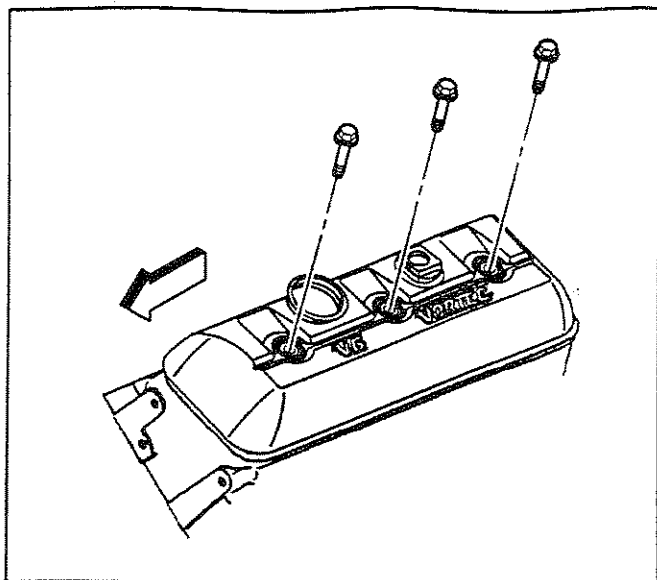


328573

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



480519



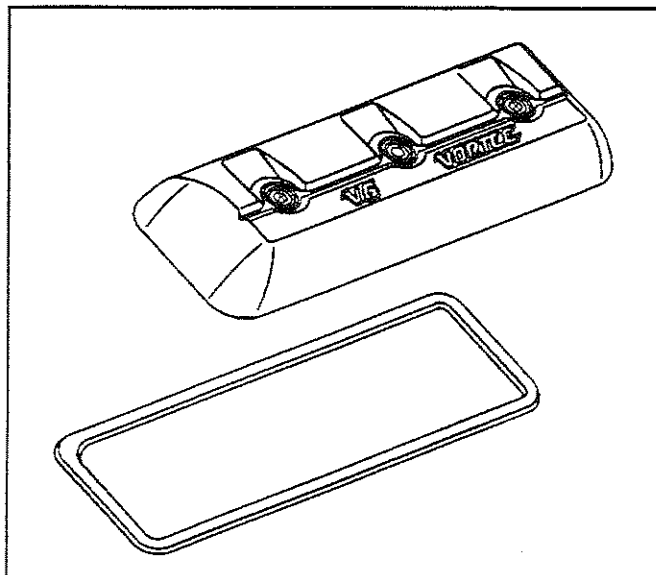
328566

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

3. Install the valve rocker arm cover bolts.

Tighten

Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in).



328573

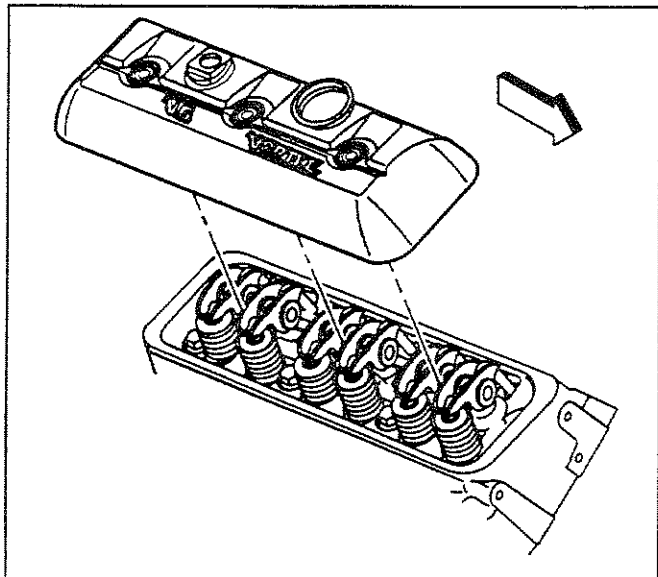
Valve Rocker Arm Cover Installation (Right)

SIE-ID # 507190

Important: Do not reuse the valve cover gasket or the valve rocker arm cover bolt grommets.

Install the NEW valve rocker arm cover gasket into the groove of the valve rocker arm cover.

1. Install the NEW valve rocker arm cover bolt grommets into the valve rocker arm cover.



480524

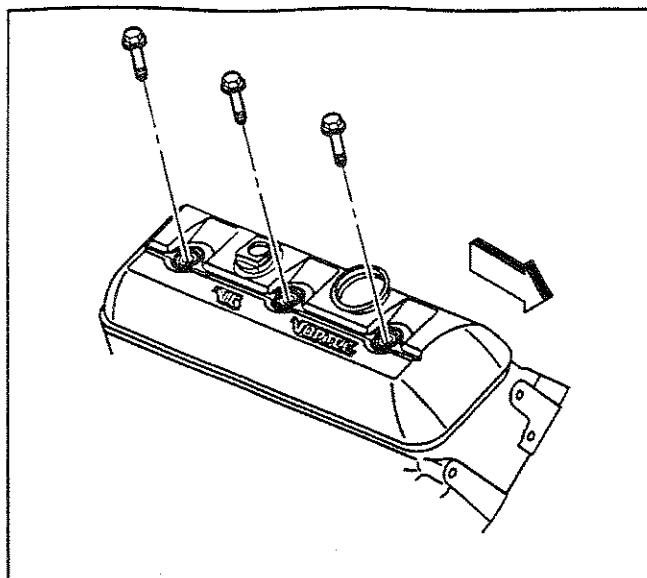
2. Install the valve rocker arm cover onto the cylinder head.

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

3. Install the valve rocker arm cover bolts.

Tighten

Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in).



