Manual Part No. 0E7085

GENERAC®
POWER SYSTEMS, INC.

8.1 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.

The 8.1 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.

◆ 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 .....7.6 L (8.0 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 .....20 L (5.3 U.S. gals.)
Engine .....8 L (2.1 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:

SERVICE 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 100 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)

- Check engine valve clearance.
- Test fuel injection nozzles.
- Test injection timing.
- Inspect all wiring.
- Test engine starter operation.
- Drain water from fuel tank.
- Retorque fan bolts.
- Drain and refill gearbox (if so equipped)

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

- Inspect engine DC alternator.
- Inspect engine starter.
- Retorque engine mounting brackets.
- Remove/test fuel injection pump.
- Remove/test cooling system thermostat.

As Required

- Bleed engine fuel system.

Notes

Engine Mechanical - 8.1L

Specifications

SIE-ID = 482216

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Camshaft Position Sensor Bolt	12 N·m	106 lb in
Camshaft Retainer Bolt	12 N·m	106 lb in
Camshaft Sprocket Bolt	30 N·m	22 lb ft
Connecting Rod Nut	30 N·m +90 Degrees	22 lb ft +90 Degrees
Coolant Drain Hole Plug		
Left Front	60 N·m	44 lb ft
Sides	30 N·m	22 lb ft
Crankshaft Balancer Bolt	255 N·m	189 lb ft
Crankshaft Bearing Cap Inner Bolts		
First Pass	30 N·m	22 lb ft
Final Pass	90 Degrees	
Crankshaft Bearing Cap Outer Studs		
First Pass	30 N·m	22 lb ft
Final Pass	80 Degrees	
Crankshaft Oil Deflector Nut	50 N·m	37 lb ft
Crankshaft Position Sensor Bolt	12 N·m	106 lb in
Cylinder Head Bolt (In Sequence)		
First Pass	30 N·m	22 lb ft
Second Pass	30 N·m+120 Degrees	22 lb ft +120 Degrees
Final Pass - Long Bolts #1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17	60 Degrees	
Final Pass - Medium Bolts #15, 18	45 Degrees	
Final Pass - Short Bolts #4, 5, 12, 13	30 Degrees	
Cylinder Head Coolant Hole Plug	23 N·m	17 lb ft
Drive Belt Tensioner Bolt	50 N·m	37 lb ft
EGR Adapter Nut	22 N·m	16 lb ft
EGR Valve Nut	22 N·m	16 lb ft
EGR Valve Pipe Bolt	30 N·m	22 lb ft
EGR Valve Pipe Bracket Bolt	50 N·m	37 lb ft
EGR Valve Pipe Nut	30 N·m	22 lb ft
EGR Valve Pipe Stud in Exhaust Manifold	12 N·m	106 lb in
Engine Block Heater	50 N·m	37 lb ft
Engine Coolant Temperature (ECT) Sensor	20 N·m	15 lb ft
Engine Coolant Temperature (ECT) Sensor Bracket Bolt	50 N·m	37 lb ft
Exhaust Manifold		
Center Bolt	35 N·m	26 lb ft
Nut	16 N·m	12 lb ft
Stud	20 N·m	15 lb ft
Exhaust Manifold Heat Shield		
Bolt	25 N·m	19 lb ft
Nut	25 N·m	19 lb ft
Flywheel Bolt		
First Pass	40 N·m	30 lb ft

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Second Pass	80 N·m	59 lb ft
Final Pass	100 N·m	74 lb ft
Flywheel Cover Bolt	12 N·m	106 lb in
Flywheel Housing		
Hex Head Bolt	67 N·m	50 lb ft
Countersunk Bolt	60 N·m	44 lb ft
Front Cover Bolt		
First Pass	6 N·m	54 lb in
Final Pass	12 N·m	106 lb in
Fuel Rail Stud	12 N·m	106 lb in
Ignition Coil Bolt	12 N·m	106 lb in
Ignition Coil Wiring Harness Bolt	12 N·m	106 lb in
Intake Manifold Bolt (In Sequence)		
First Pass	5 N·m	44 lb in
Second Pass	5 N·m	44 lb in
Third Pass	10 N·m	89 lb in
Final Pass	12 N·m	106 lb in
Knock Sensor	20 N·m	15 lb ft
Knock Sensor Heat Shield Bolt - C/K/G/C3500HD	12 N·m	106 lb in
Knock Sensor Heat Shield Bolt - Medium Duty	50 N·m	37 lb ft
MAP Sensor Bolt	12 N·m	106 lb in
Oil Cooler Hose Fittings	23 N·m	17 lb ft
Oil Fill Tube Bolt	12 N·m	106 lb in
Oil Filter	38 N·m	28 lb ft
Oil Filter Fitting	66 N·m	49 lb ft
Oil Gallery Plug		
Front	30 N·m	22 lb ft
Left	30 N·m	22 lb ft
Rear	30 N·m	22 lb ft
Top	20 N·m	15 lb ft
Oil Level Indicator Tube Bracket Nut	18 N·m	13 lb ft
Oil Level Switch	20 N·m	15 lb ft
Oil Pan Bolt		
First Pass	10 N·m	89 lb in
Final Pass	25 N·m	19 lb ft
Oil Pan Drain Plug	28 N·m	21 lb ft
Oil Pressure Gauge Sensor	30 N·m	22 lb ft
Oil Pump Bolt	75 N·m	56 lb ft
Oil Pump Cover Bolt	12 N·m	106 lb in
Oil Pump Drive Bolt	25 N·m	19 lb ft
Purge Solenoid Bolt	10 N·m	88 lb in
Spark Plug	20 N·m	15 lb ft
Thermostat Housing Bolt	30 N·m	22 lb ft
Throttle Body		
Nut	10 N·m	88 lb in
Stud	12 N·m	106 lb in
Transmission Converter Cover Bolts	12 N·m	106 lb in

Fastener Tightening Specifications (cont'd)

Application	Specification	
	Metric	English
Valve Lifter Guide Retainer Bolt	25 N·m	19 lb ft
Valve Rocker Arm Cover Bolt		
First Pass	6 N·m	53 lb in
Final Pass	12 N·m	106 lb in
Valve Rocker Arm Nut	25 N·m	19 lb ft
Valve Rocker Arm Stud	50 N·m	37 lb ft
Water Crossover Pipe Bolt	50 N·m	37 lb ft
Water Pump Bolt		
First Pass	25 N·m	18 lb ft
Final Pass	50 N·m	37 lb ft
Water Pump Pulley Bolt	25 N·m	19 lb ft

SIE-ID = 482257

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
Engine Type	V-8	
Displacement	8.1 L	496 CID
RPO	L18	
VIN C/K/G/C3500HD	G	
VIN Medium Duty	E	
Bore	107.950 mm	4.250 in
Stroke	111.00 mm	4.370 in
Compression Ratio	9.1:1	
Firing Order	1-8-7-2-6-5-4-3	
Spark Plug Gap	1.52 mm	0.060 in
Cylinder Head		
Surface Flatness	0.050 mm	0.002 in
Maximum Cylinder Head Block Deck Resurfacing	0.3048 mm	0.012 in
Exhaust Manifold		
Surface Flatness	0.254 mm	0.010 in
Lubrication System		
Oil Capacity without Filter Change	5.7 L	6 Qts
Oil Pressure (Minimum)	34 kPa @ 1,000 RPM	5 psi @ 1,000 RPM
Oil Pressure (Minimum)	69 kPa @ 2,000 RPM	10 psi @ 2,000 RPM
Oil Filter System	Full Flow	
Oil Pump Type	Gear Driven	
Cylinder Bore		
Diameter - Production	107.950–107.968 mm	4.2500–4.2507 in
Diameter - Service	107.940–107.990 mm	4.2496–4.2516 in
Out-of-Round Production (Maximum Minus Minimum Bore Diameter)	0.0180 mm (max.)	0.0007 in (max.)
Out-of-Round Service (Maximum Minus Minimum Bore Diameter)	0.050 mm (max.)	0.002 in (max.)
Taper Production	0.0180 mm (max.)	0.0007 in (max.)

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Taper Service - Thrust Axis	0.050 mm (max.)	0.002 in (max.)
Taper Service - Pin Axis	0.050 mm (max.)	0.002 in (max.)
Engine Block (Production Specifications)		
Main Bearing Bore Diameter	74.6060–74.6220 mm	2.9372–2.9379 in
Lifter Bore Diameter	21.417–21.443 mm	0.843–0.844 in
Deck Height from Crankshaft Bore	259.875–260.125 mm	10.231–10.241 in
Head Deck Surface Flatness (entire face)	0.100 mm	0.004 in
Head Deck Surface Flatness within 150 mm (6 in)	0.050 mm	0.002 in
Piston		
Piston Diameter (Coated Piston)	Not Measurable	Not Measurable
Clearance Production	Interference Fit (coated piston)	Interference Fit (coated piston)
Piston Ring Compression		
Top Groove Clearance	0.031–0.074 mm	0.0012–0.0029 in
Second Groove Clearance	0.031–0.074 mm	0.0012–0.0029 in
Top Ring Production Gap	0.300–0.450 mm	0.012–0.018 in
Top Ring Service Limit Gap	0.450–0.675 mm	0.018–0.027 in
Second Ring Production Gap	0.450–0.650 mm	0.017–0.025 in
Second Ring Service Limit Gap	0.675–0.975 mm	0.026–0.039 in
Piston Ring Oil Control		
Ring Groove Clearance	0.051–0.203 mm	0.002–0.008 in
Production Gap	0.249–0.759 mm	0.0098–0.0299 in
Service Limit Gap	0.373–1.138 mm	0.015–0.045 in
Piston Pin		
Diameter	26.416–26.419 mm	1.0400–1.0401 in
Fit in Connecting Rod	0.049–0.020 mm Interference	0.00019–0.0007 in Interference
Crankshaft		
Crankshaft Main Journal Runout - Production	0.0380 mm (max.)	0.0015 in (max.)
Crankshaft Main Journal Runout - Service	0.0510 mm (max.)	0.0020 in (max.)
Crankshaft Journal Diameter #1, #2, #3, #4, #5	69.805–69.822 mm	2.7482–2.7489 in
Crankshaft Journal Taper Production	0.0102 mm (max.)	0.0004 in
Crankshaft Journal Out-of-Round Production	0.0102 mm (max.)	0.0004 in
Crankshaft Bearing Clearance #1, #2, #3, #4 Production	0.022–0.052 mm	0.0008–0.0020 in
Crankshaft Bearing Clearance #5 Production	0.035–0.067 mm	0.0014–0.0026 in
Crankshaft Bearing Clearance #1, #2, #3, #4 Service Limit	0.022–0.089 mm	0.0008–0.0035 in
Crankshaft Bearing Clearance #5 Service Limit	0.035–0.102 mm	0.0014–0.0040 in
Crankshaft End Play	0.127–0.279 mm	0.0050–0.0110 in
Crankpin Diameter	55.854–55.870 mm	2.1990–2.1996 in
Crankpin Taper Production	0.0102 mm (max.)	0.0004 in

Engine Mechanical Specifications (cont'd)

Application	Specification	
	Metric	English
Crankpin Out-of-Round Production	0.0102 mm (max.)	0.0004 in
Rod Bearing Clearance Production	0.021–0.064 mm	0.0008–0.0025 in
Rod Bearing Clearance Service Limit	0.021–0.081 mm	0.0008–0.0032 in
Connecting Rod Side Clearance	0.384–0.686 mm	0.0151-0.0270 in
Camshaft		
Camshaft Runout - Production	0.051 mm (Maximum)	0.002 in (Maximum)
Camshaft Runout - Service	0.076 mm	0.003 in
Lobe Lift Intake	6.924–7.026 mm	0.2726–0.2766 in
Lobe Lift Exhaust	6.973–7.075 mm	0.2745–0.2785 in
Journal Diameter	49.4720–49.5220 mm	1.9477–1.9497 in
Camshaft Bearing Inside Diameter	49.5480–49.5730 mm	1.9507–1.9517 in
Valve System		
Lifter	Hydraulic, Roller Followers	
Rocker Arm Ratio	1.70:1	
Valve Lash Intake	Net Lash	
Valve Lash Exhaust	Net Lash	
Face Angle (Intake/Exhaust)	45 degrees	
Seat Angle (Intake/Exhaust)	46 degrees	
Seat Runout (Intake/Exhaust)	0.0500 mm (Maximum)	0.002 in (Maximum)
Seat Width Intake	0.800–1.200 mm	0.030–0.060 in
Seat Width Exhaust	1.651–2.159 mm	0.060–0.095 in
Stem Clearance Production Intake	0.025–0.074 mm	0.0010–0.0029 in
Stem Clearance Production Exhaust	0.030–0.079 mm	0.0012–0.0031 in
Stem Clearance Service Intake	0.025–0.088 mm	0.0010–0.0034 in
Stem Clearance Service Exhaust	0.030–0.091 mm	0.0012–0.0036 in
Valve Spring Pressure Closed	381–419 N @ 45.923 mm	86–94 lb @ 1.808 in
Valve Spring Pressure Open	962–1058 N @ 33.985 mm	216–236 lb @ 1.338 in
Valve Spring Installed Height	45.923–46.685 mm	1.808–1.838 in
Valve Spring Free Length	56.35 mm	2.218 in
Valve Head Diameter - Intake	55.63 mm	2.19 in
Valve Head Diameter - Exhaust	43.69 mm	1.72 in
Valve Stem Diameter - Intake	9.436–9.454 mm	0.3715–0.3722 in
Valve Stem Diameter - Exhaust	9.431–9.449 mm	0.3713–0.3720 in
Maximum Valve Spring Installed Height Shim (Service Only)	0.726 mm	0.030 in
Maximum Valve Spring Tension Shim (Service Only)	0.726 mm	0.030 in
Maximum Combined Valve Spring Installed Height and Valve Spring Tension Shim (Service Only - Shim Placed Under Valve Rotator Only)	1.524 mm	0.060 in

SIE-ID = 482287

Sealers, Adhesives, and Lubricants

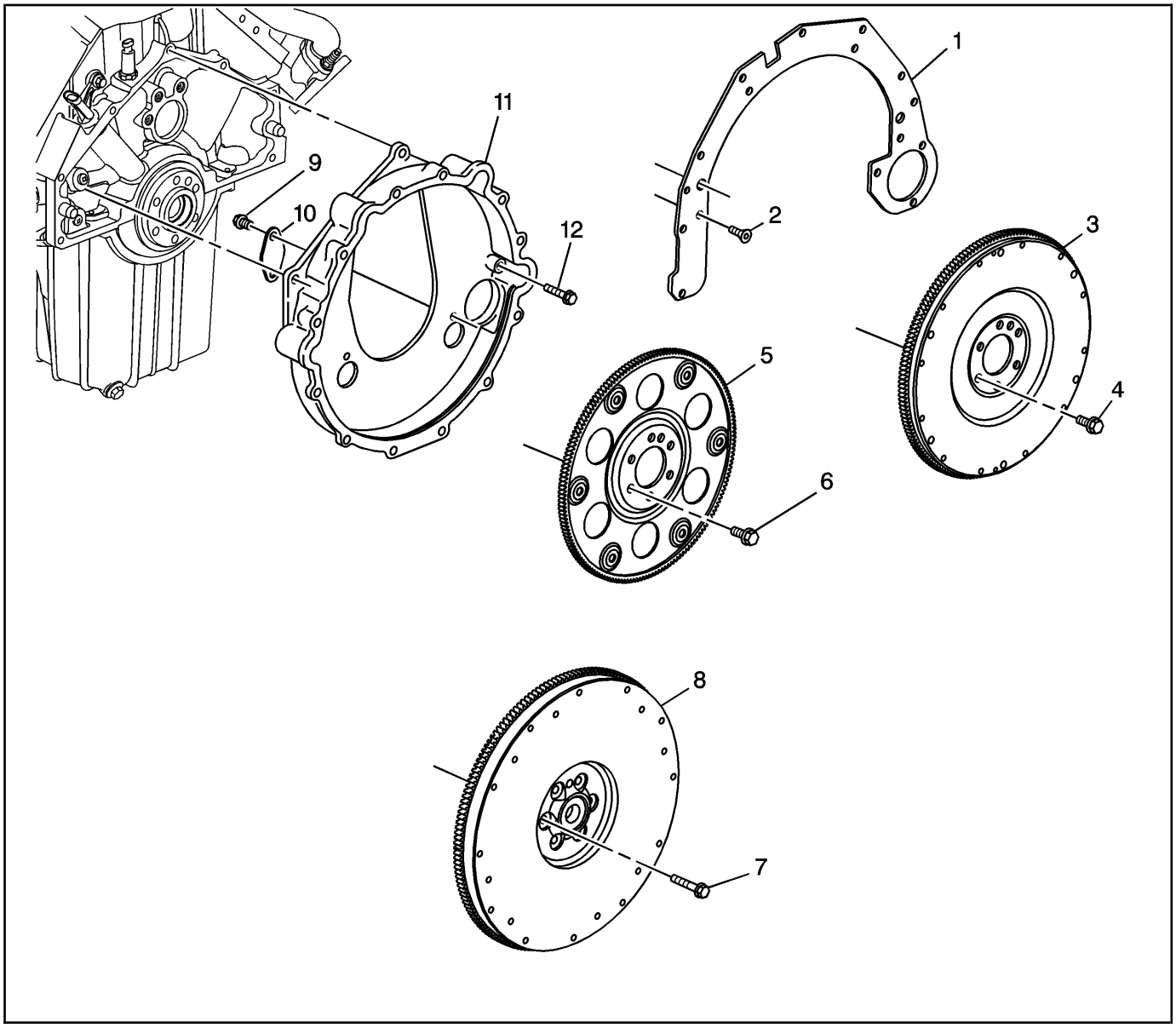
Application	Type of Material	GM Part Number	
		United States	Canada
Block Heater Threads	Sealant	12346004	10953480
Camshaft Rear Bearing Hole Plug	Sealant	12377901	10953504
Coolant Sensor (ETC) Threads	Sealant	12346004	10953480
Crankshaft Position Sensor Bolt	Thread Adhesive	12345493	10953488
Crankshaft Rear Bearing Cap	Sealant	1052942	10953466
Cylinder Head Bolt Threads	Sealant	12346004	10953480
Engine Block Coolant Drain Plugs	Sealant	12346004	10953480
Engine Block Oil Gallery Plugs	Sealant	12346004	10953480
Engine Front Cover	Sealant	12346286	10953472
Intake Manifold Bolt Threads	Thread Adhesive	12345382	10953489
Knock Sensor Threads	Sealant	12346004	10953480
Oil Cooler Hose Fittings	Sealant	12346004	10953480
Oil Pan Corners	Sealant	12346286	10953472
Oil Pressure Sensor Threads	Sealant	12346004	10953480
Purge Solenoid Bolt	Thread Adhesive	12345493	10953488
Valve Train Component Prelube	Lubricant	1052367	992869
Water Pump Bolt Threads	Sealant	12346004	10953480

Component Locator

Disassembled Views

SIE-ID = 482298

Engine Flywheel and Flywheel Housing Components **SIO-ID = 638917**



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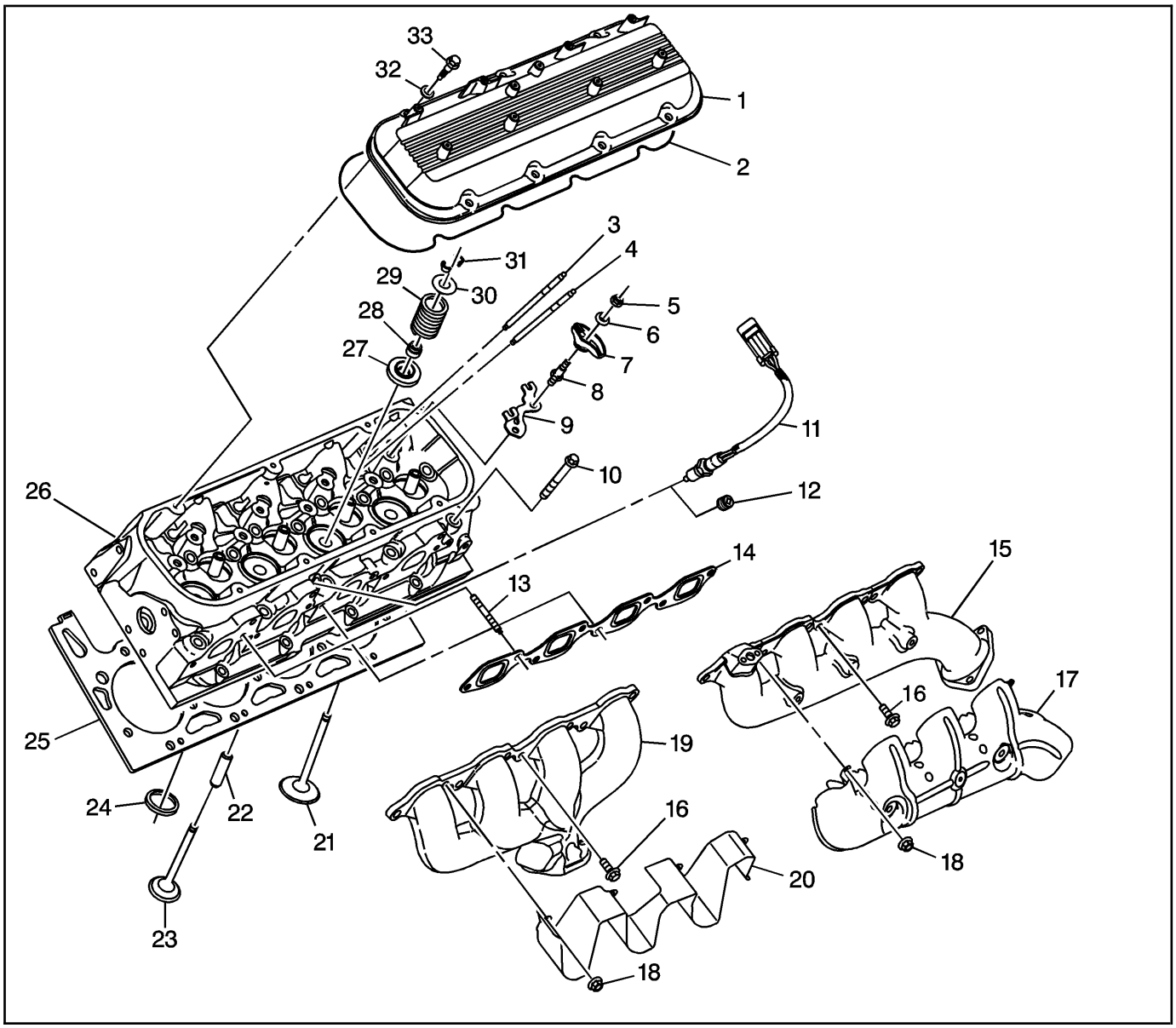
Legend

(1) Flywheel Housing Adapter - Medium Duty with Manual Transmission
(2) Flywheel Adapter Bolt
(3) Flywheel – C/K/C3500HD with Manual Transmission
(4) Flywheel Bolt
(5) Flywheel – Automatic Transmission
(6) Flywheel Bolt
(7) Flywheel Bolt
(8) Flywheel – Medium Duty with Manual Transmission
(9) Transmission Converter Cover Bolt
(10) Transmission Converter Cover
(11) Flywheel Housing – Medium Duty with Automatic Transmission
(12) Flywheel Housing Adapter Bolt

Cylinder Head and Components SIO-ID = 638918



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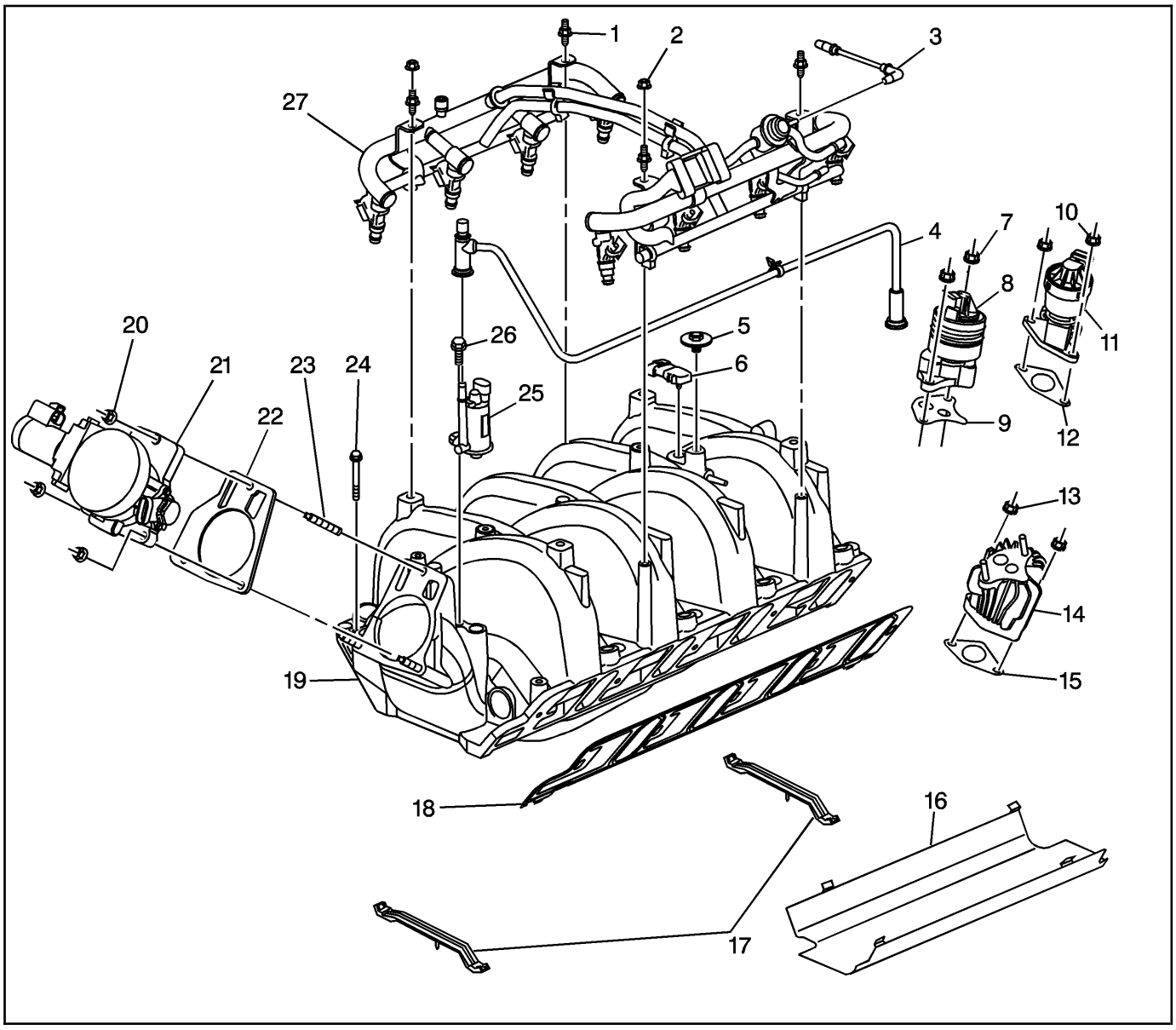
Legend

(1) Valve Rocker Arm Cover
(2) Valve Rocker Arm Cover Gasket
(3) Intake Valve Push Rod
(4) Exhaust Valve Push Rod
(5) Valve Rocker Arm Nut
(6) Valve Rocker Arm Ball
(7) Valve Rocker Arm
(8) Valve Rocker Arm Stud
(9) Push Rod Guide
(10) Cylinder Head Bolt
(11) Engine Coolant Temperature (ECT) Sensor-Right Cylinder Head
(12) Coolant Hole Plug-Left Cylinder Head
(13) Exhaust Manifold Stud
(14) Exhaust Manifold Gasket
(15) Exhaust Manifold – C/K/G/C3500HD
(16) Exhaust Manifold Bolt
(17) Heat Shield – C/K/G/C3500HD
(18) Heat Shield Nut
(19) Exhaust Manifold – Medium Duty
(20) Heat Shield – Medium Duty
(21) Intake Valve
(22) Exhaust Valve Guide
(23) Exhaust Valve
(24) Exhaust Valve Seat
(25) Cylinder Head Gasket
(26) Cylinder Head
(27) Valve Rotator
(28) Valve Stem Oil Seal
(29) Valve Spring
(30) Valve Spring Cap
(31) Valve Keys

(32) Valve Rocker Arm Cover Bolt Gasket

(33) Valve Rocker Arm Cover Bolt

Intake Manifold and Components SIO-ID = 638919



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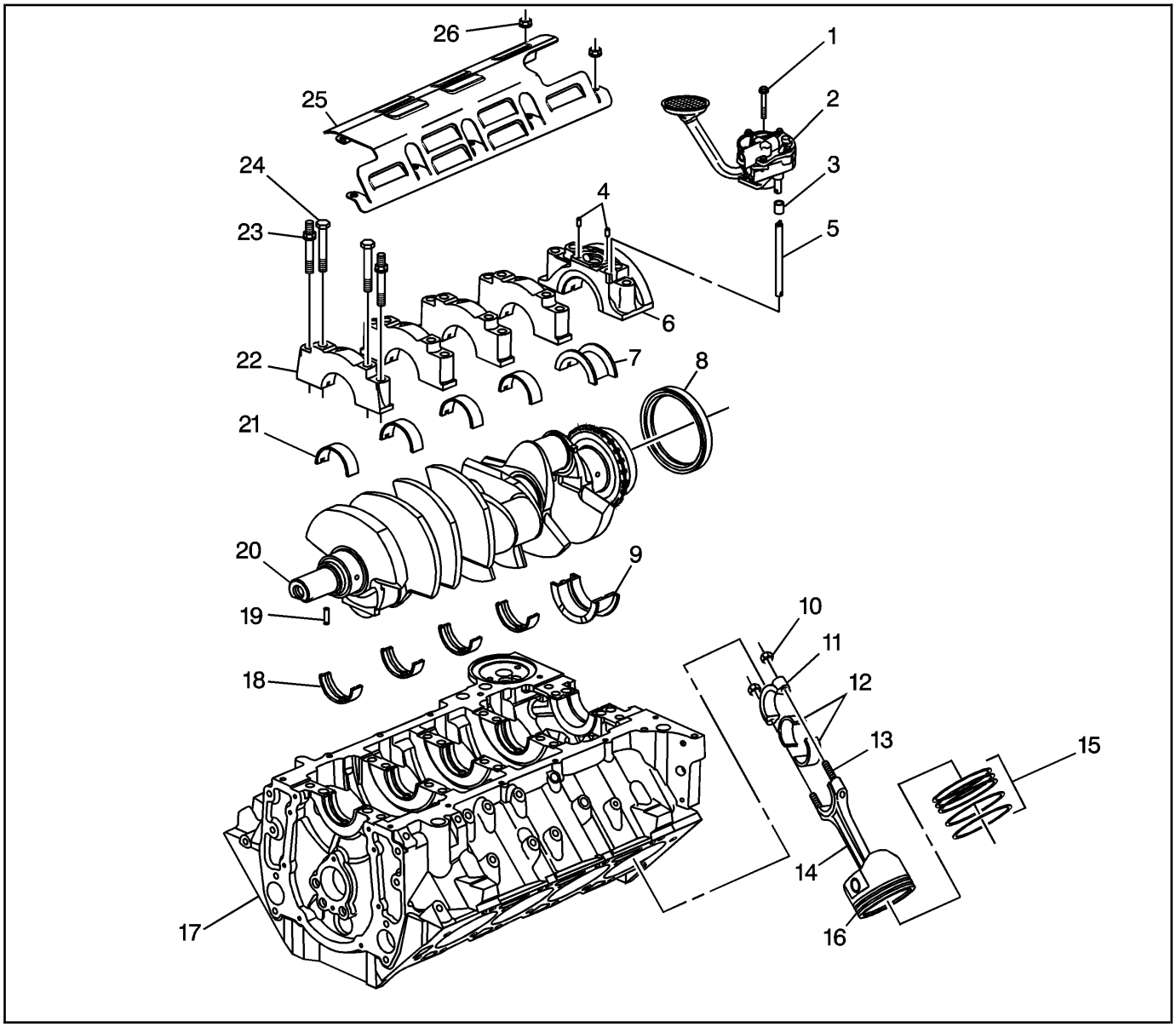
Legend

(1) Fuel Rail Studs
(2) Fuel Rail Nuts
(3) Fuel Pressure Regulator Vacuum Hose
(4) Purge Solenoid Vacuum Hose
(5) MAP Sensor Retaining Bolt
(6) MAP Sensor
(7) EGR Valve Nuts
(8) EGR Valve (C/K/C3500HD/Medium Duty)
(9) EGR Valve Gasket
(10) EGR Valve Nuts
(11) EGR Valve (G Van)
(12) EGR Valve Gasket (G Van)
(13) EGR Adapter Nuts
(14) EGR Adapter (C/K/C3500HD/Medium Duty)
(15) EGR Adapter Gasket (C/K/C3500HD/Medium Duty)
(16) Splash Shield
(17) Intake Manifold End Gaskets
(18) Intake Manifold Side Gaskets
(19) Intake Manifold
(20) Throttle Body Nuts
(21) Throttle Body
(22) Throttle Body Gasket
(23) Throttle Body Studs
(24) Intake Manifold Bolts
(25) Purge Solenoid
(26) Purge Solenoid Bolt
(27) Fuel Rail

Engine Crankshaft and Components SIO-ID = 638921



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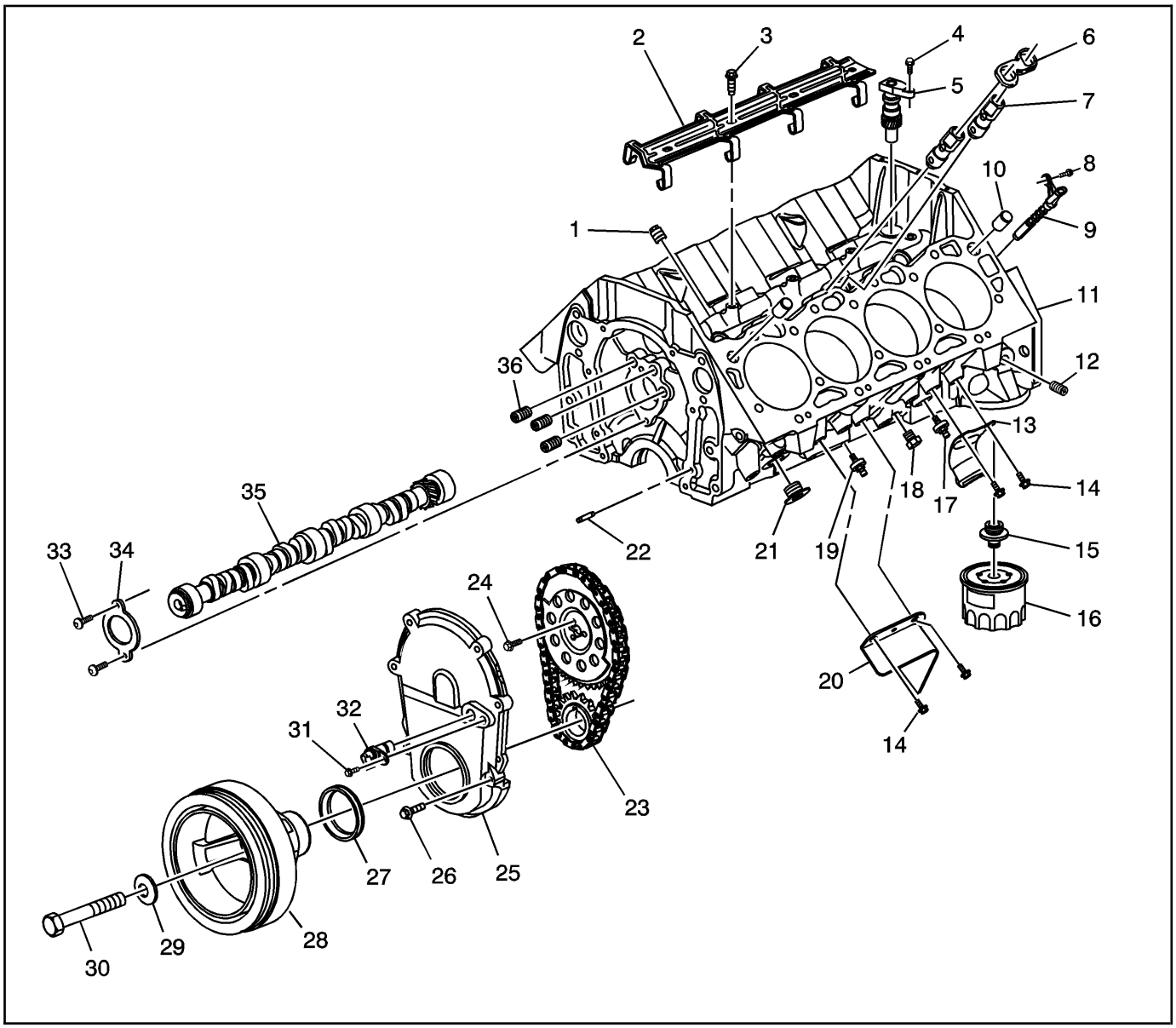
Legend

(1) Oil Pump Bolt
(2) Oil Pump Assembly
(3) Oil Pump Driveshaft Retainer
(4) Oil Pump Locating Pins
(5) Oil Pump Driveshaft
(6) Crankshaft Thrust Bearing Cap
(7) Lower Crankshaft Thrust Bearing
(8) Rear Crankshaft Seal
(9) Upper Crankshaft Thrust Bearing
(10) Connecting Rod Nut
(11) Connecting Rod Cap
(12) Connecting Rod Bearings
(13) Connecting Rod Bolt
(14) Connecting Rod
(15) Piston Rings
(16) Piston
(17) Engine Block
(18) Crankshaft Upper Bearings
(19) Crankshaft Pin
(20) Crankshaft Assembly with Reluctor Wheels
(21) Crankshaft Lower Bearings
(22) Crankshaft Bearing Caps
(23) Crankshaft Bearing Cap Outer Studs
(24) Crankshaft Bearing Cap Inner Bolts
(25) Crankshaft Oil Deflector
(26) Crankshaft Oil Deflector Nuts

Lower Engine Block and Components SIO-ID = 638922



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Legend

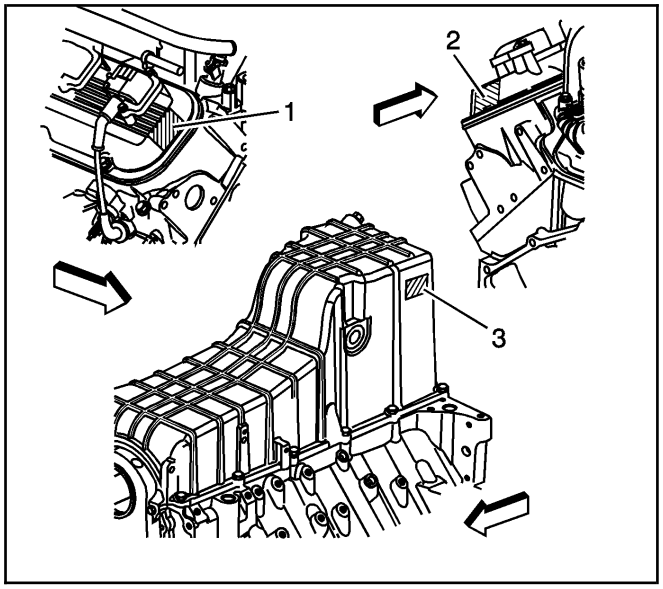
(1) Top Oil Gallery Plug
(2) Valve Lifter Guide Retainer
(3) Valve Lifter Guide Retainer Bolt
(4) Oil Pump Drive Bolt
(5) Oil Pump Drive
(6) Valve Lifter Guide
(7) Valve Lifter
(8) Crankshaft Position Sensor Bolt
(9) Crankshaft Position Sensor
(10) Cylinder Head Locating Pin
(11) Engine Block
(12) Left Oil Gallery Plug
(13) Left Knock Sensor Shield – C/K/G/C3500HD
(14) Left Knock Sensor Shield Bolt
(15) Oil Filter Fitting
(16) Oil Filter
(17) Left Knock Sensor – C/K/G/C3500HD
(18) Coolant Drain Plug
(19) Left Knock Sensor – Medium Duty
(20) Left Knock Sensor Shield – Medium Duty
(21) Coolant Hole Plug (Optional Block Heater)
(22) Front Engine Cover Locating Pin
(23) Timing Chain and Sprockets
(24) Camshaft Sprocket Bolt
(25) Front Engine Cover
(26) Front Engine Cover Bolt
(27) Front Crankshaft Oil Seal
(28) Crankshaft Balancer
(29) Crankshaft Balancer Washer
(30) Crankshaft Balancer Bolt
(31) Camshaft Position Sensor Bolt
(32) Camshaft Position Sensor

(33) Camshaft Retainer Bolt
(34) Camshaft Retainer
(35) Camshaft
(36) Front Oil Gallery Plug

Engine Identification

SIE-ID = 482310

SIO-ID = 638922



677764

The engine identification number is located on three locations. There is a label on the front of the right rocker arm cover (1), the rear of the left rocker arm cover (2), and a label on the right side of the engine oil pan (3). The engine identification number is used to track and distinguish the engine prior to installation in a vehicle.

The Vehicle Identification Number (VIN) Derivative is located on the left rear side of the engine block and is a nine digit number stamped or laser etched onto the engine at the vehicle assembly plant. If reading the identification number from the left, the following information can be obtained:

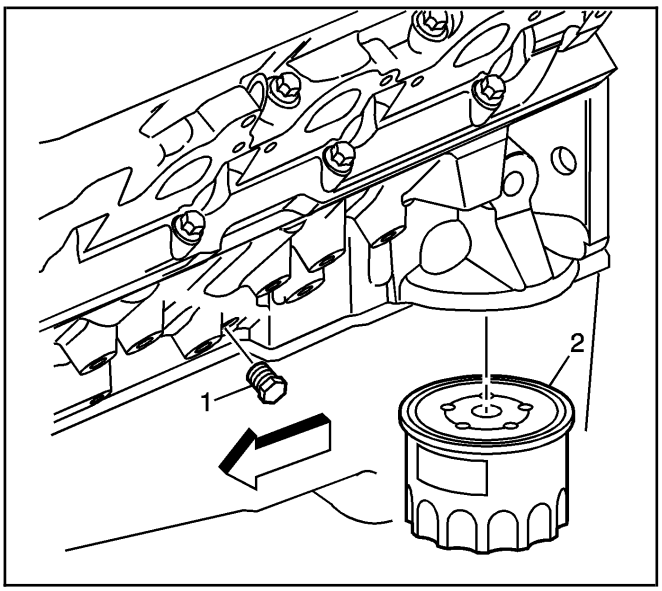
- The first digit identifies the division.
- The second digit identifies the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the Vehicle Identification Number (VIN).

Repair Instructions

Draining Fluids and Oil Filter Removal

SIE-ID = 482311

1. Remove the oil pan drain plug.
2. Drain the engine oil.
3. Remove the oil filter (2).
4. Remove the left engine coolant drain hole plug (1) and the right engine coolant drain hole plug.
5. Drain the engine coolant.



470515

Crankshaft Balancer Removal (C/K/G/C3500HD)

SIE-ID = 482704

Tools Required

- *J 38416-B* Three Jaw Puller
- *J 42846* Crankshaft Protector Button
- *J 42847* Flywheel Holding Tool

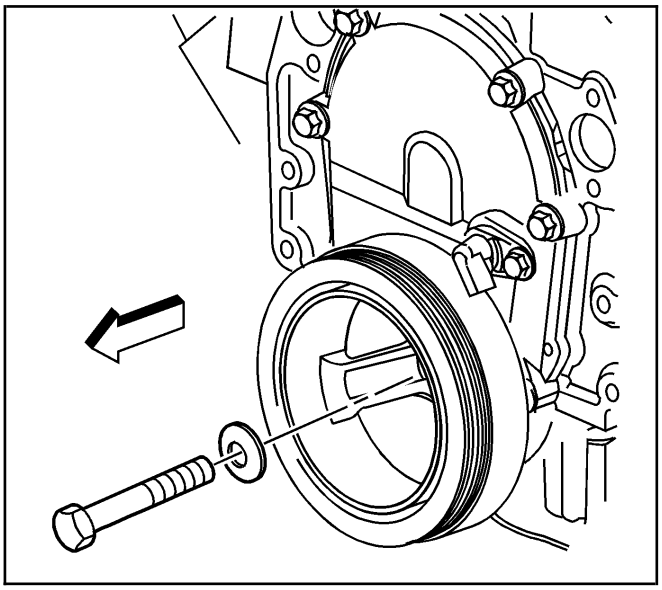
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: Make sure the teeth of the flywheel holding tool engage the engine flywheel teeth.

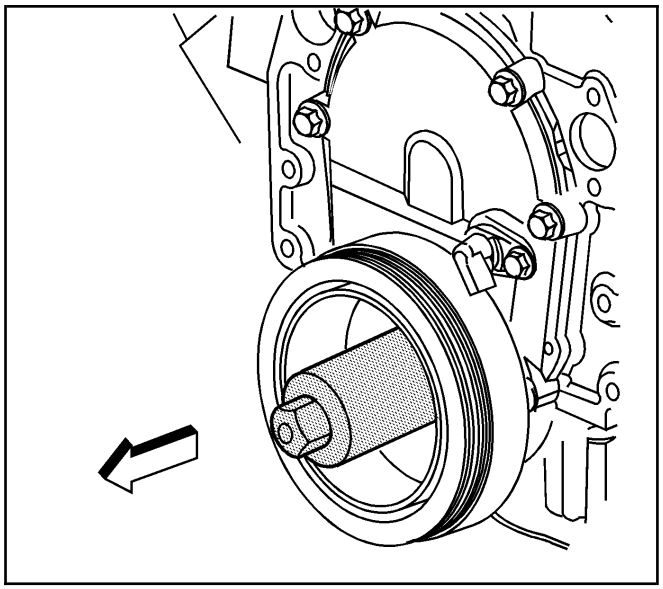
1. Install the *J 42847* to the starter bolt holes.

   Tighten

   Tighten the *J 42847* bolts to 50 N·m (37 lb ft).
2. Remove the crankshaft balancer bolt and washer.

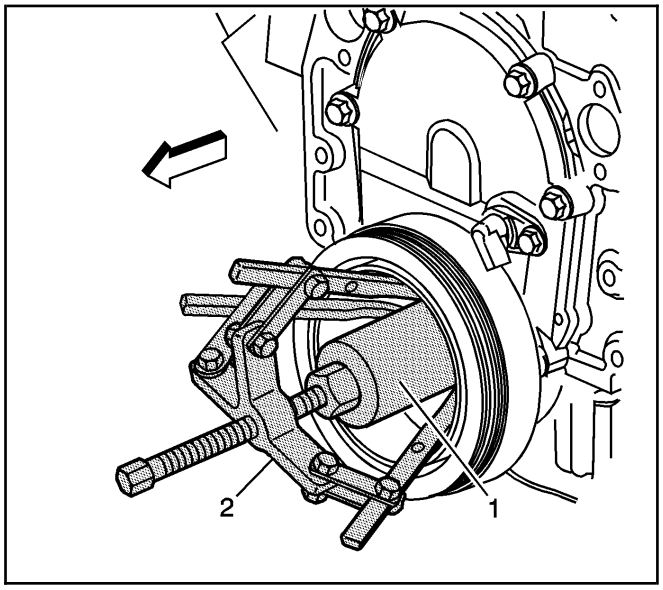


470799



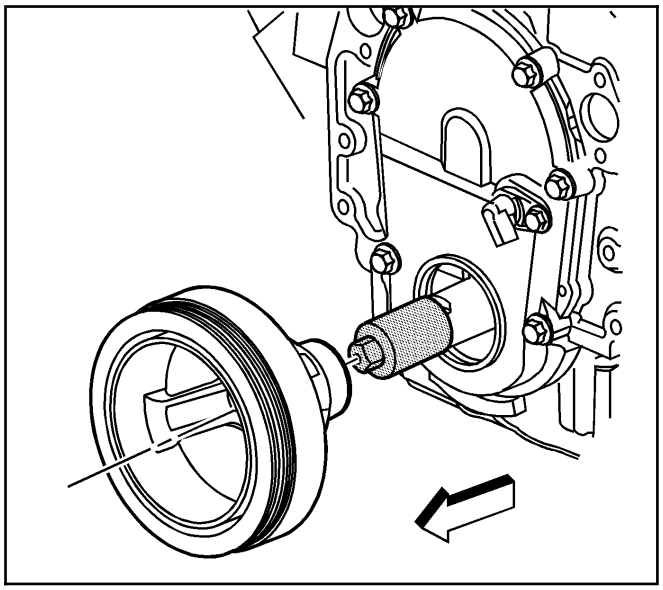
640013

3. Install the *J 42846* onto the end of the crankshaft.



640014

4. Install the *J 38416-B* (2) in order to remove the crankshaft balancer. Place the legs of the *J 38416-B* into the recesses cast into the backside of the balancer inner hub.
5. Tighten the center screw of the *J 38416-B* until the crankshaft balancer is clear of the crankshaft nose.



640015

6. Remove the *J 38416-B*.
7. Remove the crankshaft balancer.
8. Remove the *J 42846* from the end of the crankshaft.
9. Remove the *J 42847*.

Crankshaft Balancer Removal (Medium Duty)

SIE-ID = 678574

Tools Required

- *J 24420-C* Harmonic Balancer Puller
- *J 42847* Flywheel Holding Tool

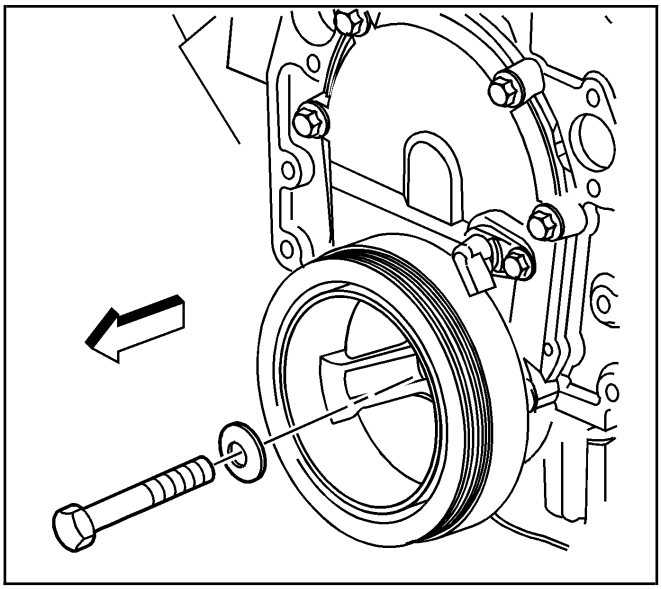
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: Make sure the teeth of the flywheel holding tool engage the engine flywheel teeth.

1. Install the *J 42847* to the starter bolt holes.

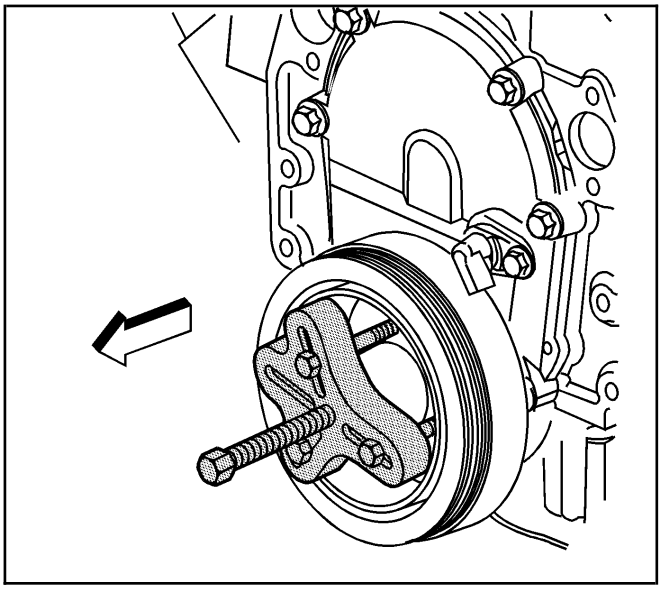
   Tighten

   Tighten the *J 42847* bolts to 50 N·m (37 lb ft).
2. Remove the crankshaft balancer bolt and washer.



470799

3. Install the *J 24420-C* or equivalent onto the crankshaft balancer.
4. Tighten the center screw of the *J 24420-C* until the crankshaft balancer is clear of the crankshaft nose.
5. Remove the crankshaft balancer.
6. Remove the *J 42847*.

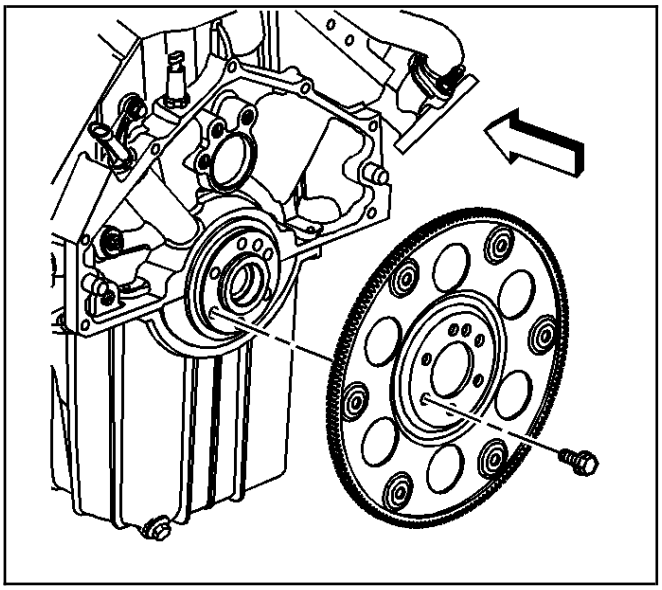


677814

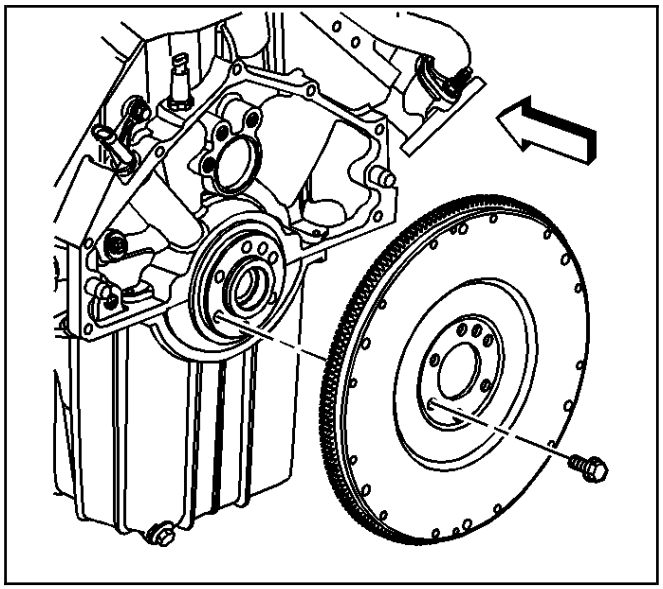
Engine Flywheel Removal (C/K/G/C3500HD with AT)

SIE-ID = 482314

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



470572



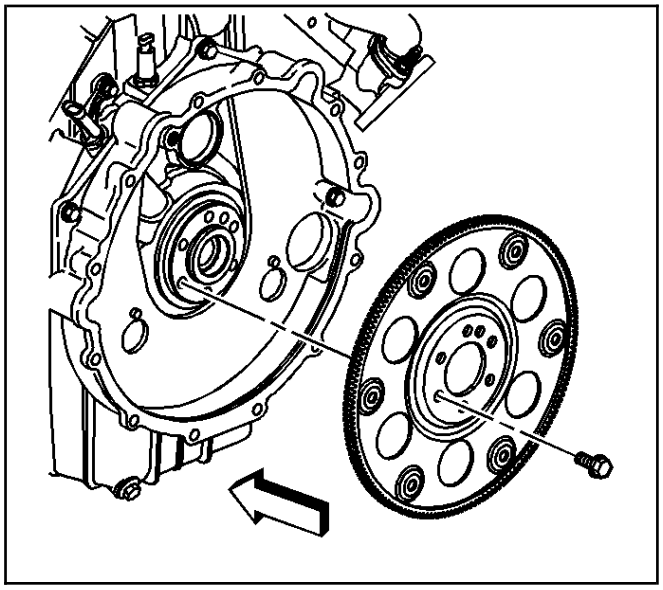
470576

Engine Flywheel Removal (C/K with MT)

SIE-ID = 482318

Important: The flywheel may need to be tapped with a non-metallic mallet from the engine side due to a slight interference fit to the crankshaft.

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

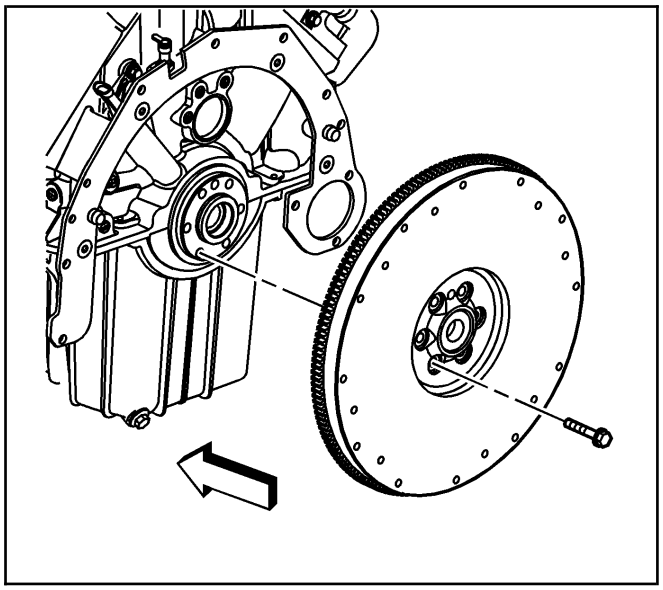


470579

Engine Flywheel Removal (Medium Duty with AT)

SIE-ID = 482320

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



679414

Engine Flywheel Removal (Medium Duty with MT)

SIE-ID = 482322

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

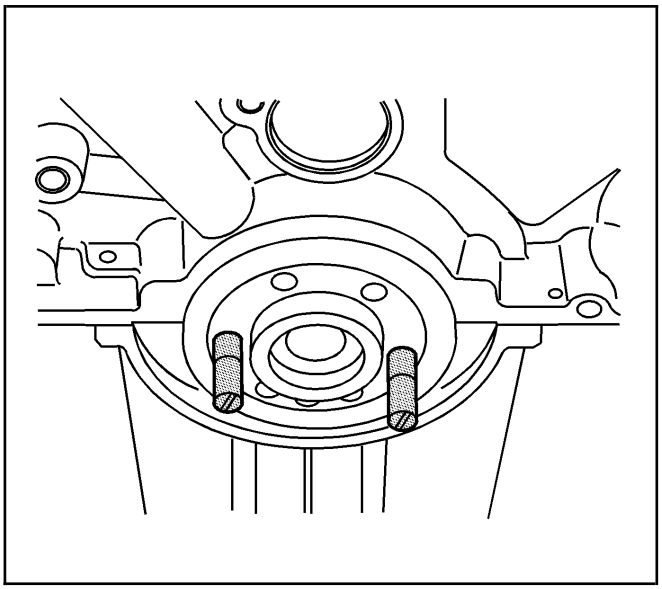
Crankshaft Rear Oil Seal Removal

SIE-ID = 482744

Tools Required

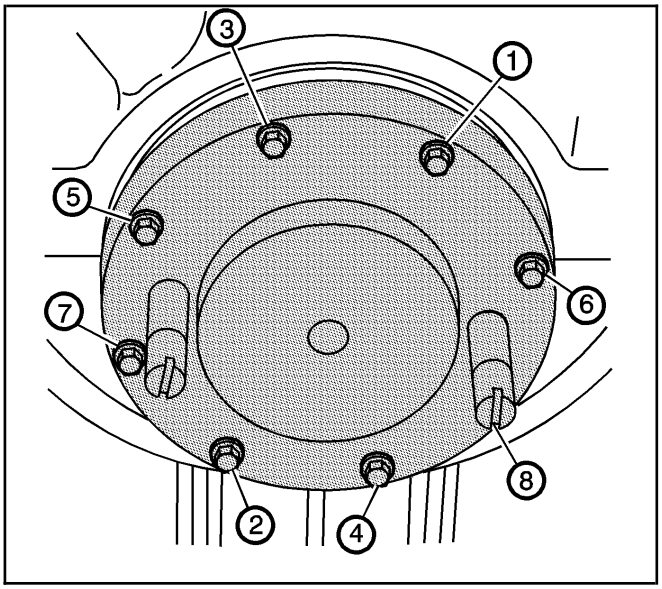
J 43320 Crankshaft Rear Seal Puller

1. Install the *J 43320* guide pins into the crankshaft.



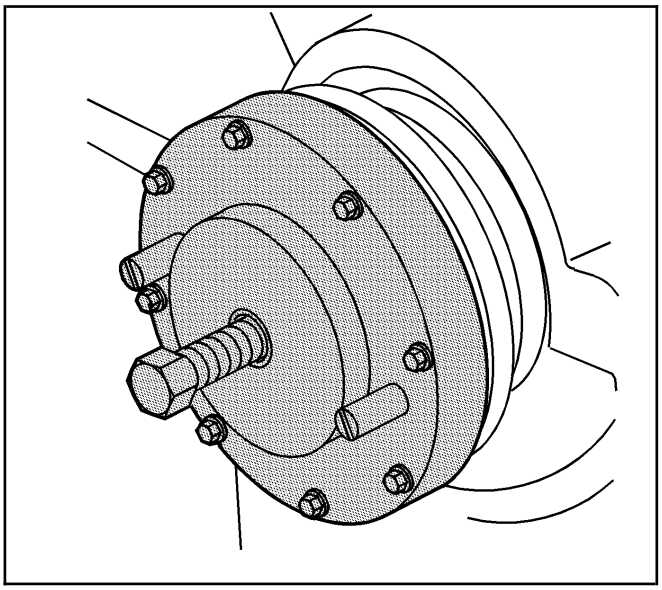
655276

2. Install the *J 43320* over the guide pins.
3. Using a suitable drill, insert eight of the self-drilling sheet metal screws into the rear crankshaft seal, using a criss-cross pattern. The self-drilling screws are included with the *J 43320*.

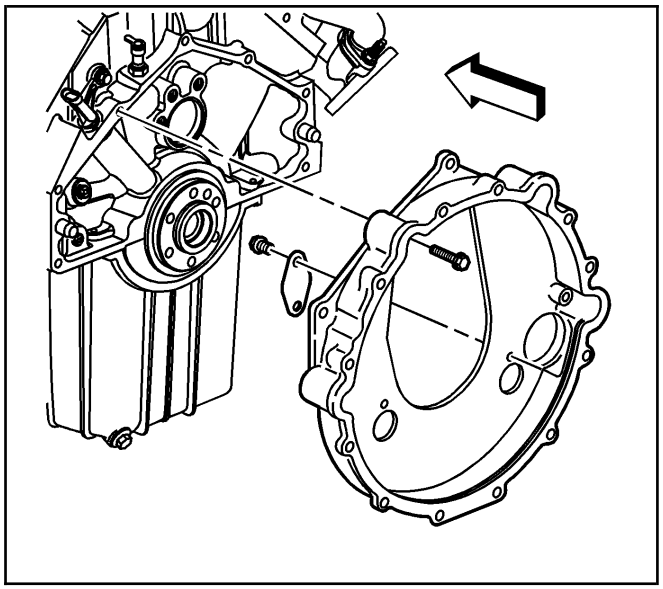


655278

4. Thread the center bolt of *J 43320* into the crankshaft to remove the seal.
5. Remove the *J 43320* guide pins from the crankshaft.



655279

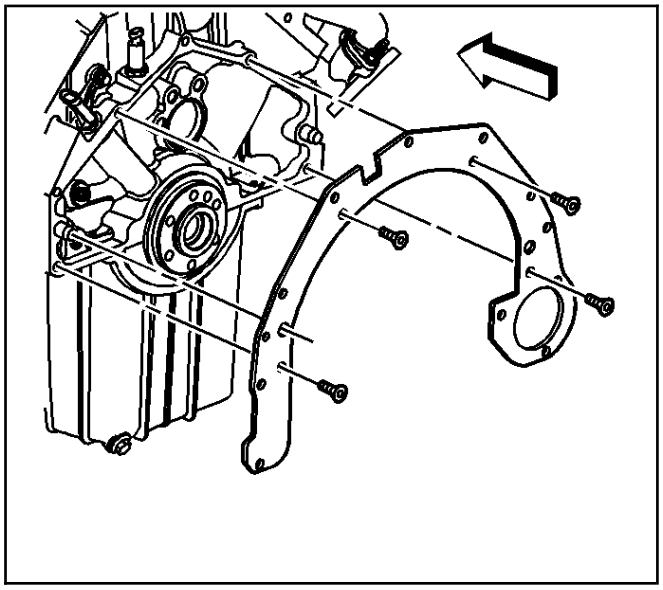


470599

Engine Flywheel Housing Removal (Medium Duty with AT)

SIE-ID = 482323

1. Remove the engine flywheel housing bolts.
2. Remove the engine flywheel housing.
3. Remove the transmission converter cover bolt.
4. Remove the transmission converter cover.

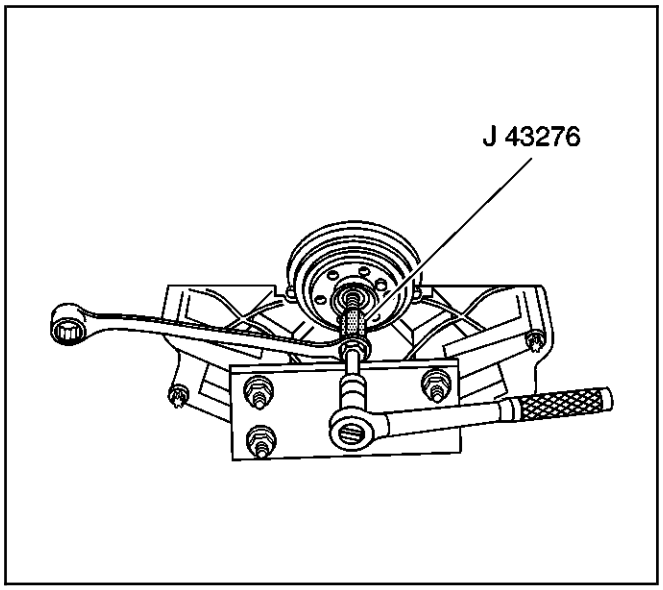


470612

Engine Flywheel Housing Removal (Medium Duty with MT)

SIE-ID = 482329

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



373133

Clutch Pilot Bearing Removal (C/K/C3500HD)

SIE-ID = 482332

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 tool body to rotate. Failing to do so will cause damage to the J 43276-1 tool body.

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

1.2. Using a wrench secure the J 43276-1 tool body.

1.3. Insert the J 43276-2 forcing screw into the J 43276-1 tool body.

1.4. Rotate the J 43276-2 forcing screw clockwise into the J 43276-1 tool body until the clutch pilot bearing is completely removed from the crankshaft.

1.5. Rotate the J 43276-2 forcing screw counterclockwise to remove the J 43276-2 forcing screw from the J 43276-1 tool body.

1.6. Remove the J 43276-1 tool body from the clutch pilot bearing.

2. Discard the clutch pilot bearing.

Clutch Pilot Bearing Removal (Medium Duty)

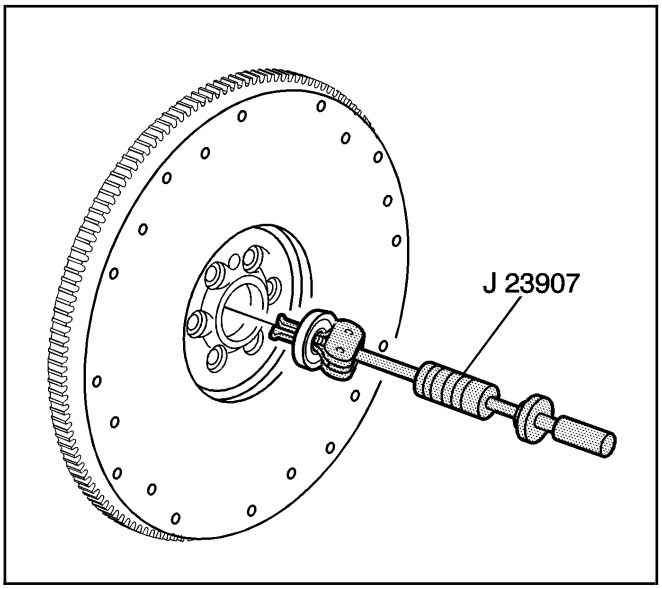
SIE-ID = 482333

Tools Required

J 23907 Slide Hammer

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

1. Remove the clutch pilot bearing using the *J 23907*.
2. Discard the clutch pilot bearing.
3. Inspect the engine flywheel clutch pilot bearing bore for serviceability.

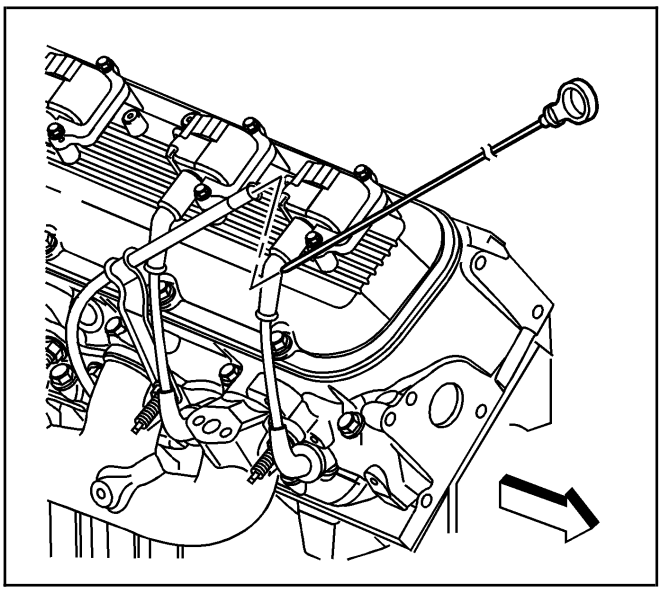


375105

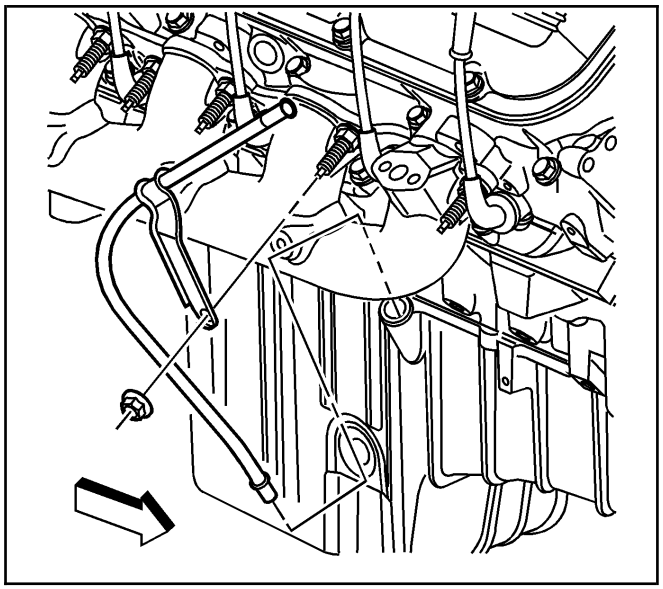
Oil Level Indicator and Tube Removal (C/K/C3500HD)

SIE-ID = 482341

1. Remove the oil level indicator from the oil level indicator tube.

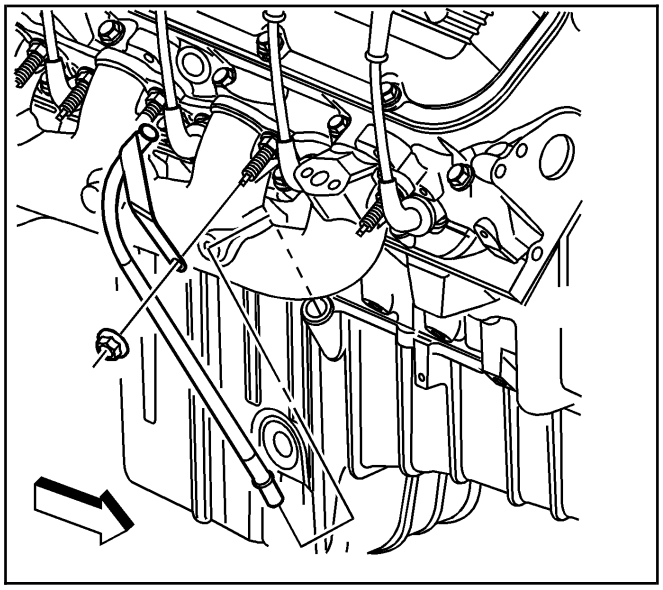


470627



470630

2. Remove the oil level indicator tube bracket nut from the exhaust manifold stud.
3. Remove the oil level indicator tube bracket from the exhaust manifold stud.
4. Remove the oil level indicator tube from the oil pan.
5. Remove the O-ring seal from the oil level indicator tube.

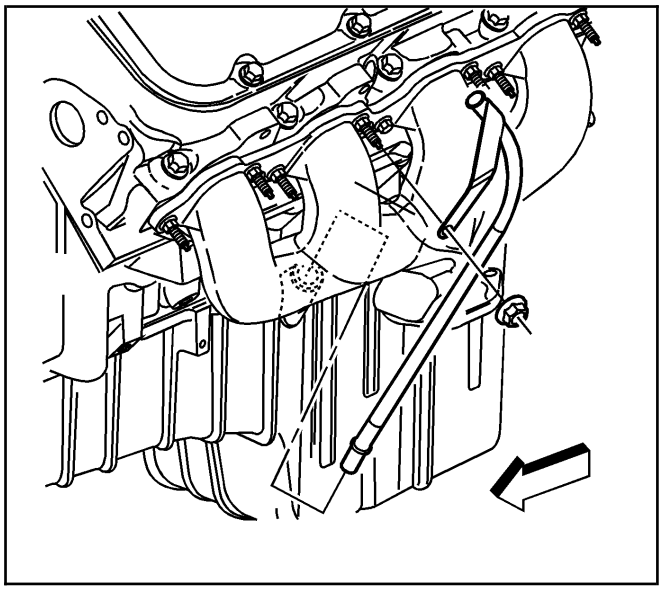


470639

Oil Level Indicator and Tube Removal (G)

SIE-ID = 482342

1. Remove the oil level indicator tube bracket nut from the exhaust manifold stud.
2. Remove the oil level indicator tube bracket from the exhaust manifold stud.
3. Remove the oil level indicator tube from the oil pan.
4. Remove the O-ring seal from the oil level indicator tube.



677829

Oil Level Indicator and Tube Removal (Medium Duty)

SIE-ID = 482344

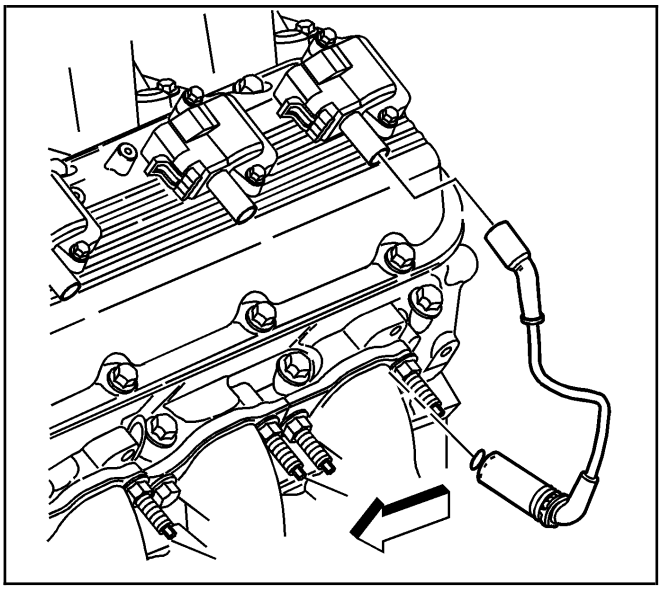
1. Remove the oil level indicator tube bracket nut from the exhaust manifold stud.
2. Remove the oil level indicator tube bracket from the exhaust manifold stud.
3. Remove the oil level indicator tube from the oil pan.
4. Remove the O-ring seal from the oil level indicator tube.

Exhaust Manifold Removal - Left (C/K/G/C3500HD)

SIE-ID = 761239

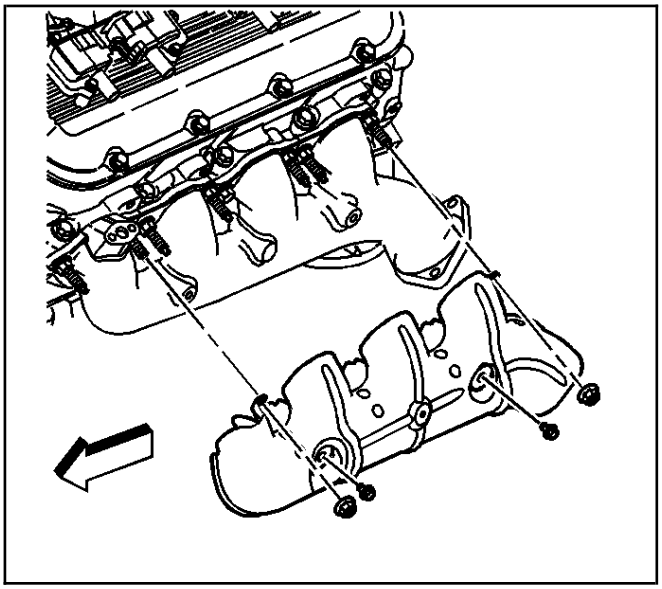
Important: Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the left spark plug wires from the spark plugs and ignition coils.



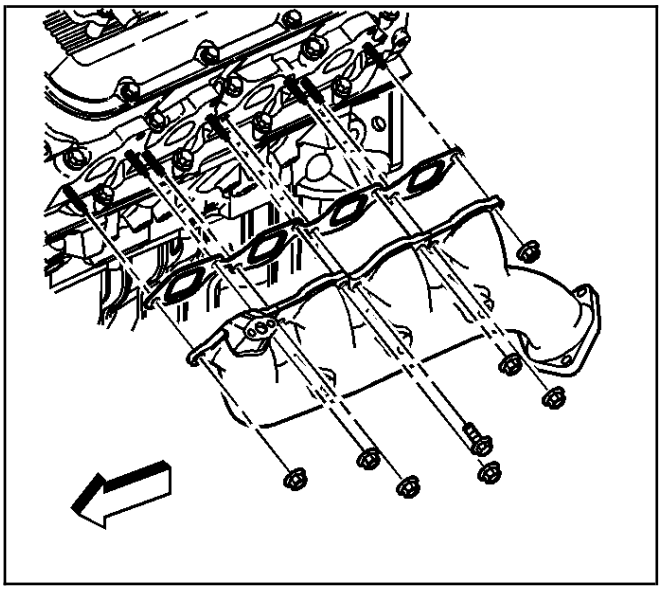
470666

2. Remove the left exhaust manifold heat shield bolts and nuts.
3. Remove the left exhaust manifold heat shield.

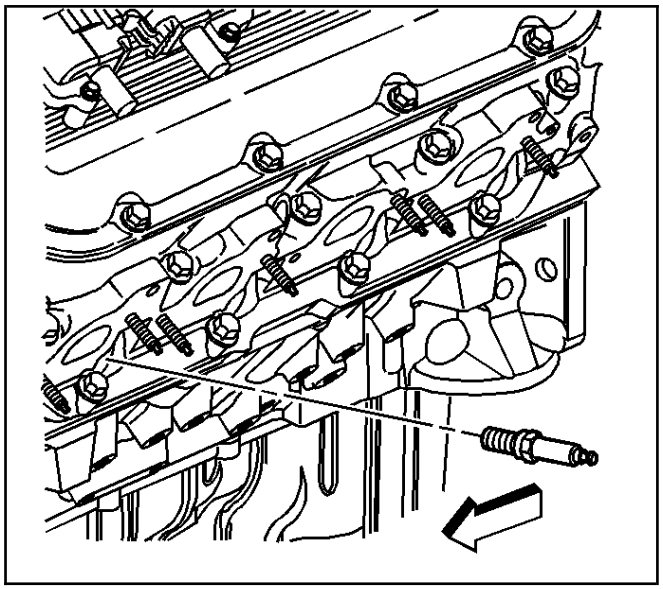


470676

4. Remove the left exhaust manifold nuts and center bolt.
5. Remove the left exhaust manifold.
6. Remove the left exhaust manifold gasket.

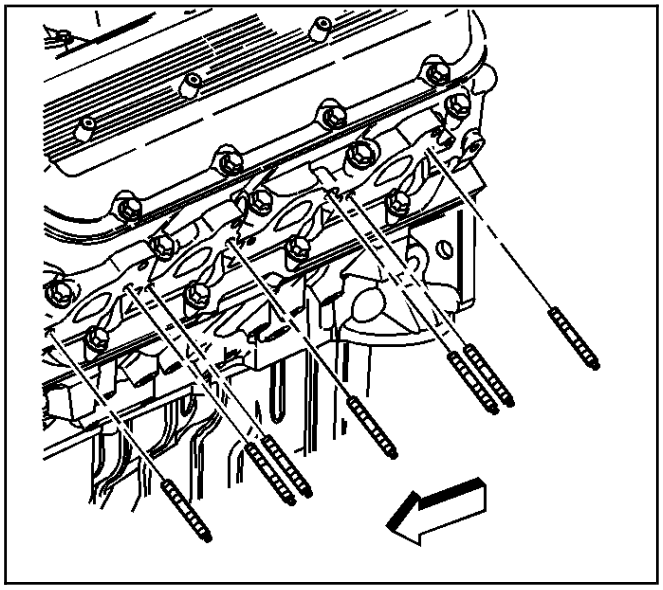


470679



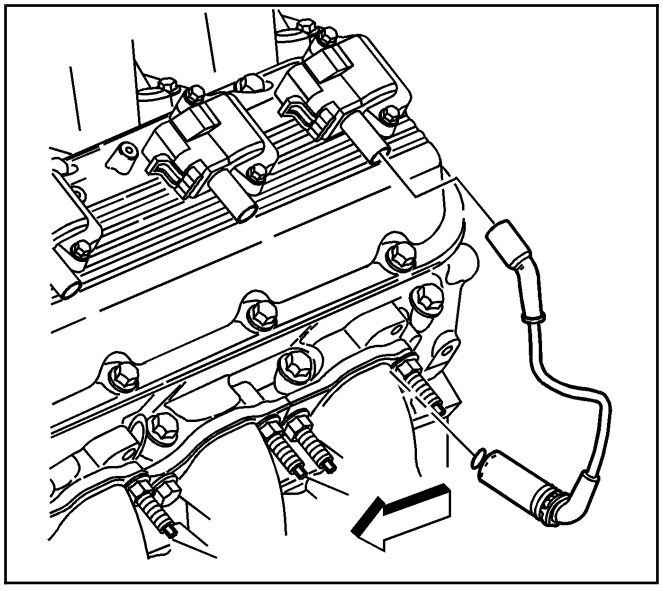
470690

7. Remove the left spark plugs.



470683

8. Remove the exhaust manifold studs, if necessary.



470666

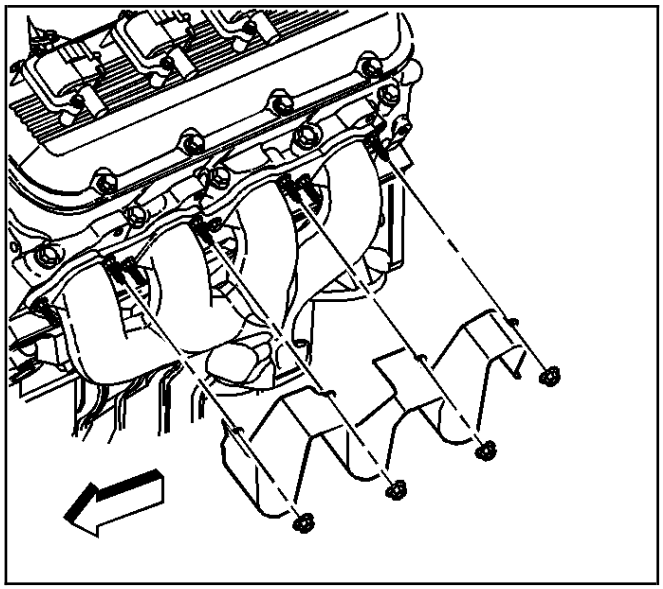
Exhaust Manifold Removal - Left (Medium Duty)

SIE-ID = 639152

Important: 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.

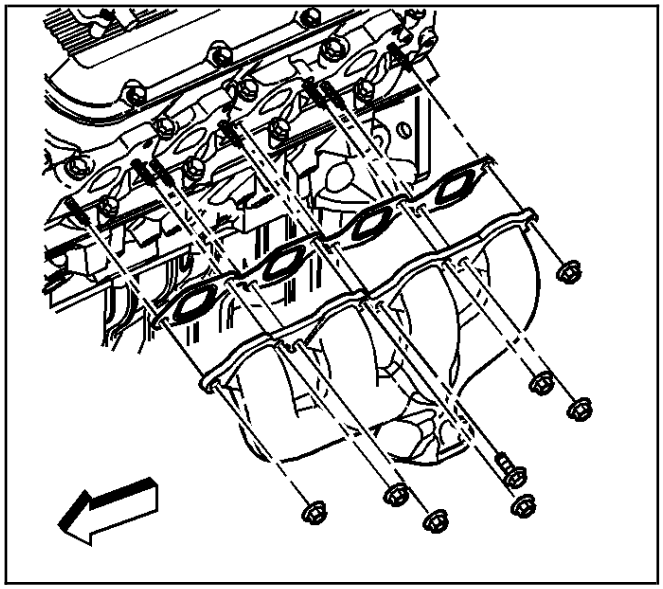
1. Remove the left spark plug wires from the spark plugs and ignition coils.

2. Remove the left exhaust manifold heat shield nuts.
3. Remove the left exhaust manifold heat shield.



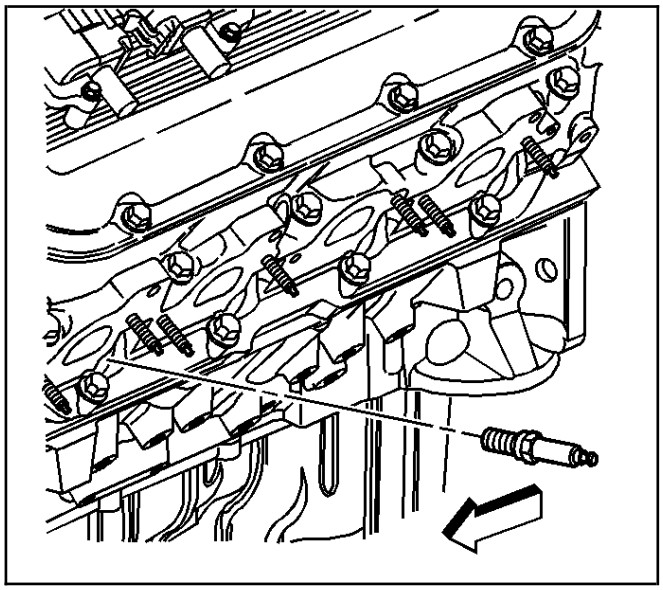
470678

4. Remove the left exhaust manifold nuts and center bolt.
5. Remove the left exhaust manifold.
6. Remove the left exhaust manifold gasket.

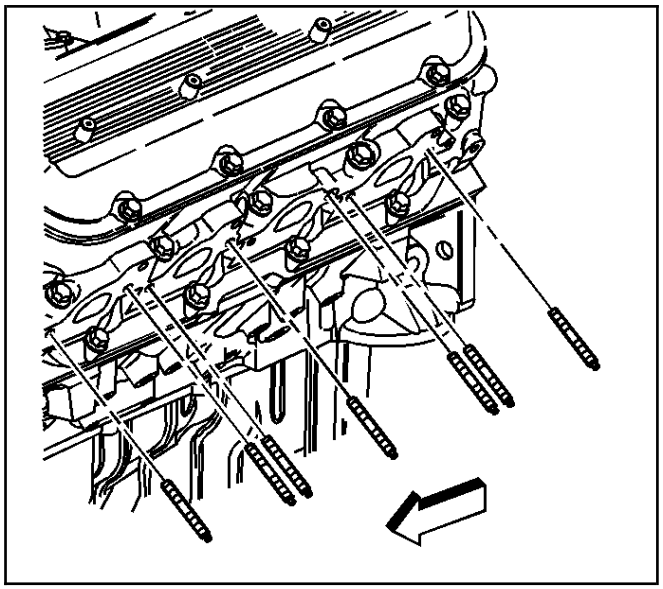


470686

7. Remove the left spark plugs.

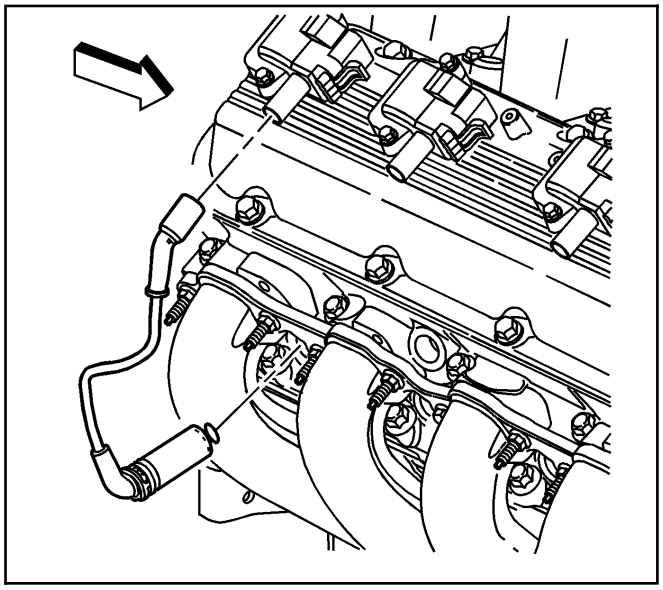


470690



470683

8. Remove the exhaust manifold studs, if necessary.



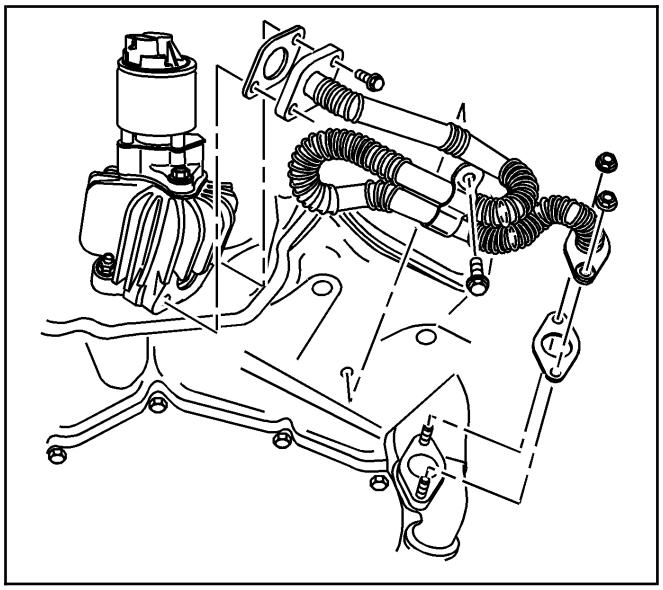
470704

Exhaust Manifold Removal - Right (C/K/C3500HD)

SIE-ID = 761240

Important: 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.

