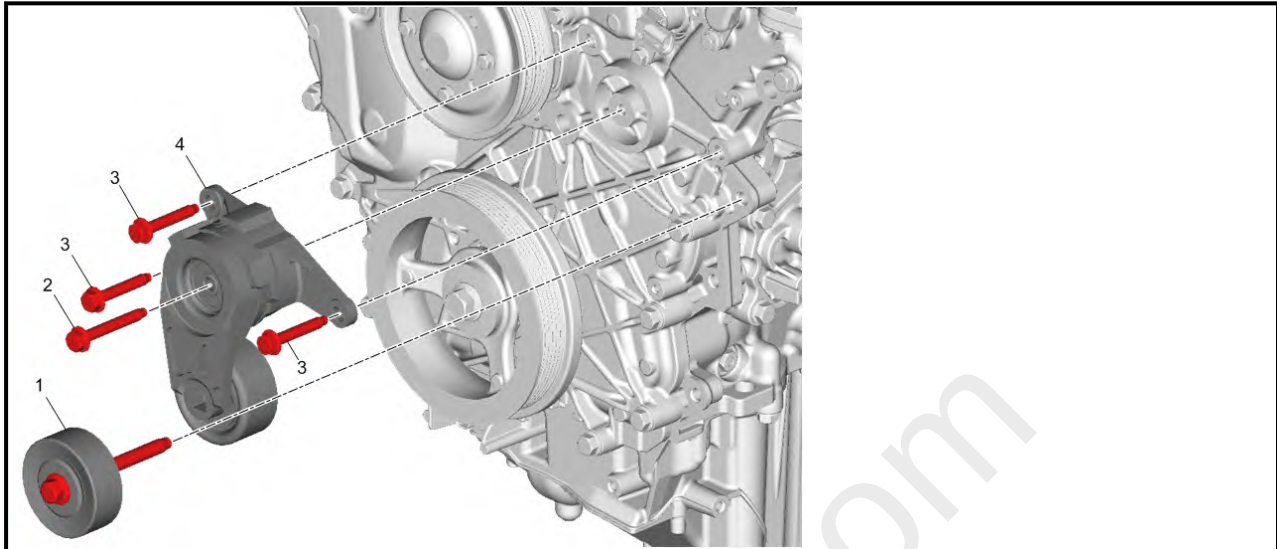


2018 ENGINE

Engine Mechanical - 3.6L (LFY) - Repair Instructions - Off Vehicle - Traverse

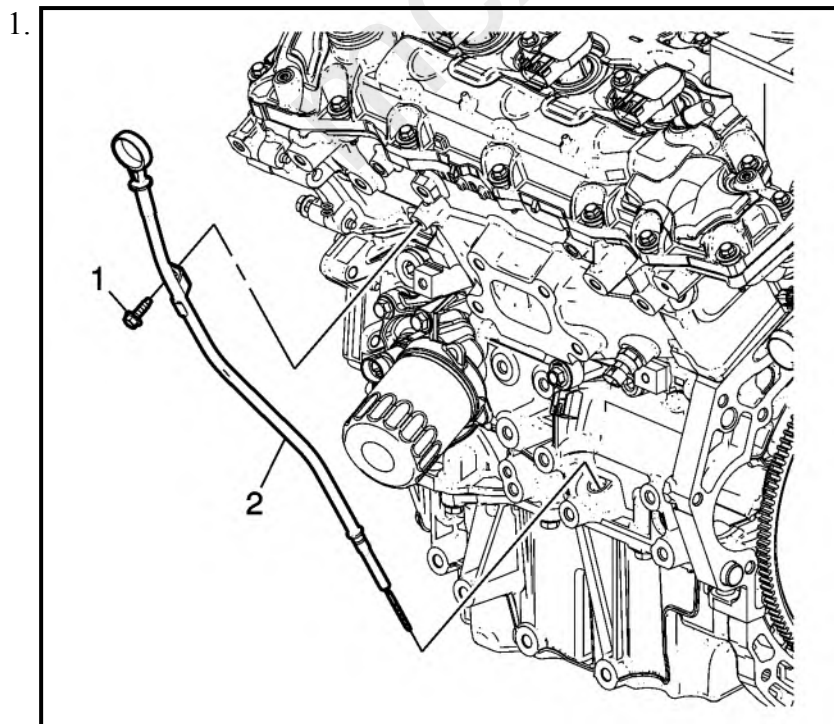
REPAIR INSTRUCTIONS - OFF VEHICLE

DRIVE BELT TENSIONER REMOVAL



Callout	Component Name
1	Idler Pulley
2	Drive Belt Tensioner Bolt
3	Engine Front Cover Bolt [3x]
4	Drive Belt Tensioner

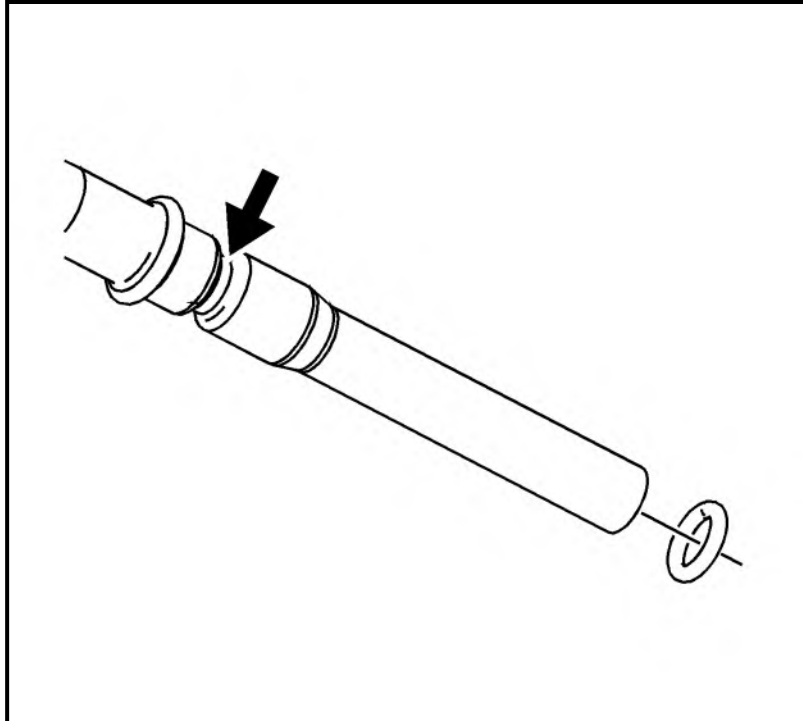
OIL LEVEL INDICATOR AND TUBE REMOVAL



Remove the oil level indicator tube bracket bolt (1).

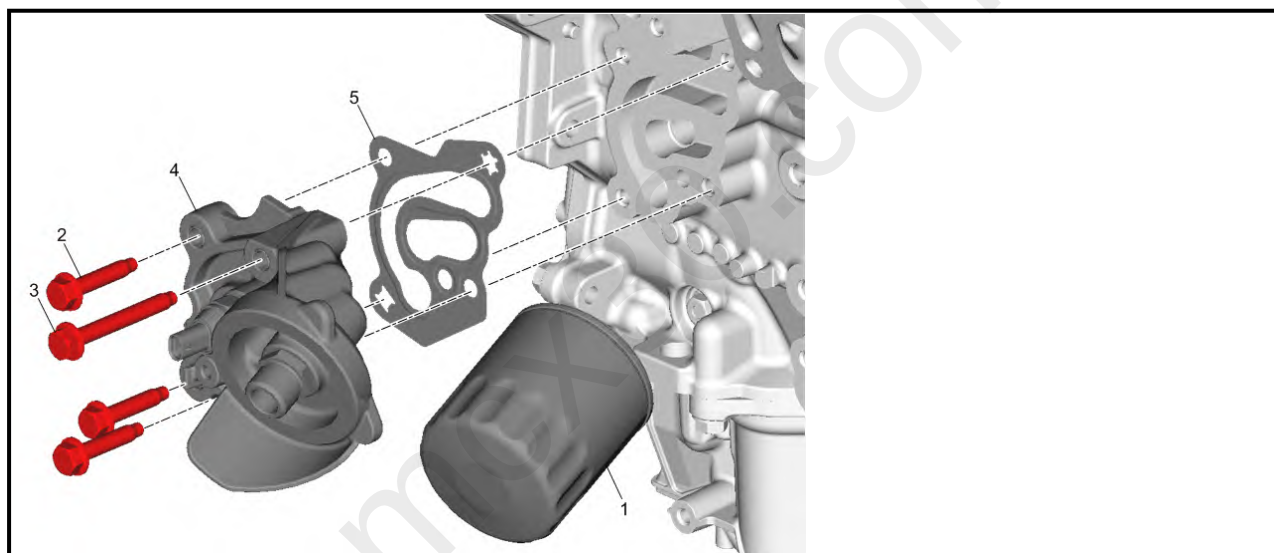
2. Remove the oil level indicator and tube (2) by sliding the tube out from the lower crankcase hole.

3.



Remove and discard the O-ring from the oil level indicator tube if damaged.

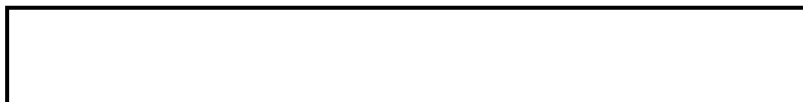
OIL FILTER ADAPTER REMOVAL

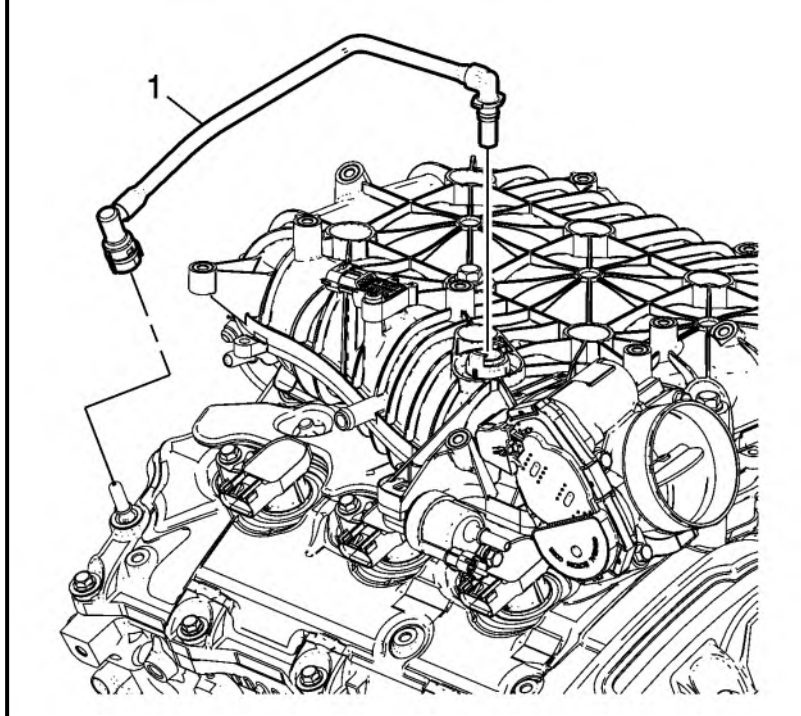


Callout	Component Name
1	Oil Filter NOTE: Remove and DISCARD the oil filter.
2	Oil Filter Adapter Bolt
3	Oil Filter Adapter Bolt [3x]
4	Oil Filter Adapter
5	Oil Filter Adapter Gasket NOTE: Remove and DISCARD the gasket.

INTAKE MANIFOLD REMOVAL

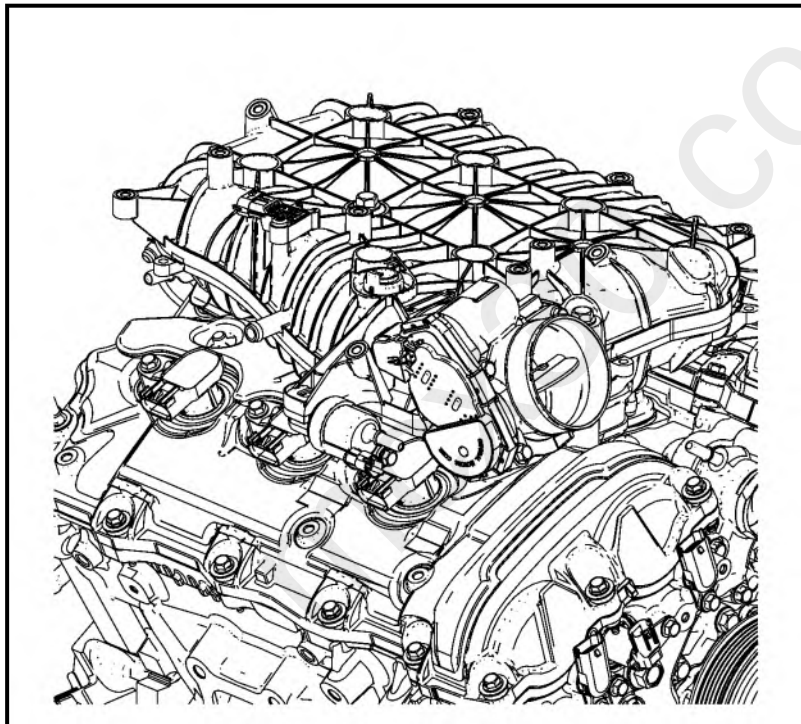
1.





Disconnect and remove the positive crankcase ventilation (PCV) tube (1) from the intake manifold and right camshaft cover.

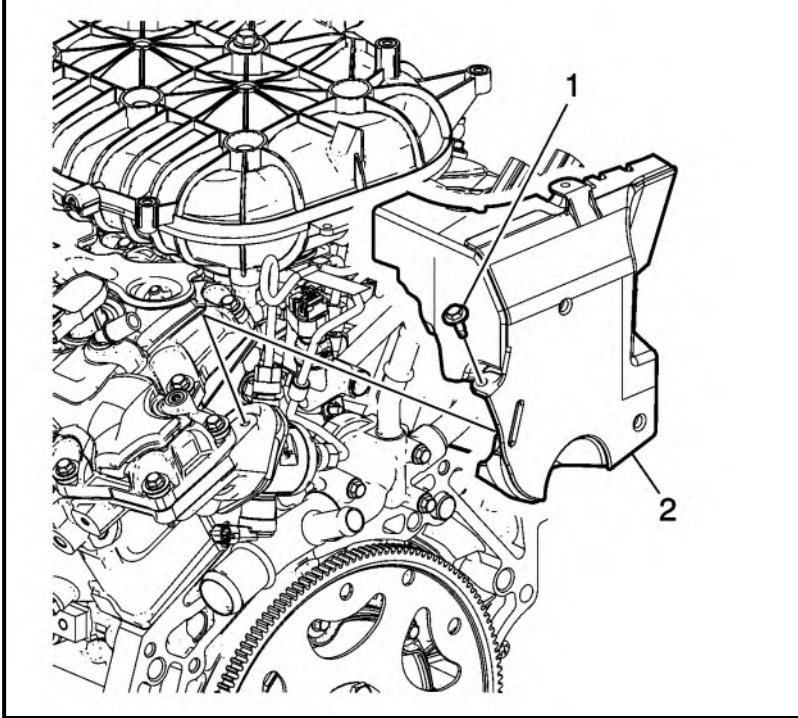
2.



Remove the evaporative (EVAP) hose from the intake manifold and EVAP solenoid.

3.

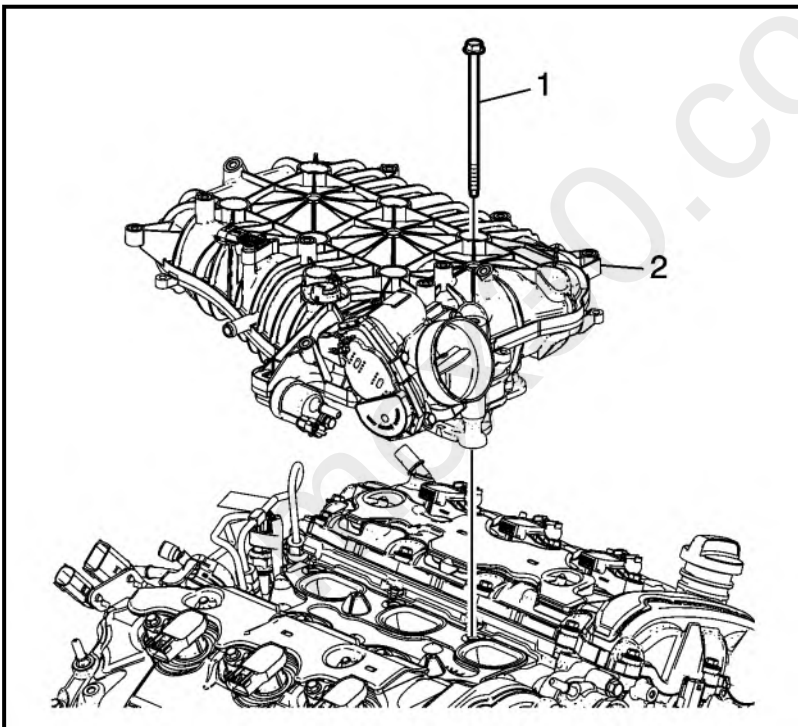




Remove the engine rear noise shield bolt (1).

4. Remove the engine rear noise shield (2).

5.

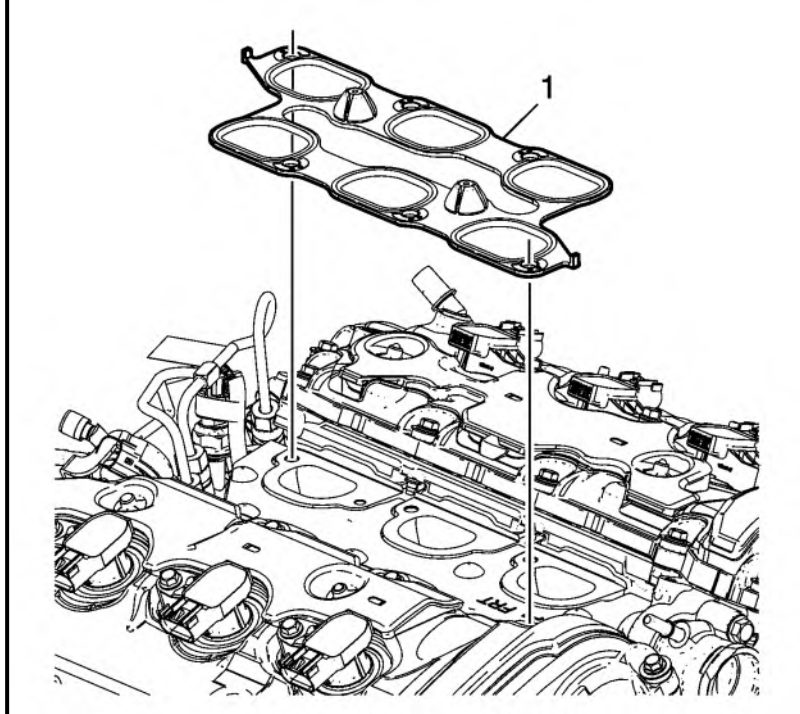


Remove the intake manifold bolts (1).

6. Remove the intake manifold assembly (2).

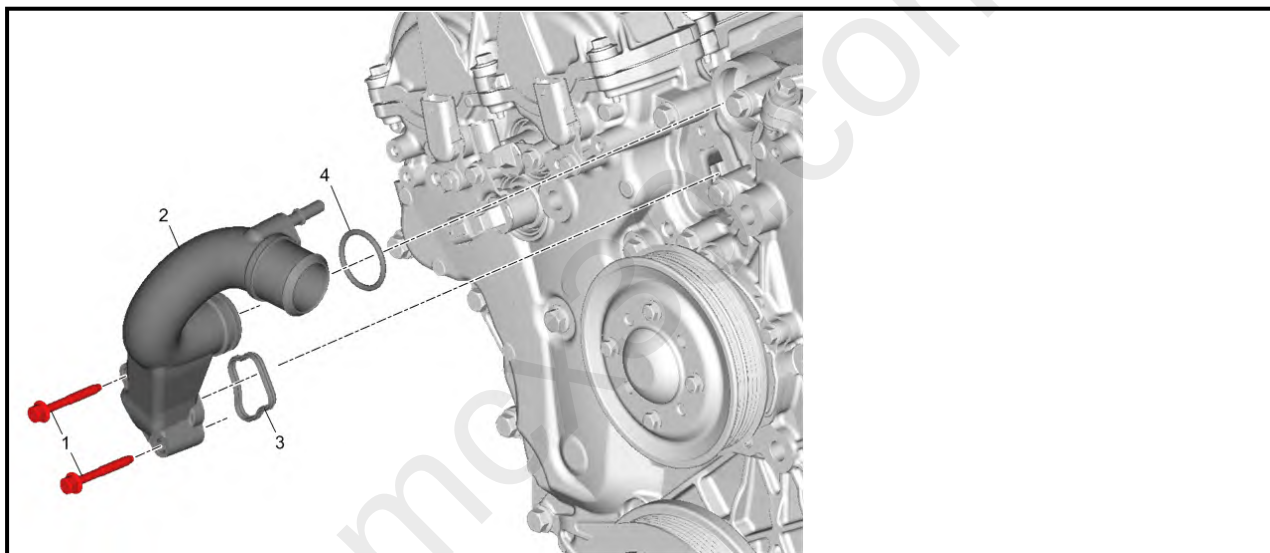
7.





Remove and discard the intake manifold gasket (1).

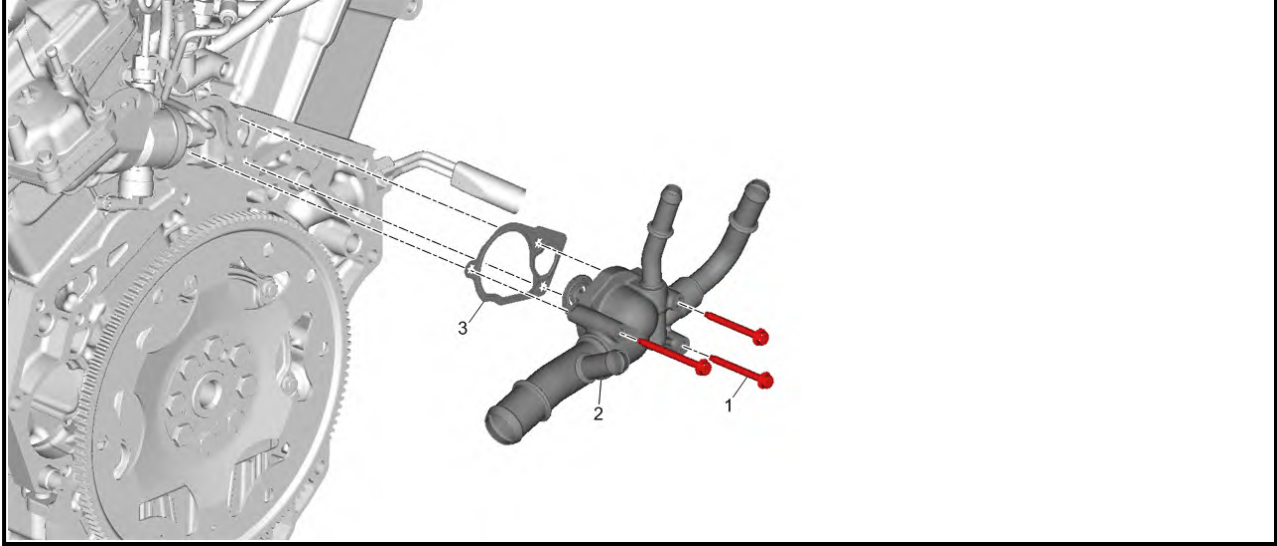
WATER OUTLET REMOVAL



Callout	Component Name
1	Water Outlet Bolt [2x]
2	Water Outlet
3	Water Outlet Seal NOTE: Discard seal, it is not reusable.
4	Water Outlet O-Ring Seal NOTE: Discard seal, it is not reusable.

ENGINE COOLANT THERMOSTAT HOUSING REMOVAL





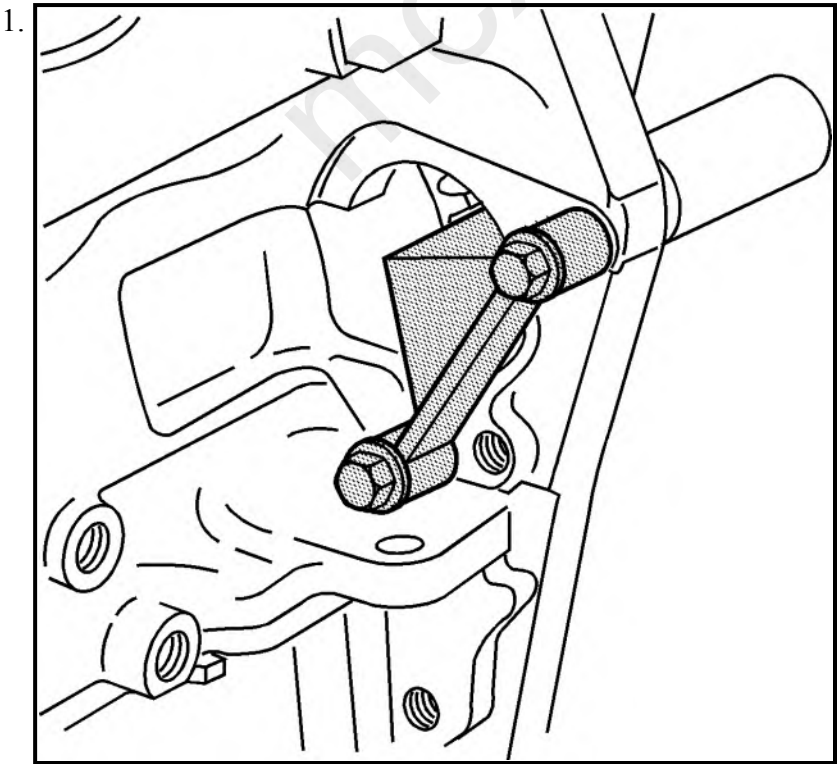
Callout	Component Name
1	Engine Coolant Thermostat Housing Bolt [3x]
2	Engine Coolant Thermostat Housing
3	Engine Coolant Thermostat Housing Gasket
	NOTE: Remove and DISCARD the gasket.

CRANKSHAFT BALANCER REMOVAL

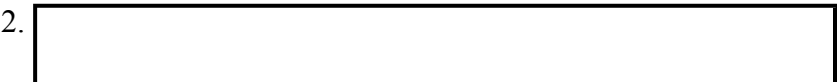
Special Tools

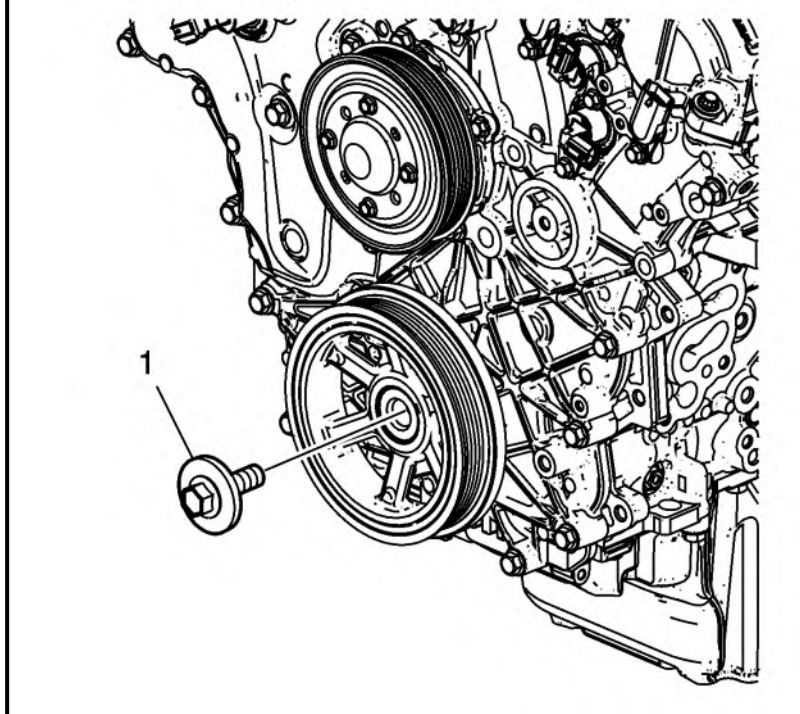
- EN 46106 Flywheel Holding Tool
- J 38416-B Harmonic Balancer Remover
- J 38416-2 Crankshaft Button

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



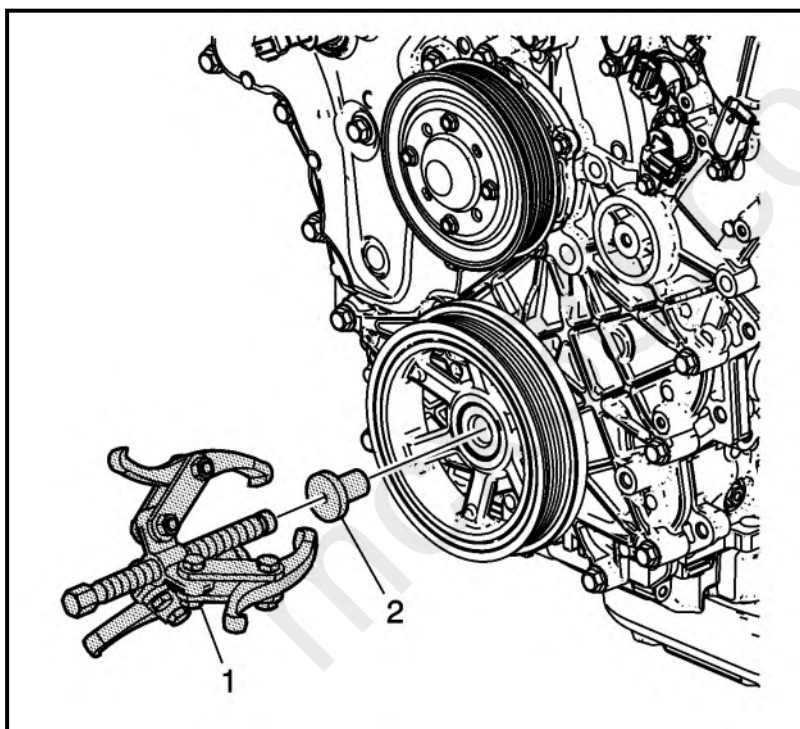
Install the **EN 46106** tool through the starter mounting hole.





Remove and discard the crankshaft balancer bolt (1).

3.

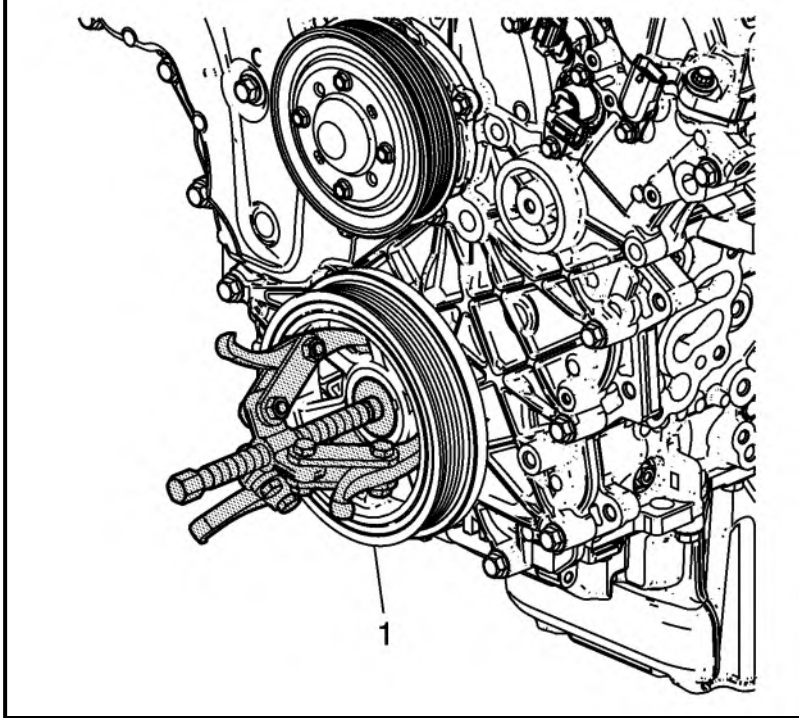


Install the **J 38416-2** button (2) in the nose of the crankshaft.

4. Install the **J 38416-B** remover (1) in order to remove the crankshaft balancer.

5.

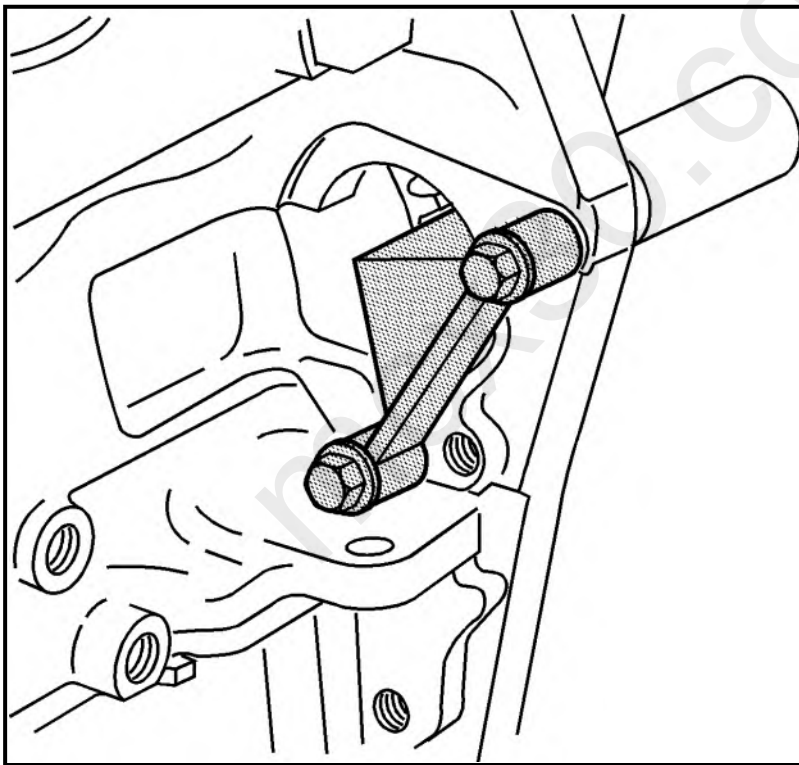




Pull the crankshaft balancer (1) off by tightening the center bolt on the **J 38416-B** remover until the crankshaft balancer pulls off of the crankshaft end.

6. Remove the **J 38416-B** remover and **J 38416-2** button from the crankshaft balancer.

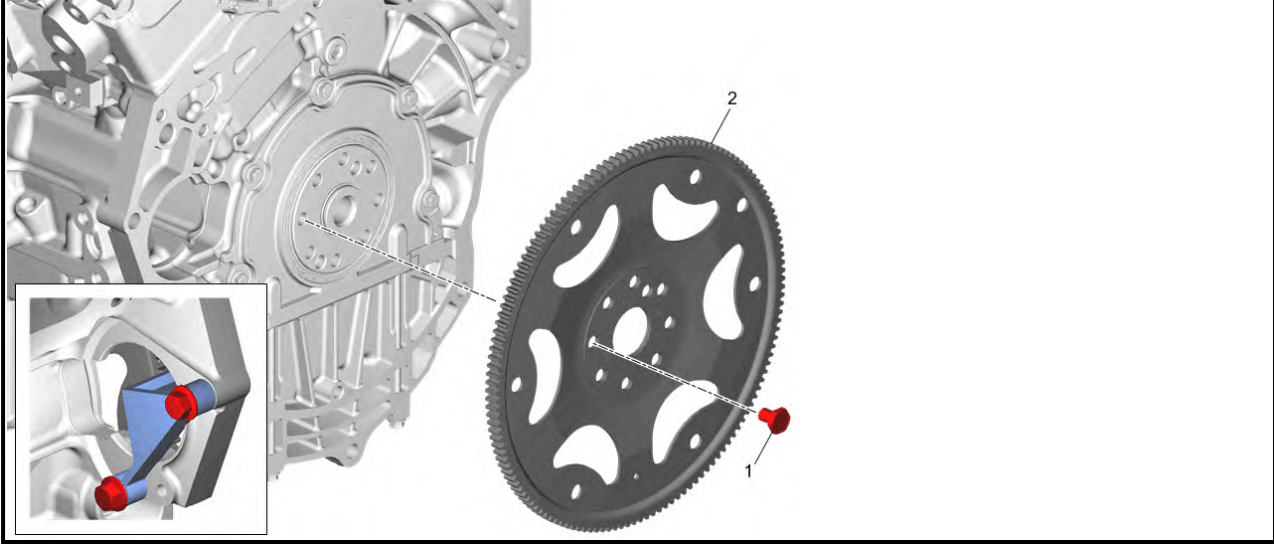
7.



Remove the **EN 46106** tool from the starter mounting hole.

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

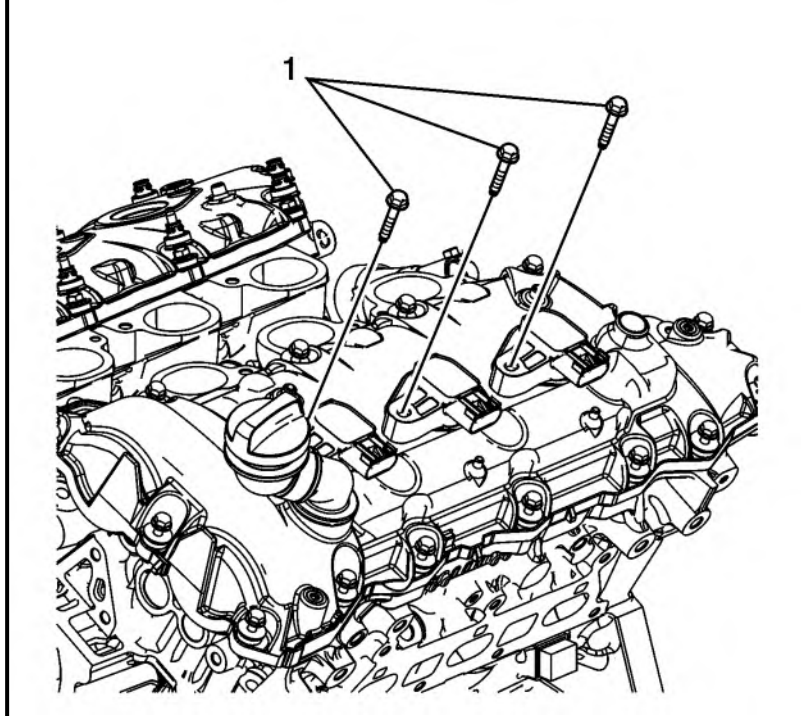




Callout	Component Name
1	Automatic Transmission Flex Plate Bolt CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. Procedure 1. Install the EN-46106 Flywheel Holding Tool through the starter mounting hole. 2. Remove the flex plate bolts (1) and discard 3. Remove the flex plate (2) from the crankshaft. 4. Remove the EN-46106 Flywheel Holding Tool through the starter mounting hole. Special Tools EN-46106 Flywheel Holding Tool Equivalent regional tools: Special Tools
2	Automatic Transmission Flex Plate

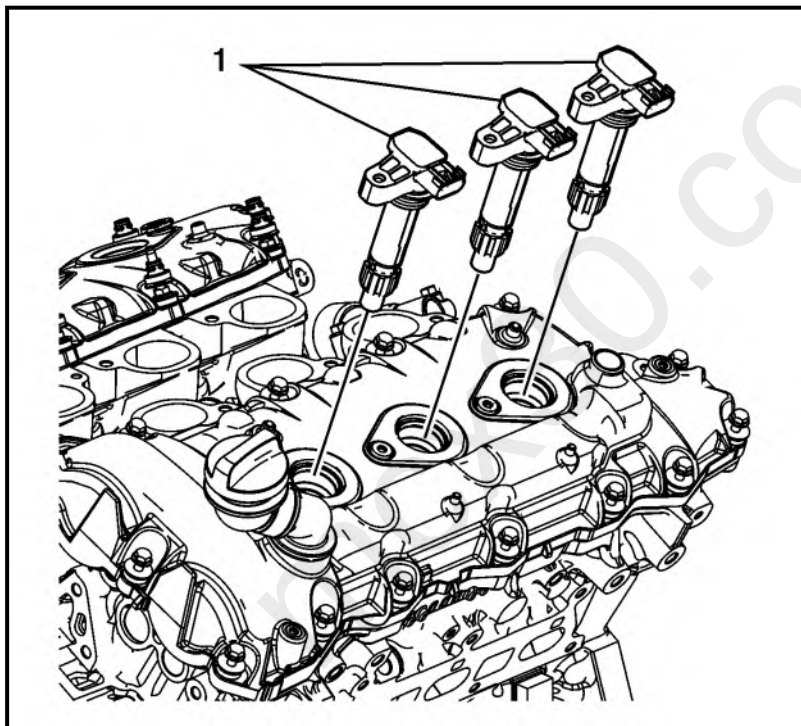
CAMSHAFT COVER REMOVAL - LEFT SIDE

- 1.



Remove the ignition coil bolts (1).

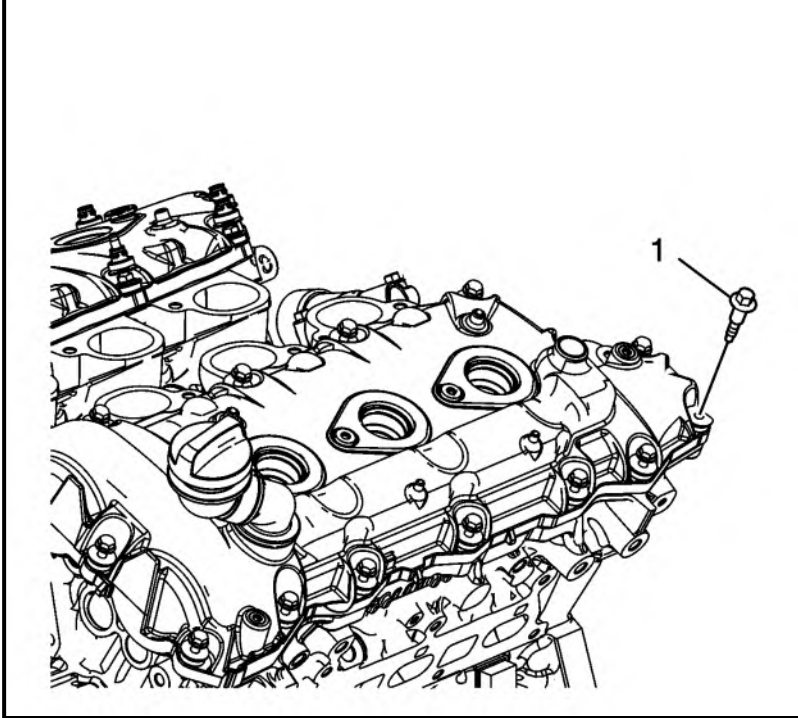
2.



Remove the ignition coils (1).

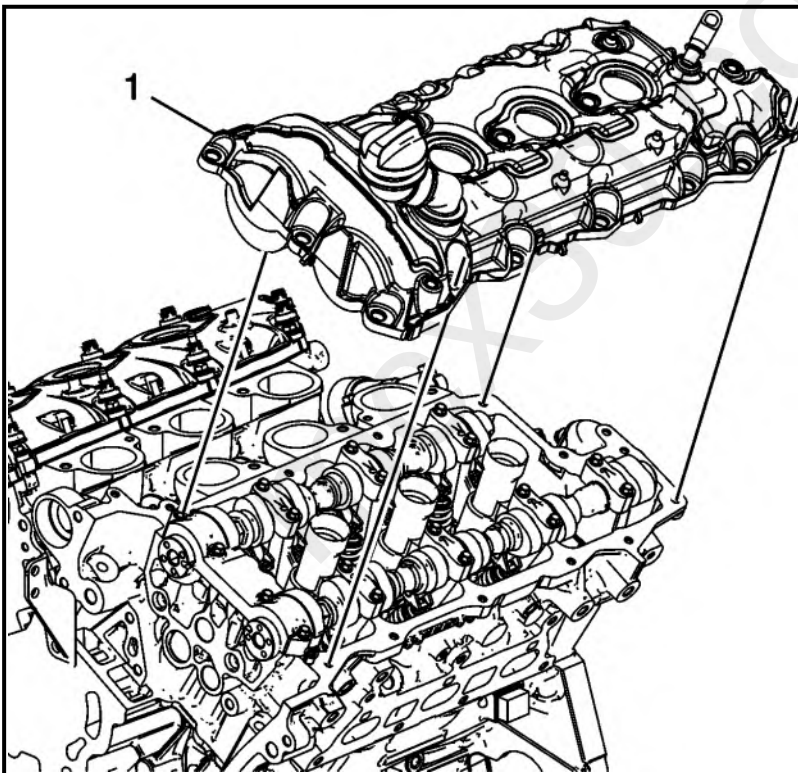
3.





Remove the left camshaft cover bolts (1).

4. Remove and discard the camshaft cover grommets and camshaft cover bolts if they are serviced with the grommet.
- 5.

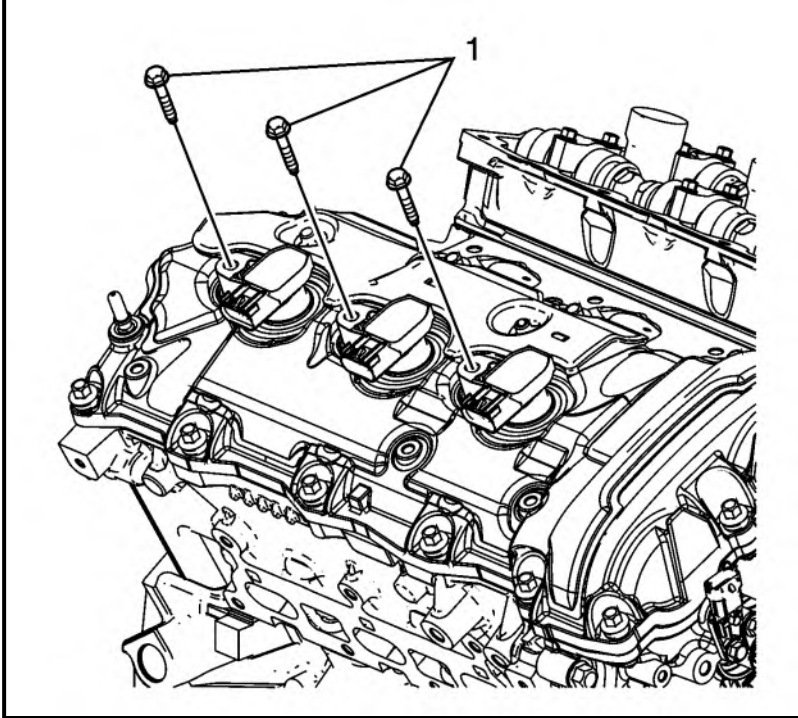


Remove the left camshaft cover (1) from the left cylinder head.

CAMSHAFT COVER REMOVAL - RIGHT SIDE

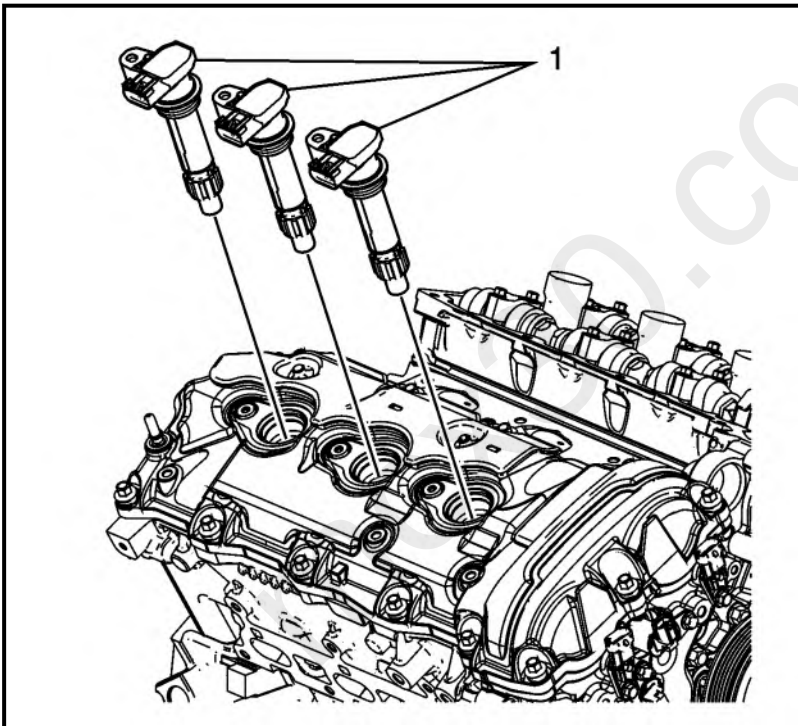
- 1.





Remove the ignition coil bolts (1).

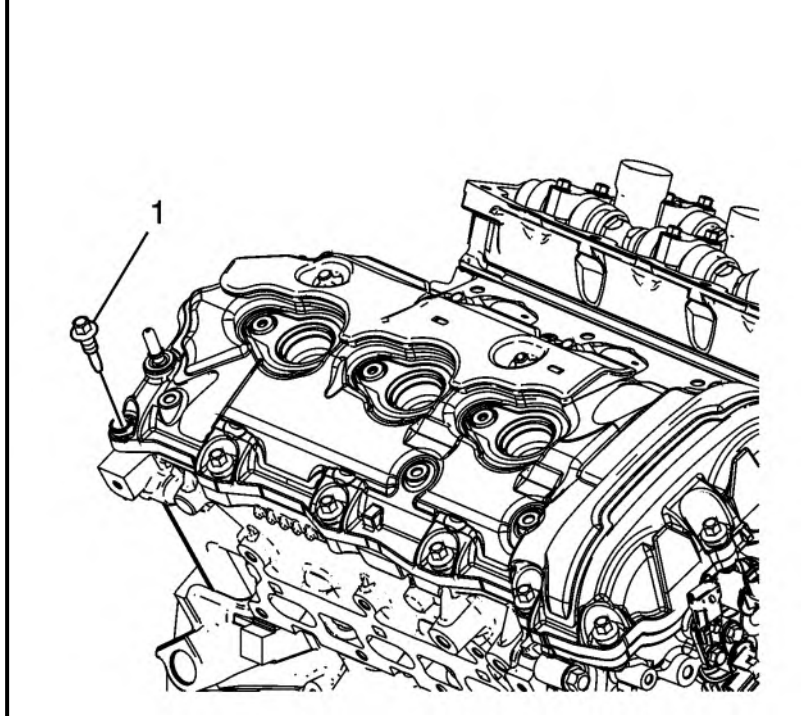
2.



Remove the ignition coils (1).

3.

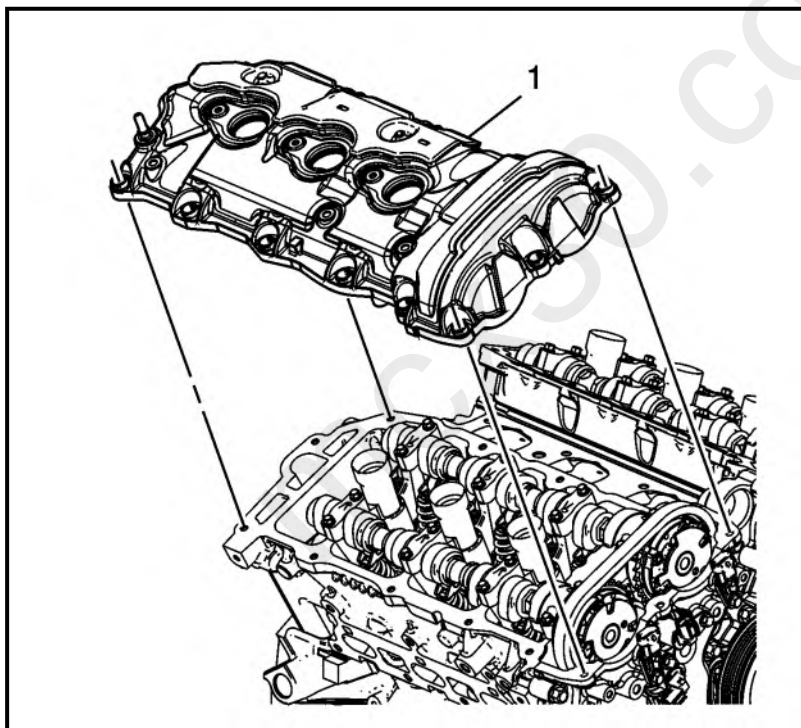




Remove the right camshaft cover bolts (1).

4. Remove and discard the camshaft cover grommets and camshaft cover bolts if they are serviced with the grommet.

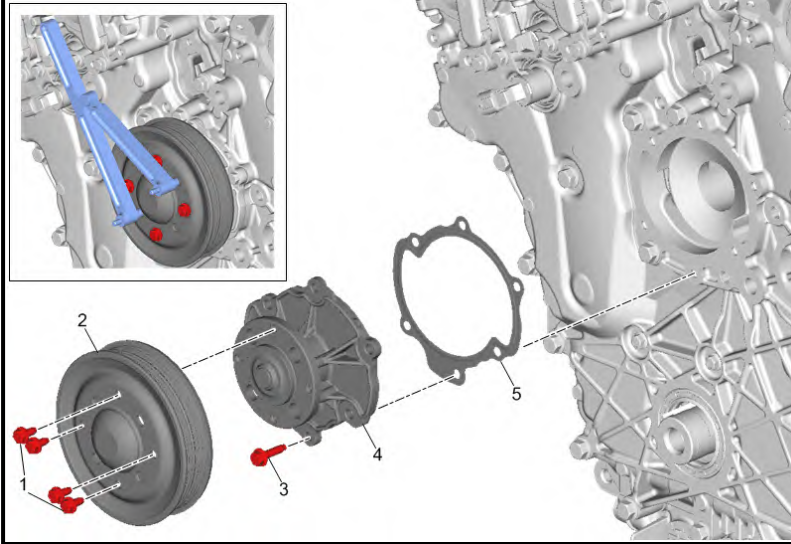
5.



Remove the right camshaft cover (1) from the right cylinder head.

WATER PUMP REMOVAL

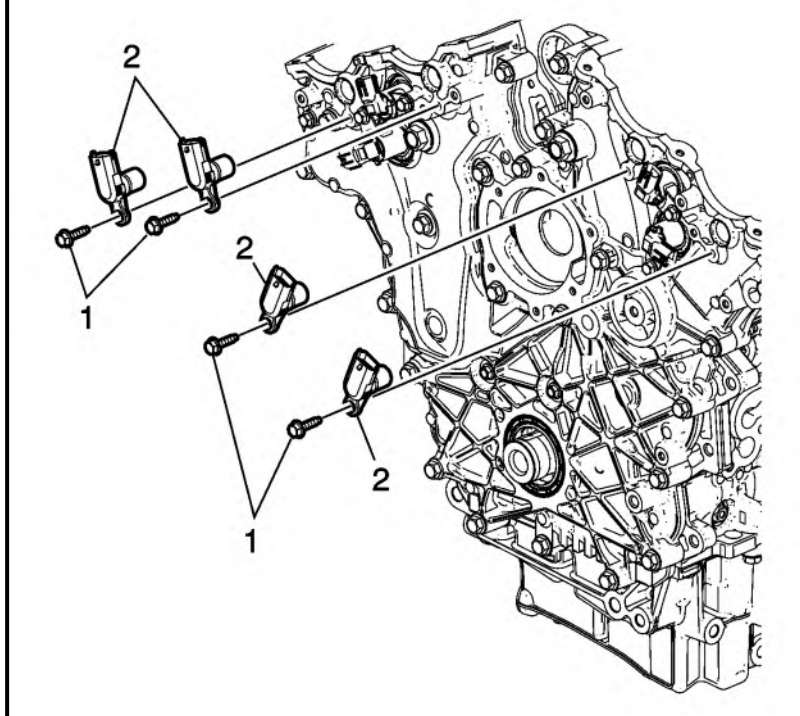




Callout	Component Name
1	Water Pump Pulley Bolt [4x] Procedure 1. Install the EN-46104 Water Pump Pulley Holding Tool onto the water pump pulley mounting holes. 2. Remove the water pump pulley bolts. 3. Remove the EN-46104 Water Pump Pulley Holding Tool from the water pump pulley. Special Tools EN - 46104 Water Pump Pulley Holding Tool Equivalent regional tools: Special Tools
2	Water Pump Pulley
3	Water Pump Bolt [6x] CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. NOTE: Remove and DISCARD the bolts.
4	Water Pump
5	Water Pump Gasket NOTE: Remove and DISCARD the gasket.

