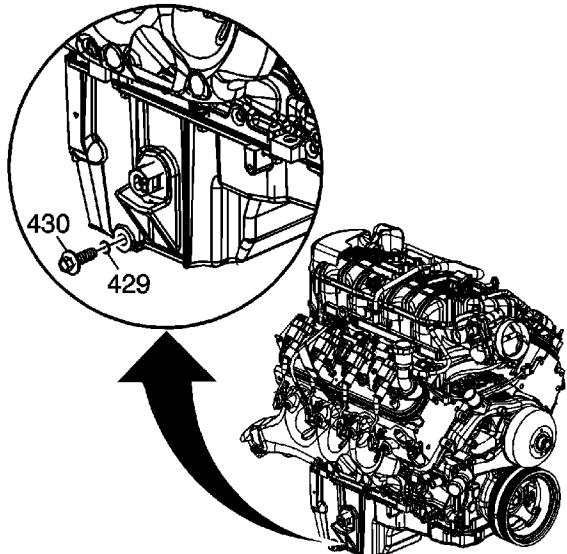
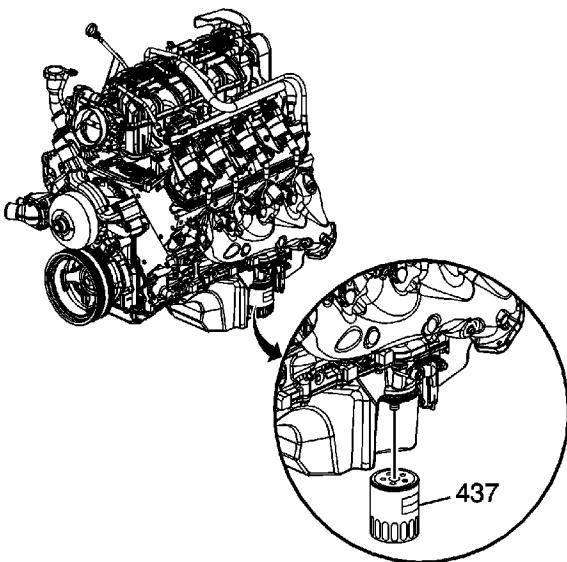


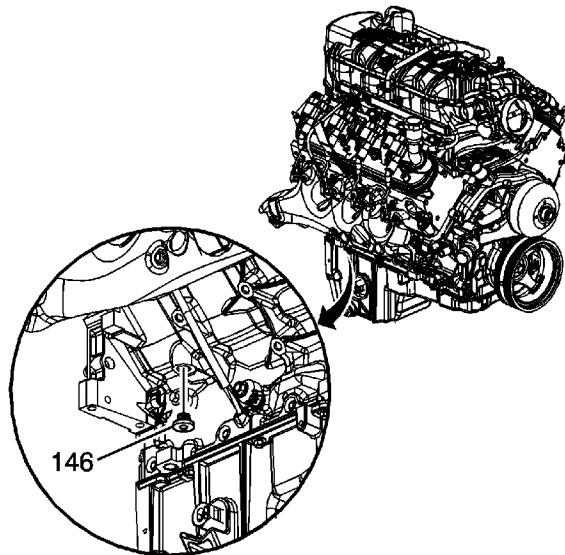
Draining Fluids and Oil Filter Removal



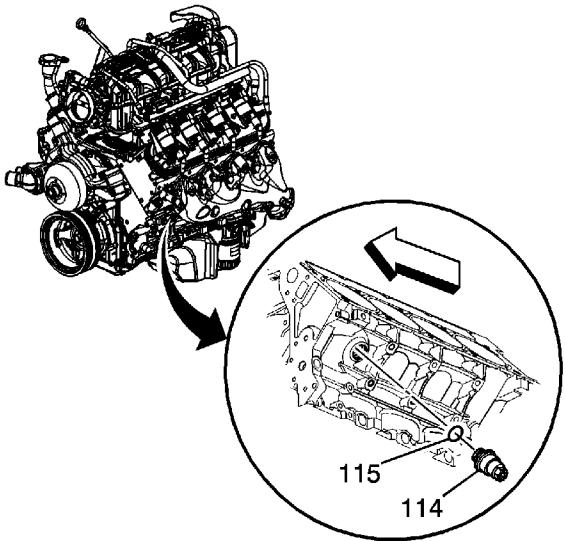
1. Remove the oil pan drain plug (430) and O-ring (429).



2. Remove the engine oil filter (437).



3. Remove the right side engine block coolant drain hole plug (146).



4. Remove the left side engine block coolant heater (114) and washer (115).

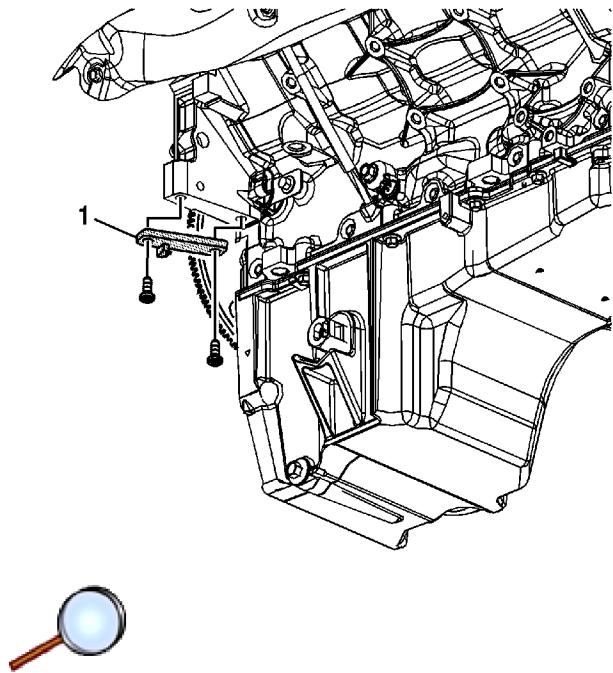
Crankshaft Balancer Removal

Special Tools

- *J41816-A* Crankshaft Balancer Remover
- *J41816-2* Crankshaft End Protector
- *J42386-A* Flywheel Holding Tool

For equivalent regional tools, refer to [Special Tools](#).

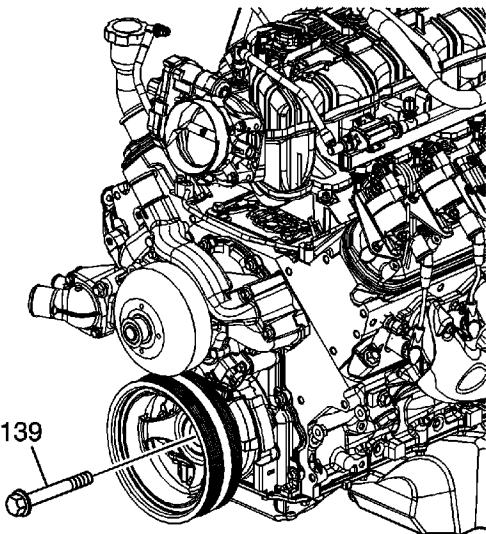
Caution: Refer to [Fastener Caution](#) in the Preface section.



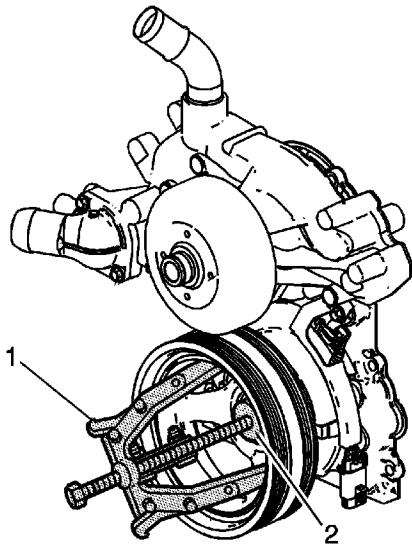
Note: Do not use the crankshaft balancer bolt again. Install a NEW crankshaft balancer bolt during final assembly.

1. Install the *J42386-A* tool (1) and bolts.

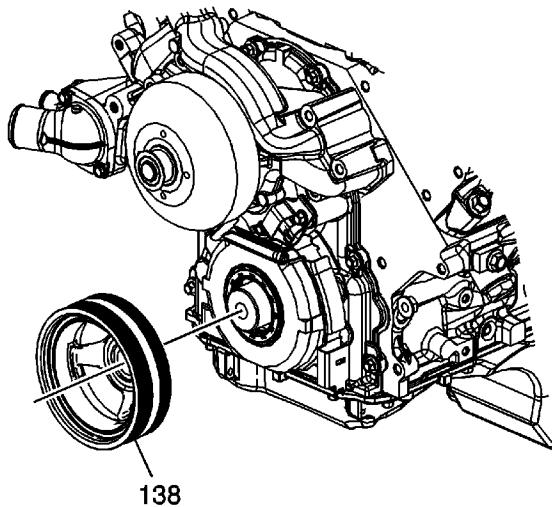
Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten the *J42386-A* tool bolts to **50 N·m (37 lb ft)**.



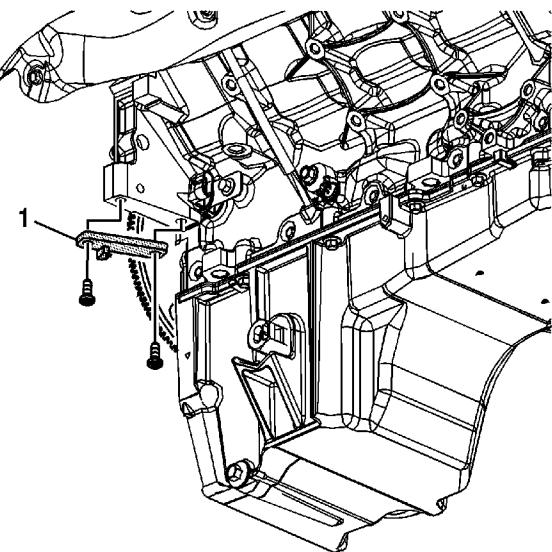
2. Remove the crankshaft balancer bolt (139).



3. Use the *J41816-A* remover (1) and the *J41816-2* protector (2) in order to remove the crankshaft balancer.

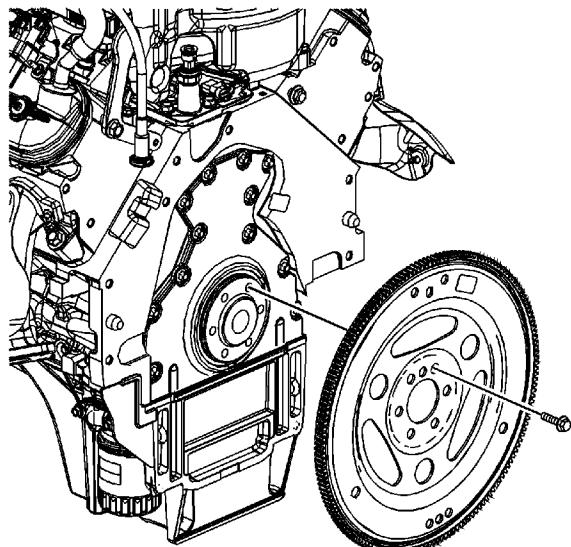


4. Remove the balancer (138).



5. Remove the *J42386-A* tool (1) and bolts.

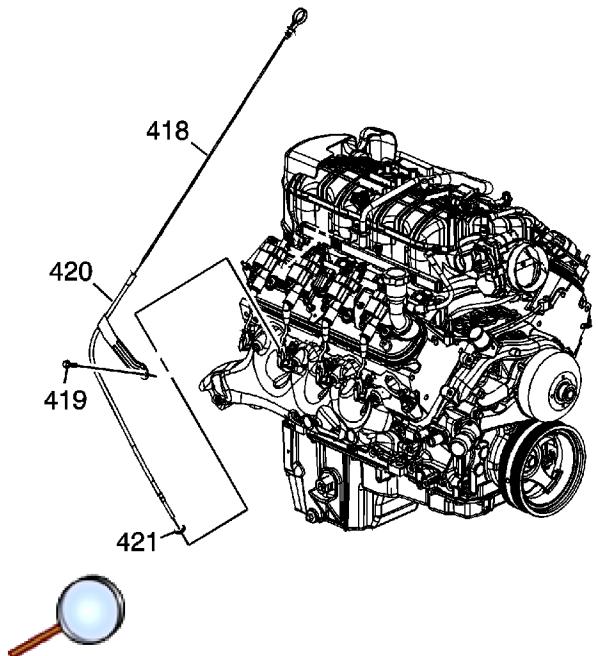
Automatic Transmission Flex Plate Removal



Important: The flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flex plate bolts. This procedure requires a 3 stage tightening process.

1. Remove the engine flex plate bolts.
2. Remove the flex plate.

Oil Level Indicator and Tube Removal

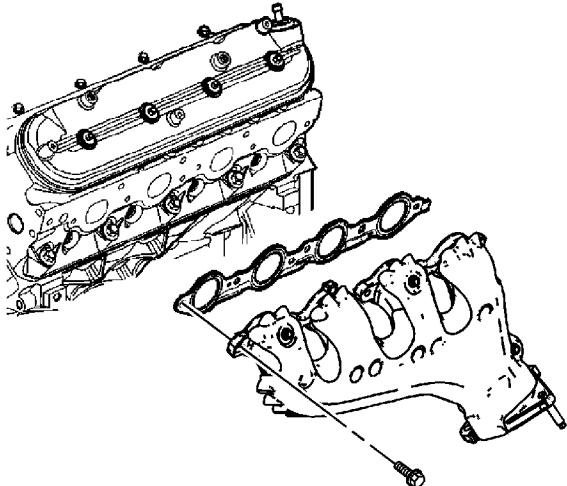


1. Remove the oil level indicator (418) from the tube.
2. Remove the oil level indicator tube bolt (419).
3. Remove the oil level indicator tube (420) from the engine block.

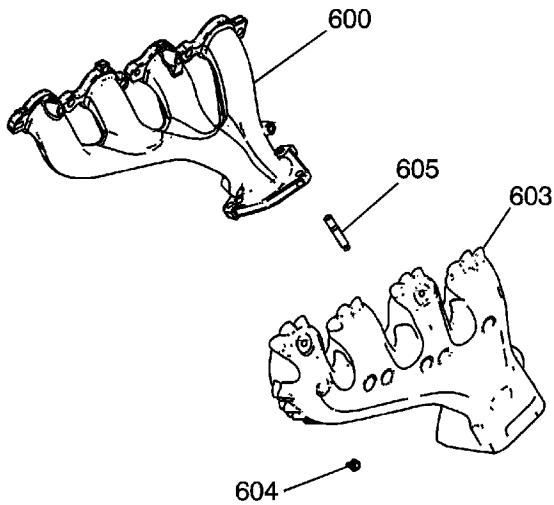
Important: Inspect the O-ring for cuts or damage. The O-ring seal may be used again if it is not cut or damaged.

4. Remove the O-ring (421) from the tube, as required.

Exhaust Manifold Removal - Left Side

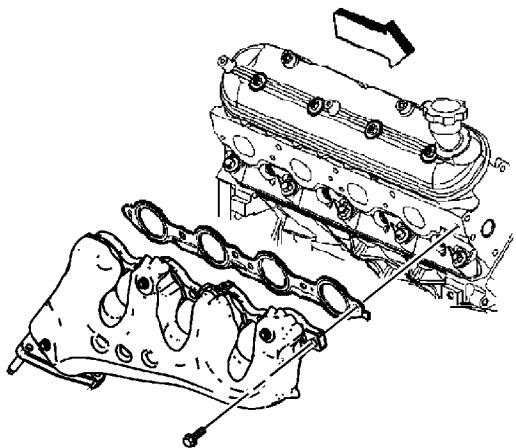


1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

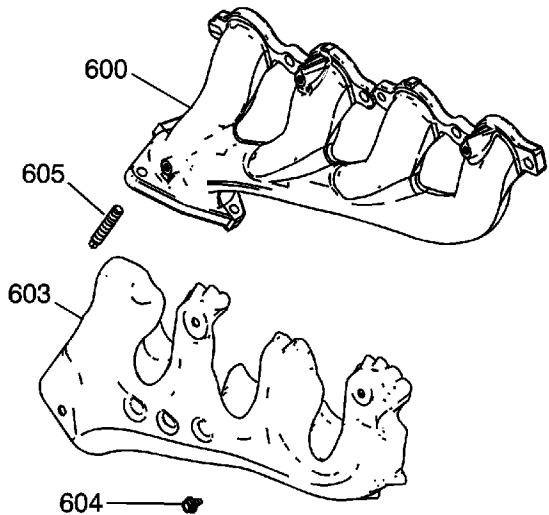


4. Remove the heat shield (603) and bolts (604) from the manifold (600), as required.
5. Remove the studs (605), as required.

Exhaust Manifold Removal - Right Side



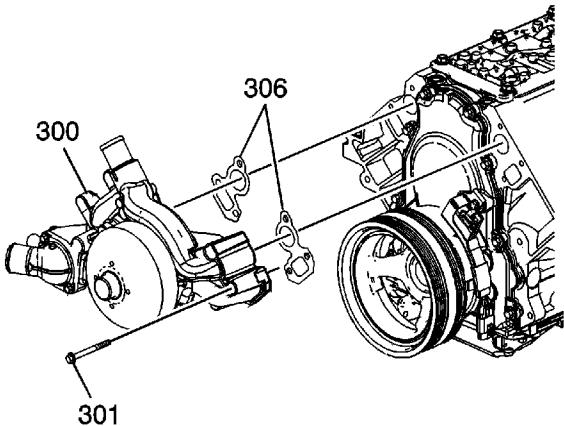
1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.



4. Remove the heat shield (603) and bolts (604) from the manifold (600), as required.
5. Remove the studs (605), as required.

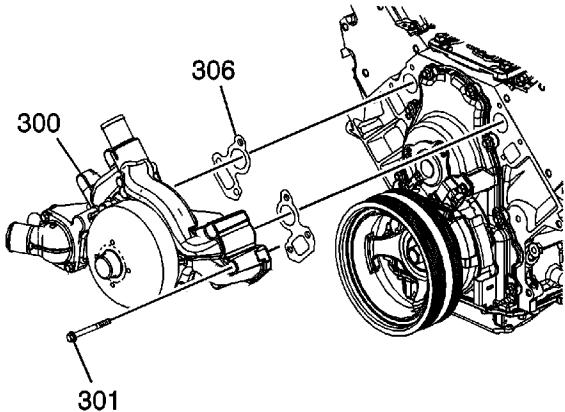
[2009 Chevrolet Silverado - 4WD](#) | [Sierra, Silverado \(VIN C/K\) Service Manual](#) | [Engine](#) |
[Engine Mechanical - 4.8L, 5.3L, 6.0L, 6.2L, or 7.0L](#) | [Repair Instructions - Off Vehicle](#) | **Document ID: 1789833**

Water Pump Removal (RPO LY2/LH6/LMG/LY5/LC9)



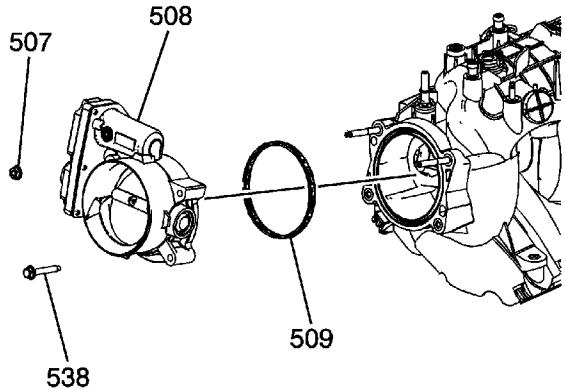
1. Remove the water pump bolts (301).
2. Remove the water pump (300) and gaskets (306).
3. Discard the water pump gaskets.

Water Pump Removal (RPO LY6/L76/L9H)



1. Remove the water pump bolts (301).
2. Remove the water pump (300) and gaskets (306).
3. Discard the water pump gaskets.

Throttle Body Removal

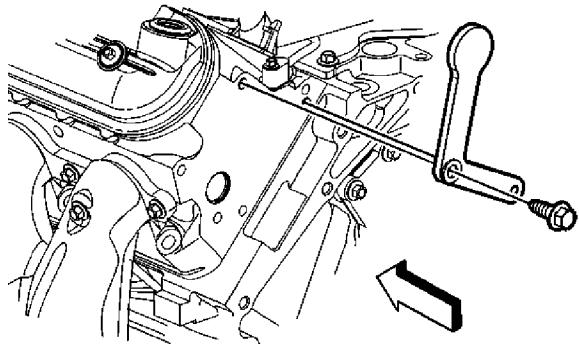


Important: The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.

1. Remove the electrical wire harness connectors from the throttle body.
2. Remove the throttle body nuts (507) and bolts (538).
3. Remove the throttle body (508).
4. Remove the throttle body gasket (509).
5. Discard the gasket.

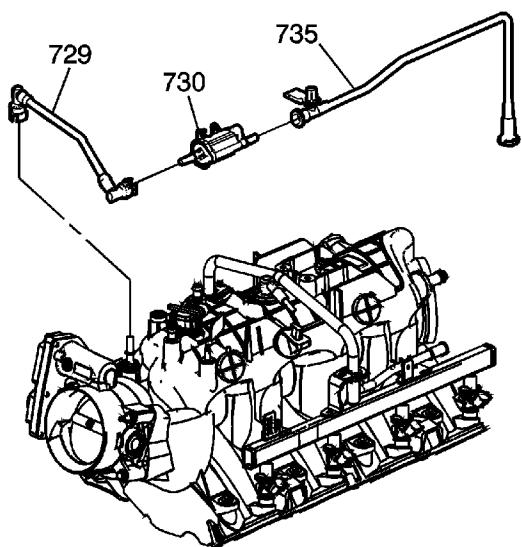
Fuel Rail and Injectors Removal

Warning: Refer to [Fuel Rail Stop Bracket Installation Warning](#) in the Preface section.



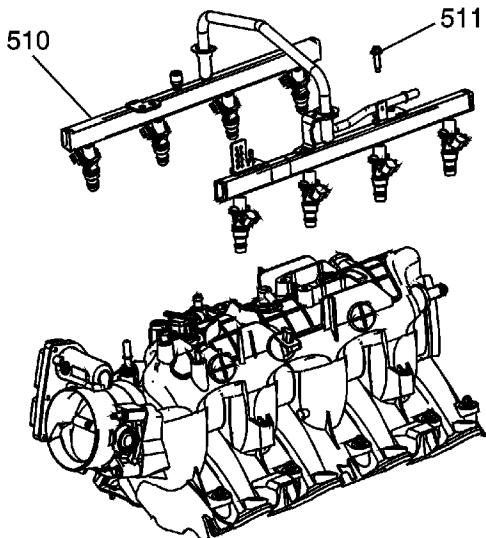
Note: The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the intake manifold as a complete assembly.

1. Remove the fuel rail stop bracket and bolt, as required.





2. Remove the evaporative emission (EVAP) canister purge solenoid valve (730) and tubes (729, 735).

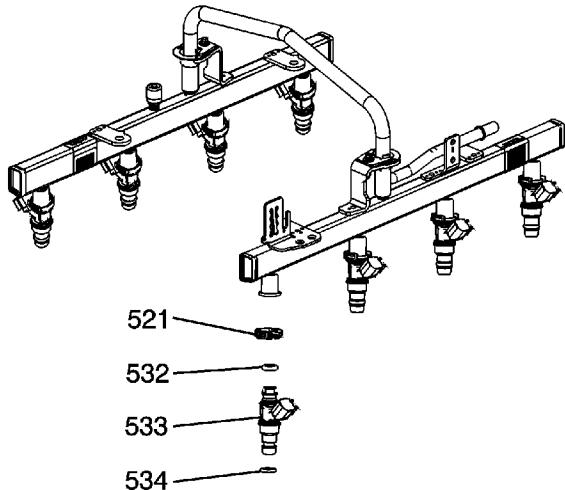


3. Remove the fuel rail bolts (511).

Note:

- Do not separate the fuel injectors from the fuel rail, unless component service is required.
- Use cleanliness and care when handling the fuel system components.
- Do not allow dirt or debris to enter the fuel injectors or fuel rail components. Cap ends, as necessary.

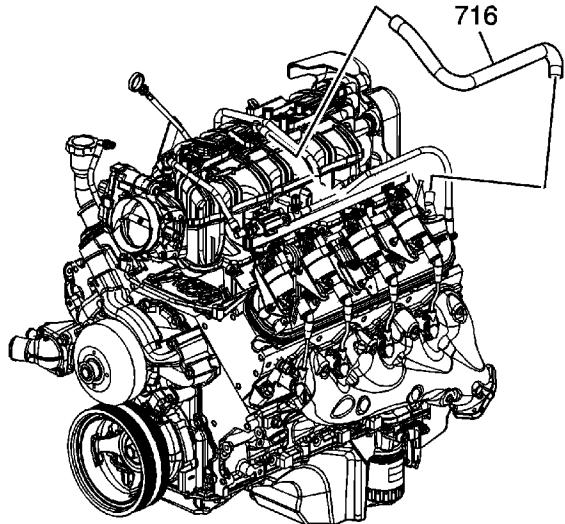
4. Remove the fuel rail (510) with injectors. Lift evenly on both sides of the fuel rail until all the injectors have left their bores.



5. Remove the fuel injector retainers (521) and fuel injectors (533), as required.
6. Remove the O-rings (532, 534) from the injectors, as required.

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[Engine Mechanical - 4.8L, 5.3L, 6.0L, 6.2L, or 7.0L](#) | [Repair Instructions - Off Vehicle](#) | Document ID: 1789864

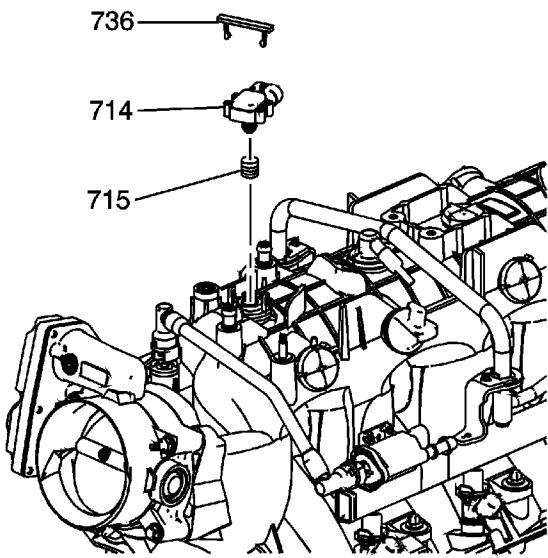
Intake Manifold Removal (RPO LH6/LMG/LY5/LC9/L76)



Important:

- The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.
- DO NOT use the intake manifold-to-cylinder head gaskets again.

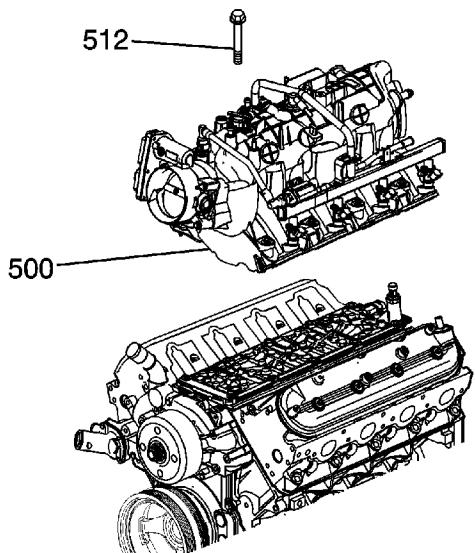
1. Remove the positive crankcase ventilation (PCV) hose - dirty air (716).



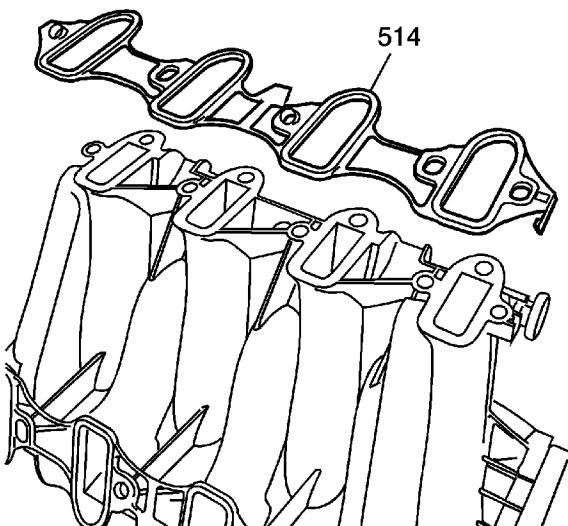
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2. Remove the manifold absolute pressure (MAP) sensor (714) and retainer (736), as required.
3. Remove the O-ring (715) from the sensor, as required.

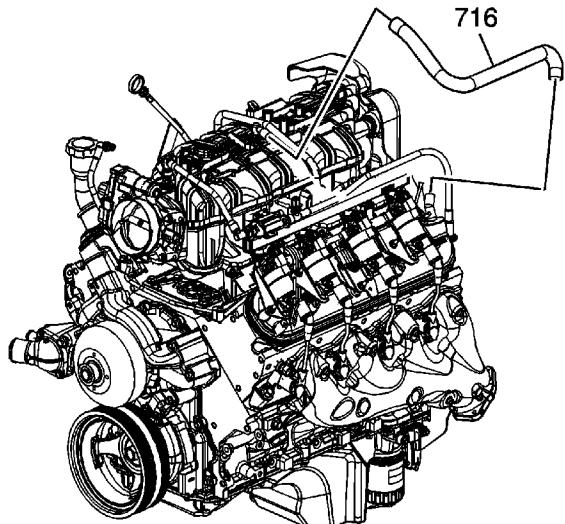


4. Remove the intake manifold bolts (512).
5. Remove the intake manifold (500) with gaskets.



6. Remove the intake manifold gaskets (514).
7. Discard the intake manifold gaskets.

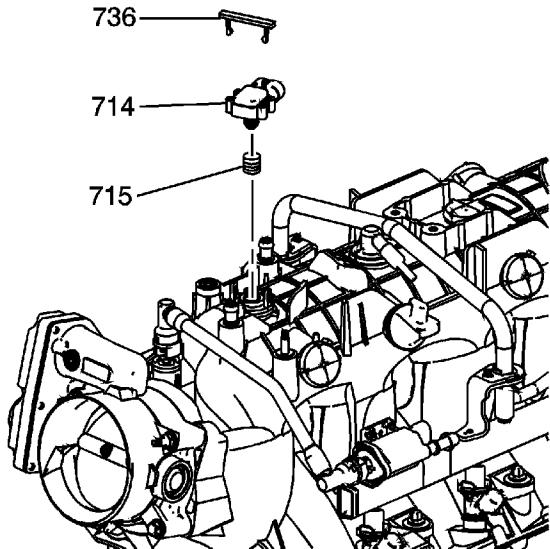
Intake Manifold Removal (RPO LY2/LY6/L9H)



Important:

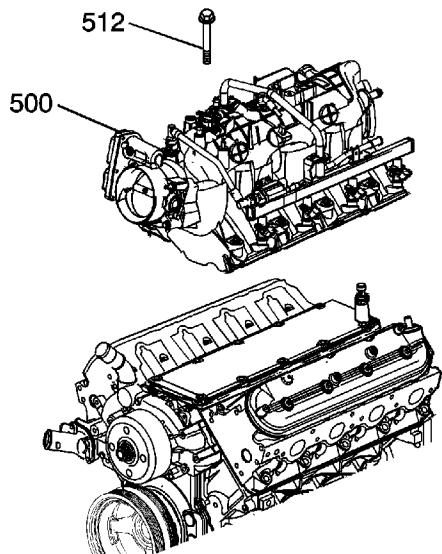
- The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.
- DO NOT use the intake manifold-to-cylinder head gaskets again.

1. Remove the positive crankcase ventilation (PCV) hose - dirty air (716).

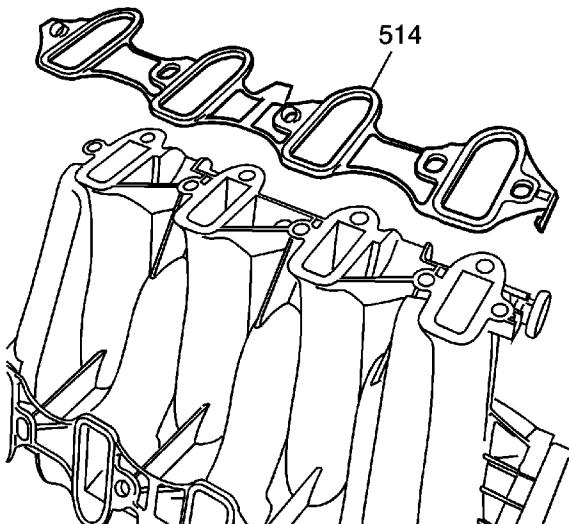




2. Remove the manifold absolute pressure (MAP) sensor (714) and retainer (736), as required.
3. Remove the O-ring (715) from the sensor, as required.



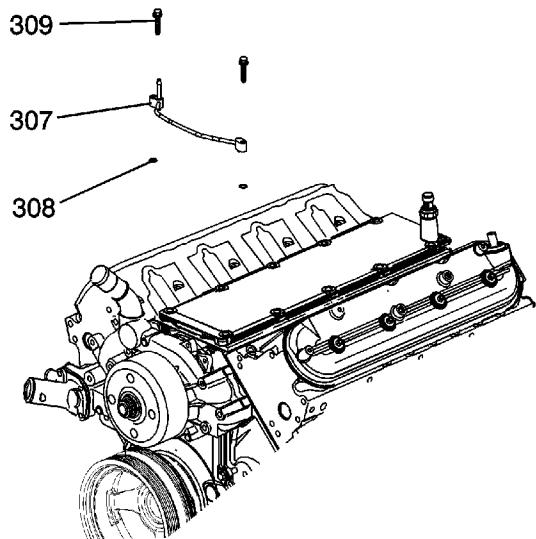
4. Remove the intake manifold bolts (512).
5. Remove the intake manifold (500) with gaskets.



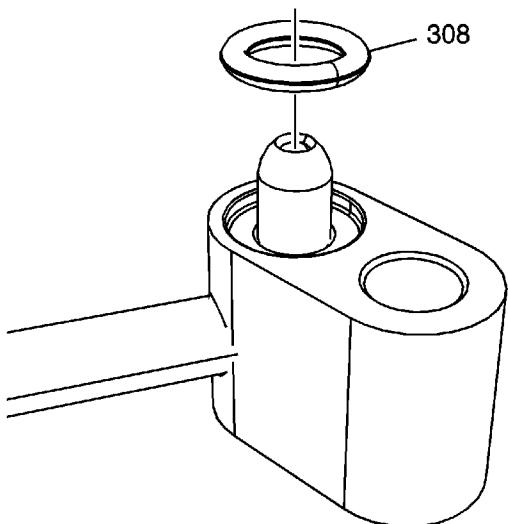
6. Remove the intake manifold gaskets (514).
7. Discard the intake manifold gaskets.

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[Engine Mechanical - 4.8L, 5.3L, 6.0L, 6.2L, or 7.0L](#) | [Repair Instructions - Off Vehicle](#) | **Document ID: 2045238**

Engine Coolant Air Bleed Pipe and Hole Cover Removal (RPO LY2/LY6/L9H)

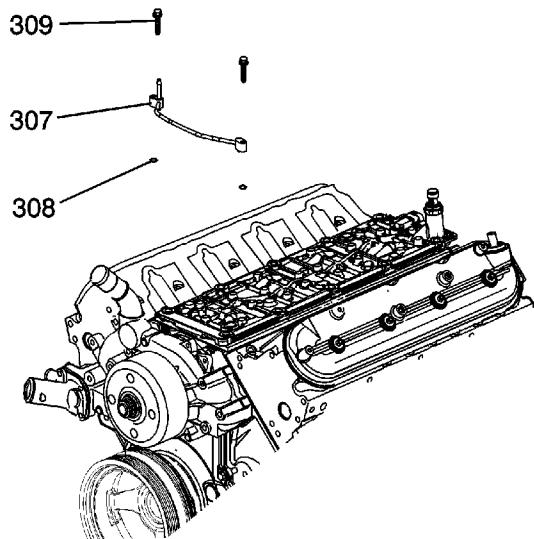


1. Remove the engine coolant air bleed pipe bolts (309).
2. Remove the pipe (307) with seals (308).

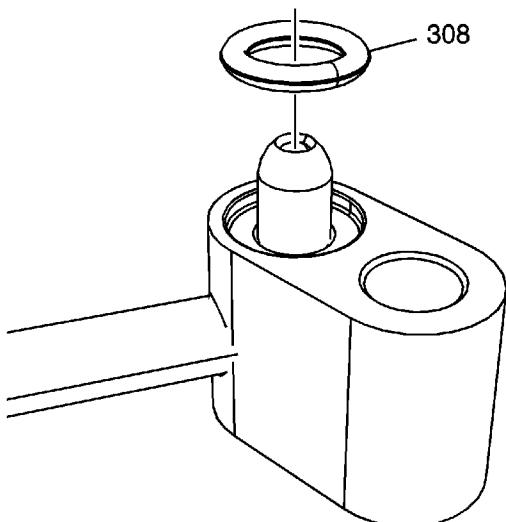


3. Remove the seals (308) from the pipe.
4. Discard the seals.

Engine Coolant Air Bleed Pipe and Hole Cover Removal (RPO LH6/LMG/LY5/LC9/L76)

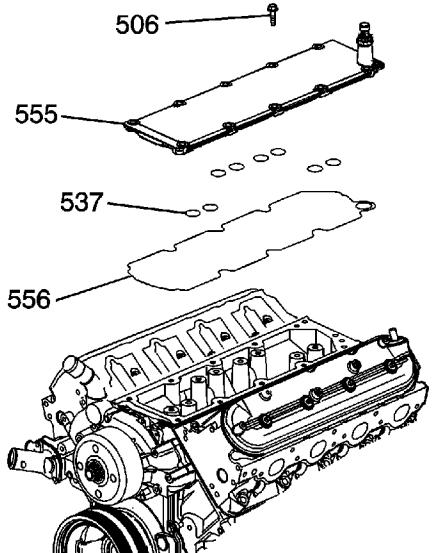


1. Remove the engine coolant air bleed pipe bolts (309).
2. Remove the pipe (307) with seals (308).

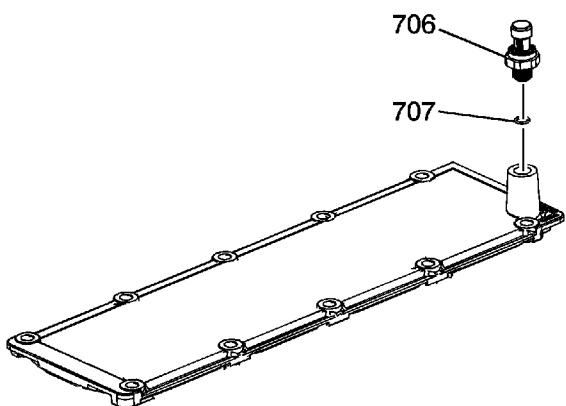


3. Remove the seals (308) from the pipe.
4. Discard the seals.

Engine Block Valley Cover Removal

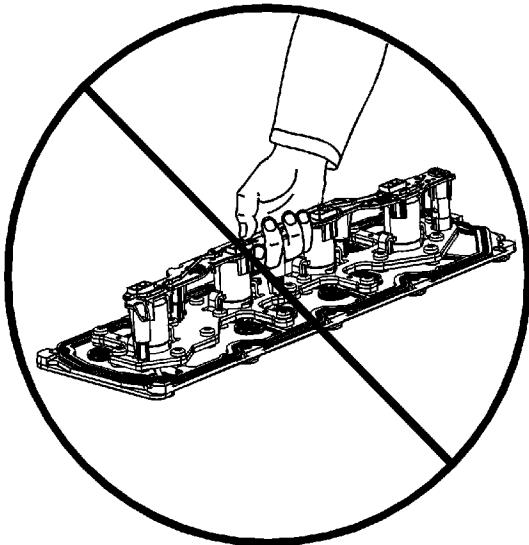


1. Remove the valley cover bolts (506).
2. Remove the valley cover (555) and gasket (556).
3. Remove the O-ring seals (537) from the cover.

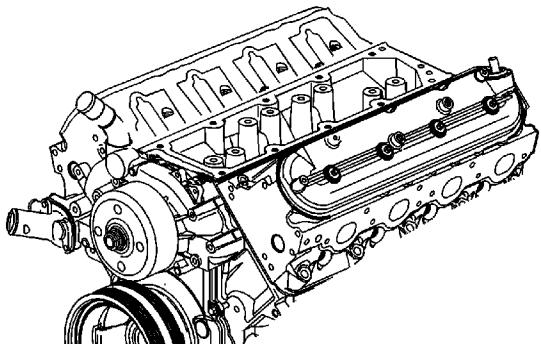
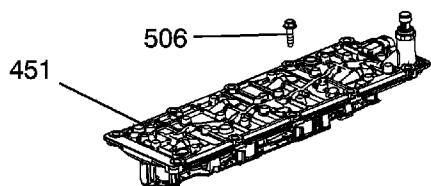


4. Remove the oil pressure sensor (706) and washer (707), as required.

Valve Lifter Oil Manifold Removal



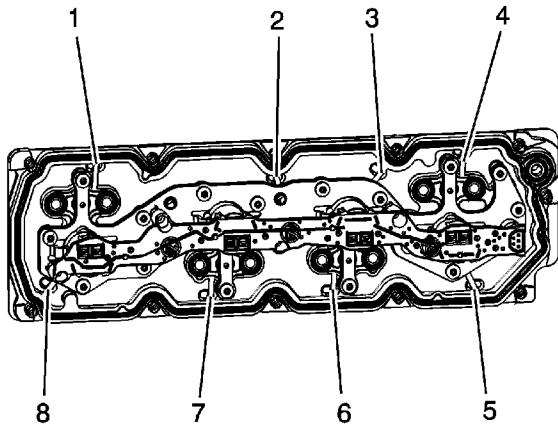
1. Do not lift the manifold by the electrical lead frame.



2. Remove the valve lifter oil manifold bolts (506).

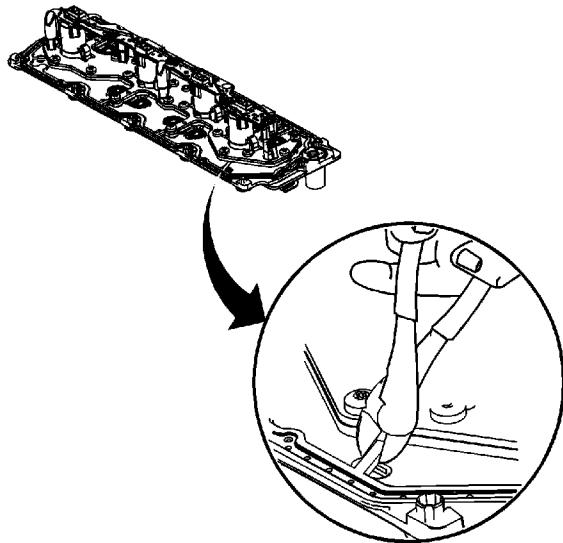
Important: Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.

3. Remove the valve lifter oil manifold (451).
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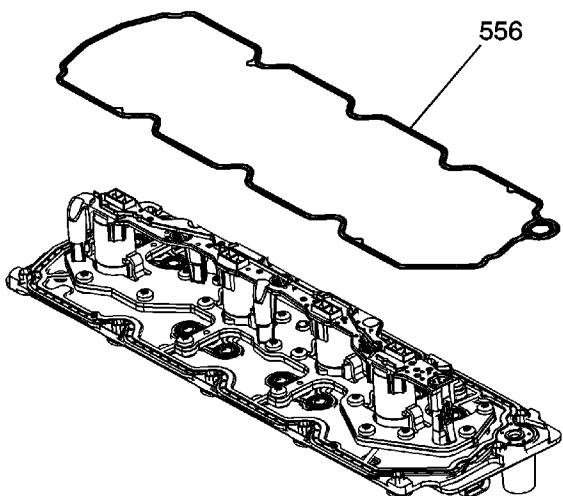


Important: Remove only the outer gasket from the manifold. Do not disassemble any of the internal components of the manifold in an attempt to remove the 8 inner sealing gaskets. If the inner gaskets are cut or damaged, replace the manifold as an assembly. Only use a wire-cutter type tool in order to minimize the amount of debris. Do not use a rotary-type cutting tool on the retaining straps.

4. Identify the 8 gasket retaining strap locations (1-8).

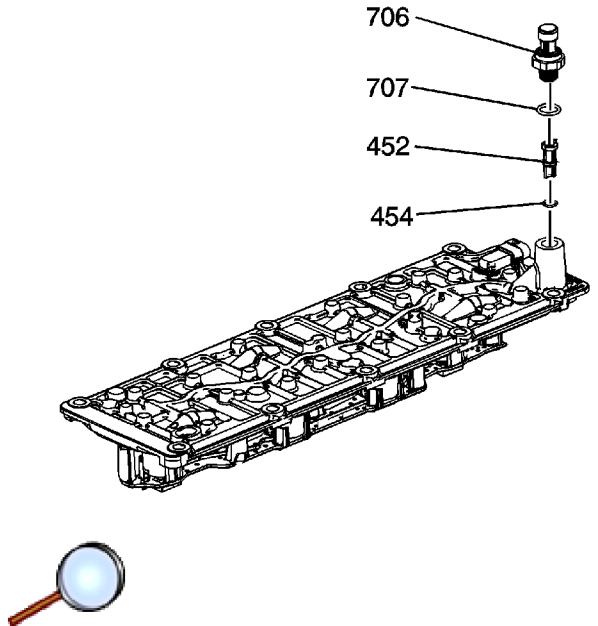


5. Using a wire-cutter type tool, cut the 8 retaining straps.



6. Remove the outer gasket (556) from the manifold.

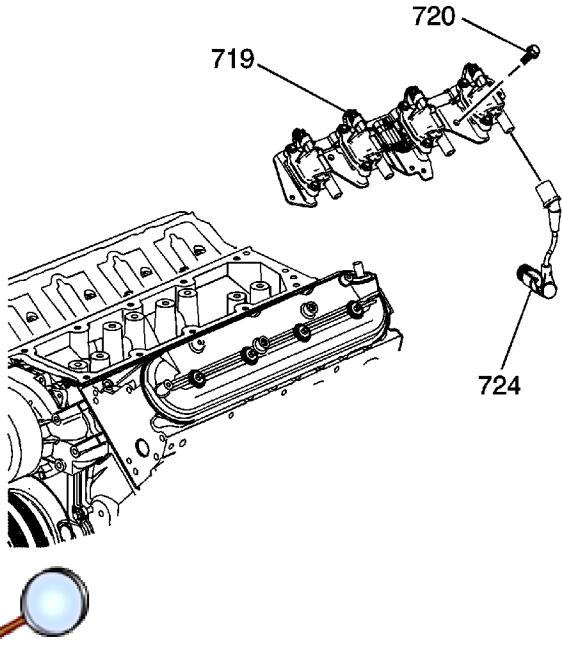
Valve Lifter Oil Filter Removal



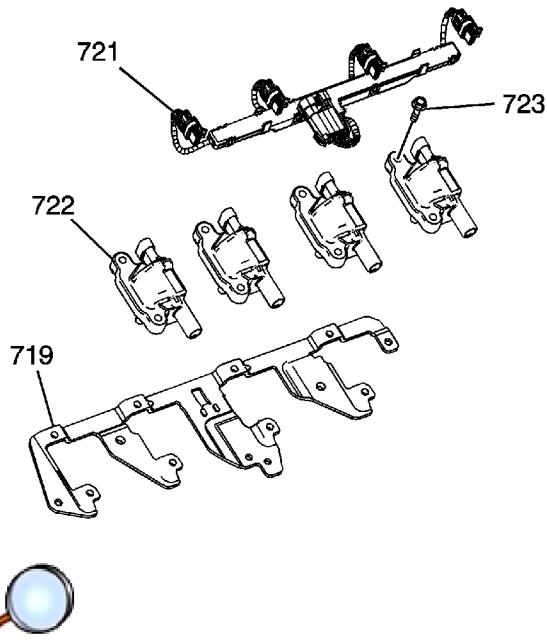
Important: Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.

1. Remove the oil pressure sensor (706).
2. Remove the oil filter (452).
3. Inspect the O-ring (454) for cuts or damage. If the filter is plugged or the O-ring is cut or damaged, replace the filter and O-ring as an assembly.

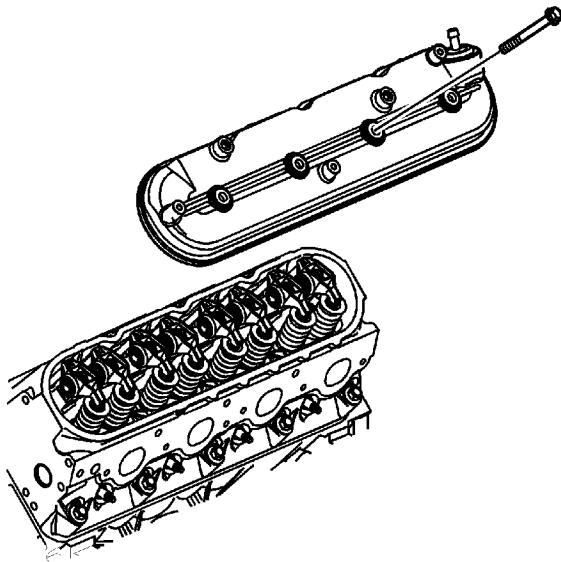
Valve Rocker Arm Cover Removal - Left Side



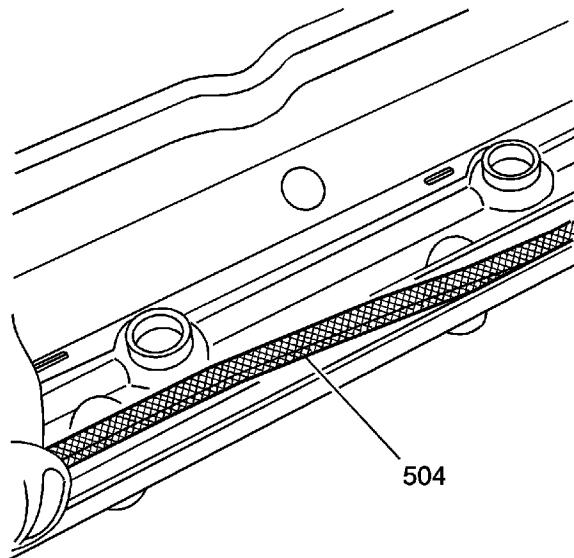
1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket studs (720).
3. Remove the ignition coil and bracket assembly (719).



4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket (719), as required.

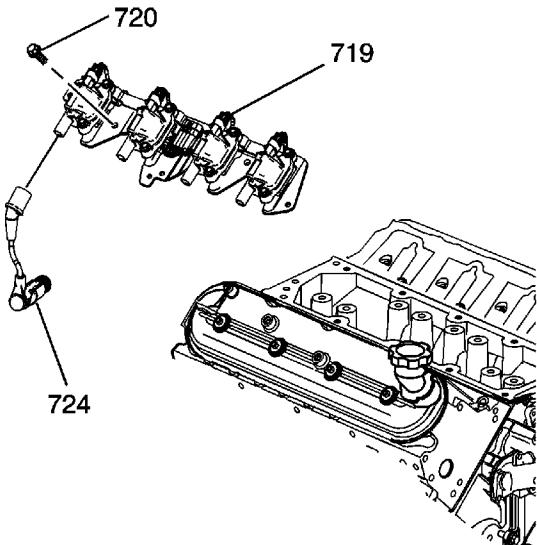


6. Remove the valve rocker arm cover bolts and cover.
7. Remove and discard the valve rocker arm cover gasket, valve rocker arm cover grommets and valve rocker arm cover bolts if they are serviced with the grommet.



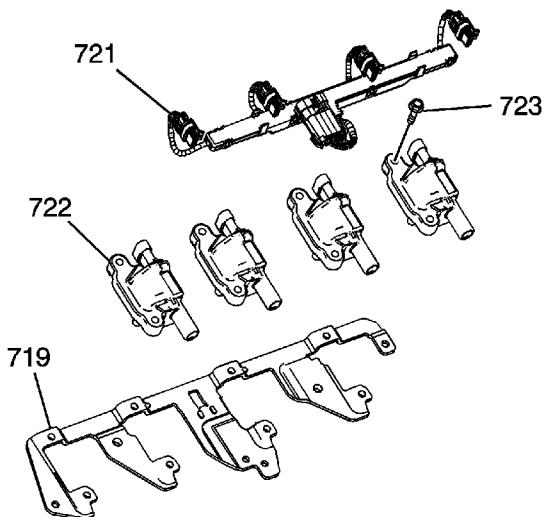
8. Remove the gasket (504) from the cover.

Valve Rocker Arm Cover Removal - Right Side



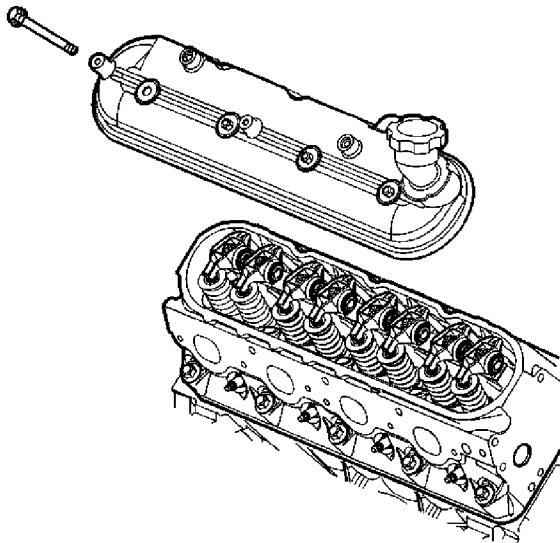
Important: Do not remove the oil fill tube from the cover, unless service is required. If the oil fill tube has been removed from the cover, install a NEW tube during assembly.

1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket studs (720).
3. Remove the ignition coil and bracket assembly (719).

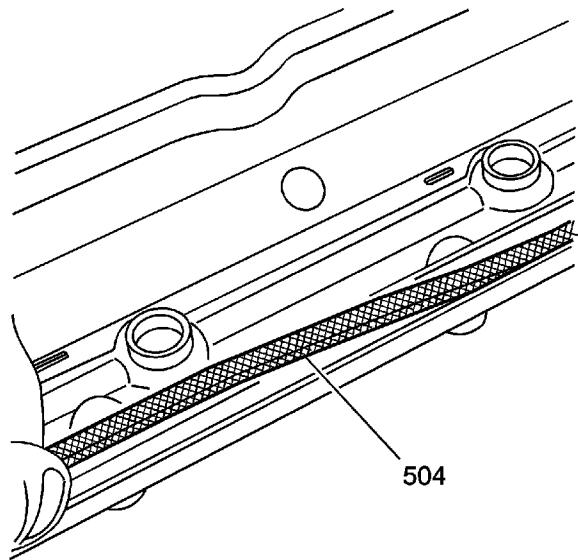


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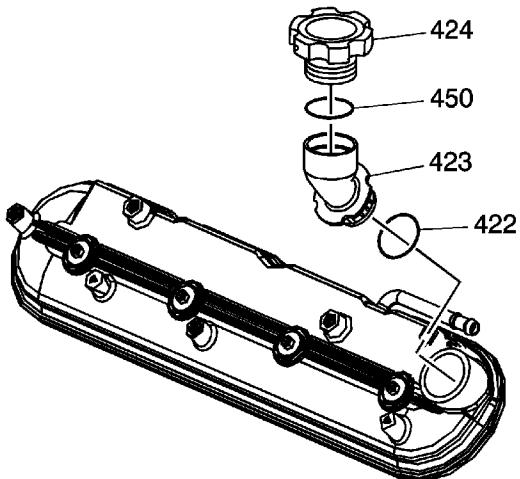
4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket (719), as required.



6. Remove the valve rocker arm cover bolts and cover.
7. Remove and discard the valve rocker arm cover gasket, valve rocker arm cover grommets and valve rocker arm cover bolts if they are serviced with the grommet.

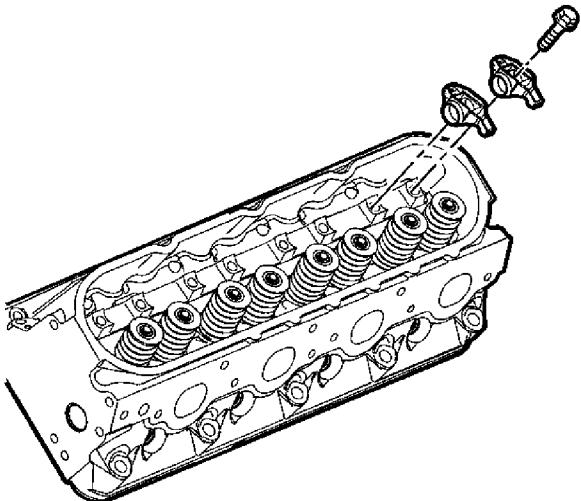


8. Remove the gasket (504) from the cover.



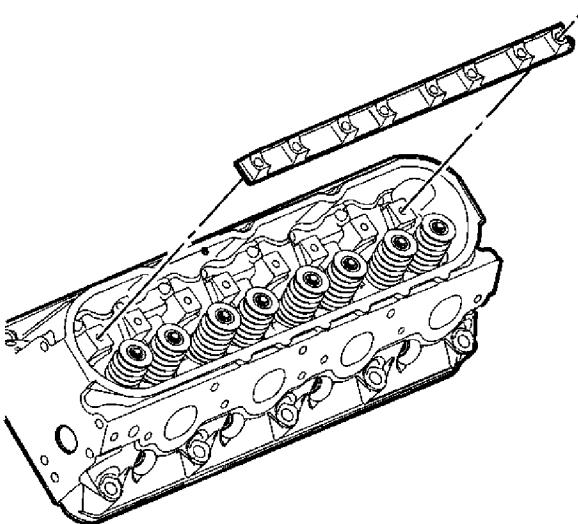
9. Remove the oil fill cap (424) from the oil fill tube (423).
10. Remove the oil fill tube, as required.
11. Discard the oil fill tube.

Valve Rocker Arm and Push Rod Removal (RPO LY2/LH6/LMG/LY5/LC9)

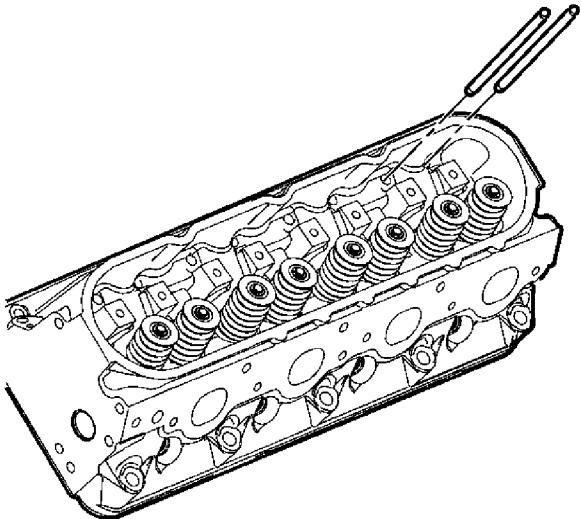


Important: Place the valve rocker arms, valve pushrods, and pivot support, in a rack so they can be installed in the same location from which they were removed.

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



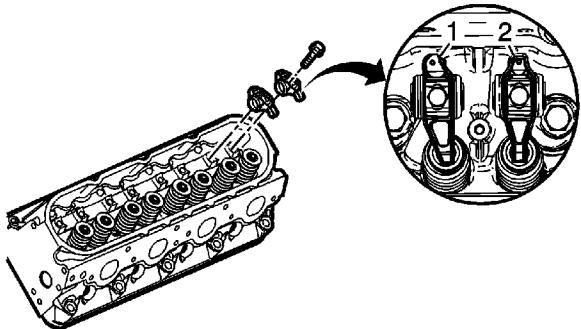
3. Remove the valve rocker arm pivot support.



4. Remove the pushrods.



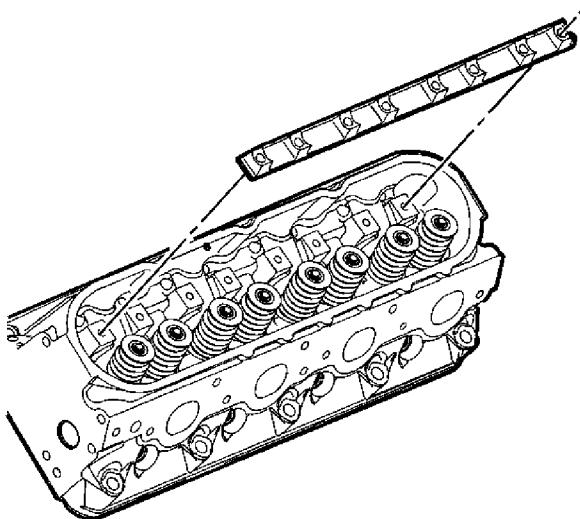
Valve Rocker Arm and Push Rod Removal (RPO LY6/L76/L9H)



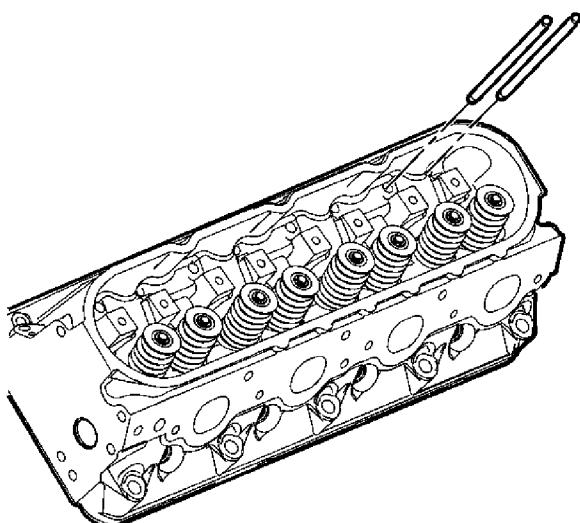
Important: Place the valve rocker arms, valve pushrods, and pivot support, in a rack so they can be installed in the same location from which they were removed.

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

The intake rocker arms (1) have an offset design.

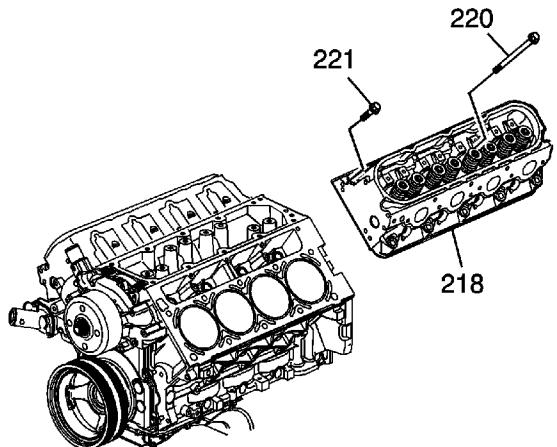


3. Remove the valve rocker arm pivot support.



4. Remove the pushrods.

Cylinder Head Removal - Left Side

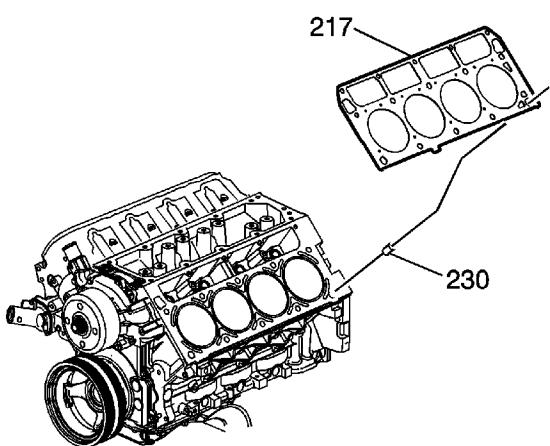


Note: The cylinder head bolts are of a torque-to-yield design and are NOT to be used again. Install NEW cylinder head bolts during assembly.

1. Remove the cylinder head bolts (220, 221).

Caution: After removal, place the cylinder head on 2 wood blocks in order to prevent damage to the sealing surfaces.

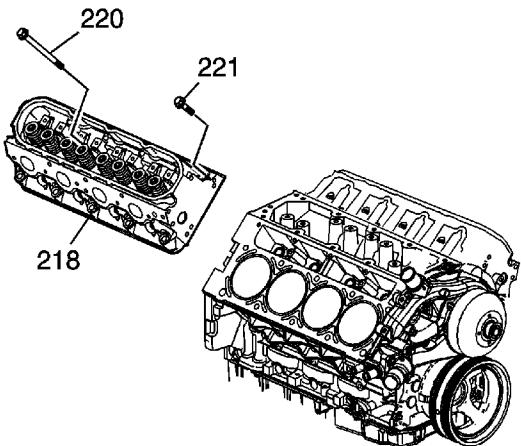
2. Remove the cylinder head (218).





3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

Cylinder Head Removal - Right Side

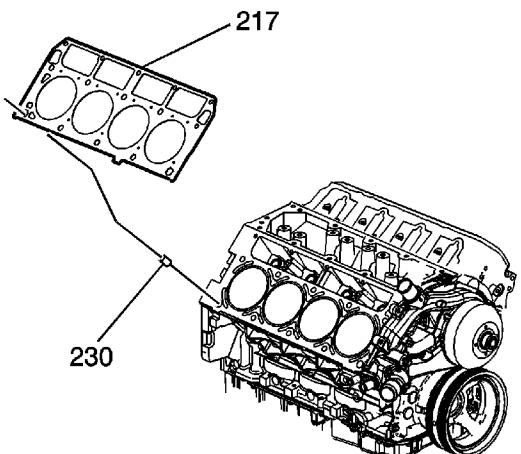


Note: The cylinder head bolts are of a torque-to-yield design and are NOT to be used again. Install NEW cylinder head bolts during assembly.

1. Remove the cylinder head bolts (220, 221).

Caution: After removal, place the cylinder head on 2 wood blocks in order to prevent damage to the sealing surfaces.

2. Remove the cylinder head (218).

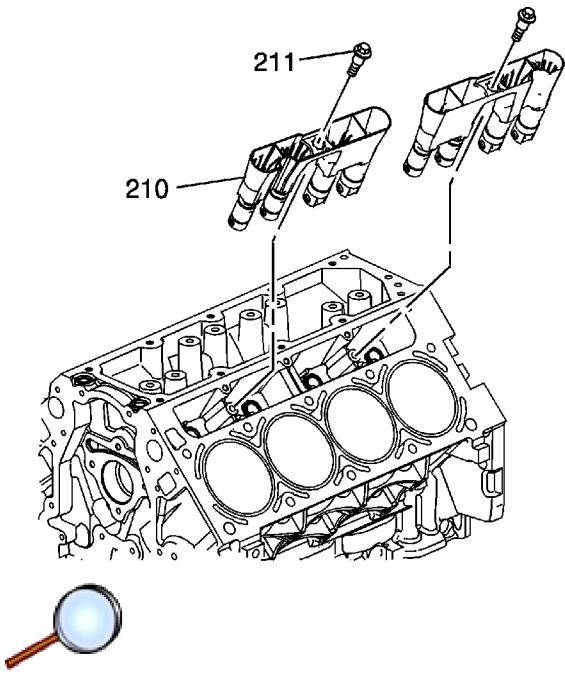




3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

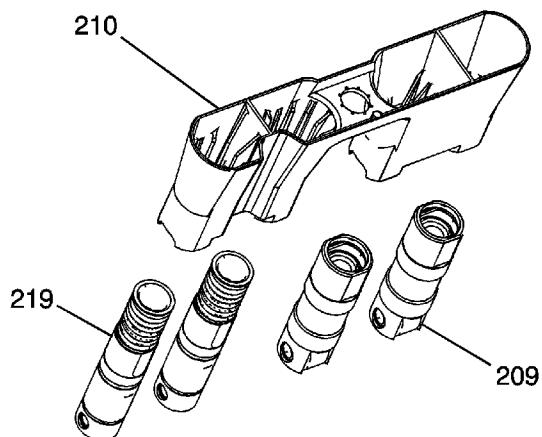
[2009 Chevrolet Silverado - 4WD](#) | [Sierra, Silverado \(VIN C/K\) Service Manual](#) | [Engine](#) |
[Engine Mechanical - 4.8L, 5.3L, 6.0L, 6.2L, or 7.0L](#) | [Repair Instructions - Off Vehicle](#) | Document ID: 1789928

Valve Lifter Removal (RPO LH6/LMG/LY5/LC9/L76)



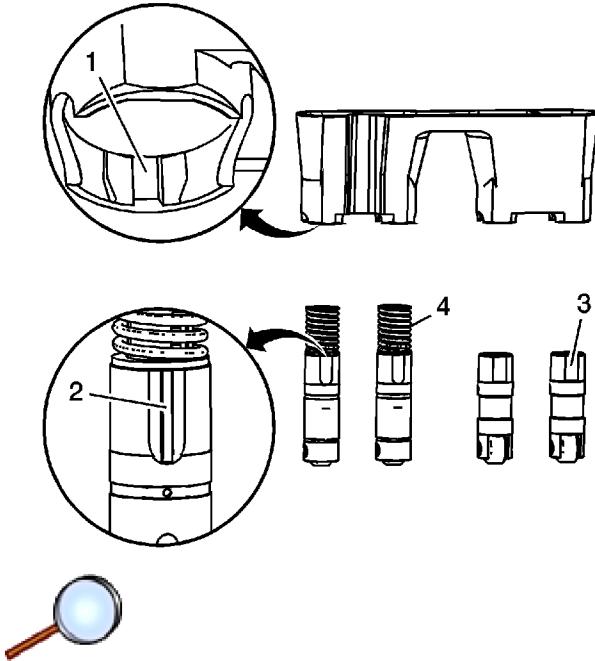
1. Remove the bolts (211).
2. Remove the guides (210) with lifters.

Note the installed position of the guides. The notched area of the guide is to align with the locating tab of the block.



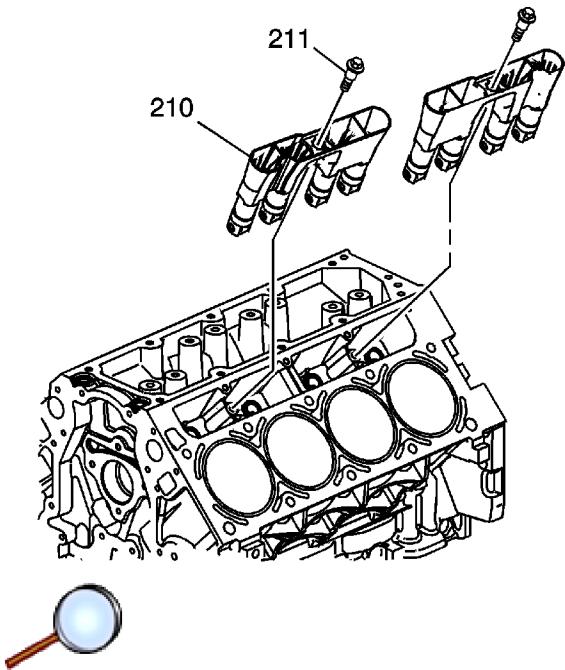
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3. Remove the valve lifters (209, 219) from the guide (210).



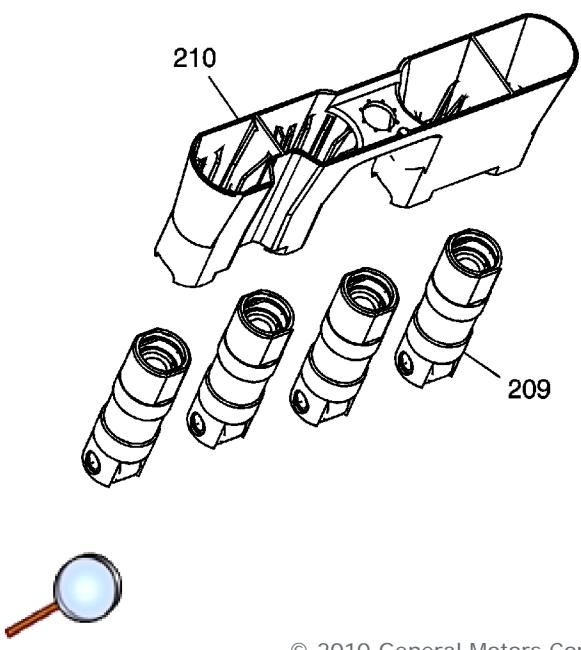
4. Organize or mark the components so they can be installed in the same location from which they were removed. The active fuel management lifters (4) are installed into the guide by aligning the notched area of the guide (1) with the raised surface on the side of the lifter (2). Refer to [Separating Parts](#).