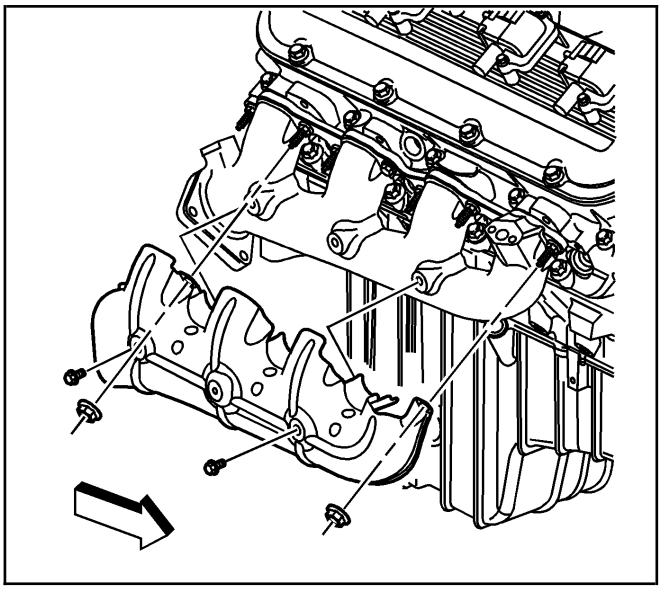
1. Remove the right spark plug wires from the spark plugs and ignition coils.



635635

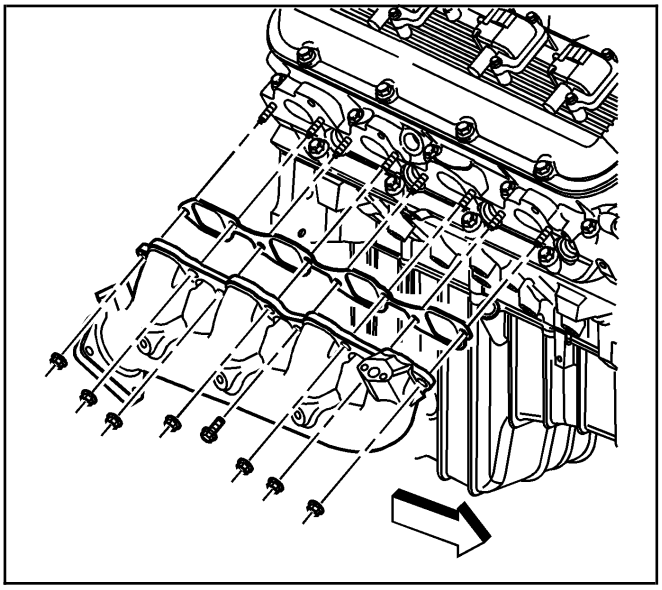
2. Remove the exhaust gas recirculation (EGR) pipe bolts from the EGR adapter plate.
3. Remove the EGR pipe nuts from the right exhaust manifold.
4. Remove the EGR pipe bracket bolt.
5. Remove the EGR pipe and gaskets.

6. Remove the right exhaust manifold heat shield bolts and nuts.
7. Remove the right exhaust manifold heat shield.



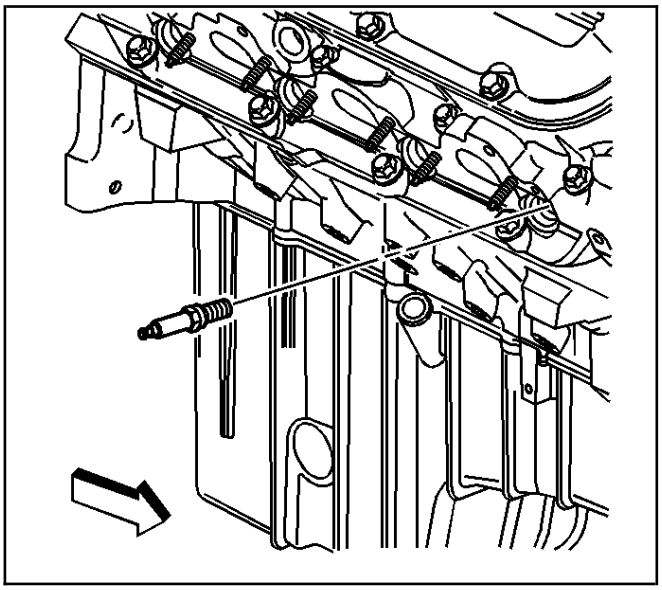
470706

8. Remove the right exhaust manifold nuts and center bolt.
9. Remove the right exhaust manifold.
10. Remove the right exhaust manifold gasket.

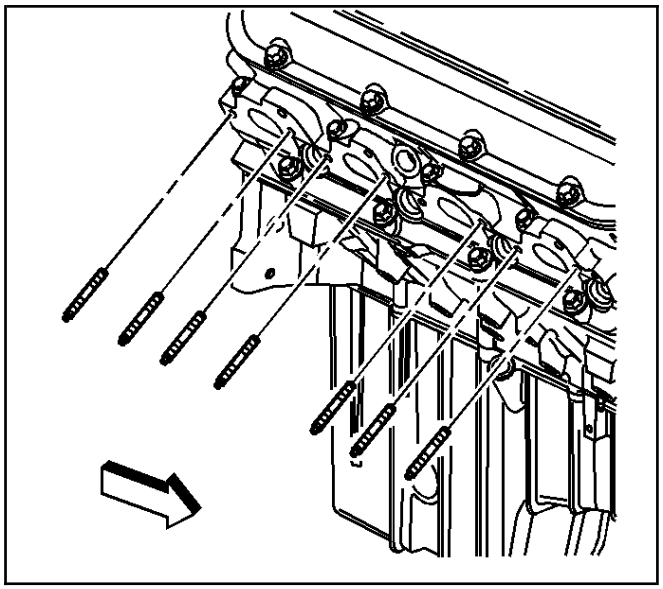


470719

11. Remove the right spark plugs.

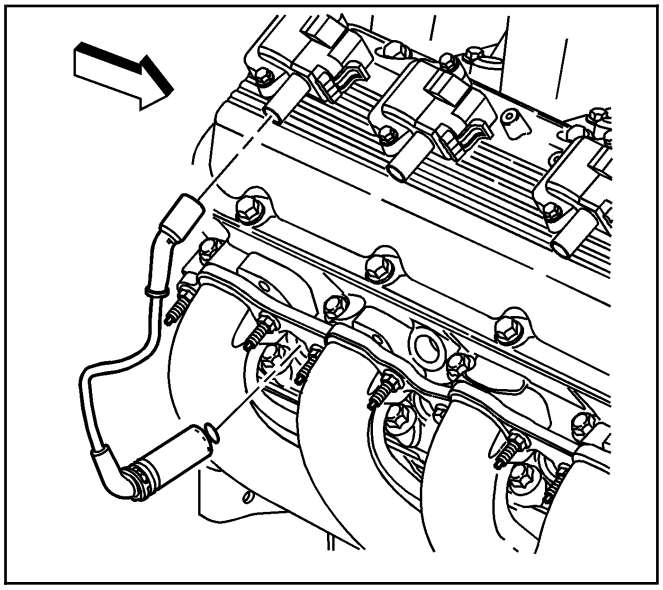


470727



470723

12. Remove the exhaust manifold studs, if necessary.



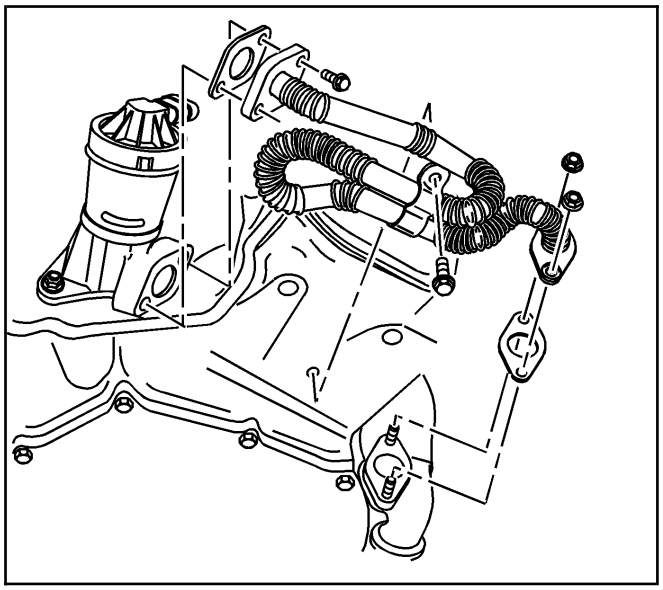
470704

Exhaust Manifold Removal - Right (G)

SIE-ID = 761241

Important: 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.

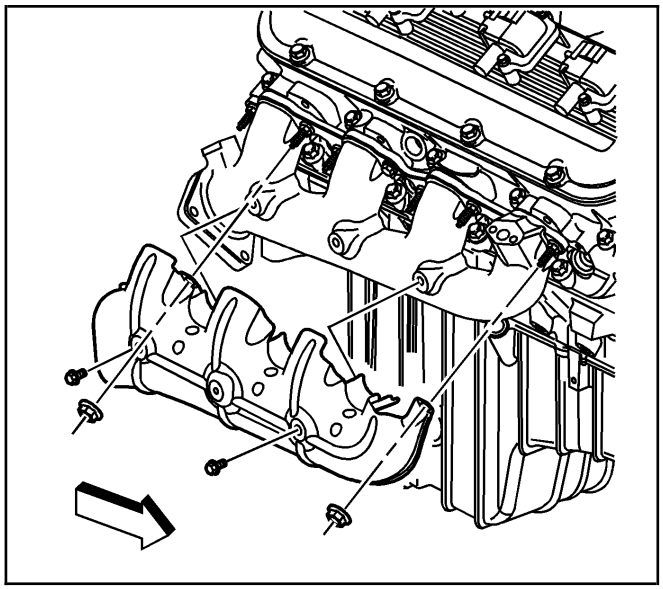
1. Remove the right spark plug wires from the spark plugs and ignition coils.



654377

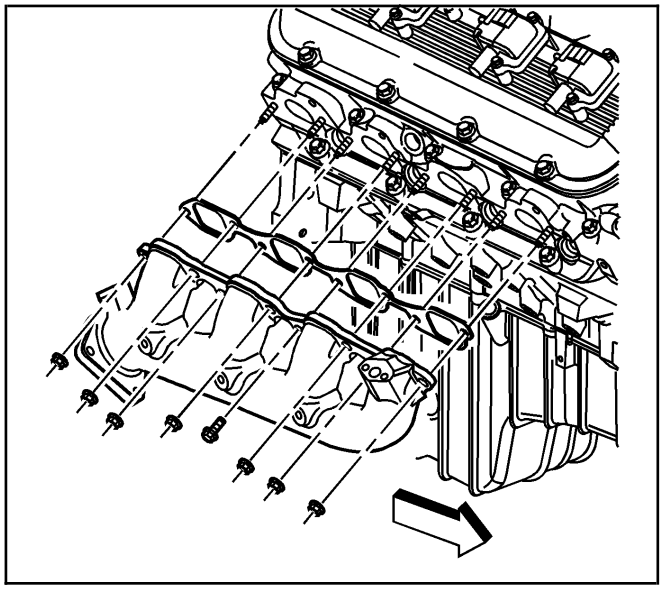
2. Remove the exhaust gas recirculation (EGR) pipe bolts from the EGR valve.
3. Remove the EGR pipe nuts from the right exhaust manifold.
4. Remove the EGR pipe bracket bolt.
5. Remove the EGR pipe and gaskets.

6. Remove the right exhaust manifold heat shield bolts and nuts.
7. Remove the right exhaust manifold heat shield.



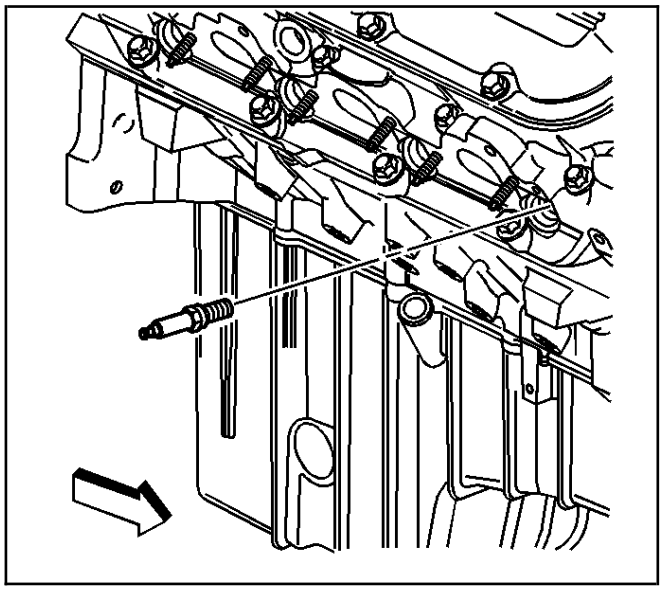
470706

8. Remove the right exhaust manifold nuts and center bolt.
9. Remove the right exhaust manifold.
10. Remove the right exhaust manifold gasket.

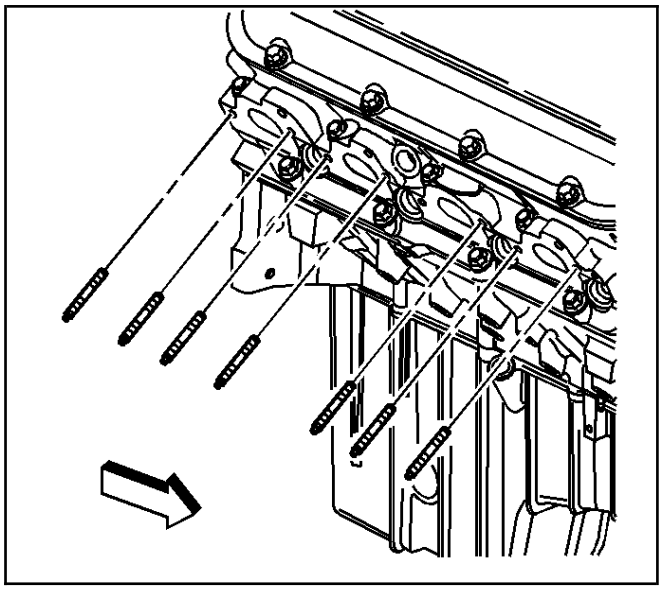


470719

11. Remove the right spark plugs.

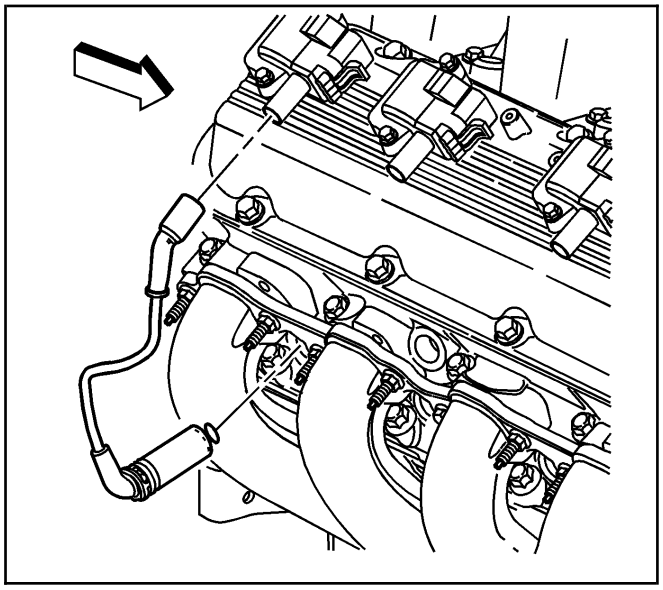


470727



470723

12. Remove the exhaust manifold studs, if necessary.



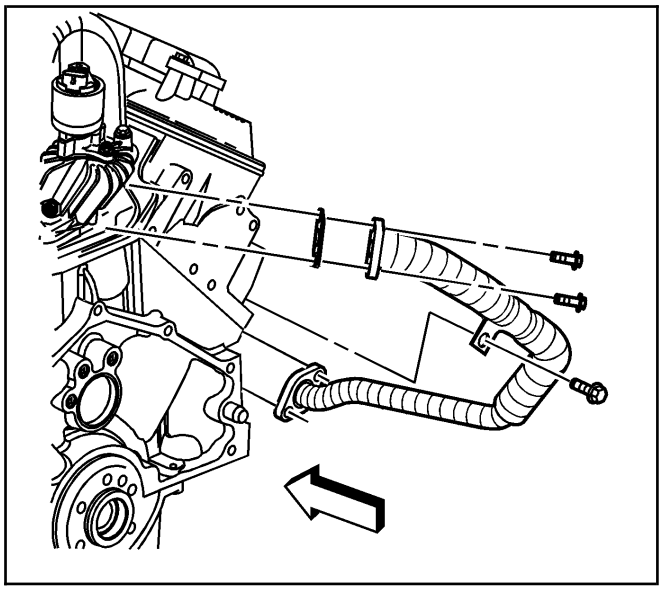
470704

Exhaust Manifold Removal - Right (Medium Duty)

SIE-ID = 639156

Important: 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.

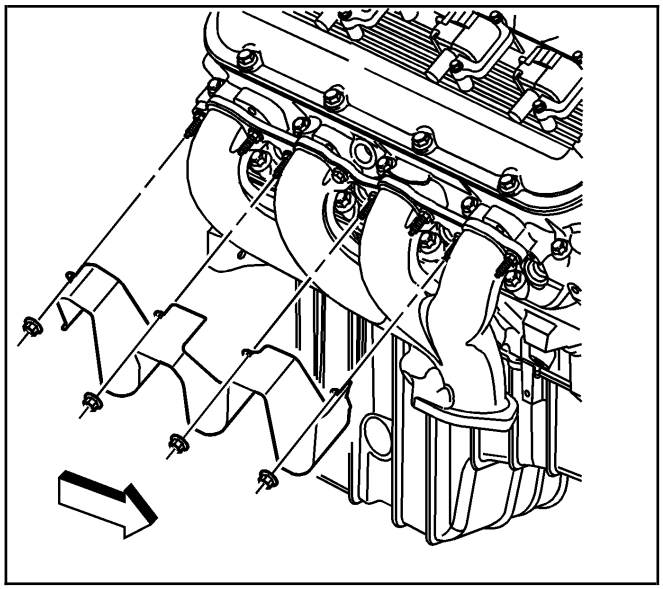
1. Remove the right spark plug wires from the spark plugs and ignition coils.



470737

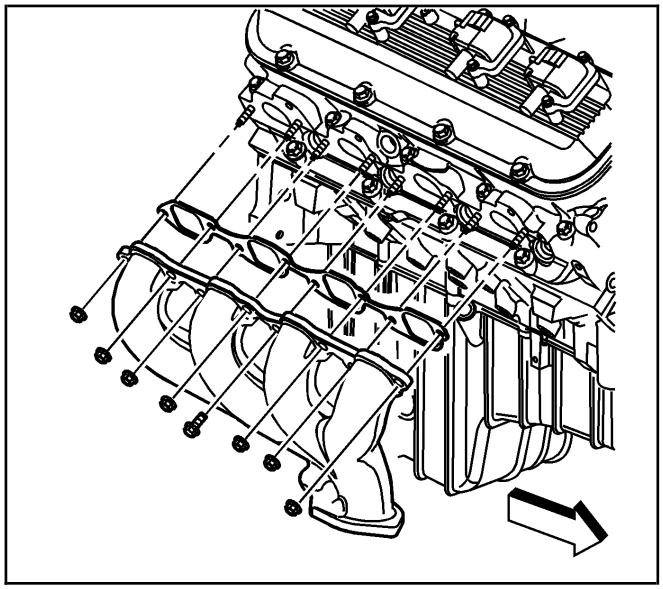
2. Remove the exhaust gas recirculation (EGR) pipe bolts from the EGR adapter.
3. Remove the EGR pipe nuts from the right exhaust manifold.
4. Remove the EGR pipe bracket bolt.
5. Remove the EGR pipe and gaskets.

6. Remove the right exhaust manifold heat shield nuts.
7. Remove the right exhaust manifold heat shield.



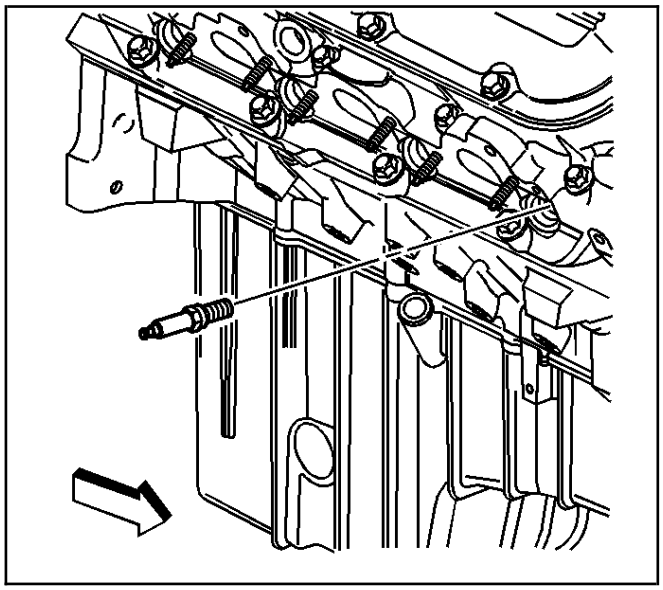
470708

8. Remove the right exhaust manifold nuts and center bolt.
9. Remove the right exhaust manifold.
10. Remove the right exhaust manifold gasket.

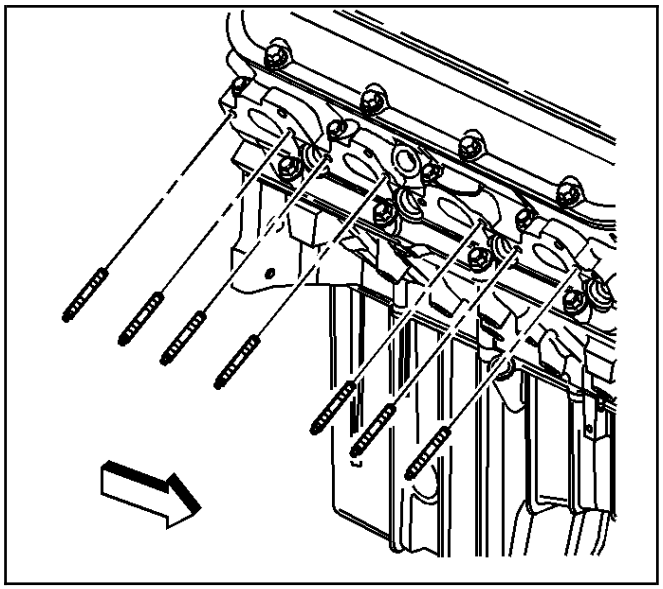


470725

11. Remove the right spark plugs.

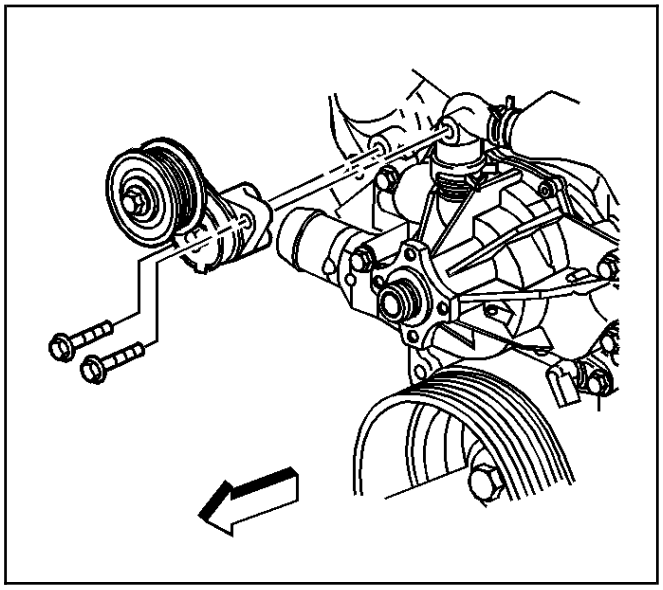


470727



470723

12. Remove the exhaust manifold studs, if necessary.

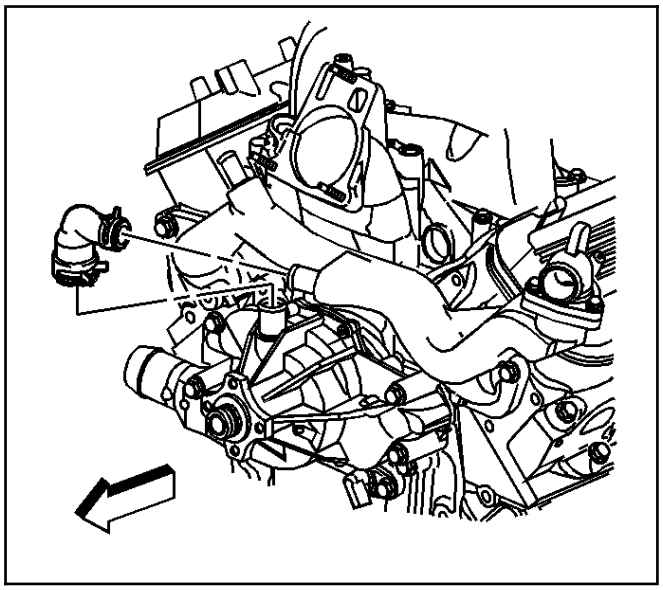


470789

Water Crossover Removal (C/K)

SIE-ID = 482688

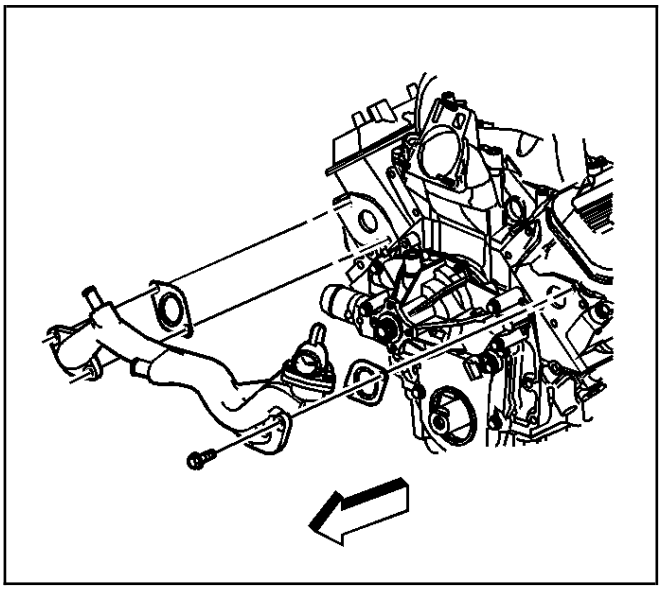
1. Remove the drive belt tensioner bolts.
2. Remove the drive belt tensioner.



470692

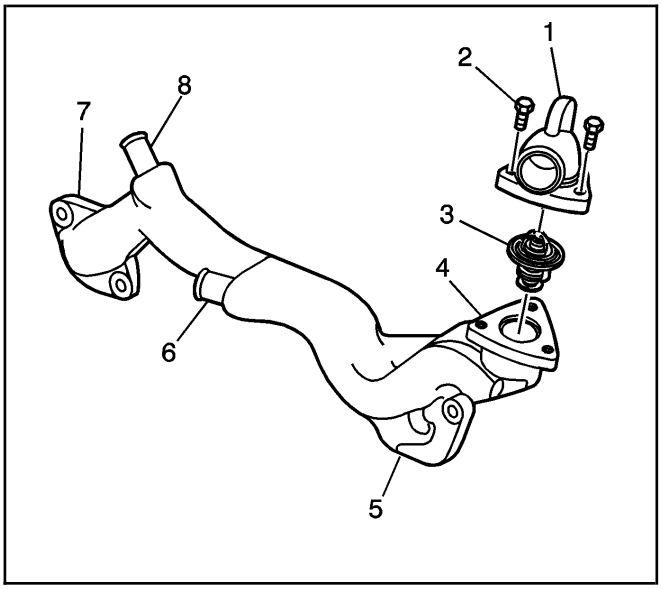
3. Remove the bypass hose.

4. Remove the coolant crossover bolts.
5. Remove the coolant crossover.
6. Remove the coolant crossover gaskets.



470698

7. Remove the water outlet bolts (2).
8. Remove the water outlet (1).
9. Remove the thermostat (3) from the coolant crossover.

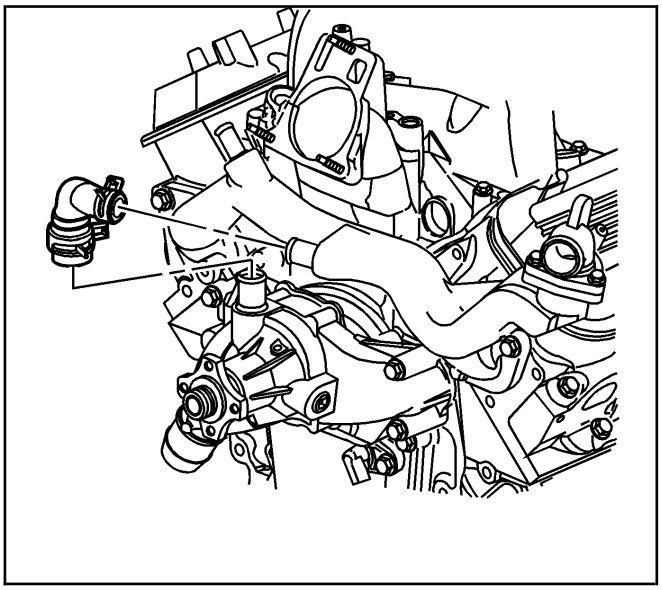


635643

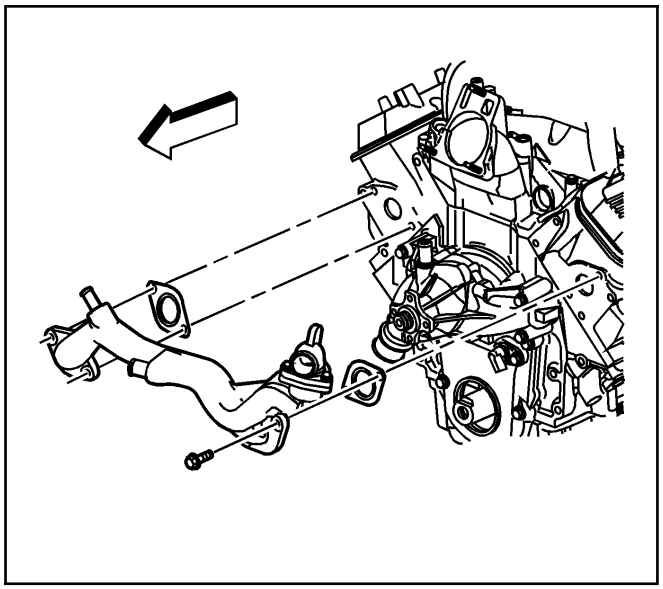
Water Crossover Removal (G/C3500HD)

SIE-ID = 678788

1. Remove the bypass hose.

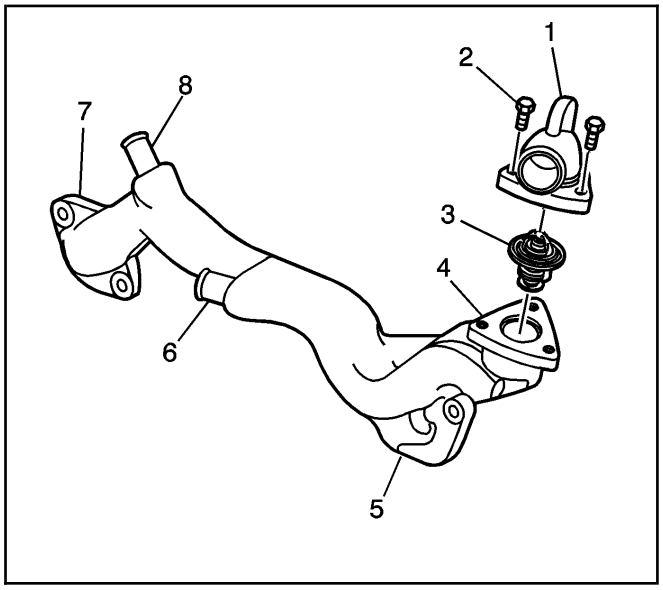


677790



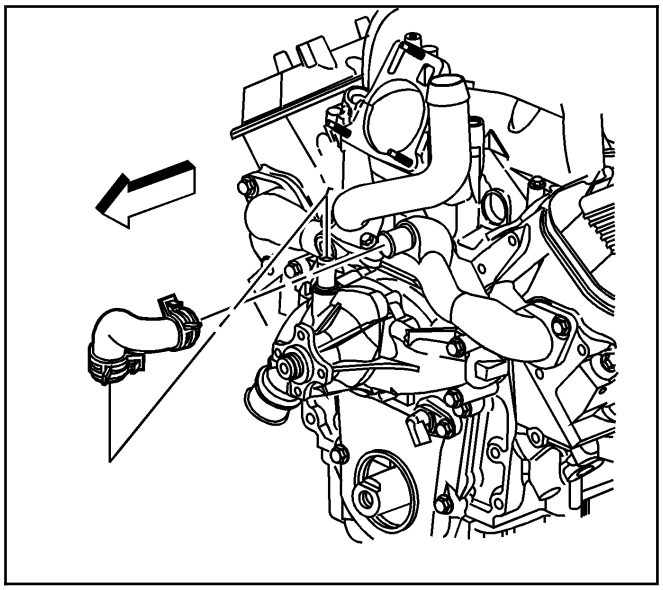
677782

2. Remove the coolant crossover bolts.
3. Remove the coolant crossover.
4. Remove the coolant crossover gaskets.



635643

5. Remove the water outlet bolts (2).
6. Remove the water outlet (1).
7. Remove the thermostat (3) from the coolant crossover.



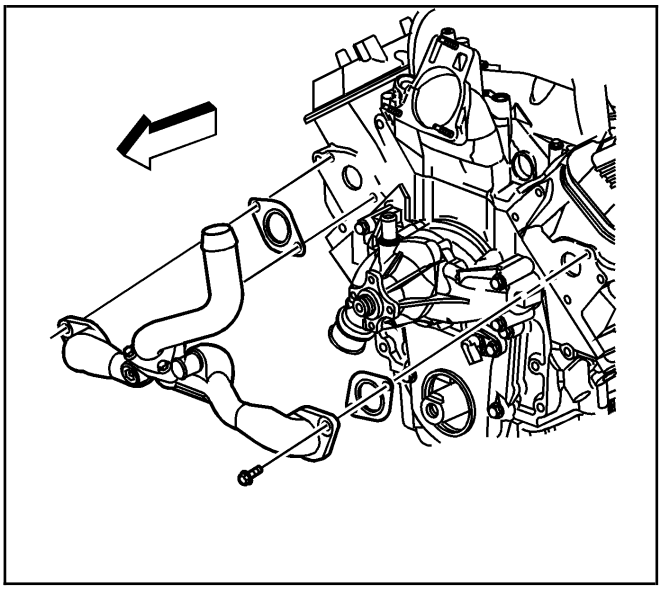
470694

Water Crossover Removal (Medium Duty)

SIE-ID = 482695

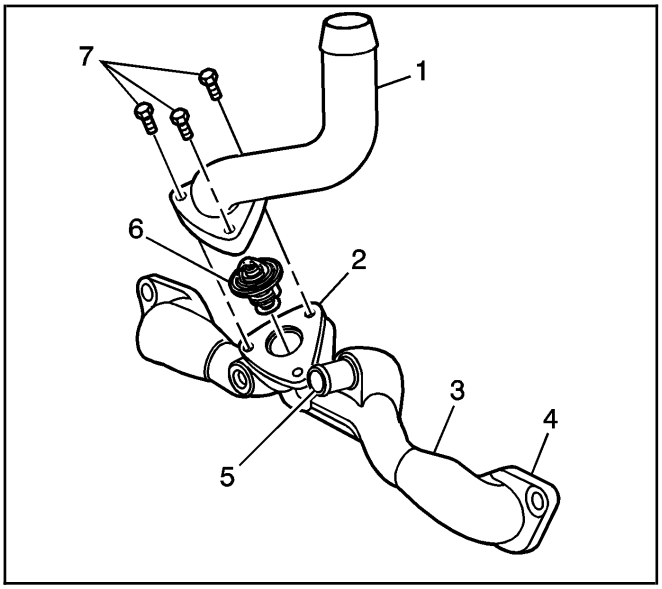
1. Remove the bypass hose.

2. Remove the coolant crossover bolts.
3. Remove the coolant crossover.
4. Remove the coolant crossover gaskets.



470699

5. Remove the water outlet bolts (7).
6. Remove the water outlet (1).
7. Remove the thermostat (6) from the coolant crossover.

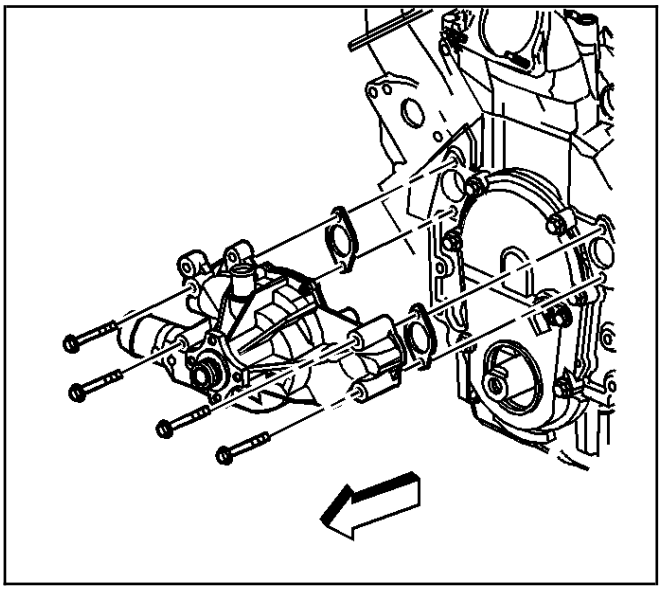


635646

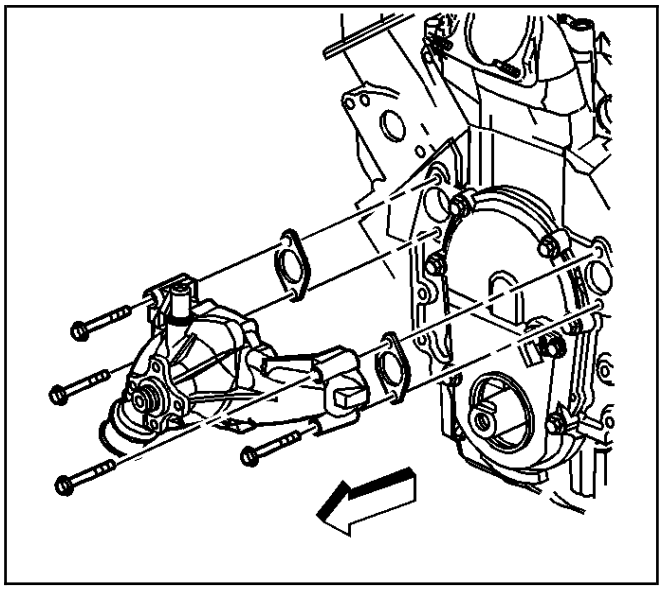
Water Pump Removal (C/K)

SIE-ID = 482700

1. Remove the water pump bolts.
2. Remove the water pump.
3. Remove the water pump gaskets.



470790

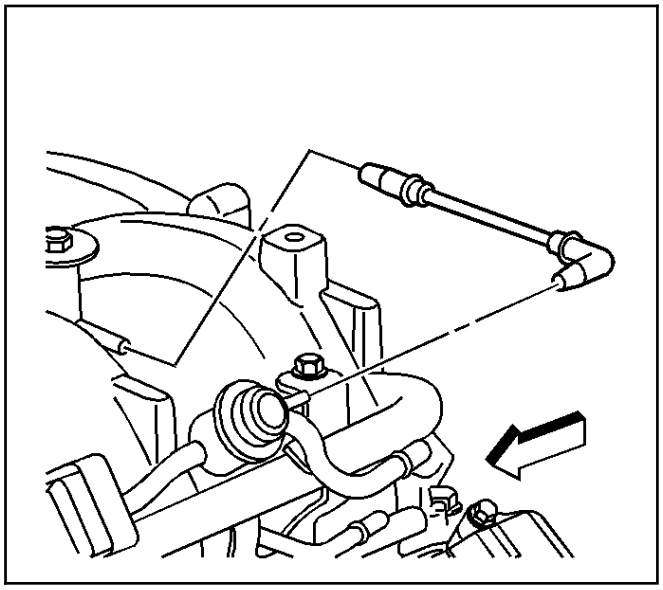


470792

Water Pump Removal (G/C3500HD/Medium Duty)

SIE-ID = 482702

1. Remove the water pump bolts.
2. Remove the water pump.
3. Remove the water pump gaskets.

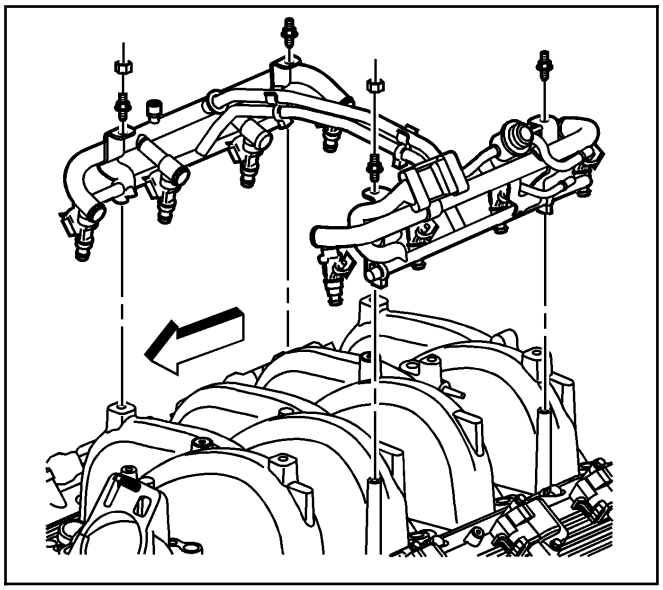


470770

Intake Manifold Removal

SIE-ID = 482715

1. Remove the fuel pressure regulator vacuum hose.



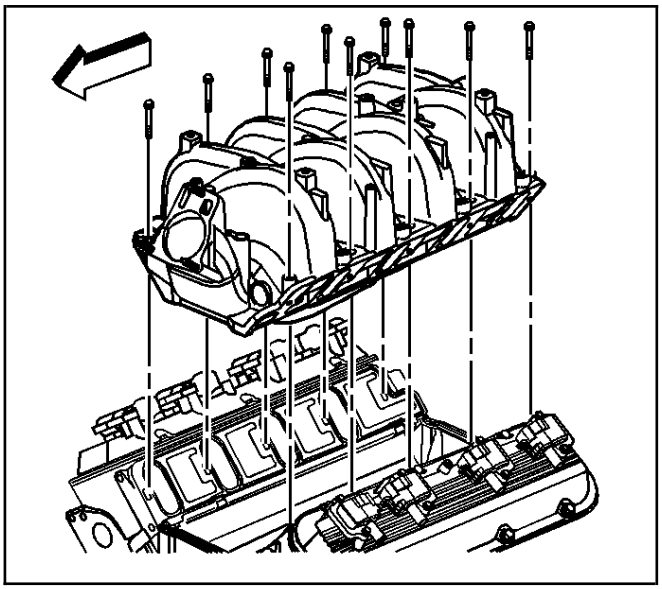
470774

2. Remove the fuel injection fuel rail bolts and/or studs.
3. Remove the fuel injection fuel rail.

4. Remove the intake manifold bolts.

Important: Do not attempt to loosen the manifold by prying under the gasket surface with any tool.

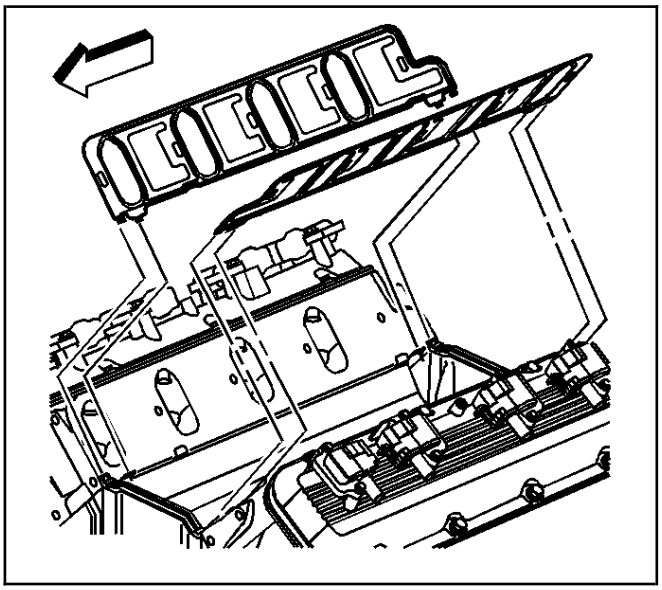
5. Remove the intake manifold.



470775

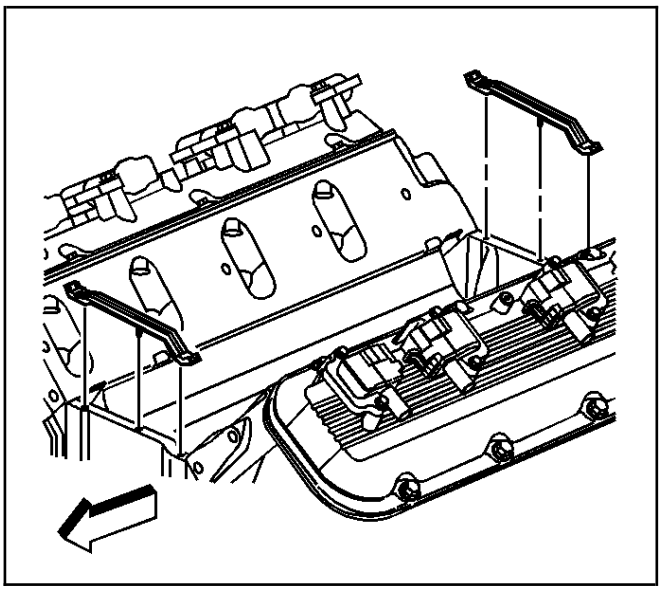
Important: The intake manifold gaskets are not reusable.

6. Remove and discard the intake manifold side gaskets.

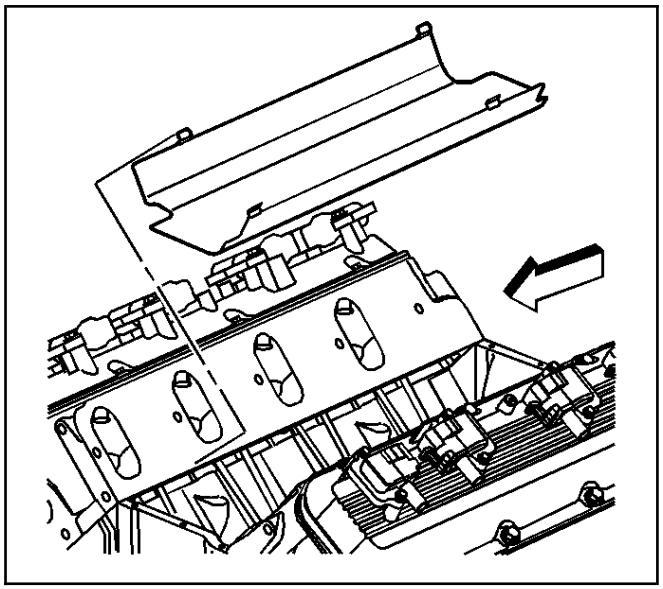


470779

7. Remove and discard the lower intake manifold end seals.



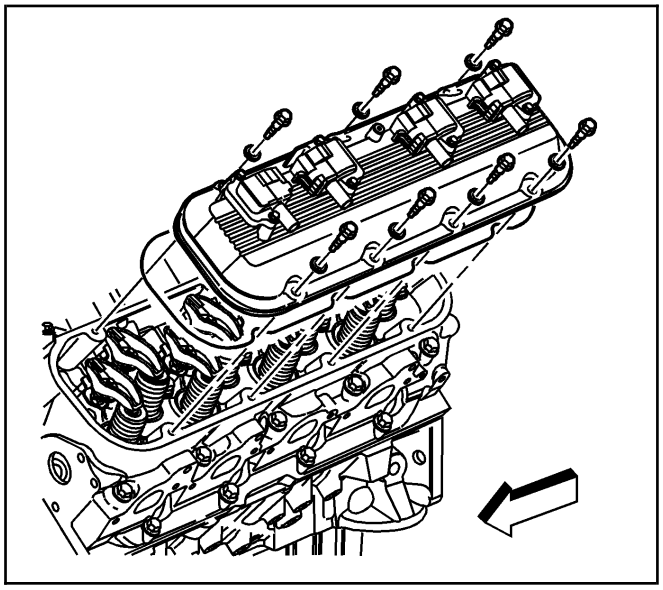
470783



470786

Important: The splash shield is secured using a snap-in fit. Do not distort the splash shield. The splash shield is reusable.

8. Remove the splash shield.



470890

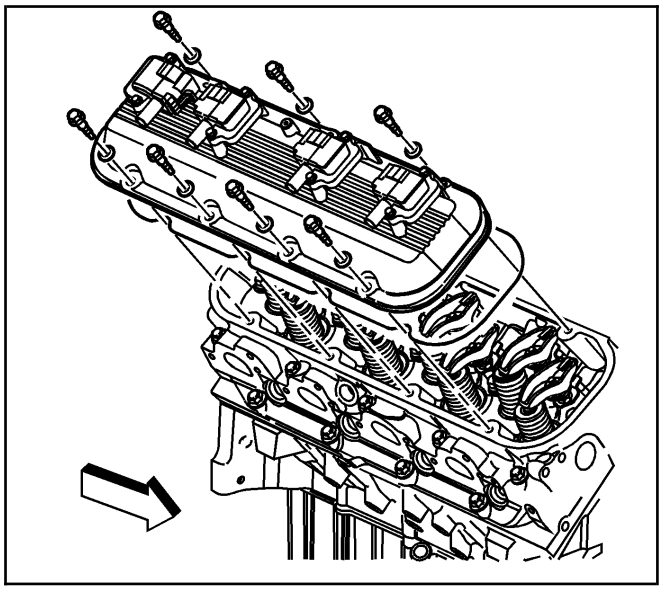
Valve Rocker Arm Cover Removal - Left

SIE-ID = 639158

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

Important: The valve rocker arm cover gasket may be reused if not removed from valve rocker arm cover.

3. Replace the valve rocker arm cover gasket if it is cut or damaged.



470897

Valve Rocker Arm Cover Removal - Right

SIE-ID = 639160

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

Important: The valve rocker arm cover gasket may be reused if not removed from the valve rocker arm cover.

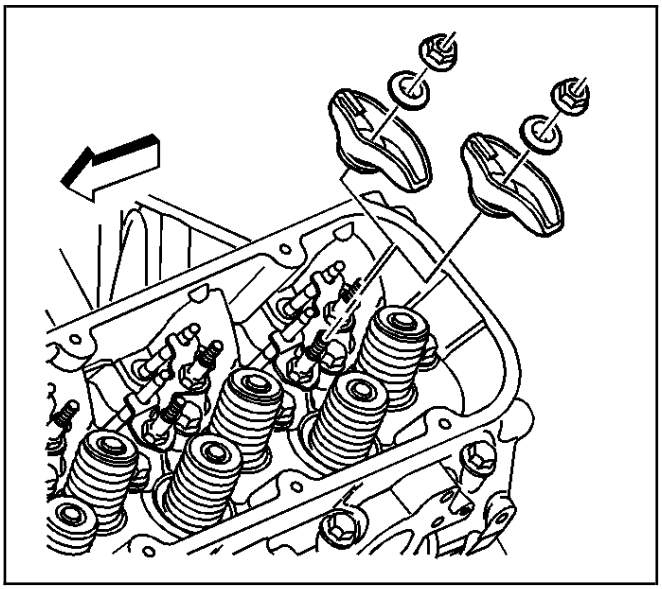
3. Replace the valve rocker arm cover gasket if it is cut or damaged.

Valve Rocker Arm and Push Rod Removal

SIE-ID = 482718

Important: Mark, organize and sort the cylinder head components. Return the components to their original location during reassembly. Make an organizer rack from a piece of wood.

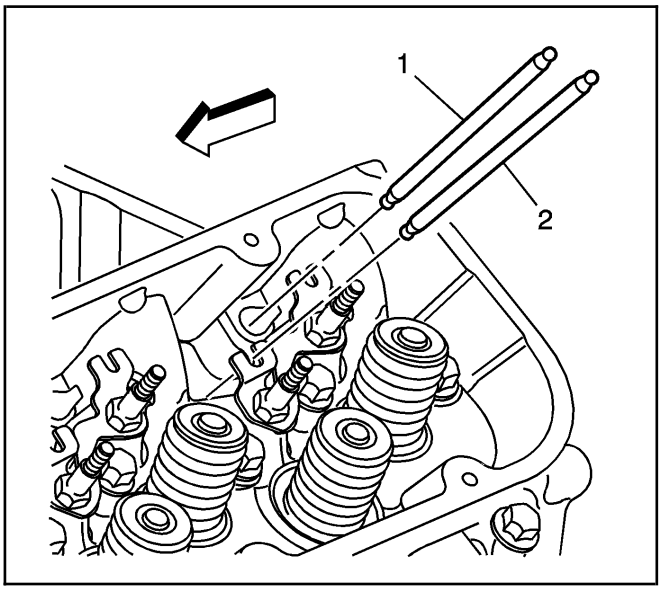
1. Remove the valve rocker arm nuts, the valve rocker arm balls and the valve rocker arms.



470899

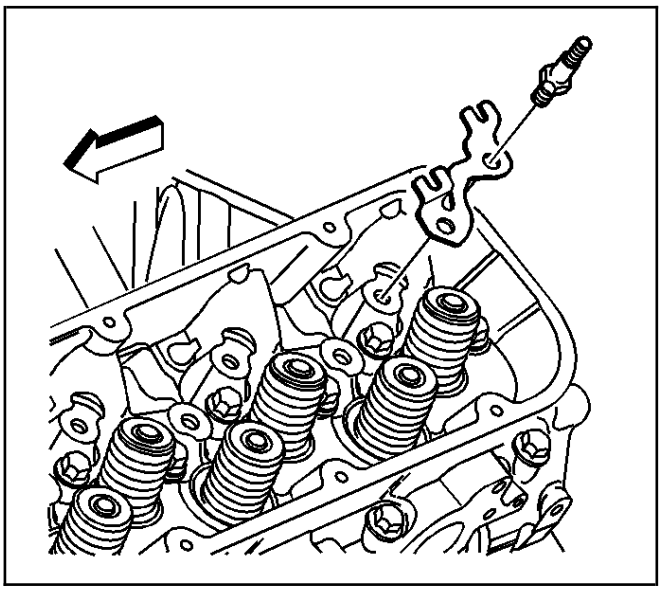
Important: The exhaust valve push rods (2) are longer than the intake valve push rods (1).

2. Remove the valve push rods.

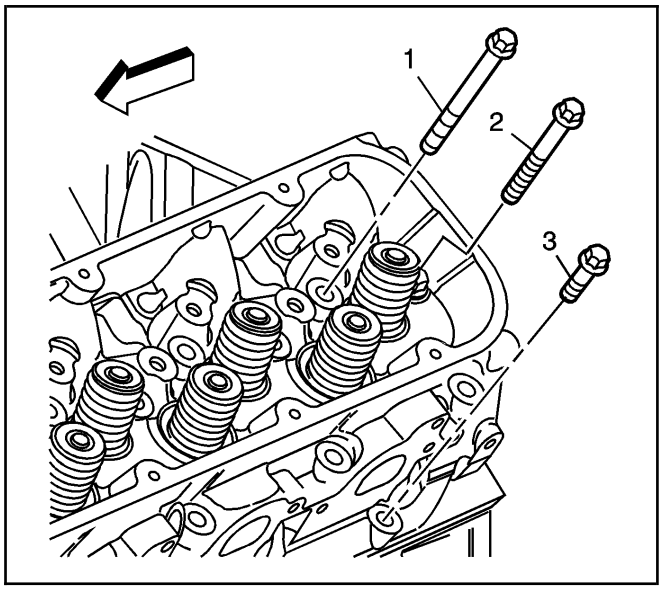


470903

3. Remove the valve rocker arm studs and push rod guides.



470906

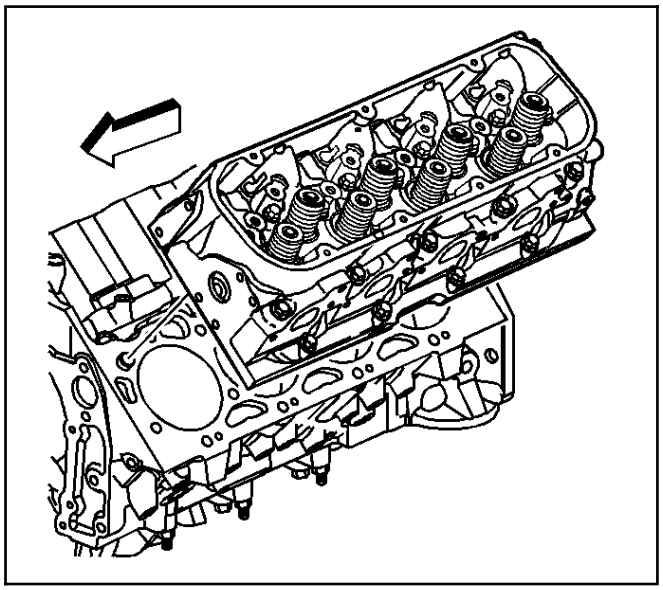


470914

Cylinder Head Removal - Left

SIE-ID = 639162

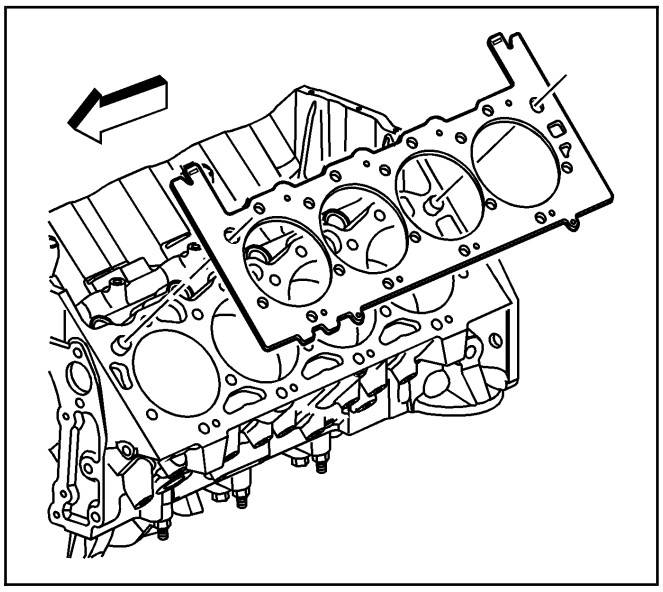
1. Remove and discard the eighteen cylinder head bolts (1, 2, 3).



470916

Important: Place cylinder head on two wood blocks to prevent damage to the sealing surfaces.

2. Remove the cylinder head.



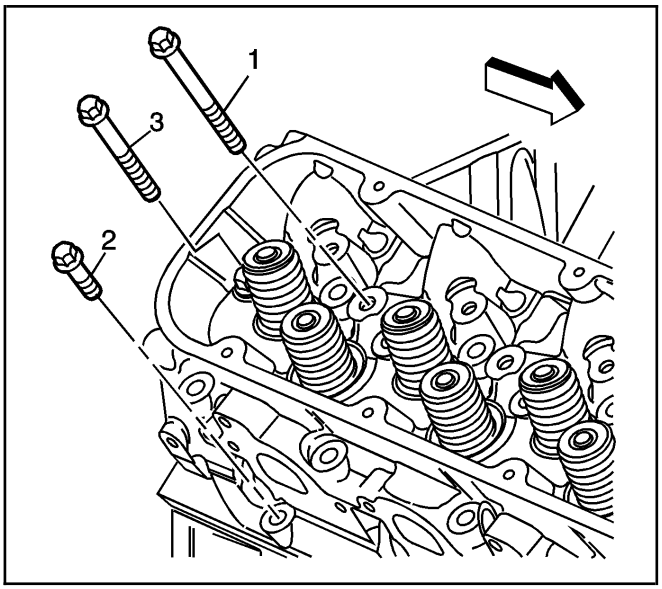
470974

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

Cylinder Head Removal - Right

SIE-ID = 639164

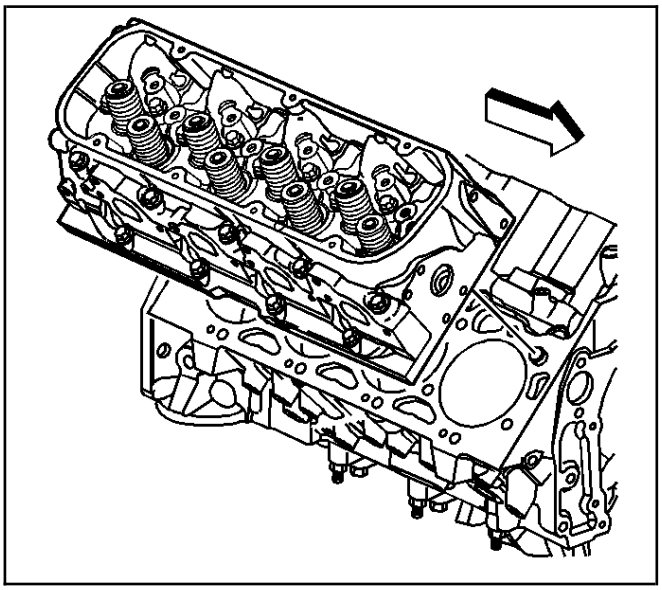
1. Remove and discard the eighteen cylinder head bolts (1, 2, 3).



470989

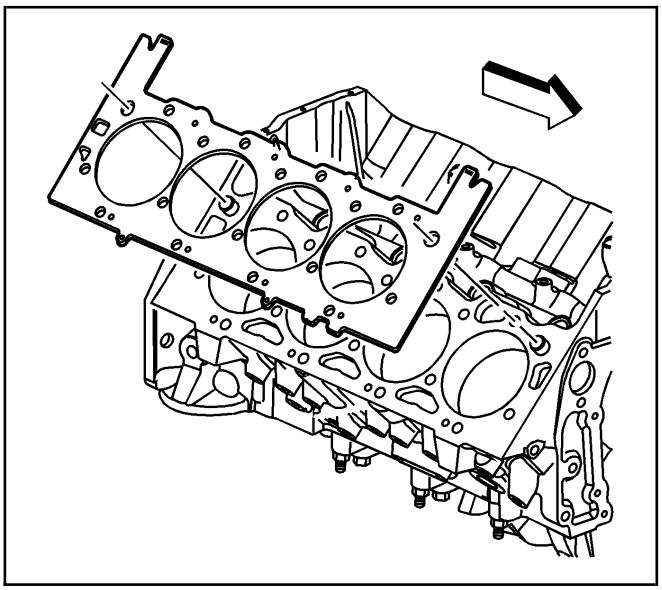
Important: Place cylinder head on two wood blocks to prevent damage to the sealing surfaces.

2. Remove the cylinder head.

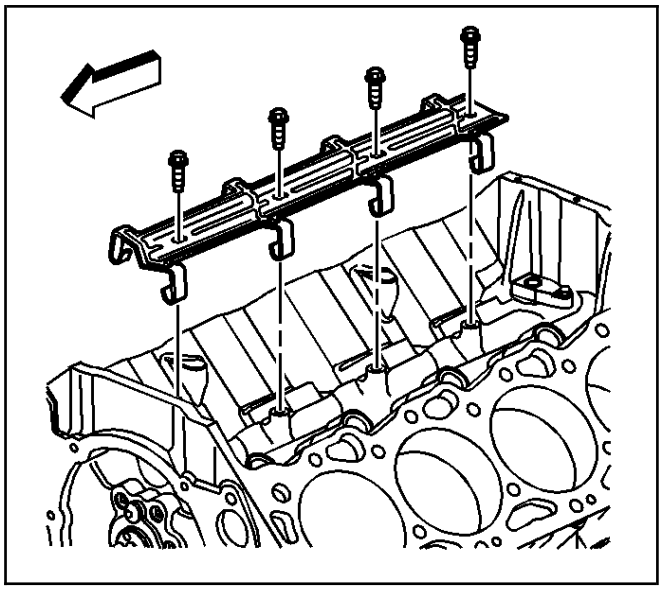


470991

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



470992



470994

Valve Lifter Removal

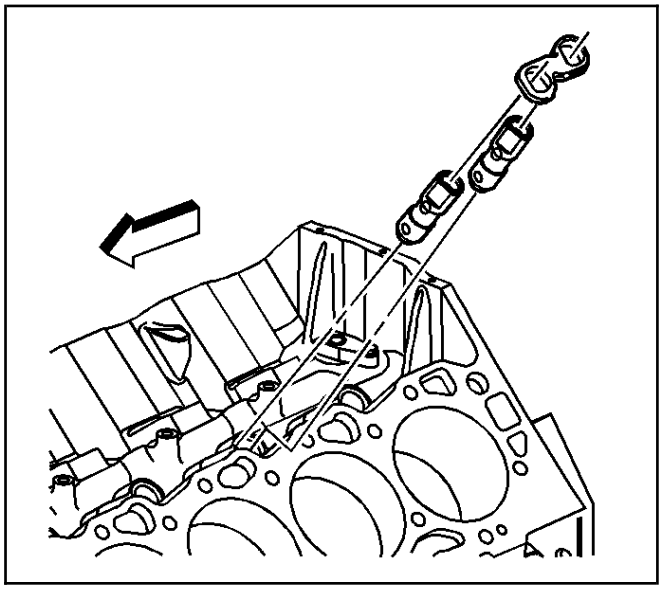
SIE-ID = 482727

Tools Required

J 3049 Valve Lifter Remover (Plier Type)

Important: Mark, sort, or organize the valve lifters and guides for return to their original location during assembly.

1. Remove the valve lifter guide retainer bolts and retainer.

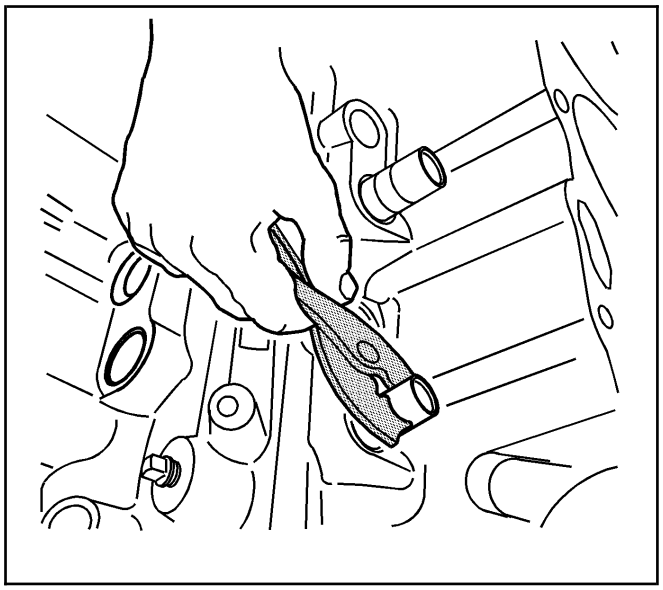


470996

2. Remove the valve lifter guides.

Important: Place the valve lifters in the organizer rack or tag them in a way to ensure they can be returned to the valve lifter bore from which they were removed.

3. Remove the valve lifters.



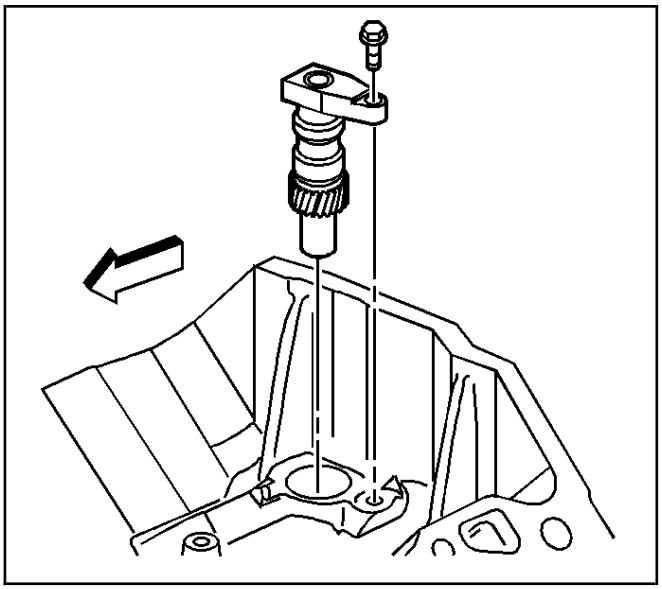
719128

4. Some valve lifters may be stuck in their bore due to gum or varnish deposits. These valve lifters can be removed using *J 3049*.

Oil Pump Drive Removal

SIE-ID = 482731

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

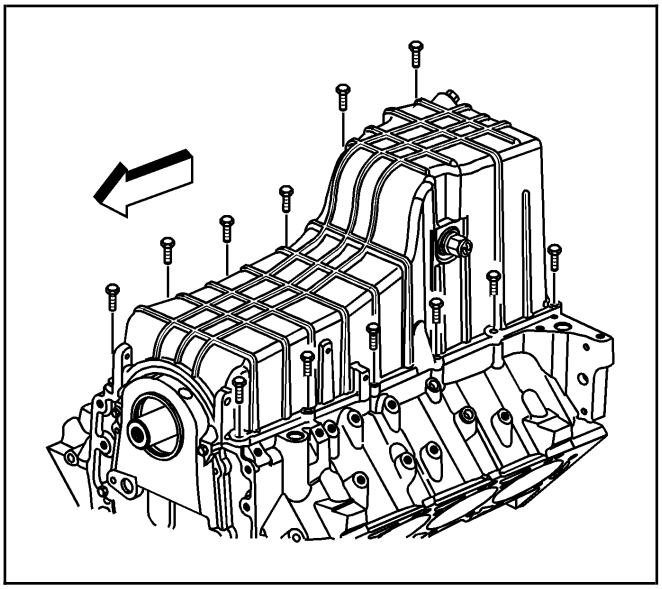


470910

Oil Pan Removal (C/K/G/C3500HD)

SIE-ID = 482733

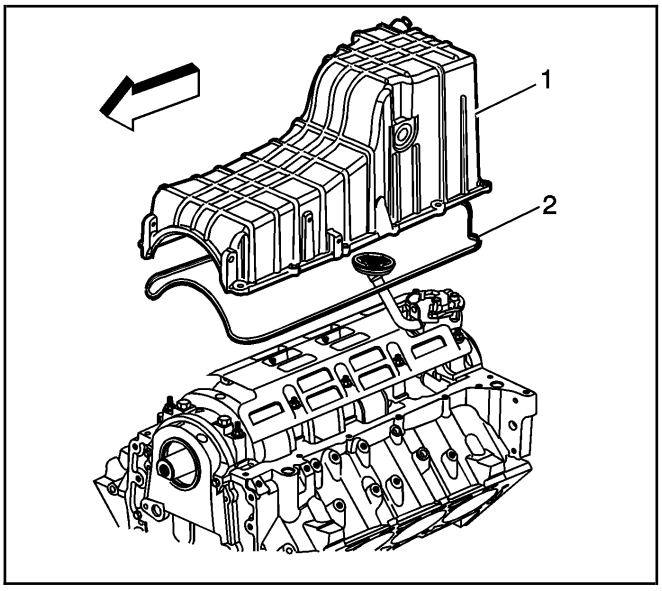
1. Remove the oil level switch from the oil pan, if equipped.
2. Remove the oil pan bolts.



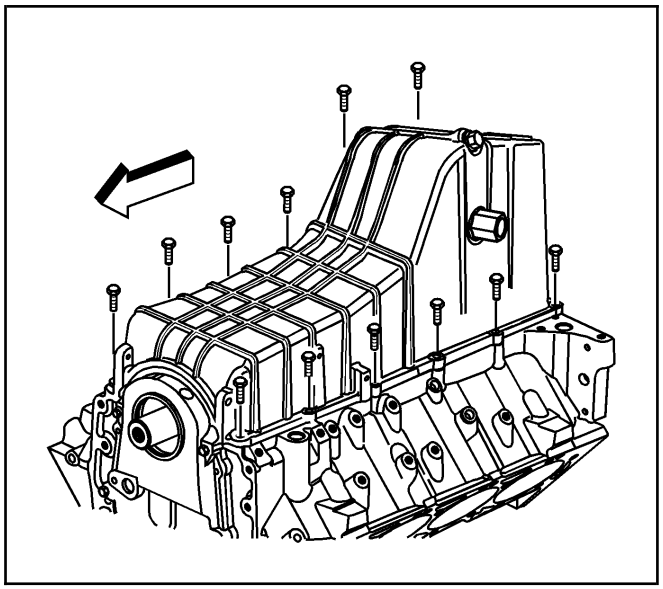
635648

Important: The oil pan gasket is reusable if not cut or damaged.

3. Remove the oil pan (1) and the captured oil pan gasket (2).



635654

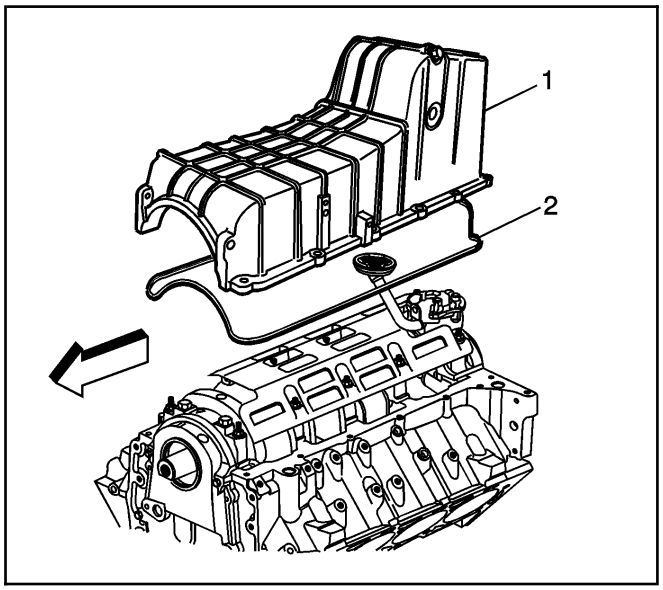


635651

Oil Pan Removal (Medium Duty)

SIE-ID = 482736

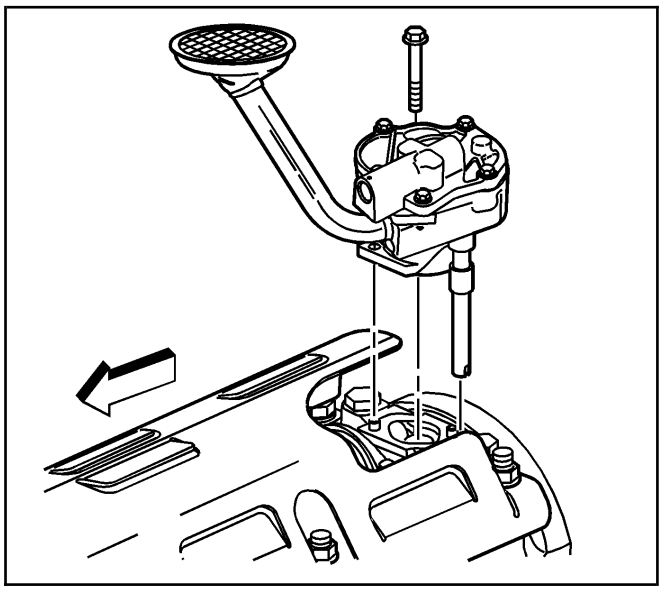
1. Remove the oil level switch from the oil pan.
2. Remove the oil pan bolts.



635649

Important: The oil pan gasket is reusable if not cut or damaged.

3. Remove the oil pan (1) and the captured oil pan gasket (2).



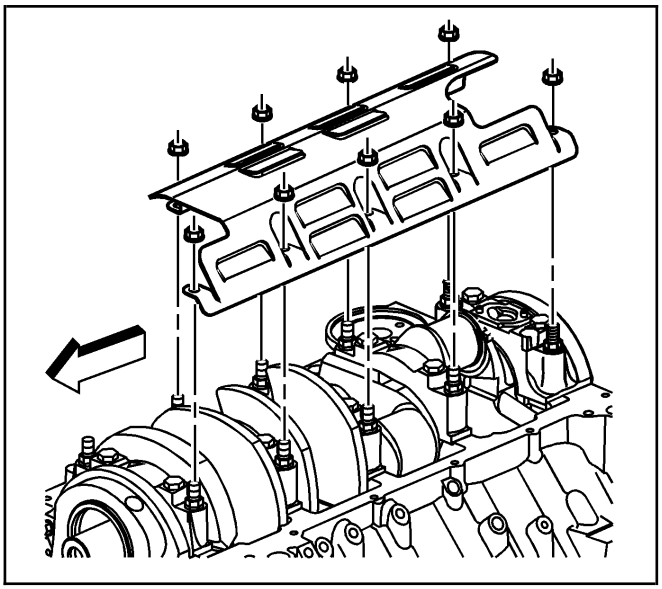
635701

Oil Pump, Pump Screen and Deflector Removal

SIE-ID = 482738

1. Remove the bolt that attaches the oil pump to the rear crankshaft bearing cap.
2. Remove the oil pump, driveshaft and retainer from the rear crankshaft bearing cap.
3. Separate the oil pump, driveshaft and retainer.
4. Discard the driveshaft retainer.

5. Remove the crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.



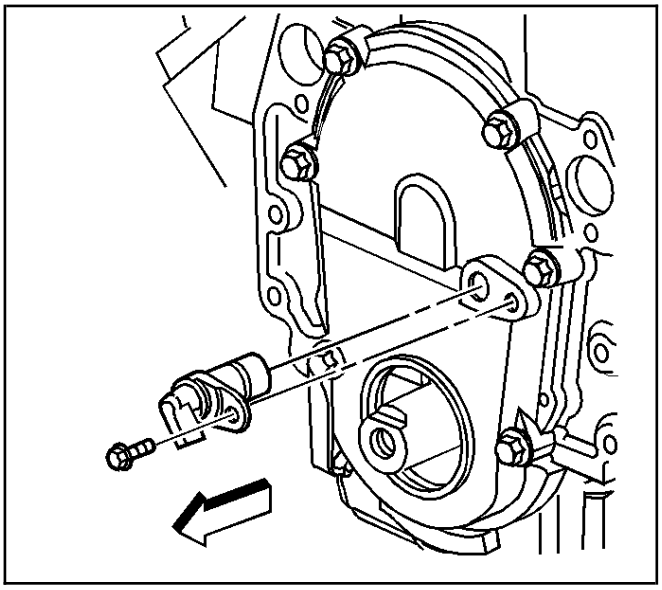
635703

Engine Front Cover Removal

SIE-ID = 482739

Notice: SIO-ID = 728980 This component is initially installed using a self-tapping bolt(s). Care should be taken when removing and/or installing the self-tapping bolt(s). Failure to use care when removing and/or installing the self-tapping bolt(s) can lead to damage and unnecessary replacement of the self-tapping bolt(s) and/or the component the self-tapping bolt(s) is threaded into.

1. Remove the camshaft position sensor bolt.
2. Remove the camshaft position sensor.
3. Inspect the camshaft position sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring as needed.

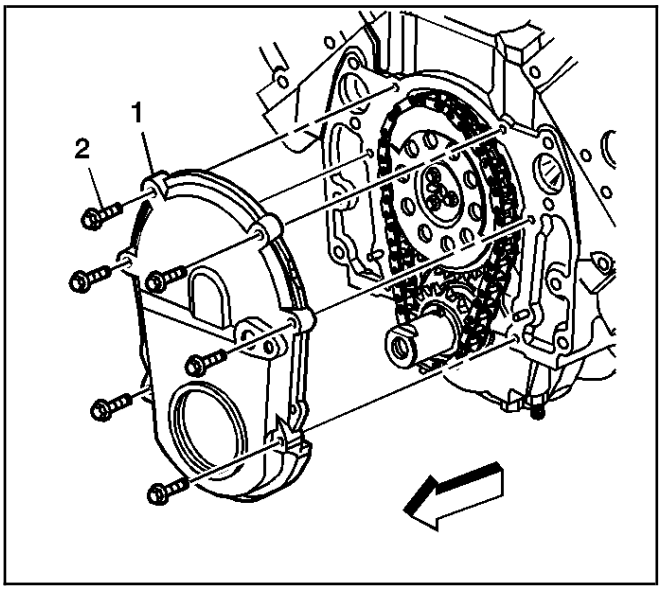


470803

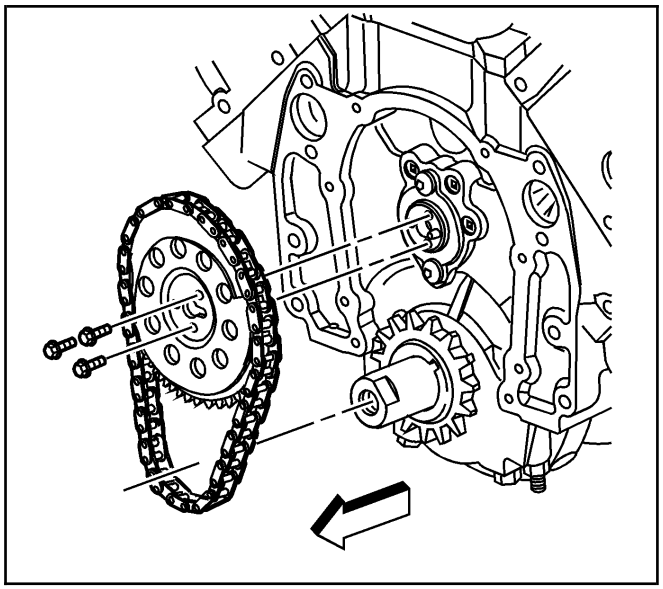
4. Remove the engine front cover bolts (2).
5. Remove the engine front cover (1).

Important: The engine front cover gasket is reusable.

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



470805



470814

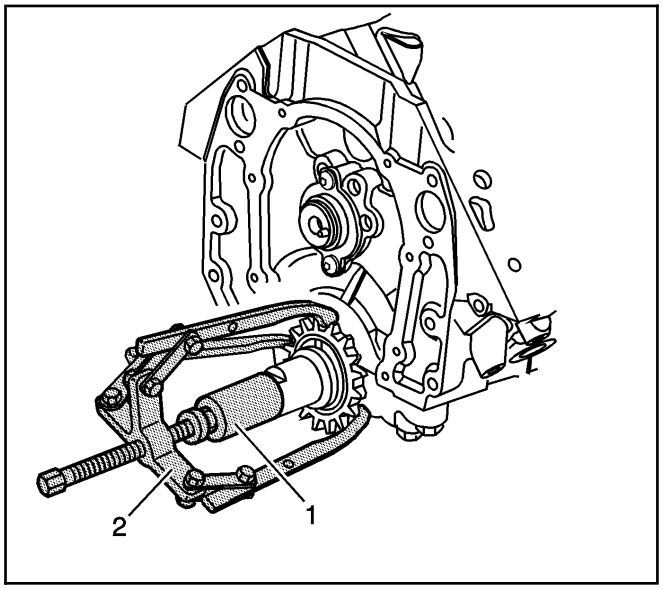
Timing Chain and Sprockets Removal

SIE-ID = 482740

Tools Required

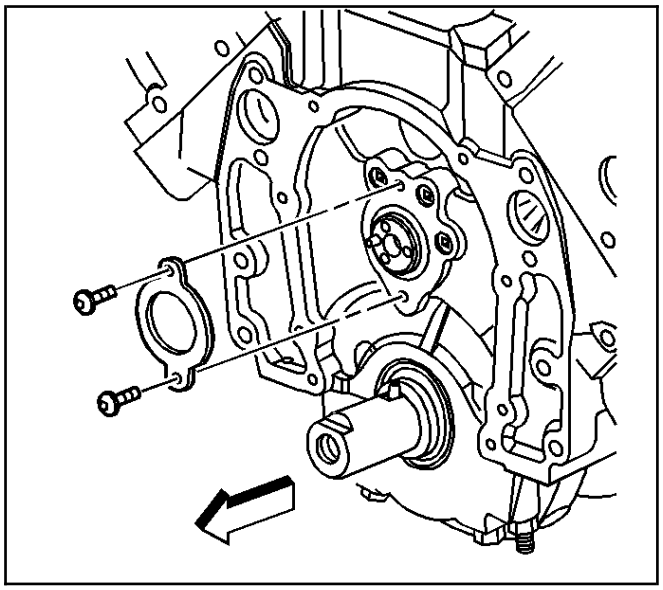
J 42846 Crankshaft Protector Button

1. Measure the camshaft timing chain free play. If the chain can be moved back and forth in excess of 16 mm (0.625 in), make a note that the camshaft timing chain and the sprockets must be replaced during assembly.
2. Remove the camshaft sprocket bolts.
3. Remove the camshaft sprocket and the camshaft timing chain.



639535

4. Install the *J 42846* (1) into the end of the crankshaft.
5. Remove the crankshaft sprocket using a suitable three jaw puller (2).



470998

Camshaft Removal

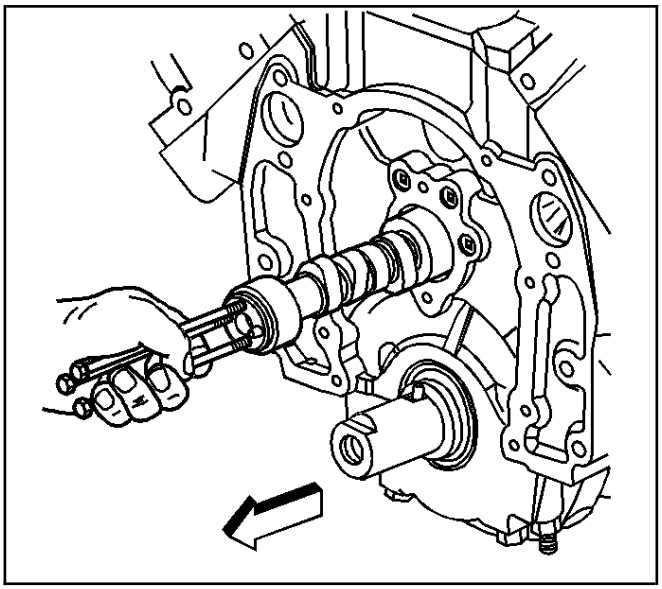
SIE-ID = 482741

1. Remove the camshaft retainer bolts.
2. Remove the camshaft retainer.

3. Install three 8-1.25 x 100 mm bolts in the 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.

4. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
5. Remove the bolts from the front of the camshaft.



471002

Piston, Connecting Rod, and Bearing Removal

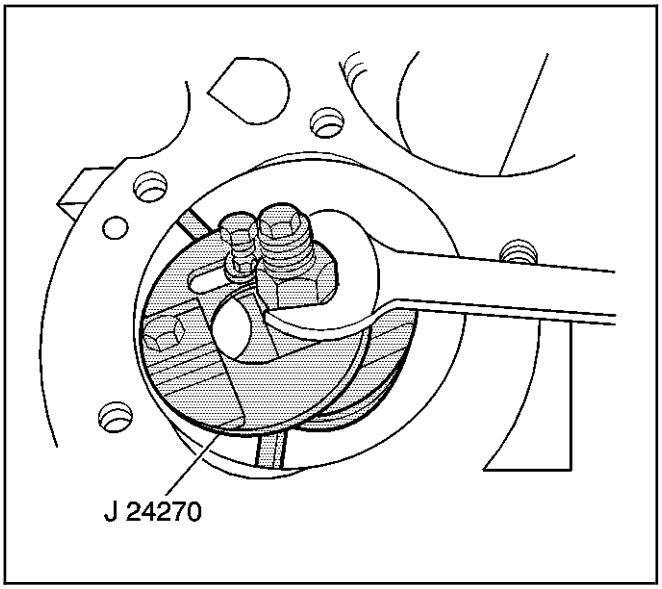
SIE-ID = 482742

Tools Required

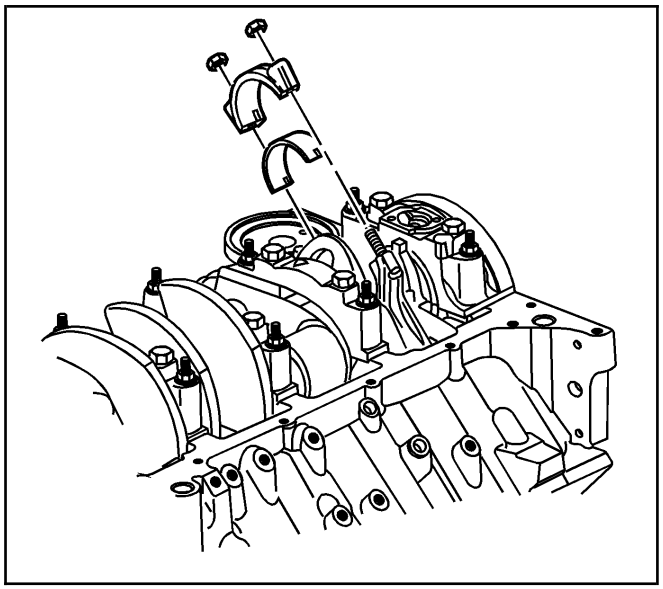
- *J 24270* Cylinder Bore Ridge Reamer
- *J 42846* Crankshaft Protector Button

Important: Do not remove the excessive material from the cylinder bore. Excessive removal of material may require cylinder boring to the next oversize.