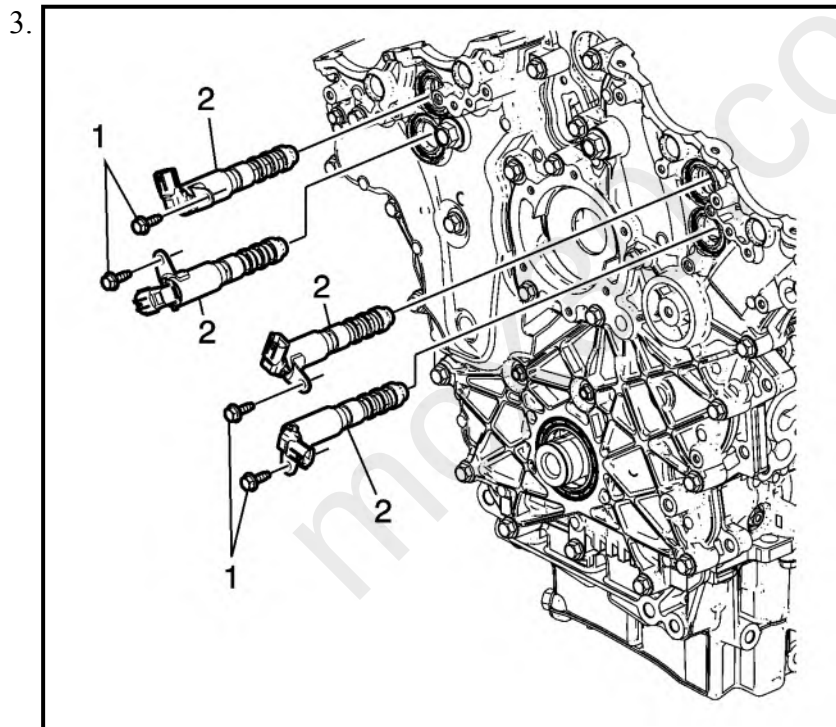
ENGINE FRONT COVER REMOVAL

1.



Remove the camshaft position sensor bolts (1).

2. Remove the camshaft position sensors (2).



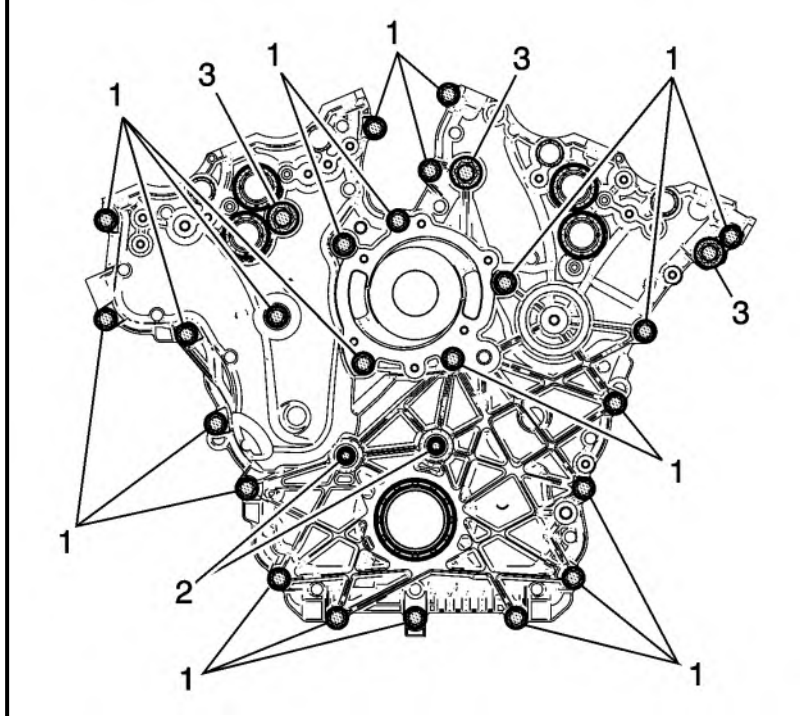
Remove the camshaft position actuator valve bolts (1).

CAUTION: The camshaft position actuator valves must be removed from the front cover prior to front cover removal or damage to the valves may occur.

4. Remove the camshaft position actuator valves (2) from the front cover.



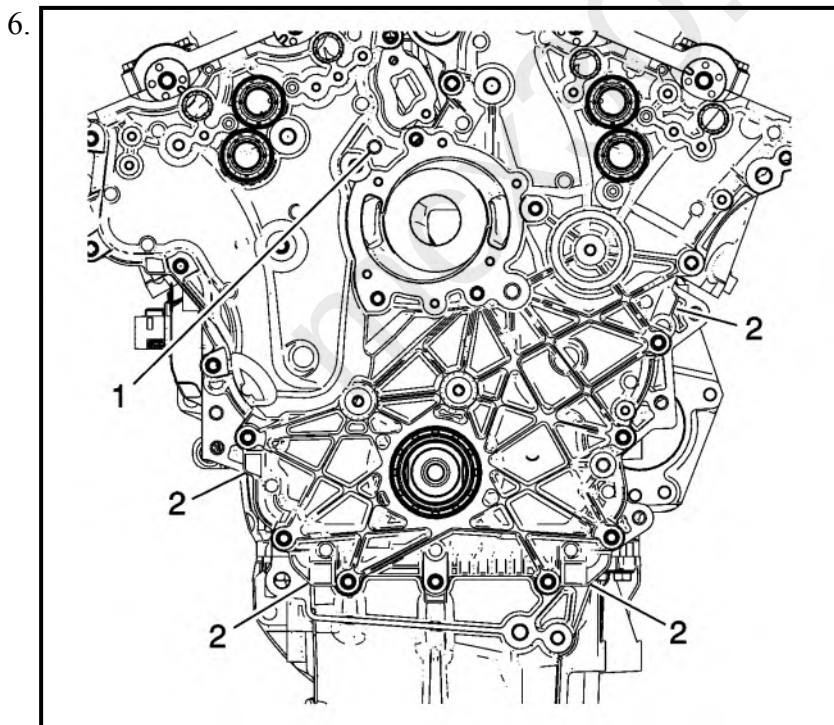
5.



NOTE: Engine front cover bolts in the number (3) location are model dependent and may have already been removed.

NOTE: There are a total of 23 M8 bolts (1) and 2 M6 bolts (2) that must be removed, and 3 optional M12 bolts (3) that may need to be removed before the front cover will separate from the engine block.

Remove the engine front cover bolts (1 - 3).



CAUTION: Do not use the jackscrew hole without first removing all engine front cover bolts. Failure to remove all engine front cover bolts before using the jackscrew hole could result in damage to components.

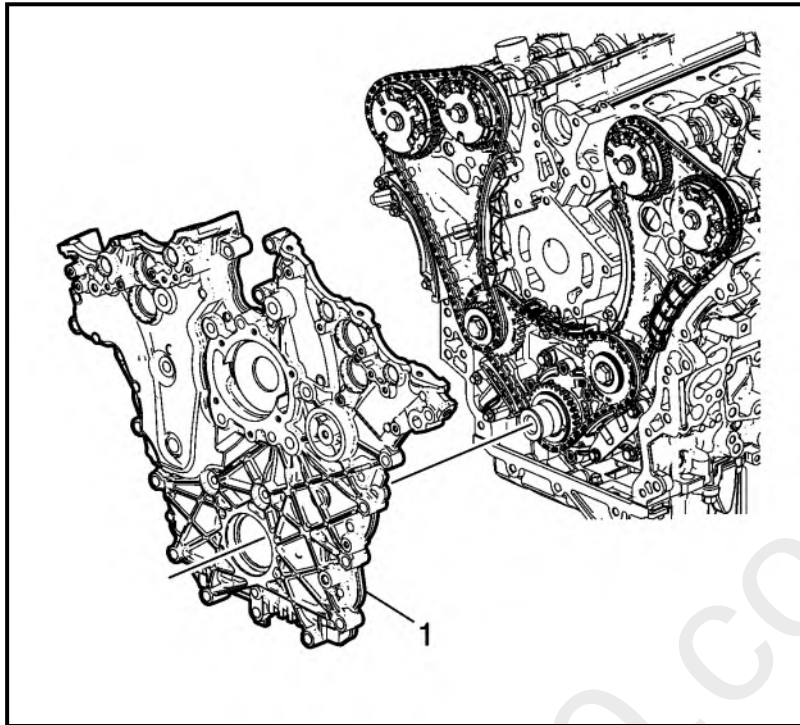
CAUTION: Do not pry between the engine front cover and the camshaft position sensors or the camshaft position actuators in order to separate the RTV. Use the pry points and a bolt in the jackscrew hole in order to remove the engine front cover. Damage to the camshaft position sensors or the camshaft position actuators may occur if the camshaft position sensors or the camshaft position

actuators are used to pry against in order to remove the engine front cover.

Loosely install a 10 x 1.5 mm bolt in the jackscrew hole (1).

7. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)
8. Using the pry points (2) located at the edge of the front cover and the jackscrew, separate the room temperature vulcanizing (RTV) sealant.

9.



Remove the engine front cover (1).

CAMSHAFT TIMING CHAIN COMPONENTS REMOVAL

Secondary Camshaft Drive Chain Components Removal - Right Side

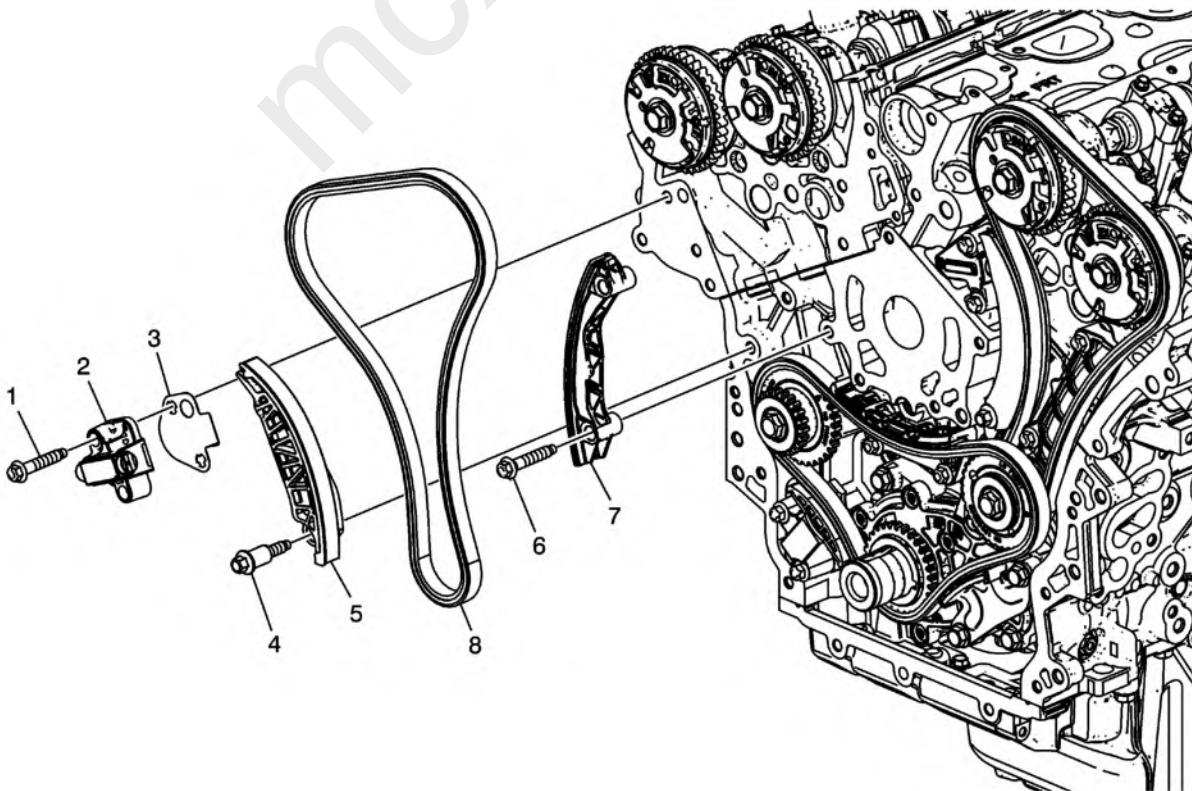


Fig. 1: Exploded View Of Secondary Camshaft Drive Chain Components - Right Side
Courtesy of GENERAL MOTORS COMPANY

Secondary Camshaft Drive Chain Components Removal - Right Side

Callout	Component Name
1	Right Secondary Timing Chain Tensioner Bolt
2	Right Secondary Timing Chain Tensioner
3	Right Timing Chain Housing Gasket NOTE: Discard the gasket.
4	Right Pivot Arm Timing Chain Guide Bolt
5	Right Pivot Arm Timing Chain Guide
6	Right Secondary Timing Chain Guide Bolt
7	Right Secondary Timing Chain Guide
8	Secondary Camshaft Intermediate Drive Chain

Primary Camshaft Drive Chain Components Removal

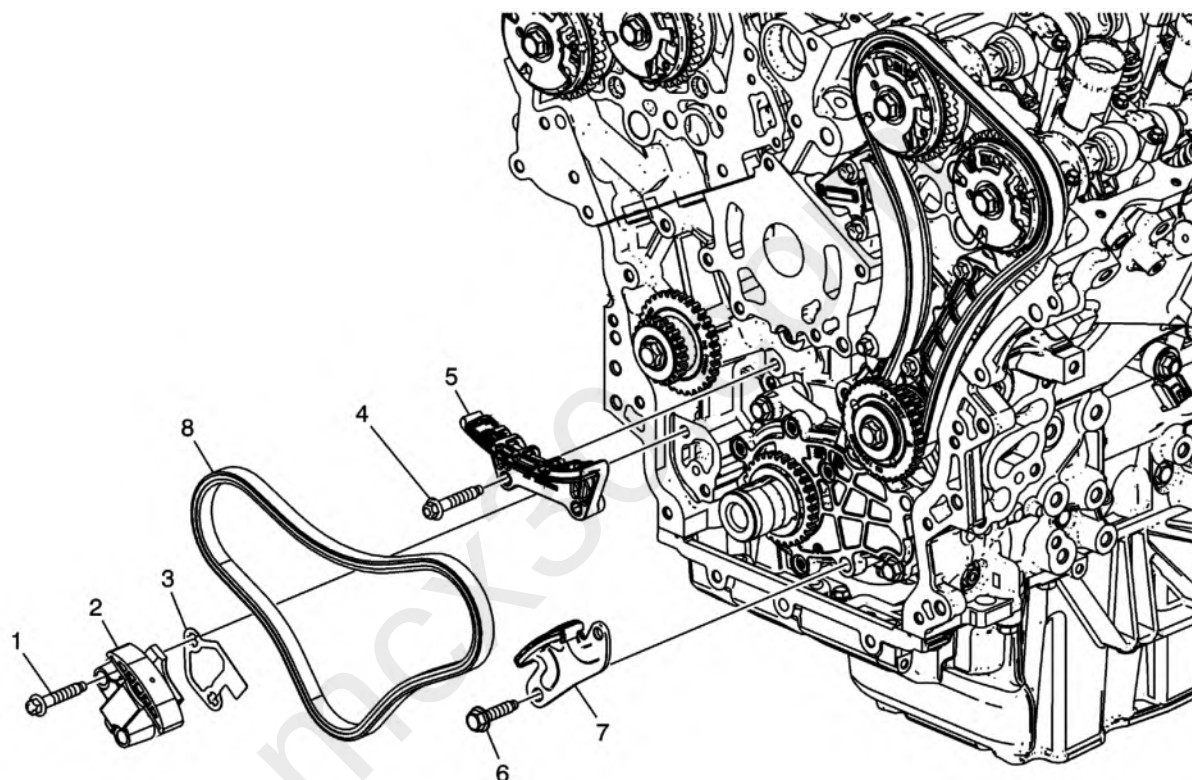


Fig. 2: Exploded View Of Primary Camshaft Drive Chain Components

Courtesy of GENERAL MOTORS COMPANY

Primary Camshaft Drive Chain Components Removal

Callout	Component Name
1	Camshaft Intermediate Drive Chain Tensioner Bolt
2	Camshaft Intermediate Drive Chain Tensioner
3	Timing Chain Housing Gasket NOTE: Discard the gasket.
4	Upper Primary Timing Chain Guide Bolt
5	Upper Primary Timing Chain Guide
6	Lower Primary Timing Chain Guide Bolt
7	Lower Primary Timing Chain Guide
8	Primary Camshaft Drive Intermediate Chain

Secondary Camshaft Drive Chain Components Removal - Left Side

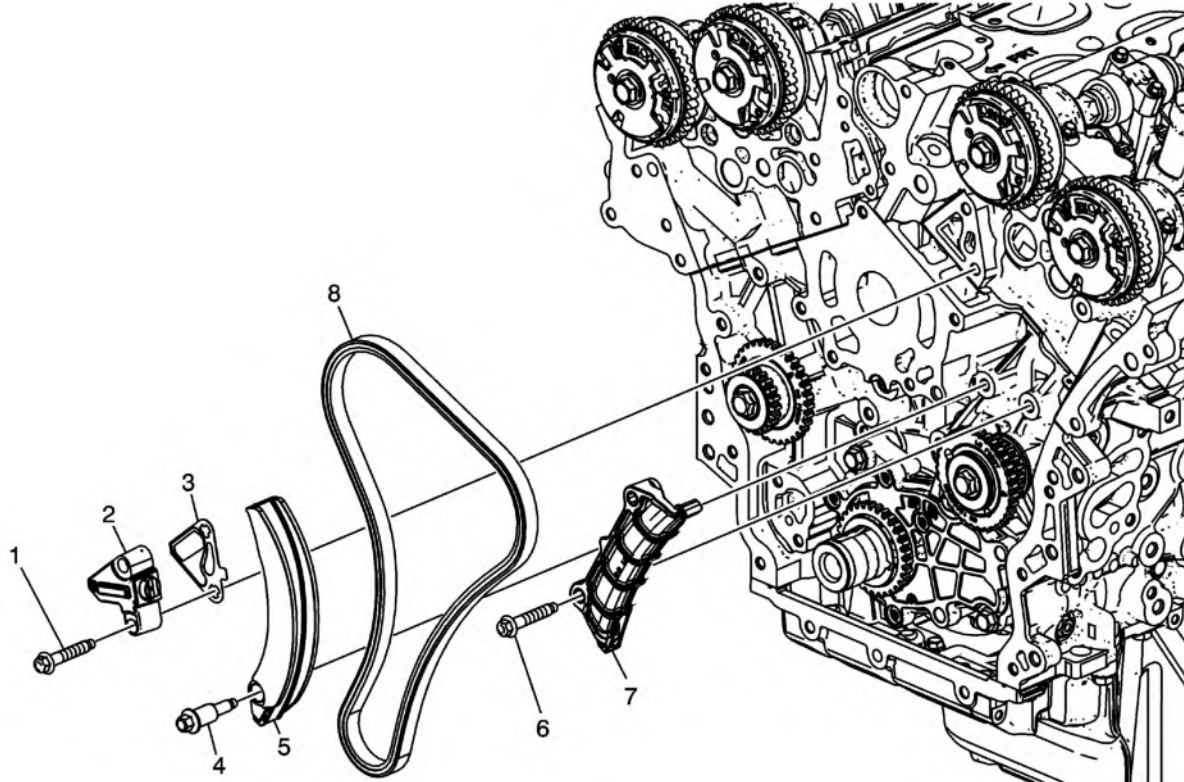
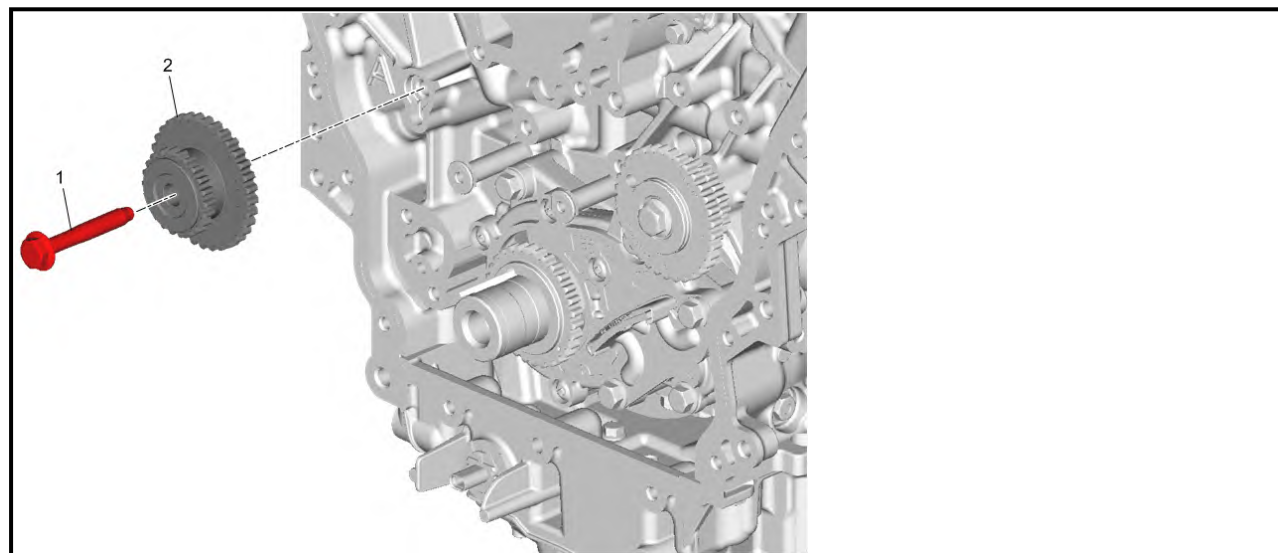


Fig. 3: Exploded View Of Secondary Camshaft Drive Chain Components - Left Side
 Courtesy of GENERAL MOTORS COMPANY

Secondary Camshaft Drive Chain Components Removal - Left Side

Callout	Component Name
1	Left Secondary Timing Chain Tensioner Bolt
2	Left Secondary Timing Chain Tensioner
3	Left Timing Chain Housing Gasket NOTE: Discard the gasket.
4	Left Pivot Arm Timing Chain Guide Bolt
5	Left Pivot Arm Timing Chain Guide
6	Left Secondary Timing Chain Guide Bolt
7	Left Secondary Timing Chain Guide
8	Secondary Camshaft Intermediate Drive Chain

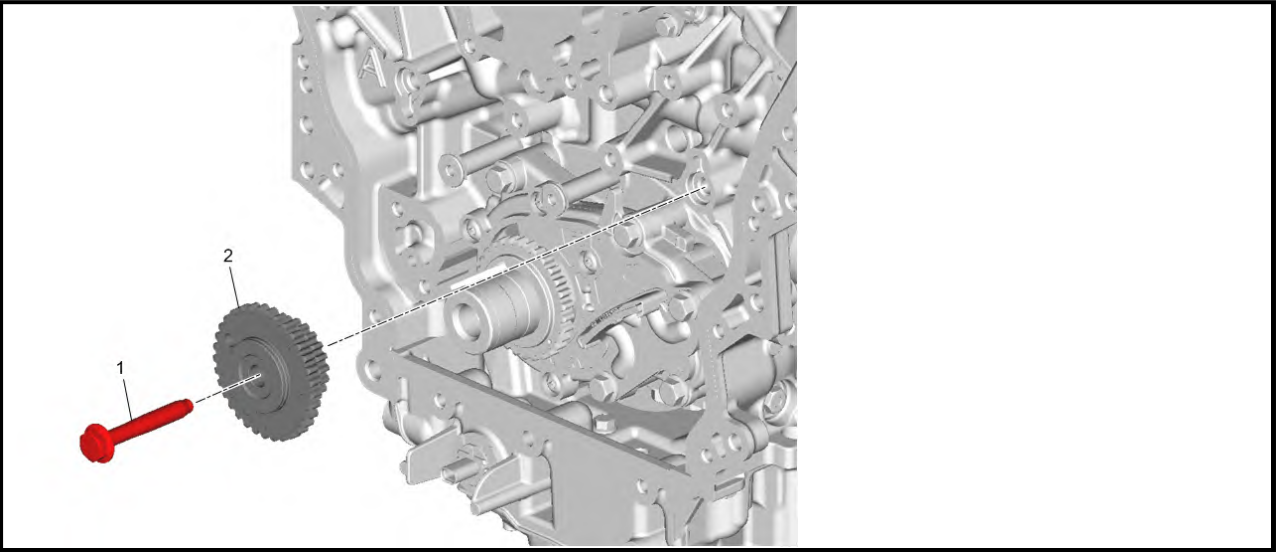
TIMING CHAIN IDLER SPROCKET REMOVAL - RIGHT SIDE



Callout	Component Name
1	Timing Chain Idler Sprocket Bolt
2	Timing Chain Idler Sprocket

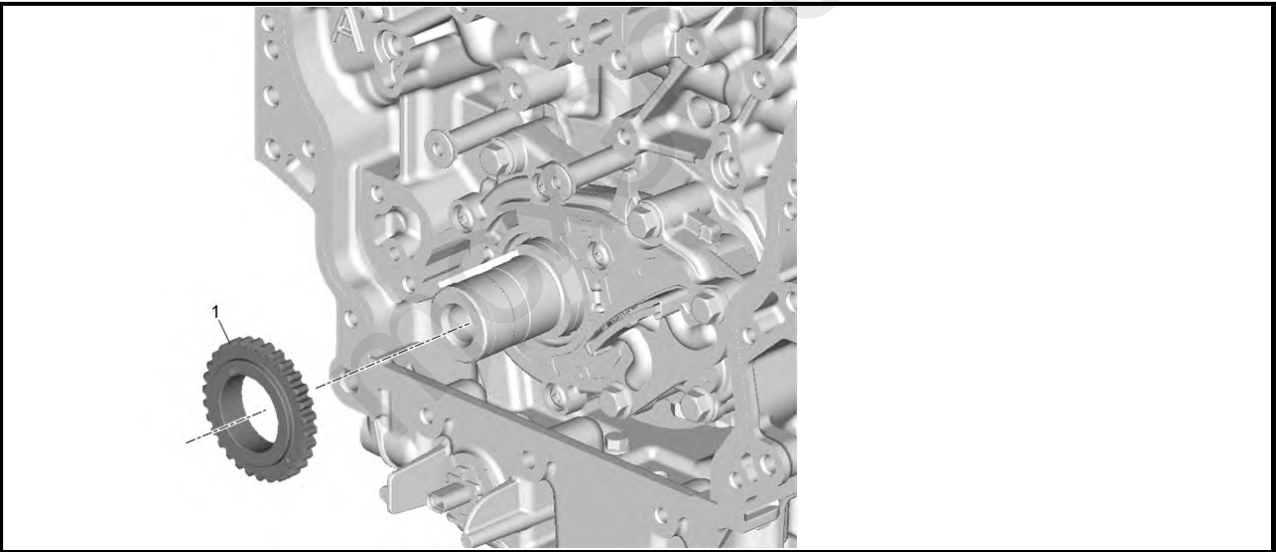
Callout	Component Name
1	Timing Chain Idler Sprocket Shaft Bolt
2	Right SideTiming Chain Idler Sprocket

TIMING CHAIN IDLER SPROCKET REMOVAL - LEFT SIDE



Callout	Component Name
1	Timing Chain Idler Sprocket Shaft Bolt
2	Left SideTiming Chain Idler Sprocket

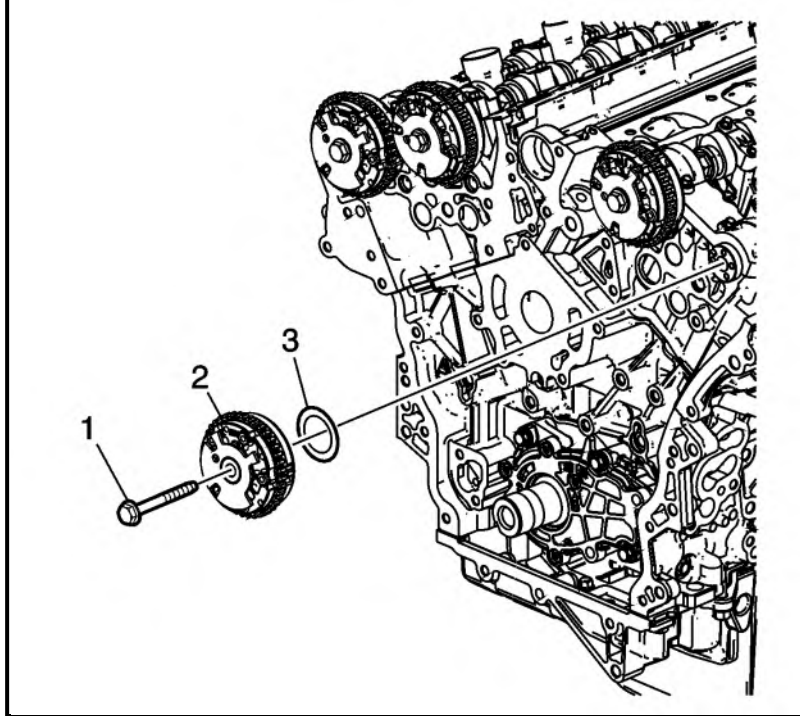
CRANKSHAFT SPROCKET REMOVAL



Callout	Component Name
1	Crankshaft Sprocket

CAMSHAFT POSITION ACTUATOR REMOVAL - LEFT SIDE EXHAUST

-

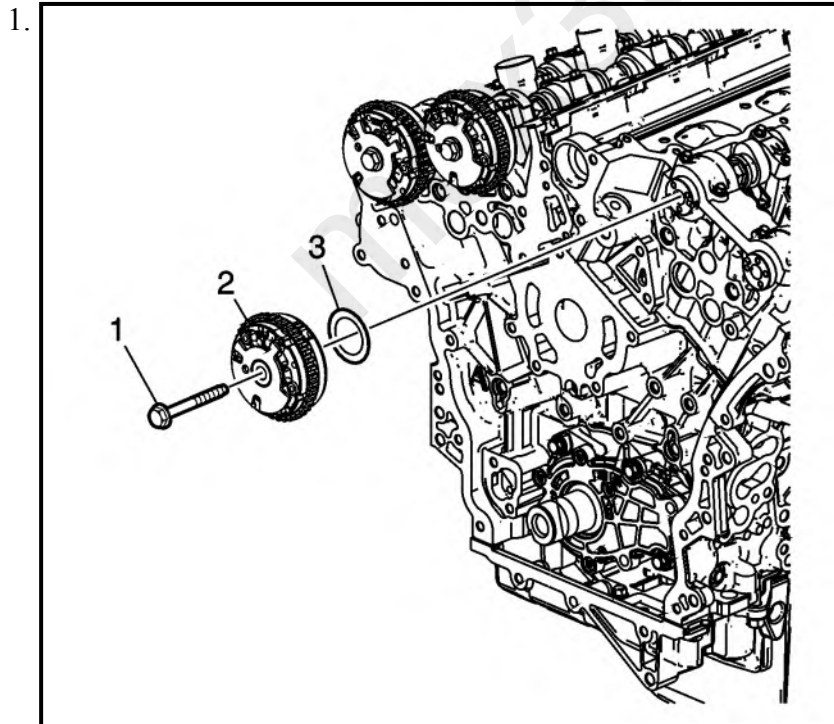


CAUTION: Refer to [Torque Reaction Against Timing Drive Chain Caution](#) .

Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.

2. Remove the left exhaust camshaft position actuator bolt (1).
3. Remove the left exhaust camshaft position actuator (2).
4. Remove the camshaft thrust washer if applicable (3).

CAMSHAFT POSITION ACTUATOR REMOVAL - LEFT SIDE INTAKE

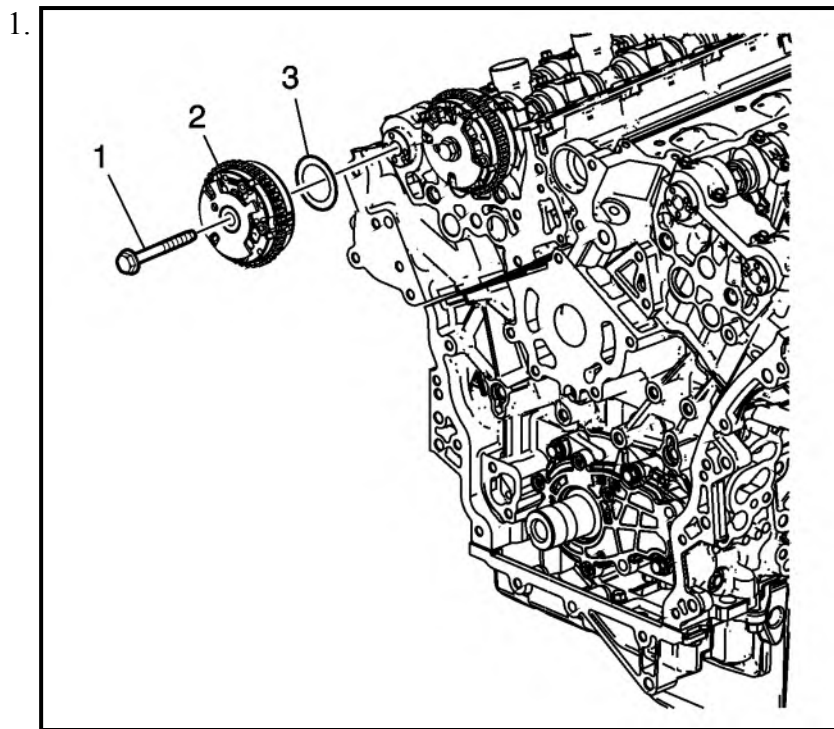


CAUTION: Refer to [Torque Reaction Against Timing Drive Chain Caution](#) .

Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.

2. Remove the left intake camshaft position actuator bolt (1).
3. Remove the left intake camshaft position actuator (2).
4. Remove the camshaft thrust washer if applicable (3).

CAMSHAFT POSITION ACTUATOR REMOVAL - RIGHT SIDE EXHAUST

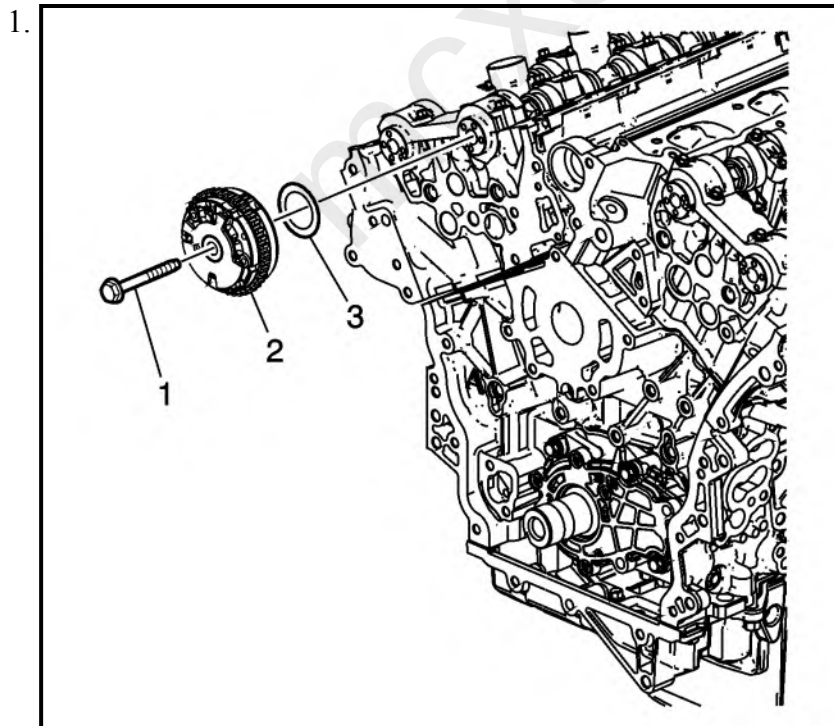


CAUTION: Refer to [Torque Reaction Against Timing Drive Chain Caution](#) .

Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.

2. Remove the right exhaust camshaft position actuator bolt (1).
3. Remove the right exhaust camshaft position actuator (2).
4. Remove the camshaft thrust washer if applicable (3).

CAMSHAFT POSITION ACTUATOR REMOVAL - RIGHT SIDE INTAKE



CAUTION: Refer to [Torque Reaction Against Timing Drive Chain Caution](#) .

Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.

2. Remove the right intake camshaft position actuator bolt (1).

3. Remove the right intake camshaft position actuator (2).
4. Remove the camshaft thrust washer if applicable (3).

FUEL PUMP REMOVAL

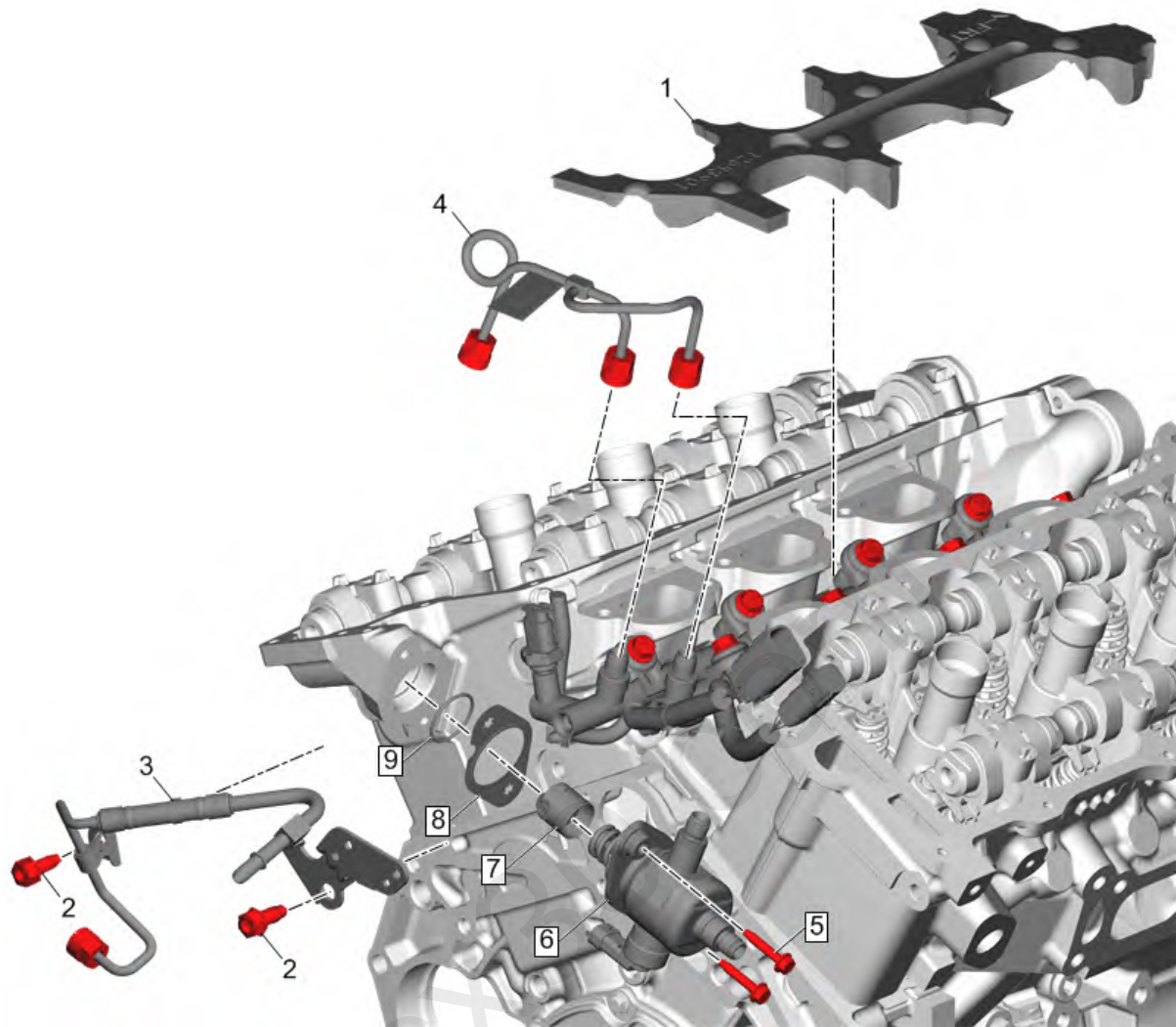
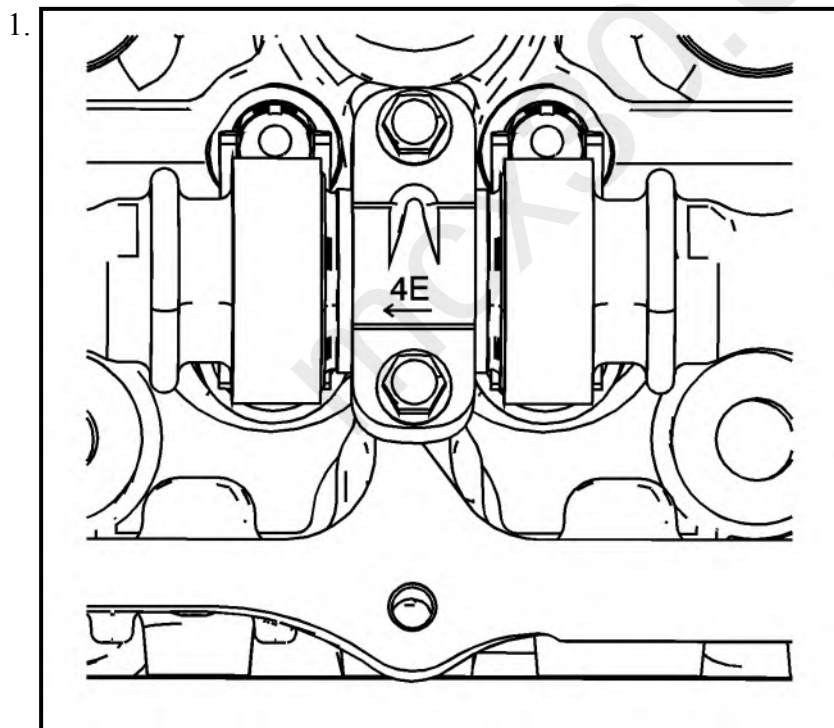


Fig. 4: Exploded View Of Fuel Pump Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injection Fuel Rail Noise Shield
2	Fuel Feed Pipe Bracket Bolt
3	Fuel Feed Pipe NOTE: Remove and DISCARD the pipe.
4	Fuel Feed Intermediate Pipe NOTE: Remove and DISCARD the pipe.

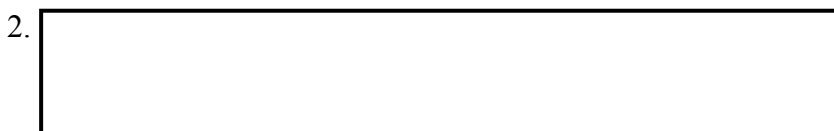
Callout	Component Name
5	Fuel Pump Bolt CAUTION: Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage NOTE: Remove and DISCARD the bolts.
6	Fuel Pump
7	Fuel Pump O-Ring NOTE: Remove and DISCARD the O-ring seal.
8	Fuel Pump Gasket NOTE: Remove and DISCARD the gasket.
9	Valve Lifter Follower

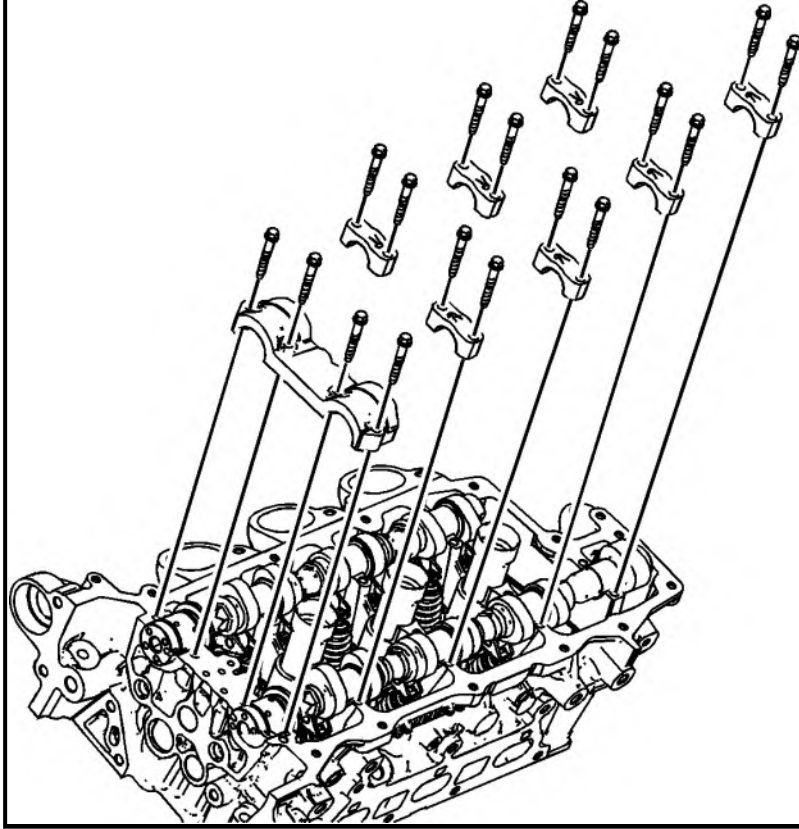
CAMSHAFT REMOVAL - LEFT SIDE



Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:

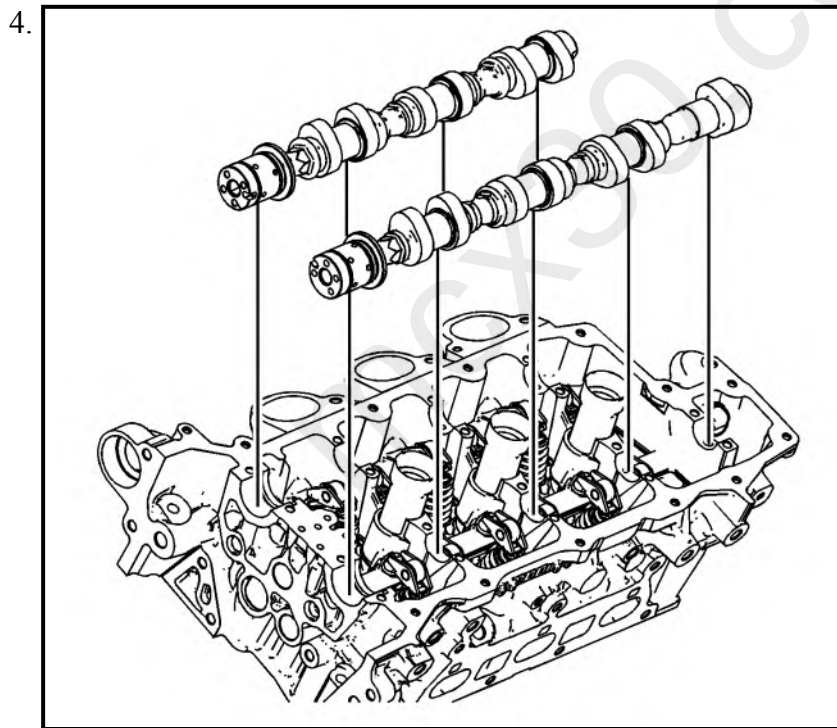
- The raised feature must always be oriented toward the center of the cylinder head.
- The I indicates the intake camshaft.
- The E indicates the exhaust camshaft.
- The number indicates the journal position from the front of the engine.





Remove the camshaft bearing cap bolts.

3. Remove the camshaft bearing caps.



NOTE: Mark the camshafts upon removal to ensure installation is in the correct position.

Remove the camshafts.

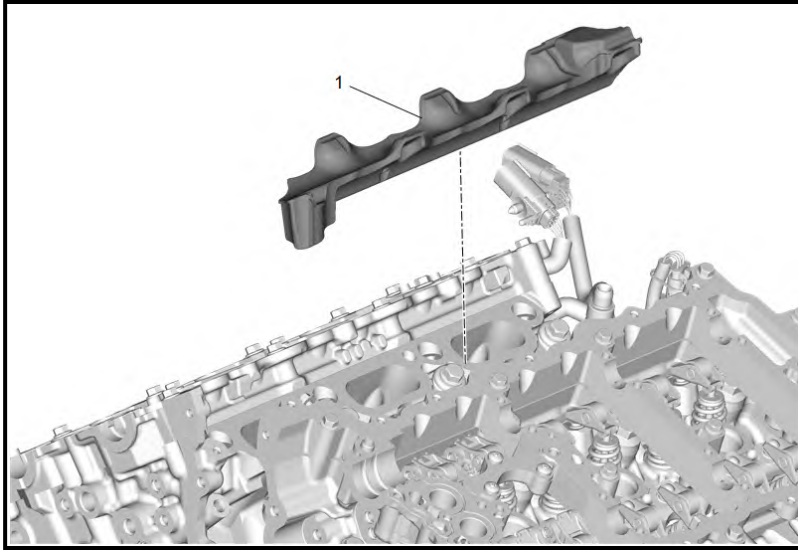
FUEL RAIL REMOVAL

Special Tools

EN-49248 Injector Rail Assembly Remover

Equivalent regional tools: [Special Tools](#)

1.

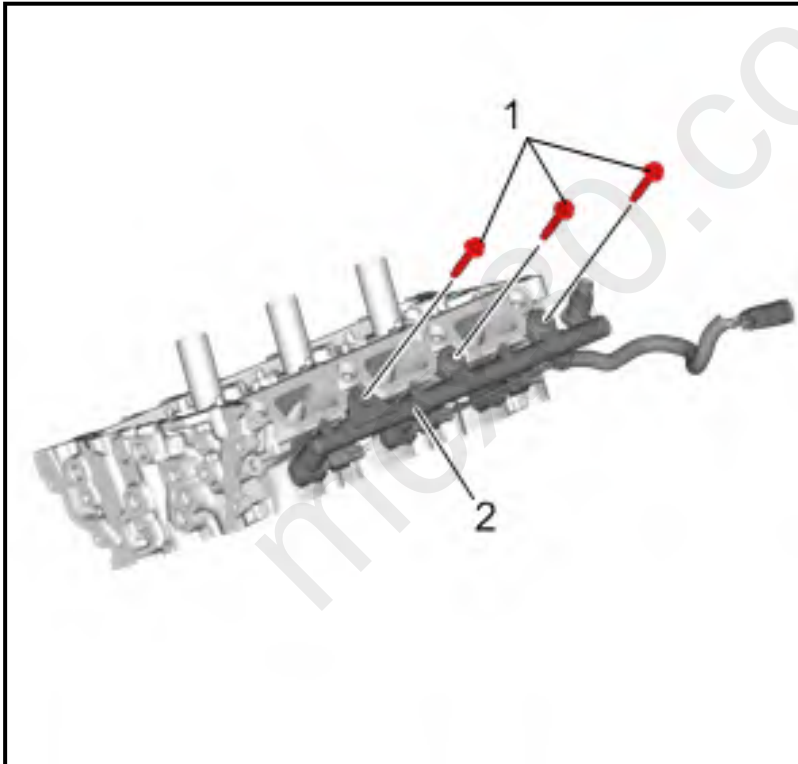


WARNING:

The noise cancelling foam component **MUST** be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

Remove the fuel injection fuel rail noise shield (1).

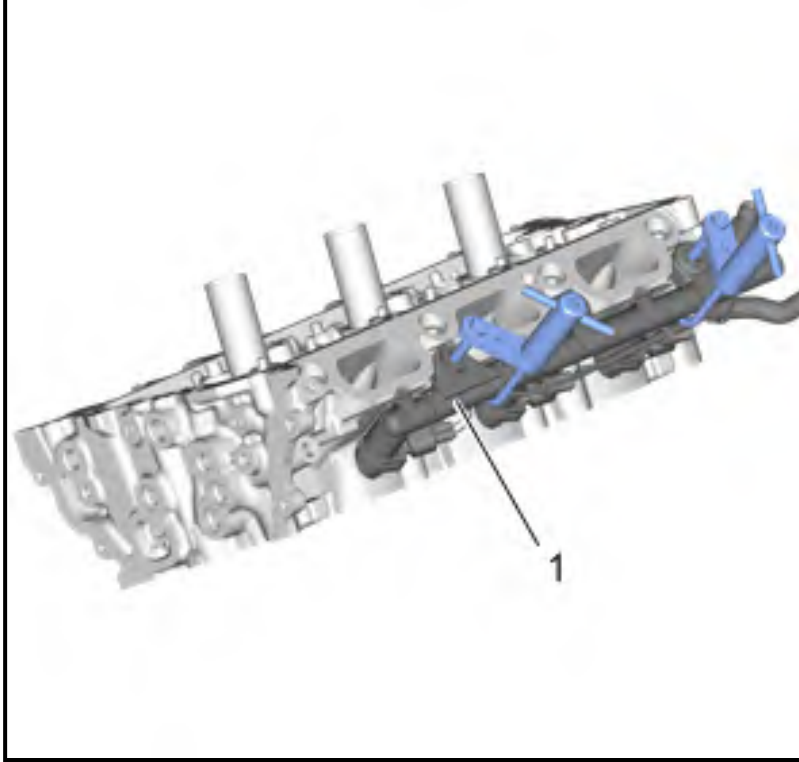
2.



Remove the fuel rail bolts (1) from the fuel rail (2).

3.



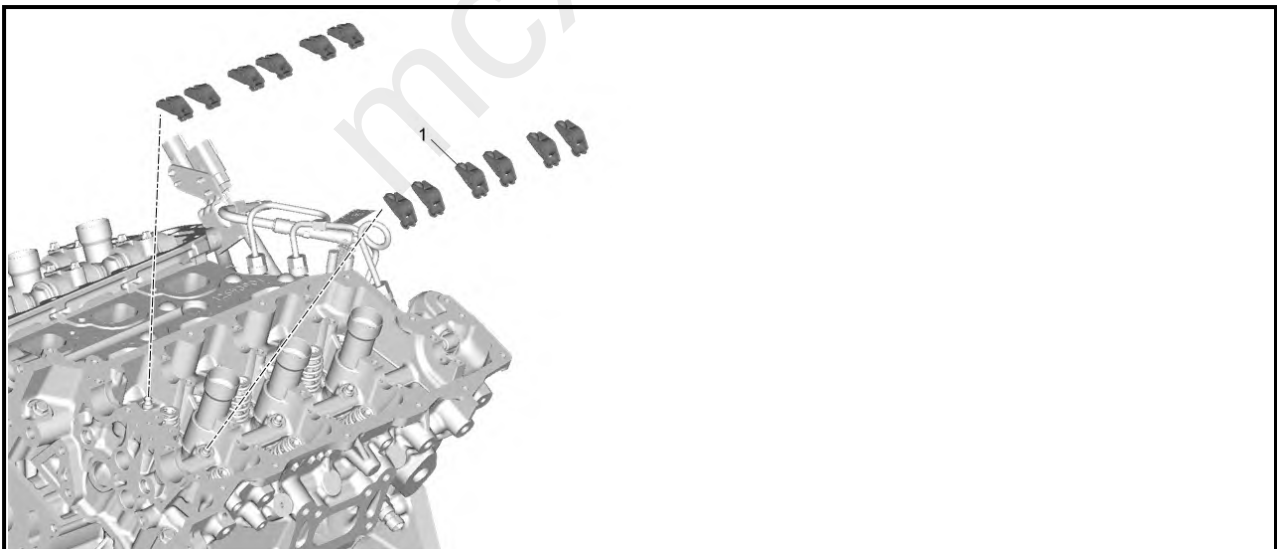


CAUTION:

- Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
- Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.

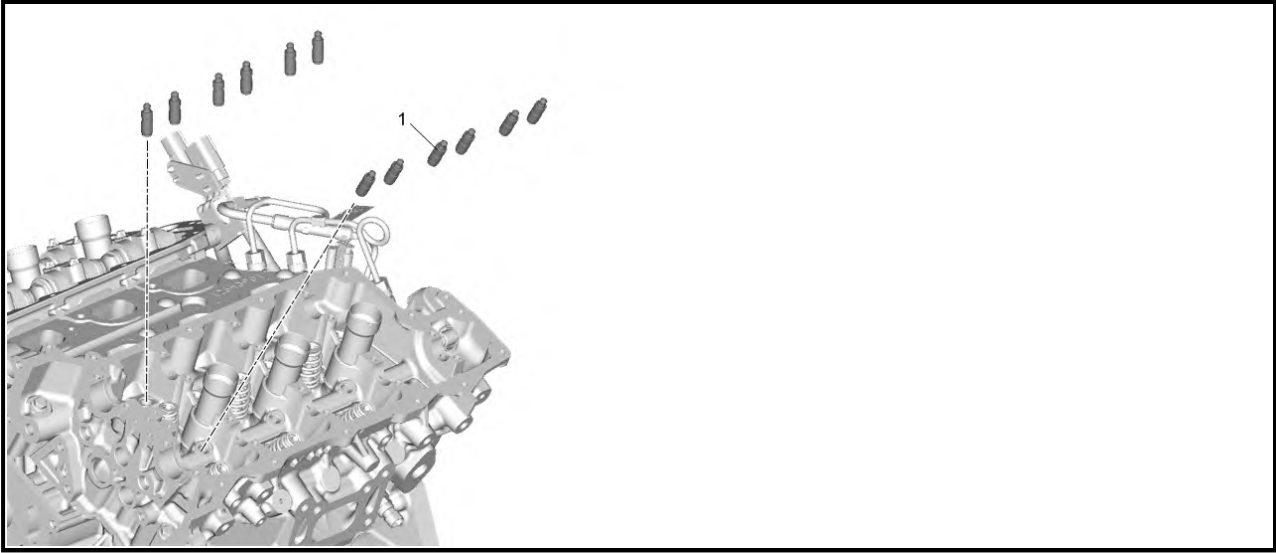
Remove the fuel rail and injectors (1) as an assembly using the EN-49248 Injector Rail Assembly Remover.