328568

Oil Level Indicator and Tube Installation

SIE-ID = 358621

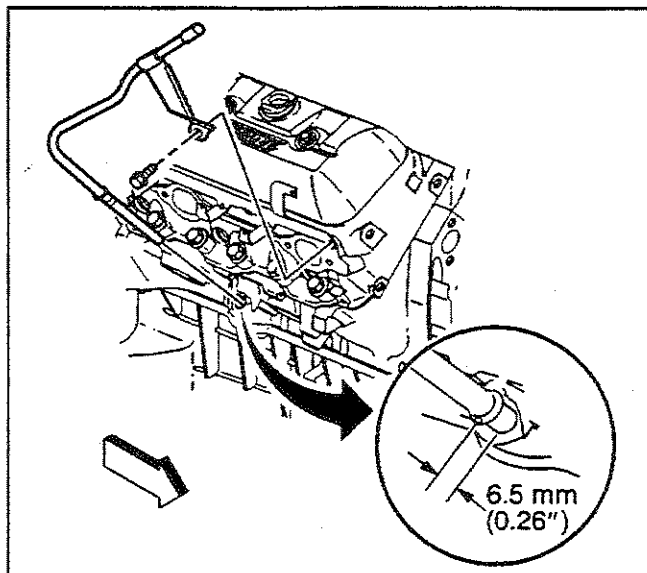
1. Apply sealant GM P/N 12346004 or equivalent around the oil level indicator tube 13 mm (0.5 in) below the tube bead.
2. Install the oil level indicator tube into the engine block. Rotate the oil level indicator tube into position.

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

3. Install the oil level indicator tube bolt.

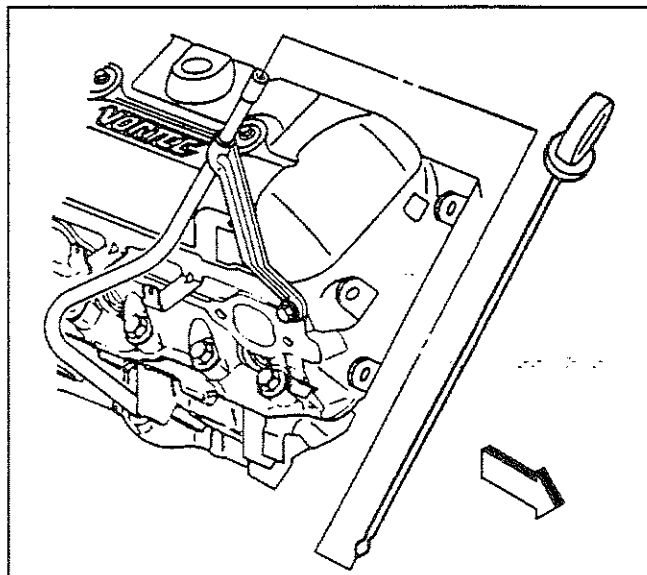
Tighten

Tighten the oil level indicator tube bolt to 12 N·m (106 lb in).



188009

4. Install the oil level indicator into the oil level indicator tube, if required.



330580

Water Pump Installation

SIE-ID - 358646

Tools Required

J 41240 Fan Clutch Remover and Installer

1. If reusing the fasteners, 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).

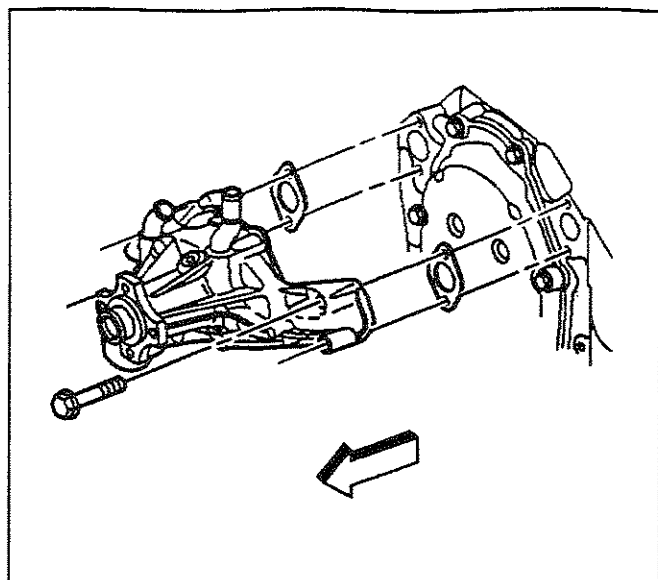
Important: After final assembly, the water pump inlet hose clamp tangs (water pump end) must point forward and the upper tang should be level with the outside diameter of the water pump inlet hose.

Install the water pump inlet hose and the water pump inlet hose clamps.

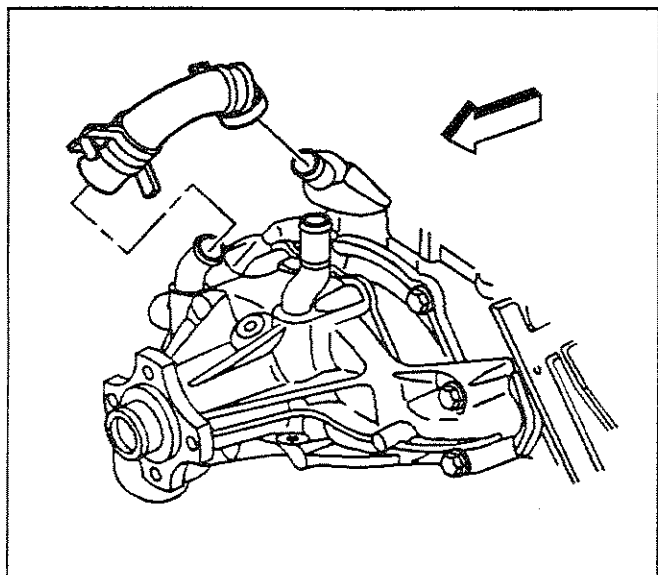
4. Install the fan and water pump pulley and bolts using the *J 41240*.