1. Remove the cylinder bore ridge as necessary.
   1.1. Install the *J 42846* onto the front of the crankshaft in order to turn the crankshaft.
   1.2. Rotate the crankshaft until the piston is at the bottom of the stroke (BDC).
   1.3. Place a cloth on top of the piston.
   1.4. Perform the cutting operation with a *J 24270*. Refer to the manufacturer's instructions before using the *J 24270*.
   1.5. Remove the *J 24270*.
   1.6. Rotate the crankshaft until the piston is at top dead center (TDC).
   1.7. Remove the cloth and the cuttings.
   1.8. Repeat the procedure for each piston.



11497

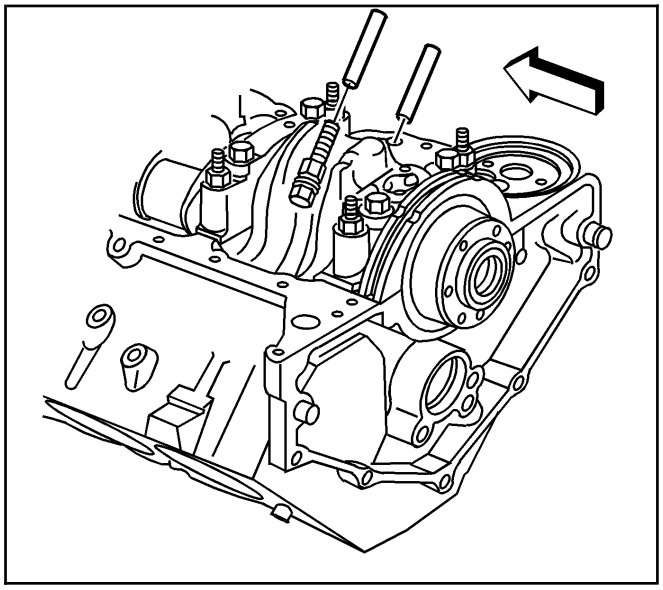


639084

Important: Place the matching marks or numbers on the connecting rods and the connecting rod caps. The connecting rod caps must be assembled to their original connecting rods.

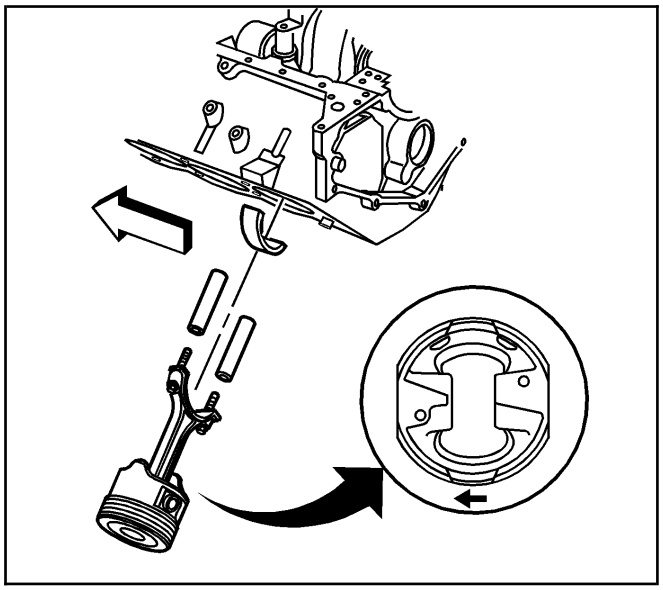
Important: When connecting rod bearings are removed, NEW bearings must be installed.

2. Remove the connecting rod nuts.
3. Remove the connecting rod cap and the lower connecting rod bearing.



639533

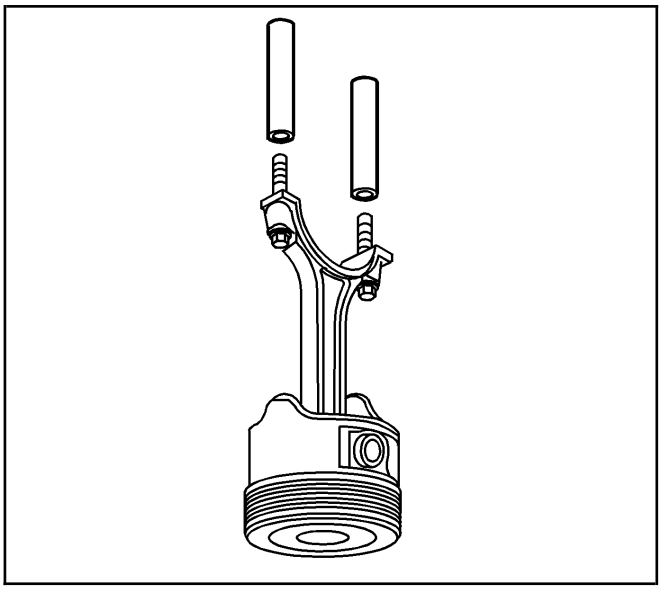
4. Install rubber fuel line onto the connecting rod bolts to prevent contact with the crankshaft.



639536

5. Remove the piston, connecting rod and upper connecting rod bearing out of the top of the engine block.

6. Remove the rubber fuel line from the connecting rod bolts.
7. Remove the remaining piston and the connecting rod assemblies.
8. Remove the *J 42846* from the front of the crankshaft.



639532

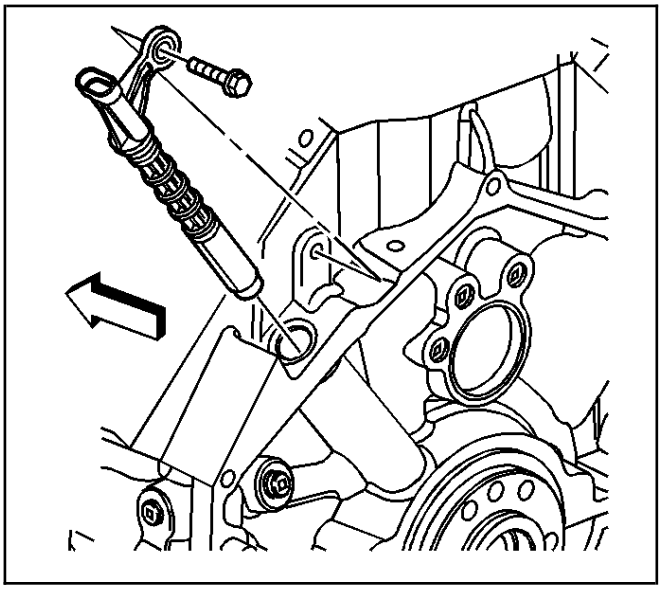
Crankshaft and Bearings Removal

SIE-ID = 482745

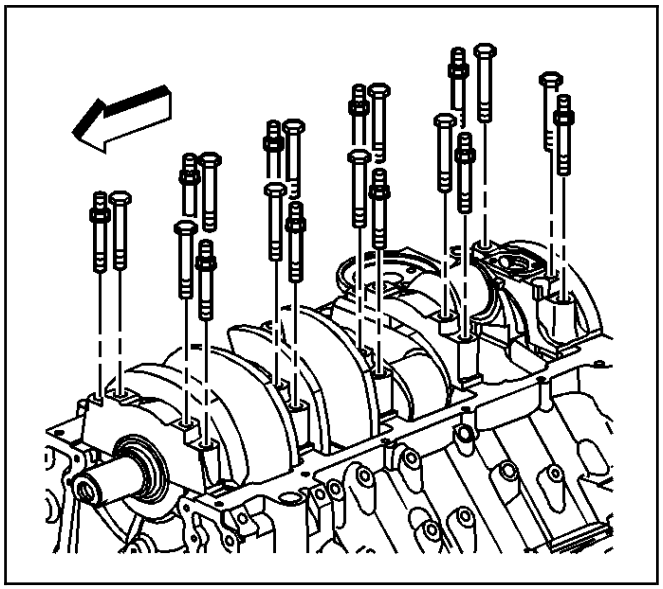
Notice: SIO-ID = 728987 In order to prevent damage to the crankshaft position sensor reluctor wheel/ring care must be used when removing or installing this component.

Important: The crankshaft position sensor is designed to contact the reluctor wheel of the crankshaft. Wear may be noticeable on the end of the sensor.

1. Remove the crankshaft position sensor bolt.
2. Apply penetrating oil to the crankshaft position sensor-to-engine block mating surface. Allow the penetrating oil to soak for several minutes, to help loosen the O-ring from the engine block.
3. Twist the sensor to break the O-ring seals loose. When removing the sensor, pull the sensor straight out of the engine block at the same angle the sensor was installed.
4. Inspect both crankshaft position sensor O-rings for cuts, cracks, tears or damage. Replace the O-rings as needed.



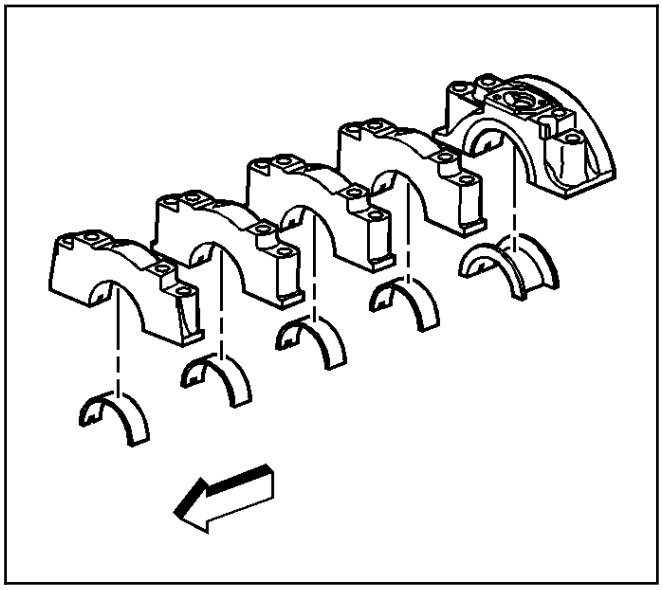
470801



471055

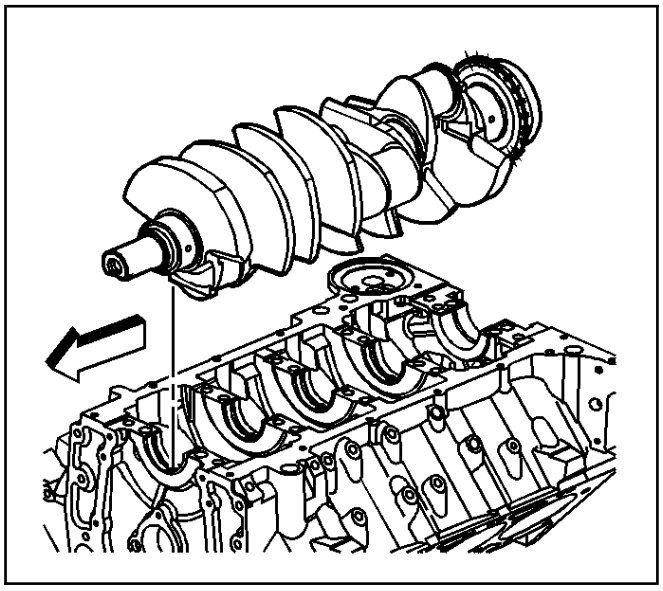
Important: Crankshaft bearing caps are machined with the engine block for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. Crankshaft bearing caps must be installed in their original locations.

5. Remove the crankshaft bearing cap bolts and studs.



471044

6. Remove the crankshaft bearing caps.
7. Remove the crankshaft lower bearings from the crankshaft bearing caps.

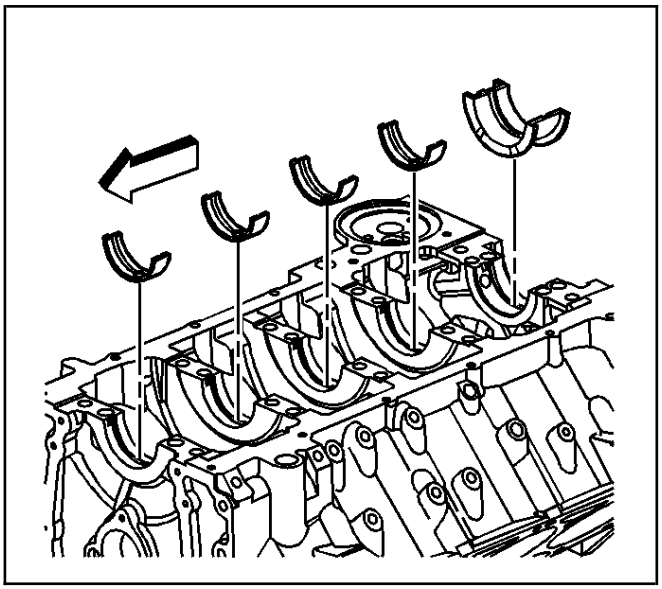


471047

Important: Care should be taken when removing the crankshaft so that the crankshaft position sensor reluctor ring is not damaged.

8. Remove the crankshaft.

9. Remove the crankshaft upper bearings from the engine block.

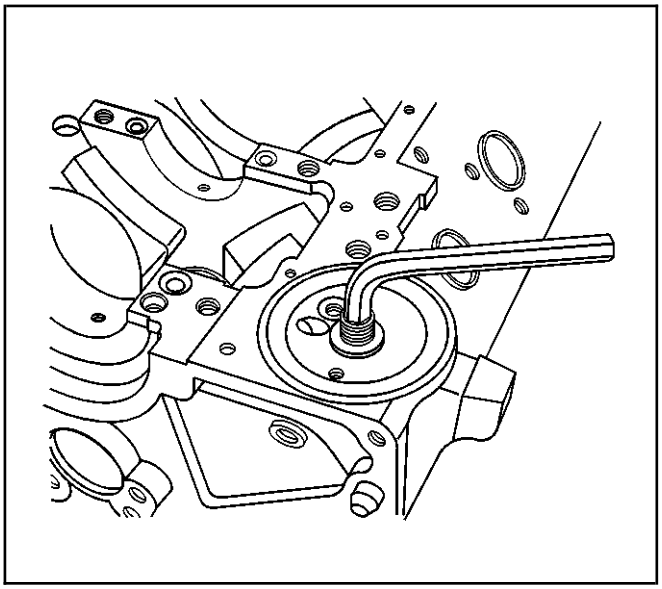


471041

Oil Filter Adapter Removal

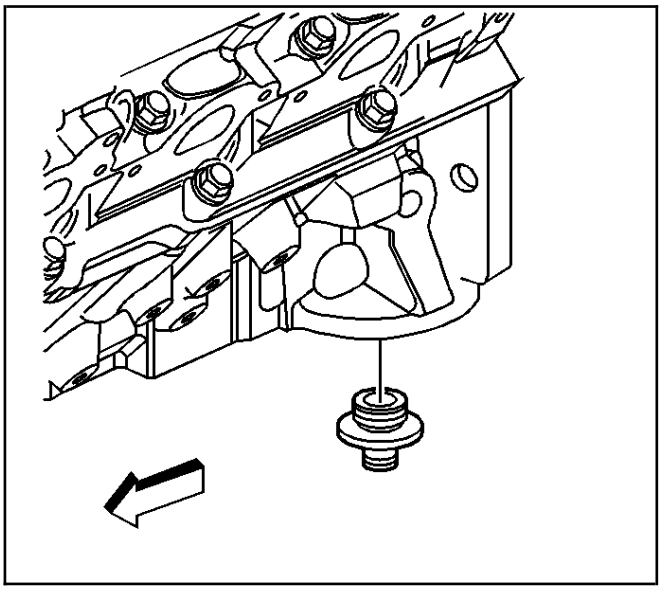
SIE-ID = 482746

1. Loosen the oil filter fitting, using a hex wrench.

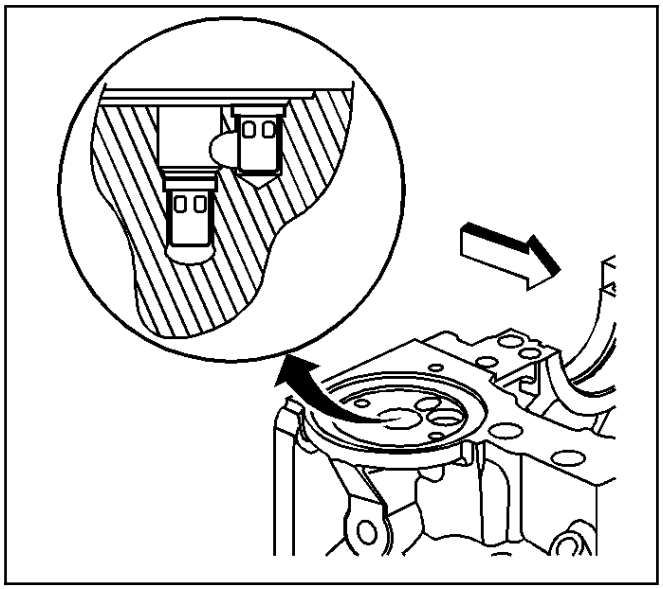


452375

2. Remove the oil filter fitting.
3. Inspect the oil filter fitting, replace if necessary.

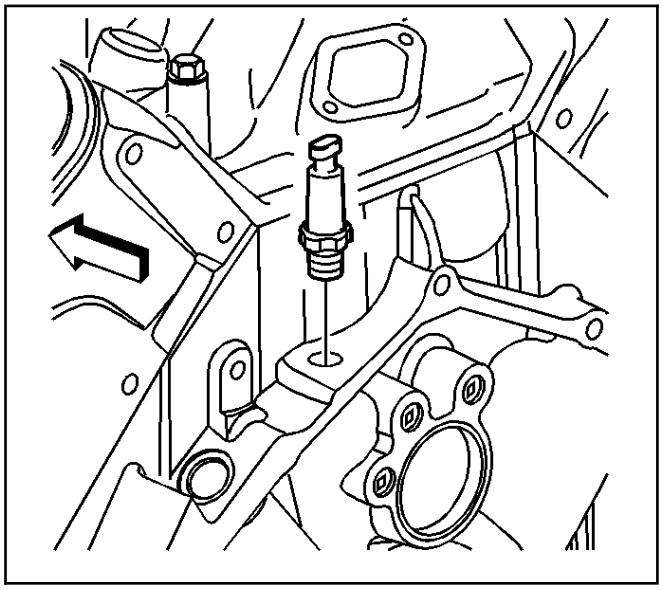


471026



471143

4. Remove the oil bypass valves (if required). Unstake the tangs on the oil bypass valves and remove with long nose pliers.
5. Discard the oil bypass valves, if removed.



471089

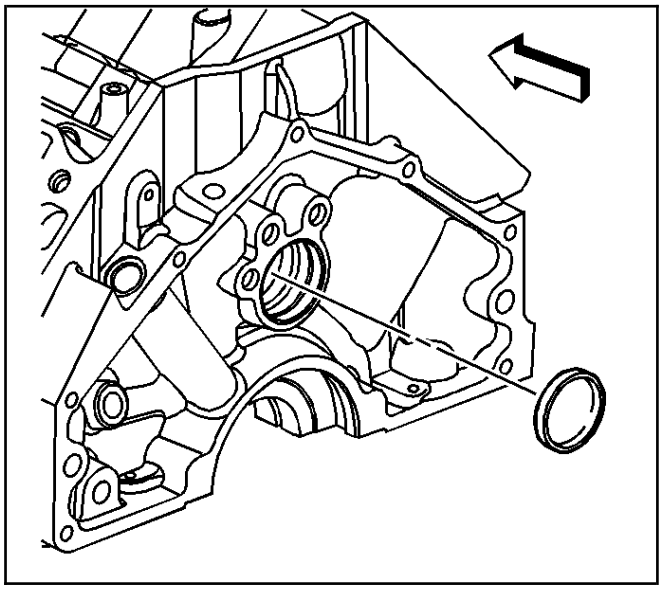
Engine Block Plug Removal (C/K/G/C3500HD)

SIE-ID = 482748

Tools Required

J 41712 Oil Pressure Sending Unit Socket

1. Remove the oil pressure switch using *J 41712*.

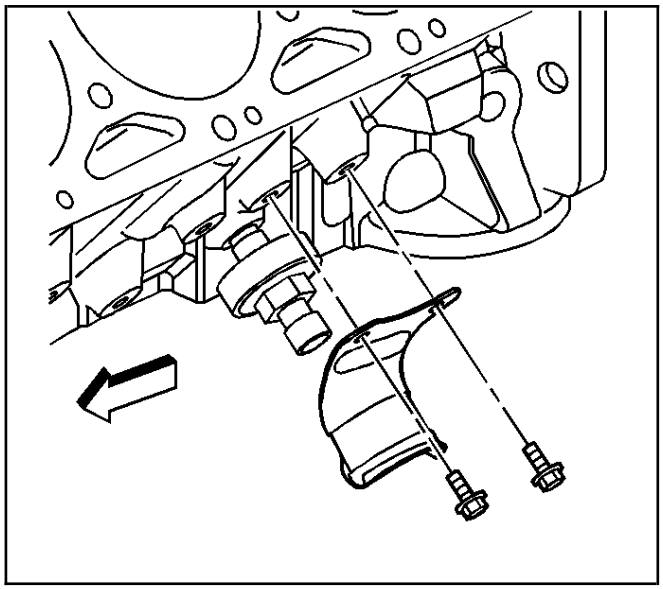


471118

Important: Use care not to damage the camshaft bearings.

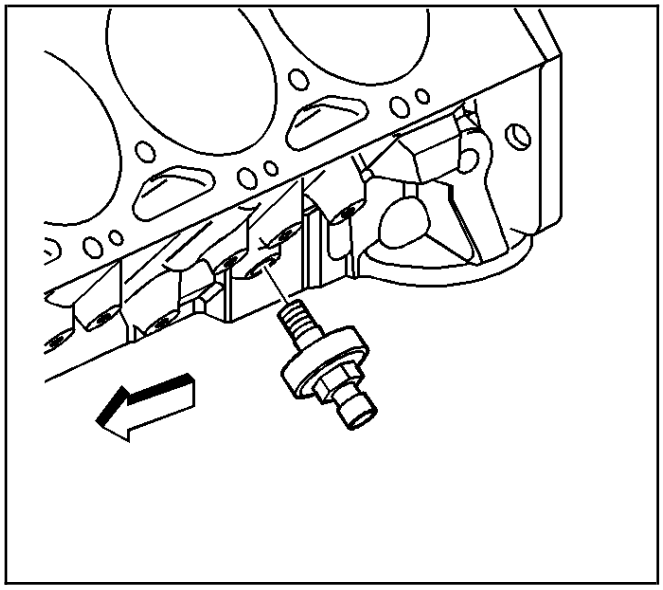
2. Remove the camshaft rear bearing hole plug:
   2.1. Obtain a suitable self-threading screw.
   2.2. Drill a hole into the plug.
   2.3. Install the self-threading screw.
   2.4. Pull on the plug until it has left the bore.
   2.5. An alternate method to remove the plug would be to insert a long shaft or bar through the front of the engine and drive the plug from the bore.

3. Remove the left side knock sensor shield bolts.
4. Remove the left side knock sensor shield.



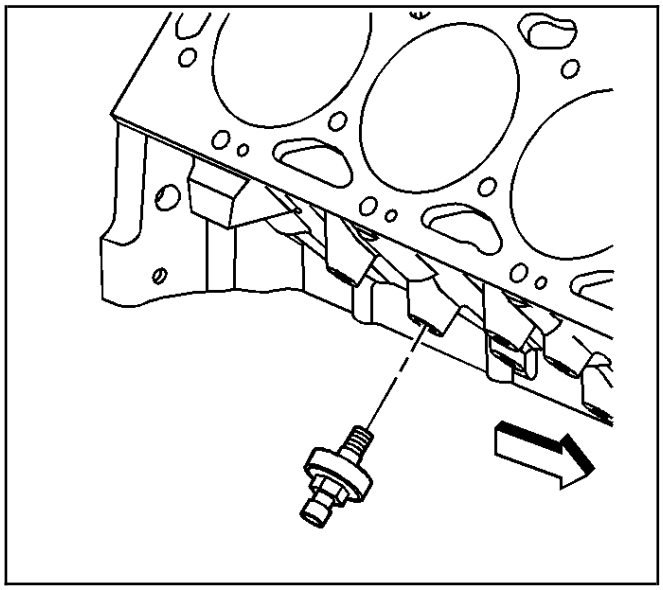
471100

5. Remove the left side knock sensor.

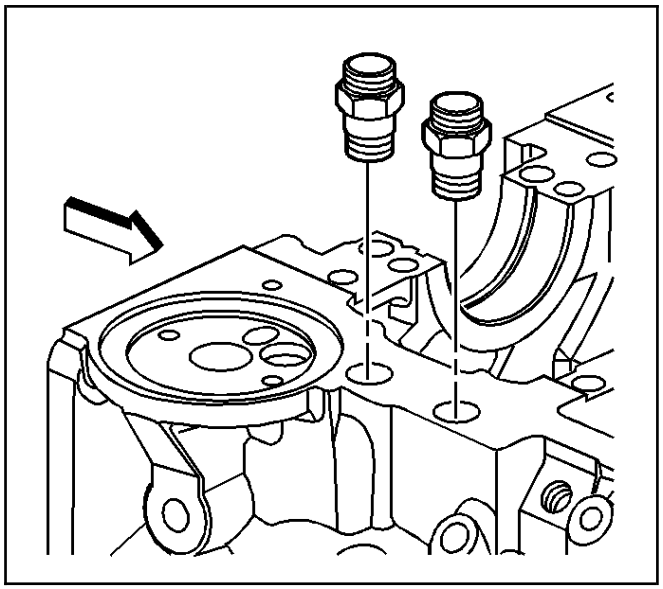


471081

6. Remove the right side knock sensor.

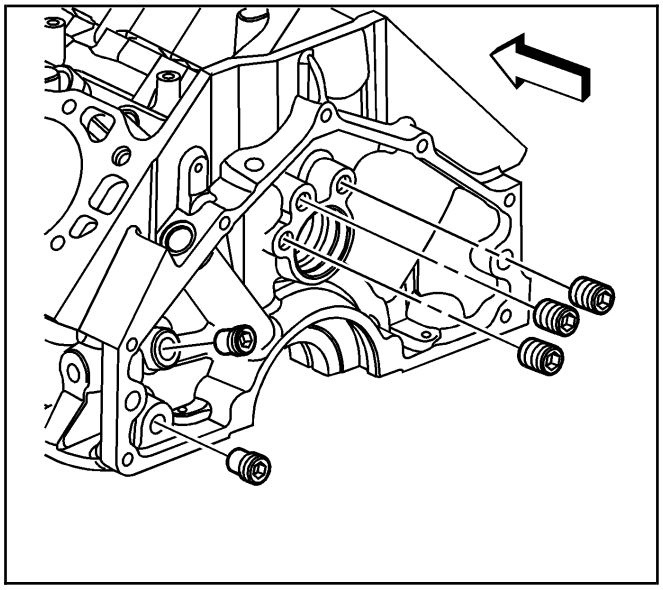


471076



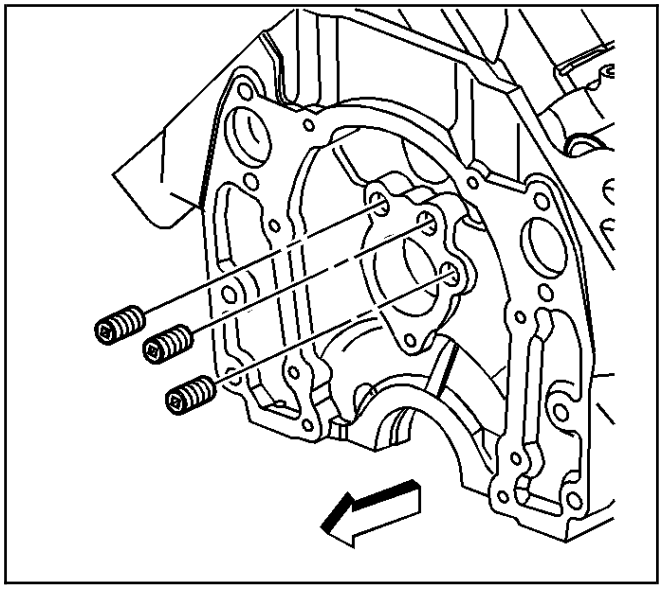
471126

7. Remove the engine block oil cooler hose fittings.



471134

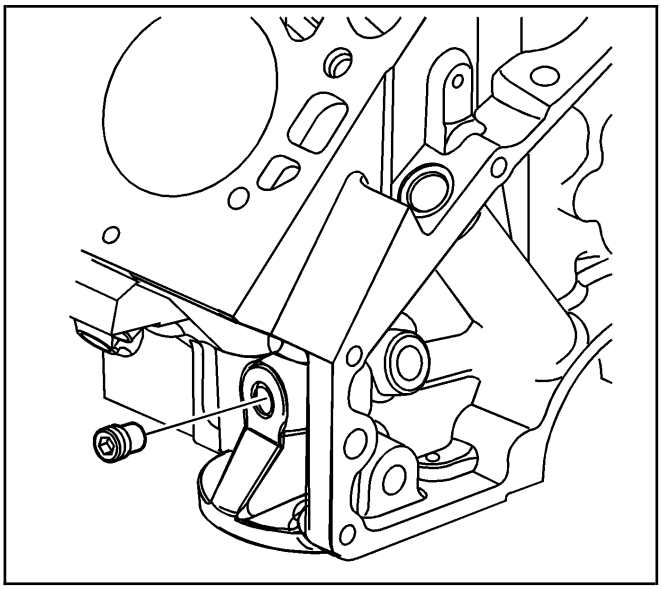
8. Remove the rear oil gallery plugs.



471133

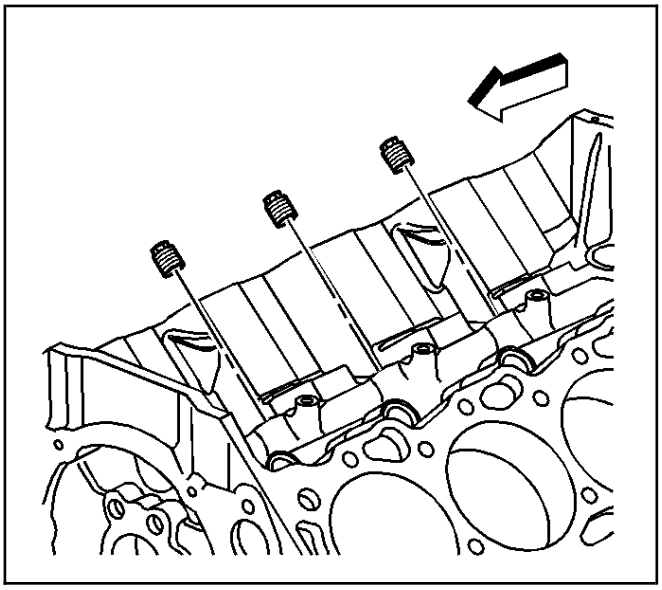
9. Remove the front oil gallery plugs.

10. Remove the left side oil gallery plugs.



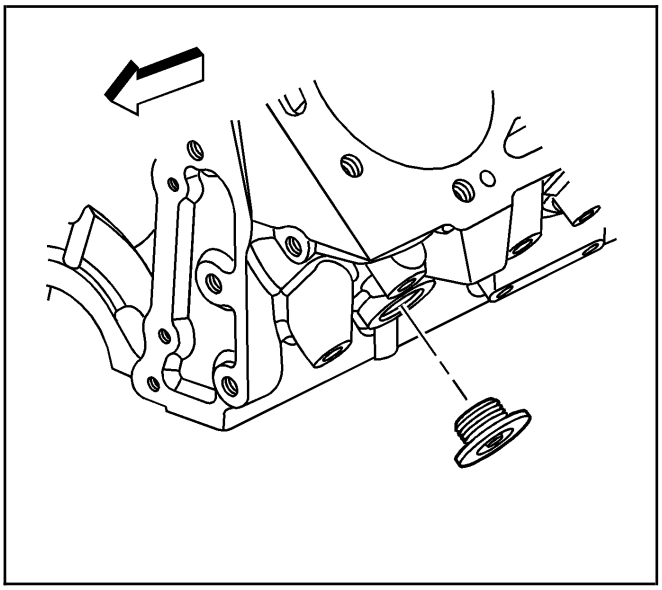
471138

11. Remove the top oil gallery plugs.

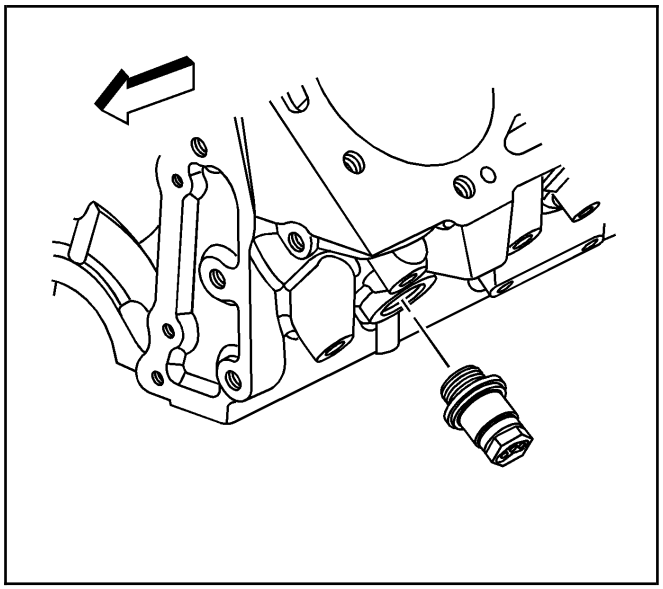


471137

12. Remove the engine coolant hole plug.

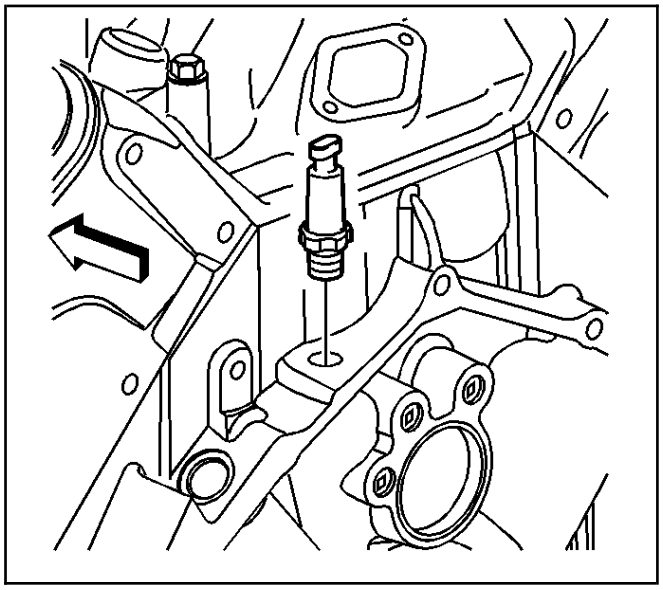


635657



635660

13. Remove the engine block heater, if equipped.



471089

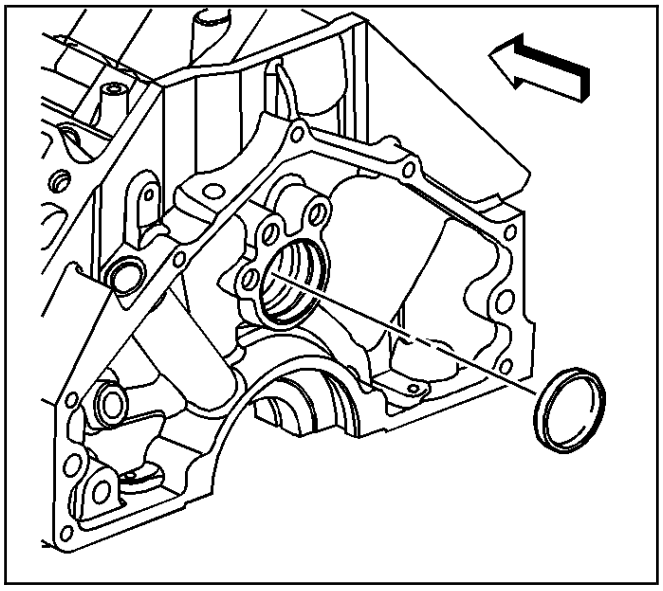
Engine Block Plug Removal (Medium Duty)

SIE-ID = 678813

Tools Required

J 41712 Oil Pressure Sending Unit Socket

1. Remove the oil pressure switch using *J 41712*.

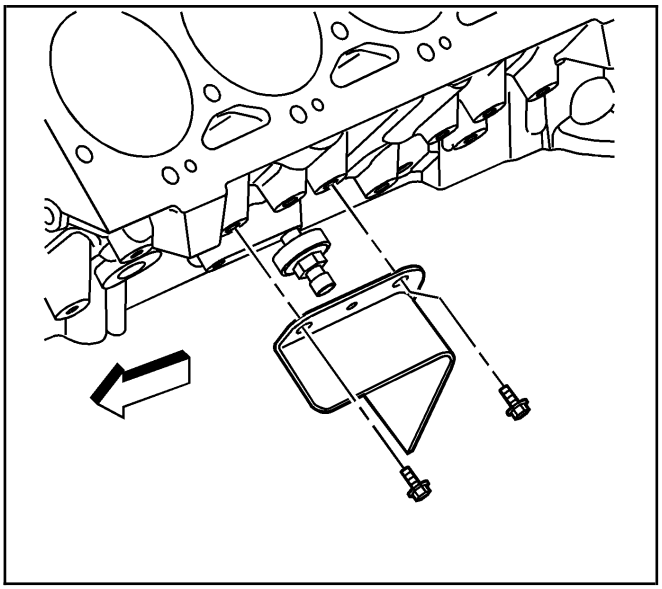


471118

Important: Use care not to damage the camshaft bearings.

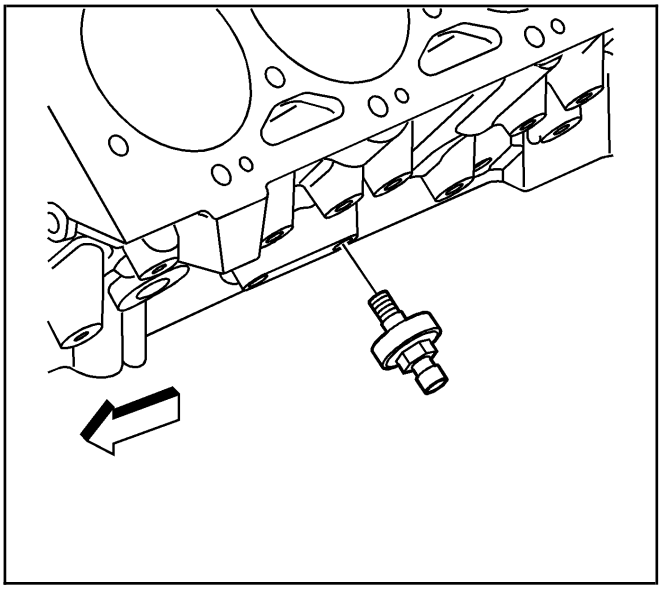
2. Remove the camshaft rear bearing hole plug:
   - 2.1. Obtain a suitable self-threading screw.
   - 2.2. Drill a hole into the plug.
   - 2.3. Install the self-threading screw.
   - 2.4. Pull on the plug until it has left the bore.
   - 2.5. An alternate method to remove the plug would be to insert a long shaft or bar through the front of the engine and drive the plug from the bore.

3. Remove the left side knock sensor shield bolts.
4. Remove the left side knock sensor shield.



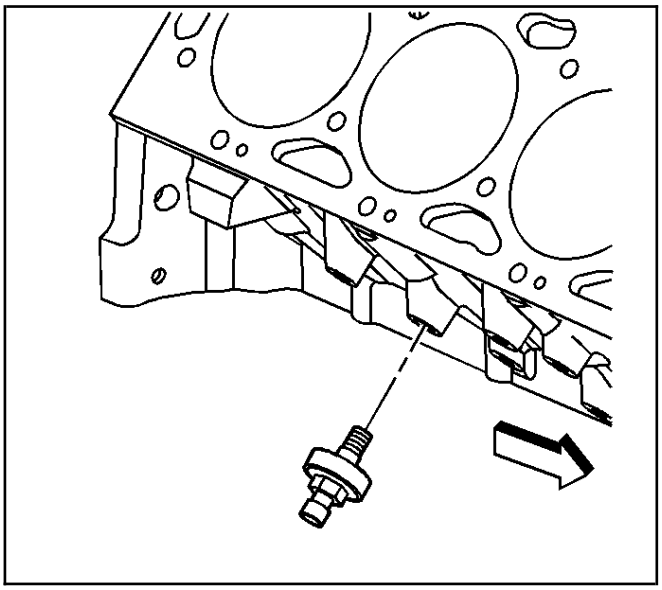
648528

5. Remove the left side knock sensor.

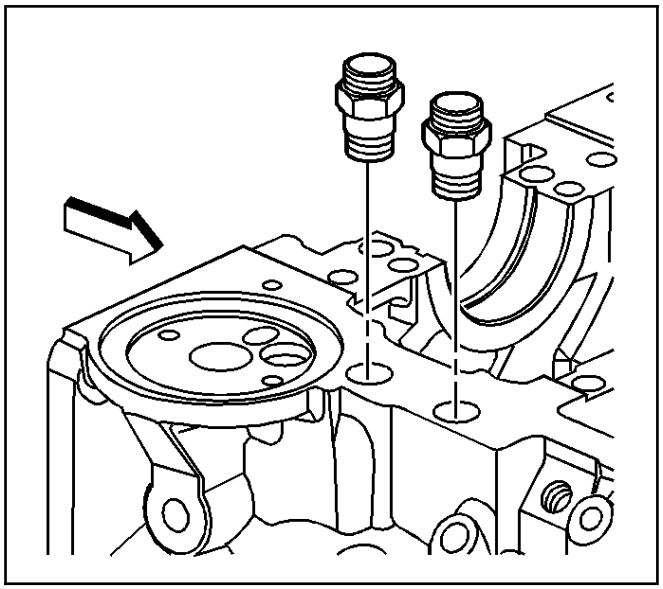


648525

6. Remove the right side knock sensor.

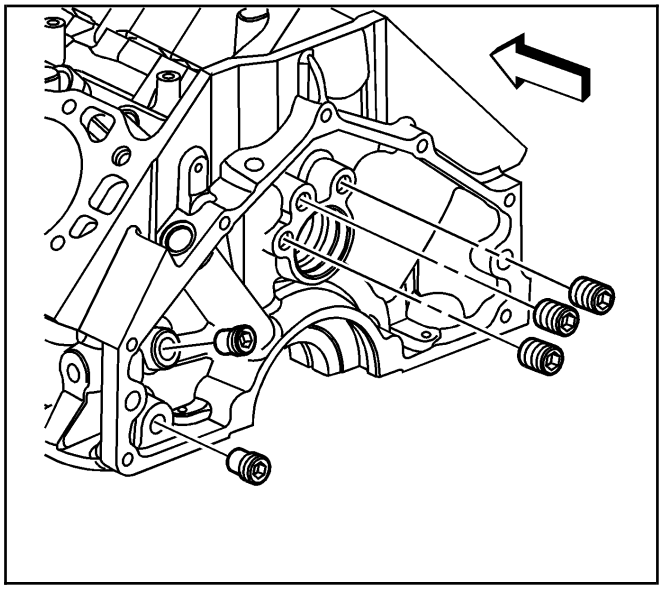


471076



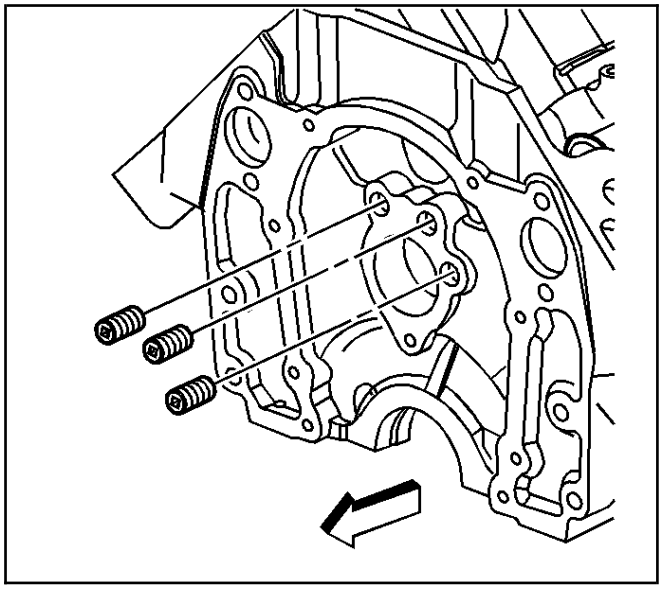
471126

7. Remove the engine block oil cooler hose fittings.



471134

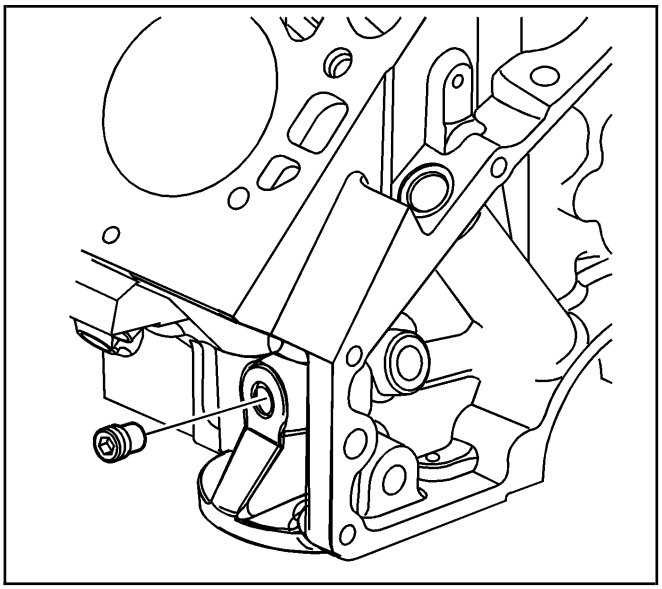
8. Remove the rear oil gallery plugs.



471133

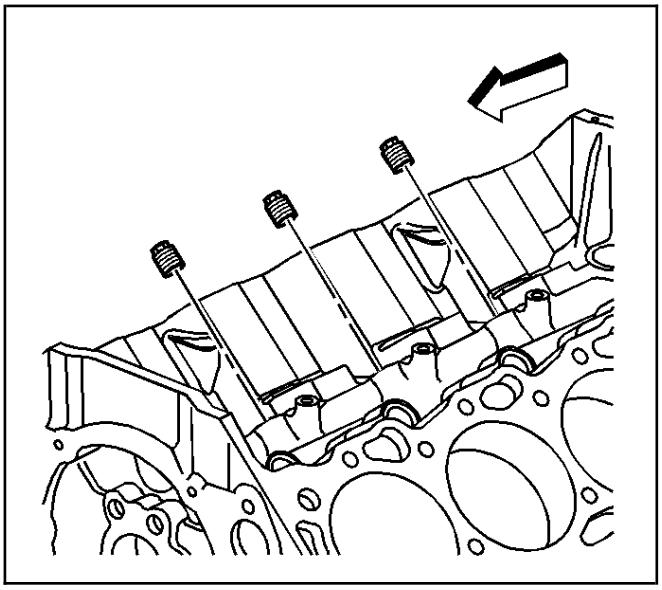
9. Remove the front oil gallery plugs.

10. Remove the left side oil gallery plugs.



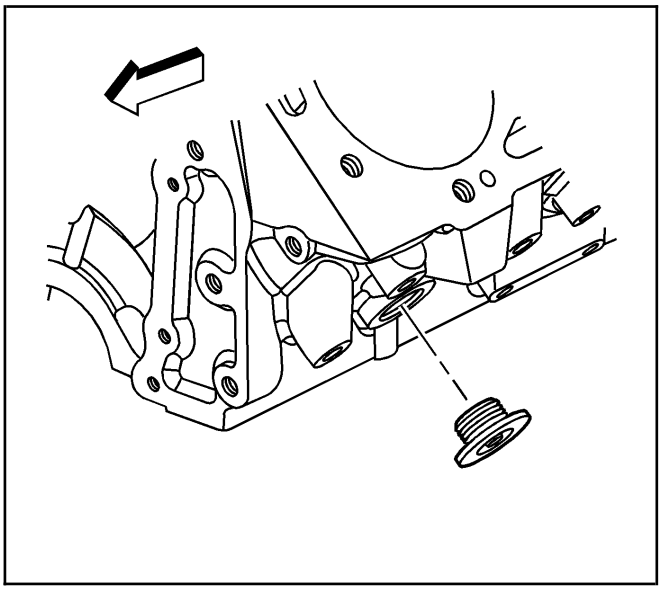
471138

11. Remove the top oil gallery plugs.



471137

12. Remove the engine coolant hole plug.



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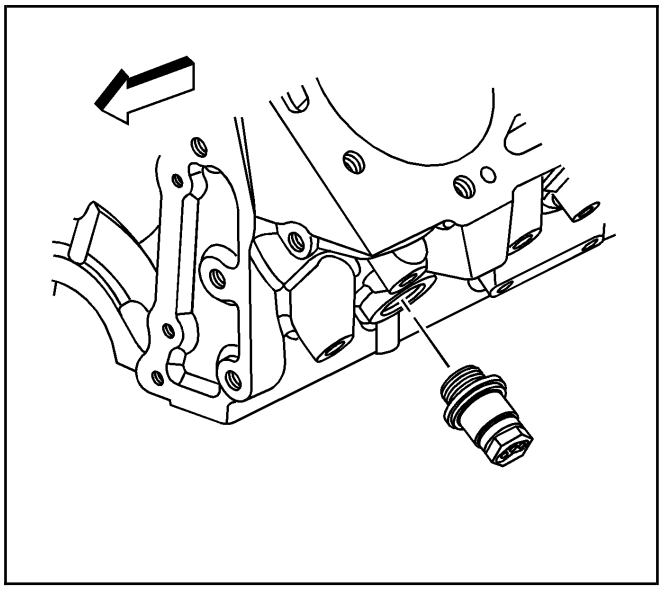

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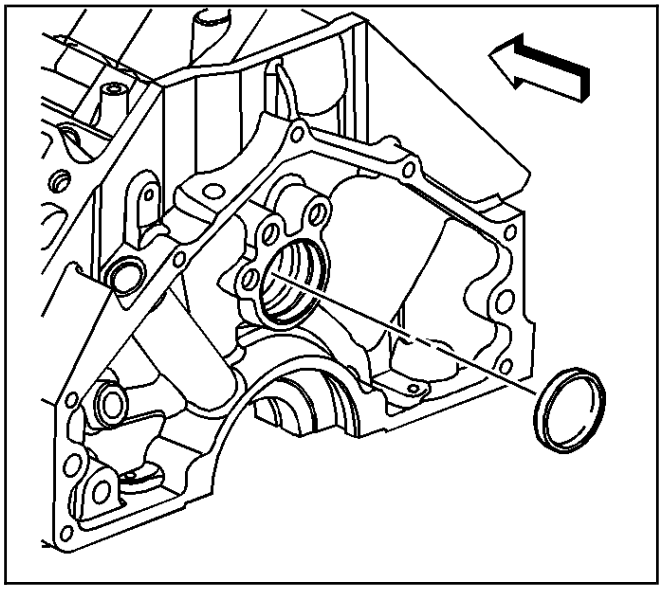
13. Remove the engine block heater, if equipped.



471118

Camshaft Bearing Removal

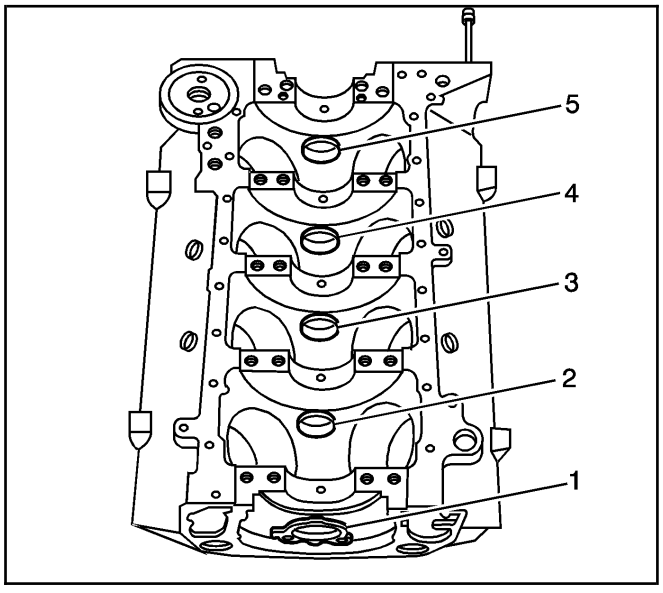
SIE-ID = 482772

Tools Required

J 33049 Camshaft Bearing Service Set

1. Remove the rear camshaft plug, if not previously removed.

   Insert a long bar through the front of the engine and drive the plug out of the rear bore.



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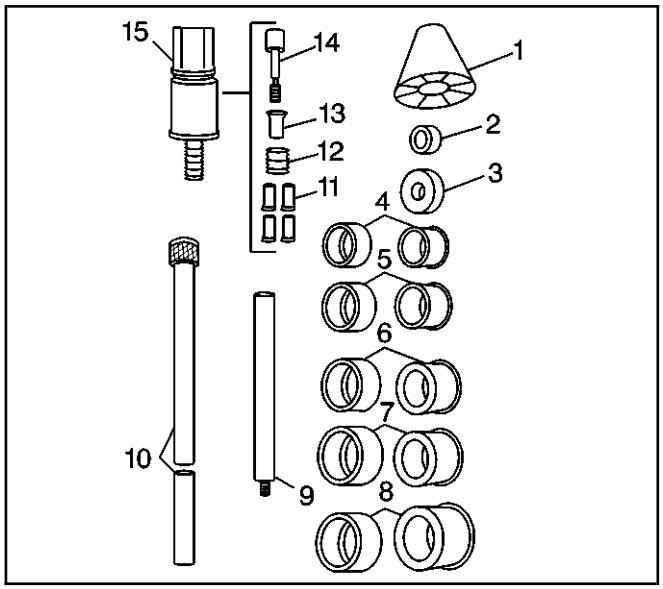
Important: A loose camshaft bearing may be caused by an enlarged, out-of-round, or damaged engine block bearing bore.

2. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores (positions 1–5).

3. Select the expanding driver (4–8) and washer (2 or 3) from the *J 33049*.
4. Assemble the *J 33049*.



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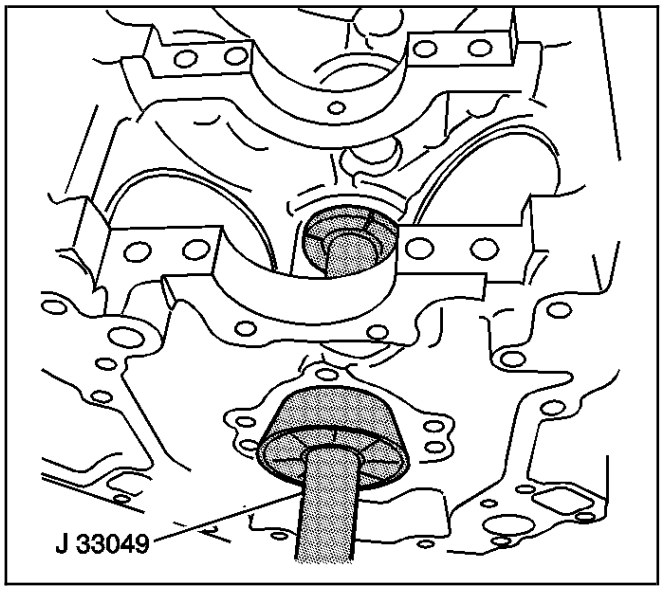
Important: Remove the inner bearings (positions 2, 3, and 4) first. The outer bearings (positions 1 and 5) serve as a guide for the *J 33049*.

5. Insert the *J 33049* through the front of the engine block and into the bearing.
6. Tighten the expander assembly nut until snug.
7. Push the guide cone into the front camshaft bearing (position 1) to align the *J 33049*.
8. Drive the inner bearings (positions 2, 3, and 4) from their block bores.



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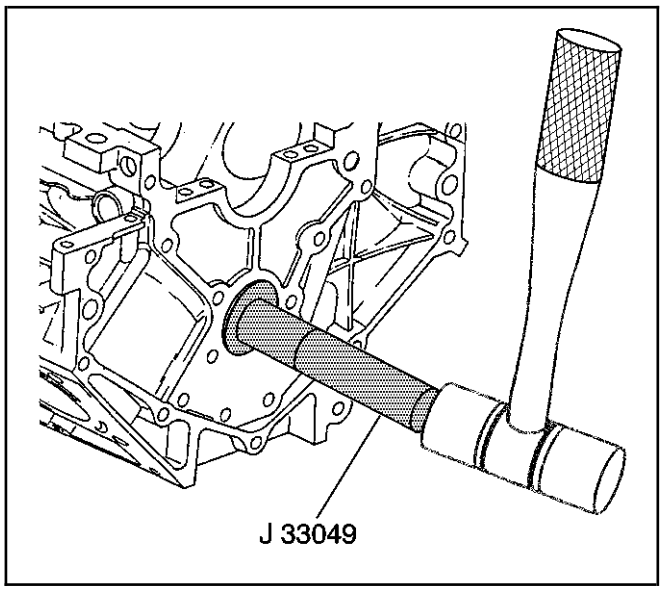
9. Assemble the *J 33049* handle, expanding driver, and washer.
10. Insert the *J 33049* into the outer camshaft bearings.
11. Drive the outer bearings from the bore.



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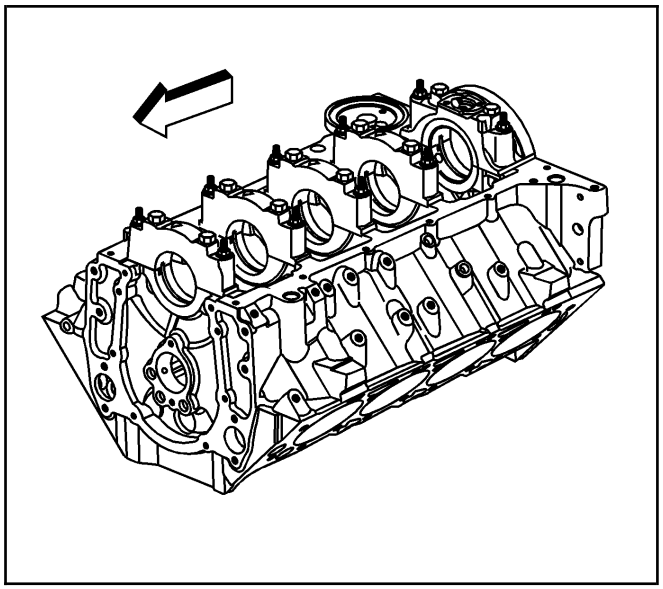


635662

Engine Block Cleaning and Inspection

SIE-ID = 482758

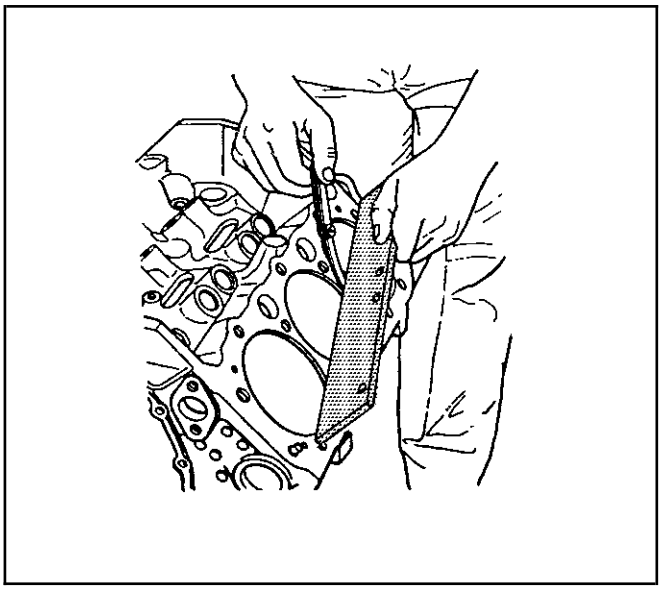
1. Boil the cylinder block in caustic solution.
2. Flush the cylinder block with clean water or steam.
3. Clean the following areas:
   - All gasket surfaces; Refer to *Replacing Engine Gaskets*
   - Cylinder bores, remove excessive cylinder ring ridge as required
   - Main bearing caps
   - Oil galleries, remove all sludge or restrictions
   - Scale deposits from the coolant passages
   - All dirt or debris from threaded bolt holes

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

4. Dry the block with compressed air.
5. Lubricate the cylinder bores with clean engine oil to prevent rusting.
6. Inspect the engine block for the following conditions:
   - Gasket surfaces for deep gouges or other damage
   - Crankshaft bearing bores for wear
     - The surfaces where the crankshaft bearings contact the crankshaft bearing bore must be smooth.
     - All crankshaft bearing bores must be round and uniform in inside diameter (ID) at all the bearing supports.
     - If a crankshaft bearing cap is damaged and requires replacement, refer to *Crankshaft and Bearings Cleaning and Inspection*.
   - Camshaft bearing bores for wear or damage
   - Valve lifter bores for scuffing or wear
   - Engine block for cracks or other damage
   - Cylinder walls for scoring or gouges
   - Coolant jackets for cracks
   - Crankshaft bearing webs for cracks
   - Engine mount bosses for damage
   - The oil passages for restrictions

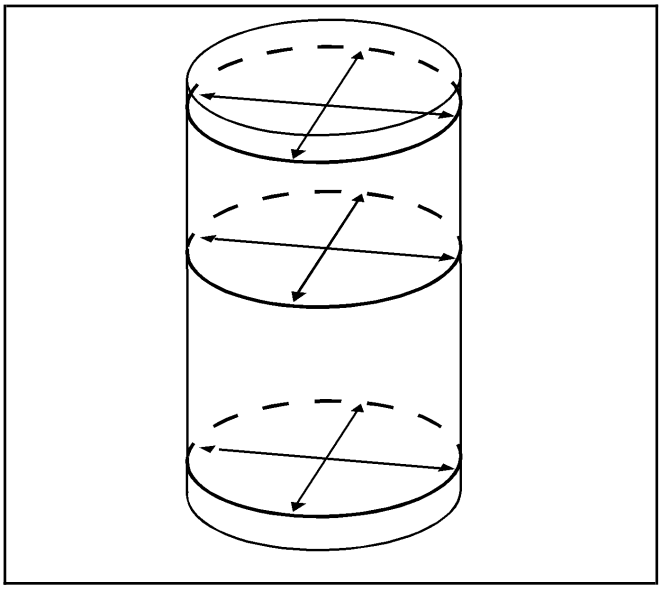
7. Inspect the engine block cylinder head deck for flatness using a straight edge and a feeler gage.

   The surface must be flat within 0.100 mm (0.004 in).



35209

8. Use a bore gage and measure the cylinder bore for taper, out-of-round and oversize. Slide the bore gage up and down throughout the length of the cylinder bore. Check the bore both parallel and perpendicular to the centerline of the crankshaft at the top, center and bottom of the bore. A cylinder bore that measures 107.940–107.990 mm (4.249–4.251 in) may be serviced with a standard size piston/connecting rod assembly. A cylinder bore that exceeds the maximum diameter must be serviced with an oversized piston/connecting rod assembly.



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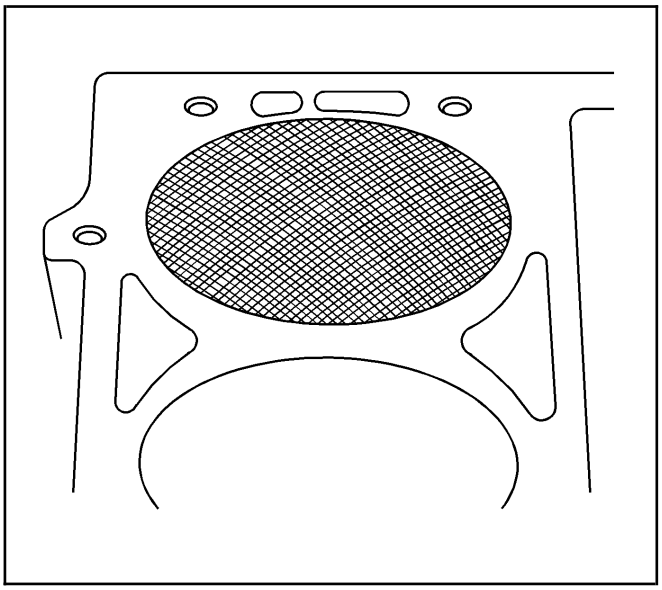
Cylinder Boring and Honing

SIE-ID = 482759

Boring Procedure

Important: The coating on the piston allows for an interference fit between the cylinder and the bore. The piston diameter can NOT be measured accurately because the piston coating is not a consistent thickness. Do NOT measure the piston diameter.

To select the correct piston for installation, the cylinder bore must be measured. If the cylinder bore diameter is within service specifications, install the original piston/connecting rod assembly or a new, standard size piston/connecting rod assembly. A used piston/connecting rod assembly may be reinstalled if, after cleaning and inspection, the piston is not damaged. If the cylinder bore is NOT within specifications, the cylinder must be resized to accept a new, oversized piston.



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Important: If you do not check the cylinder block, the boring bar may be tilted, this may result in incorrect rebored cylinder wall to crankshaft angle.

1. Before you use any type of boring bar, clean the top of the cylinder block in order to remove any dirt or burrs.
2. Carefully follow the instructions furnished by the manufacturer regarding use of equipment.
3. When you rebore cylinders, make sure all crankshaft bearing caps are in place.
   - Tighten the bearing caps to the proper torque in order to avoid distortion of the bores in the final assembly.
   - The crankshaft must be removed prior to cylinder boring.
4. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the 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 pistons, rings, and cylinder bores).

Honing Procedure

Important: Always remove all bearings and components from engine block before cleaning, boring or honing the engine block.

1. When honing the cylinders, 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 you remove.
   - 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 stone marks may be removed with fine grade stones.
   - The re-honed surface finish should be 0.25–0.50 micrometer (10–20 microinch).
   - Perform final honing with a fine-grade stone and hone the cylinder in a cross hatch pattern at 20 to 30 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly clean the cylinder bore.
   - Repeatedly check the cylinder bore for fit with the selected oversized piston.
   - All measurements of the cylinder bore should be made with the components at normal room temperature.
3. To eliminate taper in the cylinder, when honing, make full strokes of the hone in the cylinder. Repeatedly check the measurement at the top, the middle, and the bottom of the bore.
   - The finish marks should be clean but not sharp.
   - The finish marks should be free from embedded particles and torn or folded metal.

4. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round or taper requirements.
5. After final honing and before the piston is checked for fit, clean the bores with hot water and detergent.
   5.1. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores.
      - Abrasive material may cause premature wear of new piston rings and cylinder bores.
      - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
   5.2. After washing the cylinder bore, dry the bore with a clean shop towel.
6. Perform final measurements of the cylinder bore.
7. Permanently mark the piston for the specific cylinder to which it has been fitted.
8. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Crankshaft and Bearings Cleaning and Inspection

SIE-ID = 482760

Tools Required

- *J 7872* Magnetic Base Dial Indicator
- *J 36660-A* Torque/Angle Meter

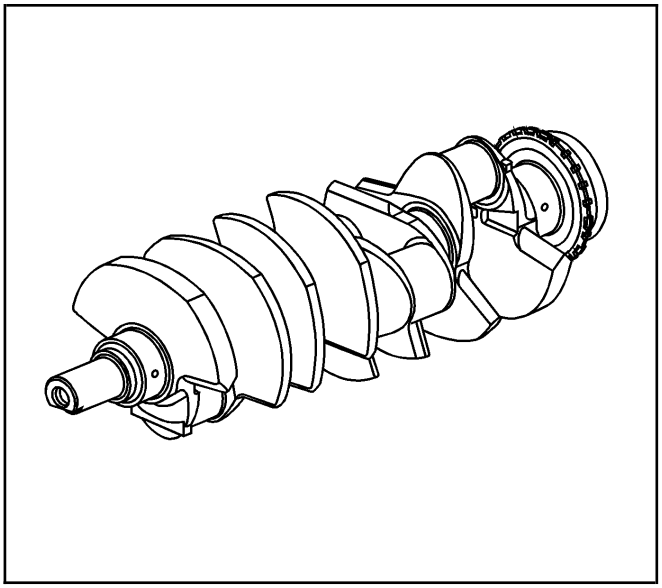
Crankshaft Inspection

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

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

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

2. Dry the crankshaft and bearings with compressed air.



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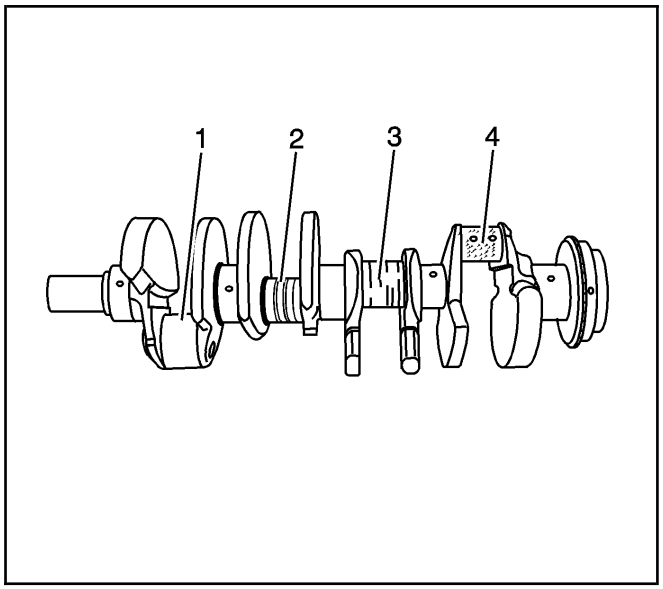

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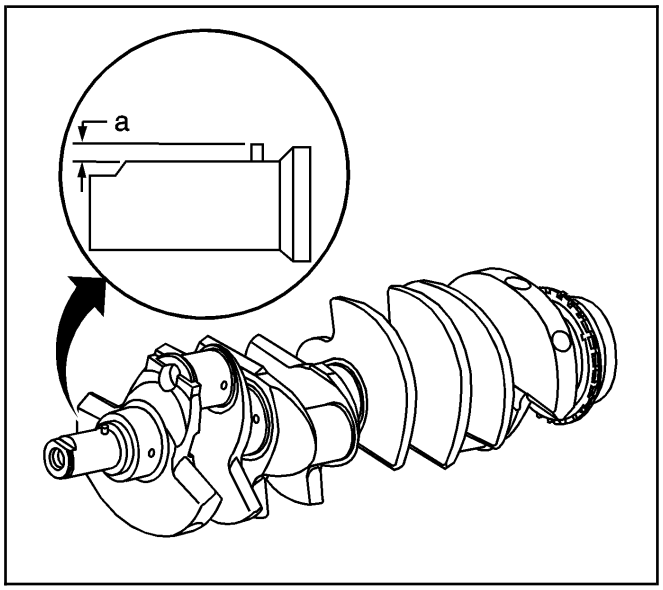
3. Inspect the crankshaft for the following conditions:
   - Crankshaft journals (1) should be smooth with no evidence of scoring or damage
   - Deep grooves (2)
   - Scratches or uneven wear (3)
   - Pitted surfaces (4)
   - Wear or damage to the thrust journal surfaces
   - Scoring or damage to the rear seal surface
   - Restrictions to oil passages
   - Damage to threaded bolt holes



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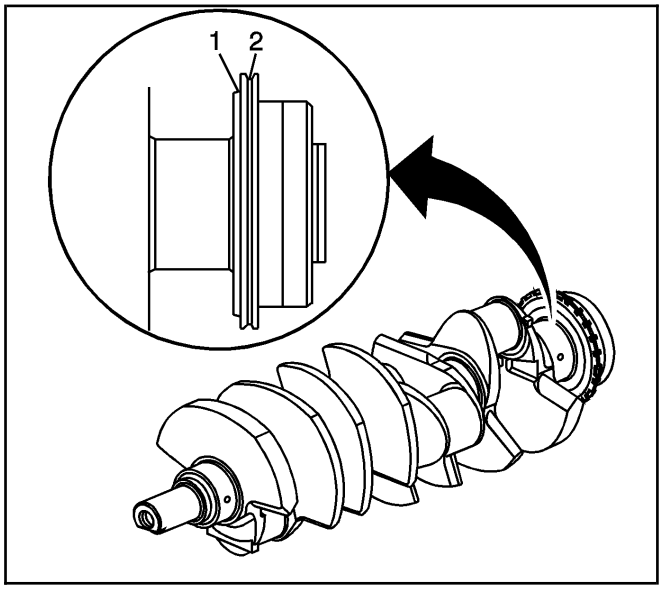
Important: The crankshaft pin is a pressed in roll pin. The pin only needs to be removed from the crankshaft if the pin is damaged.

4. Inspect the crankshaft pin for damage:
   - Measure for proper installed height (A). Correct height should be 2.00–2.25 mm (0.078–0.088 in).
   - Replace the crankshaft pin if it is damaged.

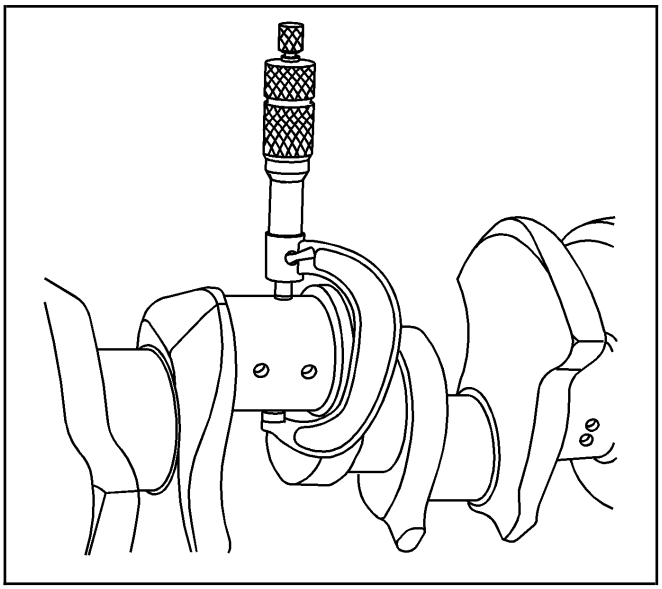


677772

Important: Do NOT attempt to remove the crankshaft reluctor wheels. If the reluctor wheels are damaged and/or removed, the crankshaft must be replaced.

5. Inspect the reluctor wheels for cracked, bent or broken teeth.
   - Measure between the crankshaft shoulder and the front reluctor wheel (1).
   - Measure between the front and rear reluctor wheels (2).
   - The maximum allowable gap is 0.15 mm (0.006 in).

6. Measure the crankshaft main journals and the crankpins for out-of-round and taper.



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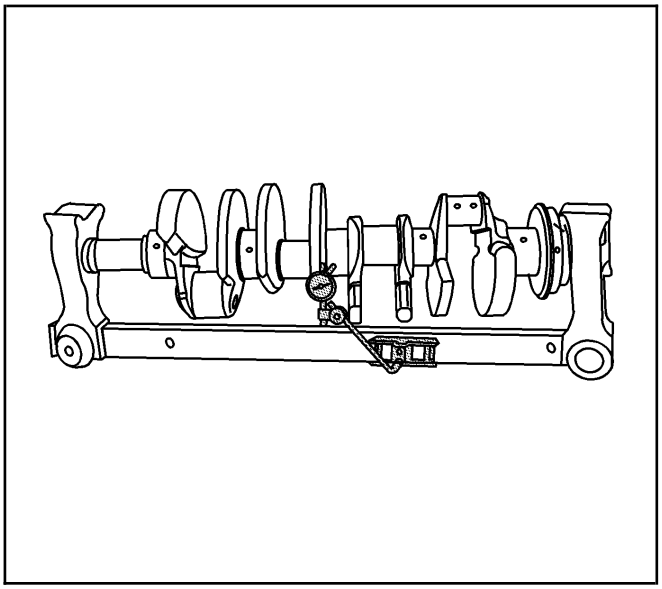
7. Using a suitable fixture, support the crankshaft.
   7.1. Measure the crankshaft runout using *J 7872*.
   7.2. Crankshaft runout should not exceed 0.051 mm (0.002 in).



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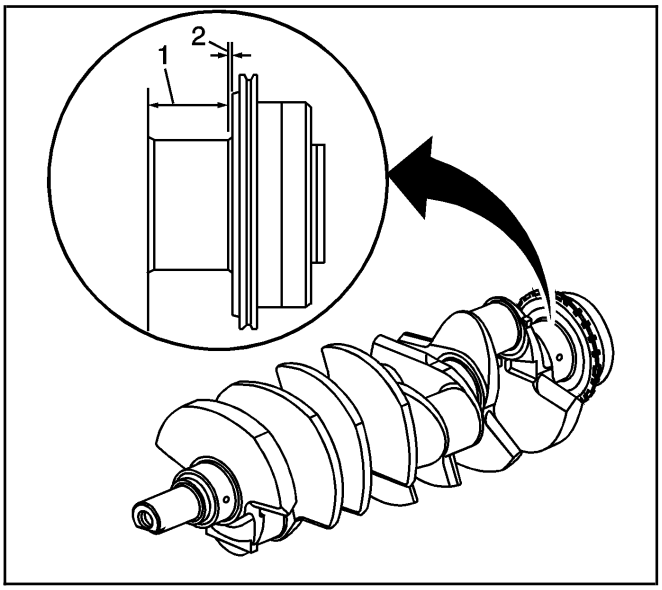
8. Inspect the crankshaft thrust wall surface for wear (1) and/or excessive runout (2). Refer to *Engine Mechanical Specifications*.



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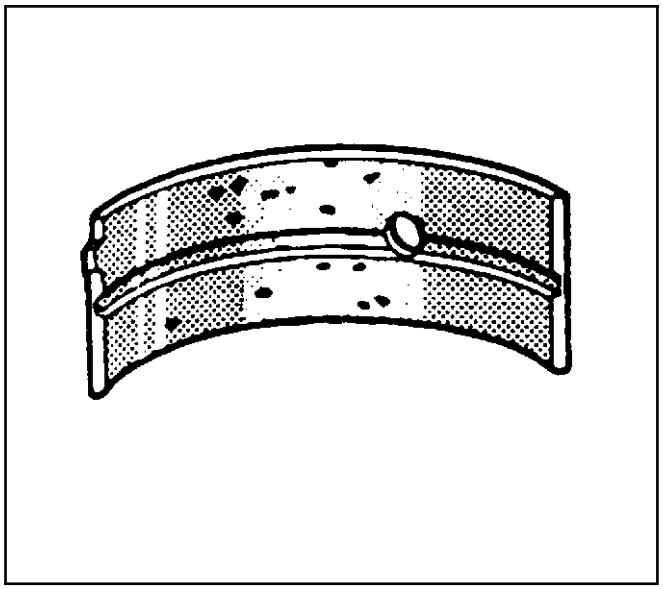

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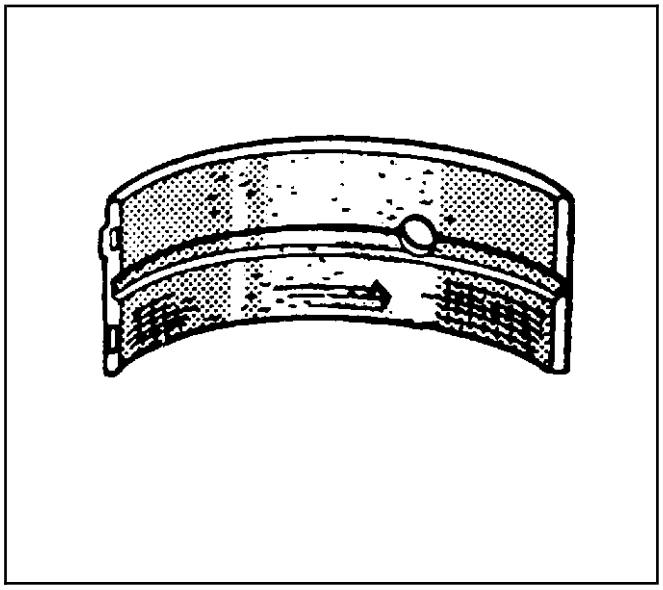
Crankshaft and Connecting Rod Bearing Inspection

Important: The crankshaft and connecting rod bearings should be inspected only to determine what kind of damage or failure has occurred. Always install NEW bearings once the bearings have been removed.

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



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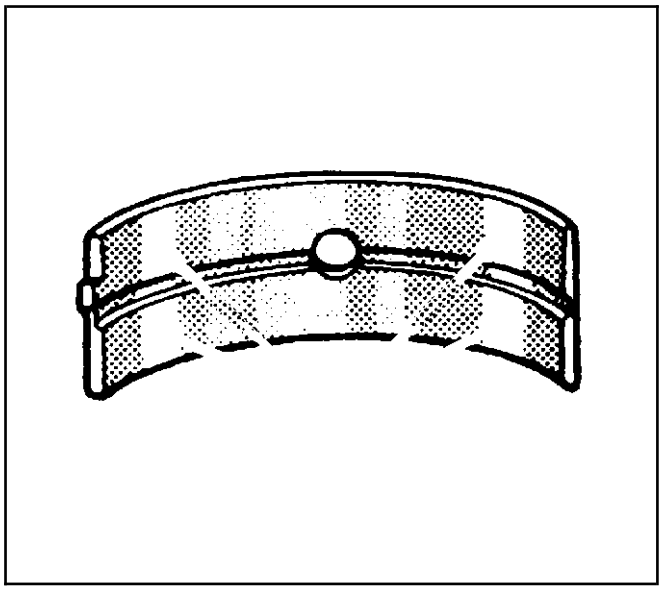
2. Inspect the bearings for excessive scoring or discoloration.
3. Inspect the bearings for dirt or debris embedded into the bearing material.



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4. Inspect the bearings for improper seating indicated by bright, polished sections of the bearings.

Crankshaft and Connecting Rod Bearing Clearance Measurement

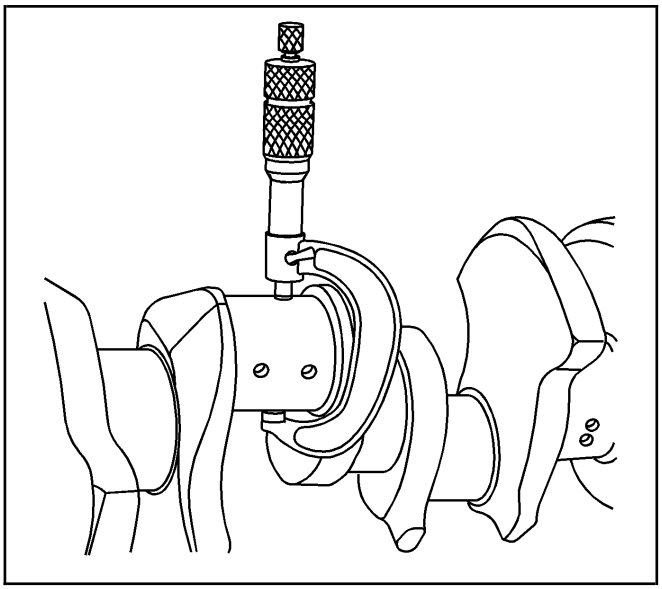
The crankshaft and connecting rod bearings are of the precision insert type and do not use shims for adjustment.

Crankshafts with journals that measure less than minimum specifications must be replaced.

Micrometer Method for Crankshaft Bearings

Important: When bearings are removed, NEW bearings must be installed during reassembly.

1. Measure the crankshaft main journal diameter with a micrometer in several places along the length approximately 90 degrees apart, (minimum of 4 places), and average the measurements.
2. Determine the taper and the out-of-round. Refer to *Engine Mechanical Specifications*.



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3. Install the NEW crankshaft bearings into the crankshaft bearing caps and the engine block.

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

Important: Tighten the inner crankshaft bearing cap bolts before tightening the outer crankshaft bearing cap studs.

4. Install the crankshaft bearing caps and the crankshaft bearing cap bolts and studs.

   Tighten

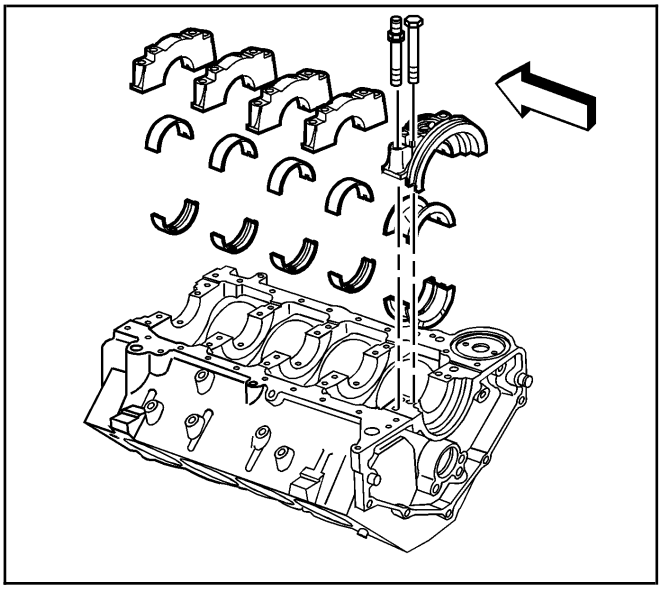
   4.1. Tighten the crankshaft bearing cap inner bolts to 30 N·m (22 lb ft).

   4.2. Tighten the crankshaft bearing cap outer studs to 30 N·m (22 lb ft).

   4.3. Using *J 36660-A*, tighten the crankshaft bearing cap inner bolts an additional 90 degrees.

   4.4. Using *J 36660-A*, tighten the crankshaft bearing cap outer studs an additional 80 degrees.

5. Measure the crankshaft bearing inside diameter (ID) using an inside micrometer. Measure at a minimum of four places and average the measurements.
6. In order to determine the crankshaft bearing clearance, subtract the crankshaft journal diameter from the crankshaft bearing ID.
7. Compare the crankshaft bearing clearance to the specifications. Refer to *Engine Mechanical Specifications*.
8. If the crankshaft bearing clearances exceeds specifications, install undersize crankshaft bearings to achieve the correct clearance.
9. Measure the new crankshaft bearing inside diameter (ID) using an inside micrometer.
10. Replace the crankshaft if the proper clearances cannot be obtained with standard size bearings.



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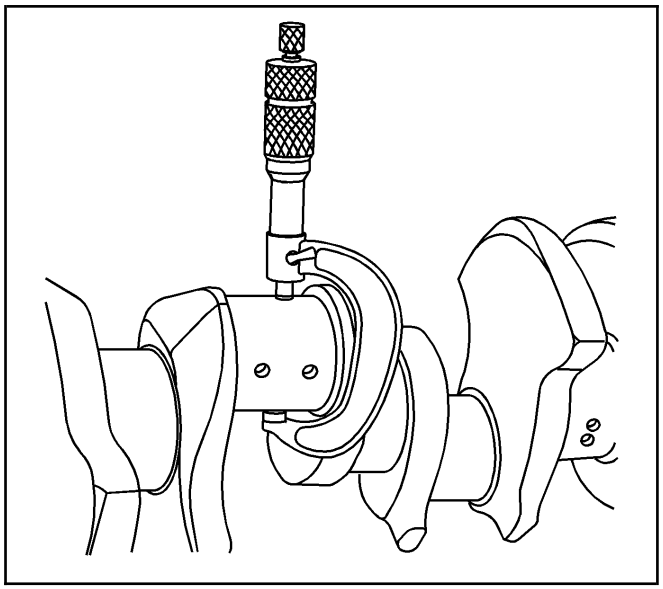

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Micrometer Method for Connecting Rod Bearings

Important: When bearings are removed, NEW bearings must be installed during reassembly.

1. Measure the crankpin diameter with a micrometer in several places along the length, approximately 90 degrees apart (minimum of 4 places), and average the measurements.
2. Determine the taper and the out-of-round. Refer to *Engine Mechanical Specifications*.
3. Install the NEW connecting rod bearings into the connecting rod cap and the connecting rod.

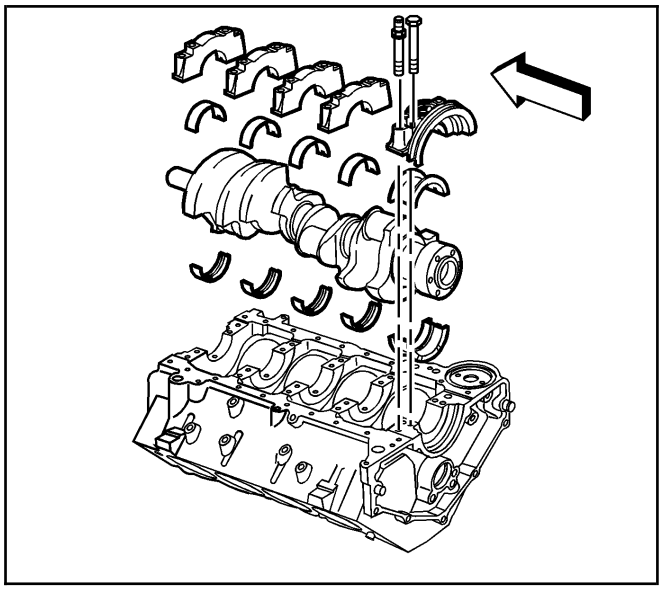
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: Use the original connecting rod nuts for clearance measurement. During final assembly new connecting rod nuts must be used to obtain correct fastener tightening.

4. Install the connecting rod cap and the original (used) nuts.

   Tighten

   Tighten the connecting rod nuts to 30 N·m (22 lb ft). Tighten the connecting rod nuts an additional 90 degrees.
5. Measure the connecting rod bearing inside diameter (ID) using an inside micrometer.
6. Compare the connecting rod bearing clearance specifications. Refer to *Engine Mechanical Specifications*.
7. If the connecting rod bearing clearances exceed specifications, replace components as required.



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Plastic Gage Method for Crankshaft Bearings

Important: When bearings are removed, NEW bearings must be installed during reassembly.

1. Install the crankshaft and the new crankshaft bearings into the block, making sure not to damage the reluctor rings of the crankshaft.

2. Install the gaging plastic the full width of the crankshaft journal.

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

Important: Tighten the inner crankshaft bearing cap bolts before tightening the outer crankshaft bearing cap studs. The crankshaft journal and the crankshaft bearing surface must be free from oil to obtain a correct measurement. Do not allow the crankshaft to rotate while performing the measurement, or an incorrect measurement will be obtained.