VALVE ROCKER ARM REMOVAL - LEFT SIDE



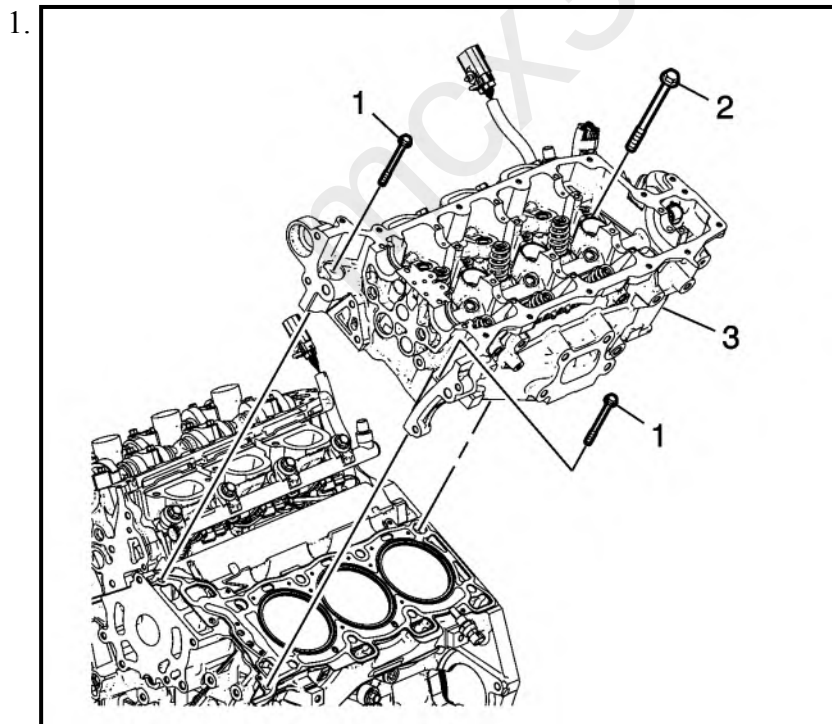
Callout	Component Name
1	Valve Rocker Arm NOTE: If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.

VALVE LIFTER REMOVAL - LEFT SIDE



Callout	Component Name
1	Hydraulic Valve Lash Adjuster NOTE: • Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber. • Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill. • If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

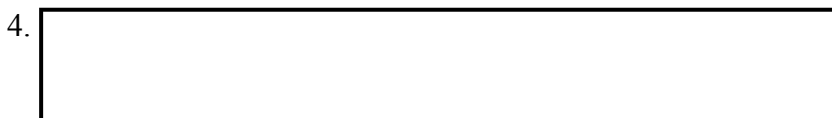
CYLINDER HEAD REMOVAL - LEFT SIDE

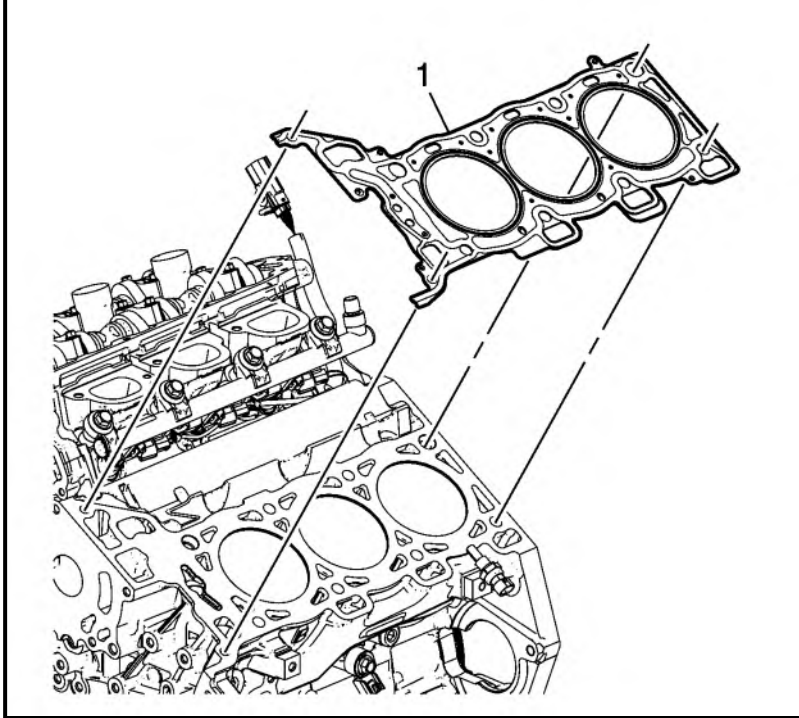


Remove the two front M8 left cylinder head bolts (1) and discard.

2. Remove the left cylinder head bolts (2) and discard.

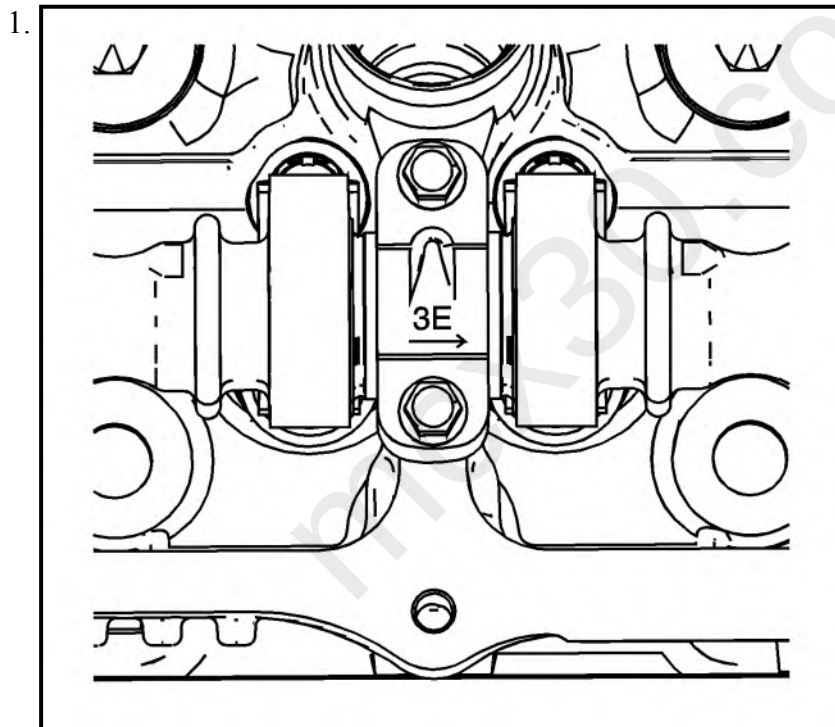
3. Remove the left cylinder head (3).





Remove and discard the left cylinder head gasket (1).

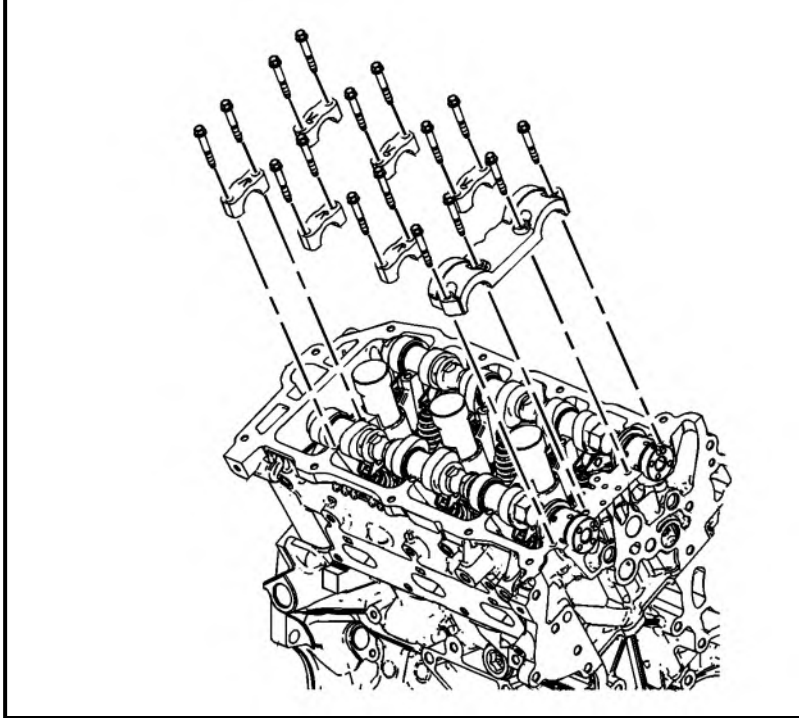
CAMSHAFT REMOVAL - RIGHT SIDE



Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:

- The raised feature must always be oriented toward the center of the cylinder head.
- The I indicates the intake camshaft.
- The E indicates the exhaust camshaft.
- The number indicates the journal position from the front of the engine.

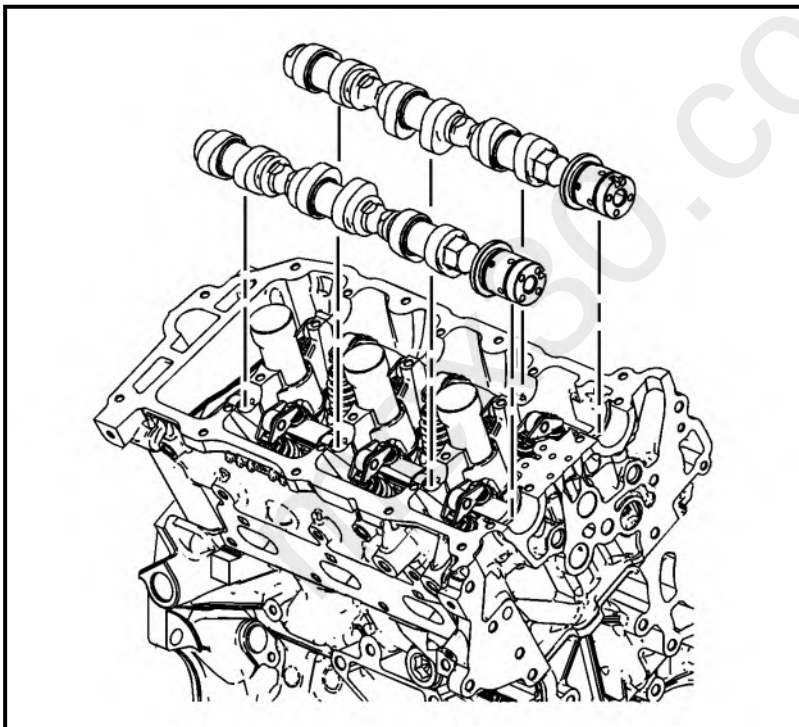




Remove the camshaft bearing cap bolts.

3. Remove the camshaft bearing caps.

4.

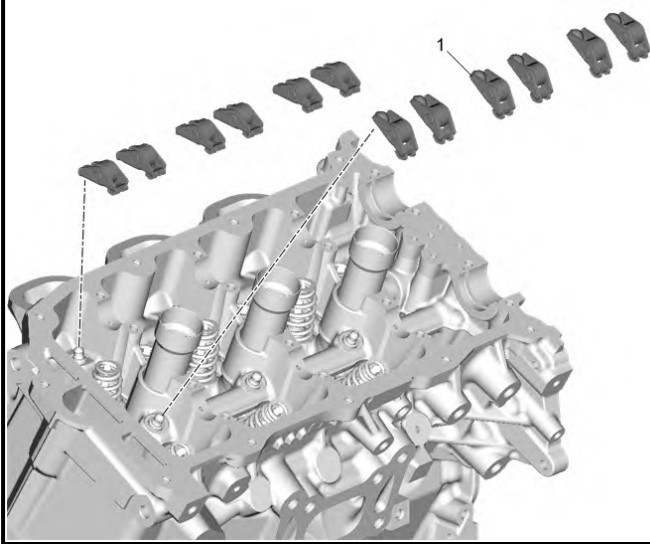


IMPORTANT: Mark the camshafts upon removal to ensure installation is in the correct position.

Remove the camshafts.

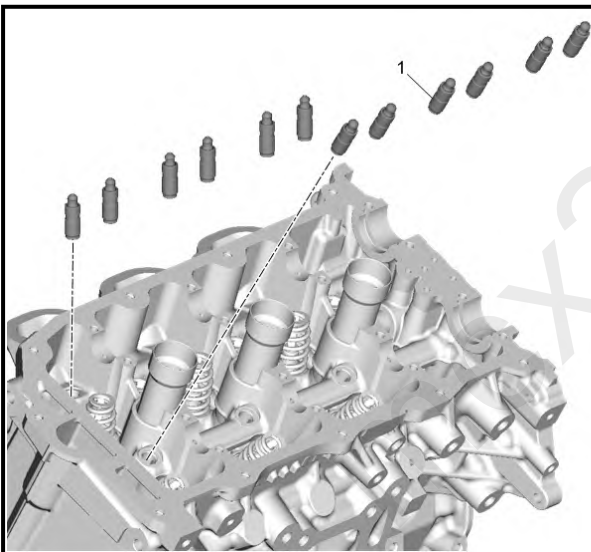
VALVE ROCKER ARM REMOVAL - RIGHT SIDE





Callout	Component Name
1	Valve Rocker Arm NOTE: If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.

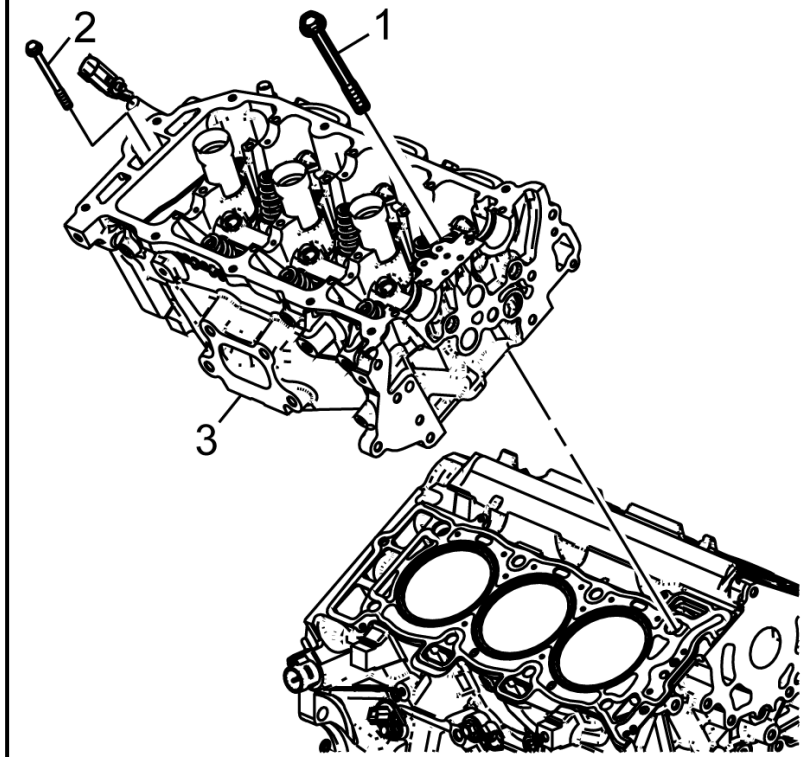
VALVE LIFTER REMOVAL - RIGHT SIDE



Callout	Component Name
1	Hydraulic Valve Lash Adjuster NOTE: - Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber. - Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill. - If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

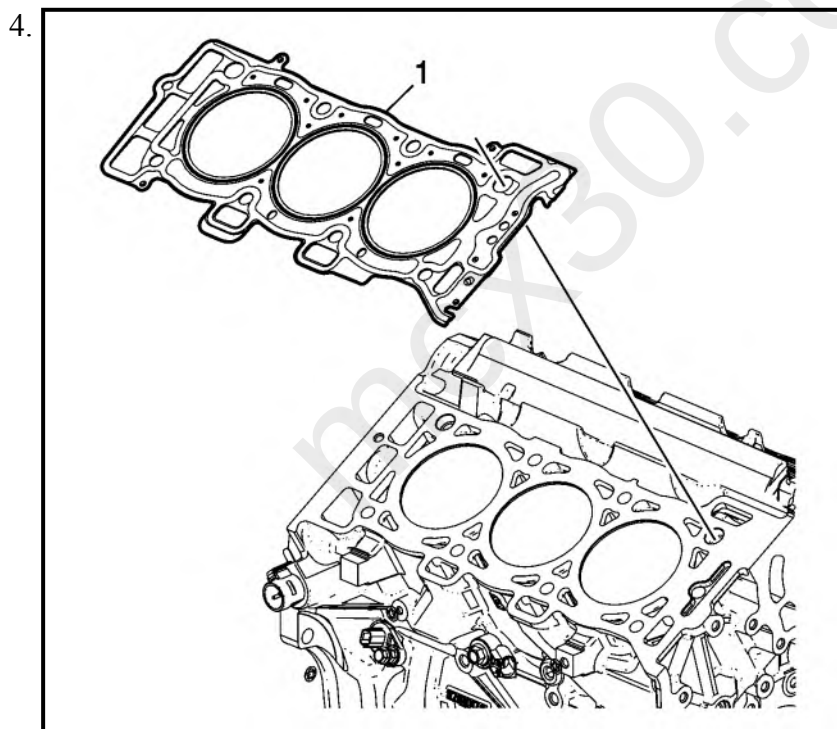
CYLINDER HEAD REMOVAL - RIGHT SIDE

-



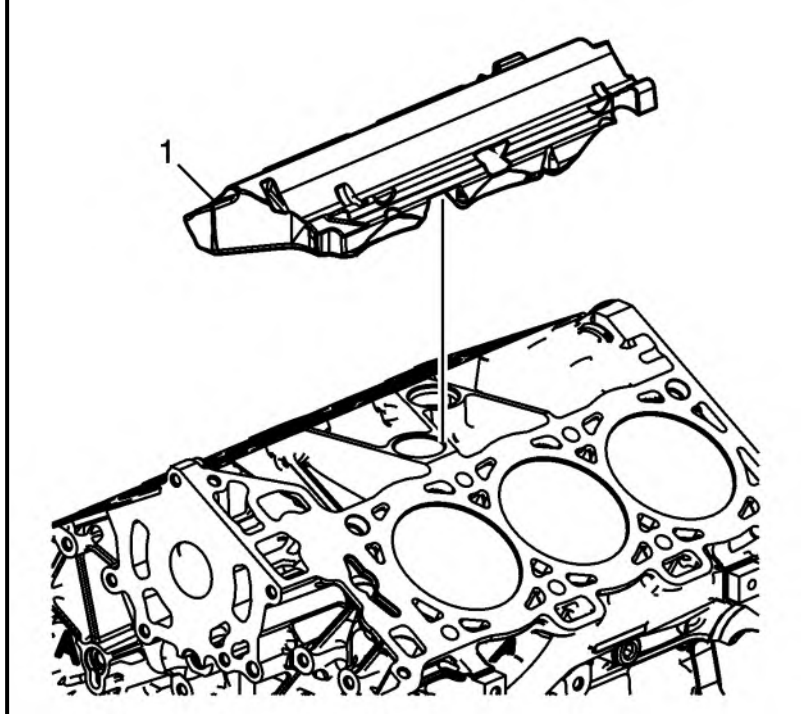
Remove the right cylinder head bolts (1) and discard.

2. Remove the M8 right cylinder head bolts (2) and discard.
3. Remove the right cylinder head (3).



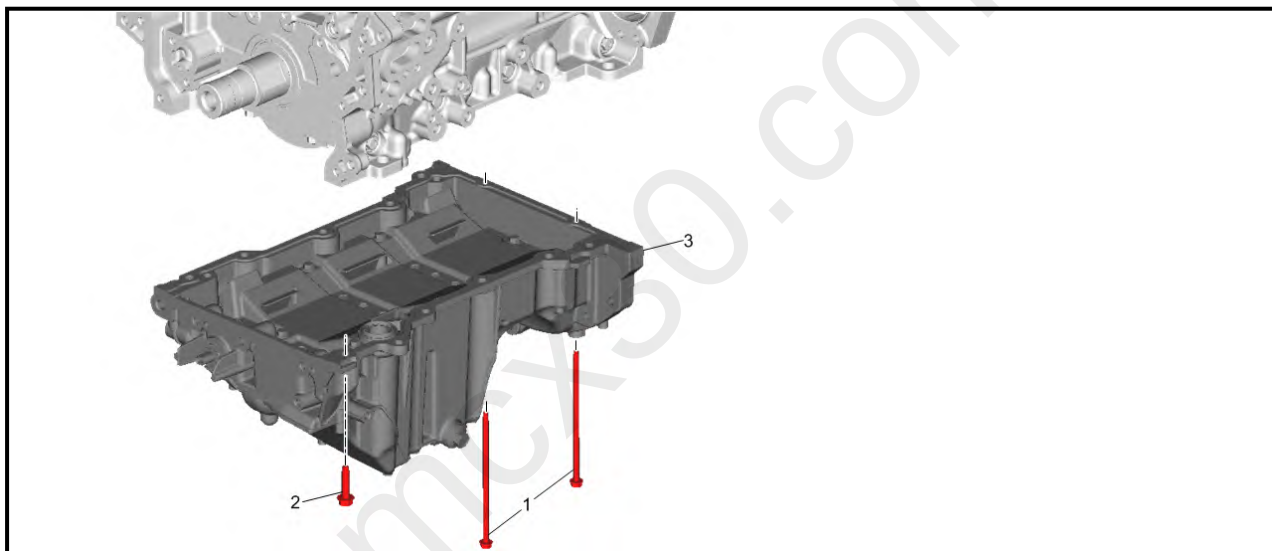
Remove and discard the right cylinder head gasket (1).





Remove the fuel injection fuel rail noise shield-lower (1).

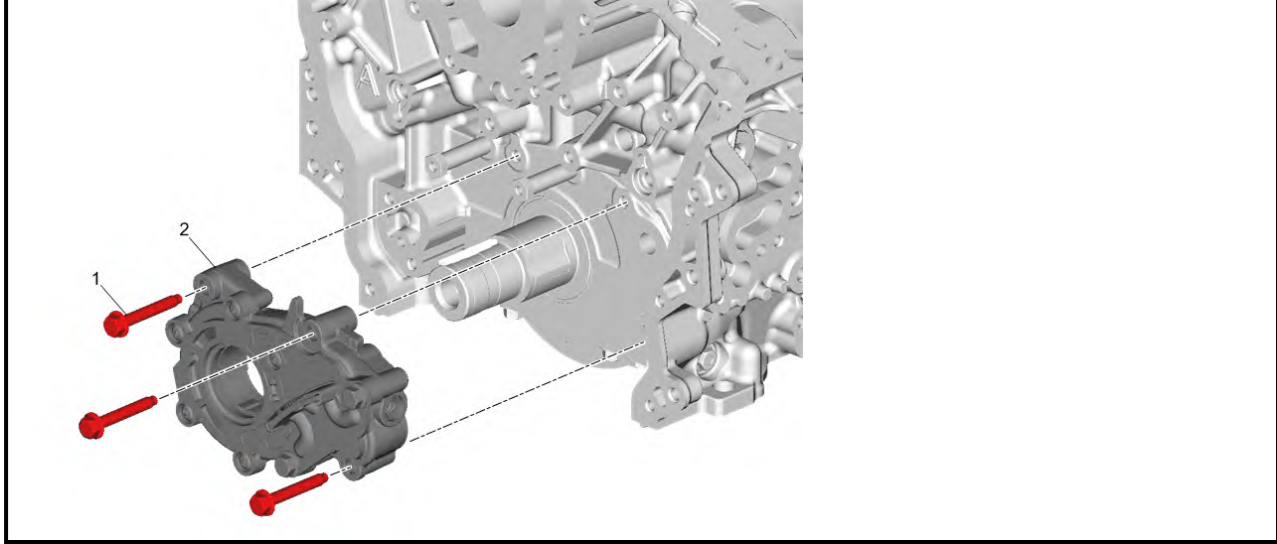
OIL PAN REMOVAL



Callout	Component Name
1	Oil Pan Bolt [2x]
2	Oil Pan Bolt [11x]
3	Oil Pan

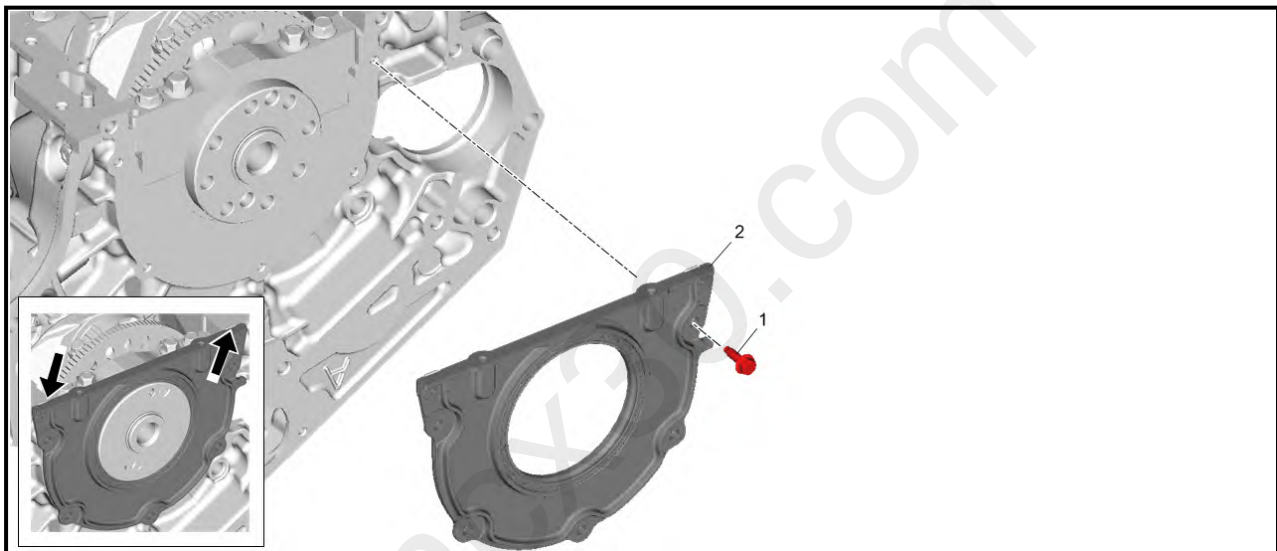
OIL PUMP REMOVAL





Callout	Component Name
1	Oil Pump Bolt [3x]
2	Oil Pump

CRANKSHAFT REAR OIL SEAL AND HOUSING REMOVAL



Callout	Component Name
1	Crankshaft Rear Oil Seal Housing Bolt
2	Crankshaft Rear Oil Seal Housing

2	Procedure • Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant • Use the pry points located at the edge of the crankshaft rear oil seal housing to separate the RTV sealant. • Remove and DISCARD the crankshaft rear oil seal housing.
---	---

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Special Tools

EN 46121 Connecting Rod Guide Pin Set

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

NOTE:

- An arrow/dot showing proper piston orientation is located on

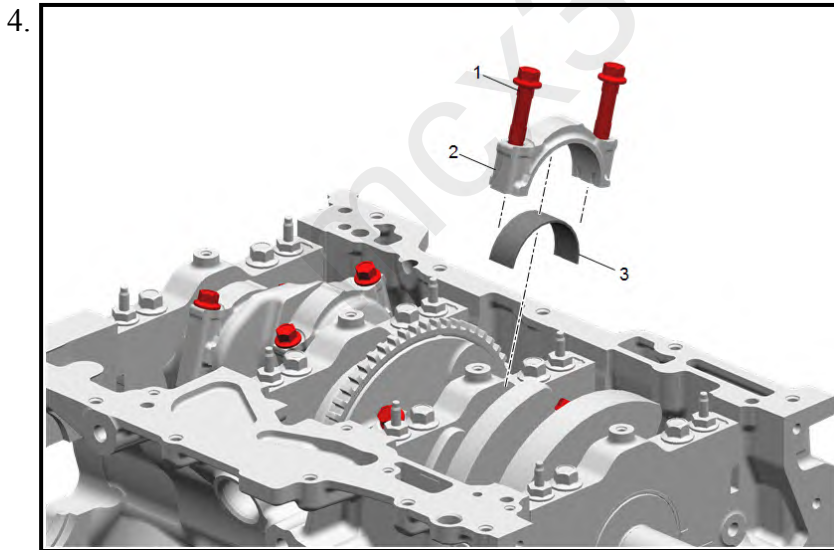
the top of the piston.

- If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.

1. Before removing the connecting rods, check the connecting rod side clearance using the following procedure:
 1. Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer.
 2. Using feeler gauges, measure the clearance between the crankshaft counterweight and the connecting rod.
 3. The connecting rod side clearance should not exceed specifications. Refer to [Engine Mechanical Specifications](#).
 4. If the end play exceeds the specified limits, measure the width of the crankpin end of the connecting rod. Refer to [Piston, Connecting Rod, and Bearing Cleaning and Inspection](#).
 5. If the connecting rod width is significantly smaller than specified and severe wear is present on the side of the connecting rod, replace the connecting rod.
 6. If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft.
2. Using a marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine.

CAUTION: Do not use a stamp, punch or any other method that may distort or stress the connecting rod or connecting rod cap. Extensive engine damage may result from a connecting rod that is distorted or stressed.

3. Mark the cylinder number on the connecting rod and the connecting rod cap with a scribe, paint stick or permanent marker.



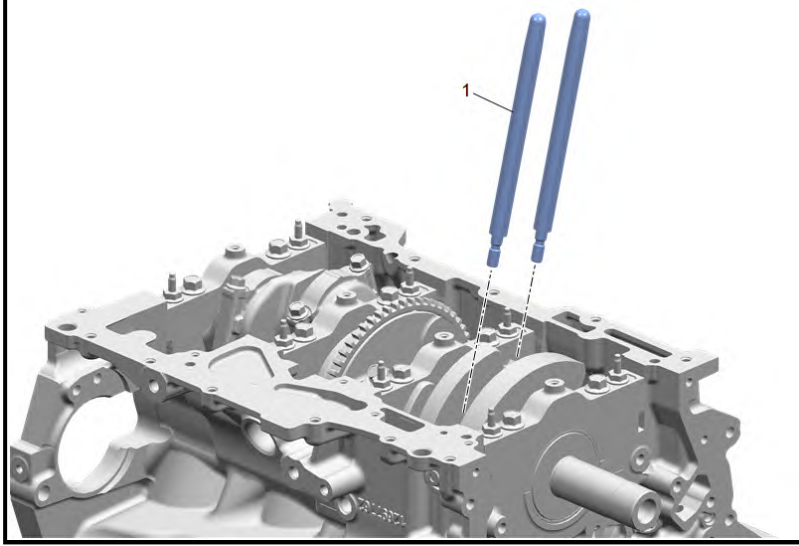
CAUTION: Powdered metal connecting rods have rod bolts which yield when torqued. If the rod bolts are loosened or removed the rod bolts must be replaced. Rod bolts that are not replaced will not torque to the correct clamp load and can lead to serious engine damage.

Remove the connecting rod bolts.

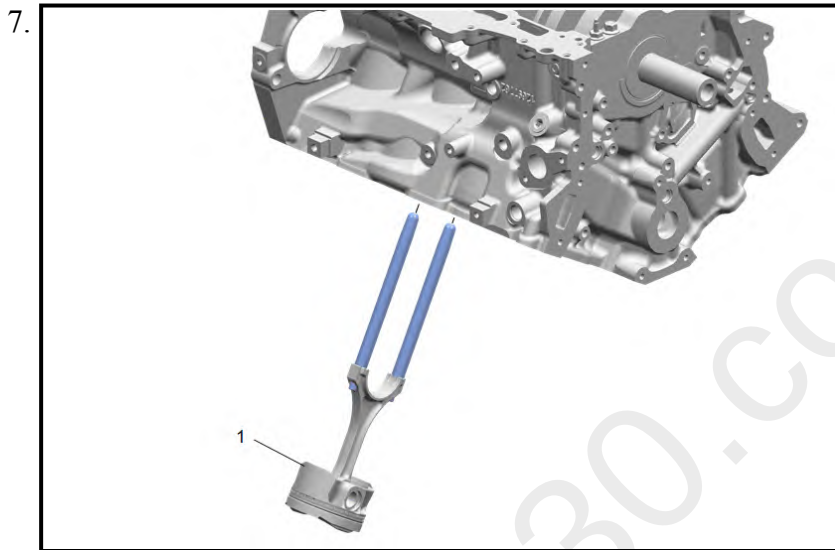
NOTE: The connecting rod caps must remain with the original connecting rod.

5. Remove the connecting rod cap.

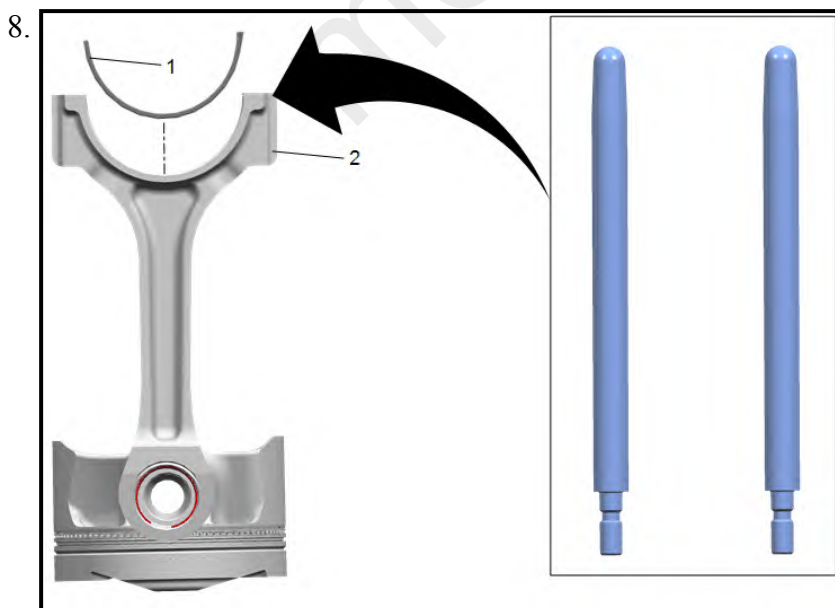
6.



Install the **EN 46121** set into the connecting rod bolt holes.

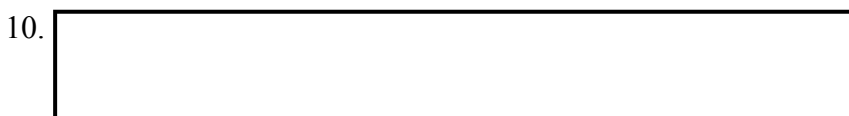


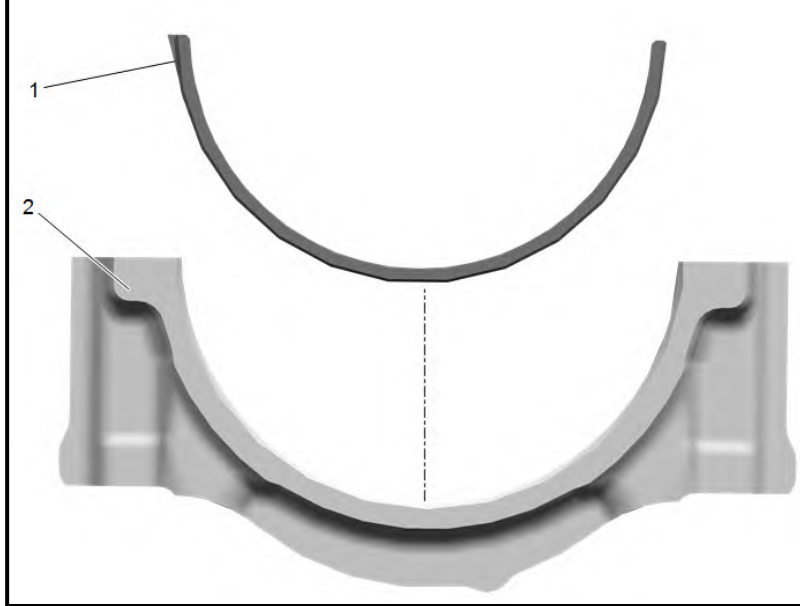
Using the **EN 46121** set, push the connecting rod and piston assembly through the top of the cylinder. **DO NOT** scratch the crankshaft journal or cylinder wall and **DO NOT** damage the oil jets when removing the connecting rod and piston assembly.



Remove the **EN 46121** set from the connecting rod bolt holes.

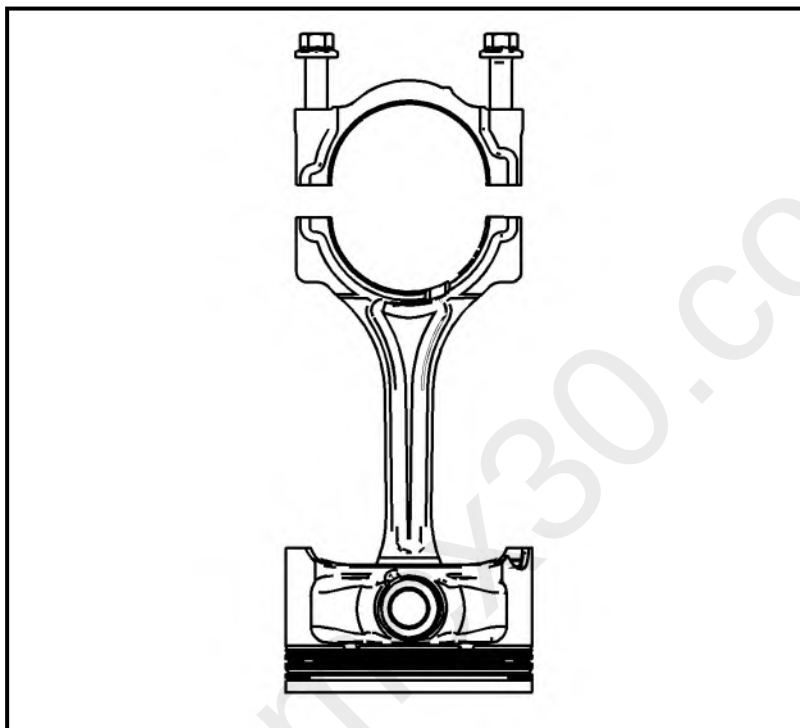
9. Remove the upper connecting rod bearing from the connecting rod.





Remove the lower connecting rod bearing from the connecting rod cap.

11.



Reattach the connecting rod cap to the connecting rod to prevent damage to their mating surfaces. The cap and rod are a matched set and must be kept together.

CRANKSHAFT AND BEARING REMOVAL

Special Tools

- **GE 6125-1B** Slide Hammer Adapter
- **EN 49102** Crankshaft Bearing Cap Remover

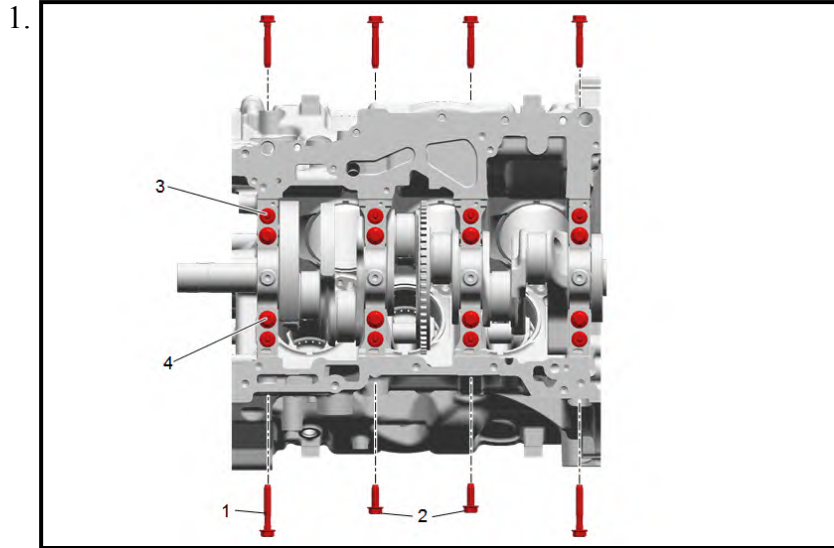
For equivalent regional tools, refer to [Special Tools](#) .

Crankshaft End Play Measurement

1. Place a dial indicator at the crankshaft nose.
2. Gently force the crankshaft to the extreme front and rear positions with a pry tool while monitoring the movement of the dial indicator.
3. The crankshaft end play should not exceed specifications. Refer to [Engine Mechanical Specifications](#) .
4. If the specifications are exceeded inspect the thrust bearing thrust OD and the crankshaft thrust wall for wear and/or excessive runout. Refer to [Engine Mechanical Specifications](#) .

5. Replace the thrust bearing or crankshaft as necessary.

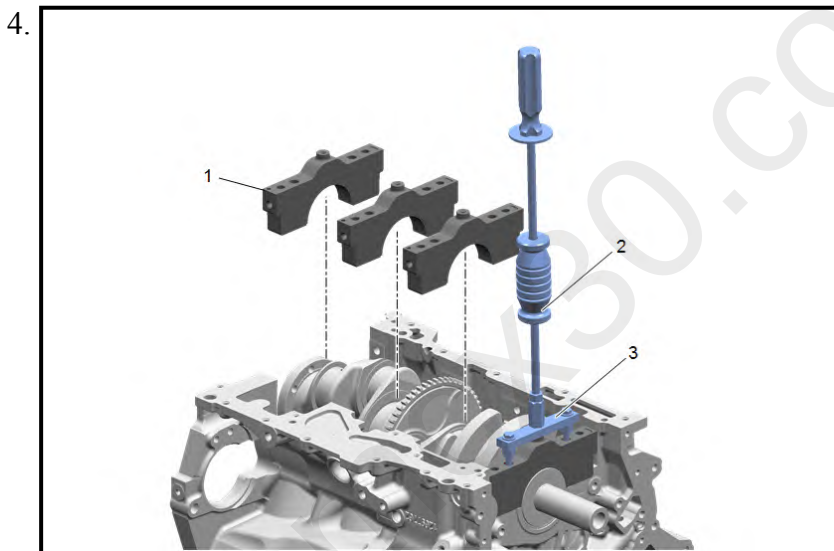
Crankshaft Removal



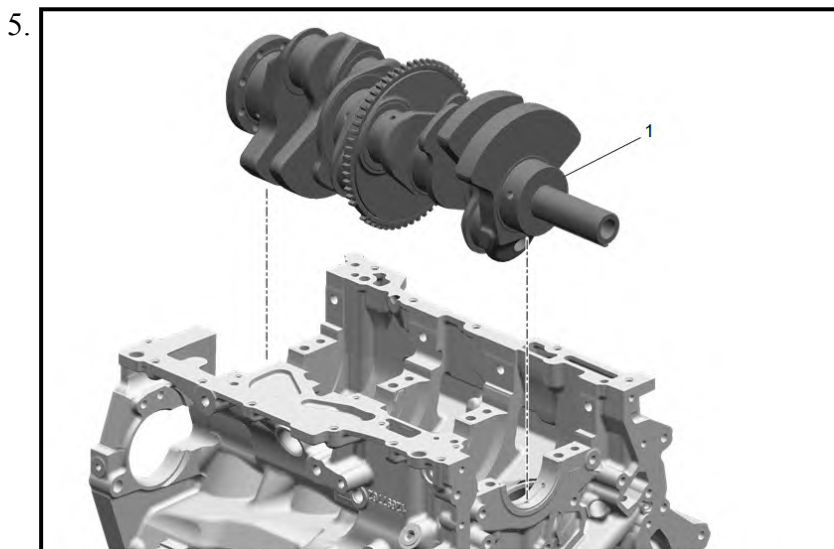
Remove the crankshaft bearing cap side bolts.

2. Remove the crankshaft bearing cap outer bolts.

3. Remove the crankshaft bearing cap inner bolts.

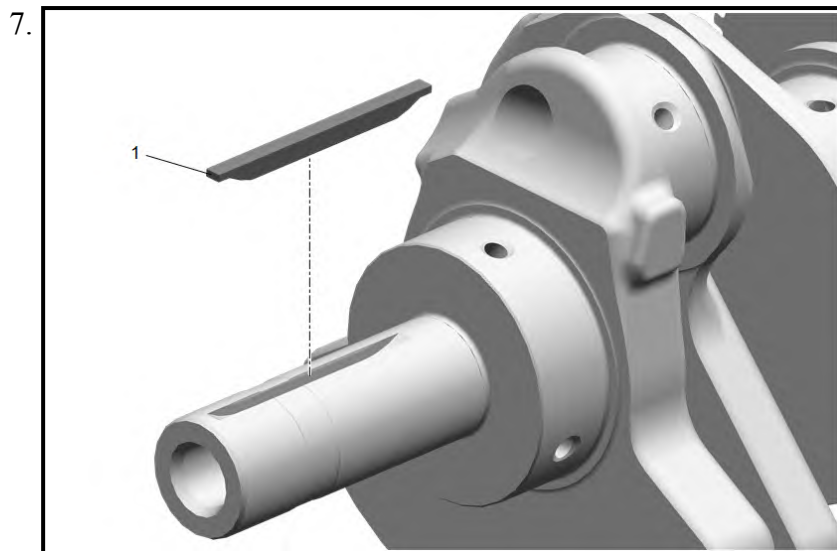


Remove the crankshaft bearing caps using the **GE 6125-1B** adapter (1) and **EN 49102** remover (2).



Using two hands, lift the crankshaft straight up from the engine block.

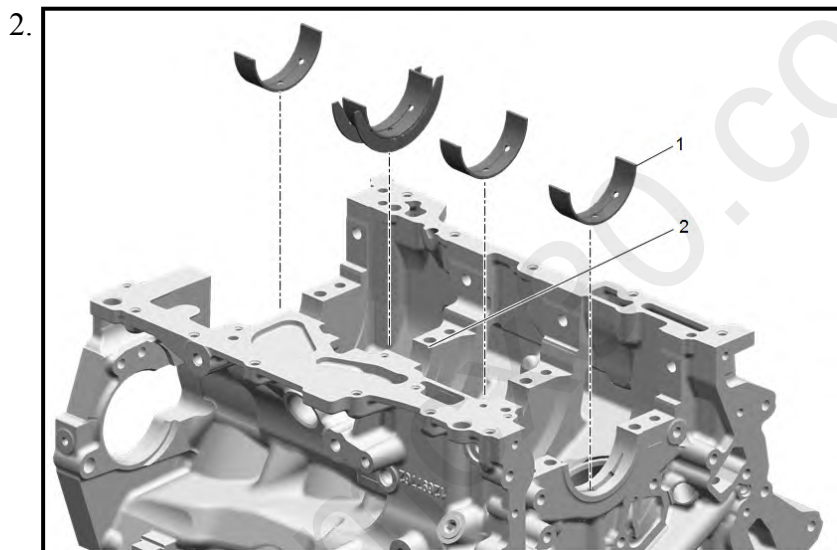
6. Place the crankshaft in a secure place.



Remove the crankshaft key from the nose of the crankshaft, if damaged.

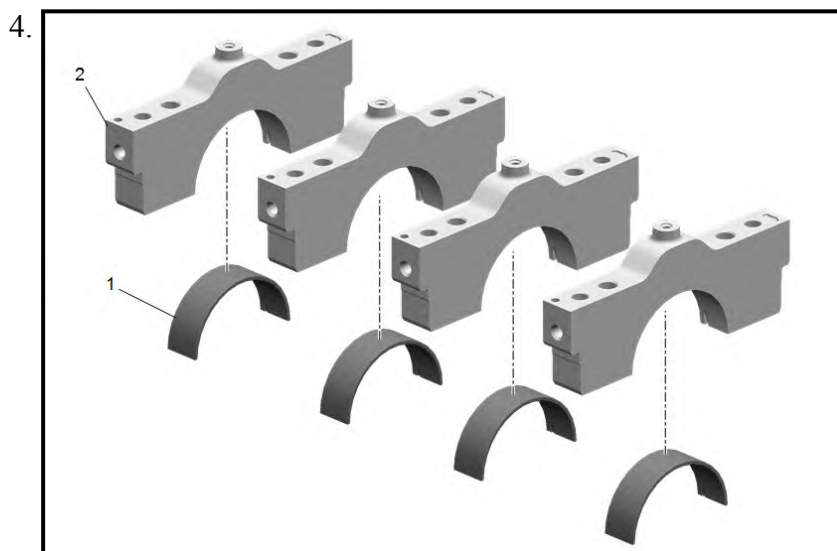
Crankshaft Bearing Removal

1. Prepare a piece of cardboard or equivalent, numbered 1 - 4 for bearing identification. Main bearing journals are numbered from the front of the engine.



Remove the crankshaft upper bearing halves from the cylinder block. Note the position of the thrust bearing (1) at the number 3 journal (2).

3. Place the crankshaft upper bearing halves on the cardboard in the correct positions. Note that the number 3 bearing is the thrust bearing.

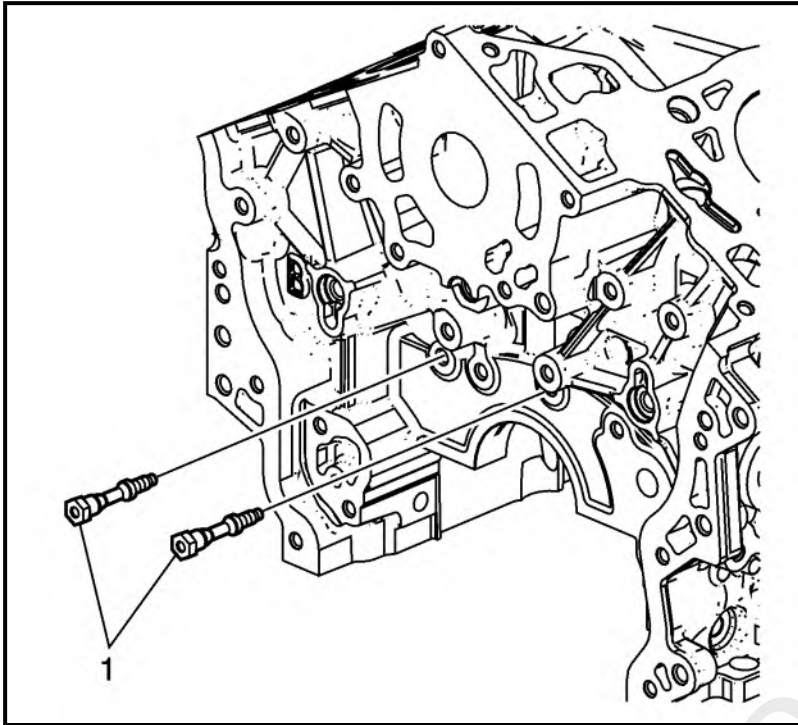


Remove the crankshaft lower bearing halves from the crankshaft bearing caps.

5. Place the crankshaft lower bearing halves in the correct positions on the cardboard.

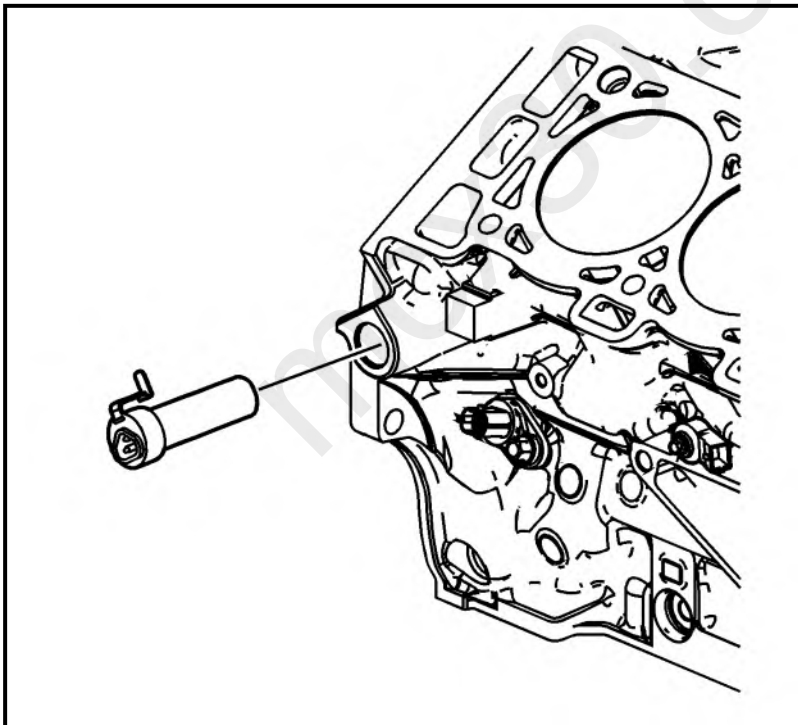
ENGINE BLOCK DISASSEMBLE

1.



Remove the engine front cover studs (1).

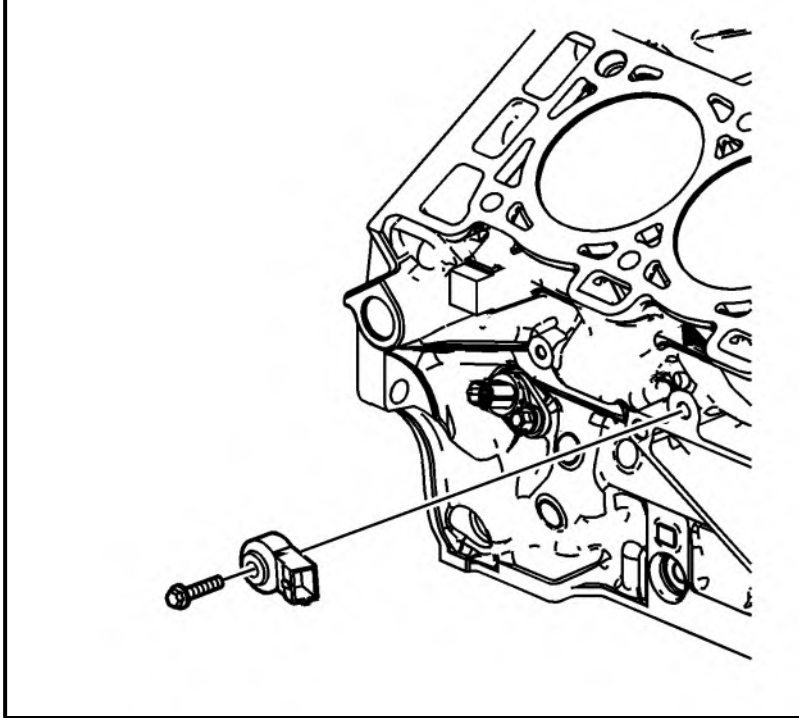
2.



Remove the block heater cartridge, if equipped.

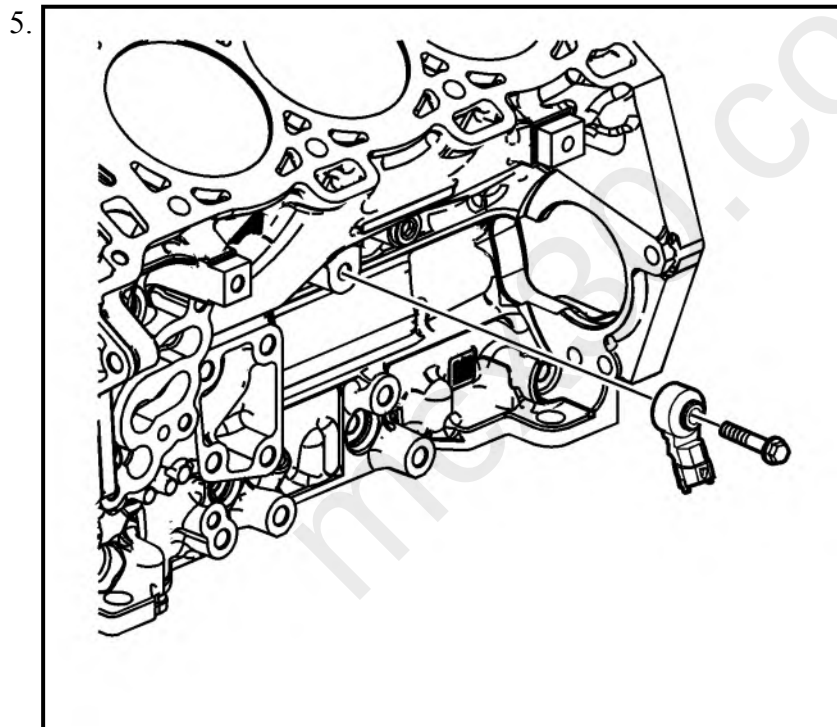
3.





Remove the right knock sensor bolt.

4. Remove the right knock sensor.

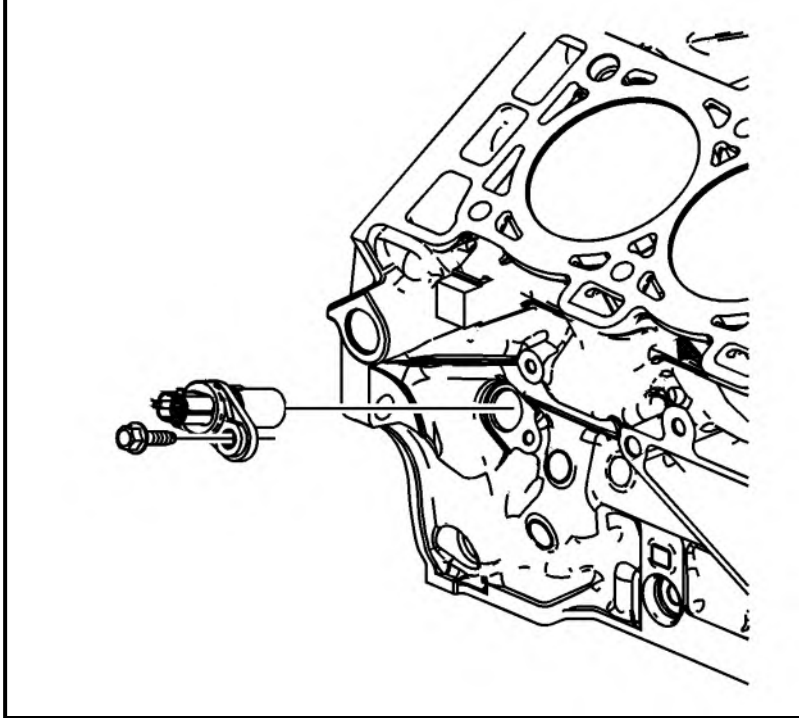


Remove the left knock sensor bolt.