Valve Lifter Removal (RPO LY2/LY6/L9H)



1. Remove the guide bolts (211).
2. Remove the guides (210) with lifters.

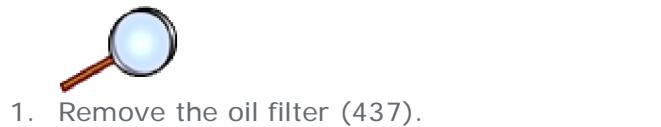
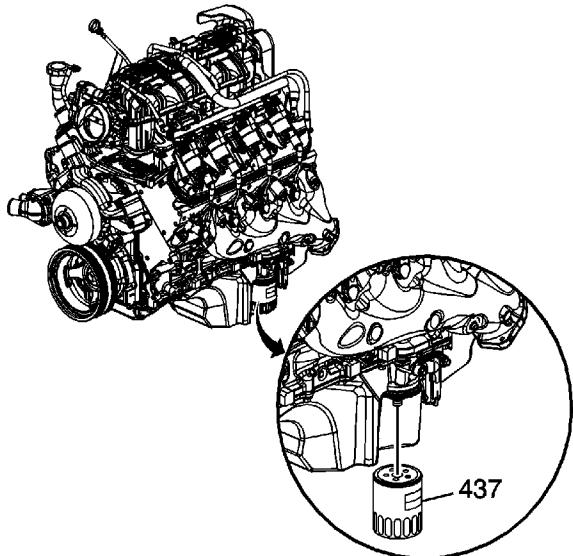
Note the installed position of the guides. The notched area of the guide is to align with the locating tab on the block.



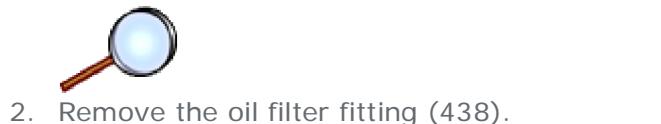
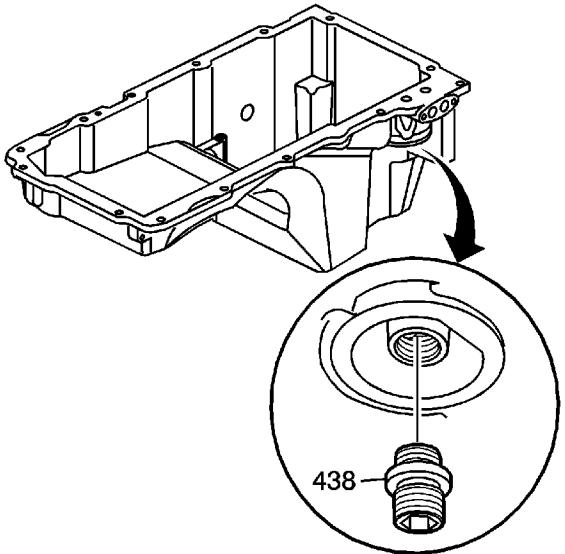
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3. Remove the valve lifters (209) from the guide (210).
4. Organize or mark the components so they can be installed in the same location from which they were removed. Refer to [Separating Parts](#).

Oil Filter Removal

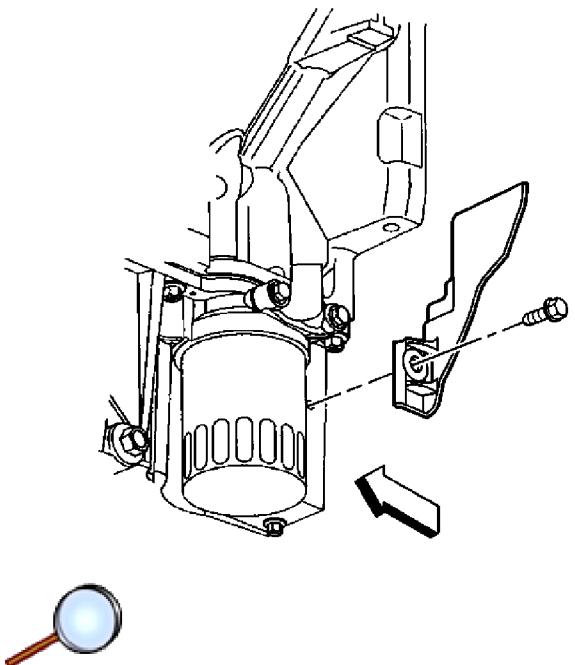


1. Remove the oil filter (437).



2. Remove the oil filter fitting (438).

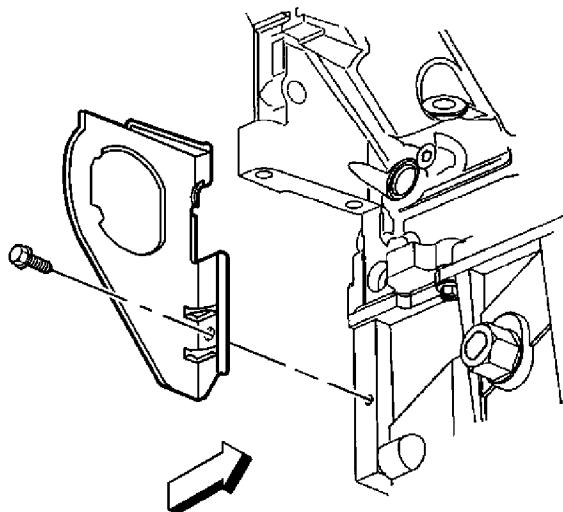
Oil Pan Removal



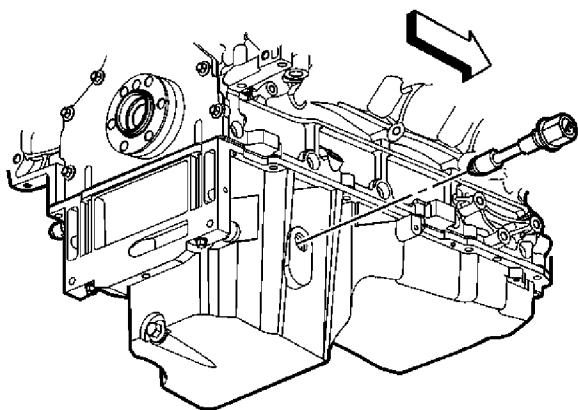
Important:

- The original oil pan gasket is retained and aligned to the oil pan by rivets. When installing a new gasket, it is not necessary to install new oil pan gasket rivets.
- DO NOT use the oil pan gasket again. When installing the oil pan, install a NEW oil pan gasket.
- It is not necessary to remove the oil level indicator switch prior to oil pan removal. Remove the oil level indicator switch, if service is required.

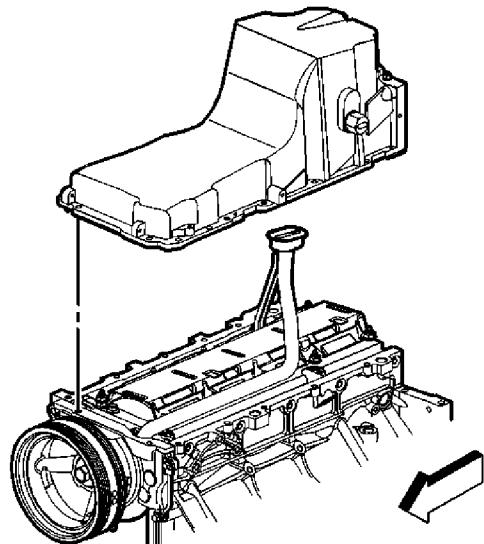
1. Remove the left closeout cover and bolt.



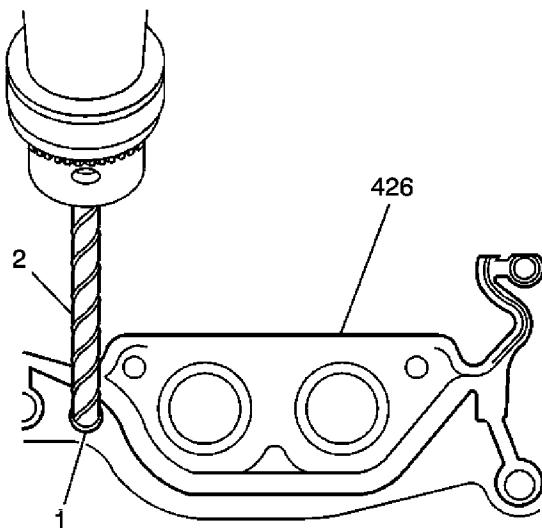
2. Remove the right closeout cover and bolt.



3. Remove the oil indicator switch from the oil pan, if required.



4. Remove the oil pan bolts.
5. Remove the oil pan.



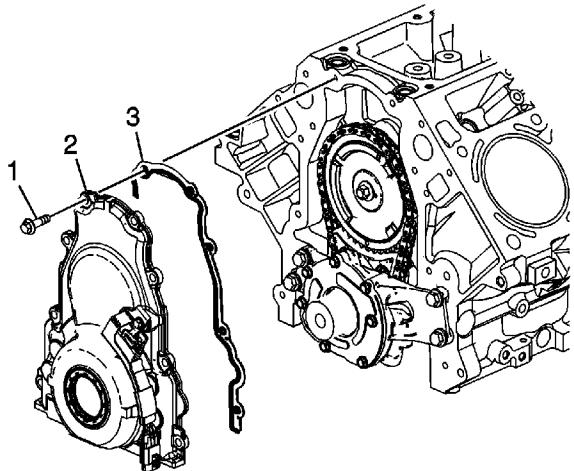
Important:

- DO NOT allow foreign material to enter the oil passages of the oil pan. Cap or cover the openings, as required.
- Use care not to gouge, score, or damage the oil pan sealing surface.

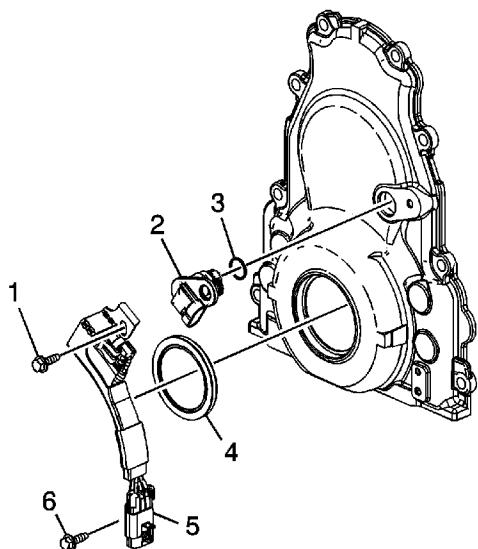
6. Drill (2) out the oil pan gasket retaining rivets (1), if required.
7. Remove the gasket (426) from the pan.
8. Discard the gasket and rivets.

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Engine Front Cover Removal (RPO LY2/LH6/LMG/LY5/LC9)



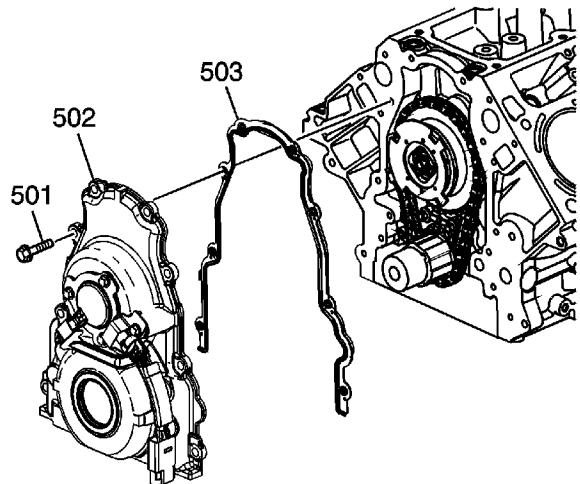
1. Remove the front cover bolts (1).
2. Remove the front cover (2) and gasket (3).
3. Discard the front cover gasket.



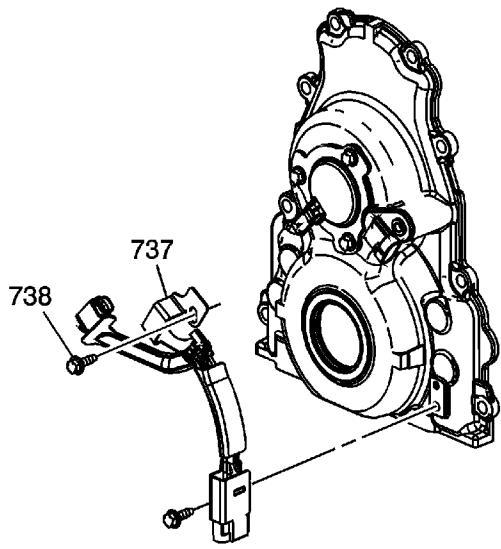
4. Remove the oil seal (4).
5. Remove the bolts (1, 6), camshaft position (CMP) sensor (2), and wire harness (5).
6. Remove the O-ring (3) from the sensor, as required.

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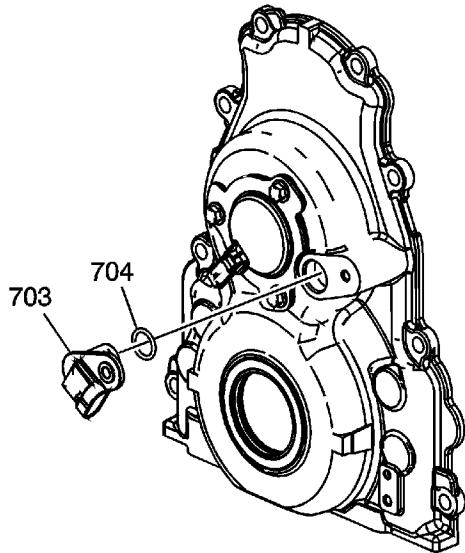
Engine Front Cover Removal (RPO LY6/L76/L9H)



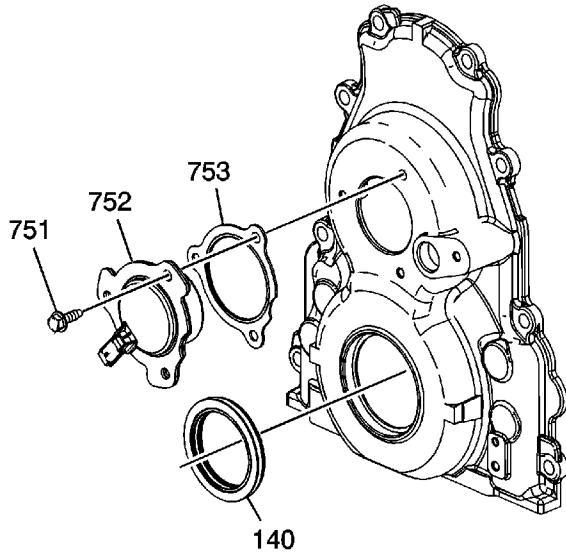
1. Remove the front cover bolts (501).
2. Remove the front cover (502) and gasket (503).
3. Discard the front cover gasket.



4. Remove the camshaft position (CMP) sensor wire harness (737) and bolts (738).

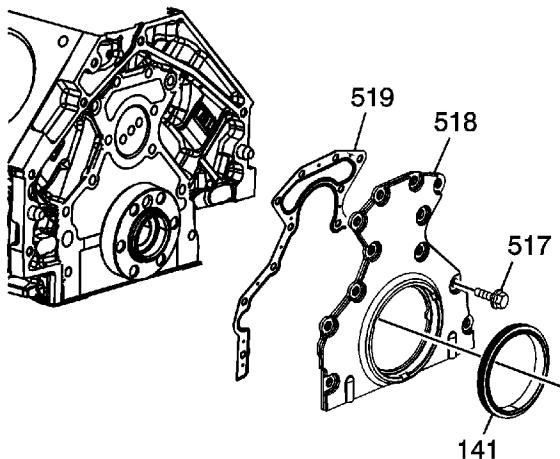


5. Remove the CMP sensor (703).
6. Remove the O-ring (704) from the sensor, as required.



7. Remove the CMP actuator magnet (752), bolts (751), and gasket (753).
8. Remove the oil seal (140).

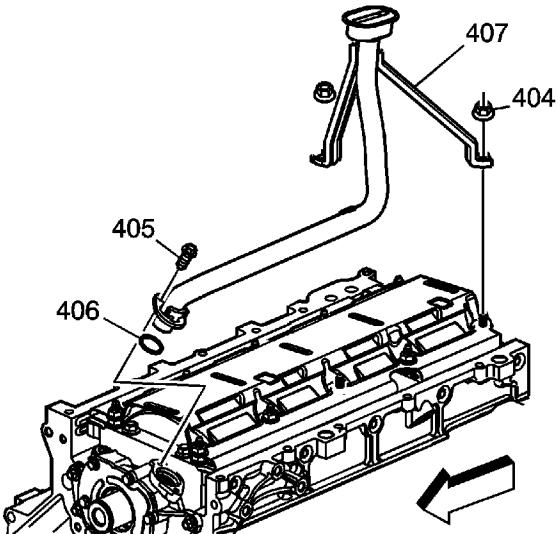
Crankshaft Rear Oil Seal Housing Removal



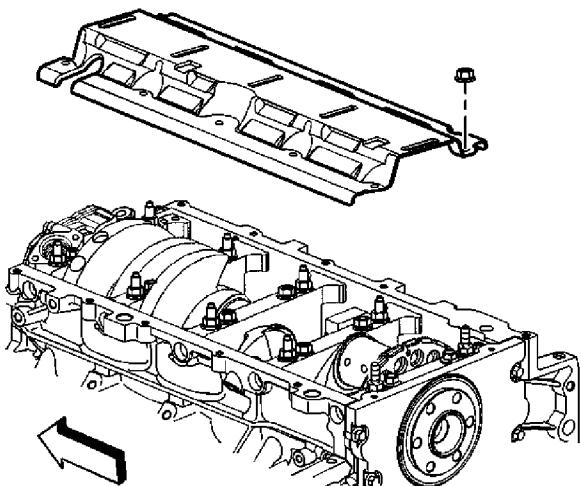
1. Remove the rear oil seal housing bolts (517).
2. Remove the housing (518) and gasket (519).
3. Remove the rear oil seal (141).

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[Engine Mechanical - 4.8L, 5.3L, 6.0L, 6.2L, or 7.0L](#) | [Repair Instructions - Off Vehicle](#) | Document ID: 1789949

Oil Pump, Screen and Crankshaft Oil Deflector Removal (RPO LY2/LH6/LMG/LY5/LC9)

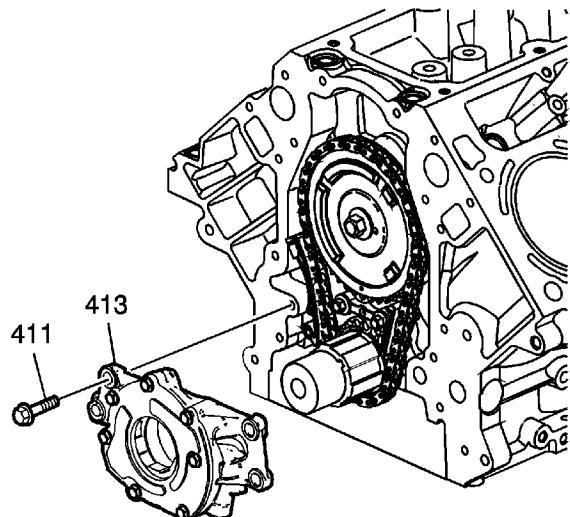


1. Remove the oil pump screen bolt (405) and nuts (404).
2. Remove the oil pump screen (407) with O-ring seal (406).
3. Remove the O-ring seal from the pump screen.
4. Discard the O-ring seal.



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

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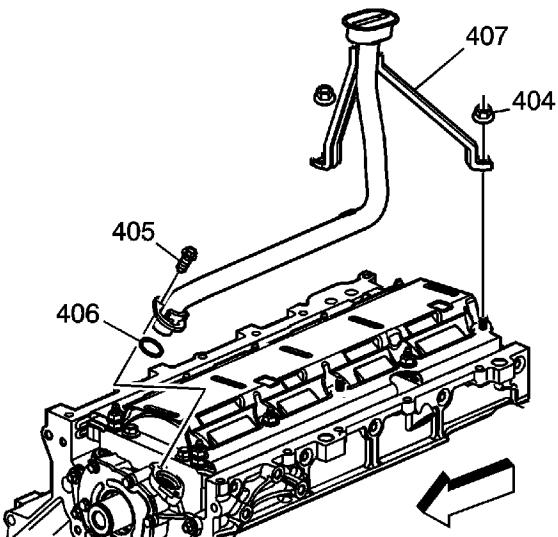
7. Remove the oil pump bolts (411).

Important: Do not allow dirt or debris to enter the oil pump assembly. Cap ends, as necessary.

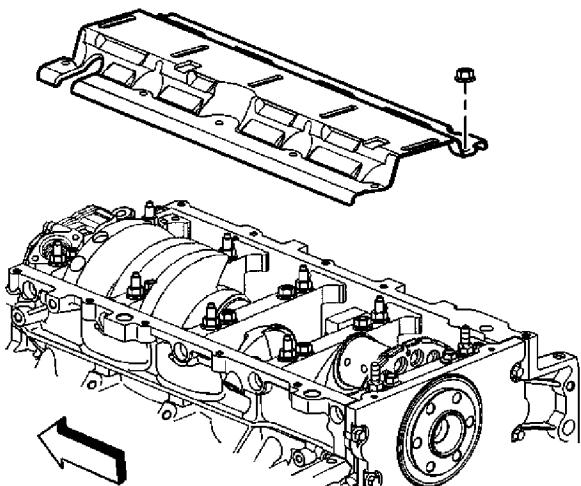
8. Remove the oil pump (413).

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[Engine Mechanical - 4.8L, 5.3L, 6.0L, 6.2L, or 7.0L](#) | [Repair Instructions - Off Vehicle](#) | Document ID: 2045769

Oil Pump, Screen and Crankshaft Oil Deflector Removal (RPO LY6/L76/L9H)

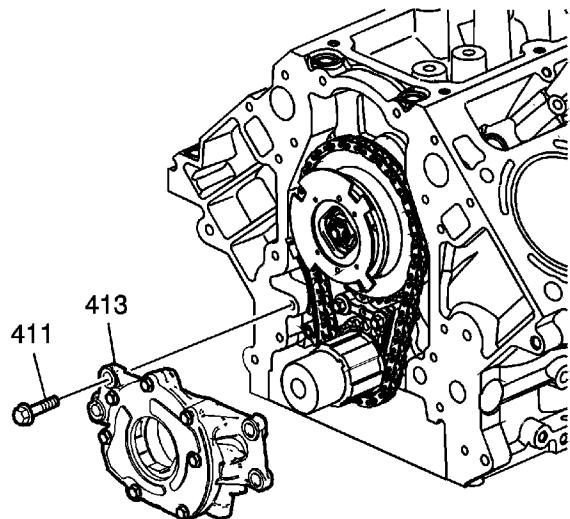


1. Remove the oil pump screen bolt (405) and nuts (404).
2. Remove the oil pump screen (407) with O-ring seal (406).
3. Remove the O-ring seal from the pump screen.
4. Discard the O-ring seal.



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

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7. Remove the oil pump bolts (411).

Important: Do not allow dirt or debris to enter the oil pump assembly. Cap ends, as necessary.

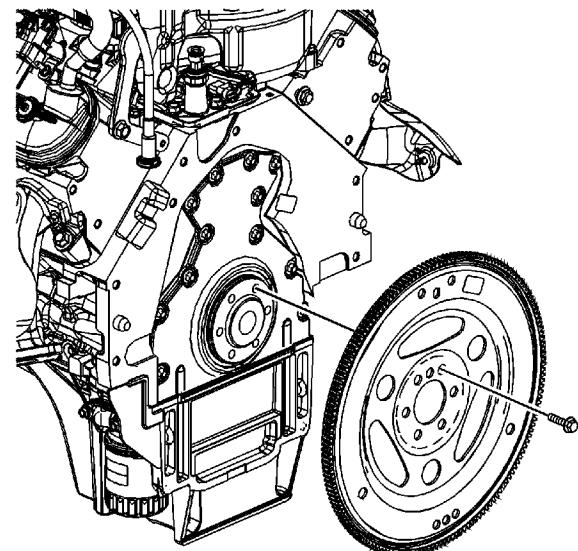
8. Remove the oil pump (413).

Timing Chain and Sprocket Removal

Special Tools

- J8433 Two Jaw Puller
- J41558 Crankshaft Sprocket Remover
- J41816-2 Crankshaft End Protector
- J42386-A Flywheel Holding Tool

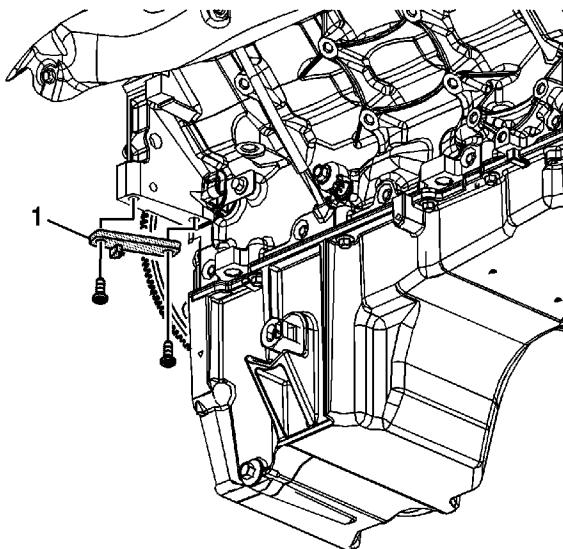
For equivalent regional tools, refer to [Special Tools](#)



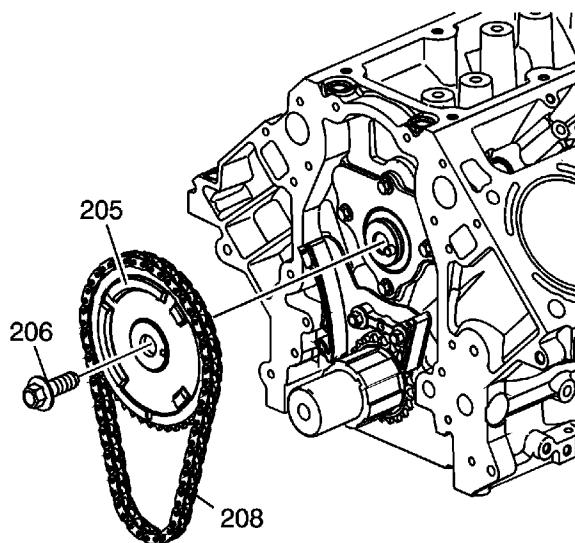
Note: Do not apply threadlock to the flex plate bolts at this time.

1. Temporarily install the automatic transmission flex plate and bolts. Refer to [Automatic Transmission Flex Plate Installation](#).

Caution: Refer to [Fastener Caution](#) in the Preface section.

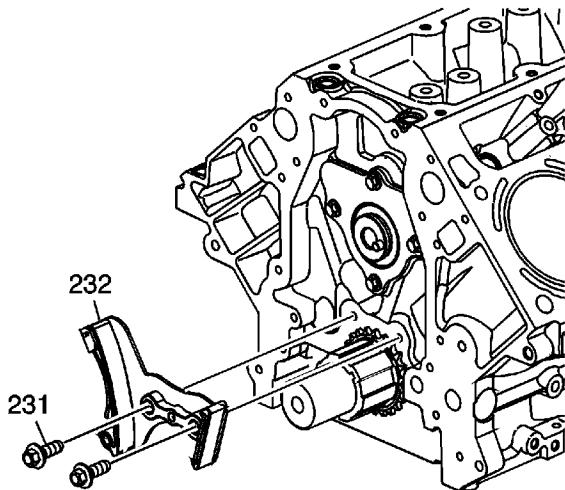


2. Install the *J42386-A* tool (1) and bolts. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation. Tighten the *J42386-A* tool bolts to **50 N·m** (**37 lb ft**).

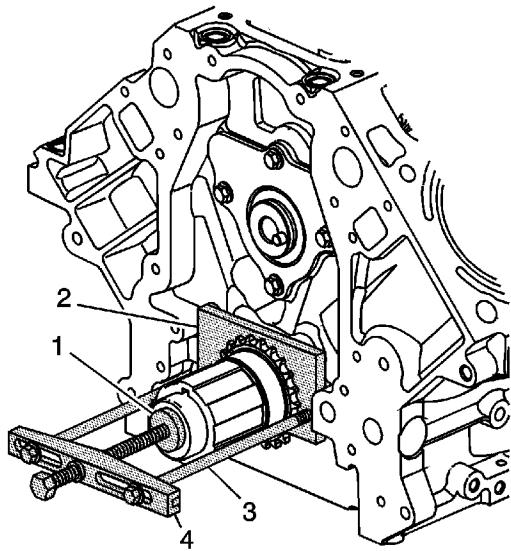


Caution: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

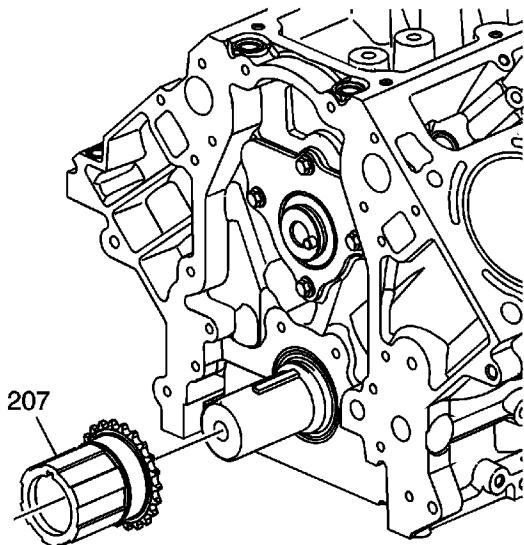
3. Remove and discard the camshaft sprocket bolt (206).
4. Remove the camshaft sprocket (205) and timing chain (208).



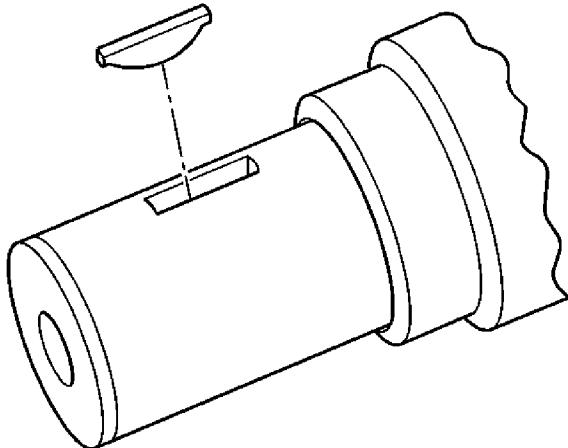
5. Remove the bolts (231) and timing chain tensioner (232).



6. Use the J41816-2 protector (1), the J41558remover (2), bolts (3), and the J8433puller J8433 (4) in order to remove the crankshaft sprocket.



7. Remove the crankshaft sprocket (207).



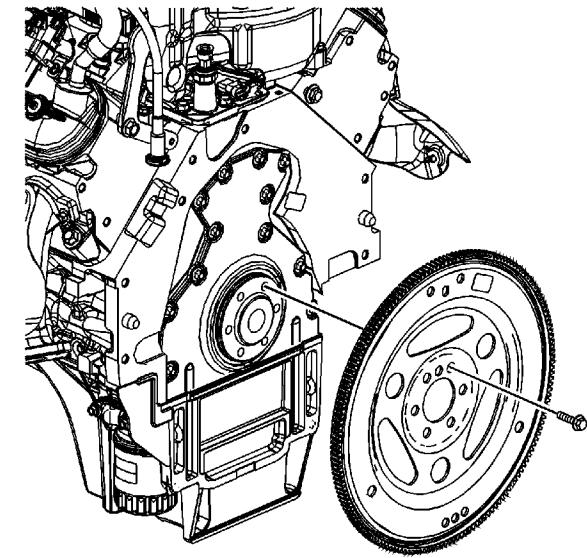
8. Remove the crankshaft sprocket key, as required.
9. Remove the automatic transmission flex plate and bolts. Refer to [Automatic Transmission Flex Plate Removal](#).
10. Remove the *J 42386-A* tool and bolts.

Camshaft Position Actuator and Solenoid Valve Removal

Special Tools

- J8433 Two Jaw Puller
- J41558 Crankshaft Sprocket Remover
- J41816-2 Crankshaft End Protector
- J42386-A Flywheel Holding Tool

For equivalent regional tools, refer to [Special Tools](#)

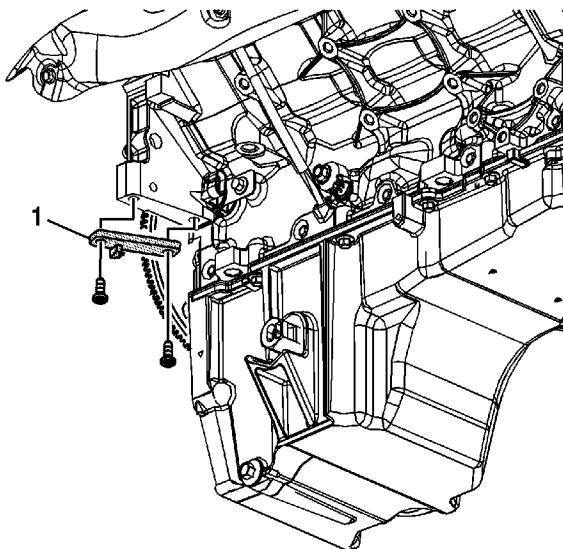


Note:

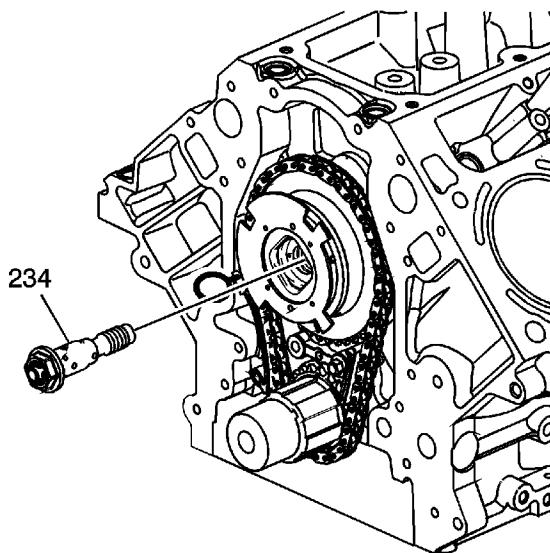
- Do not use the camshaft position (CMP) actuator solenoid valve again. Upon installation of the CMP actuator and timing chain, install a NEW valve.
- Do not apply threadlock to the flex plate bolts at this time.

1. Temporarily install the automatic transmission flex plate and bolts. Refer to [Automatic Transmission Flex Plate Installation](#).

Caution: Refer to [Fastener Caution](#) in the Preface section.

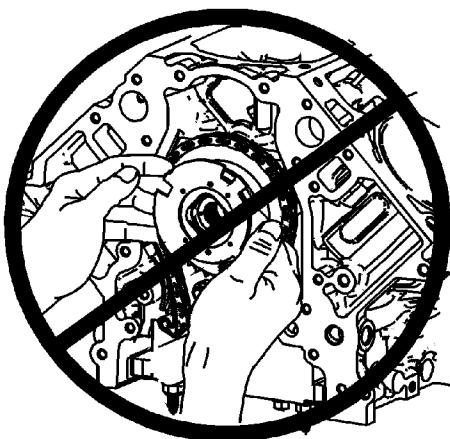
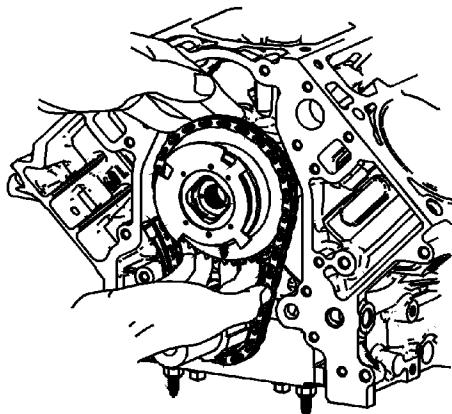


2. Install the J42386-A tool (1) and bolts. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation. Tighten the J42386-A tool bolts to **50 N·m** (**37 lb ft**).

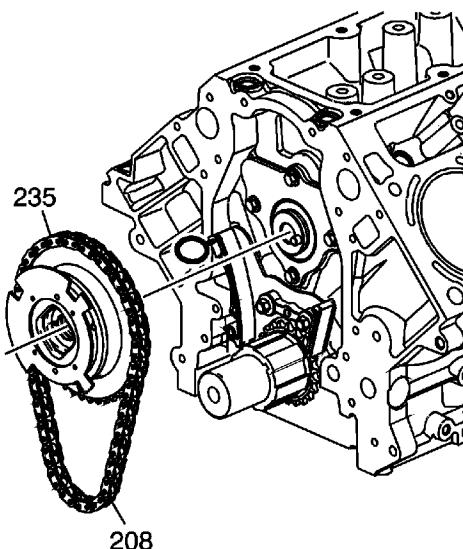


3. Remove the CMP actuator solenoid valve (234).
4. Discard the solenoid valve.

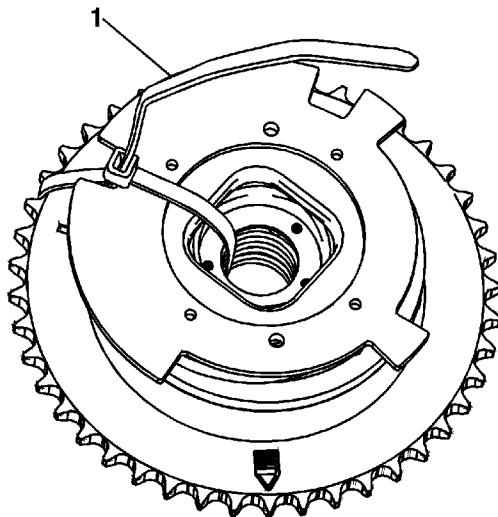
Warning: Refer to [Camshaft Position Actuator Removal and Installation Warning](#) in the Preface section.



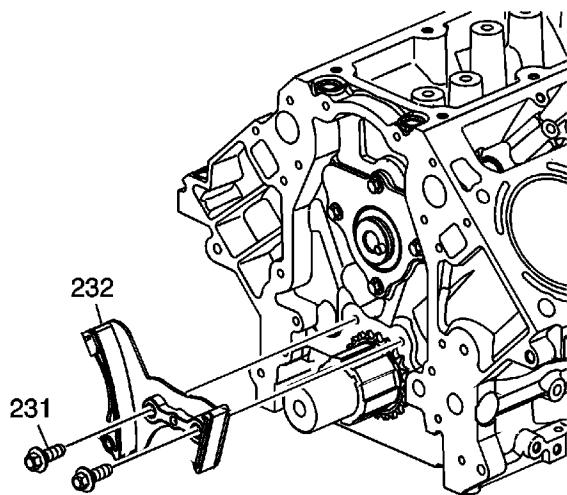
5. Loosen and separate the CMP actuator and timing chain from the camshaft. Position fingers behind the actuator sprocket and pull the actuator away from the front of the camshaft. Never pull on the reluctor wheel when attempting to remove the actuator.



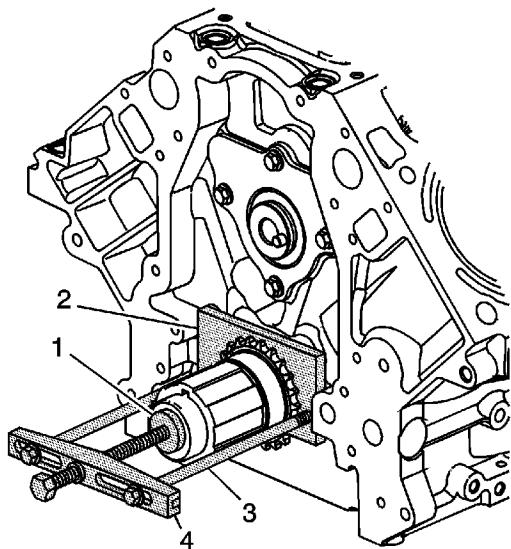
6. Remove the CMP actuator (235) and timing chain (208).



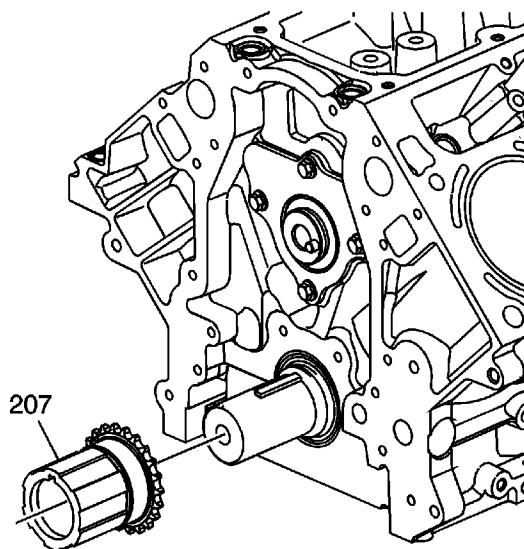
7. Insert a tie strap (1) through the center of the actuator and over the reluctor wheel.



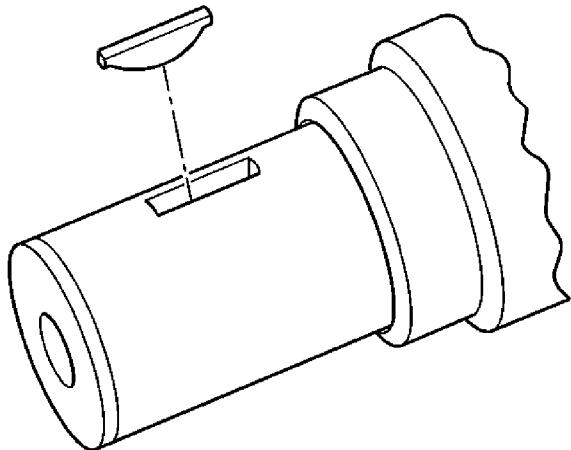
8. Remove the bolts (231) and timing chain tensioner (232).



9. Use the *J41816-2* protector (1), the *J41558* remover (2), bolts (3), and the *J8433* puller (4) in order to remove the crankshaft sprocket.

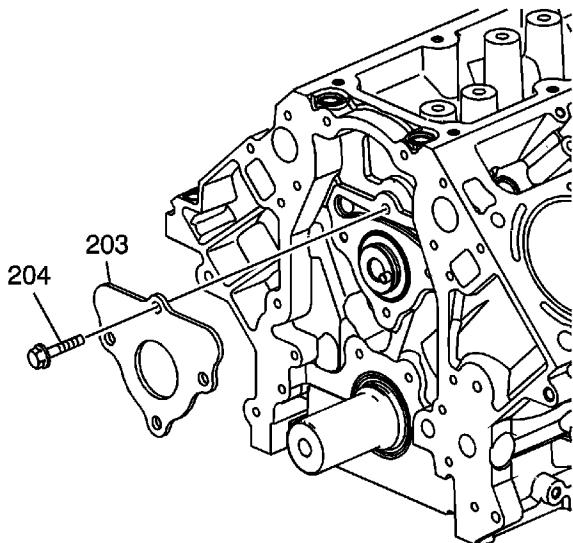


10. Remove the crankshaft sprocket (207).

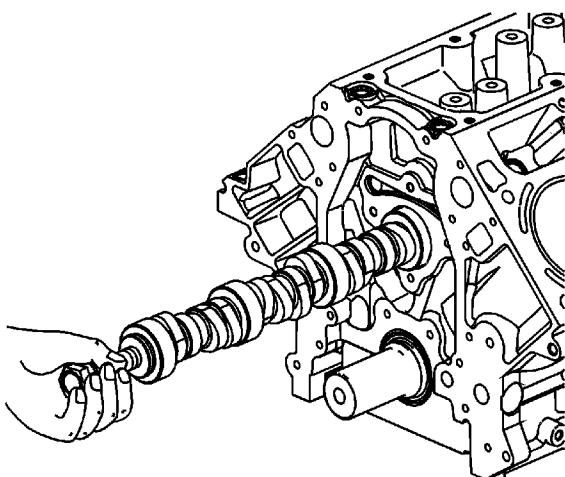


11. Remove the crankshaft sprocket key, as required.
12. Remove the flex plate and bolts. Refer to [Automatic Transmission Flex Plate Removal](#).
13. Remove the *J42386-A* tool and bolts.

Camshaft Removal



1. Remove the camshaft retainer bolts (204) and retainer (203).



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

2. Remove the camshaft.
 - 2.1. Install the camshaft sprocket bolt into the camshaft front bolt hole.

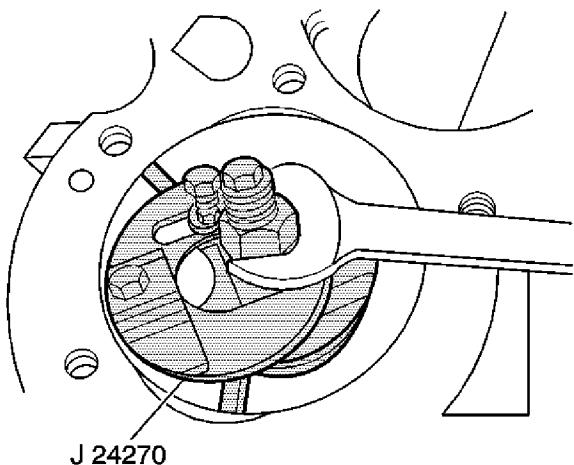
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- 2.2. Using the bolt as a handle, carefully rotate and pull the camshaft out of the engine block.
- 2.3. Remove the bolt from the front of the camshaft.

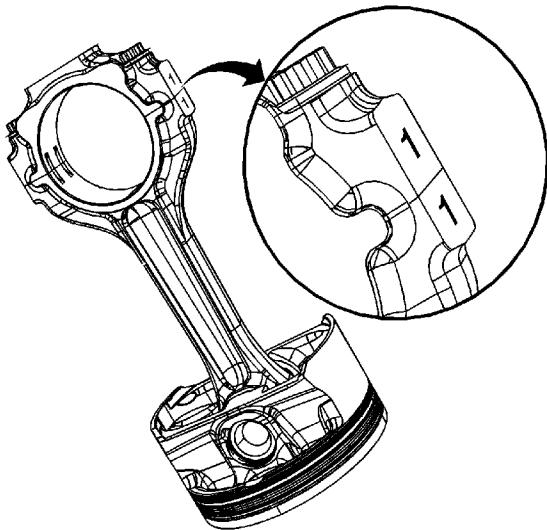
Piston, Connecting Rod, and Bearing Removal

Tools Required

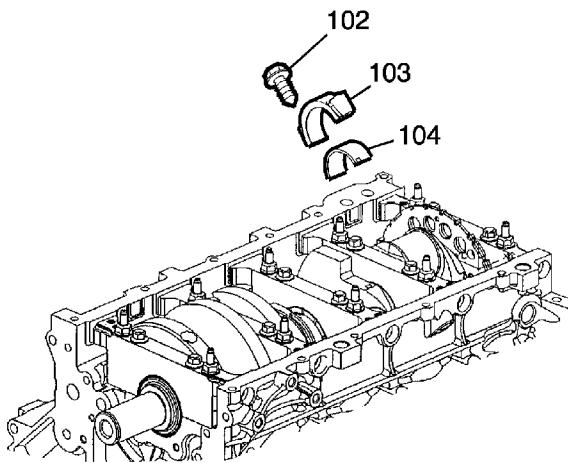
- [J 24270](#) Cylinder Bore Ridge Reamer
- [J 41556](#) Connecting Rod Guide



1. Use the [J 24270](#) in order to remove the cylinder bore ring ridge, if required.
 - 1.1. Turn the crankshaft until the piston is at the bottom of the stroke.
 - 1.2. Place a cloth on top of the piston.
 - 1.3. Use the [J 24270](#), or equivalent, in order to remove a cylinder ring ridge.
 - 1.4. Turn the crankshaft so the piston is at the top of the stroke.
 - 1.5. Remove the cloth.
 - 1.6. Remove the cutting debris from the cylinder and piston.

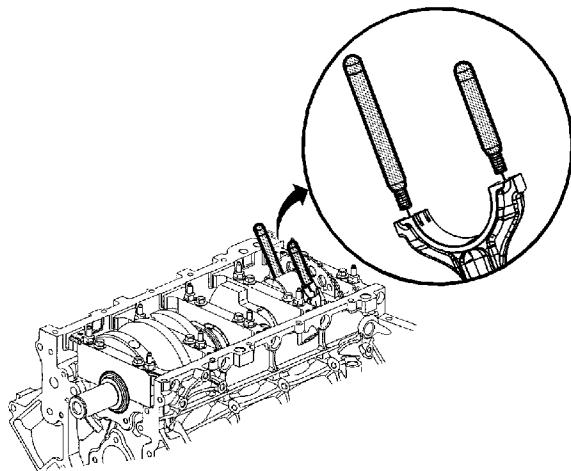


2. Using a paint stick or etching tool, place matchmarks or numbers on the connecting rods and the connecting rod caps. The connecting rods and caps MUST be assembled to their original position and direction.
 - A stamping mark on the side of the connecting rod, at the crankshaft journal, may affect component geometry.
 - Mark the top of the piston to the specific cylinder bore.

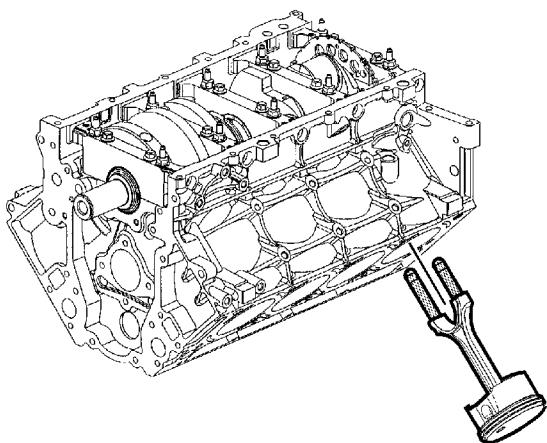


Important: Mark, sort, or organize the connecting rod bearings so they may be installed to their original position and location. The connecting rods and the bearing caps are NOT interchangeable. Refer to [Separating Parts](#).

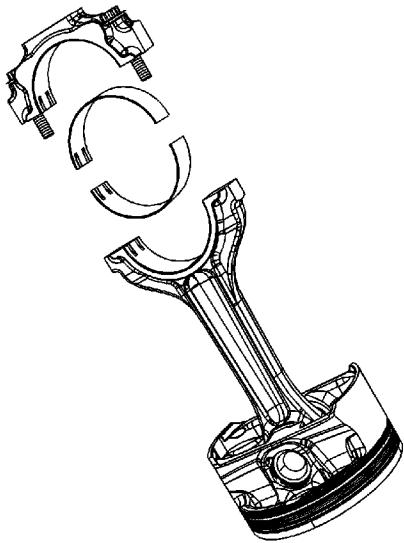
3. Remove the connecting rod bolts (102), cap (103) and bearing (104).



4. Install the [J 41556](#) to the connecting rod.



5. Using a hammer, tap lightly on the end of the [J 41556](#) in order to remove the piston and connecting rod assembly from the cylinder bore.
6. Remove the [J 41556](#).



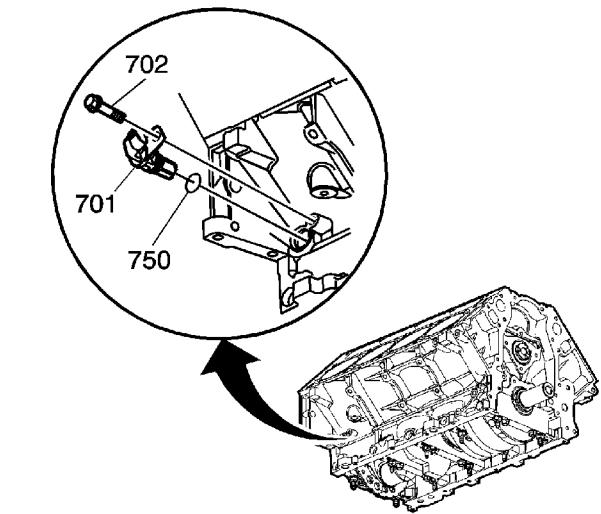
7. Upon removal of the piston and connecting rod assembly, assemble the connecting rod cap and bolts onto the matching connecting rod.

Crankshaft and Bearing Removal

Special Tools

- *J6125-1B* Slide Hammer
- *J41818* Crankshaft Bearing Cap Remover

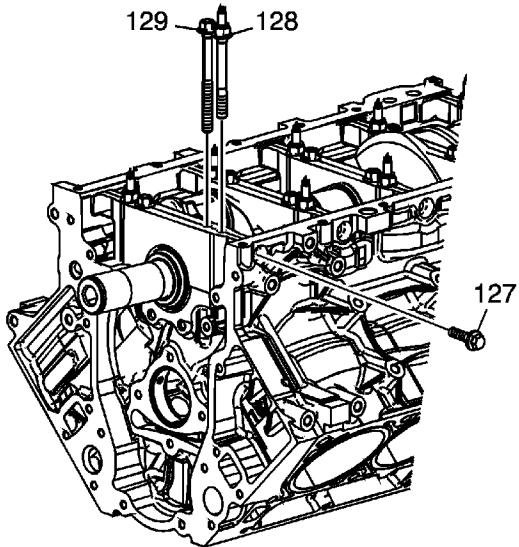
For equivalent regional tools, refer to [Special Tools](#)



Note:

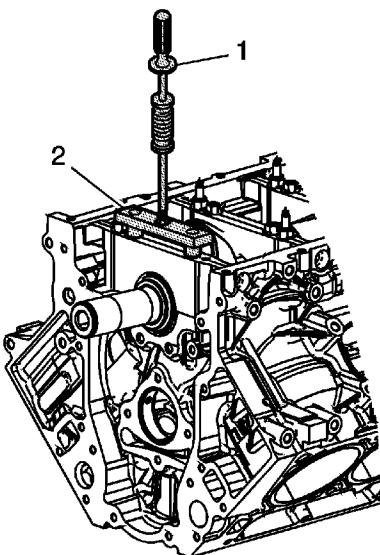
- The crankshaft bearing caps are machined with the engine block, for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. The crankshaft bearing caps MUST be installed to their original position and direction.
- Do not use the bearing cap M8 side bolts again.

1. Remove the crankshaft position (CKP) sensor bolt (702).
2. Remove the CKP sensor (701).
3. Remove the O-ring (750) from the sensor, as required.

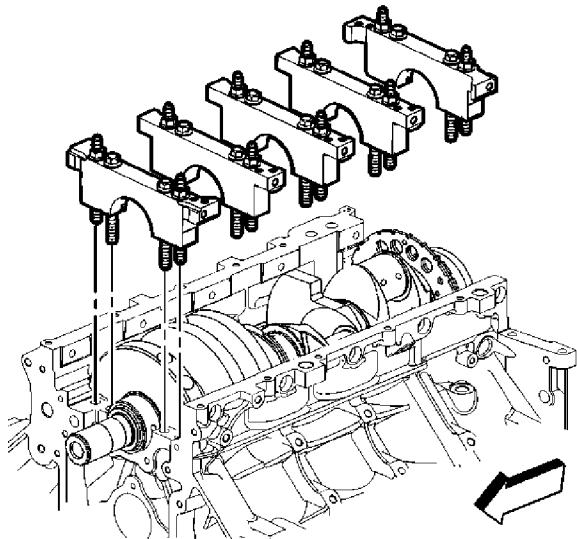


4. Remove the crankshaft bearing cap M8 bolts (127).
5. Remove the bearing cap M10 bolts (129) and studs (128).

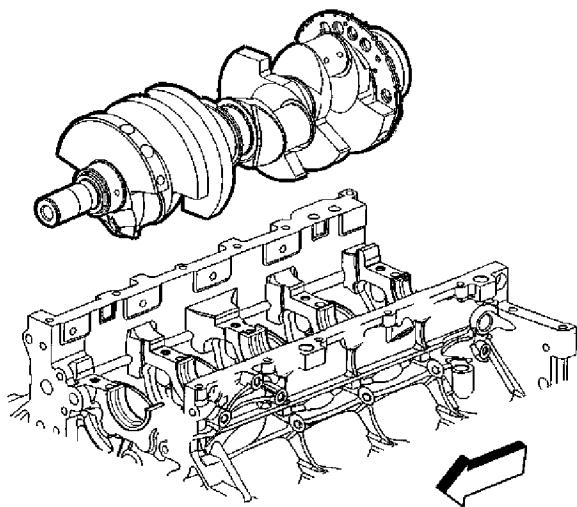
Caution: Refer to [Fastener Caution](#) in the Preface section.



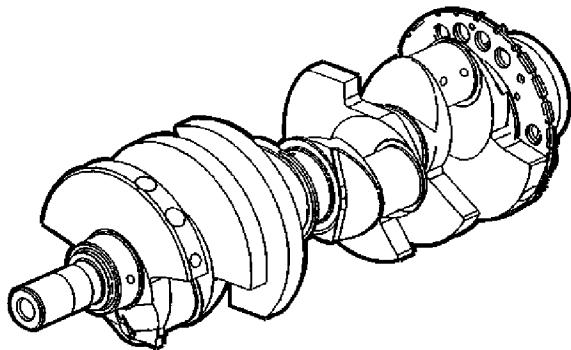
6. Install the *J41818* remover (2). Tighten the *J41818* remover (2) bolts to **11 N·m (100 lb in)**.
7. Install the *J6125-1B* hammer (1) to the *J41818* remover (2) in order to remove the crankshaft bearing caps.



8. Remove the bearing caps.

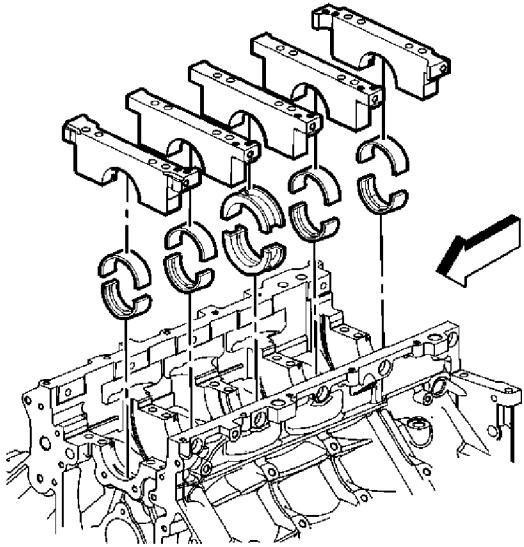


9. Remove the crankshaft.



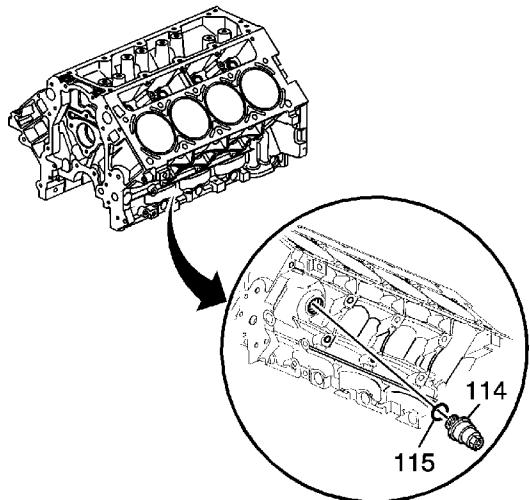
Note: Use care when handling the crankshaft. Avoid damage to the CKP sensor reluctor ring teeth. Nicks, burrs or other damage to the teeth may effect on-board diagnostics (OBD) II system performance.

10. Lay the crankshaft onto 2 wooden V-blocks or other protective surface.

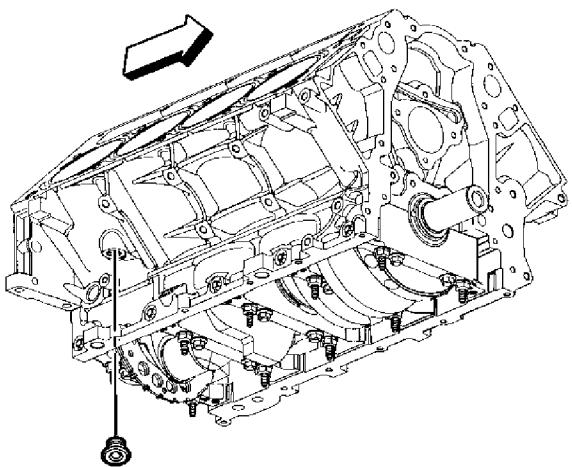


11. Remove the crankshaft bearings from the bearing caps and the engine block.
12. Mark, sort, or organize the crankshaft bearings so they may be installed to their original position and location. Refer to [Separating Parts](#).

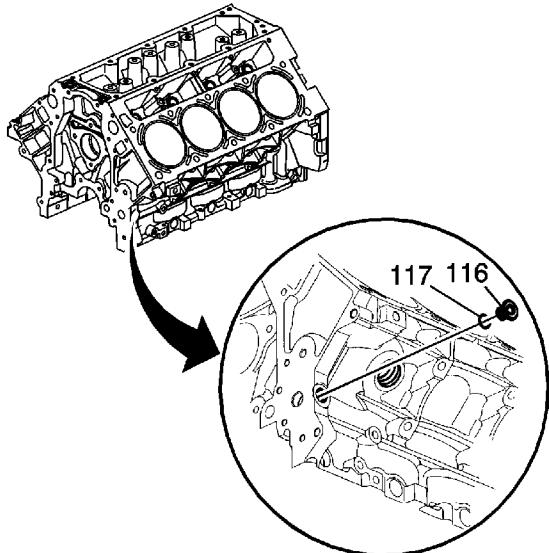
Engine Block Plug Removal



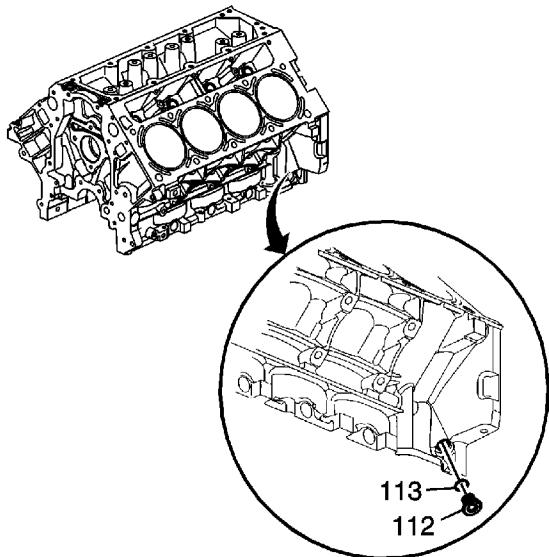
-  1. Remove the engine block coolant heater (114) and seal (115).



-  2. Remove the engine block right rear coolant drain hole plug and seal.

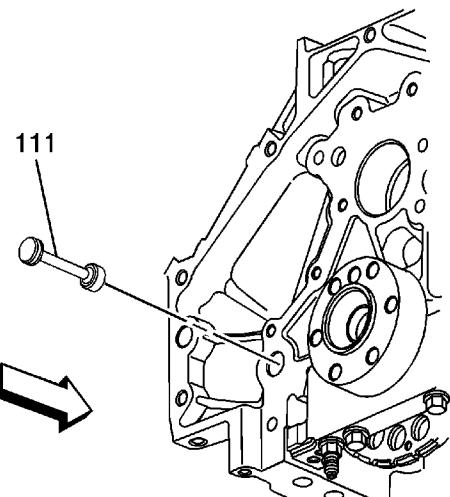


3. Remove the engine block left front oil gallery plug (116) and seal (117).



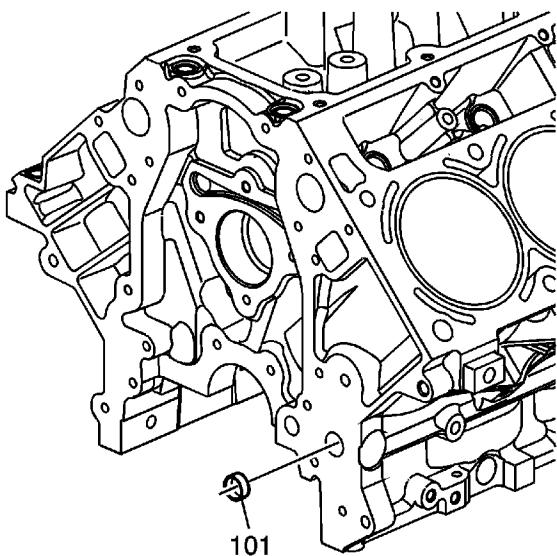
4. Remove the engine block left rear oil gallery plug (112) and seal (113).

If the block plug and coolant heater sealing washers are not damaged, they may be used during assembly.



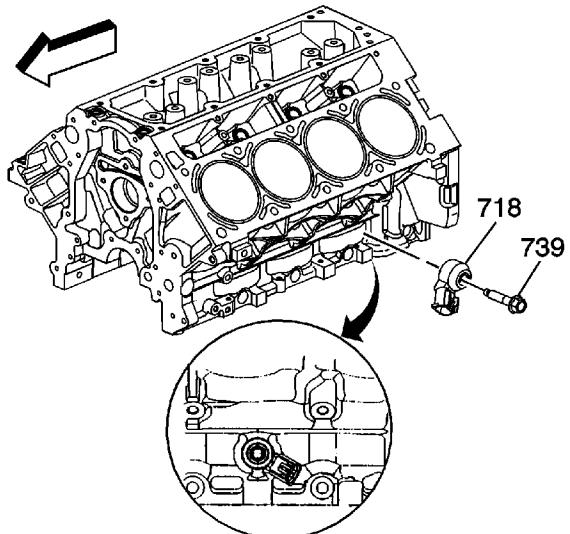
5. Remove the engine block rear oil gallery plug (111) and seal.
6. Inspect the O-ring seal of the rear oil gallery plug.

If the O-ring seal is not cut or damaged, the plug and O-ring seal may be used during assembly.

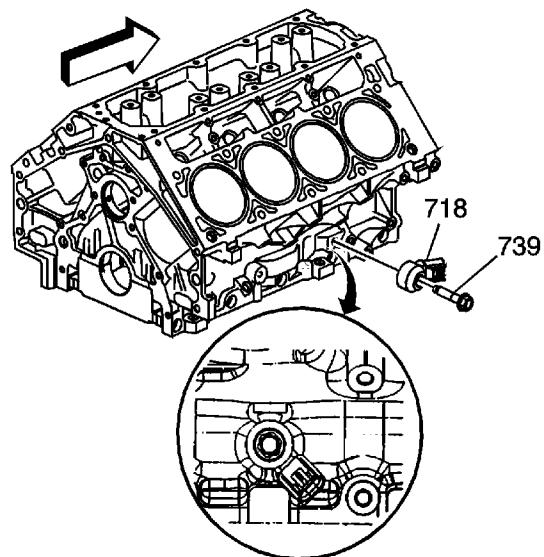


Important: Remove the front oil gallery plug, only if service is required. If the front oil gallery plug is removed, a NEW oil gallery plug must be installed.

7. Remove the engine block front oil gallery plug (101).



8. Remove the left side knock sensor (718) and bolt (739).



9. Remove the right side knock sensor (718) and bolt (739).

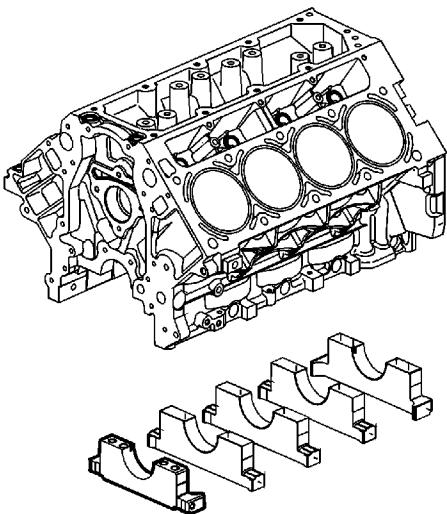
Engine Block Cleaning and Inspection

Special Tools

- *J8087* Cylinder Bore Gage
- *42385-100* Head/Main Bolt Thread Repair Kit

For equivalent regional tools, refer to [Special Tools](#)

Cleaning Procedure



Caution: Do not use a caustic solution to clean the aluminum engine block.

Note: When cleaning the engine block in a thermal type oven, do not exceed 232°C (450°F).

Clean the following components:

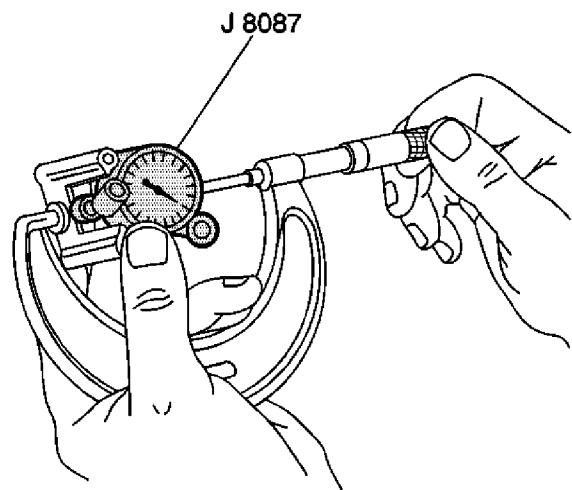
- Remove all sludge, dirt, or debris using a cleaning solvent or thermal type oven. Refer to [Cleanliness and Care](#).
- Gasket surfaces
Refer to [Replacing Engine Gaskets](#).
- Coolant passages
- Oil galleries
- Main bearing caps

- Cylinder head bolt holes to remove threadlocking material
Thread repair tool J 42385-107 may be used to clean the threads of any residual threadlocking material.

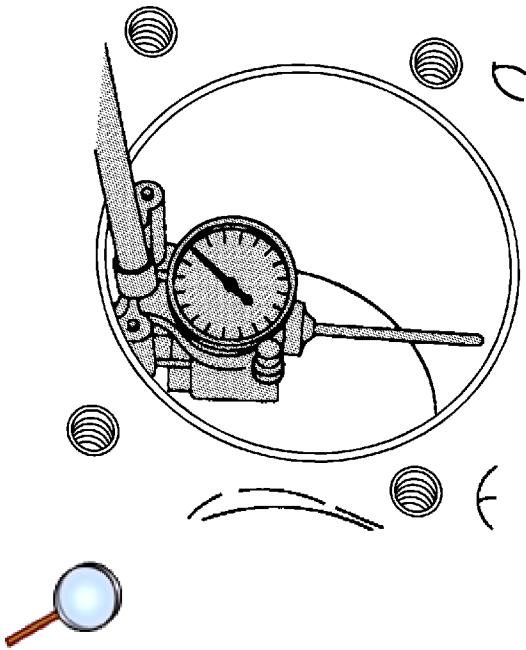
Inspection Procedure

1. Inspect the following components:
 - Cylinder walls for excessive scratches, gouging, or ring ridge
 - Cylinder bores for excessive ring ridge at the top of the cylinder
 - Coolant jacket for cracks
 - Valve lifter bores for excessive scoring or wear
 - Crankshaft bearing webs for cracks
 - Gasket sealing surfaces for excessive scratches or gouging
Refer to [Replacing Engine Gaskets](#).
 - Oil galleries for restrictions
 - Threaded bolt holes for damaged threads
 - Cylinder bores for excessive ring ridge at the top of the cylinder
2. Measure the cylinder bores for an oversize condition:

Measuring the Cylinder for Oversize



1. Adjust the micrometer to a dimension slightly smaller than the bore size. Refer to [Engine Mechanical Specifications](#).
2. Insert the J 8087 gage into the micrometer and zero the bore gage dial.



3. Use the J8087 gage and measure the cylinder bore for oversize.

Slide the bore gage up and down throughout the length of the cylinder bore. Measure 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 exceeds the maximum diameter must be serviced with an oversized piston. Refer to [Engine Mechanical Specifications](#).