3. Install the crankshaft bearing caps and the crankshaft bearing cap bolts and studs.

   Tighten

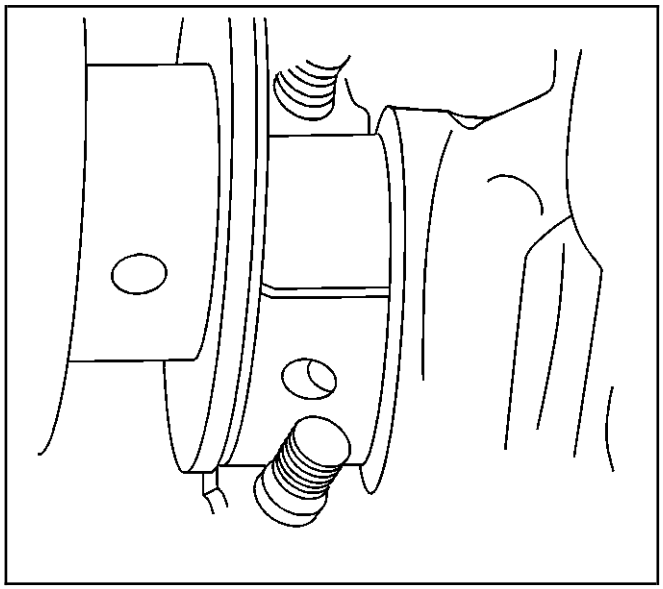
   3.1. Tighten the crankshaft bearing cap inner bolts to 30 N·m (22 lb ft).

   3.2. Tighten the crankshaft bearing cap outer studs to 30 N·m (22 lb ft).

   3.3. Using *J 36660-A*, tighten the crankshaft bearing cap inner bolts an additional 90 degrees.

   3.4. Using *J 36660-A*, tighten the crankshaft bearing cap outer studs an additional 80 degrees.

4. Remove the crankshaft bearing cap bolts and the crankshaft bearing caps. The gaging plastic may adhere to either the crankshaft journal or the crankshaft bearing surfaces.
5. On the edge of the gaging plastic envelope there is a graduated scale. Without removing the gaging plastic, measure the compressed width at the widest point.
6. If the flattened gaging 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 journal.
   - Normally the crankshaft journals wear evenly and are not out-of-round. However, if a crankshaft bearing is being fitted to an out-of-round 0.0254 mm (0.001 in maximum) crankshaft journal, be sure to fit to the maximum diameter of the crankshaft journal.
   - If the crankshaft bearing is fitted to the minimum diameter and the crankshaft journal is excessively out-of-round, the interference between the crankshaft bearing and the crankshaft journal will result in rapid crankshaft bearing failure.
7. Compare the crankshaft bearing clearance to the specifications. Refer to *Engine Mechanical Specifications*.
8. If the crankshaft bearing clearances exceeds specifications, replace components as required.
9. Measure the new crankshaft bearing inside diameter (ID) using the same method.
10. Replace the crankshaft if the proper clearances cannot be obtained with standard size bearings.



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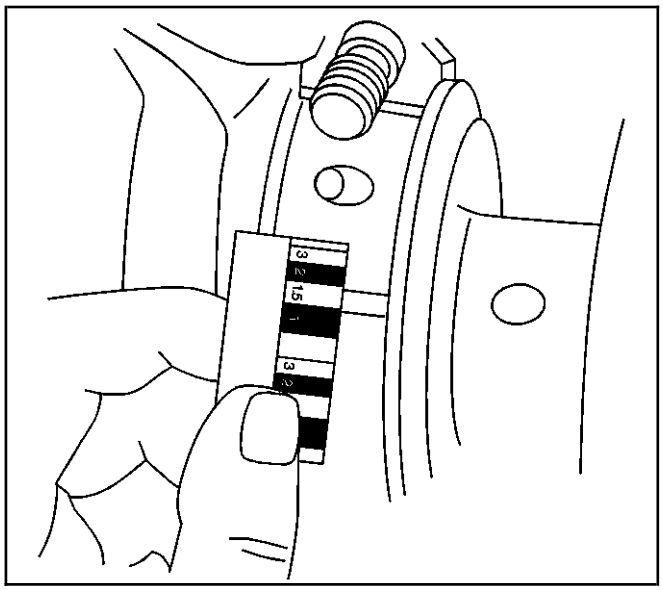

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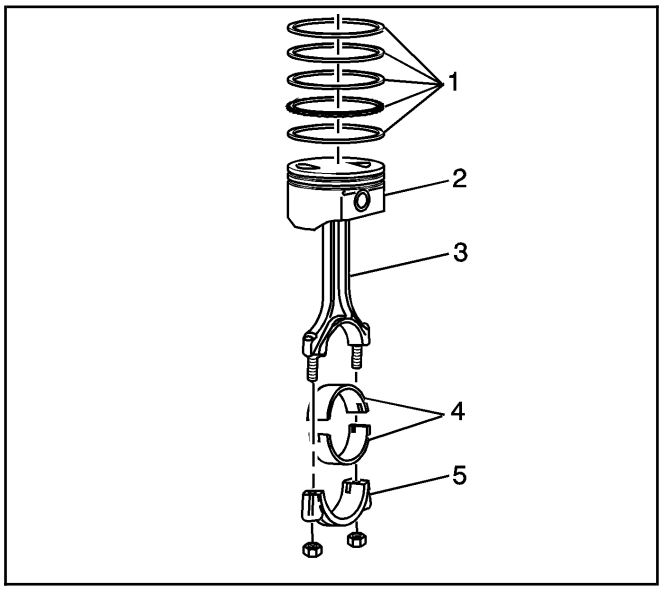

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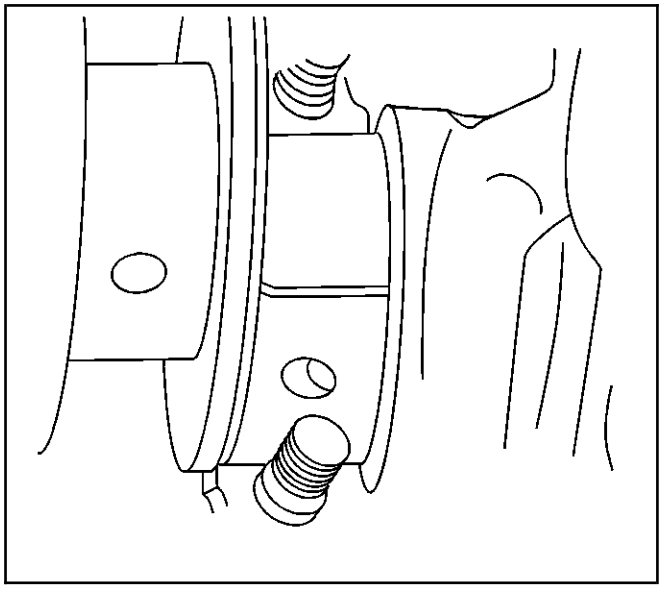


4980

11. Remove the flattened gaging plastic.
12. Measure the remaining crankshaft journals.

Plastic Gage Method for Connecting Rod Bearings

Important: When bearings are removed, NEW bearings must be installed during reassembly.

1. Install the connecting rod bearings (4) into the connecting rod (3) and the connecting rod cap (5).
2. Using rubber fuel line over the connecting rod bolts, install the piston and connecting rod assembly onto the crankpin journal.
3. Install the gaging plastic the full width of the crankpin journal.

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

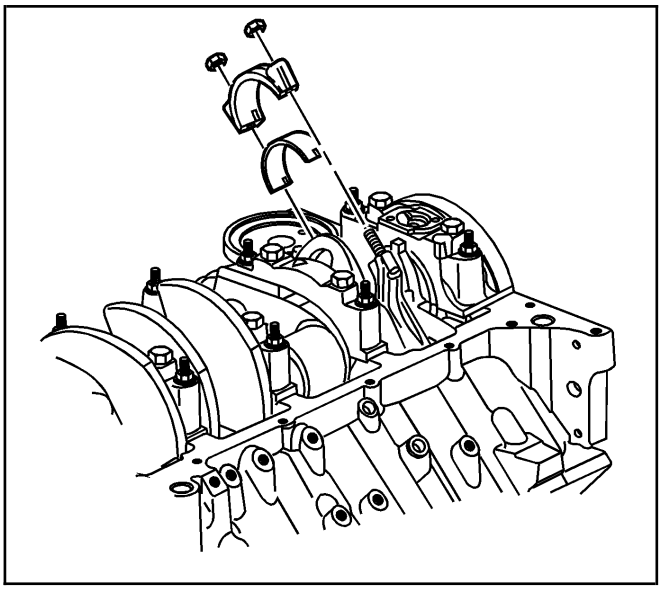
Important: Use the original connecting rod nuts for clearance measurement. During final assembly, new connecting rod nuts must be used to obtain correct fastener tightening.

4. Install the connecting rod cap and the original (used) nuts.

   Tighten

   Tighten the connecting rod nuts to 30 N·m (22 lb ft). Tighten the connecting rod nuts an additional 90 degrees.

5. Remove the connecting rod nuts and cap. The gaging plastic may adhere to either the crankpin journal or the connecting rod bearing surface.

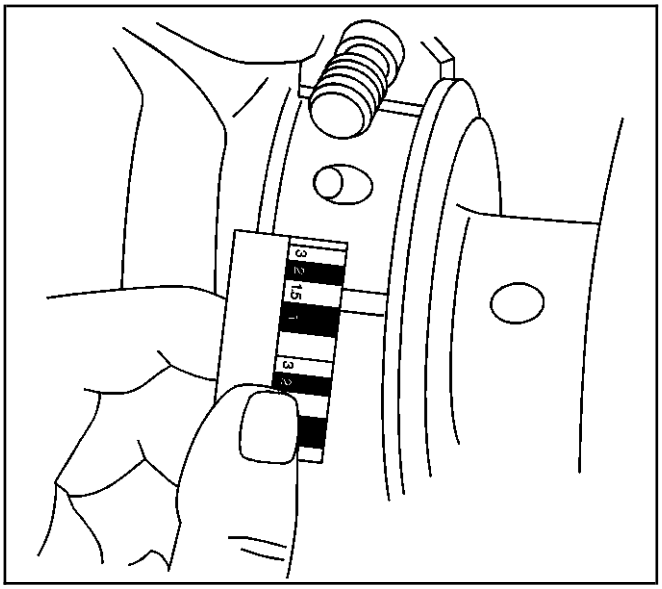


639084

6. On the edge of the gaging plastic envelope there is a graduated scale. Without removing the gaging plastic, measure the compressed width at the widest point.

   If the flattened gaging 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 crankpin journal.

7. Normally the crankpin journals wear evenly and are not out-of-round. However, if a connecting rod bearing is being fitted to an out-of-round 0.0254 mm (0.001 in maximum) crankpin journal, be sure to fit to the maximum diameter of the crankpin journal. If the connecting rod bearing is fitted to the minimum diameter and the crankpin journal is excessively out-of-round, the interference between the connecting rod bearing and the crankpin journal will result in rapid connecting rod bearing failure.
8. Compare the connecting rod bearing clearance to the specifications. Refer to *Engine Mechanical Specifications*.
9. If the connecting rod bearing clearances exceed specifications, replace components as required.
10. Remove the flattened gaging plastic.
11. Measure the remaining crankpin journals.



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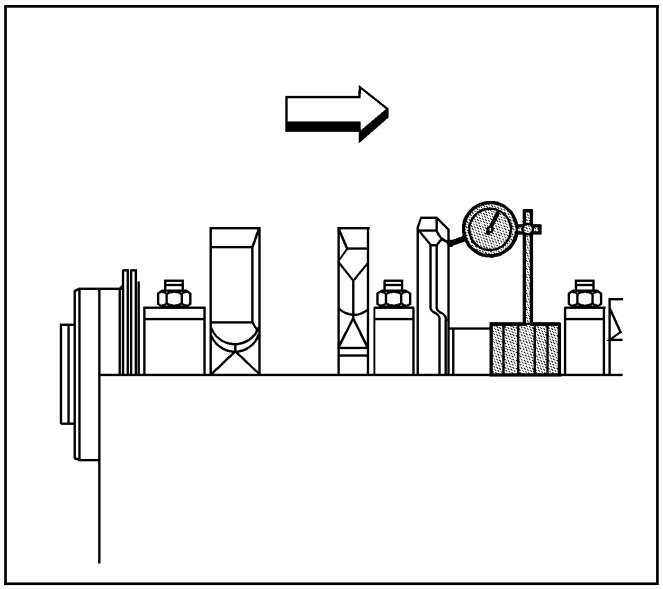
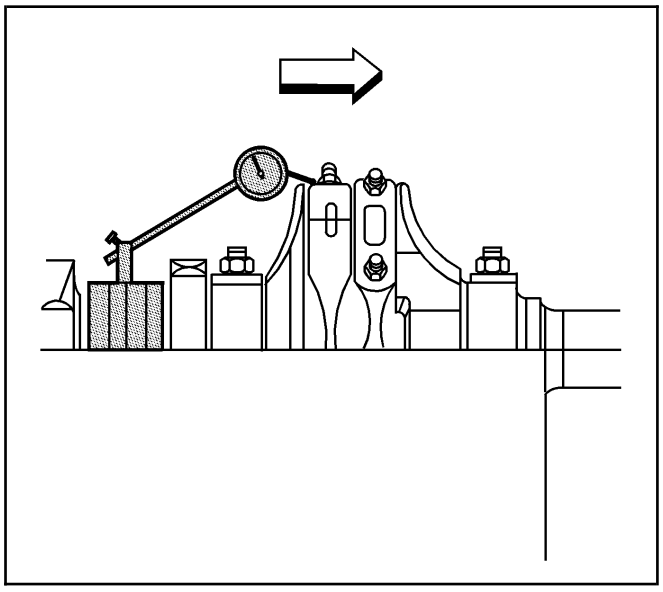


677804

Measuring Crankshaft End Play

Important: In order to properly measure the crankshaft end play, the crankshaft, bearings, bearing caps and fasteners must be installed into the engine block and the bolts tightened to specifications. Refer to *Crankshaft and Bearings Installation*.

1. Install the *J 7872* or equivalent to the cylinder block, with the dial indicator plunger against one of the counterweights of the crankshaft.
2. Firmly thrust the end of the crankshaft first rearward then forward. This will line up the rear crankshaft bearing and the crankshaft thrust surfaces.
3. With the crankshaft pushed forward, zero the dial indicator. Move the crankshaft rearward and read the endplay measurement on the dial indicator. An optional method is to insert a feeler gage between the crankshaft and the bearing surface and measure the clearance. Refer to *Engine Mechanical Specifications*.
4. If the correct end play cannot be obtained, inspect the crankshaft thrust wall surface(s) for wear and/or excessive runout.
5. Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the crankshaft bearing bolts and studs, one cap at a time, until the tight bearing is located. The following condition(s) could cause a lack of clearance at the bearing:
   - Burrs on the crankshaft bearing cap
   - Foreign matter between the crankshaft bearing and the block or the crankshaft bearing cap
   - A faulty crankshaft bearing



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Measuring Connecting Rod Side Clearance

Important: In order to properly measure the connecting rod side clearance, the piston/connecting rod assembly and bearings must be installed into the engine block and the connecting rod nuts tightened to specifications. Refer to *Piston, Connecting Rod, and Bearing Installation*.

1. Install the *J 7872* or equivalent to the cylinder block, with the dial indicator plunger against the side of the pair of connecting rods.
2. With the connecting rods pushed forward, zero the dial indicator. Firmly move the pair of connecting rods side to side and read the measurement on the dial indicator. An optional method is to insert a feeler gage between the connecting rod caps and measure the connecting rod side clearance. Refer to *Engine Mechanical Specifications*.

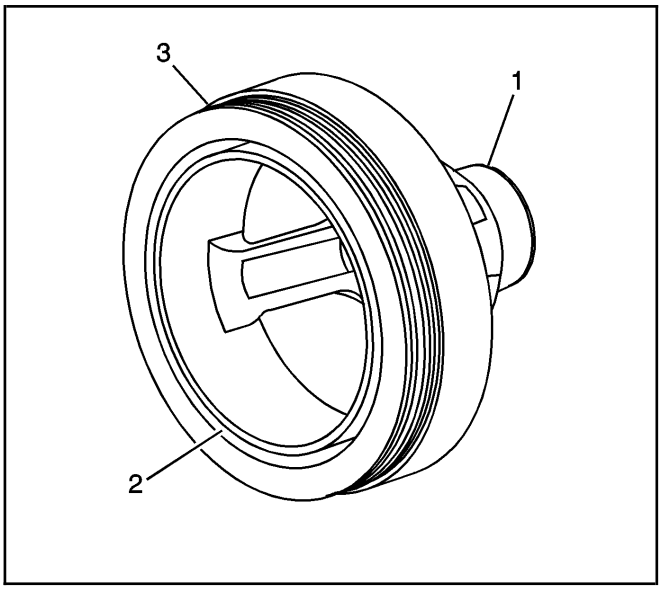
Crankshaft Balancer Cleaning and Inspection

SIE-ID = 482761

1. Clean the crankshaft balancer in solvent.

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

2. Dry the crankshaft balancer with compressed air.
3. Inspect the crankshaft balancer for the following:
   - Damaged belt grooves (3)
   - Debris in the belt grooves (3)
   - Worn, grooved, or damaged hub seal surface (1)
     - Minor imperfections on the hub seal surface may be removed with a polishing compound or fine grade of emery cloth.
     - A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.
   - Worn, chunking or deteriorated rubber between the hub and pulley (2)
4. Repair or replace the crankshaft balancer as necessary.



635666

Engine Flywheel Cleaning and Inspection (AT)

SIE-ID = 482762

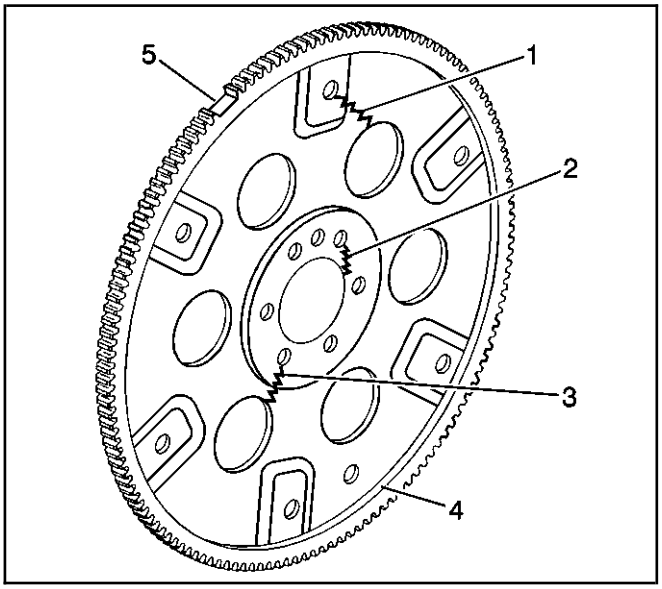
1. Clean the engine flywheel in solvent.

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

2. Dry the engine flywheel with compressed air.
3. Inspect the engine flywheel for the following conditions:
   - Stress cracks around the engine flywheel-to-torque converter mounting bolt hole locations (1) and/or engine flywheel-to-crankshaft (2, 3)

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

   - Cracks at welded areas that retain the ring gear onto the engine flywheel (4)
   - Damaged or missing ring gear teeth (5)



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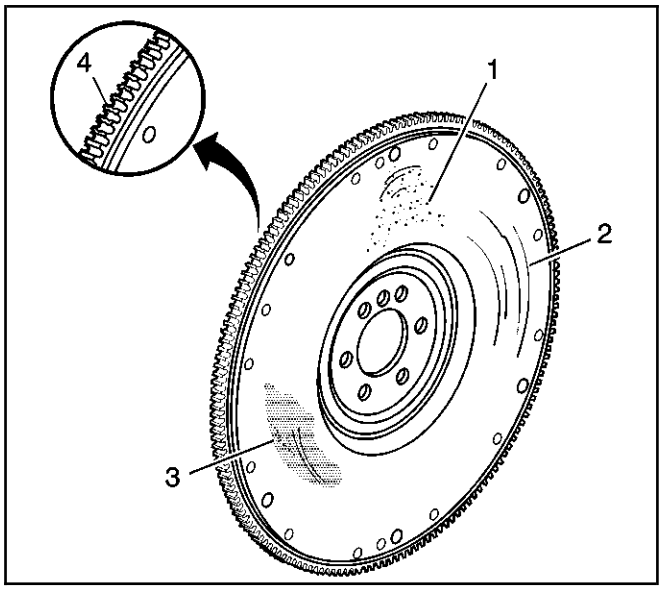

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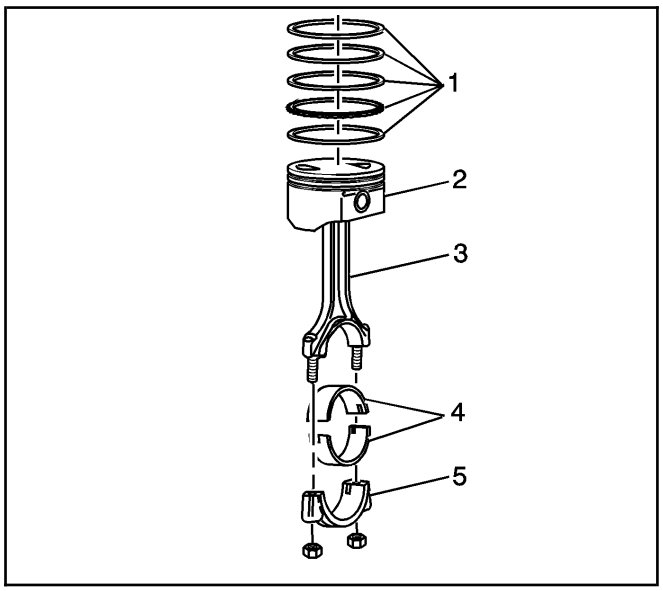


635669

Engine Flywheel Cleaning and Inspection (MT)

SIE-ID = 482763

1. Clean the engine flywheel in solvent.

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

2. Dry the engine flywheel with compressed air.
3. Inspect the manual transmission engine flywheel for the following conditions:
   - Pitted 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 should be positioned completely against the flange of the engine flywheel.

Piston and Connecting Rod Disassemble

SIE-ID = 482766

Important: The piston and connecting rod are only serviced as an assembly. If a new piston or connecting rod is required, a complete piston/connecting rod assembly must be used.

Important: New connecting rod nuts must be used when the pistons are reinstalled in the engine.

Remove the piston rings (1) from the piston (2).

Piston, Connecting Rod, and Bearings Cleaning and Inspection

SIE-ID = 482768

Important: The piston diameter can NOT be measured due to the piston coating. Do NOT measure the piston diameter.

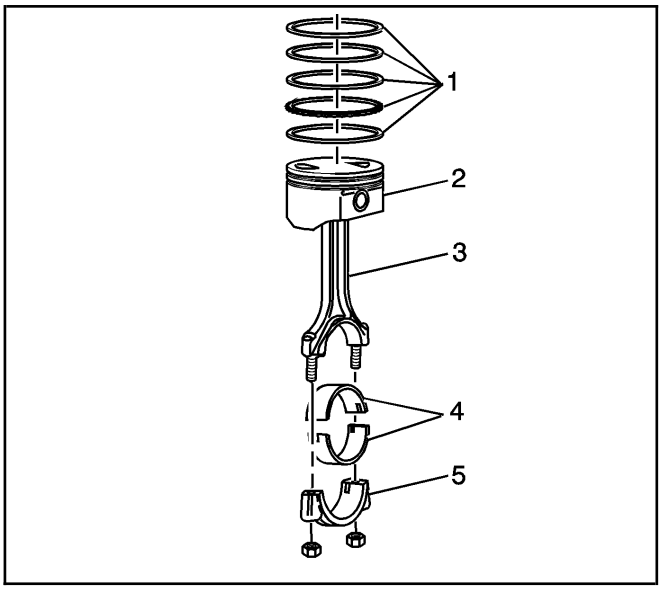
Important: Measurement of all components should be taken with the components at room temperature.

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

1. Clean the piston (2), connecting rod (3) and connecting rod cap (5) in solvent.

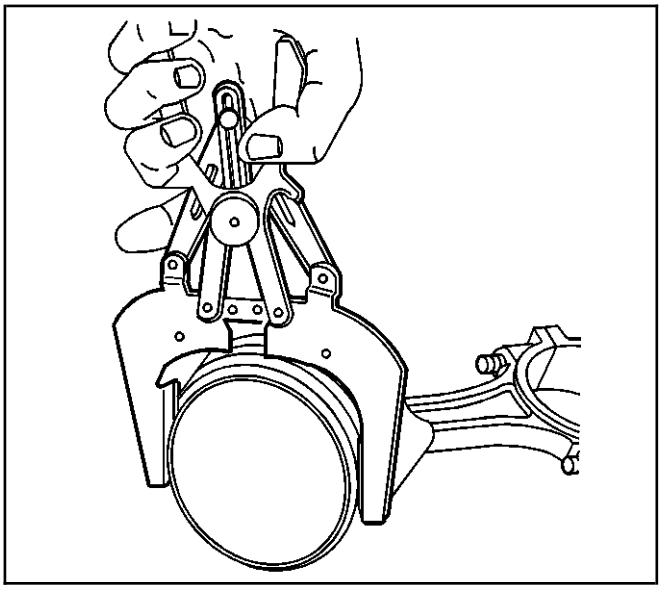
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the components with compressed air.



635669

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the piston oil lubrication holes and slots.



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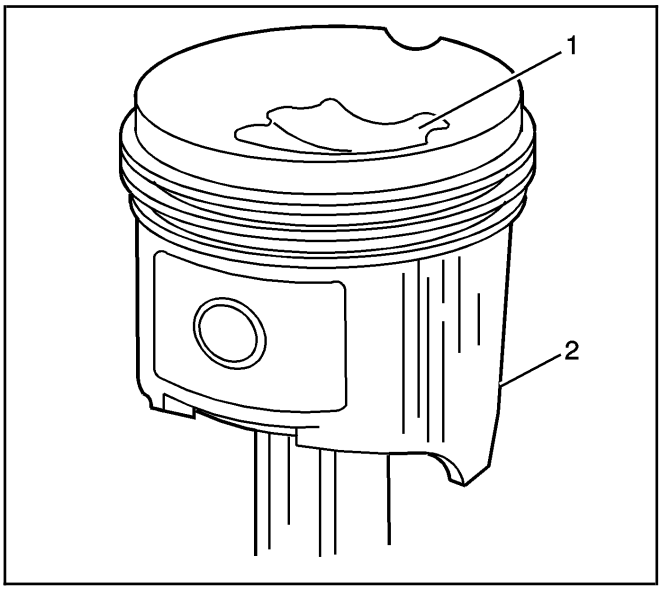
5. Inspect the piston for the following conditions:
   - Eroded areas (1) on the top of the piston
   - Scuffed or damaged skirt (2)
   - Cracks in the piston ring lands, the piston skirt, or the pin bosses
   - Piston ring grooves for nicks, burrs, or other warpage which may cause the piston ring to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



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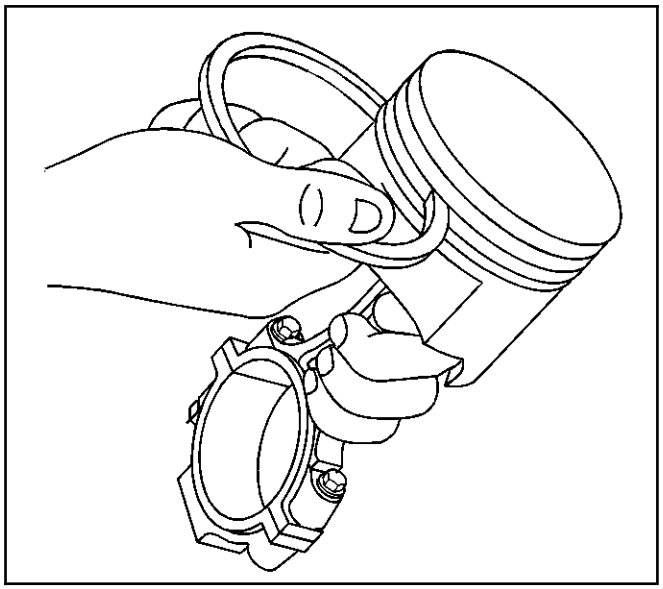
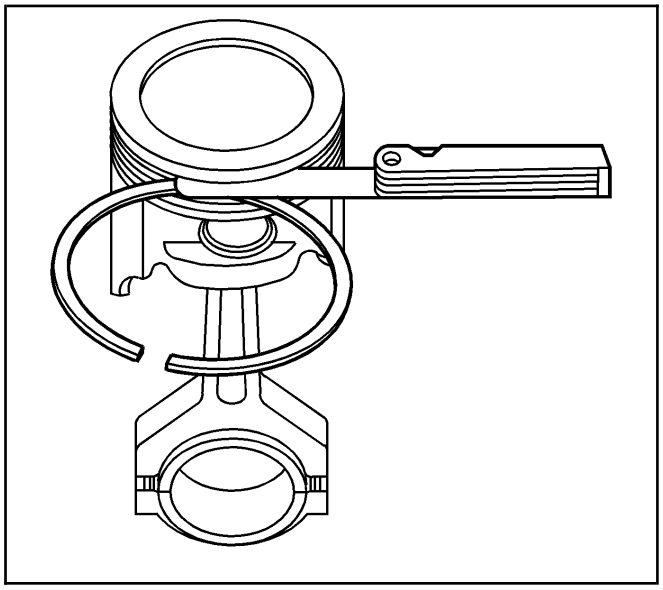


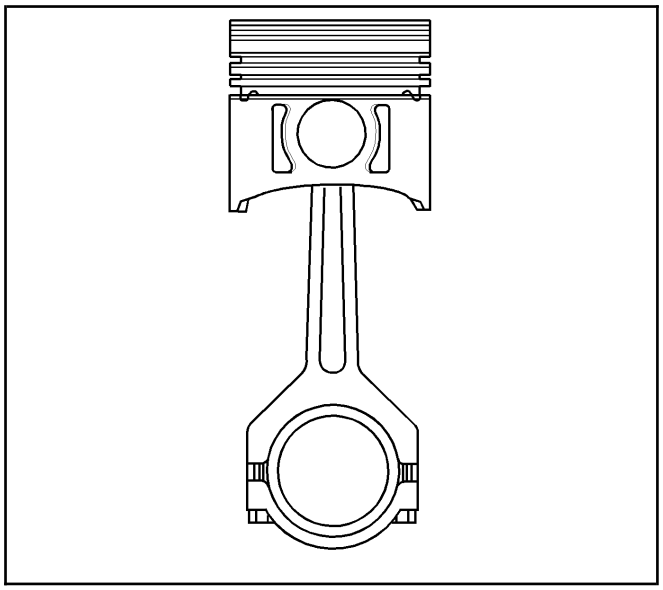
4969

7. Measure the piston ring-to-piston ring groove side clearance. Refer to *Engine Mechanical Specifications*.
   7.1. Insert the edge of the piston ring into the piston ring groove.
   Roll the piston ring completely around the piston.
   7.2. If binding is caused by a distorted piston ring groove, MINOR imperfections may be removed with a fine file.
   7.3. If binding is caused by a distorted piston ring, replace the piston ring.



639528

8. Measure the piston ring side clearance with a feeler gage.
9. If the side clearance is too small, try another piston ring set. Refer to *Engine Mechanical Specifications*.
10. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.



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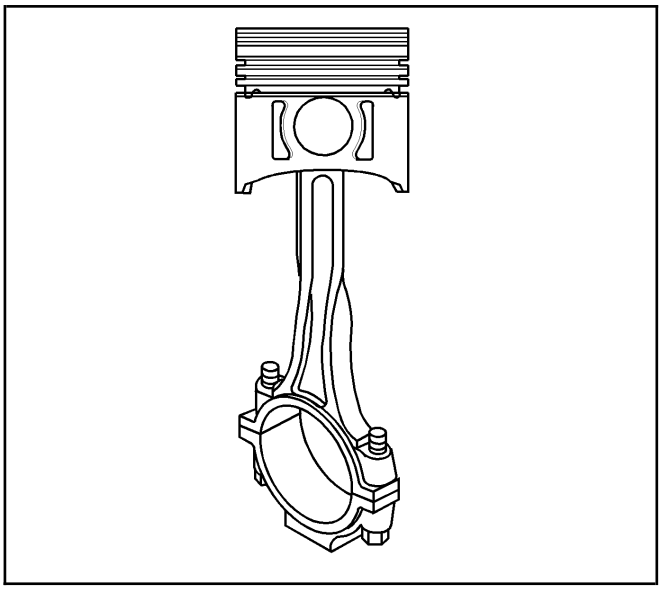
11. Inspect the connecting rod for an out-of-round bearing bore.

12. Inspect the connecting rod for twisting.
13. Inspect the connecting rod for damage to the connecting rod bolt threads.

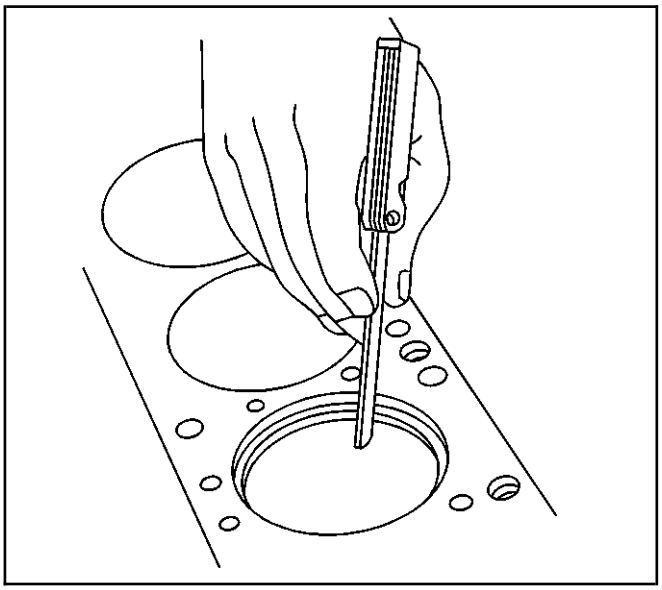


639524

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

14. Measure the piston compression ring end gap.
    - 14.1. Place the compression ring into the cylinder bore.
    - 14.2. Push the compression ring into the cylinder bore to approximately 6.5 mm (0.25 in) above the ring travel.

      The ring must be square to the cylinder wall.
    - 14.3. Use a feeler gage in order to measure the end gap.
    - 14.4. Select another size ring set if the end gap exceeds specifications.



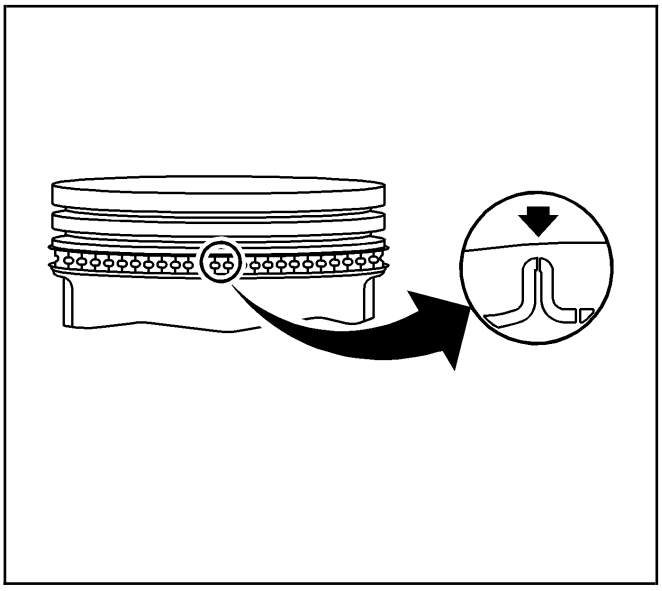
4968

Piston and Connecting Rod Assemble

SIE-ID = 482770

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 lower oil control piston ring spacer onto the piston.



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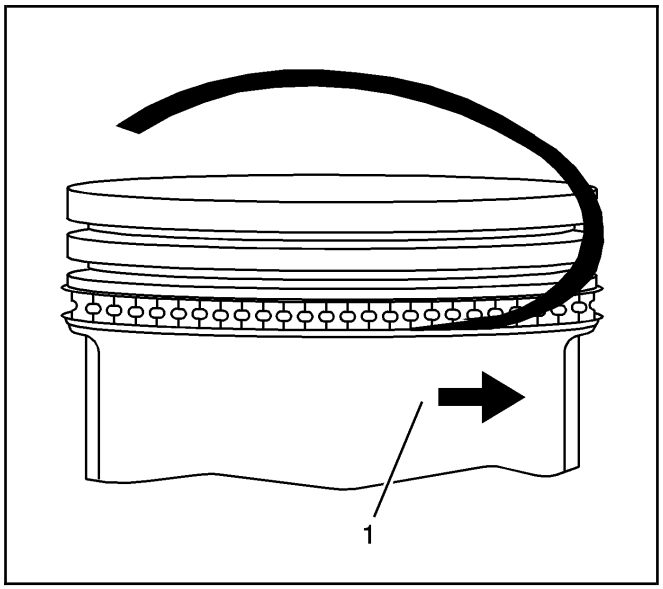

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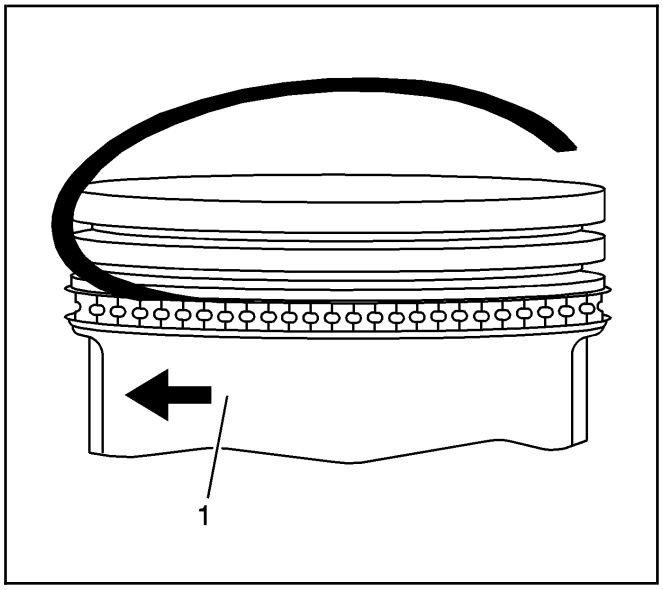
2. Install the lower oil control piston ring onto the piston (1).



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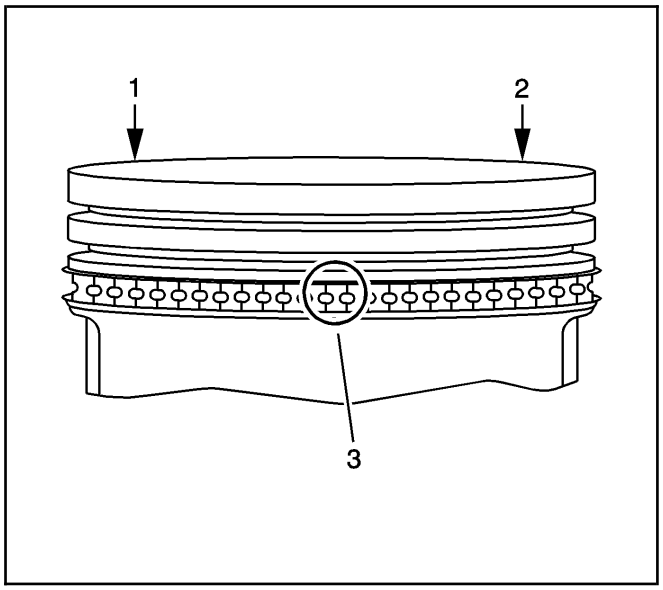
3. Install the upper oil control piston ring onto the piston (1).



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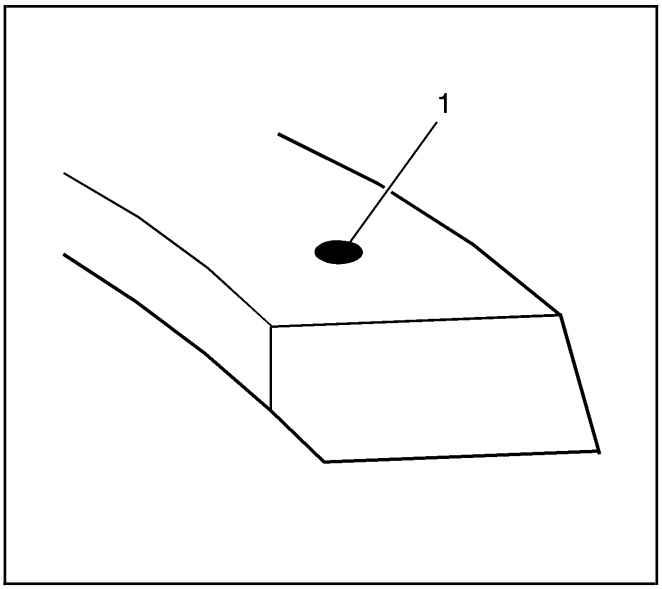
4. Space the oil control piston ring end gaps a minimum of 90 degrees apart (1, 2, 3).

5. Install the lower compression piston ring onto the piston (1). The mark on the side of the piston ring should face the top of the piston.



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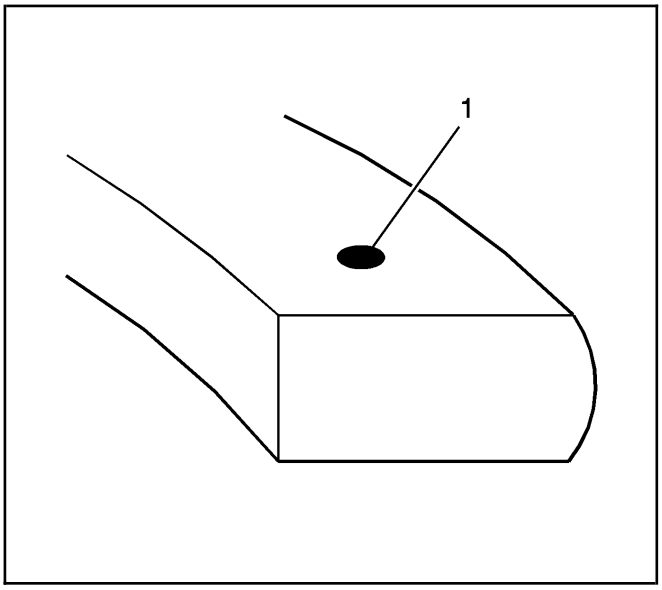
6. Install the upper compression piston ring onto the piston. The mark (1) on the side of the piston ring should face the top of the piston.
7. Space the compression piston ring end gaps 120 degrees apart.



562819

Camshaft and Bearings Cleaning and Inspection

SIE-ID = 482773

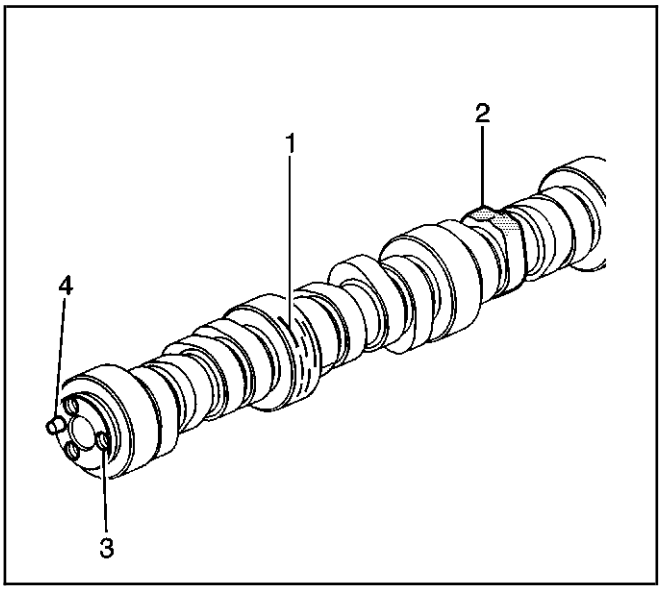
Tools Required

J 7872 Magnetic Base Dial Indicator

1. Clean the camshaft in solvent.

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

2. Dry the camshaft with compressed air.
3. Inspect the camshaft retainer plate for damage.
4. Inspect the camshaft for the following conditions:
   - Camshaft bearing journals (1) that are:
     - Worn
     - Scored
     - Damaged
   - Worn camshaft lobes (2)



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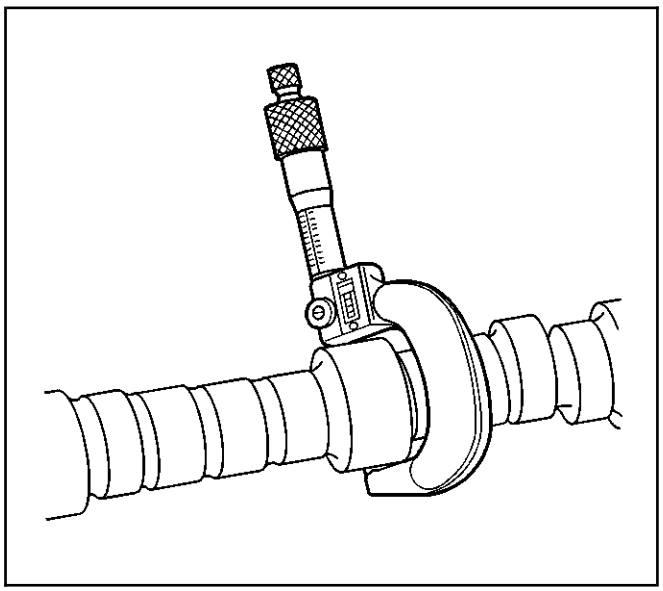
- Damaged sprocket bolt threads (3)
- Damaged sprocket pin (4)



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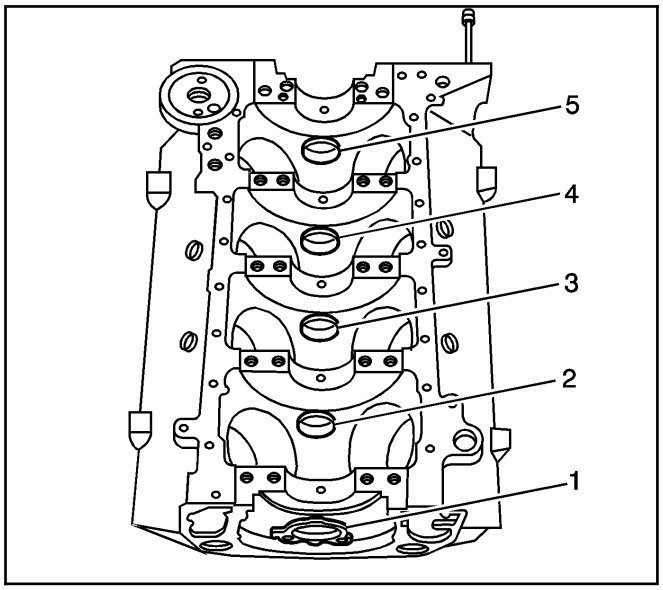
5. Measure the camshaft journals with a micrometer. Refer to *Engine Mechanical Specifications*.
6. Measure for excessive camshaft runout using *J 7872*.
   6.1. Mount the camshaft in a suitable fixture.
   6.2. Use the *J 7872* in order to measure for a bent camshaft. Refer to *Engine Mechanical Specifications*.
7. Replace the camshaft if runout exceeds specifications.



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8. Inspect the camshaft bearings (1–5) for serviceability.
9. Replace the camshaft bearings if necessary. Refer to *Camshaft Bearing Removal* and *Camshaft Bearing Installation*.

Camshaft Bearing Installation

SIE-ID = 482774

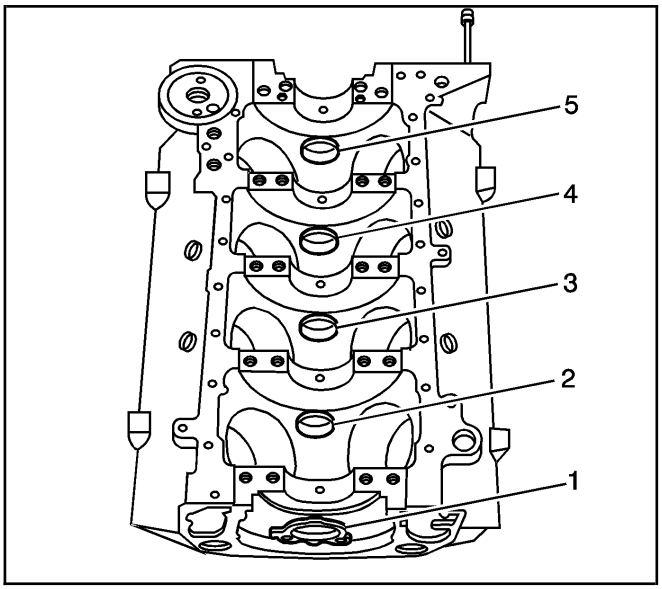
Tools Required

J 33049 Camshaft Bearing Service Set

Important: The outer camshaft bearings (positions 1 and 5) must be installed first. These bearings serve as guides for the tool and help center the inner bearings during the installation process.

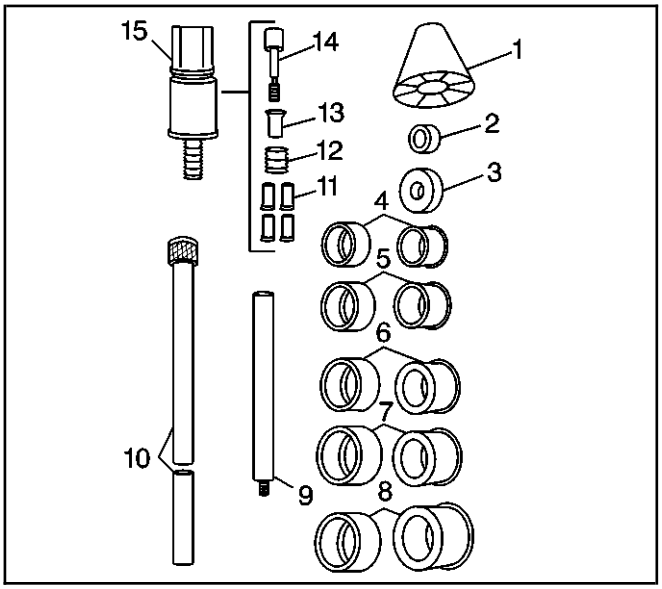
Ensure the correct camshaft bearing fits into the proper bore. The camshaft bearing bores may vary in size.

Ensure that the camshaft bearing lubrication hole or holes align with the oil gallery hole or holes in the block. On some engines, the oil holes may be difficult to see. Verify that the holes are aligned.



639523

1. Assemble the tool handle (10), expanding driver (4–8), and washer (2 or 3).



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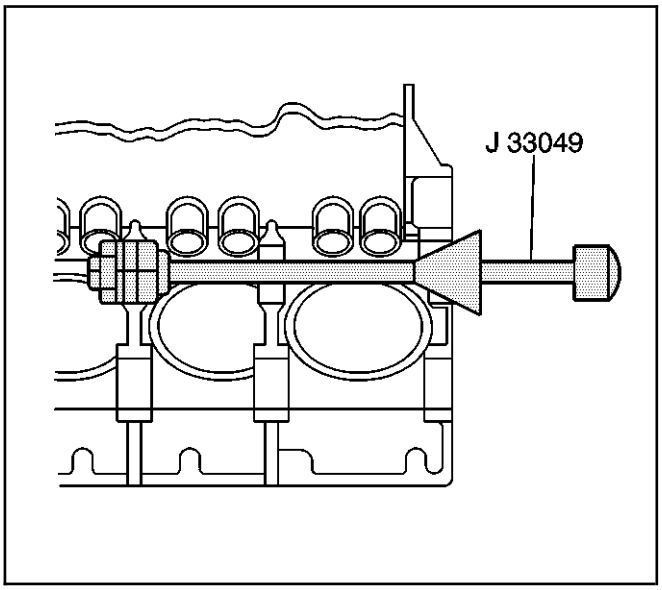
2. Insert the *J 33049* tool into the engine block end camshaft bearings.

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.

Important: An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the bearing and the camshaft journal.

3. Drive the end bearings into the bore.



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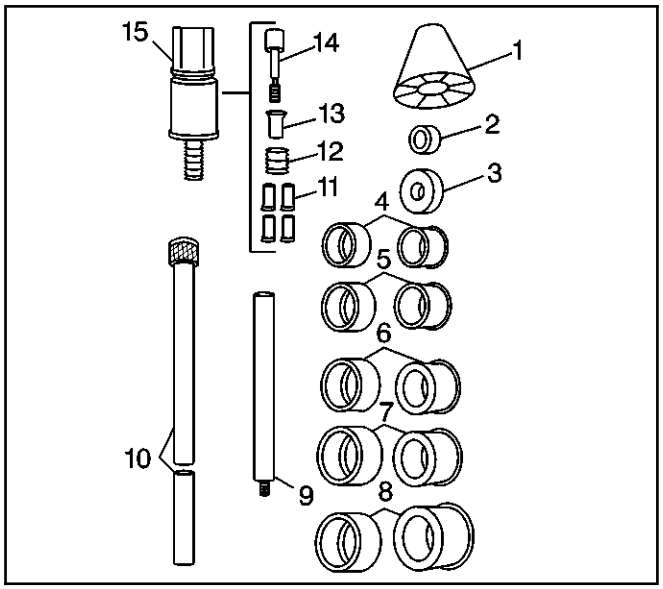

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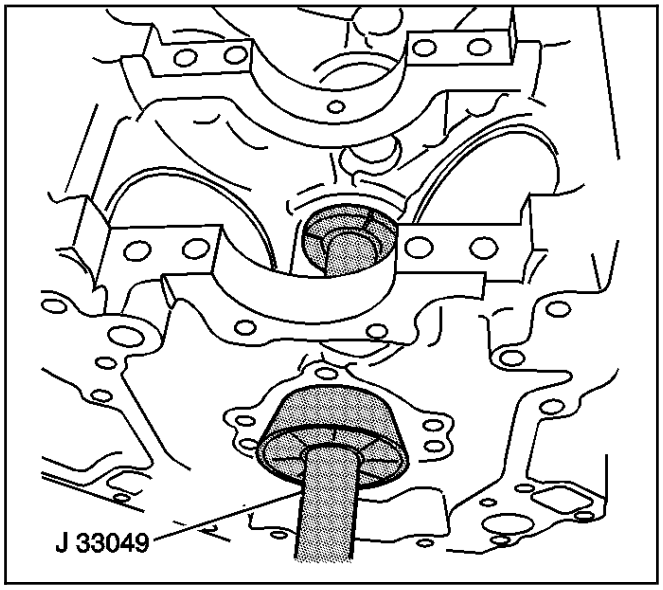
4. Select the expanding driver (4–8) and washer (2 or 3) from the *J 33049*.
5. Assemble the tool.



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6. Insert the *J 33049* tool through the front of the engine block and to the inner bearing bores.
7. Install the bearing onto the expanding driver.
8. Tighten the expander assembly nut until the tool is snug in the bearing.

Important: The camshaft bearing oil holes must align with the oil galleries in the engine block.

After installation of the camshaft bearings, inspect the camshaft bearing oil holes for proper alignment with the oil galleries.

An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the bearing and the camshaft journal.

9. Align the oil lubrication hole in the bearing with the oil galleries in the engine block.
10. Push the guide cone into the front camshaft bearing bore to align the tool.
11. Drive the bearing into the bore.

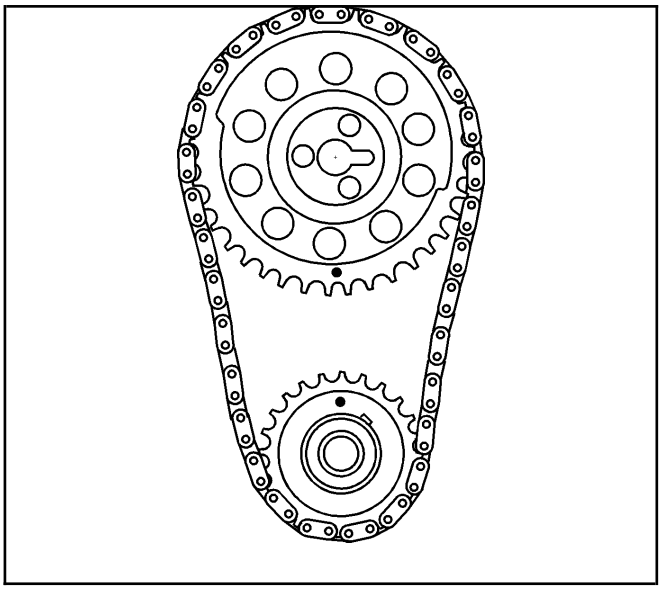
Timing Chain and Sprockets Cleaning and Inspection

SIE-ID = 482775

1. Clean the camshaft timing components in solvent.

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

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



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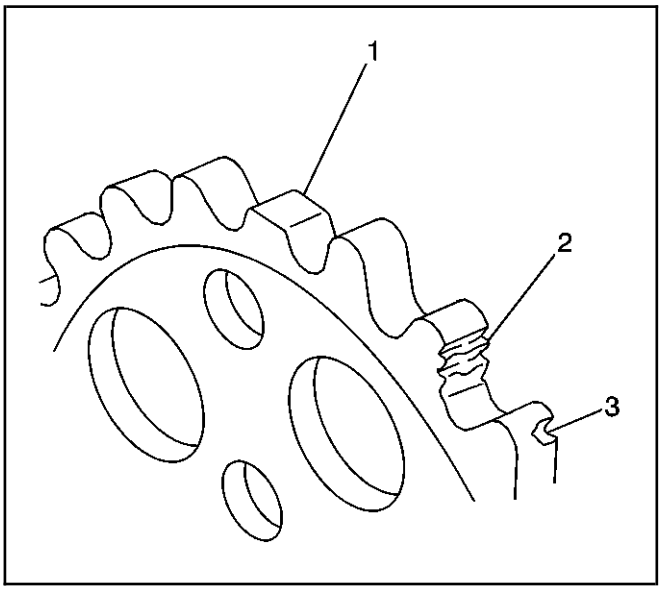
Important: If the sprocket(s) must be replaced, replace both sprockets to ensure that timing chain centerline alignment is maintained.

4. Inspect the camshaft and crankshaft sprockets for the following conditions:
   - Worn teeth (1)
   - Damaged teeth (2)
   - Chipped teeth (3)
   - Uneven wear on one edge of the teeth
   - Worn valleys between the sprocket teeth
   - Crankshaft sprocket keyway for wear



188097

Valve Rocker Arm and Push Rods Cleaning and Inspection

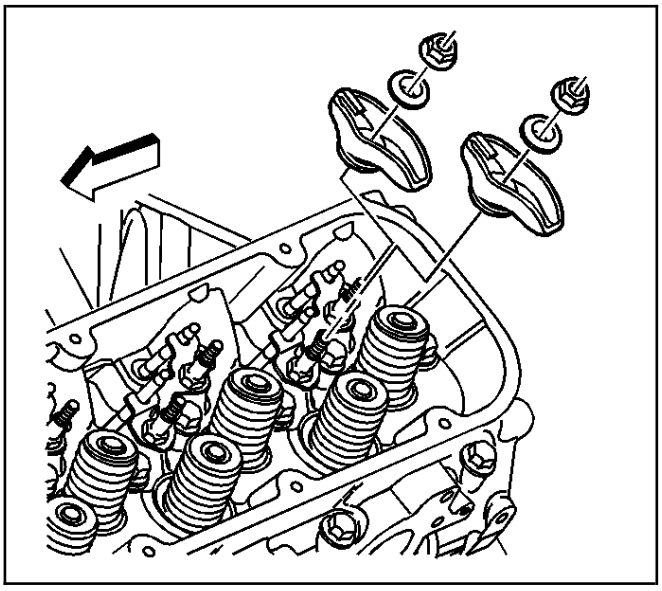
SIE-ID = 482776

Important: Parts that are to be reused must remain sorted or organized in order to return them to their original location.

1. Clean the components with cleaning solvent.

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

2. Dry the components with compressed air.
3. Inspect the valve rocker arms for wear or scoring in the ball area.
4. Inspect the valve rocker arm push rod sockets and valve stem tip mating surfaces.
5. Inspect the valve rocker arm ball for wear or scoring.



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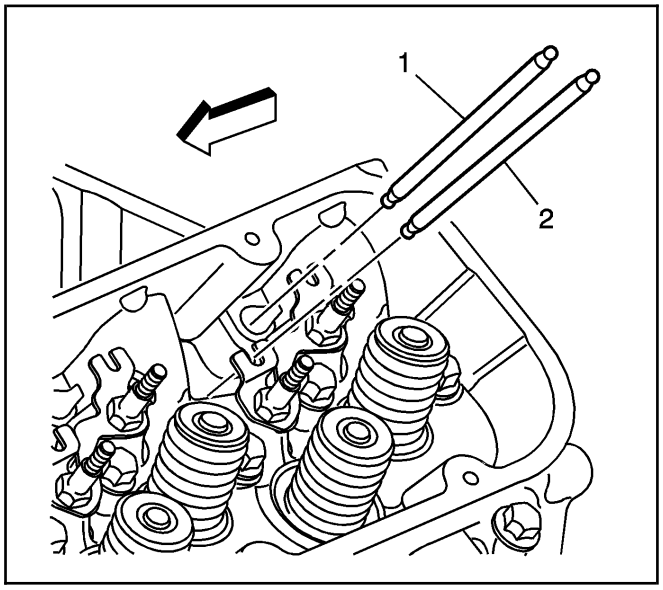

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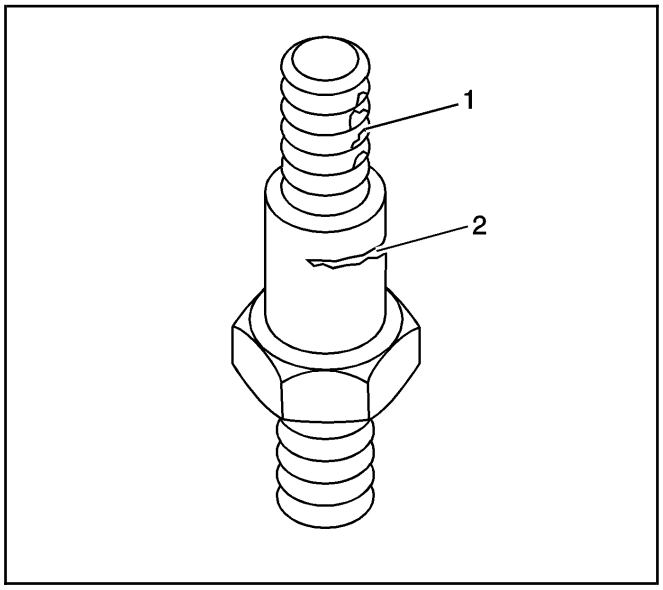
These surfaces should be smooth with no scoring or exceptional wear.

6. Inspect the push rods (1, 2) for worn or scored ends.

   These surfaces should be smooth with no scoring or exceptional wear.

7. Inspect the push rods for bends. Roll the push rods on a flat surface to determine if the push rod is bent. If it rolls smoothly, it is OK. If the push rod does not roll smoothly, replace the push rod.
8. Inspect the push rod oil passages for restrictions.
   - Clean out the push rod tube with compressed air.
   - Inspect by looking through the push rod tube for obstructions. A clear push rod will allow light through.
   - Replace push rod(s) that cannot be cleaned out.



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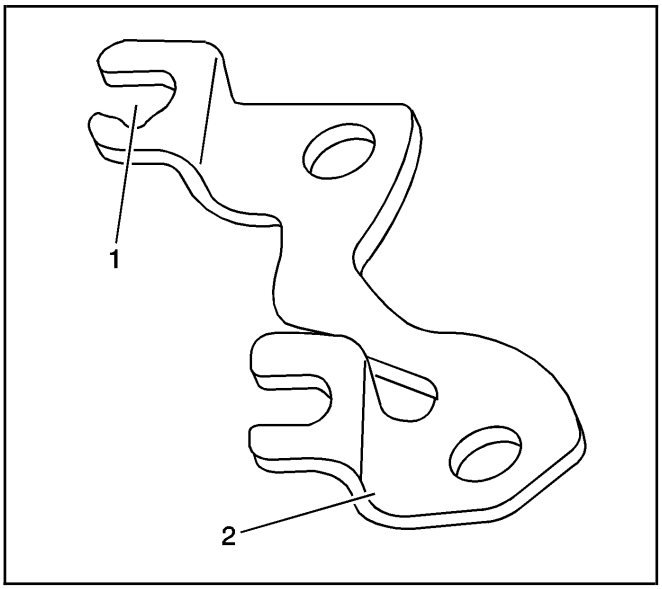
Important: A light contact mark on the rocker arm stud is normal. A noticeable groove in the rocker arm stud is excessive wear and the rocker arm stud should be replaced.

9. Inspect the rocker arm studs for the following conditions:
   - Damaged threads (1)
   - Excessive wear or damage made from contact between the rocker arm and rocker arm stud (2)
10. Valve rocker arm studs with excessive wear and/or damage must be replaced.

11. Inspect the push rod guides for the following conditions:
    - Wear between the push rod and the push rod guide (1)
    - Bent push rod guide (2)
    - Cracks
12. Push rod guides with excessive wear and/or damage must be replaced.



635675

Valve Lifters and Guides Cleaning and Inspection

SIE-ID = 482777

Important: Parts that are to be reused must remain sorted or organized in order to return them to their original location.

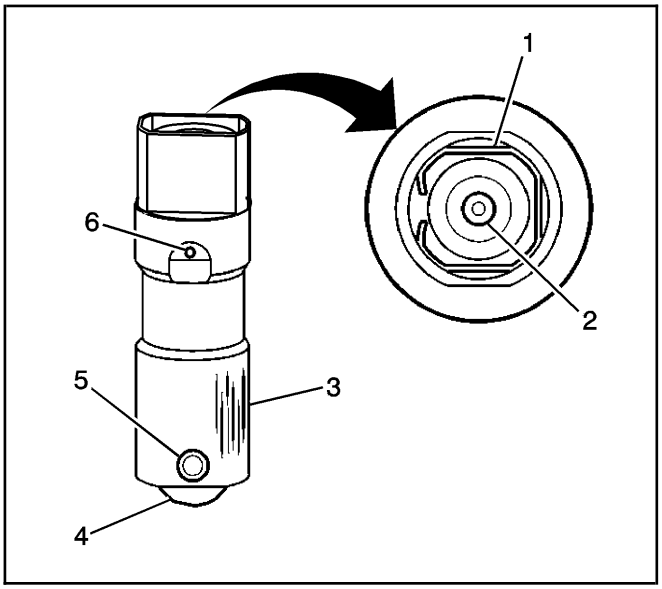
Important: Disassembly of the valve lifter(s) is not recommended.

1. Clean the components in cleaning solvent.

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

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following:
    - A damaged, mispositioned or broken clip (1)
    - A scored or worn pushrod socket (2)
    - A severely scuffed or worn lifter body (3)

      If the valve lifter body shows scuffing or wear, inspect the engine block valve lifter bores for wear or damage.
    - Flat spots on the roller (4)
    - A loose pin (5)
    - A plugged oil hole (6)
4. If flat spots are found on the lifter(s), inspect the corresponding lobe on the camshaft for damage.



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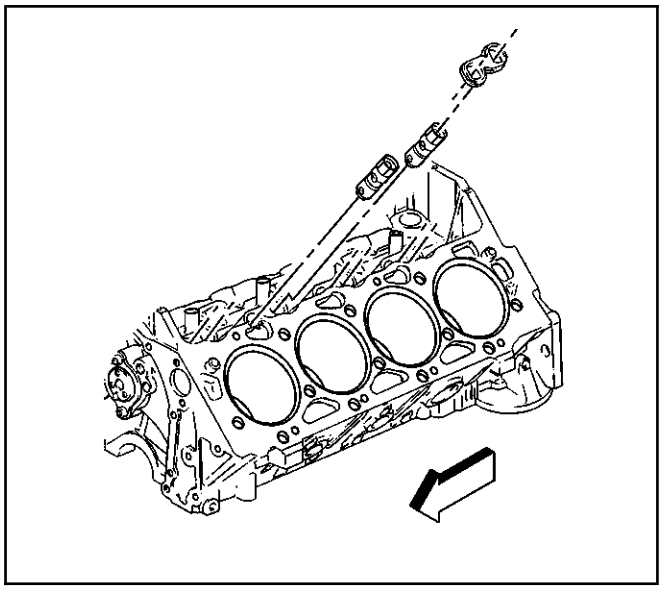
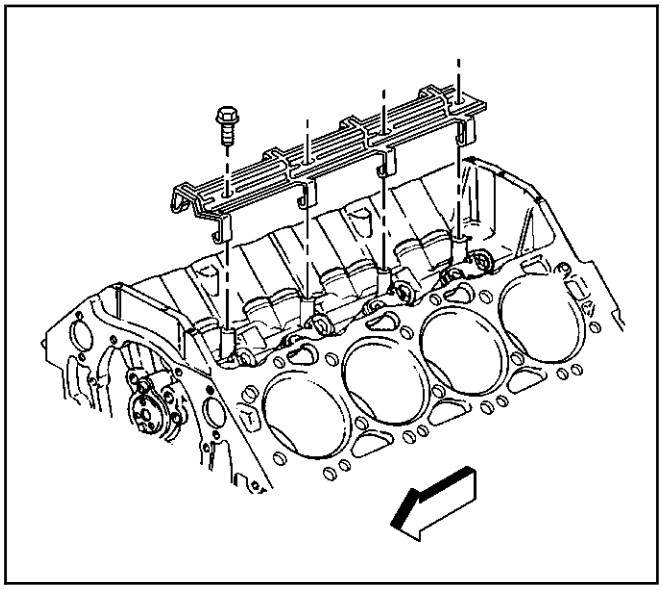


173176

5. Inspect the valve lifter guides for the following:
   - Excessive guide slot side wear
   - Cracks or damage



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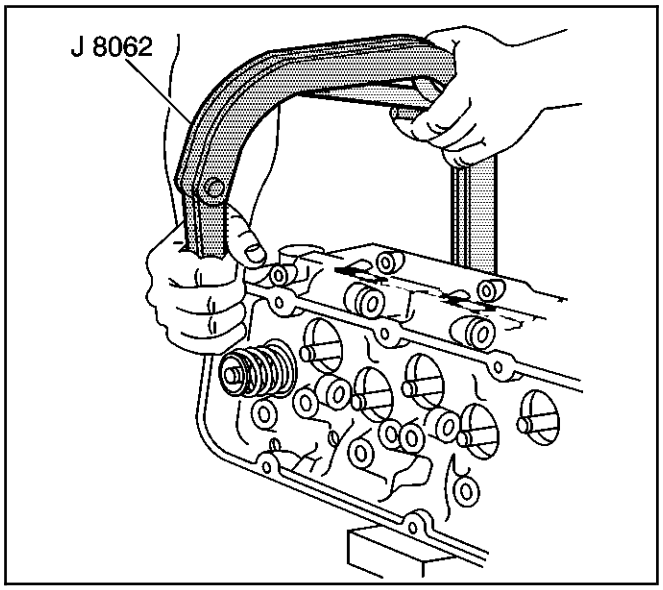
6. Inspect the valve lifter guide retainer for the following:
   - Wear, damage, or stress cracking in the leg areas
   - Wear or damage around the retainer bolt holes



196664

Cylinder Head Disassemble

SIE-ID = 482778

Tools Required

J 8062 Valve Spring Compressor - Head Off

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

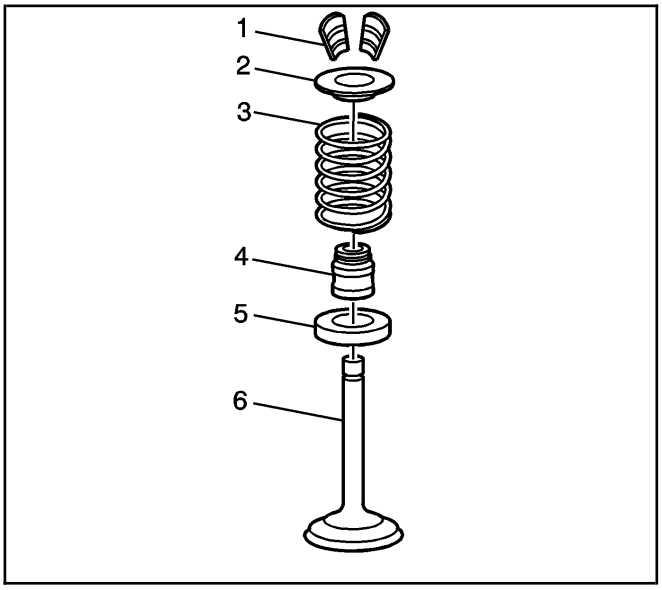
Caution: *SIO-ID = 411464* ***Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or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

Important: Mark, sort, or organize components for return to their original locations.

1. Use *J 8062* in order to compress the valve springs.
2. Remove the valve stem keys (1).
3. Release and remove *J 8062*.
4. Remove the cap (2).
5. Remove the valve spring (3).
6. Remove the positive valve stem seal (4) from the valve guide.
7. Remove the valve rotator (5).

Important: In order to prevent damage to the valve guide, small burrs on the valve tip and at the stem key groove that interfere with the valve removal can be lightly filed with a fine file or stone to facilitate valve removal.

8. Remove the valve (6).



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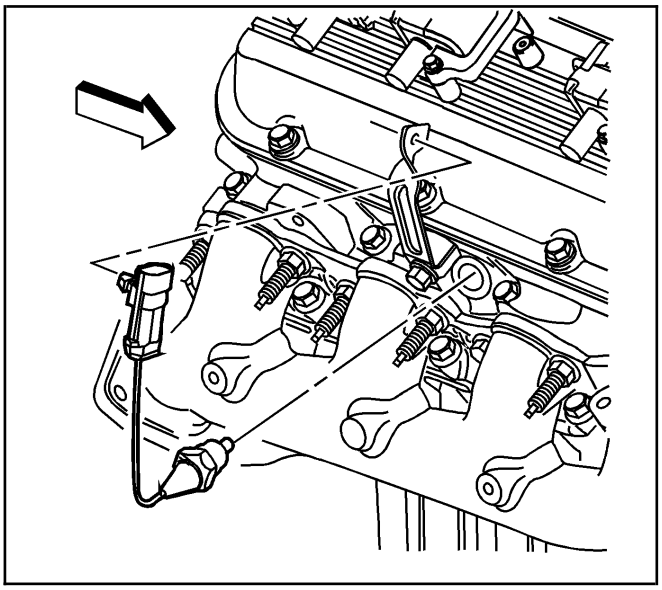
9. Disconnect the engine coolant temperature (ECT) sensor from the bracket.
10. Remove the ECT sensor from the right cylinder head.
11. Remove the ECT sensor bracket and bolt.



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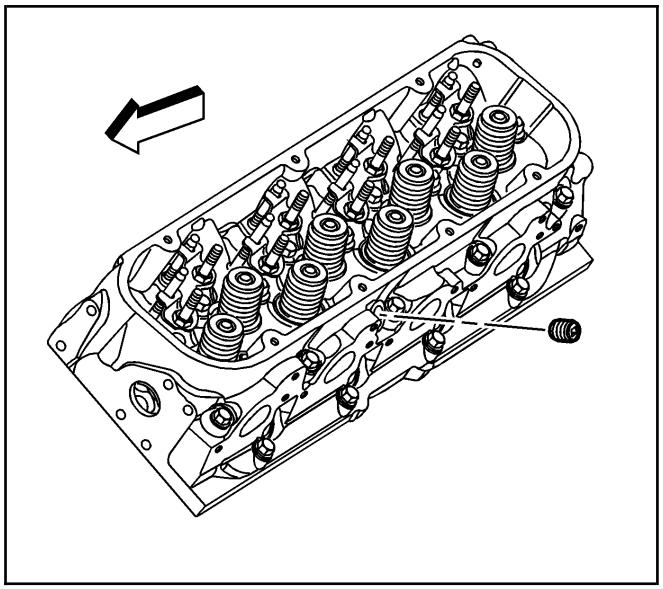

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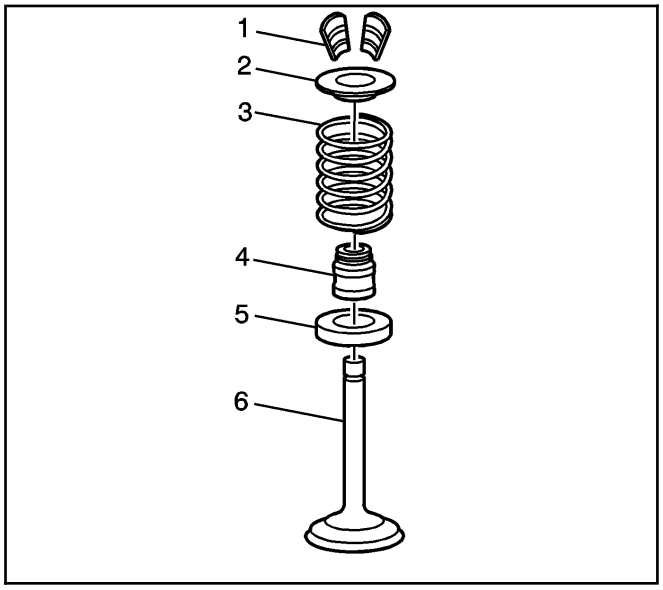
12. Remove the cylinder head coolant hole plug from the left cylinder head.



677748

Cylinder Head Cleaning and Inspection

SIE-ID = 482779

Tools Required

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

Cleaning Procedure

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

Important: Mark, sort, or organize components for return to their original locations.

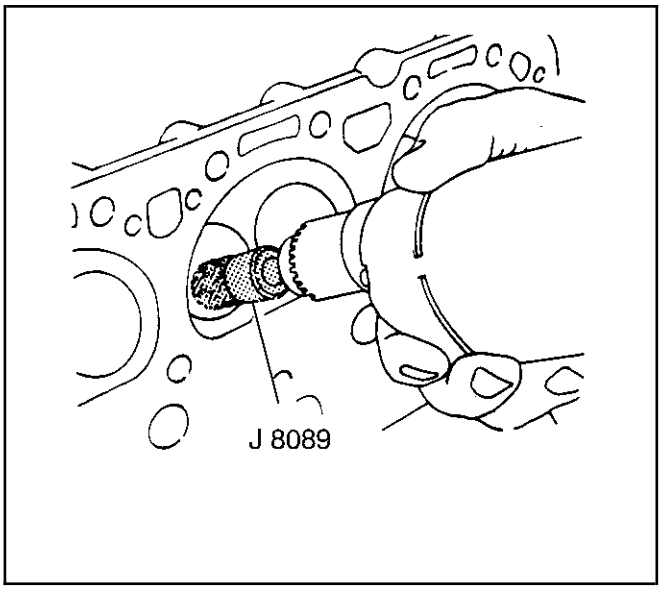
1. Clean the valve stems and heads on a buffing wheel.
2. Clean the following components in solvent:
   - Valve stem keys (1)
   - Valve spring cap (2)
   - Valve spring (3)
   - Valve Rotators (5)
   - Valve (6)
   - Cylinder head

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

3. Dry the components with compressed air.

Important: Be careful not to damage the chamber or the valve seat.

4. Use the *J 8089* in order to clean the carbon from the combustion chambers.



35201

Visual Inspection Procedure

Inspect the cylinder head for the following conditions:

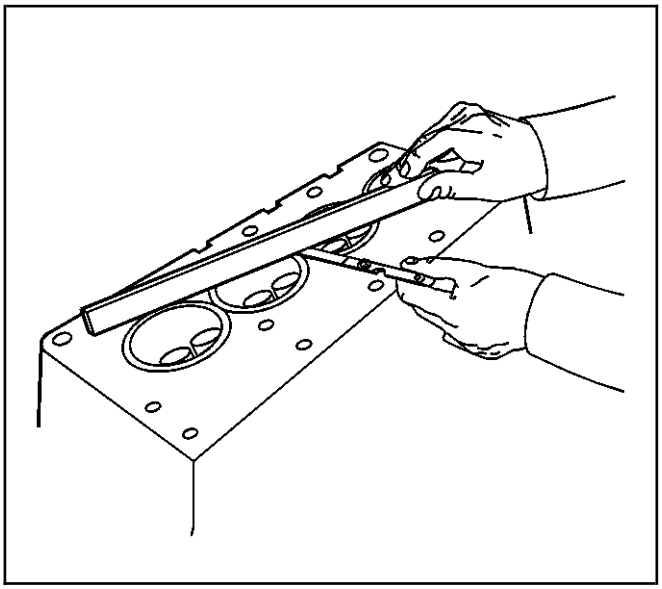
- Damaged gasket surfaces
- Damage to threaded bolt holes
- Burnt or eroded areas in the combustion chamber
- Cracks in the exhaust ports and combustion chambers
- External cracks in the water chamber
- Restrictions in the intake or exhaust passages
- Restrictions in the cooling system passages

Flatness Measurement Procedure

1. Measure the cylinder head for warpage with a straight edge and feeler gage.
   - A cylinder head block deck with warpage in excess of 0.050 mm (0.002 in) within a 150.0 mm (6.0 in) area must be repaired or replaced.
   - A cylinder head exhaust manifold deck with an overall warpage in excess of 0.102 mm (0.004 in) must be repaired or replaced.
   - A cylinder head intake manifold deck with warpage in excess of 0.080 mm (0.003 in) must be repaired or replaced.
2. A cylinder head block deck can be resurfaced up to 0.305 mm (0.012 in) maximum removal.

Important: Excessive cylinder head resurfacing will affect compression ratio and emission control.

3. A cylinder head that requires excessive resurfacing must be replaced.



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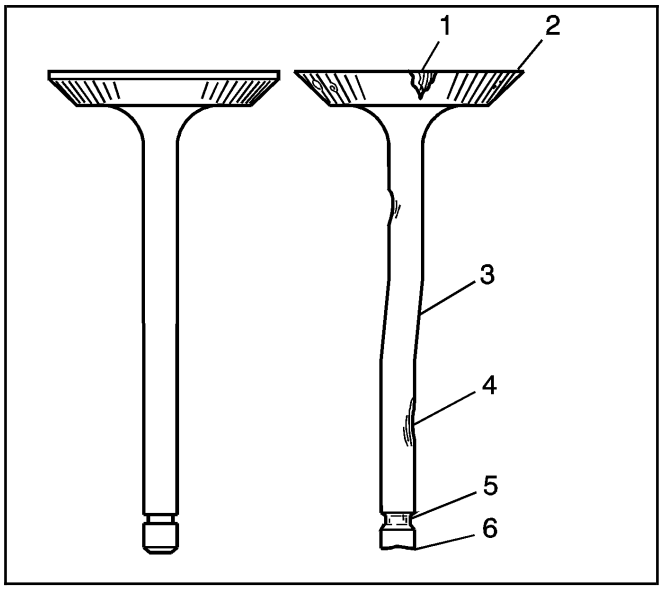

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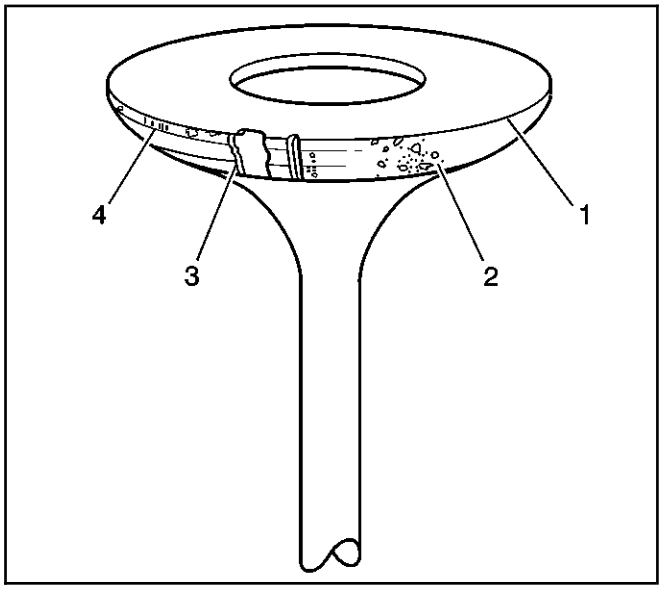
Valve Inspection Procedure

1. Inspect the valves for the following conditions:
   - Burnt or damaged areas (1)
   - Undersized valve margin (2)
   - Bent stem (3)
   - Scoring or other damage to the stem (4)
   - Worn key groove (5)
   - Worn stem tip (6)

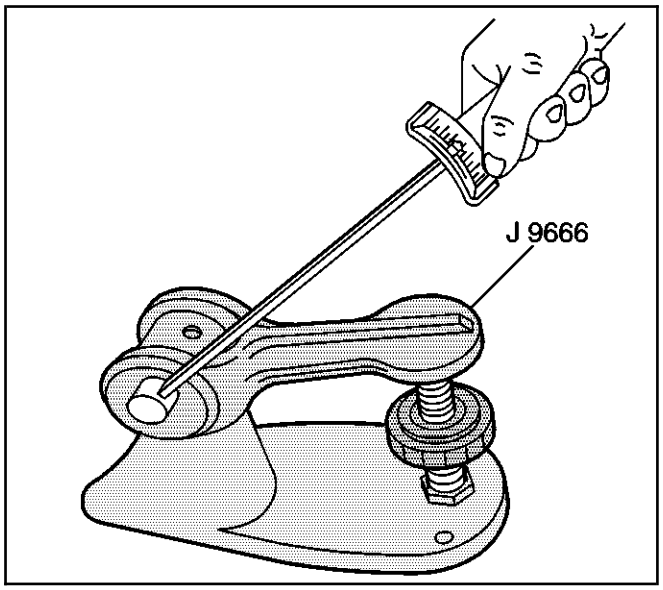


156173

2. Inspect the valve contact surface for the following conditions:
   - Undersized margin (1)
   - Pitted surface (2)
   - Burnt or eroded areas (3)
   - Acceptable edge (margin) (4)

Important: Minor imperfections of the valve may be corrected during reconditioning.

3. Valves with excessive damage must be replaced.



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Valve Spring Inspection and Measurement

1. Inspect the valve springs for broken coils or coil ends.
2. Use the *J 9666* in order to measure the valve spring force. Refer to *Engine Mechanical Specifications*.

Important: Add a maximum of one shim up to 0.726 mm (0.030 in) thick to increase tension.

3. If the valve spring tension is low, use a shim to increase tension.
4. Recheck the valve spring tension, a valve spring that does not meet specification must be replaced.

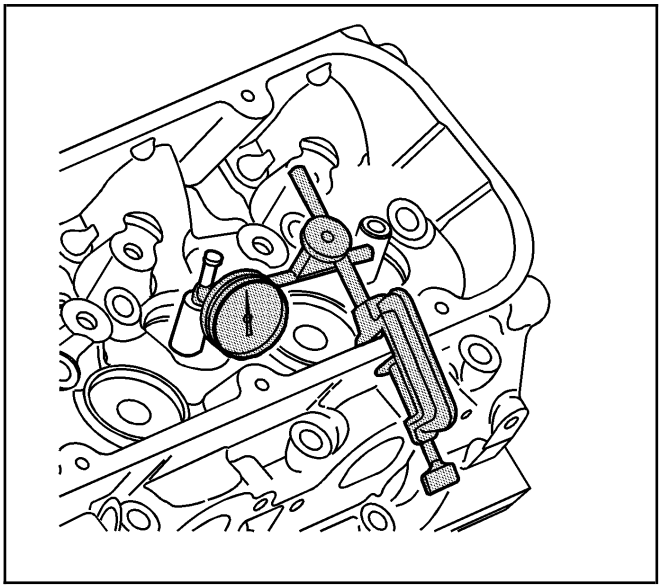
Valve Guide Measurement Procedure

Important: 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.

1. Measure the valve stem-to-guide clearance.
   1.1. Clamp the *J 8001* on the exhaust port side of the cylinder head.

Important: The indicator stem must contract the side of the valve stem just above the valve guide.

   1.2. Locate the indicator so that the movement of the valve stem from side to side (crosswise to the cylinder head) will cause a direct movement of the indicator stem.
   1.3. Drop the valve head about 1.6 mm (0.064 in) off the valve seat.
   1.4. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to *Engine Mechanical Specifications*.
2. Valve guide (2) with excessive clearance must be repaired. Refer to *Valve Guide Reaming/Valve and Seat Grinding*.
3. Replace the cylinder head if the valve guide cannot be repaired or reamed to accept an oversize valve stem.



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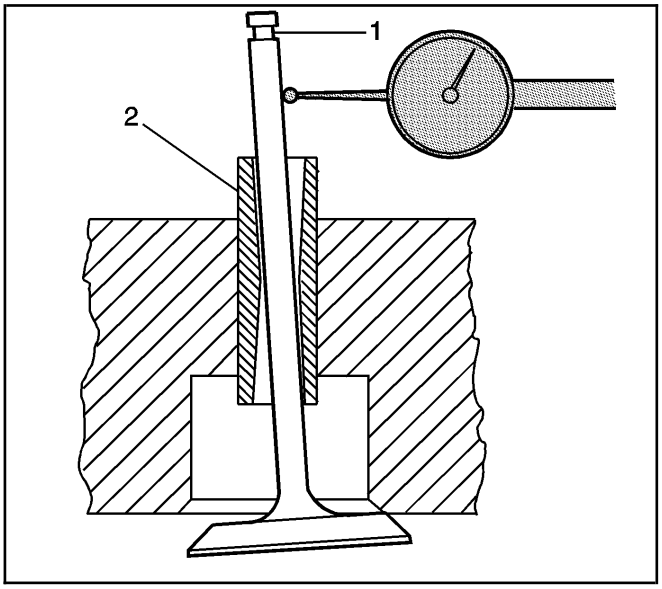

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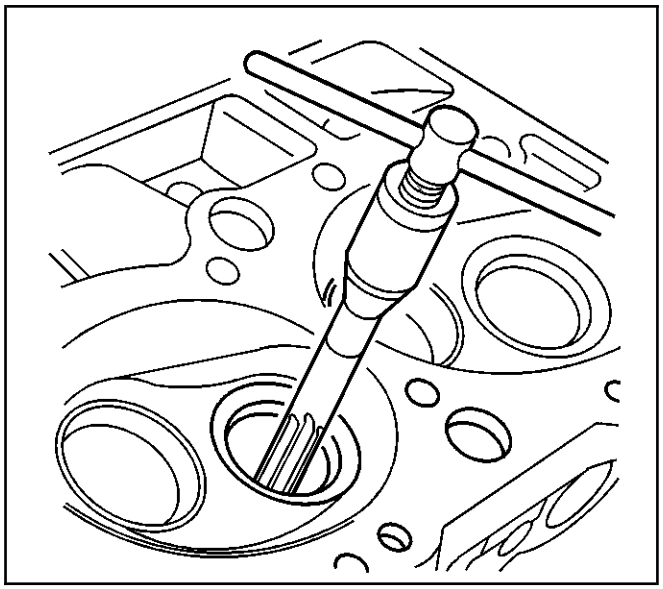

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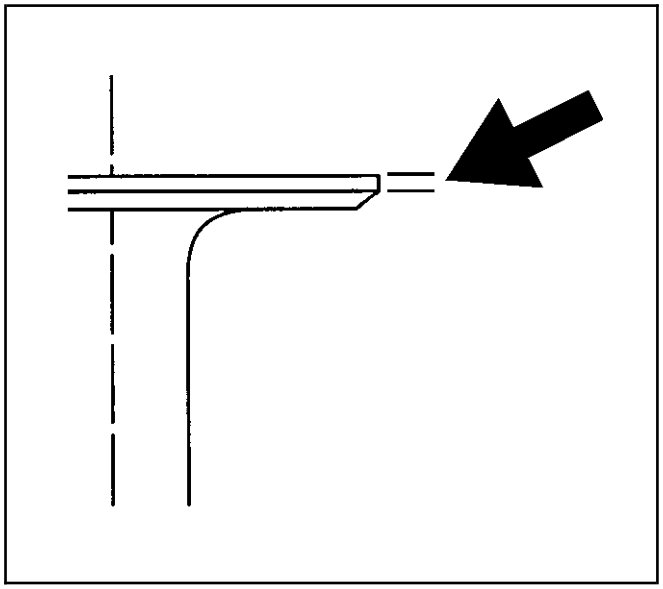

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Valve Guide Reaming/Valve and Seat Grinding

SIE-ID = 482780

Valve Guide Reaming Procedure for Oversized Valve Stems

Notice: SIO-ID = 728981 The exhaust valve guides are replaceable components and must be serviced properly. The exhaust valve guide must be pressed out and into the cylinder head in the proper directions. The old exhaust valve guide must be removed by pressing out towards the combustion chamber side of the cylinder head. The new exhaust valve guide must be installed by pressing from the combustion chamber side of the cylinder head. Failure to press the exhaust valve guide out and into the cylinder head in the proper directions will damage the cylinder head.