6. Remove the left knock sensor.

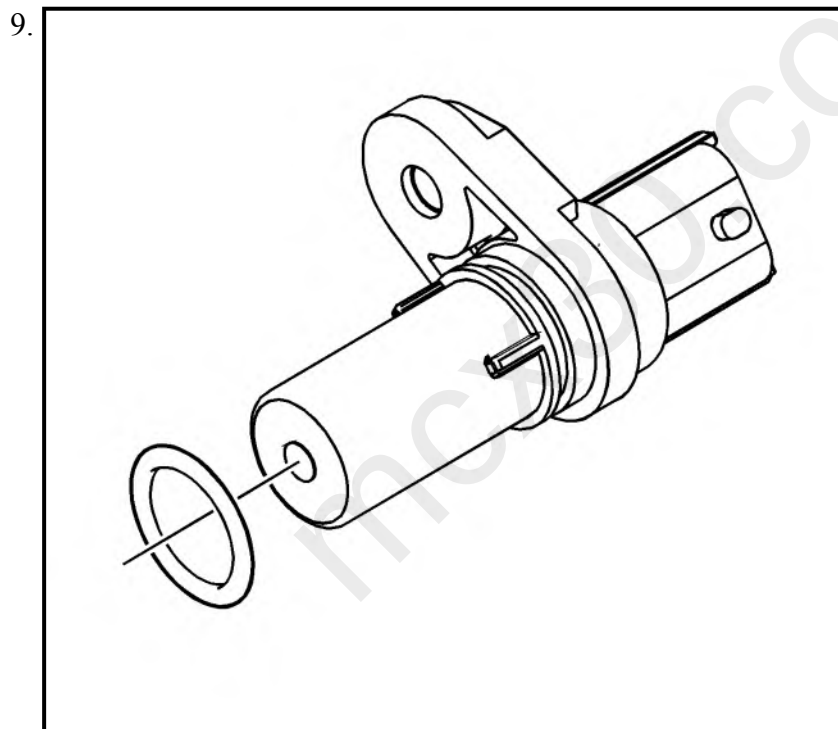


7.



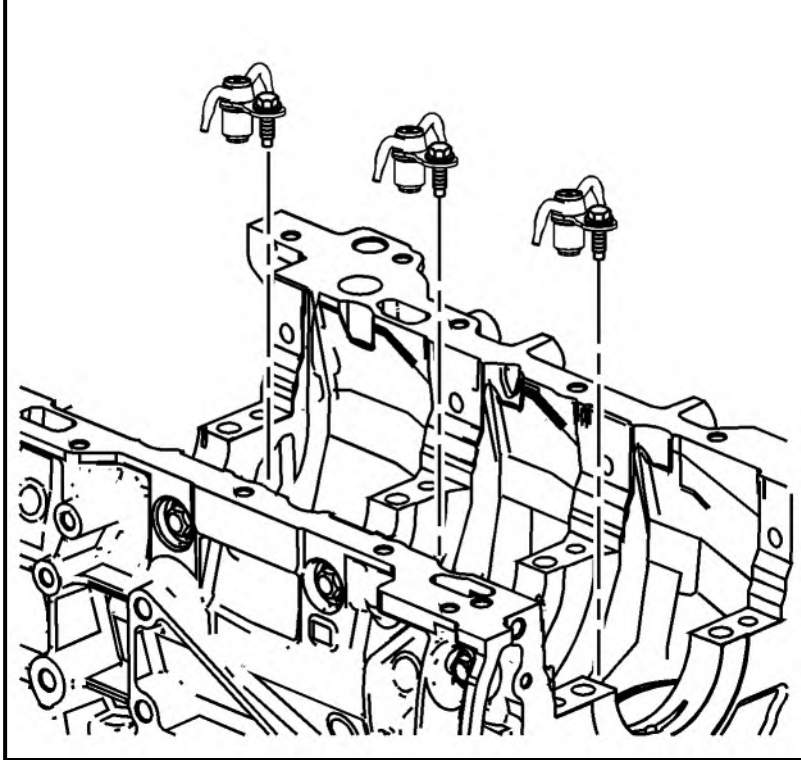
Remove the crankshaft position sensor bolt.

8. Remove the crankshaft position sensor.



Remove the crankshaft position sensor O-ring, if damaged.

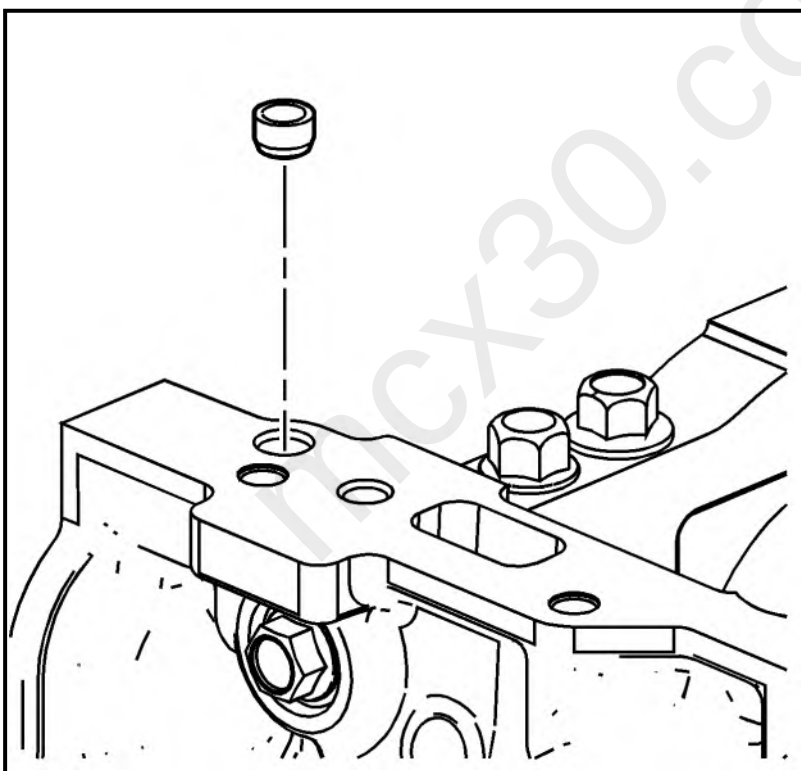
10.



Remove oil jet bolts.

11. Remove oil jets.

12.



Remove the right front oil pan rail oil gallery expansion plug.

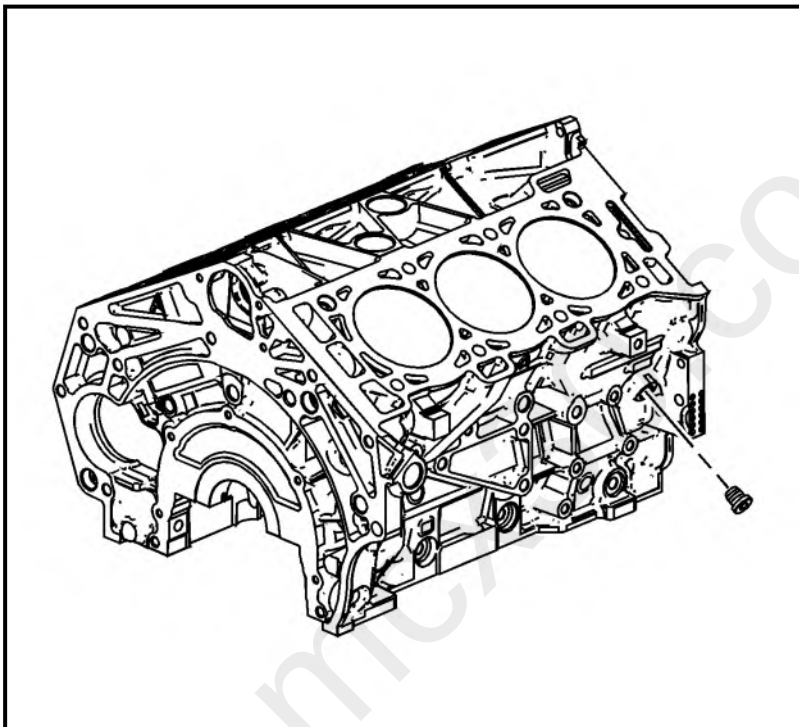
13.



No Image
Available

Remove the cylinder block-to-oil pan alignment dowels.

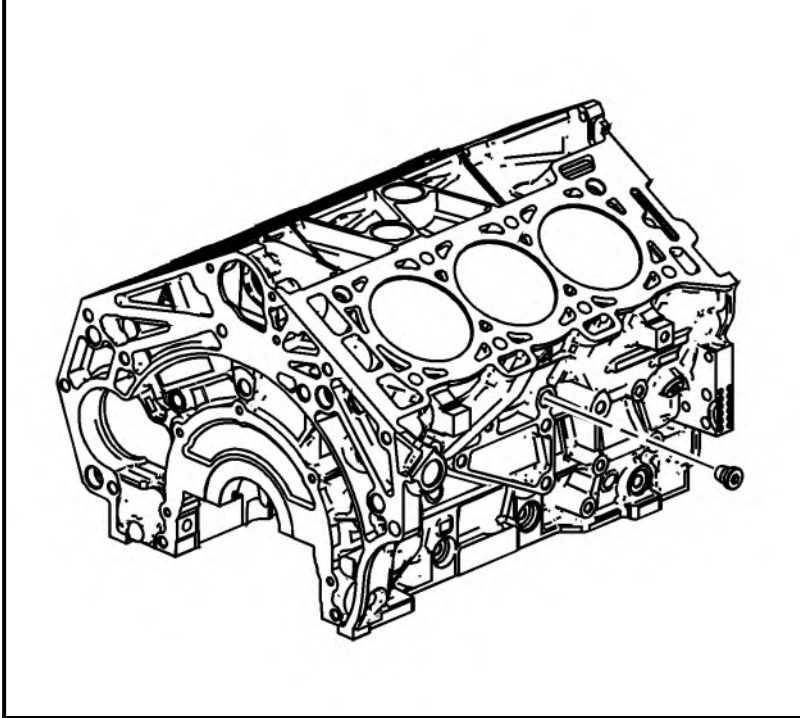
14.



Remove the M14 right side oil gallery threaded plug.

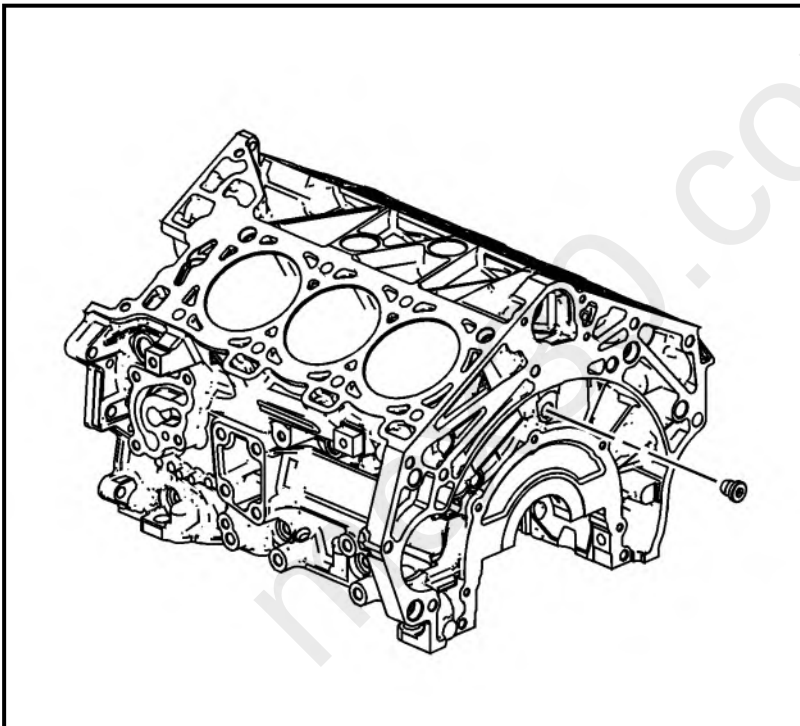
15.





Remove the M14 right side coolant drain threaded plug.

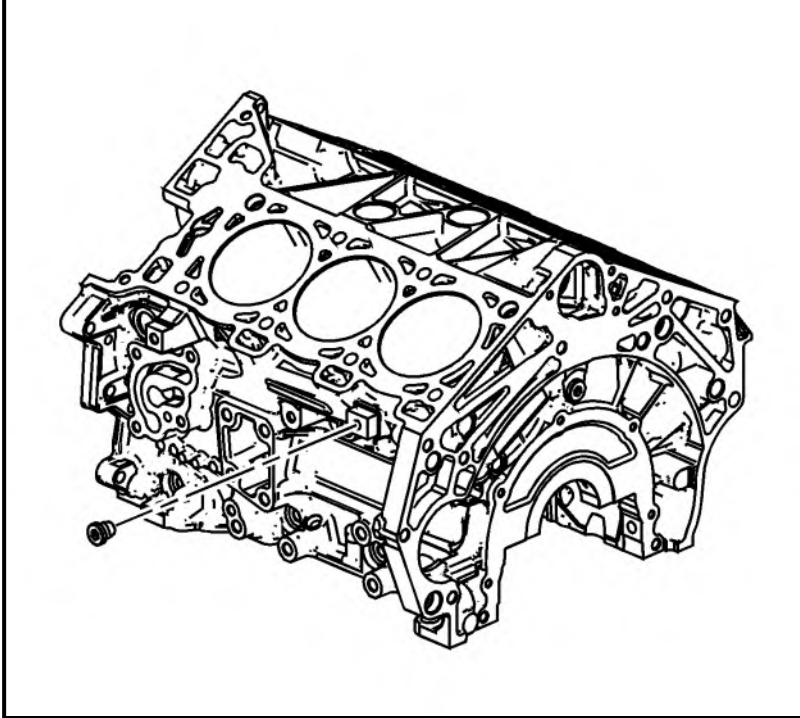
16.



Remove the M14 rear oil gallery threaded plug.

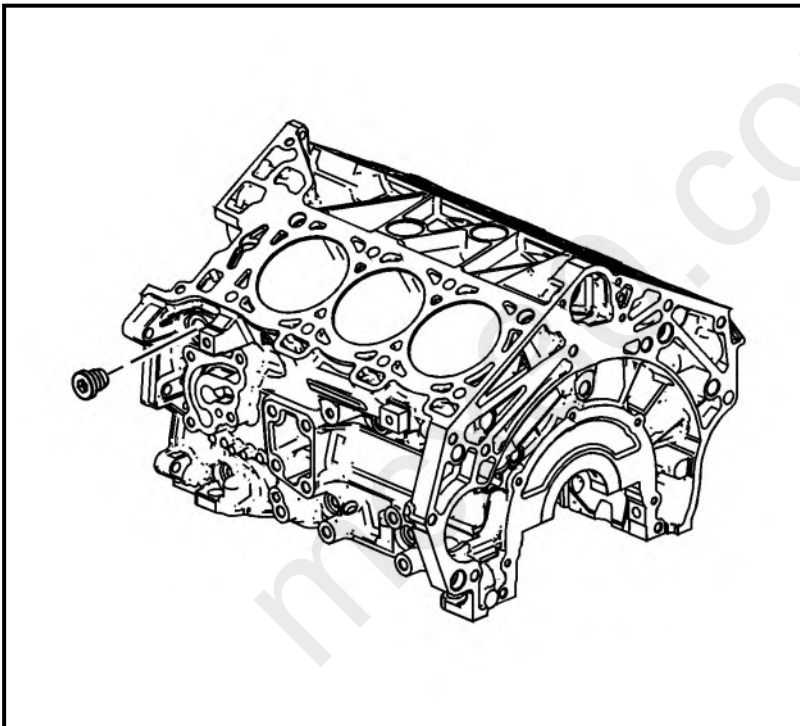
17.





Remove the M14 left side coolant drain threaded plug.

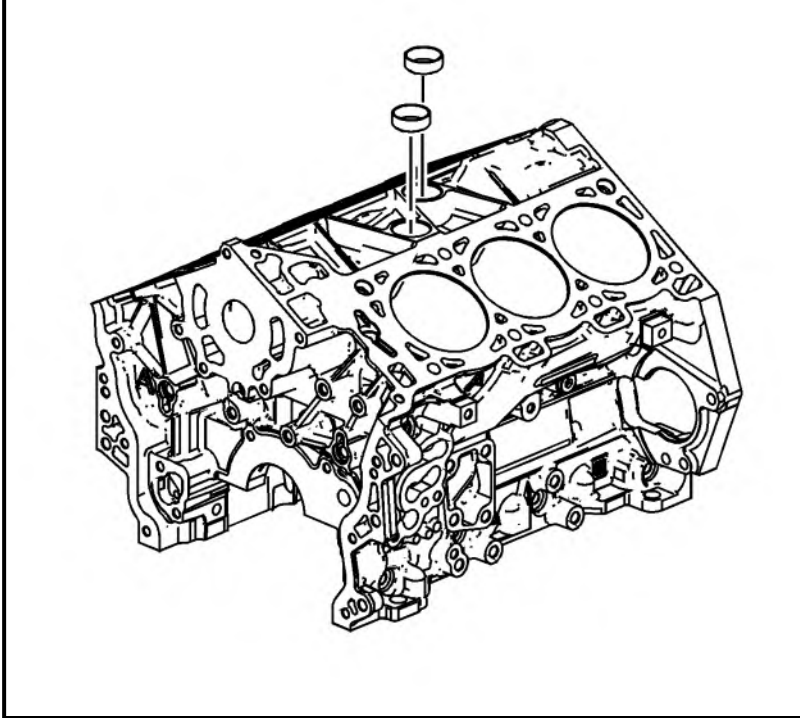
18.



Remove the M20 left side oil gallery threaded plug.

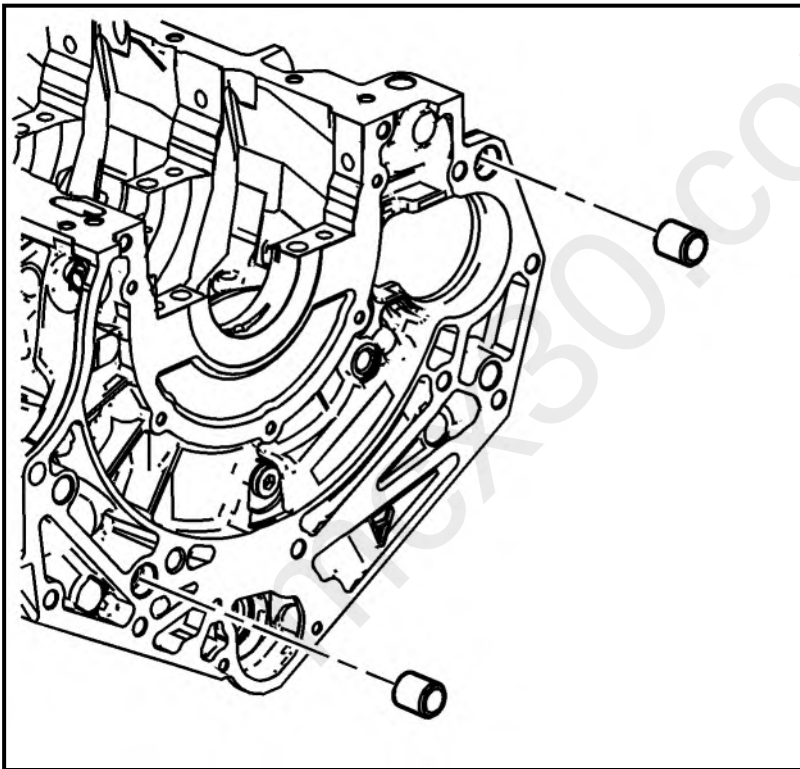
19.





Remove the coolant expansion plugs.

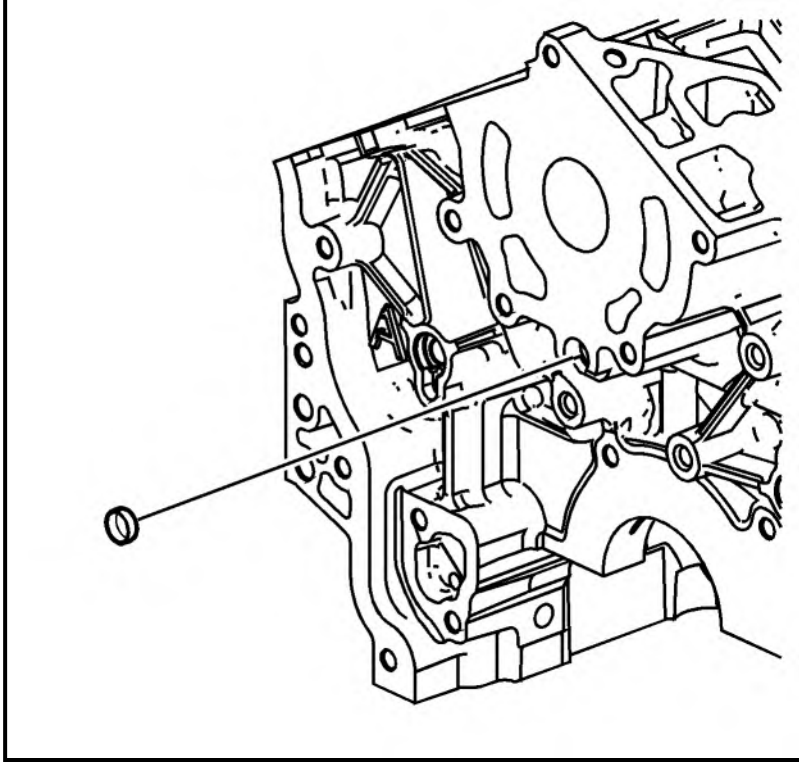
20.



Remove the cylinder block-to-transmission alignment dowels.

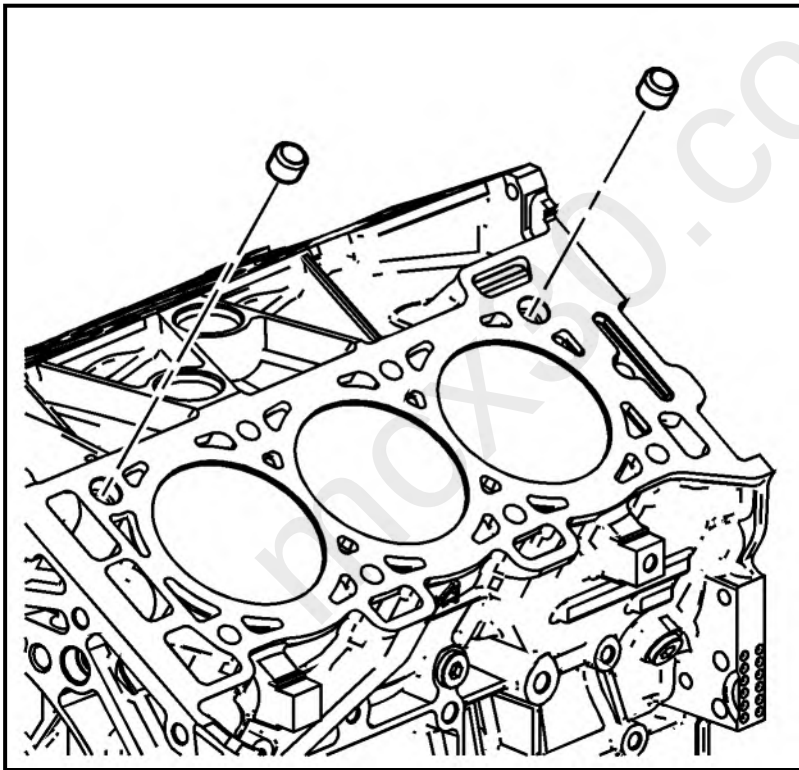
21.





Remove the front oil gallery expansion plug.

22.



Remove the cylinder block-to-cylinder head alignment dowels.

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- EN - 8087 Cylinder Bore Gauge
- EN - 28410 Gasket Remover

Equivalent regional tools: [Special Tools](#)

Cleaning Procedure

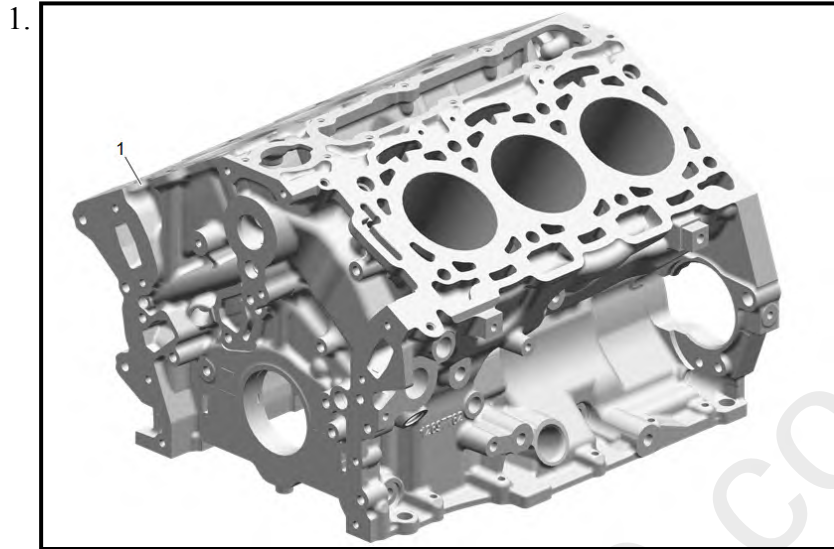
1. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)
2. Remove any old thread sealant, gasket material or sealant using EN - 28410 Gasket Remover.

3. Clean all the following areas with solvent:
 - Sealing surfaces
 - Cooling passages
 - Oil passages
 - Bearing journals
4. Clean all threaded and through holes with solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

5. Dry the engine block with compressed air.

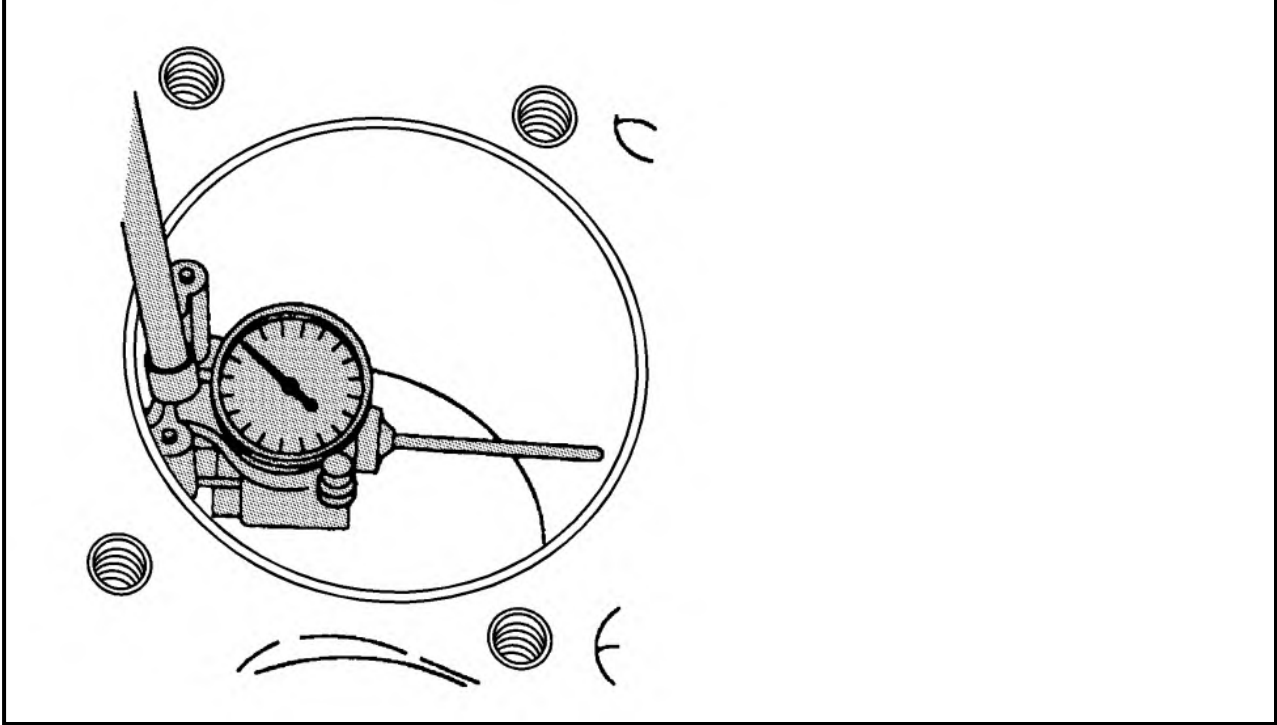
Visual Inspection



- Inspect the crankshaft bearings journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the engine block must be replaced.
2. Inspect the primary camshaft drive chain tensioner mounting surface on the engine block for burrs or any defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.
 3. Inspect all sealing and mating surfaces for damage, repair or replace the engine block if necessary.
 4. Inspect all threaded and through holes for damage or excessive debris.
 5. Inspect all bolts for damage, if damaged replace with NEW bolts only.
 6. Check the cylinder condition. Some light vertical marks may be visible on the cylinder wall. In these areas, check that the honing marks are still visible in this marked area. If they are, the cylinder surface has not been compromised and the engine block can be used.
 7. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the engine block must be replaced.
 8. Inspect the engine block for cracks. Do not repair any cracks. If cracks are found, the engine block must be replaced.
 9. Repair any damaged threaded holes. [Thread Repair Specifications](#) , and [Thread Repair](#)

Measuring Cylinder Bore Diameter





Measure the cylinder bore diameter 37 mm (1.457 in) from the deck face using the **EN - 8087** gauge.

Compare your results with the [Engine Mechanical Specifications](#) . If the cylinder diameter exceeds the specifications, the engine block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Measuring Cylinder Bore Taper

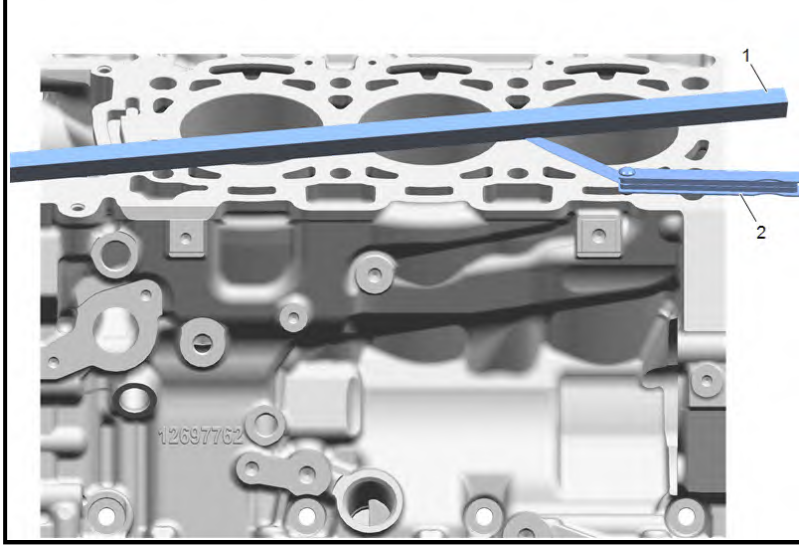
1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.397 in) below the deck surface and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.976 in) below the deck surface and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the [Engine Mechanical Specifications](#) . If the cylinders exceed the specifications, the engine block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Measuring Cylinder Bore Out-of-Round

1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.397 in) below the deck. Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.976 in) below the deck surface. Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the [Engine Mechanical Specifications](#) . If the cylinders exceed these specifications, the engine block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Deck Flatness Inspection

1.



Ensure the engine block decks are clean and free of gasket material.

2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Place a straight-edge diagonally across the engine block deck face surface.
4. Measure the clearance between the straight-edge and the engine block deck face using a feeler gauge at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the engine block deck surface does not require resurfacing.
6. If the warpage is between 0.05 - 0.20 mm (0.002 - 0.008 in) or any imperfections or scratches that could inhibit proper cylinder head gasket sealing are present, the engine block deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the engine block deck surface requires more than 0.25 mm (0.010 in) material removal the block must be replaced.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Cleaning Procedure

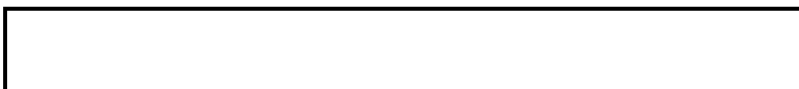
1. Clean the following components in solvent:
 - Crankshaft bearings
 - Connecting rod bearings
 - Crankshaft journals
 - Crankpin journals
 - Crankshaft oil passages
 - Crankshaft threaded holes

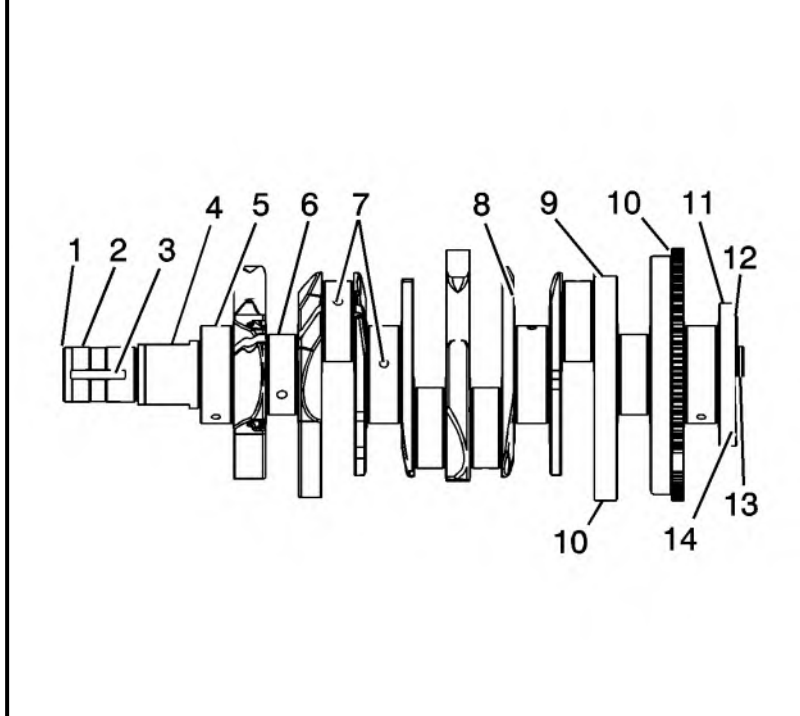
WARNING: Refer to Safety Glasses Warning .

2. Dry the following components with compressed air:
 - Crankshaft bearings
 - Connecting rod bearings
 - Crankshaft journals
 - Crankpin journals
 - Crankshaft oil passages
 - Crankshaft threaded holes

Visual Inspection

1.





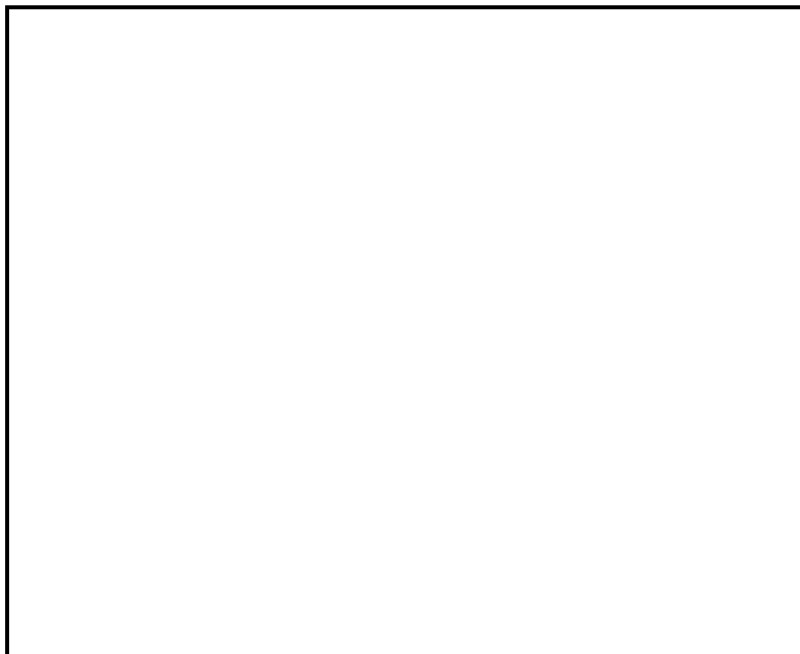
Perform the following visual inspections:

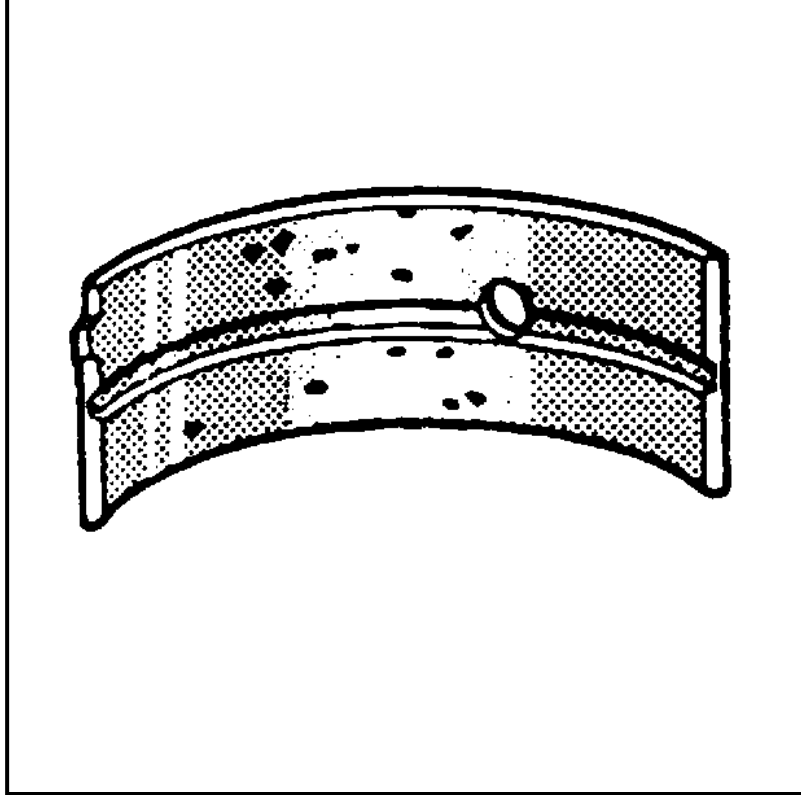
- Inspect the crankshaft balancer bolt hole (1) for thread damage.
- Inspect the crankshaft balancer mounting area (2) for damage.
- Inspect the crankshaft keyway (3) for damage.
- Inspect the oil pump drive flats (4) for damage.
- Inspect the crankshaft main journals (5) for damage.
- Inspect the crankshaft connecting rod journals (6) for damage.
- Inspect the crankshaft oil passages (7) for obstructions.
- Inspect the crankshaft main bearing thrust wall surfaces (8) for damage.
- Inspect the crankshaft counterweights (9) for damage.
- Inspect the crankshaft reluctor ring teeth (10) for damage.
- Inspect the crankshaft rear main oil seal surface (11) for damage.
- Inspect the crankshaft engine flywheel mounting surface (12) for damage.
- Inspect the crankshaft pilot hole (13) for damage.
- Inspect the crankshaft engine flywheel bolt holes (14) for thread damage.

2. Repair or replace the crankshaft as necessary.

Crankshaft Bearing Inspection

1.



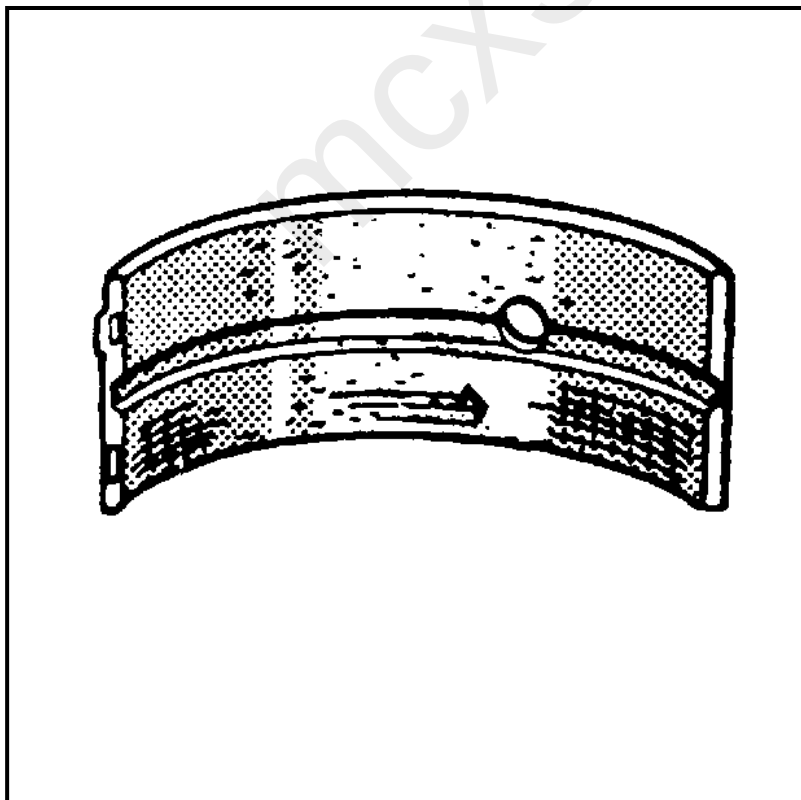


NOTE:

- All connecting rod and main journal bearings that have been used in a running engine must be replaced. Never re-use the crankshaft or connecting rod bearings.
- The following bearing wear conditions should be used to diagnose engine operating conditions or root cause of a condition.

Inspect for fatigue indicated by craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

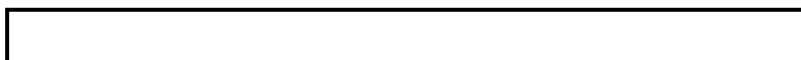
2.

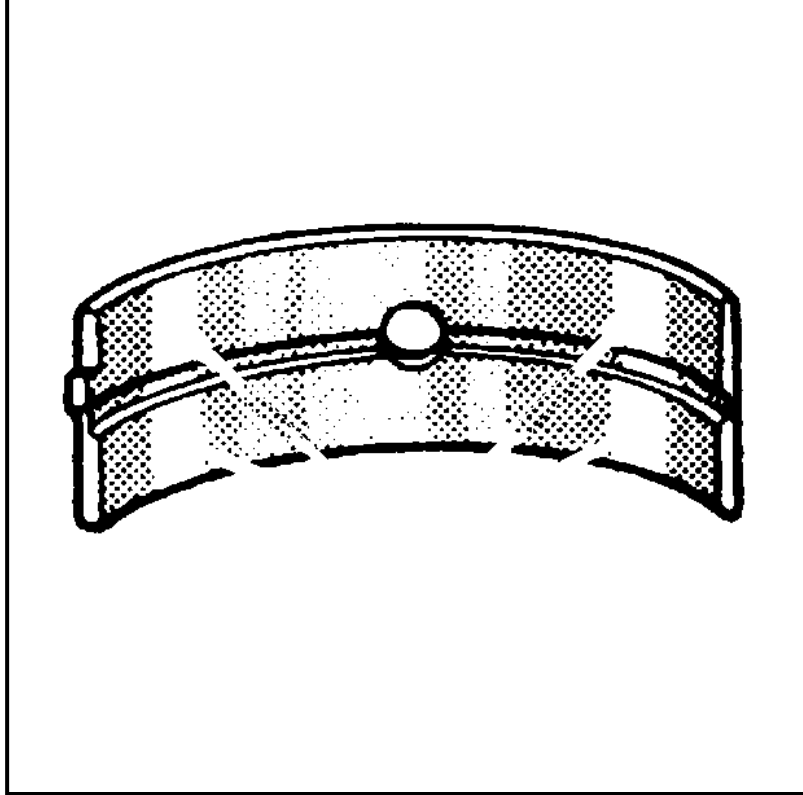


Inspect for excessive scoring or discoloration on both front and back of the bearing halves.

3. Inspect the main bearings for dirt embedded into the bearing material.

4.





Inspect for improper seating indicated by bright, polished sections.

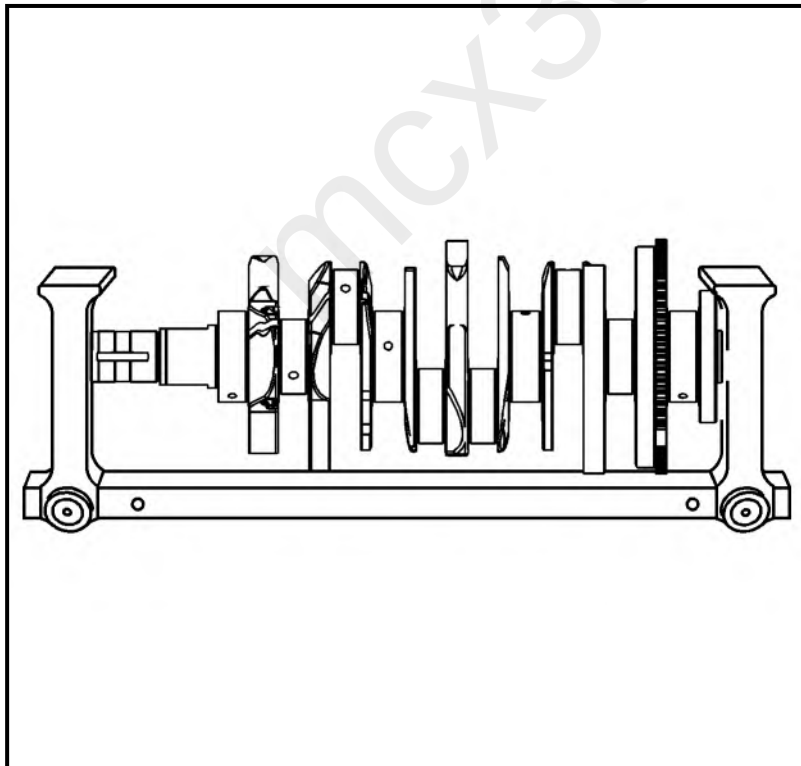
Crankshaft Measurement

Special Tools

GE 7872 Magnetic Base Dial Indicator

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

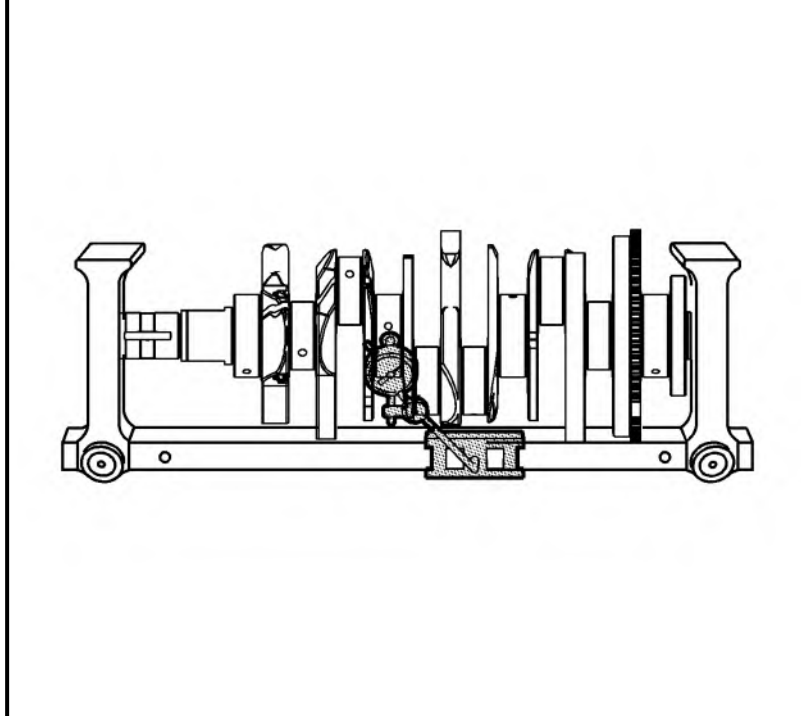
1.



Using a suitable fixture, support the crankshaft.

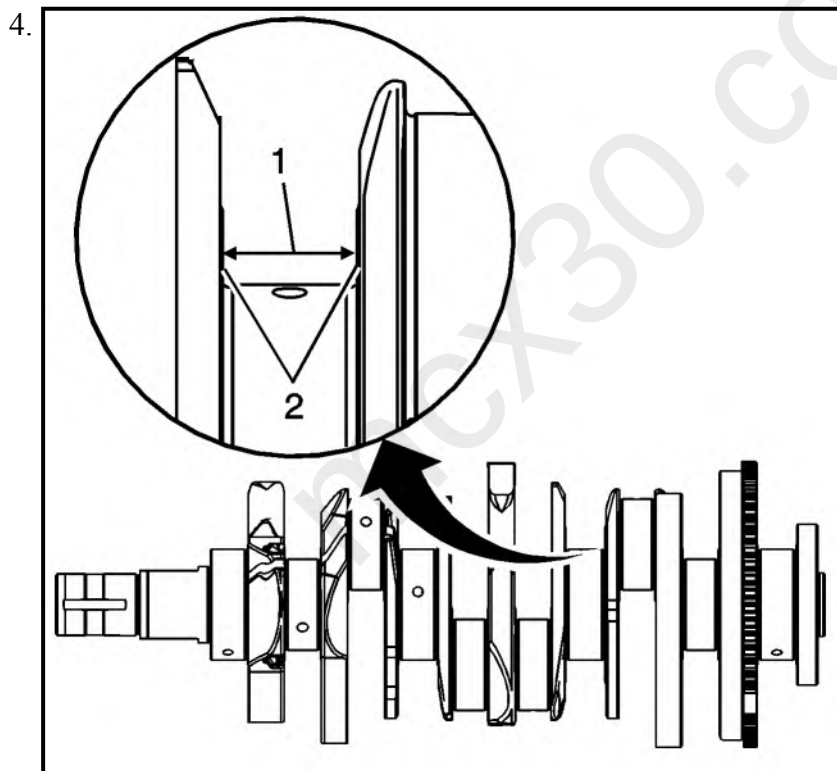
2.





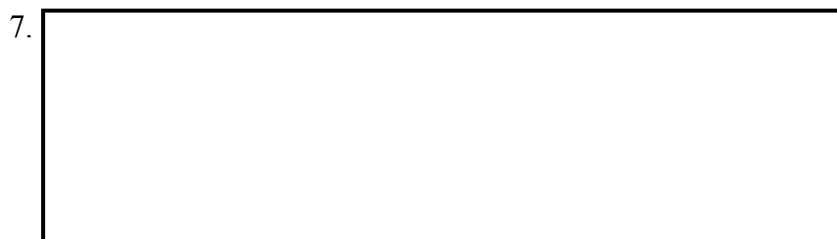
Install the **GE 7872** indicator.

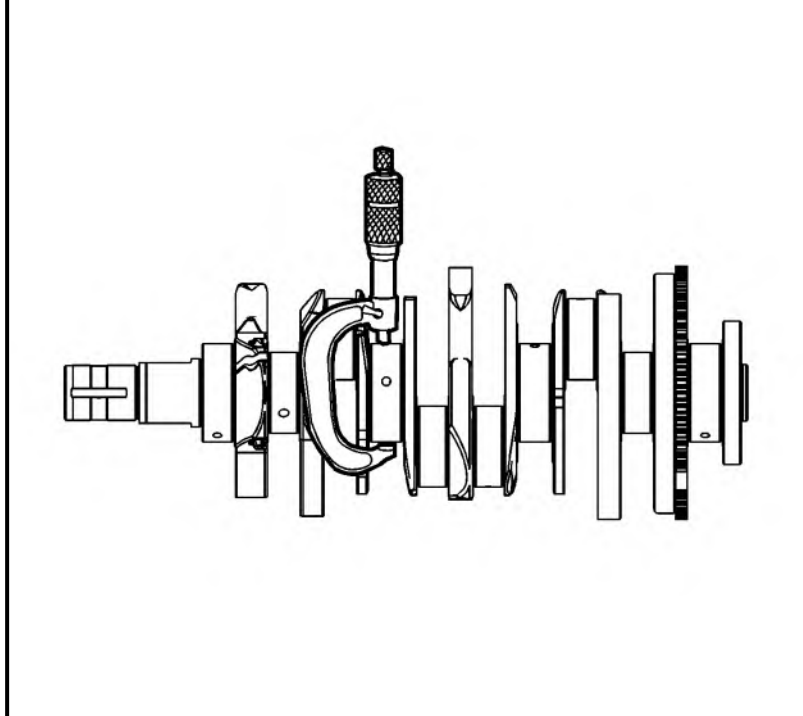
3. Measure the crankshaft runout using the **GE 7872** indicator. Refer to [Engine Mechanical Specifications](#) .



Measure the crankshaft thrust wall width (1) for wear using an inside micrometer. Refer to [Engine Mechanical Specifications](#) .

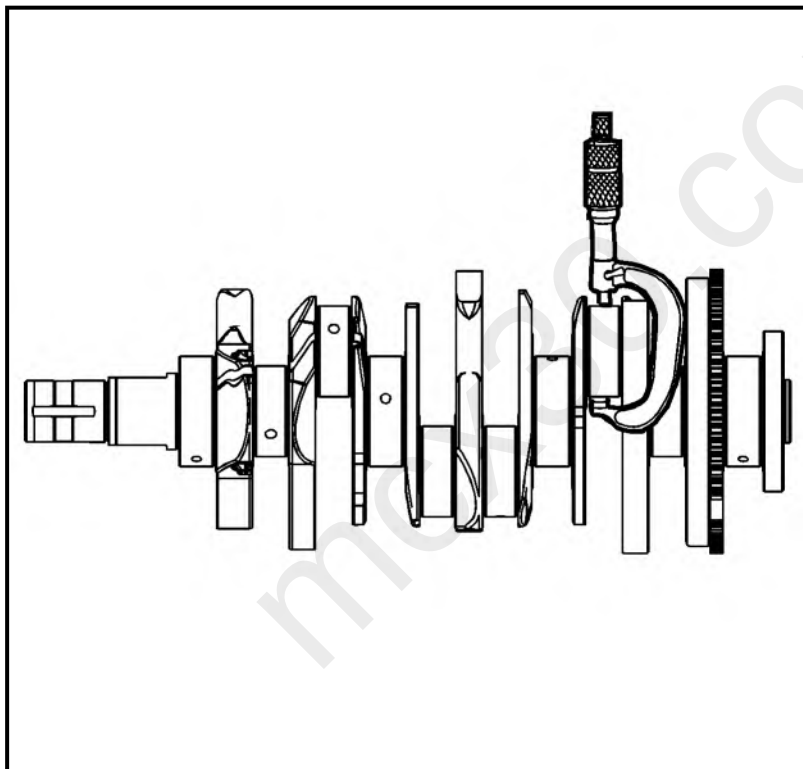
5. Measure the crankshaft thrust wall surface (2) for runout using the **GE 7872** indicator. Refer to [Engine Mechanical Specifications](#) .
6. If the crankshaft journals are damaged or worn beyond specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized main bearings available for service.





Inspect the crankshaft main journals for undersize, using an outside micrometer.

8.

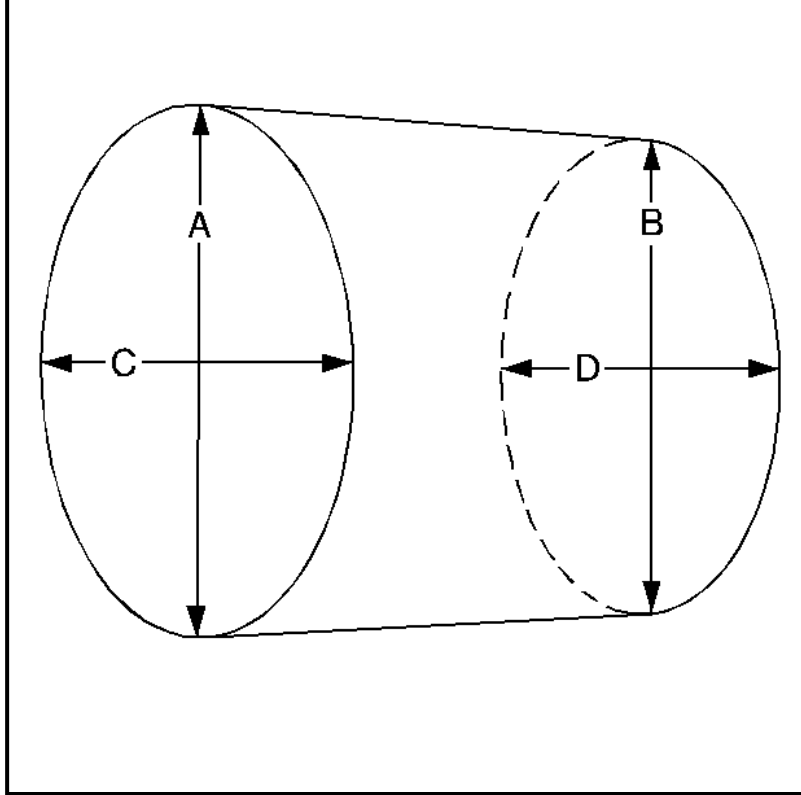


Inspect the crankpins for undersize using an outside micrometer.

9. Compare your measurements with those listed in the [Engine Mechanical Specifications](#) . If the crankpin journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized connecting rod bearings available for service.

10.