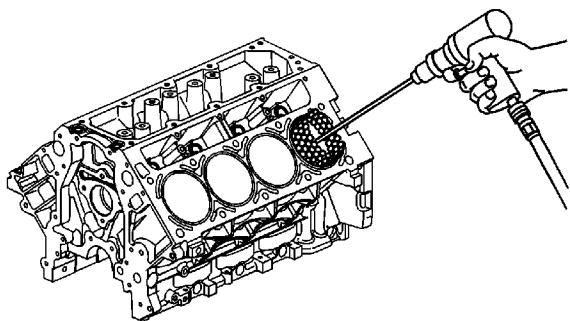
Cylinder Boring and Honing

Boring Procedure

Important: A 0.5 mm (0.02 in) oversize service piston and a piston ring set are available.

1. Measure all pistons with a micrometer to determine the cylinder bore diameter.
2. Before you use any type of boring bar, use a fine file and clean the top of the cylinder block, removing any dirt or burrs. If you do not check the cylinder block, the boring bar may be improperly positioned or tilted and the cylinder bore could be bored at an incorrect angle.
3. Carefully follow the instructions furnished by the manufacturer regarding use of the equipment.
4. When you bore the cylinders, ensure all the crankshaft bearing caps are in place. Tighten the crankshaft bearing caps to the proper torque in order to avoid distortion of the cylinder bores during final assembly.
5. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for the finish honing and fit of the piston.

Honing Procedure



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 final clearance with a coarse or medium-grade stone. Leave sufficient metal so that all stone marks may be removed with fine-grade stones. Perform final honing with a fine-grade stone, honing the cylinder to the proper clearance.
2. During the honing operation, thoroughly clean the cylinder bore. Repeatedly check the cylinder bore for fit with the selected piston.

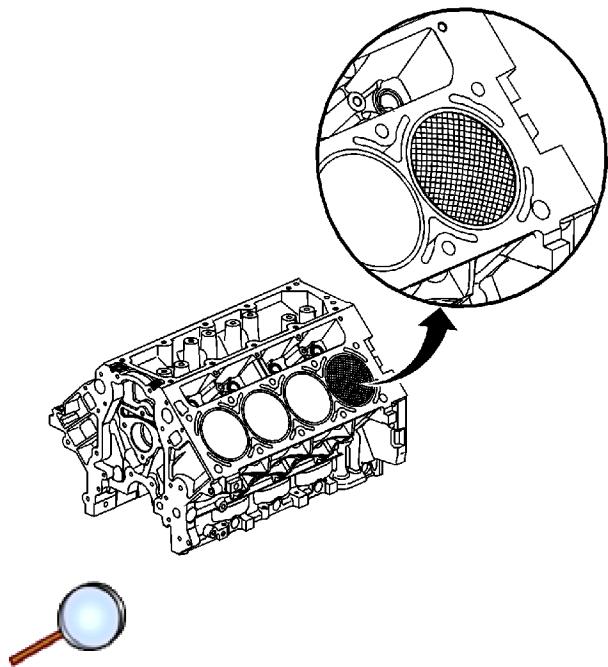
All measurements of the piston or the cylinder bore should be made with the components at normal room temperature.

3. When honing a cylinder for fit to an oversize piston, first perform the preliminary honing with a 100-grit stone.
4. Perform final cylinder honing with a 240-grit stone and obtain a 45 degree cross hatch pattern.

A 240-grit stone is preferred for final honing. If a 240-grit stone is not available, a 220-grit stone may be used as a substitute.

5. The finish marks should be clean but not sharp. The finish marks should also be free from imbedded particles and torn or folded metal.
6. By measuring the selected piston at the sizing point and by adding the average of the clearance specification, you can determine the final cylinder honing dimension required.
7. After final honing and before the piston is checked for fit, clean the cylinder bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material may cause premature wear of the new piston rings and the cylinder bores. Abrasive material will also contaminate the engine oil and may cause premature wear of the bearings. After washing the cylinder bore, dry the bore with a clean rag.
8. Perform final measurements of the piston and the cylinder bore.
9. Permanently mark the top of the piston for the specific cylinder to which it has been fitted.
10. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Deglazing Procedure



Using a ball type or self centering honing tool, deglaze the cylinder bore lightly. Deglazing should be done only to remove any deposits that may have formed. Use a 240-grit stone or silicone carbide, or equivalent, material when performing the deglazing procedure.

A 240-grit stone is preferred for final honing. If a 240-grit stone is not available, a 220-grit stone may be used as a substitute.

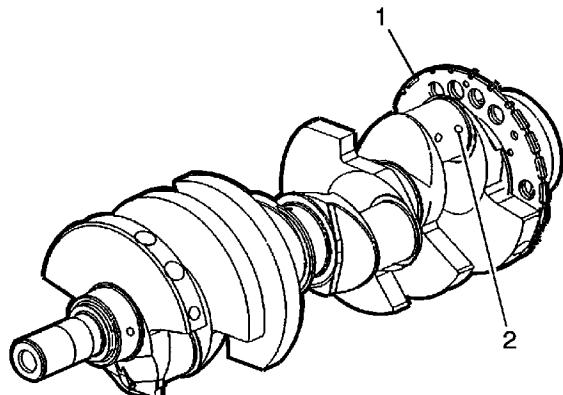
Crankshaft and Bearing Cleaning and Inspection

Special Tools

- J 7872 Magnetic Base Dial Indicator Set
- J 43690 Rod Bearing Checking Tool
- J 43690-100 Rod Bearing Checking Tool - Adapter Kit

For equivalent regional tools, refer to [Special Tools](#)

Cleaning Procedure



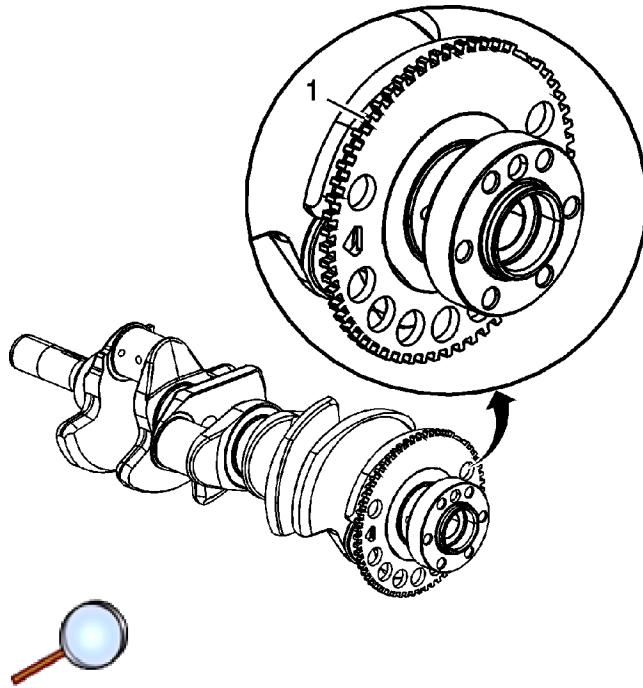
Note: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position (CKP) reluctor ring. Damage to the teeth of the CKP reluctor ring may affect on-board diagnostics (OBD) II system performance.

1. Clean the crankshaft with solvent.
2. Thoroughly clean all oil passages (2) and inspect for restrictions or burrs.

Warning: Refer to [Safety Glasses Warning](#) in the Preface section.

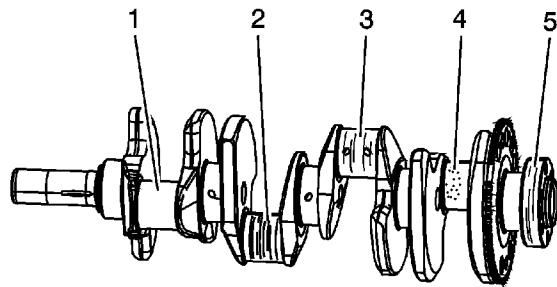
3. Dry the crankshaft with compressed air.

Inspection Procedure



Note: The CKP reluctor ring teeth should not have imperfections on the rising or falling edges. Imperfections of the reluctor ring teeth may affect OBD II system performance.

1. Inspect the CKP reluctor ring teeth (1) for damage.

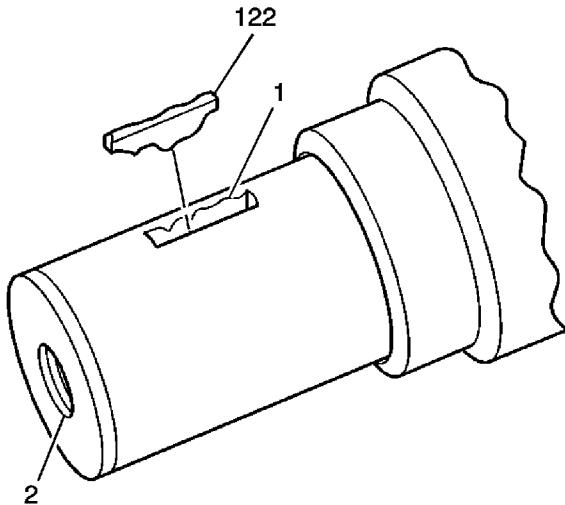


2. Inspect the crankshaft journals for wear.

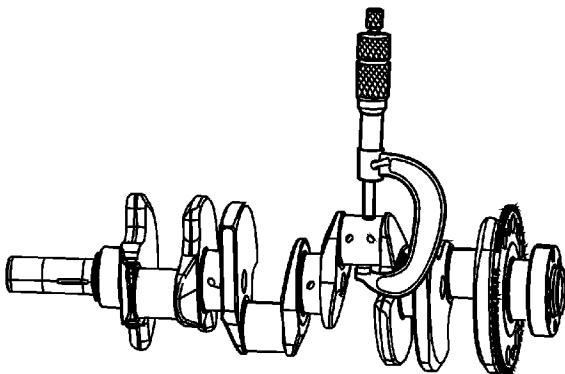
Journals should be smooth (1) with no signs of scoring, wear, or damage.

3. Inspect the crankshaft journals for grooves or scoring (2).
4. Inspect the crankshaft journals for scratches or wear (3).
5. Inspect the crankshaft journals for pitting or imbedded bearing material (4).

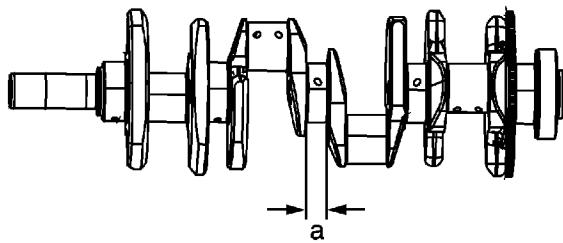
6. Inspect the crankshaft rear oil seal surface (5) for grooves or scoring.



7. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.

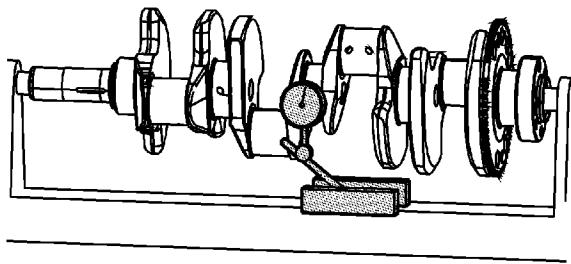


8. Measure the connecting rod journals for out-of-round and taper.



9. Measure the crankshaft thrust wall width.

A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) (a) must be replaced.



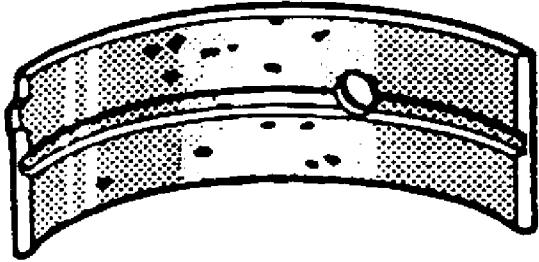
10. Measure the crankshaft runout.

Use wooden V-blocks or a fixture to support the crankshaft on the front and rear journals.

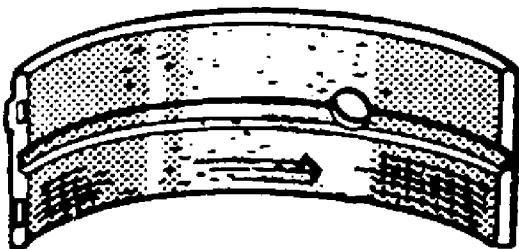
11. Use the J 7872 set in order to measure the crankshaft runout at the front and rear intermediate journals.
12. Use the J 7872 set in order to measure the runout of the crankshaft rear flange.
13. Use the J 7872 set in order to measure the runout of the crankshaft position reluctor ring.

Reluctor ring runout should be measured 1.0 mm (0.04 in) below the ring teeth.

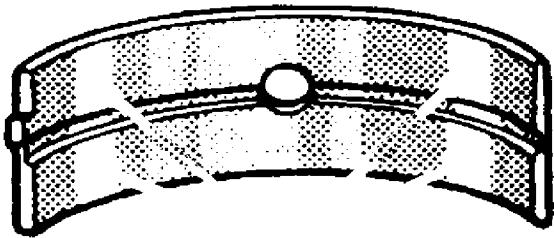
If the reluctor ring has runout in excess of 0.7 mm (0.028 in), replace the crankshaft.



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



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

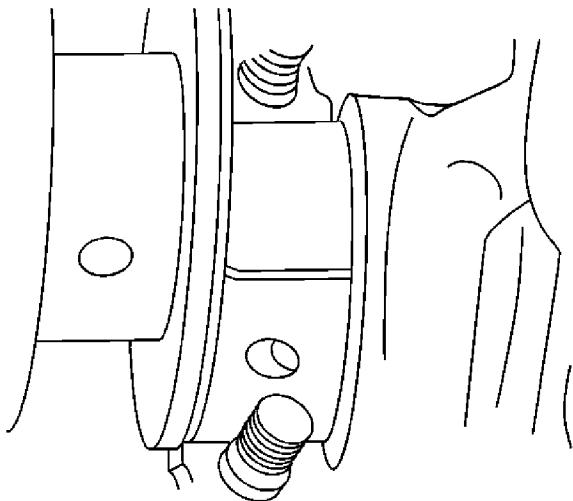


17. Inspect the crankshaft bearings for improper seating, indicated by bright, polished sections of the bearing.

If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

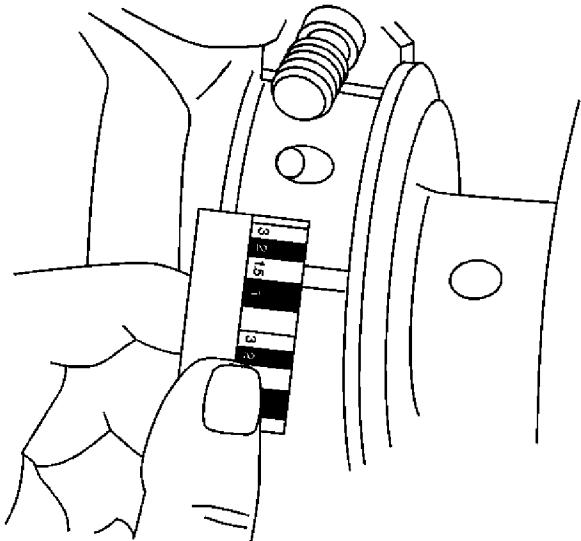
Measuring Main Bearing Clearance - Gaging Plastic Method



Note:

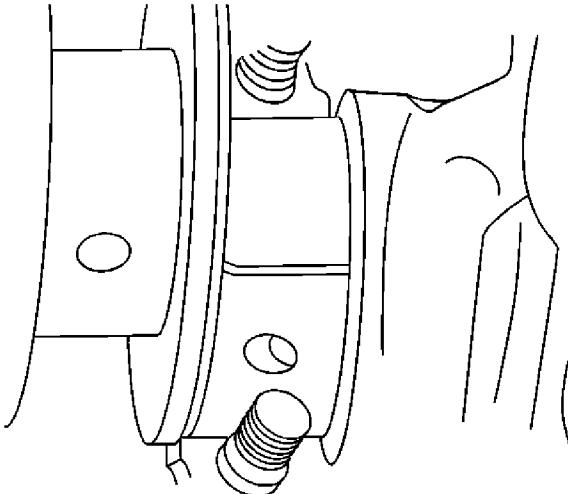
- The crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block, for proper clearance, and cannot be shimmed or filed for bearing fit. If the clearances are found to be excessive, new bearings and/or engine block and cap repair or replacement may be required.
- Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.
- The crankshaft bearing clearances are critical. Excessive bearing clearance may affect crankshaft position sensor signals and may affect OBD II system operation.
- Remove the bearing cap side bolts prior to cap removal.

1. Remove the bearing caps, bearing half, and bolts. Refer to [Crankshaft and Bearing Removal](#).
2. Install gaging plastic onto the crankshaft journal. Install the gaging plastic the full width of the crankshaft bearing journal.
3. Install the bearing caps, bearing half, and bolts. Refer to [Crankshaft and Bearing Installation](#).
4. Remove the bearing caps, bearing half, and bolts. Refer to [Crankshaft and Bearing Removal](#).



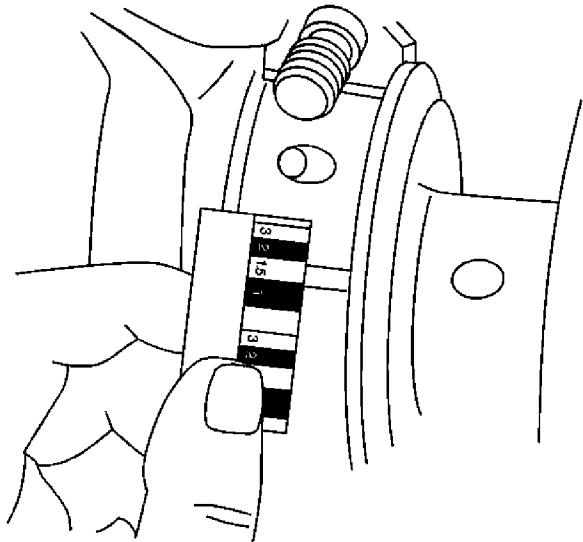
5. Using the scale supplied with the plastic gaging kit, measure the gaging plastic at its widest area.
 - If the gaging plastic shows irregularity in the journal, exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
 - If clearance cannot be brought to specifications, replace the crankshaft or engine block as required. Refer to [Engine Mechanical Specifications](#).

Measuring Connecting Rod Bearing Clearance - Gaging Plastic Method

**Note:**

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

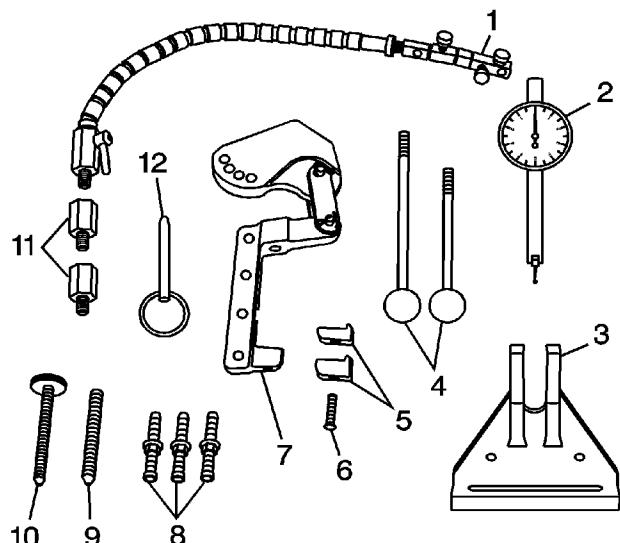
1. Remove the bearing cap, bearing half, and bolts. Refer to [Piston, Connecting Rod, and Bearing Removal](#).
2. Install the gaging plastic onto the connecting rod bearing journal. Install the gaging plastic the full width of the journal.
3. Install the bearing cap, bearing half, and bolts. Refer to [Piston, Connecting Rod, and Bearing Installation](#).
4. Remove the bearing cap, bearing half, and bolts. Refer to [Piston, Connecting Rod, and Bearing Removal](#).



5. Using the scale supplied with the plastic gaging kit, measure the gaging plastic at its widest area. Refer to [Engine Mechanical Specifications](#).

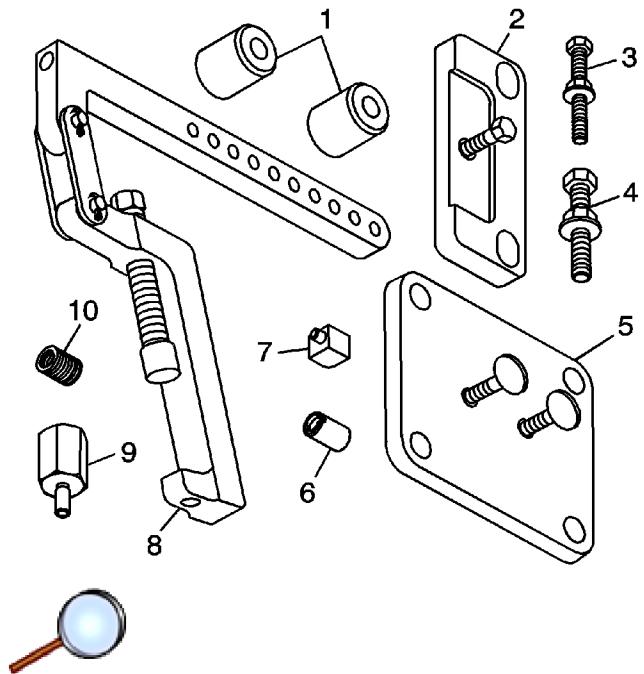
Measuring Connecting Rod Bearing Clearance - Using J 43690/J 43690-100

J 43690 tool and J 43690-100 kit have been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets supplied by the tool manufacturer.



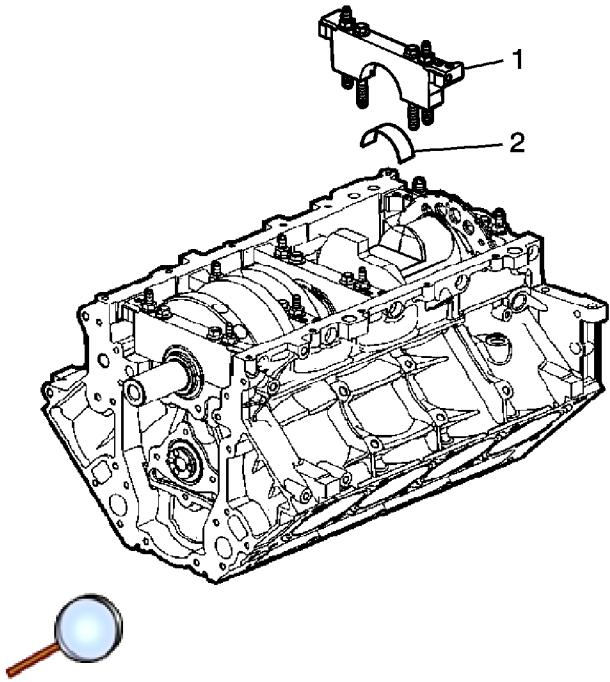
J 43690 tool

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)
- J 43690-5, J 43690-6 Handle (4)
- J 43690-10, J 43690-11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, J 43690-7, J 43690-8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, J 43690-18 Adapter (11)
- 280310 Pin (12)

*J 43690 Rod Bearing Checking Tool*

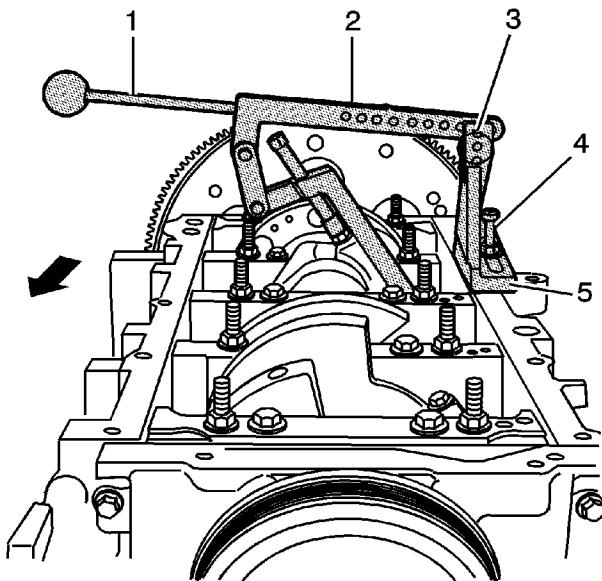
- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)

- J 43690-103 Adapter (9)
- 505439 Adapter (10)



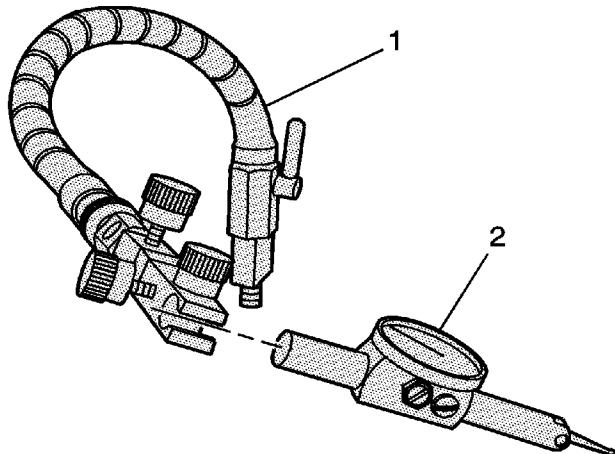
Note: The crankshaft must be secure, with no movement or rotation, in order to obtain an accurate reading.

1. Rotate the crankshaft until the journal/connecting rod to be measured is in the 12 o'clock position.
2. Remove a bearing cap and bolts (1).
3. Remove the bearing half (2).
4. Insert a piece of paper card stock onto the crankshaft journal.
5. Install the bearing half (2) and cap and bolts (1). Refer to [Fastener Tightening Specifications](#).





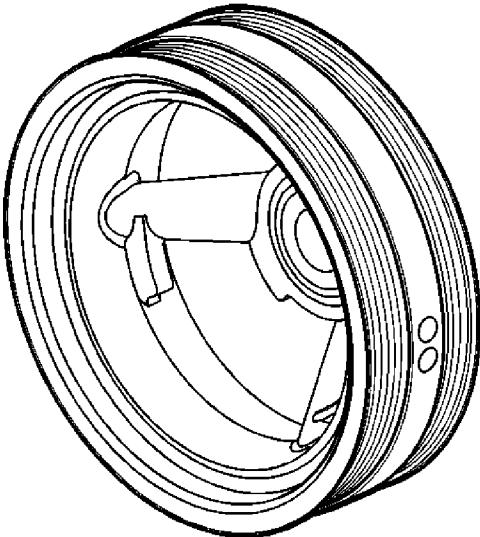
6. Install the following:
 - 6.1. J 43690-2 (5)
 - 6.2. J 43690-3 (4)
 - 6.3. J 43690-101 (2)
 - 6.4. 280310 (3)
 - 6.5. J 43690-5 (1)



7. Install the swivel base (1) and dial indicator (2).
8. Adjust per the manufacturers instructions and measure the connecting rod bearing clearance.

A connecting rod with a clearance in excess of 0.076 mm (0.003 in) is considered excessive. Service components, as required.

Crankshaft Balancer Cleaning and Inspection

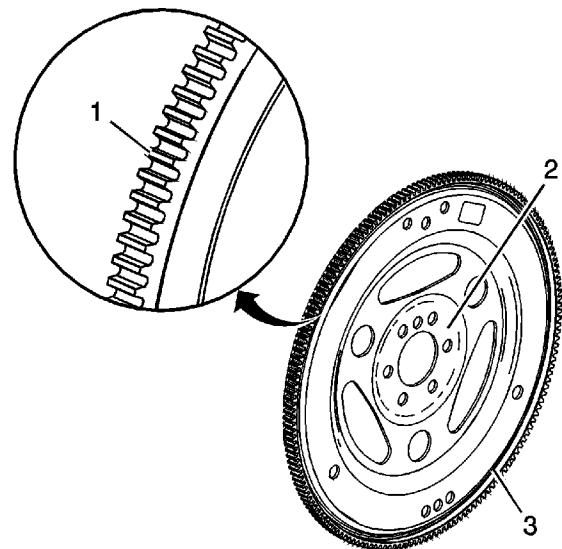


1. Clean the crankshaft balancer in solvent.
2. Clean the belt grooves of all dirt or debris with a wire brush.
3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following conditions:
 - Worn, grooved, or damaged hub seal surface
 - A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.
 - Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

Important: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

- Dirty or damaged belt grooves
- The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.
- Minor imperfections may be removed with a fine file.
- Worn, chunking, or deteriorated rubber between the hub and pulley

Automatic Transmission Flex Plate Cleaning and Inspection



1. Clean the flex plate in solvent.

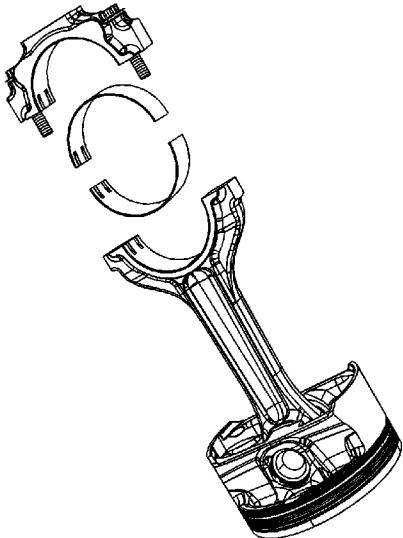
Warning: Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.

2. Dry the flex plate with compressed air.
3. Inspect the flex plate for the following conditions:
 - Damaged ring gear teeth (1)
 - Stress cracks around the flex plate-to-crankshaft bolt hole locations (2)

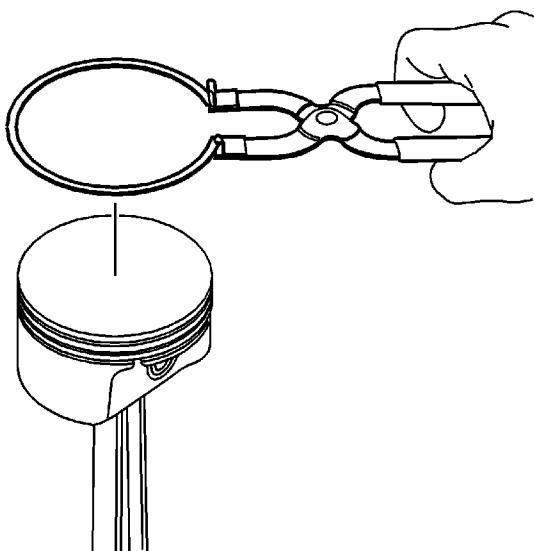
Note: Do not attempt to repair the welded areas that retain the ring gear to the flex plate. Install a new flex plate.

- Welded areas (3) that retain the ring gear onto the flex plate for cracking

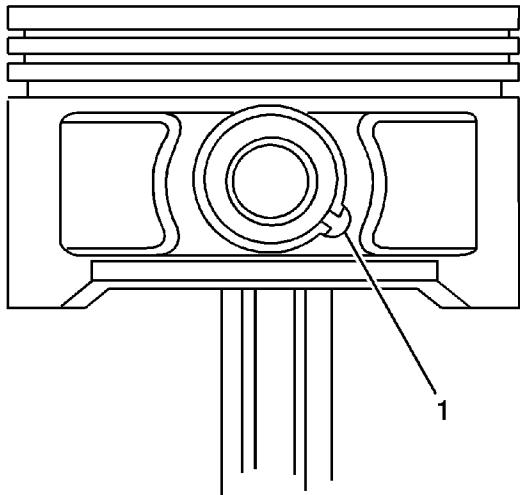
Piston and Connecting Rod Disassemble



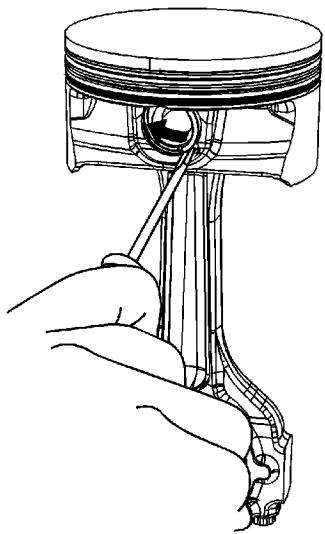
1. Remove the connecting rod bearings from the rod and cap.



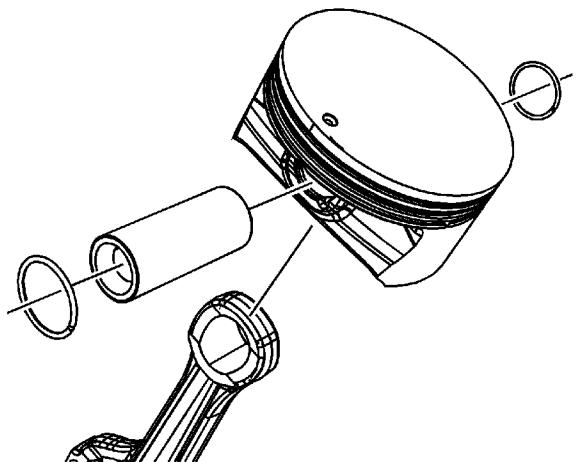
2. Using piston ring pliers, remove the piston rings from the piston.



3. Rotate the piston pin retainers until the ring end gaps are positioned in the cutout area (1) of the pin bore.



4. Remove the retainers starting in the cutout area of the pin bore.

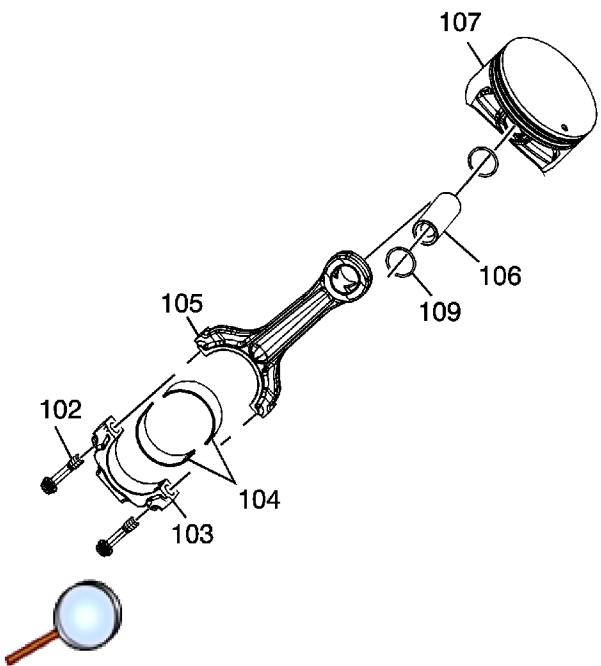


5. Remove the pin from the piston and connecting rod.
6. The piston and pin are a matched set and are not to be serviced separately.

Mark, sort, or organize the piston and the matching piston pin.

Piston, Connecting Rod, and Bearing Cleaning and Inspection

Piston, Pin, and Piston Rings



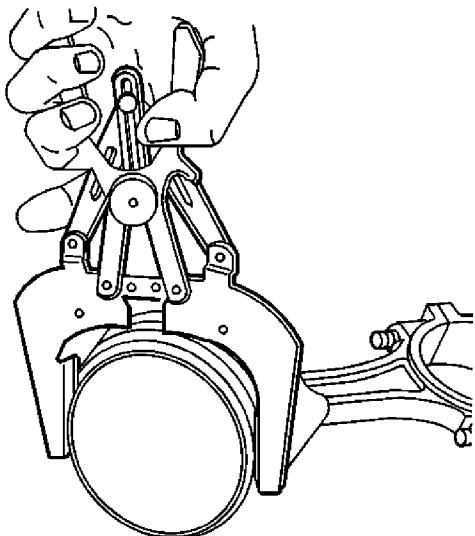
Note:

- Replace pistons, pins, and connecting rods that are damaged or show signs of excessive wear.
- The piston and pin are to be serviced as an assembly.
- Do not wire brush any part of the piston.
- Measurement of the components should be taken with the components at normal room temperature.

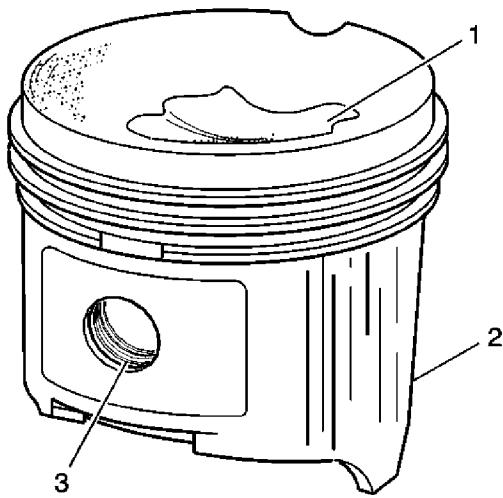
1. Clean the varnish and carbon from the piston (107) using cleaning solvent.

Warning: Refer to [Safety Glasses Warning](#) in the Preface section.

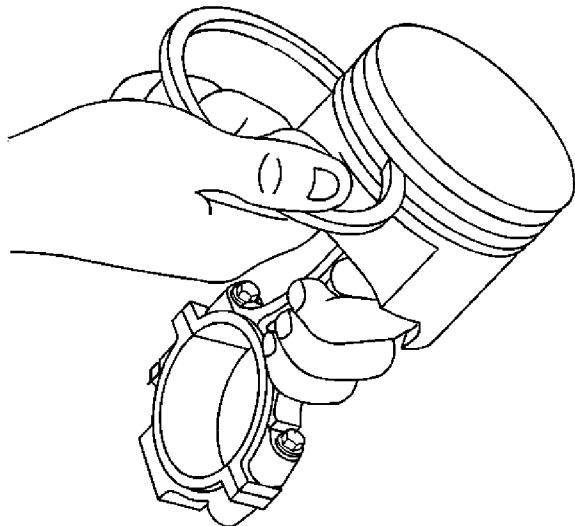
2. Dry the components with compressed air.



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

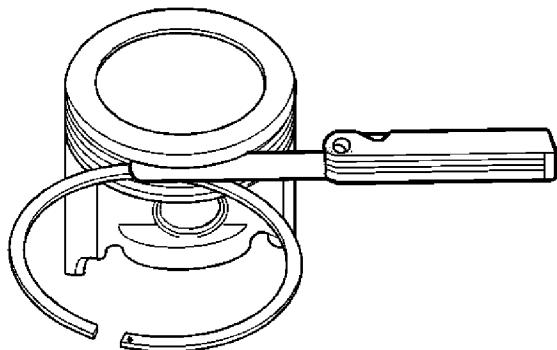


5. Inspect the piston for the following conditions:
 - Cracks in the piston ring lands, the piston skirt, or pin bosses
 - Piston ring grooves for nicks, burrs, or warpage which may cause the piston ring to bind
MINOR imperfections may be removed from the piston with a fine file.
 - Eroded areas at the top of the piston (1)
 - Scuffed or damaged skirts (2)
 - Scoring to the piston pin bore (3) or piston pin

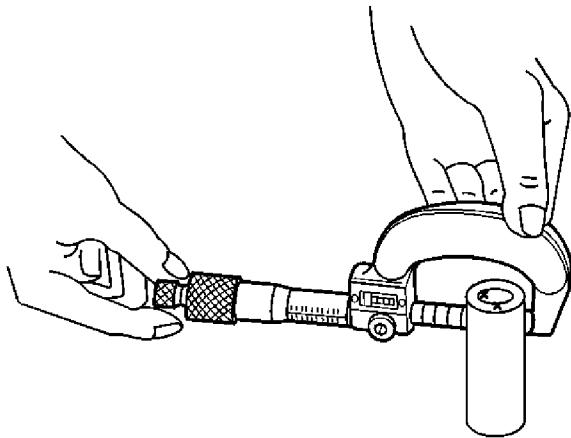


6. Insert the edge of the piston ring into the piston ring groove.

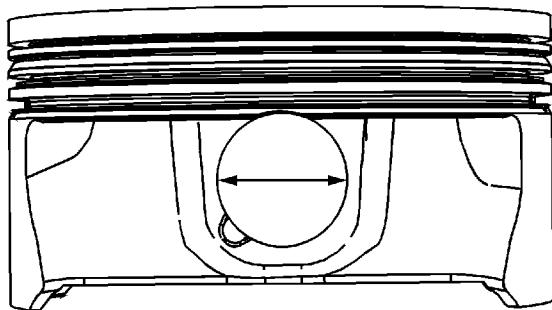
Roll the piston ring completely around the piston. If binding is caused by a distorted ring groove, MINOR imperfections may be removed with a fine file. If binding is caused by a distorted piston ring, replace the rings, as required.



7. Measure the piston ring side clearance with a feeler gage. If side clearance is not within specifications, try another piston ring. If the proper ring-to-groove clearance cannot be obtained, replace the piston and pin as an assembly. Refer to [Engine Mechanical Specifications](#).

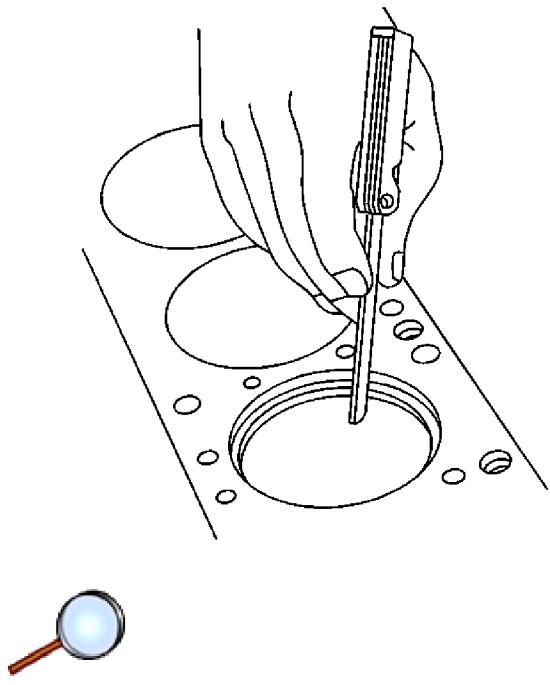


8. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).



9. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore inside diameter (ID).
10. Subtract the piston pin OD measurement from the piston pin bore ID measurement to determine pin-to-bore clearance. Refer to [Engine Mechanical Specifications](#).

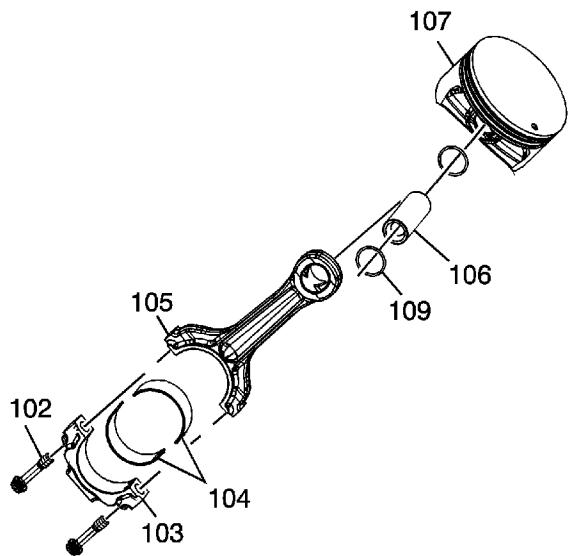
Measuring Piston Ring End Gap

**Note:**

- Do not attempt to file the end of the piston ring to achieve the proper end gap clearance.
- Measure the piston ring in the cylinder in which it will be used.

1. Place the piston ring into the cylinder bore 6.5 mm (0.25 in) below the top of the ring travel area. Both rings should be installed with the orientation marks facing the top of the piston.
2. Insert a feeler gage and measure the piston ring end gap. Refer to [Engine Mechanical Specifications](#).

Connecting Rod and Bearings



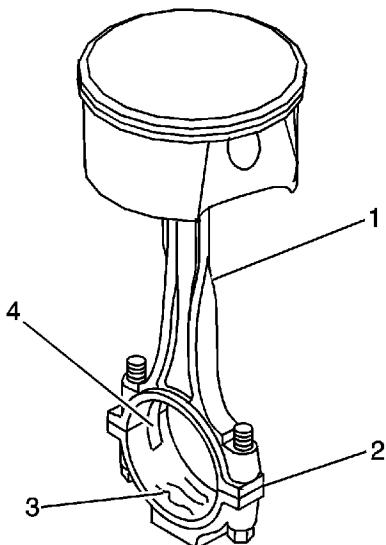
**Note:**

- The powdered metal connecting rod and cap are machined for proper clearances. The connecting rod and cap must be used as an assembly with no repair or modifications to either mating surface. Do not attempt to repair the rod or cap. If service is required, replace the rod and cap as an assembly.
- Do not attempt to repair the bolt hole threads of the connecting rod.

1. Clean the connecting rod (105) and cap (103) in solvent.

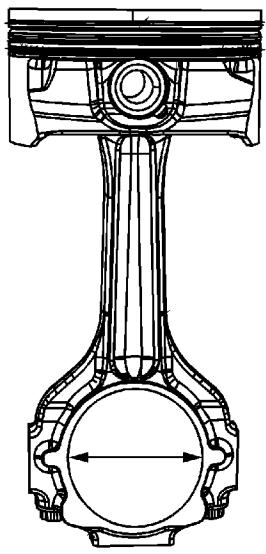
Warning: Refer to [Safety Glasses Warning](#) in the Preface section.

2. Dry the components with compressed air.

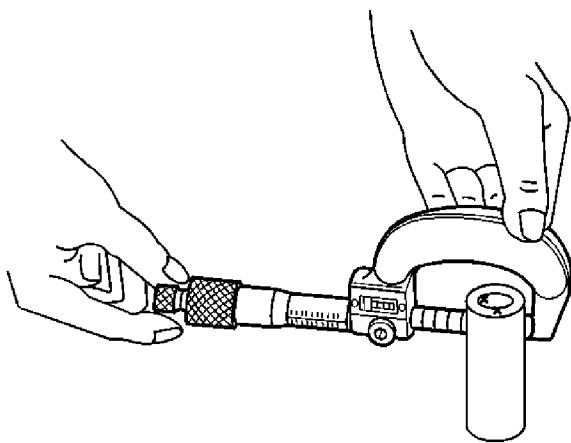


3. Inspect the connecting rod for the following conditions:

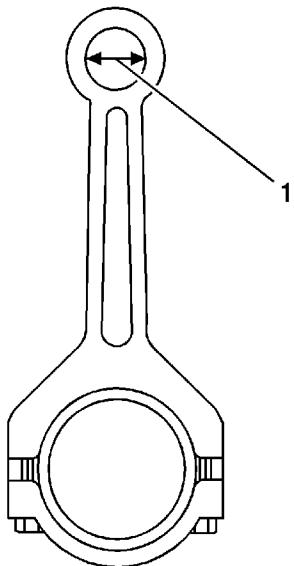
- Twisting (1)
- Proper fit of the connecting rod and cap mating surfaces (2)
- Nicks or gouges in the bearing bore (3)
- Damage to the bearing locating slots (4)



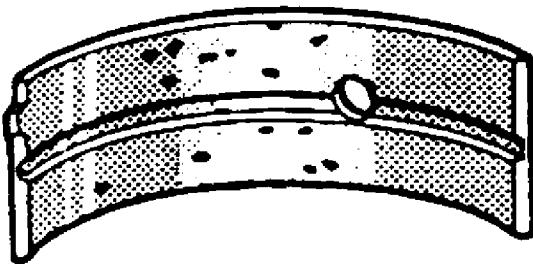
4. Measure the connecting rod bearing bore for an out-of-round condition. Refer to [Engine Mechanical Specifications](#).



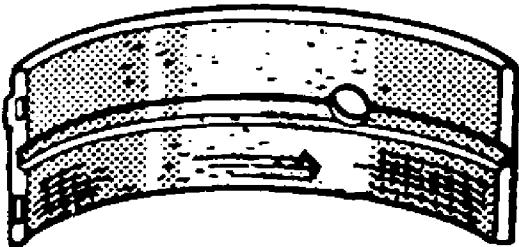
5. To determine piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin OD.



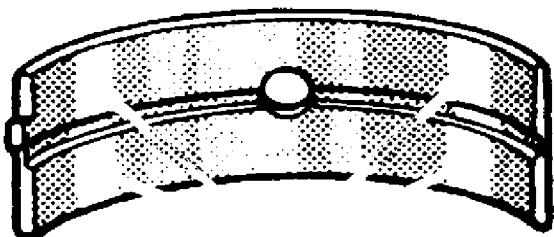
6. To determine the piston pin-to-connecting rod bore clearance, use a micrometer and measure the connecting rod pin bore (1) ID.
7. Subtract the piston pin OD measurement from the connecting rod pin bore ID measurement to determine pin-to-bore clearance. Refer to [Engine Mechanical Specifications](#).



8. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the bearing halves indicate fatigue.



9. Inspect the connecting rod bearings for excessive scoring or discoloration.
10. Inspect the connecting rod bearings for dirt or debris imbedded into the bearing material.

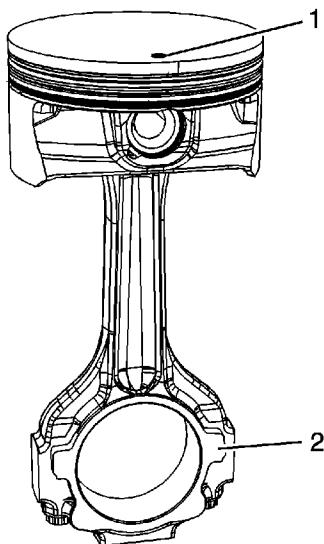


11. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing surface.
12. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore ID.
13. Subtract the piston pin OD measurement from the piston pin bore ID measurement to determine pin-to-bore clearance. Refer to [Engine Mechanical Specifications](#).

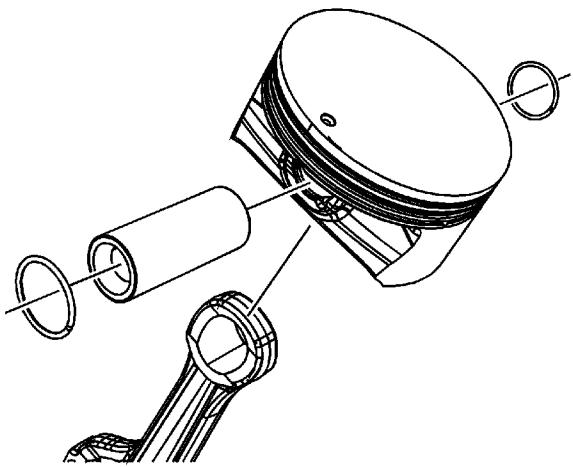
Piston and Connecting Rod Assemble



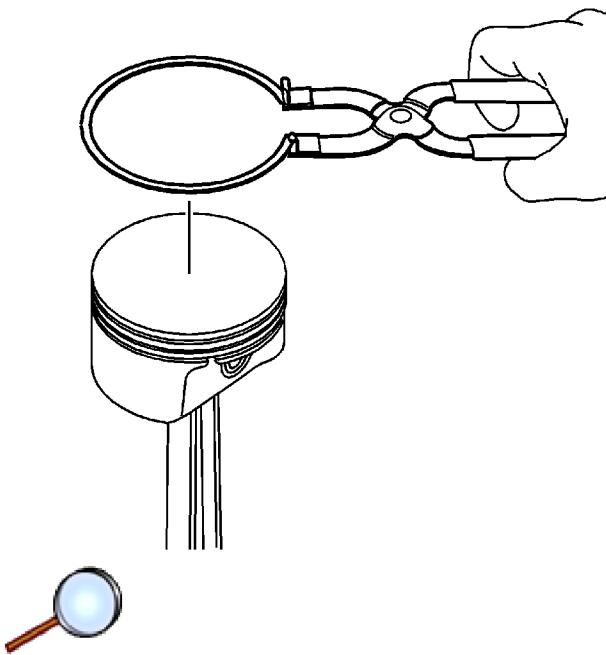
1. Install the retainer. The retainer should be seated in the groove of the pin bore.



2. Assemble the piston and connecting rod. The mark (1) on the top of the piston and the tab (2) on the side of the connecting rod should be facing the same direction.

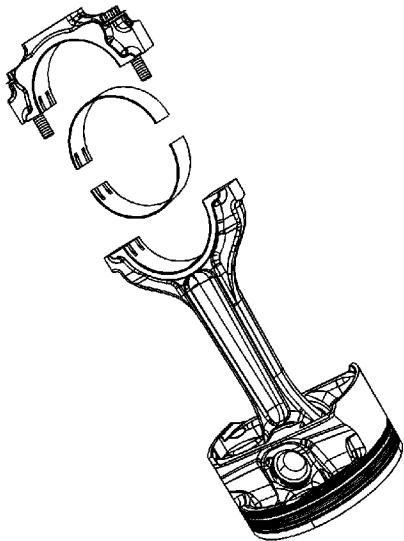


3. Install the piston pin to the piston and connecting rod.
4. Install the retainers. The retainers should be seated in the groove of the pin bore.



Important: When installing piston rings, use a ring expander plier type tool. Do not roll the rings into the grooves of the piston. Use caution and care to expand the rings only slightly larger than the outside diameter (OD) of the piston.

5. Using piston ring pliers, install the piston rings onto the piston. The dimple or mark on the piston ring should face the top of the piston. If no dimple or mark can be found on the top compression ring, it may be installed in either direction.
6. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
7. Position the compression ring end gaps 180 degrees opposite each other.

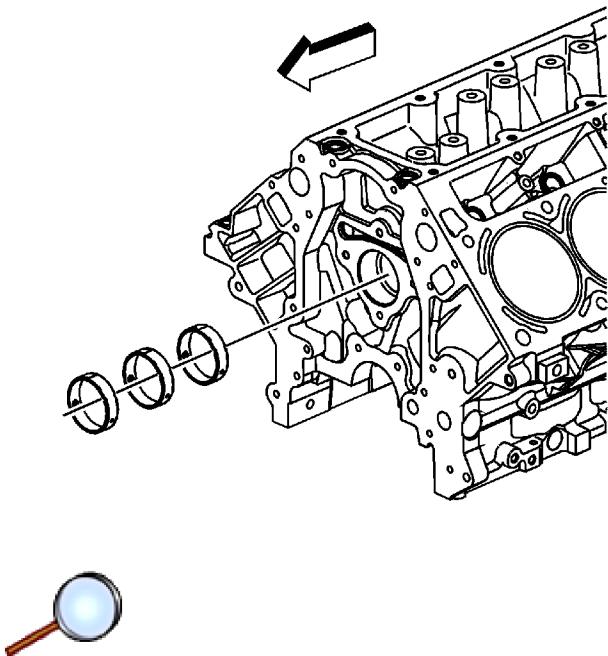


8. Install the connecting rod bearings to the rod and cap.

Camshaft Bearing Removal

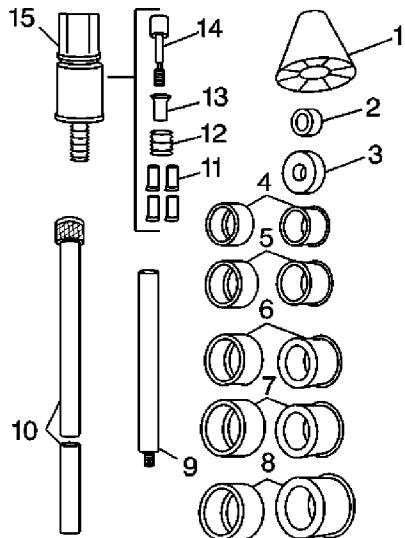
Tools Required

[J 33049](#) Camshaft Bearing Service Set

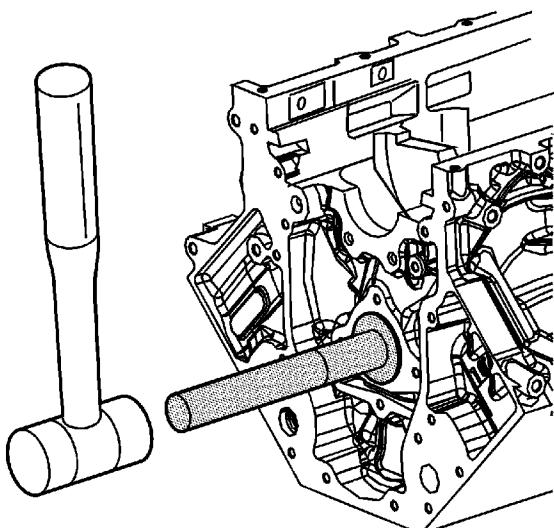


Important: A loose camshaft bearing may be caused by an enlarged, out of round, or damaged engine block bearing bore.

1. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores. Refer to [Camshaft and Bearings Cleaning and Inspection](#) .
2. Repair or replace the components, as required.



3. Select the expanding driver (4-8) and washer (2 or 3) from the [J 33049](#).
4. Assemble the tool.
5. Insert the tool through the front of the engine block and into the bearing.
6. Tighten the expander assembly (15) nut until snug.
7. Push the guide cone (1) into the front camshaft bearing in order to align the tool.



8. Drive the bearing from the block bore.

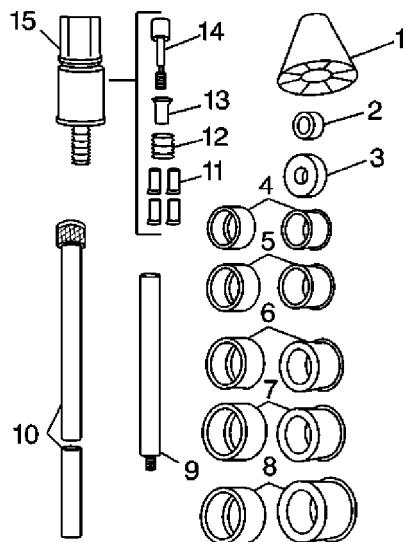
Important: In order to remove the front camshaft bearing, operate the tool from the rear of the block, using the guide cone in the rear camshaft bearing bore.

9. Repeat the above procedures in order to remove the remaining bearings.

Tool Usage Information

Bearing, Expander, and Expander Driver Information

-



- | The tool consists of a guide cone (1), driving washers (2 or 3), expander bearing drivers (4-8), driver bars (9 or 10), expander jaws (11), expander sleeve (12), expander cone (13), expander shaft (14), and expander assembly (15).
- | Expander bearing driver number 1 inside diameter is 28.575-37.465 mm (1.125-1.475 in) and is used with the expander assembly and the small washer.
- | Expander bearing driver number 2 inside diameter is 37.465-43.18 mm (1.475-1.7 in) and is used with number 1 expanding driver and the small washer.
- | Expander bearing driver number 3 inside diameter is 43.18-48.895 mm (1.7-1.925 in) and is used with number 2 expanding driver and the large washer.
- | Expander bearing driver number 4 inside diameter is 48.895-54.61 mm (1.925-2.15 in) and is used with number 3 expanding driver and the large washer.
- | Expander bearing driver number 5 inside diameter is 54.61-60.325 mm (2.150-2.375 in) and is used with number 4 expanding driver and the large washer.
- | Expander bearing driver number 6 inside diameter is 60.325-68.326 mm (2.375-2.69 in) and is used with number 5 expanding driver and the large washer.

Tool Assembly and Operation

1. Select the proper expanding driver and washer from the expanding driver and washer information.

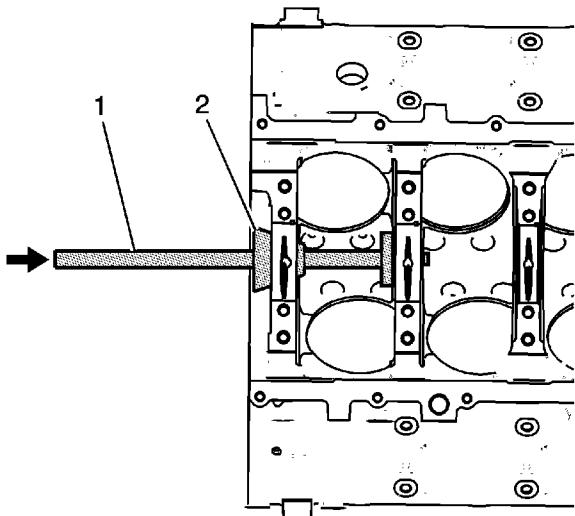
Important: To install or remove the expanding driver, always push on or pull from the ends.

Pressure on the outside diameter may cause a bind against the rubber expanding sleeve.

2. Place the expanding driver onto the expander assembly.
3. Ensure the separation lines between the segments of the expanding driver align with the separation lines of the expander assembly.

4. With the small end of the cone facing the driver assembly, place the guide cone over the driving bar.
5. Place the driving washer over the threaded portion of the expander assembly.
6. Screw the expander assembly, with driving washer, onto the driving bar.

For removal of the inner bearings, it may be necessary to install the driver bar extension.

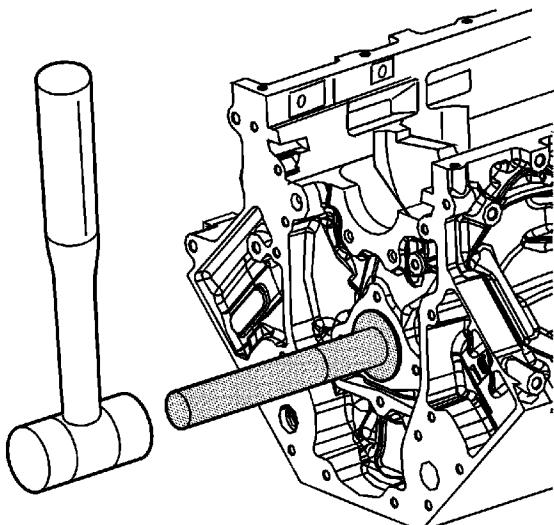


7. Insert the tool into an inner camshaft bearing and tighten until snug.

Operate the tool from the front or rear of the engine block.

On some engine blocks, the nut on the expander assembly is inaccessible, except from either end. In this case, you must use a socket and extension to enlarge and reduce the expander assembly.

8. Slide the nylon cone (2) into the front or rear camshaft bearing. This will properly align the tool.
9. Drive the bearing out of or into the engine block.
10. Repeat the procedure for the additional inner bearings.



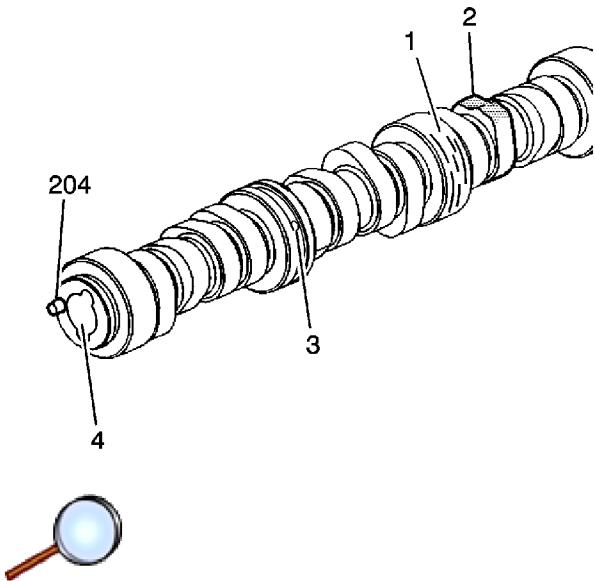
11. For the 2 end bearings, front and rear, remove the nylon cone and driver bar extension.
12. Drive the bearings out of or into the engine block.

Camshaft and Bearings Cleaning and Inspection (RPO LY6/L76/L9H)

Special Tools

- J 7872 Magnetic Base Dial Indicator Set
- J 8520 Camshaft Lobe Lift Indicator

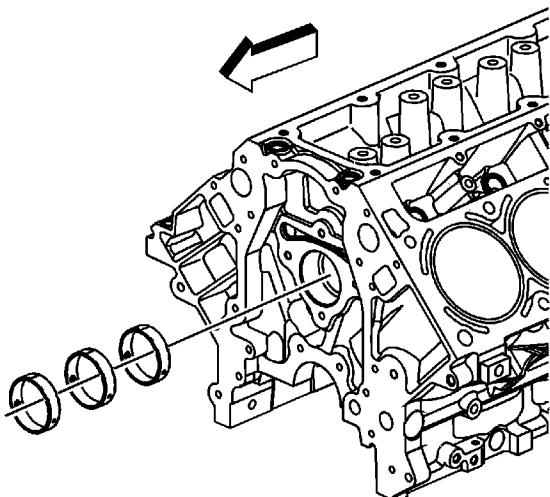
For equivalent regional tools, refer to [Special Tools](#)



1. Clean the components in solvent.

- Warning:** Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.
2. Dry the components with compressed air.
 3. Inspect the camshaft bearing journals (1) for scoring or excessive wear.
 4. Inspect the camshaft valve lifter lobes (2) for scoring or excessive wear.
 5. Inspect the camshaft position (CMP) actuator oil passages (3) for restrictions.
 6. Inspect the threaded bolt hole (4) in the front of the camshaft for damaged threads or debris.
 7. Inspect the camshaft sprocket pin (204) for damage.
 8. Inspect the camshaft retainer plate for wear or a damaged sealing gasket.

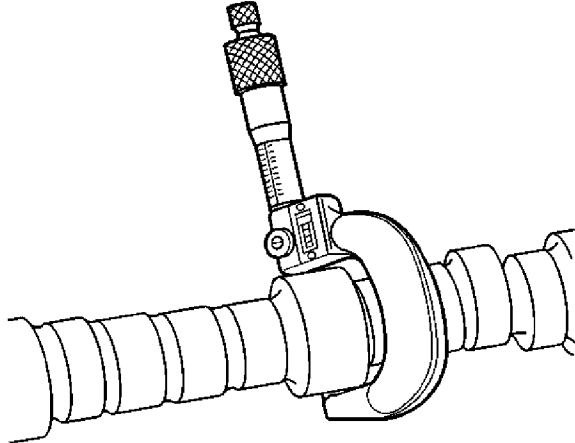
If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.



9. Inspect the camshaft bearings for the following:

- Excessive wear or scoring. The presence of the copper color bearing material should be considered normal and not a guideline for bearing replacement. Measure the bearing inside diameter (ID) as required for an over-sized condition. Refer to [Engine Mechanical Specifications](#).
- Proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in the engine block bearing bores.
- Oil lubrication hole plugged by debris.

Bearings with excessive wear or scoring must be replaced.

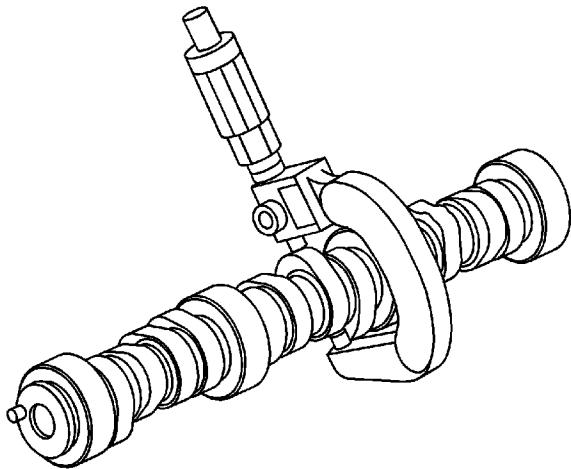


10. Using a micrometer, measure the camshaft journals for wear and out-of-round.

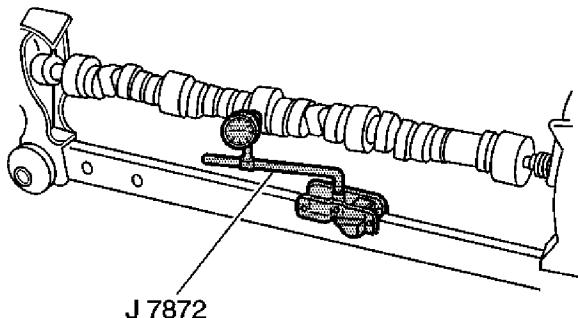
- If the camshaft bearing journals are greater than 0.025 mm (0.001 in) out-of-round,

replace the camshaft.

- If the camshaft bearing journal diameter is less than 54.99 mm (2.164 in), replace the camshaft.

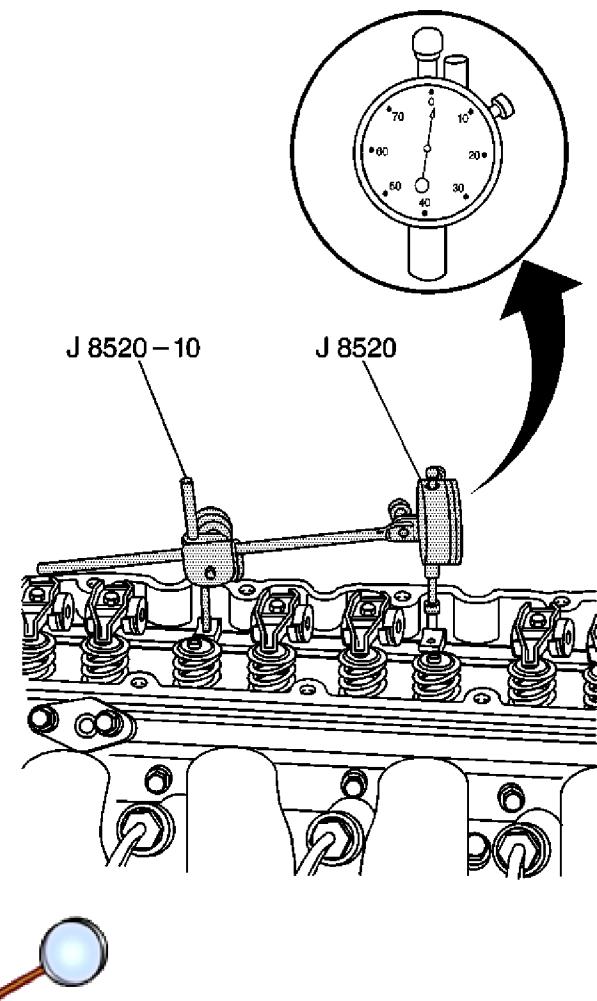


11. Using a micrometer, measure the camshaft lobes for wear. Refer to [Engine Mechanical Specifications](#).



12. Measure the camshaft runout.
- 12.1. Mount the camshaft in wooden V-blocks or between centers on a fixture.
 - 12.2. Using the J 7872 set, measure the runout of the intermediate camshaft bearing journals.
 - 12.3. If camshaft runout exceeds 0.05 mm (0.002 in), the camshaft is bent and should be replaced.

Measuring Camshaft Lobe Lift



Note: Measuring camshaft lobe lift is a procedure used to determine if the camshaft lobes have worn. This test is to be performed prior to engine disassembly and with the camshaft and valve train components installed in the engine.

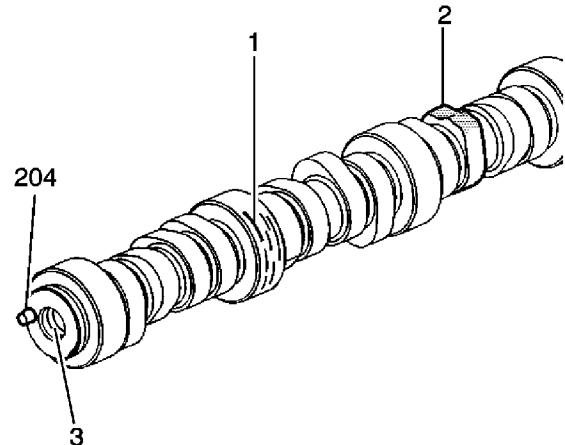
1. Using the J 8520 indicator , measure camshaft lobe lift.
2. Remove the valve rocker arms and bolts.
3. Install the dial indicator mounting stud into the valve rocker arm bolt hole.
4. Assemble the components of the J 8520 indicator and position onto the stud.
5. Position the shaft of the dial indicator onto the end of the pushrod.
6. Rotate the face of the dial indicator to zero.
7. Slowly rotate the crankshaft clockwise, until the dial indicator obtains its highest and lowest readings.
8. Compare the total to specifications. Refer to [Engine Mechanical Specifications](#).