Tighten

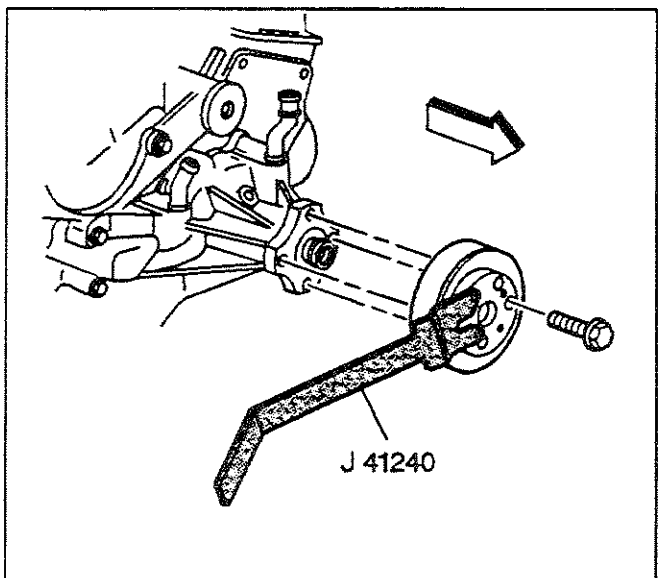
Tighten the fan and water pump pulley bolts to 25 N·m (18 lb ft).



188054



182853

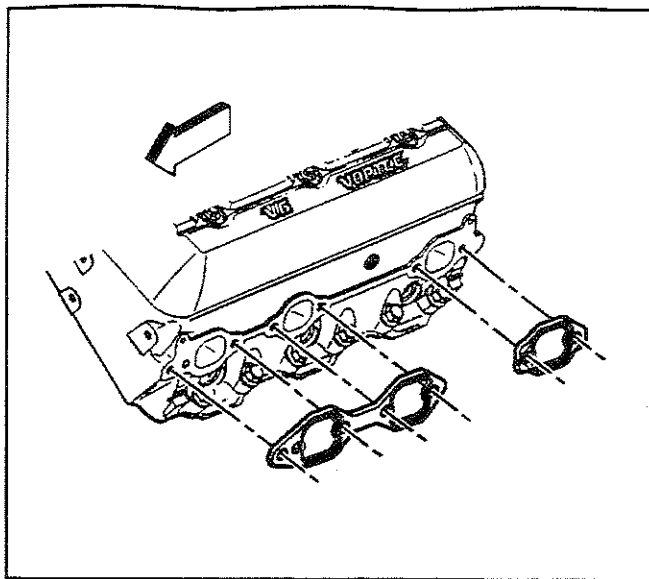


317191

Exhaust Manifold Installation (Left)

SIE-ID = 358655

1. Install the NEW exhaust manifold gaskets.



328540

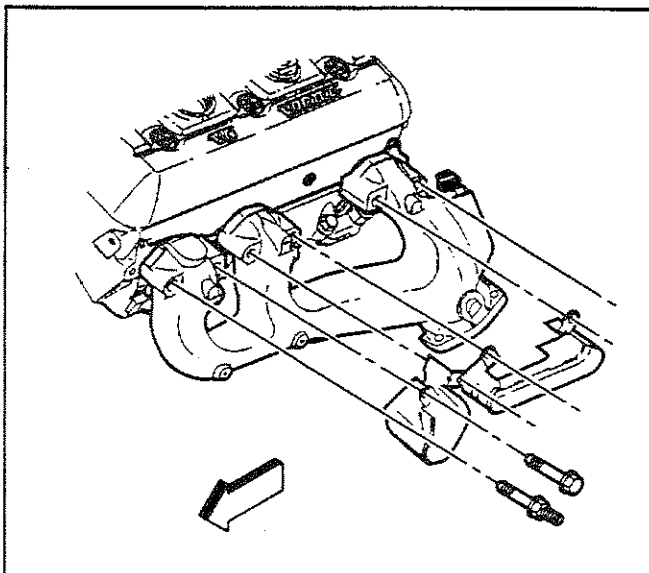
2. Install the exhaust manifold.
3. Install the spark plug wire shields.

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

4. If reusing the fasteners, apply threadlock GM P/N 12345493 or equivalent to the threads of the exhaust manifold bolts and stud.
5. Install the exhaust manifold bolts and stud.

Tighten

- 5.1. Tighten the exhaust manifold bolts and stud on the first pass to 15 N·m (11 lb ft).
- 5.2. Tighten the exhaust manifold bolts and stud on the final pass to 30 N·m (22 lb ft).
6. Install the spark plug wires to the spark plug wire retainers.
7. Install the spark plug wires onto the spark plugs.