Measure the main bearing and crankpin journals for out-of-round using the following procedure:

1. Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
 2. Measure the journal in 2 new locations exactly 90 degrees from the first points. Call these points C and D.
 3. Subtract A from C and B from D. The differences will indicate journal out-of-round.
 4. The out-of-round should not exceed 0.004 mm (0.00016 in) maximum.
 5. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.
11. Measure the main bearing and crankpin journals for taper using the following procedure:
1. Using an outside micrometer, measure the journal at the extreme front (A) and rear (B) of the journal parallel to the crankshaft centerline.
 2. Subtract the smallest from the largest measurement. The result will be the journal taper.
 3. If the main bearing journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.
 4. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION

Cleaning Procedure

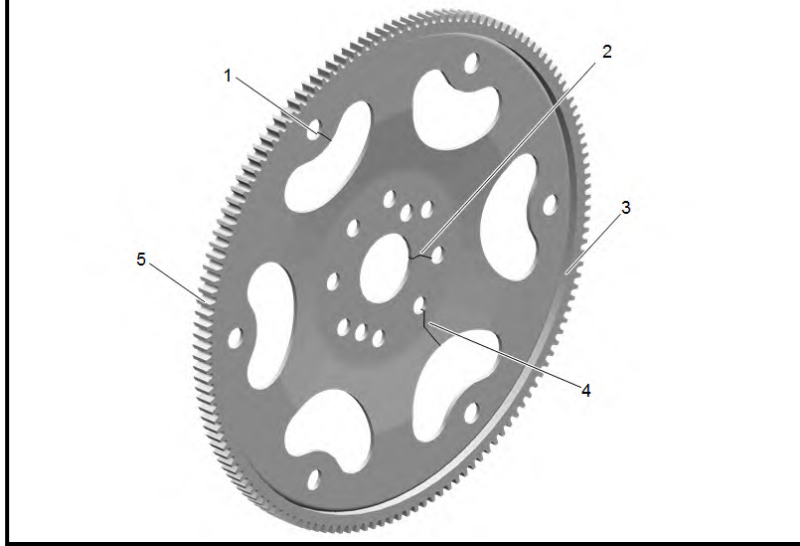
1. Clean the flex plate in solvent.

WARNING: Refer to Safety Glasses Warning .

2. Dry the flex plate with compressed air.

Inspection Procedure

1.



Inspect the flex plate for the following conditions:

- Stress cracks around the flex plate-to-torque converter mounting bolt hole locations (1) and/or flex plate-to-crankshaft (2, 4)

NOTE:

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

- Cracks at welded areas that retain the ring gear onto the flex plate (3)
- Damaged or missing ring gear teeth (5)

2. Replace the flex plate as necessary.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

Cleaning Procedure

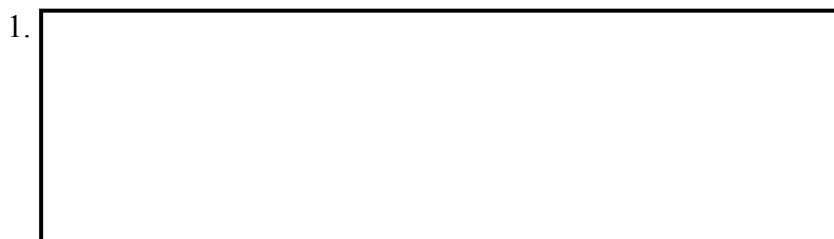


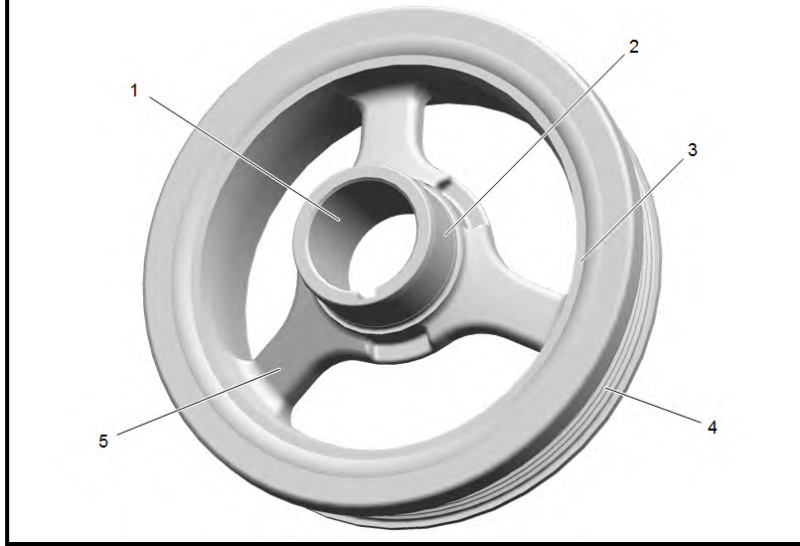
Clean the crankshaft balancer in solvent that is compatible with the rubber (1).

WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the crankshaft balancer with compressed air.

Inspection Procedure





Inspect the crankshaft balancer for the following:

- Worn or damaged hub-to-crankshaft surface (1)
- Worn, grooved or damaged hub seal surface (2)

A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

- Worn, chunking or deteriorated rubber between the hub and pulley (3)
- Damaged drive belt ribs (4)
- Damaged webs (5)

2. Repair or replace the crankshaft balancer as necessary.

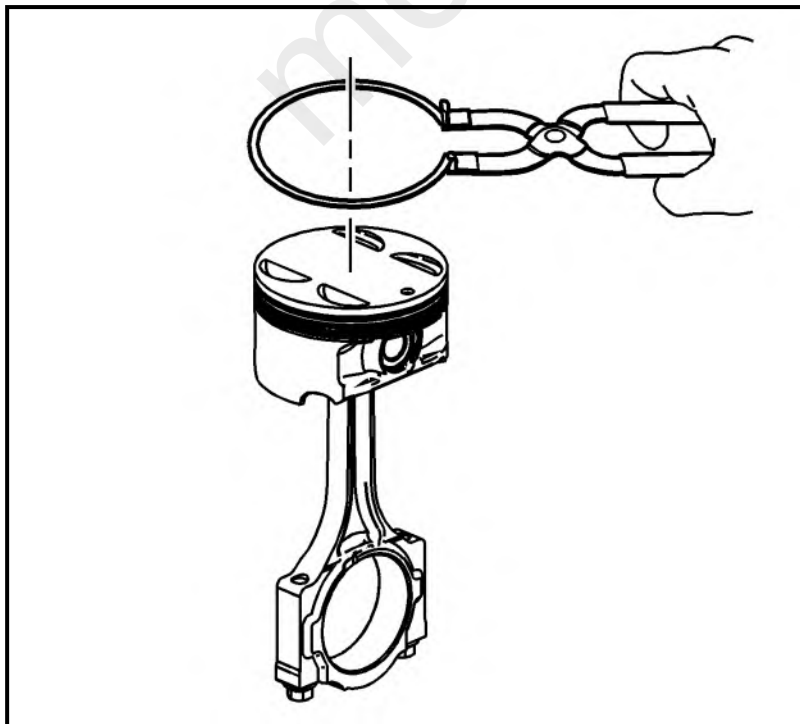
PISTON AND CONNECTING ROD DISASSEMBLE

Special Tools

EN-46745 Piston Pin Clip Remover/Installer

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

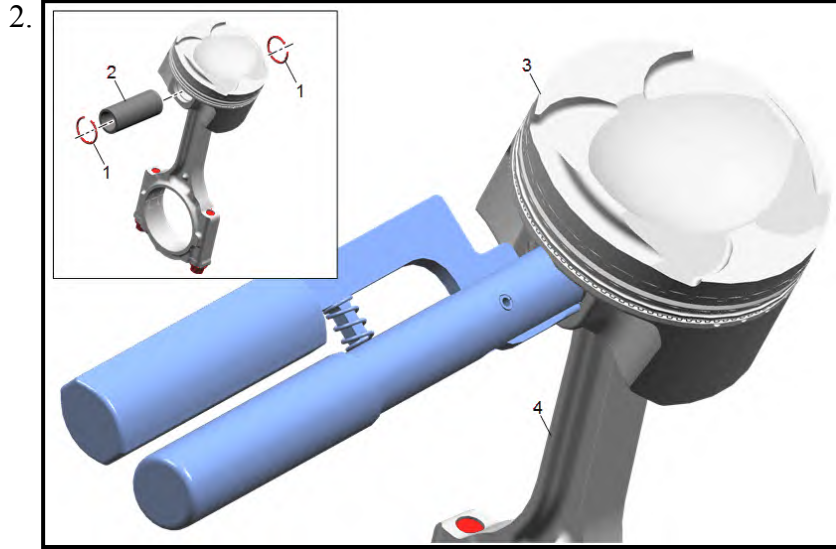
1.



CAUTION: You must use a piston ring expander to remove and install the piston rings. Only expand the rings far enough to fit over the piston

lands. If the rings are overexpanded, the top ring will shatter and the others will distort.

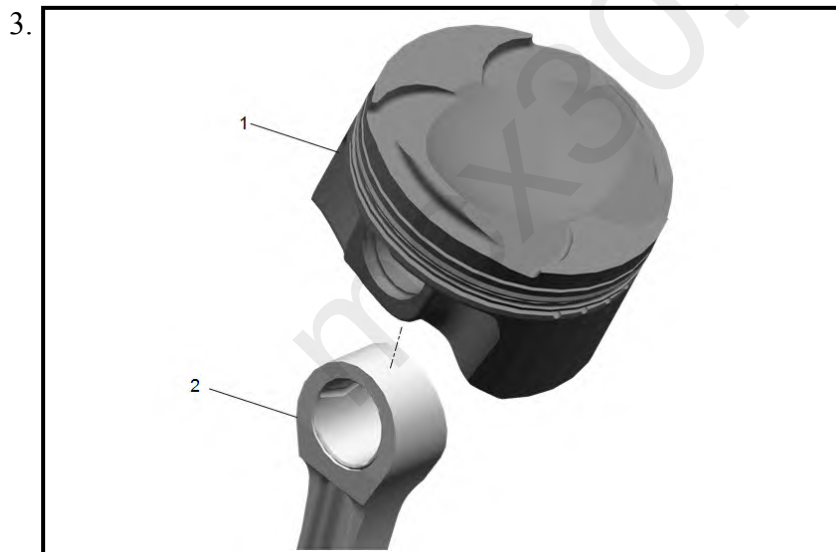
Remove the piston rings using a piston ring expander. Place each ring in a clean shop towel for storage.



NOTE:

- The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.
- DO NOT reuse the piston pin retainers.

Using the **EN-46745** remover/installer, remove the piston pin retainers by using the removal access notch (1) in the side of the piston. Discard the piston pin retainers.



Slide the piston pin out of the piston. The piston will disconnect from the connecting rod.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Cleaning Procedure

NOTE: DO NOT wire brush any part of the piston.

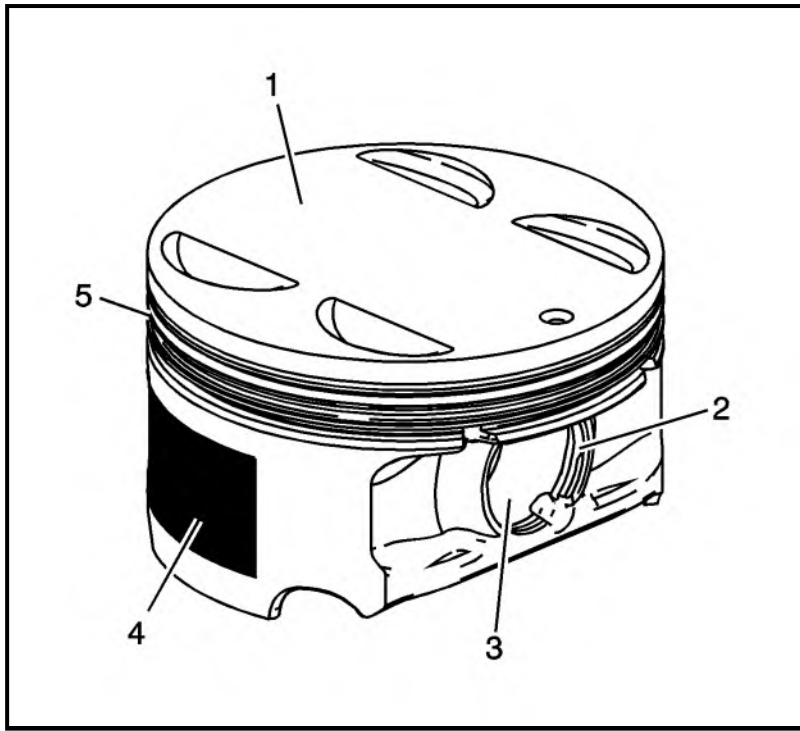
1. Clean the piston skirts and the pins with a cleaning solvent.
2. Clean the piston ring grooves with a groove cleaner. Ensure that the oil ring holes and slots are clean.

WARNING: Refer to [Safety Glasses Warning](#) .

3. Dry the piston with compressed air.

Piston Inspection Procedure

1.



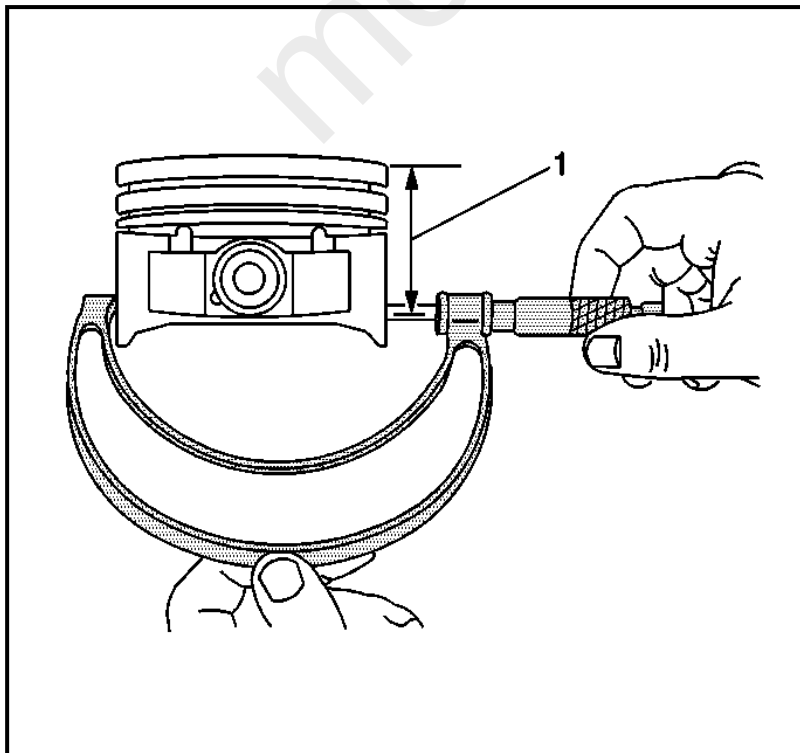
Inspect the pistons for the following conditions:

- Cracked ring lands, skirts or pin bosses
- Ring grooves for nicks, burrs that may cause binding (5)
- Warped or worn ring lands (5)
- Piston pin retainer grooves for burrs (2)
- Eroded areas at the top of the piston (1)
- Scuffed or damaged skirt coating (4)
- Worn piston pin bores or worn piston pins (3)

2. Replace pistons that show any signs of damage or excessive wear.

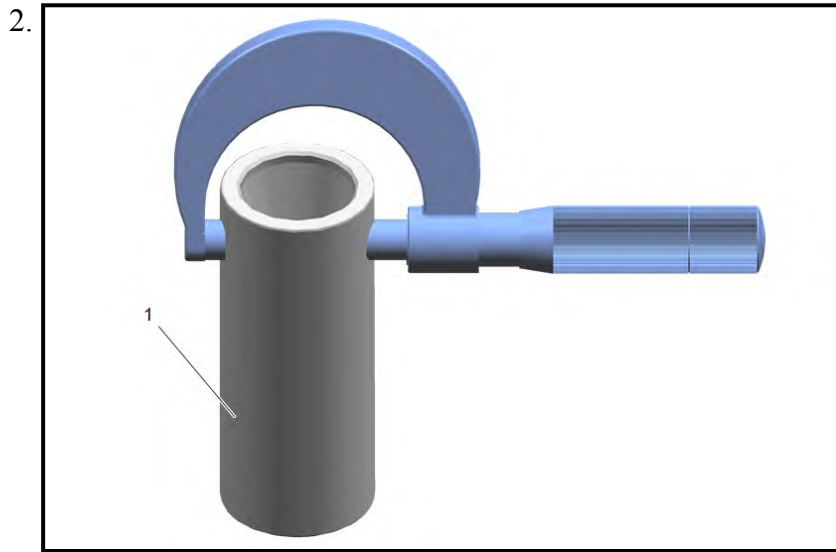
Piston Measurement Procedure

1.



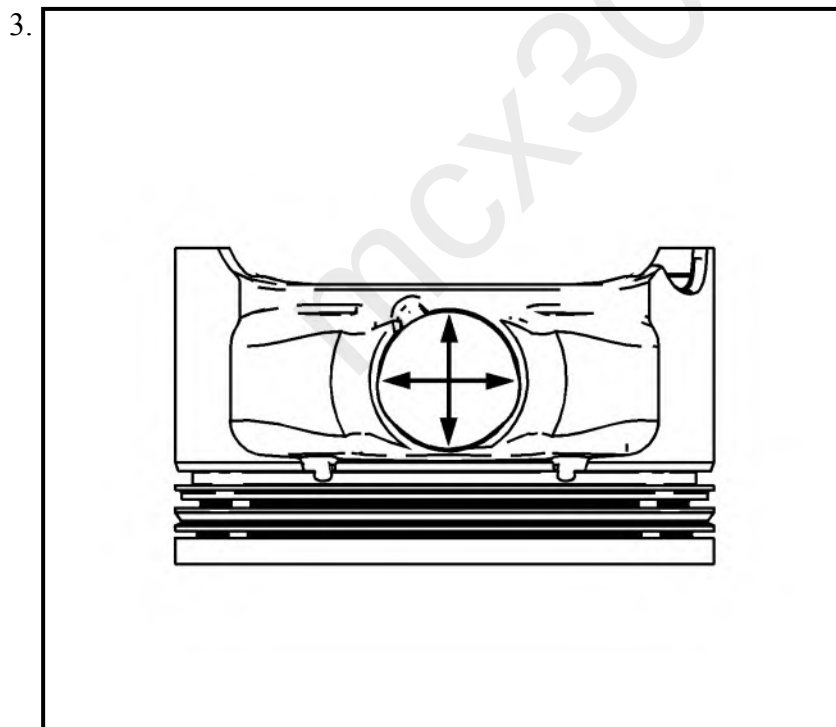
Measure piston width using the following procedure:

1. Using an outside micrometer, measure the width of the piston at 30 mm (1.181 in) below the crown, top (1), at the thrust surfaces of the piston, perpendicular to the piston pin centerline.
2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
3. Check your measurements with the [Engine Mechanical Specifications](#) .
4. If the clearance obtained through measurement is greater than the provided specifications and the cylinder bores are within specification, replace the piston.



Measure the piston pin bore to piston pin clearances using the following procedure:

1. Piston pin bores and pins must be free of varnish or scuffing.
2. Use an outside micrometer to measure the piston pin in the piston contact areas.



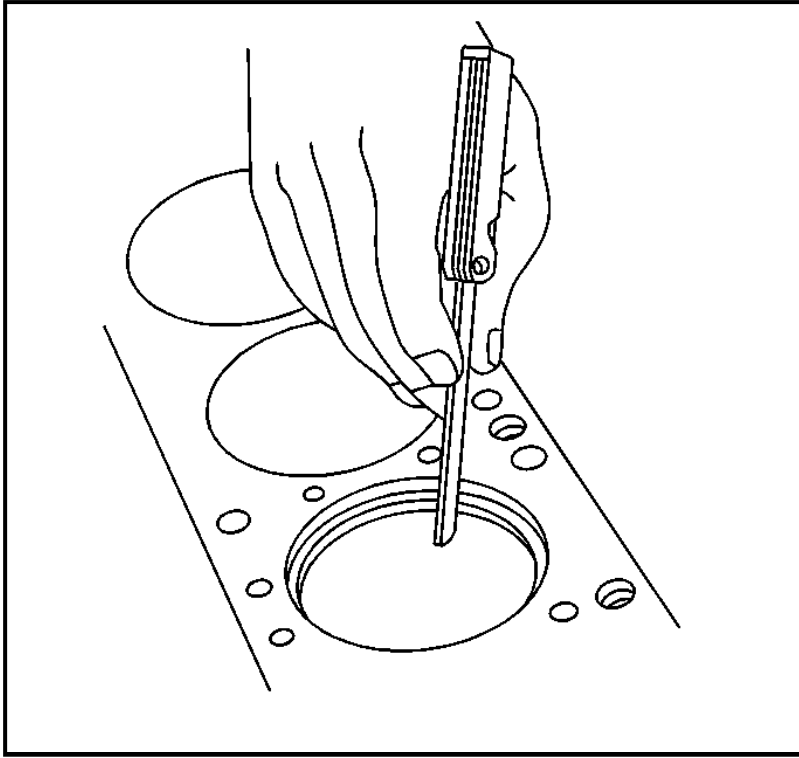
Using an inside micrometer, measure the piston pin bore. Compare your result with the piston pin diameter and piston pin to piston pin bore clearance listed in the [Engine Mechanical Specifications](#) .

4. If the clearance is excessive, determine which piece is out of specification and replace as necessary.
5. You must replace the piston if any of its dimensions are out of specification.
6. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available

for service.

Piston Ring Measurement Procedure

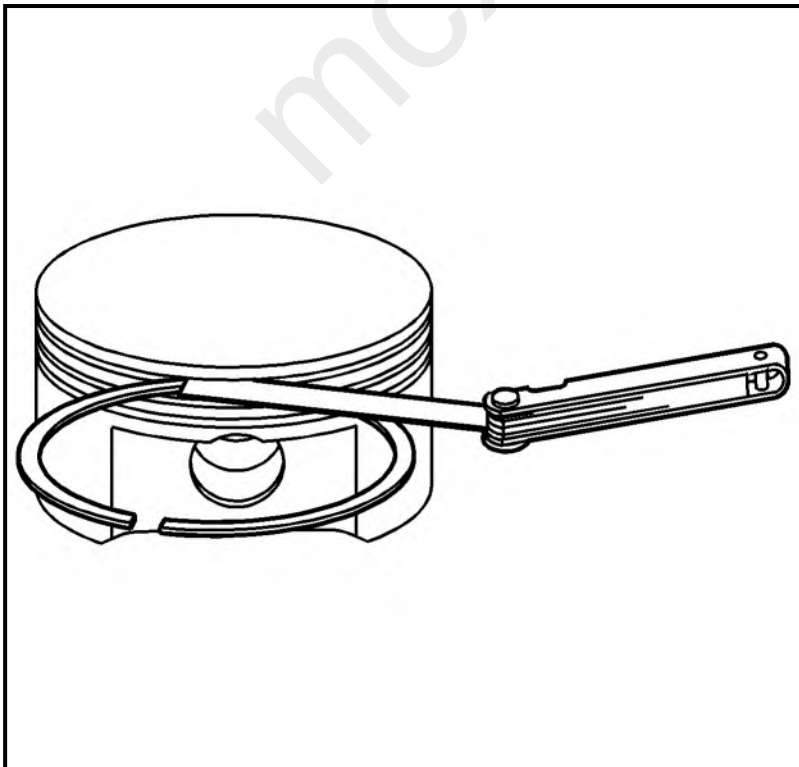
1.



Measure the piston ring end gap using the following procedure:

1. Place the piston ring in the area of the bore where the piston ring will travel approximately 25 mm (1 in) down from the deck surface. Ensure that the ring is square with the cylinder bore by positioning the ring with the piston head.
2. Measure the end gap of the piston ring with feeler gauges. Refer to [Engine Mechanical Specifications](#).
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.

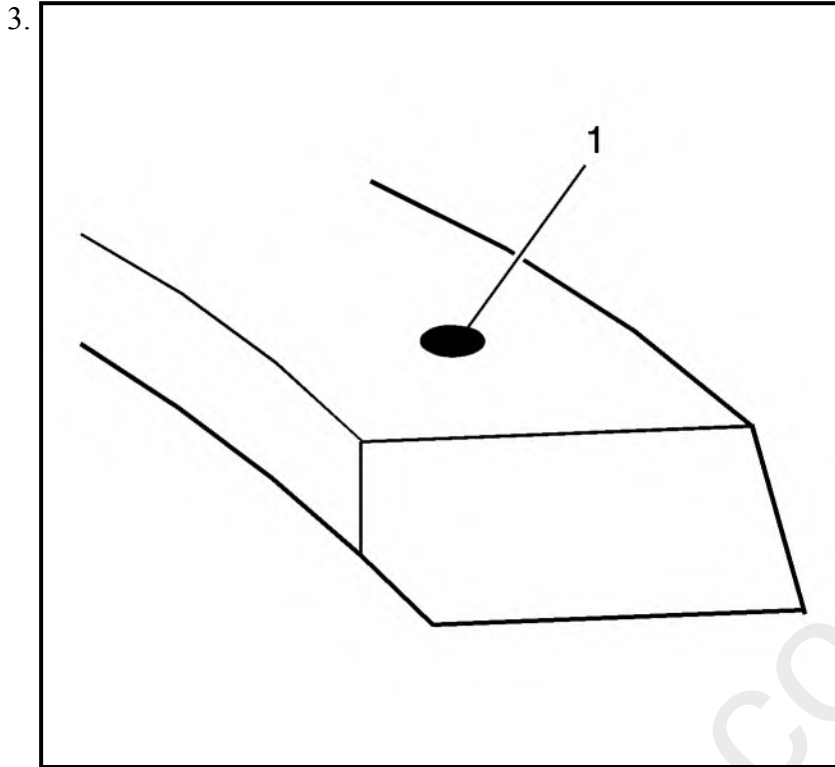
2.



Measure the piston ring side clearance using the following procedure:

1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston

- ring, replace the ring.
2. With the piston ring on the piston, use feeler gauges to check clearance at multiple locations.
 3. Compare the measurements with piston ring side clearance listed in the [Engine Mechanical Specifications](#).
 4. If the clearance is greater than specifications, replace the piston rings.



There is a locating dimple (1) on the compression rings near the end for identification. Install the compression rings with the dimple facing up.

4. If the new ring does not reduce the clearance to the proper specification, install a new piston.
5. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

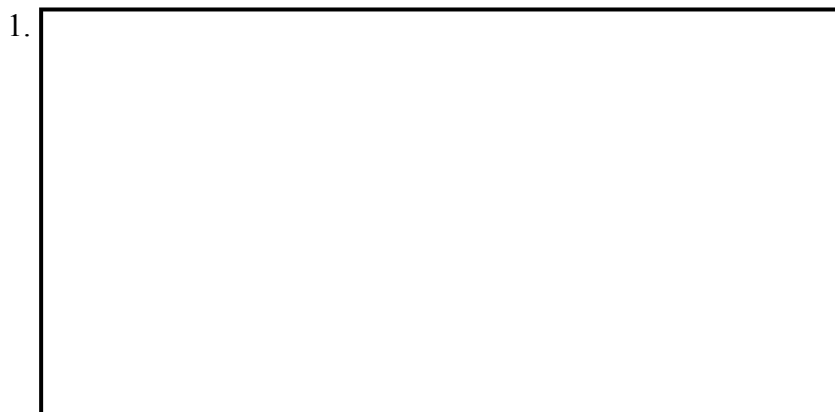
Connecting Rod Cleaning Procedure

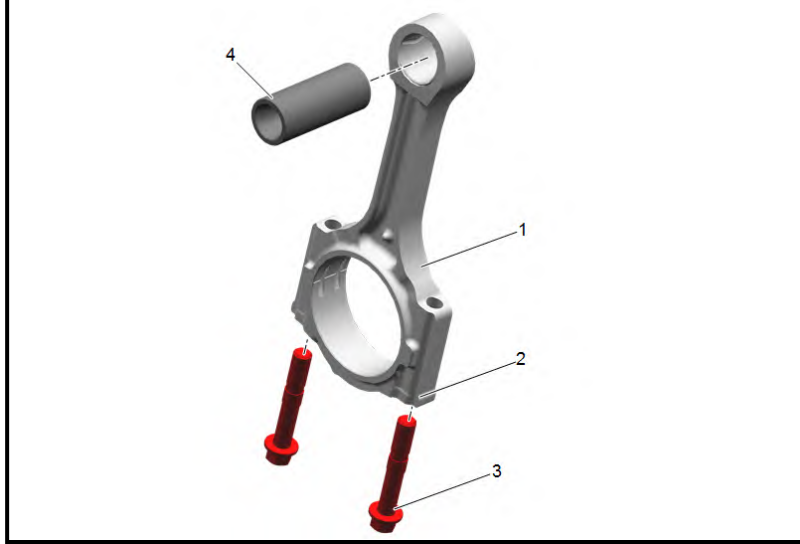
1. Clean the connecting rods in solvent.

WARNING: Refer to [Safety Glasses Warning](#).

2. Dry the connecting rod using compressed air.
3. Remove the connecting rod cap and clean the threads.
4. Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

Connecting Rod Visual Inspection Procedure





Inspect the piston pin bushing (4) for scoring or damage.

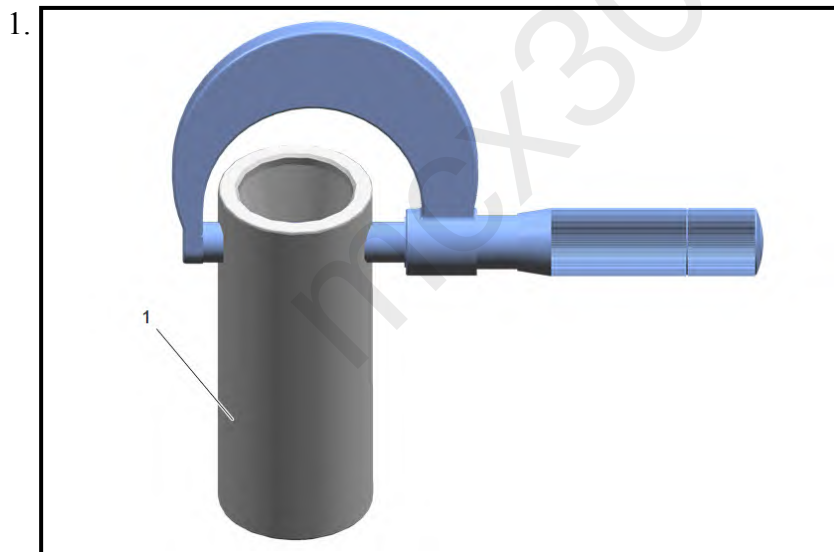
2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.
4. Inspect for scratches or abrasion on the rod bearing seating surface.

NOTE: DO NOT scrape the rod or rod cap.

5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.

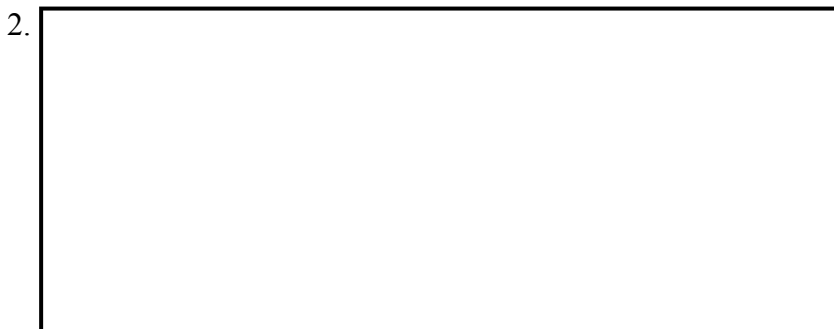
Connecting Rod Measurement Procedure

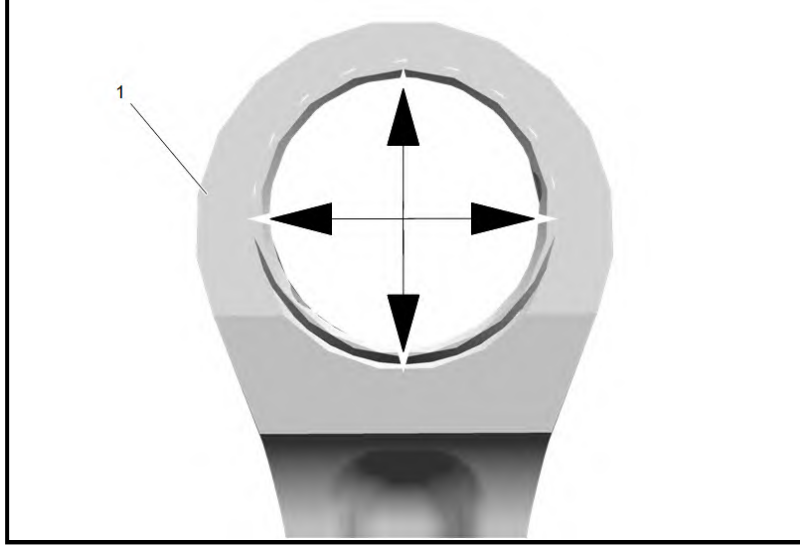
Piston Pin End



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

Using an outside micrometer, take 2 measurements of the piston pin in the area of the connecting rod contact.

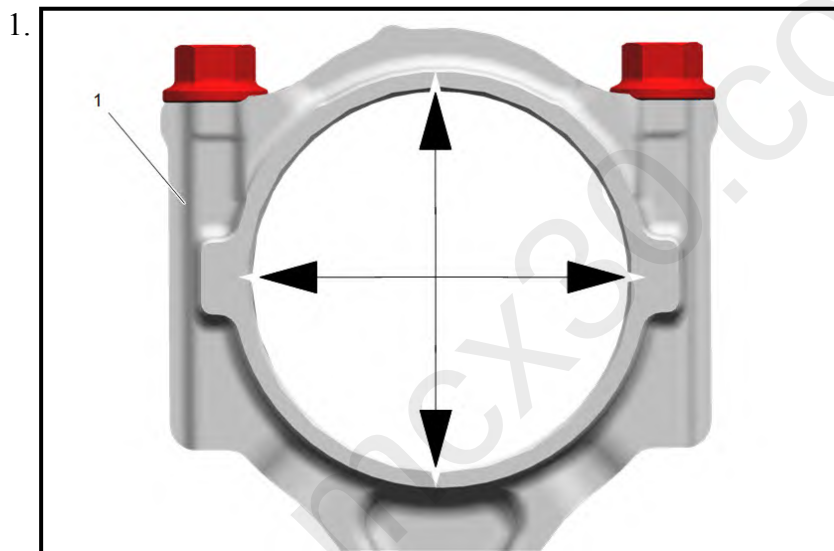




Using an inside micrometer, measure the connecting rod piston pin bore.

3. Subtract the piston pin diameter from the piston pin bore.
4. Compare the clearance measurements with the [Engine Mechanical Specifications](#).
5. If the clearance is excessive, replace the piston pin. If a new pin does not resolve the clearance problem, replace the connecting rod.

Connecting Rod Crankshaft Bearing End



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

Using an inside micrometer, measure the connecting rod crankshaft bearing bore.

2. Compare the bore measurements with the [Engine Mechanical Specifications](#).
3. Replace the connecting rod if the bore is out of specifications. DO NOT recondition the connecting rod.

PISTON AND CONNECTING ROD ASSEMBLE

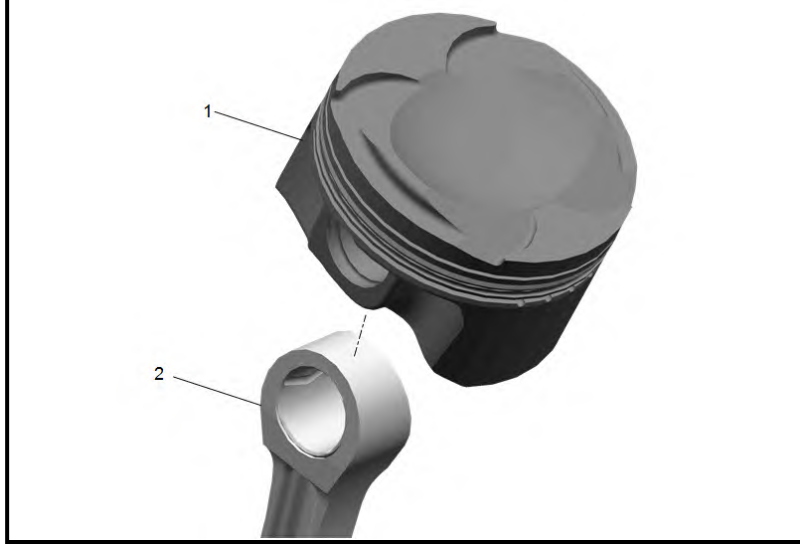
Special Tools

- EN-46121 Connecting Rod Guide Pin Set
- EN-46745 Piston Pin Clip Remover/Installer

Equivalent regional tools: [Special Tools](#)

Piston and Piston Pin Installation Procedure

1.

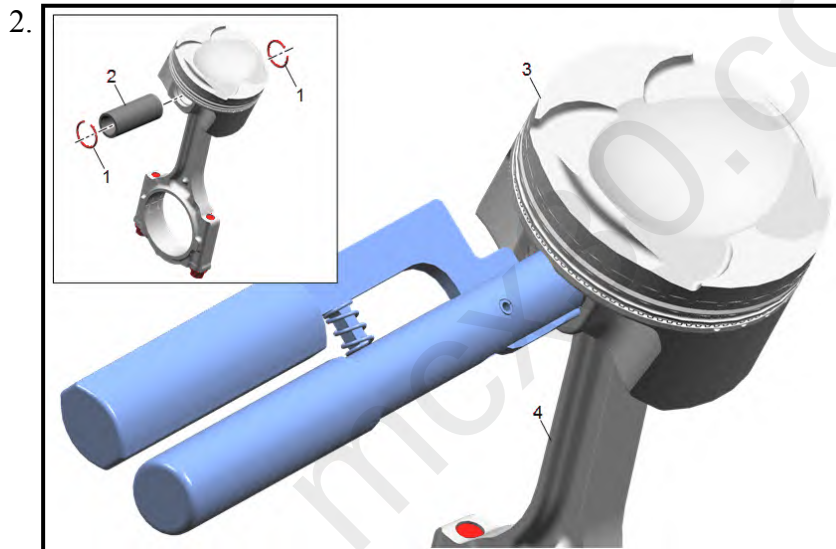


NOTE:

- The piston is directional and must be installed in the engine block in the proper direction. The dot on the top of the piston must face the front of the engine.
- The piston is model dependent and may not appear exactly as shown.

Lubricate the piston pin bores in the piston (1) and the connecting rod (2) with prelube lubricant.

[Adhesives, Fluids, Lubricants, and Sealers](#)



Assemble the piston (3) and piston pin (2) to the connecting rod (4). Properly orient the piston when reusing a marked connecting rod.

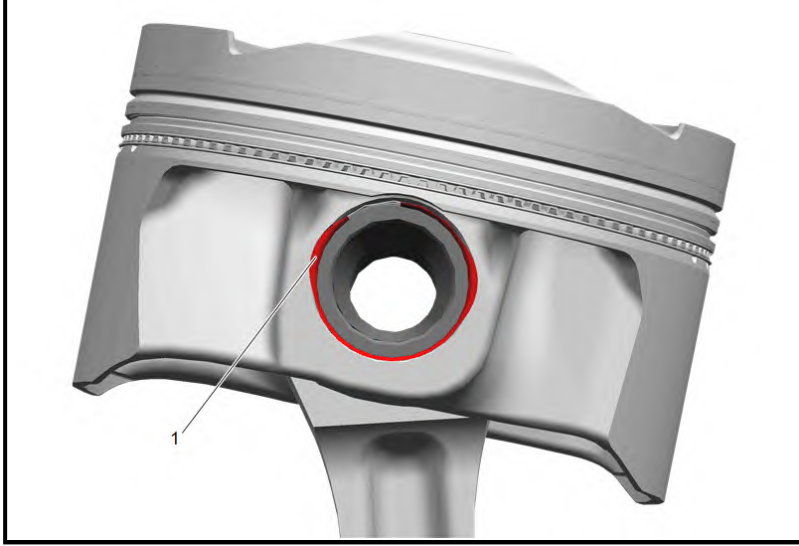
3. Align the piston pin bore with the connecting rod pin bore.
4. Slide the piston pin (1) into the piston (3) and the connecting rod (4).

NOTE:

New piston pin retainers must be used. Never reuse the piston pin retainers.

5. Install NEW piston pin retainers (1) using the **EN-46745** remover/installer. Align the **EN-46745** Piston Pin Clip Remover/Installer to the notch in the piston.

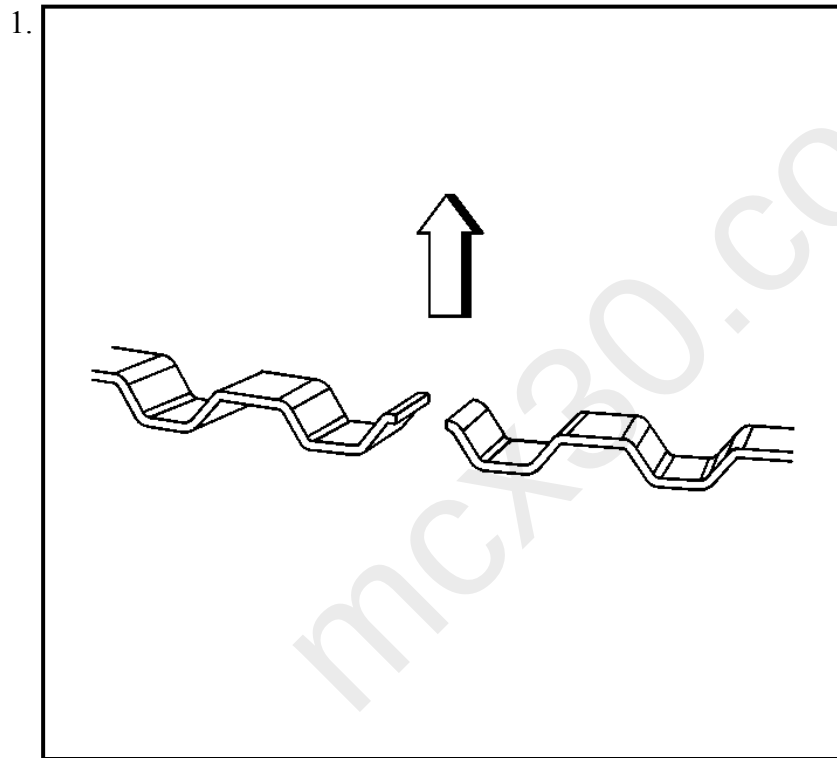




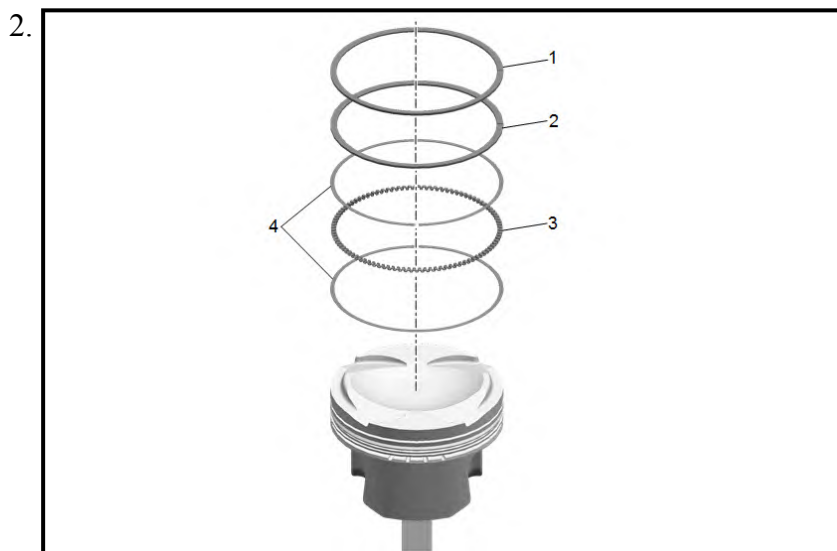
Ensure that the piston pin retainers (1) are fully seated in their grooves.

7. Repeat these procedures for the remaining pistons.

Piston Ring Installation Procedure



Properly orient the oil control ring expander as shown before installation. The ends of the expander must be facing toward the top of the piston.



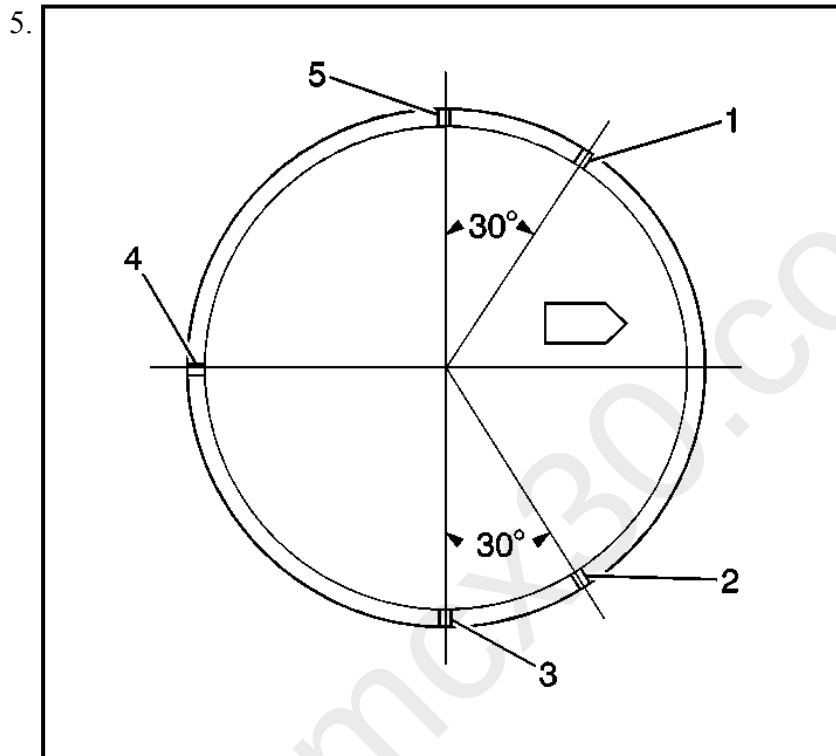
Using a piston ring expander, install the oil control ring assembly using the following procedure:

1. Install the expander ring (3).
2. Install the 2 oil scraper rings (4). Expand the rings only enough to clear the piston diameter. Overexpanding the piston rings will distort or crack the rings.

NOTE: The lower compression piston ring (2) is thicker and will not fit in the upper compression rings (1) position.

NOTE: For the LY7, the upper compression ring is symmetrical and may be installed either side up. For all other RPO's, the mark on the piston ring should face the top of the piston.

3. Install the lower compression piston ring (2) onto the piston with the mark facing the top of the piston.
4. Install the upper compression piston ring (1) onto the piston with the mark facing the top of the piston, if required.

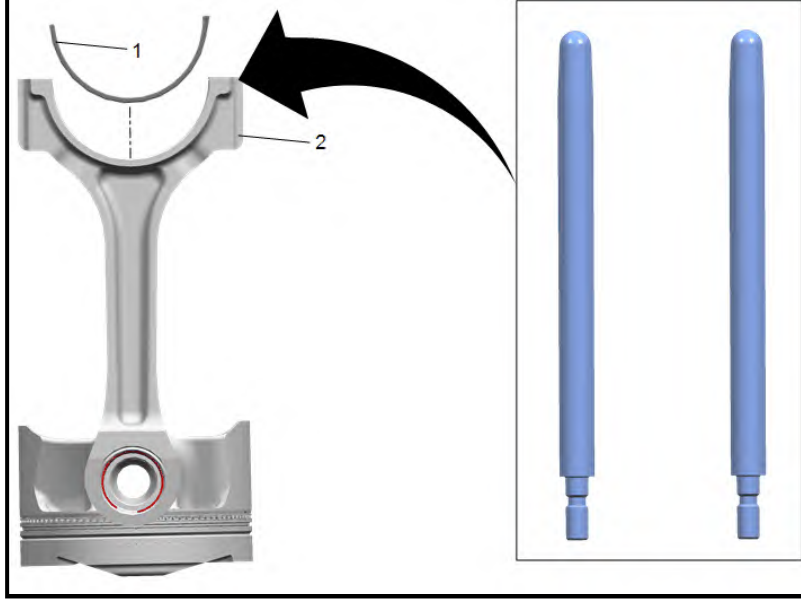


Once the rings are installed, set the ring gaps for the oil control, second and top ring as follows. Use the piston location arrow for reference.

1. Lower oil control ring - position 1
2. Upper oil control ring - position 2
3. Top Ring - position 3
4. Oil control ring expander - position 4
5. Second ring - position 5

Connecting Rod Bearing Installation Procedure

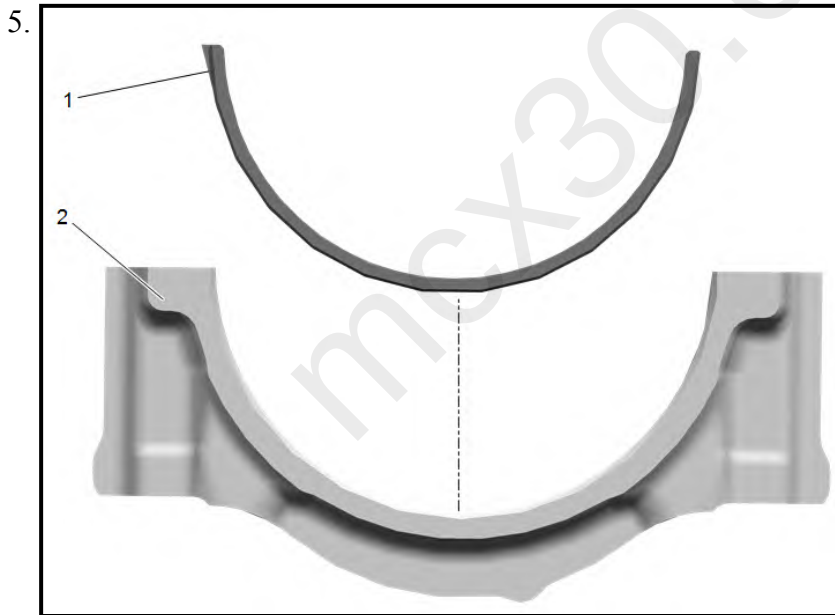
- 1.



NOTE: If the connecting rod bearings have been used in a running engine, you must replace them with **NEW** connecting rod bearings for reassembly.

Clean the connecting rod (2) and the connecting rod cap bearing bore with a lint-free cloth.

2. Clean all the oil from behind the connecting rod bearing halves.
3. Install **NEW** upper connecting rod bearing (1) into position. Roll the bearing into position so that the lock tang engages the alignment slot. The bearing must fit flush in the connecting rod.
4. Install the **EN-46121** Connecting Rod Guide Pin Set into the connecting rod bolt holes.



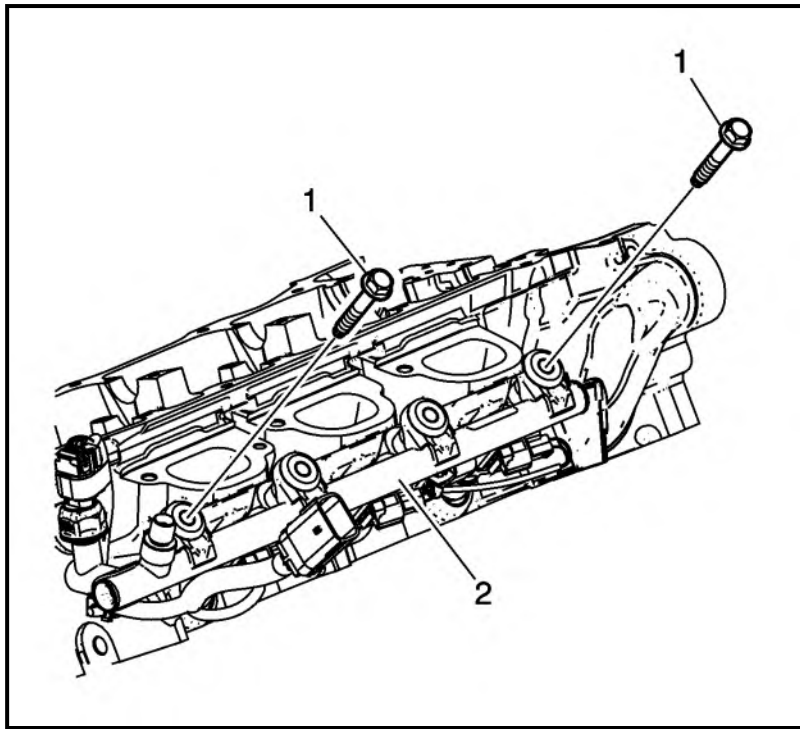
Install **NEW** lower connecting rod bearing (1) into position in the connecting rod cap (2). Roll the bearing into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap.

CYLINDER HEAD DISASSEMBLE

Special Tools

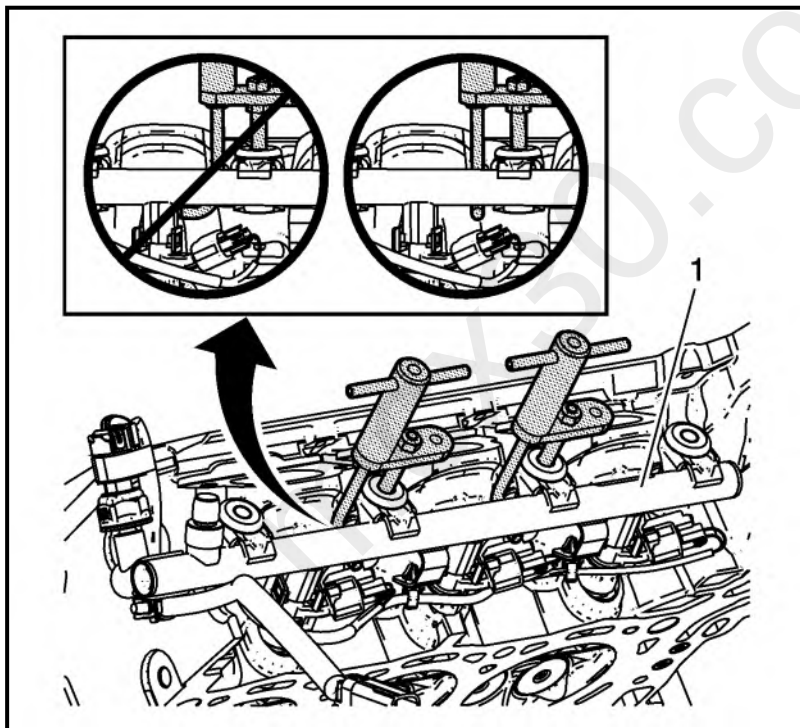
- **EN-8062** Valve Spring Compressor - Head Off
- **EN-46116** Valve Stem Seal Remover/Installer
- **EN-46117** Valve Stem Key Remover/Installer
- **EN-46119** Off-Vehicle Valve Spring Compressor Adapter
- **EN-46122** Camshaft Position Actuator Check-Ball Valve Remover/Installer
- **EN-49248** Injector Rail Assembly Remover

1.



Remove the fuel rail bolts (1).

2.



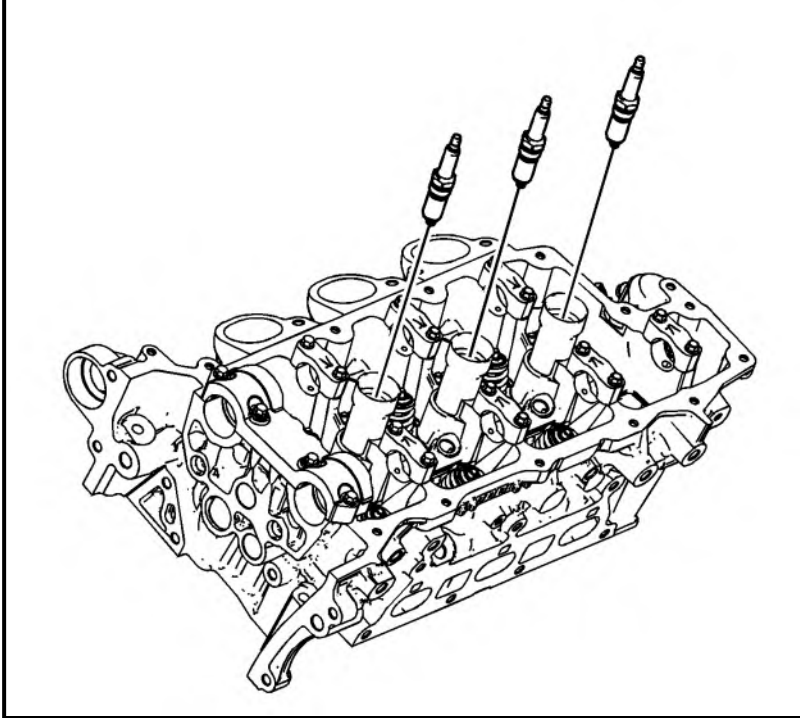
CAUTION:

- Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
- Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.

Remove the fuel rail and injectors (1) as an assembly using the EN-49248 remover.

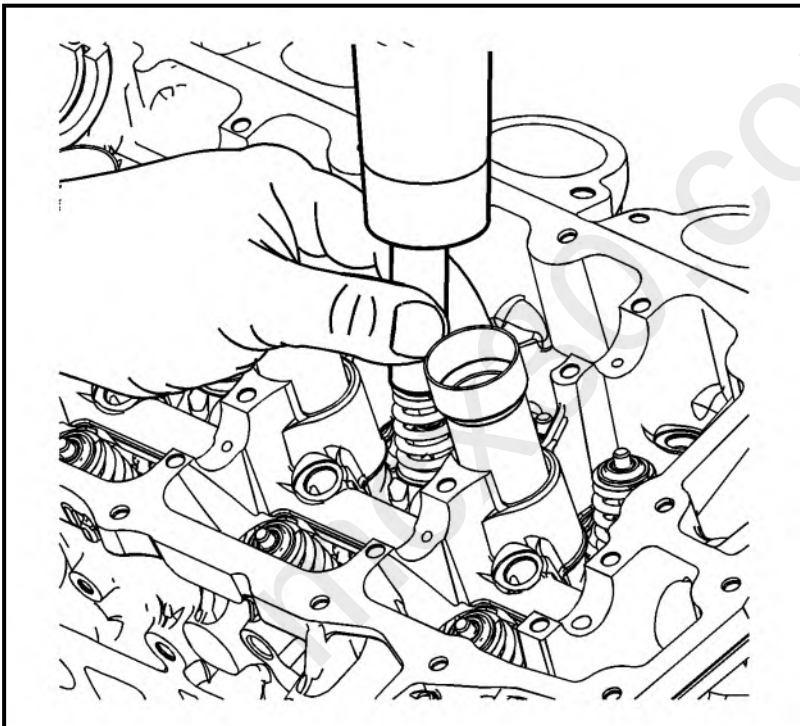
3.