Camshaft and Bearings Cleaning and Inspection (RPO LY2/LH6/LMG/LY5/LC9)

Special Tools

- J 7872 Magnetic Base Dial Indicator Set
- J 8520 Camshaft Lobe Lift Indicator

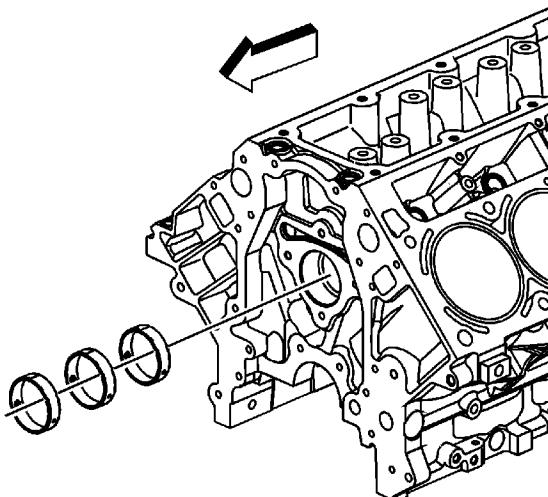
For equivalent regional tools, refer to [Special Tools](#)



1. Clean the components in solvent.

- Warning:** Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.
2. Dry the components with compressed air.
 3. Inspect the camshaft bearing journals (1) for scoring or excessive wear.
 4. Inspect the camshaft valve lifter lobes (2) for scoring or excessive wear.
 5. Inspect the threaded bolt hole (3) in the front of the camshaft for damaged threads or debris.
 6. Inspect the camshaft sprocket pin (204) for damage.
 7. Inspect the camshaft retainer plate for wear or a damaged sealing gasket.

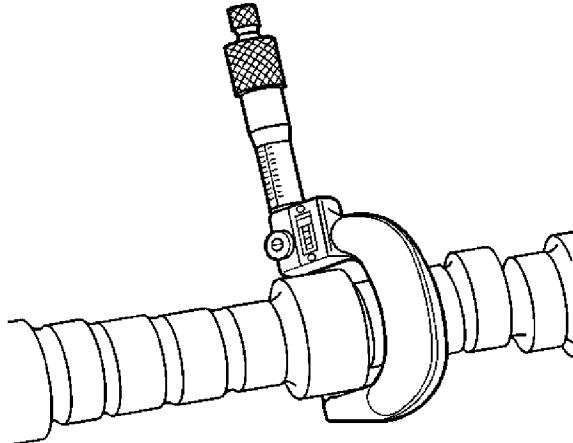
If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.



8. Inspect the camshaft bearings for the following:

- Excessive wear or scoring. The presence of the copper color bearing material should be considered normal and not a guideline for bearing replacement. Measure the bearing inside diameter (ID) as required for an over-sized condition. Refer to [Engine Mechanical Specifications](#).
- Proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in the engine block bearing bores.
- Oil lubrication hole plugged by debris.

Bearings with excessive wear or scoring must be replaced.

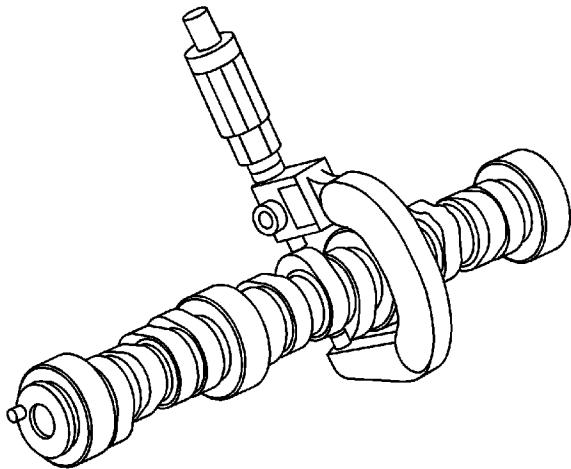


9. Using a micrometer, measure the camshaft journals for wear and out-of-round.

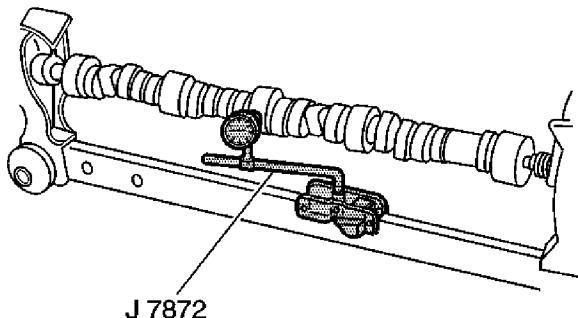
- If the camshaft bearing journals are greater than 0.025 mm (0.001 in) out-of-round,

replace the camshaft.

- If the camshaft bearing journal diameter is less than 54.99 mm (2.164 in), replace the camshaft.

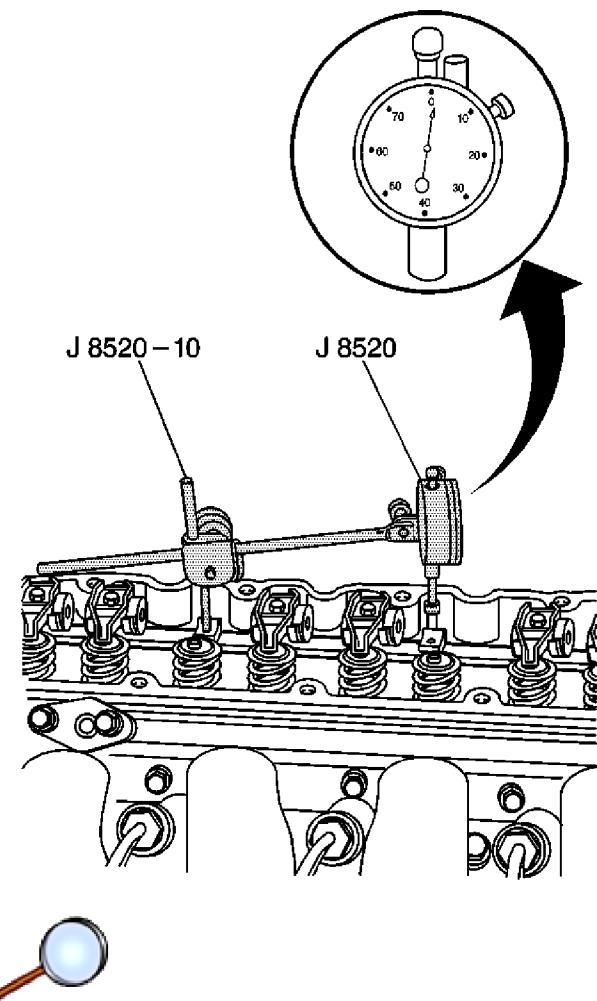


10. Using a micrometer, measure the camshaft lobes for wear. Refer to [Engine Mechanical Specifications](#).



11. Measure the camshaft runout.
- 11.1. Mount the camshaft in wooden V-blocks or between centers on a fixture.
 - 11.2. Using the J 7872 set, measure the runout of the intermediate camshaft bearing journals.
 - 11.3. If camshaft runout exceeds 0.05 mm (0.002 in), the camshaft is bent and should be replaced.

Measuring Camshaft Lobe Lift



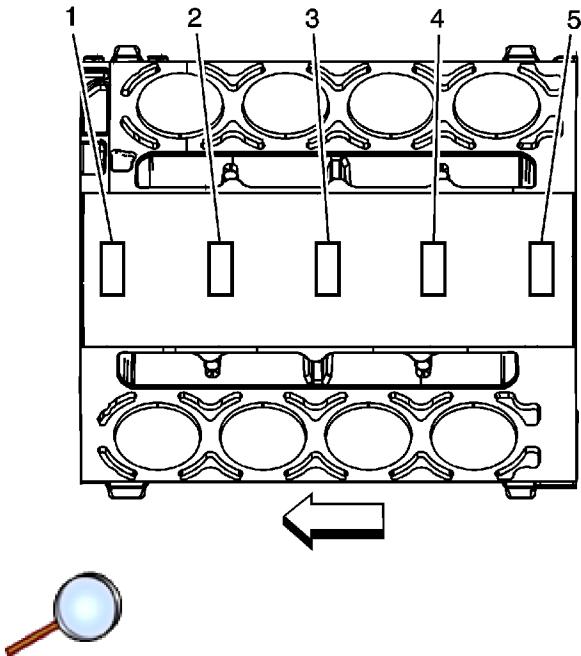
Note: Measuring camshaft lobe lift is a procedure used to determine if the camshaft lobes have worn. This test is to be performed prior to engine disassembly and with the camshaft and valve train components installed in the engine.

1. Using the J 8520 indicator , measure camshaft lobe lift.
2. Remove the valve rocker arms and bolts.
3. Install the dial indicator mounting stud into the valve rocker arm bolt hole.
4. Assemble the components of the J 8520 indicator and position onto the stud.
5. Position the shaft of the dial indicator onto the end of the pushrod.
6. Rotate the face of the dial indicator to zero.
7. Slowly rotate the crankshaft clockwise, until the dial indicator obtains its highest and lowest readings.
8. Compare the total to specifications. Refer to [Engine Mechanical Specifications](#).

Camshaft Bearing Installation

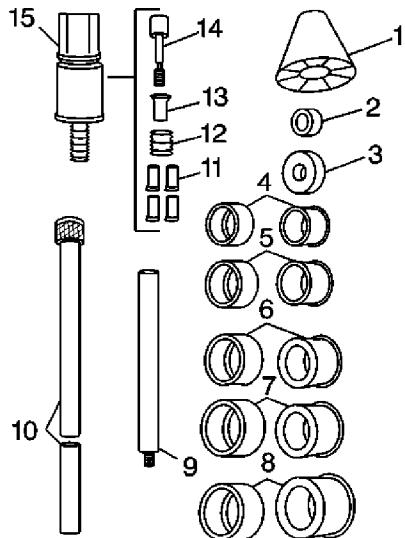
Tools Required

[J 33049](#) Camshaft Bearing Service Set

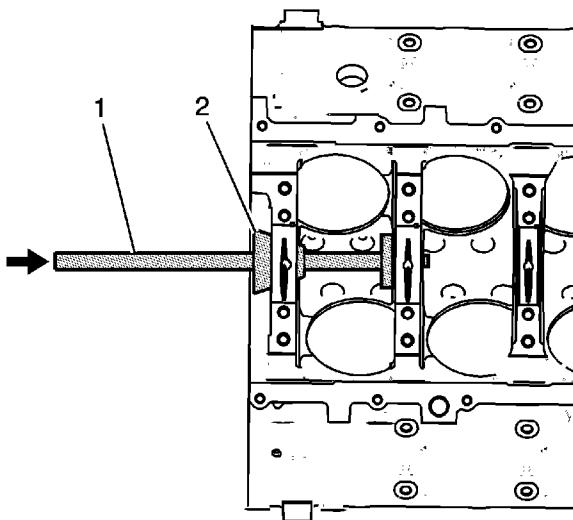


Important: The engine block camshaft bearing bores are machined for 3 different outside diameter (OD) size bearings. Position 1 and 5 are the largest diameter bores. Position 3 is the smallest diameter bore. Position 2 and 4 are the intermediate size bores. The inside diameter (ID) for all camshaft bearings is the same size.

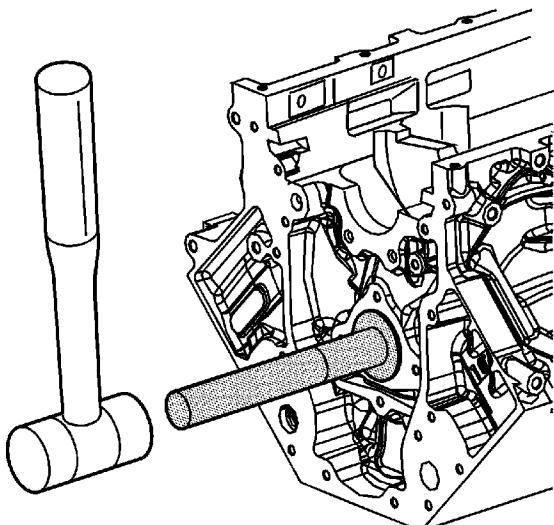
1. Measure the engine block camshaft bearing bores (1-5) in order to identify the correct OD size bearing for each position. Refer to [Engine Mechanical Specifications](#) .



2. Select the expanding driver (4-8) and washer (2 or 3) from the [J 33049](#). Refer to [Piston and Connecting Rod Assemble](#).
3. Assemble the tool.

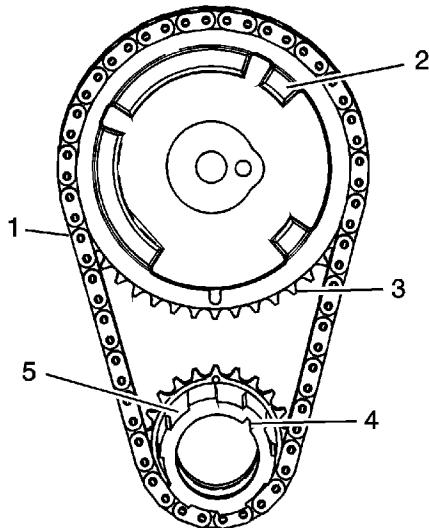


4. Insert the tool (1) through the front of the engine block and into the bearing.
5. Tighten the expander assembly nut until snug.
6. Push the guide cone (2) into the front camshaft bearing in order to align the tool.
7. Drive the bearing into the block bore.



8. Install the front and rear bearings to the block.

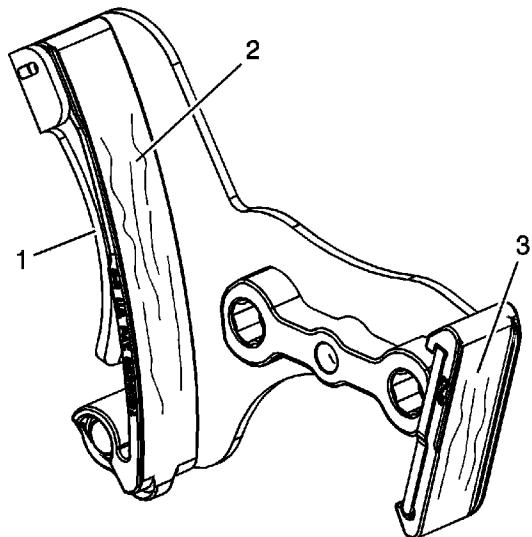
Camshaft Timing Chain and Sprocket Cleaning and Inspection



1. Clean the components with cleaning solvent.

Warning: Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.

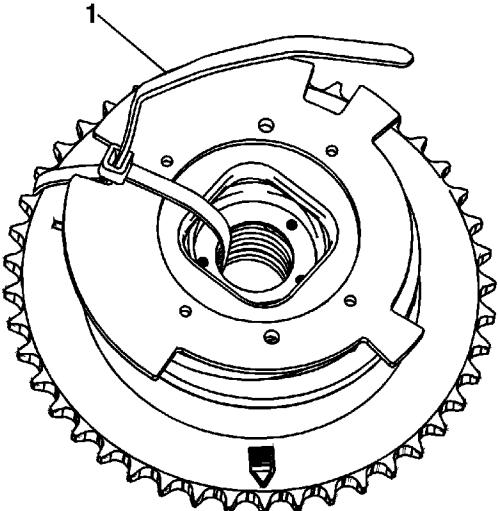
2. Dry the components with compressed air.
3. Inspect the timing chain (1) for binding or wear.
4. Inspect the camshaft position (CMP) sensor raised areas (2) for nicks or damage.
5. Inspect for worn, damaged, or chipped teeth (3).
6. Inspect for a damaged keyway (4).
7. Inspect for worn oil pump drive splines (5).



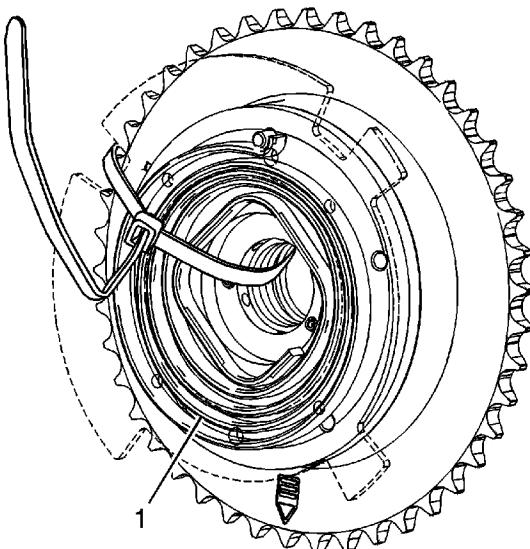
8. Inspect the timing chain tensioner for the following conditions:
 - Damaged or broken tension spring (1)
 - Excessive wear or scoring on the chain guide surfaces (2, 3)

Camshaft Position Actuator Cleaning and Inspection

Warning: Refer to [Camshaft Position Actuator Removal and Installation Warning](#) in the Preface section.



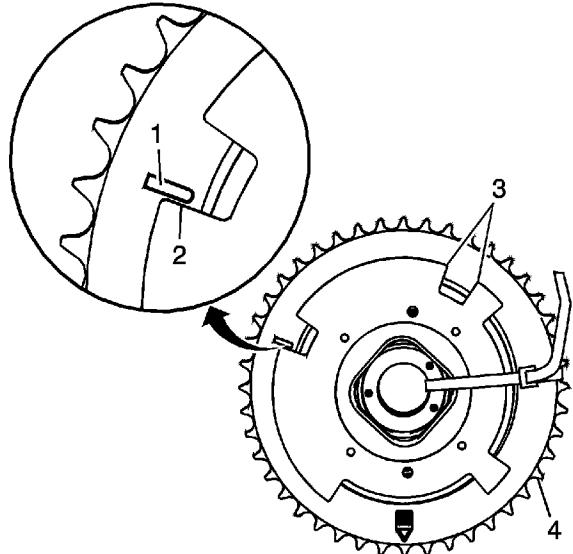
1. Insert a tie strap (1) through the center of the camshaft position (CMP) actuator and over the reluctor wheel.



2. Clean the CMP actuator with cleaning solvent.

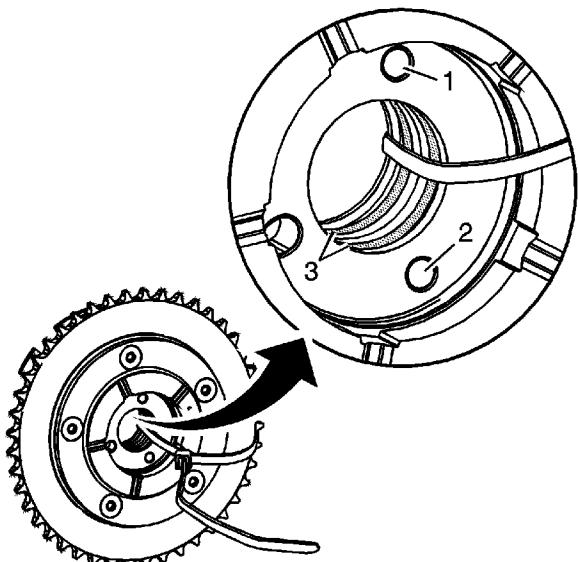
Warning: Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.

3. Dry the components with compressed air.
4. Inspect the CMP actuator for a broken spring (1).



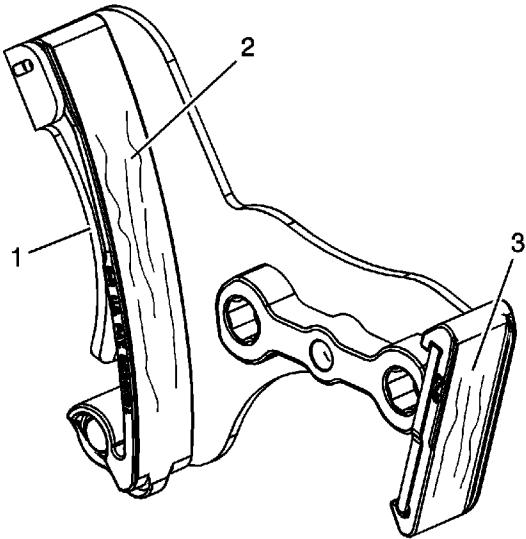
5. Inspect the CMP actuator for the following conditions:

- Improper positioning of the CMP reluctor wheel. The actuator return spring should reposition the reluctor wheel to the PARK position. Inspect for proper alignment of the mark on the face of the sprocket (1) with the flat edge of the reluctor wheel (2). If the reluctor wheel is not properly positioned, the internal components of the actuator are sticking or the return spring is broken and the actuator should be replaced as an assembly.
- Nicked or damaged edges (3) on the CMP reluctor wheel
- Damaged timing chain teeth (4)





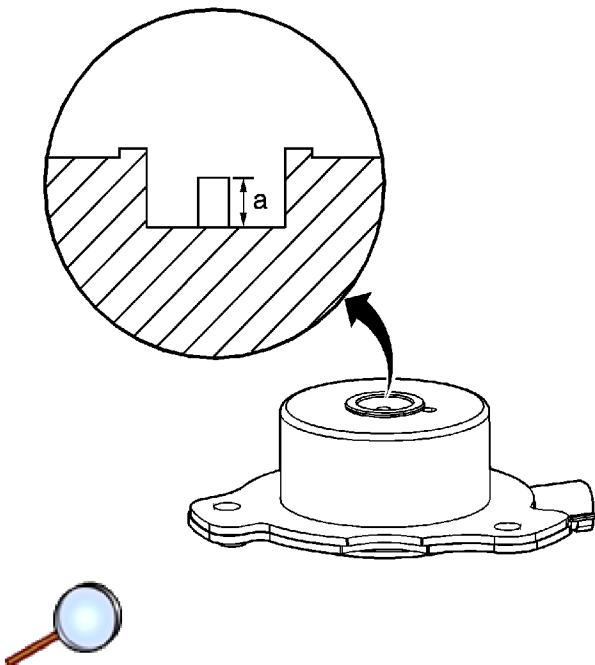
6. Inspect the CMP actuator for dirt, debris, or restrictions within the oil passages (1, 2, 3).



7. Inspect the timing chain tensioner for the following conditions:

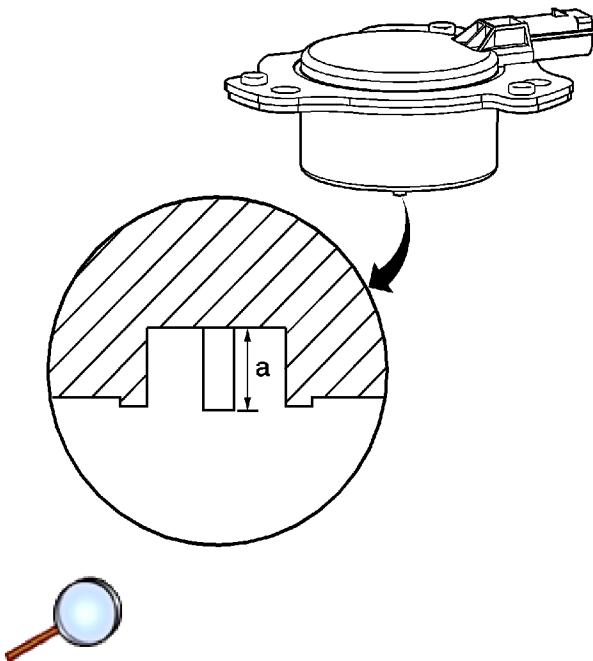
- Damaged or broken tension spring (1)
- Excessive wear or scoring on the chain guide surfaces (2, 3)

Camshaft Position Actuator Magnet Cleaning and Inspection



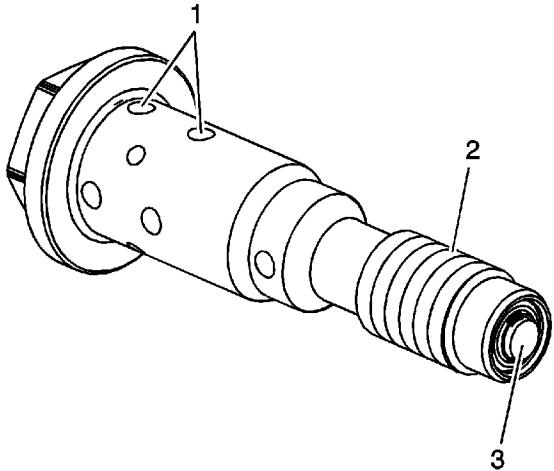
Important: Do not energize the camshaft position (CMP) magnet using a 12-volt power supply.

1. Inspect the CMP magnet for the following conditions:
 - A damaged electrical connector
 - An accumulation of dirt or debris in the recessed area around the pintle
 - A build-up of burnt engine oil on the shaft of the pintle which may cause the pintle to stick and not move freely within the proper range of travel
2. Holding the CMP magnet with the pintle facing upward, measure the pintle retracted position (a). Record the dimension.



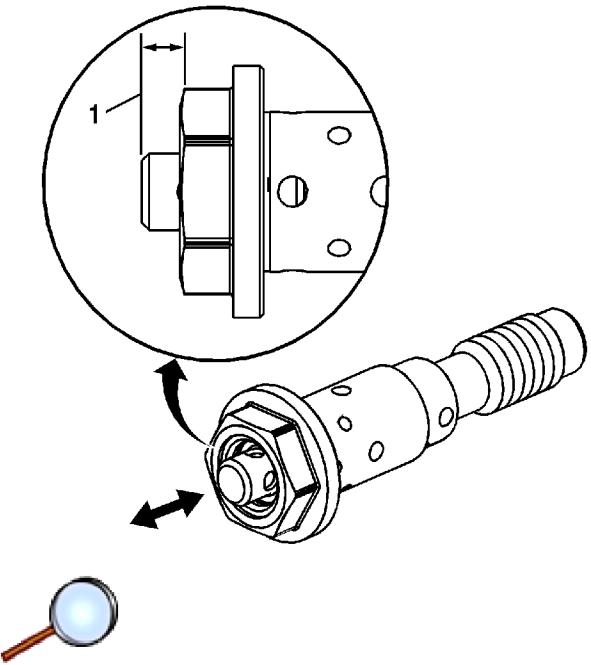
3. Holding the CMP magnet with the pintle facing downward, measure the pintle extended position (a). Record the dimension.
4. Subtract the retracted dimension from the extended dimension to determine pintle travel. A properly moving pintle will travel 3.0-5.5 mm (0.12-0.22 in).
5. If the pintle of the CMP magnet is binding or does not move within the proper range of travel, replace the CMP magnet as an assembly.

Camshaft Position Actuator Solenoid Valve Inspection (Off-Vehicle)



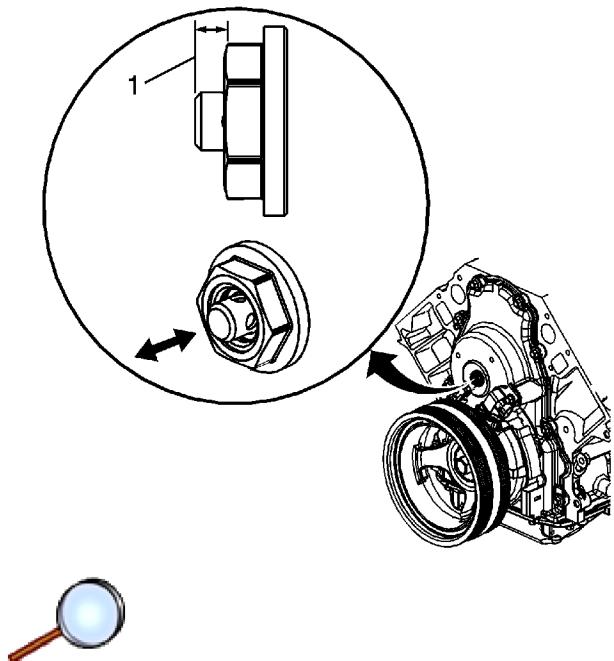
Important: Do not use the camshaft position (CMP) actuator solenoid valve again. Install a NEW valve during assembly. The inspection procedure below is provided for off-vehicle diagnostic purposes only.

1. Inspect the CMP valve for the following conditions:
 - Dirt, debris, or restrictions within the oil passages (1)
 - Damaged threads (2)
 - If the threads of the valve are damaged, also inspect the threads in the front of the camshaft for damage.
 - Dirt, debris, or restrictions within the oil inlet check valve (3)
 - If debris is detected, the engine assembly should be inspected to determine the source of contamination.



- 2. Inspect for a sticking valve spool or broken valve spool spring.
- 3. Depress the valve spool into the housing. The valve should move freely with no binding or sticking and minimal resistance inward. When released, the valve spring should return the spool to the proper extended position (1) of 6.08-6.12 mm (0.239-0.241 in).

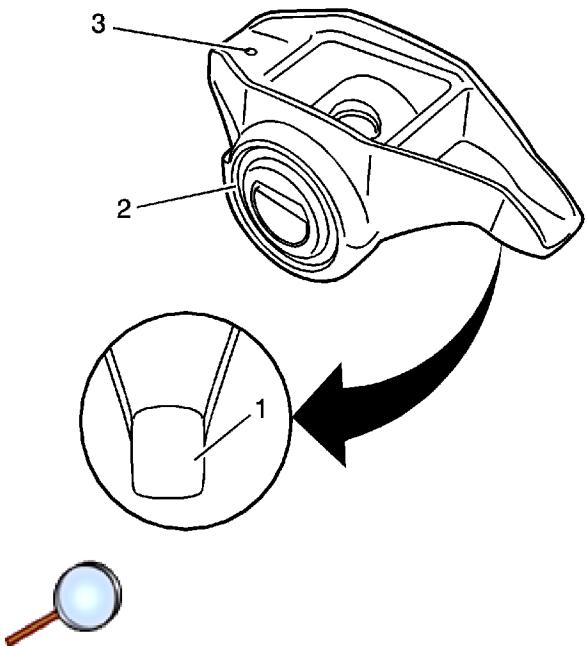
Camshaft Position Actuator Solenoid Valve Inspection (On-Vehicle)



Important: Do not use the camshaft position (CMP) actuator solenoid valve again. Install a NEW valve during assembly. The inspection procedure below is provided for on-vehicle diagnostic purposes only.

1. With the CMP magnet removed, inspect for a sticking valve spool or broken valve spool spring.
2. Depress the valve spool into the housing. The valve should move freely with no binding or sticking and minimal resistance inward. When released, the valve spring should return the spool to the proper extended position (1) of 6.08-6.12 mm (0.239-0.241 in).

Valve Rocker Arm and Push Rod Cleaning and Inspection



Note: Parts that are to be used again must be marked, sorted or organized for assembly.

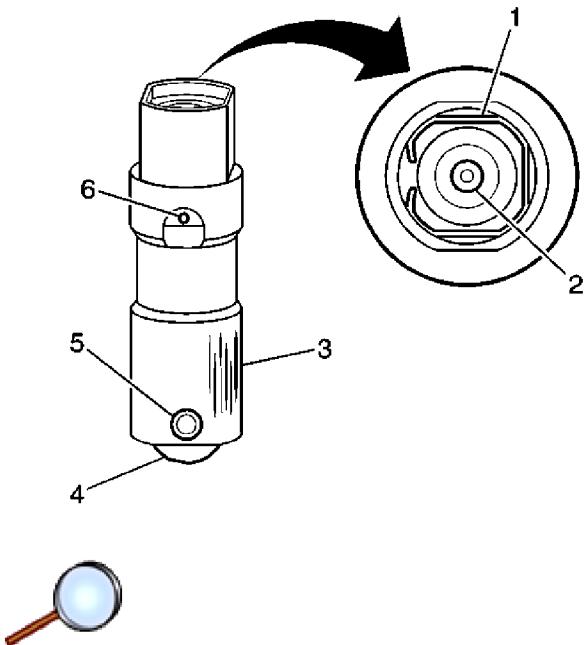
1. Mark, sort, or organize the components for assembly. Refer to [Separating Parts](#).
2. Clean the components with cleaning solvent.

Warning: Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.

3. Dry the components with compressed air.
4. Inspect the valve rocker arms bearings (2) for binding or roughness.
5. Inspect the valve rocker arm pushrod sockets (3) and valve stem mating surfaces (1). These surfaces should be smooth with no scoring or exceptional wear.
6. Inspect the pushrods for worn or scored ends. These surfaces should be smooth with no scoring or exceptional wear.
7. Inspect the pushrods for bends. Roll the pushrod on a flat surface to determine if the pushrod is bent.
8. Inspect the pushrod oil passages for restrictions.
9. Inspect the rocker arm pivot supports for cracks, wear, or other damage.

Valve Lifter and Guide Cleaning and Inspection (RPO LY2/LY6/L9H)

Valve Lifters



Note: Components that are to be used again must be marked, sorted or organized for assembly.

1. Clean the components in cleaning solvent.

Warning: Refer to Safety Glasses and Compressed Air Warning in the Preface section.

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
 - Bent or broken clip (1)
 - Worn pushrod socket (2)
 - Scuffed or worn sides (3)

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

- Flat spots on the roller (4)
- Loose or damaged pin (5)
- Plugged oil hole (6)
- Worn or damaged roller bearing

The roller should rotate freely with no binding or roughness.

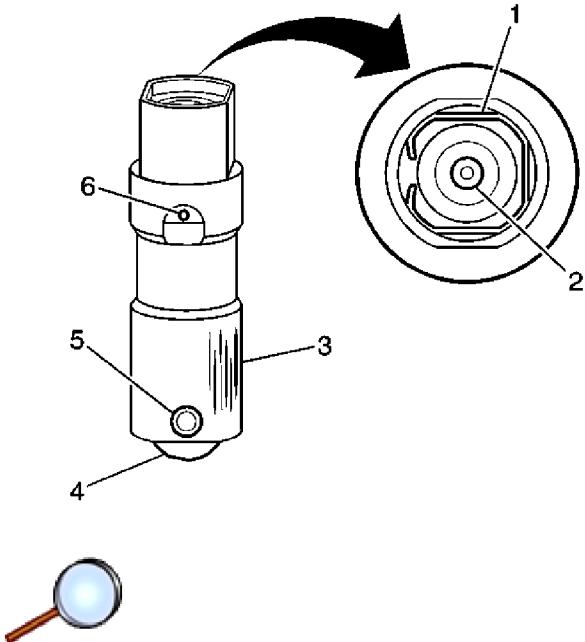
Valve Guides

Inspect the valve lifter guides for the following conditions:

- Cracks or damage
- Excessive wear in the lifter mounting bores

Valve Lifter and Guide Cleaning and Inspection (RPO LH6/LMG/LY5/LC9/L76)

Non Active Fuel Management Valve Lifters



Note: Components that are to be used again must be marked, sorted or organized for assembly.

1. Clean the components in cleaning solvent.

Warning: Refer to Safety Glasses and Compressed Air Warning in the Preface section.

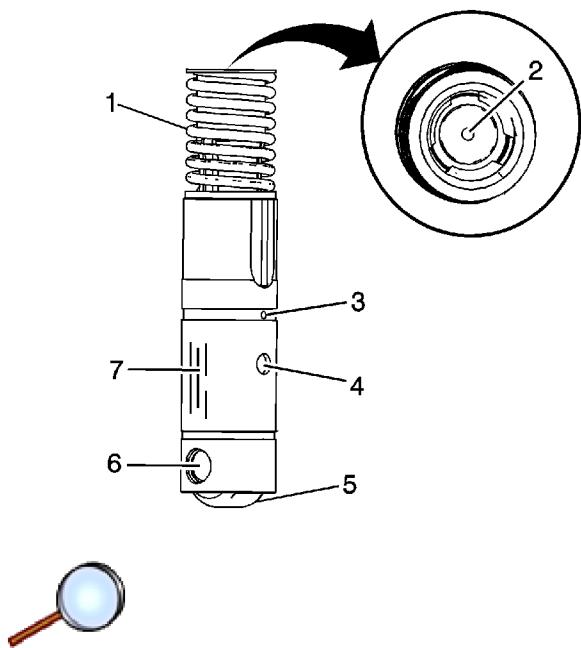
2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
 - Bent or broken clip (1)
 - Worn pushrod socket (2)
 - Scuffed or worn sides (3)

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

- Flat spots on the roller (4)
- Loose or damaged pin (5)
- Plugged oil hole (6)
- Worn or damaged roller bearing

The roller should rotate freely with no binding or roughness.

Active Fuel Management Valve Lifters



Note: Components that are to be used again must be marked, sorted or organized for assembly.

1. Clean the components in cleaning solvent.

Warning: Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
 - Broken or collapsed spring (1)
 - Worn pushrod socket (2)
 - Plugged lubrication hole (3)
 - Plugged lifter oil-switching hole (4)
 - Flat spots on the roller (5)
 - Worn or damaged roller bearing (6)
The roller should rotate freely with no binding or roughness.
 - Scuffed or worn sides (7)

Valve Guides

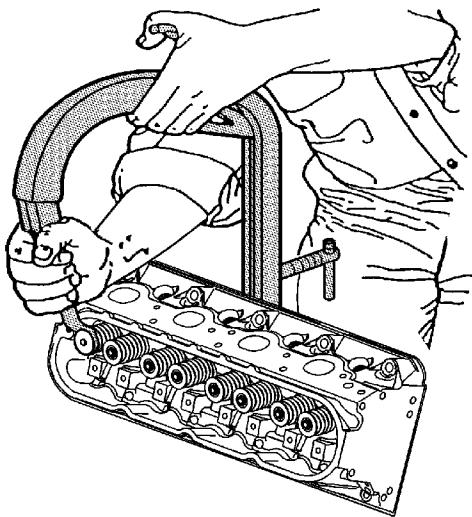
Inspect the valve lifter guides for the following conditions:

- Cracks or damage
- Excessive wear in the lifter mounting bores

Cylinder Head Disassemble

Special Tools

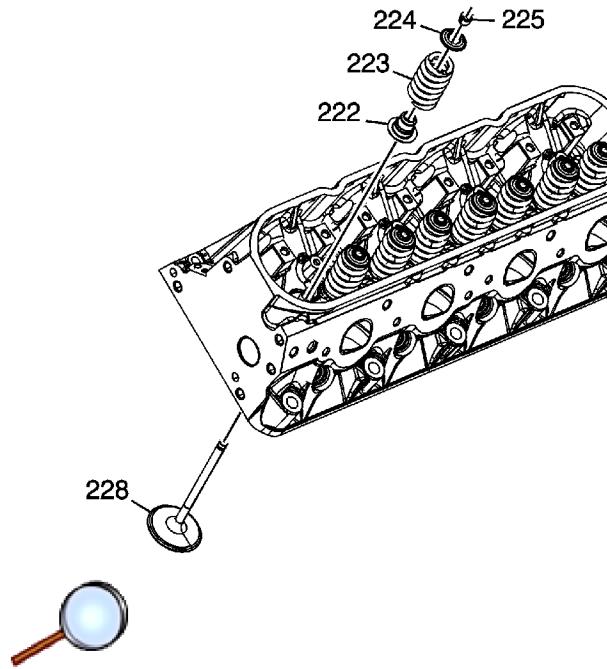
[J 8062](#) Valve Spring Compressor - Head Off



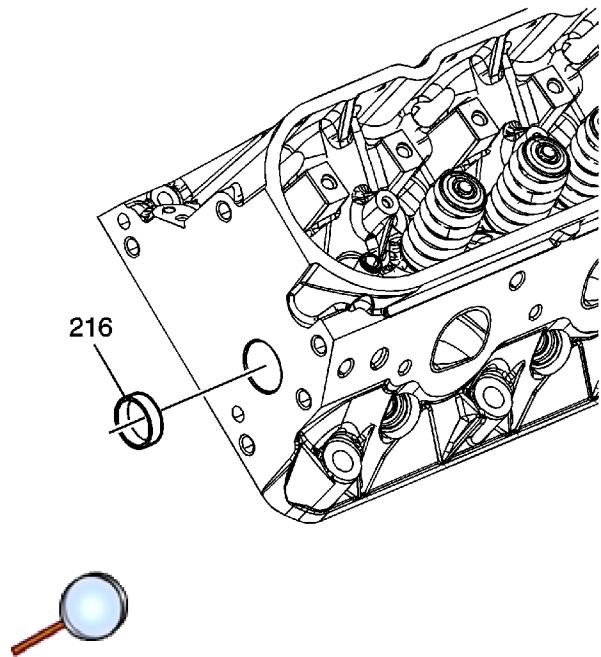
Important:

- With the components at room temperature, remove the spark plugs from the cylinder head.
- Mark, organize, or sort the cylinder head components for assembly. Return the components to their original location during assembly.

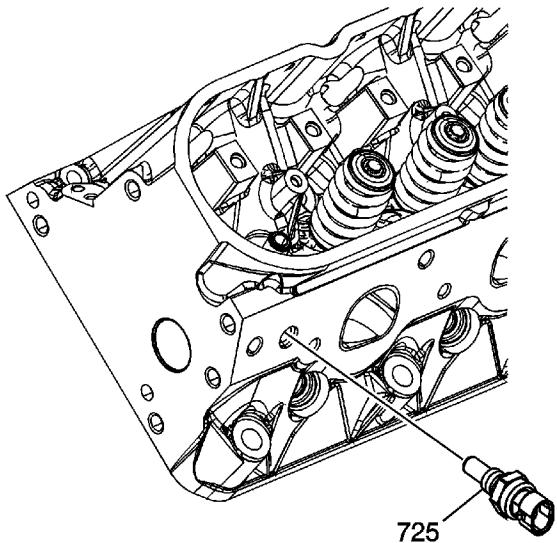
- Remove the spark plugs from the cylinder heads.
- Use the [J 8062](#) in order to compress the valve spring.



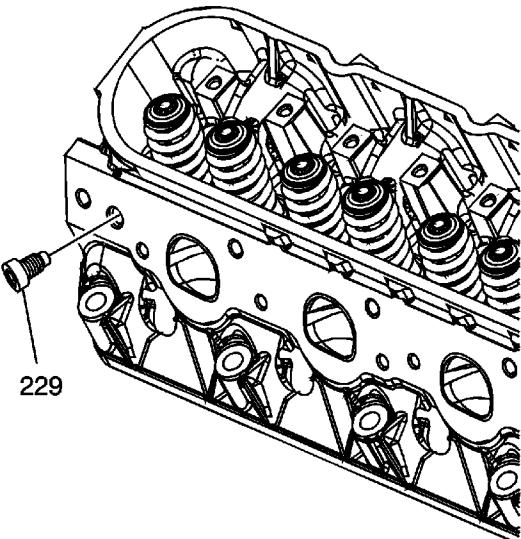
3. Remove the valve stem keys (225).
4. Remove the valve spring cap (224).
5. Remove the valve spring (223).
6. Remove the valves (228).
7. Remove the valve stem oil seal (222). Refer to [Separating Parts](#).



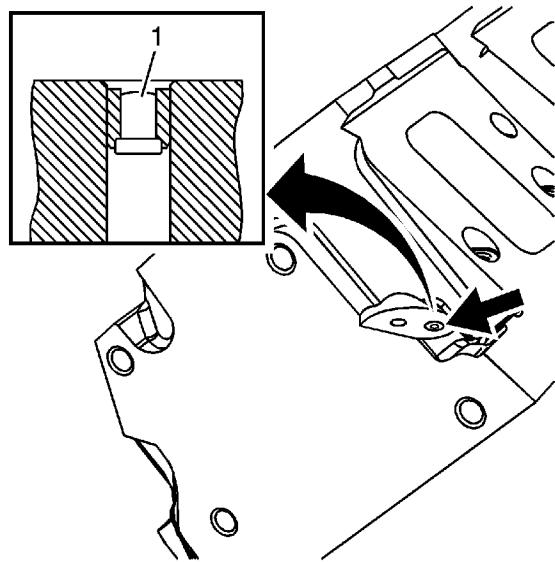
8. Remove the cylinder head core hole plugs (216), as required.



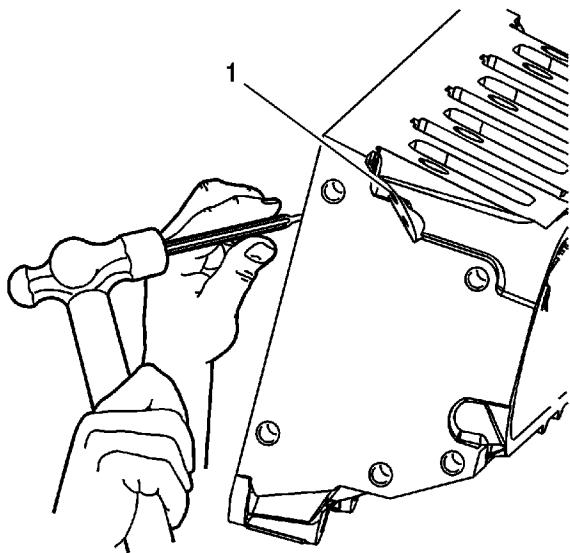
9. Remove the coolant temperature sensor (725) from the left cylinder head.



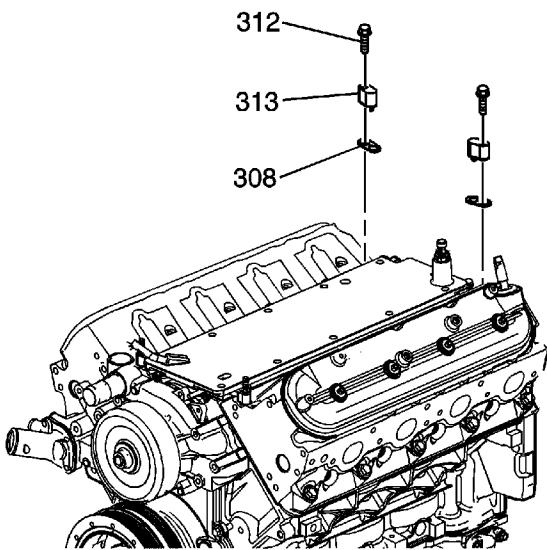
10. Remove the cylinder head plug (229) from the right cylinder head.



11. Inspect for a leaking plug (1). Second design applications use a rivet-type plug at the top rear coolant passage of each cylinder head. If service of a leaking plug is required, it is necessary to remove the cylinder head from the engine to properly remove the plug.



12. Using a 6.43 mm (0.25 in) or smaller punch, remove the plug assembly (1) from the cylinder head.



13. If plug removal is required, install a first design coolant air bleed cover (313), seal (308), and bolt (312) to complete the repair.

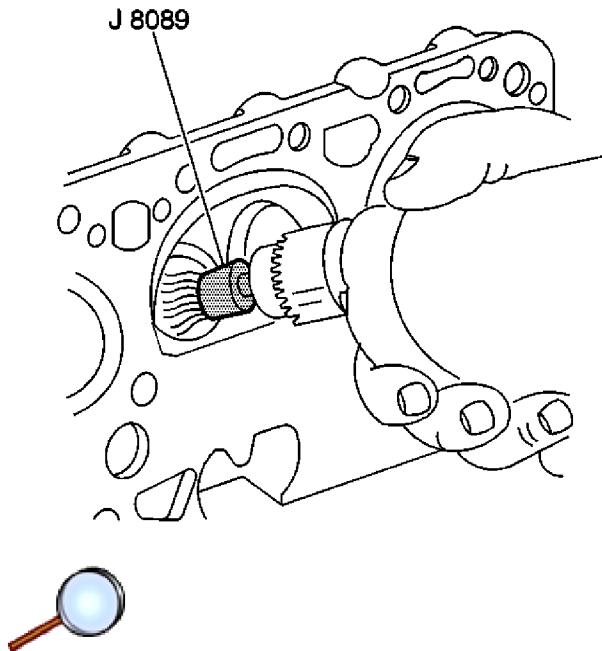
Cylinder Head Cleaning and Inspection

Special Tools

- J 8089 Carbon Removal Brush
- J 9666 Valve Spring Tester

For equivalent regional tools, refer to [Special Tools](#)

Warning: Refer to [Safety Glasses Warning](#) in the Preface section.



Note:

- When cleaning a cylinder head in a thermal type oven, do not exceed 204°C (400°F).
- Be careful not to scuff the chamber.

1. Clean the following components:

- Use the J 8089 brush in order to remove the carbon from the combustion chambers.
- Gasket surfaces
Refer to [Replacing Engine Gaskets](#).
- Valve stems and heads on a buffing wheel
- Bolt hole threads
Remove all dirt, debris, or threadlocking material from the bolt holes.

2. Inspect the cylinder head for the following conditions:

- 2.1. Cracks in the exhaust ports and combustion chambers

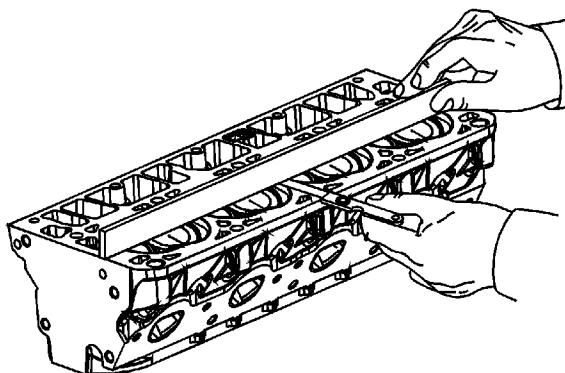
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- 2.2. External cracks in the water chambers
- 2.3. Gasket surfaces for excessive scratches or gouging

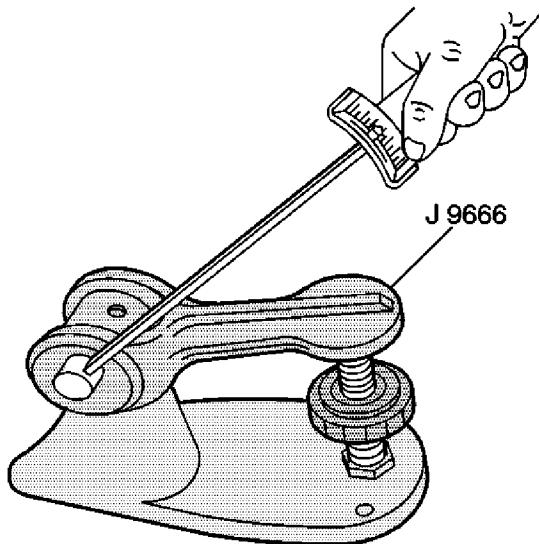
Refer to [Replacing Engine Gaskets.](#)

- 2.4. Bolt hole threads for debris or damaged threads

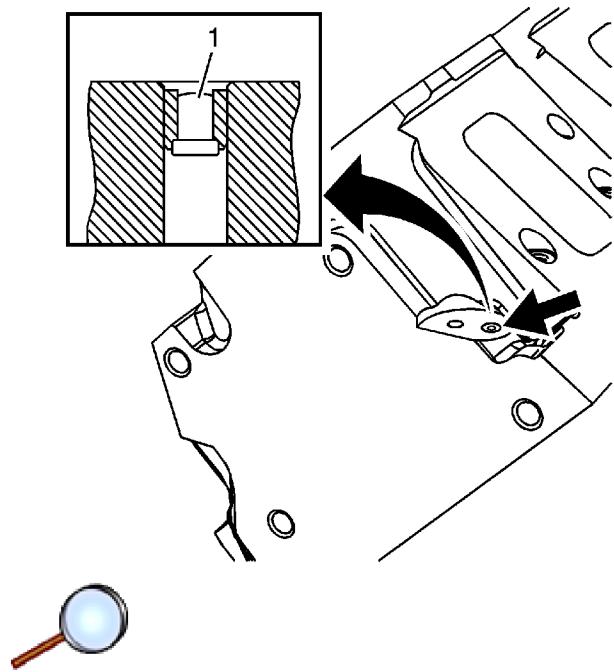
Refer to [Thread Repair](#) or [Thread Repair Specifications](#).



3. Inspect the cylinder head for warpage. Refer to [Engine Mechanical Specifications](#).



4. Use the J 9666 tester in order to measure the valve spring tension. Refer to [Engine](#)

Mechanical Specifications.

5. Inspect for a leaking plug (1). Second design applications use a rivet-type plug at the top rear coolant passage of each cylinder head. If service of a leaking plug is required, it is necessary to remove the cylinder head from the engine to properly remove the plug. Refer to [Cylinder Head Disassemble](#).

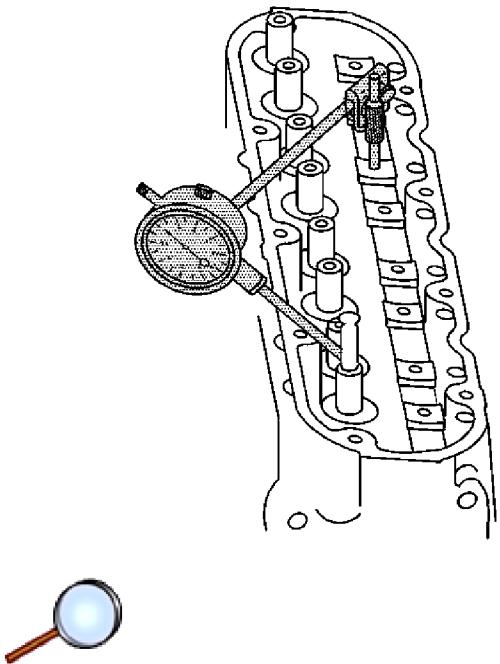
Valve Guide Reaming, and Valve and Seat Grinding

Special Tools

J37378-1 Valve Guide Reamer

For equivalent regional tools, refer to [Special Tools](#)

Valve Guide Reaming

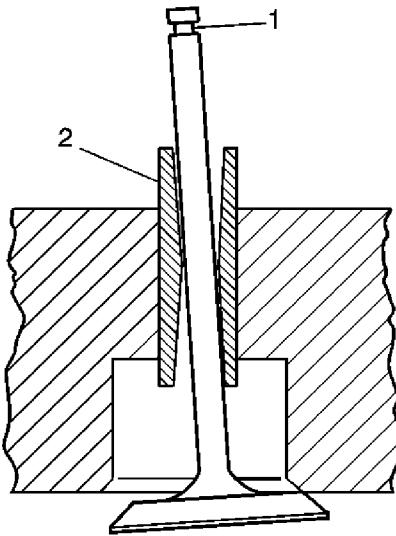


Caution: Excessive valve stem-to-guide clearance may cause a noisy valve train, premature valve stem oil seal wear, component damage, and/or excessive engine oil consumption.

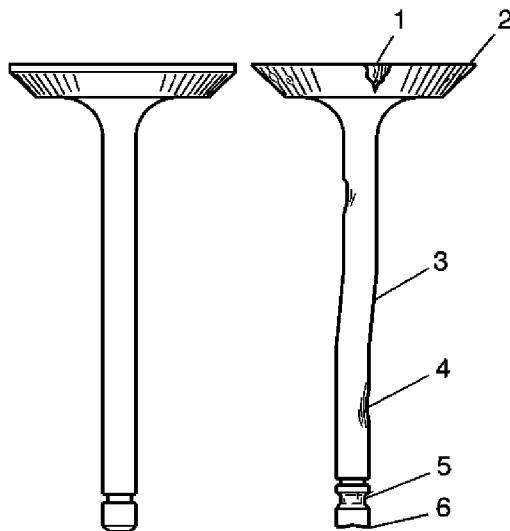
Caution: Insufficient valve stem-to-guide clearance will result in noisy or sticking valves. Valves that are too tight may disturb engine smoothness or lead to component damage.

1. Using a dial indicator, measure the valve stem-to-guide clearance. Position the tip of the dial indicator at the top of the valve guide.

Valve stem-to-guide clearance may also be obtained by using a micrometer to measure the valve stem diameter and a ball type measuring gage to measure the guide bore.



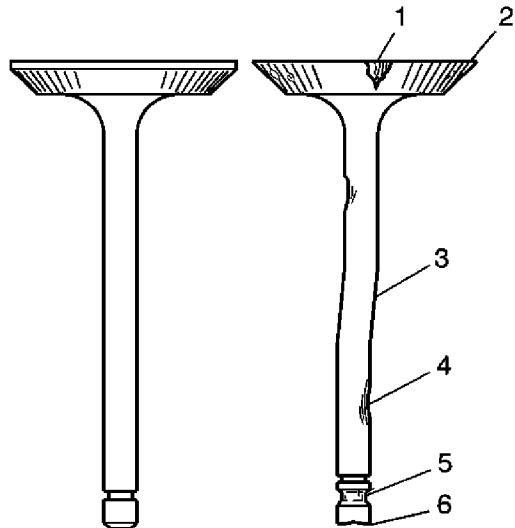
2. A valve stem (1) and guide (2), with excessive clearance, must be replaced or the cylinder head replaced. Refer to [Engine Mechanical Specifications](#).



3. Inspect the valve stems for excessive scoring, wear, or warpage.
 - A valve stem that has excessive scoring (3 or 4) or wear (4 or 6) must be replaced.
 - If a valve guide is worn or has excessive stem-to-guide clearance, the cylinder head should be replaced.
4. Measure the valve stem diameter. A valve stem with a diameter less than 7.95 mm (0.313 in) must be replaced.

If the valve stem diameter is within specifications, and the stem-to-guide clearance is excessive, the cylinder head must be replaced.

Valve and Seat Grinding



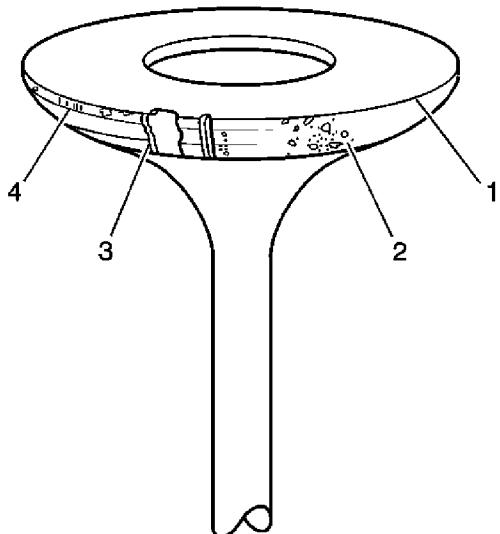
Note:

- Reconditioning the valve seats is very important. The seating of the valves must be perfect for the engine to deliver optimum power and performance. Several different types of equipment are available for grinding valve seats.
- Another important factor is the cooling of the valve head. Good contact between the valve and the seat will ensure that heat will be properly dissipated.
- The recommendations of the equipment manufacturer should be followed carefully to obtain the proper results. Regardless of the type of equipment used, it is essential that valve guide bores be free of carbon or dirt to ensure proper centering of the tool pilot in the guide.
- Valves that are pitted must be refaced to the proper angle. Valve stems that show excessive wear, or valves that are warped excessively must be replaced. When a valve head that is warped excessively is refaced, a knife edge may be ground on part or all of the valve head due to the amount of metal that must be removed. Knife edges lead to breakage, burning or pre-ignition due to heat localizing on this knife edge. If the edge of the valve head is less than 1.25 mm (0.05 in) after grinding, replace the valve.
- Several different types of equipment are available for refacing valves. The recommendation of the equipment manufacturer should be carefully followed to obtain the proper results.
- **DO NOT** reface intake valves. Intake valves with excessive wear or damage **MUST** be replaced.

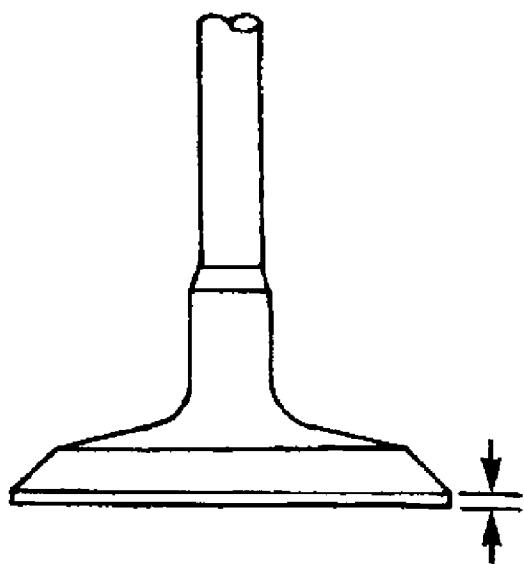
1. Inspect the valve for the following conditions:

- Burnt or eroded areas (1)
- A worn margin (2)
- A bent stem (3)

- A worn or scored stem (4)
- A worn key groove (5)
- A worn stem tip (6)



2. Inspect the valve face for the following conditions:
 - Worn or no margin (1 or 4)
 - Pitted surfaces (2)
 - Burnt or eroded areas (3)



3. Inspect the valve margin.

The exhaust valve may be refaced if the margin is greater than 1.25 mm (0.05 in) thick before grinding.

4. Reface pitted exhaust valves on a suitable valve refacing machine.
5. Replace the valve if the margin is less than 1.25 mm (0.05 in) thick after grinding.
6. If the valve face has been ground, it may be necessary to shim the valve spring in order to obtain the proper spring installed height. Refer to [Cylinder Head Disassemble](#).
7. Inspect for a loose valve seat in the cylinder head. The valve seat has an interference fit to the cylinder head.
8. Clean the valve guide bores with a suitable tool. Remove all carbon or dirt from the bores.

The valve guide must be clean for the seat grinding tool to obtain proper results.

9. Grind the valve seat.

The recommendations of the equipment manufacturer should be followed carefully to obtain the proper results. Regardless of the type of equipment used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.

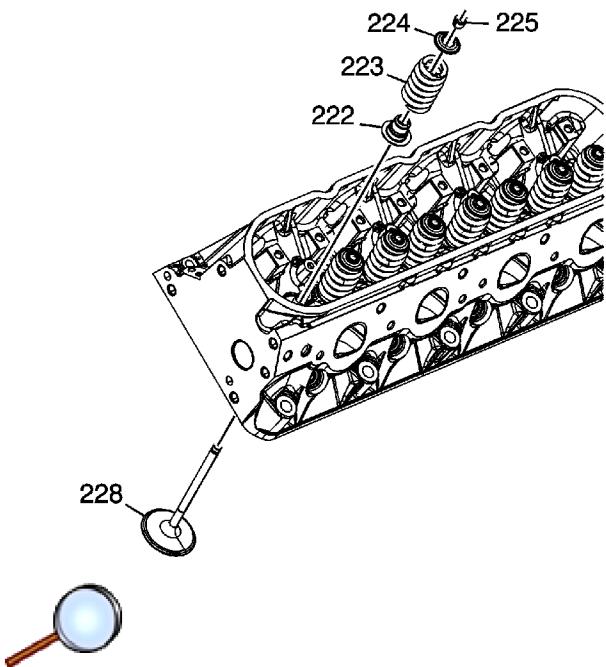
10. Inspect the valve seats.
 - The valve seats should be concentric to within 0.05 mm (0.0021 in) total indicator reading.
 - If the valve seat has been ground, it may be necessary to shim the valve spring in order to attain the proper spring installed height. Refer to [Cylinder Head Disassemble](#).

Cylinder Head Assemble

Special Tools

J8062 Valve Spring Compressor - Head Off

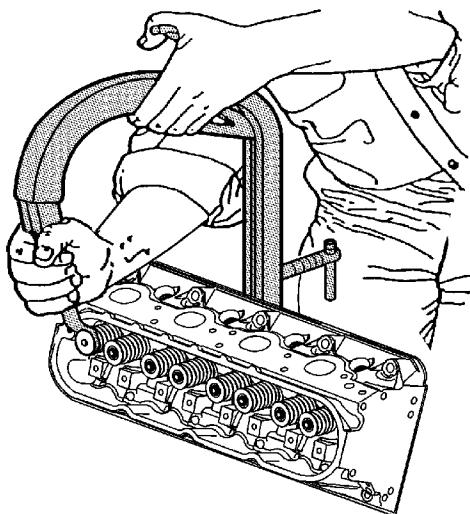
For equivalent regional tools, refer to [Special Tools](#)



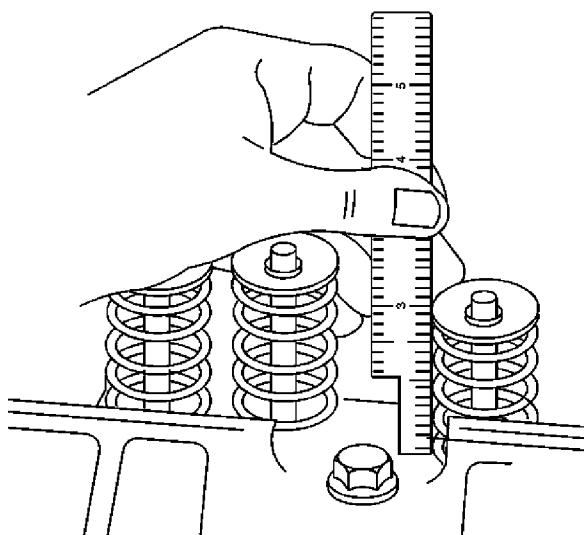
1. Clean the cylinder head valve spring shim area.

Note: When using the valves and related components again, install the parts to their original location.

2. Install the valves (228) into the proper port. Refer to [Separating Parts](#)
3. Install the valve stem oil seal (222).
4. Install the valve spring (223).
5. Install the valve spring cap (224).



6. Using the J8062 compressor , compress the valve spring.
7. Install the valve stem keys.
 - 7.1. Use grease in order to hold the keys in place and remove the J8062 compressor .
 - 7.2. Ensure the keys seat properly in the groove of the valve stem.
 - 7.3. Tap the end of the valve stem with a plastic face hammer to seat the keys, if necessary.



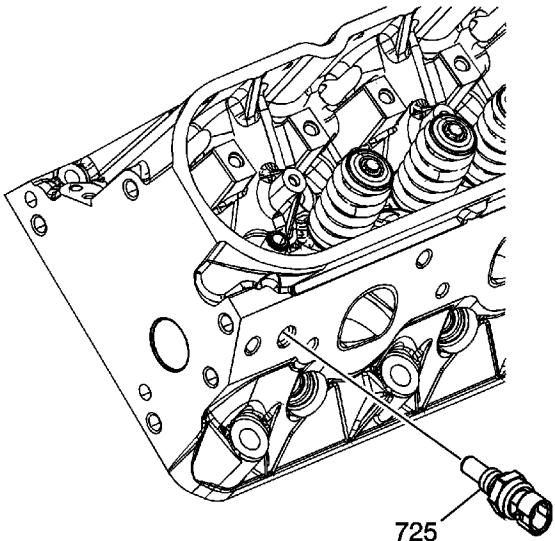
8. Using a ruler, measure the valve spring installed height.

Measure from the base of the valve spring to the top of the valve spring.

Specification

- If the installed height exceeds 46.25 mm (1.82 in), install a valve spring shim of approximately 0.5 mm (0.02 in) thick.
- Do not shim the valve spring to obtain less than the specified height.
Do not assemble the components without a spring shim on the cylinder head.

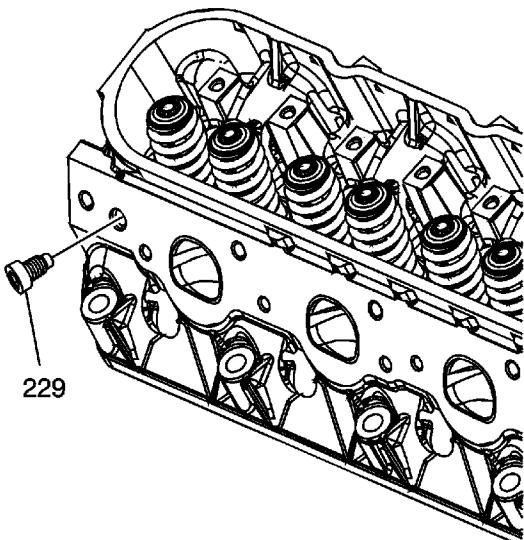
9. Install the remaining valves, springs, and other components.



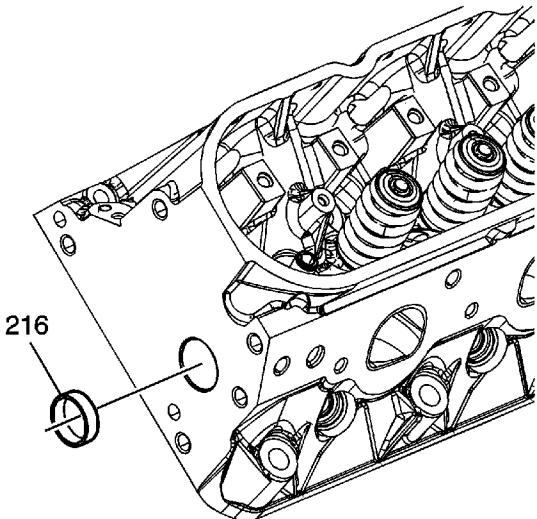
10. Install sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the threads of the coolant temperature sensor (725).

Caution: Refer to [Fastener Caution](#) in the Preface section.

11. Install the coolant temperature sensor into the left cylinder head and tighten to **20 N·m (15 lb ft)**.

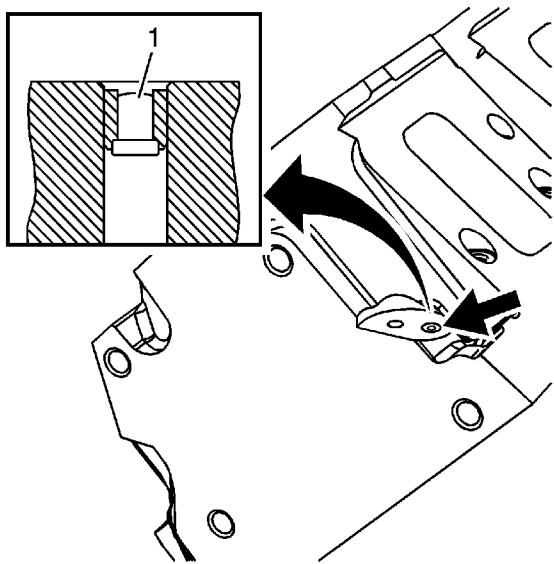


12. Install sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the threads of the cylinder head plug (229).
13. Install the cylinder head plug to the right cylinder head and tighten to **20 N·m (15 lb ft)**.

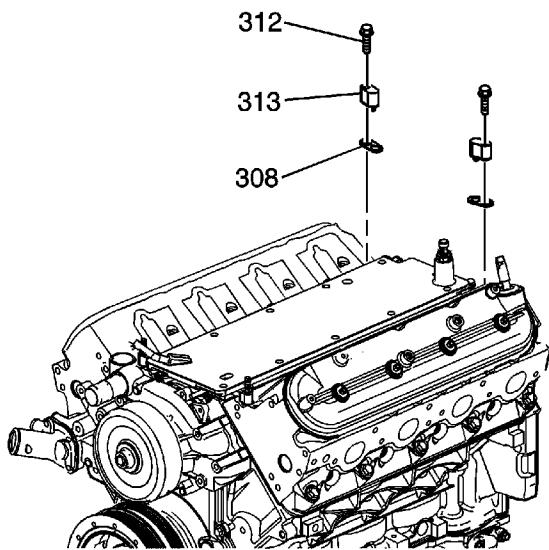


14. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the sides of the cylinder head plugs (216).
15. Install the cylinder head plugs into the cylinder head.

A properly installed plug should be installed 2.5 mm (0.1 in) below the end face of the head.

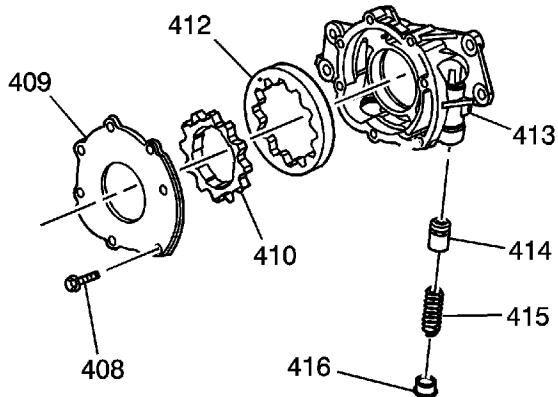


16. Second design applications use a rivet-type plug (1) at the top rear coolant passage of each cylinder head. If service of a leaking plug is required, it is necessary to remove the cylinder head from the engine to properly remove the plug.



17. If plug removal is required, install a first design coolant air bleed cover and bolt to complete the repair.

Oil Pump Disassemble



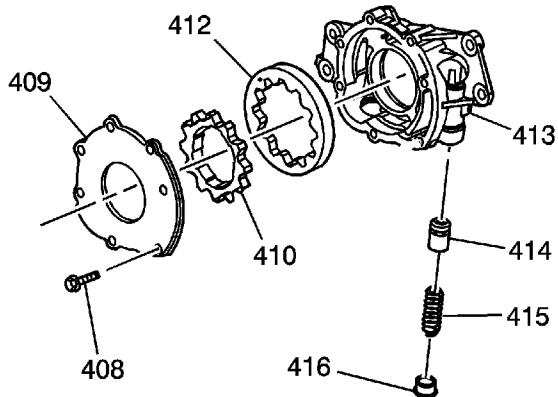
Important: The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

1. Remove the oil pump cover bolts (408).
2. Remove the oil pump cover (409).

Important: Mark or identify the gears for assembly. Refer to [Separating Parts](#).