1. Ream the valve guide as necessary to achieve proper valve stem-to-guide clearance with the new, oversized valve stems.
2. Always recondition the valve seat after reaming the valve guide bores or installing new valves.
3. Replace the cylinder head if the valve guide cannot be repaired or reamed to accept an oversize valve stem.

Valve Reconditioning Procedure

1. Replace the valve if the valve stem shows excessive wear or is warped.

Important: Several different types of equipment are available for reconditioning valves. Use the manufacturers recommendations of equipment to attain the proper results.

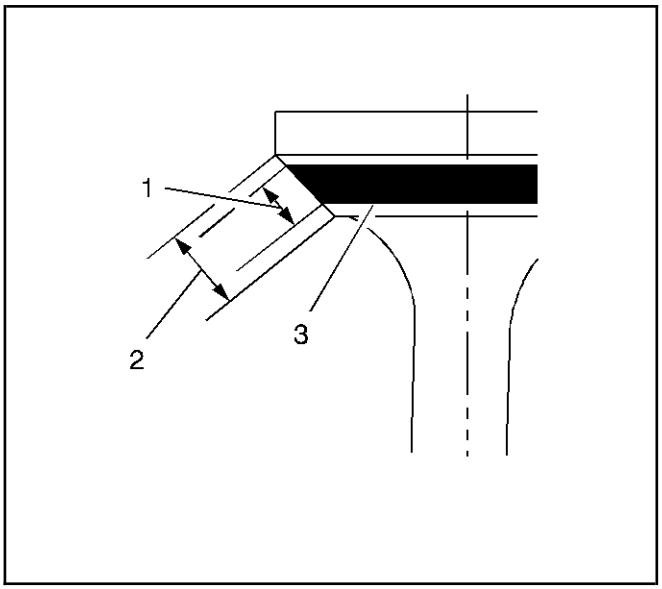
2. Reface pitted valves on a valve refacing machine in order to insure the correct relationship between the head and the stem.
3. Replace the valve if the edge of the head is less than 0.79 mm (0.031 in) thick after grinding.

Valve Seat Reconditioning Procedure

Important: Several different types of equipment are available for reconditioning valve seats. Use the manufacturers recommendations of equipment to attain the proper results.

Important: Always recondition the valve seat after reaming the valve guide bores or installing new valves.

1. Recondition the valve seats.
2. The valves must seat perfectly for the engine to deliver optimum power and performance.
3. Ensure that the valve seat and valve are not shrouded after valve seat reconditioning. Adequate flow past the valve seat and valve is essential for cooling the valve head and valve seat area.
4. Correct contact (1) between each valve and its seat in the cylinder head is also essential to ensure that the heat in the valve head is properly carried away.



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Important: Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the guide.

5. The valve seats should be concentric to within 0.050 mm (0.002 in) total indicator runout.

Cylinder Head Assemble

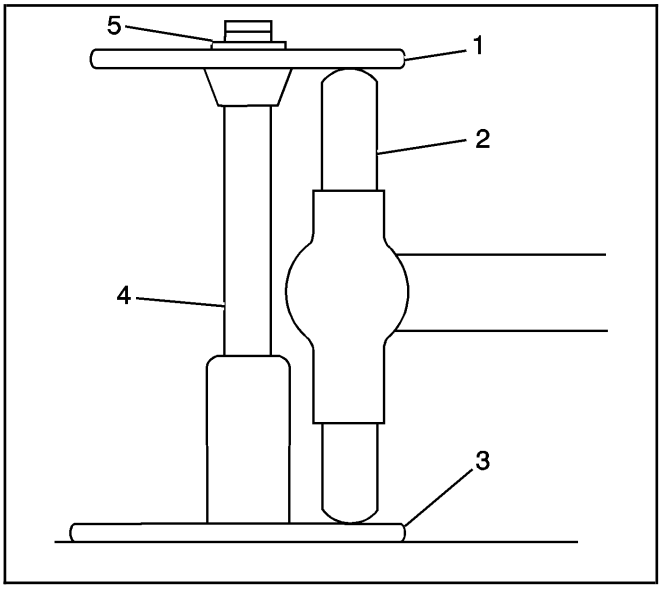
SIE-ID = 482781

Tools Required

- *J 8062* Valve Spring Compressor
- *J 43105* Valve Stem Seal Installer

Checking Valve Spring Installed Height

1. Install the valve rotator (3), the valve (4), the valve spring cap (1) and the valve stem keys (5) into the cylinder head.
2. Using a snap gage or inside micrometer, measure the distance from the top of the valve rotator to the bottom of the valve spring cap. Refer to *Engine Mechanical Specifications* for proper valve spring installed height specifications.



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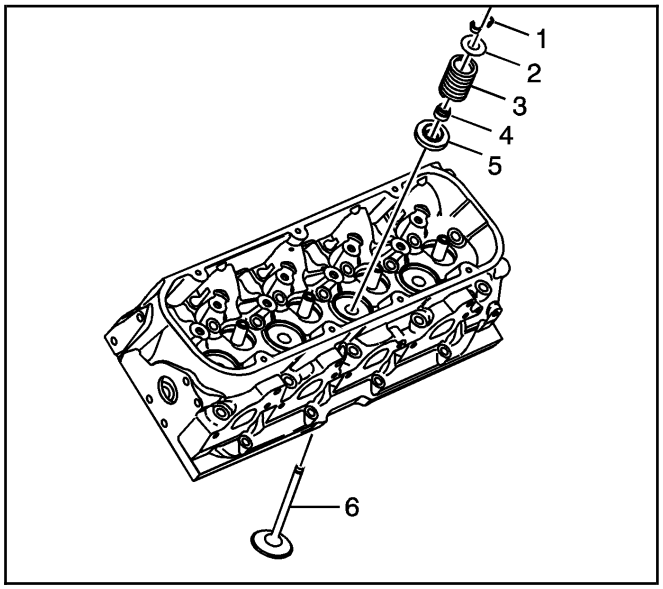
Important:

- Never shim the spring to obtain an installed height under the specified amount.
- Install the valve spring seat shims under the rotator (between the rotator and the cylinder head spring seat).
- Add a maximum of one valve spring seat shim, up to 0.726 mm (0.030 in) thick to achieve the valve spring installed height specification.
- The combination of valve spring seat shims to correct valve spring installed height and valve spring tension should not exceed 1.524 mm (0.060 in) thick.

3. Install a valve spring seat shim if the valve spring installed height measurement is above the specification.



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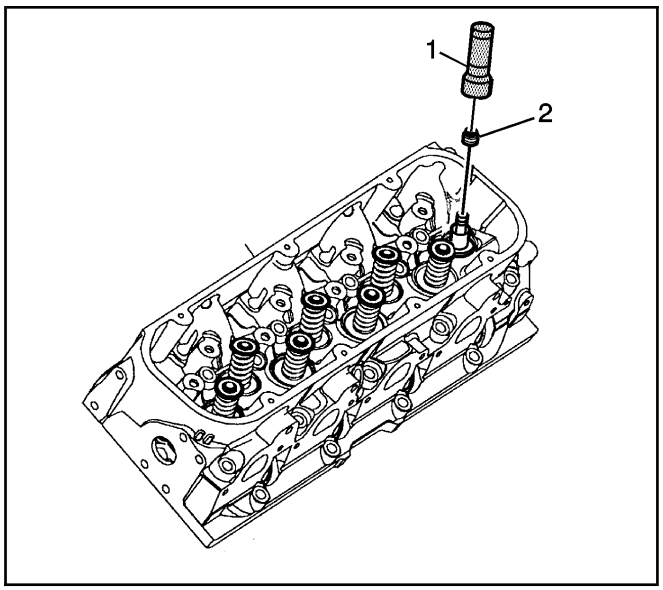

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4. Recheck the valve spring installed height, replace the cylinder head if the valve spring installed height cannot be obtained.

Valve Installation

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

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.***

1. Lubricate the valve stems (6) with clean engine oil.
2. Insert the valves into their proper locations.
3. Install the necessary valve spring shims onto the cylinder head, if applicable.
4. Lubricate the rotators (5) with clean engine oil.
5. Install the rotators over the guide and on top of the cylinder head or valve spring shims, if applicable.

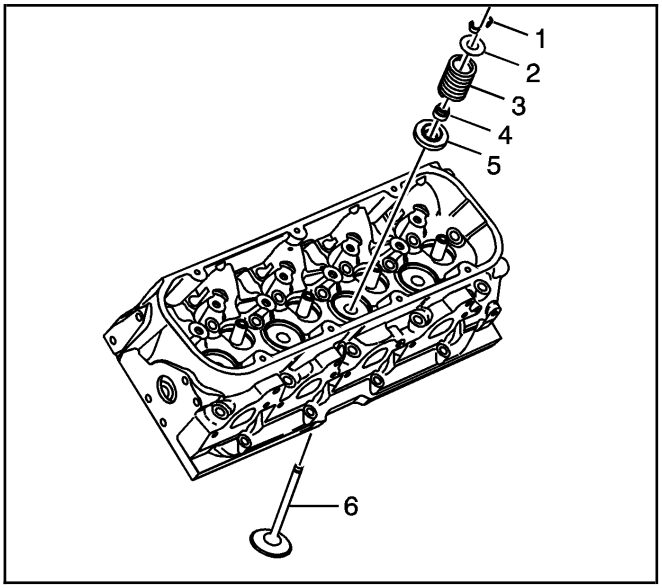
Important: When installing valve stem oil seals onto the valve guides, be careful not to tear the seal lip.

Important: When installing valve seals, *J 43105* must be used to achieve correct installation. Failure to use *J 43105* may cause excessive oil consumption.

6. Lubricate the valve stem seal and the outside diameter of the valve guide with clean engine oil.
7. Install the valve stem oil seals (2) over the valve tip and onto the valve guides using *J 43105*. Tap the valve stem seal onto the valve guide until the *J 43105* fully seats the seal.

Important: When installing valve springs, the small end of the valve spring must be installed up.

8. Install the valve springs (3).
9. Install the valve spring caps (2).



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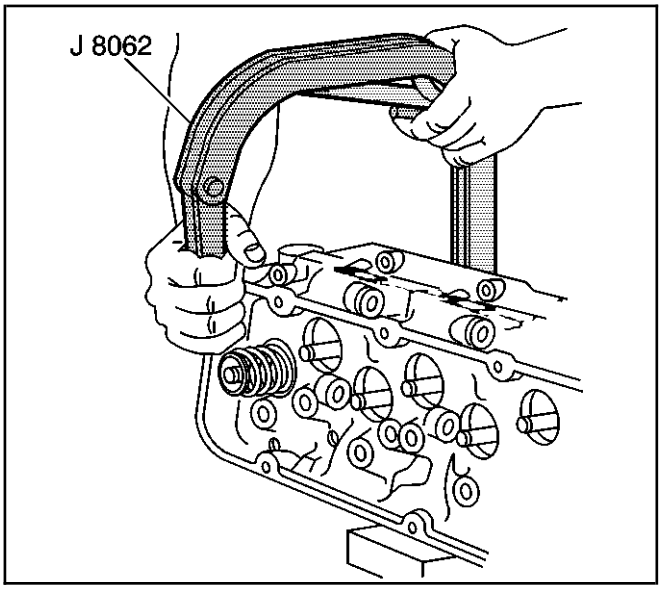
10. Use the *J 8062* in order to compress the valve spring. Compress the spring enough to clearly see the valve stem key grooves of the valve.
11. Install the valve stem keys.
    - Use grease to hold the keys in place.
    - Ensure that the keys seat properly in the upper groove of the valve stem.
12. Release and remove the *J 8062*.
13. Lightly tap the end of the valve stem with a plastic-faced hammer to seat the keys.



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

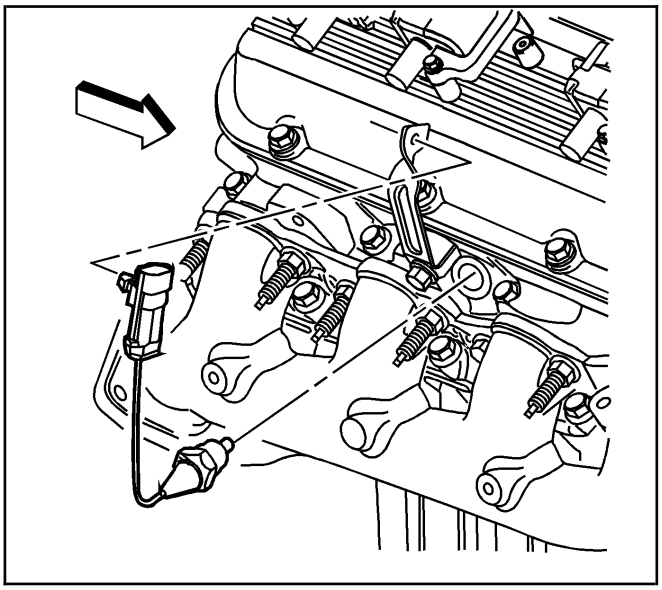
14. Install the engine coolant temperature (ECT) sensor into the right cylinder head.

    Tighten

    Tighten the ECT sensor to 20 N·m (15 lb ft).
15. Install the ECT sensor bracket and bolt.

    Tighten

    Tighten the ECT sensor bracket bolt to 50 N·m (37 lb ft).



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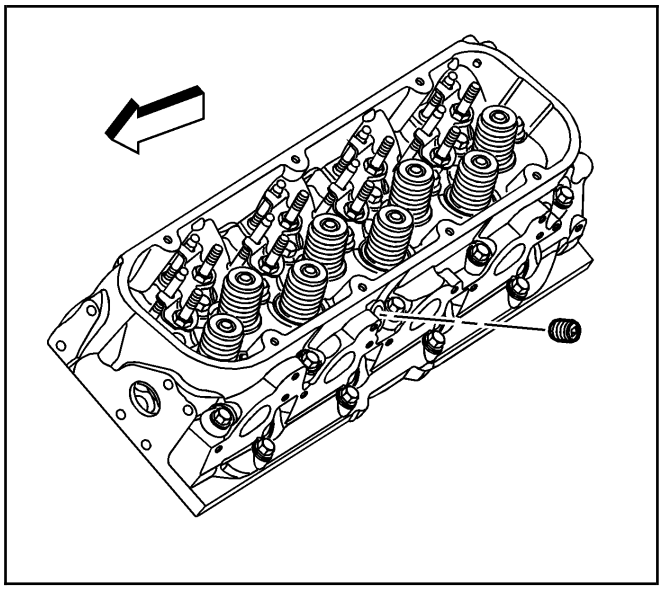

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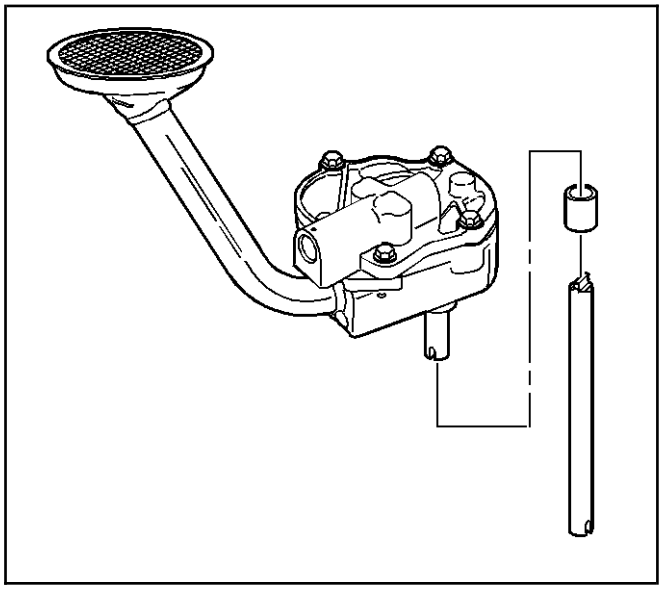
16. Install the cylinder head coolant hole plug into the left cylinder head.

    Tighten

    Tighten the cylinder head coolant hole plug to 23 N·m (17 lb ft).



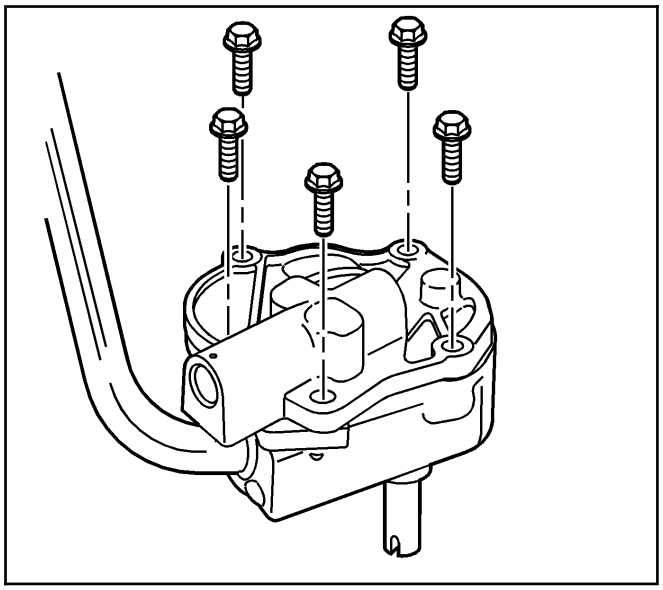
427935

Oil Pump Disassemble

SIE-ID = 482782

Important: The oil pump pipe has a press fit into the oil pump. DO NOT remove the pipe from the oil pump. The pipe and oil pump are serviced as a complete assembly.

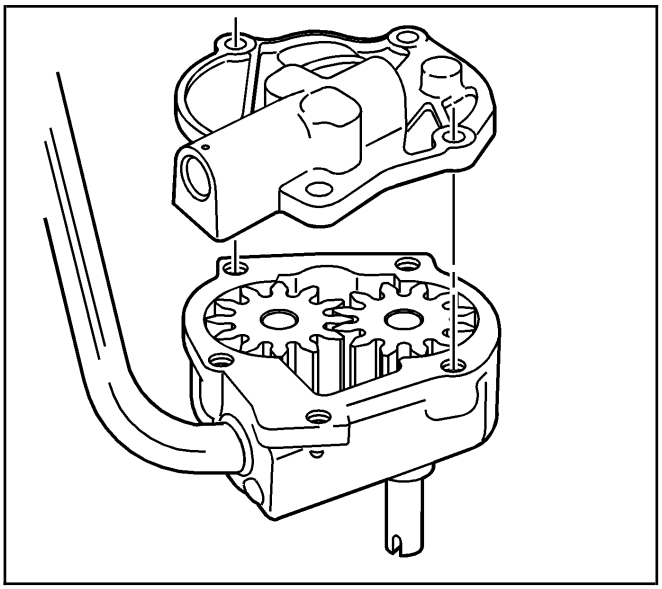
1. Remove the oil pump driveshaft and retainer.



678105

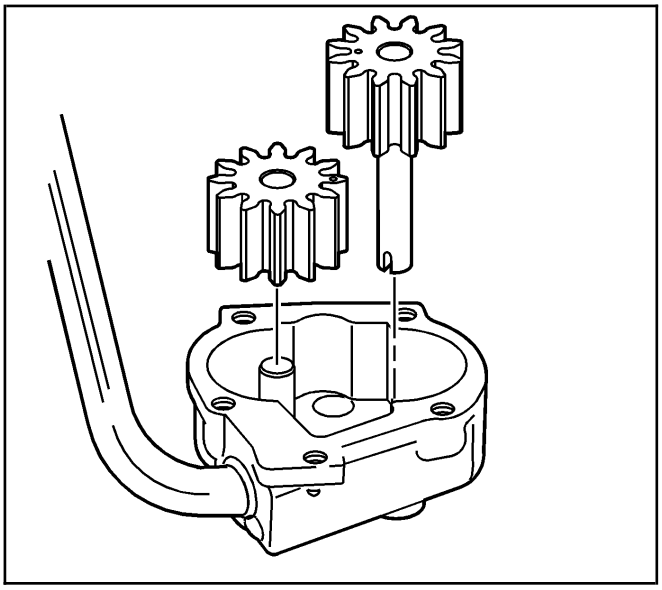
2. Remove the oil pump cover bolts.

3. Remove the pump cover.



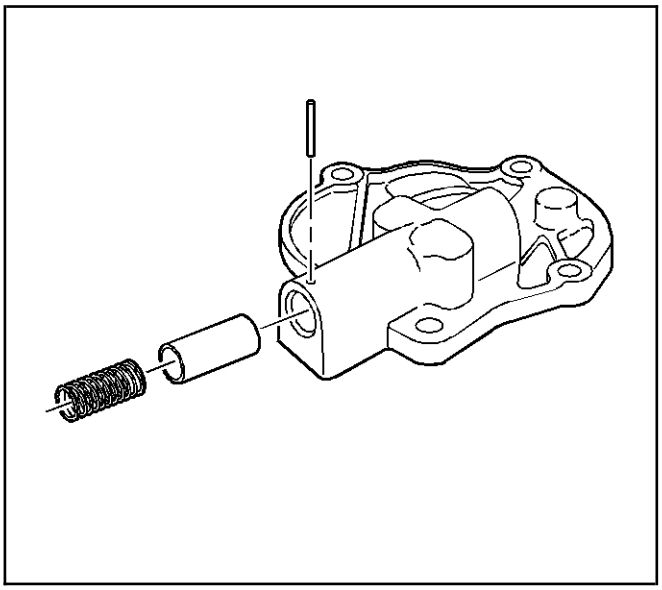
678106

4. Remove the drive gear and the driven gear. Matchmark the gear teeth for assembly.

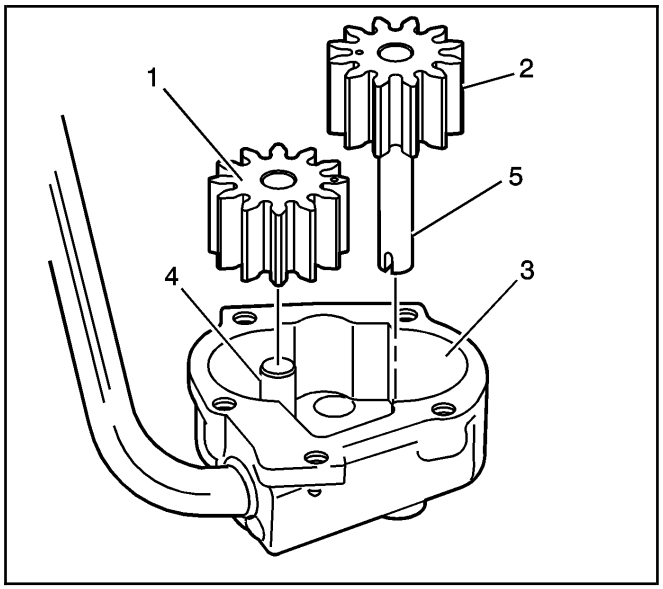


678107

5. Remove the following items:
   5.1. The retaining pin
   5.2. The pressure relief spring
   5.3. The pressure relief valve



427947



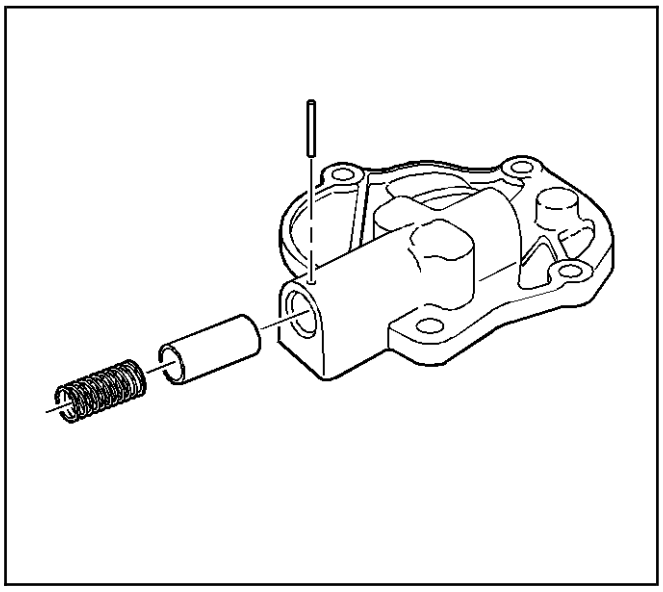
678109

Oil Pump Cleaning and Inspection

SIE-ID = 482783

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.



427947

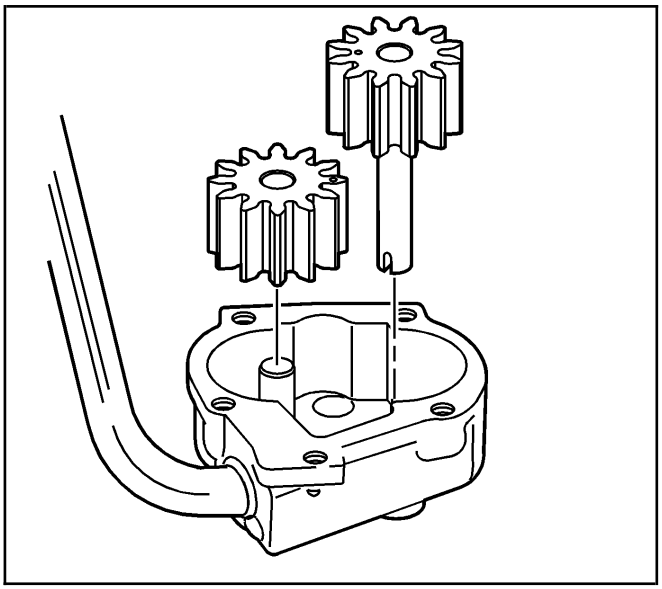
Oil Pump Assemble

SIE-ID = 482784

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

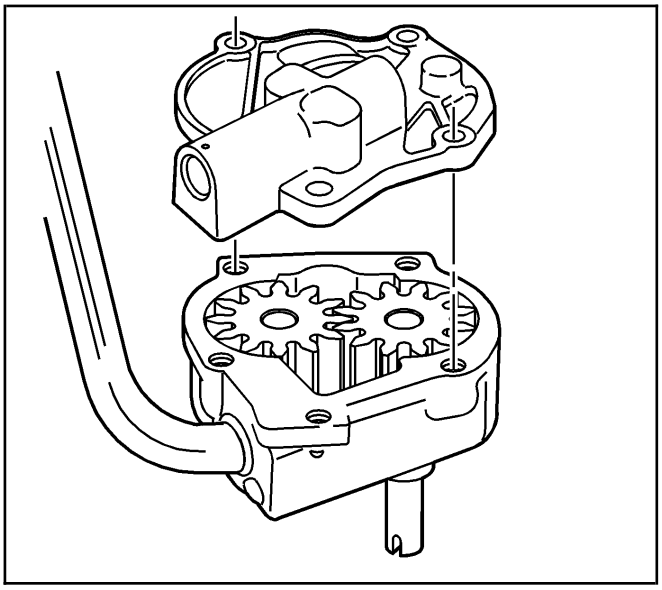
1. Install the following items:
   1.1. The pressure relief valve
   1.2. The pressure relief spring
   1.3. The retaining pin

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



678107

4. Install the oil pump cover.



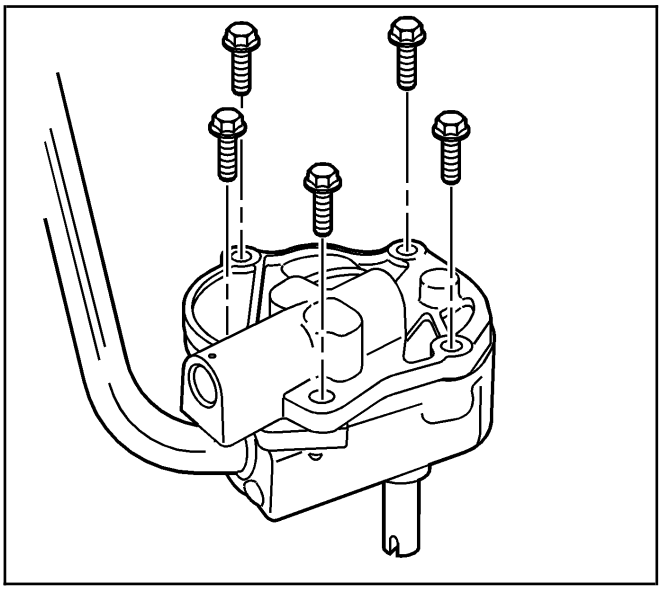
678106

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

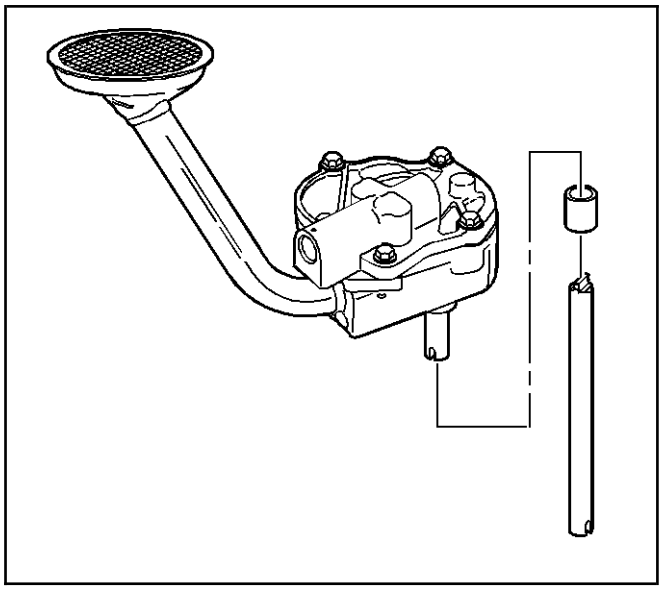
5. Install the oil pump cover bolts.

   Tighten

   Tighten the oil pump cover 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.



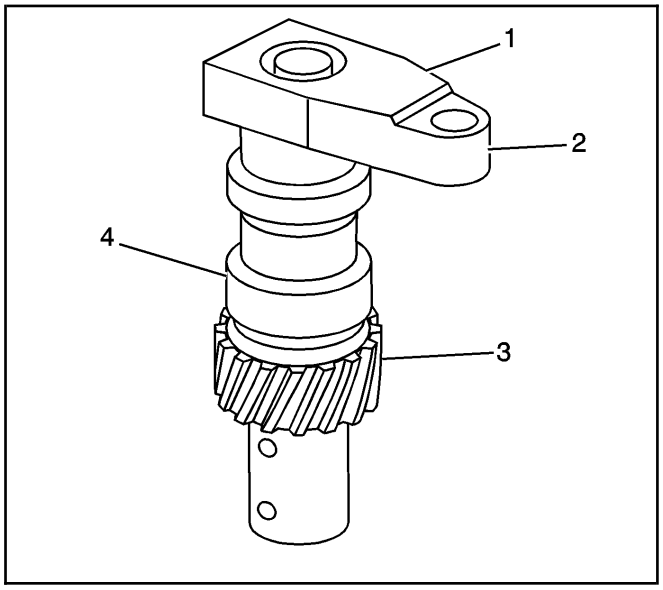
678105



427935

Notice: SIO-ID = 728983 Ensure the oil pump driveshaft is inspected for wear and/or damage, and replaced if necessary. An excessively worn or damaged oil pump driveshaft may fail causing severe engine damage.

7. Install the oil pump driveshaft and the new retainer.



635685

Oil Pump Drive Cleaning and Inspection

SIE-ID = 482785

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

1. Clean the oil pump drive in cleaning solvent.
2. Dry the oil pump drive with compressed air.
3. Inspect the oil pump drive for the following conditions:
   - Excessive play in the oil pump drive bearing (1)
   - Damage to the oil pump drive clamp bolt hole (2)
   - Damaged gear (3) for the following:
     - Chipping
     - Galling
     - Wear
     - Damage to the oil pump drive shaft tang
4. Damage to the oil pump drive body (4).
5. If the oil pump drive is to be reused, lubricate the bearing (1) with clean engine oil, and apply grease to the gear (3).

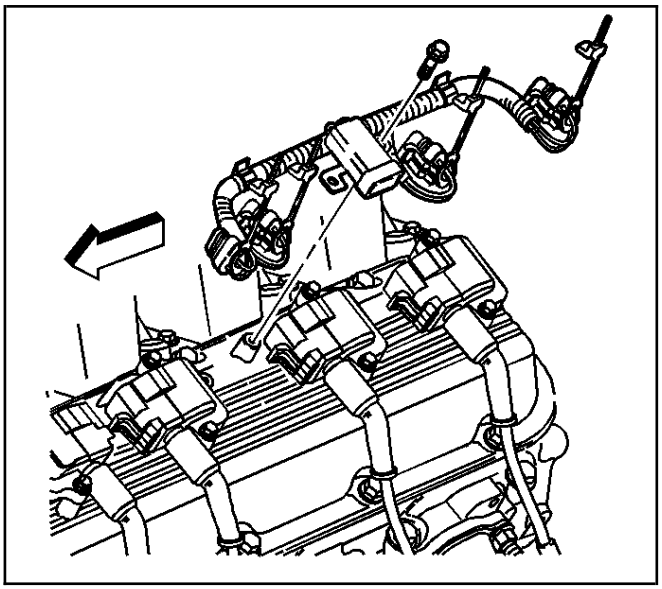
Valve Rocker Arm Cover Cleaning and Inspection

SIE-ID = 482786

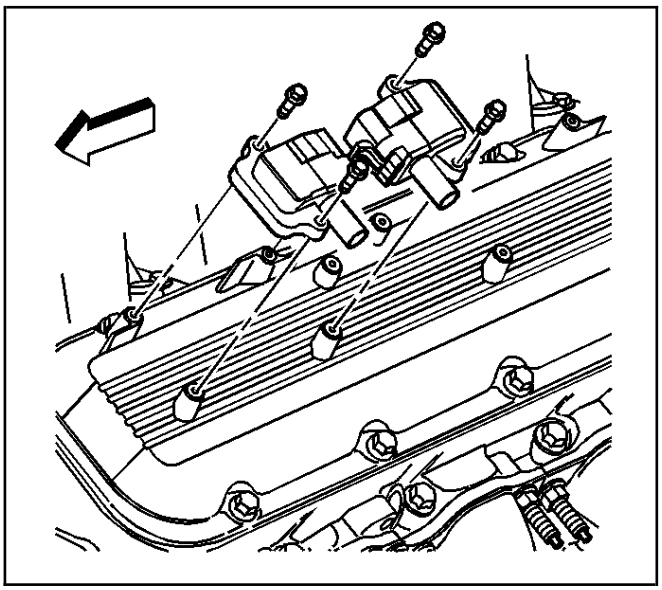
Notice: SIO-ID = 728985 In order to ensure correct reinstallation, mark the ignition wiring harness connectors for cylinders one and three, and cylinders six and eight prior to disconnection. Failure to reconnect the ignition wiring harness connectors to the proper ignition coils may result in serious engine damage.

Notice: SIO-ID = 728980 This component is initially installed using a self-tapping bolt(s). Care should be taken when removing and/or installing the self-tapping bolt(s). Failure to use care when removing and/or installing the self-tapping bolt(s) can lead to damage and unnecessary replacement of the self-tapping bolt(s) and/or the component the self-tapping bolt(s) is threaded into.

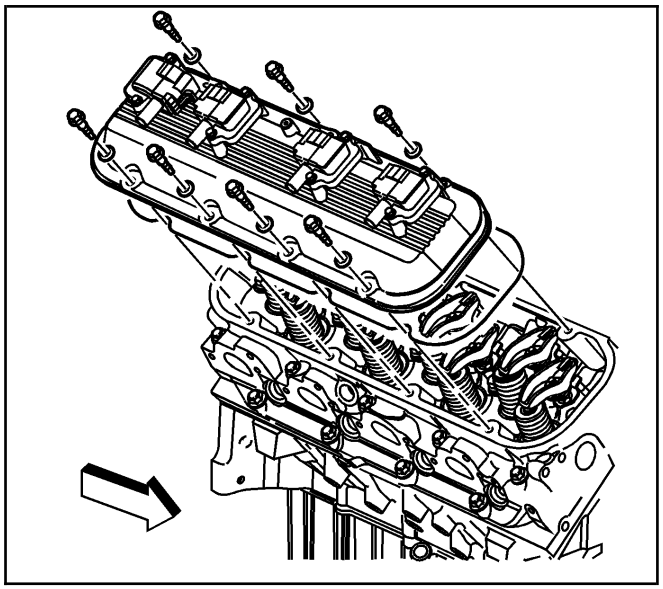
1. Remove the white wiring harness clip locks.
2. Disconnect the ignition coil wiring harness from the ignition coils.
3. Remove the ignition coil wiring harness retainer bolts.
4. Open the 2 wiring harness retainers and remove the ignition coil wiring harness.
5. Remove the ignition coil bolts.
6. Remove the ignition coils.



470659



470887



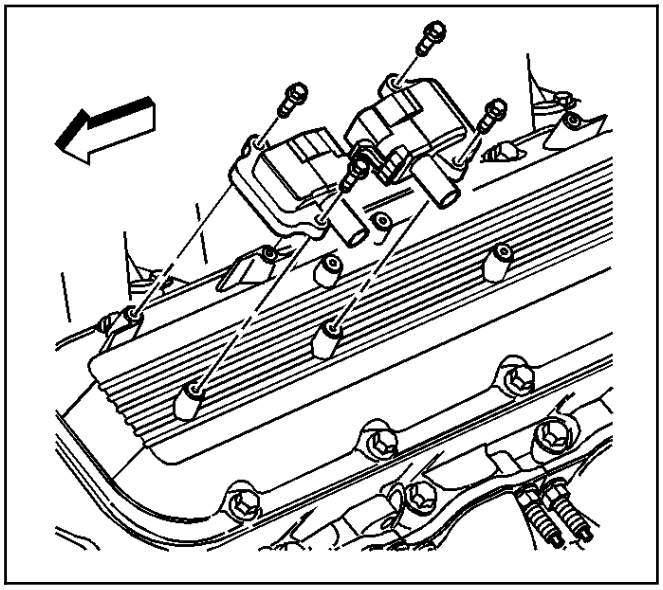
470897

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

Important: Do not clean or submerge the ignition coils in solvent.

Remove the ignition coils before cleaning the cover in solvent. To prevent damage to the gasket, minimize solvent contact with the gaskets.

7. Clean the valve rocker arm cover in solvent.
8. Dry the covers with compressed air.
9. Inspect the covers for the following:
   - Gouges or damage to the sealing surfaces
   - Cracking or damage to the valve cover gasket
   - Debris or damage to the bolt hole threads



470887

Notice: SIO-ID = 451379 This bolt is a self-tapping bolt. If installing this bolt into a new component, installation of the bolt may be difficult. Ensure that the bolt is not over-torqued during the initial installation (thread cutting). Failure to limit torque can lead to bolt failure.

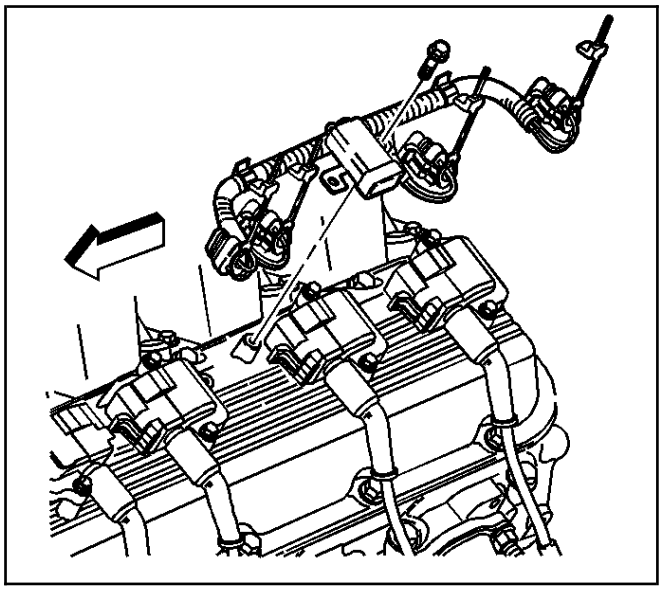
10. Install the ignition coils.

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

11. Install the ignition coil bolts.

    Tighten

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



470659

12. Install and secure the ignition coil wiring harness into the 2 wiring harness retainers.
13. Install the ignition coil wiring harness retainer bolts.

    Tighten

    Tighten the ignition coil wiring harness retainer bolts to 12 N·m (106 lb in).
14. Connect the ignition coil wiring harness to the ignition coils, making sure the connectors for cylinders one and three, and cylinders six and eight are connected to the corresponding ignition coils.
15. Install the white wiring harness clip locks.

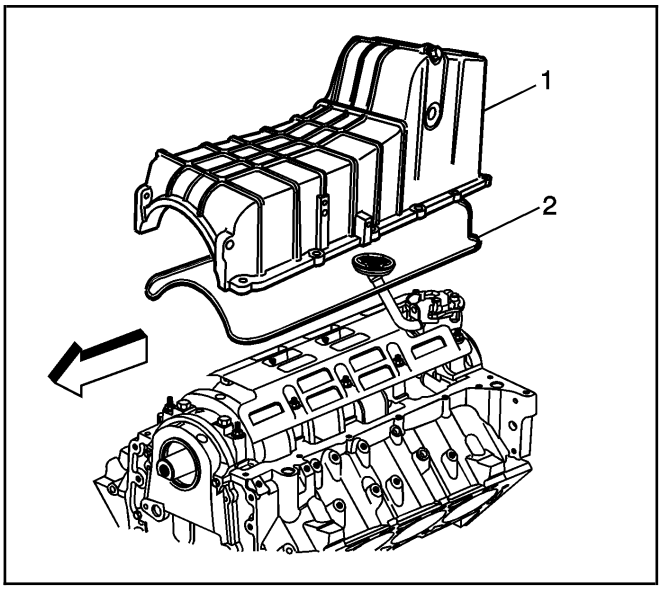
Oil Pan Cleaning and Inspection

SIE-ID = 482787

1. Remove the oil pan gasket (2) from the groove in the oil pan (1).
2. Clean the oil pan in solvent.

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

3. Dry with compressed air.
4. Inspect the oil pan for the following conditions:
   - The drain plug hole for damaged threads
   - Gouges or damage to the oil pan sealing surfaces
   - Cracks or damage to the exterior of the oil pan
   - Damage to the oil level indicator tube area
   - Damage to the oil pan gasket

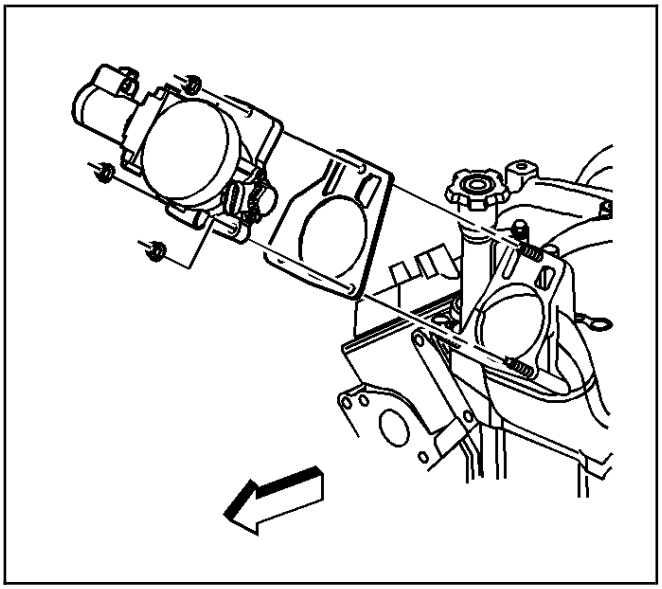


635649

Intake Manifold Disassemble (C/K/C3500HD/Medium Duty)

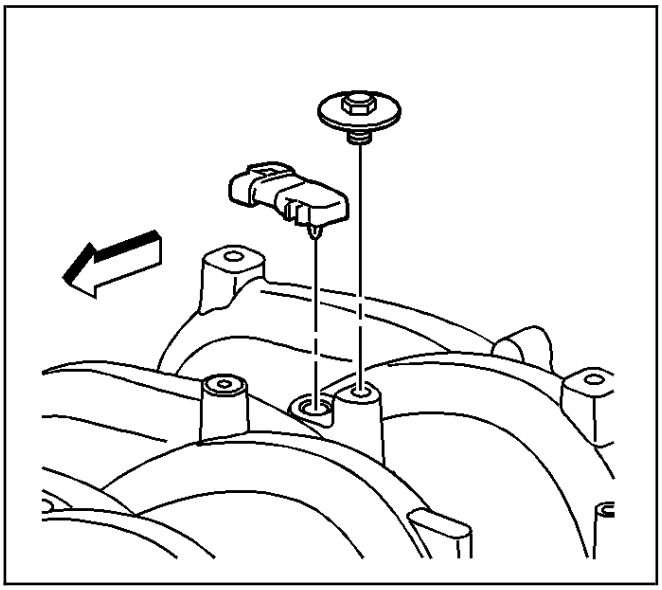
SIE-ID = 482788

1. Remove the throttle body nuts and throttle body.
2. Remove and discard the throttle body gasket.

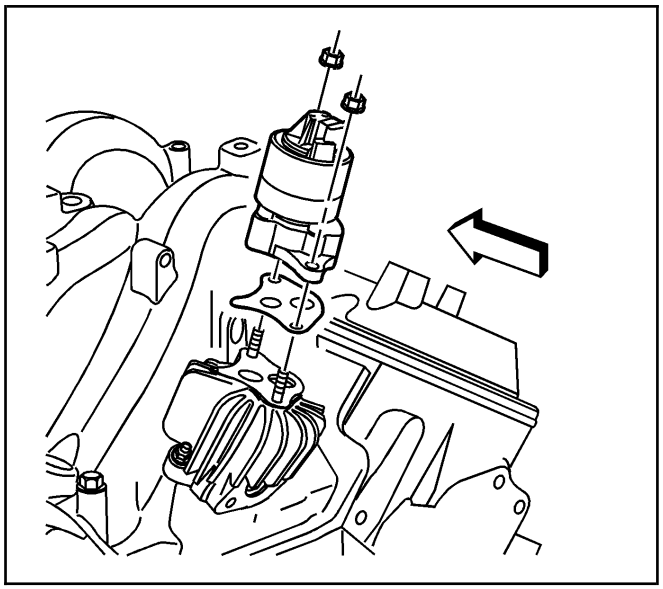


470760

3. Remove the MAP sensor bolt and MAP sensor.
4. Inspect the MAP sensor seal for damage.

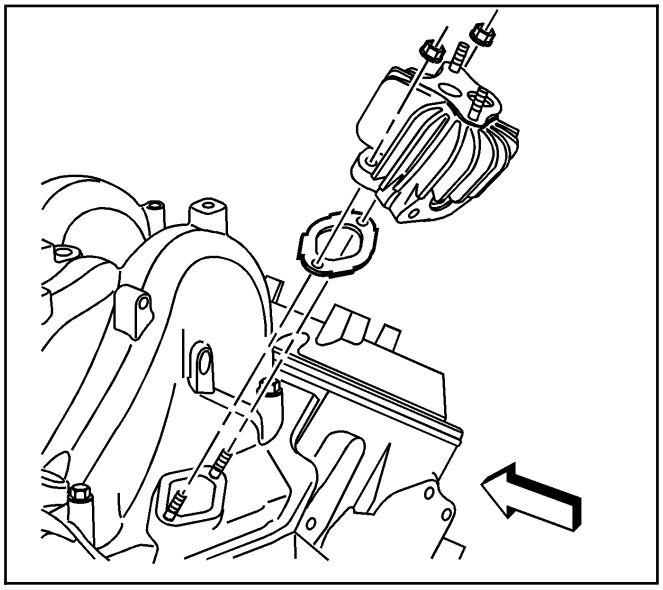


471023



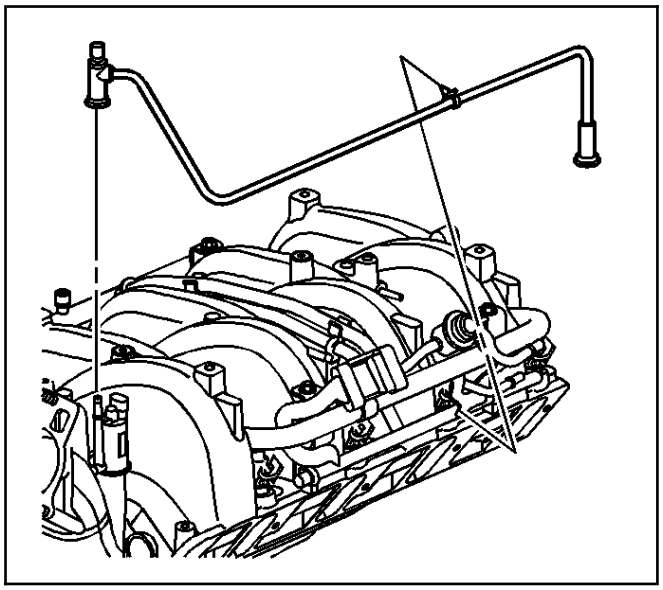
471008

5. Remove the EGR valve nuts, EGR valve and EGR valve gasket.
6. Discard the EGR valve gasket.



471009

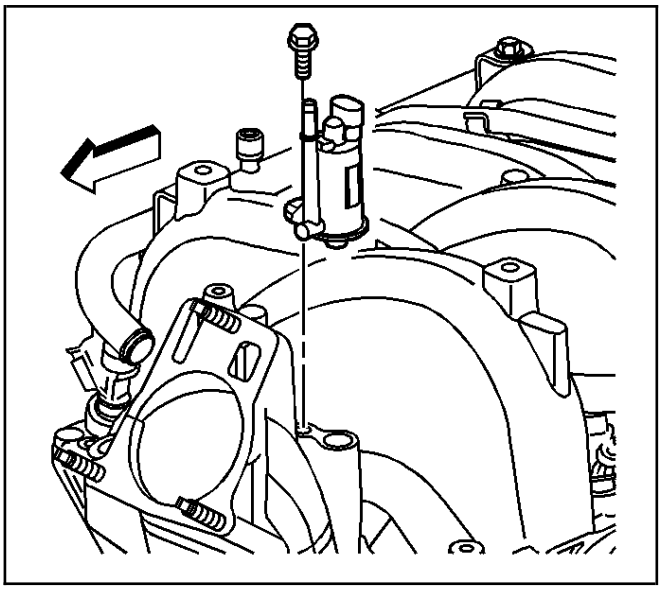
7. Remove the EGR adapter nuts, EGR adapter and EGR adapter gasket.
8. Discard the EGR adapter gasket.



471013

9. Remove the purge solenoid vacuum hose.

10. Remove the purge solenoid bolt and the purge solenoid.
11. Inspect the purge solenoid seal for damage. Replace the seal as needed.

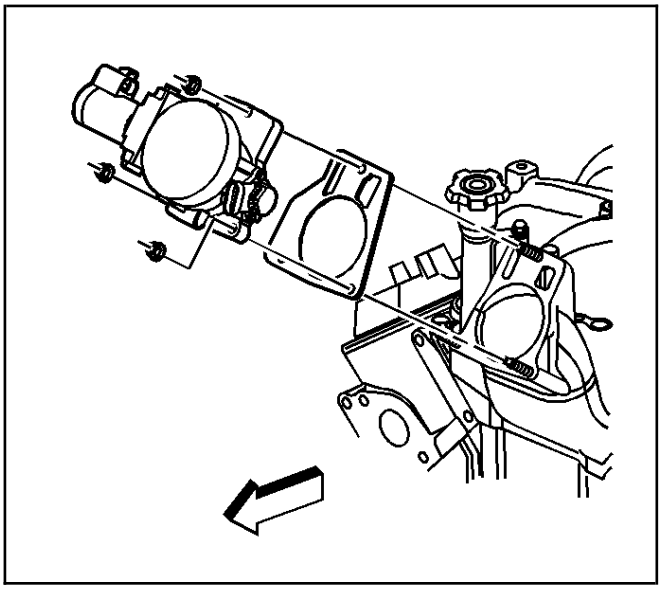


471015

Intake Manifold Disassemble (G)

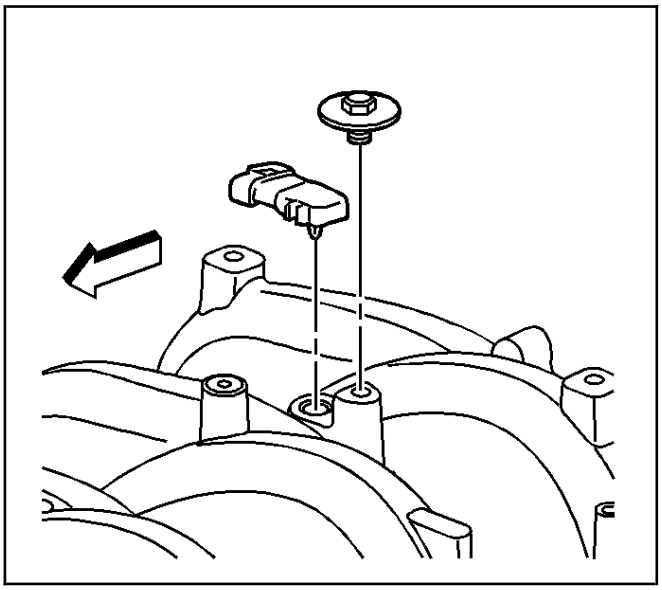
SIE-ID = 679298

1. Remove the throttle body nuts and throttle body.
2. Remove and discard the throttle body gasket.

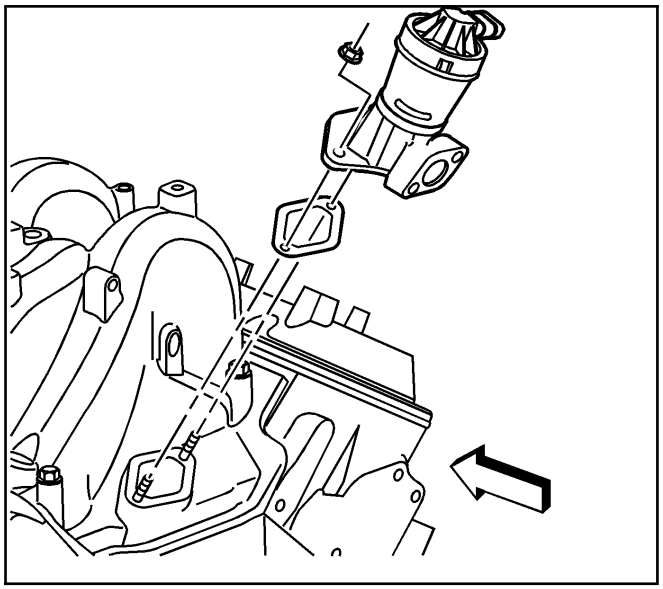


470760

3. Remove the MAP sensor bolt and MAP sensor.
4. Inspect the MAP sensor seal for damage.

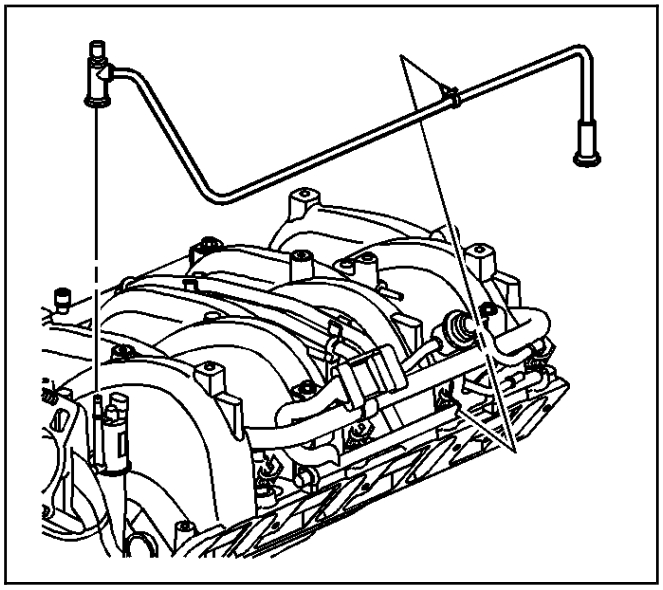


471023



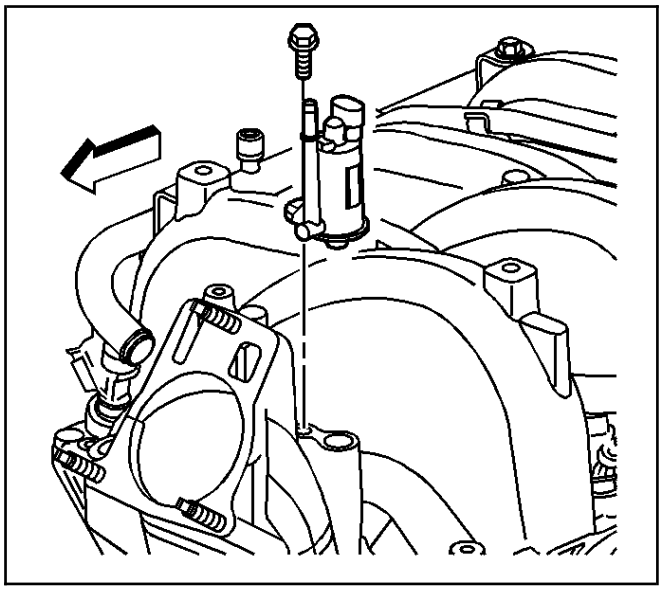
677740

5. Remove the EGR valve nuts, EGR valve and EGR valve gasket.
6. Discard the EGR valve gasket.



471013

7. Remove the purge solenoid vacuum hose.



471015

8. Remove the purge solenoid bolt and the purge solenoid.
9. Inspect the purge solenoid seal for damage. Replace the seal as needed.

Intake Manifold Cleaning and Inspection

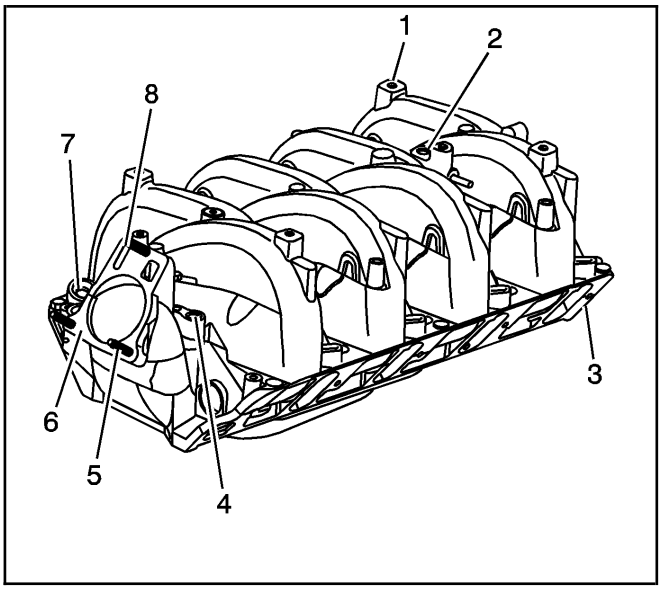
SIE-ID = 482789

Important: Do not reuse the lower intake manifold gaskets or end seals.

1. Clean the intake manifold in an approved solvent.
   - Clean debris out of all bolt holes. Clean the intake manifold gasket sealing surfaces.
   - Clean all carbon from the EGR passages.
   - Clean all intake manifold ports.

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

2. Dry the intake manifold with compressed air.
3. Inspect the following:
   - The intake manifold bolt holes (1) for cracks and/or damage
   - The MAP sensor sealing surface (2) for damage
   - The purge solenoid sealing surface (4) for damage. The purge solenoid bolt has a sealer that may come off during removal of the bolt. Ensure all sealant is removed from the bolt hole.
   - The intake manifold-to-cylinder head sealing surfaces (3) for damage
   - The EGR adapter mounting surface for damage
   - The throttle body studs (5) for damage. Replace as necessary.
   - The throttle body mounting surface (6) for damage
   - The oil fill tube hole (7) for signs of leakage. Reseal as necessary.
   - PCV port (8) for debris or varnish buildup
   - EGR pipe for damage



635688

Intake Manifold Assemble (C/K/C3500HD/Medium Duty)

SIE-ID = 482790

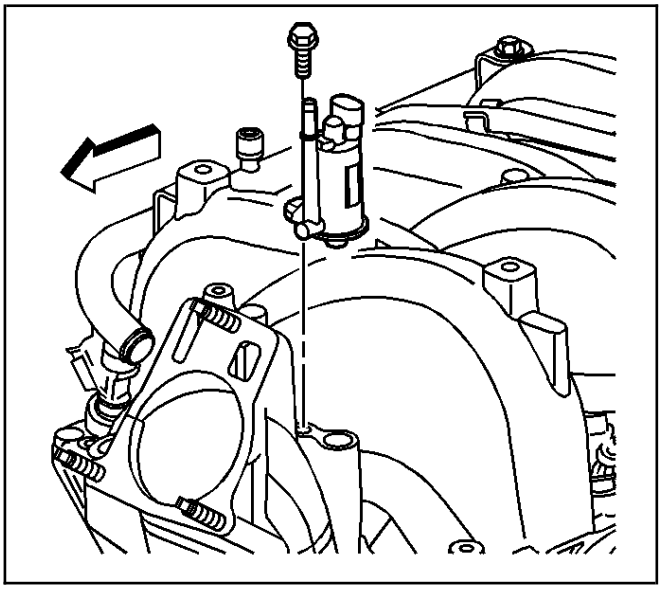
1. Apply a very light film of clean engine oil to the purge solenoid seal.
2. Install the purge solenoid.
3. Apply thread adhesive GM P/N United States 12345493, GM P/N Canada 10953488, or equivalent to the threads of the purge solenoid bolt.

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

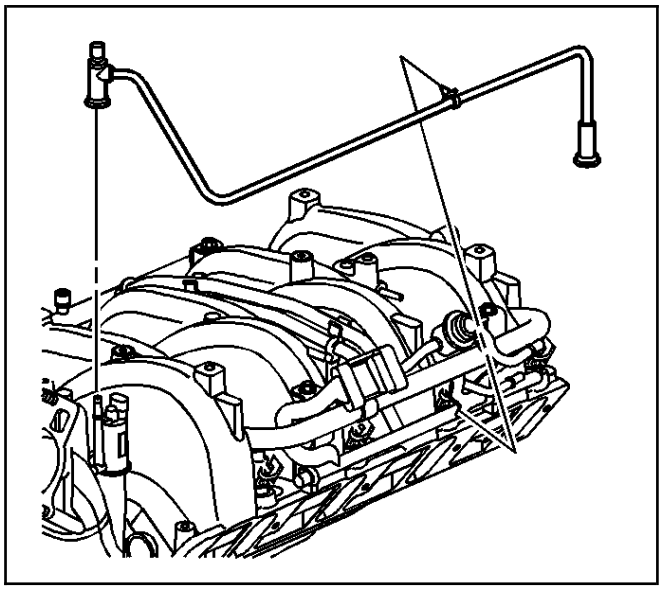
4. Install the purge solenoid bolt.

   Tighten

   Tighten the purge solenoid bolt to 10 N·m (88 lb in).

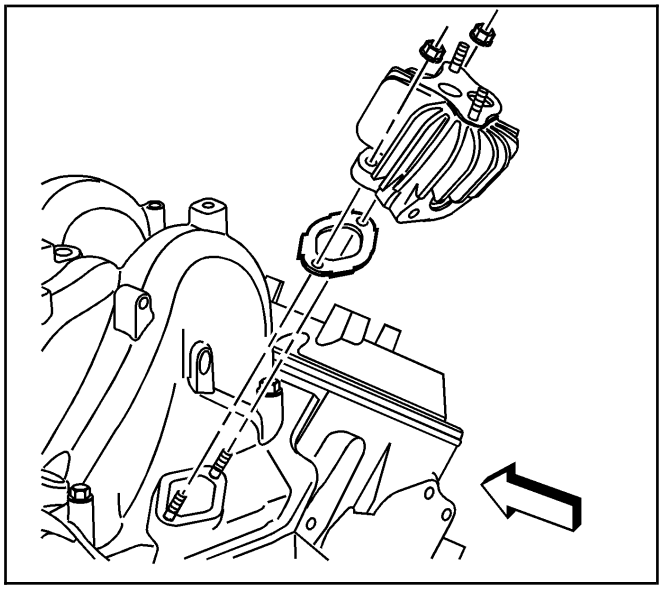


471015



471013

5. Install the purge solenoid vacuum hose.

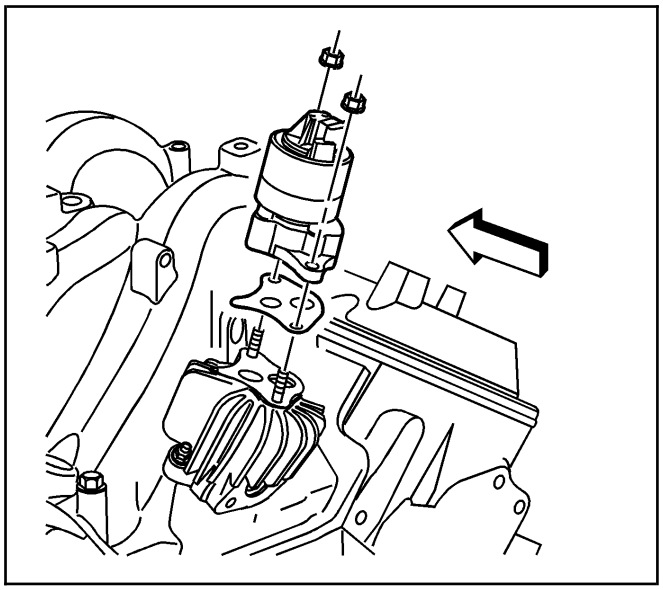


471009

6. Install the EGR adapter gasket.
7. Install the EGR adapter.
8. Install the EGR adapter nuts.

   Tighten

   Tighten the EGR adapter nuts to 22 N·m (16 lb ft).



471008

9. Install the EGR valve gasket.
10. Install the EGR valve.
11. Install the EGR valve nuts.

    Tighten

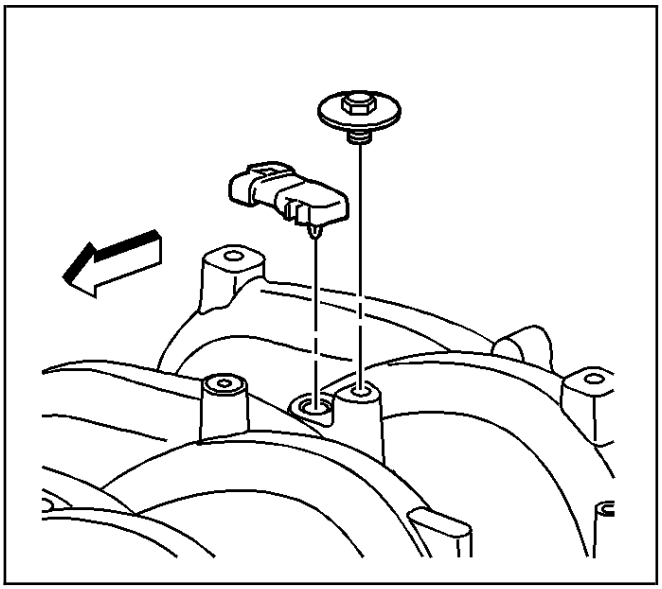
    Tighten the EGR valve nuts to 22 N·m (16 lb ft).

Important: Lubricate the port of the MAP sensor with clean engine oil. Avoid dipping the sensor port directly into the lubricant or using a solid type of lubricant, as they may block the vacuum port signal.

12. Install the MAP sensor.
13. Install the MAP sensor bolt.

    Tighten

    Tighten the MAP sensor bolt to 12 N·m (106 lb in).

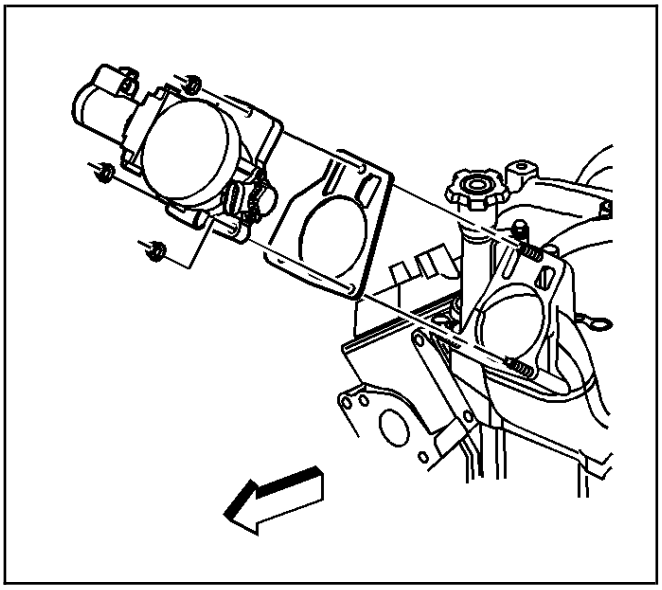


471023

14. Install the throttle body gasket.
15. Install the throttle body.
16. Install the throttle body nut.

    Tighten

    Tighten the throttle body nuts to 10 N·m (88 lb in).



470760

Intake Manifold Assemble (G)

SIE-ID = 679347

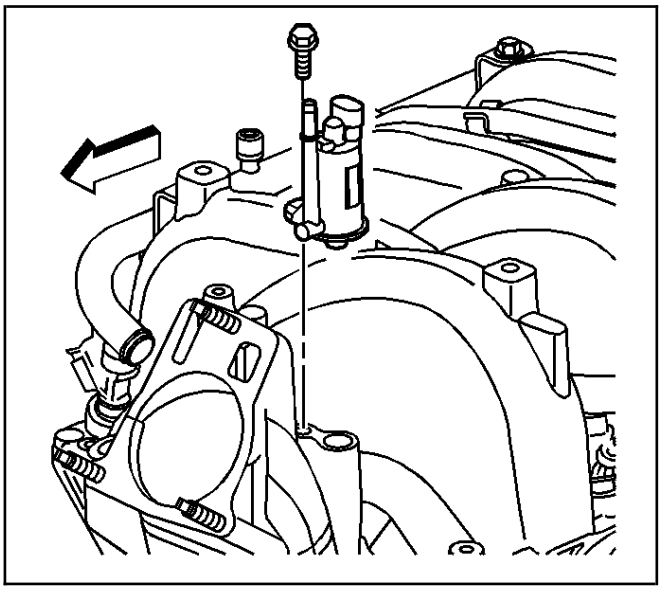
1. Apply a very light film of clean engine oil to the purge solenoid seal.
2. Install the purge solenoid.
3. Apply thread adhesive GM P/N United States 12345493, GM P/N Canada 10953488, or equivalent to the threads of the purge solenoid bolt.

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

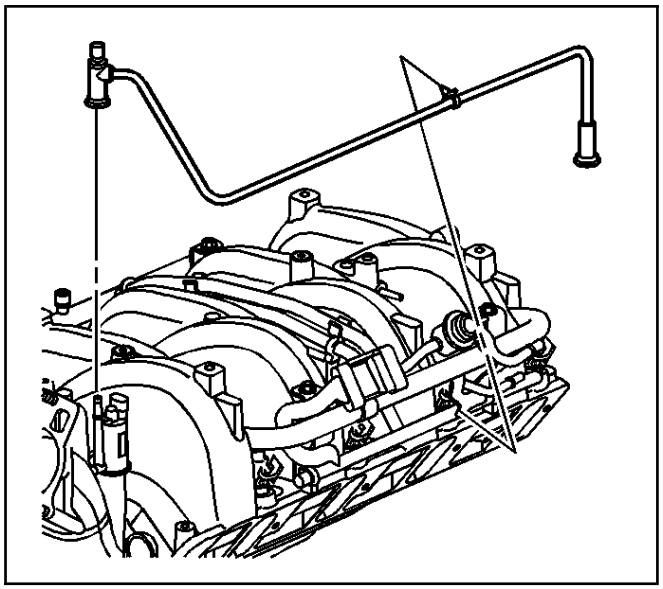
4. Install the purge solenoid bolt.

    Tighten

    Tighten the purge solenoid bolt to 10 N·m (88 lb in).

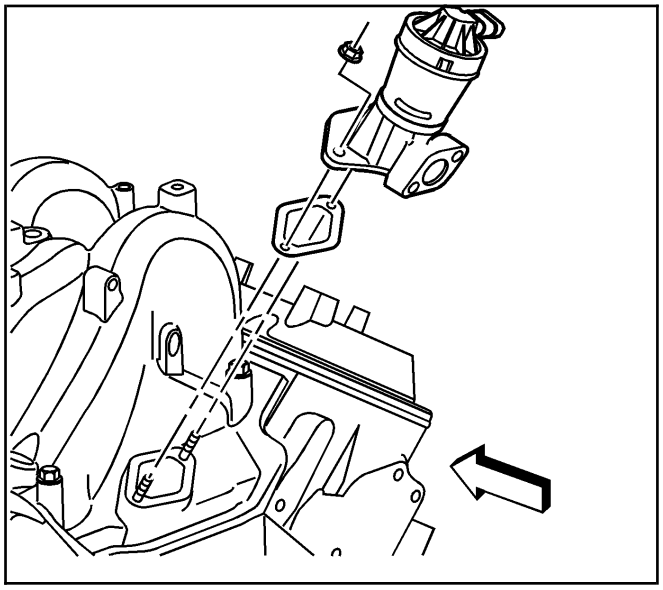


471015



471013

5. Install the purge solenoid vacuum hose.

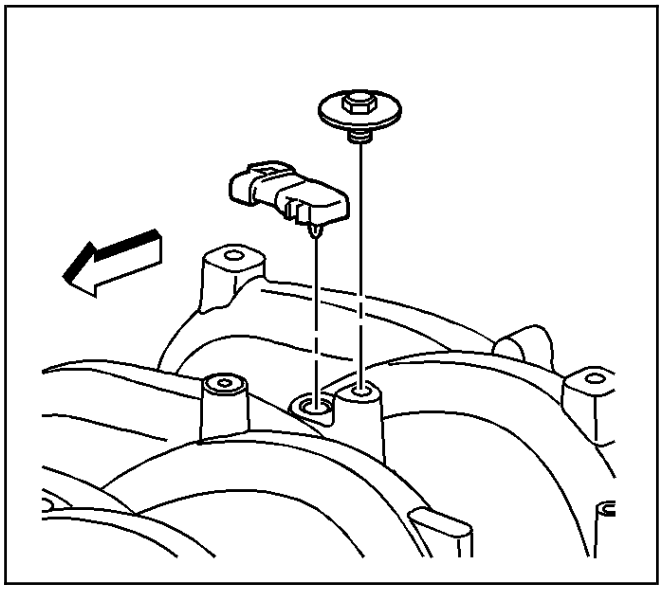


677740

6. Install the EGR valve gasket.
7. Install the EGR valve.
8. Install the EGR valve nuts.

   Tighten

   Tighten the EGR valve nuts to 22 N·m (16 lb ft).



471023

Important: Lubricate the port of the MAP sensor with clean engine oil. Avoid dipping the sensor port directly into the lubricant or using a solid type of lubricant, as they may block the vacuum port signal.

9. Install the MAP sensor.
10. Install the MAP sensor bolt.

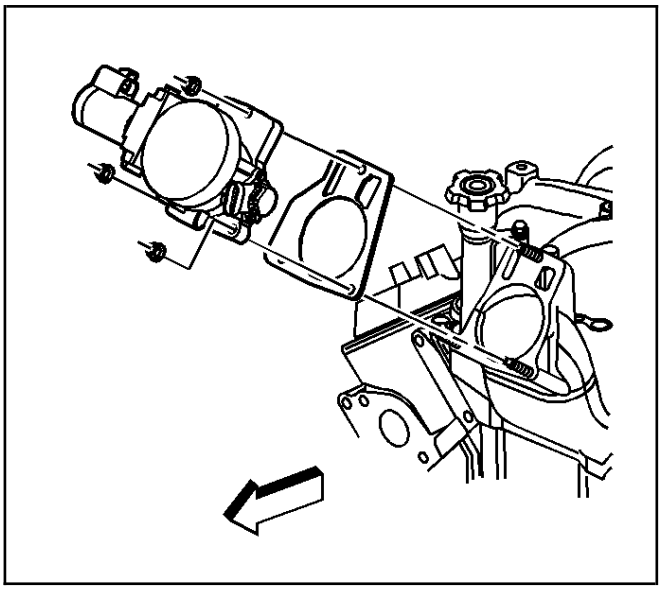
    Tighten

    Tighten the MAP sensor bolt to 12 N·m (106 lb in).

11. Install the throttle body gasket.
12. Install the throttle body.
13. Install the throttle body nut.

    Tighten

    Tighten the throttle body nuts to 10 N·m (88 lb in).



470760

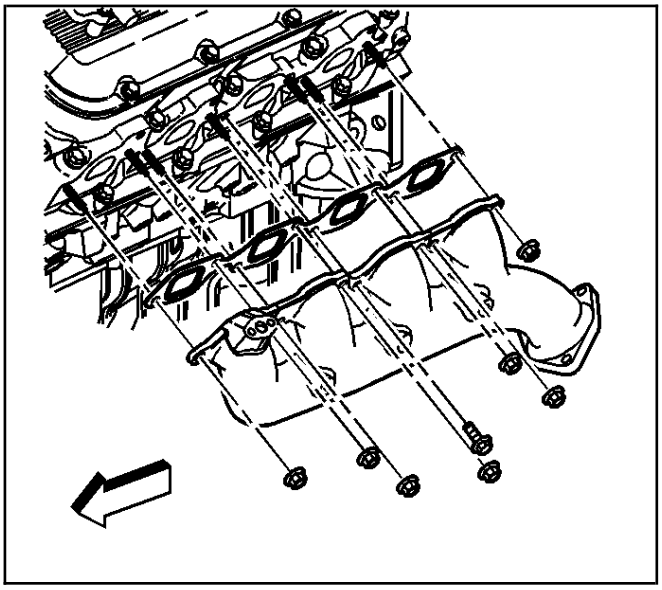
Exhaust Manifold Cleaning and Inspection

SIE-ID = 482792

1. Clean the exhaust manifolds in solvent.

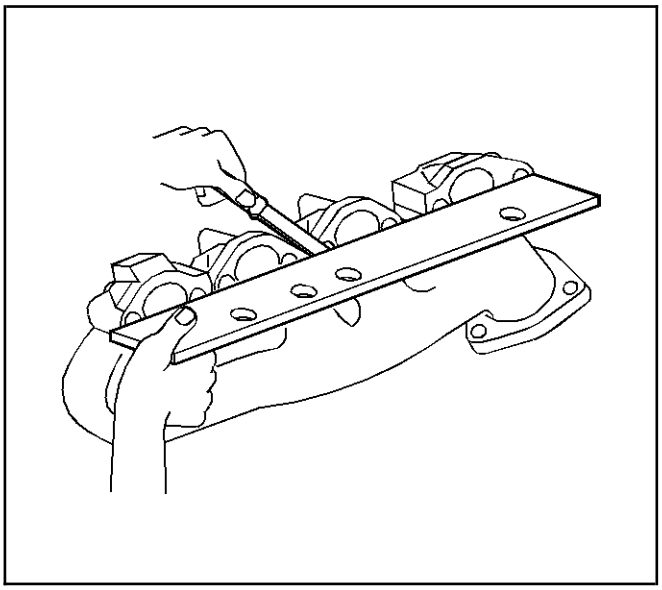
Caution: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the components with compressed air.
3. Inspect the exhaust manifolds for the following:
   - Damage to the gasket sealing surfaces
   - Damaged exhaust gas recirculation (EGR) pipe mounting studs (if applicable)
   - Damage to the exhaust manifold studs
   - Broken or damaged heat shields
   - Cracks in the exhaust manifold
   - Restrictions within the exhaust passages

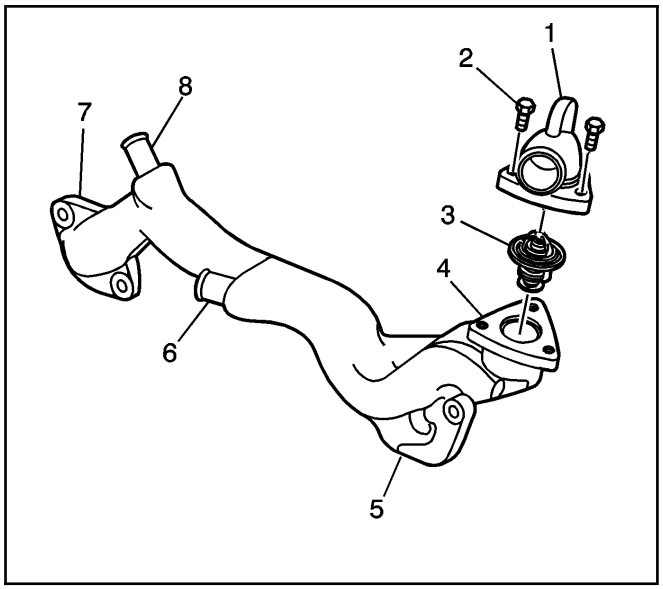


470679

4. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gage. Exhaust manifold surface flatness must not exceed 0.254 mm (0.01 in).
5. If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.



66607



635643

Water Crossover Cleaning and Inspection (C/K/G/C3500HD)

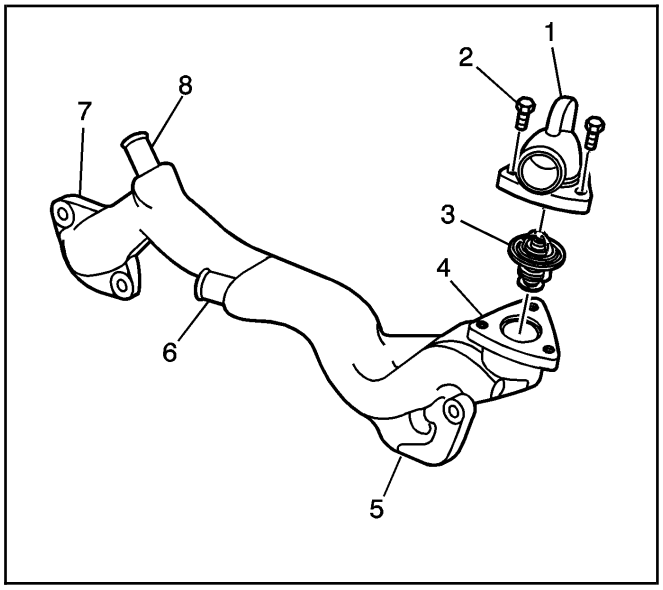
SIE-ID = 482794

Cleaning Procedure

1. Clean the coolant crossover (7) and water outlet (1) in solvent.

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

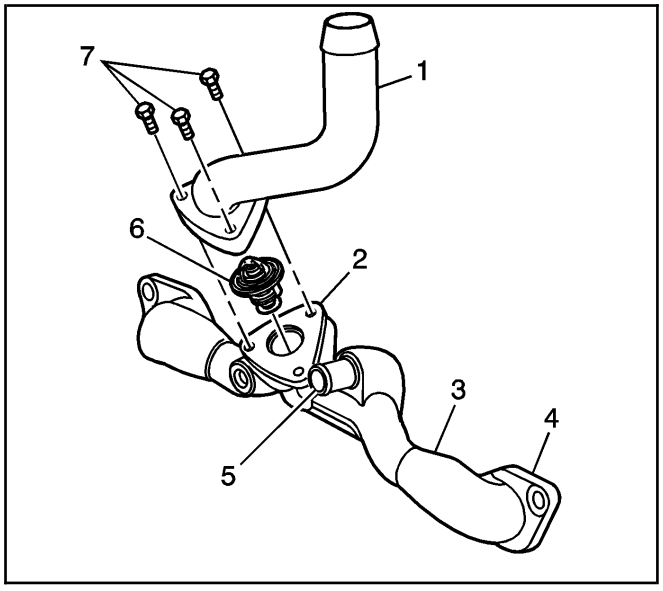
2. Dry the coolant crossover and water outlet with compressed air.



635643

Inspection Procedure

1. Inspect the coolant crossover (7) for the following:
   - Corrosion or damage to the gasket sealing surfaces (5)
   - Corrosion or damage to the bypass hose fitting (6)
   - Corrosion or damage to the heater hose fitting (8)
   - Corrosion or damage to the threads for the water outlet (4)
2. Inspect the water outlet (1) for corrosion or damage.
3. Repair or replace the coolant crossover and/or water outlet as necessary.



635646

Water Crossover Cleaning and Inspection (Medium Duty)

SIE-ID = 635918

Cleaning Procedure

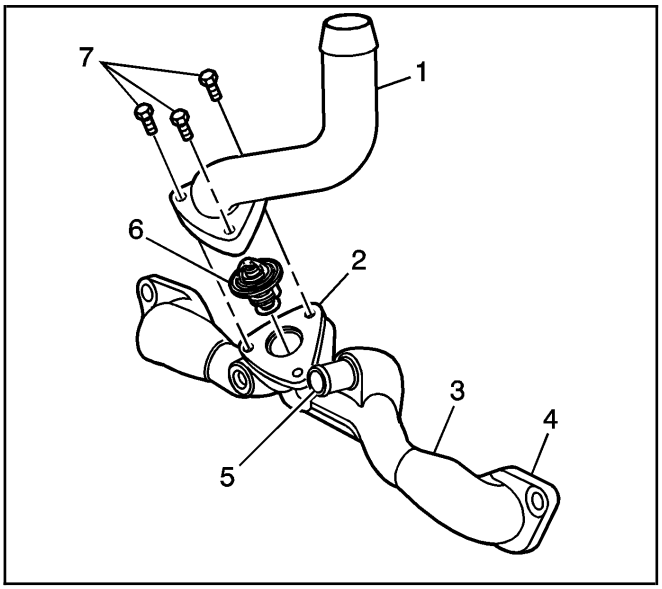
1. Clean the coolant crossover (3) and water outlet (1) in solvent.

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

2. Dry the coolant crossover and water outlet with compressed air.

Inspection Procedure

1. Inspect the coolant crossover (3) for the following:
   - Corrosion or damage to the gasket sealing surfaces (4)
   - Corrosion or damage to the bypass hose fitting (5)
   - Corrosion or damage to the threads for the water outlet (2)
2. Inspect the water outlet (1) for corrosion or damage.
3. Repair or replace the coolant crossover and/or water outlet as necessary.



635646

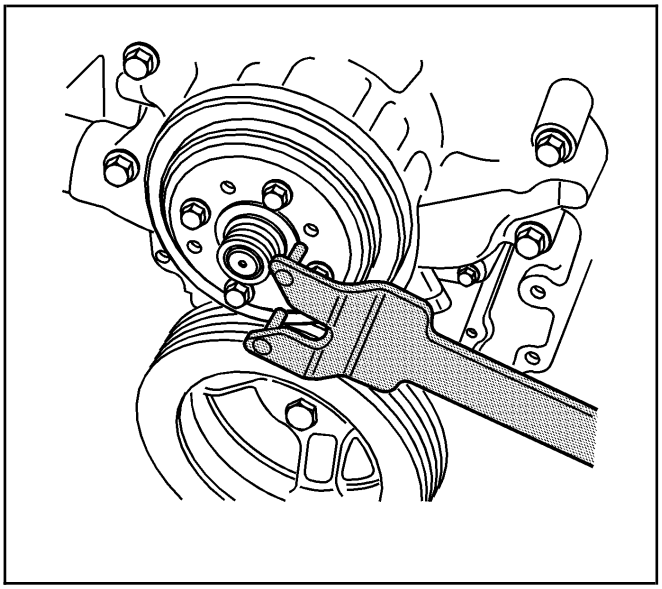
Water Pump Cleaning and Inspection (C/K)

SIE-ID = 482795

Tools Required

J 41240 Fan Clutch Wrench

1. Remove the water pump pulley bolts using the *J 41240* in order to prevent water pump pulley rotation.
2. Remove the water pump pulley.
3. Inspect the water pump pulley for damage at the belt contact area and the pulley-to-water pump mounting surface.