Remove the spark plugs.

4.

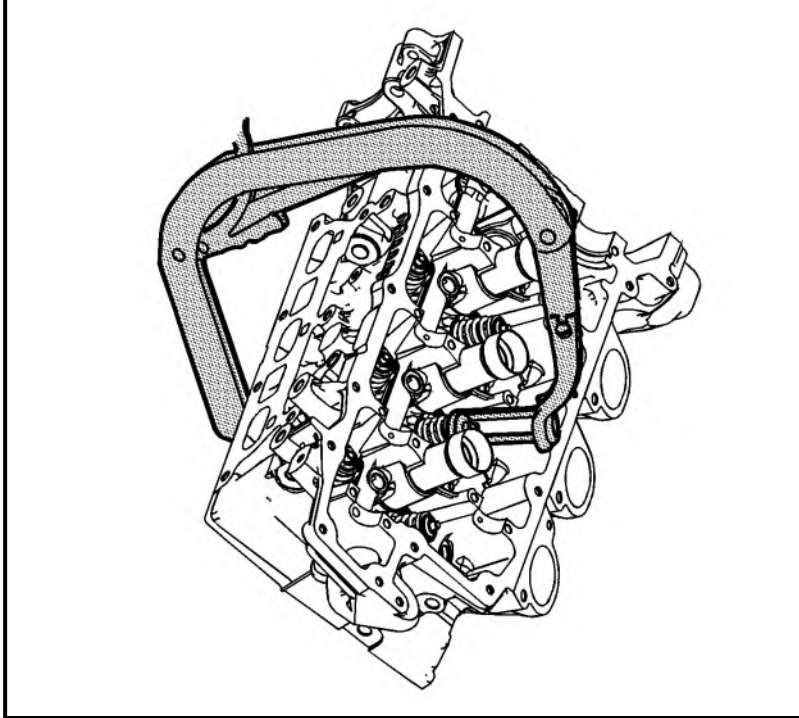


NOTE: Ensure valve heads will not contact anything during the following step in order to avoid bending or damage.

Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve keepers.

5.

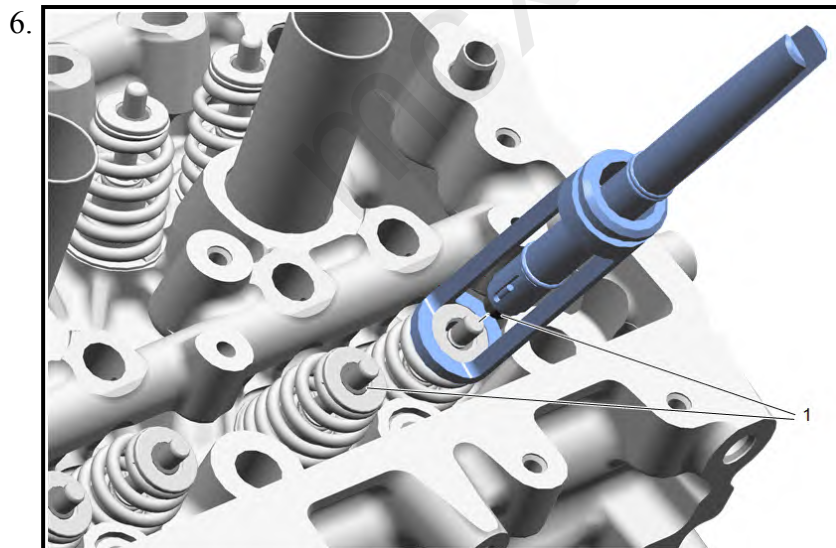




WARNING: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

CAUTION: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

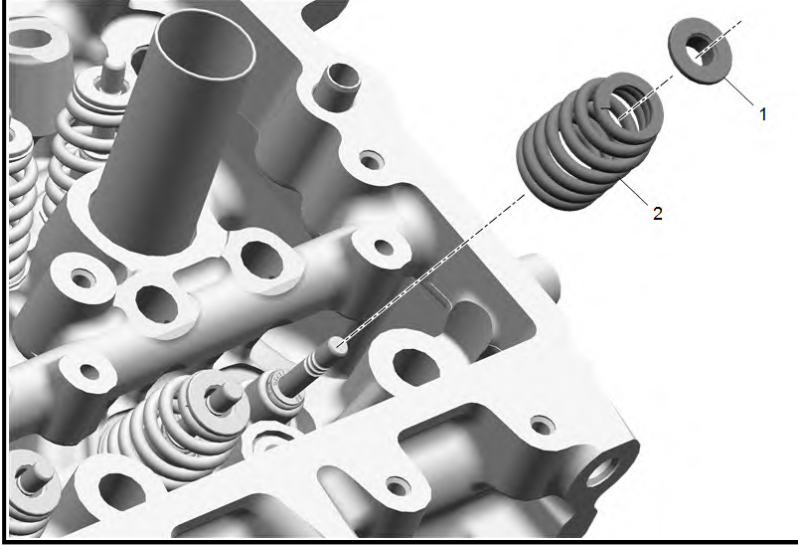
Compress the valve spring using the **EN-8062** compressor and the **EN-46119** adapter.



Use the magnet of the **EN-46117** remover/installer in order to remove the valve keepers.

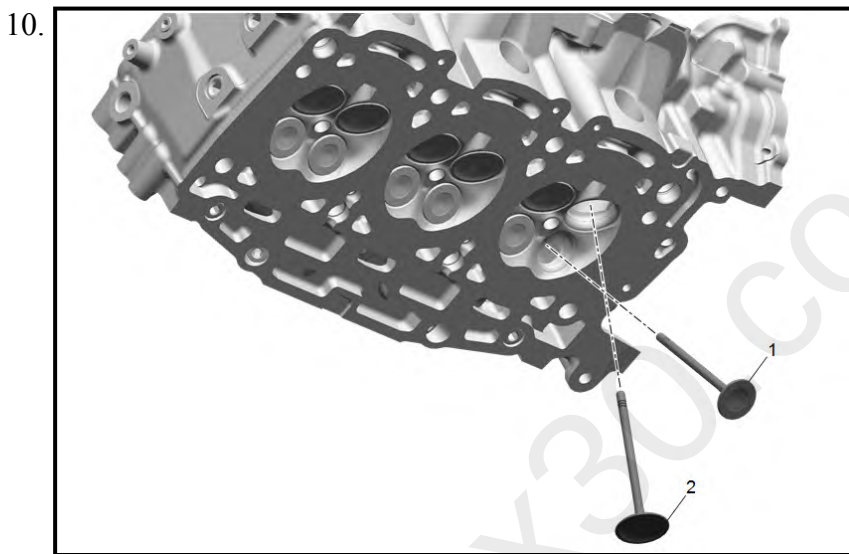
7. Remove the valve spring compressor and the adapter.

8.

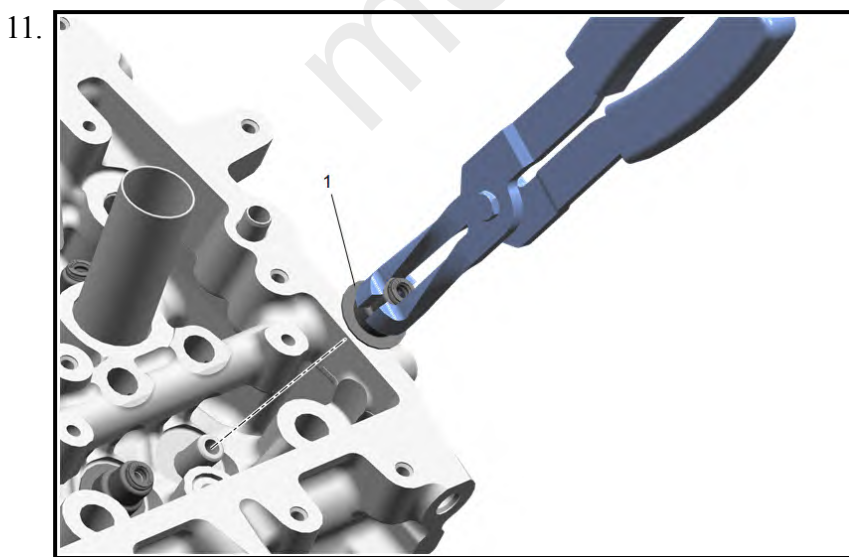


Remove the valve spring retainer.

9. Remove the valve spring.



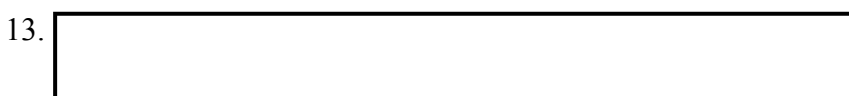
Remove the valve.

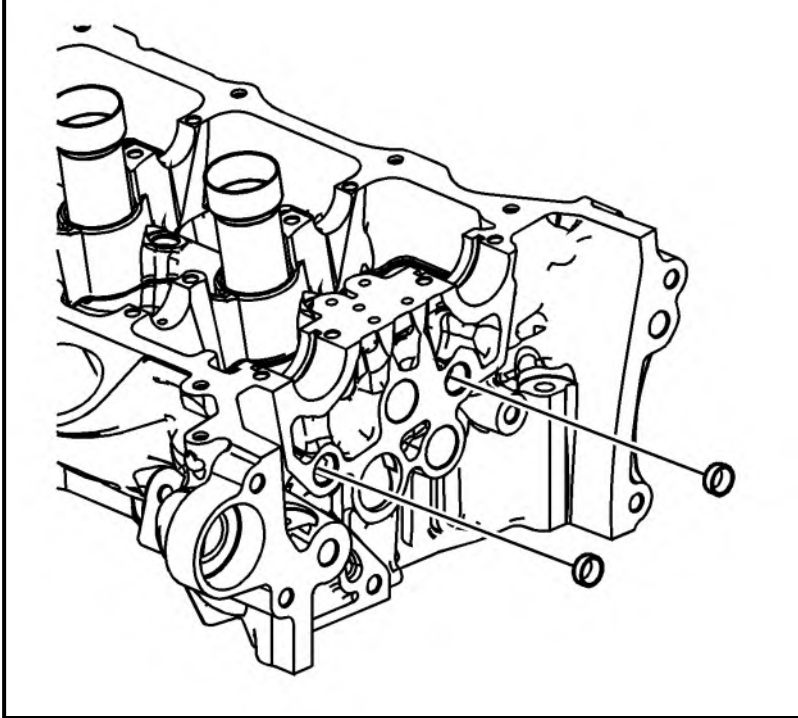


NOTE: NEVER reuse a valve stem oil seal.

Remove the valve stem oil seal using the **EN-46116** remover/installer and discard.

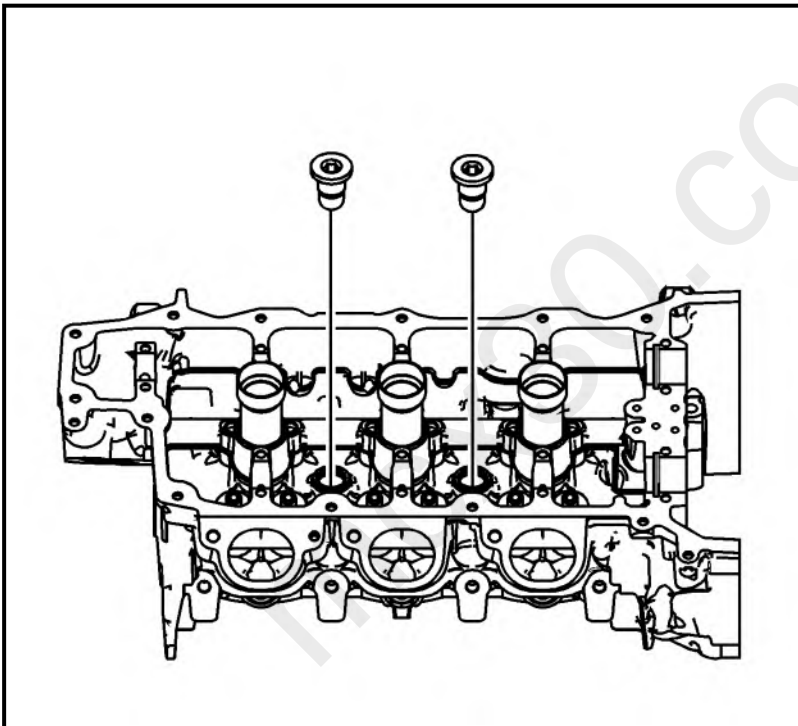
12. Repeat these procedures for the remaining valves.





Remove the cylinder head oil gallery expansion plugs.

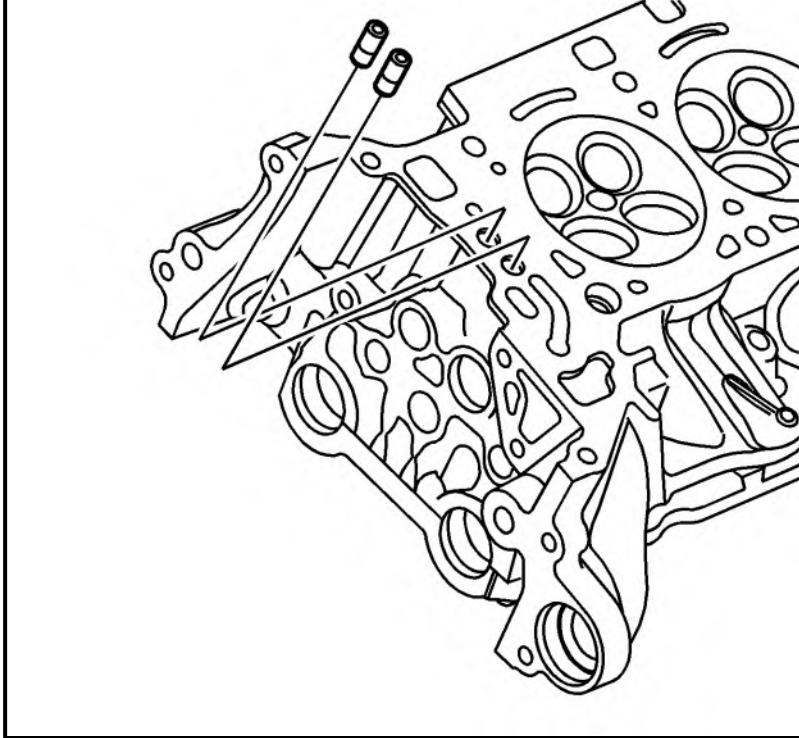
14.



Remove the cylinder head coolant threaded plugs.

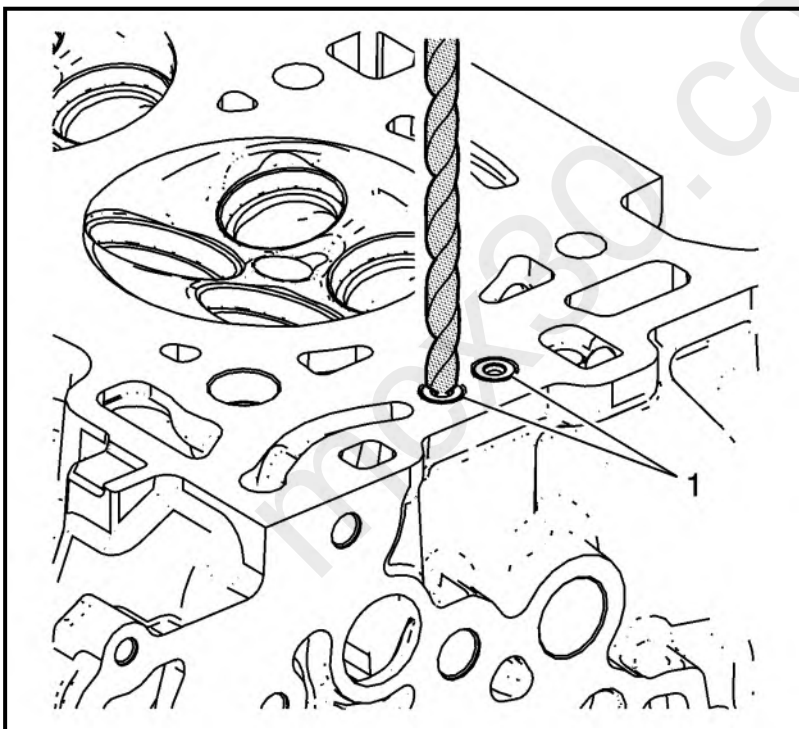
15.





Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced. If check valves are OK, disregard remaining steps which detail replacing the check valves.

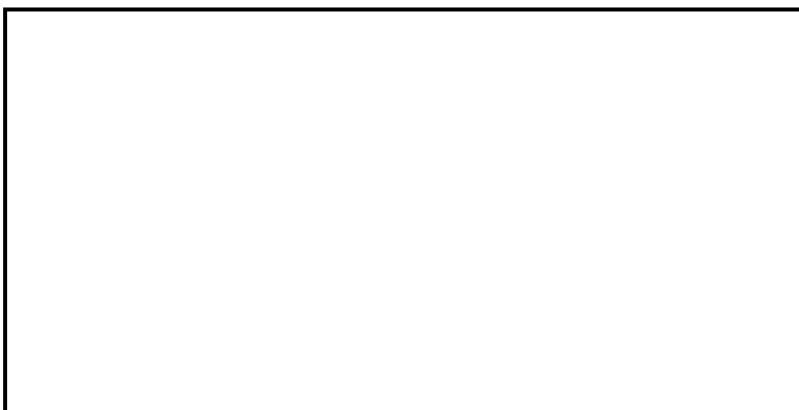
16.

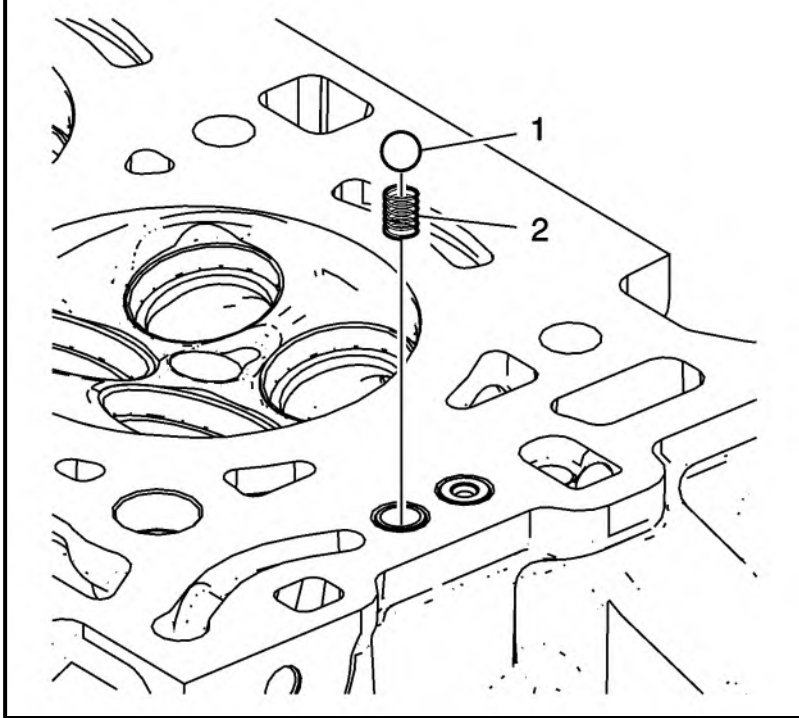


Place cylinder head on firm surface with check valves (1) facing up. Protect all cylinder head components and machined surfaces.

17. Using drill bit EN-46122-3, drill out top portion of check valve to expose internal check ball.

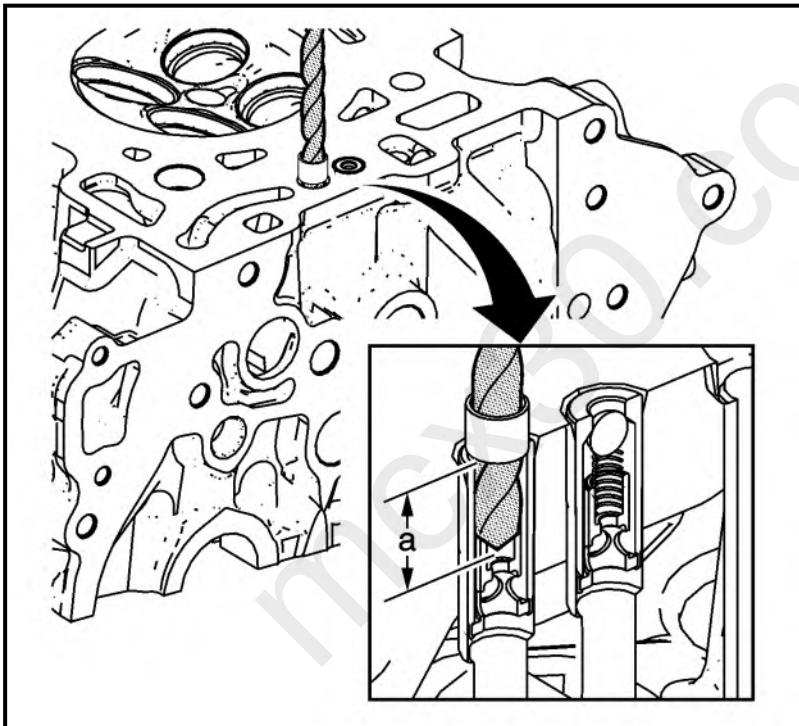
18.





Remove check ball (1) and check ball spring (2) from inside of check valve.

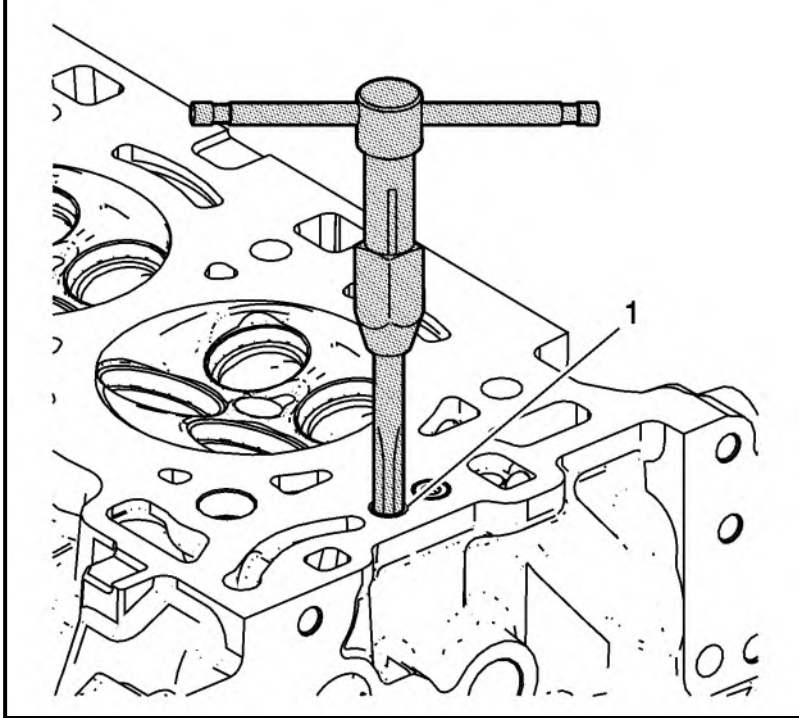
19.



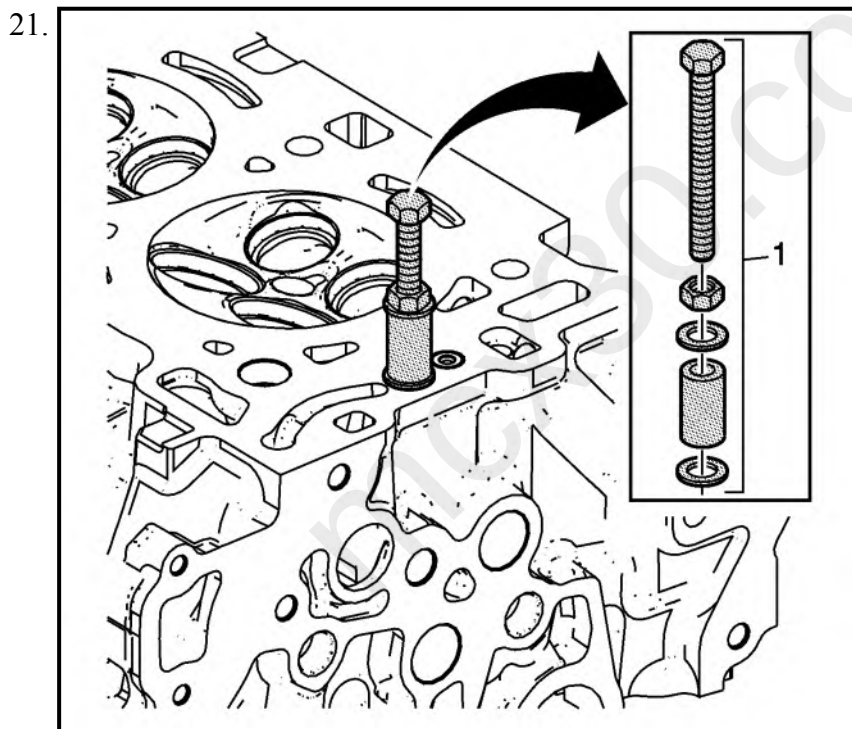
Continue drilling remainder of check valve sleeve to a depth of approximately 19 mm (0.75 in) (a) by placing tape on drill bit as a depth gauge. It is not necessary or desirable to drill completely through the bottom of the check valve.

20.





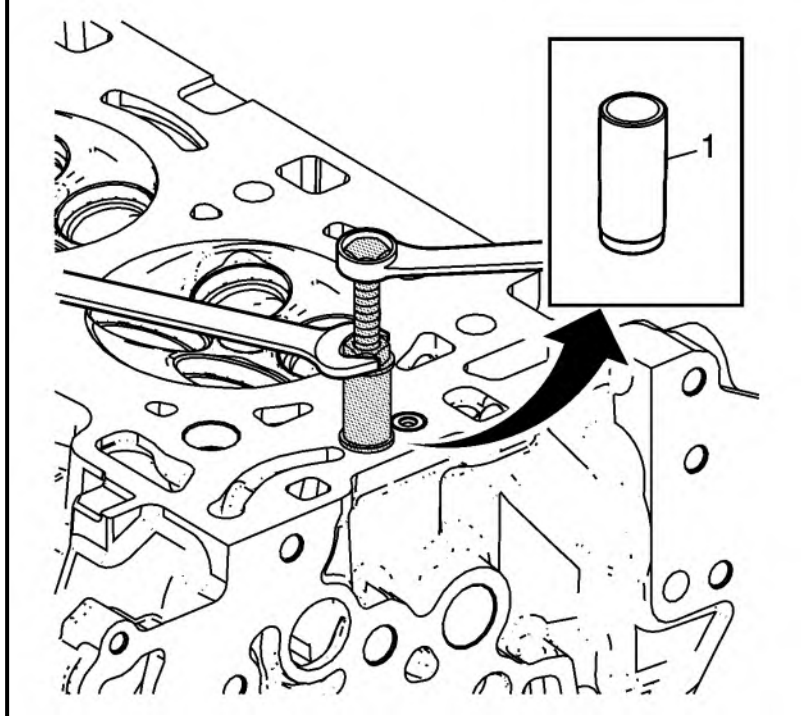
Lubricate tap **EN-46122 - 4** with lubricant included in **EN-46122** remover/installer. Tap drilled out portion of check valve (1) remaining in cylinder head. Tap to full depth possible until tap bottoms out in head.



Assemble bolt, nut, washers, and collar **EN-46122 - 2** (1) as shown. Position collar with slightly-larger inside diameter DOWN toward the cylinder head.

22. Screw bolt by hand fully down into threaded check valve sleeve, then lightly tighten nut against washer.





Hold bolt with one wrench, and use another to tighten the nut until the check valve sleeve (1) is removed from the cylinder head.

24. Clean check valve bore and related passages thoroughly to remove any drilling chips or other debris.

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- GE - 8001 Dial Indicator Set
- GE - 8358 Carbon Removal Brush
- EN - 28410 Gasket Remover
- EN - 42096 Valve Guide Reamer
- EN - 47909 Injector Bore and Sleeve Cleaning Kit

Equivalent regional tools: Special Tools

Cleaning Procedure

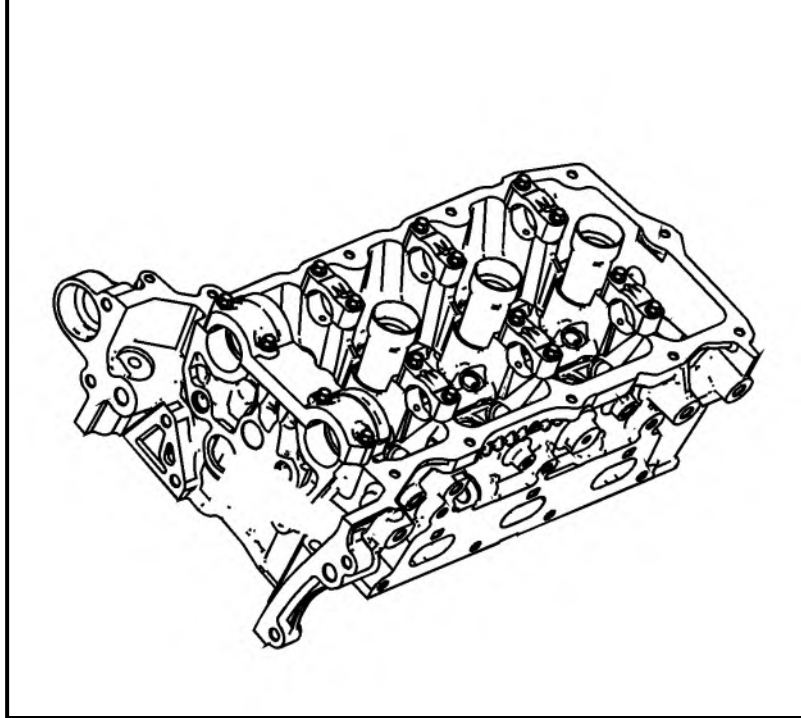
1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
2. Remove any old thread sealant, gasket material or sealant using EN - 28410 Gasket Remover.
3. Clean all cylinder head surfaces with non-corrosive solvent.

WARNING: Refer to Safety Glasses Warning .

4. Blow out all the oil galleries using compressed air.
5. Remove any carbon deposits from the combustion chambers using the GE - 8358 Carbon Removal Brush.
6. Clean any debris or build-up from the lifter pockets.

Visual Inspection

1.

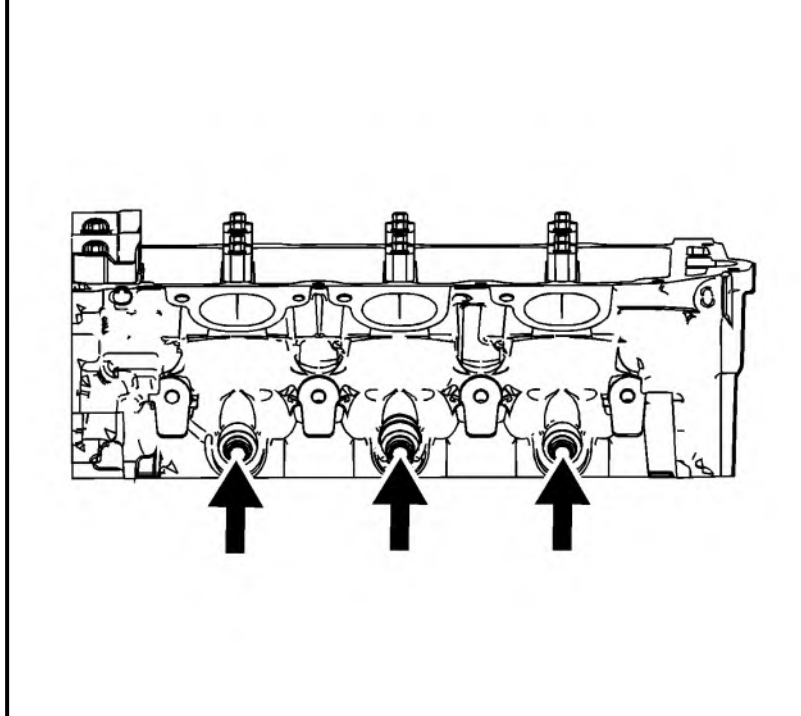


Inspect the cylinder head camshaft bearing surfaces for the following conditions:

- Excessive scoring or pitting
 - Discoloration from overheating
 - Deformation from excessive wear
 - If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head. DO NOT machine the camshaft bearing journals.
2. If any of the above conditions exist on the camshaft bearing surfaces, replace the cylinder head.
3. Inspect the cylinder head for the following:
- Cracks, damage or pitting in the combustion chambers
 - Debris in the oil galleries - Continue to clean the galleries until all debris is removed.
 - Coolant leaks or damage to the deck face sealing surface - If coolant leaks are present, measure the surface warpage as described under Cylinder Head Measurement - Deck Flatness Inspection.
 - Burrs or any defects that would degrade the sealing of the NEW secondary camshaft drive chain tensioner gasket
 - Damage to any gasket surfaces
 - Damage to any threaded bolt holes
 - Burnt or eroded areas in the combustion chamber
 - Cracks in the exhaust ports and combustion chambers
 - External cracks in the water passages
 - Restrictions in the intake or exhaust passages
 - Restrictions in the cooling system passages
 - Rusted, damaged or leaking core plugs
4. If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is recommended.

5.





Inspect the fuel rail injector bores and clean with **EN - 47909** Injector Bore and Sleeve Cleaning Kit, if required.

Cylinder Head Measurement

Camshaft Journal Clearance

1. Install the camshaft bearing cap in the cylinder head without the camshaft.

CAUTION: Refer to [Fastener Caution](#) .

2. Install the camshaft cap bolts and tighten to 10 N.m (89 lb in).
3. Measure the camshaft bearings using an inside micrometer.
4. Subtract the camshaft journal diameter from the camshaft bearing diameter. This will provide the running clearance. If the running clearance exceeds specifications and the camshaft journals are within specification, replace the cylinder head.

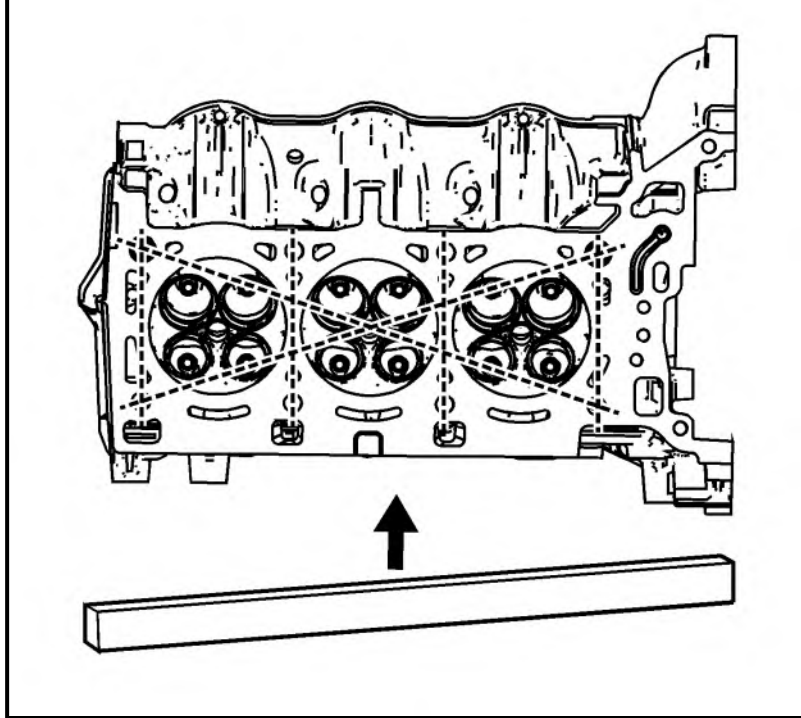
Camshaft Journal Alignment

1. Ensure the camshafts are serviceable.
2. Inspect the cylinder head camshaft bearing surfaces for any imperfections or scratches that could inhibit proper camshaft clearances. Repair minor imperfections or scratches.
3. Install the camshafts in the cylinder head.
4. Install the camshaft bearing caps.
5. Install the camshaft cap bolts and tighten to 10 N.m (89 lb in).
6. Ensure the camshafts spin freely in the cylinder head. If the camshaft does not run freely, replace the cylinder head.

Deck Flatness Inspection

- 1.



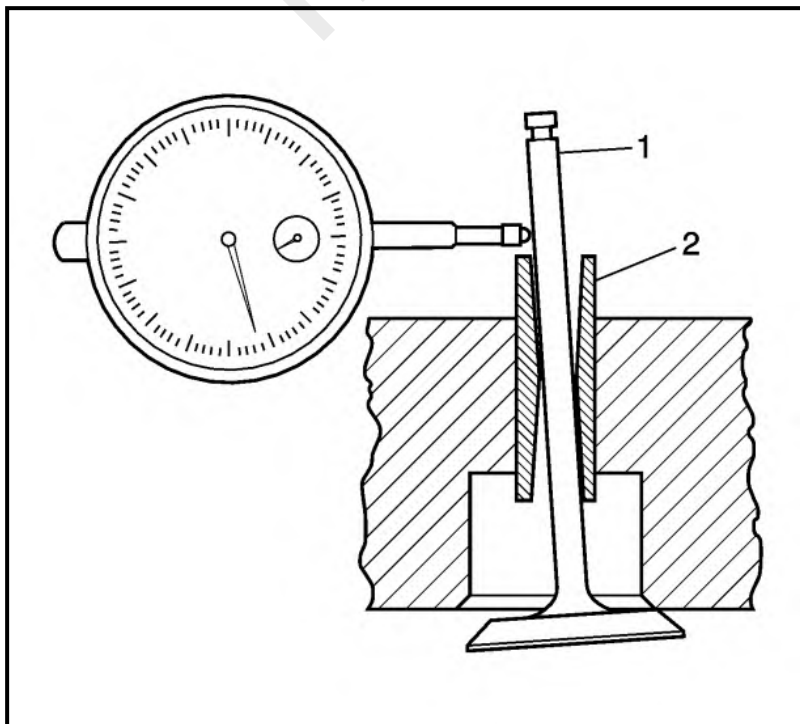


Ensure the cylinder head decks are clean and free of gasket material.

2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder head deck face surface.
4. Measure the clearance between the straight-edge and the cylinder head deck face using a feeler gauge at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder head deck surface does not require resurfacing.
6. If the warpage is between 0.05 - 0.20 mm (0.002 - 0.008 in) or any imperfections or scratches that could inhibit proper cylinder head gasket sealing are present, the cylinder head deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder head deck surface requires more than 0.25 mm (0.010 in) material removal the head must be replaced.

Valve Guide Measurement

1.



Measure the valve stem (1)-to-guide (2) clearance. Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.

2. Clamp the **GE - 8001** Dial Indicator Set to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. **Engine Mechanical Specifications**
 - If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, the valve guide may be oversized by 0.075 mm (0.003 in) using the **EN - 42096** Valve Guide Reamer. There is 1 size of oversized valve stem available for service.
 - Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.
 - If oversizing the guide does not bring the clearance within specifications, replace the cylinder head.

VALVE SPRING INSPECTION AND MEASUREMENT

Special Tools

EN-22738-B Valve Spring Tester

Equivalent regional tools: **Special Tools**

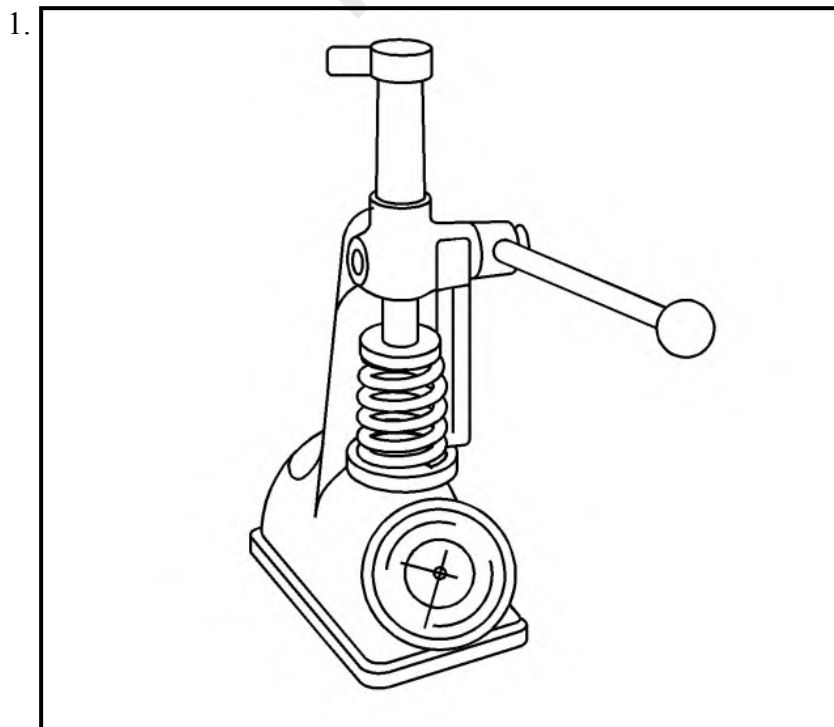
Inspection Procedure

1. Clean the valve springs in solvent.

WARNING: Refer to **Safety Glasses Warning** .

2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.

Measurement Procedure



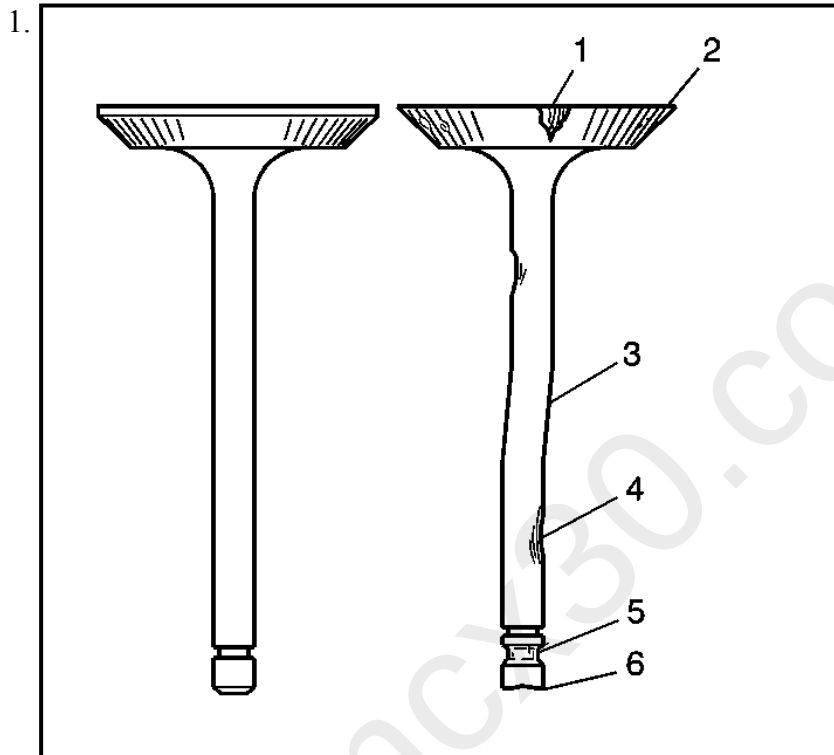
2. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

VALVE AND SEAT GRINDING

Valve Cleaning Procedure

1. Use soft bristle wire brush to clean any carbon build-up from the valve head. DO NOT use a wire brush on any part of the valve stem. The valve stem is chrome plated to provide enhanced wear characteristics. Wire brushing the stem could remove the chrome plating.
2. Thoroughly clean the valve with solvent and wipe dry.

Valve Visual Inspection Procedure



Inspect the valve for damage from the head to tip for the following conditions:

- Pitting in the valve seat area (1)
 - Lack of valve margin (2)
 - Bending in the valve stem (3)
 - Pitting or excessive wear in the stem (4)
 - Worn valve key grooves (5)
 - Worn valve tip (6)
2. Replace the valve if any of these conditions exist.

Valve Measurement Overview

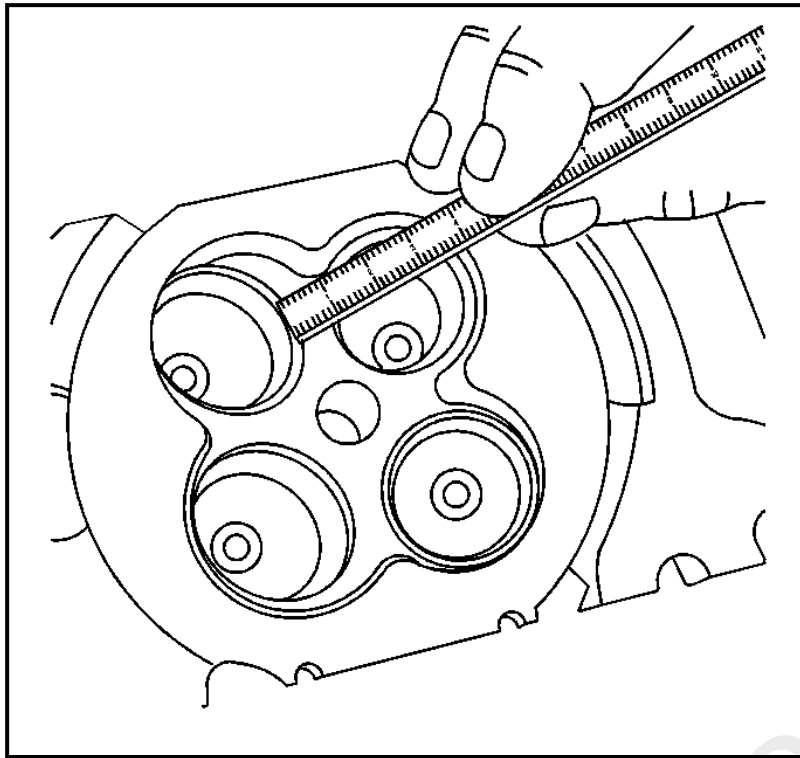
NOTE: The following measurement and reconditioning procedures must be followed to ensure proper engine performance.

1. Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
2. If the measurement procedures reveal that the valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning. Valves for E85-compatible engines CANNOT be reconditioned. Any grinding, lapping, wire-brushing or other similar procedure will

damage or destroy the coating that gives the valve the E-85 compatible features. If an E85-compatible valve is out of specification in any area, replace it.

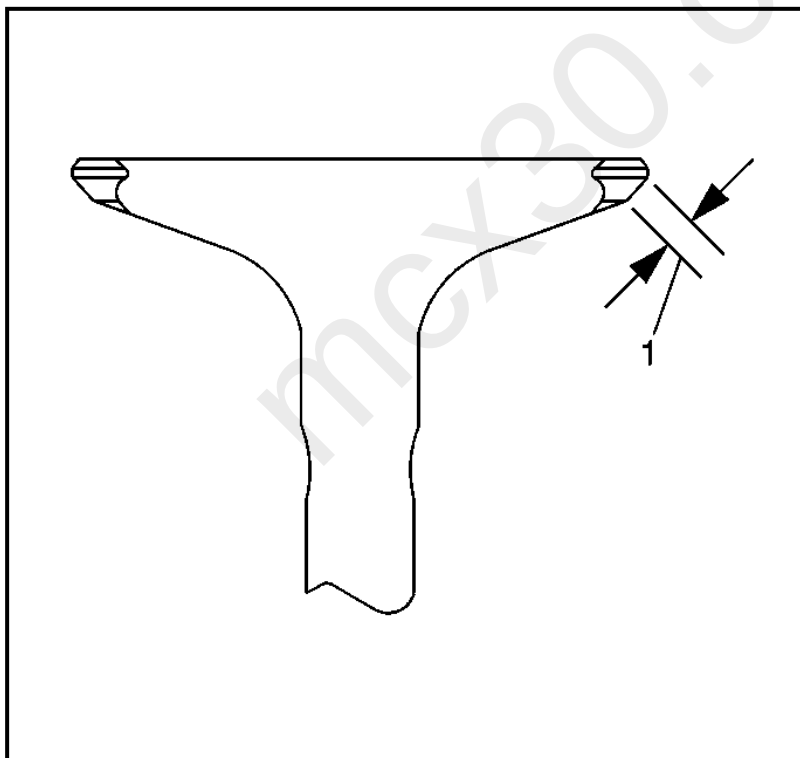
Valve Seat Width Measurement Procedure

1.



Measure the valve seat width in the cylinder head using a proper scale.

2.



Measure the seat width on the valve face (1) using a proper scale.

NOTE: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter (margin) of the valve. If the contact area is too close to the margins, the valve must be replaced.

3. Compare your measurements with the specifications listed in [Engine Mechanical Specifications](#).
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must replace the valve. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

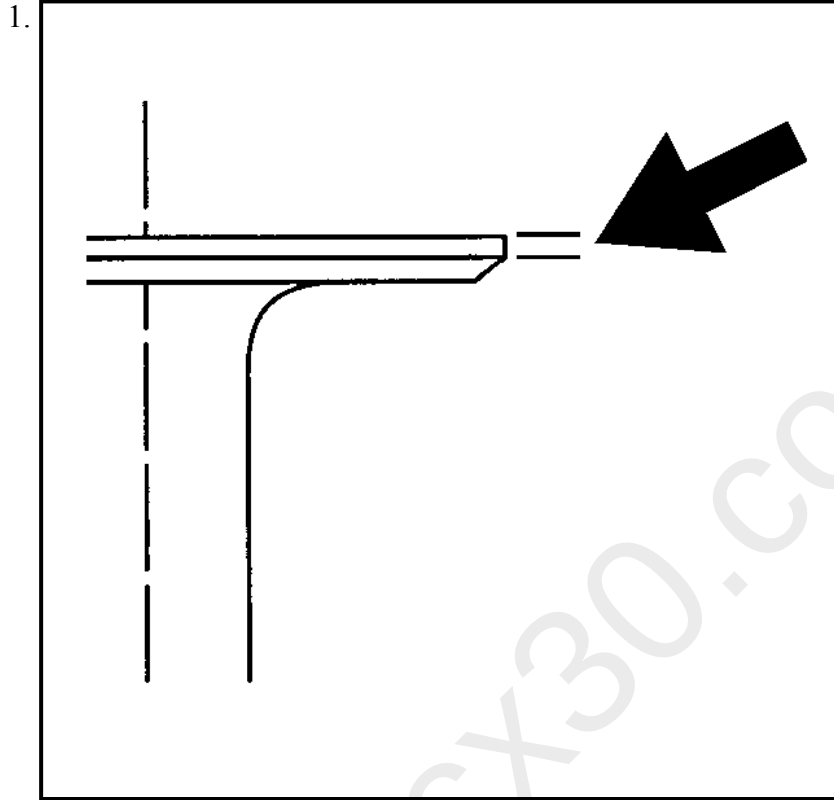
Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

CAUTION: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.

2. Compare your measurements with the specifications listed in [Engine Mechanical Specifications](#).
3. If the valve seat exceeds the roundness specification, you must replace the valve.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

Valve Margin Measurement Procedure



Measure the valve margin using an appropriate scale.

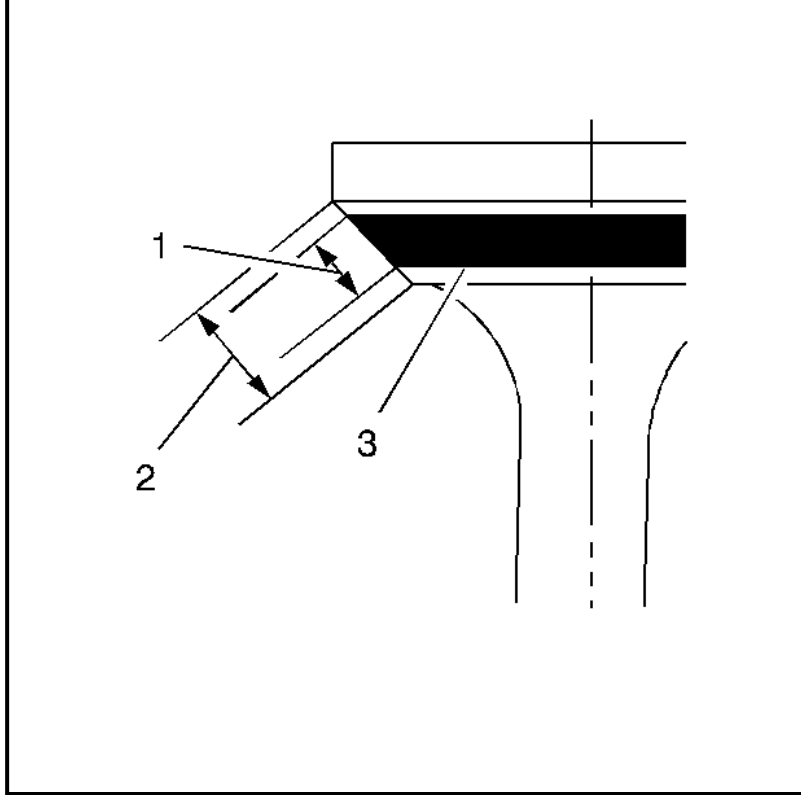
2. Reference the specifications in this section for minimum valve margin and compare them to your measurements.
3. If the valve margins are beyond specification, replace the valves.
4. If the valve margins are within specification, test the valve for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve-to-Seat Concentricity Measurement Procedure

NOTE:

- Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.
- You must measure the valve face and the valve seat to ensure proper valve sealing.





Coat the valve face lightly with blue dye (3).

2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.
 - If the valve face is concentric, providing a proper seal-with the valve stem, a continuous mark will be made around the entire face (1).

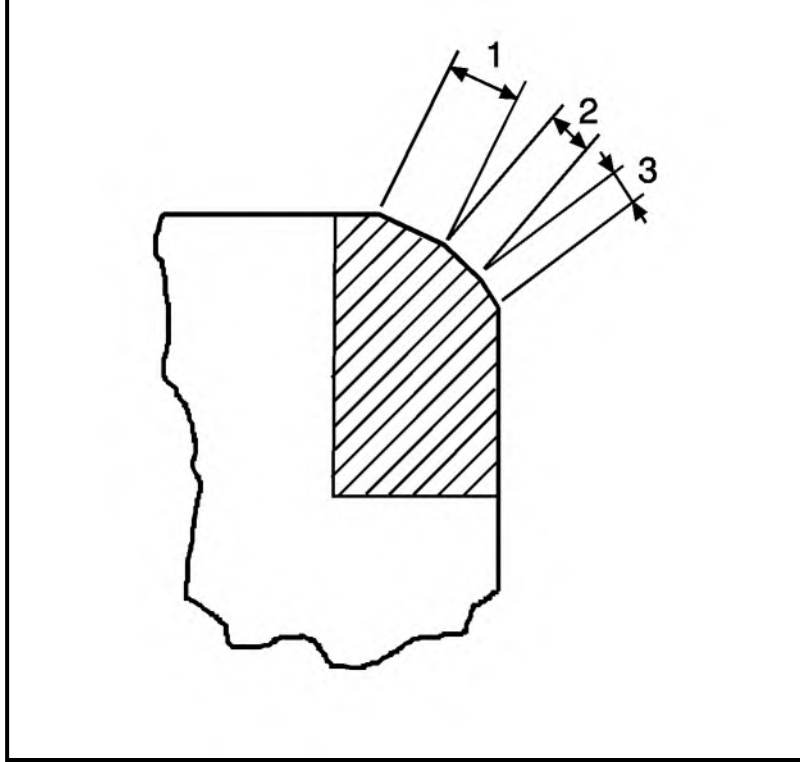
NOTE: The wear mark **MUST** be at least 0.5 mm (0.020 in) from the outer diameter, the margin, of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

- If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

Valve and Seat Reconditioning Procedure

1.





NOTE:

- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the buildup of carbon on the seats.
- A NEW valve must be used with any reconditioned seat.

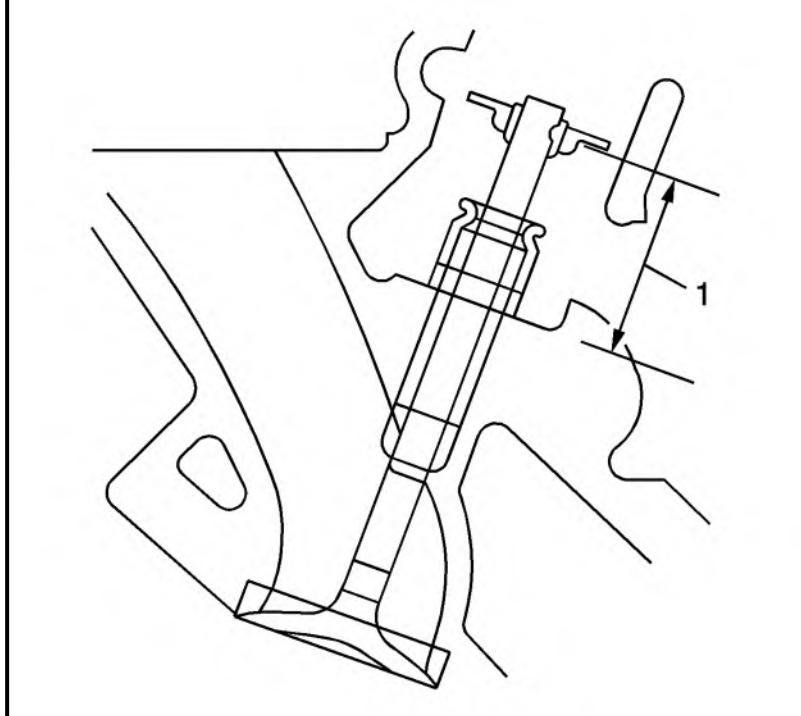
Grind the valve seats (2) to the proper angle specification listed in [Engine Mechanical Specifications](#) .