3. Remove the drive gear (410).
4. Remove the driven gear (412).
5. Remove the pressure relief valve plug (416).
6. Remove the pressure relief valve spring (415).
7. Remove the pressure relief valve (414).
8. Inspect the oil pump components. Refer to [Oil Pump Cleaning and Inspection](#).

Oil Pump Cleaning and Inspection



Note:

- The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.
- The oil pump pipe and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the pump and screen assembly.

1. Clean the parts in solvent.

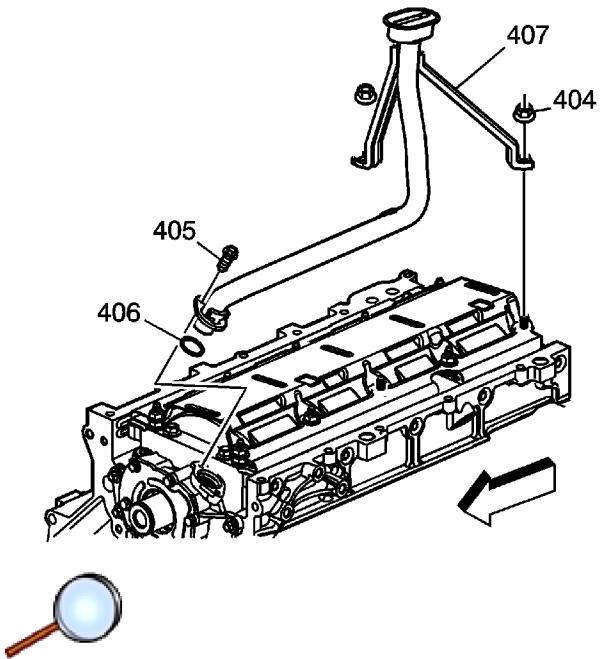
Warning: Refer to [Safety Glasses Warning](#) in the Preface section.

2. Dry the parts with compressed air.
3. Inspect the oil pump housing (413) and the cover (409) for cracks, excessive wear, scoring, or casting imperfections.
4. Inspect the oil pump housing-to-engine block oil gallery surface for scratches or gouging.
5. Inspect the oil pump housing for damaged bolt hole threads.
6. Inspect the relief valve plug (416) and plug bore for damaged threads.
7. Inspect the oil pump internal oil passages for restrictions.
8. Inspect the drive gear (410) and driven gear (412) for chipping, galling, or wear.

Minor burrs or imperfections on the gears may be removed with a fine oil stone.

9. Inspect the drive gear splines for excessive wear.
10. Inspect the pressure relief valve (414) and bore for scoring or wear.

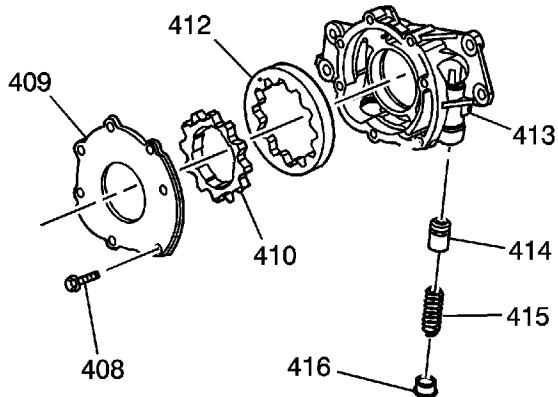
The valve must move freely in the bore with no restrictions.



- 11. Inspect the oil pump screen (407) for debris or restrictions.
- 12. Inspect the oil pump screen for broken or loose wire mesh.



Oil Pump Assemble



Note: Prior to assembling the oil pump, coat all wear or internal surfaces with clean engine oil.

1. Install the driven gear (412) into the pump housing (413).

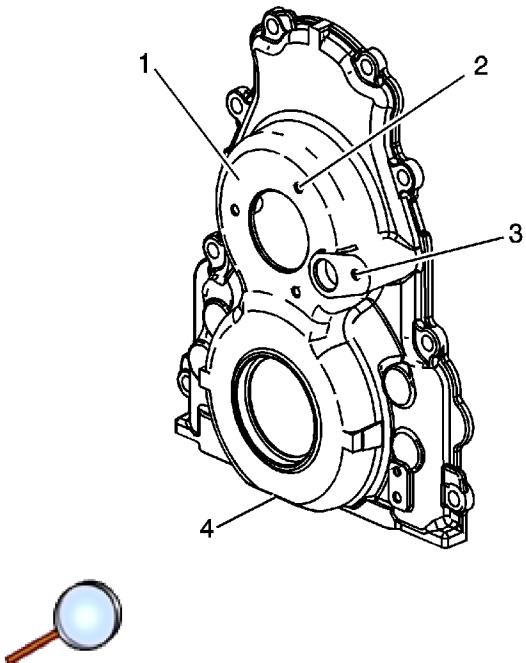
Install the driven gear with the orientation mark facing the pump cover.

2. Install the drive gear (410) into the pump housing.
3. Install the oil pump cover (409).

Caution: Refer to [Fastener Caution](#) in the Preface section.

4. Install the oil pump cover bolts (408) and tighten to **12 N·m (106 lb in)**.
5. Install the relief valve (414).
6. Install the relief valve spring (415).
7. Install the relief valve plug (416) and tighten to **12 N·m (106 lb in)**.
8. Inspect the oil pump for smooth operation by rotating the drive gear.

Engine Front Cover Cleaning and Inspection (RPO LY6/L76/L9H)



Note:

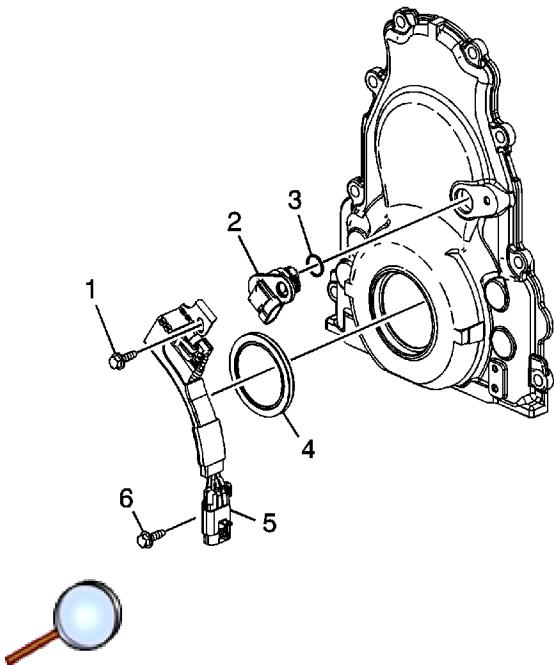
- Do not use the crankshaft front oil seal again. Install a NEW crankshaft front oil seal during assembly.
- Do not use the front cover-to-engine block gasket again. Install a NEW gasket during assembly.
- Do not use the camshaft position (CMP) actuator magnet gasket again. Install a NEW gasket during assembly.

1. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to [Replacing Engine Gaskets](#).

Warning: Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.

2. Dry the cover with compressed air.
3. Inspect the gasket sealing surfaces (1, 4) for excessive scratches or gouging.
4. Inspect the threaded bolt holes (2, 3) for damaged threads or debris.

Engine Front Cover Cleaning and Inspection (RPO LY2/LH6/LMG/LY5/LC9)



Note:

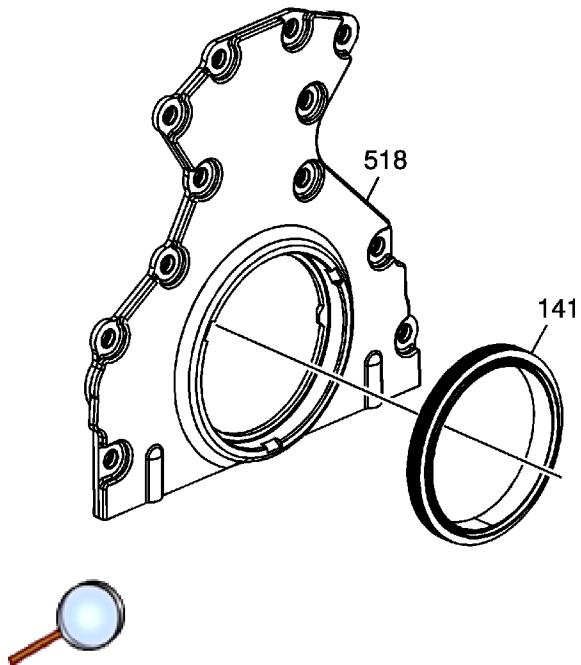
- Do not use the crankshaft front oil seal again. Install a NEW crankshaft front oil seal during assembly.
- Do not use the front cover-to-engine block gasket again. Install a NEW gasket during assembly.

1. Remove the crankshaft front oil seal (140) from the front cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to [Replacing Engine Gaskets](#).

Warning: Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal and camshaft position (CMP) sensor mounting bore for damage.

Crankshaft Rear Oil Seal Housing Cleaning and Inspection



Note:

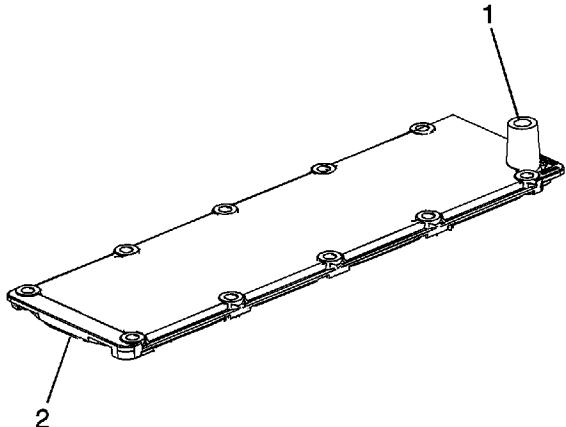
- Do not use the crankshaft rear oil seal again. Install a NEW crankshaft oil seal during assembly.
- Do not use the rear housing-to-engine block gasket again. Install a NEW gasket during assembly.

1. Remove the crankshaft oil seal (141) from the rear housing.
2. Clean the housing in solvent. Remove the sealant from the housing oil pan surface. Refer to [Replacing Engine Gaskets](#).

Warning: Refer to [Safety Glasses Warning](#) in the Preface section.

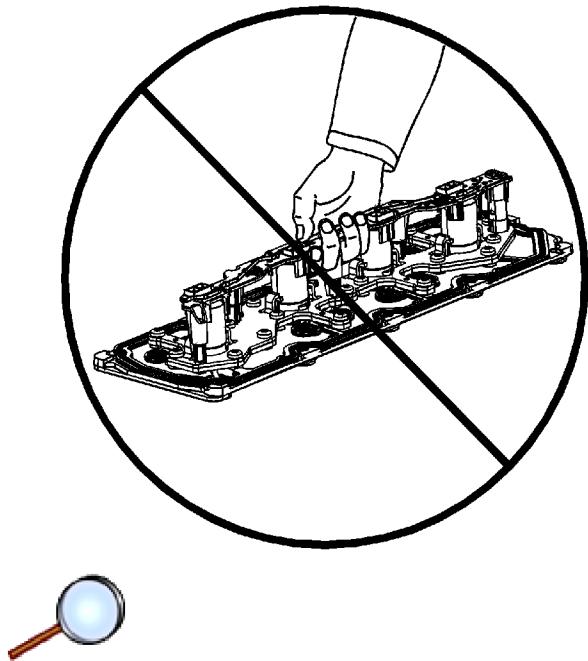
3. Dry the housing with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the housing-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.

Engine Block Valley Cover Cleaning and Inspection



1. Clean the valley cover in solvent.
Warning: Refer to [Safety Glasses Warning](#) in the Preface section.
2. Dry with compressed air.
3. Inspect for damaged threads (1) and damaged sealing surfaces (2).

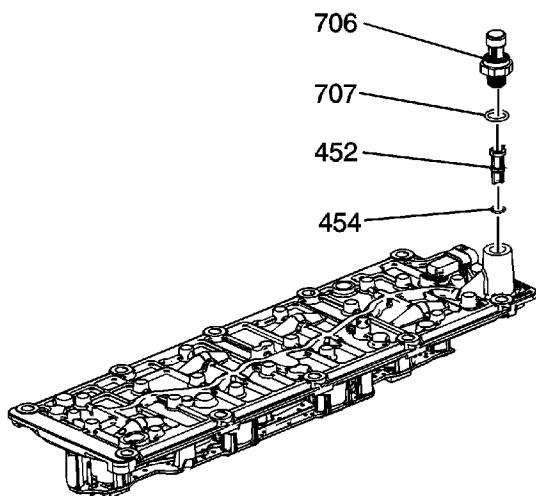
Valve Lifter Oil Manifold Cleaning and Inspection



Note:

- Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.
- Do not disassemble the electrical components from the manifold.
- Do not submerge the electrical components in cleaning solvent.
- Do not use the manifold exterior gasket again. Remove the exterior gasket and install a NEW service gasket during assembly.

1. Do not lift the manifold assembly by the electrical lead frame.



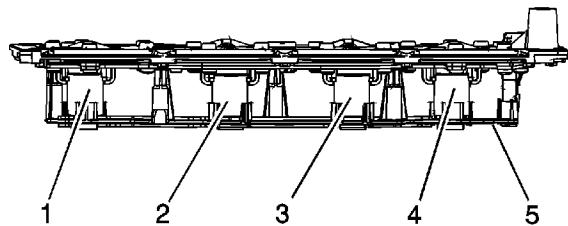
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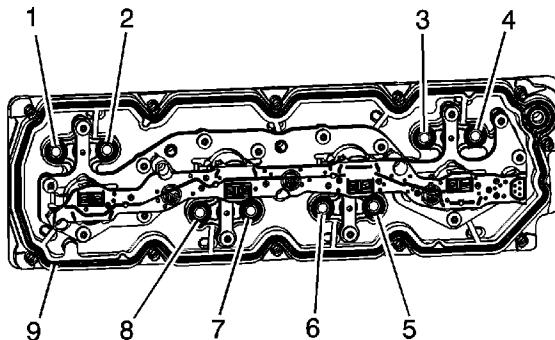
2. Remove the oil pressure sensor (706) and washer (707).
3. Remove the oil screen (452) with O-ring (454).

Warning: Refer to [Safety Glasses and Compressed Air Warning](#) in the Preface section.

4. Clean the manifold with compressed air.



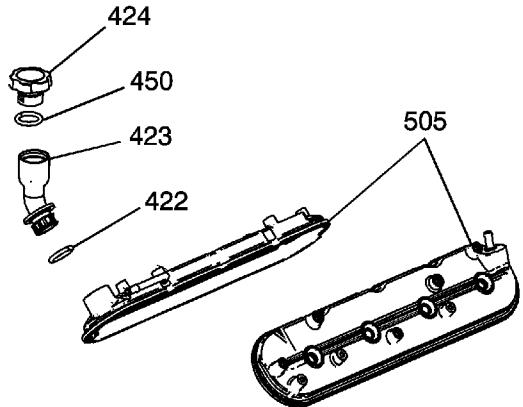
5. Inspect for loose electrical solenoids (1-4) or loose or missing bolts.
6. Inspect for damage to the electrical lead frame (5).
7. Inspect for a damaged electrical connector, for bent or corroded pins.



8. Inspect for damaged interior sealing gaskets (1-8). If the interior sealing gaskets are damaged, the manifold must be replaced as an assembly.

9. Inspect for a damaged exterior sealing gasket (9) or scored gasket surfaces.
10. Inspect for debris or restrictions within the oil passages of the manifold. Refer to [Cylinder Deactivation \(Active Fuel Management\) Valve Lifter Oil Manifold Diagnosis and Testing](#).

Valve Rocker Arm Cover Cleaning and Inspection

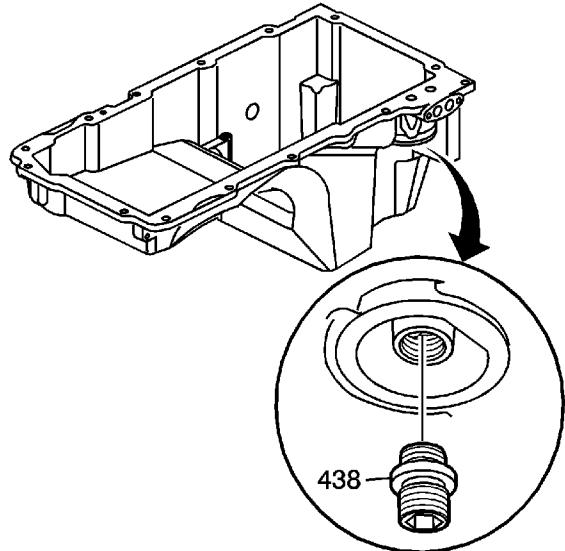


Important:

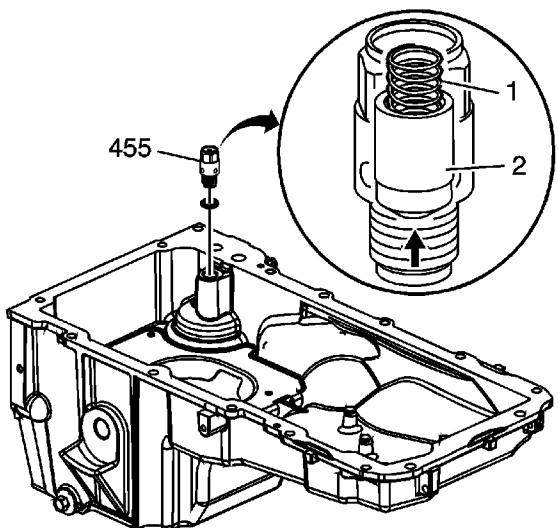
- Do not use the valve rocker arm cover gasket again. Install a NEW gasket during assembly.
- Remove the ignition coils before cleaning the cover in solvent. Do not submerge the ignition coils in solvent.
- Do not remove the oil fill tube from the covers unless service is required. If the tube is removed from the cover, install a NEW tube (423) and seal (422) during assembly.

1. Inspect the oil fill tube (423) for a loose fit or damage.
2. Inspect the covers (505) for the following conditions:
 - Scoring or damage to the gasket surfaces
 - Ventilation system passages for restrictions
 - Threaded bolt holes for damage or debris

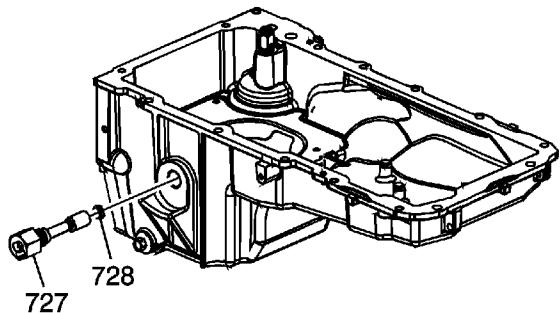
Oil Pan Cleaning and Inspection



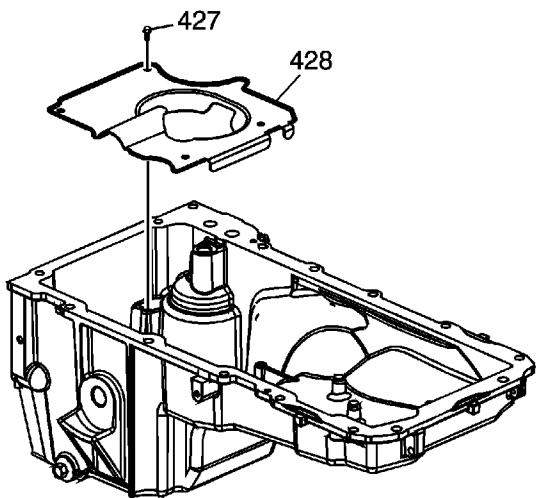
-  1. Remove the oil filter fitting (438), as required.



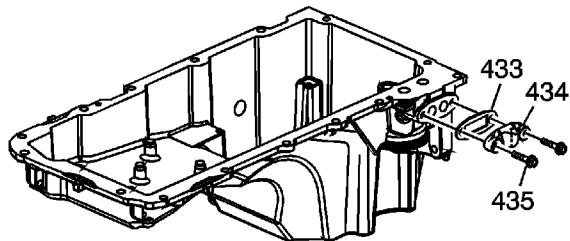
-  2. Remove the active fuel management oil pressure relief valve (455) and washer.
3. Inspect the oil pressure relief valve for proper operation. Lightly depress the valve (2). The valve spring (1) should seat the valve to the proper closed position.



4. Remove the oil level sensor (727) and O-ring (728).



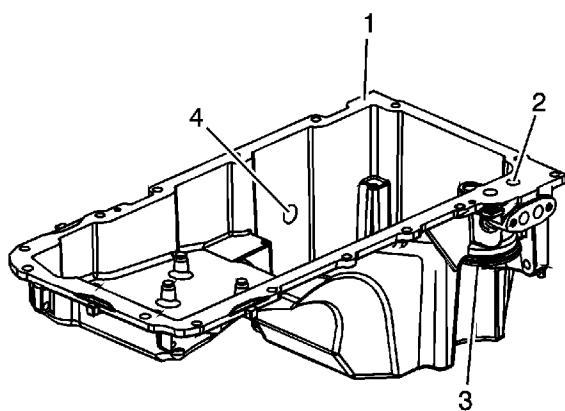
5. Remove the bolts (427) and baffle (428).



6. Remove the oil pan cover (434), bolts (435), and gasket (433).
7. Clean the oil pan in solvent.

Warning: Refer to [Safety Glasses Warning](#) in the Preface section.

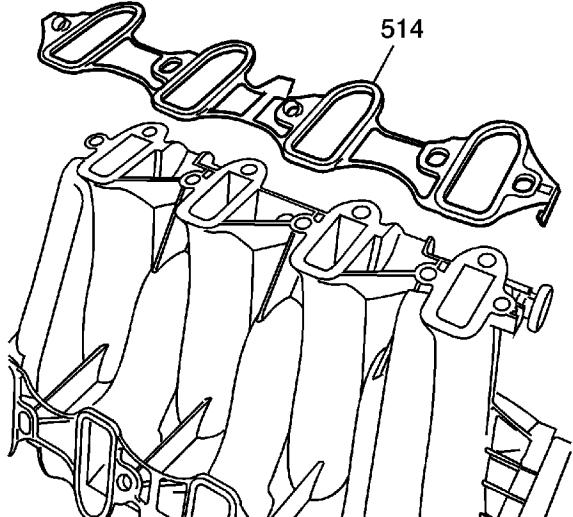
8. Dry the oil pan with compressed air.



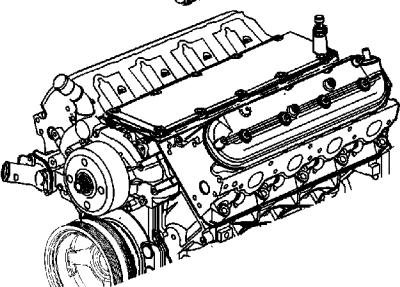
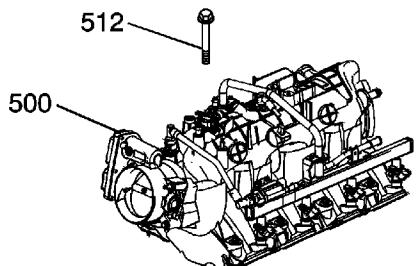
9. Inspect the oil pan for the following conditions:
 - Damaged gasket surfaces (1)
 - Restrictions within the oil passages (2) of the pan
 - Damaged oil filter seal surface (3)
 - Threaded oil level sensor hole (4) for damage

Intake Manifold Cleaning and Inspection

Cleaning Procedure



1. Remove and discard the intake manifold-to-cylinder head gaskets (514).



2. Remove the manifold absolute pressure (MAP) sensor. Refer to [Intake Manifold Removal](#).
3. Remove the evaporative emission (EVAP) canister purge solenoid valve, EVAP tubes, and fuel rail with injectors. Refer to [Fuel Rail and Injectors Removal](#).
4. Remove the throttle body and gasket. Refer to [Throttle Body Removal](#).

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5. Clean the intake manifold (500) in solvent.

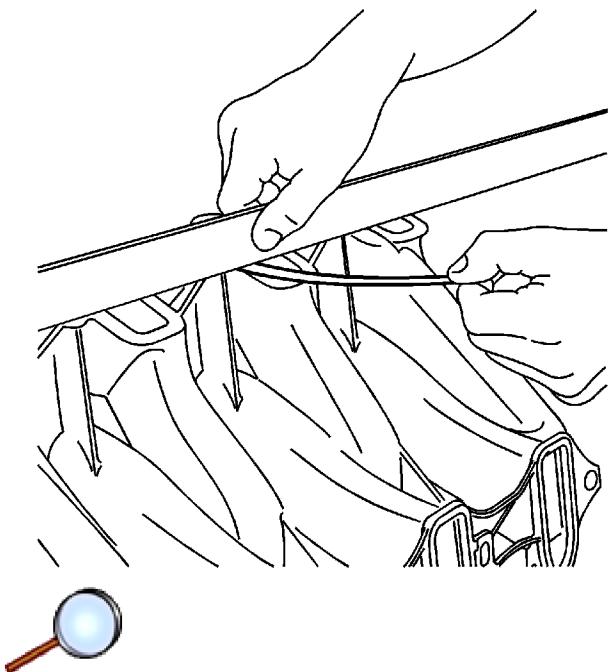
Warning: Refer to Safety Glasses and Compressed Air Warning in the Preface section.

6. Dry the intake manifold with compressed air.

Inspection Procedure

1. Inspect the manifold for the following conditions:

- Damaged gasket or sealing surfaces
- Loose threaded inserts or studs
- Debris or restrictions within the passages of the manifold
- Damaged or broken vacuum fittings
- Inspect the composite intake manifold assembly for cracks or other damage.



2. Inspect the intake manifold cylinder head deck for warpage.

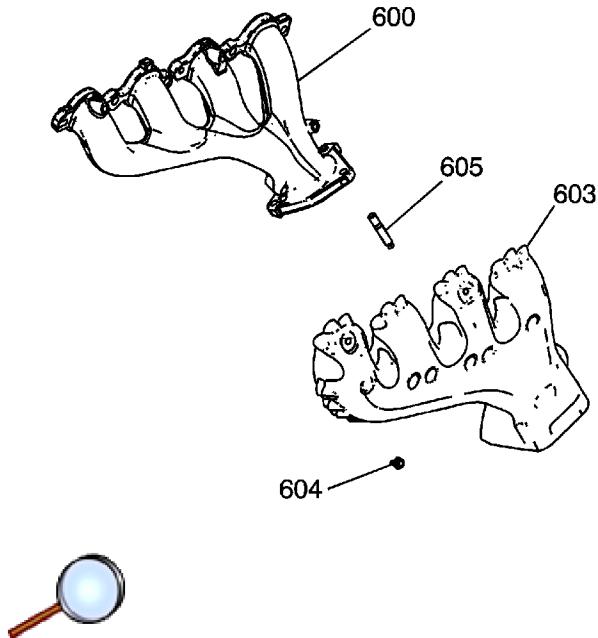
2.1. Locate a straight edge across the intake manifold cylinder head deck surface.

Position the straight edge across a minimum of two runner port openings.

2.2. Insert a feeler gage between the intake manifold and the straight edge.

An intake manifold with warpage in excess of 3 mm (0.118 in) over a 200 mm (7.87 in) area is warped and should be replaced.

Exhaust Manifold Cleaning and Inspection

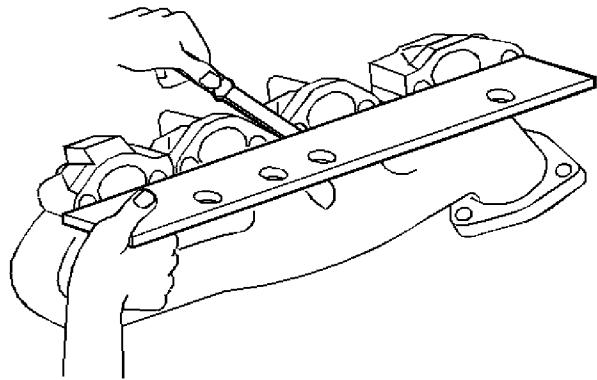


Note: Do not use the exhaust manifold-to-cylinder head gaskets again. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may affect on-board diagnostics (OBD) II system performance.

1. Clean the exhaust manifold (600) and heat shield (603) in solvent.

Warning: Refer to [Safety Glasses Warning](#) in the Preface section.

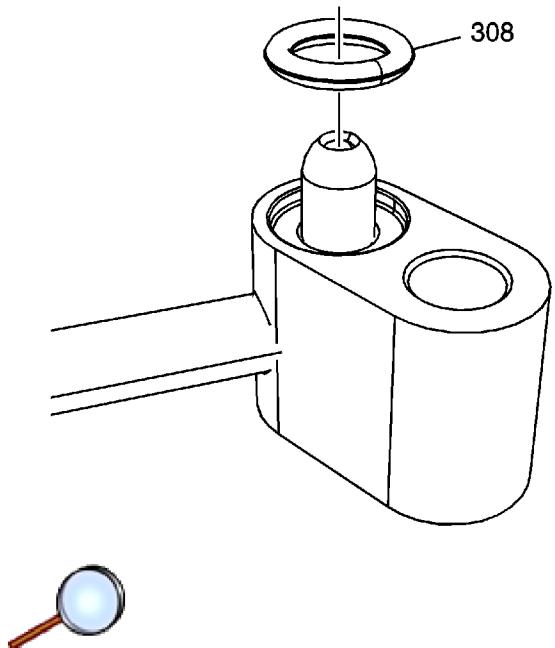
2. Dry the exhaust manifold with compressed air.
3. Inspect the exhaust manifold-to-cylinder head gasket surface for excessive scratches or gouging.
4. Inspect for a loose, damaged, or cracked heat shield (603).
5. Inspect the studs (605) for damaged threads.



6. Use a straight edge and a feeler gage and measure the exhaust manifold cylinder head deck for warpage.

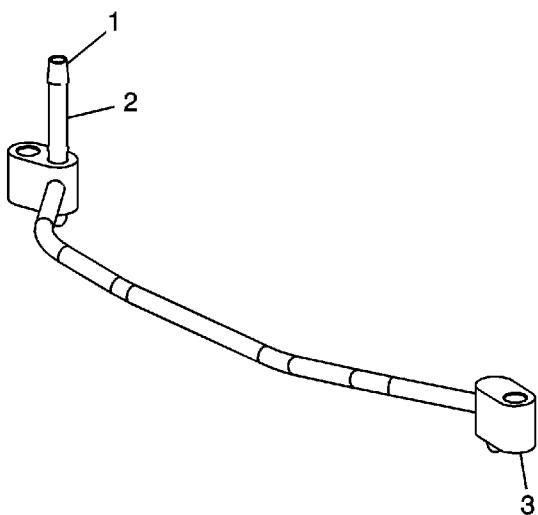
An exhaust manifold deck with warpage in excess of 0.25 mm (0.01 in) within the 2 front or 2 rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may affect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

Engine Coolant Air Bleed Pipe and Hole Cover Cleaning and Inspection



Note: Do not use the engine coolant air bleed pipe and cover seals again. Upon installation of the pipe and covers, install NEW seals.

1. Remove the seals (308) from the pipe and covers.



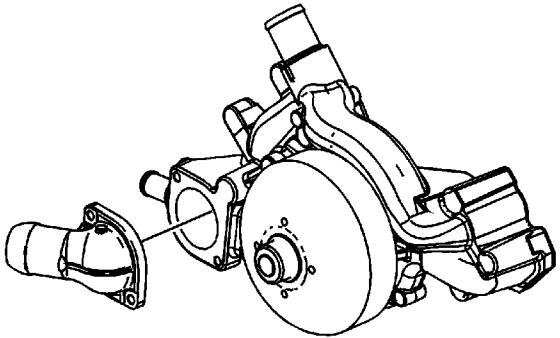
2. Clean the pipe and covers in solvent.

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Warning: Refer to Safety Glasses and Compressed Air Warning in the Preface section.

3. Dry the pipe and covers with compressed air.
4. Inspect the pipe and covers for restrictions within the pipe (1) or damaged sealing surfaces (2, 3).

Water Pump Cleaning and Inspection



1. Remove the old gasket from the water pump sealing surfaces. Refer to [Replacing Engine Gaskets](#).
2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump for the following conditions:
 - Gasket and hose sealing surfaces for excessive scratches or gouging
 - Restrictions within the internal coolant passages
 - Excessive side-to-side play in the pulley shaft
 - Leakage at the water inlet housing or rear cover
 - Leakage at the water pump vent hole
 - A stain around the vent hole is acceptable. If leakage, dripping, occurs with the engine running and the cooling system pressurized, replace the water pump.
 - Wear or damage in the belt tracking area of the pulley

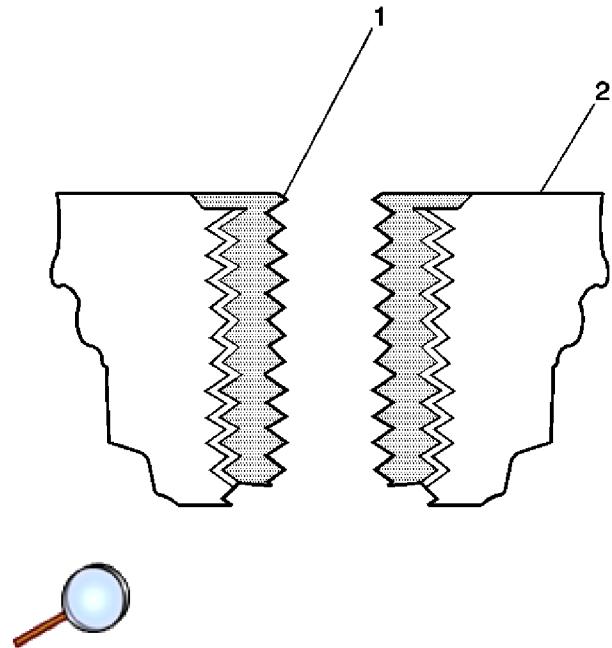
Thread Repair

Special Tools

- J 42385-100 Head/Main Bolt Thread Repair Kit
- J 42385-200 Common Thread Repair Kit
- J 42385-300 Fixtures and Hardware Kit

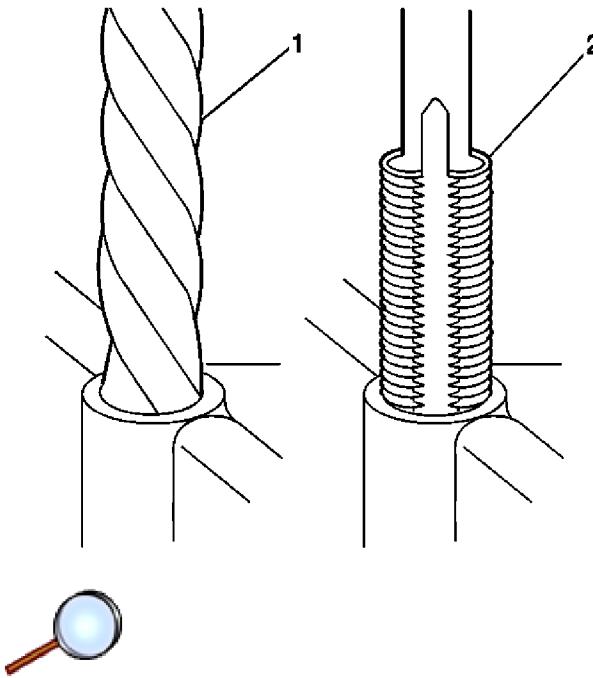
For equivalent regional tools, refer to [Special Tools](#)

General Thread Repair



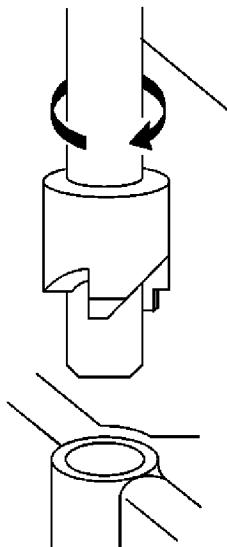
The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

Warning: Refer to [Safety Glasses Warning](#) in the Preface section.

**Note:**

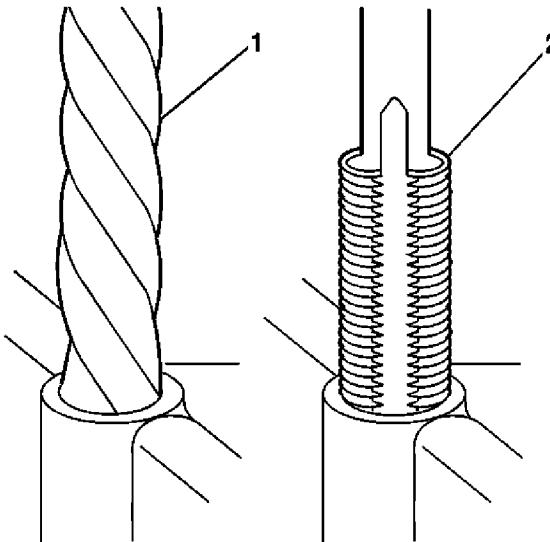
- The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures.
- Driver oil MUST be used on the installer driver tool.
- The tool kits are designed for use with either a suitable tap wrench or drill motor.

1. Drill out the threads of the damaged hole (1).
 - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
 - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
 - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.

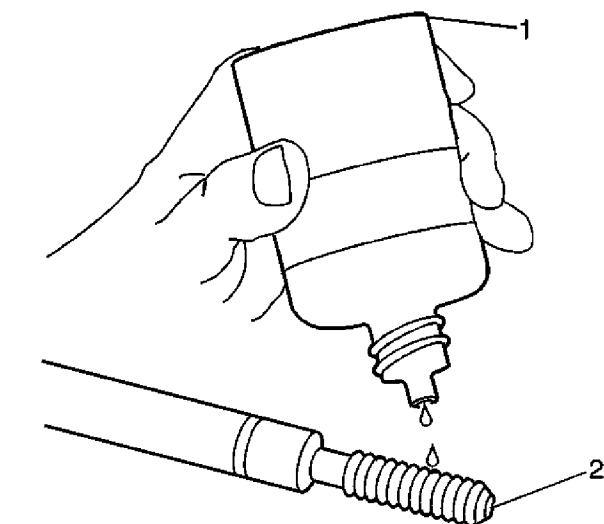




3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

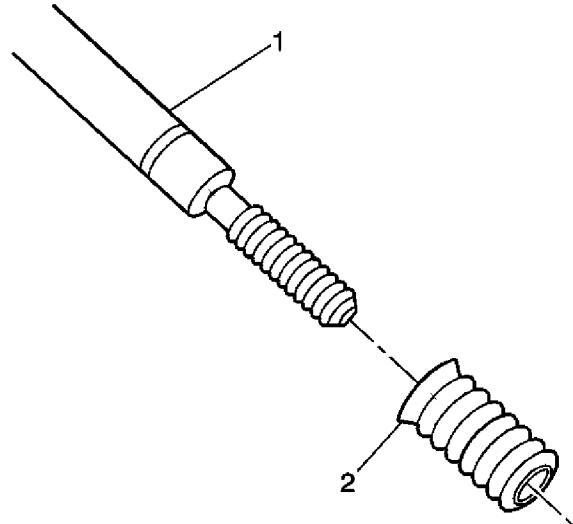


5. Using a tap wrench (2), tap the threads of the drilled hole.
 - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
 - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
 - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

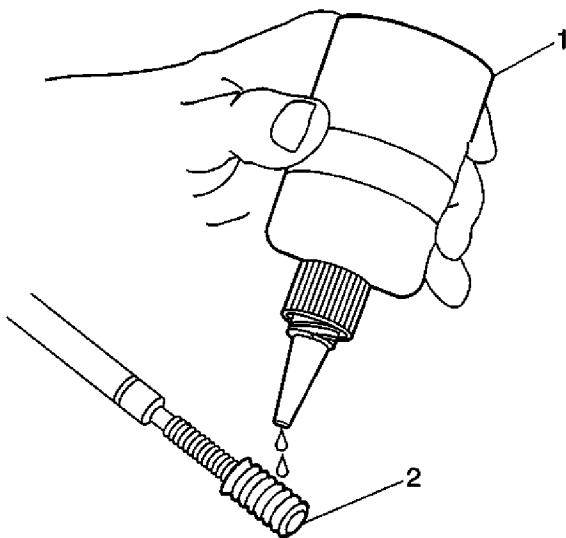


Note: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

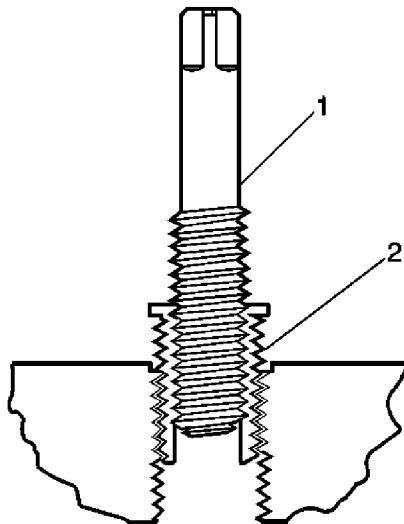
9. Lubricate the threads of the installer tool (2) with the driver oil (1).



10. Install the insert (2) onto the driver tool (1).



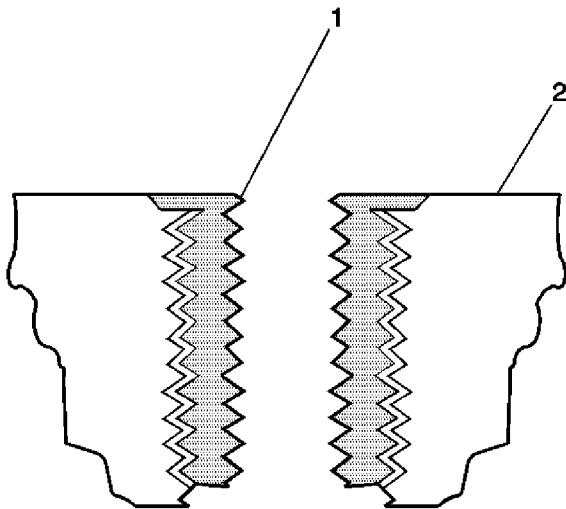
11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).



12. Install the insert (2) into the hole.

Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

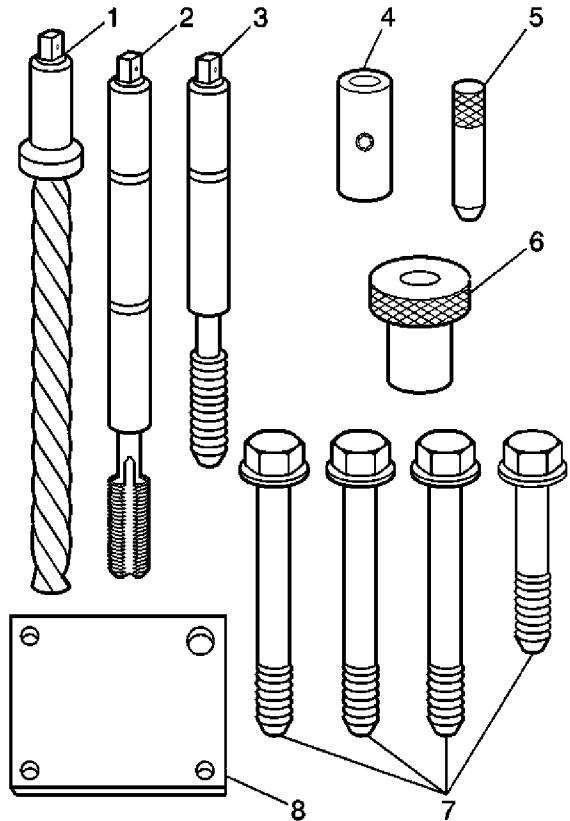


13. Inspect the insert for proper installation into the hole.

A properly installed insert (1) will be either flush or slightly below flush with the surface of

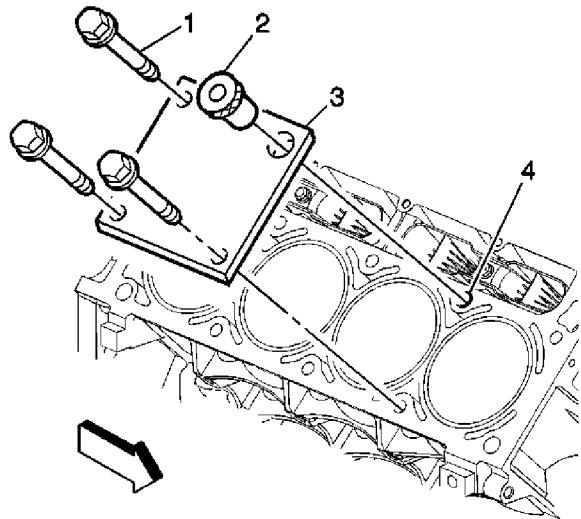
the base material (2).

Cylinder Head Bolt Hole Thread Repair



1. The cylinder head bolt hole thread repair kit consists of the following items:
 - The drill (1)
 - The tap (2)
 - The installer (3)
 - The sleeve (4)
 - The alignment pin (5)
 - The bushing (6)
 - The bolts (7)
 - The fixture plate (8)

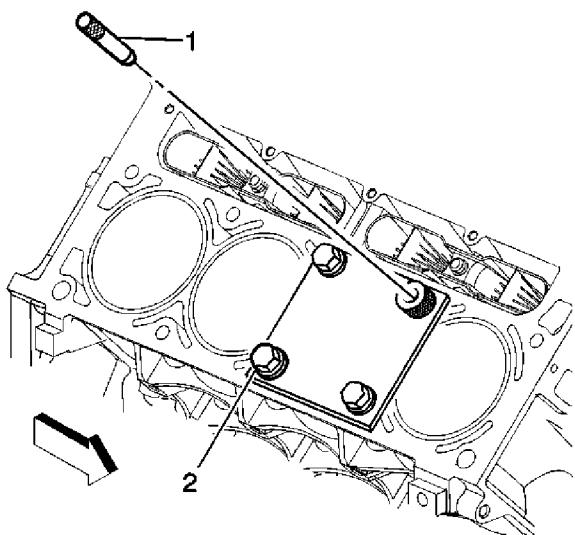
Warning: Refer to [Safety Glasses Warning](#) in the Preface section.

**Note:**

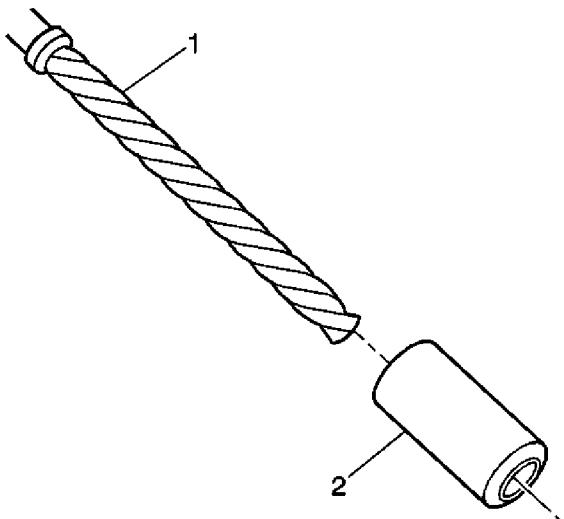
- The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling and tapping procedures.
- Driver oil MUST be used on the installer driver tool.
- The tool kits are designed for use with either a suitable tap wrench or drill motor.

2. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

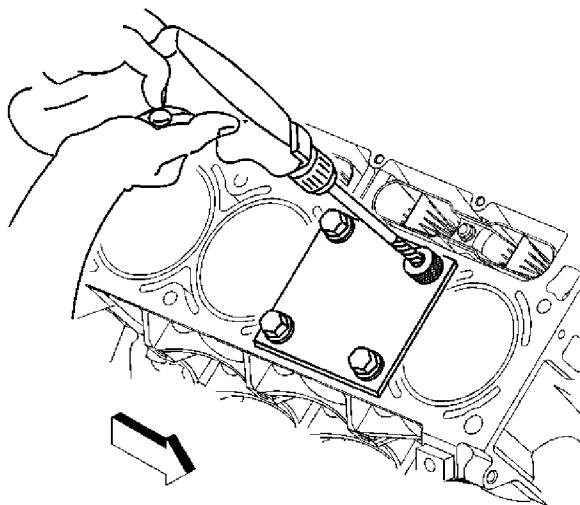
Position the fixture plate and bushing over the hole that is to be repaired (4).



3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.



- 
6. Install the sleeve (2) onto the drill (1).

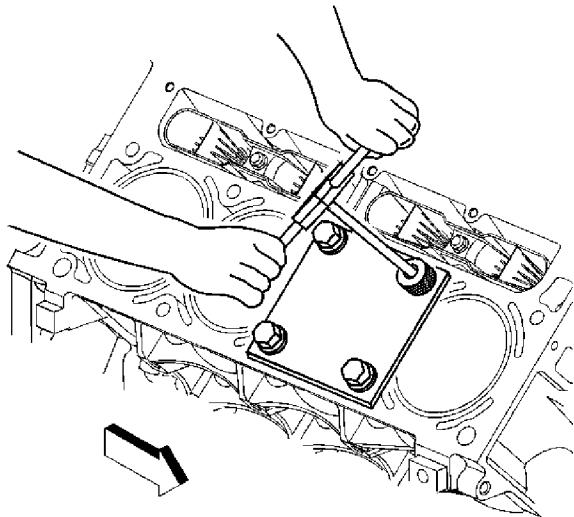


Note: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

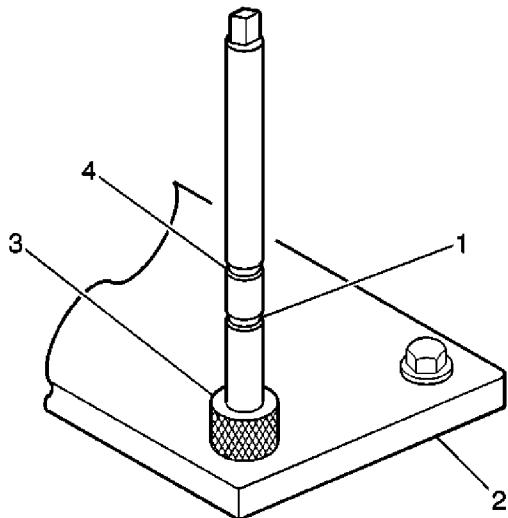
7. Drill out the threads of the damaged hole.

Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

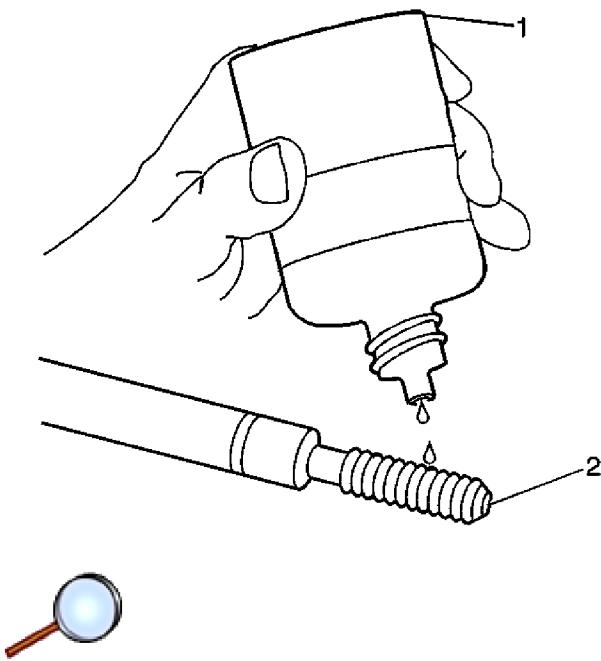
8. Using compressed air, clean out any chips.



9. Using a tap wrench, tap the threads of the drilled hole.

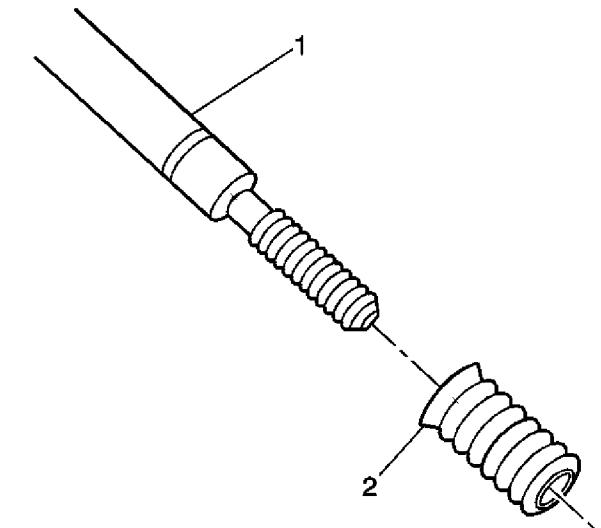


10. In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (1) on the tap aligns with the top of the drill bushing (3).
11. Remove the fixture plate (2), bushing (3), and bolts.
12. Using compressed air, clean out any chips.
13. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.

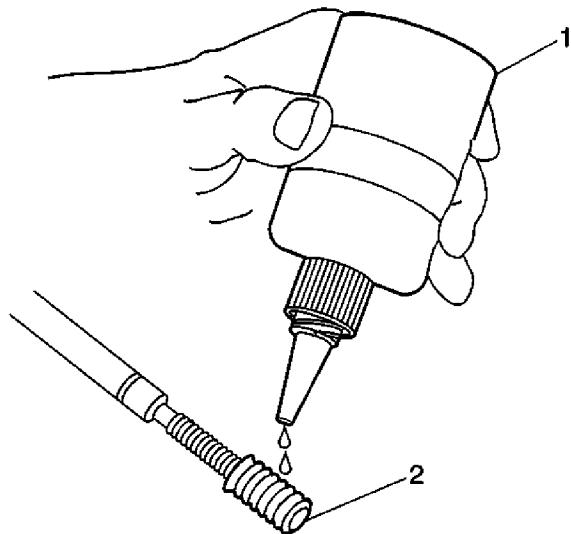


Note: Do not allow oil or foreign material to contact the OD of the insert.

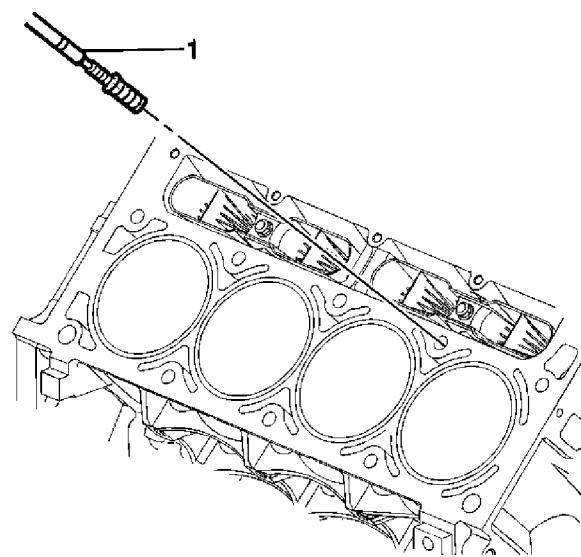
15. Lubricate the threads of the installer tool (2) with the driver oil (1).



16. Install the insert (2) onto the driver tool (1).



17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

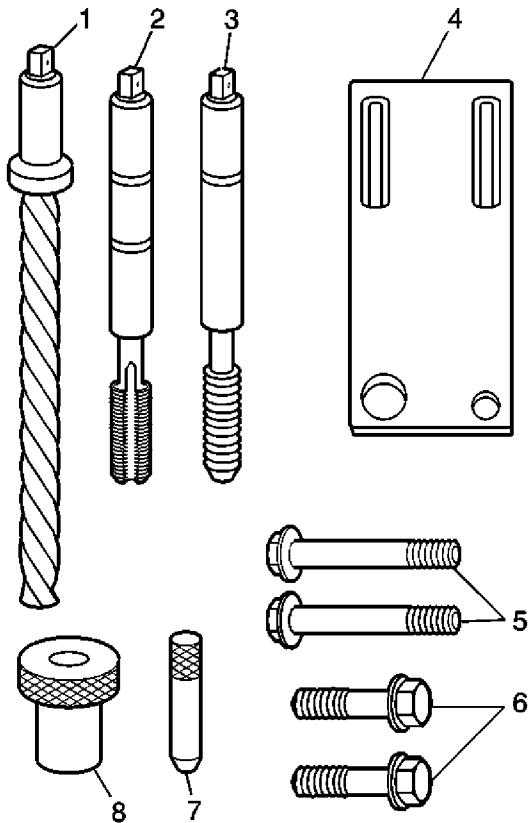


18. Install the insert and driver (1) into the hole.

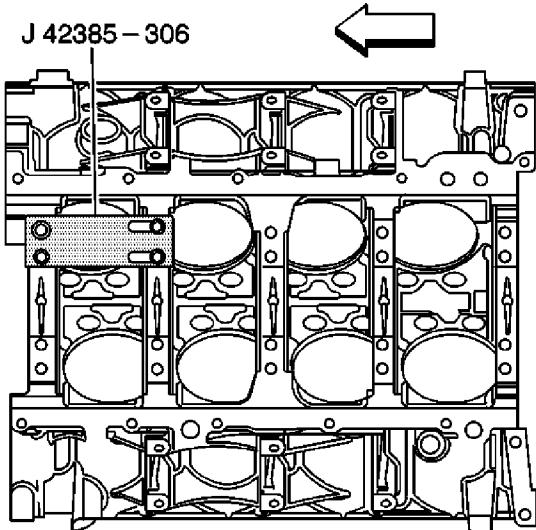
Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block.

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

Main Cap Bolt Hole Thread Repair



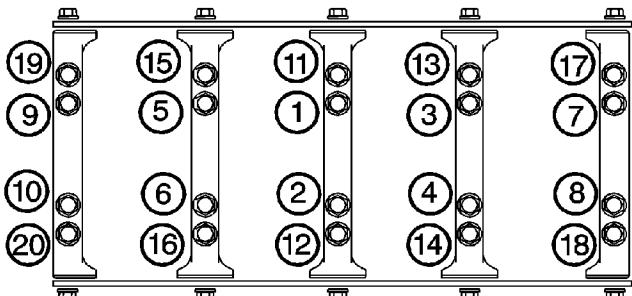
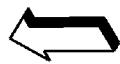
1. The main cap bolt hole thread repair kit consists of the following items:
 - The drill (1)
 - The tap (2)
 - The installer (3)
 - The fixture plate (4)
 - The long bolts (5)
 - The short bolts (6)
 - The alignment pin (7)
 - The bushing (8)



2. Install the fixture plate, bolt, and bushing onto the engine block.

Position the fixture plate and bushing over the hole that is to be repaired.

3. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.

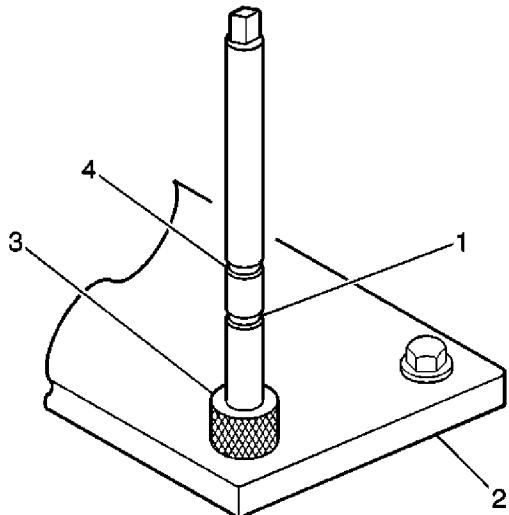


4. Drill out the damaged hole.

The outer bolt hole locations 11-20 have the shallower counterbores. Use sleeve J 42385-316 with the drill.

Drill until the stop collar of the drill bit or the sleeve contacts the bushing.

5. Using compressed air, clean out any chips.



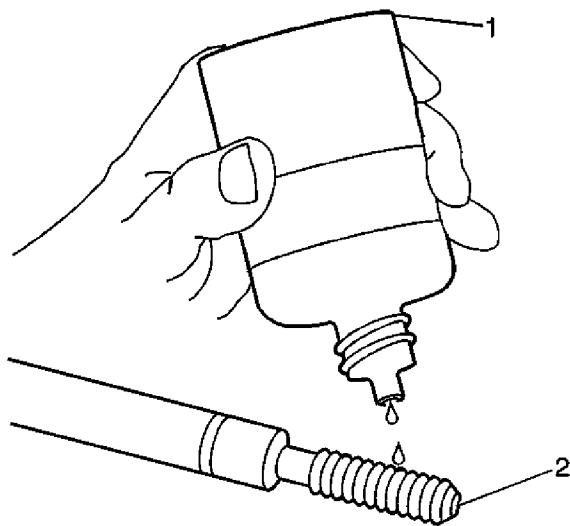
6. Using a tap wrench, tap the threads of the drilled hole.

In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark on the tap aligns with the top of the bushing.

For the deeper main cap holes 1-10, rotate the tap until the upper mark (4) on the tap aligns with the top of the bushing (3).

For the shallower main cap holes 11-20, rotate the tap until the lower mark (1) on the tap aligns with top of the bushing (3).

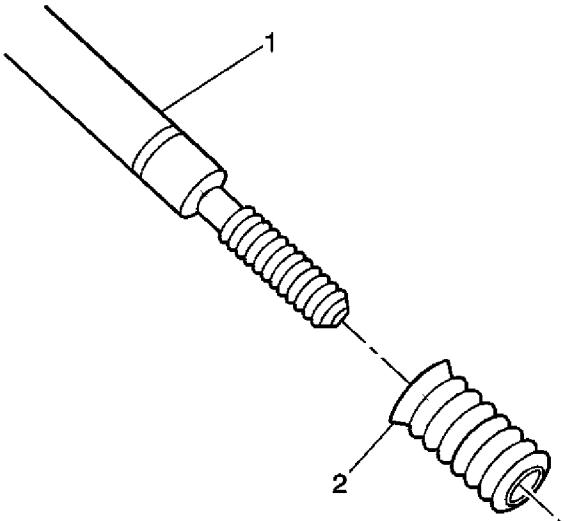
7. Using compressed air, clean out any chips.
8. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), or equivalent, into the hole.
9. Using compressed air, clean any cutting oil and chips out of the hole.



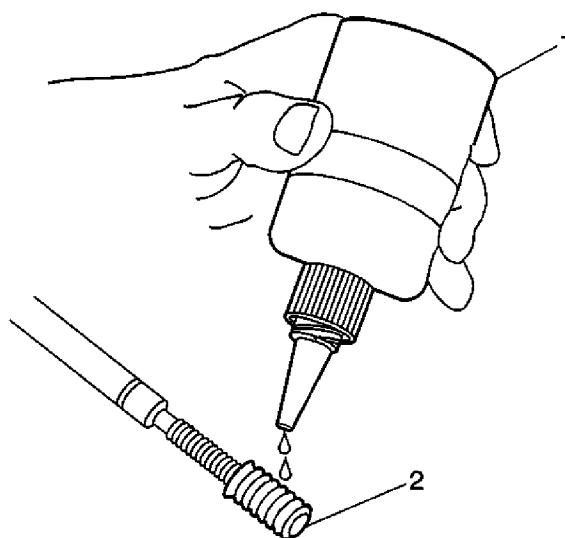


Note: Do not allow oil or foreign material to contact the OD of the insert.

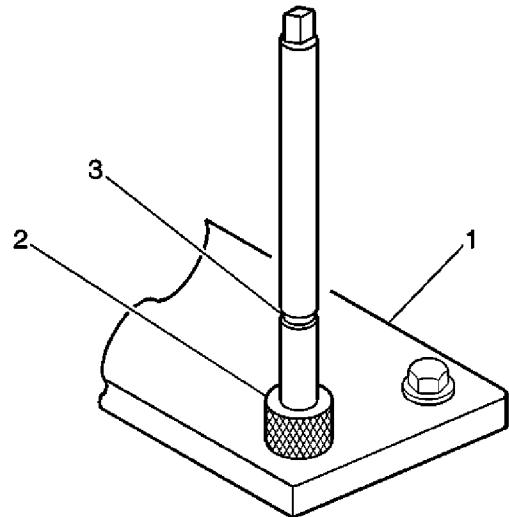
10. Lubricate the threads of the installer tool (2) with the driver oil (1).



11. Install the insert (2) onto the driver tool (1).



12. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).



Note: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

13. Install the insert and driver (1) through the fixture plate and bushing and into the hole.

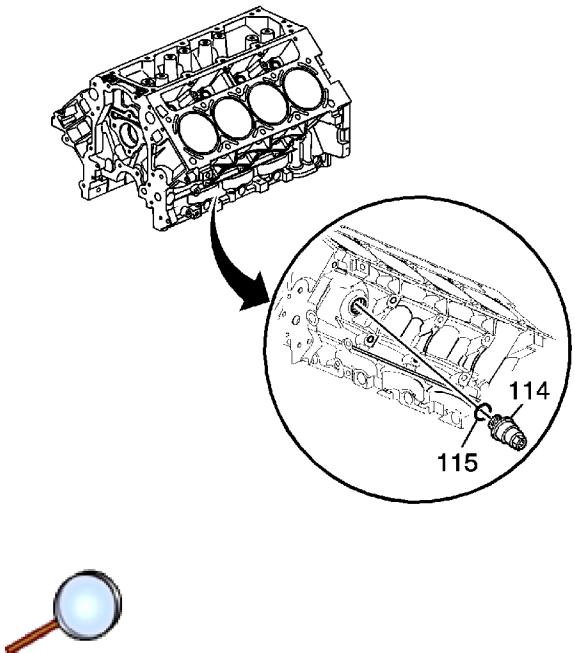
Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

Service Prior to Assembly

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all components. Refer to [Cleanliness and Care](#).
- Use the proper tools to measure components when inspecting for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When the components are installed into an engine, return the components to their original location, position and direction. Refer to [Separating Parts](#).
- During assembly, lubricate all moving parts with clean engine oil. This provides initial lubrication when the engine is first started.

Engine Block Plug Installation

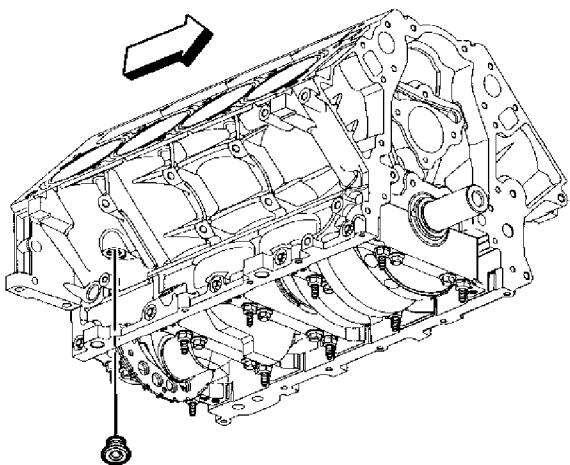


Note: Engine block plug, oil gallery, and coolant sealing washers may be used again if not bent, scored or otherwise damaged.

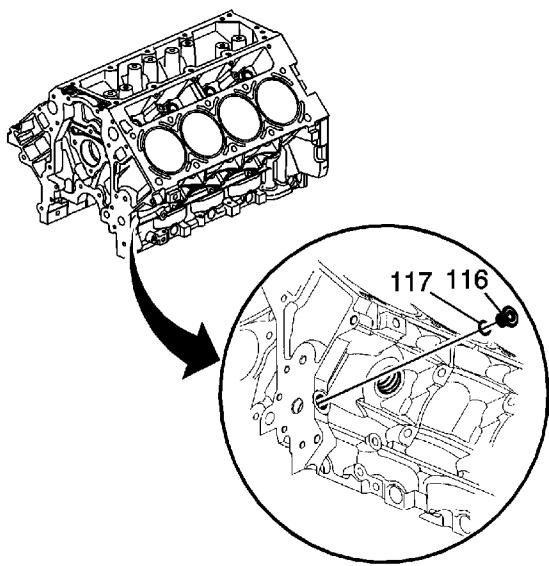
1. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block coolant heater sealing washer (115), if applicable. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

Caution: Refer to [Fastener Caution](#) in the Preface section.

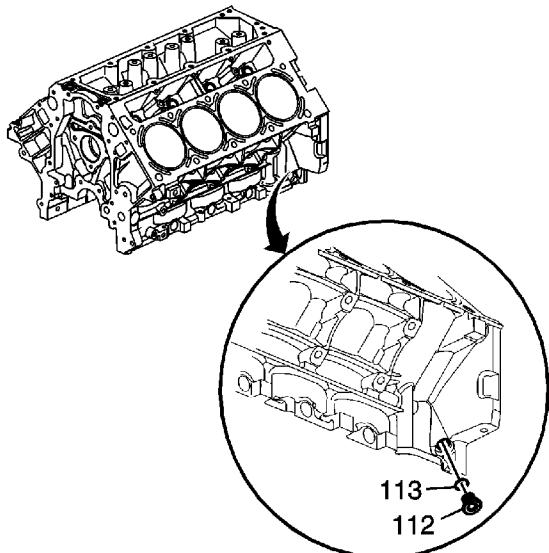
2. Install the engine block coolant heater (114) to the engine block and tighten to **50 N·m (37 lb ft)**.



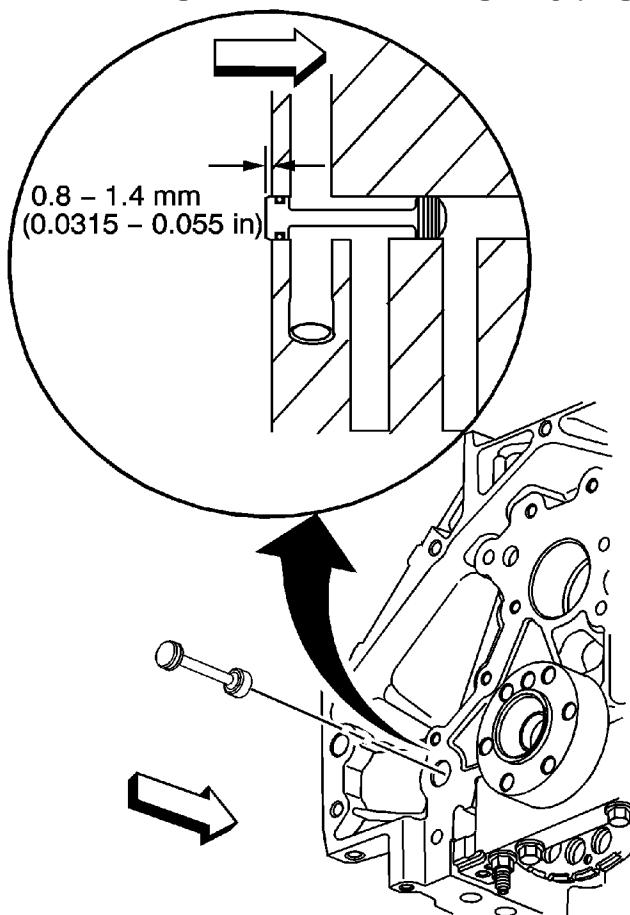
3. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block right rear coolant drain hole plug sealing washer.
4. Install the engine block right rear coolant drain hole plug and tighten to **60 N·m (44 lb ft)**.



5. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left front oil gallery plug sealing washer (117).
6. Install the engine block left front oil gallery plug (116) and tighten to **60 N·m (44 lb ft)**.



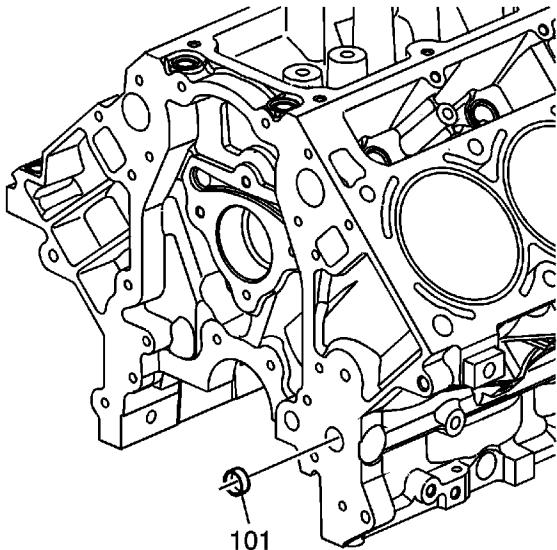
7. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left rear oil gallery plug sealing washer (113).
8. Install the engine block left rear oil gallery plug (112) and tighten to **60 N·m (44 lb ft)**.