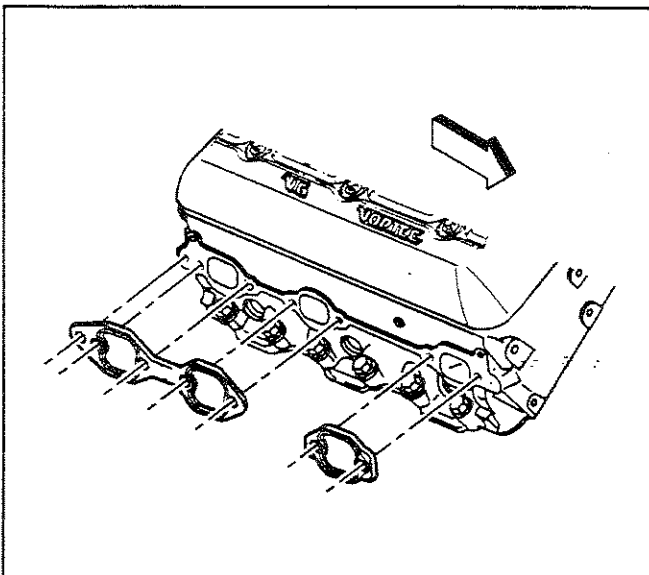


188045

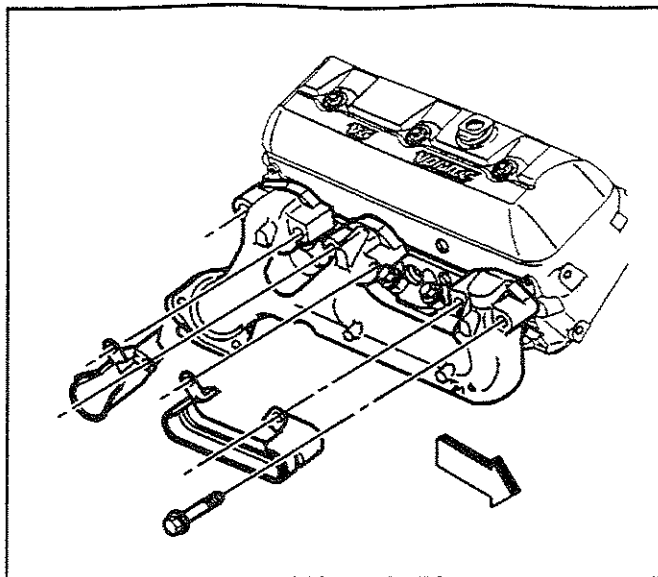
Exhaust Manifold Installation (Right)

SIE-ID = 358657

1. Install the NEW exhaust manifold gaskets.



328555



188121

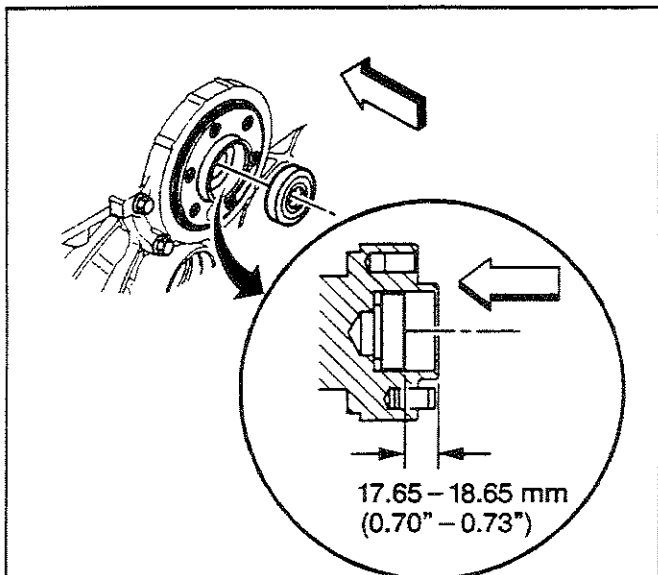
2. Install the exhaust manifold.
3. Install the spark plug wire shields.

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

4. If reusing the fasteners, apply threadlock GM P/N 12345493 or equivalent to the threads of the exhaust manifold bolts.
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 wires to the spark plug wire retainers.
7. Install the spark plug wires onto the spark plugs.



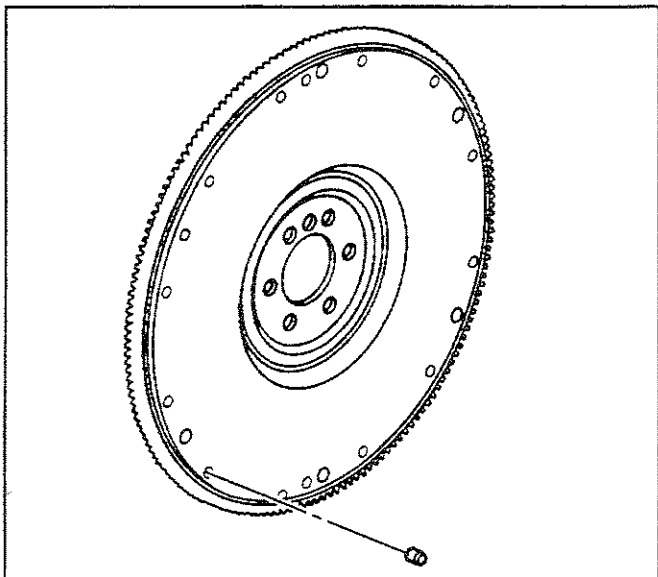
334385

Clutch Pilot Bearing Installation

SIE-ID - 358659

Caution: Refer to *Safety Glasses Caution* in Cautions and Notices.

1. Install the NEW clutch pilot bearing using a suitable clutch pilot bearing installation tool.
2. Measure to ensure the proper installation depth is obtained.