2. Using the proper angle specification listed in [Engine Mechanical Specifications](#) , grind, relieve, the valve seats (1) to correctly position the valve seating surface (2) to the valve.
3. Using the proper angle specification listed in [Engine Mechanical Specifications](#) , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in [Engine Mechanical Specifications](#) .
4. When grinding the seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
5. Install the valve in the cylinder head. Do not lap the valves under any condition, whether the valves are new or used.
6. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
7. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve Stem Height Measurement Procedure

1.





NOTE: To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.

Install the valve into the valve guide.

2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (1) between the cylinder head to the bottom of the valve spring retainer. Refer to [Engine Mechanical Specifications](#).
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

CAUTION: DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.

CAUTION: DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.

7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

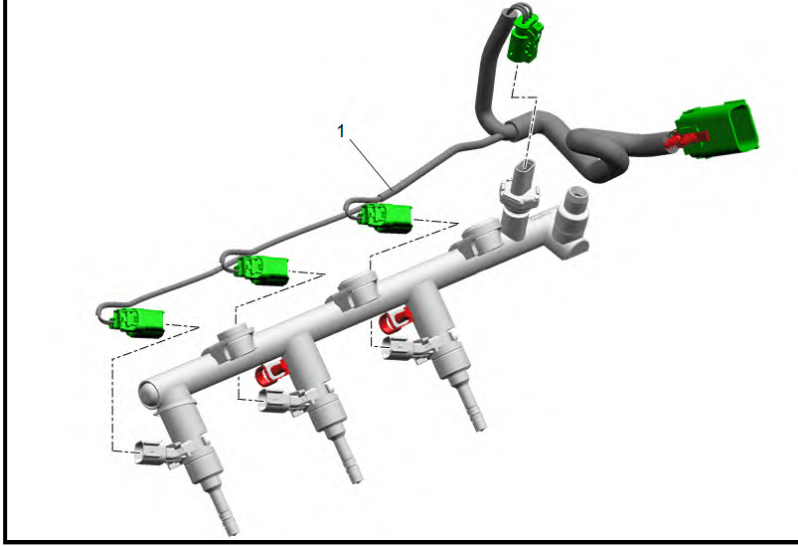
Special Tools

- EN-47909 Injector Bore and Sleeve Cleaning Kit
- EN-49245 Injector Seal Installer Kit
- EN-49247 Injector Retaining Clip Installer

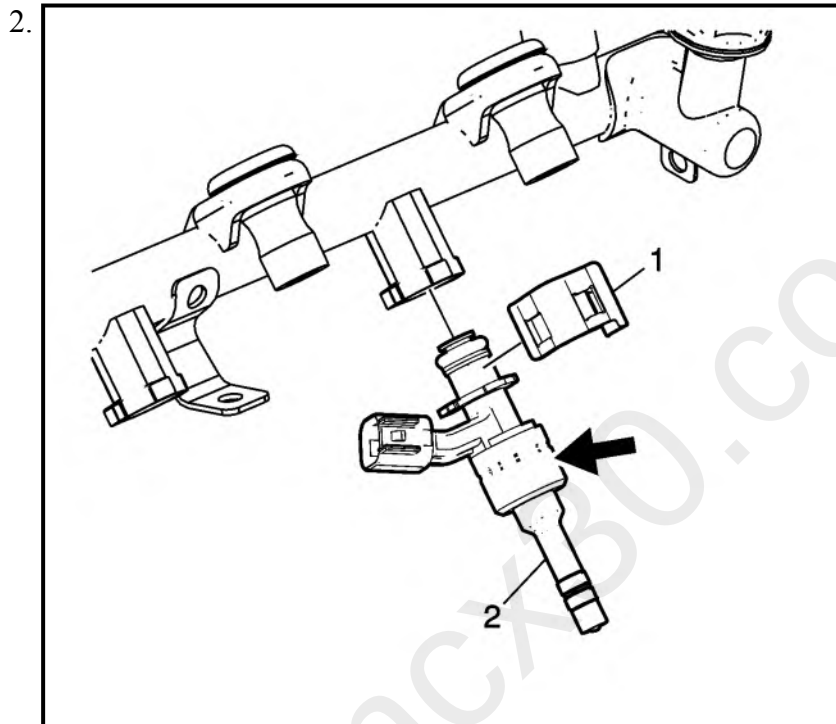
For equivalent regional tools, refer to [Special Tools](#).

1.





Detach and remove the fuel rail wiring harness (1) from the fuel injector rail.

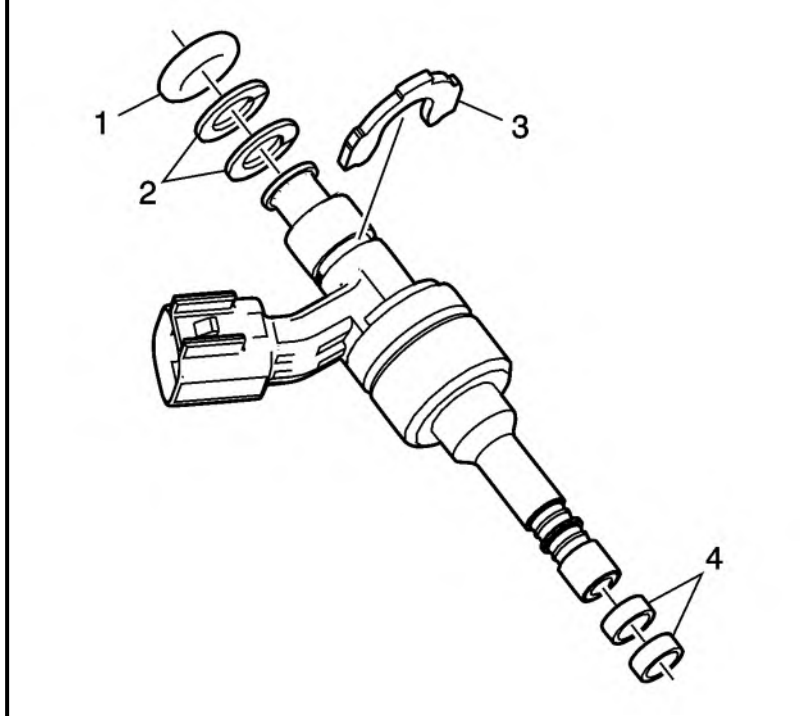


Using a suitable tool remove the fuel injector to rail retainer (1) from the fuel injector rail by spreading both sides of the fuel injector to rail retainer at the same time.

3. Discard the fuel injector to rail retainer (1).

4. Carefully twist the fuel injector to remove the fuel injector (2) from the fuel injector rail.



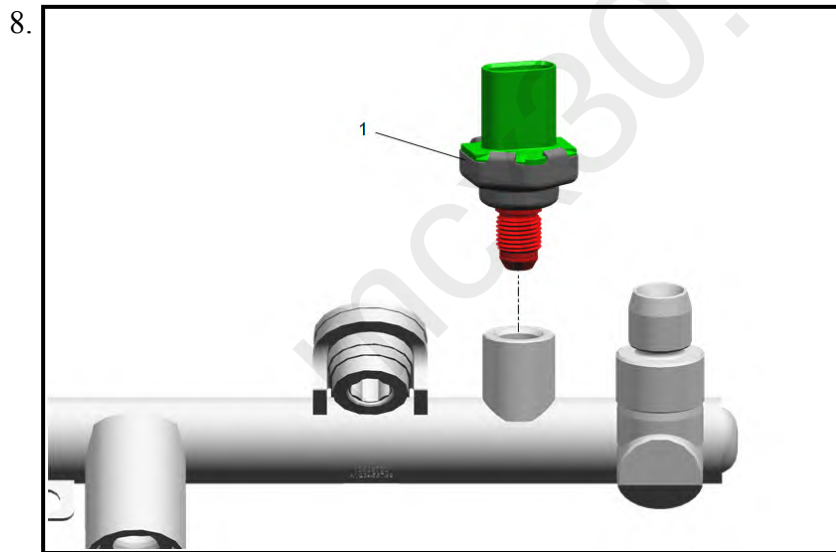


Using a suitable tool remove the fuel injector bushing (3).

6. Discard fuel injector bushing.

7. Remove and discard the following components:

- Fuel injector O-ring (1).
- Plastic spacers (2).
- Fuel injector seals (4).



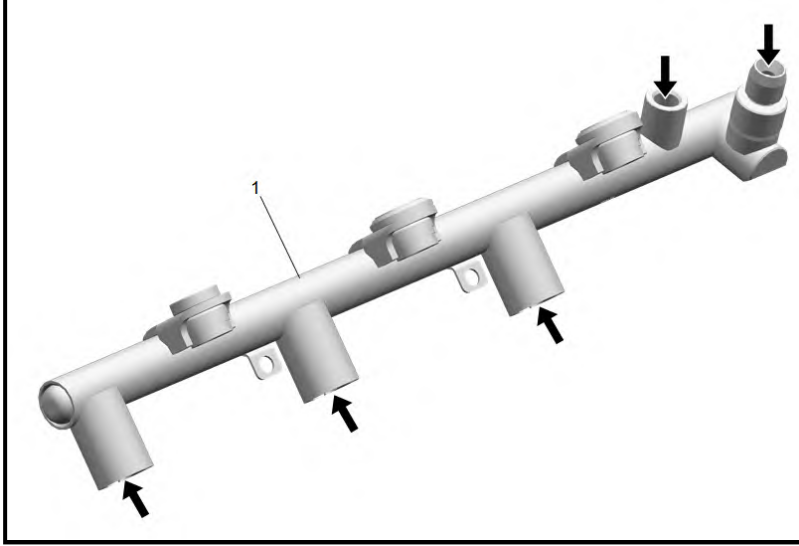
NOTE: Do not apply force to the plastic housing of the fuel pressure sensor. Failure to comply will destroy the sensor.

Remove the fuel pressure sensor (1) from the fuel injector rail.

NOTE: Do not soak or submerge the fuel rail or injectors in solvent.

9. Clean the exterior of the fuel injector rail and fuel injectors with solvent using the injector bore and sleeve cleaning kit **EN-47909** injector bore and sleeve cleaning kit.



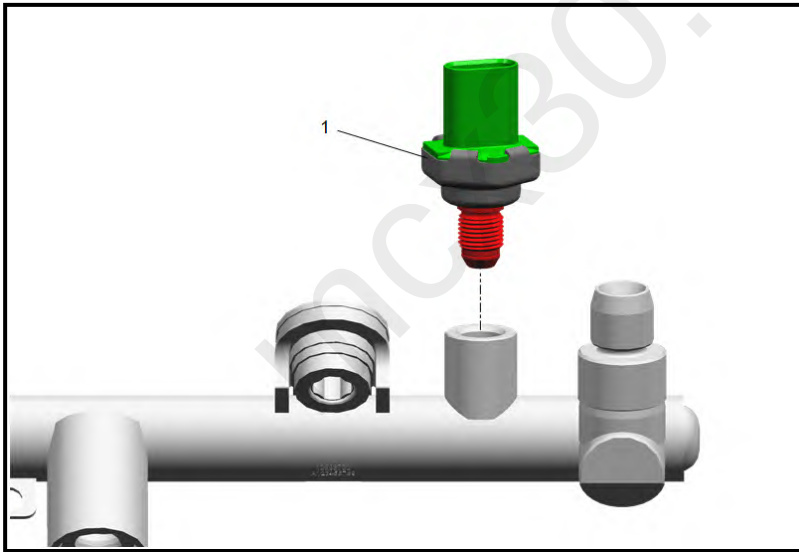


Inspect the fuel injector rail (1) for the following conditions:

- Damage, debris or restrictions to the fuel rail
- Damage, debris or restrictions to the fuel ports in the fuel rail
- Damage to the mounting area for the fuel rail
- Damage to the fuel rail mounting bolts or mounting bolt grommets/isolators
- Damage to the threads on the fuel rail feed fitting
- Damage to the threads in the fuel pressure sensor bore
- Damage to the fuel pressure sensor connector, threads, or sealing face

11. If any of the above conditions are found, replace the fuel injector rails. Do not attempt to repair the fuel injector rails.

12.



NOTE: Do not apply force to the plastic housing of the fuel pressure sensor. Failure to comply will destroy the sensor.

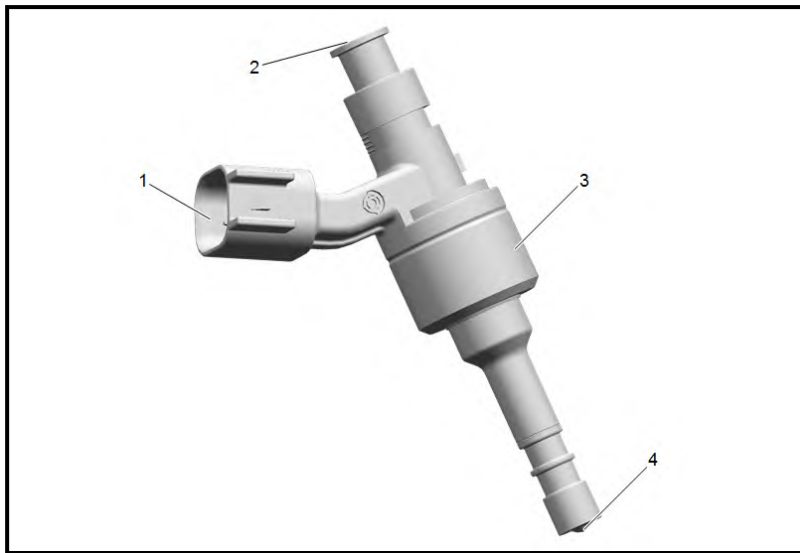
Install the fuel pressure sensor (1) to the fuel injector rail.

NOTE: Ensure that the fuel rail threads have been cleaned of any excess fuel or the fuel pressure sensor will NOT seal properly.

1. Lubricate the threads and the sealing area in the fuel rail with silicon free engine oil. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.
2. Lubricate the threads and the sealing area on the fuel pressure sensor with silicon free engine oil. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.
3. Install the fuel pressure sensor to the fuel injector rail and hand tighten.
4. Remove the fuel pressure sensor from the fuel injector rail and re-lubricate.

5. Install the fuel pressure sensor to the fuel injector rail and tighten to 33 N.m (25 lb ft).

13.

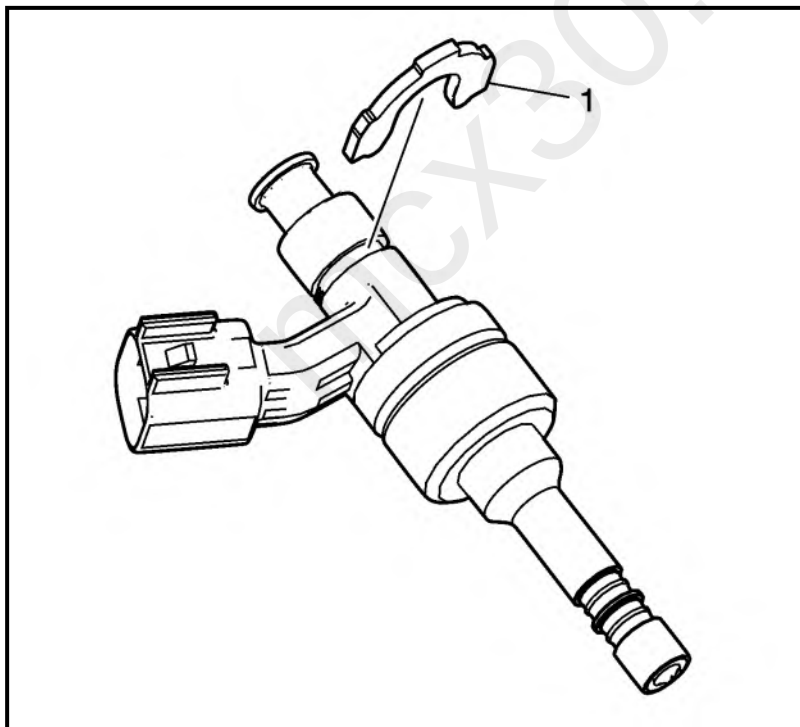


Inspect the fuel injectors for the following conditions:

- Damage to the fuel injector connector (1)
- Damage to the fuel inlet cone (2)
- Damage to the fuel injector body (3)
- Damage to the fuel injector tip (4)

14. Replace the fuel injector if any of the above conditions are found. Do not attempt to repair the fuel injectors.

15.



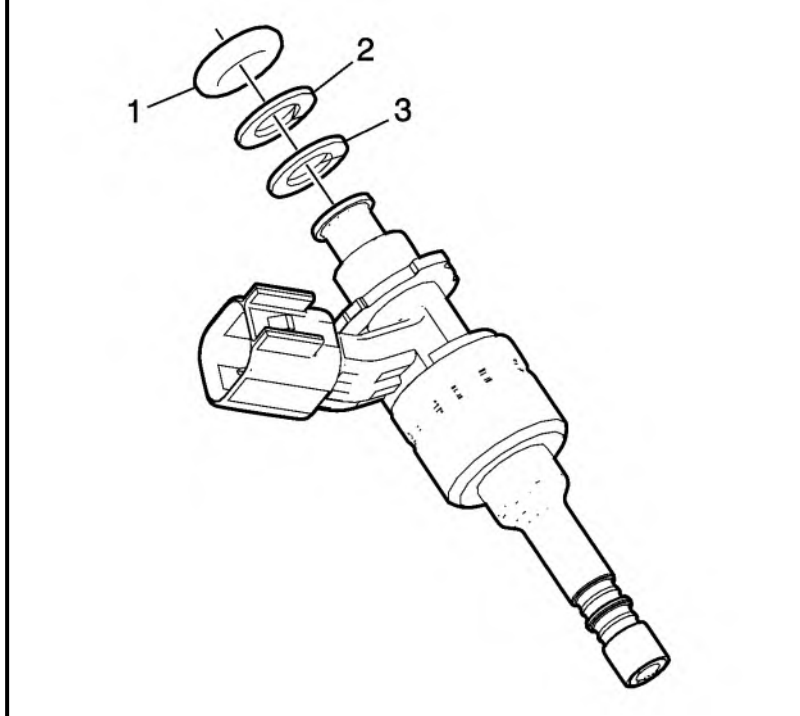
NOTE:

- The fuel injector bushing (1) is to be installed **BEFORE** O-ring or backup rings are installed.
- Listen for an audible click to confirm correct installation of the fuel injector bushing

Install NEW fuel injector bushing (1) onto injector body. Bushing should seat with a distinct "snap" sound and feel. Ensure bushing is fully seated.

16.

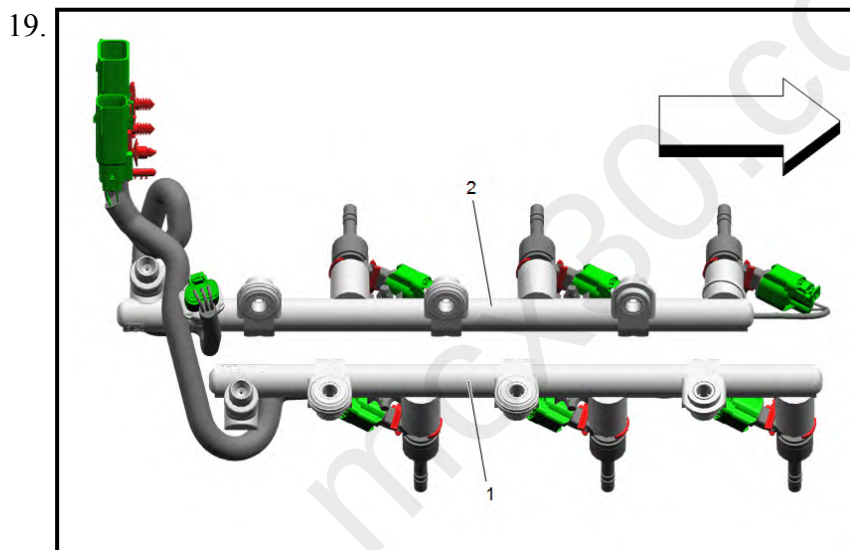




Install the NEW white plastic spacer (3) on the fuel injector first.

17. Install the brown plastic spacer (2) second.

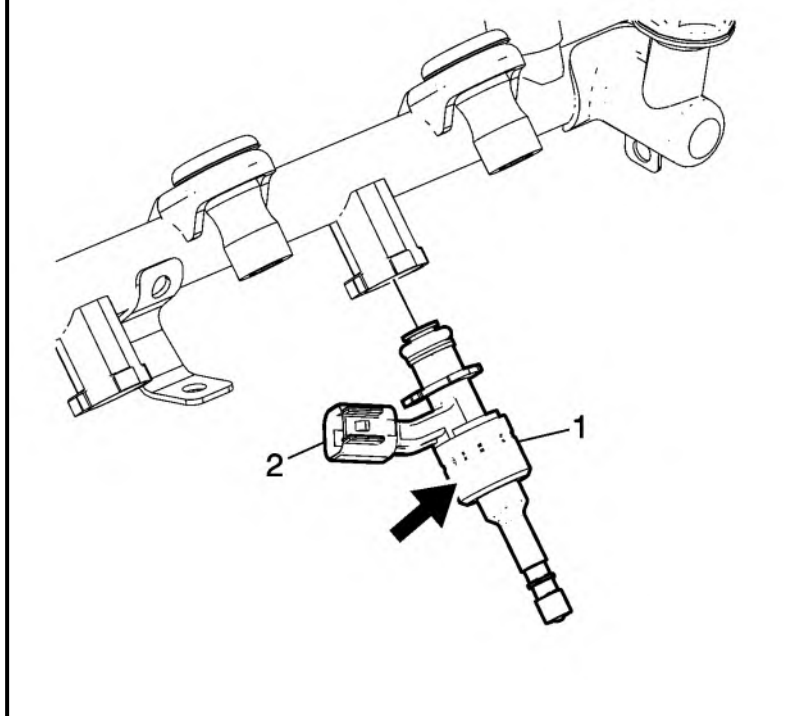
18. Lubricate the NEW O-ring (1) with one drop of clean engine oil.



CAUTION: Ensure the fuel injectors are installed in the correct orientation. Improper orientation of the fuel injectors may result in engine misfire and possible engine damage.

The right side (bank 1) fuel injector wiring harness connectors (1) should point to the rear of the engine. The left side (bank 2) fuel injector wiring harness connectors (2) should point to the front of the engine.





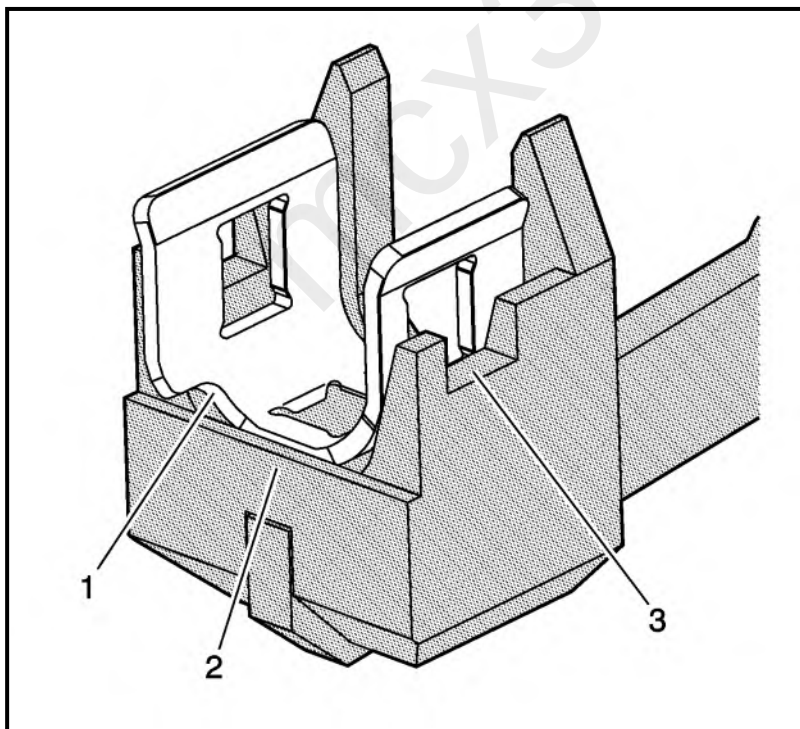
NOTE:

- Do NOT install the Teflon injector tip/bore seals until AFTER the injectors are installed on the fuel rail.
- Make sure that the fuel injector connectors are placed in the correct position.

Holding the largest diameter/body of the injector only, indicated by arrow in graphic, insert the injector assembly (1) into the fuel rail. Ensure correct orientation of the electrical connector (2).

21. Clamp the fuel rail in a bench vise USING SOFT JAWS to aid in holding the rail during the installation of the retainer.

22.



Support the fuel injector fuel rail in a vise.

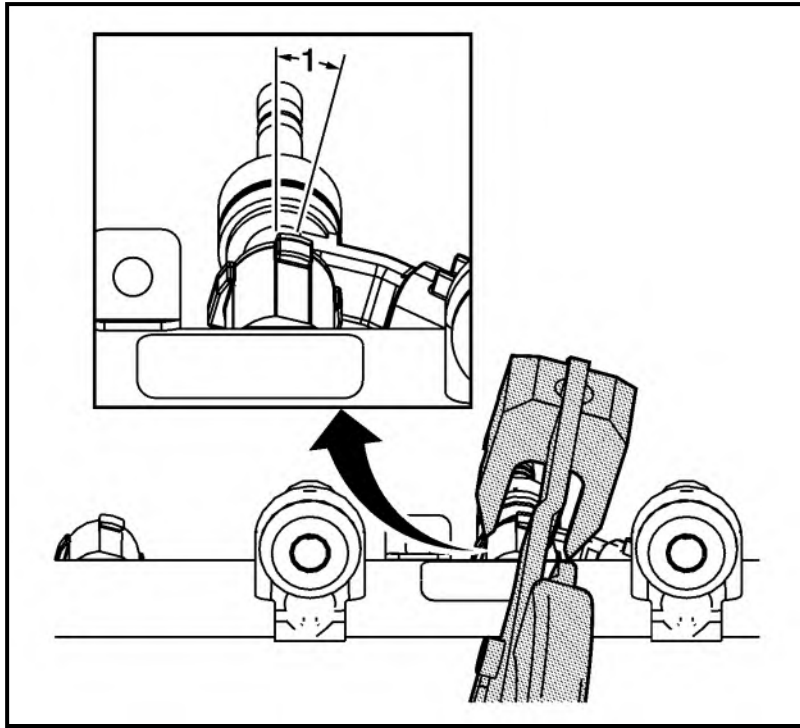
NOTE:

Ensure the retainer is set properly into EN-49247 installer.

- The notch (1) should always face forward
- The fuel injector to fuel rail retainer should be behind the plate (2)
- The tool windows (3) allow for visual alignment

23. Install the fuel injector to fuel rail retainer to the **EN-49247** injector retaining clip installer.

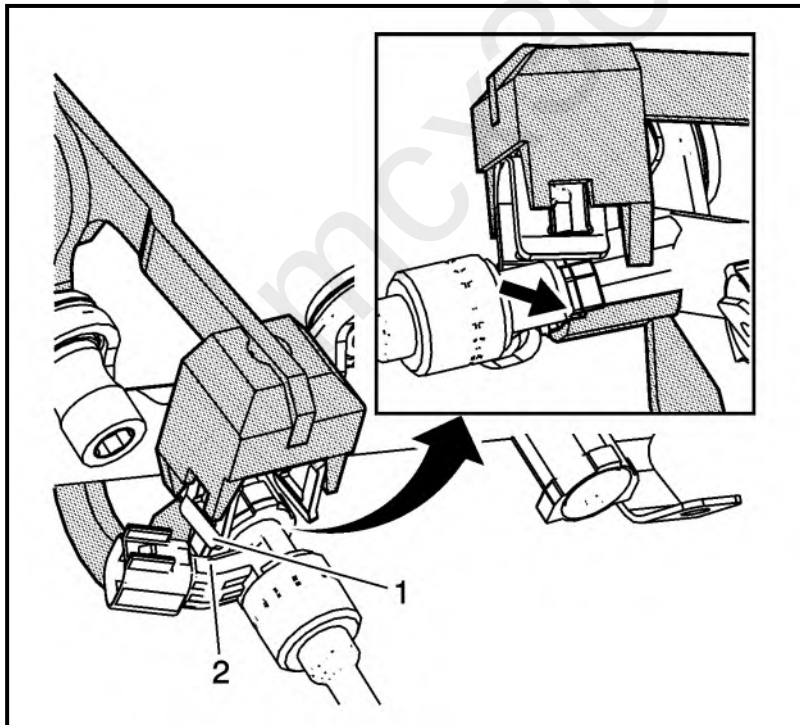
24.



NOTE: Observe the following steps before installing the fuel injector to fuel rail retainer.

There is a 15-degree angle of rotation (1) with the fuel injector rail flanges relative to the fuel injector rail. Hold the **EN-49247** injector retaining clip installer at a similar angle to aid the correct installation of the fuel injector to fuel rail retainer.

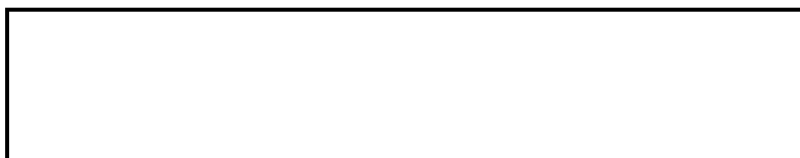
25.

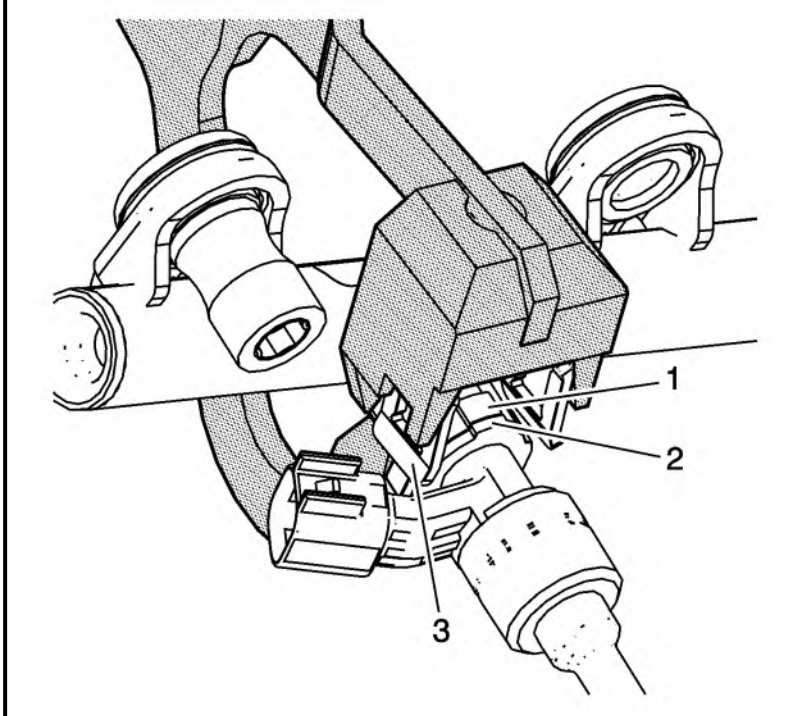


When mounting the **EN-49247** injector retaining clip installer to the fuel injector rail, the fuel injector to fuel rail retainer should nearly be touching the electrical connector (2).

26. The base of the **EN-49247** injector retaining clip installer should be positioned as shown before squeezing the tool to complete the installation.

27.

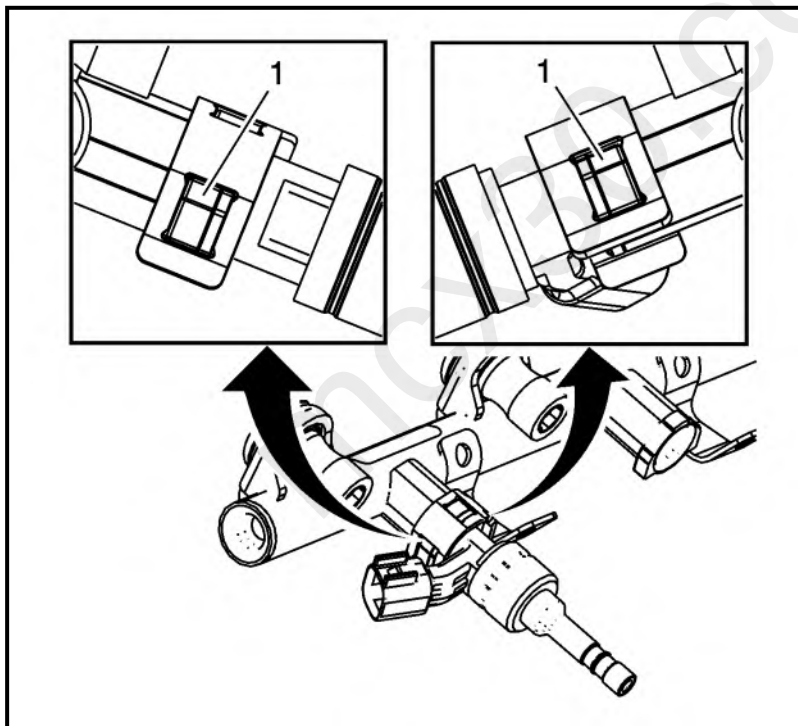




Hold the injector bushing (2) and fuel injector rail flanges (1) in alignment.

28. Hold the injector assembly firmly against the fuel injector rail to prevent a gap forming between the fuel injector and the fuel injector rail.
29. Install the fuel injector to fuel rail retainer (3).

30.



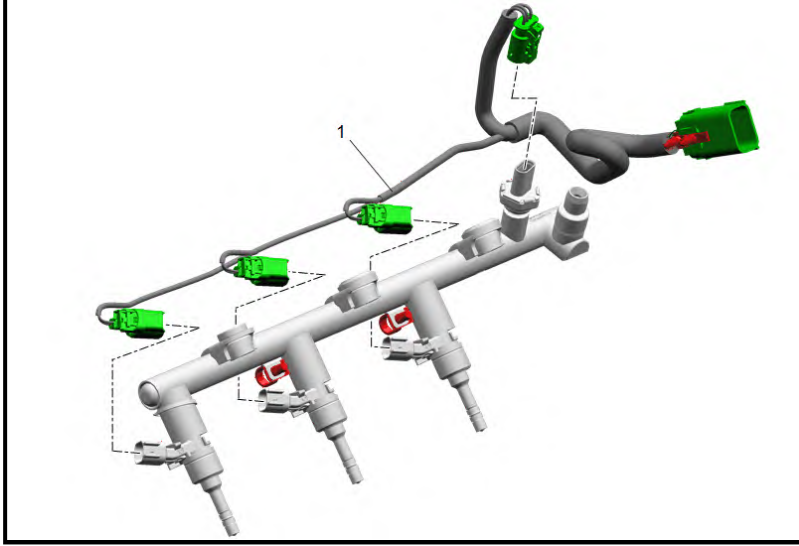
CAUTION: Ensure the fuel injector retainer is properly installed. Failure to completely install the retainers may degrade fuel injection system performance or cause system malfunction.

Ensure all 3 fuel injector bushing tabs and fuel rail flanges (1) are properly and completely captured by the fuel injector retainer.

31. Repeat the above steps for the remaining fuel injectors until all the fuel injectors are installed and retained in the fuel injector rail.

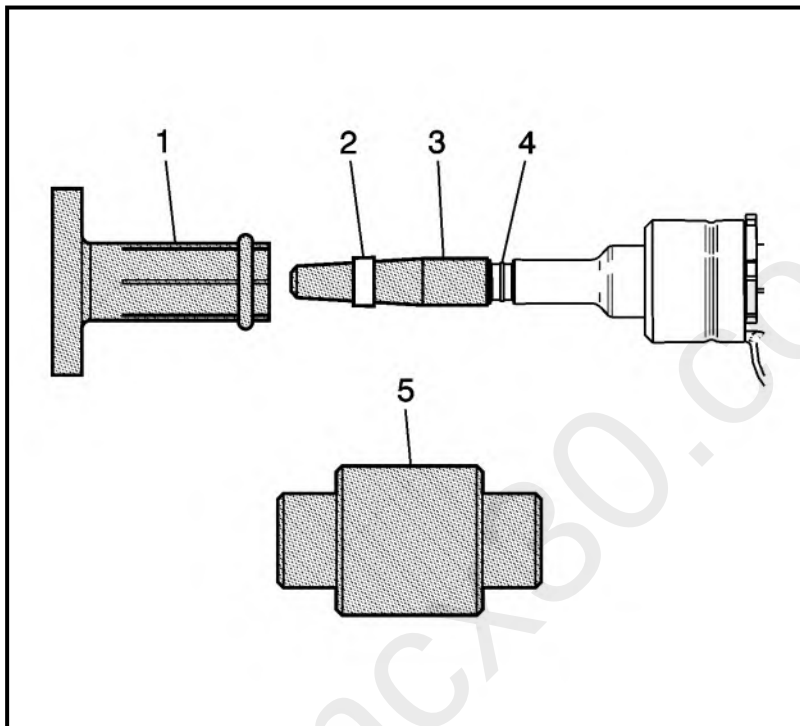
32.





Install the fuel injector rail wiring harness (1) to the fuel injector rail.

33.



NOTE: Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector tip.

Install the long protector (3) of the **EN-49245-1** fuel injector seal install/sizer to the fuel injector spray tip covering the first recessed area closest to the tip.

34. Place a NEW seal (2) onto long protector (3) of the **EN-49245-1** fuel injector seal install/sizer.

35. Using the pusher (1) of the **EN-49245-3** fuel injector seal install/sizer, push the seal (2) into the second recessed area (4) of the fuel injector.

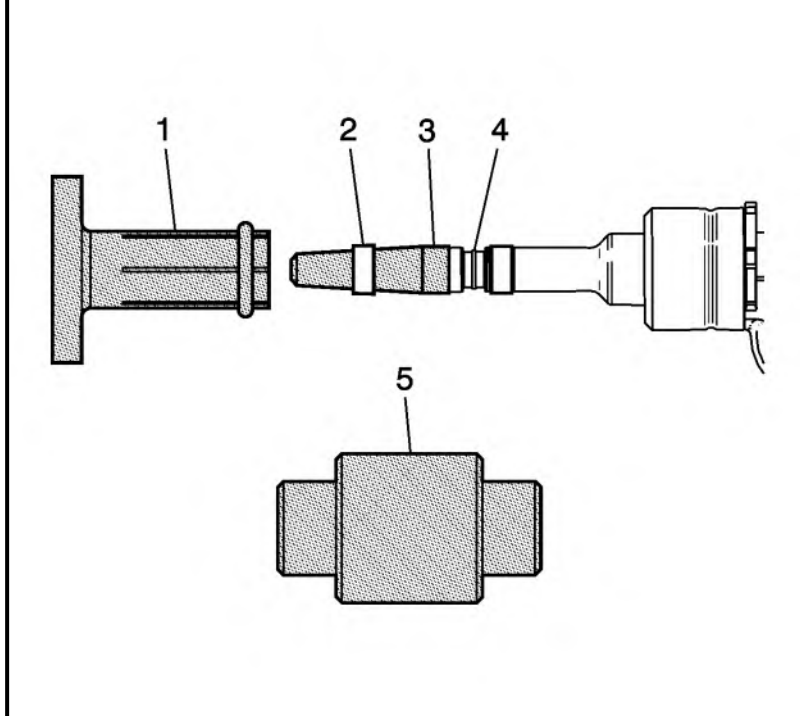
NOTE: The sizer (5) of the **EN-49245-4** fuel injector seal install/sizer is two sided, and either direction will size the seal correctly.

36. Compress the seal (2) with your fingers.

37. Resize the seal (2) using the sizer (5) of the **EN-49245-4** fuel injector seal install/sizer.

38.





NOTE: Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector tip.

Install the short protector (3) of the **EN-49245-2** fuel injector seal install/sizer to the fuel injector tip.

39. Place a NEW seal (2) onto the short protector (3) of **EN-49245-2** fuel injector seal install/sizer.
40. Using the pusher (1) of the **EN-49245-3** fuel injector seal install/sizer, push the seal (2) into the first recessed area (4) of the fuel injector.

NOTE: The sizer (5) of the **EN-49245-4** fuel injector seal install/sizer is two sided, and either direction will size the seal correctly.

41. Compress the seal (2) with your fingers.
42. Resize the seal (2) using the sizer (5) of the **EN-49245-4** fuel injector seal install/sizer.

CYLINDER HEAD ASSEMBLE

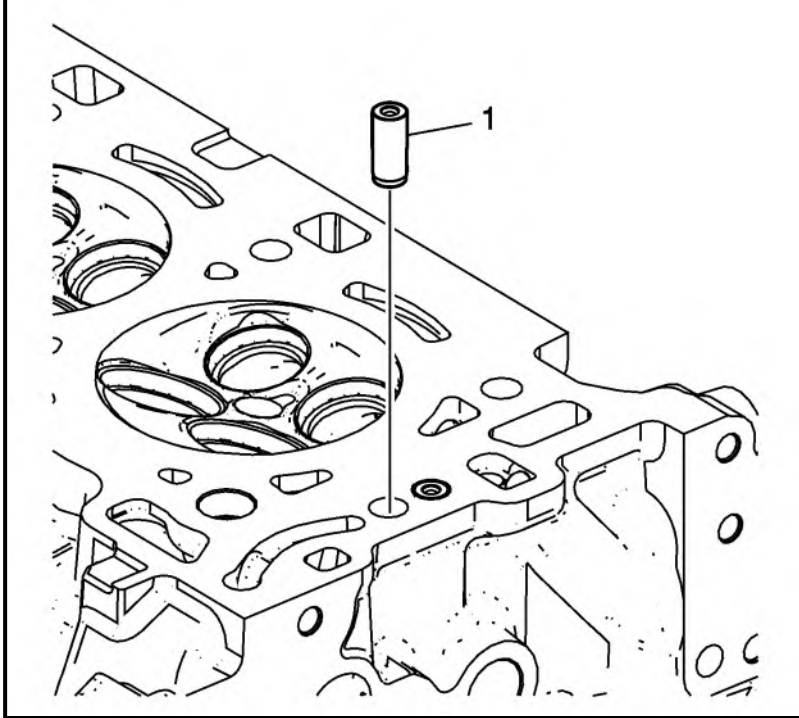
Special Tools

- **EN 8062** Valve Spring Compressor - Head Off
- **EN 46116** Valve Stem Seal Remover/Installer
- **EN 46117** Valve Stem Key Remover/Installer
- **EN 46119** Off-Vehicle Valve Spring Compressor Adapter
- **EN 46122** Camshaft Position Actuator Check-Ball Valve Remover/Installer

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

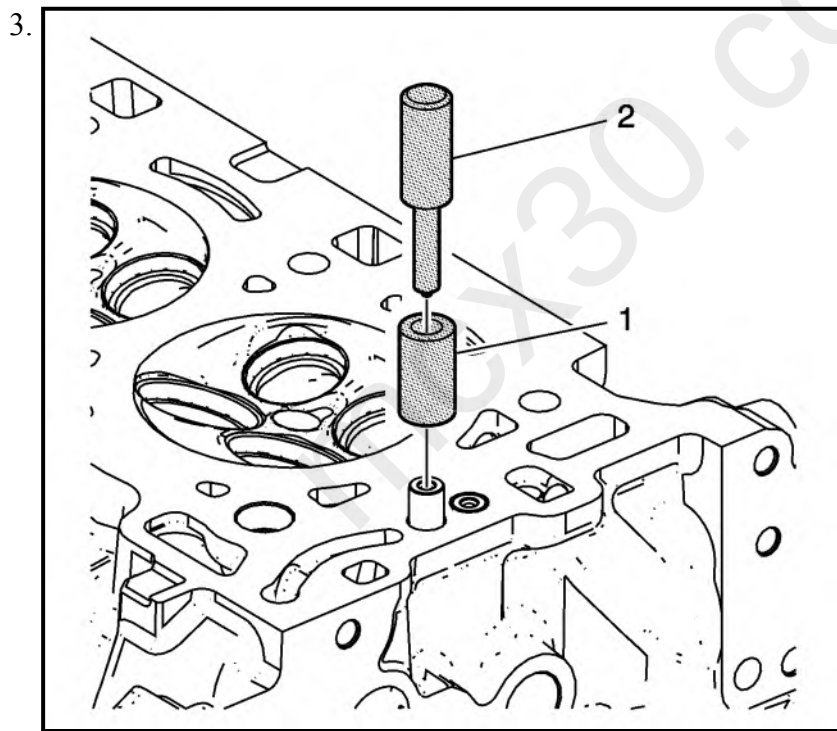
1.





Use lubricant included with **EN 46122** remover/installer to lubricate outside of new check valve (1).

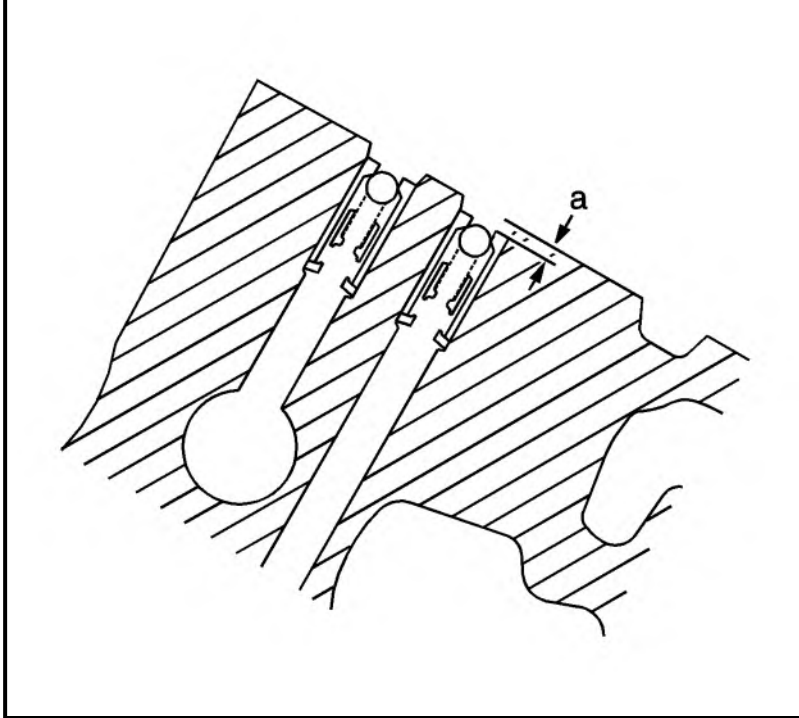
2. With the check ball end of the check valve facing UP, away from the head, insert the NEW check valve into the check valve bore in the cylinder head.



Place collar EN 46122-2 (1) over the new check valve with the slightly-larger inside diameter of the collar DOWN toward the cylinder head.

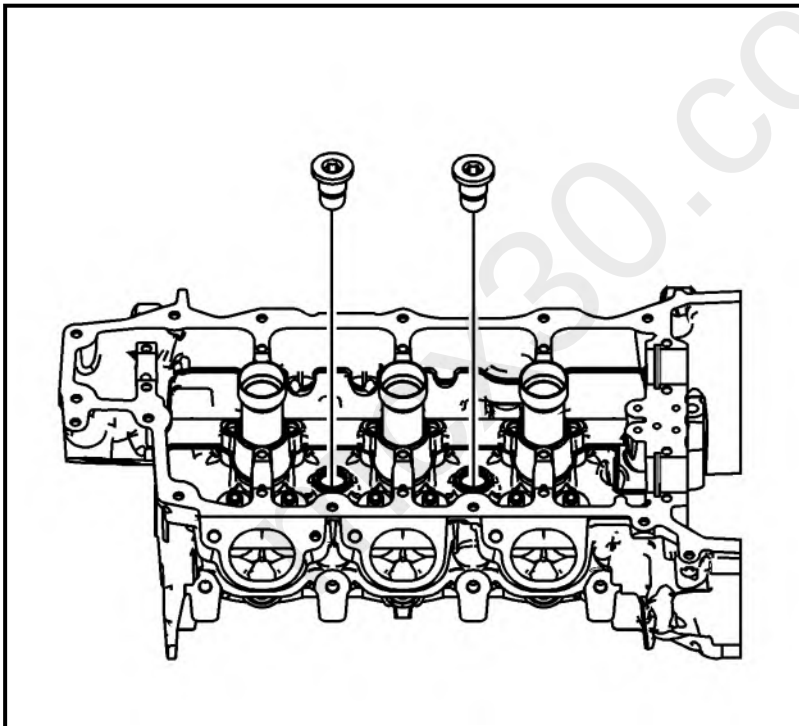
4. Using the driver EN 46122-1 (2), lightly tap the new check valve into place until the driver stops against the top of the collar.





Inspect the camshaft position actuator oil feed check valves in order to ensure they are properly installed in the cylinder head. The camshaft position actuator oil feed check valve should be flush to 2 mm (0.0787 in) below the cylinder head deck surface (a).

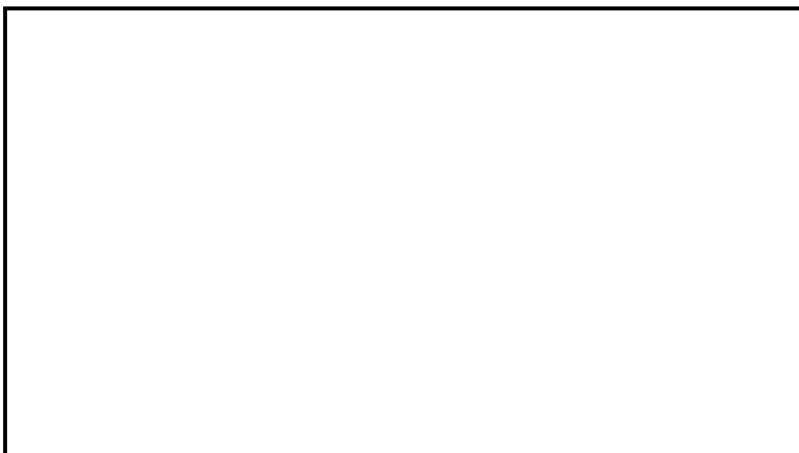
6.

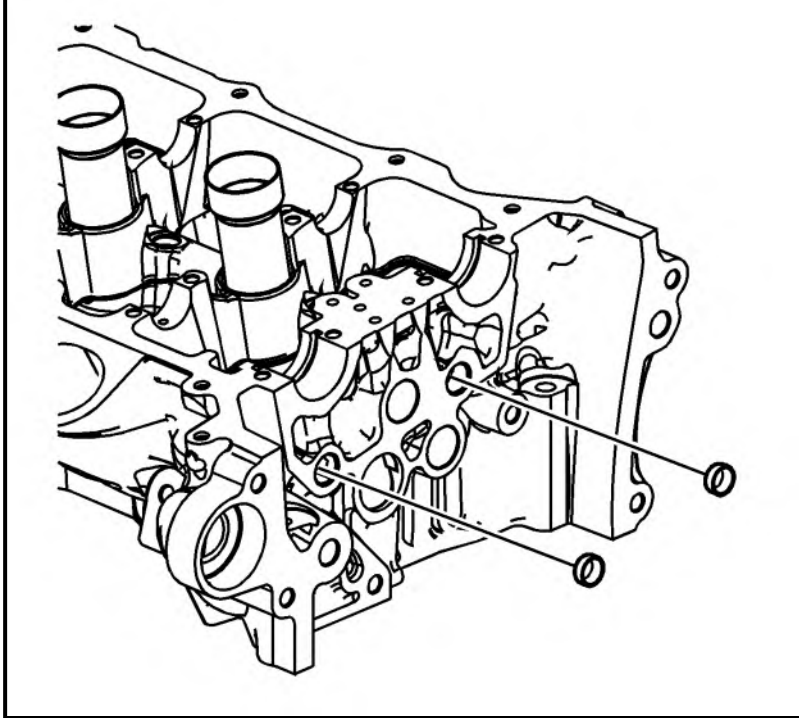


CAUTION: Refer to [Fastener Caution](#) .

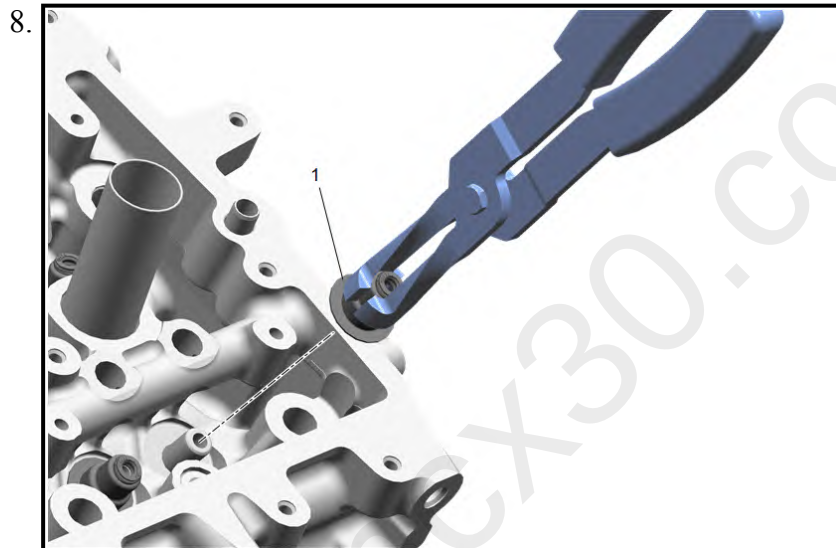
Install the cylinder head coolant threaded plugs and tighten to 75 N.m (55 lb ft).

7.





Install the NEW cylinder head oil gallery expansion plugs.



Place the valve stem oil seals onto the guides.

NOTE: NEVER reuse a valve stem oil seal. Always use new seals when assembling the cylinder head.

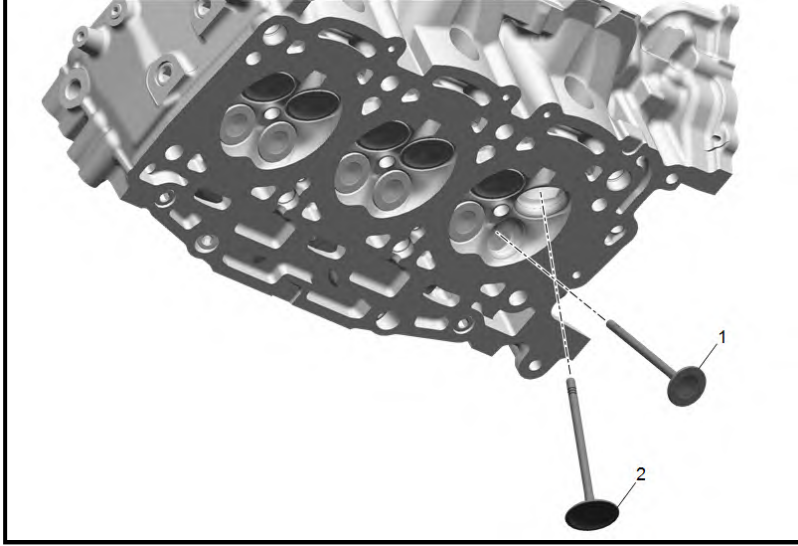
9. Mount a new valve stem oil seal using the EN 46116 remover/installer.

NOTE: Force should only be applied to the valve spring contact area of the new valve stem oil seal during installation.

10. Push and twist the valve stem oil seal into position on the valve guide until the seal positively locks on the guide using the EN 46116 remover/installer.

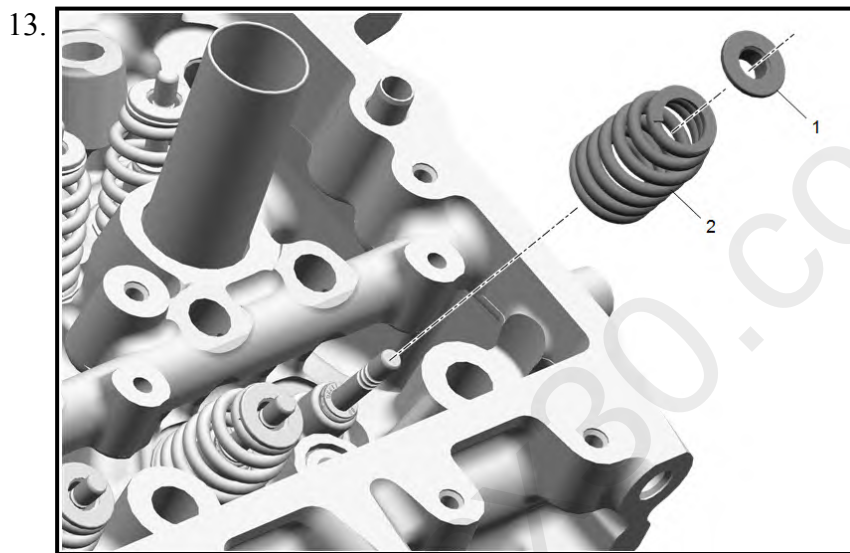
11. Lubricate the valve stem and valve guide ID with clean engine oil. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.