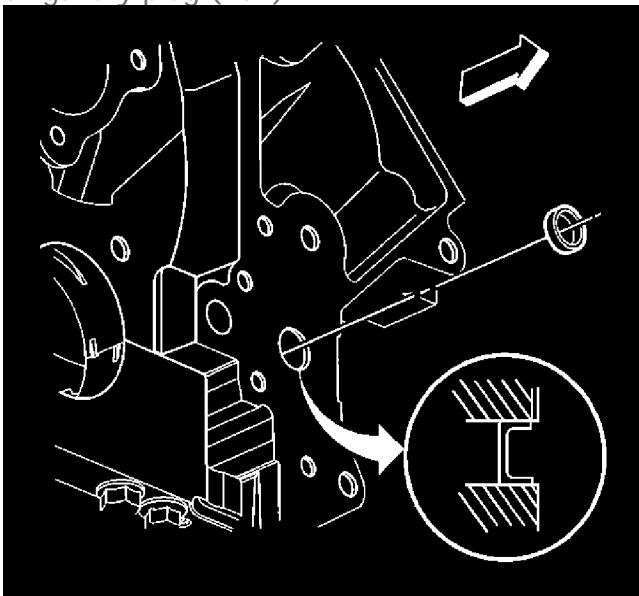
9. Inspect the engine block rear oil gallery plug and O-ring seal. If the O-ring seal on the plug is

not cut or damaged, the rear oil gallery plug may be used again.

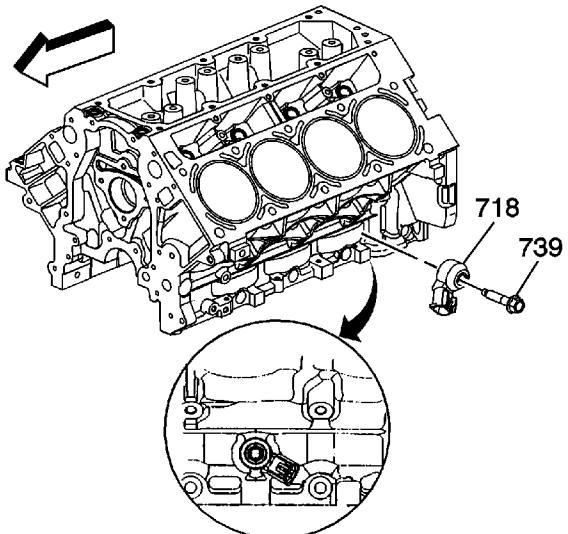
10. Lubricate the O-ring seal with clean engine oil.
11. Install the O-ring seal onto the plug.
12. Install the engine block rear oil gallery plug into the oil gallery bore. A properly installed block plug will protrude 0.8-1.4 mm (0.0315-0.055 in) beyond the rear face of the block.



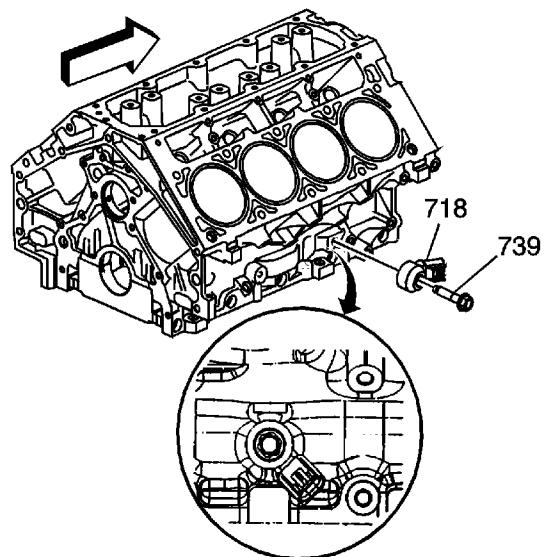
13. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the sides of the NEW front oil gallery plug (101).



14. Install a NEW engine block front oil gallery plug. Install the plug into the oil gallery bore 2.2-2.8 mm (0.0086-0.011 in) below flush.



15. Install the left side knock sensor (718) and bolt (739) and tighten to **20 N·m (15 lb ft)**.



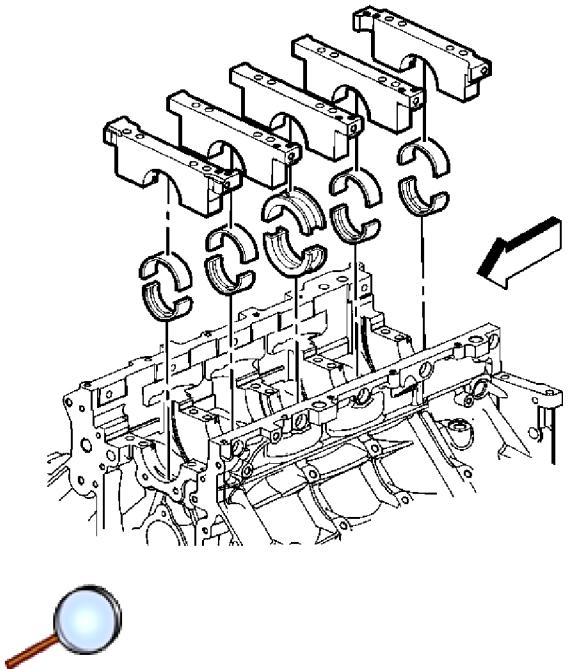
16. Install the right side knock sensor (718) and bolt (739) and tighten to **20 N·m (15 lb ft)**.

Crankshaft and Bearing Installation

Special Tools

J 45059 Angle Meter

For equivalent regional tools, refer to [Special Tools](#)

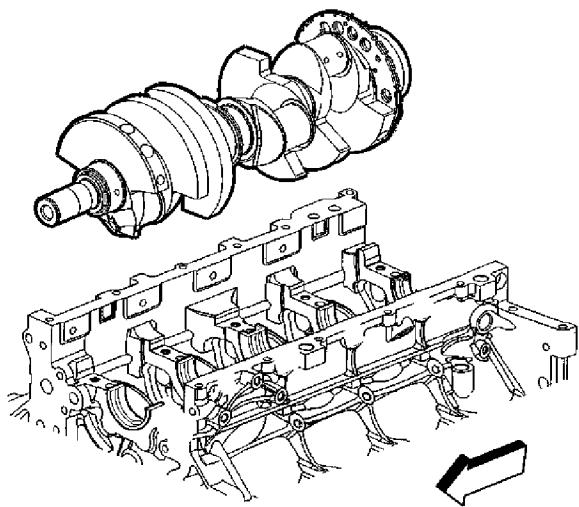


Note:

- Crankshaft bearing clearances are critical. Excessive crankshaft bearing clearance may affect crankshaft position (CKP) sensor signals and/or on-board diagnostic (OBD) II system performance.
- Crankshaft bearing caps must be installed to the proper location and direction.
- When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.
- Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.
- In order to prevent engine block oil leakage, install NEW M8 crankshaft bearing cap side bolts.

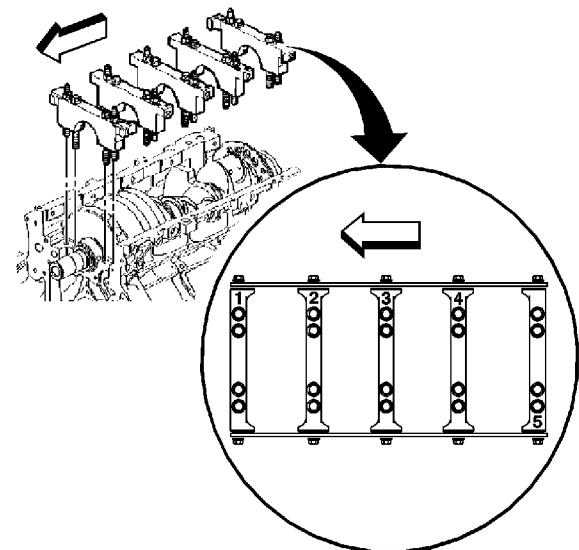
The crankshaft bearing cap M8 side bolts have a pre-applied sealant patch applied to the bolt flange.

1. Install the crankshaft bearings to the engine block and bearing caps. The thrust bearings are to be installed into center journal.
2. Lubricate the bearing surfaces and crankshaft journals with clean engine oil.



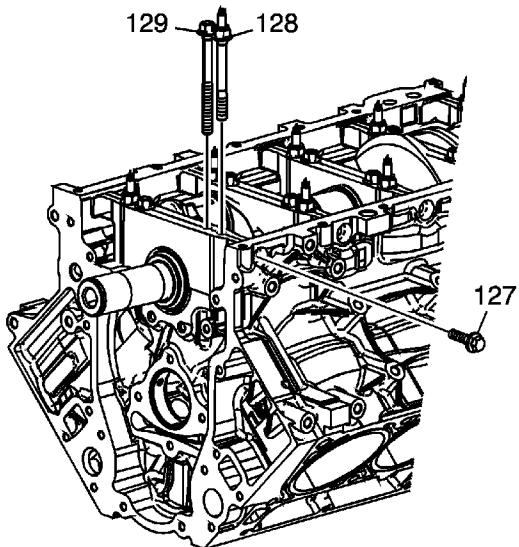
Caution: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

3. Install the crankshaft.



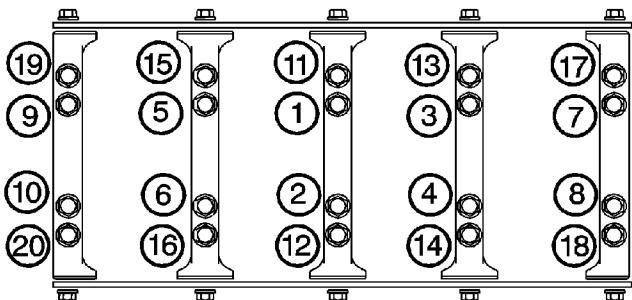
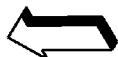
Note: The bearing caps must be installed in the proper location and direction.

4. Install the crankshaft bearing caps, with bearings, into the engine block.



5. Install the M10 bolts (129) and studs (128).
6. Using a plastic-face hammer, tap the bearing caps into place.
7. Install the NEW M8 bearing cap side bolts (127).

Caution: Refer to [Fastener Caution](#) in the Preface section.

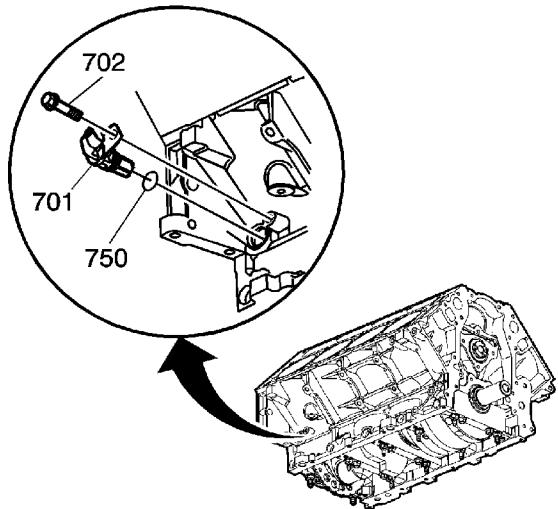


8. Tighten the bearing cap M10 bolts (1-10). Tighten the M10 bearing cap bolts (1-10) a first pass in sequence to **20 N·m (15 lb ft)**.

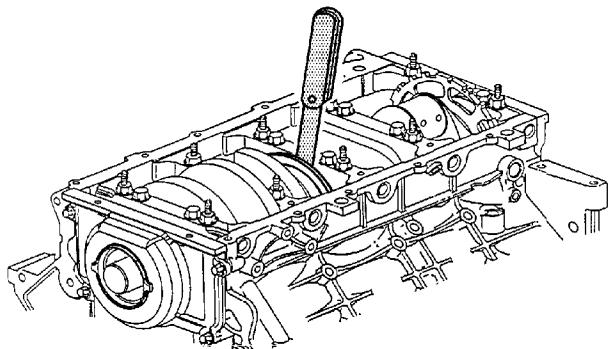
Note: To properly align the crankshaft thrust bearings, the final thrust of the crankshaft MUST be in the forward direction.

9. Using a plastic-face hammer, tap the crankshaft rearward, then forward in order to align the thrust bearings.
 - 9.1. Tighten the M10 bolts (1-10) a final pass in sequence **80 degrees** using the *J45059* meter .
 - 9.2. Tighten the M10 studs (11-20) a first pass in sequence to **20 N·m (15 lb ft)**.
 - 9.3. Tighten the M10 studs (11-20) a final pass in sequence **51 degrees** using the *J45059* meter .
 - 9.4. Tighten the bearing cap side M8 bolts to **25 N·m (18 lb ft)**.

Tighten the bolt on 1 side of the bearing cap and then tighten the bolt on the opposite side of the same bearing cap.



10. Install the CKP sensor.
 - 10.1. Inspect the CKP sensor O-ring seal (750). If the O-ring seal is not cut or damaged, it may be used again.
 - 10.2. Coat the O-ring seal with clean engine oil.
 - 10.3. Install the O-ring onto the sensor.
 - 10.4. Install the sensor (701). Rotate the sensor until the locating hole in the bracket aligns with the bolt hole in the block.
 - 10.5. Install the sensor bolt (702) and tighten to **25 N·m (18 lb ft)**.



11. Measure the crankshaft end play.
 - 11.1. Thrust the crankshaft forward or rearward.
 - 11.2. Insert a feeler gage between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.

The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).

- 11.3. If the bearing clearance is not within specifications, inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.

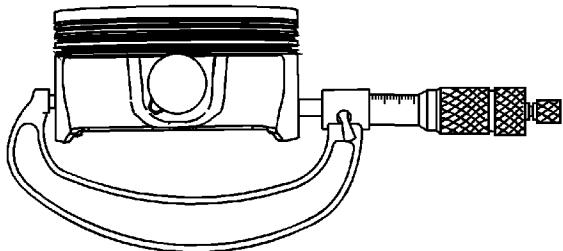
Piston, Connecting Rod, and Bearing Installation

Special Tools

- J8037 Piston Ring Compressor
- J8087 Cylinder Bore Gage
- J41556 Connecting Rod Guide
- J45059 Angle Meter

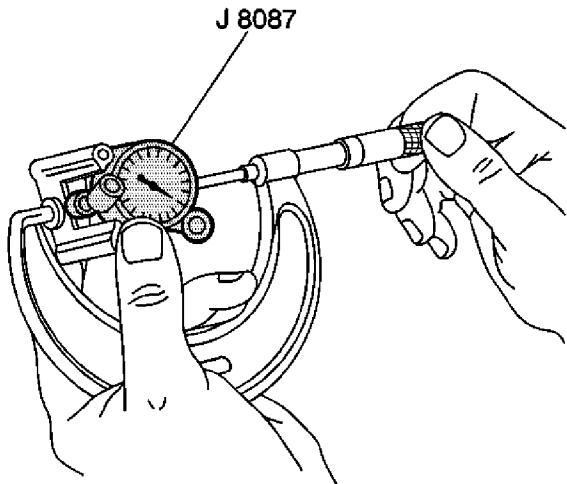
For equivalent regional tools, refer to [Special Tools](#)

Piston Selection

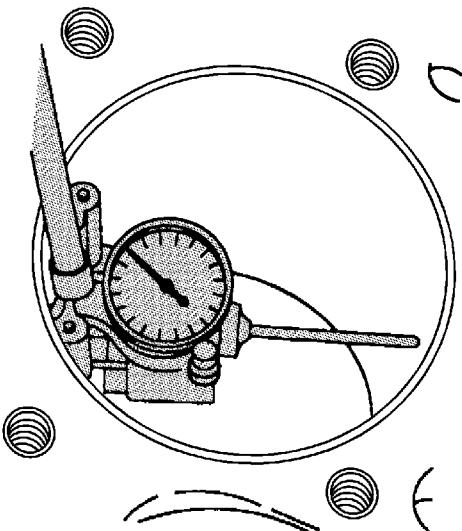


Note: Measurements of all components should be taken with the components at normal room temperature. For proper piston fit, the engine block cylinder bores must not have excessive wear or taper. A used piston, pin, and connecting rod assembly may be installed if, after inspection is within specifications.

1. With a micrometer at a right angle, measure the piston outside diameter (OD). Measure the diameter 43 mm (1.69 in) from the top of the piston. Refer to [Engine Mechanical Specifications](#).
2. Record the piston OD.

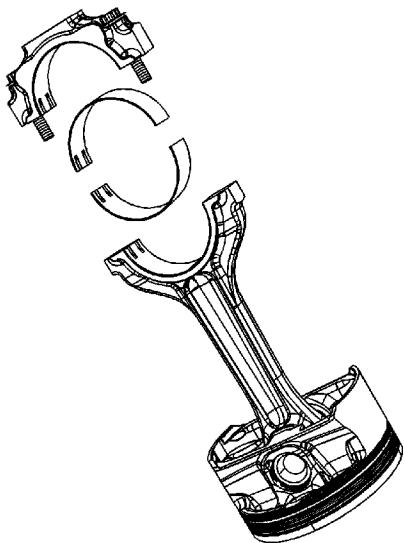


3. Adjust the micrometer to the recorded piston OD.
4. Insert the J 8037 gage into the micrometer and zero the gage dial.

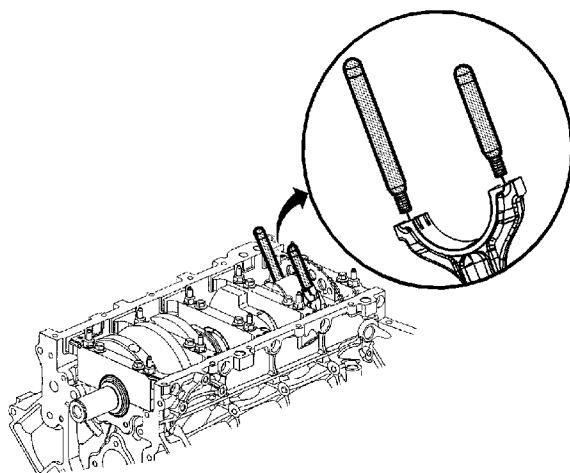


5. Using the J 8037 gage , measure the cylinder bore inside diameter (ID). Measure at a point 64 mm (2.5 in) from the top of the cylinder.
6. Record the cylinder bore ID.
7. Subtract the piston OD from the cylinder bore ID in order to determine the piston-to-bore clearance. Refer to [Engine Mechanical Specifications](#).
8. If the proper clearance cannot be obtained, select another piston and pin assembly and measure the clearances again. If the proper fit cannot be obtained, the cylinder bore may require honing for an oversize piston.

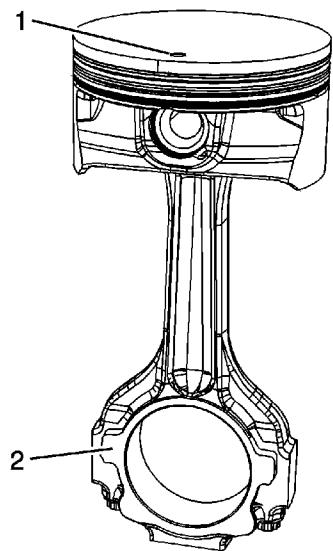
Piston, Pin, and Connecting Rod Installation



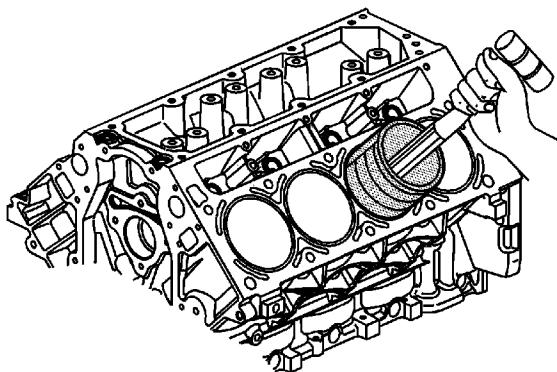
1. Lubricate the following components with clean engine oil:
 - Piston
 - Piston rings
 - Cylinder bore
 - Bearings and bearing surfaces
2. Install the bearings to the connecting rod and cap.
3. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
4. Position the compression ring end gaps 180 degrees opposite each other.



5. Install the *J41556* guide to the connecting rod.



6. Identify the proper installation direction of the piston and connecting rod assembly. When installing the piston and connecting rod assembly, the mark on the top of the piston (1) and the tab (2) on the side of the connecting rod should face the front of the engine.

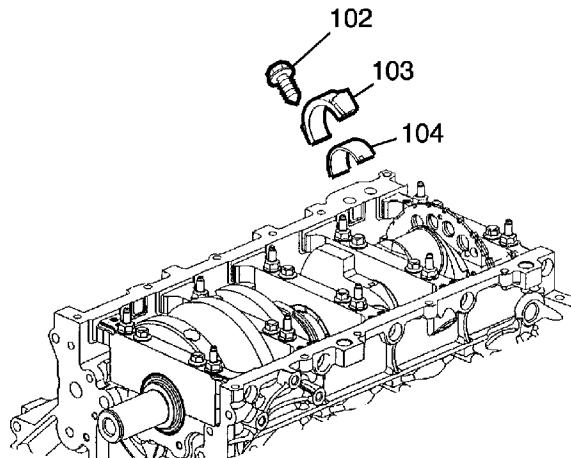


7. Install the J8037 compressor onto the piston and compress the piston rings.

Note: The piston alignment mark MUST face the front of the engine block.

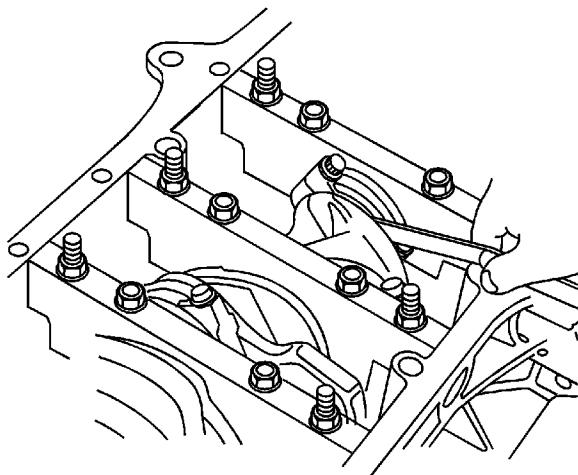
8. Install the piston, pin, and connecting rod assembly into the cylinder bore. Hold the piston ring compressor firmly against the engine block. Using a wooden hammer handle, lightly tap the top of the piston until all piston rings have entered the cylinder bore.
9. Use the J41556 guide to guide the connecting rod onto the crankshaft journal.
10. Remove the J41556 guide from the connecting rod.

Caution: Refer to [Fastener Caution](#) in the Preface section.



Note: The connecting rod and cap must be assembled with the mating surfaces properly aligned.

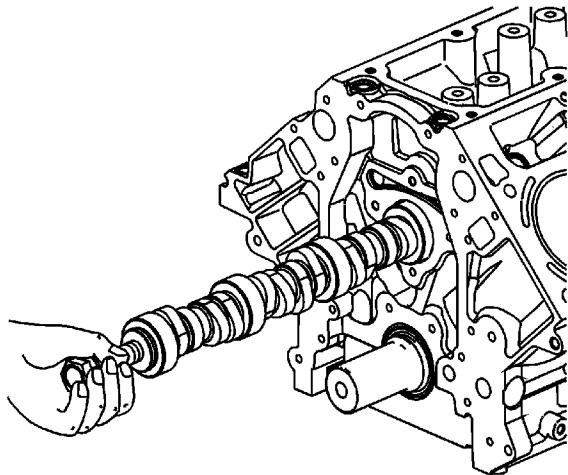
11. Install the bearing cap (103), bearing (104), and bolts (102).
 - 11.1. Tighten the bolts a first pass to **20 N·m (15 lb ft)**.
 - 11.2. Tighten the bolts a final pass to **85 degrees** using the *J45059* meter .



12. Measure the connecting rods for the proper side clearance. Refer to [Engine Mechanical](#)

[Specifications.](#)

Camshaft Installation

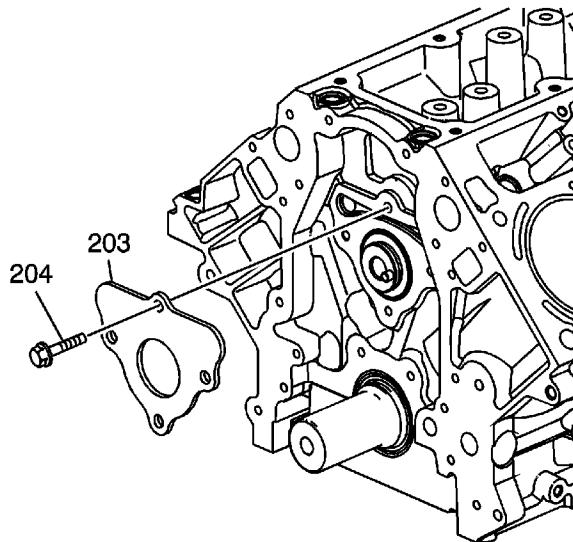


Note: If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the camshaft journals and the bearings with clean engine oil.
2. Install the camshaft sprocket bolt into the camshaft front bolt hole.

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

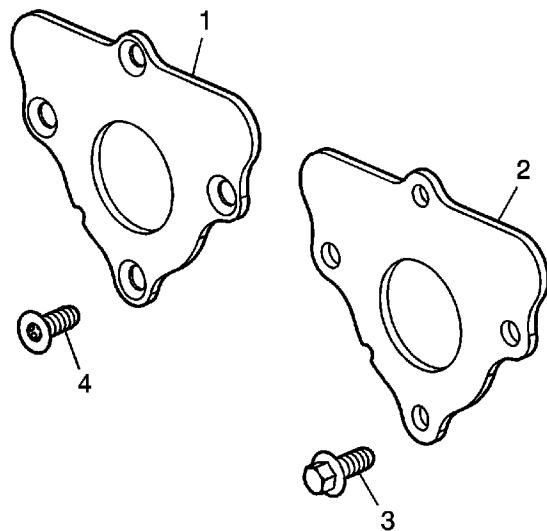
3. Using the bolt as a handle, carefully install the camshaft into the engine block.
4. Remove the bolt from the front of the camshaft.



Note: The gasket surface on the engine block should be clean and free of dirt or debris.

5. Install the camshaft retainer (203) and the bolts (204). Install the retainer with the sealing gasket facing the front of the engine block.

Caution: Refer to [Fastener Caution](#) in the Preface section.



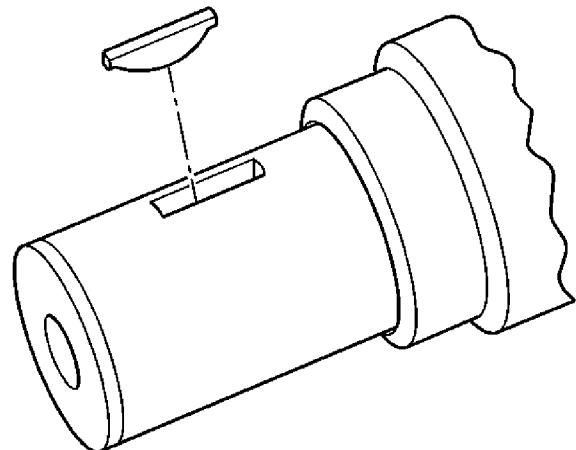
6. Tighten the camshaft retainer bolts.
 - Tighten the first design hex head bolts (3) to **25 N·m (18 lb ft)**.
 - Tighten the second design TORX® head bolts (4) to **15 N·m (11 lb ft)**.

Camshaft Position Actuator and Solenoid Valve Installation

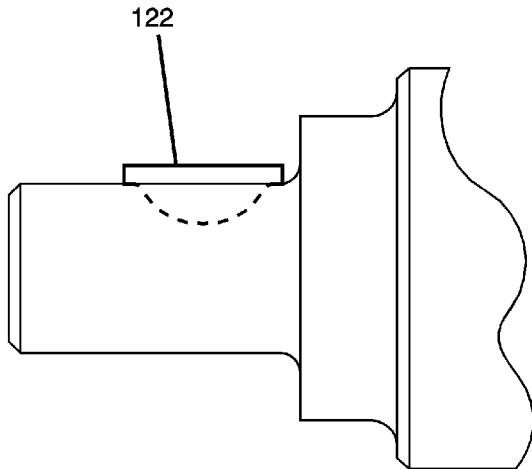
Special Tools

- *EN 46330* Timing Belt Tensioner Retaining Pin
- *J 41478* Crankshaft Front Oil Seal Installer
- *J 41665* Crankshaft Balancer and Sprocket Installer
- *J 42386-A* Flywheel Holding Tool
- *J 45059* Angle Meter

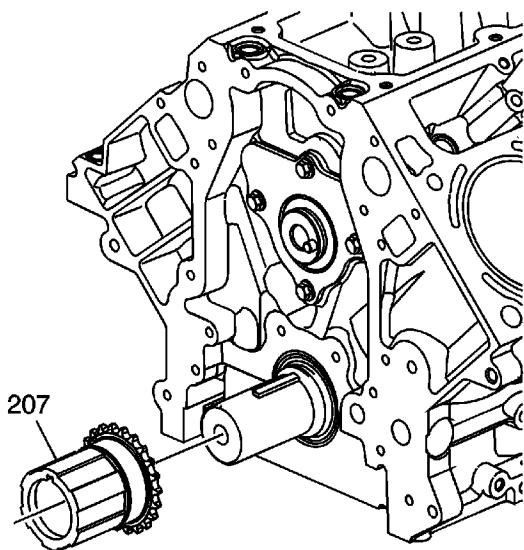
For equivalent regional tools, refer to [Special Tools](#)



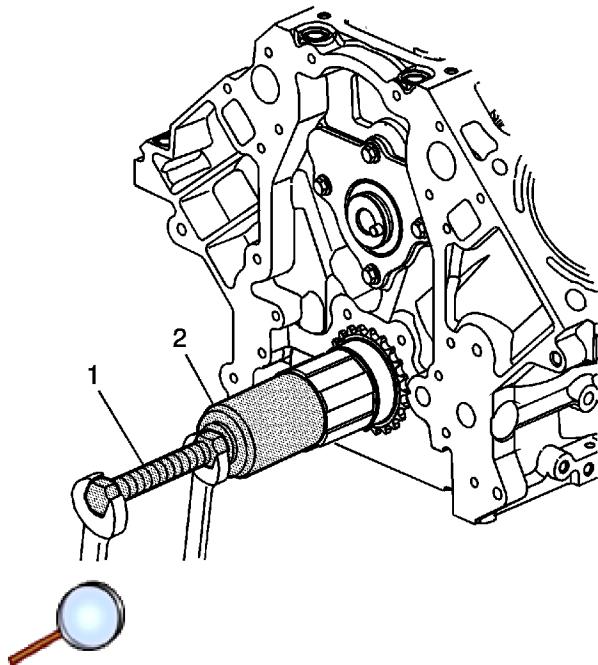
1. Install the key into the crankshaft keyway, if previously removed.



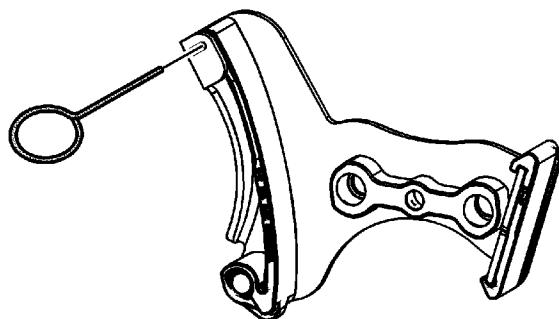
2. Tap the key (122) into the keyway until both ends of the key bottom onto the crankshaft.



3. Install the crankshaft sprocket (207) onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.

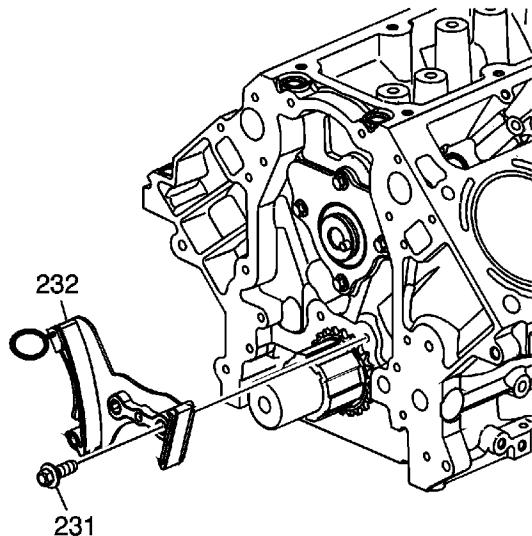


4. Use the *J41478* installer (1) and the *J41665* installer (2) in order to install the crankshaft sprocket. Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.
5. Rotate the crankshaft sprocket until the sprocket alignment mark is in the 12 o'clock position.



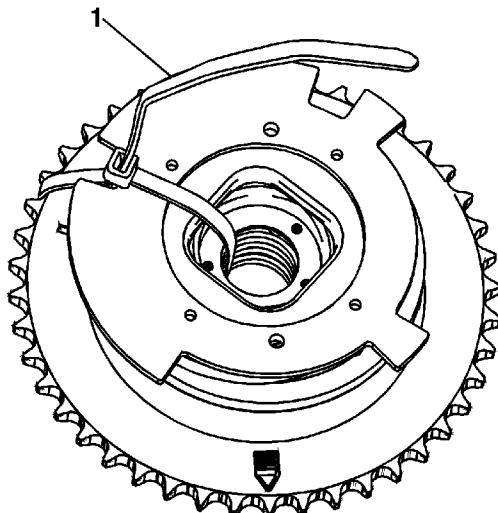
6. Compress the timing chain tensioner guide and install the *EN46330* pin .

Caution: Refer to [Fastener Caution](#) in the Preface section.

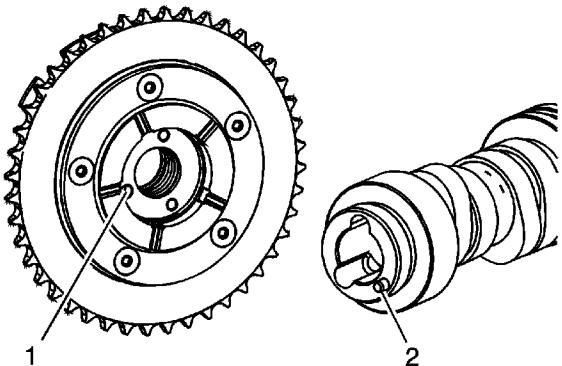


7. Install the timing chain tensioner (232) and left side bolt (231). Do not install the right side bolt at this time. The right side bolt will be installed after the camshaft position (CMP) actuator and chain have been installed onto the engine.

Warning: Refer to [Camshaft Position Actuator Removal and Installation Warning](#) in the Preface section.



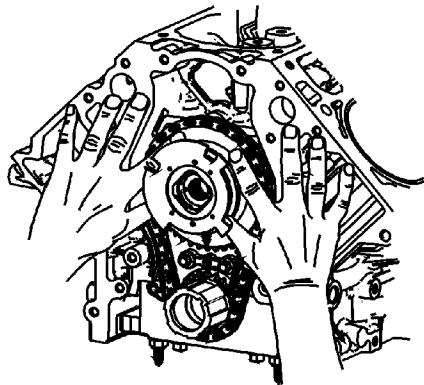
8. Remove the tie strap (1) from the actuator.

**Note:**

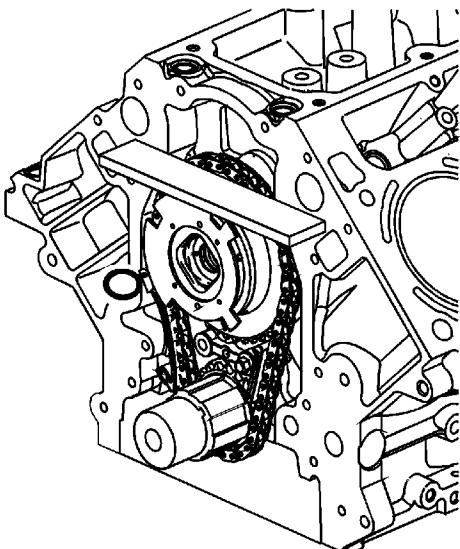
- Properly locate the CMP actuator onto the locating pin of the camshaft.
- The sprocket teeth and timing chain must mesh.
- The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly.
- Do not use the CMP solenoid valve again. Install a NEW valve during assembly.

9. Identify the alignment hole (1) in the rear face of the CMP actuator and the locating pin (2) on the front face of the camshaft.

Warning: Refer to [Camshaft Position Actuator Removal and Installation Warning](#) in the Preface section.

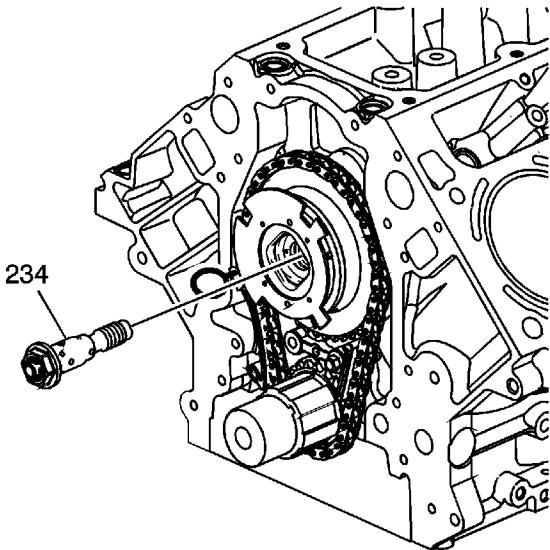


10. Install the CMP actuator and timing chain. Align the hole in the rear face of the CMP actuator with the locating pin on the front face of the camshaft. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks. Use care to install the actuator completely onto the front of the camshaft. Position fingers onto the face of the actuator sprocket and push the actuator onto the front of the camshaft. Never push on the reluctor wheel when attempting to install the actuator.

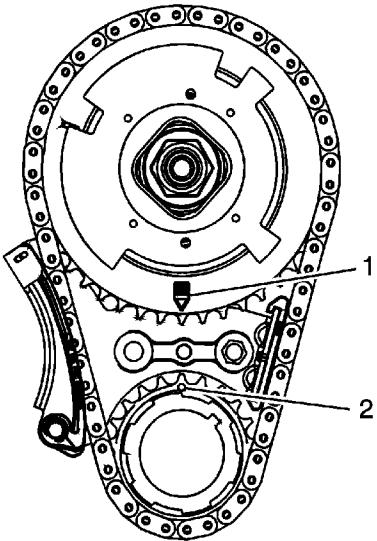




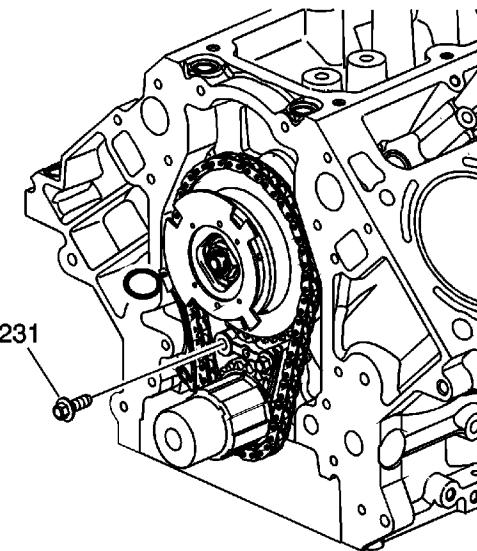
11. Locate a straight edge across the front face of the engine block and inspect for proper installation of the CMP actuator and timing chain. With the CMP actuator properly and completely installed onto the front of camshaft, the timing chain will not protrude beyond the front face of engine block.



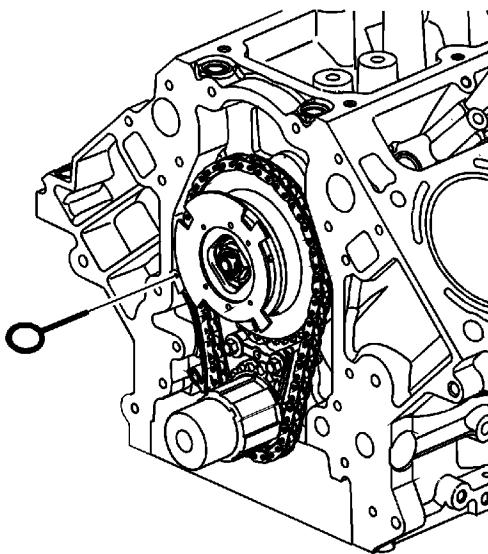
12. Install a NEW CMP actuator solenoid valve (234). With the CMP actuator properly positioned onto the camshaft, the CMP actuator solenoid valve can be threaded completely into the camshaft using light hand pressure. Tighten by hand until snug.



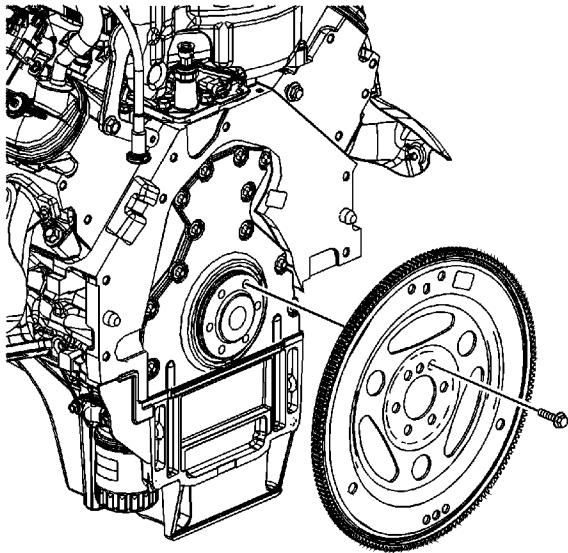
13. Inspect the sprockets for proper alignment. The mark on the CMP actuator sprocket (1) should be located in the 6 o'clock position and the mark on the crankshaft sprocket (2) should be located in the 12 o'clock position.



14. Install the right side bolt (231) into the timing chain tensioner and tighten to **25 N·m** (**18 lb ft**).

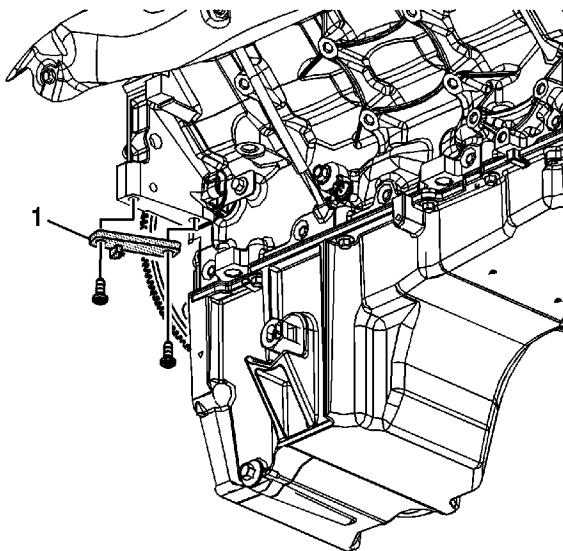


15. Remove the *EN 46330* pin .

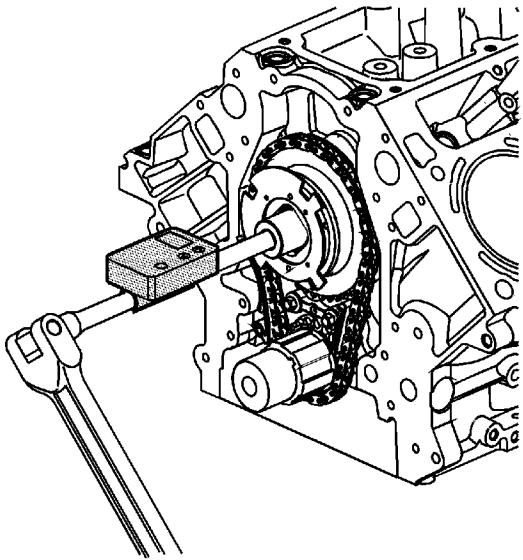


Note: Do not apply threadlock to the flex plate bolts at this time.

16. Temporarily install the automatic transmission flex plate and bolts. Refer to [Automatic Transmission Flex Plate Installation](#).



17. Install the *J42386-A* tool (1) and bolts. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation. Tighten the *J42386-A* tool bolts to **50 N·m** (**37 lb ft**).



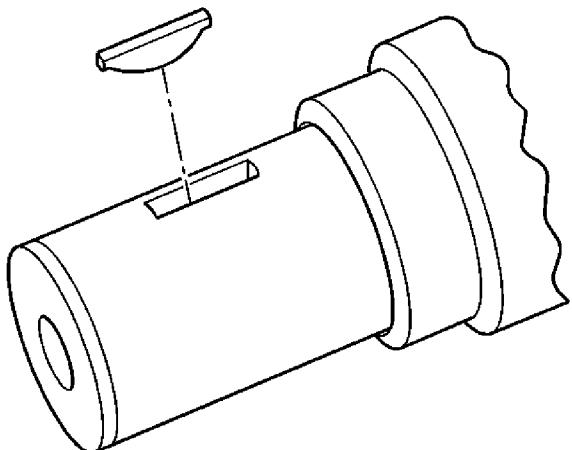
18. Tighten the CMP actuator solenoid valve.
 - 18.1. Tighten the CMP actuator solenoid valve a first pass to **65 N·m (48 lb ft)**.
 - 18.2. Tighten the CMP actuator solenoid valve a final pass an additional **90 degrees** using the *J 45059* meter .
19. Remove the *J 42386-A* tool and bolts.
20. Remove the automatic transmission flex plate and bolts. Refer to [Automatic Transmission Flex Plate Removal](#).

Timing Chain and Sprocket Installation

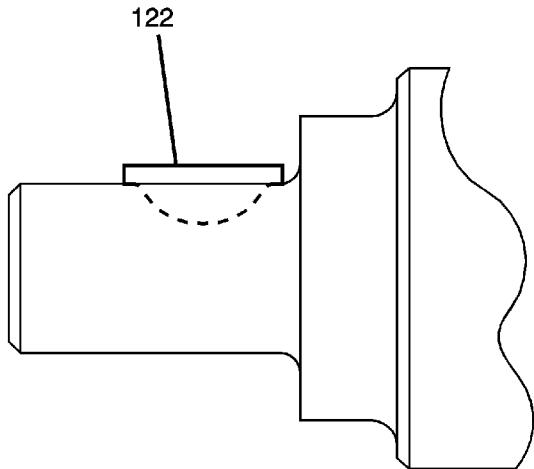
Special Tools

- *EN 46330* Timing Belt Tensioner Retaining Pin
- *J 41478* Crankshaft Front Oil Seal Installer
- *J 41665* Crankshaft Balancer and Sprocket Installer
- *J 42386-A* Flywheel Holding Tool
- *J 45059* Angle Meter

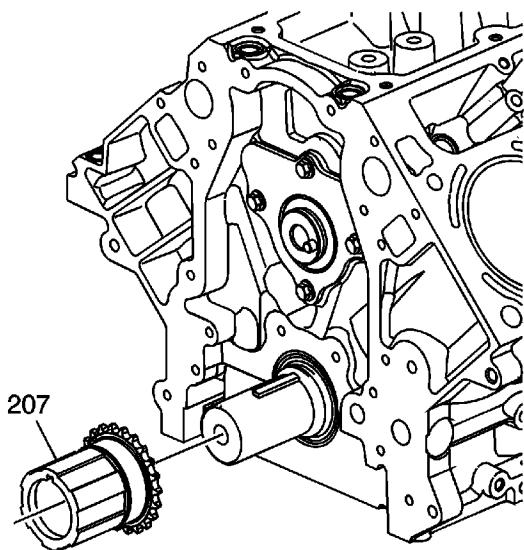
For equivalent regional tools, refer to [Special Tools](#)



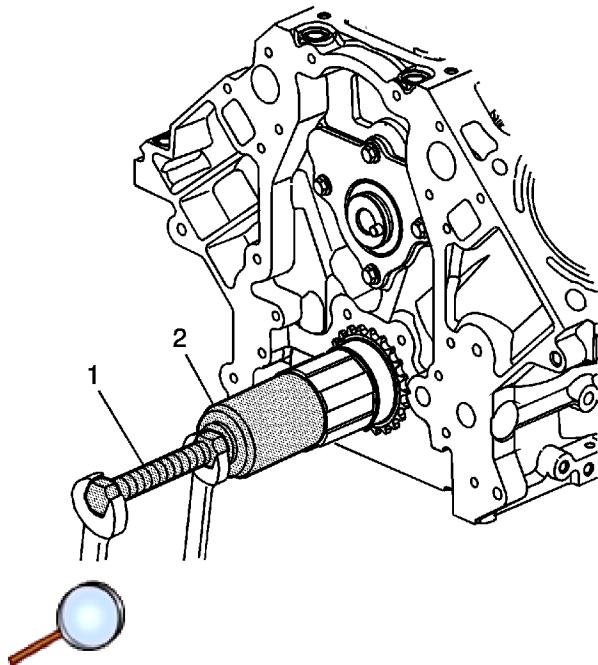
1. Install the key into the crankshaft keyway, if previously removed.



2. Tap the key (122) into the keyway until both ends of the key bottom onto the crankshaft.



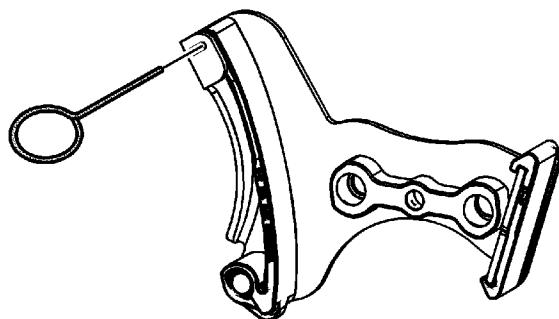
3. Install the crankshaft sprocket (207) onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.



4. Use the *J41478* installer (1) and the *J41665* installer (2) in order to install the crankshaft sprocket.

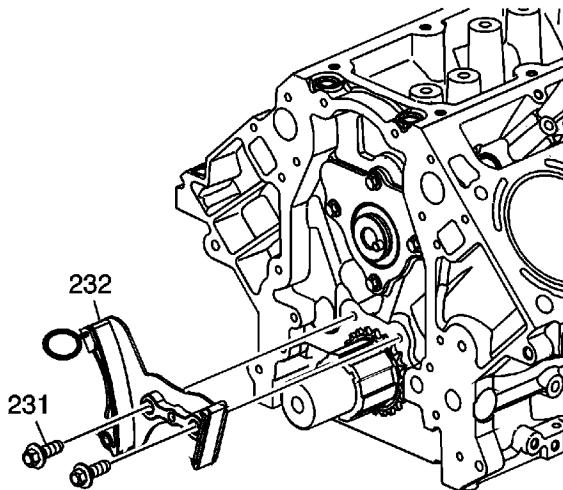
Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.

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

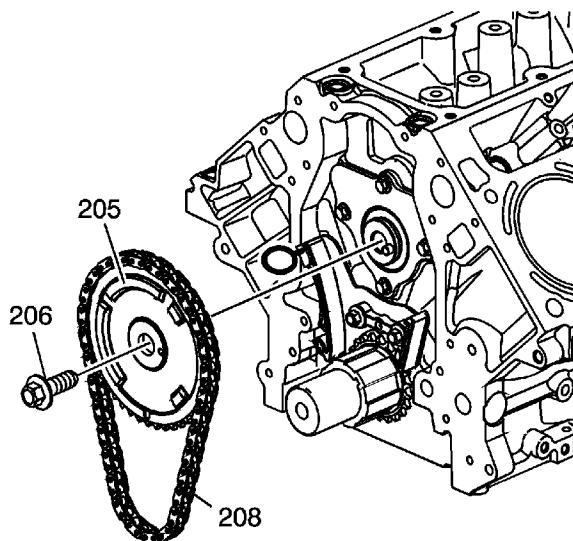


6. Compress the timing chain tensioner guide and install the *EN 46330* pin .

Caution: Refer to [Fastener Caution](#) in the Preface section.



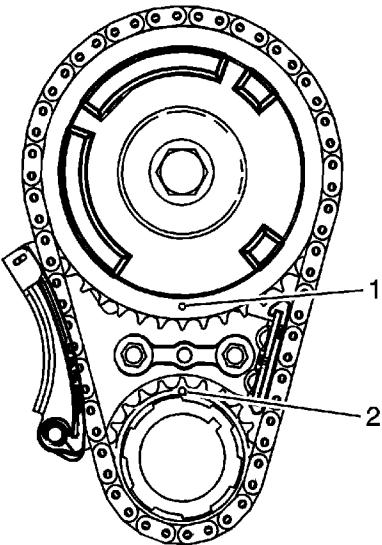
7. Install the timing chain tensioner (232) and bolts (231). Tighten the timing chain tensioner bolts to **25 N·m (18 lb ft)**.



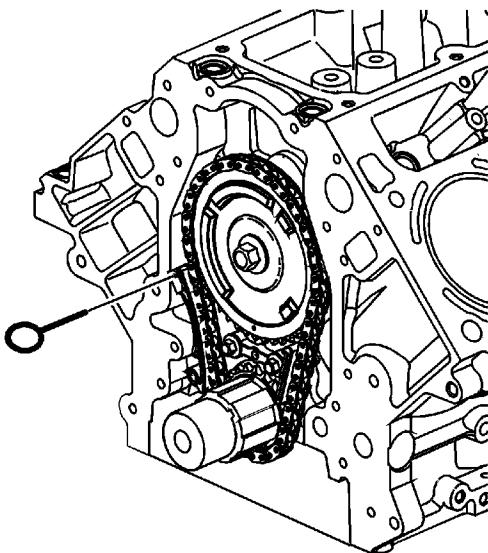
Note:

- Do not use the camshaft sprocket bolt again. Install a **NEW** bolt during assembly.
- The sprocket teeth and timing chain must mesh.
- The camshaft and the crankshaft sprocket alignment marks **MUST** be aligned properly.

8. Install the camshaft sprocket (205), timing chain (208), and **NEW** bolt (206).



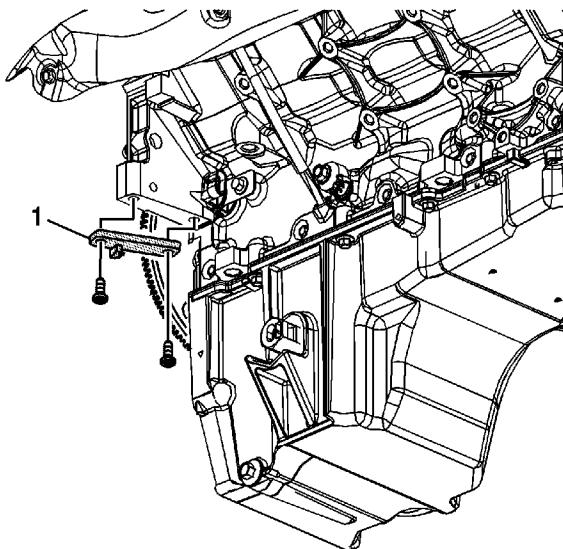
9. Inspect the sprockets for proper alignment. The mark on the camshaft sprocket (1) should be located in the 6 o'clock position and the mark on the crankshaft sprocket (2) should be located in the 12 o'clock position.



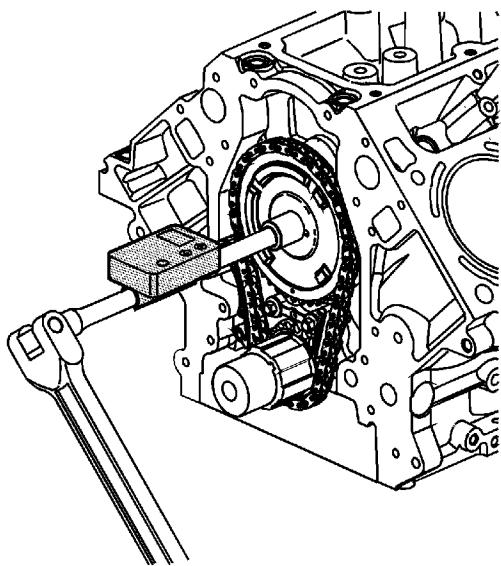
10. Remove the *EN 46330* pin .

Note: Do not apply threadlock to the flex plate bolts at this time.

11. Temporarily install the automatic transmission flex plate and bolts. Refer to [Automatic Transmission Flex Plate Installation](#).

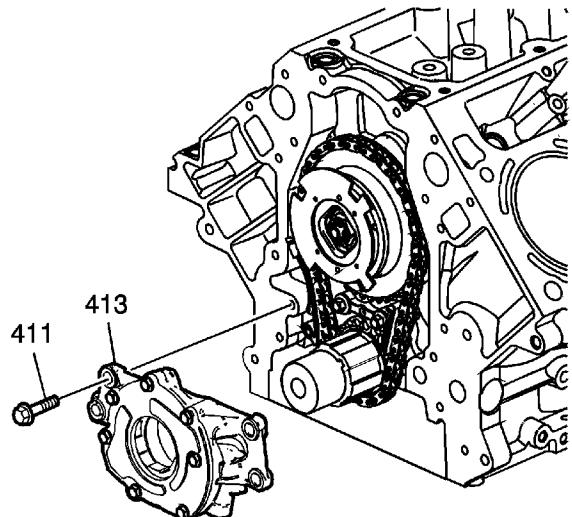


12. Install the *J 42386-A* tool (1) and bolts. Use 1 M10-1.5 x 120 mm bolt and 1 M10-1.5 x 45 mm bolt for proper tool operation. Tighten the *J 42386-A* tool bolts to **50 N·m** (**37 lb ft**).



13. Tighten the camshaft sprocket bolt.
 - 13.1. Tighten the camshaft sprocket bolt a first pass to **75 N·m** (**55 lb ft**).
 - 13.2. Tighten the camshaft sprocket bolt a final pass an additional **50 degrees** using the *J 45059* meter .
14. Remove the *J 42386-A* tool and bolts.
15. Remove the automatic transmission flex plate and bolt. Refer to [Automatic Transmission Flex Plate Removal](#).

Oil Pump, Screen and Crankshaft Oil Deflector Installation (RPO LY6/L76/L9H)

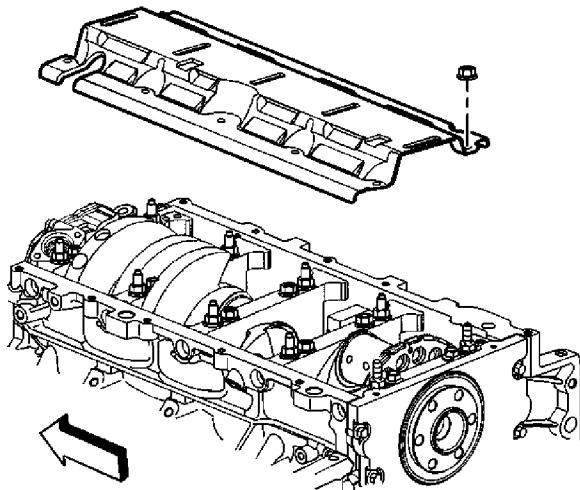


Note: Inspect the oil pump and engine block oil gallery passages. These surfaces must be clear and free of debris or restrictions.

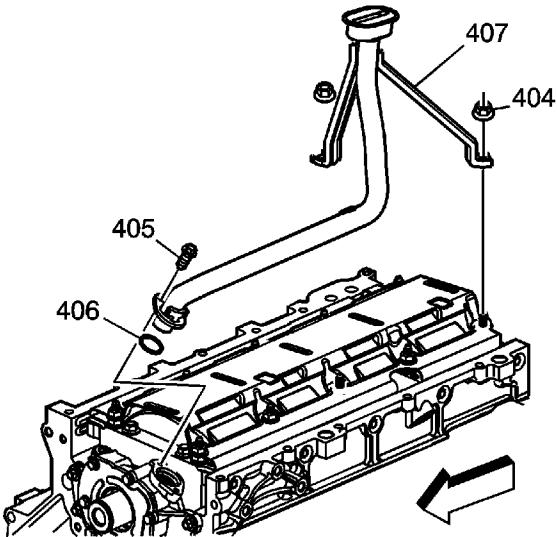
1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump (413).
2. Install the oil pump (413) onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the oil pump bolts (411) and tighten to **25 N·m (18 lb ft)**.



4. Install the crankshaft oil deflector (425) and nuts (403).



5. Lubricate a NEW oil pump screen O-ring seal (406) with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

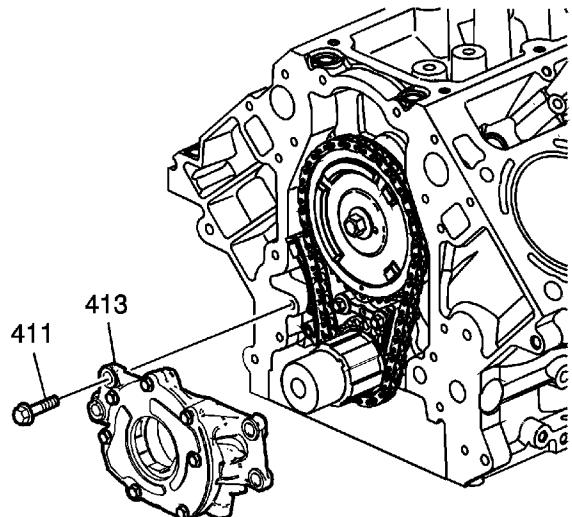
Note:

- Push the oil pump screen tube completely into the oil pump prior to tightening the bolt.
Do not allow the bolt to pull the tube into the pump.
- Align the oil pump screen mounting brackets with the correct crankshaft bearing cap bolt/studs.

7. Install the oil pump screen (407).
8. Install the oil pump screen bolt (405) and the nut (404).

- 8.1. Tighten the oil pump screen bolt to **12 N·m (106 lb in)**.
- 8.2. Tighten the crankshaft oil deflector nut to **25 N·m (18 lb ft)**.

Oil Pump, Screen and Crankshaft Oil Deflector Installation (RPO LY2/LH6/LMG/LY5/LC9)

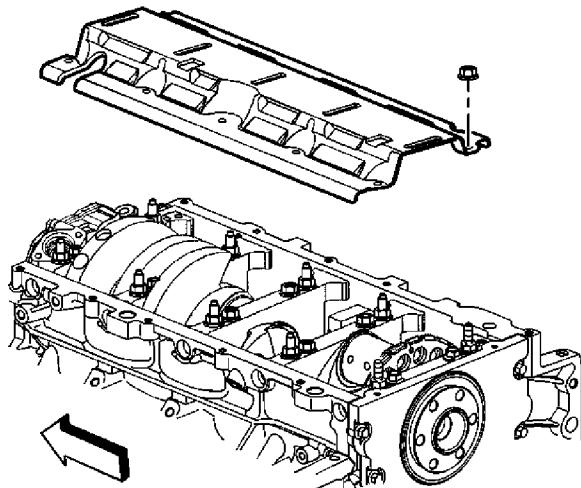


Note: Inspect the oil pump and engine block oil gallery passages. These surfaces must be clear and free of debris or restrictions.

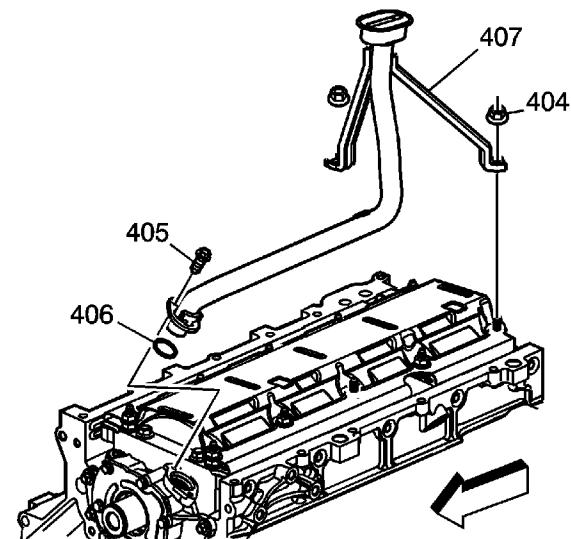
1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump (413).
2. Install the oil pump (413) onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the oil pump bolts (411) and tighten to **25 N·m (18 lb ft)**.



4. Install the crankshaft oil deflector (425) and nuts (403).



5. Lubricate a NEW oil pump screen O-ring seal (406) with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

Note:

- Push the oil pump screen tube completely into the oil pump prior to tightening the bolt.
Do not allow the bolt to pull the tube into the pump.
- Align the oil pump screen mounting brackets with the correct crankshaft bearing cap bolt/studs.

7. Install the oil pump screen (407).
8. Install the oil pump screen bolt (405) and the nut (404).

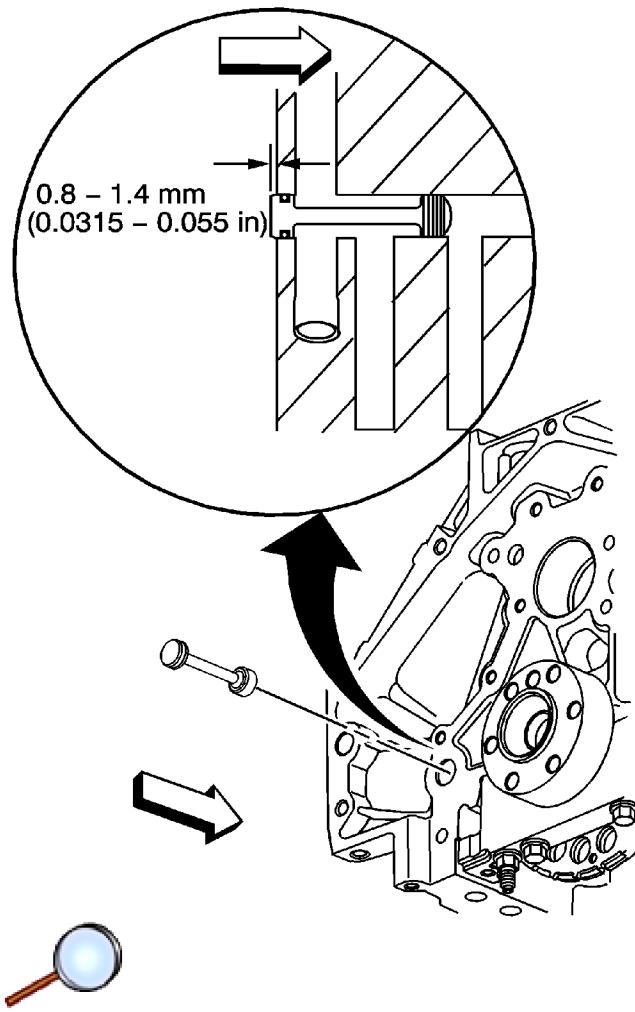
- 8.1. Tighten the oil pump screen bolt to **12 N·m (106 lb in)**.
- 8.2. Tighten the crankshaft oil deflector nut to **25 N·m (18 lb ft)**.

Crankshaft Rear Oil Seal Housing Installation (Without Seal in Housing)

Special Tools

- J41476 Front and Rear Cover Alignment Tool
- J41480 Front and Rear Cover Alignment

For equivalent regional tools, refer to [Special Tools](#).



Note:

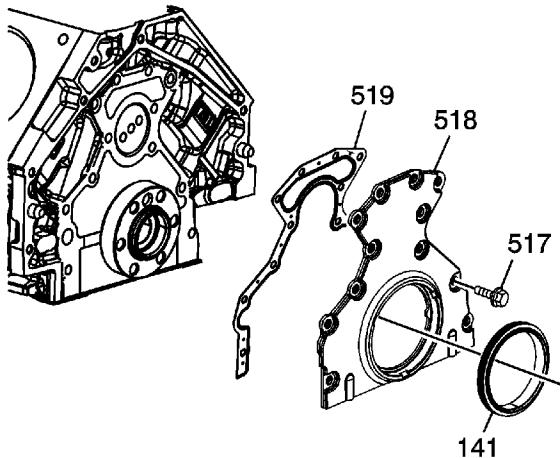
- Do not use the crankshaft rear oil seal or the engine rear housing gasket again.
- Do not apply any type of sealant to the rear housing gasket, unless specified.
- The special tools in this procedure are used to properly align the engine rear housing at the oil pan surface and to center the crankshaft rear oil seal.
- The crankshaft rear oil seal will be installed after the rear housing has been installed.

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and aligned. Install the rear housing without the crankshaft oil seal.

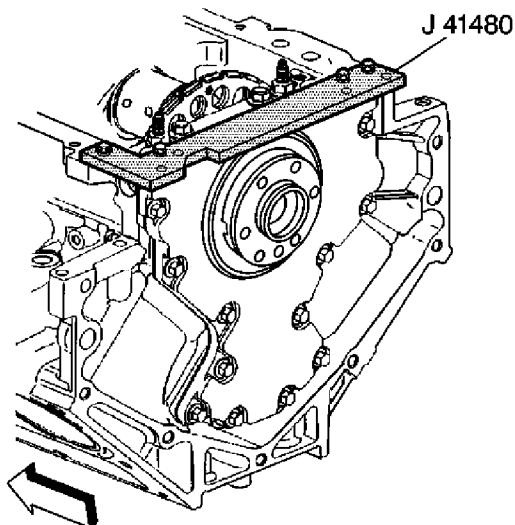
- The crankshaft rear oil seal MUST be centered in relation to the crankshaft.
- The oil pan sealing surface at the rear housing, and the engine block, MUST be aligned within specifications.
- An improperly aligned rear housing may cause premature rear oil seal wear and/or engine assembly oil leaks.

1. Inspect the rear oil gallery plug for proper installation.



2. Install the rear housing gasket (519), rear housing (518), and bolts (517).
3. Tighten the bolts finger tight. Do not overtighten.

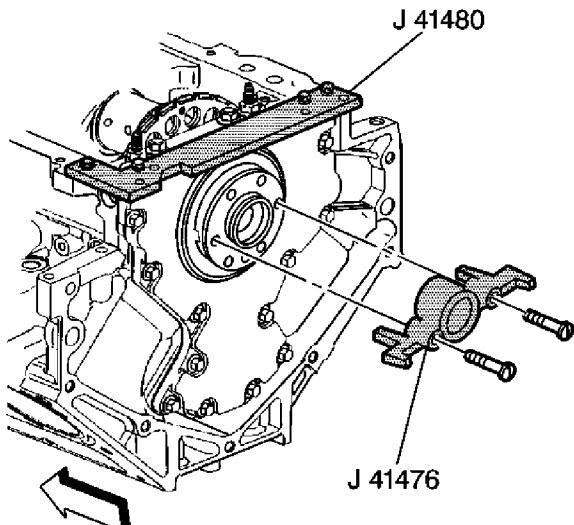
Caution: Refer to [Fastener Caution](#) in the Preface section.





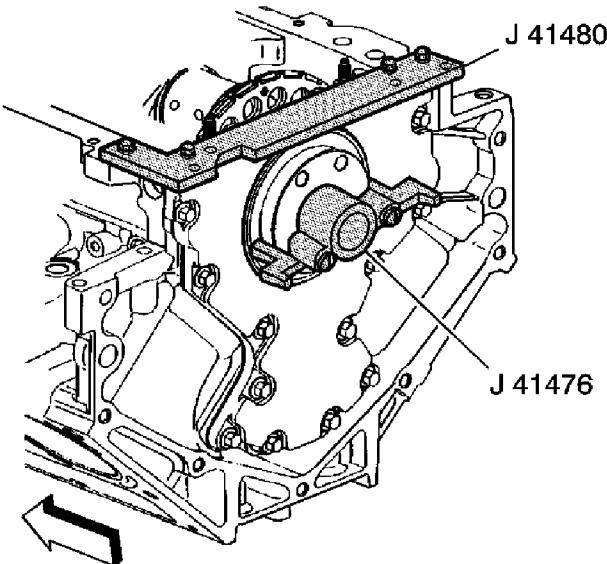
Note: Start the *J 41480* alignment tool-to-rear housing bolts. Do not tighten the bolts at this time.

4. Install the *J 41480* alignment and bolts. Tighten the tool-to-engine block bolts to **25 N·m** (**18 lb ft**).



Note: To properly align the rear housing, the *J 41476* tool must be installed onto the rear of the crankshaft with the tool mounting bolts parallel to the oil pan surface.