64126

Engine Flywheel Installation

SIE-ID - 43080

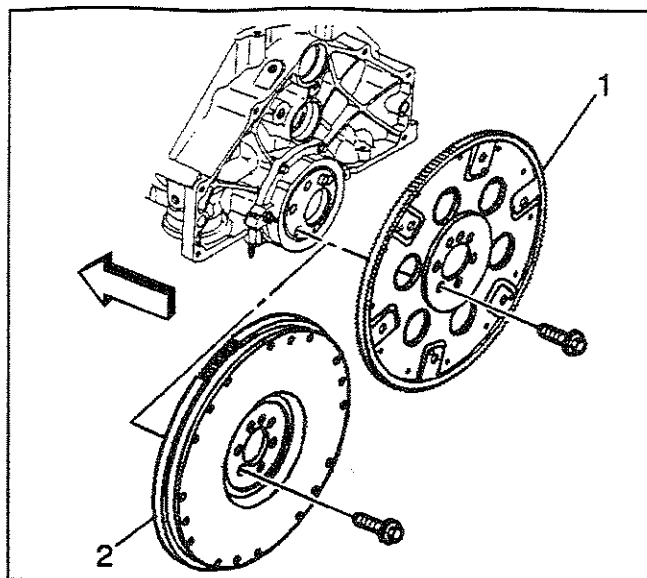
Important: If replacing the engine flywheel (manual transmission), note the position of the original flywheel weights (if applicable). Flywheel weights must be installed into the new engine flywheel in the same location as the old flywheel weights were in the old engine flywheel.

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.

1. Install the engine flywheel (1) or (2) to the crankshaft.

Align the engine flywheel locator hole to the flywheel locator pin.



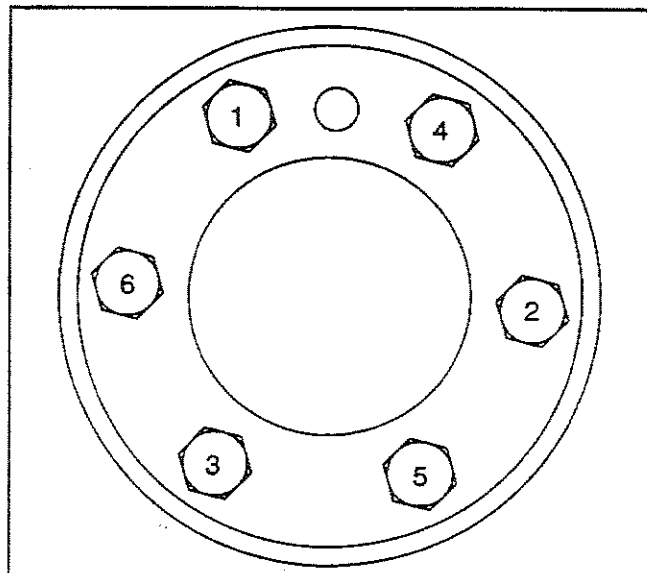
188129

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

2. Install the engine flywheel bolts.

Tighten

Tighten the engine flywheel bolts in sequence (1-6) to 100 N·m (74 lb ft).



63174

Engine Set-Up and Testing

SIE-ID = 223034

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 engine oil.
2. Add engine oil supplement GM P/N 1052367 or equivalent to the engine oil.

Notice: SIO-ID = 73446 DO NOT use cooling system seal tabs (or similar compounds) unless otherwise instructed. The use of cooling system seal tabs (or similar compounds) may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.

3. Fill the cooling system with the proper quantity and grade of coolant.
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. Operate the engine at about 1,000 RPM until the engine has reached normal operating temperature.
8. Listen for improperly adjusted or sticking valves, sticking valve lifters, or other unusual noises.
9. Inspect for oil and/or coolant leaks while the engine is operating.
10. Verify that the distributor is properly positioned.
11. Perform a final inspection for the proper engine oil and coolant levels.

Description and Operation

Engine Component Description

SIE-ID = 507196

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 crankshaft bearing at the rear of the engine is the end thrust bearing. The crankshaft bearings are retained by bearing caps that are machined with the engine block for proper alignment and clearances. The crankshaft position sensor reluctor ring has three lugs used for crankshaft timing and is constructed of powdered metal. The crankshaft position sensor 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 4.3L heavy duty applications have pressed in exhaust valve seats. The valve rocker arms are positioned on the valve rocker arm supports and retained by a bolt.

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 fuel 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. The piston pins 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

Motion is transmitted from the camshaft through the hydraulic roller valve lifters and the tubular valve pushrods to the roller type valve rocker arms. The roller type valve rocker arm pivots on a needle type bearing in order to open the valve. The valve rocker arms for each bank of cylinders are mounted to a one piece valve rocker arm support. Each valve rocker arm is retained on the valve rocker arm support and the cylinder head by a bolt. The hydraulic valve lifters keep all the parts of the valve train in constant contact. Each hydraulic valve lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment.

Drive Belt System Description

SIE-ID = 558948

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
 - The power steering pump, if belt driven
 - The generator
 - The A/C compressor, if equipped
 - The engine cooling fan, if belt driven

- The water pump, if belt driven
- The vacuum pump, if equipped
- The air compressor, if equipped

The drive belt system may use one belt or two belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers (chloroprene or EPDM) and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

New Product Information

SIE-ID - 571053

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

- Eliminated the oil filter adapter assembly
- Revised the water pump seal
- Revised the engine coolant thermostat
- New roller type timing chain and sprockets
- New roller pivot type valve rocker arm assemblies using a one piece valve rocker arm support to replace the ball pivot type valve rocker arm system
- Cylinder heads revised using dry holes for the valve rocker arm bolts

Torque Values and/or Fastener Tightening Strategies

- Cylinder head bolts, the crankshaft bearing cap bolts, the connecting rod bolts, and balance shaft bolt 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 1999 products.

New Sealants and/or Adhesives

No new sealants or adhesive have been added.

Disassembly and Assembly Procedure Revisions

- Valve rocker arm and pushrod
- Timing chain and sprockets
- 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.