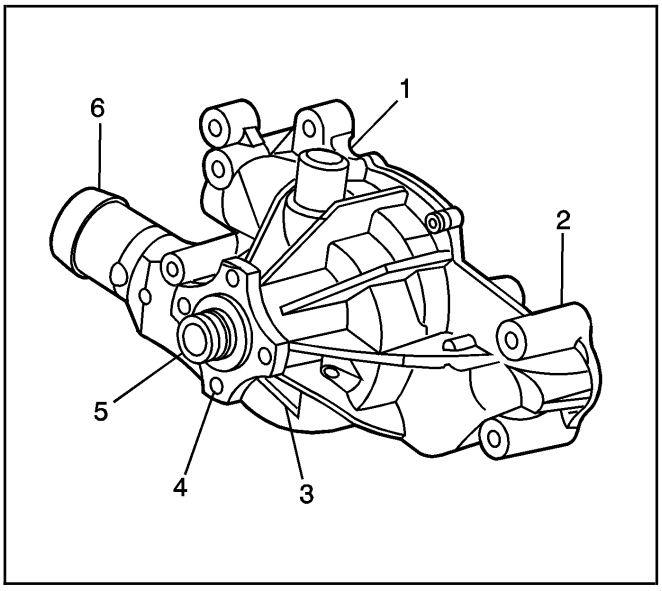


635640

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

4. Clean all excess dirt and debris from the water pump housing.
5. Inspect the water pump for the following:
   - Leakage at the hose fitting (1)
   - Leakage at the water pump weep hole (3)

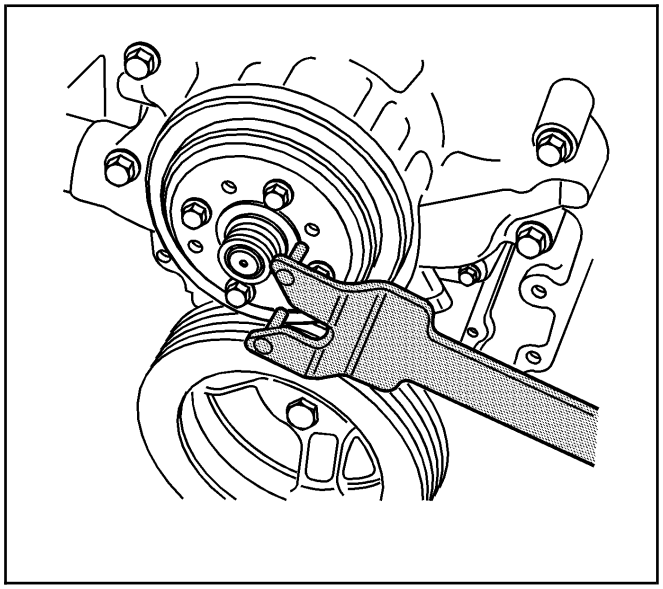
     A stain around the weep hole is acceptable. If leakage occurs (dripping) with the engine running and the cooling system pressurized, replace the water pump.
   - Gasket sealing surfaces (2) for excessive scratches or gouging
   - Restrictions within the internal coolant passages (6)



635691

- Excessive side-to-side play in the pulley shaft (5)

  If the shaft end play exceeds 0.381 mm (0.015 in), replace the water pump.
- Rotate the pump shaft by hand and inspect for roughness of operation
  - If the hub wobbles, is noisy or feels rough when rotated, replace the water pump.
  - The shaft and fan hub must turn straight and smoothly.
- Damage to threaded bolt holes (4)
- Damage to the fan clutch mounting threads (5)



635640

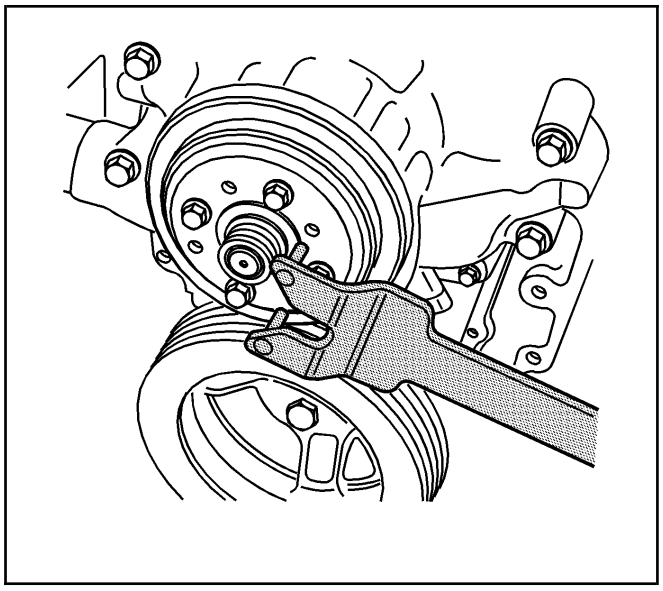
6. Install the water pump pulley.

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

7. Install the water pump pulley bolts using the *J 41240* in order to prevent water pump pulley rotation.

   Tighten

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



635640

Water Pump Cleaning and Inspection (G/C3500HD/Medium Duty)

SIE-ID = 635921

Tools Required

J 41240 Fan Clutch Wrench

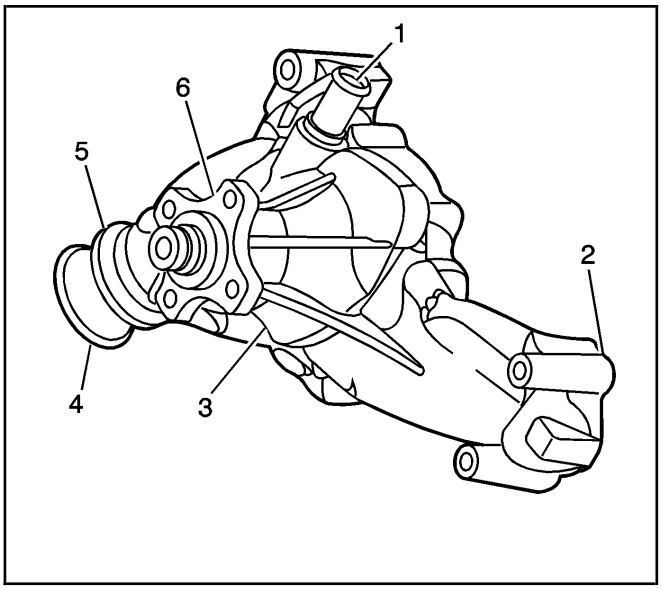
1. Remove the water pump pulley bolts using the *J 41240* in order to prevent water pump pulley rotation.
2. Remove the water pump pulley.
3. Inspect the water pump pulley for damage at the belt contact area and the pulley-to-water pump mounting surface.

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

4. Clean all excess dirt and debris from the water pump housing.
5. Inspect the water pump for the following:
   - Leakage at the hose fitting (1)
   - Leakage at the water pump weep hole (3)

     A stain around the weep hole is acceptable. If leakage occurs (dripping) with the engine running and the cooling system pressurized, replace the water pump.
   - Gasket sealing surfaces (2) for excessive scratches or gouging
   - Restrictions within the internal coolant passages (4)
   - Excessive side-to-side play in the pulley shaft (5)

     If the shaft end play exceeds 0.381 mm (0.015 in), replace the water pump.
   - Rotate the pump shaft by hand and inspect for roughness of operation
     - − If the hub wobbles, is noisy, or feels rough when rotated, replace the water pump.
     - − The shaft and fan hub must turn straight and smoothly.
   - Damage to threaded bolt holes (6)
   - Damage to the fan clutch mounting threads (5)



635719

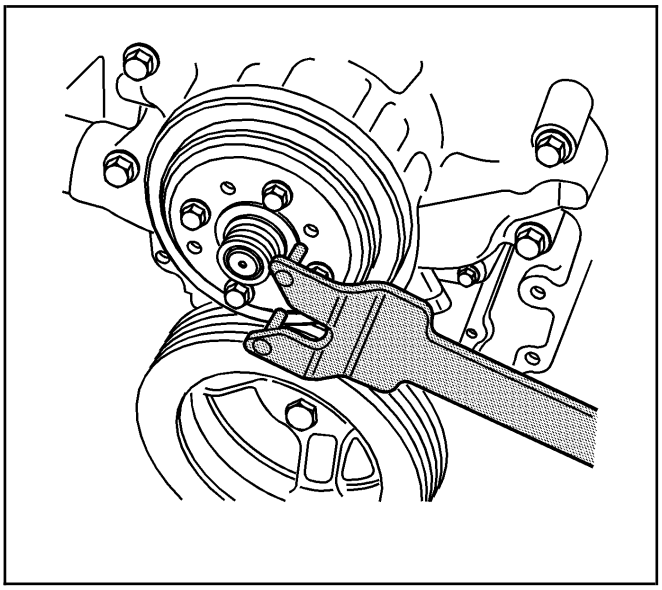
6. Install the water pump pulley.

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

7. Install the water pump pulley bolts using the *J 41240* in order to prevent water pump pulley rotation.

   Tighten

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


635640

Thread Repair

SIE-ID = 587293

Tools Required

J 39345 Thread Repair Kit

The following procedure is used to accomplish proper and durable thread repairs in the cylinder head and the cylinder block.

Important: Take appropriate precautions to assure that machining chips will not remain inside the engine. For example, block all intake passages, oil drainback holes and exhaust passages with a towel or tape before performing thread repairs.

1. Select the proper size drill as indicated in the schematic charts found in Thread Repair Specifications for the hole being repaired.
2. Drill out the damaged threads to the original depth or completely through for through holes.

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

3. Apply compressed air with a shop towel wrapped around the air spout, in order to retain the chips forced out of the hole.
4. Select the correct size tap, using the appropriate chart for the hole being repaired.
5. Coat the tap and the hole with spray machining oil.
6. Tap the hole to the original depth. In order to clean the threads, reverse the rotation of the tap periodically.
7. Use solvent to clean out all of the chips.
8. Apply compressed air with a shop towel wrapped around the air spout, in order to retain the chips forced out of the hole.
9. Tap the hole again to clean the threads. The tap should thread in with little resistance.

Important: Make sure all of the chips are cleared from the hole.

10. Use solvent to clean out all of the chips.
11. Apply compressed air with a shop towel wrapped around the air spout, in order to retain the chips forced out of the hole.
12. Use a flashlight to confirm that all of the chips are removed from the hole.
13. Continue to clean the hole until all of the chips are cleared.
14. Install the heli-coil insert as follows:
    - 14.1. In order to determine the correct size installation tool and length insert, refer to the appropriate picture and chart.
    - 14.2. Screw the insert on the mandrel of the installation tool until the driving tang is fully engaged in the driving contour.
    - 14.3. Coat the insert with spray machining oil.
    - 14.4. Install the insert as follows:
        - 14.4.1. Slide the prewinder over the mandrel and insert.
        - 14.4.2. Rotate the mandrel clockwise until 1 or 2 threads of the insert are threaded into the prewinder.
        - 14.4.3. Place the insert in position on the threaded hole being repaired.
        - 14.4.4. Rotate the mandrel clockwise until the insert is flush with the top surface of the threaded hole.
        - 14.4.5. Remove the prewinder except when repairing cylinder head bolts.
        - 14.4.6. Continue to install the insert until reaching the original thread depth.
        - 14.4.7. Remove the mandrel.
    - 14.5. Remove the driving tang from the thread insert as follows. The tang must be removed in order to allow passage of the fastener through the insert.
        - 14.5.1. Place the square end of the punch, no chamfer, on the tang after installation.
        - 14.5.2. Strike the punch sharply with the hammer. The tang will break off at the notch.
15. Clean the hole using compressed air. Take appropriate steps to assure that chips are not blown into the engine.

Service Prior to Assembly

SIE-ID = 482798

SIO-ID = 40497

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

Engine Block Plug Installation (C/K/G/C3500HD)

SIE-ID = 482799

Tools Required

J 41712 Oil Pressure Sending Unit Socket

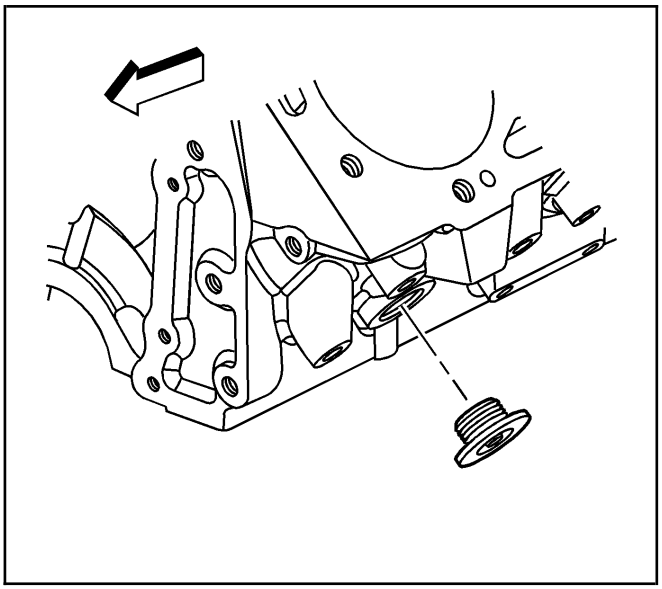
1. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the coolant hole plug.

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

2. Install the engine coolant hole plug into the block.

   Tighten

   Tighten the engine coolant hole plug to 60 N·m (40 lb ft).

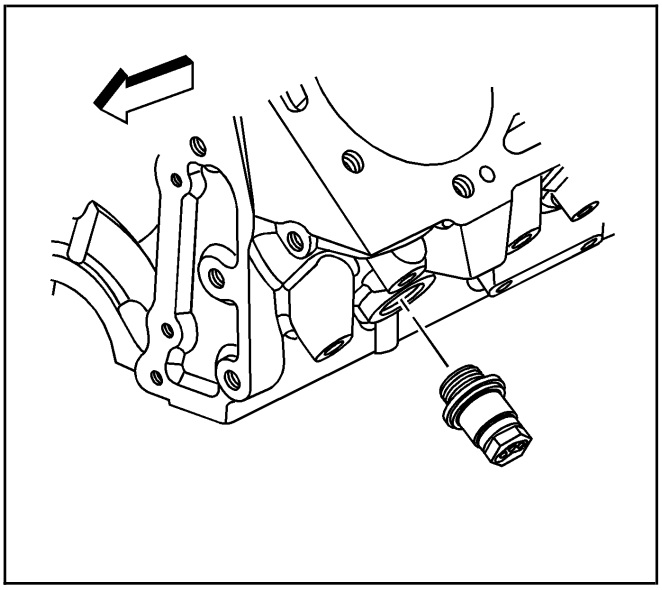


635657

3. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the engine block heater, if applicable.
4. Install the engine block heater into the block.

   Tighten

   Tighten the engine block heater to 50 N·m (37 lb ft).

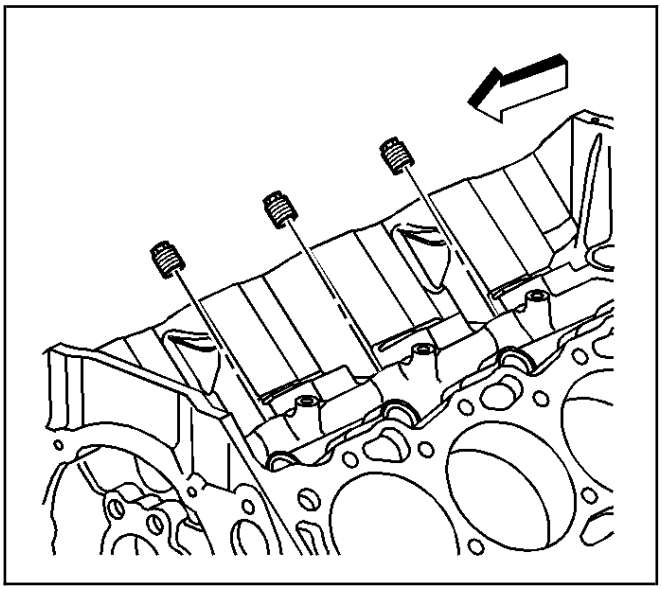


635660

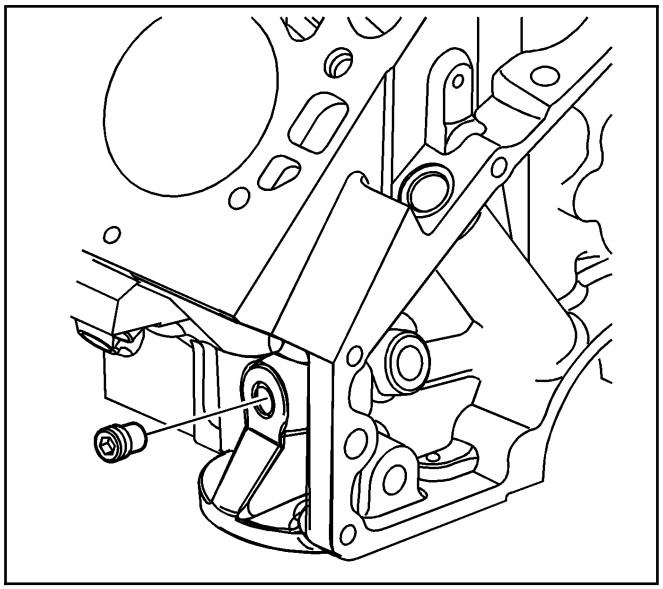
5. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil gallery plugs.
6. Install the engine block top oil gallery plugs.

   Tighten

   Tighten the top oil gallery plugs to 20 N·m (15 lb ft).



471137

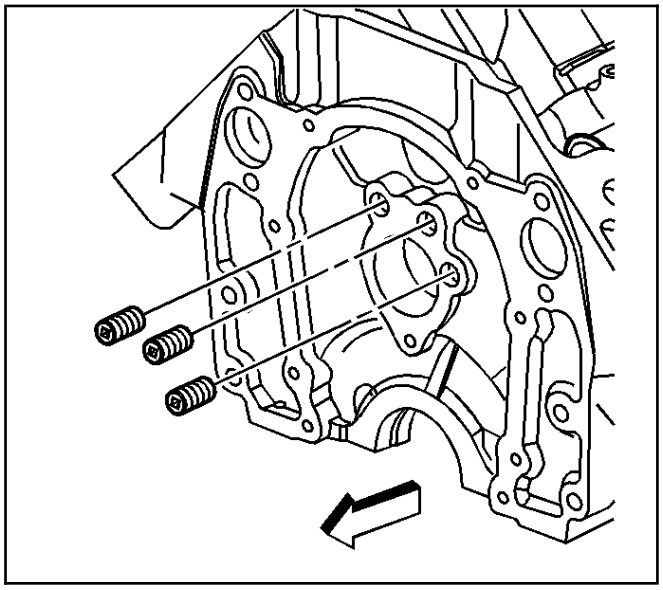


471138

7. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil gallery plug.
8. Install the engine block left side oil gallery plug.

   Tighten

   Tighten the left oil gallery plug to 30 N·m (22 lb ft).

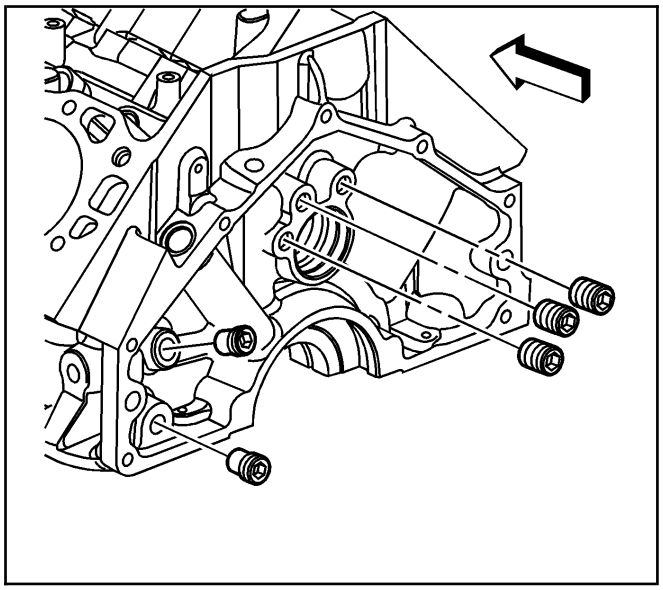


471133

9. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil gallery plugs.
10. Install the front oil gallery plugs.

    Tighten

    Tighten the front oil gallery plugs to 30 N·m (22 lb ft).



471134

11. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil gallery plugs.
12. Install the rear oil gallery plugs.

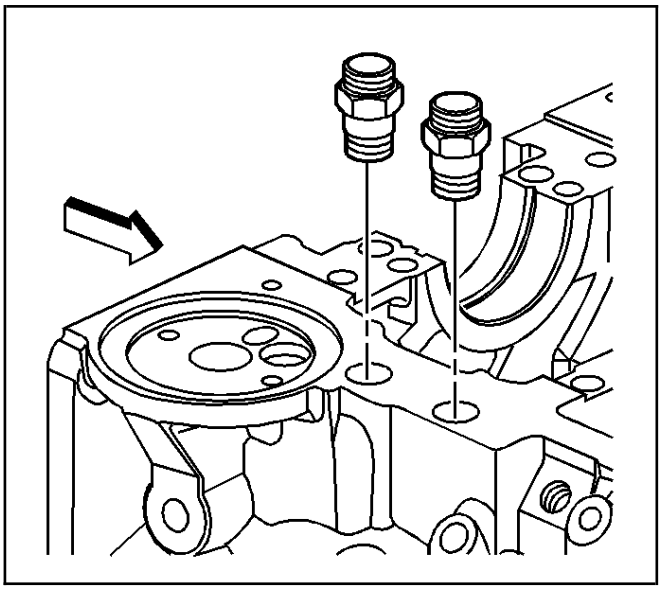
    Tighten

    Tighten the rear oil gallery plugs to 30 N·m (22 lb ft).

13. Apply thread adhesive GM P/N United States 12345493, GM P/N Canada 10953488, or equivalent to the threads of the engine block oil cooler hose fittings.
14. Install the engine block oil cooler hose fittings.

    Tighten

    Tighten the engine block oil cooler hose fittings to 23 N·m (17 lb ft).



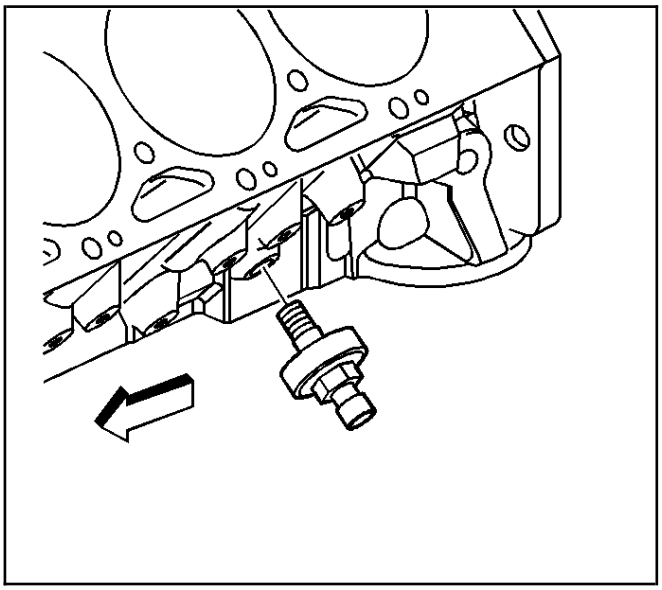
471126

Important: Do not overtighten the knock sensor.

15. Install the left knock sensor to the engine block.

    Tighten

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

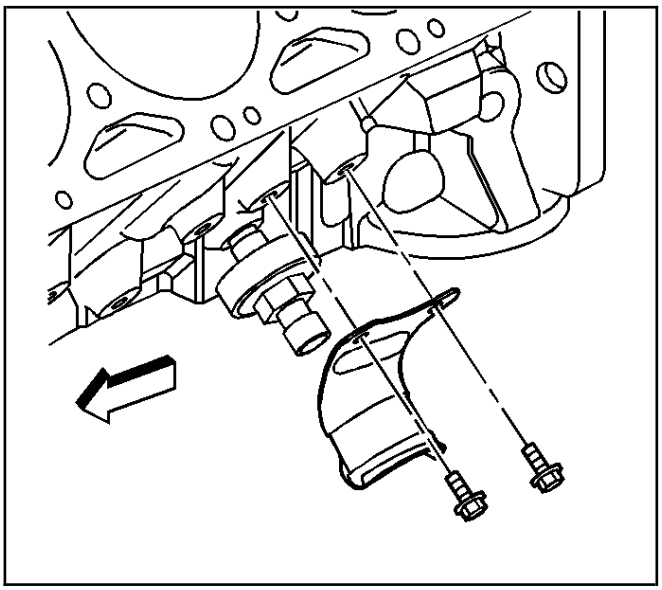


471081

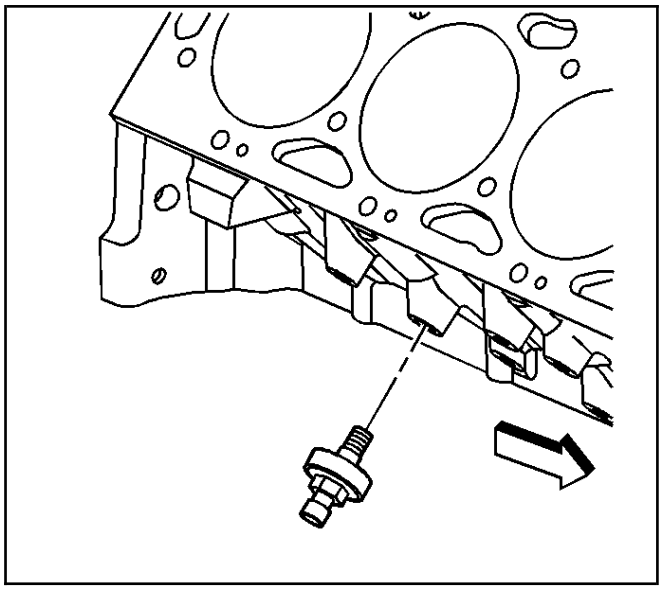
16. Install the left side knock sensor shield.
17. Install the left side knock sensor shield bolts.

    Tighten

    Tighten the left side knock sensor shield bolts to 12 N·m (106 lb in).



471100



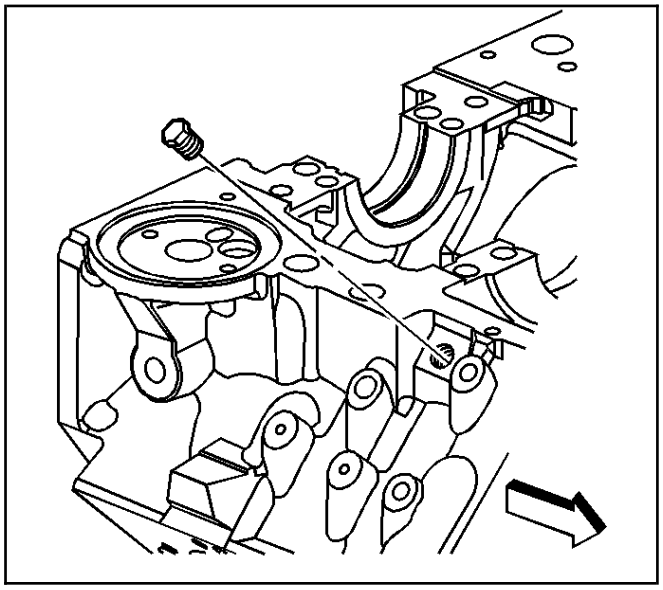
471076

Important: Do not overtighten the knock sensor.

18. Install the right knock sensor to the engine block.

    Tighten

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

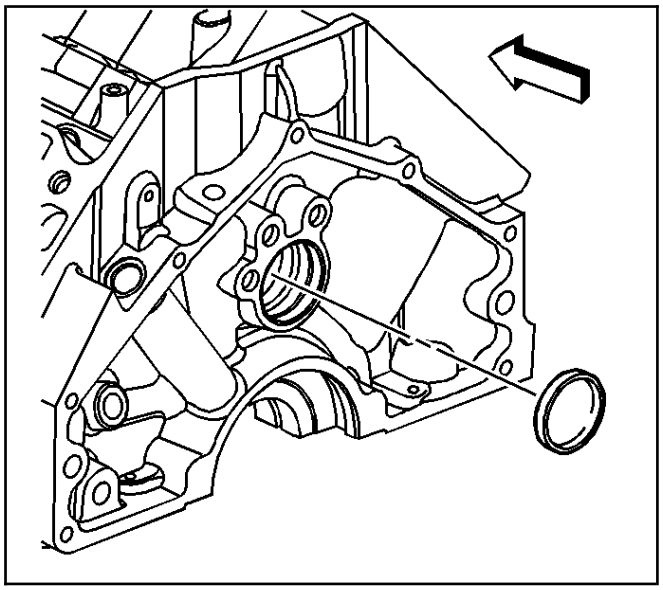


470568

19. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the engine block coolant drain hole plugs.
20. Install the engine block coolant drain hole plugs.

    Tighten

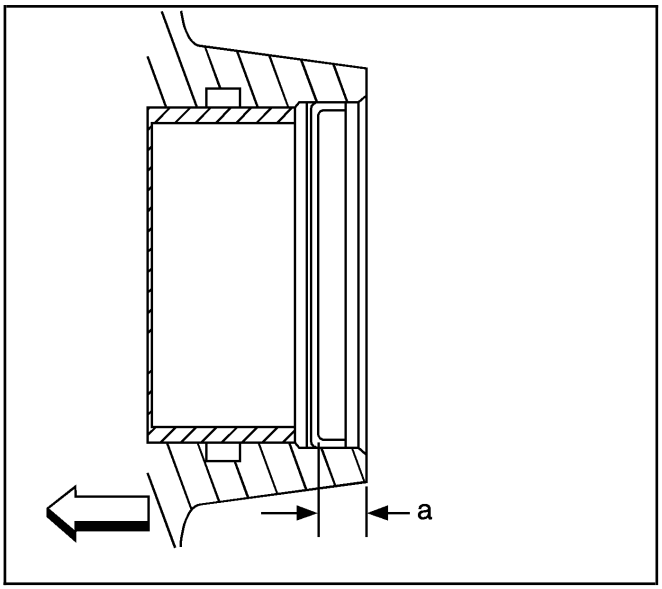
    Tighten the coolant drain hole plugs to 30 N·m (22 lb ft).



471118

21. Apply sealer GM P/N United States 12377901, GM P/N Canada 10953504, to the outside diameter of the new camshaft rear bearing hole plug.

22. Install the NEW camshaft rear bearing hole plug to the proper depth of (A) 7.600–6.200 mm (0.299–0.244 in).

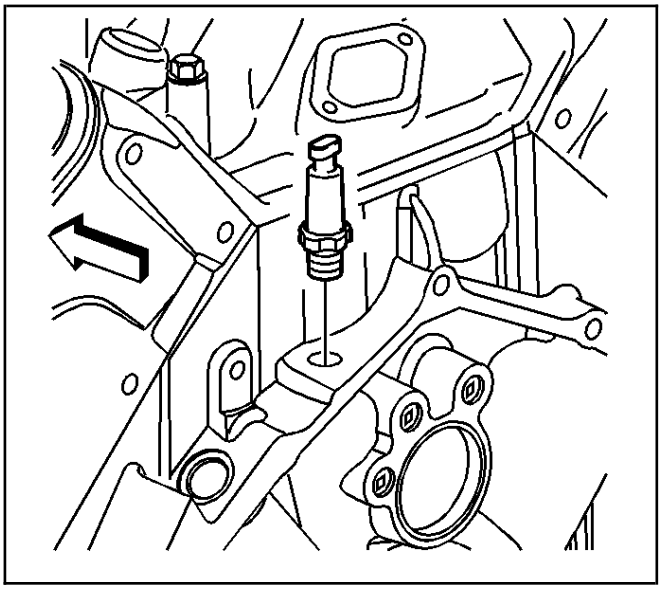


471122

23. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil pressure sensor.
24. Install the oil pressure sensor.

    Tighten

    Using the *J 41712*, tighten the oil pressure sensor to 30 N·m (22 lb ft).



471089

Engine Block Plug Installation (Medium Duty)

SIE-ID = 679492

Tools Required

J 41712 Oil Pressure Sending Unit Socket

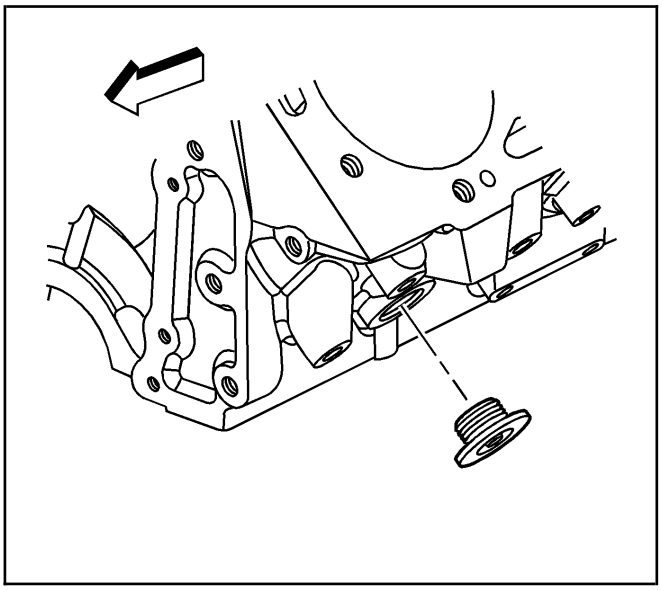
1. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the coolant hole plug.

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

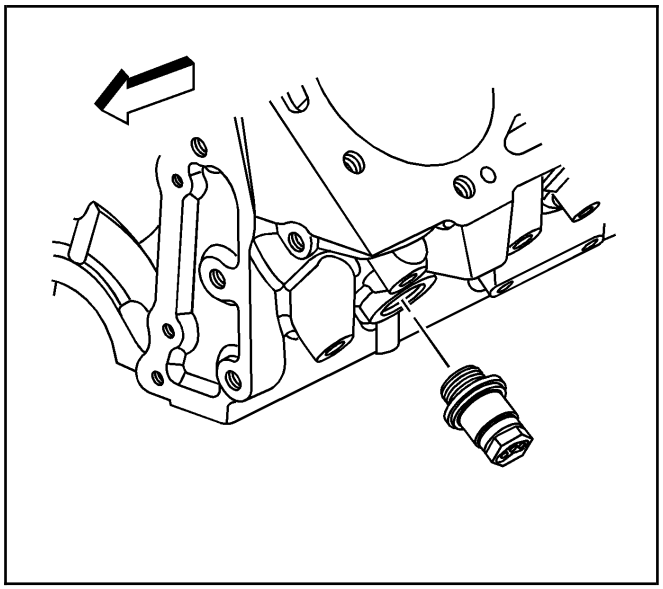
2. Install the engine coolant hole plug into the block.

    Tighten

    Tighten the engine coolant hole plug to 60 N·m (40 lb ft).



635657

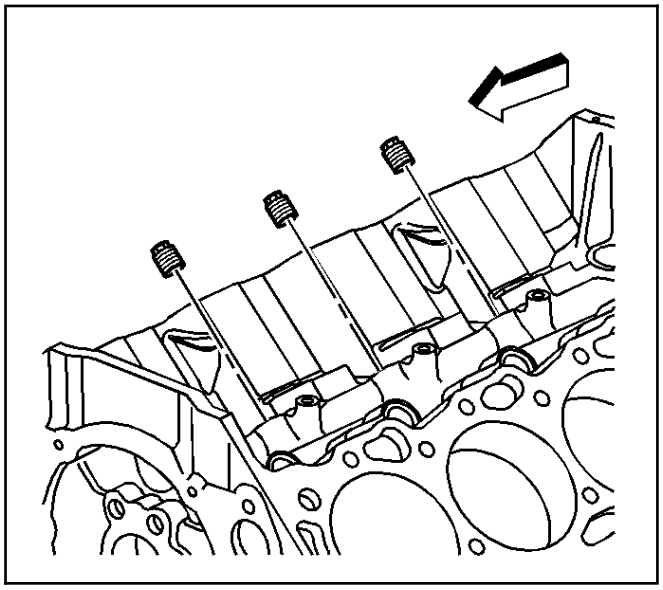


635660

3. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the engine block heater, if applicable.
4. Install the engine block heater into the block.

Tighten

Tighten the engine block heater to 50 N·m (37 lb ft).

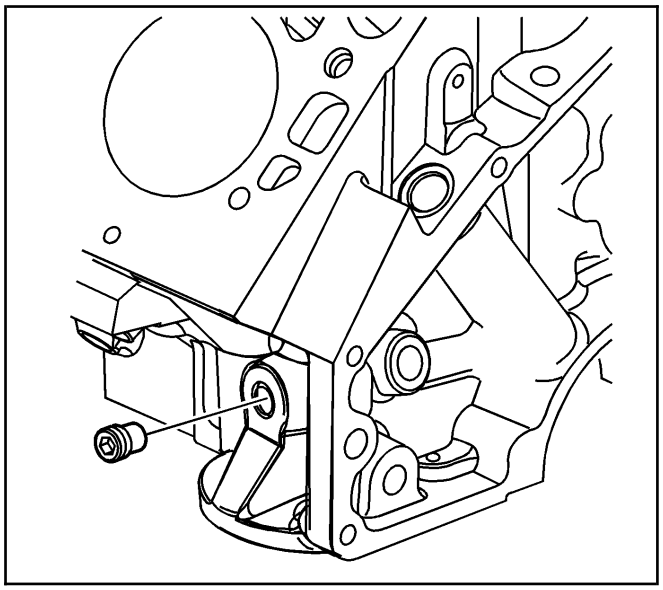


471137

5. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil gallery plugs.
6. Install the engine block top oil gallery plugs.

Tighten

Tighten the top oil gallery plugs to 20 N·m (15 lb ft).



471138

7. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil gallery plug.
8. Install the engine block left side oil gallery plug.

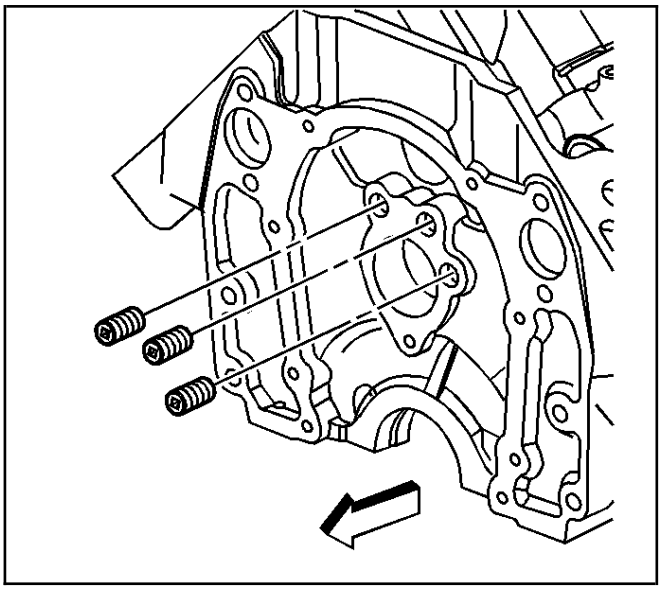
Tighten

Tighten the left oil gallery plugs to 30 N·m (22 lb ft).

9. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil gallery plugs.
10. Install the front oil gallery plugs.

    Tighten

    Tighten the front oil gallery plugs to 30 N·m (22 lb ft).

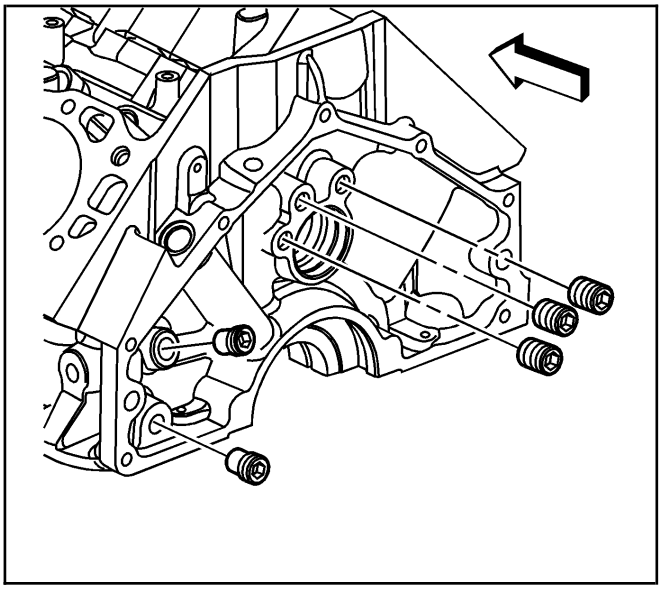


471133

11. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil gallery plugs.
12. Install the rear oil gallery plugs.

    Tighten

    Tighten the rear oil gallery plugs to 30 N·m (22 lb ft).

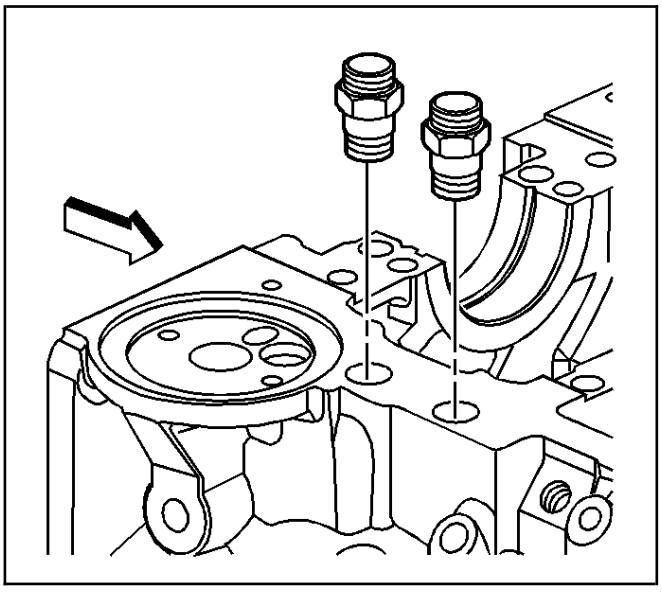


471134

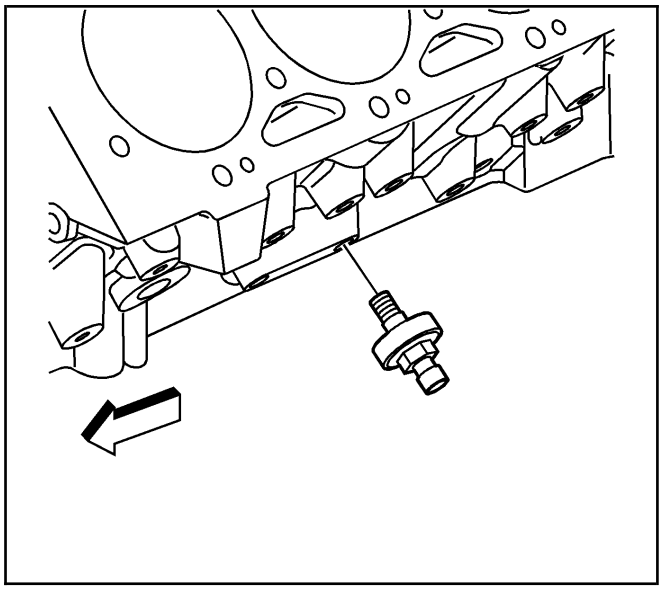
13. Apply thread adhesive GM P/N United States 12345493, GM P/N Canada 10953488, or equivalent to the threads of the engine block oil cooler hose fittings.
14. Install the engine block oil cooler hose fittings.

    Tighten

    Tighten the engine block oil cooler hose fittings to 23 N·m (17 lb ft).



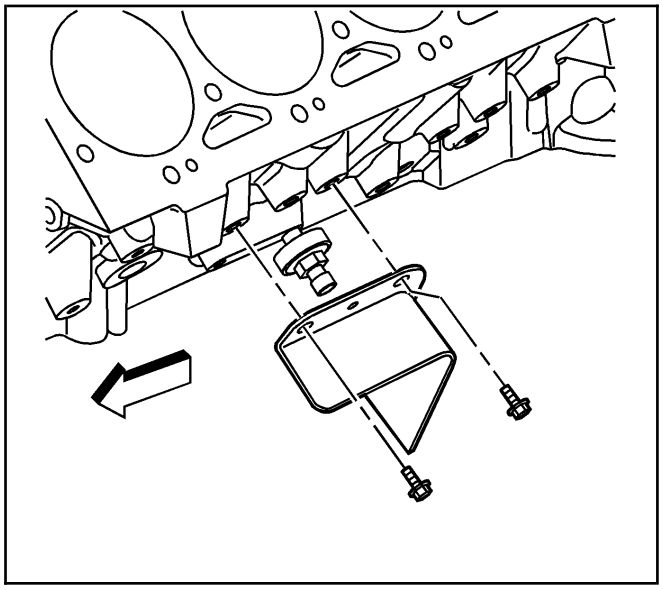
471126



648525

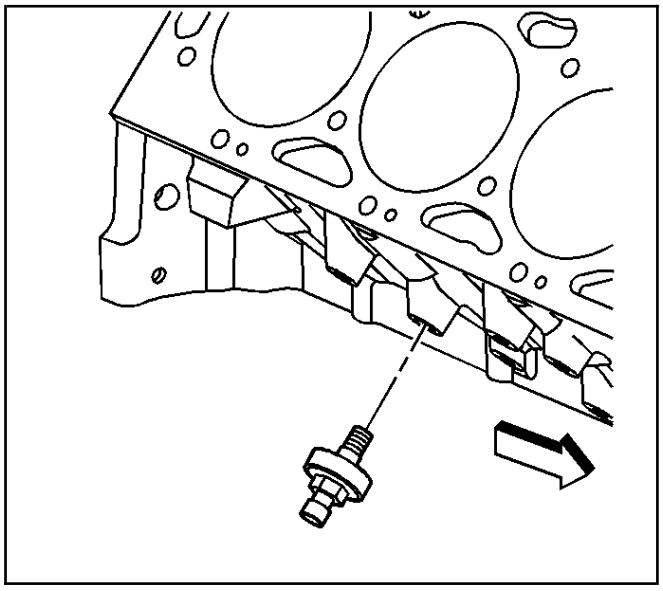
Important: Do not overtighten the knock sensor.

15. Install the left knock sensor to the engine block.
    Tighten
    Tighten the left knock sensor to 20 N·m (15 lb ft).



648528

16. Install the left side knock sensor shield.
17. Install the left side knock sensor shield bolts.
    Tighten
    Tighten the left side knock sensor shield bolts to 50 N·m (37 lb ft).



471076

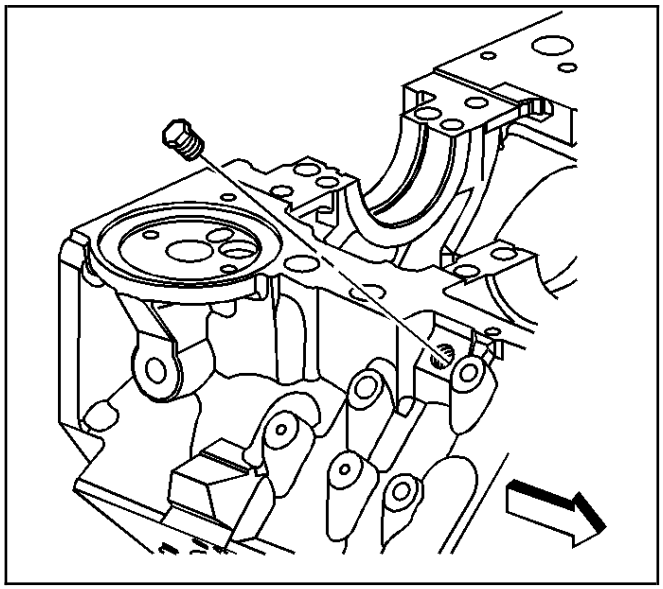
Important: Do not overtighten the knock sensor.

18. Install the right knock sensor to the engine block.
    Tighten
    Tighten the right knock sensor to 20 N·m (15 lb ft).

19. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the engine block coolant drain hole plugs.
20. Install the engine block coolant drain hole plugs.

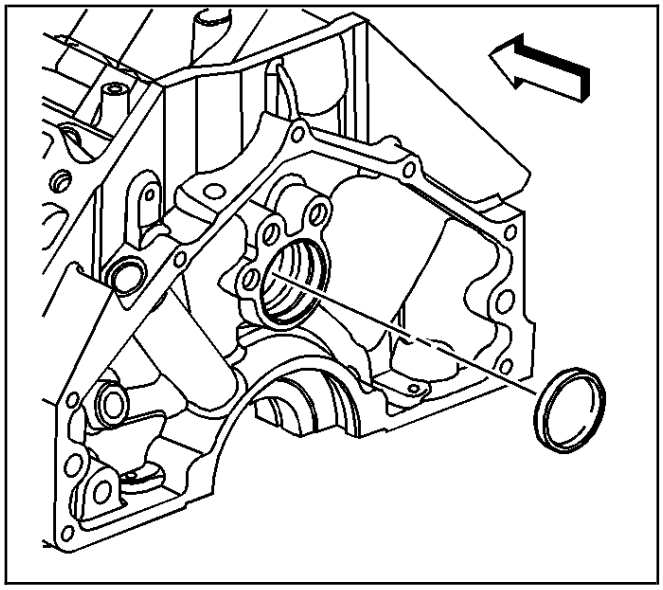
    Tighten

    Tighten the coolant drain hole plugs to 30 N·m (22 lb ft).



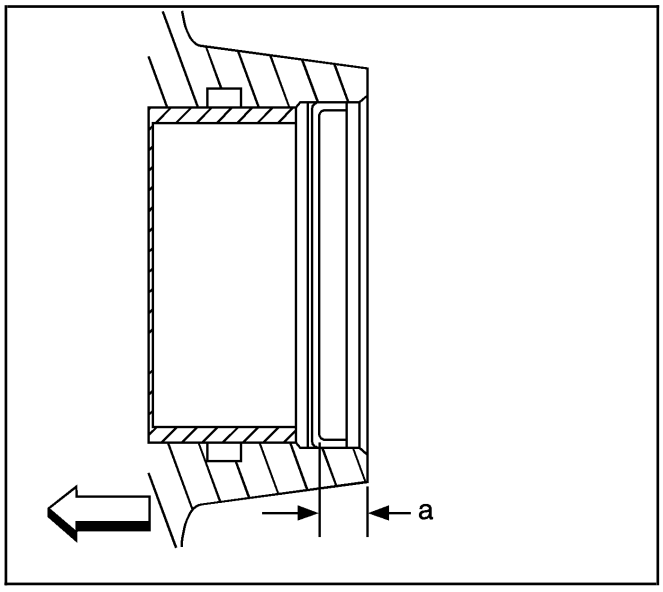
470568

21. Apply sealer GM P/N United States 12377901, GM P/N Canada 10953504, to the outside diameter of the new camshaft rear bearing hole plug.

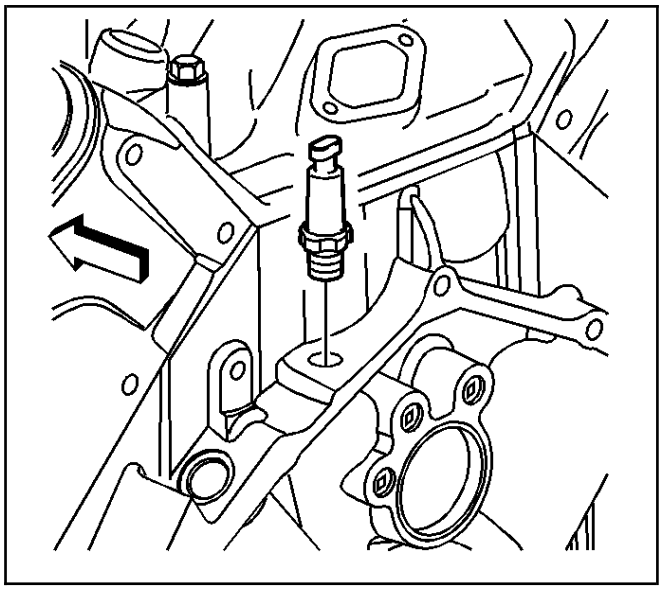


471118

22. Install the NEW camshaft rear bearing hole plug to the proper depth of (A) 7.600–6.200 mm (0.299–0.244 in).



471122

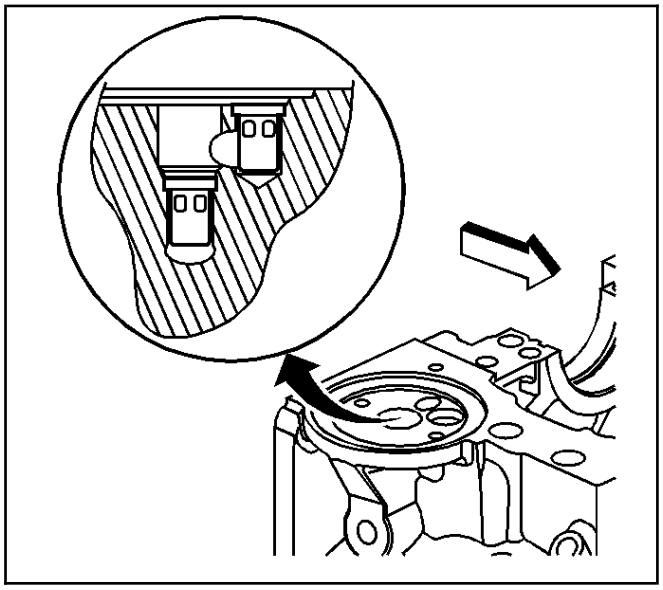


471089

23. Apply sealant GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the threads of the oil pressure sensor.
24. Install the oil pressure sensor.

    Tighten

    Using the *J 41712* tighten the oil pressure sensor to 30 N·m (22 lb ft).

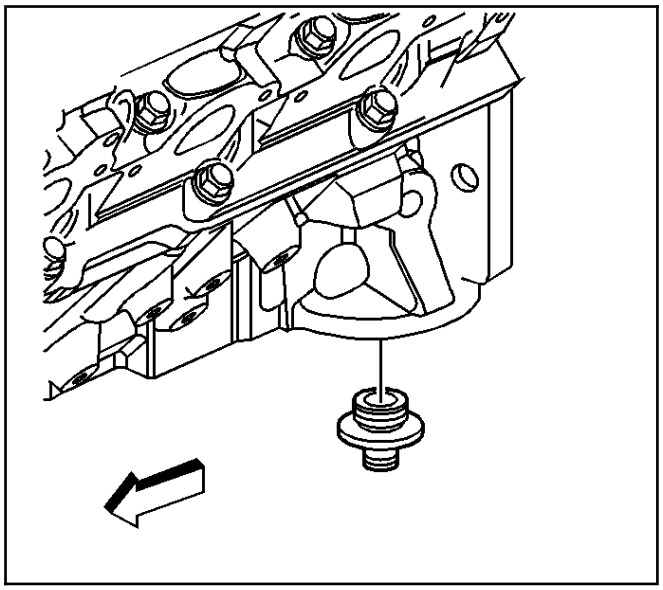


471143

Oil Filter Adapter Installation

SIE-ID = 482800

1. If removed, install the new oil bypass valves. Stake the tangs on the oil bypass valves.



471026

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

2. Install the oil filter fitting.

   Tighten

   Tighten the oil filter fitting to 66 N·m (49 lb ft).

Crankshaft and Bearings Installation

SIE-ID = 482802

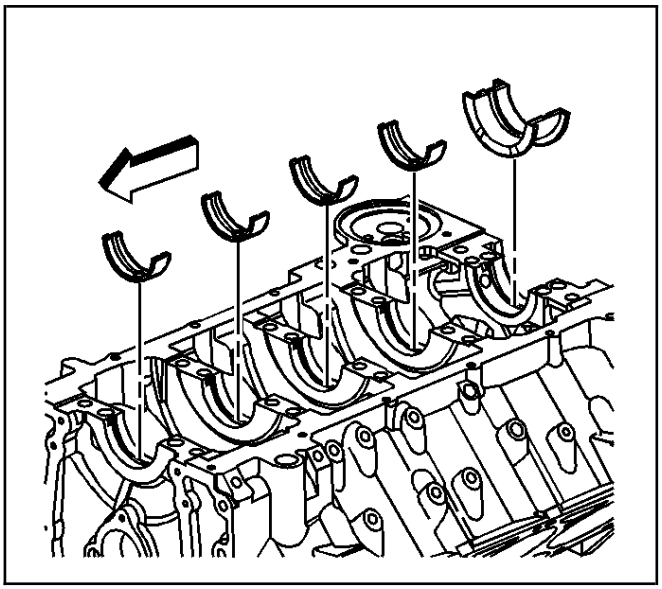
Tools Required

- *J 8001* Dial Indicator Set
- *J 36660-A* Torque/Angle Meter

Important:

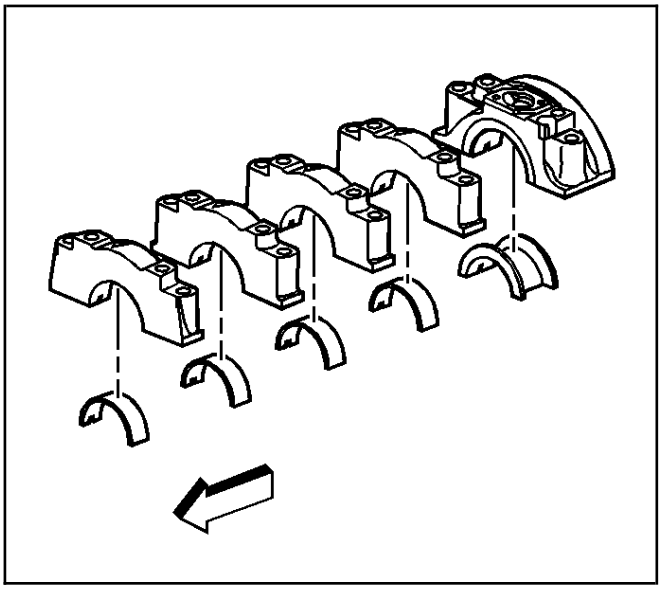
- Lubricate the crankshaft bearings and crankshaft with clean engine oil.
- If undersized bearings are used, ensure that the bearings are fitted to the proper journals.

1. Install the crankshaft upper bearings into the block. Apply clean engine oil to the bearing surfaces.



471041

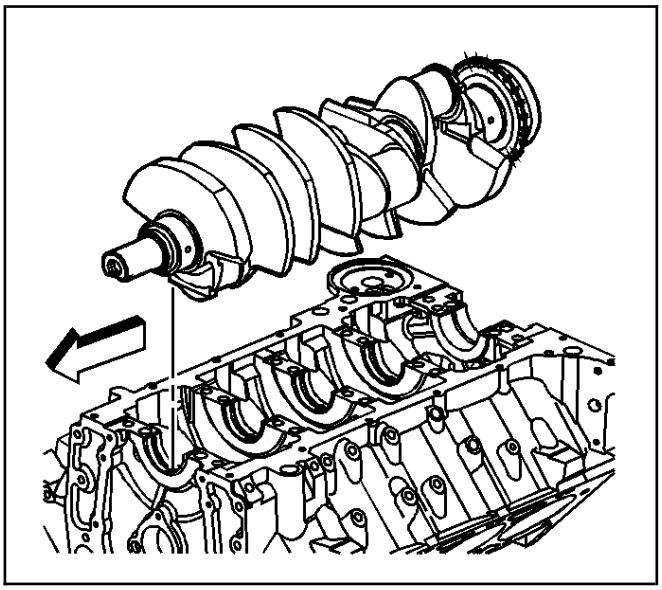
2. Install the crankshaft lower bearings into the crankshaft bearing caps. Apply clean engine oil to the bearing surfaces.



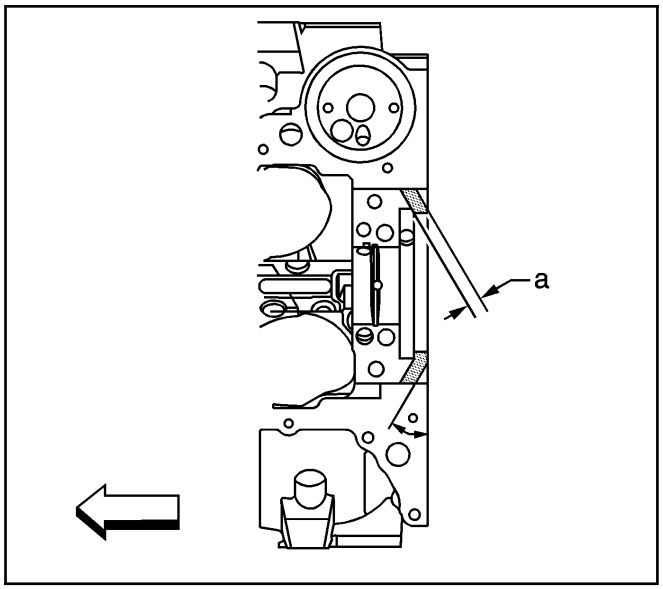
471044

Notice: SIO-ID = 728987 In order to prevent damage to the crankshaft position sensor reluctor wheel/ring care must be used when removing or installing this component.

3. Install the crankshaft.



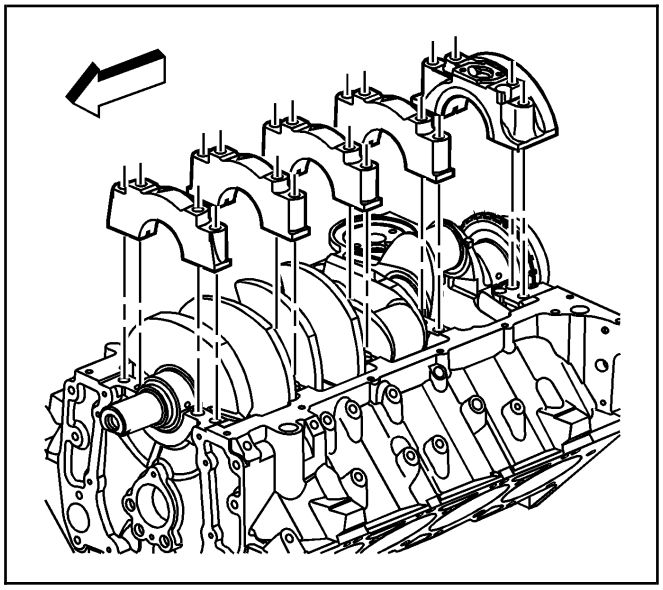
471047



647705

Important: The bearing caps must be seated within 60 minutes of the sealer being applied. The bearing cap fasteners must be tightened within 5 minutes of the bearing caps being installed onto the engine block.

4. Apply a (A) 13 mm (0.500 in) light film of GM P/N United States 1052942, GM P/N Canada 10953466, or equivalent to the rear bearing cap sealing face or to the rear bearing cap channel of the engine block. Apply the sealant to the bearing cap mating surface and bearing cap channel from the rear seal bore to the oil pan surface.



679831

Notice: SIO-ID = 16506 In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

Notice: SIO-ID = 728989 The crankshaft position sensor reluctor wheel/ring is not serviced separately. Do not repair the crankshaft position sensor reluctor wheel/ring. If the crankshaft position sensor reluctor ring is damaged, the crankshaft assembly must be replaced.

Important: Ensure that the triangle symbols on the crankshaft bearing caps are facing the front of the engine.

5. Install the crankshaft bearing caps in the location the caps were marked and originally removed from.

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

Important: Tighten the crankshaft bearing cap inner bolts before tightening the crankshaft bearing cap outer studs.

6. Install the crankshaft bearing cap bolts and studs.

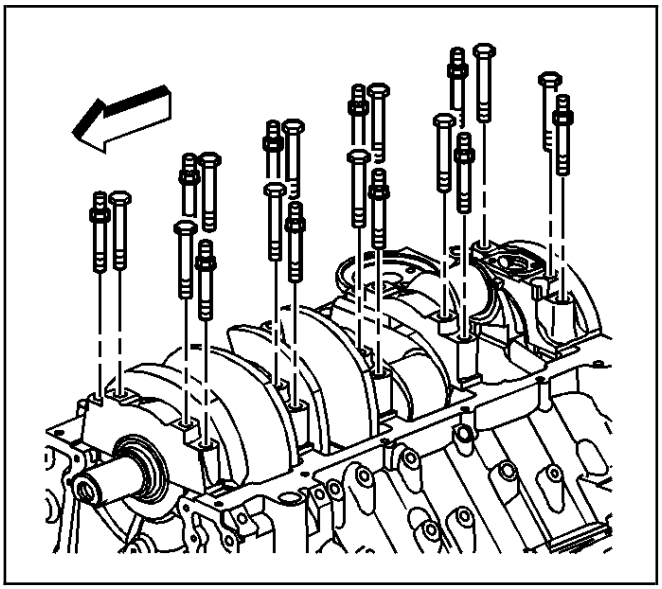
   Tighten

   6.1. Tighten the crankshaft bearing cap inner bolts to 30 N·m (22 lb ft).

   6.2. Tighten the crankshaft bearing cap outer studs to 30 N·m (22 lb ft).

   6.3. Using *J 36660-A*, tighten the crankshaft bearing cap inner bolts an additional 90 degrees.

   6.4. Using *J 36660-A*, tighten the crankshaft bearing cap outer studs an additional 80 degrees.



471055

7. Measure the crankshaft end play as follows:

   7.1. Install the *J 8001* or equivalent to the cylinder block, with the dial indicator plunger against one of the counterweights of the crankshaft.

   7.2. Firmly thrust the end of the crankshaft first rearward then forward. This will line up the rear crankshaft bearing and the crankshaft thrust surfaces.

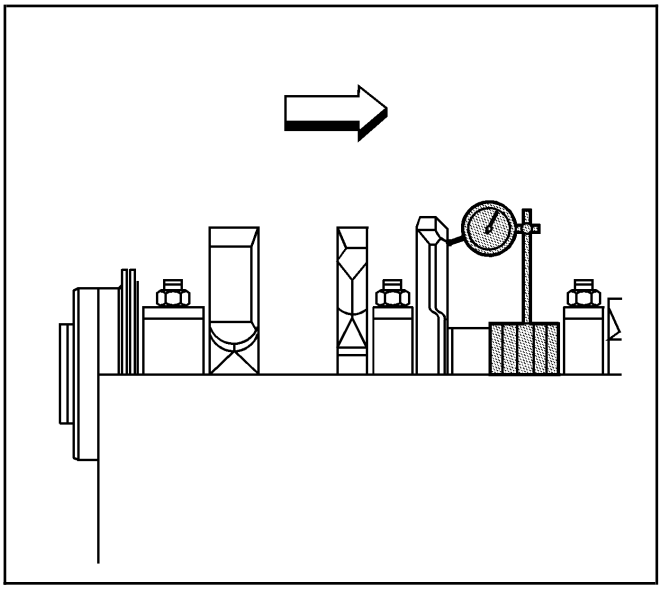
   7.3. With the crankshaft pushed forward, zero the dial indicator. Move the crankshaft rearward, and read the end play measurement on the dial indicator. An optional method is to insert a feeler gage between the crankshaft and the bearing surface and measure the clearance. Refer to *Engine Mechanical Specifications*.

   7.4. If the correct end play cannot be obtained, inspect for the following conditions:

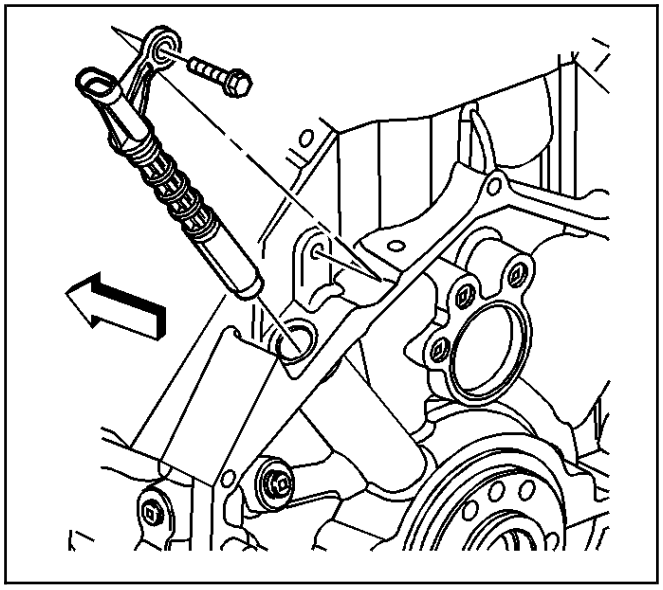
   - Verify that the correct size crankshaft bearing has been installed. Refer to *Engine Mechanical Specifications*.
   - Inspect the crankshaft thrust wall surface(s) for wear and/or excessive runout. Refer to *Engine Mechanical Specifications*.

   7.5. Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the crankshaft bearing bolts and studs, one cap at a time, until the tight bearing is located. The following condition(s) could cause a lack of clearance at the bearing:

   - Burrs on the crankshaft bearing cap
   - Foreign material between the bearing and the block
   - Foreign material between the bearing and the bearing cap
   - A faulty crankshaft bearing



677804



470801

- Improper size bearing

Important:

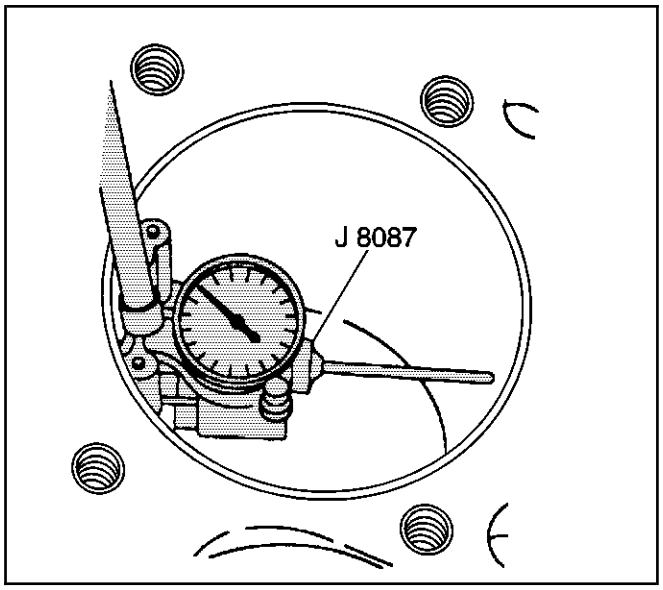
- Ensure that the crankshaft position sensor is fully seated against the crankshaft reluctor ring. The upper flange on the sensor MAY NOT seat against the engine block.
- The crankshaft position sensor bolt has a thread sealant applied to the threads. The thread sealant may have come off during the removal of the bolt. Ensure that the bolt hole is clean of any debris before installing the crankshaft sensor bolt.

8. Inspect both crankshaft position sensor O-rings for cuts, cracks, tears or damage. Replace the O-rings as needed. Lubricate the crankshaft position sensor O-rings with clean engine oil.
9. Install the crankshaft position sensor into the block.

   There may be a slight resistance as the O-rings seat into the engine block.
10. Apply thread adhesive GM P/N United States 12345493, GM P/N Canada 10953488, or equivalent to the crankshaft position sensor bolt.
11. Install the crankshaft position sensor bolt.

    Tighten

    Tighten the crankshaft position sensor bolt to 12 N·m (106 lb in).



4972

Piston, Connecting Rod, and Bearing Installation

SIE-ID = 482805

Tools Required

- *J 8037* Piston Ring Compressor
- *J 8087* Cylinder Bore Gage

Piston Selection

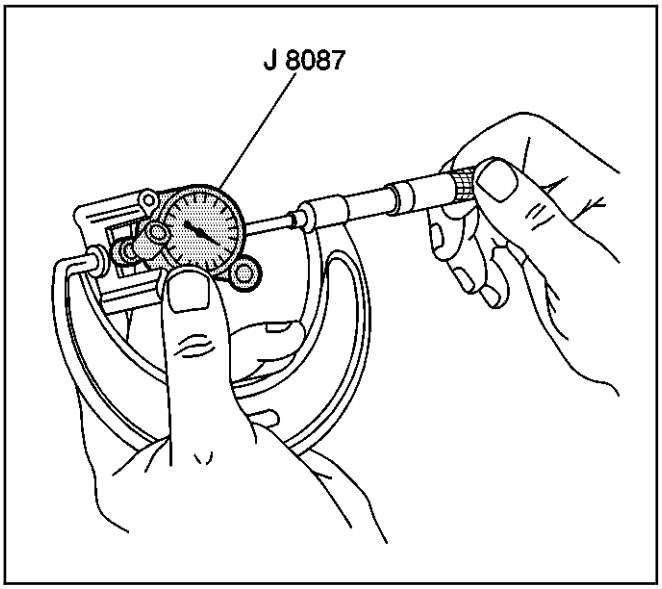
Important: The coating on the piston allows for an interference fit between the cylinder and the bore. The piston diameter can NOT be measured accurately because the piston coating is not a consistent thickness. Do NOT measure the piston diameter.

To select the correct piston for installation, the cylinder bore must be measured. If the cylinder bore diameter is within service specifications, install the original piston/connecting rod assembly or a new, standard size piston/connecting rod assembly. A used piston/connecting rod assembly may be reinstalled if, after cleaning and inspection, the piston is not damaged. If the cylinder bore is NOT within specifications, the cylinder must be resized to accept a new, oversized piston.

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

1. Inspect the engine block cylinder bore. Refer to *Engine Block Cleaning and Inspection*.
2. Inspect the piston/connecting rod assembly for damage. Refer to *Piston, Connecting Rod, and Bearings Cleaning and Inspection*.

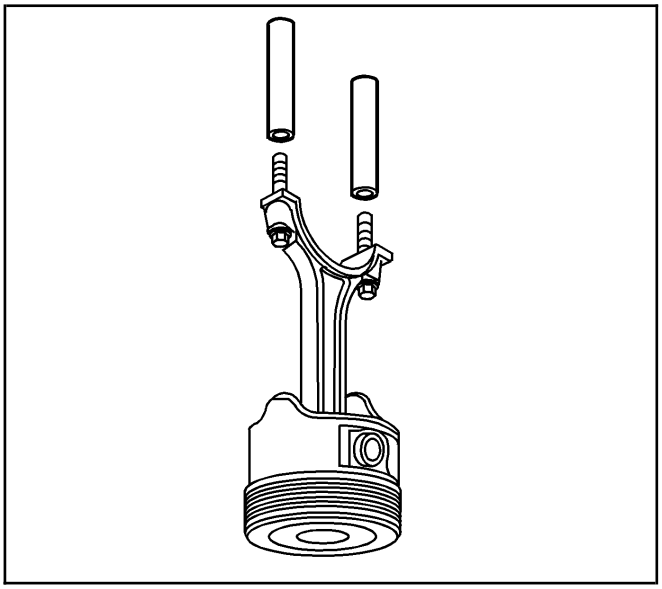
3. Use the *J 8087* and measure the cylinder bore diameter. Refer to *Engine Block Cleaning and Inspection*.
4. Measure the *J 8087* with a micrometer and record the reading.
5. Compare the cylinder bore measurement to the specifications. Refer to *Engine Mechanical Specifications*.
   5.1. If the cylinder bore is within specifications, select the original piston or a new, original size piston.
   5.2. If the cylinder bore is not within specifications, select the next oversized piston/connecting rod assembly, then bore and hone the cylinder bore to fit the oversize piston.

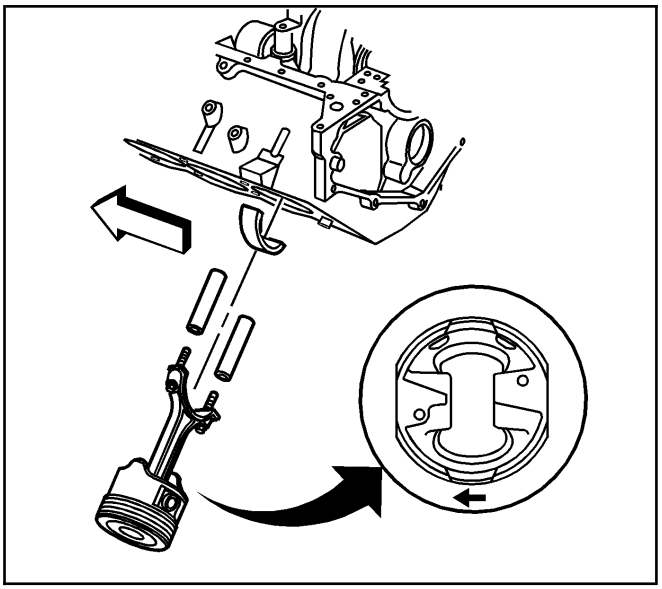


4974

Piston Installation

1. Coat the following components with clean engine oil:
   - The piston
   - The piston rings
   - The cylinder bore
   - The bearing surfaces
2. Install rubber fuel line onto the connecting rod bolts.

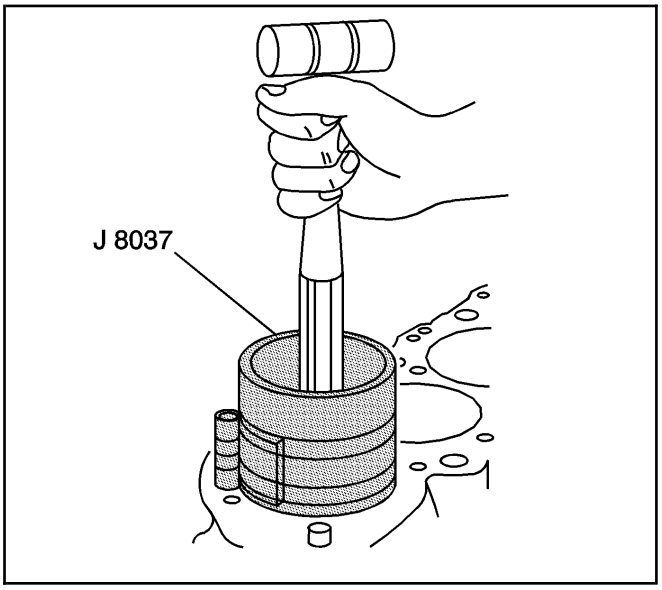

639532



639536

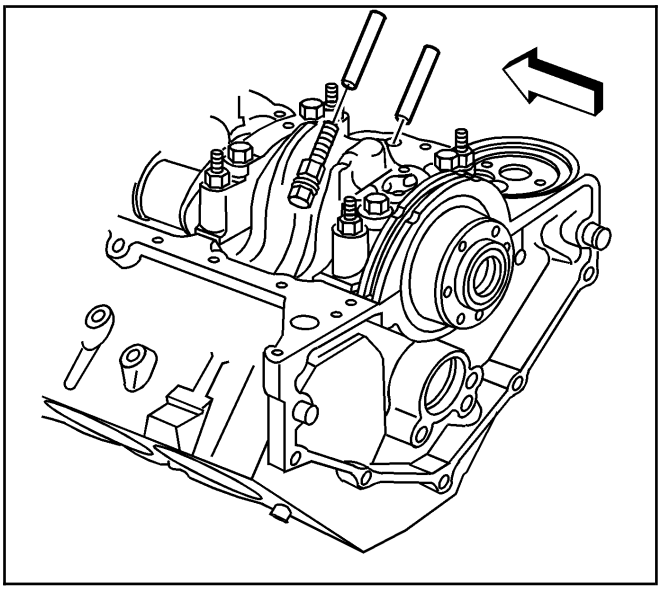
Important: The mark on the top of the piston must face the front of the engine block. When assembled, the flanges on the connecting rod and cap should face to the front of block on the left bank and to the rear of block on the right bank.

3. Install the piston, connecting rod and upper connecting rod bearing through the top of the engine block.



5159

4. Install the *J 8037* onto the piston and compress the piston rings.
5. Use the *J 8037* and lightly tap the top of the piston with a wooden hammer handle.
6. Hold the *J 8037* firmly against the engine block until all of the piston rings have entered the cylinder bore.



639533

7. Use the rubber fuel line in order to guide the connecting rod onto the crankshaft journal.
8. Remove the rubber fuel line.

9. Install the connecting rod cap and lower connecting rod bearing.

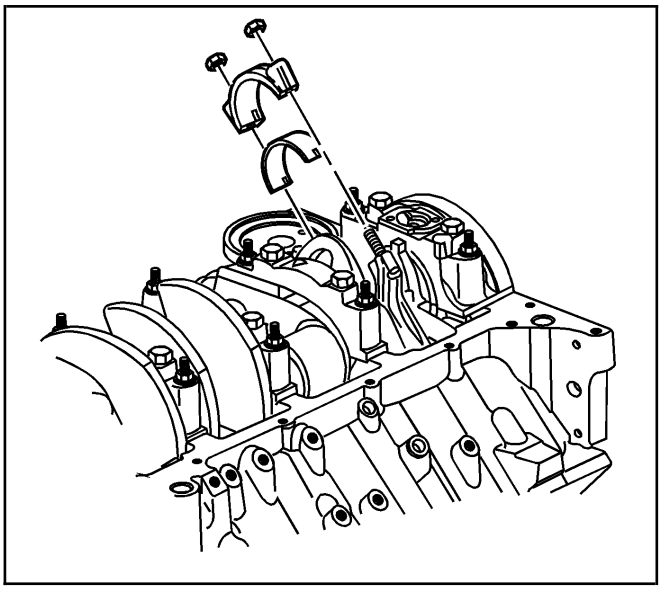
Notice: Refer to *Fastener Notice* in Cautions and Notices.

Important: When installing the piston/connecting rod assembly, NEW connecting rod nuts must be installed.

10. Install the new connecting rod nuts.

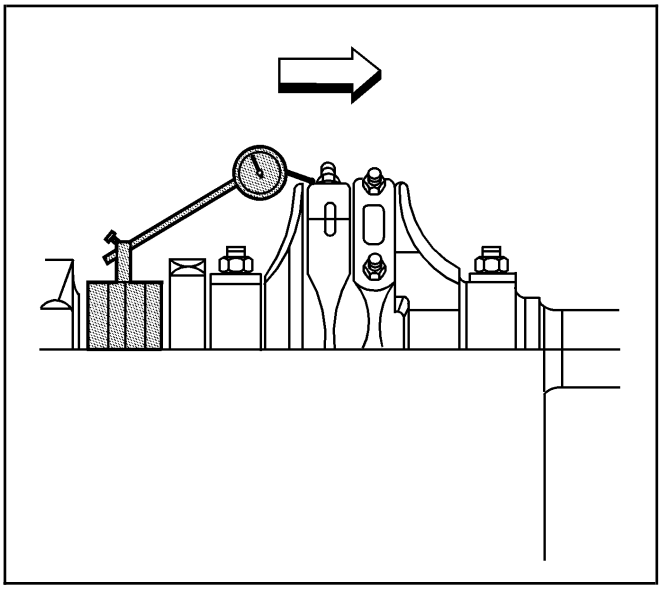
    Tighten

    Tighten the connecting rod nuts to 30 N·m (22 lb ft) plus an additional 90 degrees.



639084

11. Once the piston and connecting rod assemblies have been installed, lightly tap each connecting rod assembly (parallel to the crankpin) in order to make sure that they have side clearance.
12. Use a feeler gage or a dial indicator to measure the side clearance between the connecting rod caps. The rod side clearance should be 0.384–0.686 mm (0.0151–0.0270 in).



677801

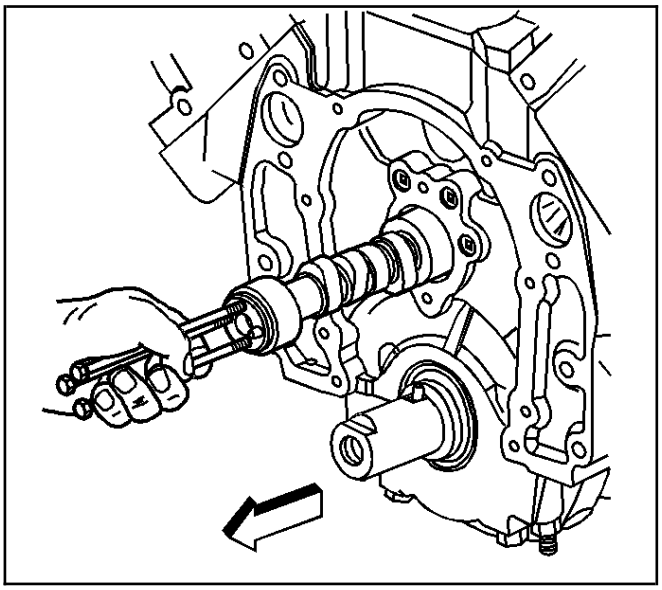
Camshaft Installation

SIE-ID = 482806

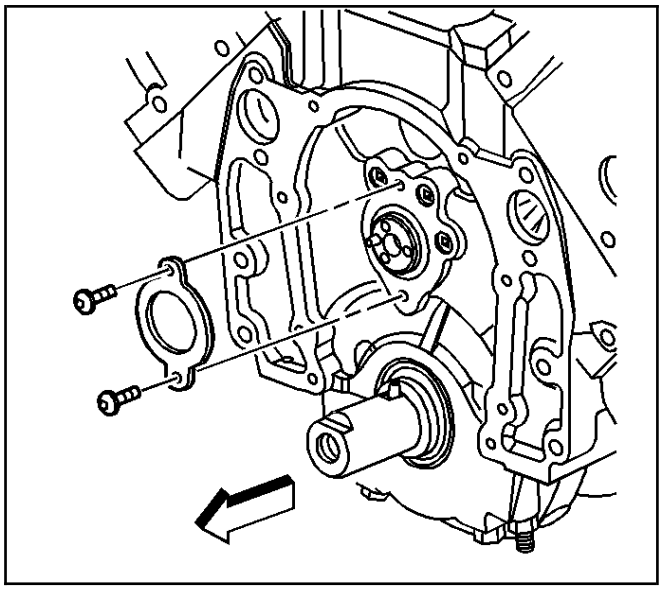
1. Lubricate the following components with clean engine oil, engine oil supplement GM P/N United States 1052367, GM P/N Canada 992869, or equivalent:
   - The camshaft lobes
   - The camshaft bearing journals
   - The camshaft bearings

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. Install the three 8–1.25 x 100 mm bolts in the camshaft front bolt holes.
3. Using the bolts as a handle, install the camshaft.
4. Remove the three bolts from the front of the camshaft.



471002



470998

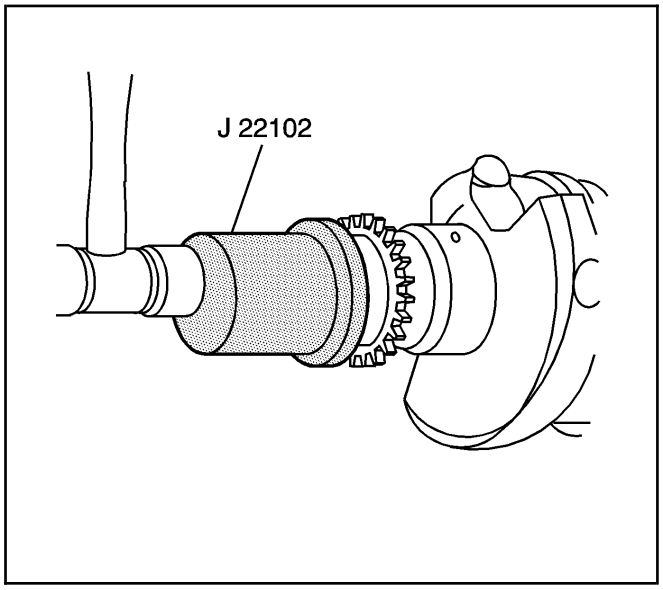
5. Install the camshaft retainer.

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

6. Install the camshaft retainer bolts.

   Tighten

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



65850

Timing Chain and Sprockets Installation

SIE-ID = 482807

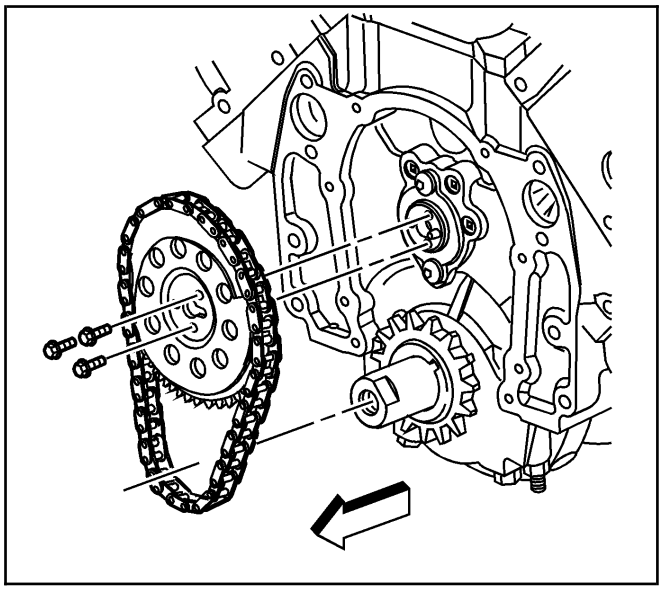
Tools Required

J 22102 Front Cover Aligner and Seal Installer

1. Use the *J 22102* in order to install the crankshaft sprocket.

   Align the keyway of the crankshaft sprocket with the crankshaft pin.

2. Rotate the crankshaft until the crankshaft sprocket alignment mark is in the 12 o'clock position.



470814

Notice: SIO-ID = 16333 Do not hammer the camshaft sprocket onto the camshaft. To do so may dislodge the rear camshaft plug and damage the camshaft.

Important: Install the camshaft sprocket with the alignment mark in the 6 o'clock position.

Important: The sprocket teeth must mesh with the timing chain in order to prevent damage to the camshaft retainer.

3. Install the camshaft sprocket and timing chain.

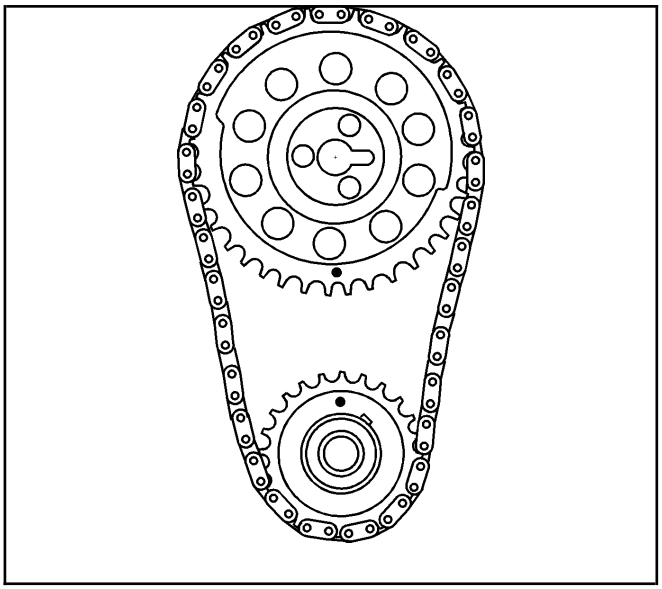
4. Look to ensure that the crankshaft sprocket is aligned at the 12 o'clock position and the camshaft sprocket is aligned at the 6 o'clock position.

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

5. Install camshaft sprocket bolts.

   Tighten

   - Tighten the three camshaft sprocket bolts to 30 N·m (22 lb ft).
   - Tighten the camshaft sprocket bolts in a second pass to 30 N·m (22 lb ft).



677756

Engine Front Cover Installation

SIE-ID = 482808

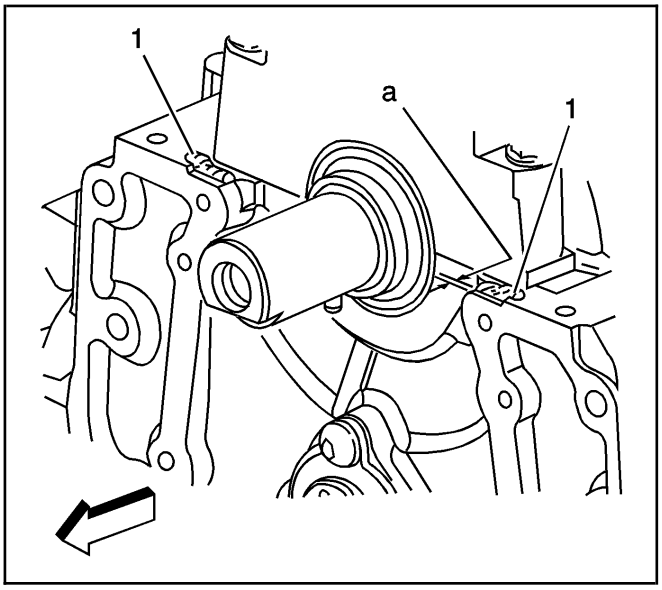
Tools Required

J 42851 Front Cover Oil Seal Installer

1. Install the NEW crankshaft front oil seal using the *J 42851*.
2. Lubricate the sealing surface of the crankshaft front oil seal with clean engine oil.