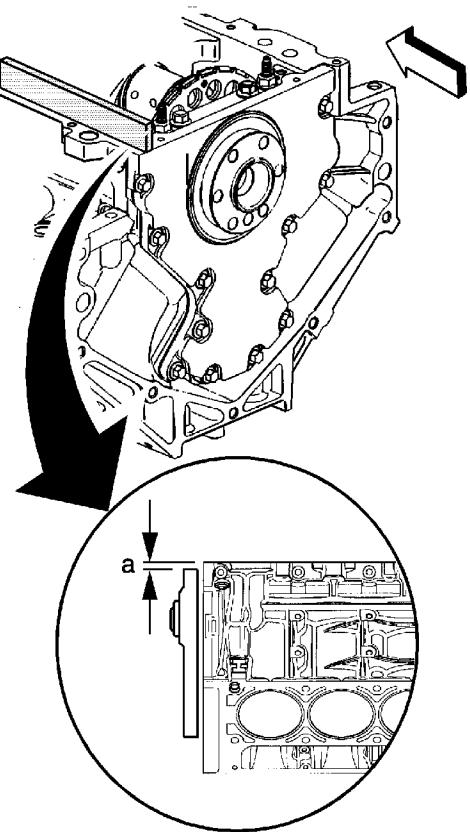
5. Rotate the crankshaft until 2 opposing flywheel bolt holes are parallel to the oil pan surface.





Note: The tapered legs of the alignment tool must enter the rear housing oil seal bore.

6. Install the *J41476* tool and bolts onto the rear of the crankshaft.
 - 6.1. Tighten the tool mounting bolts until snug. Do not overtighten.
 - 6.2. Tighten the *J41480* alignment tool-to-rear housing bolts evenly to **12 N·m (106 lb in)**.
 - 6.3. Tighten the rear housing bolts to **30 N·m (22 lb ft)**.
7. Remove the tools.



8. Measure the rear housing-to-engine block oil pan surface for flatness.
 - 8.1. Place a straight edge onto the engine block and rear housing oil pan sealing surfaces.

Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

- 8.2. Insert a feeler gage between the rear housing and the straight edge. The housing must be flush with the oil pan or no greater than 0.5 mm (0.02 in) below flush (a).
9. If the rear housing-to-engine block oil pan surface alignment is not within specifications, repeat the housing alignment procedure.
10. If the correct rear housing-to-engine block alignment at the oil pan surface cannot be

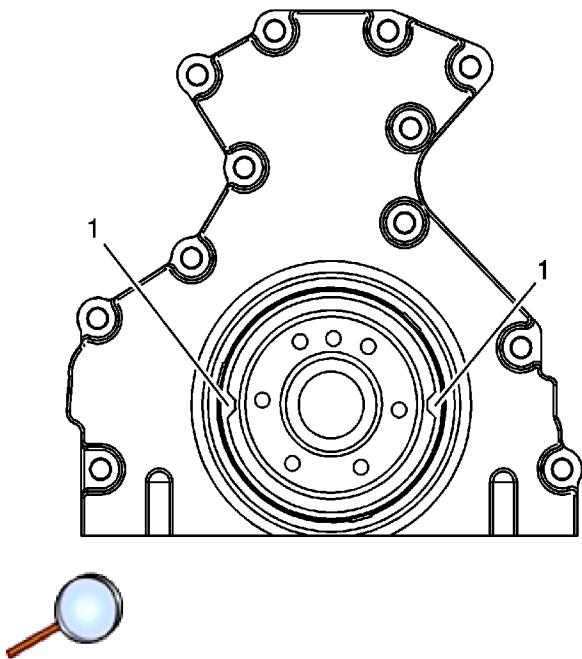
obtained, replace the rear housing.

Crankshaft Rear Oil Seal Housing Installation (With Seal in Housing)

Special Tools

- *J 41479-2A* Crankshaft Rear Oil Seal Installation Guide
- *J 41480* Front and Rear Cover Alignment

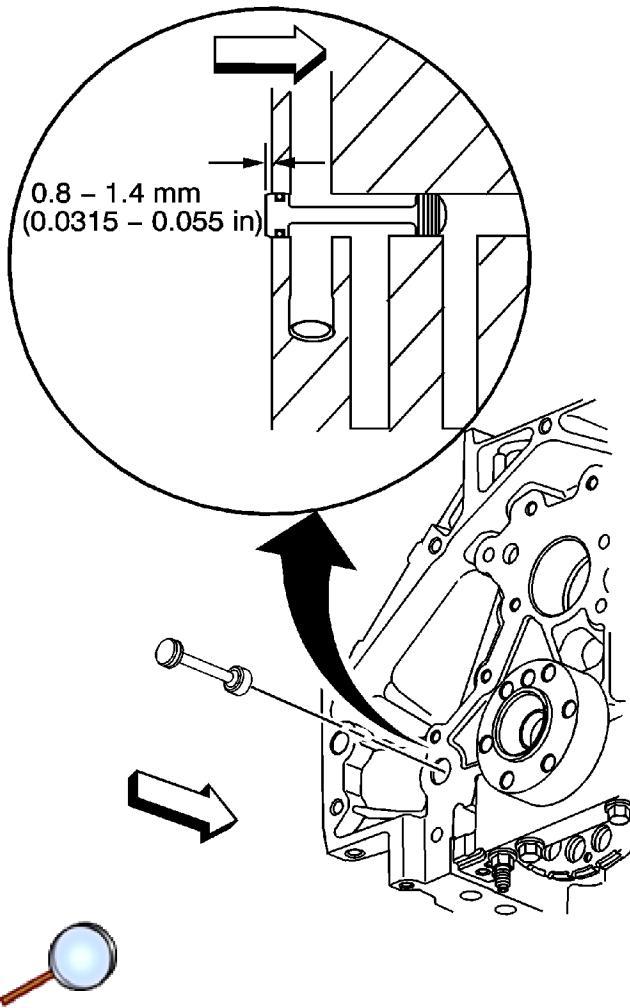
For equivalent regional tools, refer to [Special Tools](#)



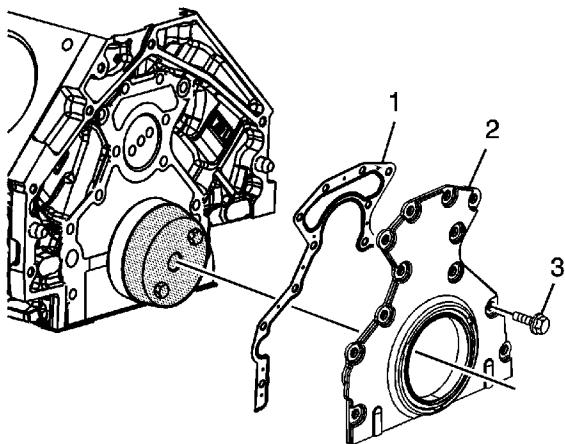
Note:

- Do not use the crankshaft rear oil seal or the engine rear housing gasket again.
- Do not apply any type of sealant to the rear housing gasket, unless specified.
- The special tool in this procedure is used to properly align the engine rear housing at the oil pan surface.
- First design rear housings do not have alignment tabs for alignment of the housing horizontally. *J 41476* tool is required to properly align first design rear housings. The rear oil seal must be removed from the housing for proper use of the tool.
- Second design rear housings have alignment tabs for alignment of the housing horizontally. *J 41476* tool is not required for proper alignment of second design rear housings. The housing may be installed and aligned with the seal already installed into the housing.

1. Inspect the rear housing to identify for alignment tabs (1).



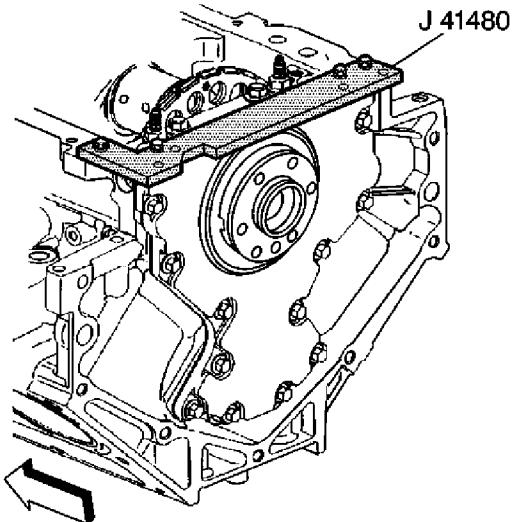
2. Inspect the rear oil gallery plug for proper installation.



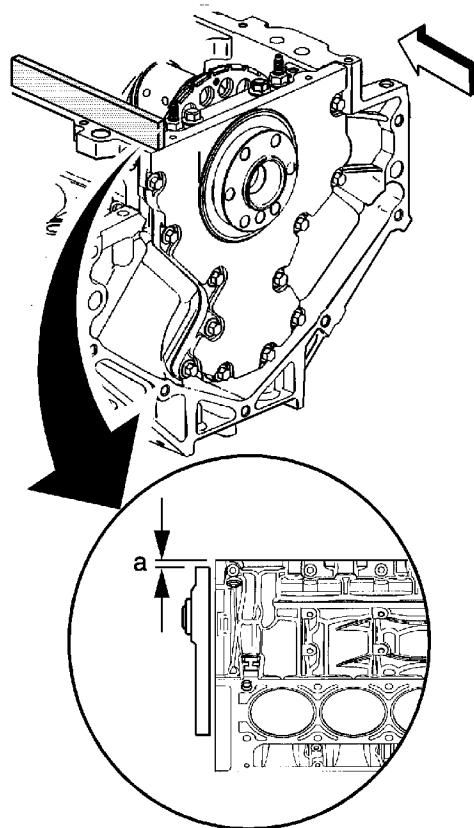
3. Install the *J41479-2A* guide cone and bolts onto the rear of the crankshaft.
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear housing gasket (1), rear housing with seal (2), and bolts (3).

6. Tighten the bolts finger tight. Do not overtighten.
7. Remove the *J 41479-2A* guide and bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.



8. Install the *J 41480* alignment and bolts.
 - 8.1. Tighten the tool-to-engine block bolts to **25 N·m (18 lb ft)**.
 - 8.2. Tighten the *J 41480* alignment tool-to-rear housing bolts evenly to **12 N·m (106 lb in)**.
 - 8.3. Tighten the rear housing-to-engine block bolts to **30 N·m (22 lb ft)**.
9. Remove the *J 41480* alignment and bolts.



10. Measure the rear housing-to-engine block oil pan surface for flatness.
 - 10.1. Place a straight edge onto the engine block and rear housing oil pan sealing surfaces.

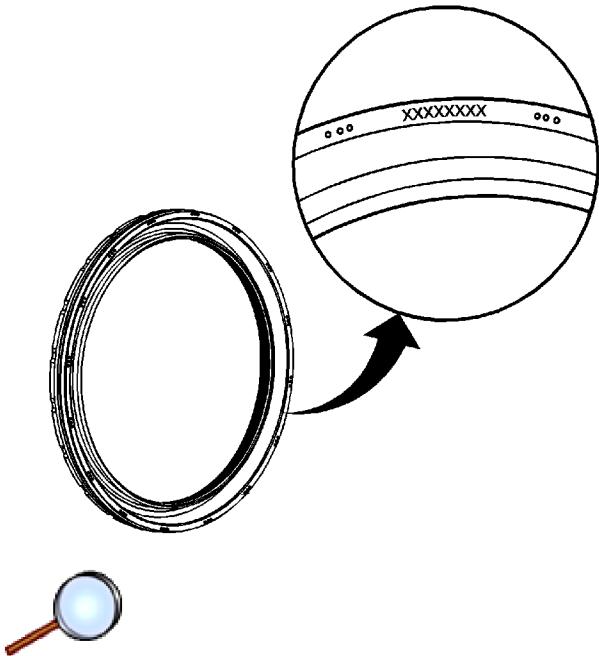
Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

 - 10.2. Insert a feeler gage between the rear housing and the straight edge. The housing must be flush with the oil pan or no greater than 0.5 mm (0.02 in) (a) below flush.
 11. If the rear housing-to-engine block oil pan surface alignment is not within specifications, repeat the housing alignment procedure.
 12. If the correct rear housing-to-engine block alignment at the oil pan surface cannot be obtained, replace the rear housing.

Crankshaft Rear Oil Seal Installation

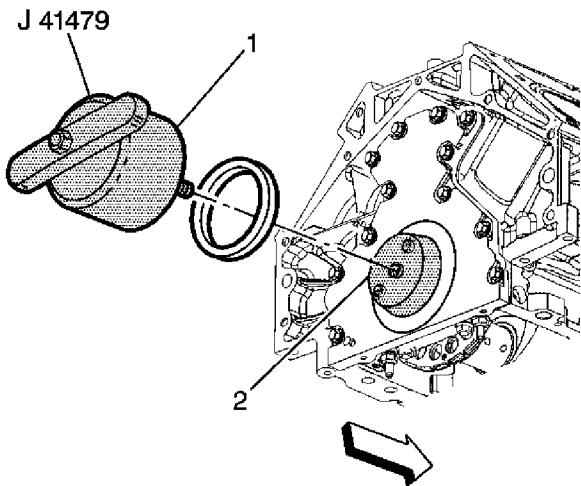
Special Tools

- [J 41479](#) Crankshaft Rear Oil Seal Installer
- [J 41479-2A](#) Crankshaft Rear Oil Seal Installation Guide



Important: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. The part number is applied to the outside face of the seal, as shown.

1. Inspect the seal and identify the part number markings for proper orientation.



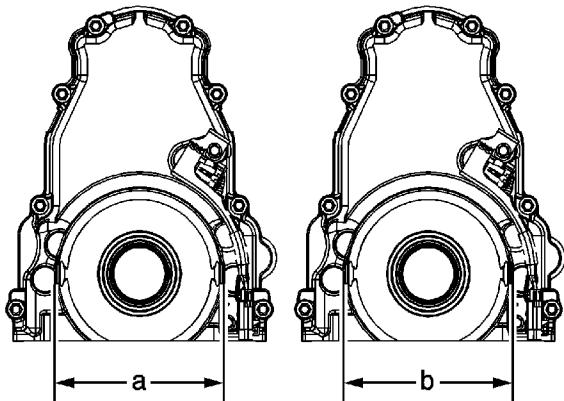
2. Install the [J 41479](#) or the [J 41479-2A](#) cone (2) and bolts onto the rear of the crankshaft. The [J 41479-2A](#) may be required for manual transmission or 5.3L LS4 applications.
3. Tighten the bolts until snug. Do not overtighten.
4. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear seal bore. Install the oil seal with the part number markings facing away from the engine.
5. Thread the [J 41479](#) threaded rod into the tapered cone until the tool (1) contacts the oil seal.
6. Align the oil seal onto the tool (1).
7. Rotate the handle of the tool (1) clockwise until the seal enters the rear housing and bottoms into the seal bore.
8. Remove the tool.

Engine Front Cover Installation (without Camshaft Position Actuator)

Special Tools

- *EN-48853* Front Cover Alignment Tool
- *J41480* Front and Rear Cover Alignment

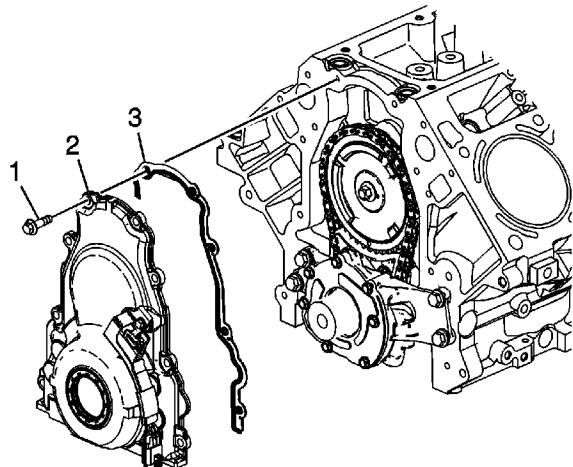
For equivalent regional tools, refer to [Special Tools](#)



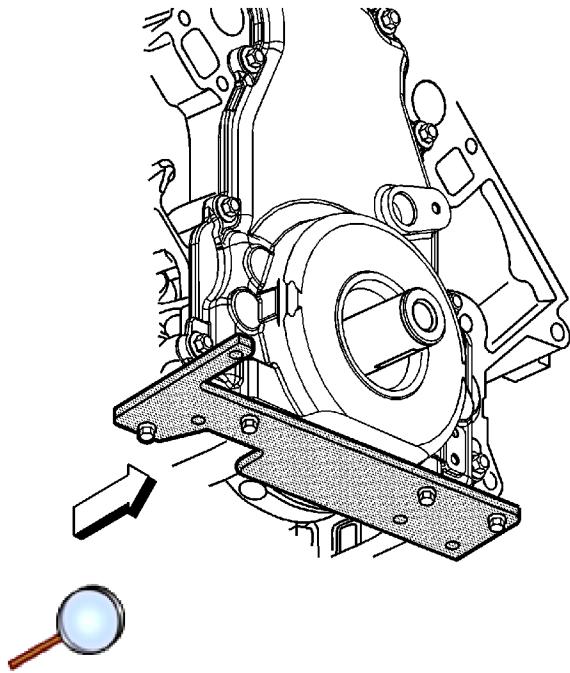
1. Measure the alignment tab distance on the front cover.

For 2009 model year, the engine front cover may have either a 141 mm (5.55 in) dimension (a) or 159 mm (6.26 in) dimension (b) alignment tab distance. Front cover alignment tool *EN-48853* tool is designed to properly align both front covers. For the 141 mm (5.55 in) cover, adapters EN 48853-2 must be used.

Caution: Refer to [Fastener Caution](#) in the Preface section.

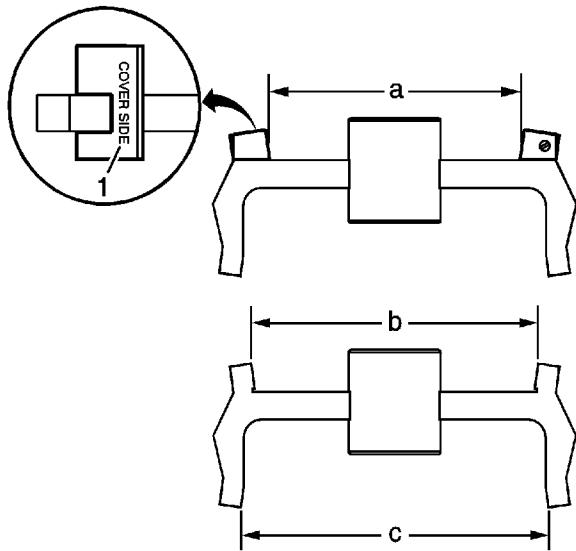
**Note:**

- Do not use the crankshaft oil seal or the engine front cover gasket again.
 - Do not apply any type of sealant to the front cover gasket, unless specified.
 - The special tools in this procedure are used to properly align the engine front cover at the oil pan surface and to center the crankshaft front oil seal.
 - All gasket surfaces should be free of oil or other foreign material during assembly.
 - The crankshaft front oil seal MUST be centered in relation to the crankshaft.
 - The oil pan sealing surface at the front cover and engine block MUST be aligned within specifications.
 - An improperly aligned front cover may cause premature front oil seal wear and/or engine assembly oil leaks.
2. Install the front cover gasket (3), front cover (2), and bolts (1).
3. Tighten the cover bolts finger tight. Do not overtighten.

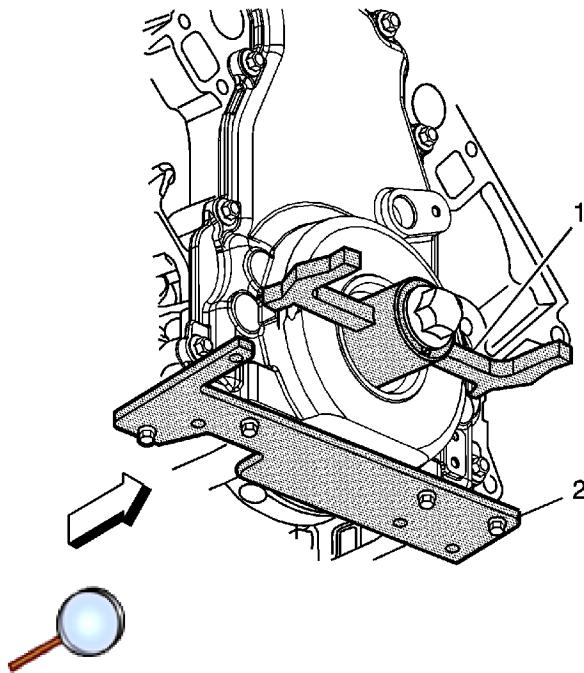


Note: Start the tool-to-front cover bolts. Do not tighten the bolts at this time.

4. Install the *J41480* cover alignment and tighten the tool-to-engine block bolts to **25 N·m** (**18 lb ft**).

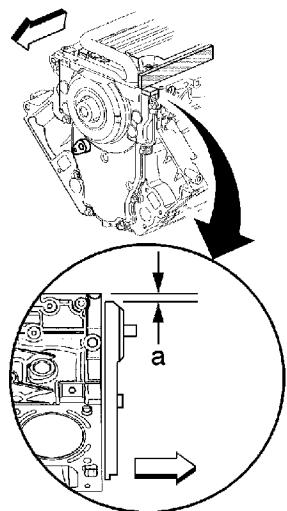


5. Install the *EN 48853-2* adapters as required for usage on the 141 mm (5.55 in) dimension (a) front cover. Position the adapters against the legs of the *EN-48853* tool with the words "cover side" (1) facing away from the tool.



Note: Align the tapered legs of the tool with the machined alignment surfaces on the front cover.

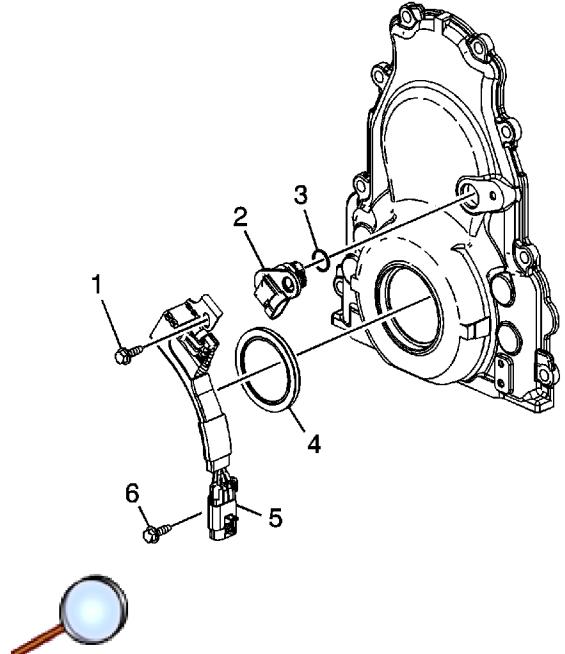
6. Install the *EN-48853* tool (1).
7. Install the crankshaft balancer bolt.
8. Tighten the crankshaft balancer bolt by hand until snug. Do not overtighten.
9. Tighten the *J41480* alignment (2).
10. Tighten the engine front cover bolts to **25 N·m (18 lb ft)**.
11. Remove the tools.



12. Measure the oil pan surface flatness, front cover-to-engine block.
 - 12.1. Place a straight edge across the engine block and front cover oil pan sealing surfaces.

Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

- 12.2. Insert a feeler gage between the front cover and the straight edge tool. The cover must be flush with the oil pan surface or no greater than 0.5 mm (0.02 in) (a) below flush.
13. If the front cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
14. If the correct front cover-to-engine block alignment cannot be obtained, replace the front cover.



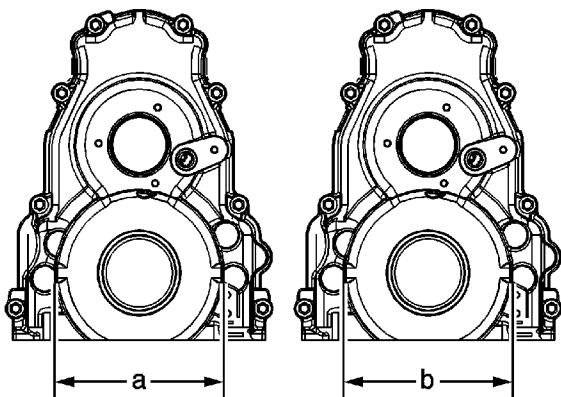
-  15. Inspect the camshaft position (CMP) sensor O-ring seal (3) for cuts or damage. If the seal is not cut or damaged, it may be used again.
16. Lubricate the O-ring seal with clean engine oil.
17. Install the O-ring seal onto the sensor (2).
18. Install the sensor to the cover.
19. Install the CMP sensor wire harness (5) and bolts (1, 6).

Engine Front Cover Installation (with Camshaft Position Actuator)

Special Tools

- *EN-48853* Front Cover Alignment Tool
- *J41480* Front and Rear Cover Alignment

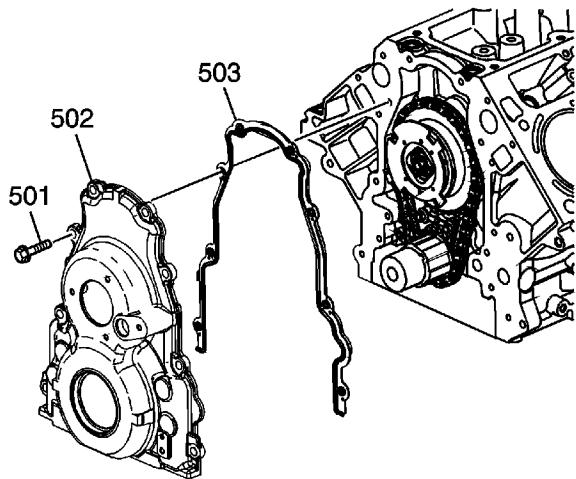
For equivalent regional tools, refer to [Special Tools](#)



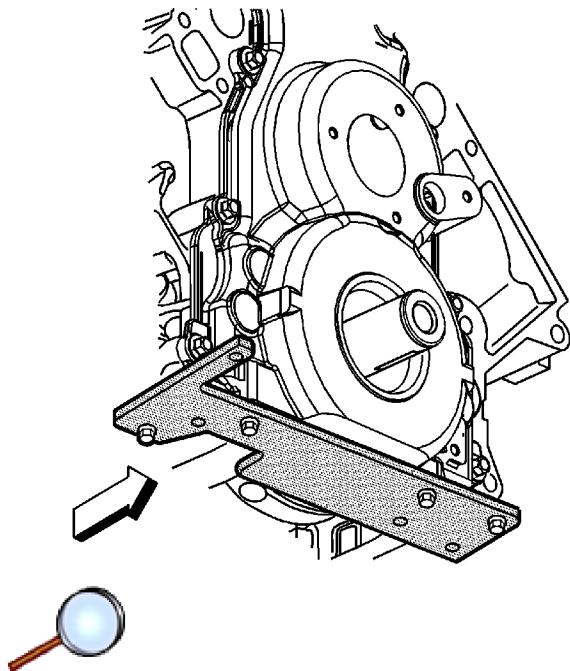
1. Measure the alignment tab distance on the front cover.

The engine front cover may have either a 141 mm (5.55 in) dimension (a) or 159 mm (6.26 in) dimension (b) alignment tab distance. Front cover alignment tool *EN-48853* tool is designed to properly align both design front covers. For the 141 mm (5.55 in) cover, adapters EN 48853-2 must be used.

Caution: Refer to [Fastener Caution](#) in the Preface section.

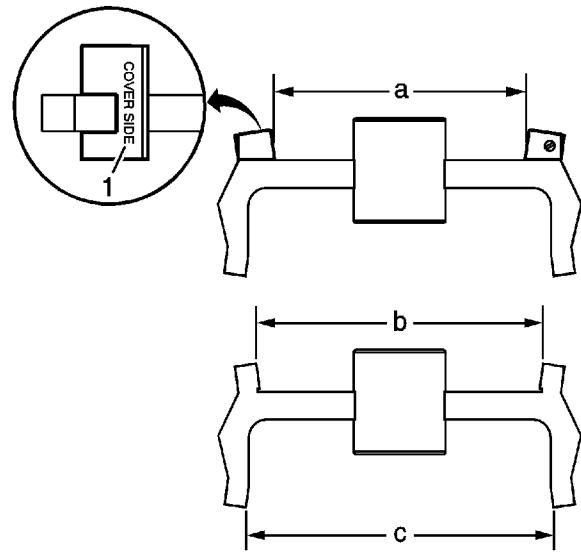
**Note:**

- Do not use the crankshaft oil seal or the engine front cover gasket again.
 - Do not apply any type of sealant to the front cover gasket, unless specified.
 - The special tools in this procedure are used to properly align the engine front cover at the oil pan surface and to center the crankshaft front oil seal.
 - All gasket surfaces should be free of oil or other foreign material during assembly.
 - The crankshaft front oil seal MUST be centered in relation to the crankshaft.
 - The oil pan sealing surface at the front cover and engine block MUST be aligned within specifications.
 - An improperly aligned front cover may cause premature front oil seal wear and/or engine assembly oil leaks.
2. Install the front cover gasket (503), front cover (502), and bolts (501).
3. Tighten the cover bolts finger tight. Do not overtighten.

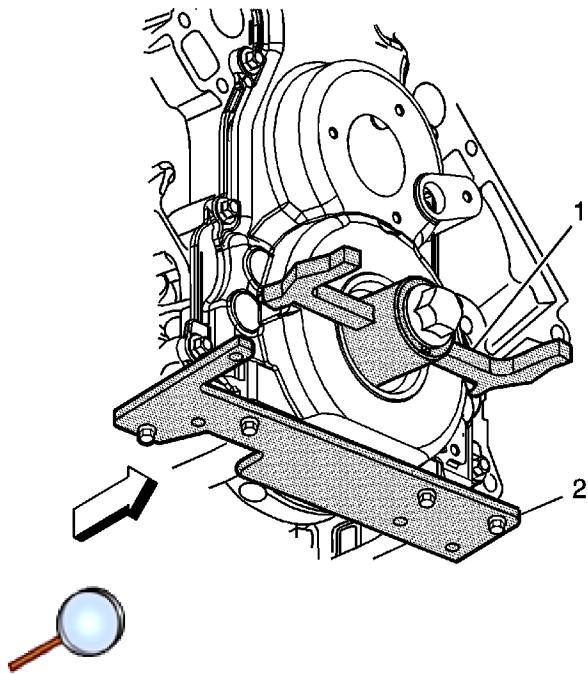


Note: Start the tool-to-front cover bolts. Do not tighten the bolts at this time.

4. Install the *J41480* alignment and tighten to **25 N·m (18 lb ft)**.

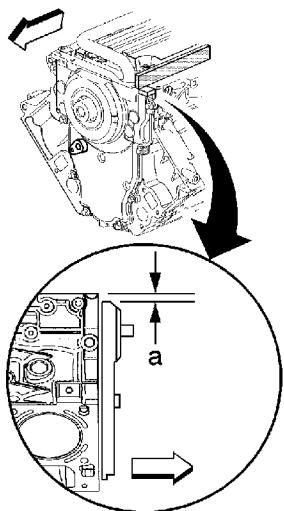


5. Install the EN 48853-2 adapters as required for usage on the 141 mm (5.55 in) dimension (a) front cover. Position the adapters against the legs of the *EN-48853* tool with the words "cover side" (1) facing away from the tool.



Note: Align the tapered legs of the tool with the machined alignment surfaces on the front cover.

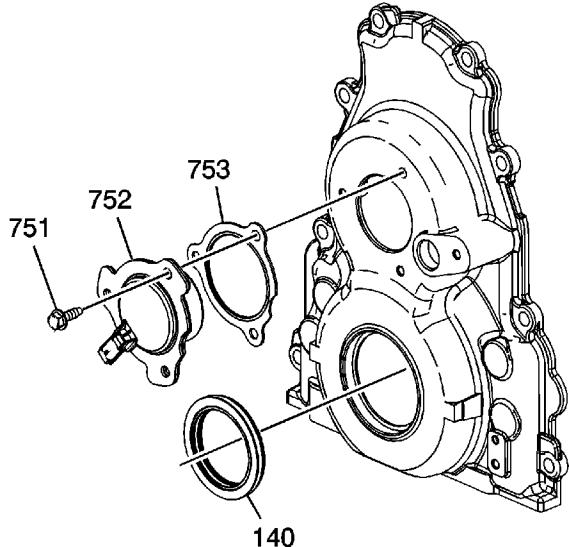
6. Install the *EN-48853* tool (1).
7. Install the crankshaft balancer bolt.
 - 7.1. Tighten the crankshaft balancer bolt by hand until snug. Do not overtighten.
 - 7.2. Tighten the *J41480* alignment (2).
 - 7.3. Tighten the engine front cover bolts to **25 N·m (18 lb ft)**.
8. Remove the tools.



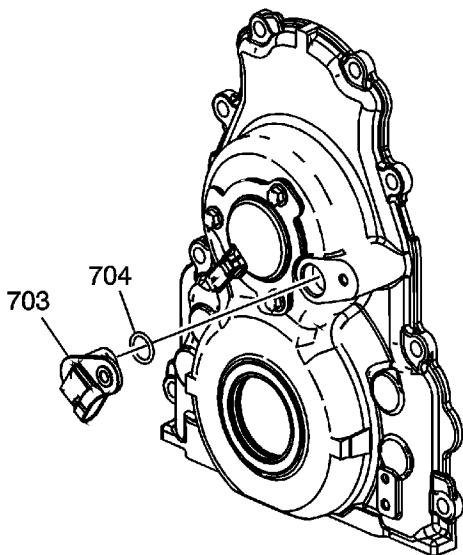
- Magnifying glass icon:**
9. Measure the oil pan surface flatness, front cover-to-engine block.
 - 9.1. Place a straight edge across the engine block and front cover oil pan sealing surfaces.

Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

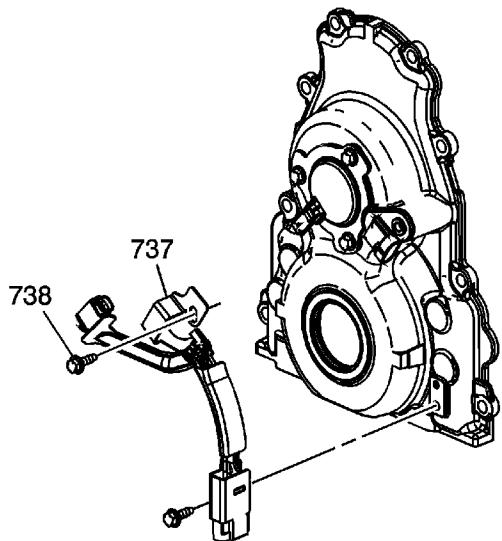
- 9.2. Insert a feeler gage between the front cover and the straight edge tool. The cover must be flush with the oil pan surface or no greater than 0.5 mm (0.02 in) (a) below flush.
10. If the front cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
11. If the correct front cover-to-engine block alignment cannot be obtained, replace the front cover.



12. Install the camshaft position (CMP) actuator magnet (752), gasket (753), and bolts (751). Tighten the bolts to **12 N·m (106 lb in)**.



13. Install the CMP sensor (703) and O-ring (704).

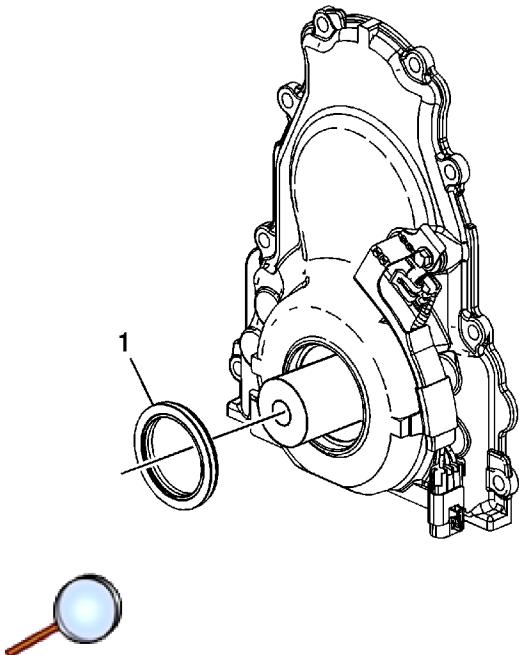


14. Install the CMP sensor wire harness (737) and bolts (738). Tighten the bolts to **12 N·m (106 lb in)**.

Crankshaft Front Oil Seal Installation (RPO LY2/LH6/LMG/LY5/LC9)

Tools Required

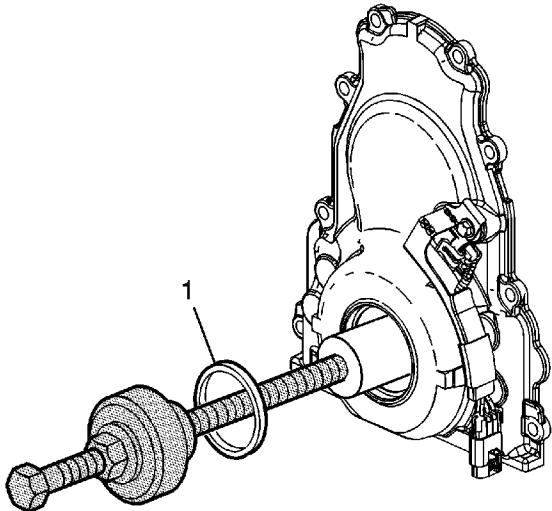
[J 41478](#) Crankshaft Front Oil Seal Installer



Important:

- Do not lubricate the oil seal sealing surface.
- Do not use the crankshaft front oil seal again.

1. Lubricate the outer edge of the oil seal (1) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.

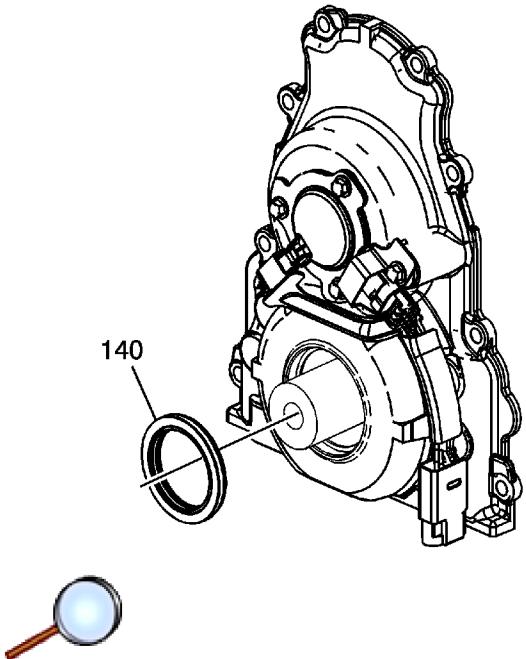


3. Install the crankshaft front oil seal (1) onto the [J 41478](#).
4. Install the [J 41478](#) threaded rod, with nut, washer, guide, and oil seal, into the end of the crankshaft.
5. Use the [J 41478](#) in order to install the oil seal into the cover bore.
 - 5.1. Use a wrench and hold the hex on the installer bolt.
 - 5.2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
 - 5.3. Remove the tool.
 - 5.4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.

Crankshaft Front Oil Seal Installation (RPO LY6/L76/L9H)

Tools Required

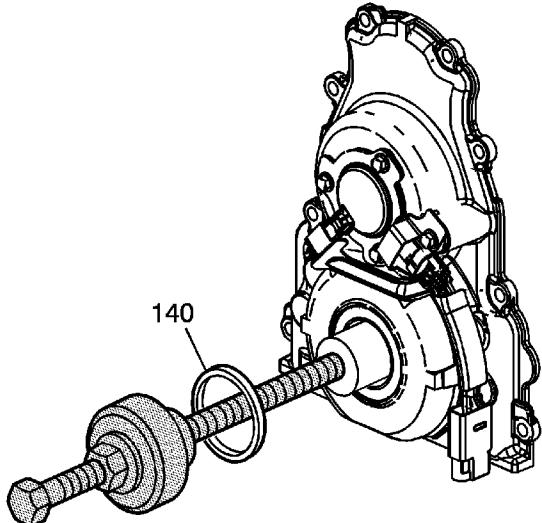
[J 41478](#) Crankshaft Front Oil Seal Installer



Important:

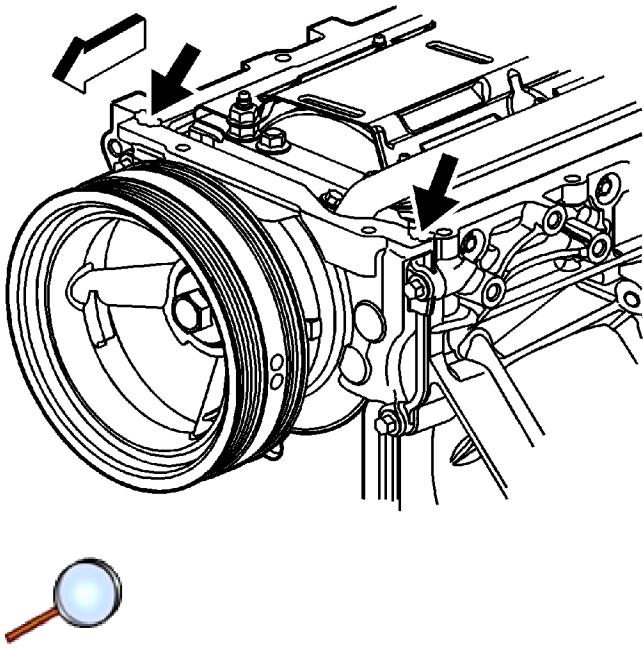
- Do not lubricate the oil seal sealing surface.
- Do not use the crankshaft front oil seal again.

1. Lubricate the outer edge of the oil seal (140) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.



3. Install the crankshaft front oil seal (140) onto the [J 41478](#).
4. Install the [J 41478](#) threaded rod, with nut, washer, guide, and oil seal, into the end of the crankshaft.
5. Use the [J 41478](#) in order to install the oil seal into the cover bore.
 - 5.1. Use a wrench and hold the hex on the installer bolt.
 - 5.2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
 - 5.3. Remove the tool.
 - 5.4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.

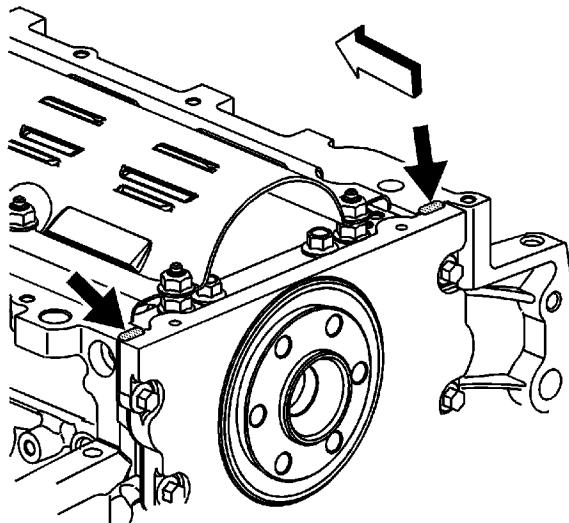
Oil Pan Installation



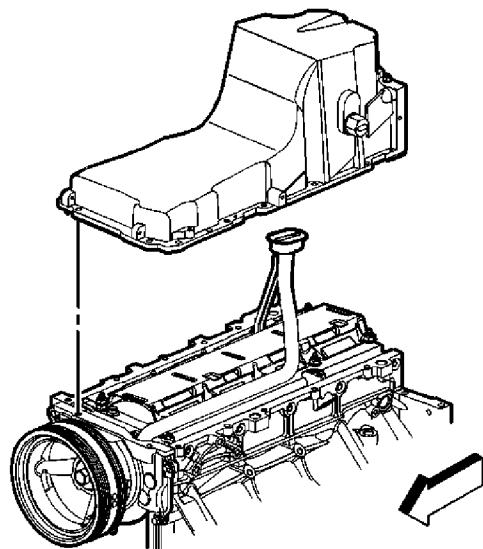
Note:

- The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission housing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan are flush or even. The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing plane.
- Do not use the oil pan gasket again.
- It is not necessary to rivet the NEW gasket to the oil pan.
- It is not necessary to remove the oil level sensor prior to oil pan installation.

1. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378521 (Canadian P/N 88901148), or equivalent, 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrude into the oil pan surface. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).



2. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378521 (Canadian P/N 88901148), or equivalent, 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the rear housing gasket that protrude into the oil pan surface.

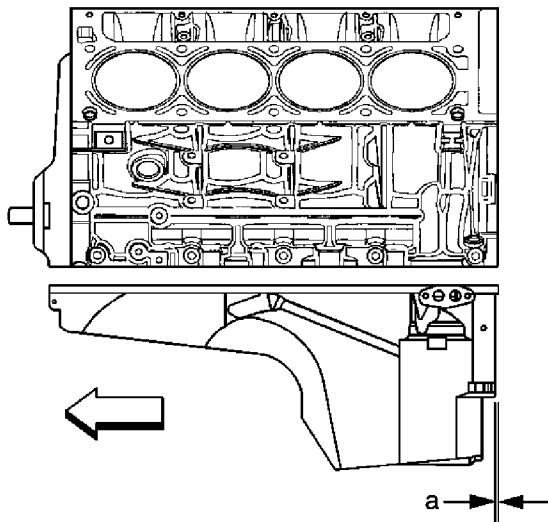


Note: Be sure to align the oil gallery passages in the oil pan and engine block properly with the oil pan gasket.

3. Pre-assemble the oil pan gasket to the pan.
 - 3.1. Install the gasket onto the oil pan.
 - 3.2. Install the oil pan bolts to the pan and through the gasket.
4. Install the oil pan, gasket, and bolts to the engine block.
5. Tighten the bolts finger tight. Do not overtighten.
6. Place a straight edge across the rear of the engine block and the rear of the oil pan at the

transmission housing mounting surfaces.

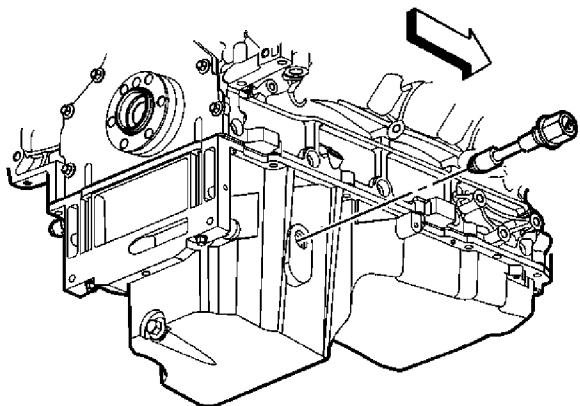
Caution: Refer to [Fastener Caution](#) in the Preface section.



7. Align the oil pan until the rear of engine block and rear of oil pan are flush or even.
 - Tighten the oil pan-to-block and oil pan-to-front cover bolts to **25 N·m (18 lb ft)**.
 - Tighten the oil pan-to-rear cover bolts to **12 N·m (106 lb in)**.
8. Measure the oil pan-to-engine block alignment (a).
 - 8.1. Place a straight edge across the rear of the engine block and rear of oil pan at the transmission housing mounting surfaces.

Note: The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing mounting surfaces.

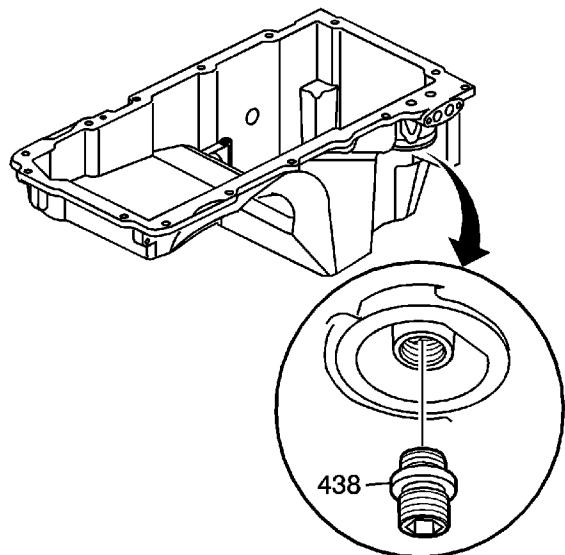
- 8.2. Insert a feeler gage between the straight edge and the oil pan transmission housing mounting surface and measure to ensure that there is no greater than a 0.1 mm (0.004 in) gap between the pan and straight edge.
- 8.3. If the oil pan alignment is not within specifications, remove the oil pan and repeat the above procedure.



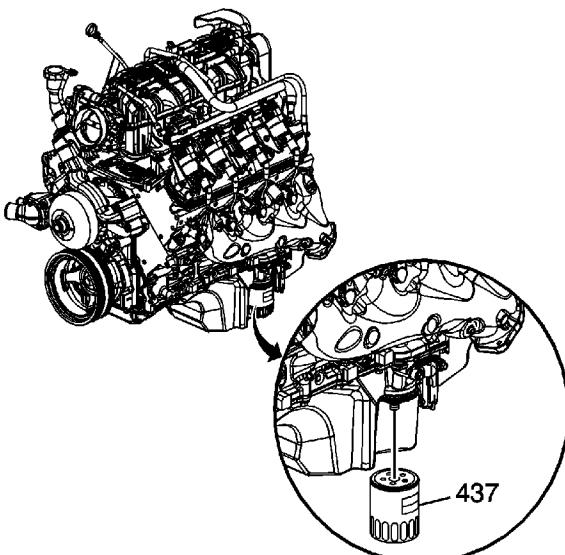
9. Install the oil level indicator switch and tighten to **20 N·m (15 lb in)**.

Oil Filter Installation

Caution: Refer to [Fastener Caution](#) in the Preface section.

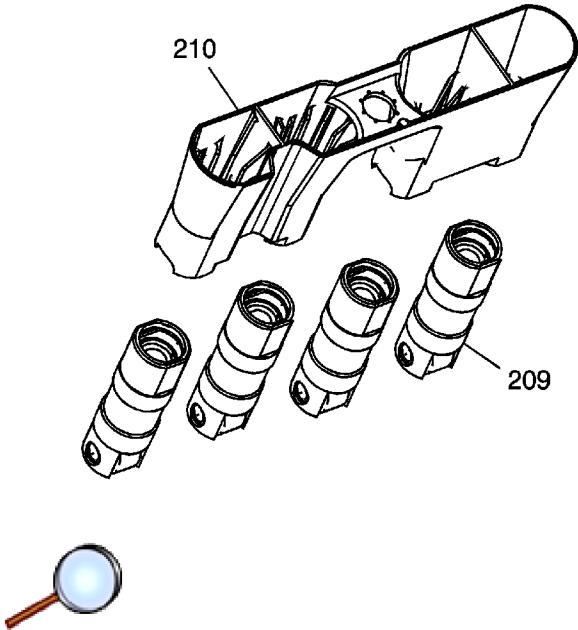


1. Install the oil filter fitting (438) and tighten to **55 N·m (40 lb ft)**.



2. Lubricate the oil filter seal with clean engine oil.
3. Install the oil filter (437) and tighten to **30 N·m (22 lb ft)**.

Valve Lifter Installation (RPO LY2/LY6/L9H)

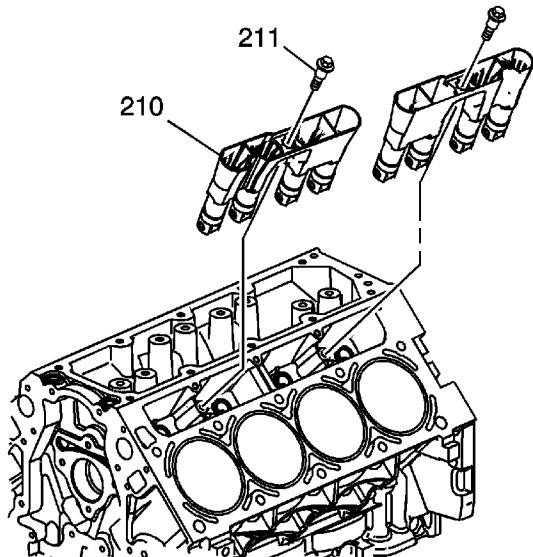


Note:

- When using the valve lifters again, install the lifters to their original locations.
- If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the valve lifters (209) and engine block valve lifter bores with clean engine oil.
2. Insert the valve lifters into the lifter guides (210).

Align the flat area on the top of the lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.

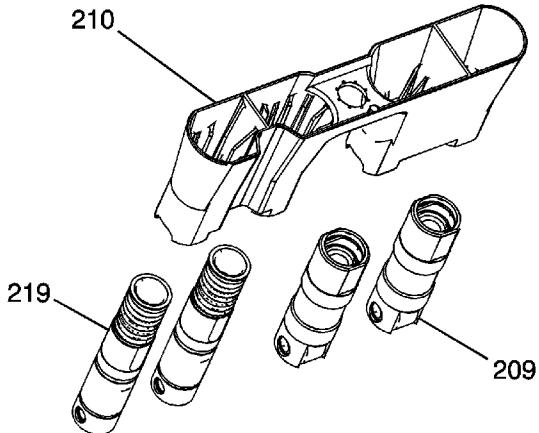


3. Install the valve lifters and guide assembly (210) to the engine block.

Caution: Refer to [Fastener Caution](#) in the Preface section.

4. Install the valve lifter guide bolts (211) and tighten to **12 N·m (106 lb in)**.

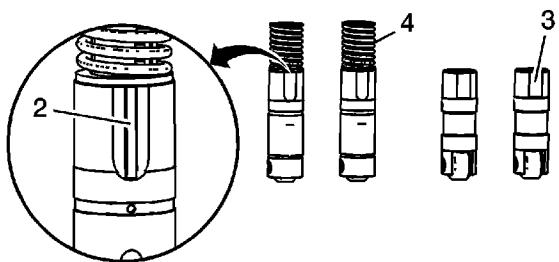
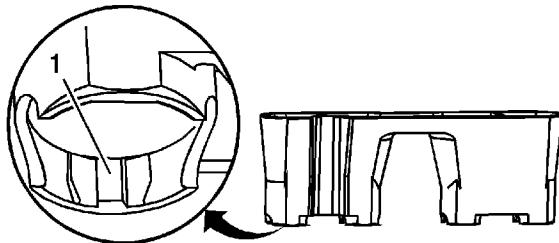
Valve Lifter Installation (RPO LH6/LMG/LY5/LC9/L76)



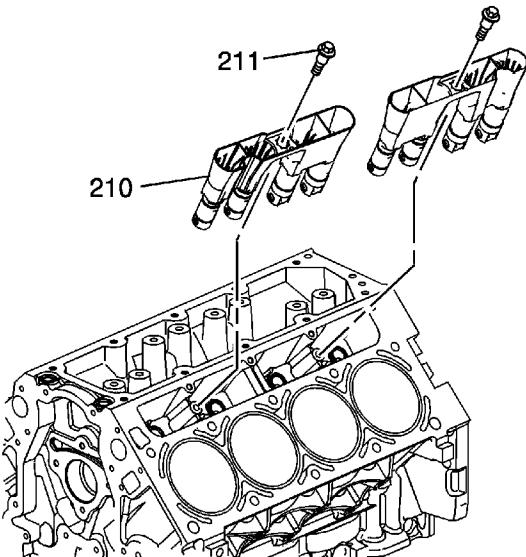
Note:

- When using the valve lifters again, install the lifters to their original locations.
- If camshaft replacement is required, the valve lifters must also be replaced.
- Each of the 4 valve guide assemblies will contain 2 active fuel management valve lifters and 2 non-active fuel management valve lifters.
- With the lifters and guides properly installed, cylinders 1, 4, 6, and 7 lifter bores will each contain 2 active fuel management valve lifters.

1. Lubricate the valve lifters (209, 219) and engine block valve lifter bores with clean engine oil.



2. Insert the valve lifters into the lifter guides.
 - Align the flat area (3) on the top of the non-active fuel management lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.
 - The active fuel management lifters (4) are to be installed into the guide, with the notch in the guide (1) aligned with the raised area (2) of the lifter.



3. Install the valve lifters and guide assembly (210) to the engine block.

Caution: Refer to [Fastener Caution](#) in the Preface section.

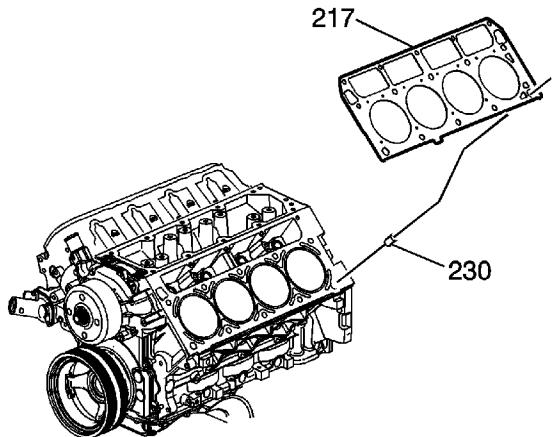
4. Install the valve lifter guide bolts (211) and tighten to **12 N·m (106 lb in)**.

Cylinder Head Installation - Left Side

Tools Required

- [J 42385-100](#) Head/Main Bolt Thread Repair Kit
- [J 45059](#) Angle Meter

Warning: Refer to [Safety Glasses Warning](#) in the Preface section.



Caution: Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

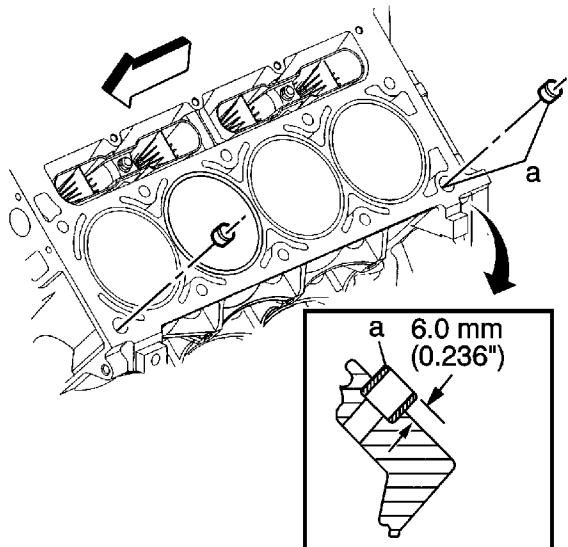
Important:

- Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.
- Do not use any type of sealant on the cylinder head gasket, unless specified.

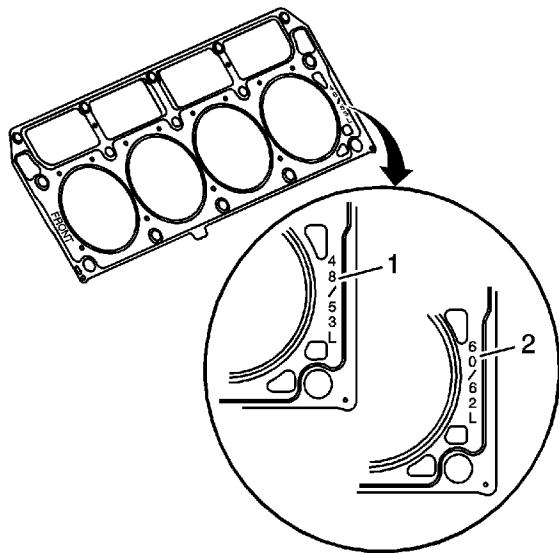
1. Clean the engine block cylinder head bolt holes, if required.

Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

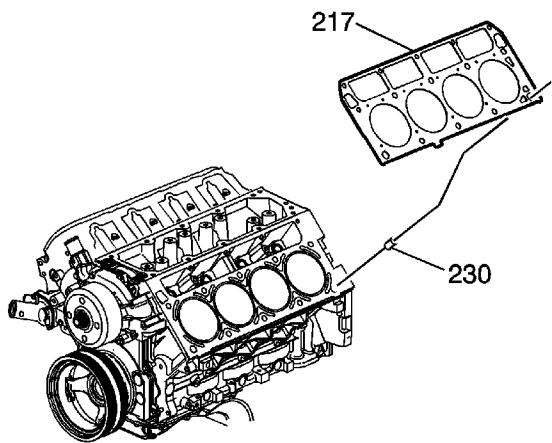
2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Install the cylinder head ~~adhesive pins~~ (230).



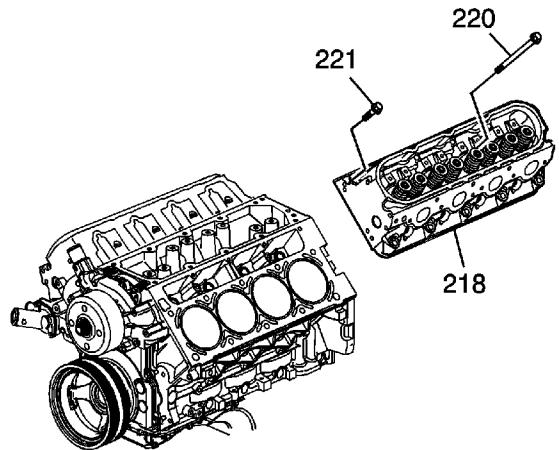
5. Inspect the locating pins for proper installation.



6. Inspect the displacement markings (1, 2) on the gasket, for proper usage.

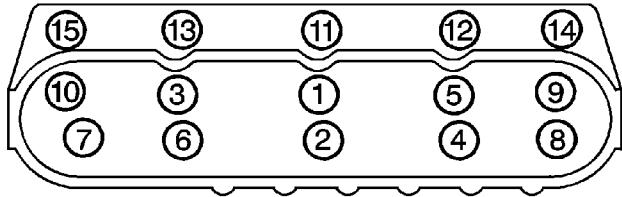


7. Install the NEW cylinder head gasket (217) onto the locating pins.



8. Install the cylinder head (218) onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts (220, 221).

Caution: Refer to [Fastener Caution](#) in the Preface section.



10. Tighten the cylinder head bolts.

Tighten

1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to 30 N·m (22 lb ft).
2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using the [J 45059](#).
3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using the [J 45059](#).
4. Tighten the M8 cylinder head bolts (11-15) to 30 N·m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

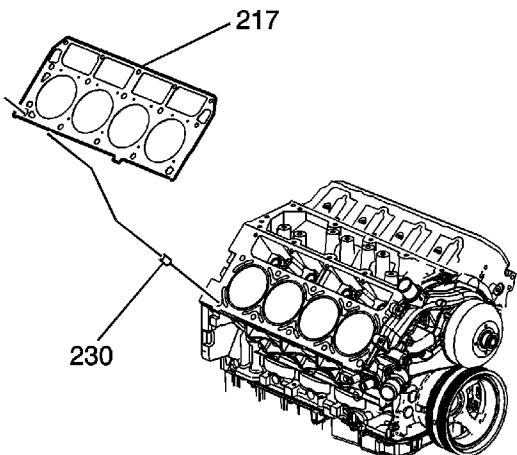
Cylinder Head Installation - Right Side

Special Tools

- J 42385-100 Head/Main Bolt Thread Repair Kit
- J 45059 Angle Meter

For equivalent regional tools refer to [Special Tools](#).

Warning: Refer to [Safety Glasses Warning](#) in the Preface section.



Caution: Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

Note:

- Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.
- Do not use any type of sealant on the cylinder head gasket, unless specified.

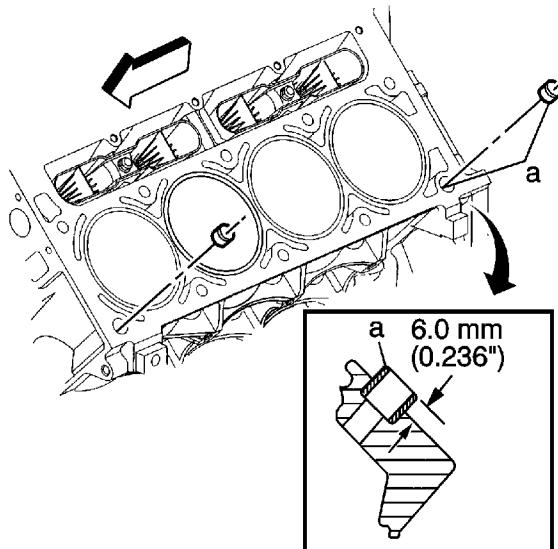
1. Clean the engine block cylinder head bolt holes, if required.

Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

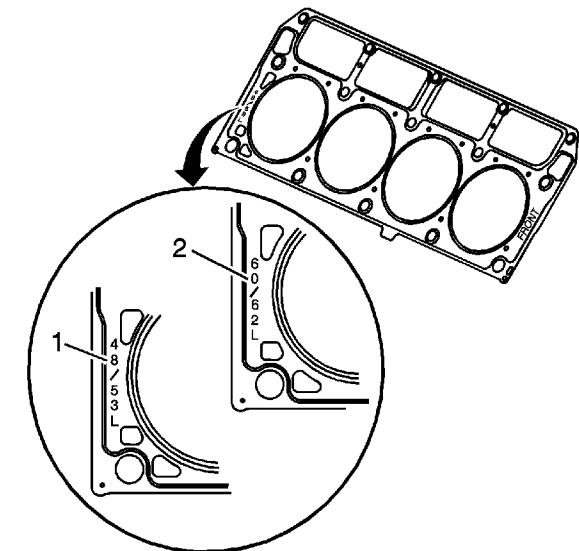
2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981

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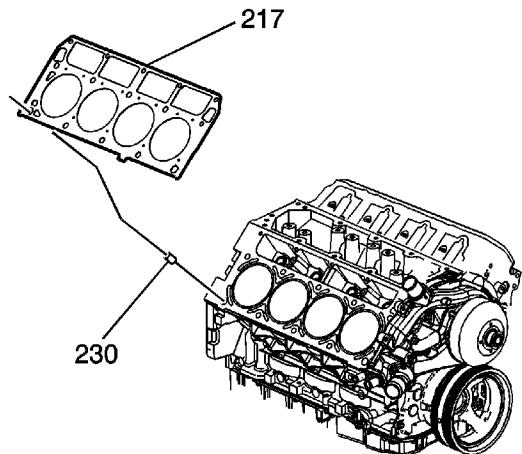
- (Canadian P/N 10953463), or equivalent, into the hole.
3. Clean the cylinder head bolt holes with compressed air.
 4. Install the cylinder head locating pins (230).



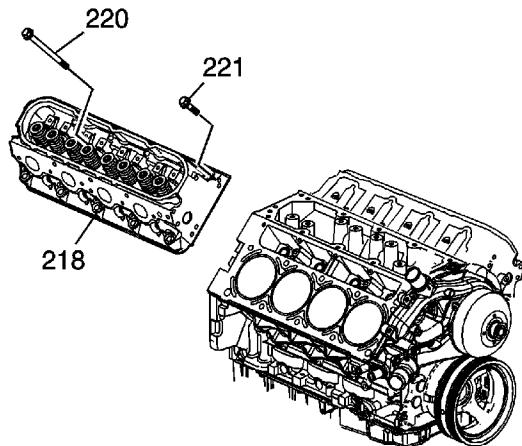
5. Inspect the locating pins for proper installation.



6. Inspect the displacement markings (1, 2) on the gasket, for proper usage.

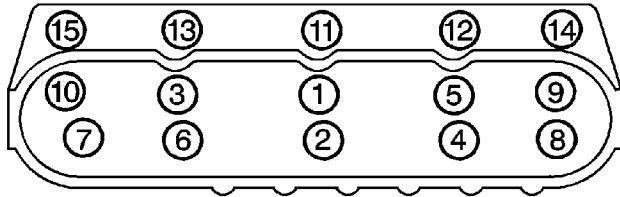


7. Install the NEW cylinder head gasket (217) onto the locating pins.



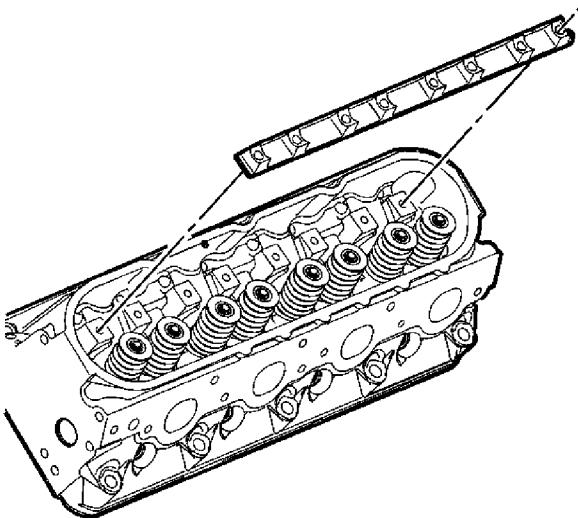
8. Install the cylinder head (218) onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts (220, 221).

Caution: Refer to [Fastener Caution](#) in the Preface section.



10. Tighten the cylinder head bolts.
 - 10.1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to **30 N·m (22 lb ft)**.
 - 10.2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to **90 degrees** using the *J45059* angle meter .
 - 10.3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to **70 degrees** using the *J45059* angle meter .
 - 10.4. Tighten the M8 cylinder head bolts (11-15) to **30 N·m (22 lb ft)**. Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

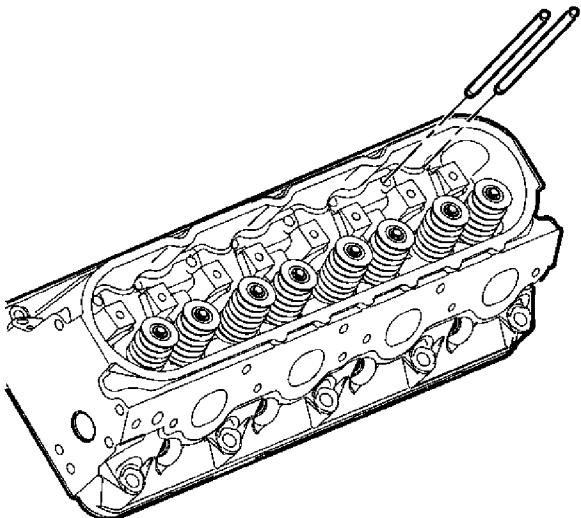
Valve Rocker Arm and Push Rod Installation (RPO LY6/L76/L9H)



Note:

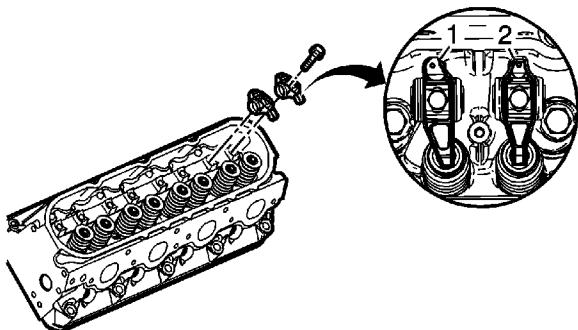
- When using the valve train components again, always install the components to the original location and position.
- Valve lash is net build. No valve adjustment is required.

1. Lubricate the valve rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolts with clean engine oil.
3. Install the valve rocker arm pivot support.



Note: Ensure the pushrods seat properly to the valve lifter sockets.

4. Install the pushrods.

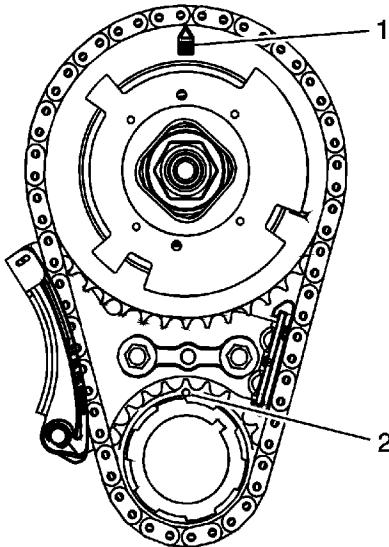


Note:

- Ensure the pushrods seat properly to the ends of the rocker arms.
- DO NOT tighten the rocker arm bolts at this time.

5. Install the rocker arms and bolts.

The intake rocker arms (1) have an offset design.