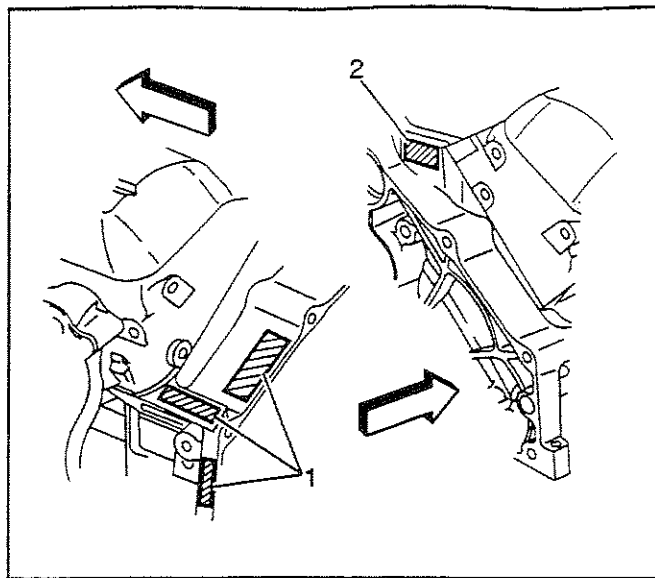
Potential or probable causes are supplied for each specific concern.

New Special Tools Required

No new special tools are required.

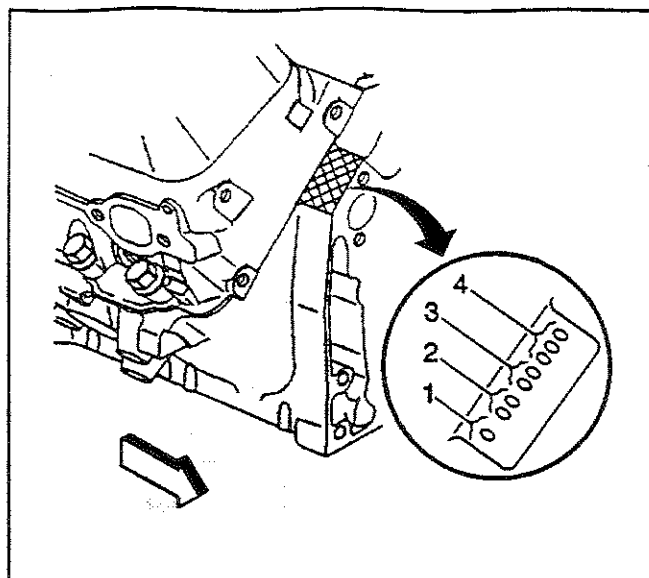
Engine Identification

SIE-ID - 199882



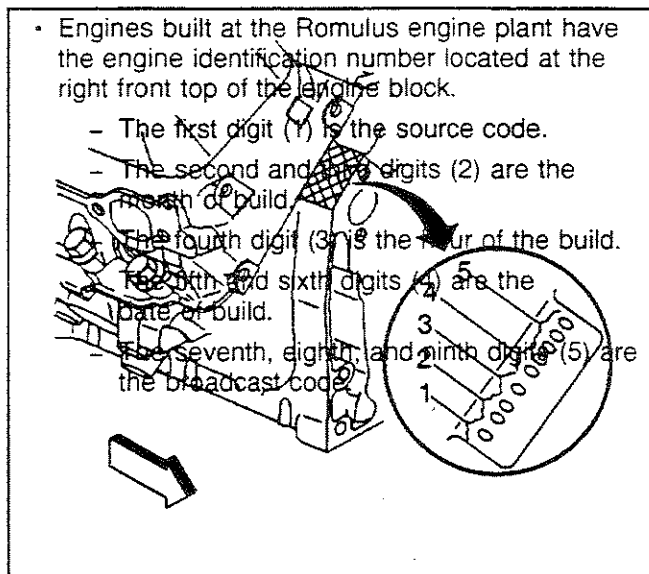
569359

- 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.