Important: The engine front cover must be installed and the fasteners tightened while the sealant is still wet to the touch.

3. Apply the sealant GM P/N United States 12346286, GM P/N Canada 10953472, or equivalent in two sealant points (1) on the engine block where the front cover meets the oil pan. The sealant (A) should be 2.0 mm (0.080 in) away from the front of the engine block.

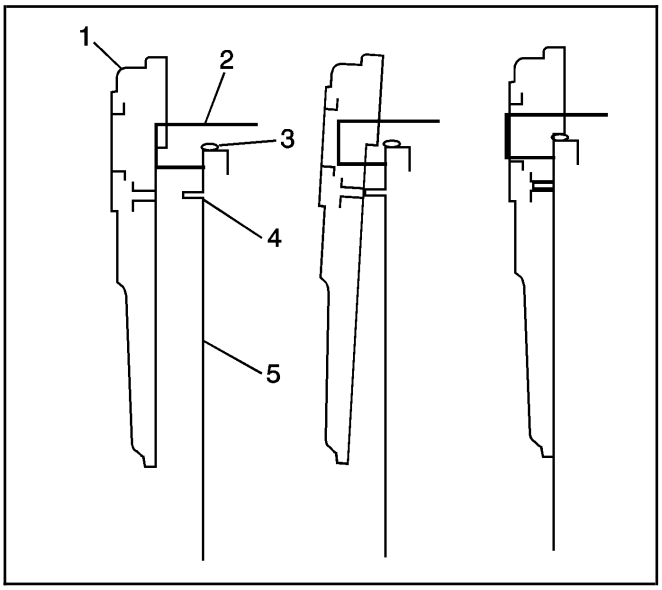


470807

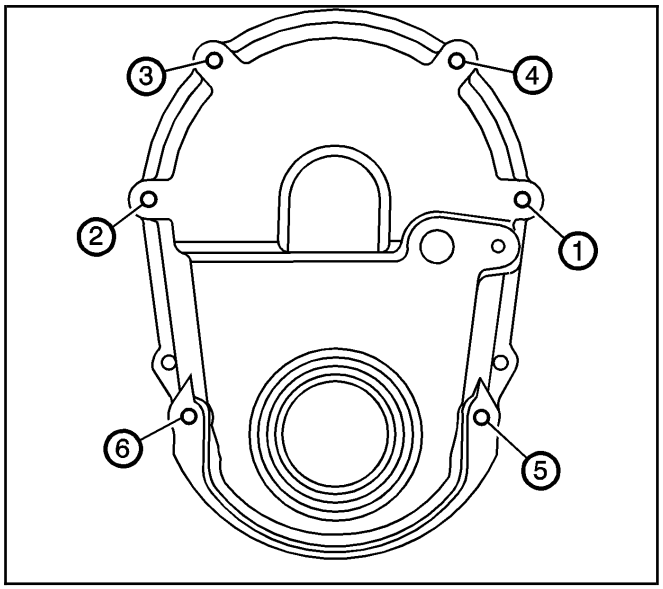
4. Install the engine front cover gasket into the front cover.

Important: The following method must be used when installing the engine front cover. Failure to follow the instructions will push the sealant out, which may cause an oil leak.

5. Install the engine front cover.
   5.1. Hold the front cover (1) up to the crankshaft (2).
   5.2. Lift the front cover (1) while sliding the cover over the crankshaft (2).
   5.3. Slide the front cover towards the engine block (5) while keeping the cover raised.
   5.4. Lower the cover down over the dowel pin (4), allowing the front cover to rest on the sealant (3).



719124



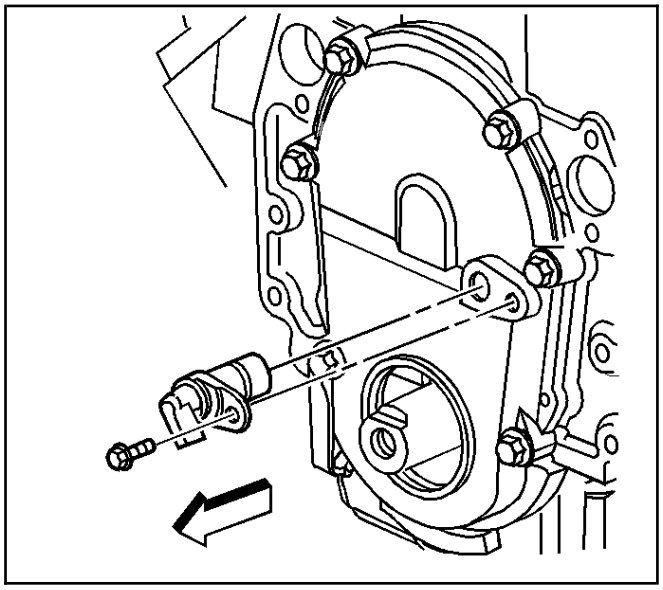
677874

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

6. Install the engine front cover bolts.

   Tighten

   - Tighten the engine front cover bolts in sequence to 6 N·m (54 lb in) in the first pass.
   - Tighten the engine front cover bolts in sequence to 12 N·m (106 lb in) in the second pass.



470803

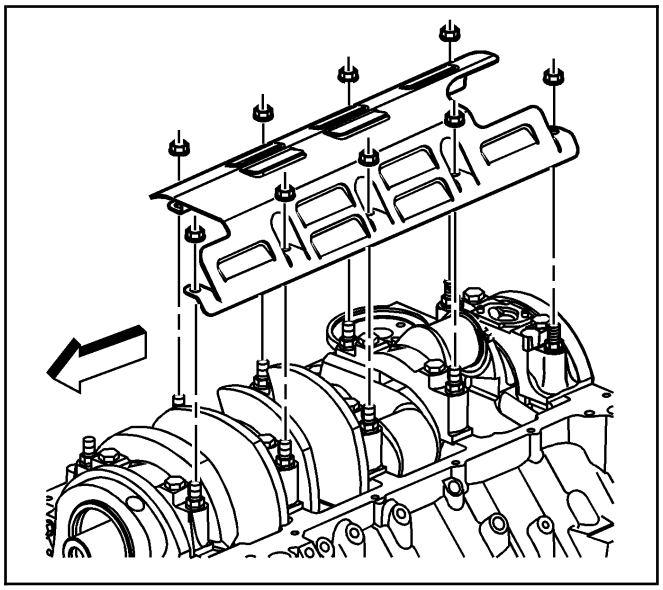
7. Inspect the camshaft position sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring as needed.
8. Apply a light film of clean engine oil to the camshaft position sensor O-ring.
9. Install the camshaft position sensor.

Notice: SIO-ID = 451379 This bolt is a self-tapping bolt. If installing this bolt into a new component, installation of the bolt may be difficult. Ensure that the bolt is not over-torqued during the initial installation (thread cutting). Failure to limit torque can lead to bolt failure.

10. Install the camshaft position sensor bolt.

    Tighten

    Tighten the camshaft position sensor bolt to 12 N·m (106 lb in).



635703

Oil Pump, Pump Screen and Deflector Installation

SIE-ID = 482809

1. Install the crankshaft oil deflector.

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

2. Install the crankshaft oil deflector nuts.

   Tighten

   Tighten the crankshaft oil deflector nuts to 50 N·m (37 lb ft).

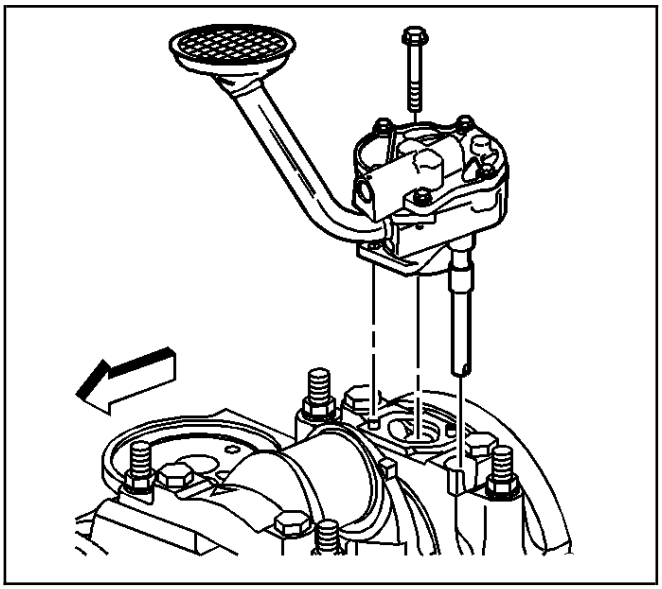
Important: During assembly, install a NEW oil pump driveshaft retainer. Slightly heat retainer above room temperature for ease of installation onto the oil pump driveshaft.

3. Assemble the oil pump, driveshaft, and a NEW retainer.
4. Install the oil pump assembly.

   Position the oil pump onto the locating pins.
5. Install the bolt attaching the oil pump to the rear crankshaft bearing cap.

   Tighten

   Tighten the oil pump bolt to 75 N·m (55 lb ft).
6. Pour clean engine oil into the oil pump pickup screen.
7. Rotate crankshaft in direction of engine rotation in order to prime the oil pump.



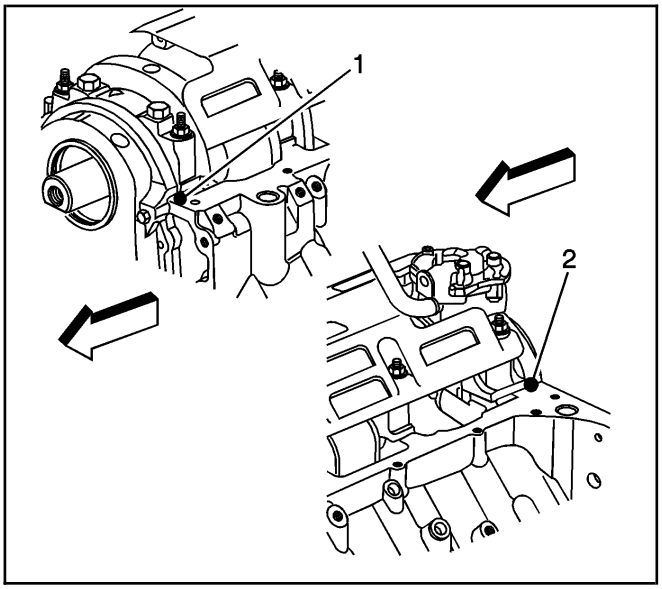
471060

Oil Pan Installation (C/K/G/C3500HD)

SIE-ID = 482810

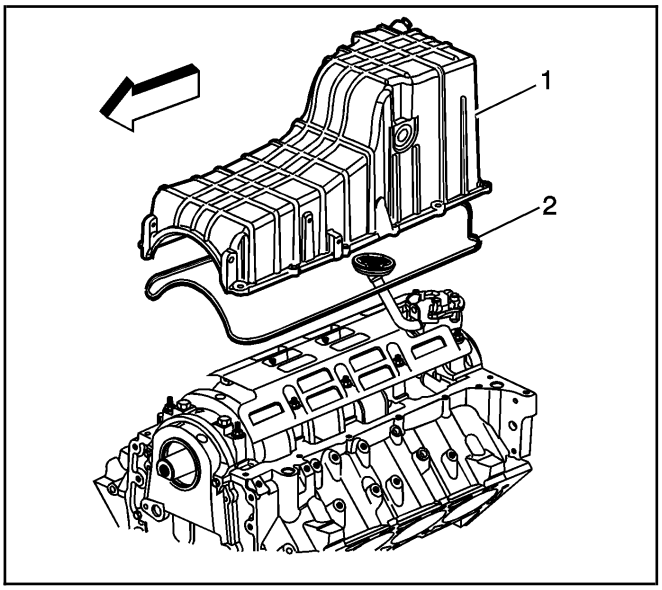
Important: The oil pan must be installed within five minutes of the sealer being applied or the sealer will begin to cure, causing an inadequate seal.

1. Apply sealant GM P/N United States 12346286, GM P/N Canada 10953472, to the side of the front cover (1) and rear (2) crankshaft bearing cap, on both the left and right sides (four locations total).

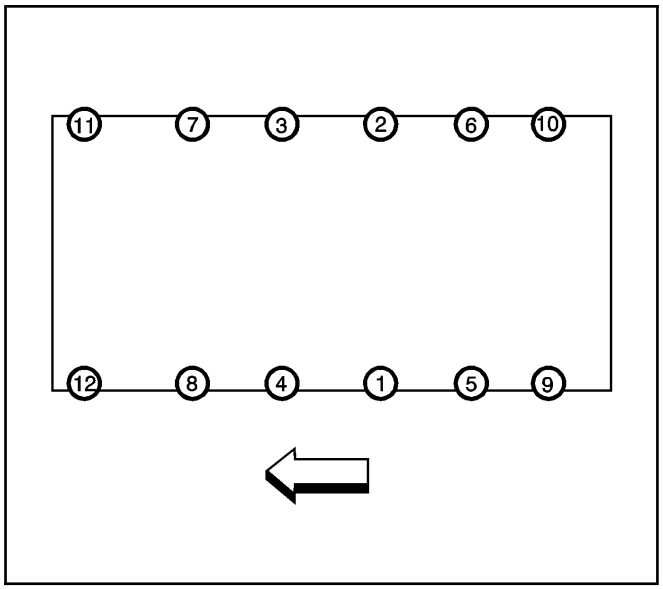


677833

2. Install the new oil pan gasket (2) into the oil pan groove.
3. Install the oil pan (1).



635654



677869

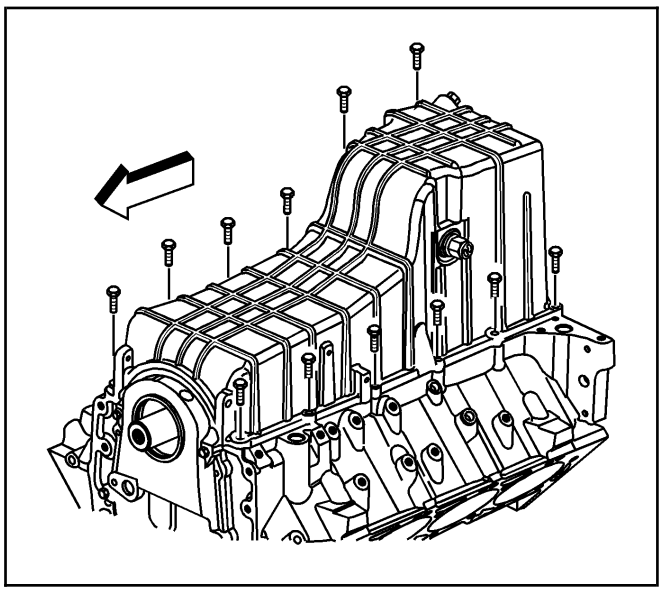
4. Install the oil pan bolts.

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

5. Tighten the oil pan bolts in sequence.

   Tighten

   - Tighten the oil pan bolts in sequence to 10 N·m (88 lb in) in a first pass.
   - Tighten the oil pan bolts in sequence to 25 N·m (18 lb ft) in a second pass.



635648

6. Install the oil pan drain plug.

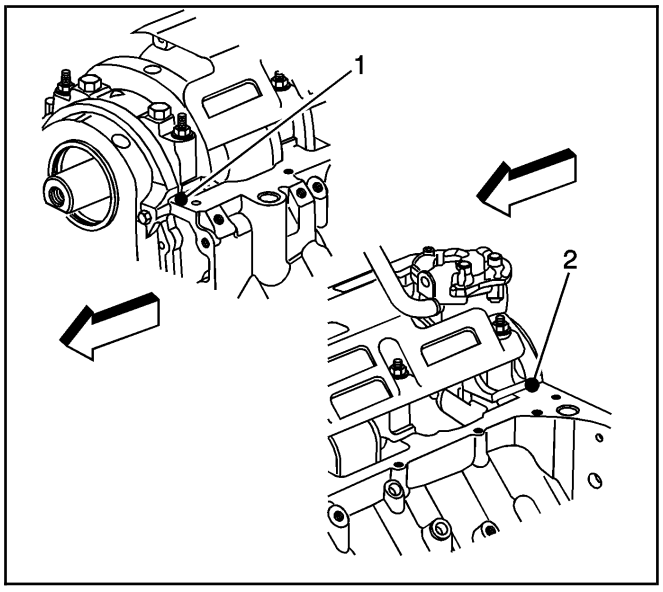
   Tighten

   Tighten the oil pan drain plug to 28 N·m (21 lb ft).

7. Install the oil level switch, if applicable.

   Tighten

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



677833

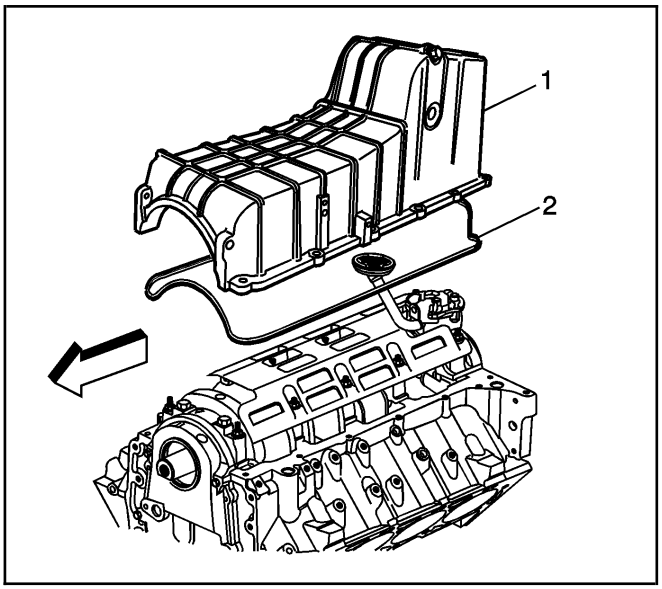
Oil Pan Installation (Medium Duty)

SIE-ID = 482812

Important: The oil pan must be installed within five minutes of the sealer being applied or the sealer will begin to cure, causing an inadequate seal.

1. Apply sealant GM P/N United States 12346286, GM P/N Canada 10953472, to the side of the front cover (1) and rear (2) crankshaft bearing cap, on both the left and right sides (four locations total).

2. Install the new oil pan gasket (2) into the oil pan groove.
3. Install the oil pan (1).



635649

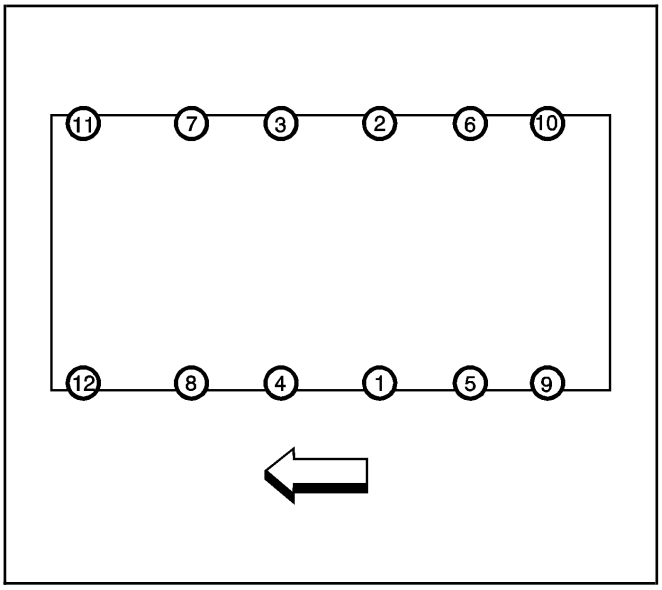
4. Install the oil pan bolts.

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

5. Tighten the oil pan bolts in sequence.

   Tighten

   - Tighten the oil pan bolts in sequence to 10 N·m (88 lb in) in a first pass.
   - Tighten the oil pan bolts in sequence to 25 N·m (18 lb ft) in a second pass.



677869

6. Install the oil pan drain plug.

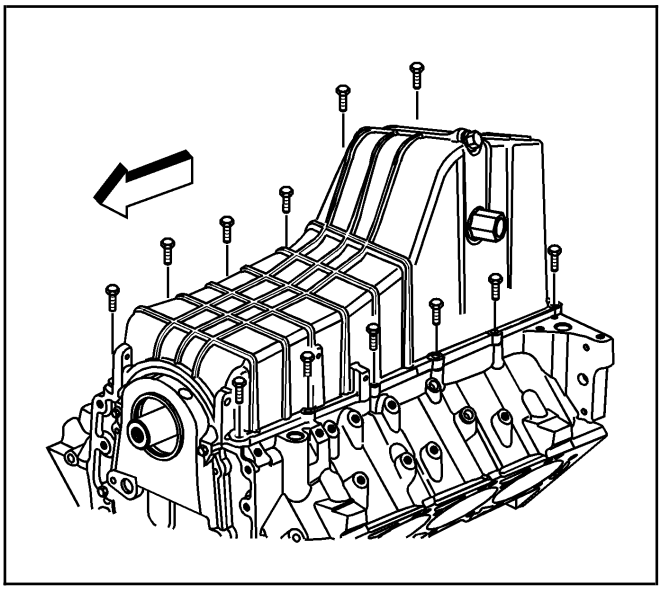
   Tighten

   Tighten the oil pan drain plug to 28 N·m (21 lb ft).

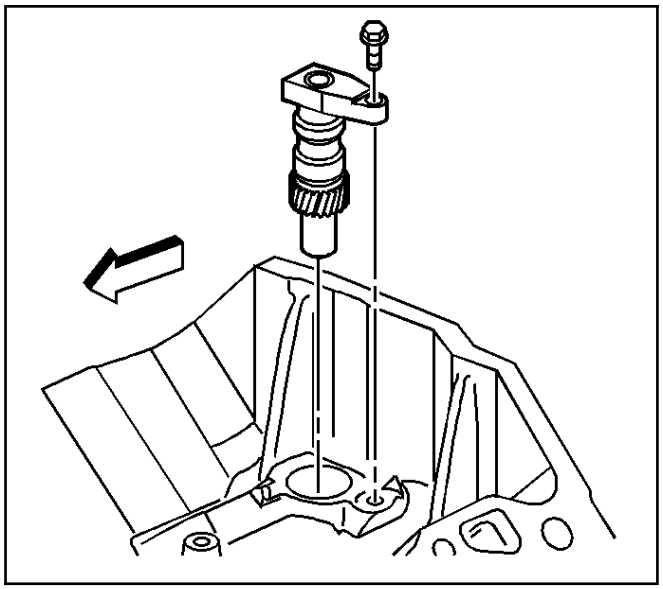
7. Install the oil level switch.

   Tighten

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



635651



470910

Oil Pump Drive Installation

SIE-ID = 482814

1. Apply grease to the oil pump drive gear for ease of assembly.

Notice: SIO-ID = 728984 Ensure both components are aligned correctly or serious engine damage will occur.

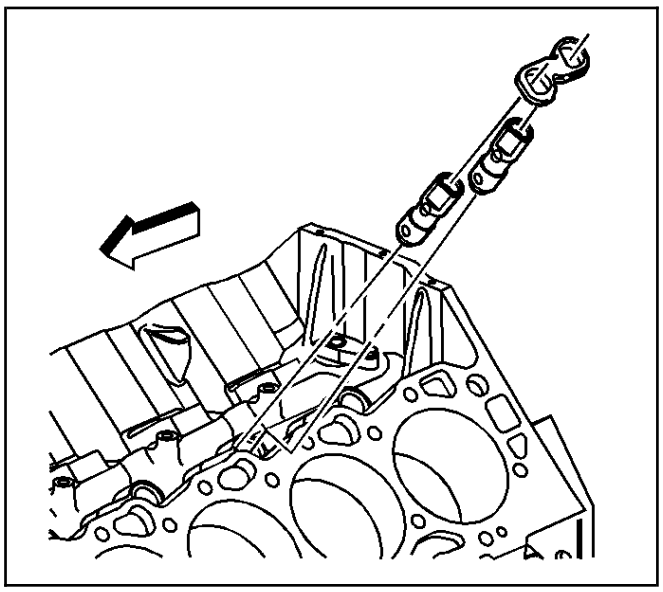
2. Line up the oil pump drive gear with the oil pump drive shaft.
3. Install the oil pump drive, making sure that the oil pump drive is fully seated in the engine block.

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

4. Install the oil pump drive bolt.

   Tighten

   Tighten the oil pump drive bolt to 25 N·m (18 lb ft).



470996

Valve Lifter Installation

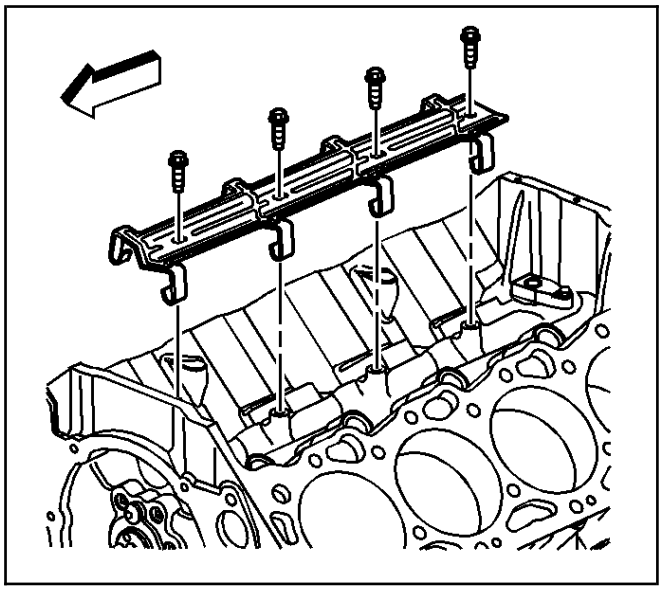
SIE-ID = 482815

Important: If a new camshaft is installed, replace all the valve lifters.

1. Coat the valve lifter rollers with prelube, GM P/N United States 1052367, GM P/N Canada 992869, or equivalent.

Important: If reusing the valve lifters, install in their original location. The valve lifter guide retainer must contact all of the valve lifter guides. If the valve lifter guide retainer is bent, the valve lifter guide retainer must be replaced.

2. Install the valve lifters.
3. Install the valve lifter guides over the flats on the valve lifters, making sure the rollers of the valve lifters are properly aligned with the camshaft lobes.



470994

4. Install the valve lifter guide retainer.

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

5. Install the valve lifter guide retainer bolts.

   Tighten

   Tighten the valve lifter guide retainer bolts to 25 N·m (18 lb ft).

Cylinder Head Installation - Left

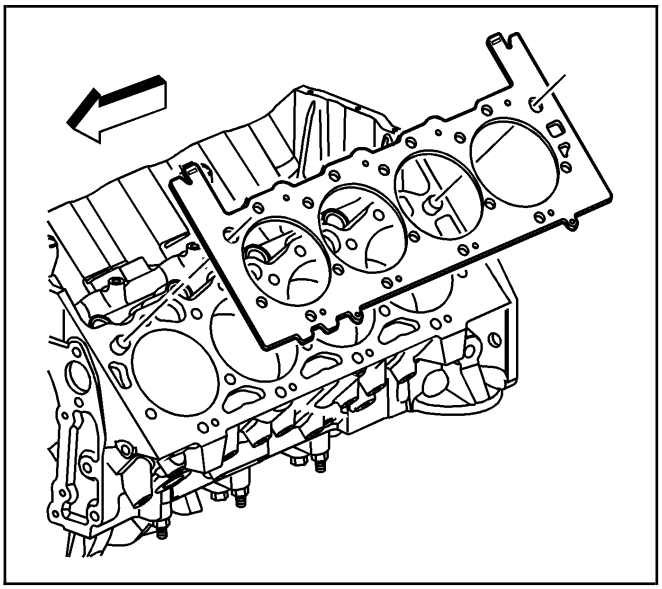
SIE-ID = 639165

Tools Required

J 36660-A Torque/Angle Meter

Notice: SIO-ID = 63461 Do not use a sealant or adhesive when installing this component. Use of a sealant or adhesive can cause improper sealing. A component that is not sealed properly can leak leading to extensive engine damage.

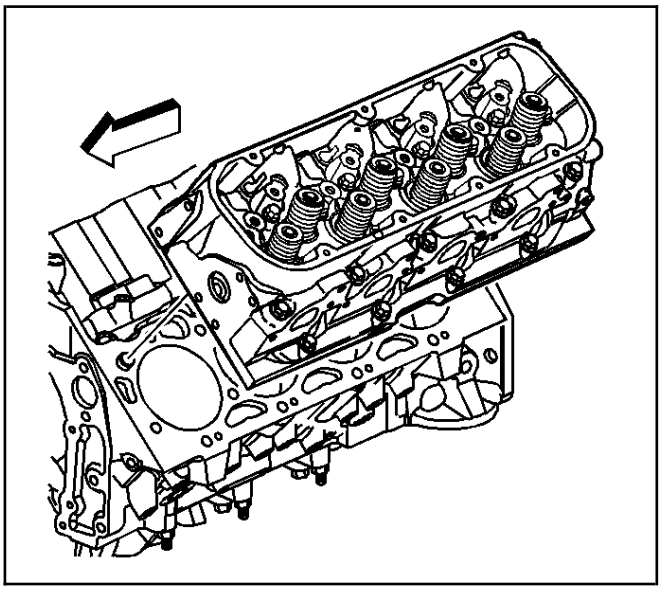
1. Place the cylinder head gasket in position over the cylinder head locating pins.



470974

Important: Guide the cylinder head carefully into place over the locating pins and the cylinder head gasket.

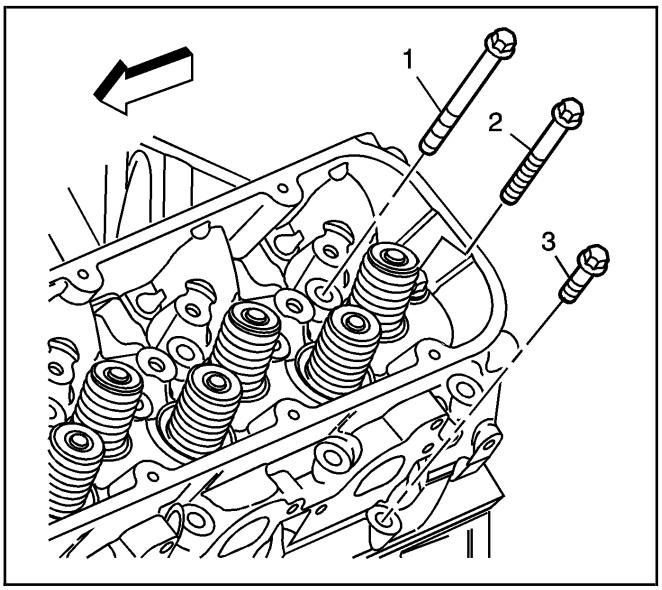
2. Install the cylinder head to the block.



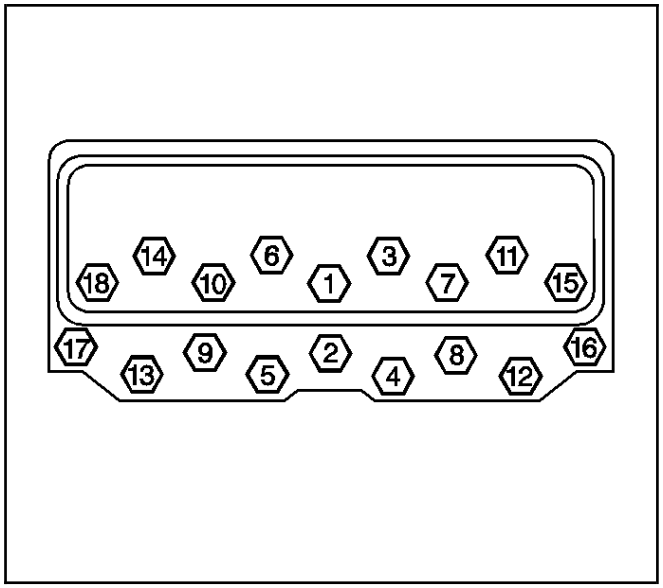
470916

Notice: SIO-ID = 311287 Do not reuse the cylinder head bolts. NEW cylinder head bolts must be used. The cylinder head bolts are torque-to-yield bolts and cannot be reused once the initial torque is applied. During the initial torque of the cylinder head bolt the cylinder head bolt is stretched to achieve proper clamp load. Proper clamp load will not be achieved if a used cylinder head bolt is torqued again. A stretched cylinder head bolt can also break when torqued. Failure to replace the used cylinder head bolts with NEW cylinder head bolts can lead to improper clamp loads and extensive engine damage.

Important: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.



470914



470987

3. If not pre-applied to the new cylinder head bolts, apply sealer GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the cylinder head bolts. Refer to Use of RTV and Anaerobic Sealer.

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

Notice: SIO-ID = 797597 Do not reuse a cylinder head gasket once the initial clamping loads are applied. The initial tightening sequence procedure of the cylinder head bolts compresses the cylinder head gasket. If any bolt must be loosened once the initial sequence is started the cylinder head gasket must be replaced. Failure to replace the cylinder head gasket can lead to cylinder head bolt breakage or cylinder head gasket failure. A broken cylinder head bolt or failed cylinder head gasket can lead to extensive engine damage.

Notice: SIO-ID = 797598 The cylinder head bolt tightening sequence must be followed. The final angle tightening sequence of the cylinder head bolts varies depending on the length of the cylinder head bolt. Failure to angle tighten the specific length bolt the proper number of degrees can lead to cylinder head bolt failure or improper clamping load of the cylinder head gasket. Cylinder head bolt or cylinder head gasket failure can lead to extensive engine damage.

Important: The long bolts are used in locations 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16 and 17. The medium length bolts are used in locations 15 and 18. The short bolts are used in locations 4, 5, 12 and 13.

4. Install the cylinder head bolts.

   Tighten

   4.1. Tighten the bolts a first pass in sequence to 30 N·m (22 lb ft).

   4.2. Retighten the bolts in a second pass in sequence to 30 N·m (22 lb ft), then an additional 120 degrees using the *J 36660-A*.

   4.3. Tighten the bolts, 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17, an additional 60 degrees, bolts, 15 and 18, an additional 45 degrees, and bolts, 4, 5, 12, 13, an additional 30 degrees a final pass in sequence using the *J 36660-A*.

Cylinder Head Installation - Right

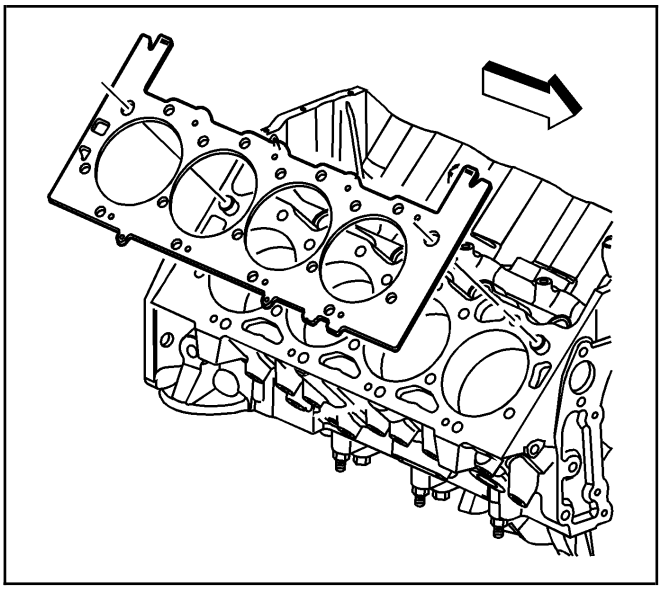
SIE-ID = 639166

Tools Required

J 36660-A Torque/Angle Meter

Notice: SIO-ID = 63461 Do not use a sealant or adhesive when installing this component. Use of a sealant or adhesive can cause improper sealing. A component that is not sealed properly can leak leading to extensive engine damage.

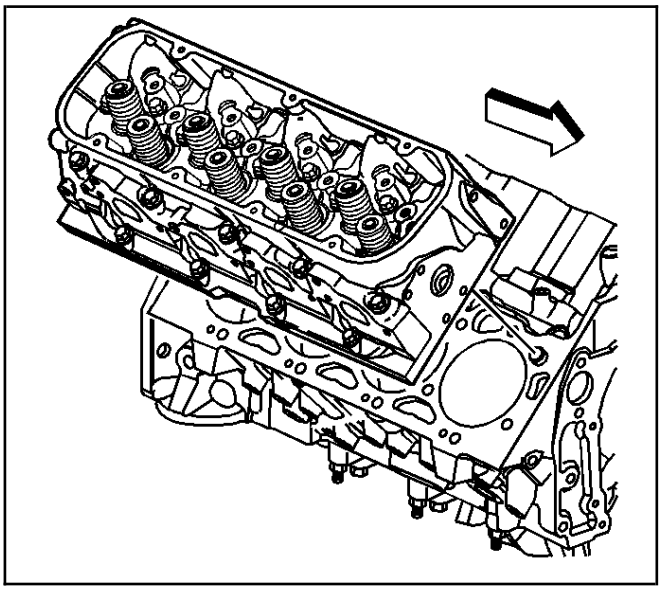
1. Place the cylinder head gasket in position over the cylinder head locating pins.



470992

Important: Guide the cylinder head carefully into place over the locating pins and the cylinder head gasket.

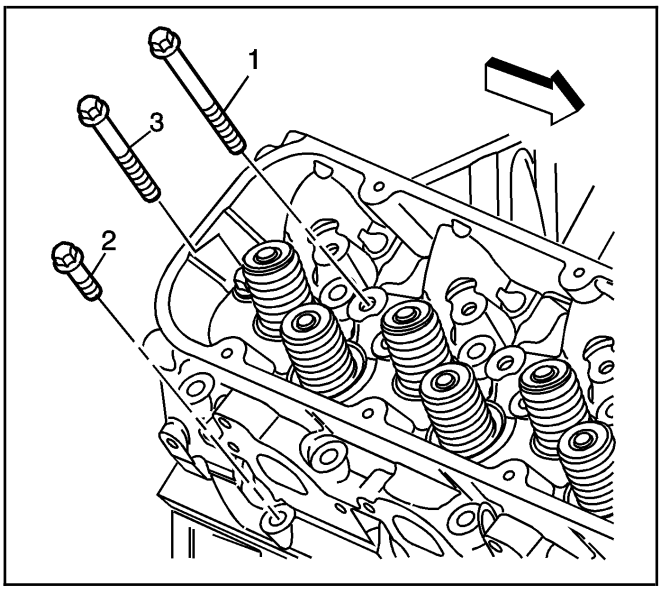
2. Install the cylinder head to the block.



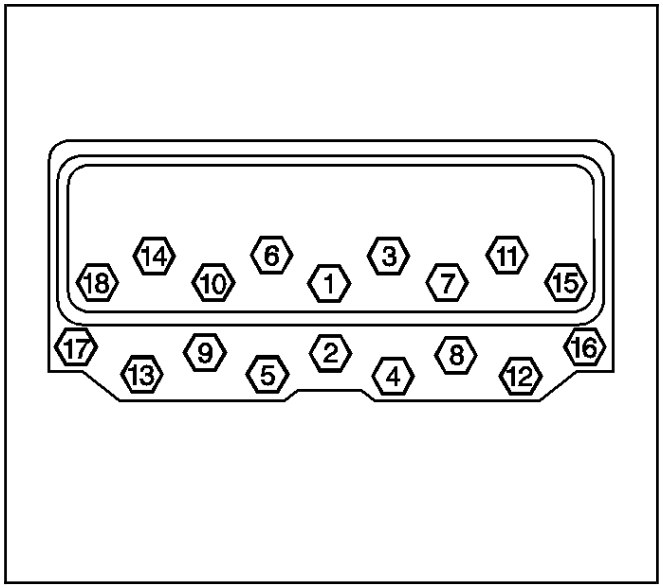
470991

Notice: SIO-ID = 311287 Do not reuse the cylinder head bolts. NEW cylinder head bolts must be used. The cylinder head bolts are torque-to-yield bolts and cannot be reused once the initial torque is applied. During the initial torque of the cylinder head bolt the cylinder head bolt is stretched to achieve proper clamp load. Proper clamp load will not be achieved if a used cylinder head bolt is torqued again. A stretched cylinder head bolt can also break when torqued. Failure to replace the used cylinder head bolts with NEW cylinder head bolts can lead to improper clamp loads and extensive engine damage.

Important: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.



470989



470987

3. If not pre-applied to the new cylinder head bolts (1–3), apply sealer GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the cylinder head bolts. Refer to Use of RTV and Anaerobic Sealer.

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

Notice: SIO-ID = 797597 Do not reuse a cylinder head gasket once the initial clamping loads are applied. The initial tightening sequence procedure of the cylinder head bolts compresses the cylinder head gasket. If any bolt must be loosened once the initial sequence is started the cylinder head gasket must be replaced. Failure to replace the cylinder head gasket can lead to cylinder head bolt breakage or cylinder head gasket failure. A broken cylinder head bolt or failed cylinder head gasket can lead to extensive engine damage.

Notice: SIO-ID = 797598 The cylinder head bolt tightening sequence must be followed. The final angle tightening sequence of the cylinder head bolts varies depending on the length of the cylinder head bolt. Failure to angle tighten the specific length bolt the proper number of degrees can lead to cylinder head bolt failure or improper clamping load of the cylinder head gasket. Cylinder head bolt or cylinder head gasket failure can lead to extensive engine damage.

Important: The long bolts are used in locations 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16 and 17. The medium length bolts are used in locations 15 and 18. The short bolts are used in locations 4, 5, 12 and 13.

4. Install the cylinder head bolts.

   Tighten

   4.1. Tighten the bolts a first pass in sequence to 30 N·m (22 lb ft).

   4.2. Re-tighten the bolts a second pass in sequence to 30 N·m (22 lb ft), then an additional 120 degrees using the *J 36660-A*.

   4.3. Tighten the bolts, 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17, an additional 60 degrees, bolts, 15 and 18, an additional 45 degrees, and bolts, 4, 5, 12, 13, an additional 30 degrees a final pass in sequence using the *J 36660-A*.

Valve Rocker Arm and Push Rod Installation

SIE-ID = 482818

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

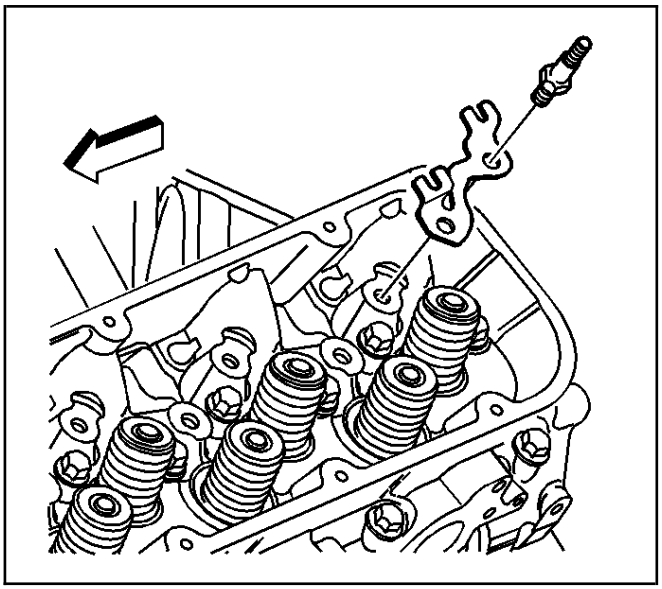
1. Apply sealer GM P/N United States 12346004, GM P/N Canada 10953480, or equivalent to the valve rocker arm stud-to-cylinder head threads.

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

2. Install the push rod guides and valve rocker arm studs onto the cylinder head.

   Tighten

   Tighten the valve rocker arm studs to 50 N·m (37 lb ft).

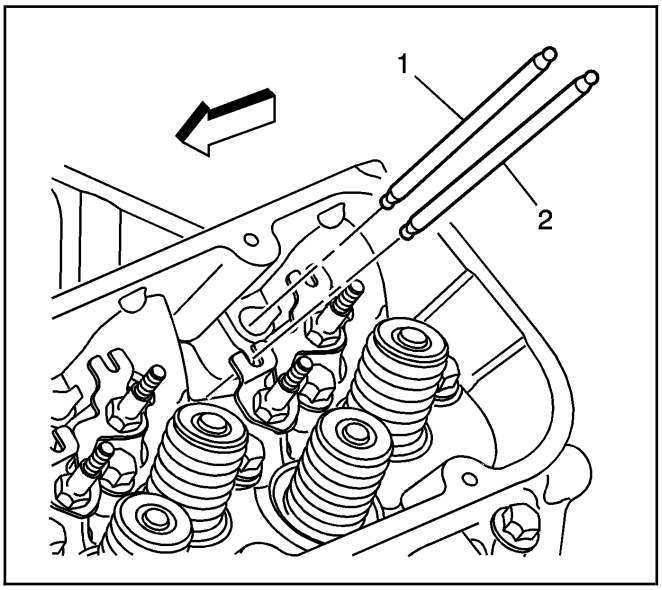


470906

Important: The 8.1 L engine uses different length intake and exhaust valve push rods.

The exhaust valve push rods (2) are longer than the intake valve push rods (1).

3. Install the valve push rods.

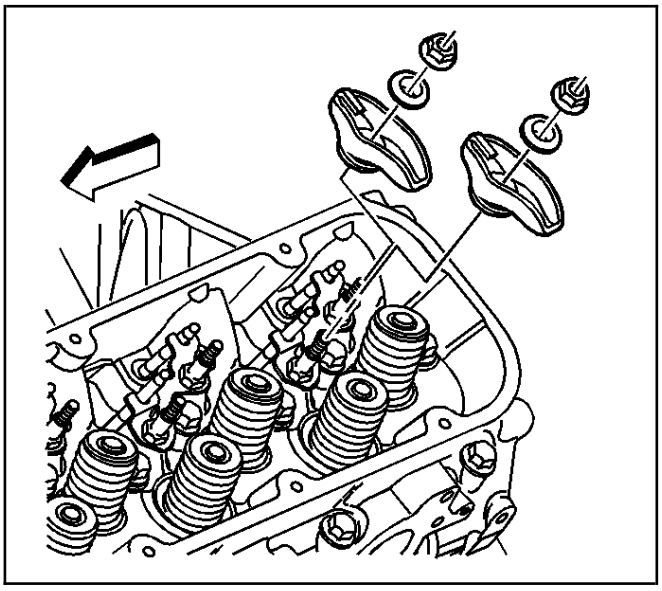


470903

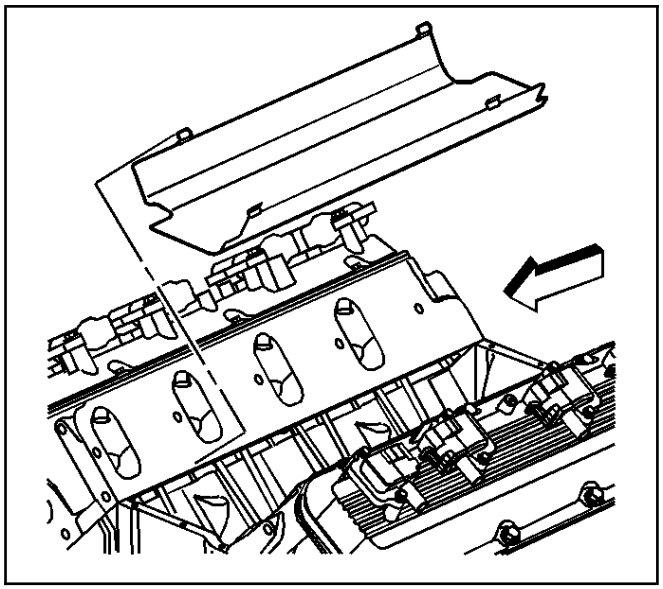
4. Coat the valve rocker arm and valve rocker arm ball bearing surfaces with prelube GM P/N United States 1052367, GM P/N Canada 992869, or equivalent.
5. Install the valve rocker arms, the valve rocker arm balls and the valve rocker arm nuts.

   Tighten

   Tighten the valve rocker arm nuts slowly, to 25 N·m (18 lb ft), while guiding the tips of the rocker arms over the tips of the valves.



470899

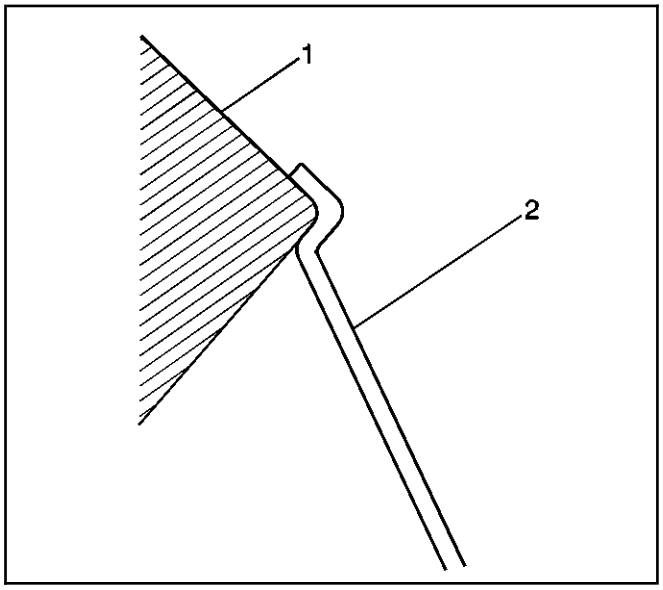


470786

Intake Manifold Installation

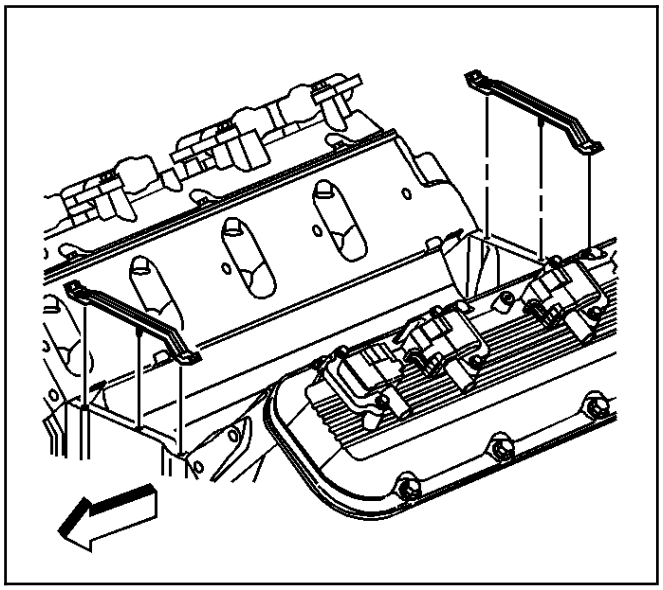
SIE-ID = 482874

1. Install the splash shield.



413867

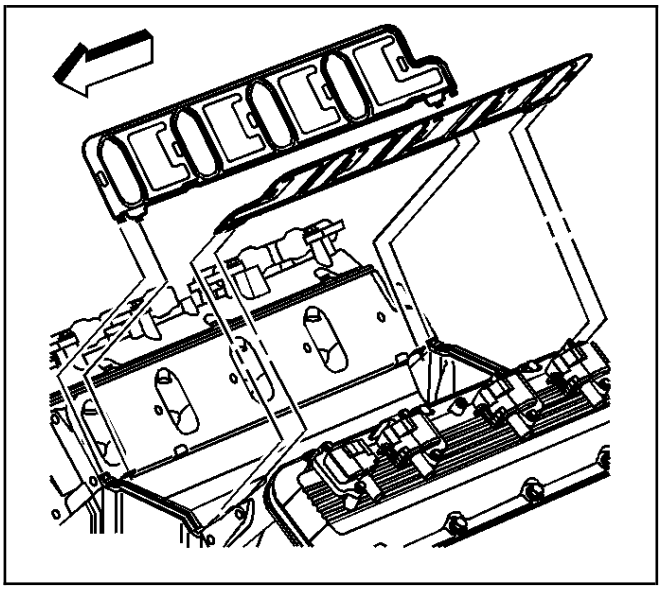
2. Ensure the splash shield (2) snap fits between the cylinder heads (1).



470783

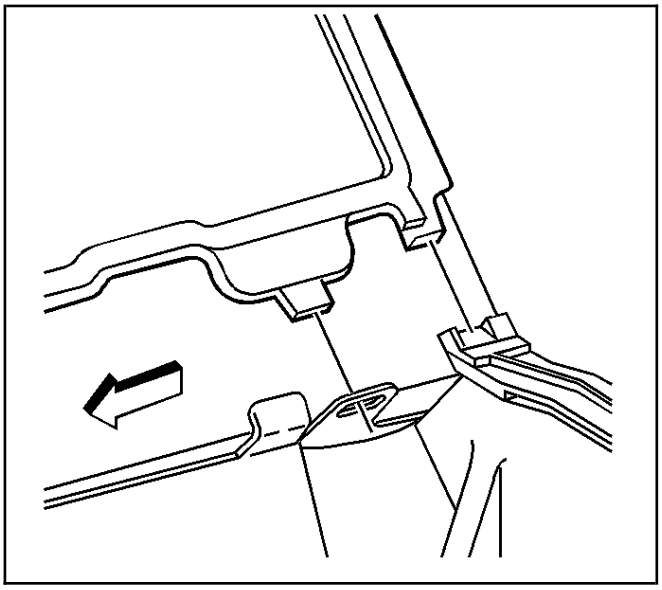
3. Install the new intake manifold end seals.

4. Install the new intake manifold side gaskets onto the cylinder heads.



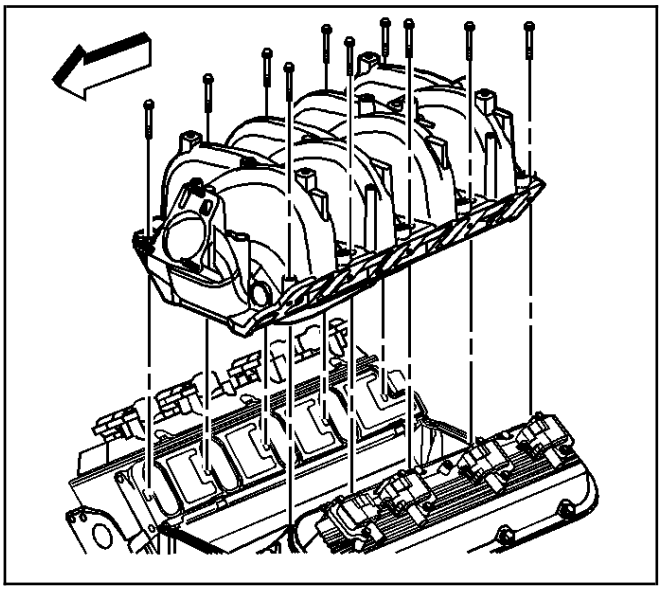
470779

5. Ensure the intake manifold gasket tabs align with the hole in the head gasket.
6. Ensure the intake manifold gasket tabs align with the slot in the intake manifold end seals.

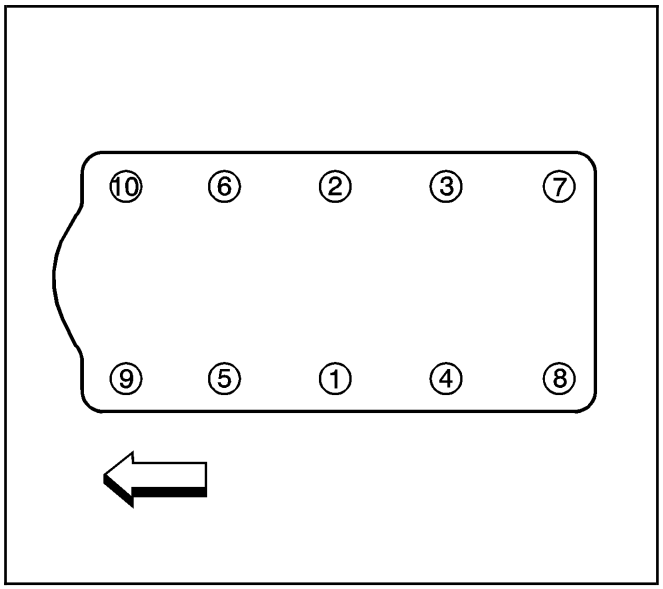


470778

7. Install the intake manifold onto the engine block.



470775



640010

Notice: SIO-ID = 728990 Ensure the intake manifold does not shift as the intake manifold bolts are tightened in the proper sequence. Failure to follow the entire intake manifold bolt tightening sequence exactly, may result in an oil leak and serious engine damage.

Important: The entire intake manifold tightening sequence must be promptly completed due to the anaerobic thread adhesive. The final pass of the tightening sequence must be completed before the adhesive starts to cure, or false torque readings and ineffective thread locking may result.

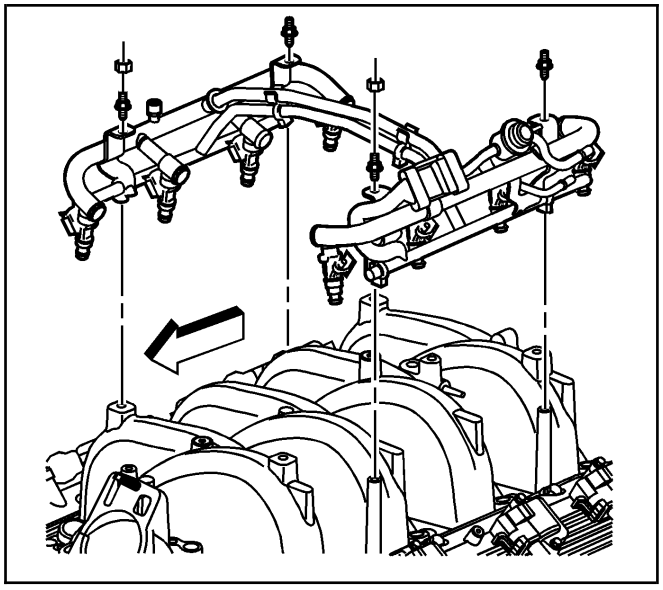
8. Apply thread adhesive GM P/N United States 12345382, GM P/N Canada 10953489, or equivalent to a minimum of eight threads of the intake manifold bolts.
9. Install the intake manifold bolts.

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

10. Tighten the intake manifold bolts in sequence, using four passes.

    Tighten

    - Tighten the intake manifold bolts in sequence to 5 N·m (44 lb in) on the first pass.
    - Tighten the intake manifold bolts in sequence to 5 N·m (44 lb in) on the second pass. Inspect the intake manifold joints for signs of intake manifold shifting. Correct as required.
    - Tighten the intake manifold bolts in sequence to 10 N·m (88 lb in) on the third pass.
    - Tighten the intake manifold bolts in sequence to 12 N·m (106 lb in) on the final pass.



470774

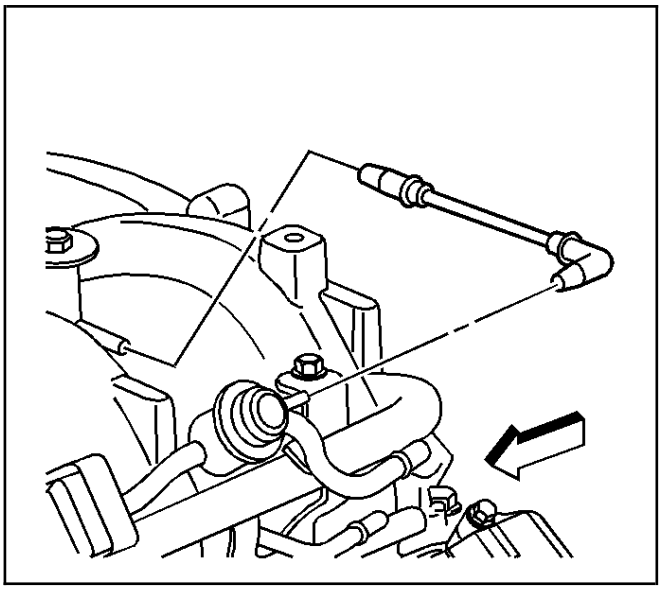
Important: Lubricate the injector O-ring seals with clean engine oil and install onto the spray tip end of each injector.

11. Install the fuel injection fuel rail.
12. Install the fuel injection fuel rail studs and/or bolts.

    Tighten

    Tighten the fuel injection fuel rail studs and/or bolts to 12 N·m (106 lb in).

13. Install the fuel pressure regulator vacuum hose.

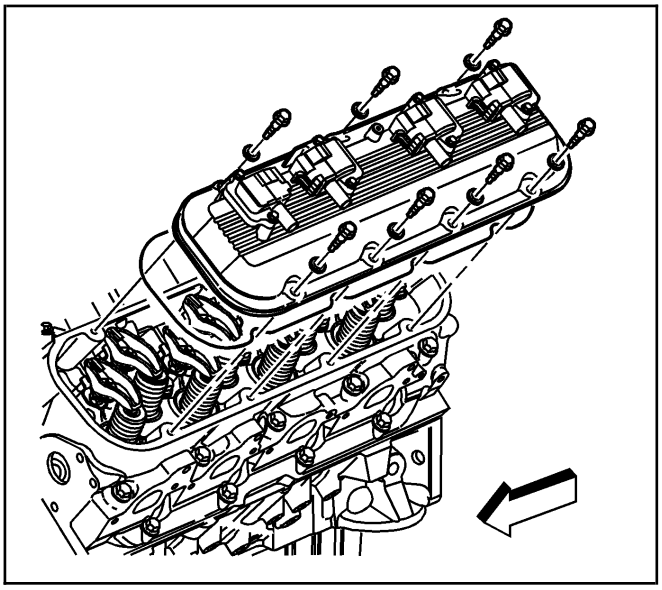


470770

Valve Rocker Arm Cover Installation - Left

SIE-ID = 639169

1. Install a new valve rocker arm cover gasket if the gasket was removed from the valve rocker arm cover.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm cover bolts.



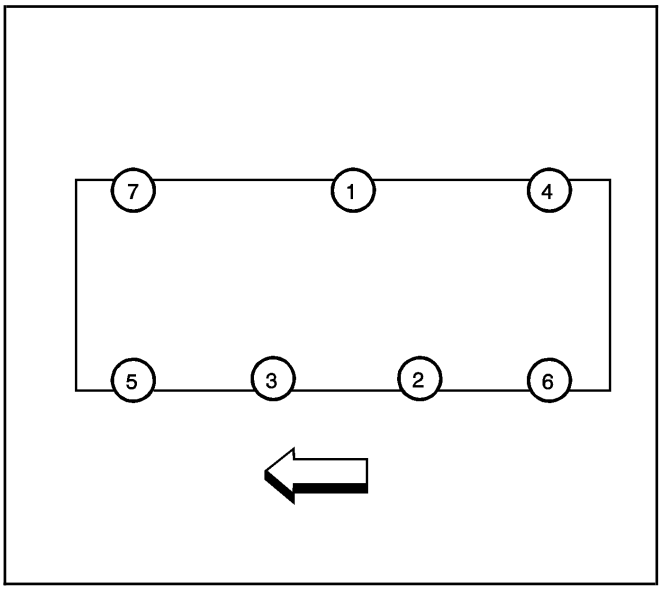
470890

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

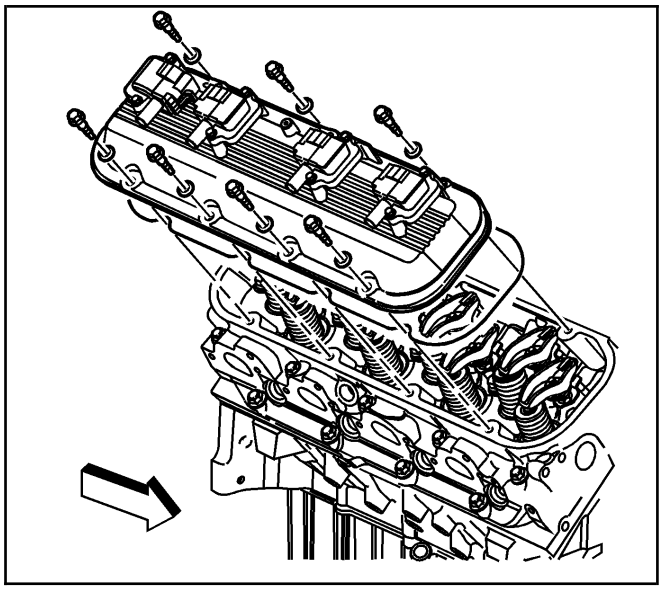
4. Tighten the valve rocker arm cover bolts in sequence using two passes.

   Tighten

   - Tighten the valve rocker arm cover bolts to 6 N·m (54 lb in) for the first pass.
   - Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in) for the second pass.



677858

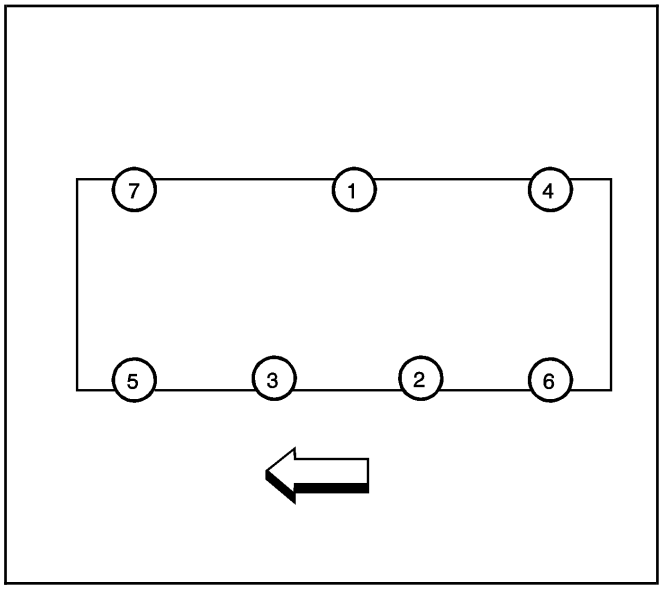


470897

Valve Rocker Arm Cover Installation - Right

SIE-ID = 639170

1. Install a new valve rocker arm cover gasket if the gasket was removed from the valve rocker arm cover.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm cover bolts.



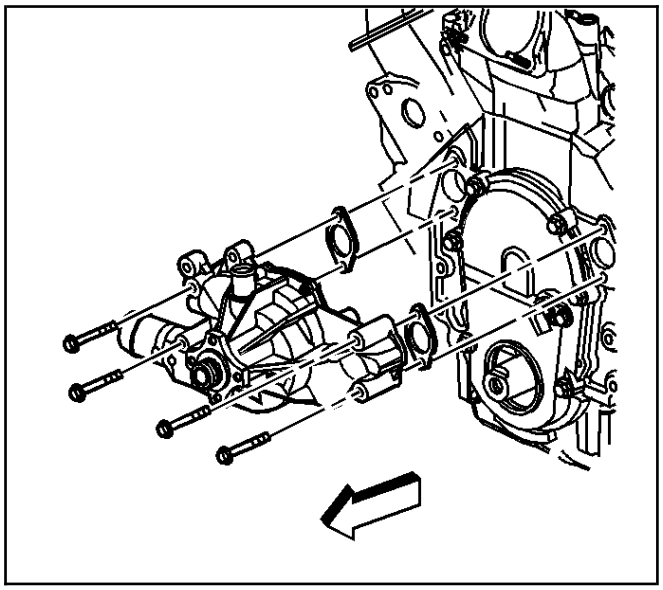
677858

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

4. Tighten the valve rocker arm cover bolts in sequence using two passes.

   Tighten

   - Tighten the valve rocker arm cover bolts to 6 N·m (54 lb in) for the first pass.
   - Tighten the valve rocker arm cover bolts to 12 N·m (106 lb in) for the second pass.



470790

Water Pump Installation (C/K)

SIE-ID = 482893

1. Place the water pump gaskets and the water pump into position.

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

2. Install the water pump bolts.

   Tighten

   - Tighten the water pump bolts to 25 N·m (18 lb ft) for the first pass.
   - Tighten the water pump bolts to 50 N·m (37 lb ft) for the final pass.

Water Pump Installation (G/C3500HD/Medium Duty)

SIE-ID = 482894

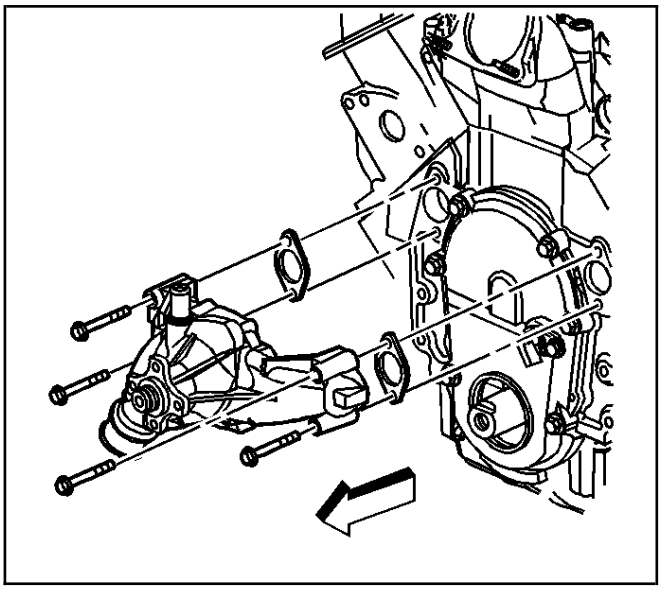
1. Place the water pump gaskets and the water pump into position.

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

2. Install the water pump bolts.

   Tighten

   - Tighten the water pump bolts to 25 N·m (18 lb ft) for the first pass.
   - Tighten the water pump bolts to 50 N·m (37 lb ft) for the final pass.



470792

Water Crossover Installation (C/K)

SIE-ID = 482895

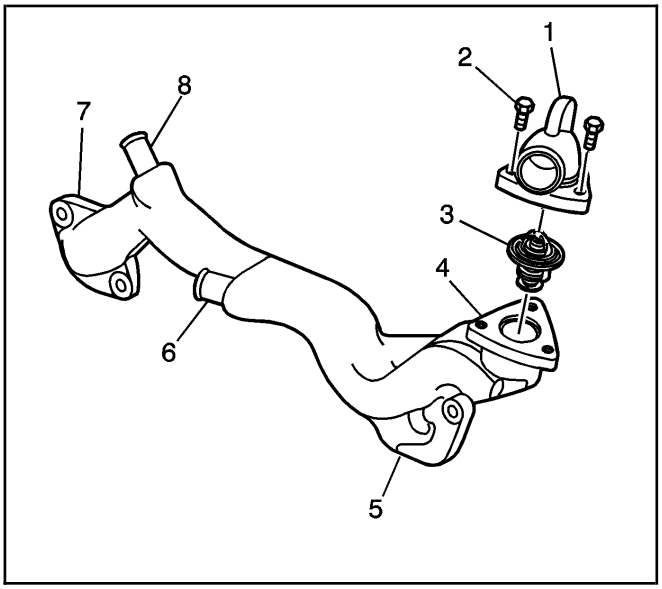
1. Install the thermostat (3) with the seal into the coolant crossover (7).
2. Install the water outlet (1).

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

3. Install the water outlet bolts (2).

   Tighten

   Tighten the water outlet bolts to 30 N·m (22 lb ft).

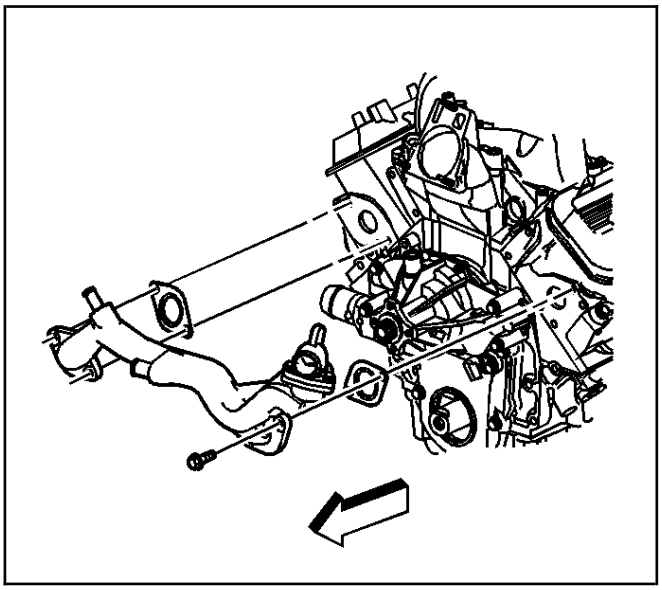


635643

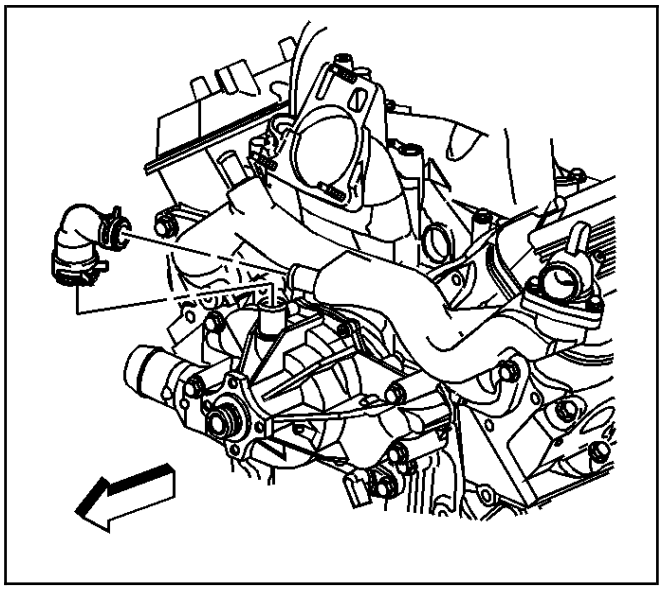
4. Place the coolant crossover gaskets and the coolant crossover in position.
5. Install the coolant crossover bolts.

   Tighten

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



470698

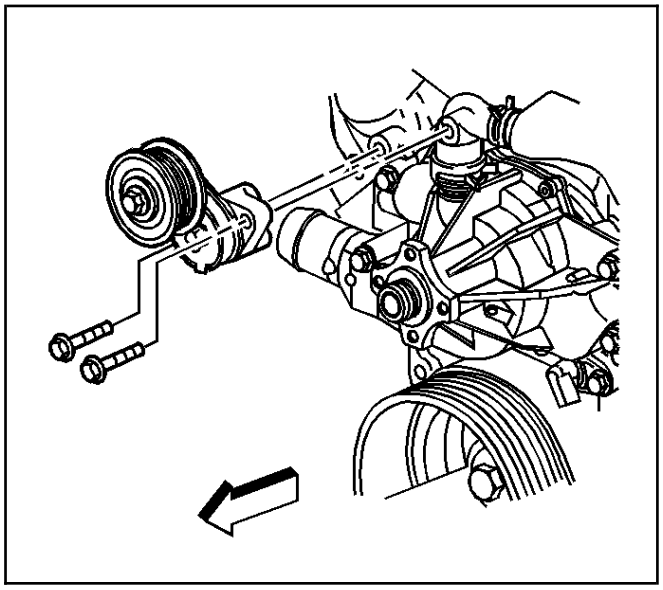


470692

6. Install the thermostat bypass hose clamps onto the thermostat bypass hose.
7. Install the thermostat bypass hose.

Important: Properly position the bypass hose clamps to avoid water pump pulley interference.

8. Position the thermostat bypass hose clamps.

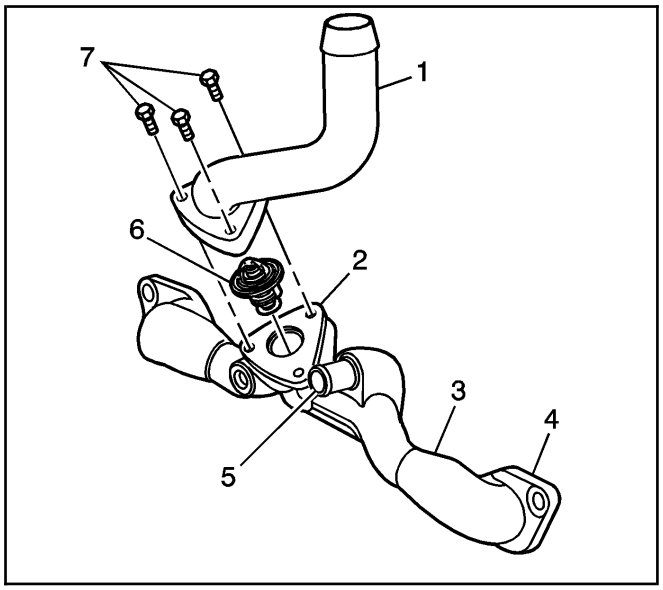


470789

9. Install the drive belt tensioner.
10. Install the drive belt tensioner bolts.

    Tighten

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



635646

Water Crossover Installation (Medium Duty)

SIE-ID = 482897

1. Install the thermostat (6) with the seal into the coolant crossover.
2. Install the water outlet (1).

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

3. Install the water outlet bolts (7).

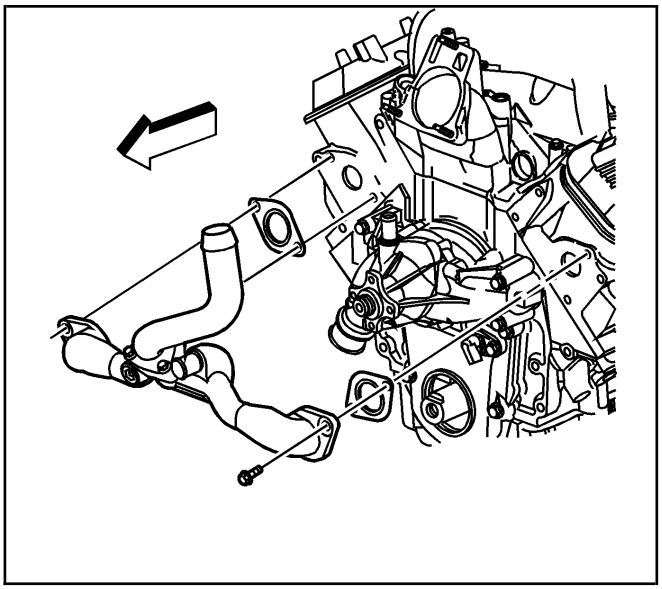
    Tighten

    Tighten the water outlet bolts to 30 N·m (22 lb ft).

4. Place the coolant crossover gaskets and the coolant crossover in position.
5. Install the coolant crossover bolts.

   Tighten

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

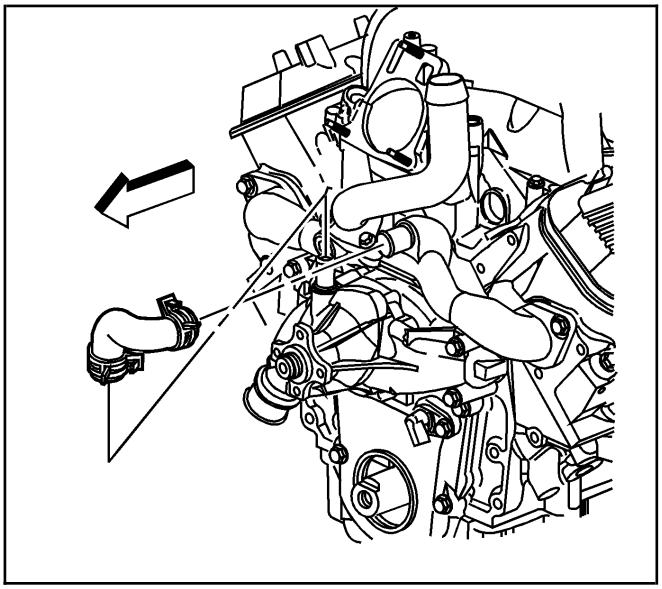


470699

6. Install the thermostat bypass hose clamps onto the thermostat bypass hose.
7. Install the thermostat bypass hose.

Important: Properly position the bypass hose clamps to avoid water pump pulley interference.

8. Position the thermostat bypass hose clamps.



470694

Water Crossover Installation (G/C3500HD)

SIE-ID = 679939

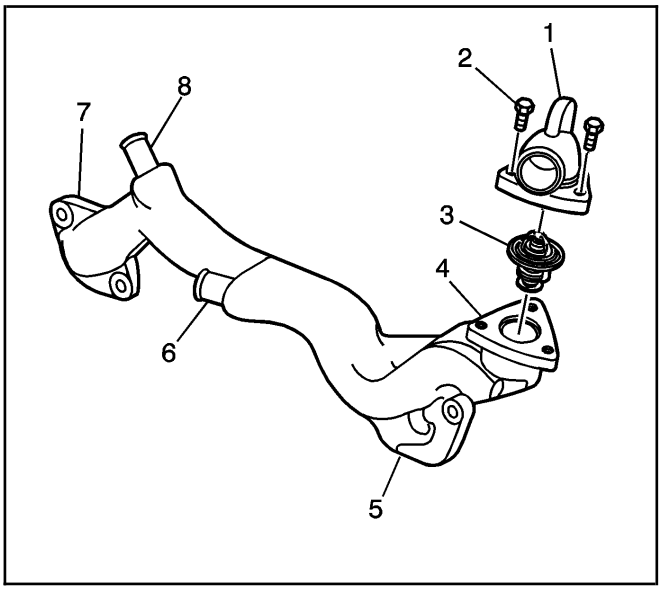
1. Install the thermostat (3) with the seal into the coolant crossover (7).
2. Install the water outlet (1).

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

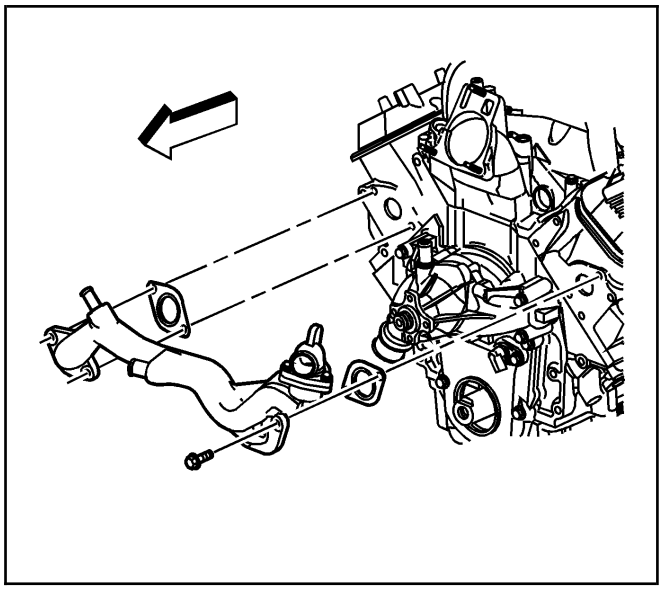
3. Install the water outlet bolts (2).

   Tighten

   Tighten the water outlet bolts to 30 N·m (22 lb ft).



635643

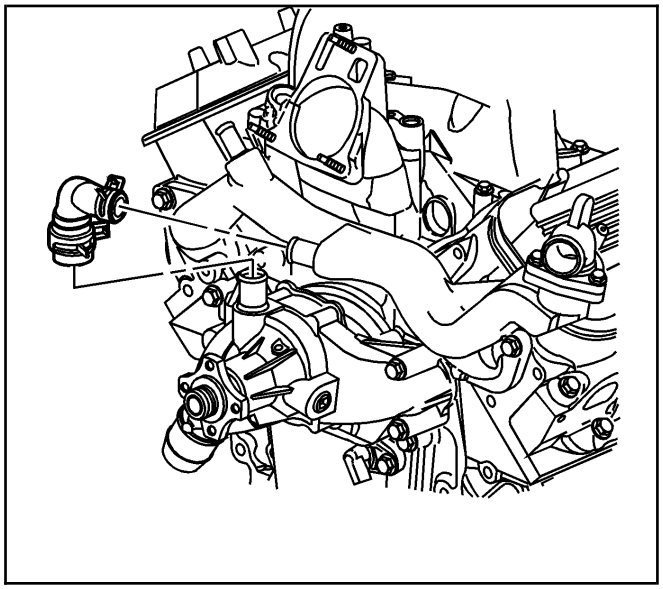


677782

4. Place the coolant crossover gaskets and the coolant crossover in position.
5. Install the coolant crossover bolts.

   Tighten

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

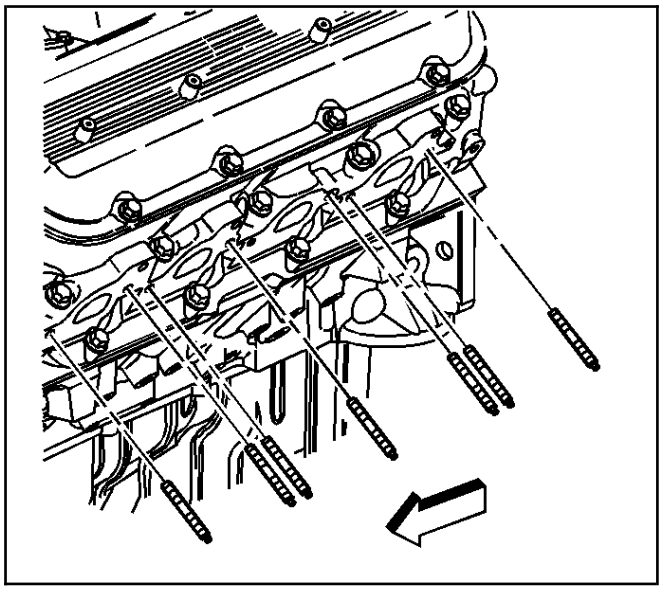


677790

6. Install the thermostat bypass hose clamps onto the thermostat bypass hose.
7. Install the thermostat bypass hose.

Important: Properly position the bypass hose clamps to avoid water pump pulley interference.

8. Position the thermostat bypass hose clamps.



470683

Exhaust Manifold Installation - Left (C/K/G/C3500HD)

SIE-ID = 761242

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

1. Install the exhaust manifold studs into the cylinder head, if necessary.

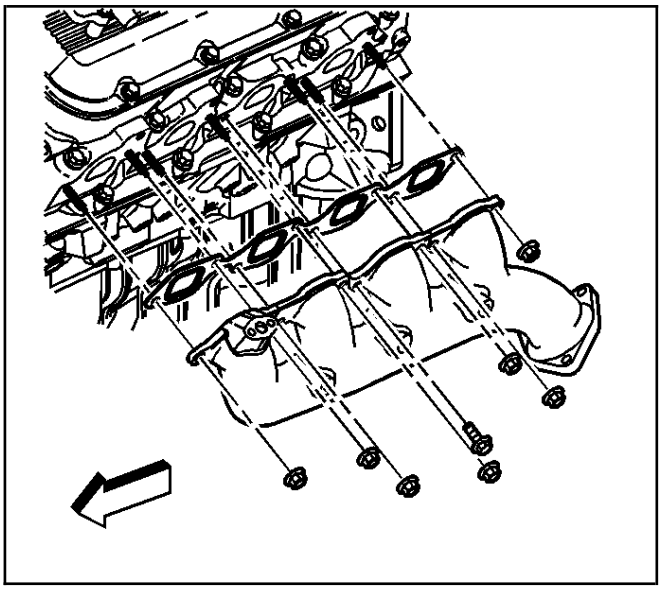
   Tighten

   Tighten the exhaust manifold studs to 20 N·m (15 lb ft).

2. Install the NEW left exhaust manifold gasket.
3. Install the left exhaust manifold.
4. Install the left exhaust manifold nuts and center bolt.

   Tighten

   - Tighten the left exhaust manifold center bolt to 35 N·m (26 lb ft).
   - Tighten the left exhaust manifold nuts to 16 N·m (12 lb ft).

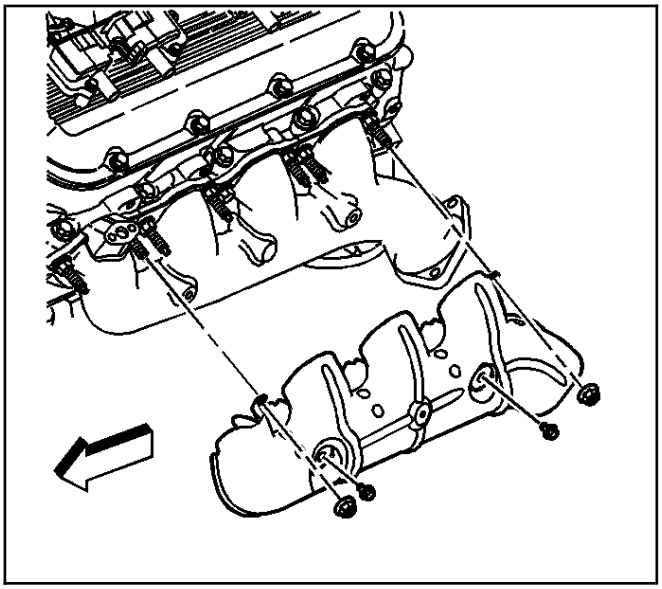


470679

5. Install the left exhaust manifold heat shield.
6. Install the left exhaust manifold heat shield bolts and nuts.

   Tighten

   Tighten the left exhaust manifold heat shield bolts and nuts to 25 N·m (18 lb ft).

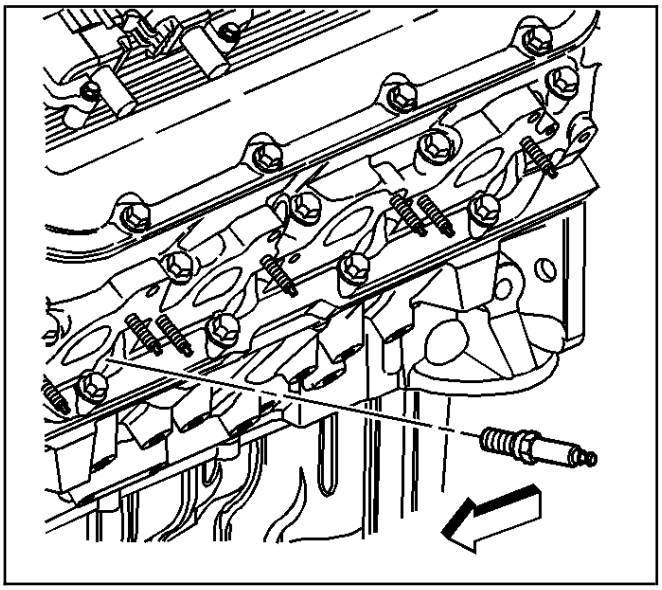


470676

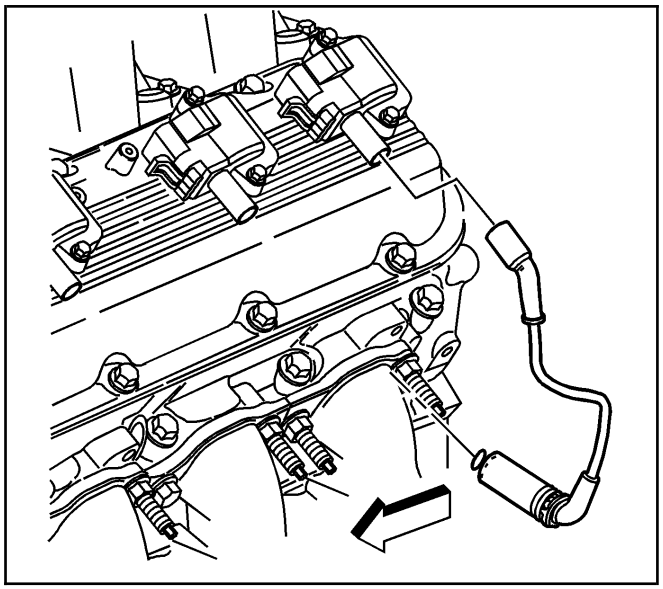
7. Install the left spark plugs.