6. Rotate the crankshaft until number 1 piston is at top dead center of compression stroke.

In this position, cylinder number 1 rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks (1, 2) will be in the 12 o'clock position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

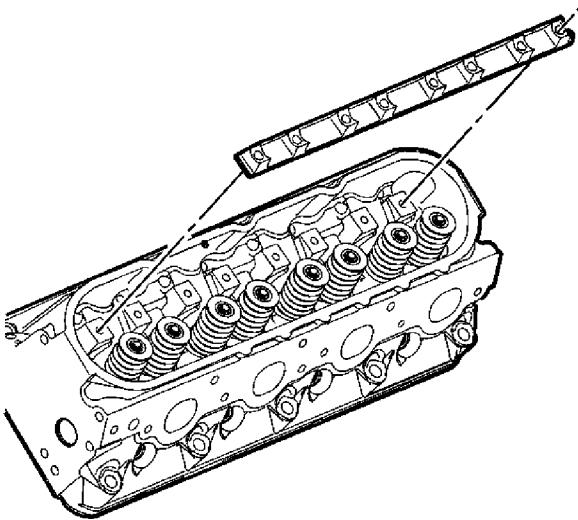
Cylinders 1, 3, 5 and 7 are left bank.

Cylinders 2, 4, 6, and 8 are right bank.

Caution: Refer to [Fastener Caution](#) in the Preface section.

7. With the engine in the number 1 firing position, tighten the following valve rocker arm bolts:
 - 7.1. Tighten the exhaust valve rocker arm bolts 1, 2, 7, and 8 to **30 N·m (22 lb ft)**.
 - 7.2. Tighten the intake valve rocker arm bolts 1, 3, 4, and 5 to **30 N·m (22 lb ft)**.
8. Rotate the crankshaft 360 degrees.
9. Tighten the following valve rocker arm bolts:
 - Tighten the exhaust valve rocker arm bolts 3, 4, 5, and 6 to **30 N·m (22 lb ft)**.
 - Tighten the intake valve rocker arm bolts 2, 6, 7, and 8 to **30 N·m (22 lb ft)**.

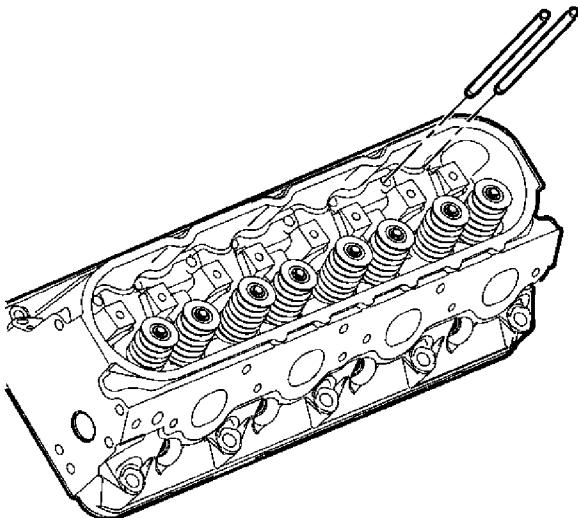
Valve Rocker Arm and Push Rod Installation (RPO LY2/LH6/LMG/LY5/LC9)



Note:

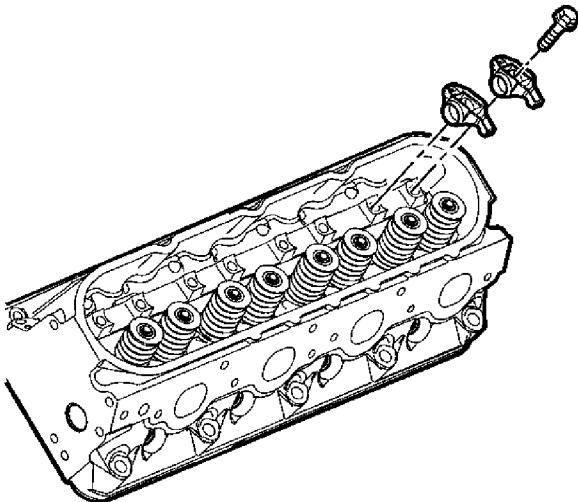
- When using the valve train components again, always install the components to the original location and position.
- Valve lash is net build. No valve adjustment is required.

1. Lubricate the valve rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolts with clean engine oil.
3. Install the valve rocker arm pivot support.



Note: Ensure the pushrods seat properly to the valve lifter sockets.

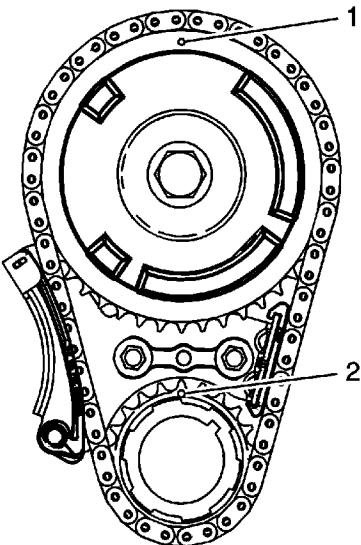
4. Install the pushrods.



Note:

- Ensure the pushrods seat properly to the ends of the rocker arms.
- DO NOT tighten the rocker arm bolts at this time.

5. Install the rocker arms and bolts.



6. Rotate the crankshaft until number 1 piston is at top dead center of compression stroke.

In this position, cylinder number 1 rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks (1, 2) will be in the 12 o'clock position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

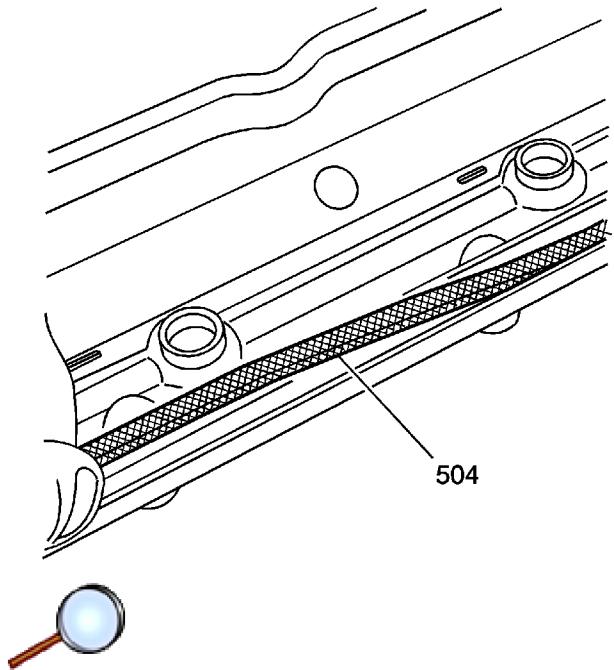
Cylinders 1, 3, 5 and 7 are left bank.

Cylinders 2, 4, 6, and 8 are right bank.

Caution: Refer to [Fastener Caution](#) in the Preface section.

7. With the engine in the number 1 firing position, tighten the following valve rocker arm bolts:
 - 7.1. Tighten the exhaust valve rocker arm bolts 1, 2, 7, and 8 to **30 N·m (22 lb ft)**.
 - 7.2. Tighten the intake valve rocker arm bolts 1, 3, 4, and 5 to **30 N·m (22 lb ft)**.
8. Rotate the crankshaft 360 degrees.
9. Tighten the following valve rocker arm bolts:
 - 9.1. Tighten the exhaust valve rocker arm bolts 3, 4, 5, and 6 to **30 N·m (22 lb ft)**.
 - 9.2. Tighten the intake valve rocker arm bolts 2, 6, 7, and 8 to **30 N·m (22 lb ft)**.

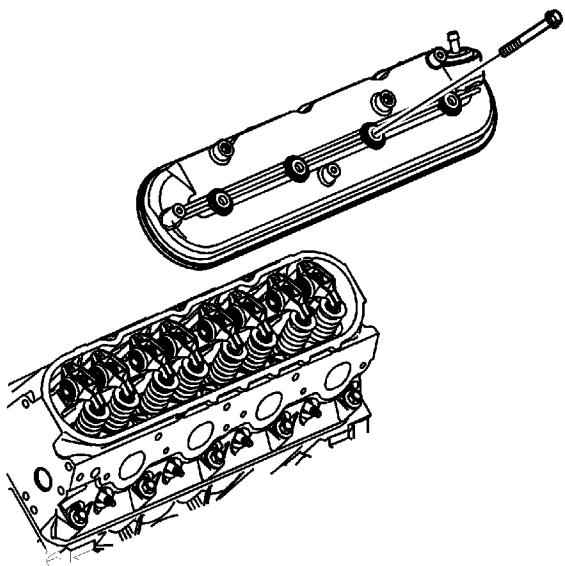
Valve Rocker Arm Cover Installation - Left Side



Note:

- All gasket surfaces should be free of oil or other foreign material during assembly.
- DO NOT use the valve rocker arm cover gasket again.

1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.
2. Install a NEW gasket (504) into the valve rocker arm cover.

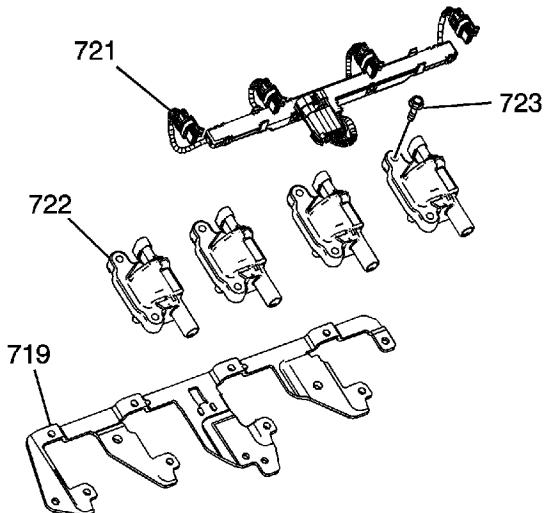




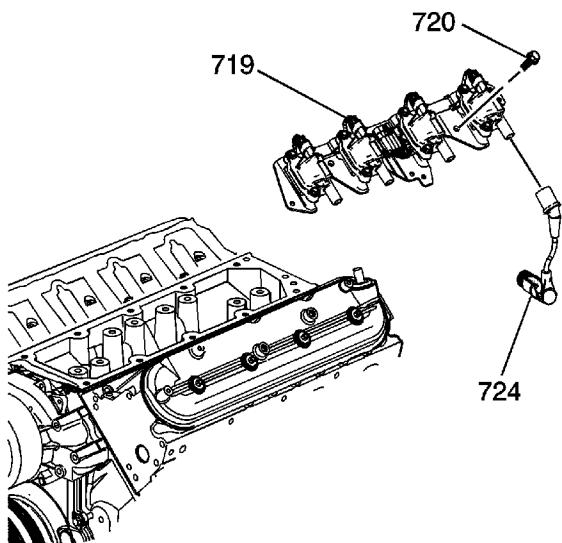
3. Install the valve rocker arm cover onto the cylinder head.

Caution: Refer to [Fastener Caution](#) in the Preface section.

4. Install the cover bolts with grommets and tighten to **12 N·m (106 lb in)**.



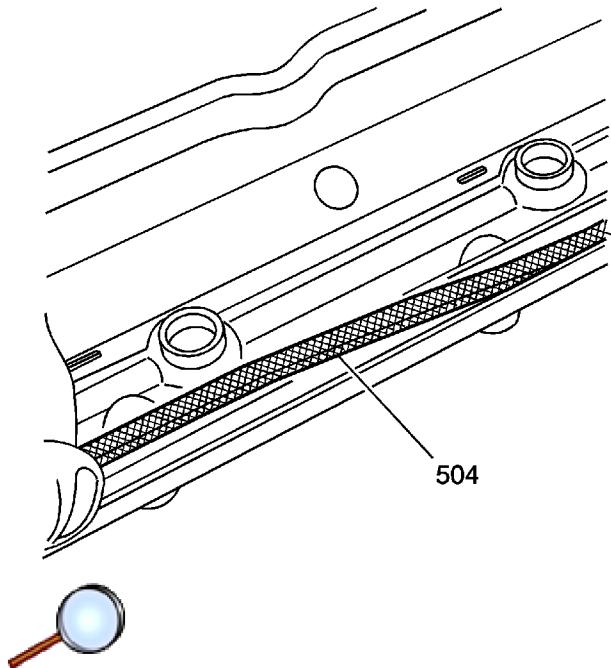
5. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bolts (723).
6. Install the ignition coils (722), wire harness (721), and bolts (723) to the bracket (719). Tighten the ignition coil bolts to **10 N·m (89 lb in)**.



7. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bracket studs (720).

8. Install the ignition coil and bracket assembly (719) and studs (720). Tighten the bracket studs to **12 N·m (106 lb in)**.

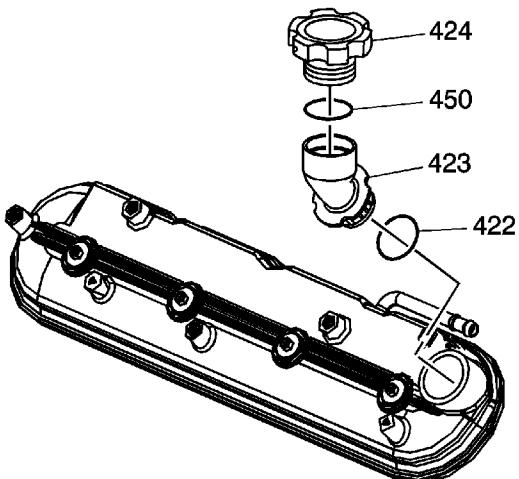
Valve Rocker Arm Cover Installation - Right Side



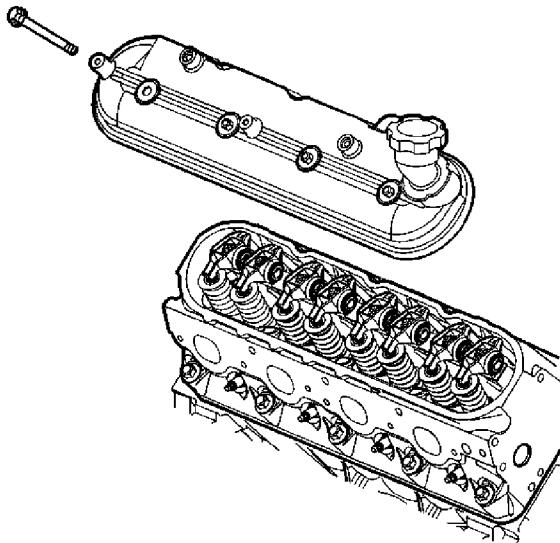
Note:

- All gasket surfaces should be free of oil or other foreign material during assembly.
- DO NOT use the valve rocker arm cover gasket again.

1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.
2. Install a NEW gasket (504) into the valve rocker arm cover.



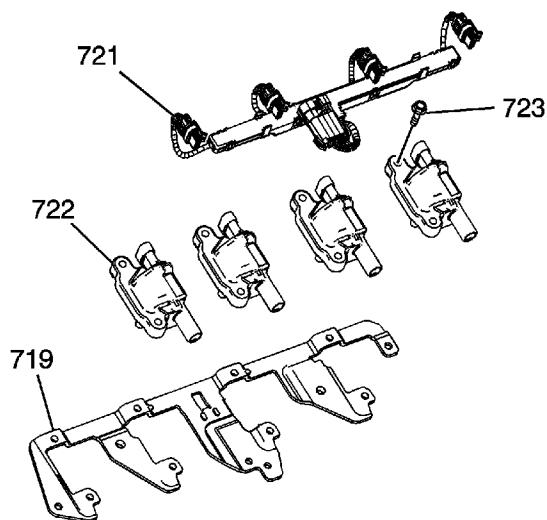
-  3. Install a NEW oil fill tube (423) to the valve rocker arm cover.
- 4. Install the oil fill cap (424).



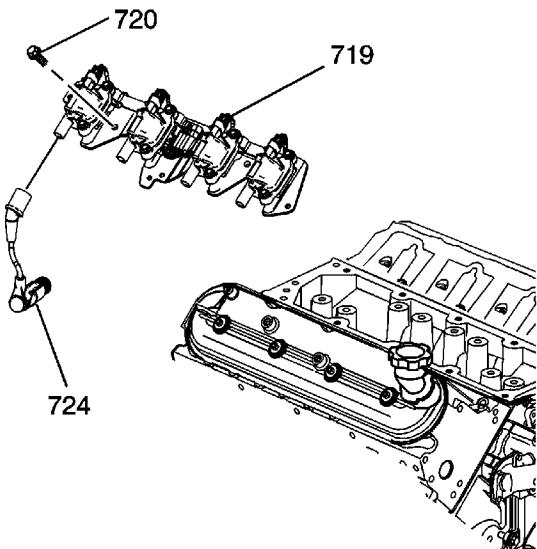
-  5. Install the valve rocker arm cover onto the cylinder head.

Caution: Refer to [Fastener Caution](#) in the Preface section.

- 6. Install the cover bolts with grommets and tighten to **12 N·m (106 lb in)**.

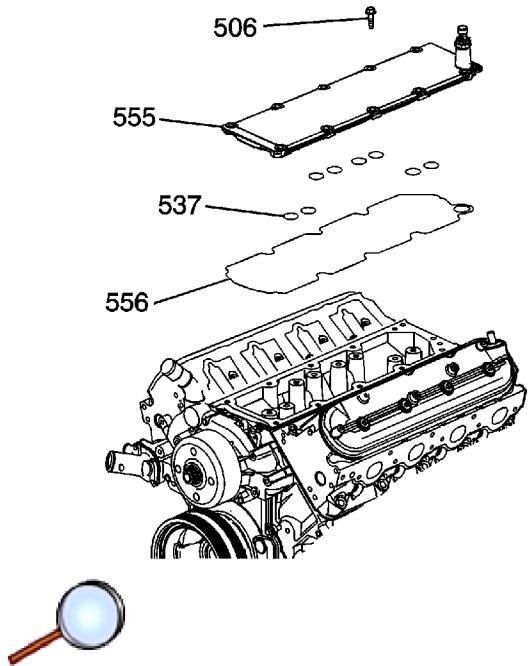


-  7. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bolts (723).
- 8. Install the ignition coils (722), wire harness (721), and bolts (723) to the bracket (719). Tighten the ignition coil bolts to **10 N·m (89 lb in)**.



9. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bracket studs (720).
10. Install the ignition coil and bracket assembly (719) and studs (720). Tighten the bracket studs to **12 N·m (106 lb in)**.

Engine Block Valley Cover Installation

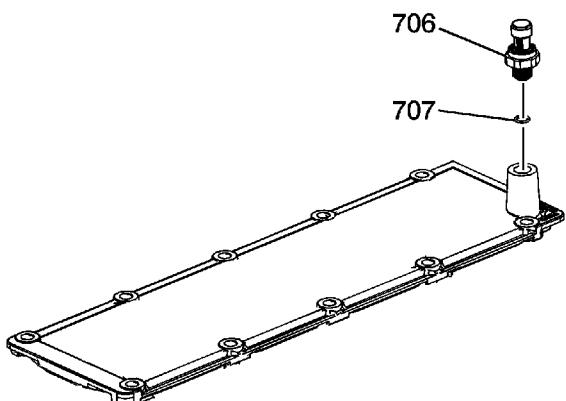


Note: All gasket surfaces should be free of oil or other foreign material during assembly.

1. Lubricate the O-ring seals with clean engine oil.
2. Install the O-ring seals (537) to the cover (555).

Caution: Refer to [Fastener Caution](#) in the Preface section.

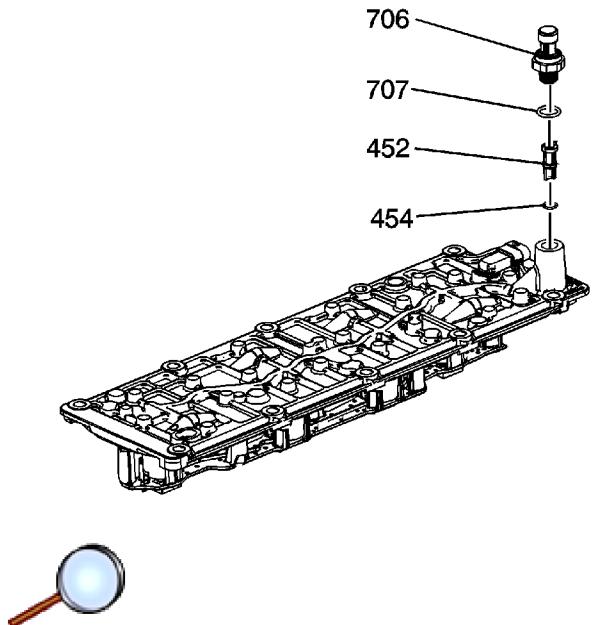
3. Install the cover (555), gasket (556), and bolts (506). Tighten the manifold bolts to **25 N·m (18 lb ft)**.





4. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the threads of the sensor.
5. Install the oil pressure sensor (706) and sealing washer (707). Tighten the sensor to **35 N·m (26 lb ft)**.

Valve Lifter Oil Filter Installation



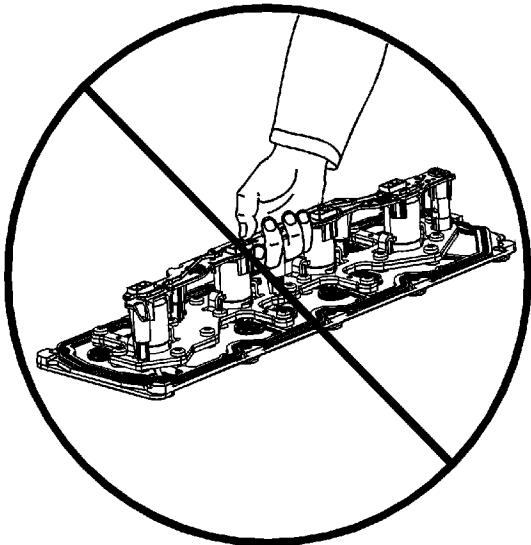
Note: Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.

1. Install a NEW oil filter (452) and O-ring (454) assembly.
2. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor.

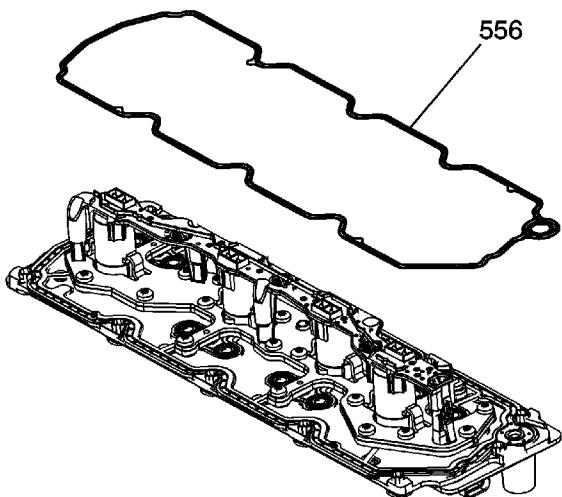
Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the oil pressure sensor (706) and washer (707). Tighten the oil pressure sensor to **35 N·m (26 lb ft)**.

Valve Lifter Oil Manifold Installation



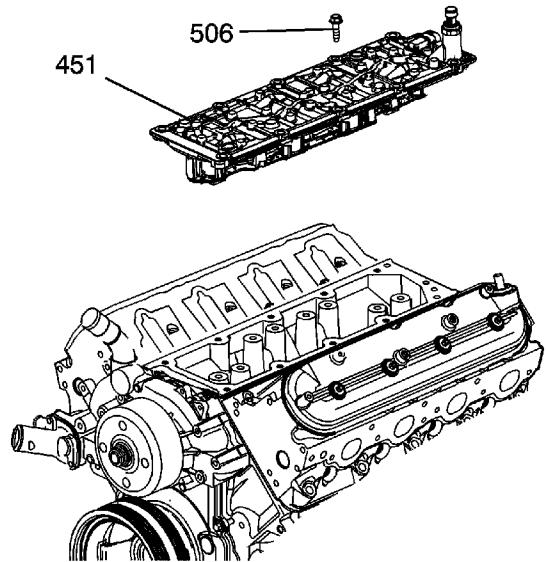
1. Do not lift the manifold assembly by the electrical lead frame.



Note:

- All gasket surfaces should be free of oil or other foreign material during assembly.
- Do not allow dirt or debris to enter the manifold. Plug, as required.

2. Install the service gasket (556) onto the manifold.

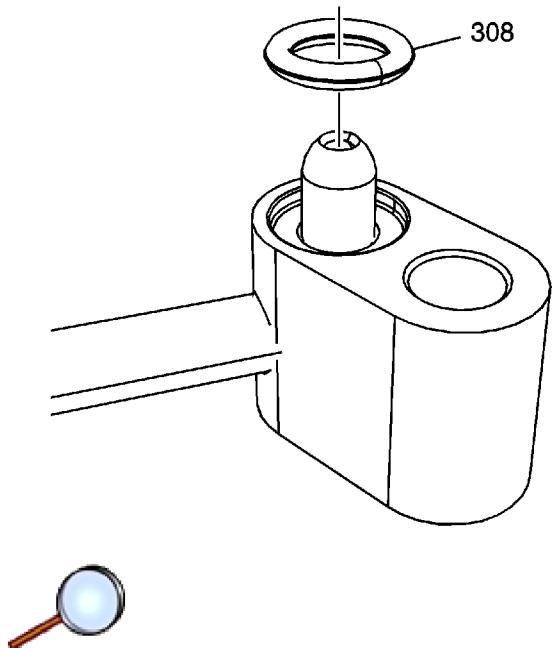


3. Install the manifold (451) with gasket.

Caution: Refer to [Fastener Caution](#) in the Preface section.

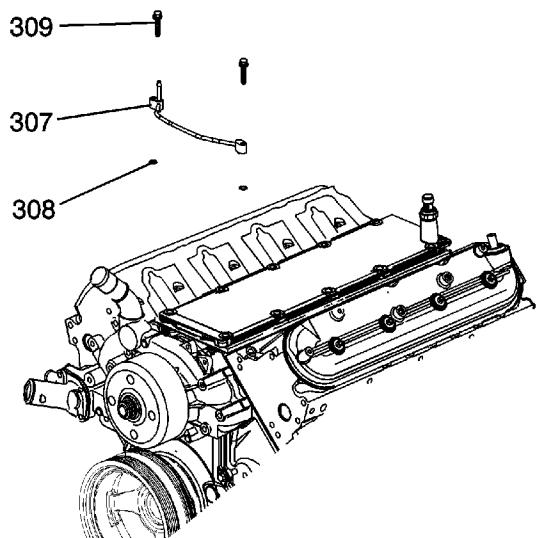
4. Install the manifold bolts (506) and tighten to **25 N·m (18 lb ft)**.

Engine Coolant Air Bleed Pipe and Hole Cover Installation (RPO LY2/LY6/L9H)



Note: Position the gasket O-ring seal (308) onto the nipple portion of the pipe.

1. Install the seals onto the engine coolant air bleed pipe and covers.

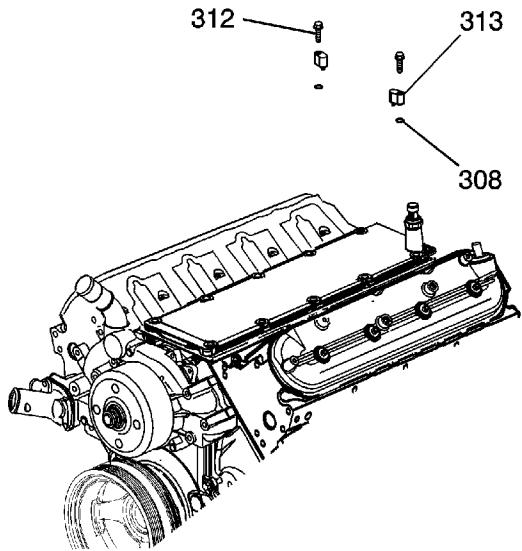


2. Install the pipe (307) and seals (308).

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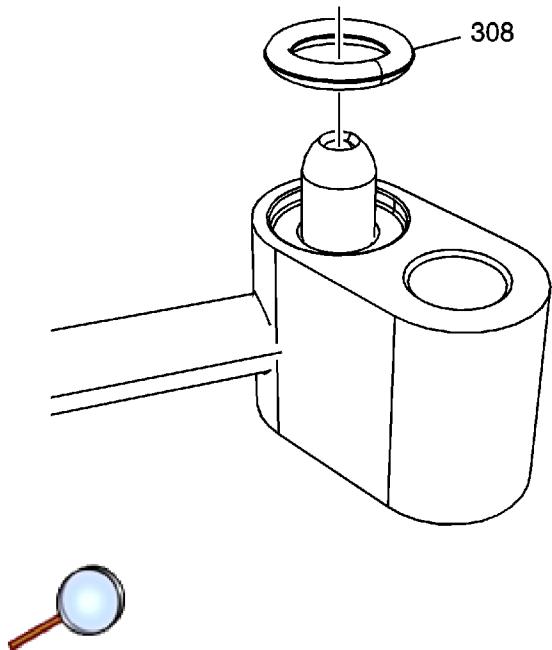
Caution: Refer to [Fastener Caution](#) in the Preface section.

3. Install the bolts (309) and tighten to **12 N·m (106 lb in)**.



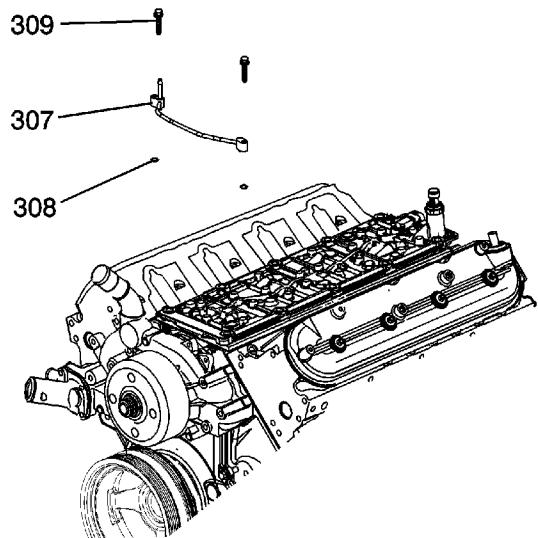
4. Install the covers (313) and seals (308).
5. Install the bolts (312) and tighten to **12 N·m (106 lb in)**.

Engine Coolant Air Bleed Pipe and Hole Cover Installation (RPO LH6/LMG/LY5/LC9/L76)



Note: Position the O-ring seal onto the nipple portion of the pipe.

1. Install the seals (308) onto the engine coolant air bleed pipe and covers.

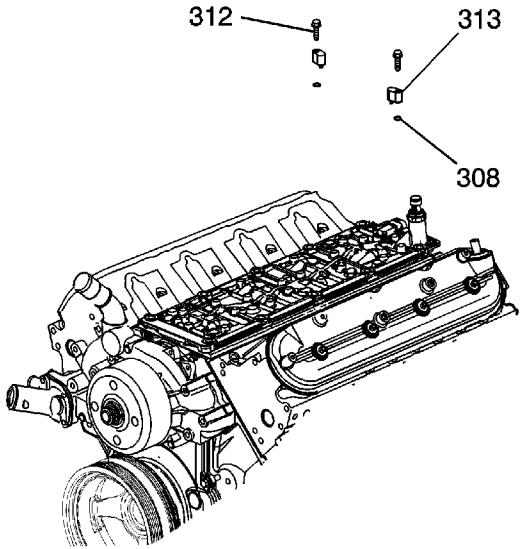


2. Install the pipe (307) and seals (308).

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Caution: Refer to [Fastener Caution](#) in the Preface section.

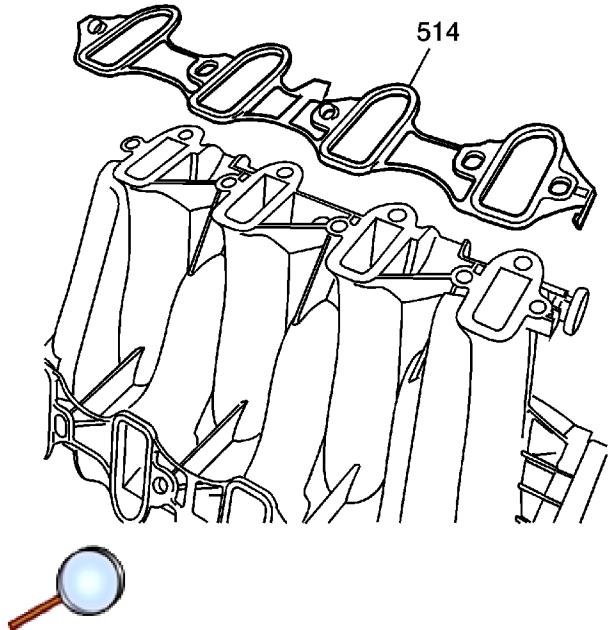
3. Install the bolts (309) and tighten to **12 N·m (106 lb in)**.



4. Install the covers (313) and seals (308).
5. Install the bolts (312) and tighten to **12 N·m (106 lb in)**.

[2009 Chevrolet Silverado - 4WD](#) | [Sierra, Silverado \(VIN C/K\) Service Manual](#) | [Engine](#) |
[Engine Mechanical - 4.8L, 5.3L, 6.0L, 6.2L, or 7.0L](#) | [Repair Instructions - Off Vehicle](#) | Document ID: 2161786

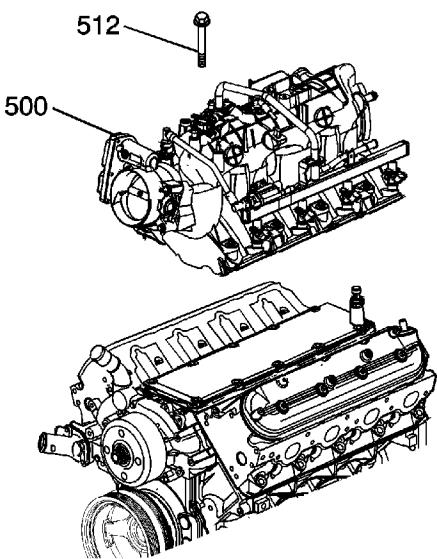
Intake Manifold Installation (RPO LY2/LY6/L9H)



Note:

- The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, install the intake manifold as a complete assembly.
- DO NOT use the intake manifold gaskets again. Install NEW intake manifold-to-cylinder head gaskets.

1. Install NEW intake manifold-to-cylinder head gaskets (514).

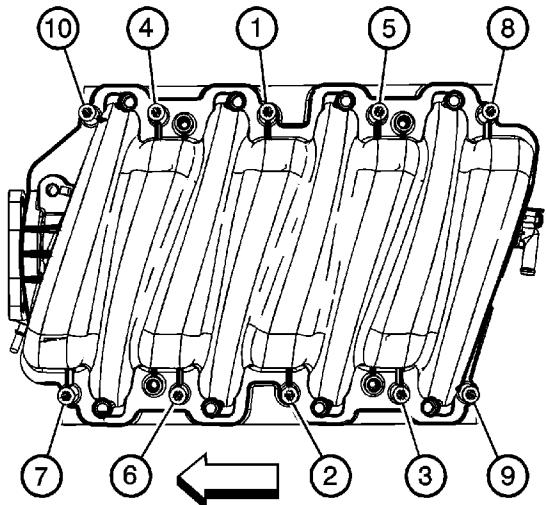


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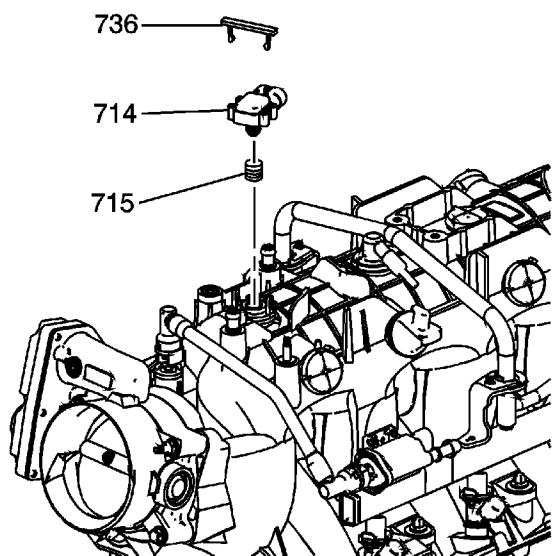


2. Install the intake manifold (500).
3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) to the threads of the intake manifold bolts (512). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

Caution: Refer to [Fastener Caution](#) in the Preface section.

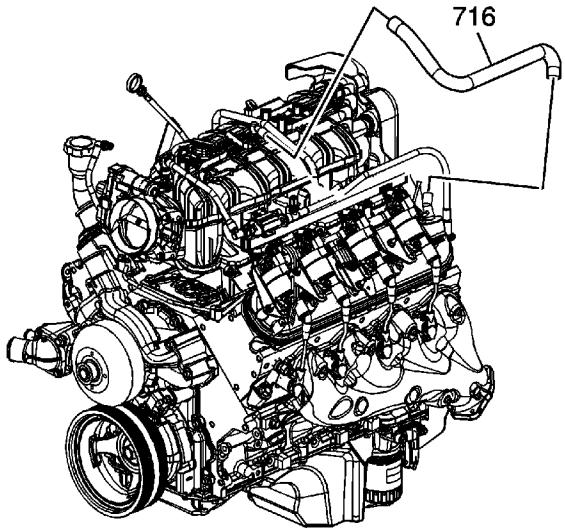


4. Install the intake manifold bolts.
 - 4.1. Tighten the intake manifold bolts (1-10) a first pass in sequence to **5 N·m (44 lb in)**.
 - 4.2. Tighten the intake manifold bolts (1-10) a final pass in sequence to **10 N·m (89 lb in)**.



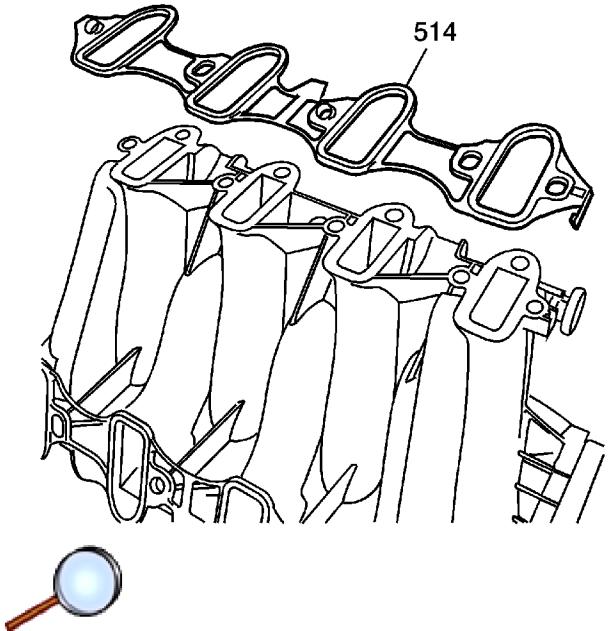


5. Install the fuel rail. Refer to [Fuel Rail and Injectors Installation](#).
6. Lubricate the manifold absolute pressure (MAP) sensor grommet (715) with clean engine oil.
7. Install the grommet onto the MAP sensor (714).
8. Install the MAP sensor and retainer (736).



9. Install the positive crankcase ventilation (PCV) hose - dirty air (716).

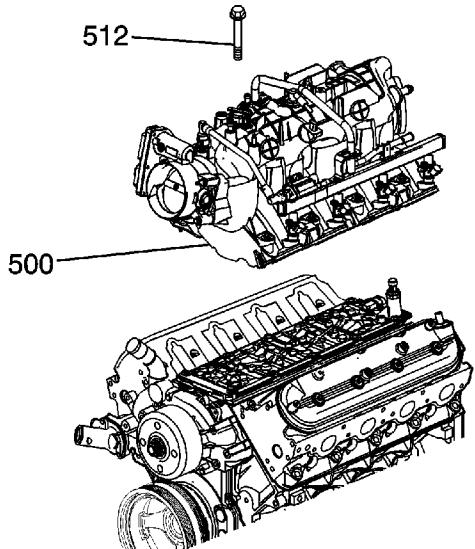
Intake Manifold Installation (RPO LH6/LMG/LY5/LC9/L76)



Note:

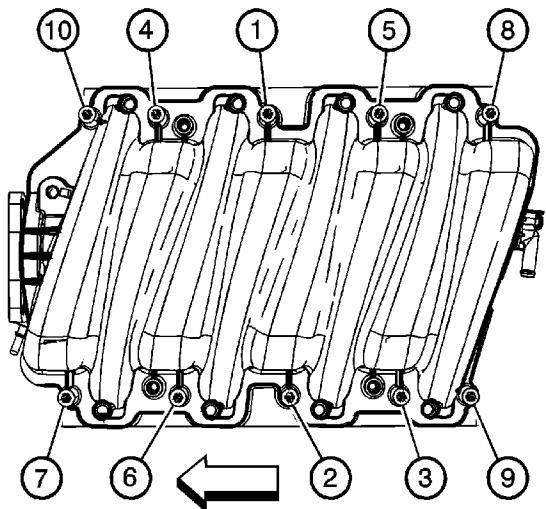
- The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, install the intake manifold as a complete assembly.
- DO NOT use the intake manifold gaskets again. Install NEW intake manifold-to-cylinder head gaskets.

1. Install NEW intake manifold-to-cylinder head gaskets (514).

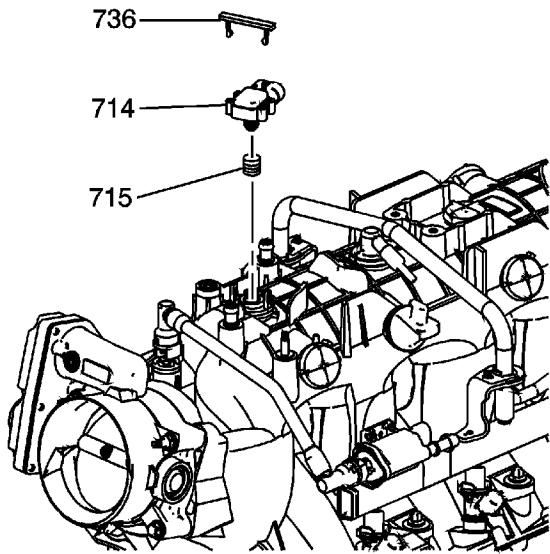


-  2. Install the intake manifold (500).
- 3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) to the threads of the intake manifold bolts (512). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

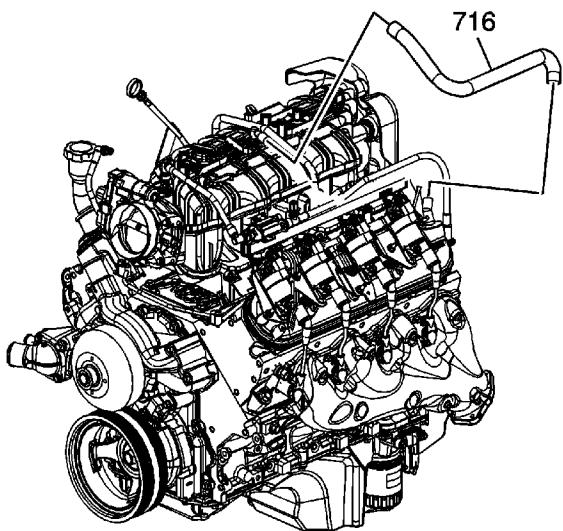
Caution: Refer to [Fastener Caution](#) in the Preface section.



-  4. Install the intake manifold bolts.
 - 4.1. Tighten the intake manifold bolts (1-10) a first pass in sequence to **5 N·m (44 lb in)**.
 - 4.2. Tighten the intake manifold bolts (1-10) a final pass in sequence to **10 N·m (89 lb in)**.



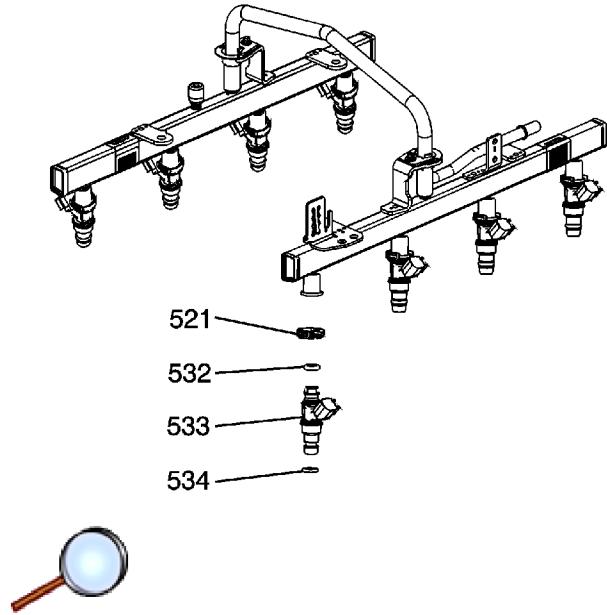
5. Install the fuel rail. Refer to [Fuel Rail and Injectors Installation](#).
6. Lubricate the manifold absolute pressure (MAP) sensor grommet (715) with clean engine oil.
7. Install the grommet onto the MAP sensor (714).
8. Install the MAP sensor and retainer (736).



9. Install the positive crankcase ventilation (PCV) hose - dirty air (716).

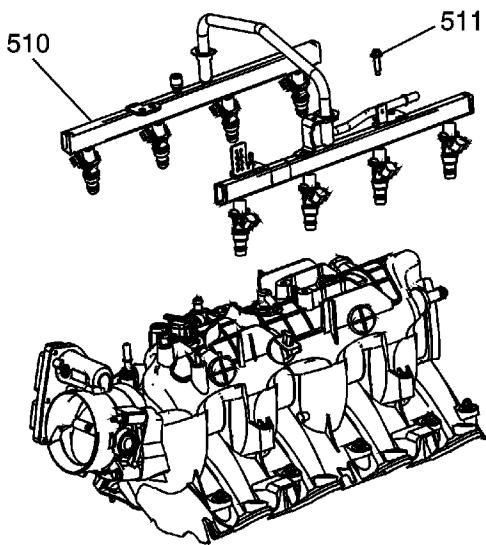
Fuel Rail and Injectors Installation

Warning: Refer to [Fuel Rail Stop Bracket Installation Warning](#) in the Preface section.



Note: DO NOT use the fuel injector O-ring seals again. Install NEW fuel injector O-ring seals during assembly.

1. Lubricate the NEW fuel injector O-ring seals (532, 534) with clean engine oil.
2. Install the O-ring seals to the fuel injectors.
3. Install the fuel injectors (533) and retainers (521).

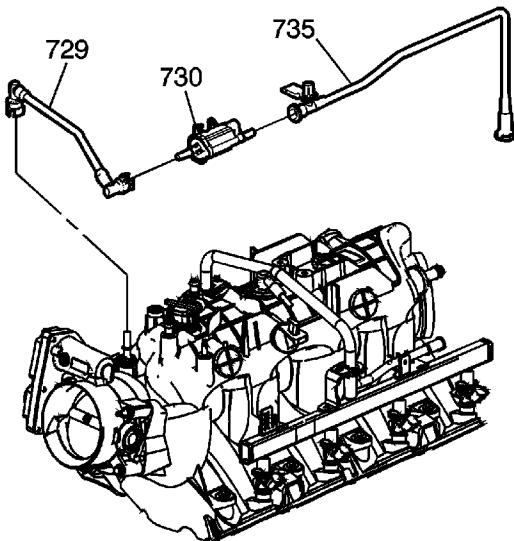




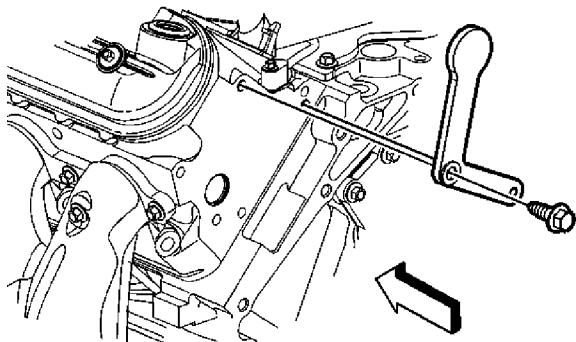
4. Install the fuel rail assembly (510) to the manifold. Push firmly on both sides of the rail until all the injectors have entered their bores.
5. Apply a 5 mm (0.2 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the fuel rail bolts. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

Caution: Refer to [Fastener Caution](#) in the Preface section.

6. Install the fuel rail bolts (511) and tighten to **10 N·m (89 lb in)**.



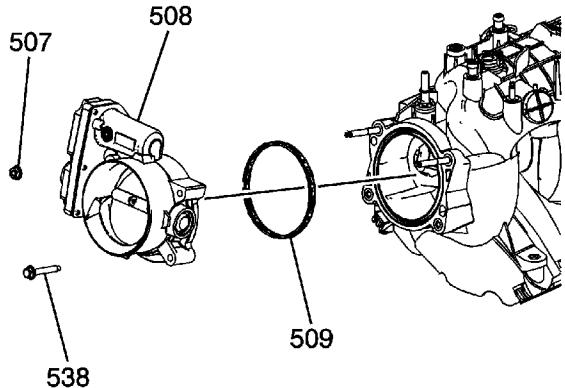
7. Install the evaporative emission (EVAP) canister purge solenoid valve (730) and tubes (729, 735).



8. Install the fuel rail stop bracket and bolt and tighten to **50 N·m (37 lb ft)**.

Throttle Body Installation

Caution: Refer to [Fastener Caution](#) in the Preface section.

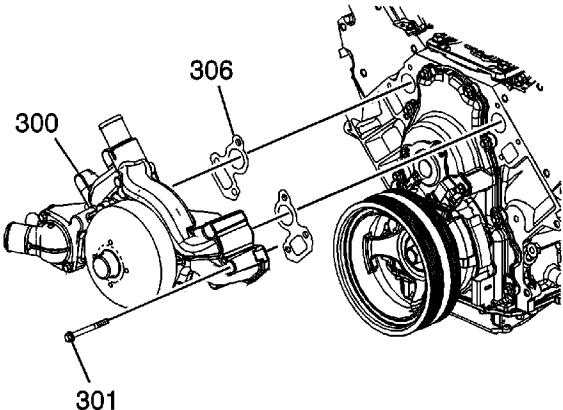


1. Install the throttle body studs, as required. Tighten the throttle body studs to **6 N·m (53 lb in)**.

Note: DO NOT use the throttle body gasket again. Install a NEW gasket during assembly.

2. Install the throttle body gasket (509) to the intake manifold. Align the locating tab of the gasket with the notch in the manifold.
3. Install the throttle body (508), bolts (538), and nuts (507). Tighten the throttle body nuts and bolts to **10 N·m (89 lb in)**.

Water Pump Installation (RPO LY6/L76/L9H)



Caution: DO NOT use cooling system seal tabs, or similar compounds, unless otherwise instructed. The use of cooling system seal tabs, or similar compounds, may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.

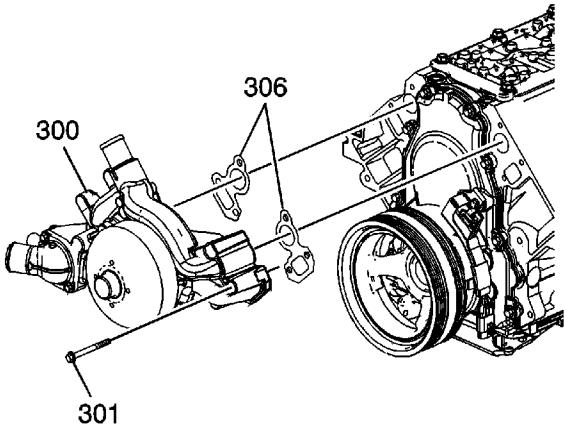
Note: All gasket surfaces are to be free of oil or other foreign material during assembly.

1. Install the water pump (300) and NEW gaskets (306).

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the water pump bolts (301).
 - 2.1. Tighten the water pump bolts a first pass to **15 N·m (11 lb ft)**.
 - 2.2. Tighten the water pump bolts a final pass to **30 N·m (22 lb ft)**.

Water Pump Installation (RPO LY2/LH6/LMG/LY5/LC9)



Caution: DO NOT use cooling system seal tabs, or similar compounds, unless otherwise instructed. The use of cooling system seal tabs, or similar compounds, may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.

Note: All gasket surfaces are to be free of oil or other foreign material during assembly.

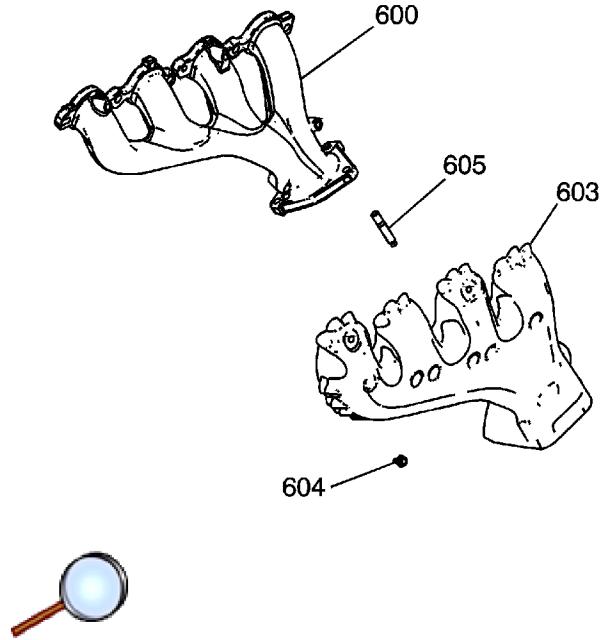
1. Install the water pump (300) and NEW gaskets (306).

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the water pump bolts (301).
 - Tighten the water pump bolts a first pass to **15 N·m (11 lb ft)**.
 - Tighten the water pump bolts a final pass to **30 N·m (22 lb ft)**.

Exhaust Manifold Installation - Left Side

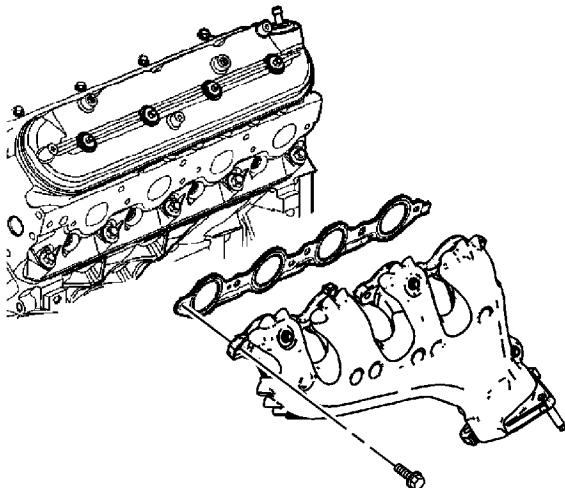
Caution: Refer to [Fastener Caution](#) in the Preface section.



Note:

- Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or on-board diagnostic (OBD) II system performance.
- The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.
- Do not apply sealant to the first 3 threads of the bolt.

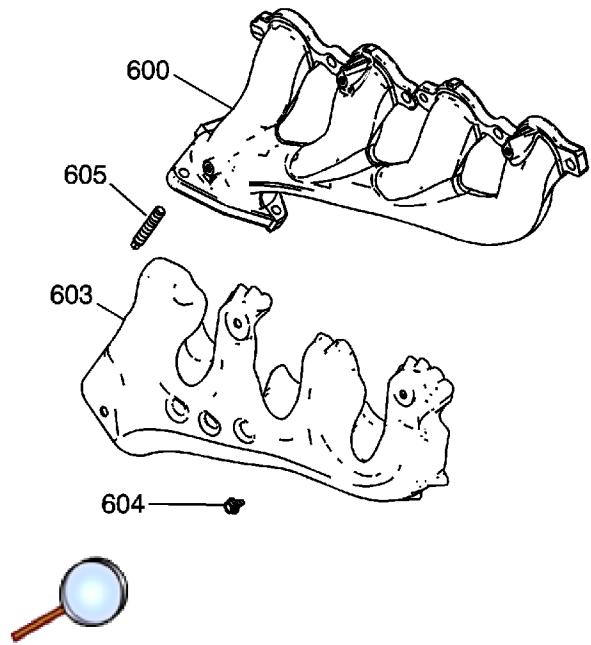
1. Install the heat shield (603) and bolts (604). Tighten the heat shield bolts to **9 N·m (80 lb in)**.
2. Install the exhaust pipe studs (605) and tighten to **20 N·m (15 lb ft)**.



3. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488), or equivalent, to the threads of the exhaust manifold bolts. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
4. Install the exhaust manifold, NEW gasket, and bolts.
 - 4.1. Tighten the exhaust manifold bolts a first pass to **15 N·m (11 lb ft)**. Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.
 - 4.2. Tighten the exhaust manifold bolts a final pass to **20 N·m (15 lb ft)**. Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.
5. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.

Exhaust Manifold Installation - Right Side

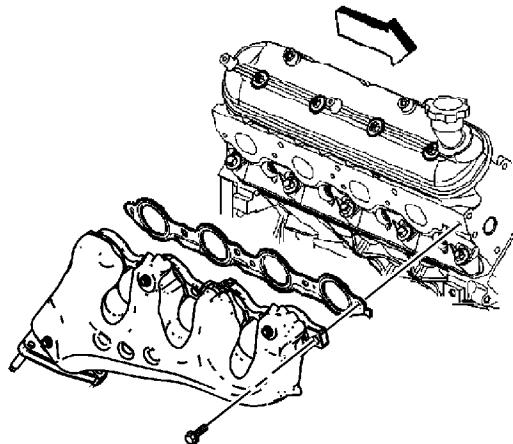
Caution: Refer to [Fastener Caution](#) in the Preface section.



Note:

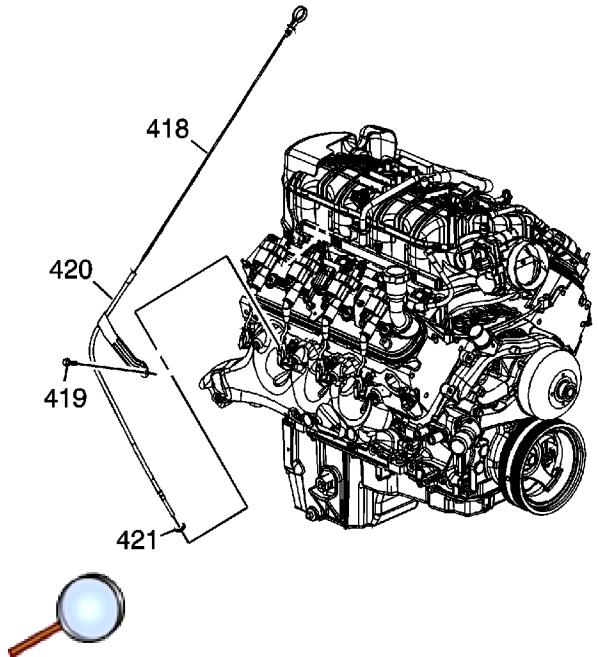
- Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or on-board diagnostic (OBD) II system performance.
- The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.
- Do not apply sealant to the first 3 threads of the bolt.

1. Install the heat shield (603) and bolts (604). Tighten the heat shield bolts to **9 N·m (80 lb in)**.
2. Install the exhaust pipe studs (605) and tighten to **20 N·m (15 lb ft)**.



3. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488), or equivalent, to the threads of the exhaust manifold bolts. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
4. Install the exhaust manifold, NEW gasket and bolts.
 - 4.1. Tighten the exhaust manifold bolts a first pass to **15 N·m (11 lb ft)**. Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.
 - 4.2. Tighten the exhaust manifold bolts a final pass to **20 N·m (15 lb ft)**. Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.
5. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.

Oil Level Indicator and Tube Installation

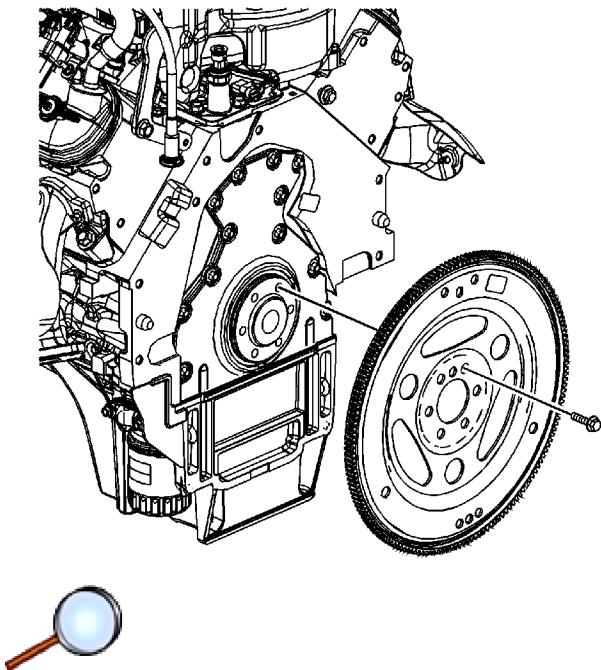


1. Inspect the O-ring seal (421) for cuts or damage. If the oil level indicator tube O-ring seal is not cut or damaged, it may be used again.
2. Lubricate the O-ring seal with clean engine oil.
3. Install the O-ring seal onto the oil level indicator tube (420).
4. Install the oil level indicator tube into the engine block and rotate into proper position.

Caution: Refer to [Fastener Caution](#) in the Preface section.

5. Install the tube bolt (419) and tighten to **25 N·m (18 lb ft)**.
6. Install the oil level indicator (418) into the tube.

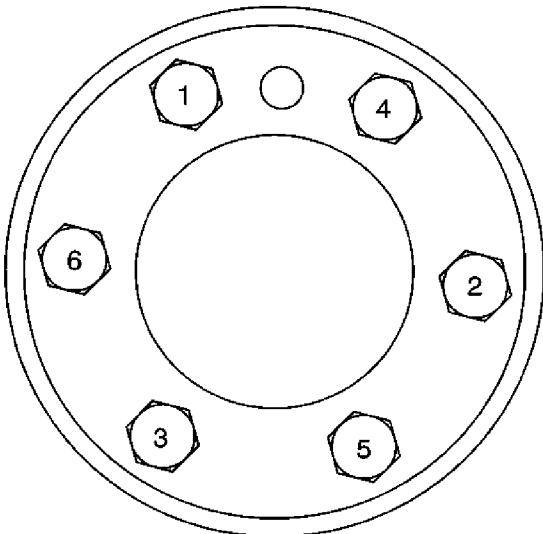
Automatic Transmission Flex Plate Installation



Note: The flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flex plate bolts. This procedure requires a 3 stage tightening process.

1. Install the flex plate to the crankshaft.
2. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the flex plate bolts.

Caution: Refer to [Fastener Caution](#) in the Preface section.



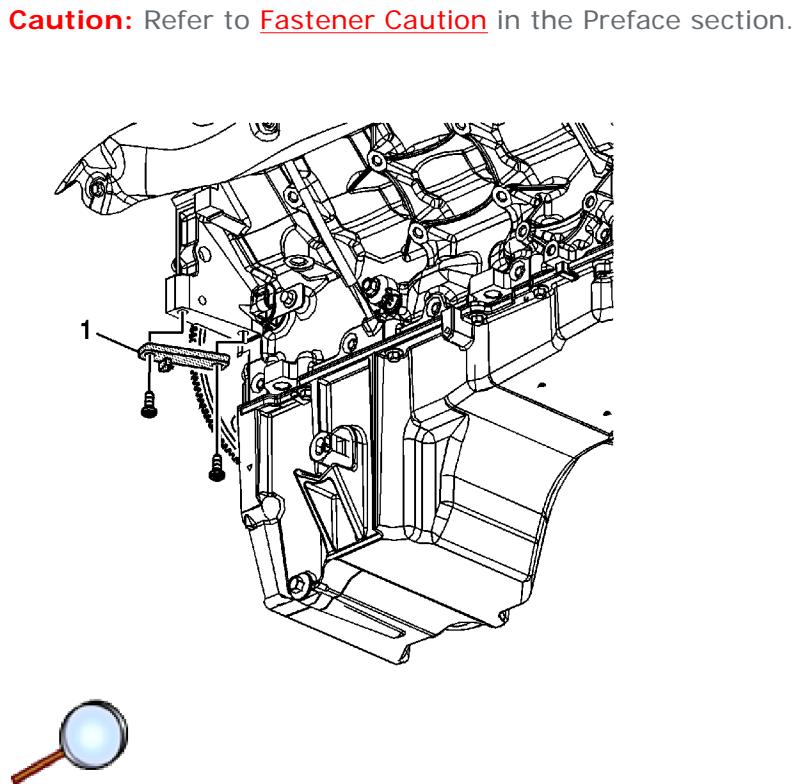
3. Install the engine flex plate bolts.
 - 3.1. Tighten the engine flex plate bolts (1-6) a first pass in sequence to **20 N·m (15 lb ft)**.
 - 3.2. Tighten the engine flex plate bolts (1-6) a second pass in sequence to **50 N·m (37 lb ft)**.
 - 3.3. Tighten the engine flex plate bolts (1-6) a final pass in sequence to **100 N·m (74 lb ft)**.

Crankshaft Balancer Installation

Special Tools

- *J 41478* Crankshaft Front Oil Seal Installer
- *J 41665* Crankshaft Balancer and Sprocket Installer
- *J 42386-A* Flywheel Holding Tool
- *J 45059* Angle Meter

For equivalent regional tools, refer to [Special Tools](#)

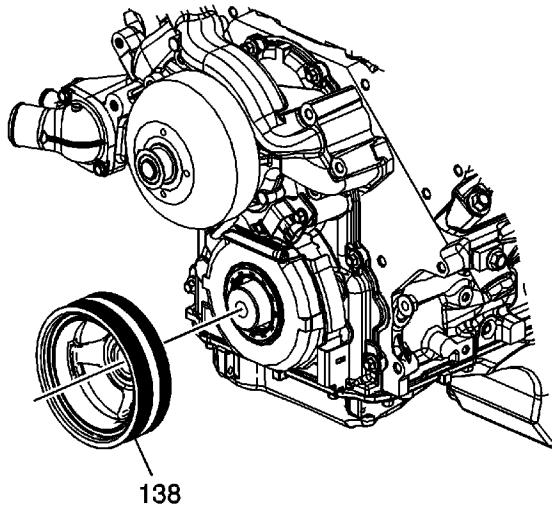


Note:

- The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.
- The crankshaft balancer installation and bolt tightening involves a 4 stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third, and fourth passes tighten the NEW bolt to the proper torque.
- Ensure the teeth of the tool engage the engine flywheel teeth.

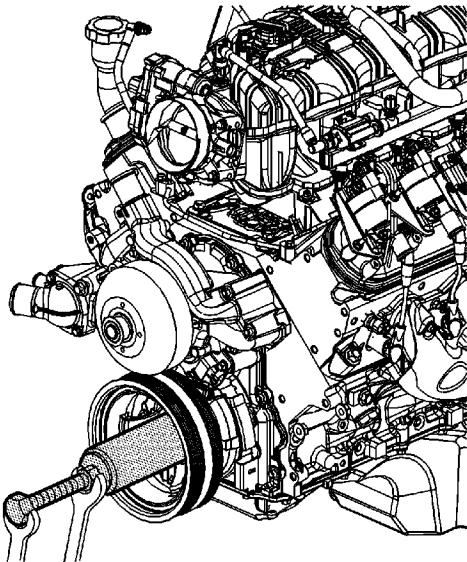
1. Install the *J 42386-A* tool (1) and bolts.

Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten the *J 42386-A* tool bolts to **50 N·m (37 lb·ft)**. ©2010 General Motors Corporation. All rights reserved.



Note: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

2. Position the balancer (138) onto the end of the crankshaft.



3. Use the J41665 installer and the J41478 installer in order to install the balancer.
 - 3.1. Assemble the J41478 installer threaded rod, nut, washer and the J41665 installer .

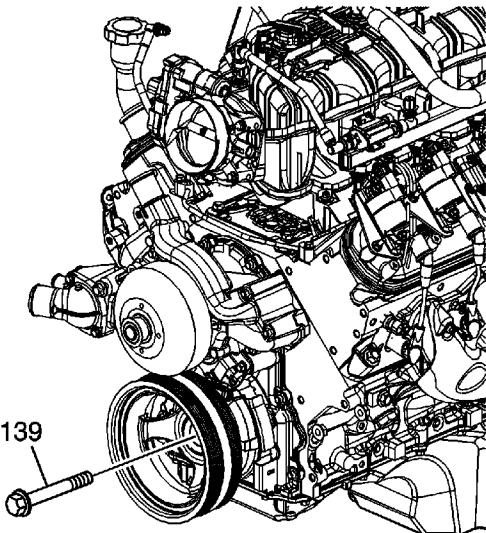
Insert the smaller end of the installer into the front of the balancer.

- 3.2. Use a wrench and hold the hex end of the threaded rod.

- 3.3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft.
- 3.4. Remove the tool and reverse the installation tool.

Position the larger end of the installer against the front of the balancer.

- 3.5. Use a wrench and hold the hex end of the threaded rod.
- 3.6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
- 3.7. Remove the balancer installation tools.



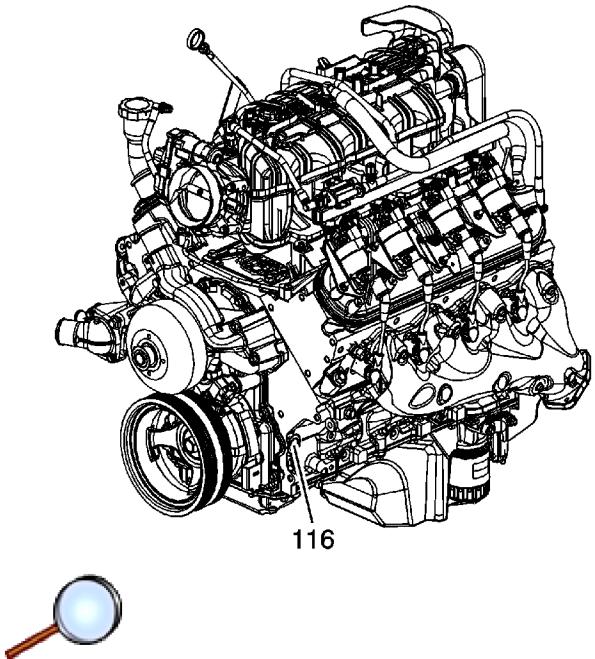
-  4. Install the NEW crankshaft balancer bolt (139) and
- 4.1. Tighten the crankshaft balancer bolt a first pass to **150 N·m (110 lb ft)**.
 - 4.2. Loosen the crankshaft balancer bolt a second pass 360 degrees.
 - 4.3. Tighten the crankshaft balancer bolt a third pass to **50 N·m (37 lb ft)**.
 - 4.4. Tighten the crankshaft balancer bolt a final pass 230 degrees using the *J45059* meter .
5. Remove the *J42386-A* tool .

Engine Prelubing

Special Tools

J 45299 Engine Preluber

For equivalent regional tools, refer to [Special Tools](#)

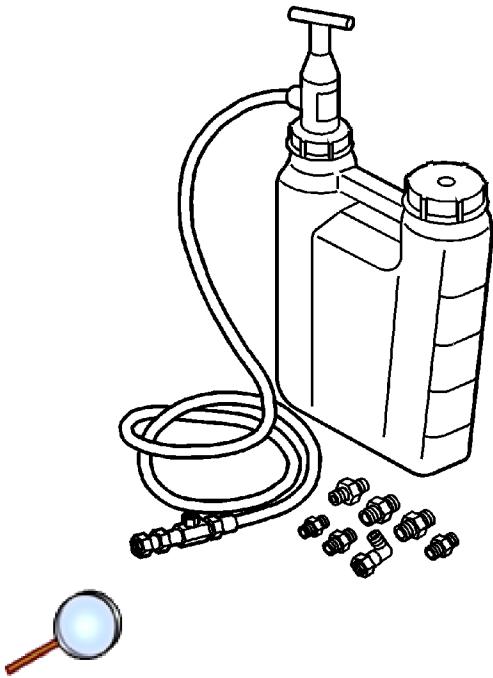


Note: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Use an approved engine oil as specified in the owners manual.

1. Remove the engine oil filter and fill with clean engine oil.

Caution: Refer to [Fastener Caution](#) in the Preface section.

2. Install the oil filter and tighten to **30 N·m (22 lb ft)**.
3. Locate the engine block left front oil gallery plug (116).
4. Install the M16 x 1.5 adapter P/N 509375.



5. Install the flexible hose to the adapter and open the valve.
6. Pump the handle on the *J45299* preluber in order to flow a minimum of 1-1.9 liters (1-2 quarts) engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
7. Close the valve and remove the flexible hose and adapter from the engine.
8. Install the gallery plug to the engine and tighten to **60 N·m (44 lb ft)**.
9. Top-off the engine oil to the proper level.