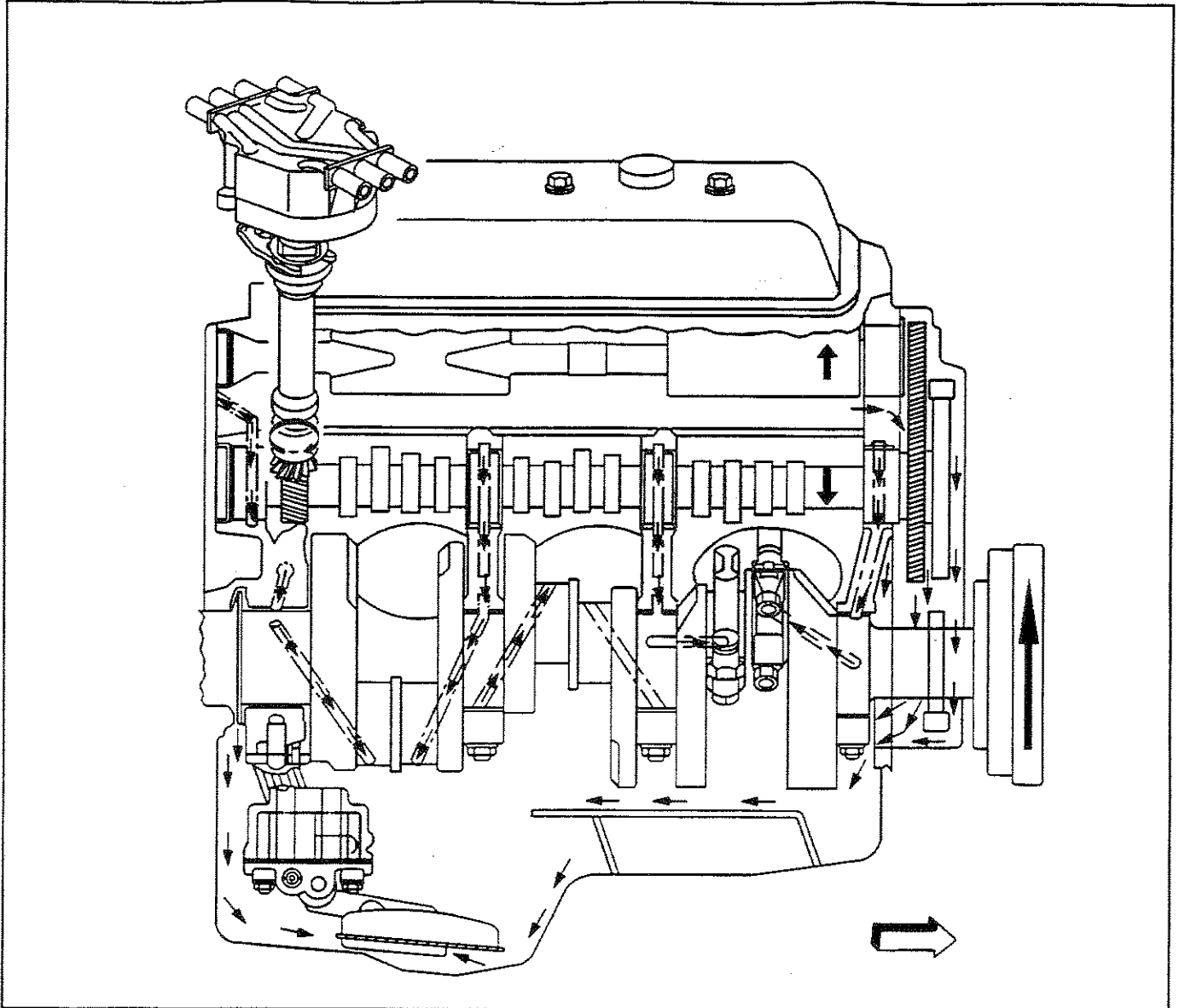
195339

- 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 date 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.

Lubrication

SIE-ID = 43423

Engine Lubrication SIO-ID = 41430



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.

Cleanliness and Care

SIE-ID = 19007

- 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.

Replacing Engine Gaskets

SIE-ID - 66654

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.

Use of RTV and Anaerobic Sealer

SIE-ID - 411537

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.

Separating Parts

SIE-ID - 507212

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, valve rocker arms, and valve rocker arm supports
- Valve to the valve guide
- Valve spring to cylinder head location

- Engine block bearing cap location and direction
- Oil pump drive and driven gears

Tools and Equipment

SIE-ID = 507215

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. The tools (or the equivalents) are specially designed to quickly and safely accomplish the operations for which the tools are intended. The use of 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

SIE-ID - 356712

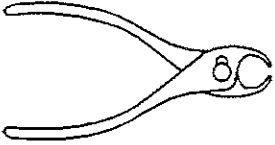
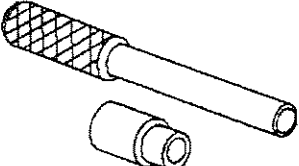
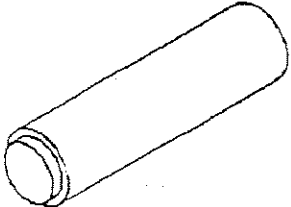
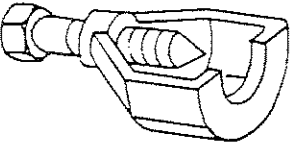
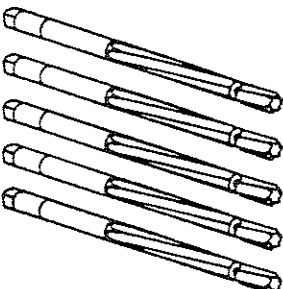
Illustration	Tool Number/ Description
 14487	J 3049-A Valve Lifter Remover
 3404	J 5239 Connecting Rod Bolt Guide Set
 3407	J 5590 Installer
 3406	J 5825-A Crankshaft Gear Remover
 4999	J 5830-02 Valve Guide Reamer Set

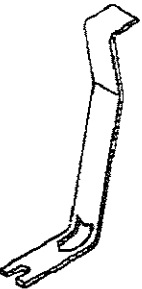
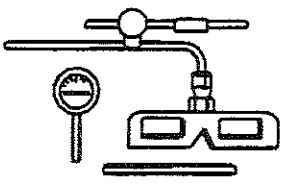
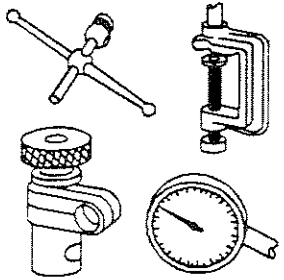
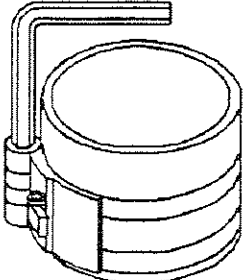
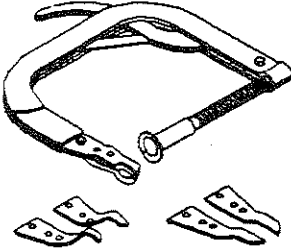
Illustration	Tool Number/ Description
 3399	J 5892-D Valve Spring Compressor
 35463	J 7872 Magnetic Base Dial Indicator
 2014	J 8001 Dial Indicator Set
 3403	J 8037 Ring Compressor
 3414	J 8062 Valve Spring Compressor