   Tighten

   Tighten the left spark plugs to 20 N·m (15 lb ft).



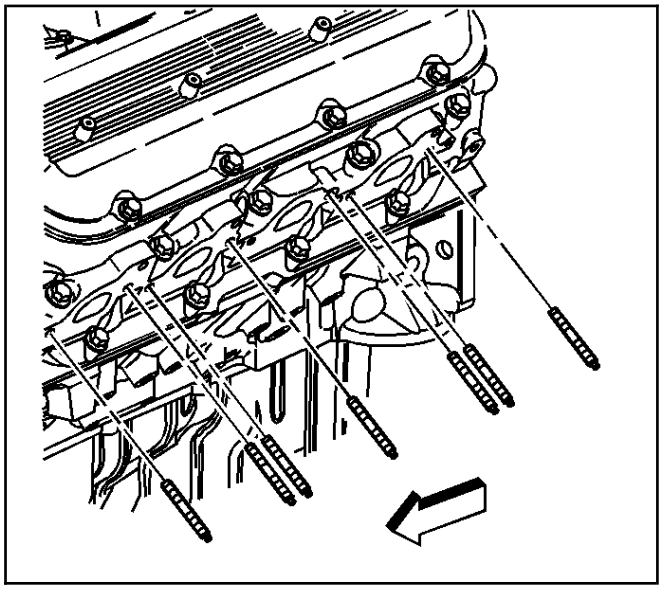
470690



470666

Important: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire on to the spark plug by using the metal heat shield.

8. Install the left spark plug wires to the spark plugs and ignition coils.



470683

Exhaust Manifold Installation - Left (Medium Duty)

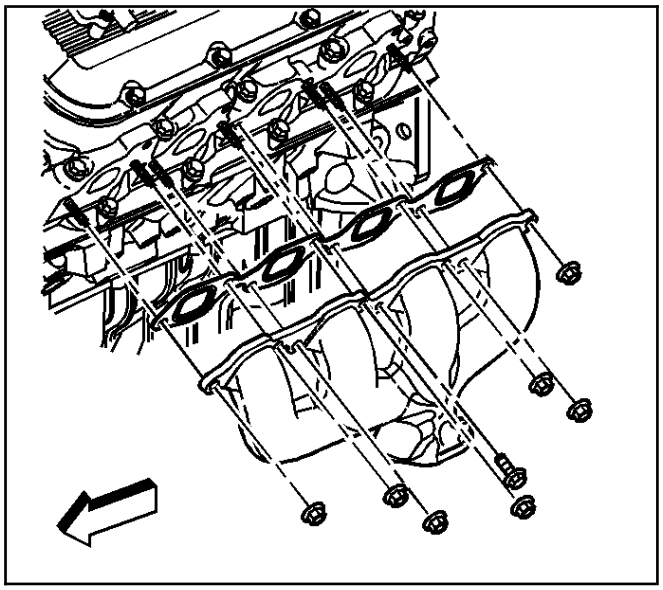
SIE-ID = 639172

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

1. Install the exhaust manifold studs into the cylinder head, if necessary.

   Tighten

   Tighten the exhaust manifold studs to 20 N·m (15 lb ft).



470686

2. Install the NEW left exhaust manifold gasket.
3. Install the left exhaust manifold.
4. Install the left exhaust manifold nuts and center bolt.

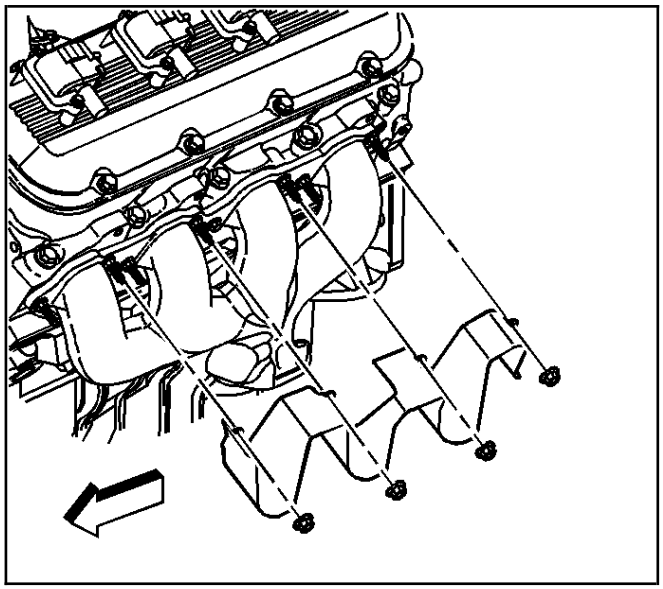
   Tighten

   - Tighten the left exhaust manifold center bolt to 35 N·m (26 lb ft).
   - Tighten the left exhaust manifold nuts to 16 N·m (12 lb ft).

5. Install the left exhaust manifold heat shield.
6. Install the left exhaust manifold heat shield nuts.

   Tighten

   Tighten the left exhaust manifold heat shield nuts to 25 N·m (18 lb ft).

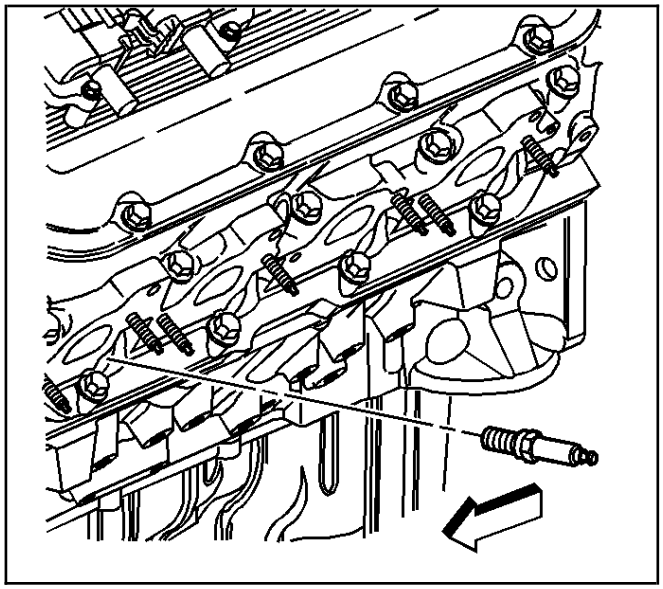


470678

7. Install the left spark plugs.

   Tighten

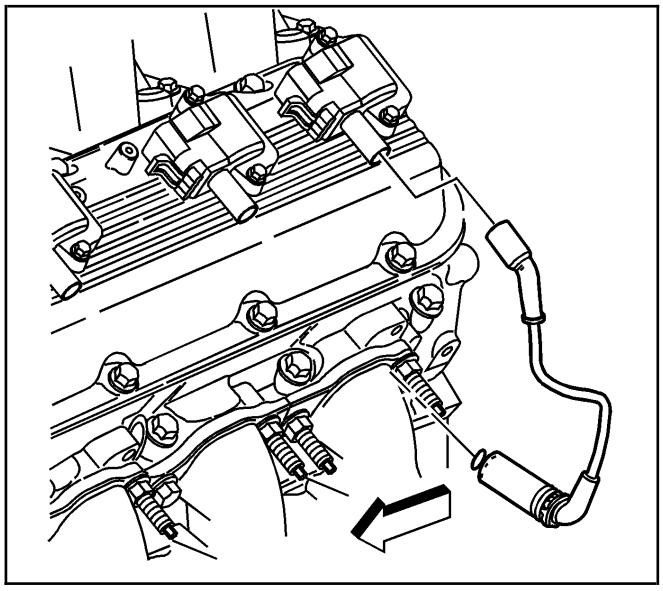
   Tighten the left spark plugs to 20 N·m (15 lb ft).



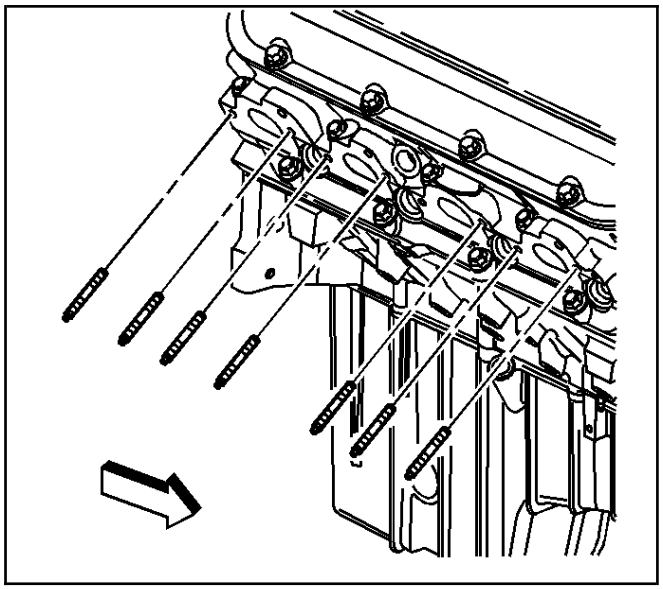
470690

Important: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire onto the spark plug by using the metal heat shield.

8. Install the left spark plug wires to the spark plugs and ignition coils.



470666



470723

Exhaust Manifold Installation - Right (C/K/C3500HD)

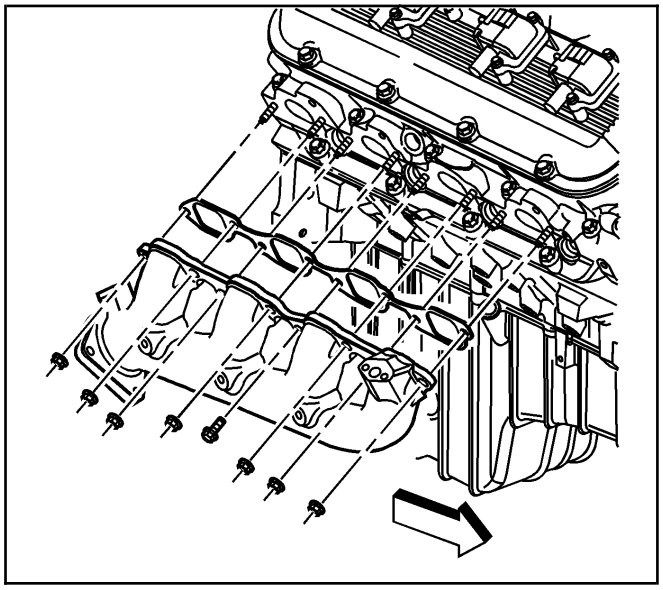
SIE-ID = 761243

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

1. Install the exhaust manifold studs into the cylinder head, if necessary.

   Tighten

   Tighten the exhaust manifold studs to 20 N·m (15 lb ft).

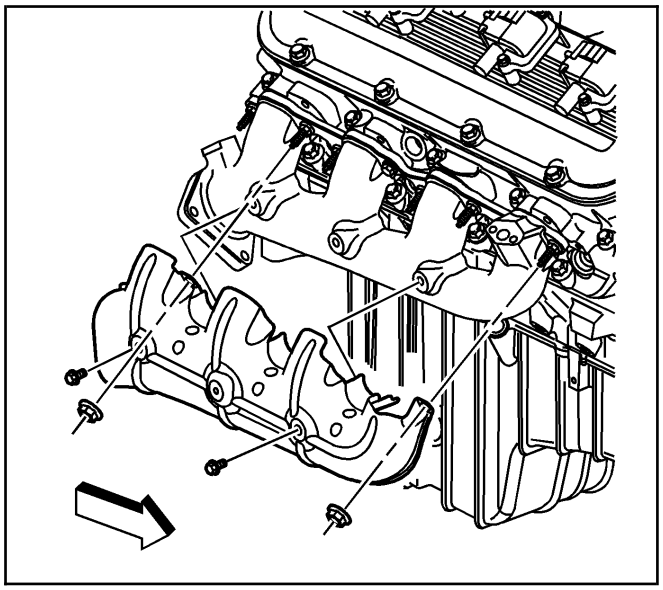


470719

2. Install the NEW right exhaust manifold gasket.
3. Install the right exhaust manifold.
4. Install the right exhaust manifold nuts and center bolt.

   Tighten

   - Tighten the right exhaust manifold center bolt to 35 N·m (26 lb ft).
   - Tighten the right exhaust manifold nuts to 16 N·m (12 lb ft).



470706

5. Install the right exhaust manifold heat shield.
6. Install the right exhaust manifold heat shield bolts and nuts.

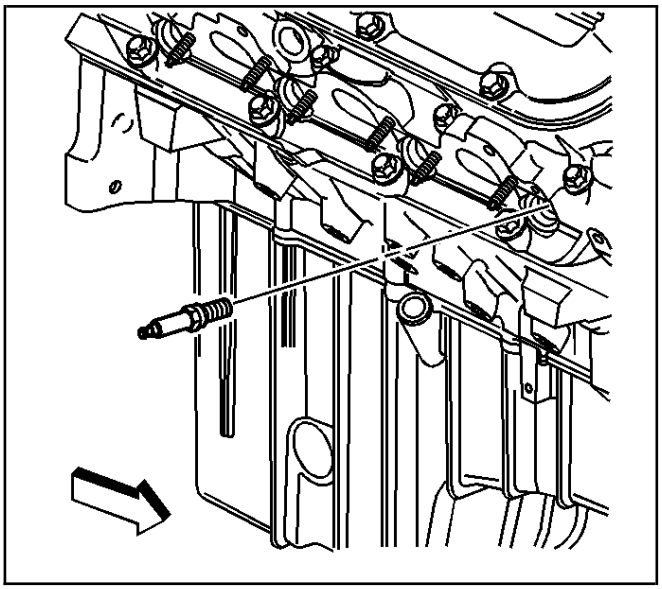
   Tighten

   Tighten the right exhaust manifold heat shield bolts and nuts to 25 N·m (18 lb ft).

7. Install the right spark plugs.

   Tighten

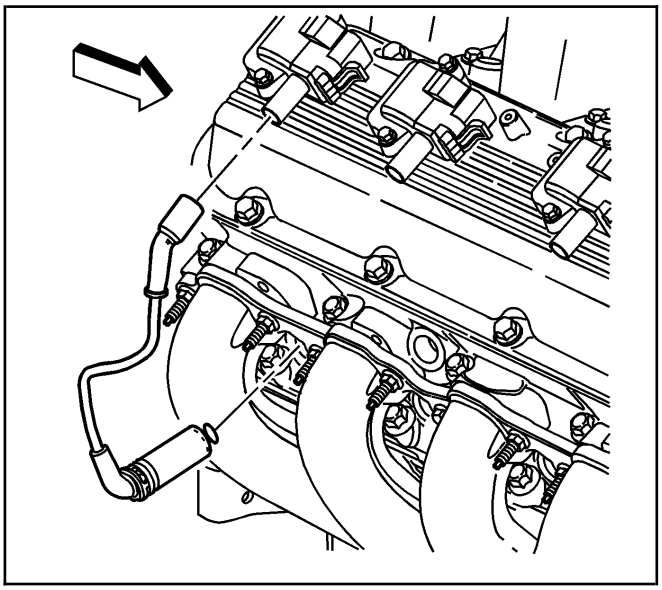
   Tighten the right spark plugs to 20 N·m (15 lb ft).



470727

Important: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire on to the spark plug by using the metal heat shield.

8. Install the right spark plug wires to the spark plugs and ignition coils.



470704

9. Install the exhaust gas recirculation (EGR) pipe and NEW EGR pipe gaskets.
10. Install the EGR pipe nuts to the right exhaust manifold.

    Tighten

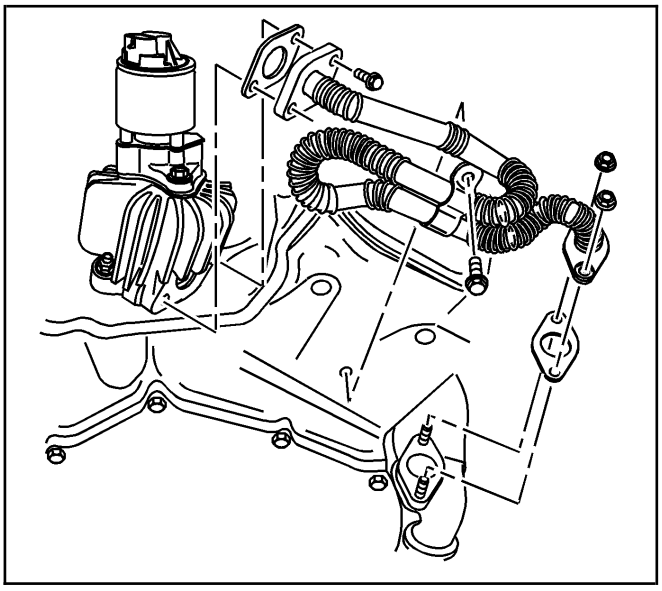
    Tighten the EGR pipe nuts to 30 N·m (22 lb ft).
11. Install the EGR pipe bolts to the EGR adapter.

    Tighten

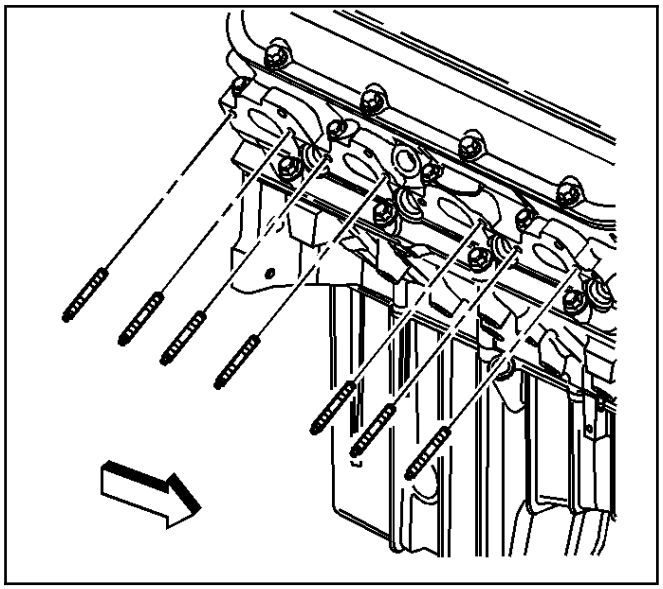
    Tighten the EGR pipe bolts to 30 N·m (22 lb ft).
12. Install the EGR pipe bracket bolt.

    Tighten

    Tighten the EGR pipe bracket bolt to 50 N·m (37 lb ft).



635635



470723

Exhaust Manifold Installation - Right (G)

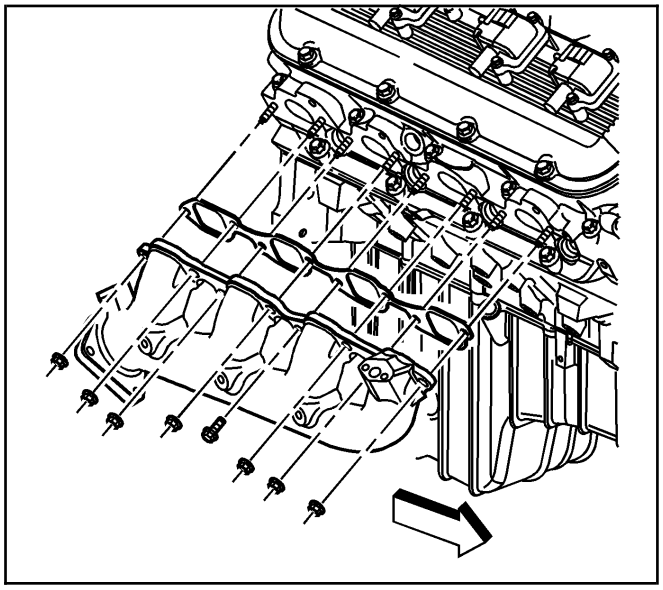
SIE-ID = 761244

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

1. Install the exhaust manifold studs into the cylinder head, if necessary.

   Tighten

   Tighten the exhaust manifold studs to 20 N·m (15 lb ft).

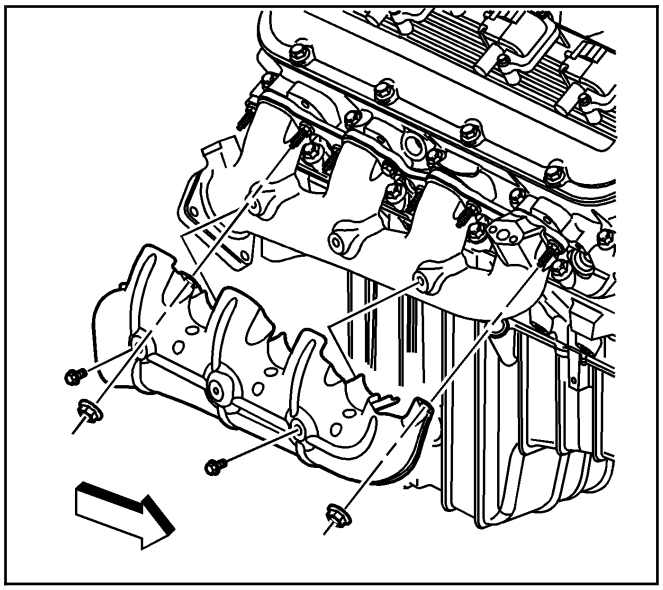


470719

2. Install the NEW right exhaust manifold gasket.
3. Install the right exhaust manifold.
4. Install the right exhaust manifold nuts and center bolt.

   Tighten

   - Tighten the right exhaust manifold center bolt to 35 N·m (26 lb ft).
   - Tighten the right exhaust manifold nuts to 16 N·m (12 lb ft).



470706

5. Install the right exhaust manifold heat shield.
6. Install the right exhaust manifold heat shield bolts and nuts.

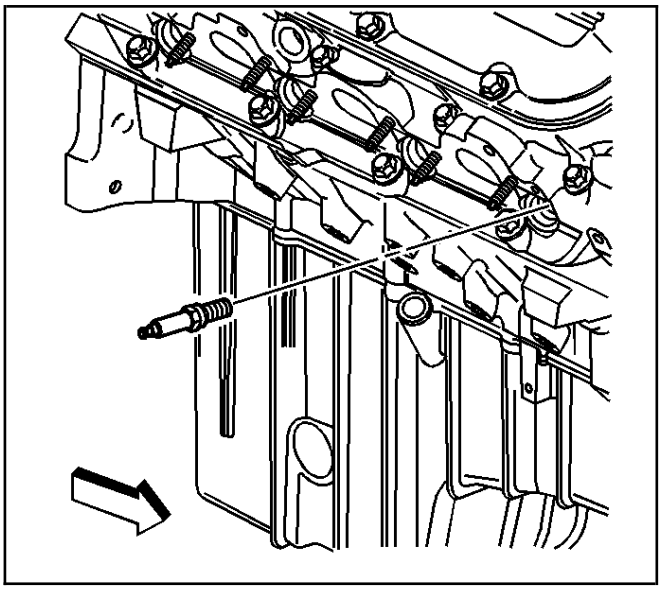
   Tighten

   Tighten the right exhaust manifold heat shield bolts and nuts to 25 N·m (18 lb ft).

7. Install the right spark plugs.

   Tighten

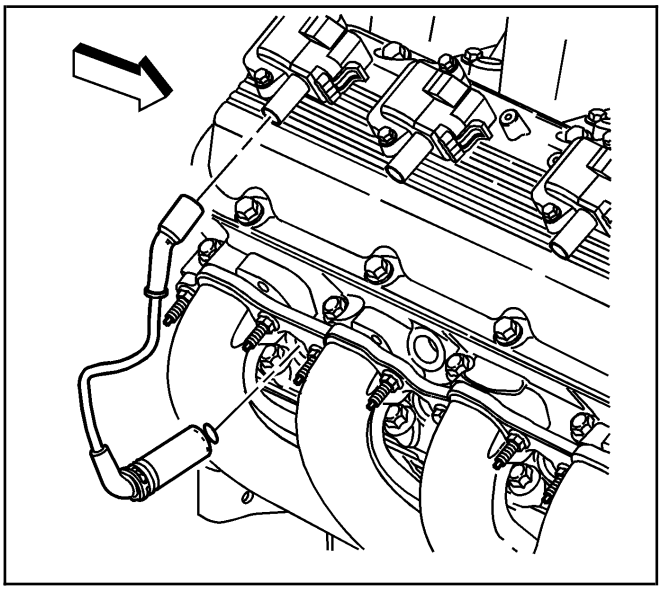
   Tighten the right spark plugs to 20 N·m (15 lb ft).



470727

Important: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire on to the spark plug by using the metal heat shield.

8. Install the right spark plug wires to the spark plugs and ignition coils.



470704

9. Install the exhaust gas recirculation (EGR) pipe and NEW EGR pipe gaskets.
10. Install the EGR pipe nuts to the right exhaust manifold.

    Tighten

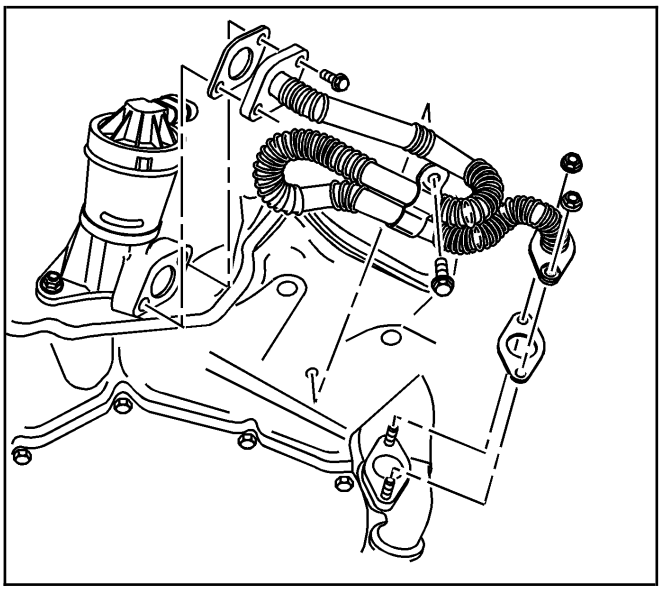
    Tighten the EGR pipe nuts to 30 N·m (22 lb ft).
11. Install the EGR pipe bolts to the EGR valve.

    Tighten

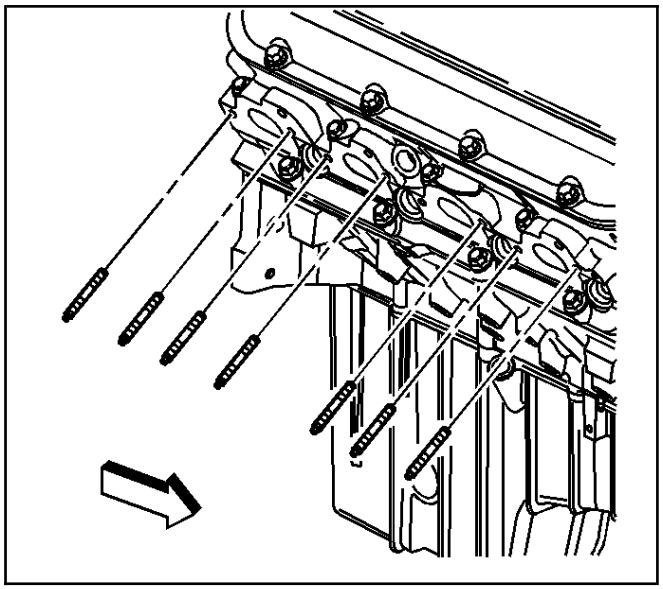
    Tighten the EGR pipe bolts to 25 N·m (19 lb ft).
12. Install the EGR pipe bracket bolt.

    Tighten

    Tighten the EGR pipe bracket bolt to 50 N·m (37 lb ft).



654377



470723

Exhaust Manifold Installation - Right (Medium Duty)

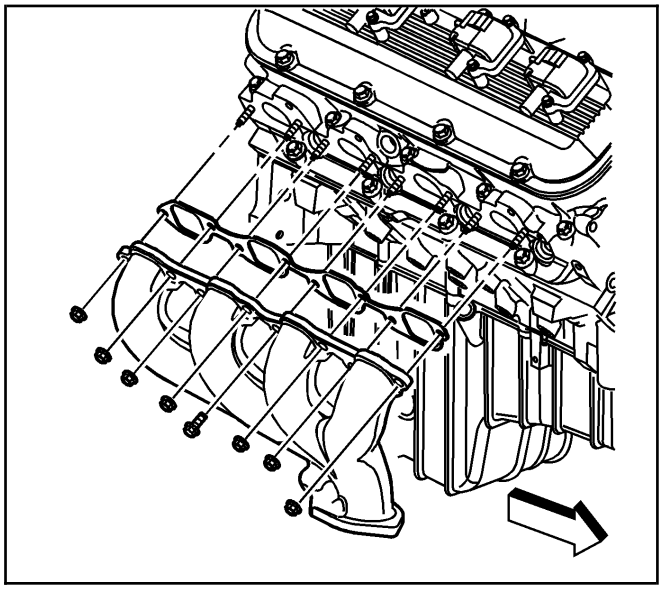
SIE-ID = 639175

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

1. Install the exhaust manifold studs into the cylinder head, if necessary.

   Tighten

   Tighten the exhaust manifold studs to 20 N·m (15 lb ft).

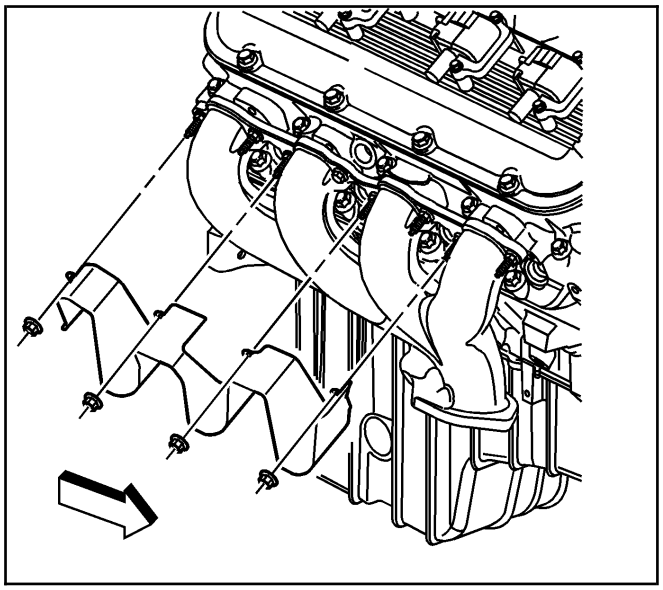


470725

2. Install the NEW right exhaust manifold gasket.
3. Install the right exhaust manifold.
4. Install the right exhaust manifold nuts and center bolt.

   Tighten

   - Tighten the right exhaust manifold center bolt to 35 N·m (26 lb ft).
   - Tighten the right exhaust manifold nuts to 16 N·m (12 lb ft).



470708

5. Install the right exhaust manifold heat shield.
6. Install the right exhaust manifold heat shield nuts.

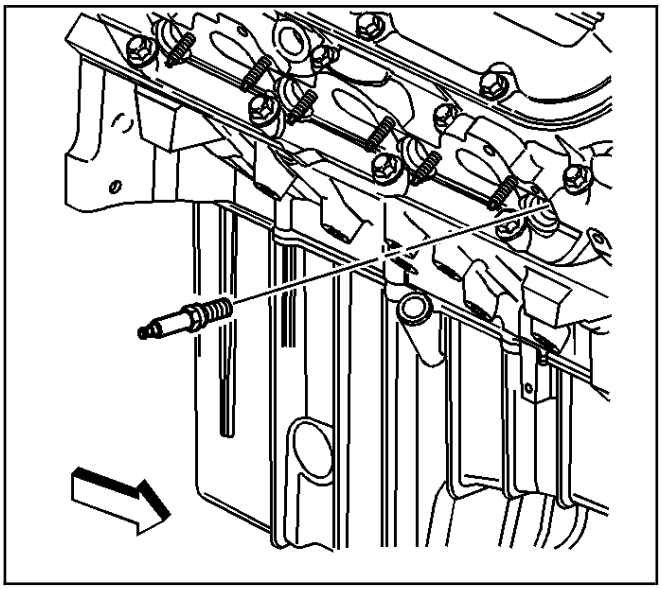
   Tighten

   Tighten the right exhaust manifold heat shield nuts to 25 N·m (18 lb ft).

7. Install the right spark plugs.

   Tighten

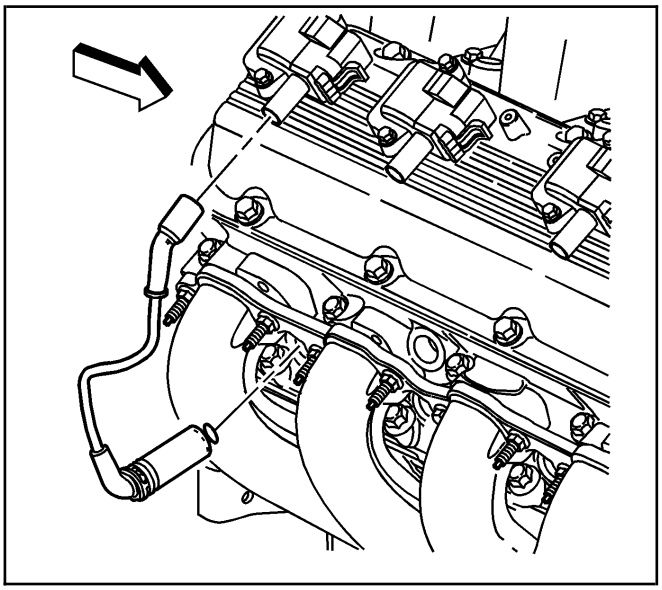
   Tighten the right spark plugs to 20 N·m (15 lb ft).



470727

Important: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire onto the spark plug by using the metal heat shield.

8. Install the right spark plug wires to the spark plugs and ignition coils.



470704

9. Install the exhaust gas recirculation (EGR) pipe and NEW EGR pipe gaskets.
10. Install the EGR pipe nuts to the right exhaust manifold.

    Tighten

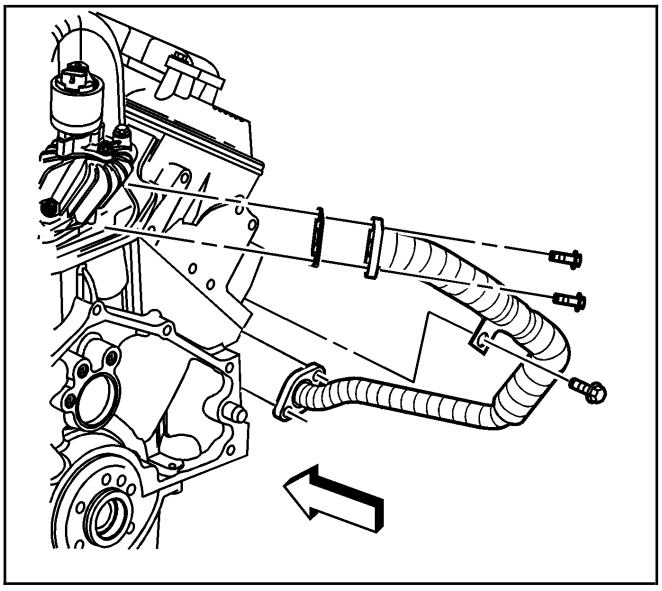
    Tighten the EGR pipe nuts to 30 N·m (22 lb ft).
11. Install the EGR pipe bolts to the EGR adapter.

    Tighten

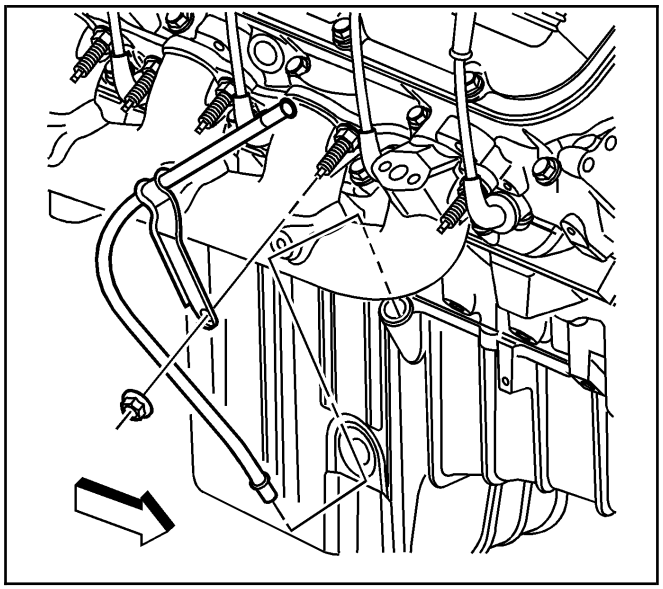
    Tighten the EGR pipe bolts to 30 N·m (22 lb ft).
12. Install the EGR pipe bracket bolt.

    Tighten

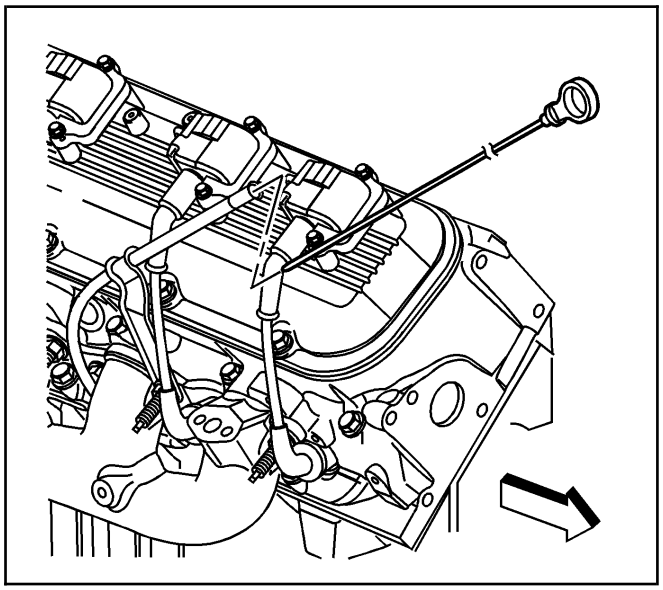
    Tighten the EGR pipe bracket bolt to 50 N·m (37 lb ft).



470737



470630



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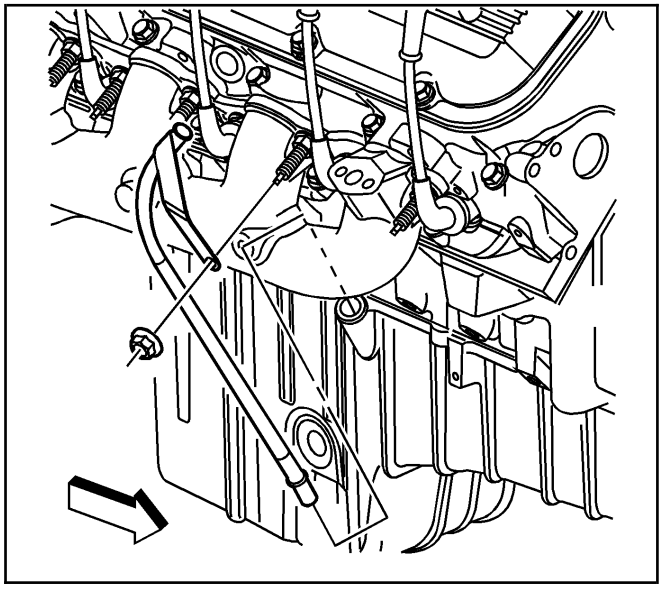


470639

Oil Level Indicator and Tube Installation (C/K/C3500HD)

SIE-ID = 482904

Important: Make sure the oil level indicator tube does not come in contact with the spark plug wires. Route the spark plug wires around the oil level indicator tube.

1. Install a NEW O-ring seal onto the oil level indicator tube.
2. Install the oil level indicator tube into the oil pan.
3. Install the oil level indicator tube bracket to the exhaust manifold stud.

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

4. Install the oil level indicator tube bracket nut to the exhaust manifold stud.

   Tighten

   Tighten the oil level indicator tube bracket nut to 18 N·m (13 lb ft).
5. Install the oil level indicator into the oil level indicator tube.

Oil Level Indicator and Tube Installation (G)

SIE-ID = 482905

Important: Make sure the oil level indicator tube does not come in contact with the spark plug wires. Route the spark plug wires around the oil level indicator tube.

1. Install a NEW O-ring seal onto the oil level indicator tube.
2. Install the oil level indicator tube into the oil pan.
3. Install the oil level indicator tube bracket to the exhaust manifold stud.

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

4. Install the oil level indicator tube bracket nut to the exhaust manifold stud.

   Tighten

Tighten the oil level indicator tube bracket nut to 18 N·m (13 lb ft).

Oil Level Indicator and Tube Installation (Medium Duty)

SIE-ID = 482909

Important: Make sure the oil level indicator tube does not come in contact with the spark plug wires. Route the spark plug wires around the oil level indicator tube.

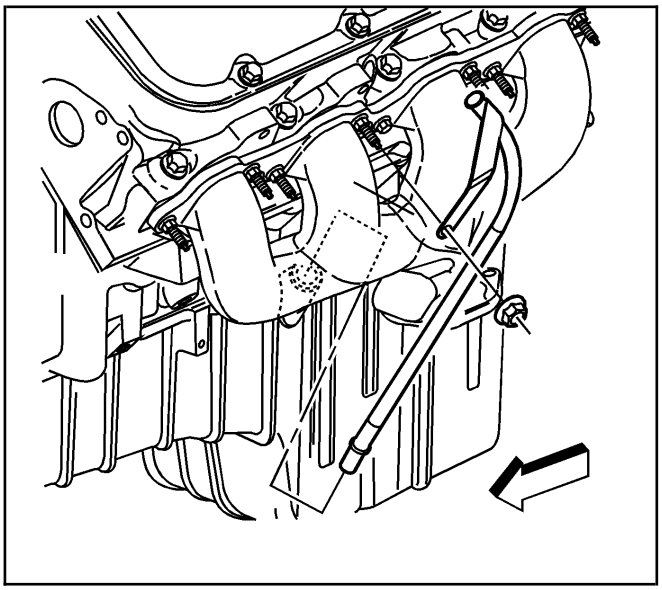
1. Install a NEW O-ring seal onto the oil level indicator tube.
2. Install the oil level indicator tube into the oil pan.
3. Install the oil level indicator tube bracket to the exhaust manifold stud.

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

4. Install the oil level indicator tube bracket nut to the exhaust manifold stud.

   Tighten

   Tighten the oil level indicator tube bracket nut to 18 N·m (13 lb ft).



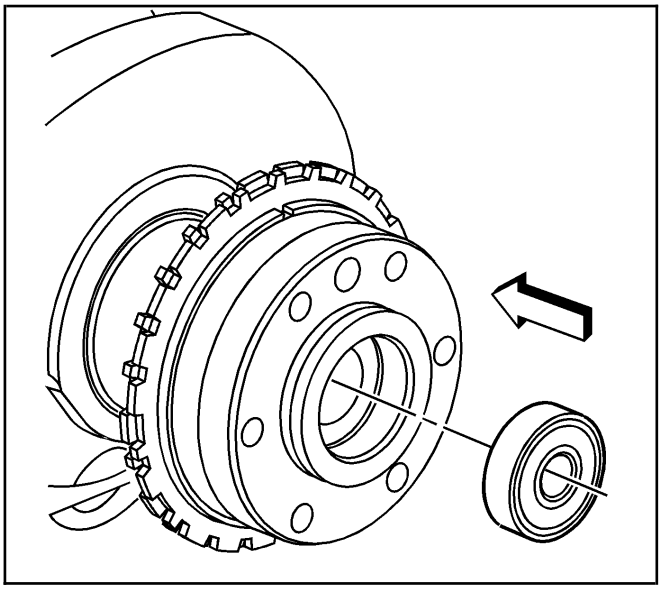
677829

Clutch Pilot Bearing Installation (C/K/C3500HD)

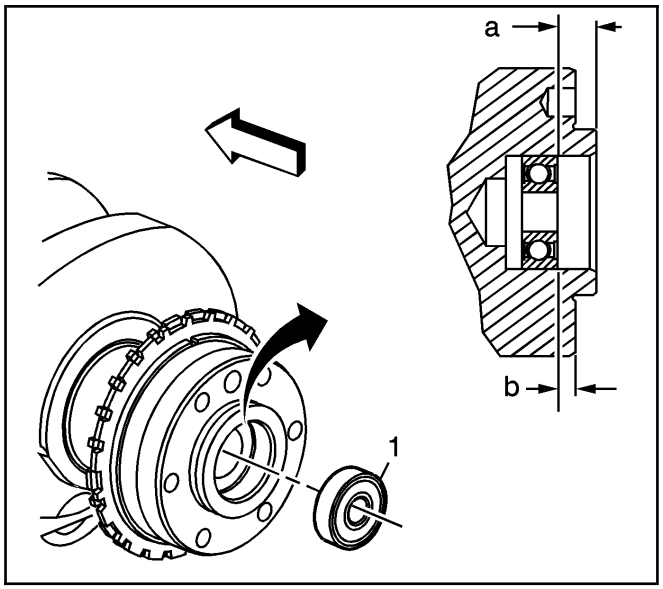
SIE-ID = 482915

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

1. Install the NEW clutch pilot bearing.



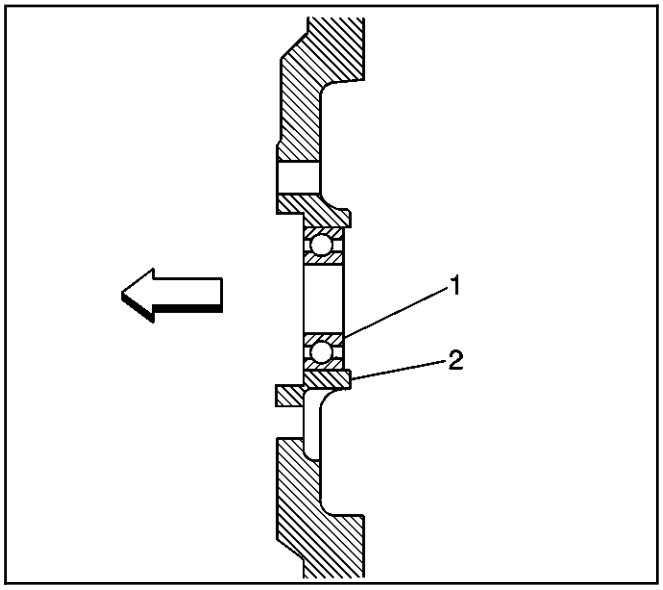
470617



470620

Important: Make sure the bearing is installed parallel to the rear of the crankshaft.

2. Measure to ensure the proper installation depth is obtained. The bearing (1) should be (A) 14.650–15.650 mm (0.577–0.616 in) from the lip of the crankshaft, or (B) 6.400–7.400 mm (0.252–0.291 in) from the crankshaft flange.



375107

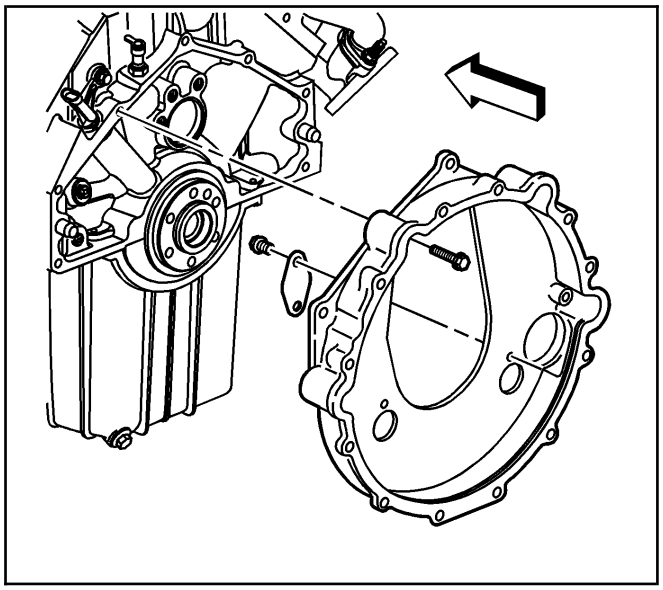
Clutch Pilot Bearing Installation (Medium Duty)

SIE-ID = 482916

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

Important: Install the bearing from the crankshaft side of the engine flywheel.

1. Install the NEW clutch pilot bearing (1) flush with the surface of the crankshaft flange bore (2).
2. Ensure that proper installation is obtained.



470599

Engine Flywheel Housing Installation (Medium Duty with AT)

SIE-ID = 482917

1. Install the transmission converter covers.

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

2. Install the transmission converter cover bolts.

   Tighten

   Tighten the transmission converter cover bolts to 12 N·m (106 lb in).
3. Install the engine flywheel housing.
4. Install the engine flywheel housing bolts.

   Tighten

   Tighten the flywheel housing bolts to 67 N·m (49 lb ft).

Engine Flywheel Housing Installation (Medium Duty with MT)

SIE-ID = 482922

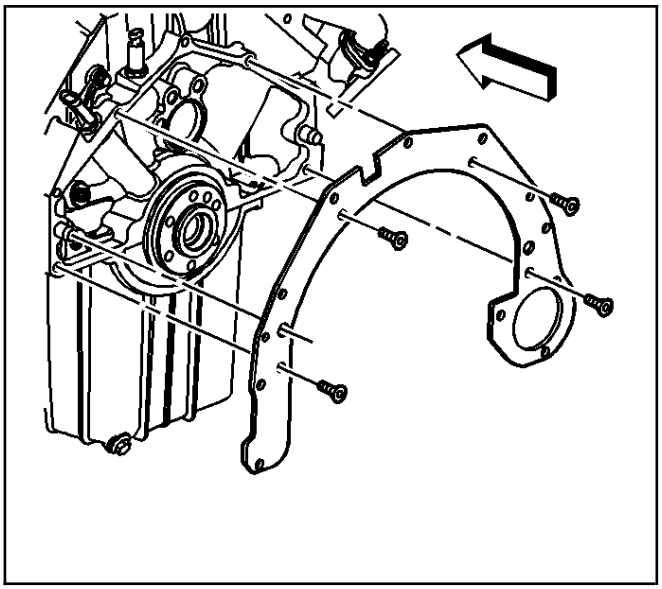
1. Install the engine flywheel housing.

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

2. Install the engine flywheel housing bolts.

   Tighten

   Tighten the engine flywheel housing bolts to 60 N·m (44 lb ft).



470612

Crankshaft Rear Oil Seal Installation

SIE-ID = 482804

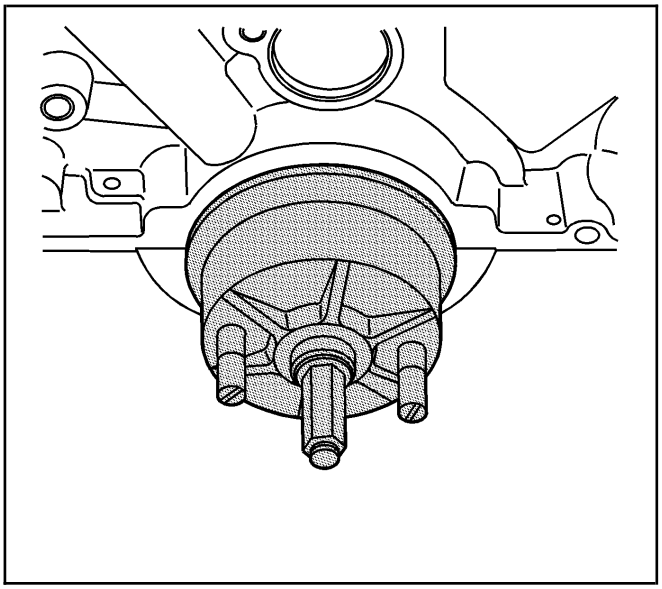
Tools Required

J 42849 Crankshaft Rear Seal Installer

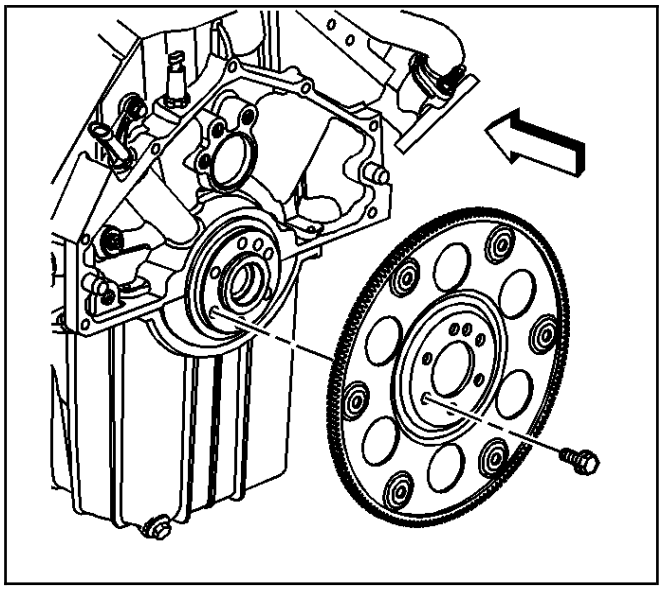
Important: Crankshaft rear oil seal and engine flywheel installation requires adequate space for installation. If the engine stand does not allow suitable space to use the *J 42849*, install the crankshaft rear oil seal and engine flywheel with the engine properly supported on the floor.

1. Make sure the crankshaft rear chamfer is free of grit, loose rust, and burrs. Correct as needed.
2. Apply a very light film of oil onto the crankshaft sealing surface.

   DO NOT apply oil to the sealing surface of the engine block.
3. Install the seal on the *J 42849*.
4. Position *J 42849* against the crankshaft. Thread the attaching screws into the tapped holes in the crankshaft.
5. Tighten the screws securely with a screwdriver in order to ensure that the seal is installed squarely over the crankshaft.
6. Rotate the center nut until the *J 42849* bottoms.
7. Remove the *J 42849*.



640011



470572

Engine Flywheel Installation (C/K/G/C3500HD with AT)

SIE-ID = 482923

Important: Make sure the flywheel is installed correctly. Engine Side is stamped on the flywheel to assist with installation.

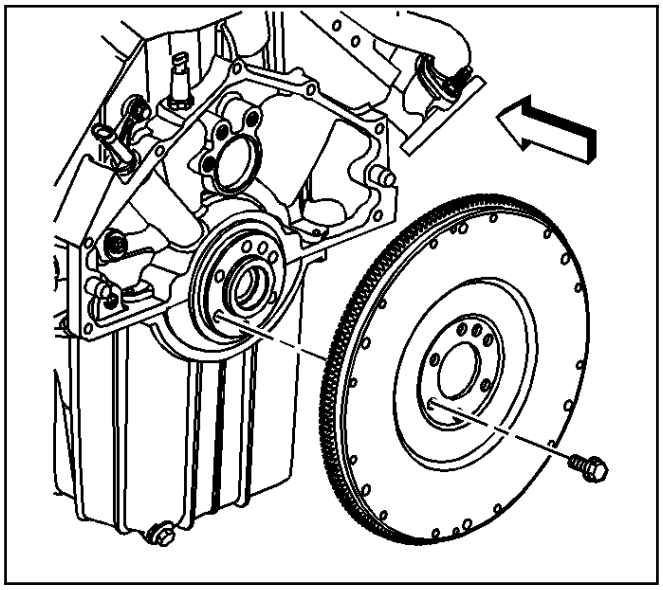
1. Install the engine flywheel.

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

2. Install the engine flywheel bolts.

Tighten

- Tighten the engine flywheel bolts to 40 N·m (30 lb ft) for the first pass.
- Tighten the engine flywheel bolts to 80 N·m (59 lb ft) for the second pass.
- Tighten the engine flywheel bolts to 100 N·m (74 lb ft) for the final pass.



470576

Engine Flywheel Installation (C/K with MT)

SIE-ID = 482924

1. Install the engine flywheel.

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

2. Install the engine flywheel bolts.

Tighten

- Tighten the engine flywheel bolts to 40 N·m (30 lb ft) for the first pass.
- Tighten the engine flywheel bolts to 80 N·m (59 lb ft) for the second pass.
- Tighten the engine flywheel bolts to 100 N·m (74 lb ft) for the final pass.

Engine Flywheel Installation (Medium Duty with AT)

SIE-ID = 482926

Important: Make sure the flywheel is installed correctly. Engine Side is stamped on the flywheel to assist with installation.

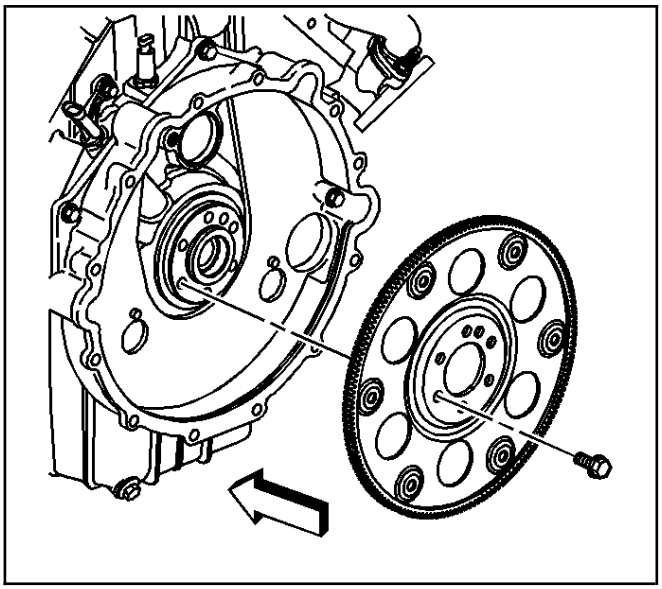
1. Install the engine flywheel.

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

2. Install the engine flywheel bolts.

   Tighten

   - Tighten the engine flywheel bolts to 40 N·m (30 lb ft) for the first pass.
   - Tighten the engine flywheel bolts to 80 N·m (59 lb ft) for the second pass.
   - Tighten the engine flywheel bolts to 100 N·m (74 lb ft) for the final pass.



470579

Engine Flywheel Installation (Medium Duty with MT)

SIE-ID = 482928

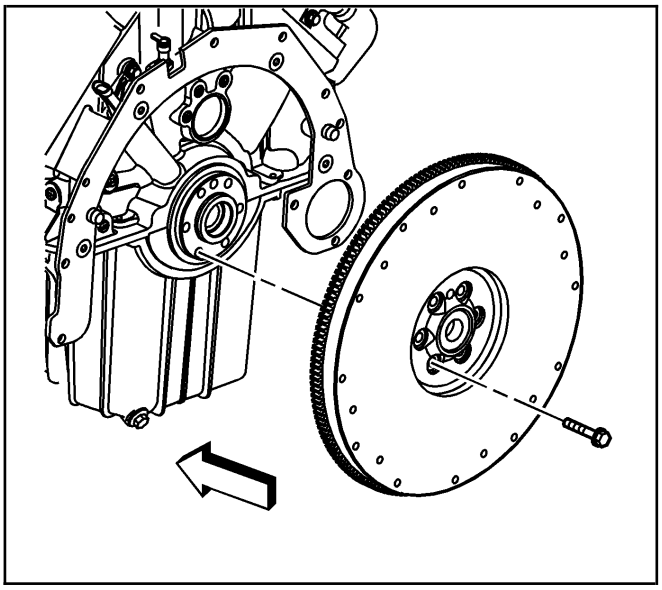
1. Install the engine flywheel.

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

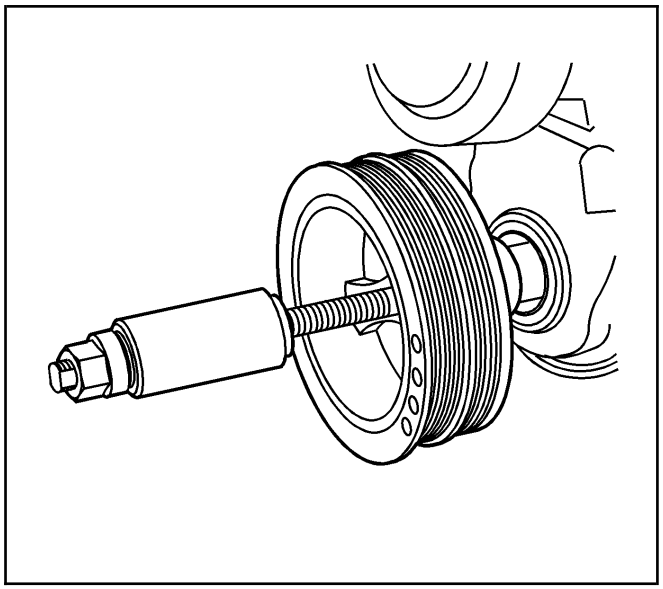
2. Install the engine flywheel bolts.

   Tighten

   - Tighten the engine flywheel bolts to 40 N·m (30 lb ft) for the first pass.
   - Tighten the engine flywheel bolts to 80 N·m (59 lb ft) for the second pass.
   - Tighten the engine flywheel bolts to 100 N·m (74 lb ft) for the final pass.



679414



639537

Crankshaft Balancer Installation

SIE-ID = 482890

Tools Required

- *J 42845* Crankshaft Balancer Installer
- *J 42847* Flywheel Holding Tool

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

Important:

- Make sure the teeth of the flywheel holding tool engage the engine flywheel teeth.
- The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

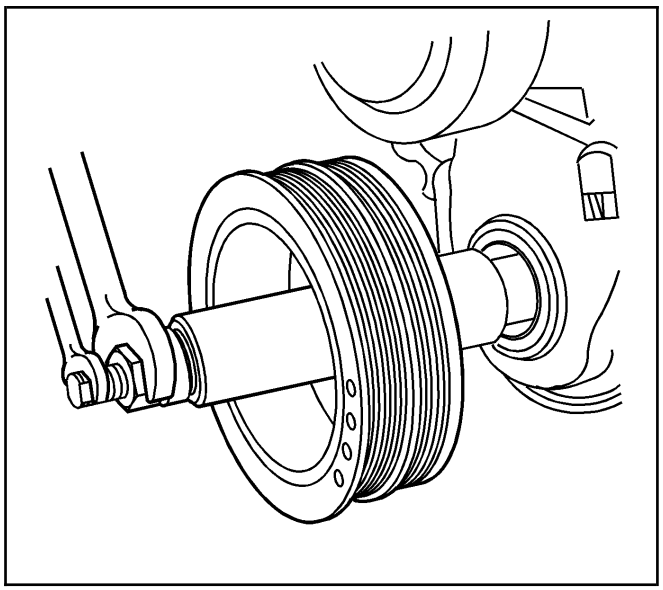
1. Install the *J 42847* to the starter bolt holes.

   Tighten

   Tighten the *J 42847* bolts to 50 N·m (37 lb ft).

Important: Apply grease or clean engine oil to the inside of the crankshaft balancer or the end of the crankshaft, to prevent galling during assembly.

2. Install the balancer onto the end of the crankshaft.



639539

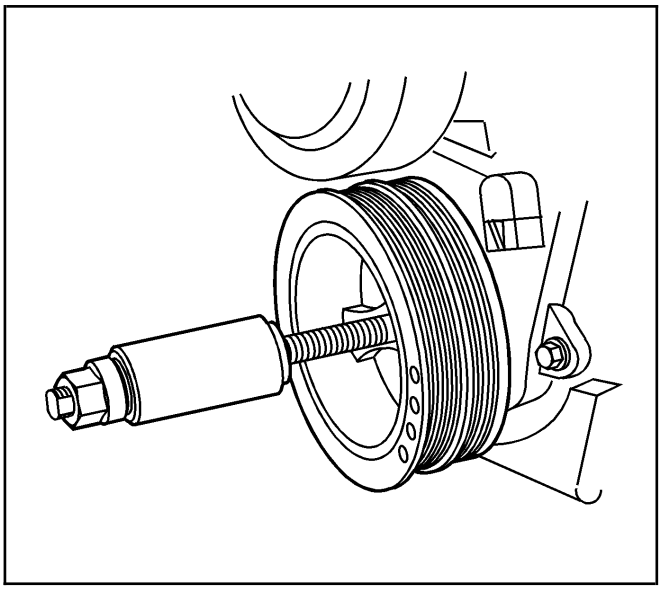
Important: Apply the lubricant that comes with *J 42845* each time the tool is used. Failure to lubricate *J 42845* may prevent the balancer from installing completely.

3. Use the *J 42845* in order to install the balancer.

Notice: SIO-ID = 728991 Ensure the crankshaft balancer is installed to the proper depth. The crankshaft balancer nose must be seated against the crankshaft sprocket. Failure to install the crankshaft balancer properly may result in improper torque to the crankshaft balancer bolt. An improperly torqued crankshaft balancer bolt may loosen causing serious engine damage.

4. Tighten the *J 42845* until the crankshaft balancer is completely seated against the crankshaft sprocket.

5. Remove the *J 42845* from the crankshaft.



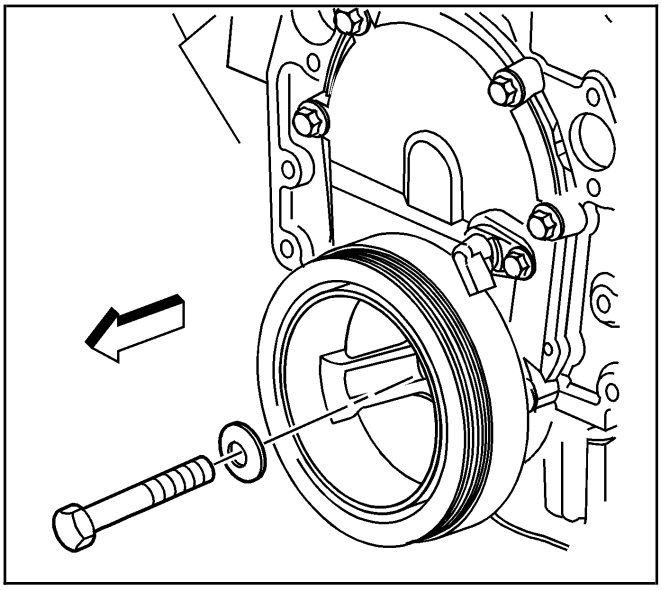
639542

6. Install the crankshaft balancer washer and bolt.

   Tighten

   Tighten the crankshaft balancer bolt to 255 N·m (189 lb ft).

7. Remove the *J 42847*.

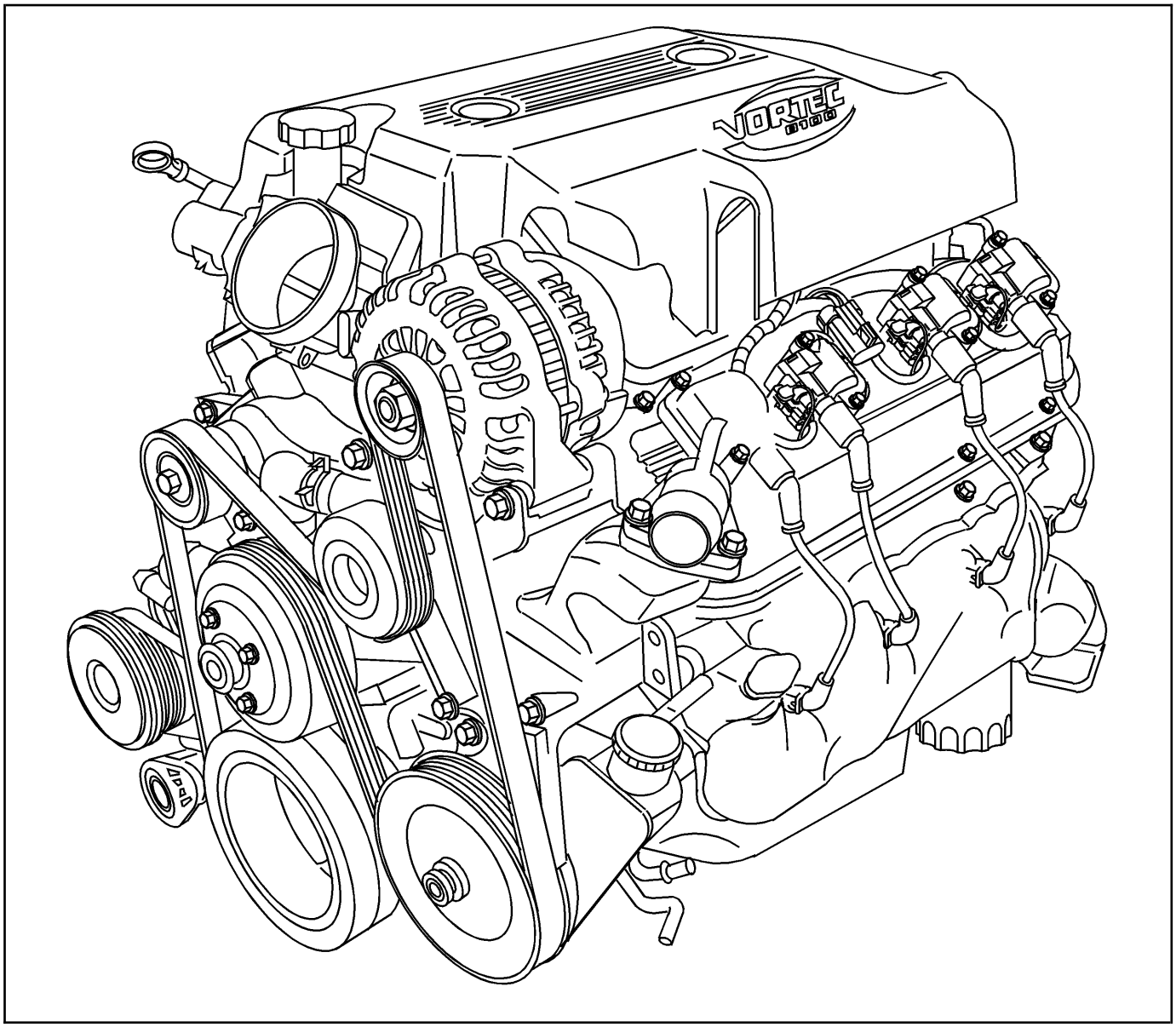


470799

Description and Operation

Engine Component Description

SIE-ID = 775828



775817

Cylinder Block

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

Cylinder Head

The cylinder heads are made of cast iron and have parent metal intake valve guides and intake valve seats. The cast iron exhaust valve guides and powdered metal valve seats are pressed into the exhaust ports. A spark plug is located between the valves in the side of the cylinder head. The water crossover pipe attaches to the front of each cylinder head.

Camshaft

A steel camshaft is supported by five bearings pressed into the engine block. The camshaft sprocket is mounted to the front of the camshaft and is driven by the crankshaft sprocket through a camshaft timing chain.

Motion from the camshaft is transmitted to the valves by hydraulic roller valve lifters, valve push rods, and ball-pivot type rocker arms. A spiral gear machined into the camshaft near the rear journal drives a shaft assembly which operates the oil pump driveshaft assembly. Ignition synchronization with the camshaft is provided by a physical feature integral with the camshaft sprocket.

Crankshaft

The crankshaft is made of cast nodular iron. The crankshaft is supported by five crankshaft bearings. The crankshaft bearings are retained by the crankshaft bearing caps. The crankshaft bearing caps are machined with the engine block for proper alignment and clearance. The crankshaft bearing caps are retained by two bolts and two studs each. The number five crankshaft bearing at the rear of the engine block is the end thrust bearing. The four connecting rod journals (two rods per journal) are spaced 90 degrees apart. The crankshaft position sensor reluctor ring is pushed onto the rear of the crankshaft. The crankshaft position sensor reluctor is constructed of powdered metal. The reluctor ring has an interference fit onto the crankshaft and an internal keyway for correct positioning.

Pistons and Connecting Rods

The pistons are cast aluminum alloy that use two compression rings and one oil control ring assembly. The piston pins are a floating fit in the pistons and the piston pins are retained by a press fit in the connecting rod assembly. The pistons are coated in order to create an interference fit into the cylinder. The connecting rods are forged steel and have precision insert type crankpin bearings. The piston and connecting rod is only serviced as an assembly.

Valve Train

The valve train is a ball pivot type. Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular valve push rods to the valve rocker arms. The valve rocker arm pivots on a ball in order to open the valve. The hydraulic roller valve lifters keep all parts of the valve train in constant contact. Each valve lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment. The valve rocker arm stud and nut retains the valve rocker arm and ball seat. The valve rocker arm stud is threaded into the cylinder head. The valve stem seal is pressed over the valve guide of the cylinder head.

Intake Manifold

The intake manifold is a one-piece design. The intake manifold is made of cast aluminum. The throttle body is attached to the front of the intake manifold. A linear exhaust gas recirculation (EGR) port is cast into the manifold for exhaust gas recirculation mixture. The EGR valve bolts onto the rear of the intake manifold. The fuel rail assembly with eight separate fuel injectors is retained to the intake manifold by four studs. The fuel injectors are seated in their individual manifold bores with O-ring seals to provide sealing. A Manifold Absolute Pressure (MAP) sensor is mounted on the top of the intake manifold and sealed by an O-ring seal. The MAP sensor is held in place with a retainer bolt. The evaporative emission canister solenoid is located in the front of the intake manifold. The positive crankcase ventilation (PCV) system is internally cast into the intake manifold. There is not a PCV valve. A splash shield is installed under the intake manifold. The shield prevents hot oil from contacting the bottom of the intake manifold, maintaining air inlet charge density.

Exhaust Manifold

The two exhaust manifolds are constructed of cast stainless steel. The exhaust manifolds direct exhaust gases from the combustion chambers to the exhaust system. The right exhaust manifold has a flange for the EGR pipe.

New Product Information

SIE-ID = 761245

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

Changes may include one or more of the following items:

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

Torque Values and/or Fastener Tightening Strategies

No torque or fastener tightening changes from the previous year. Refer to *Fastener Tightening Specifications*.

Changed Engine Specifications

No changed engine specifications. Refer to *Engine Mechanical Specifications*.

New Sealants and/or Adhesives

No sealant or adhesive changes from the previous year. Refer to *Sealers, Adhesives, and Lubricants*.

Disassembly and Assembly Procedure Revisions

No disassembly or assembly revisions.

Engine Mechanical Diagnostic Procedure Revisions

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system problem. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to *Strategy Based Diagnosis* in General Information or *Diagnostic Starting Point - Engine Mechanical* in Engine Mechanical.

New Special Tools Required

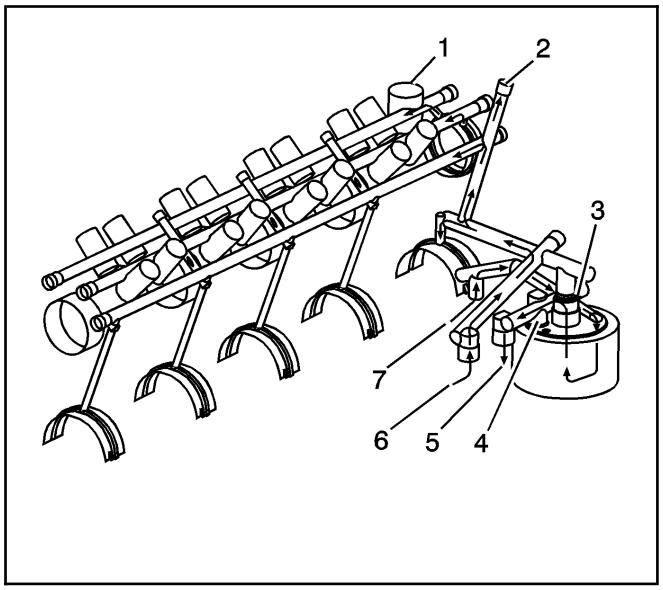
No new special tools are required.

A Component Comparison from the Previous Year

The A.I.R. system has been removed from the engine. Refer to *Disassembled Views*.

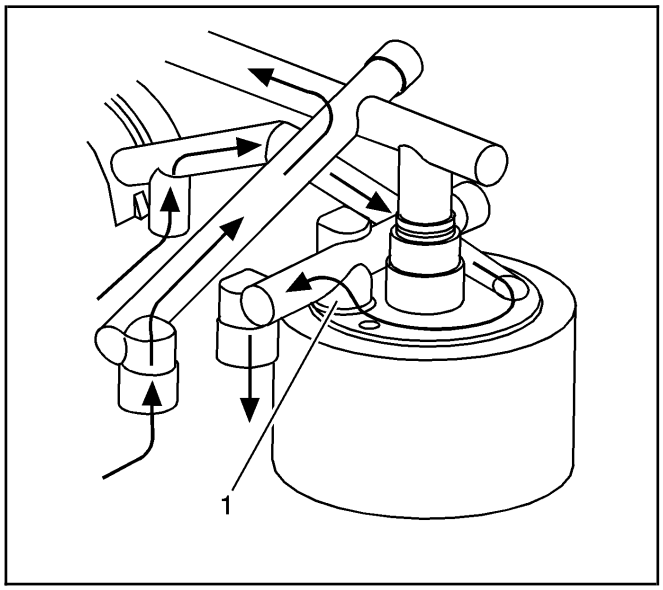
Lubrication Description

SIE-ID = 644443



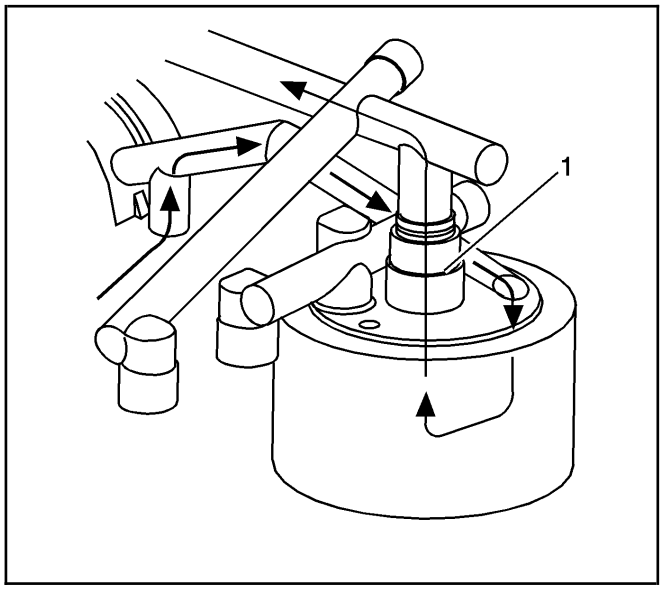
677880

The gear-type oil pump is driven through an extension driveshaft. The extension driveshaft is driven by the oil pump drive, which is gear driven by the camshaft. The oil is drawn from the oil pan through a pickup screen and tube, into the oil pump (7). Pressurized oil flows through the oil filter, into the oil cooler (5), back into the engine (6), up to the oil pressure gage port (2) and rear crankshaft bearing, and is then distributed to the upper oil galleries. Oil must flow around the oil pump drive (1) in order to reach the right side valve lifters properly. The oil is delivered through internal passages in order to lubricate camshaft and crankshaft bearings and to provide lash control in the hydraulic valve lifters. Oil is metered from the valve lifters through the valve push rods in order to lubricate the valve rocker arms and ball pivots. Oil returning to the oil pan from the cylinder heads and the front camshaft bearing, lubricates the camshaft timing chain and the crankshaft and the camshaft sprockets. There are two bypass valves located in the engine block, above the oil filter. The oil filter bypass valve (4) and the oil cooler bypass valve (3).



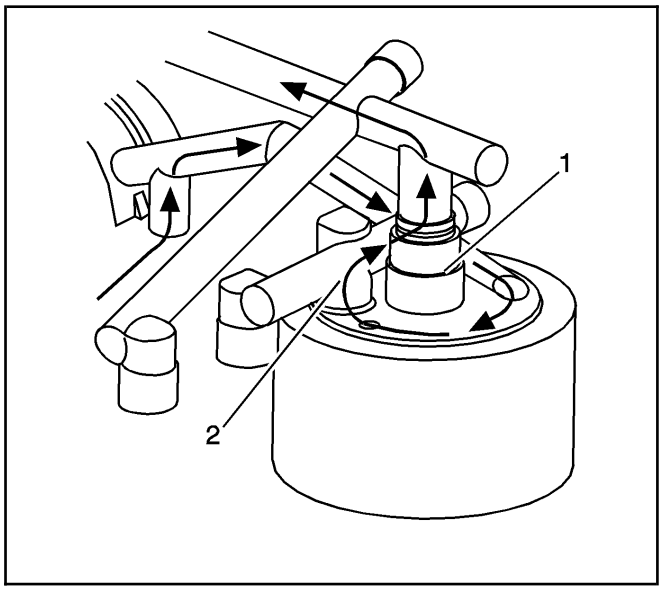
677884

If the oil filter becomes plugged, the pressurized oil is diverted around the top of the oil filter. The oil filter bypass valve (1) is forced open, allowing the oil to continue on to the oil cooler and engine oil passages. No oil filtration occurs because the oil is not allowed into the oil filter.



677891

If the oil cooler flow becomes blocked, either from a plugged oil cooler or blocked or kinked oil cooler line, the oil cooler bypass valve (1) is forced open, allowing oil to flow directly into the engine oil passages. Oil does not flow into or out of the engine oil cooler.



677892

If both the oil filter and the oil cooler are plugged, the pressurized oil is routed around the top of the oil filter, through the oil filter bypass valve (2), through the oil cooler bypass valve (1) and directly into the engine oil passages. Lubrication still occurs, but the oil is not filtered or directed through the oil cooler.

Separating Parts

SIE-ID = 640184

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

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

Separate, mark, or organize the following components:

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

Cleanliness and Care

SIE-ID = 189826

SIO-ID = 189770

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

Replacing Engine Gaskets

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.

Important: Do not overtighten the fasteners.

- Tighten the fasteners to the proper specifications.

Use of RTV and Anaerobic Sealer

SIE-ID = 720107

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 plastic and aluminum 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 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.

Notice: SIO-ID = 768432 Do not allow the pipe sealant to enter a blind hole. The pipe sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

- 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.

Tools and Equipment

SIE-ID = 190154

SIO-ID = 190145

- Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.
- To properly service the engine assembly, the following items should be readily available:
  - Approved eye protection and safety gloves
  - A clean, well-lit, work area
  - A suitable parts cleaning tank
  - A compressed air supply
  - Trays or storage containers to keep parts and fasteners organized
  - An adequate set of hand tools
  - Approved engine repair stand
  - An approved engine lifting device that will adequately support the weight of the components

Special Tools and Equipment

SIE-ID = 482933

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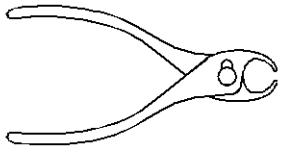
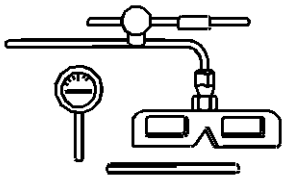
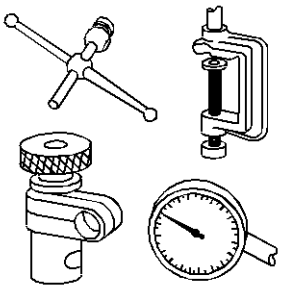
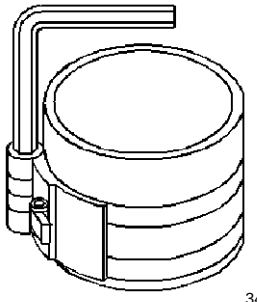
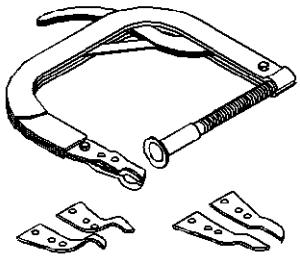
 14487	J 3049-A Valve Lifter Removal (Plier Type)
 35463	J 7872 Magnetic Base Dial Indicator
 2014	J 8001 Dial Indicator Set
 3403	J 8037 Piston Ring Compressor
 3414	J 8062 Valve Spring Compressor - Head Off

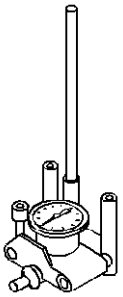
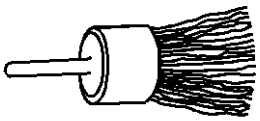
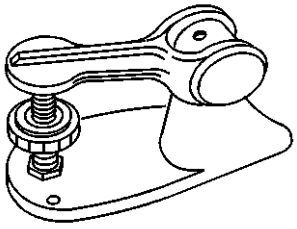
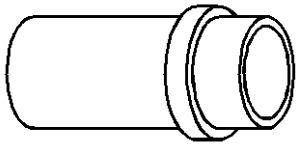
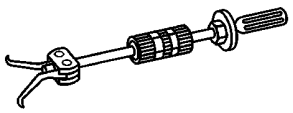
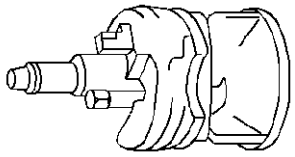
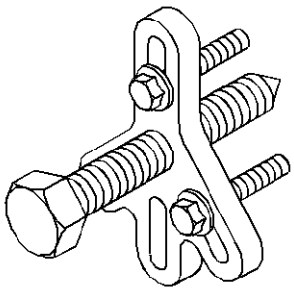
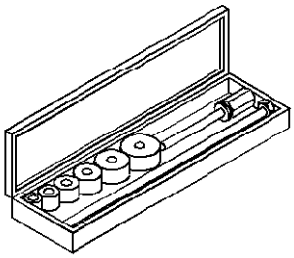
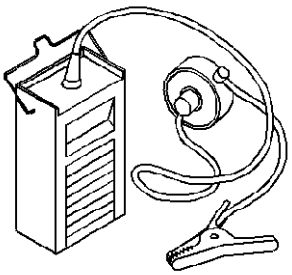
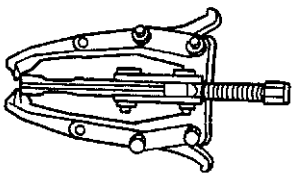
Illustration	Tool Number/Description
 5110	J 8087 Cylinder Bore Checking Gage
 4994	J 8089 Carbon Removal Brush
 4997	J 9666 Valve Spring Tester
 65325	J 22102 Front Cover Aligner and Seal Installer
 163061	J 23907 Slide Hammer

Illustration	Tool Number/Description
 3412	J 24270 Cylinder Bore Ridge Reamer
 5116	J 24420-C Harmonic Balancer Puller
 5118	J 33049 Camshaft Bearing Service Set
 3413	J 36660-A Torque Angle Meter
 54474	J 38416-B Three Jaw Puller

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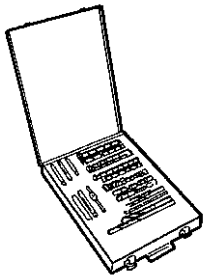
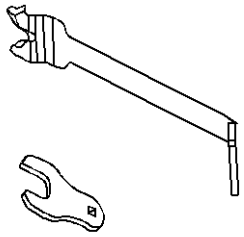
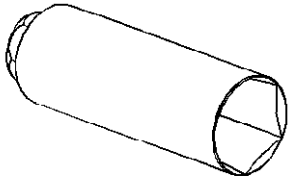
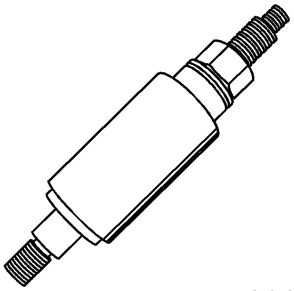
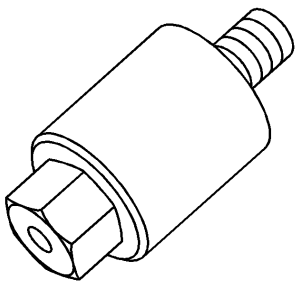
 54577	J 39345 Thread Repair Kit
 48304	J 41240 Fan Clutch Wrench
 67136	J 41712 Oil Pressure Sending Unit Socket
 642100	J 42845 Crankshaft Balancer Installer
 642102	J 42846 Crankshaft Protector Button

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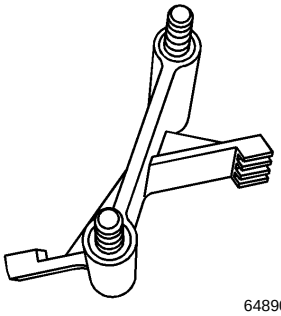
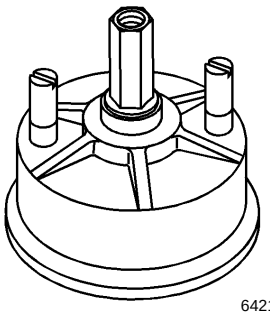
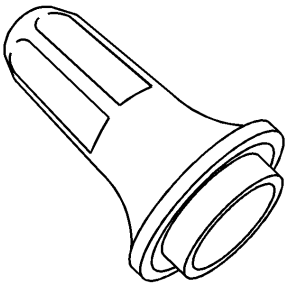
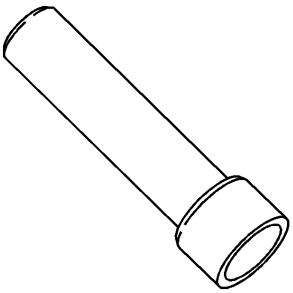
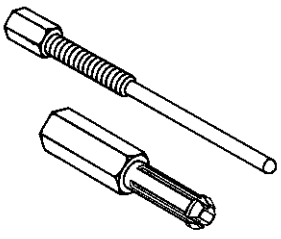
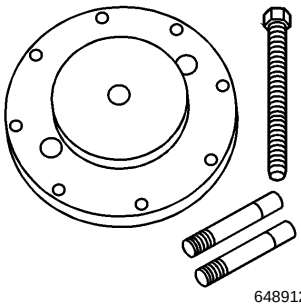
 648906	J 42847 Flywheel Holding Tool
 642103	J 42849 Crankshaft Rear Seal Installer
 642106	J 42851 Front Cover Oil Seal Installer
 642108	J 43105 Valve Stem Seal Installer
 355040	J 43276 Clutch Pilot Bearing Remover

Illustration	Tool Number/Description
 648912	J 43320 Crankshaft Rear Seal Puller

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