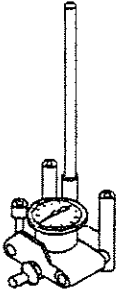
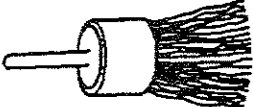
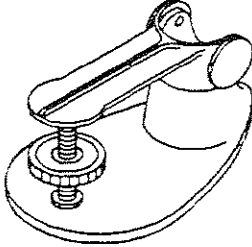
Illustration	Tool Number/ Description
 5110	J 8087 Cylinder Bore Gauge
 35464	J 8089 Carbon Removing Brush
 2015	J 8092 Universal Driver Handle
 5112	J 9666 Valve Spring Tester
 3416	J 21882 Oil Suction Pipe Installer

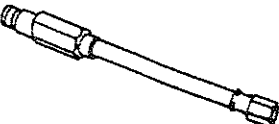
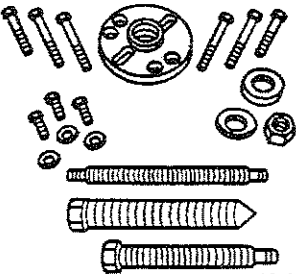
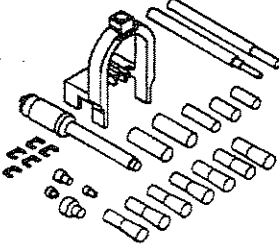
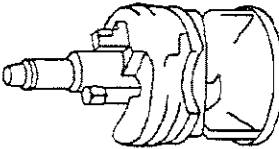
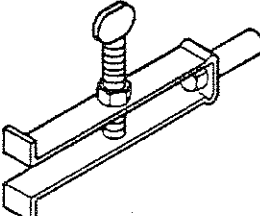
Illustration	Tool Number/ Description
 26998	J 22794 Spark Plug Port Adapter
 66168	J 23523-F Balancer Remover and Installer
 14495	J 24086-C Piston Pin Remover/Installer
 3412	J 24270 Cylinder Bore Ridge Reamer
 4862	J 26941 Bushing/Bearing Remover

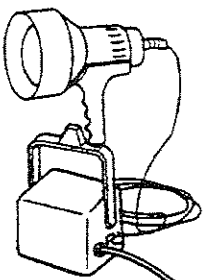
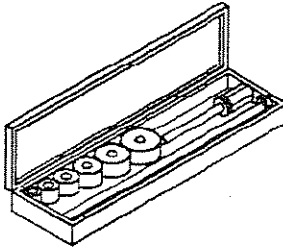
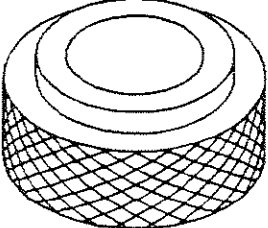
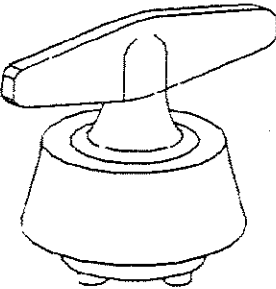
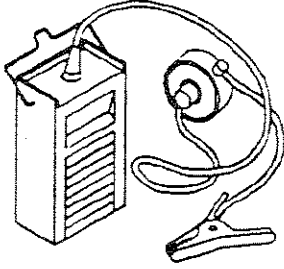
Illustration	Tool Number/ Description
 62292	J 28428-E High Intensity Black Light Kit
 5118	J 33049 Camshaft Bearing Service Kit
 3401	J 35468 Cover Aligner/Seal Installer
 350498	J 35621-B Rear Main Seal Installer
 3413	J 36660 Electronic Torque Angle Meter

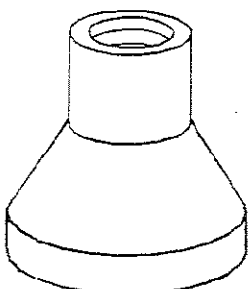
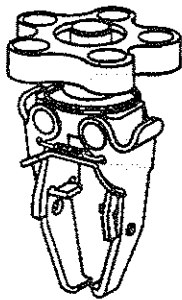
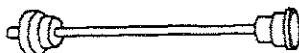
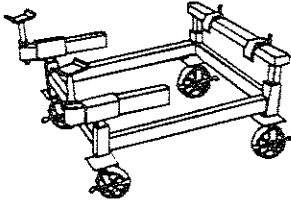
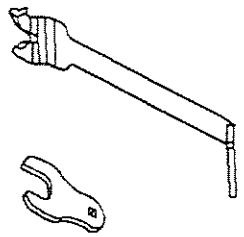
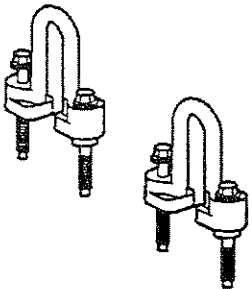
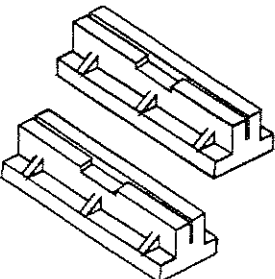
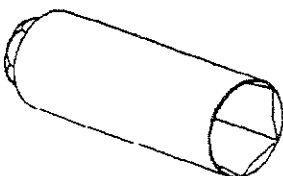
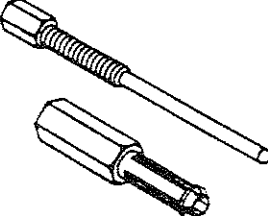
Illustration	Tool Number/ Description
 3411	J 36996 Balance Shaft Installer
 33658	J 38606 Valve Spring Compressor
 3410	J 38834 Balance Shaft Service Kit
 52122	J 39580 Engine Support Table
 48304	J 41240 Fan Clutch Remover and Installer

Illustration	Tool Number/ Description
 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
 355040	J 43276 Clutch Pilot Bearing Remover