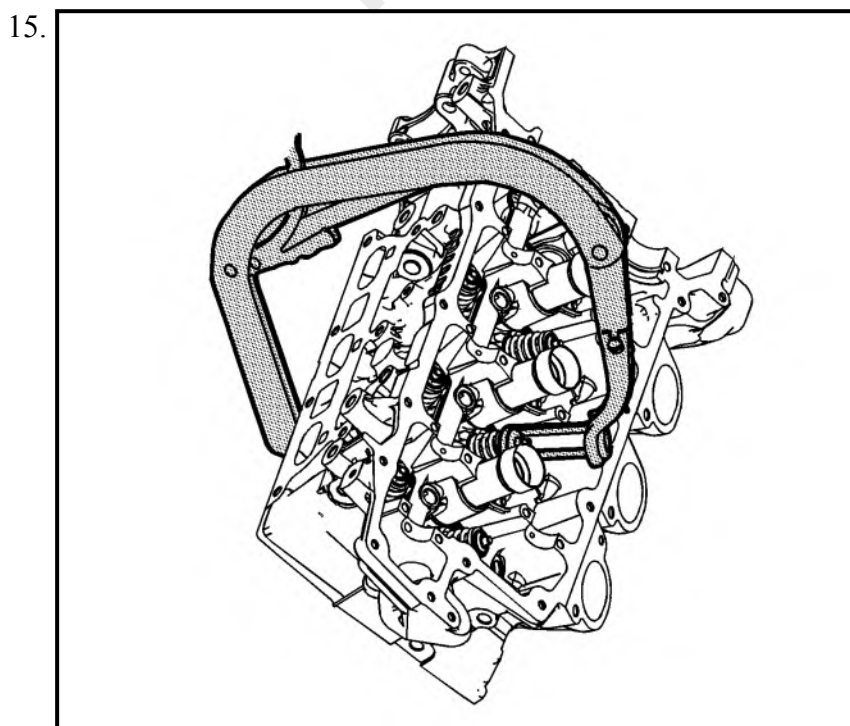
NOTE: The valve stem oil seal must not come loose from the valve guide when the valve is installed.

Insert the valve into the valve guide until it bottoms on the valve seat.



Position the valve spring on the spring seat.

14. Place the valve spring retainer onto the valve spring.



WARNING:

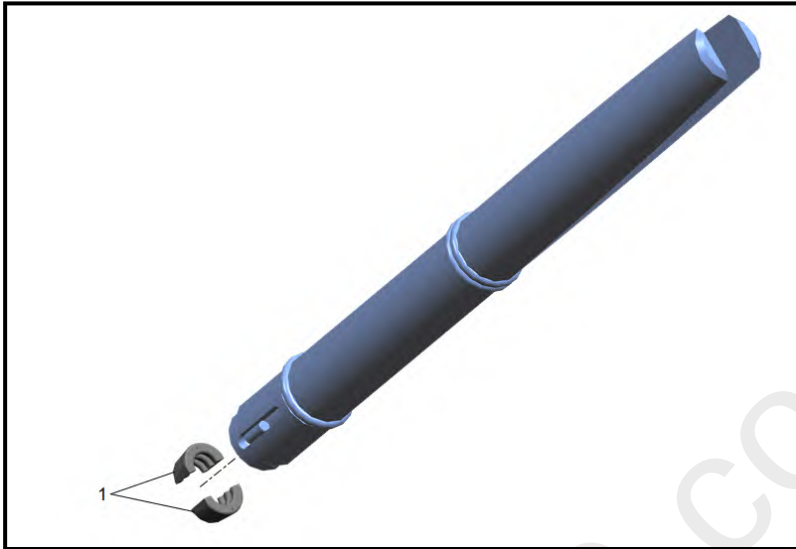
Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

CAUTION:

Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

Compress the valve spring using the **EN 8062** compressor and the **EN 46119** adapter.

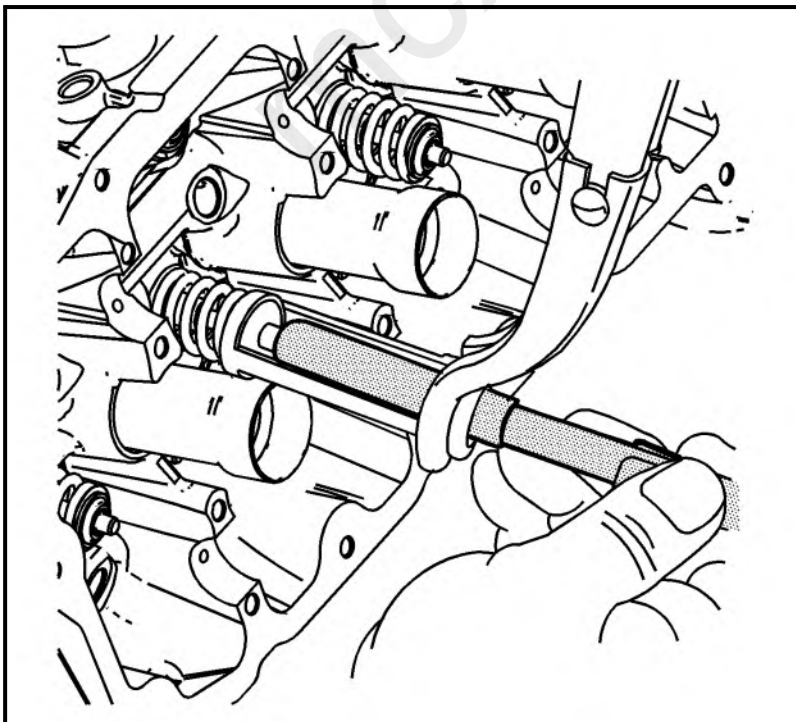
16.

**NOTE:**

Ensure proper directional placement of valve keepers in the **EN 46117** remover/installer. The valve keepers must be installed with the tapered end towards the valve stem seal.

With the spring compressed, install the valve keepers into the **EN 46117** remover/installer.

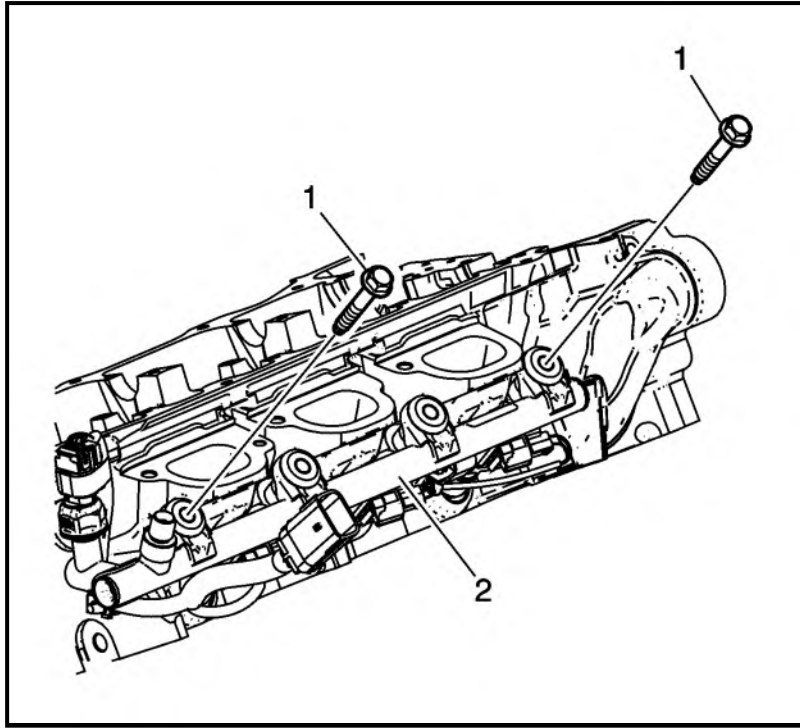
17.



Place the keepers into position by pushing the tool downward. While holding the tool lightly together in the area between the O-rings, using the thumb and forefinger, release tension on the **EN-46119** adapter and the **EN 8062** compressor. This will slowly push the **EN-46117** remover/installer off the valve stem, leaving the keepers in place.

18. Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer.

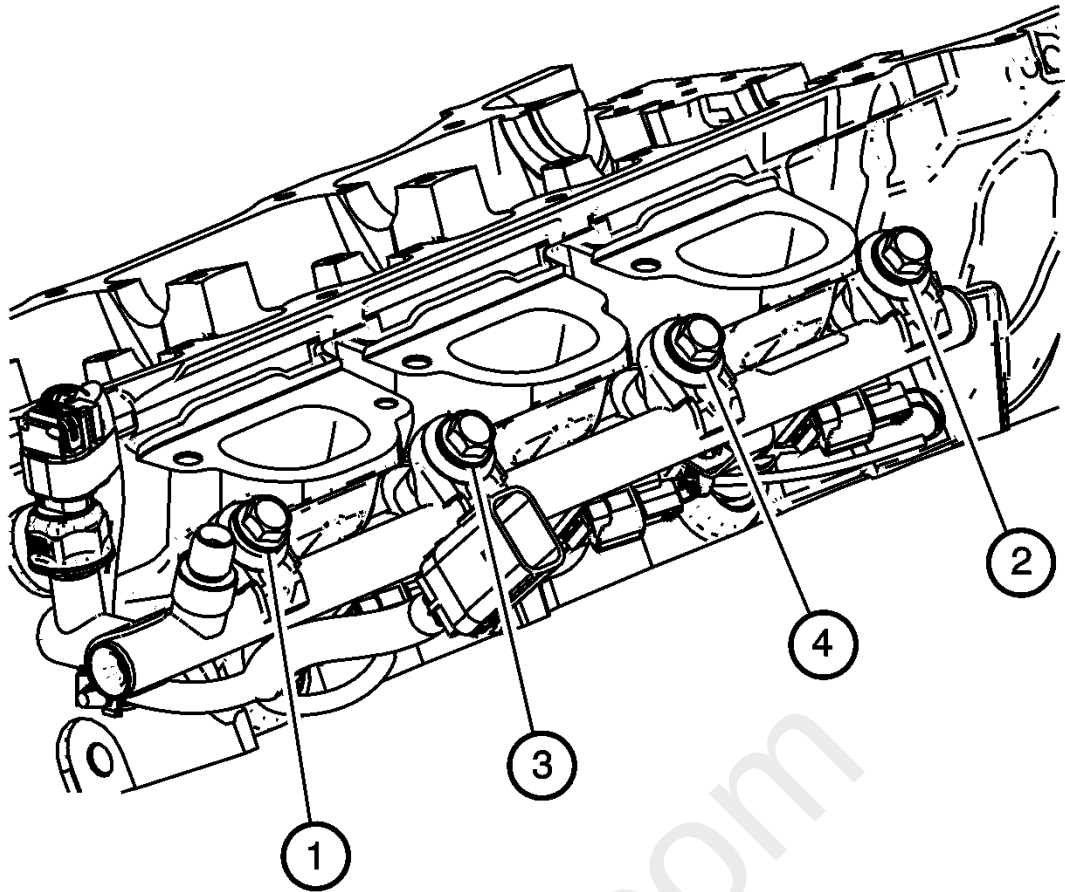
19.



NOTE: If the fuel rail was removed from the cylinder head, the fuel injector tip seals must be replaced. Refer to [Fuel Rail and Injectors Cleaning and Inspection](#).

Install the fuel rail with injectors (2) into the cylinder head evenly.

20. Install and hand tighten the two outer fuel rail bolts (1) to seat the injectors in the injector bores.
21. Install and hand tighten the two inner fuel rail bolts.



22.

Fig. 5: Fuel Rail Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

Tighten the fuel rail bolts in the sequence shown to 25 N.m (18 lb ft).

CAMSHAFT CLEANING AND INSPECTION

Special Tools

GE-7872 Magnetic Base Dial Indicator

Equivalent regional tools: **Special Tools**

Cleaning Procedure

1. Clean the camshaft in solvent.

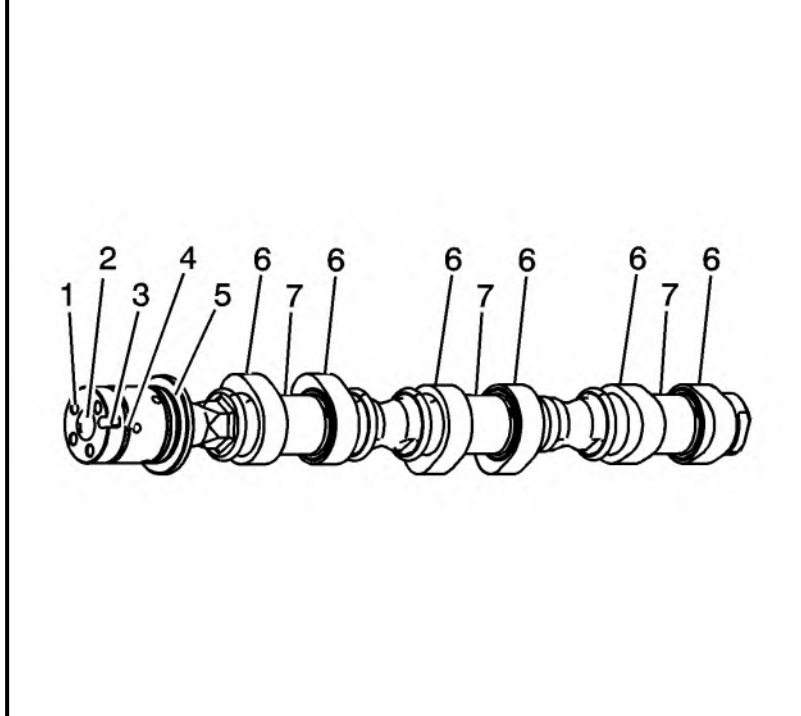
WARNING: Refer to **Safety Glasses Warning** .

2. Dry the camshaft with compressed air.

Visual Inspection

- 1.

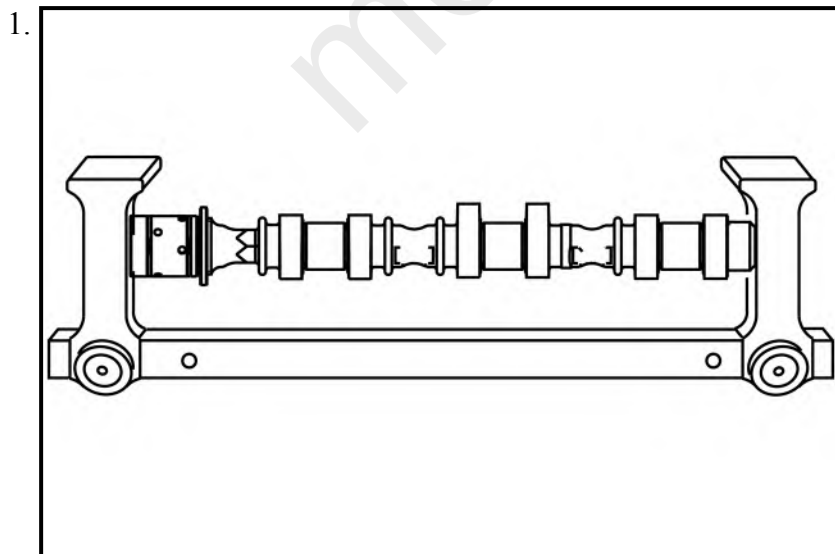




Inspect the camshaft oil feed holes (1) to the camshaft position actuator for dirt, debris or blockage.

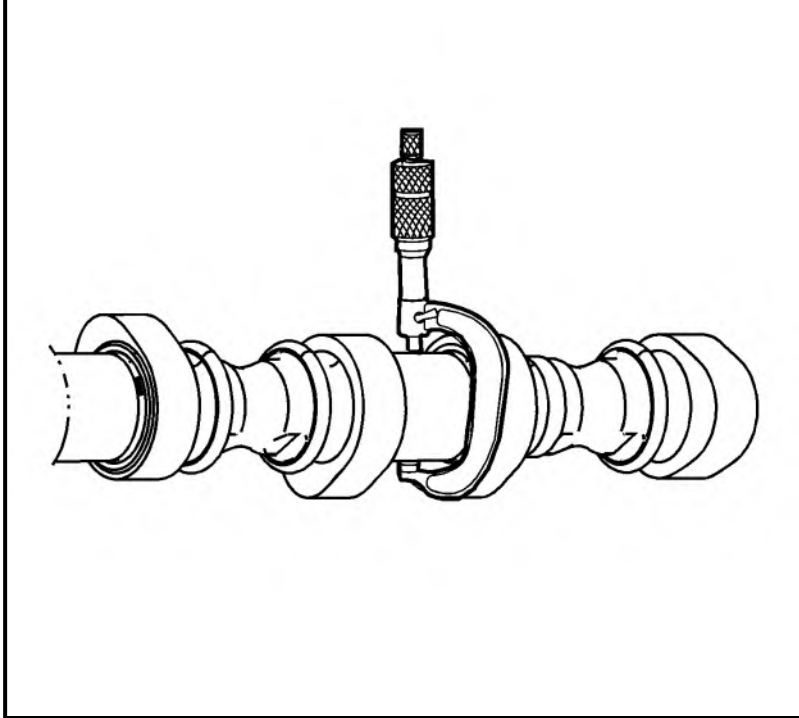
2. Inspect the threaded hole (2) for damage.
3. Inspect the camshaft position actuator locating notch (3) for damage or wear.
4. Inspect the camshaft sealing grooves (4) for damage.
5. Inspect the camshaft thrust surface (5) for damage.
6. Inspect the camshaft lobes (6) and journals (7) for the following conditions:
 - Excessive scoring or pitting
 - Discoloration from overheating
 - Deformation from excessive wear, especially the camshaft lobes
7. If any of the above conditions exist on the camshaft, replace the camshaft.

Camshaft Measurement



With the camshaft in a suitable fixture, measure the camshaft for wear.



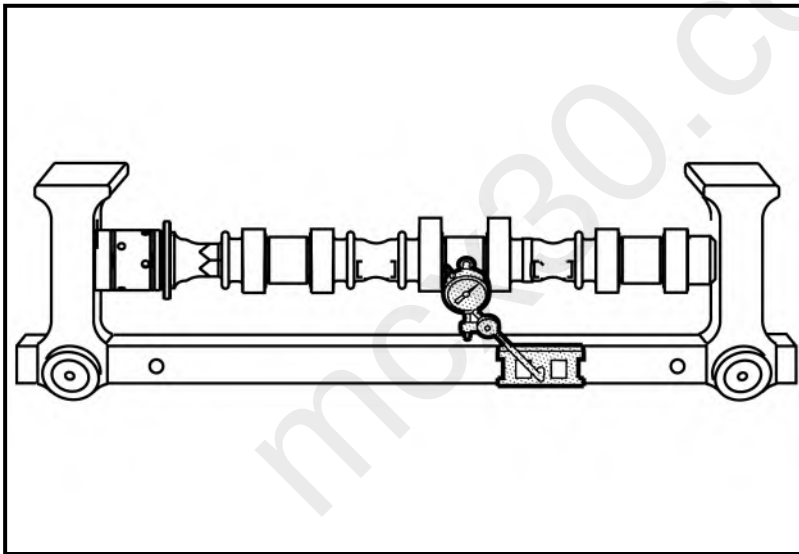


Measure the camshaft journals for diameter and out-of-round using an outside micrometer.

Engine Mechanical Specifications

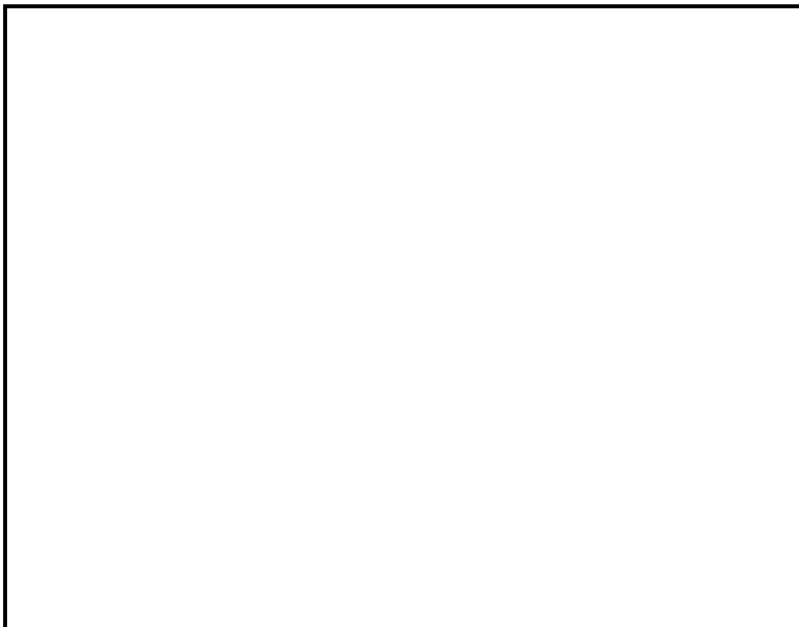
- If the diameter is smaller than specifications, replace the camshaft.
- If the out-of-round exceeds specifications, replace the camshaft.

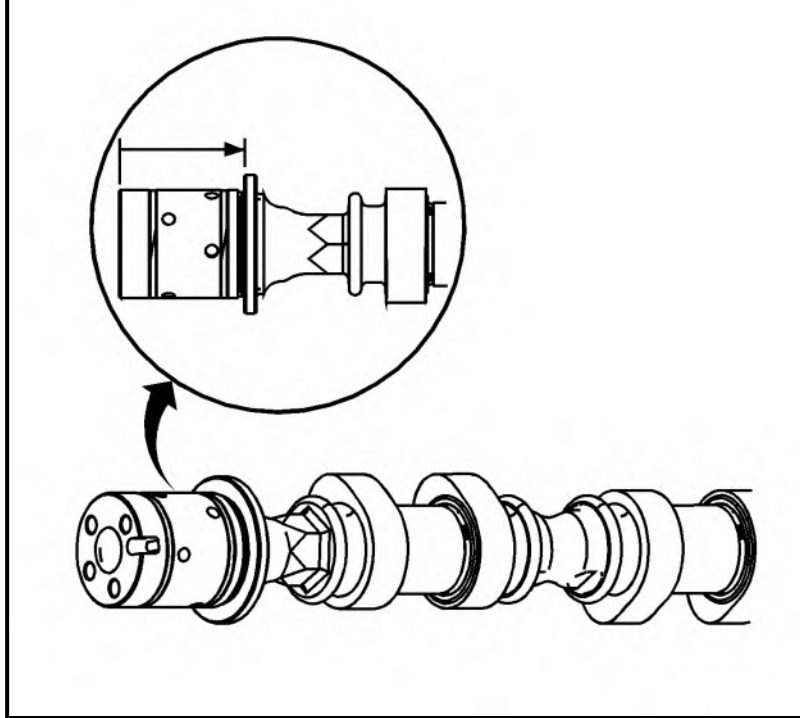
3.



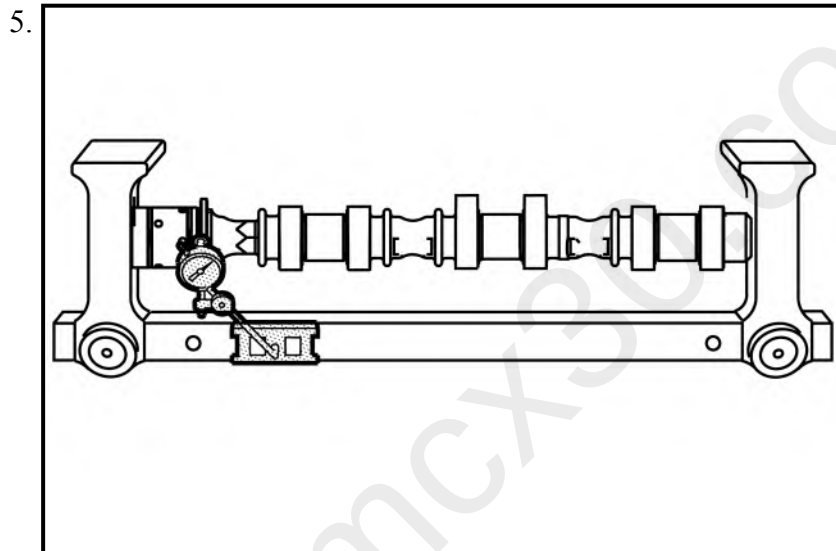
Measure the camshaft runout using the **GE-7872** indicator. **Engine Mechanical Specifications**

4.



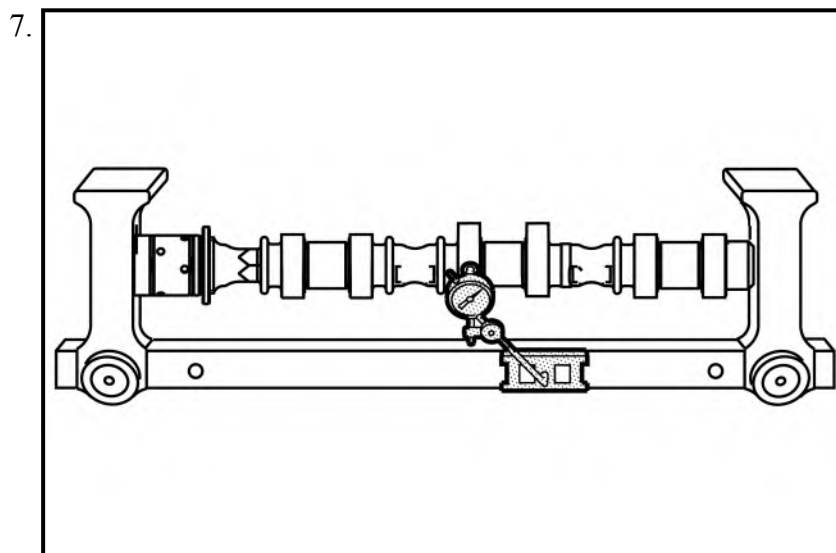


Measure the camshaft thrust width for wear using a depth micrometer. [Engine Mechanical Specifications](#)

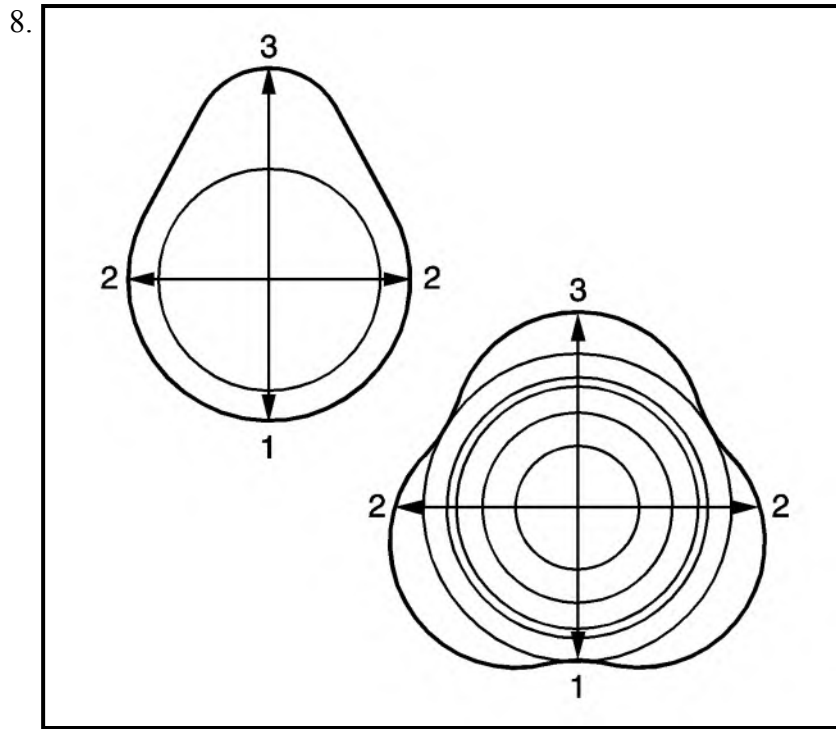


Measure the camshaft thrust wall surface for runout using **GE-7872** indicator. [Engine Mechanical Specifications](#)

6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.



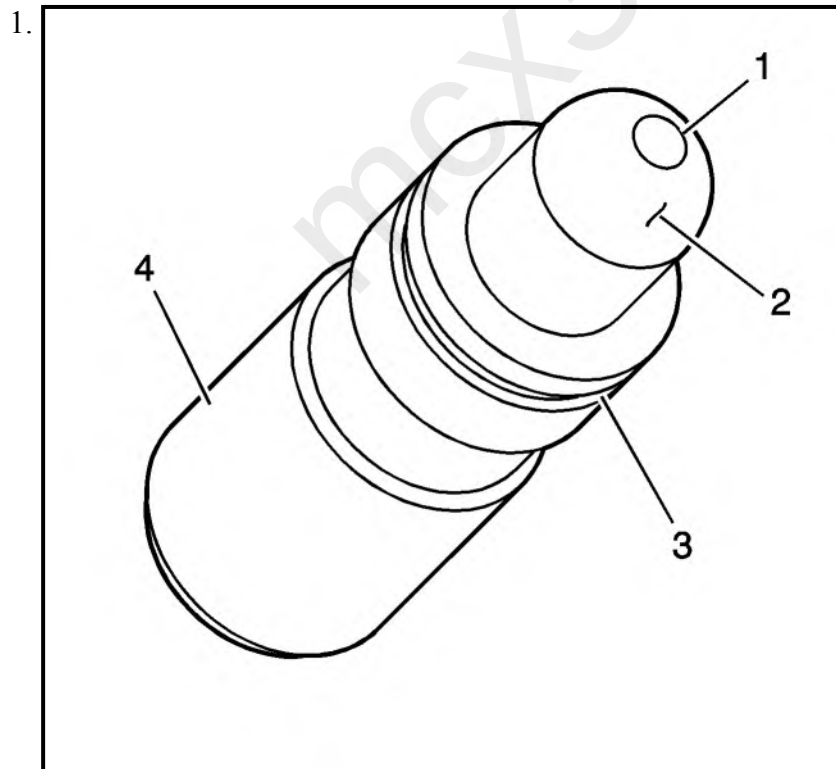
Measure the camshaft lobes for wear using the **GE-7872** indicator.



Place the **GE-7872** indicator with the indicator tip on the base circle (1) of the camshaft lobe.

1. Place the **GE-7872** indicator at zero.
2. Rotate the camshaft until the indicator tip is at the highest point (3) on the lobe. This reading is the lift of the camshaft lobe. **Engine Mechanical Specifications**
3. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

VALVE LIFTER CLEANING AND INSPECTION



CAUTION: Refer to **Valve Lifter Priming Caution** .

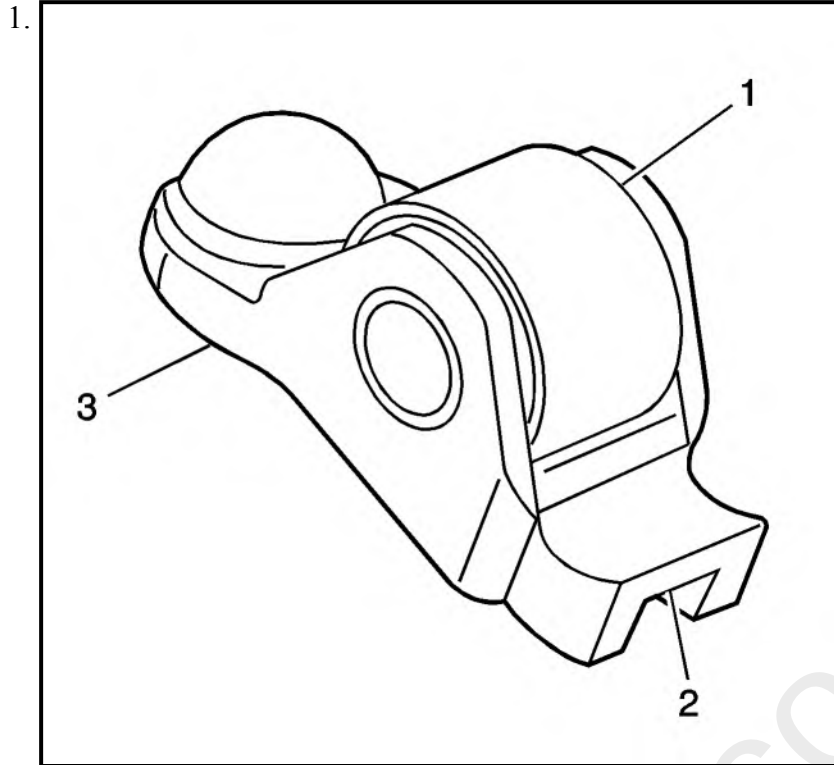
Inspect the stationary hydraulic lash adjuster (SHLA) in the following areas:

- A plugged oil passage (1)
- A scored or worn camshaft follower pivot area (2)

- A damaged or broken retainer (3), some applications
- A severely scuffed or worn SHLA body (4)

2. Replace the SHLA or SHLAs as necessary.

VALVE ROCKER ARM CLEANING AND INSPECTION



Inspect the camshaft follower roller (1) for the following:

- Flat spots
- Excessive scoring and pitting
- Ensure the roller spins freely

2. Inspect the camshaft follower valve tip area (2).

3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).

4. Replace the camshaft follower or followers as necessary.

CAMSHAFT TIMING DRIVE COMPONENTS CLEANING AND INSPECTION

Cleaning Procedure

1. Clean all the following components with solvent:

- Crankshaft sprocket
- Primary timing drive chain
- Primary timing drive chain shoe
- Primary timing drive chain guides
- Primary timing drive chain tensioner
- Secondary timing drive chains
- Secondary timing drive chain shoes
- Secondary timing drive chain guides
- Secondary timing drive chain tensioners
- Timing component fastening bolts

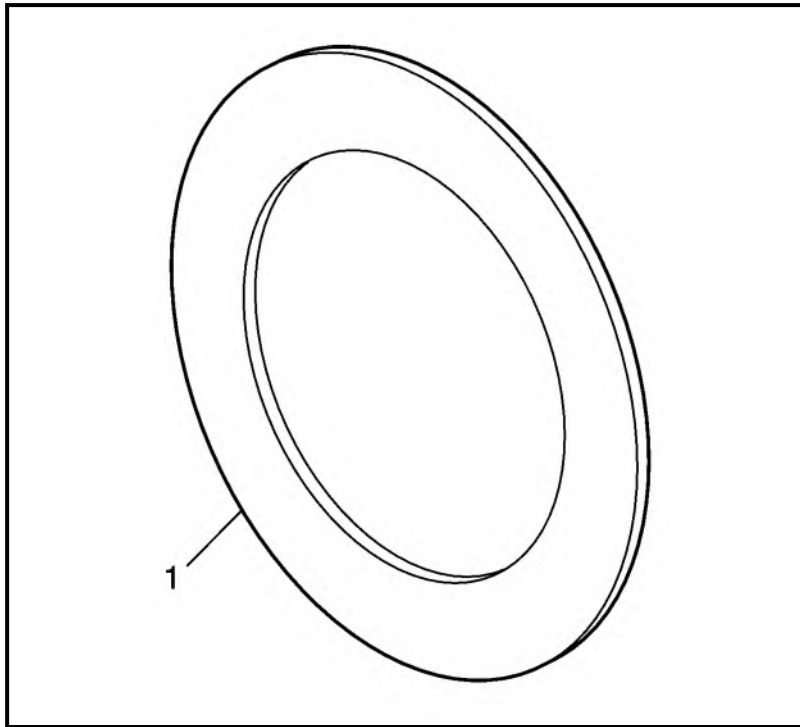
2. Clean each camshaft position actuator's exterior with solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

3. Dry the timing components with compressed air.

Camshaft Thrust Washers (If Equipped)

1.

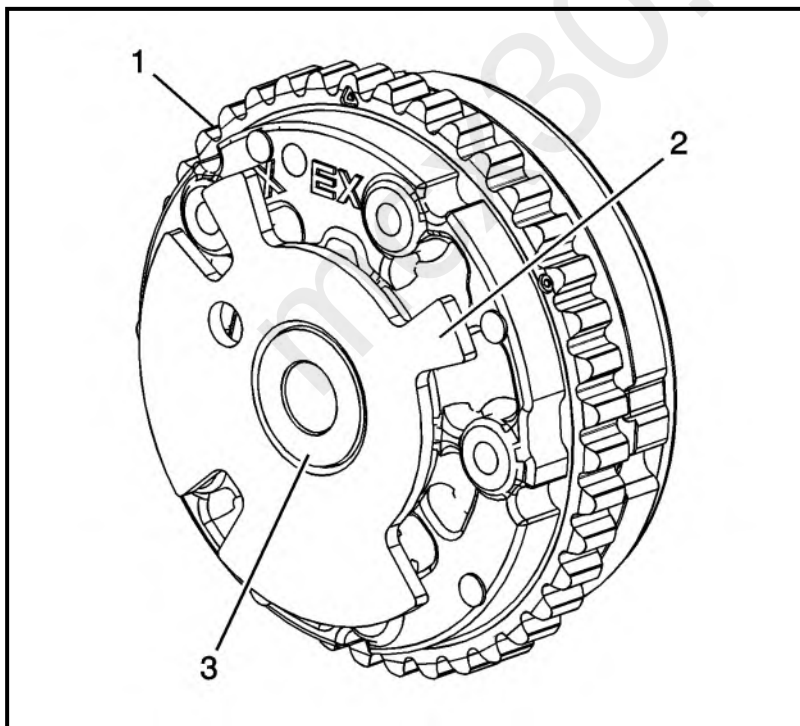


Inspect the camshaft thrust washers for deep scoring or uneven wear (1).

2. Replace as necessary.

Camshaft Position Actuators

1.



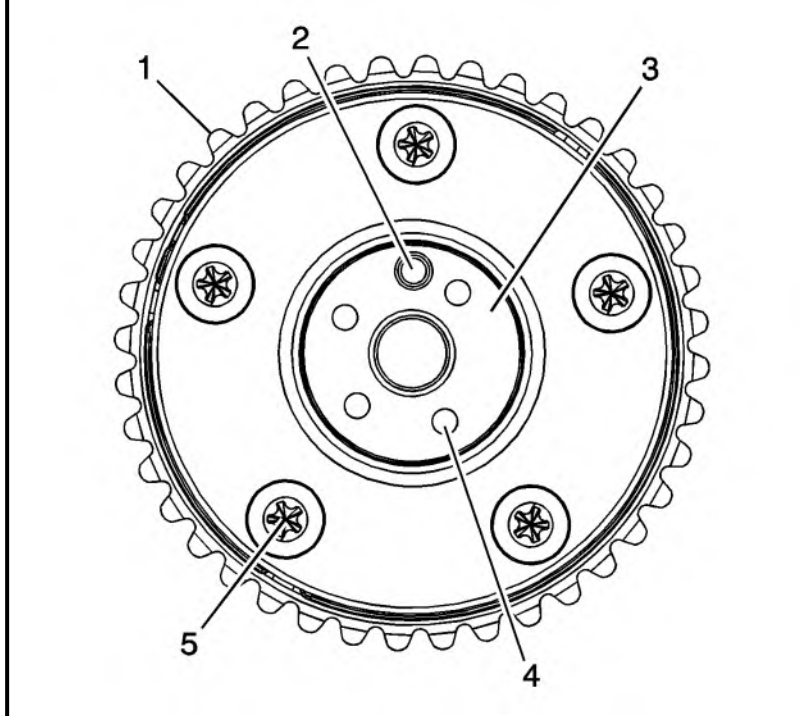
NOTE: Actual camshaft position actuators may vary in appearance from the ones shown.

Inspect the front of the exhaust camshaft position actuators for the following:

- Sprocket damage (1)
- Reluctor/sensor wheel damage (2)
- Camshaft position actuator bolt seating/sealing inner hub flange damage (3)

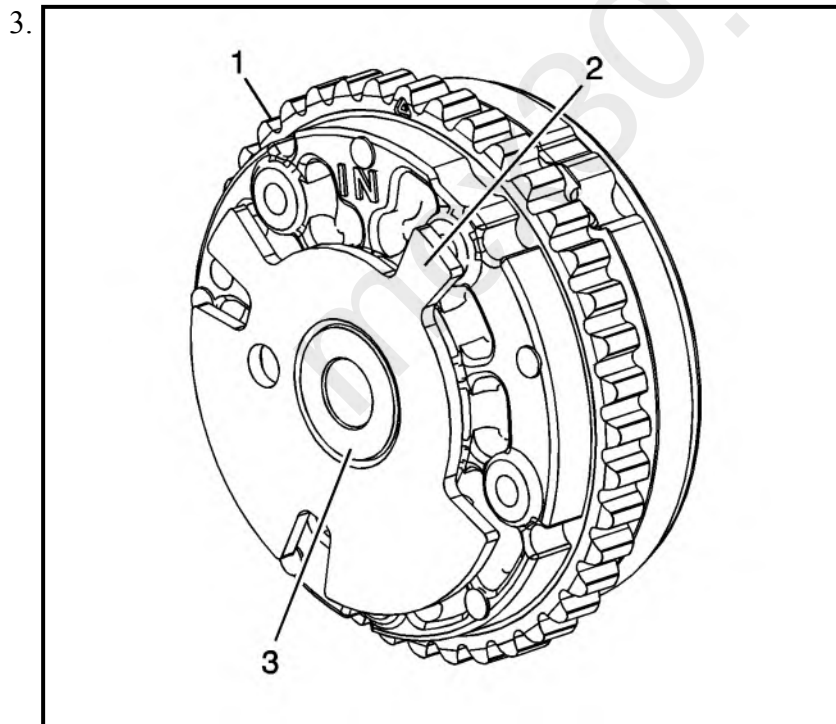
2.





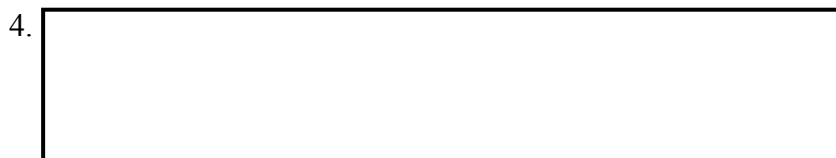
Inspect the back of the exhaust camshaft position actuators for the following:

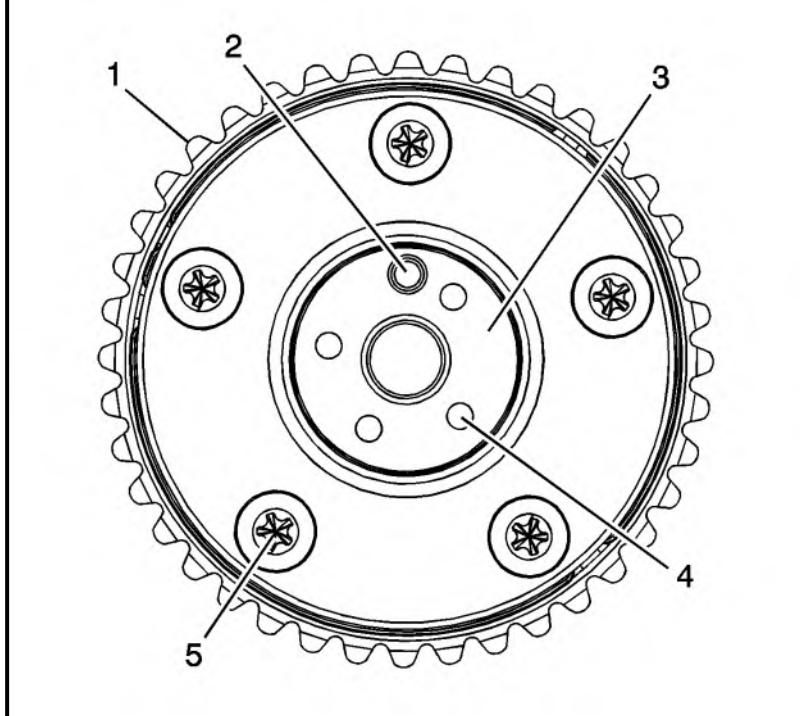
- Sprocket damage (1)
- Camshaft locating pin damage (2)
- Camshaft seating/sealing inner hub flange damage (3)
- Blockage to the oil passages (4)
- Loose or missing housing bolts (5)



Inspect the front of the left intake camshaft position actuators for the following:

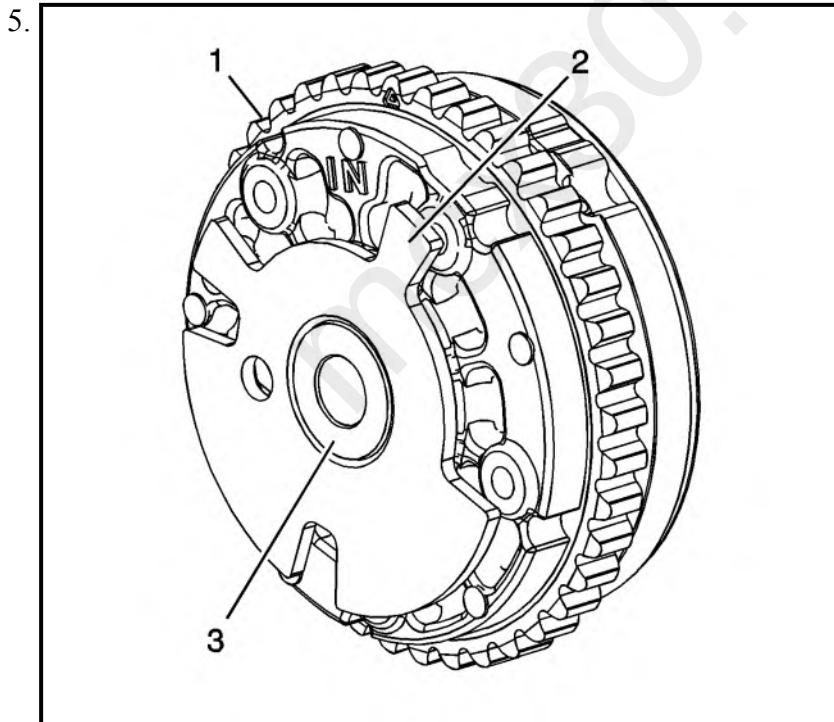
- Sprocket damage (1)
- Reluctor/sensor wheel damage (2)
- Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (3)





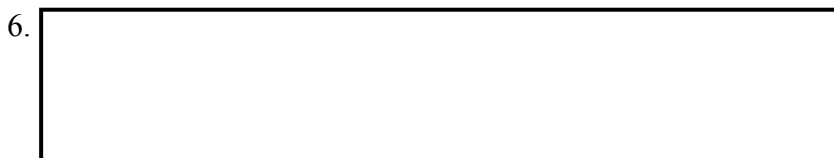
Inspect the back of the left intake camshaft position actuators for the following:

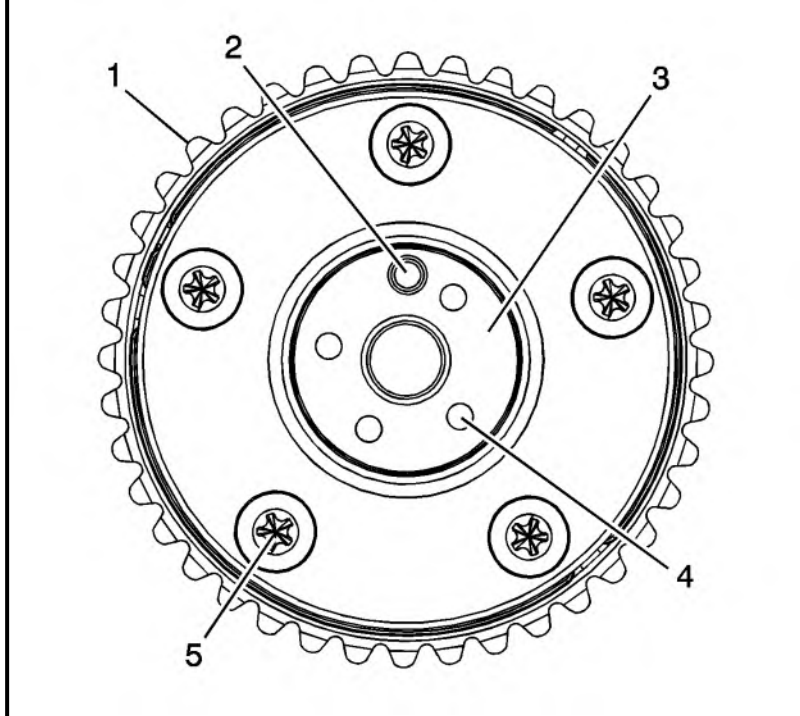
- Sprocket damage (1)
- Camshaft locating pin damage (2)
- Camshaft seating/sealing inner hub flange damage (3)
- Blockage to the oil passages (4)
- Loose or missing housing bolts (5)



Inspect the front of the right intake camshaft position actuators for the following:

- Sprocket damage (1)
- Reluctor/sensor wheel damage (2)
- Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (3)



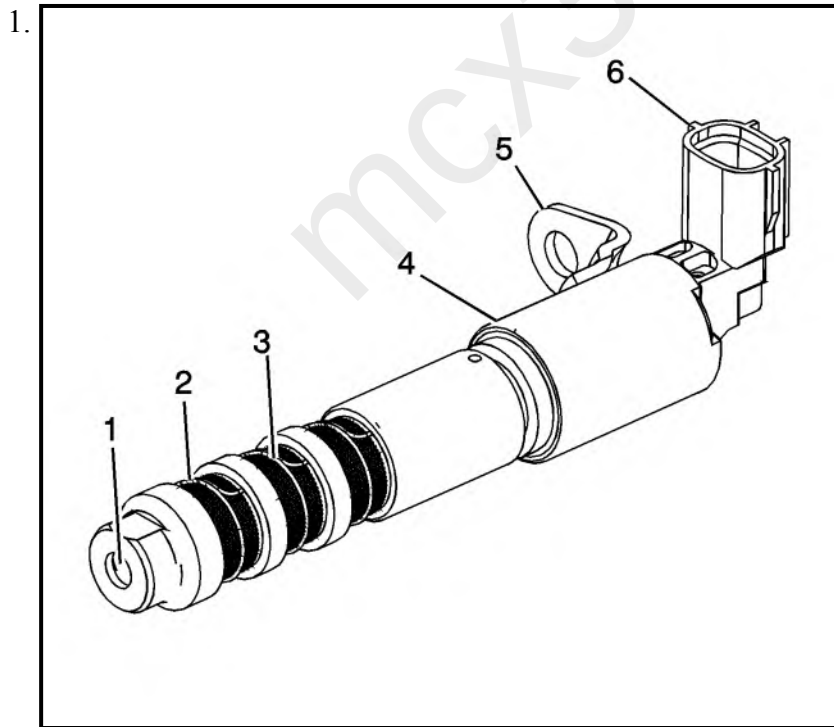


Inspect the back of the right intake camshaft position actuators for the following:

- Sprocket damage (1)
- Camshaft locating pin damage (2)
- Camshaft seating/sealing inner hub flange damage (3)
- Blockage to the oil passages (4)
- Loose or missing housing bolts (5)

7. Replace a damaged camshaft position actuator.

Camshaft Position Actuator Oil Control Valves



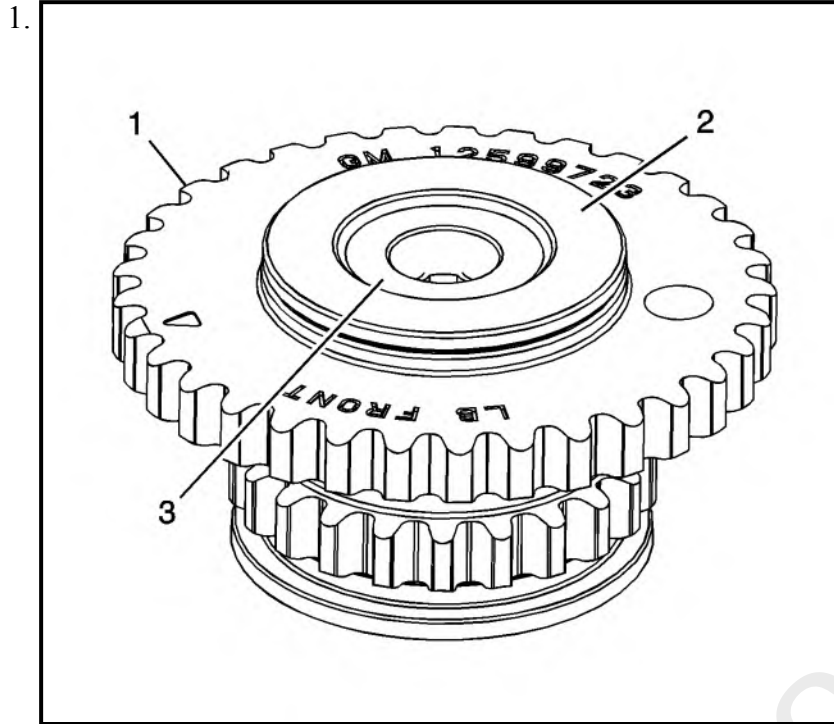
Inspect the camshaft position actuator oil control valves for the following:

- Blockage to the oil passage (1)
- Missing or damaged oil screen clip (2)
- Blockage or damage to the oil screen (3)
- Damage to the sealing surface for the camshaft position actuator oil control valve solenoid oil seal (4)

- Damage to the bracket (5)
- Damage to the wiring harness connection and/or terminals (6)

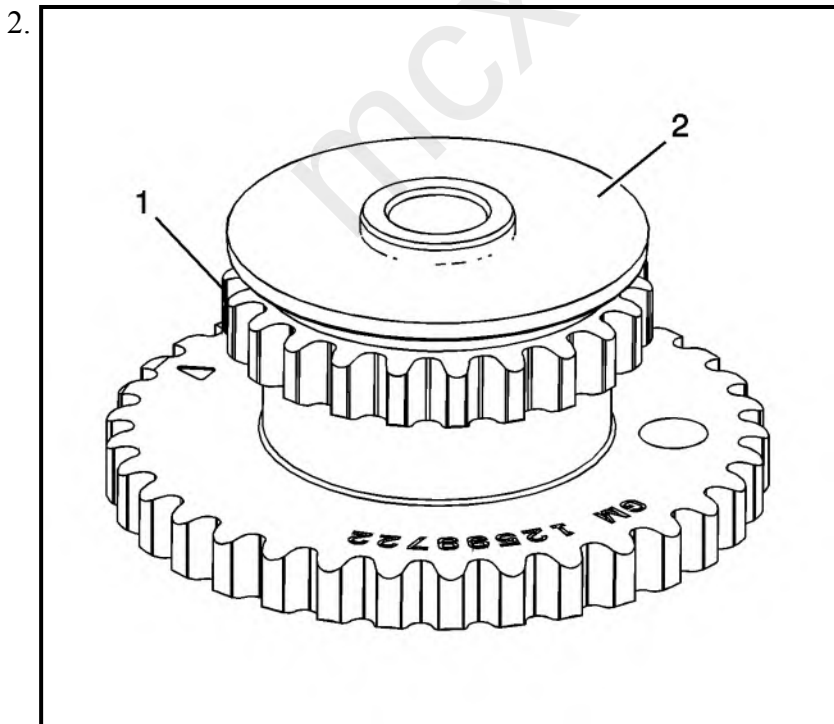
2. Replace a damaged camshaft position actuator oil control valve.

Left Intermediate Sprocket with Primary and Secondary Inverted Tooth (IT) Chain



Inspect the front of the left intermediate sprocket for the following:

- Damage to the primary camshaft drive chain sprocket (1)
- Damage to the hub bearing (2) - Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy, or feels rough when rotated, replace the intermediate sprocket.
- Damage to the bolt flange seating/sealing surface (3)



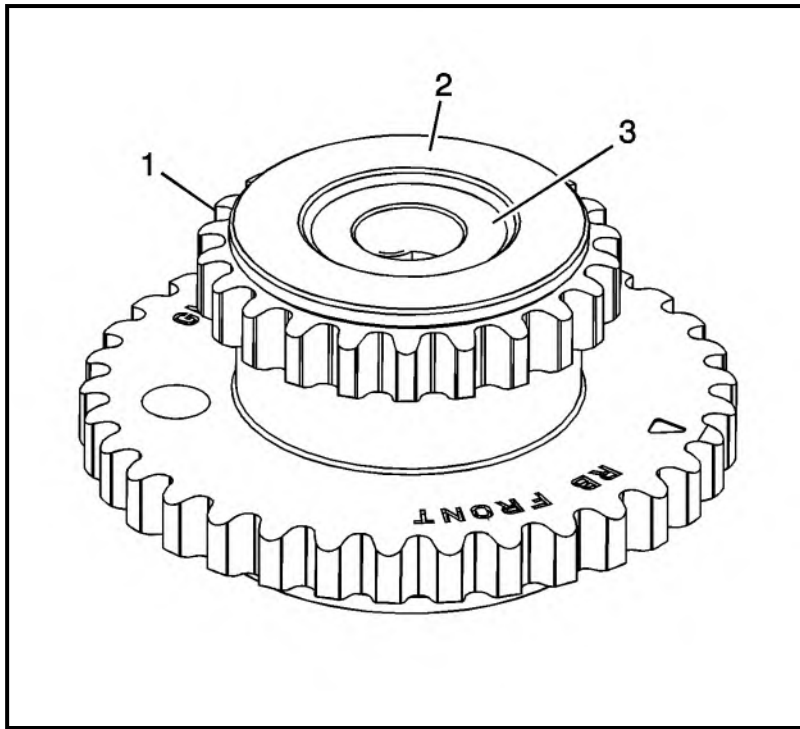
Inspect the back of the left intermediate sprocket for the following:

- Damage to the left secondary camshaft drive chain sprocket (1)
- Damage to the bearing hub-to-engine block sealing surface (2)

3. Replace a damaged left intermediate sprocket.

Right Intermediate Sprocket with Primary and Secondary Inverted Tooth (IT) Chain

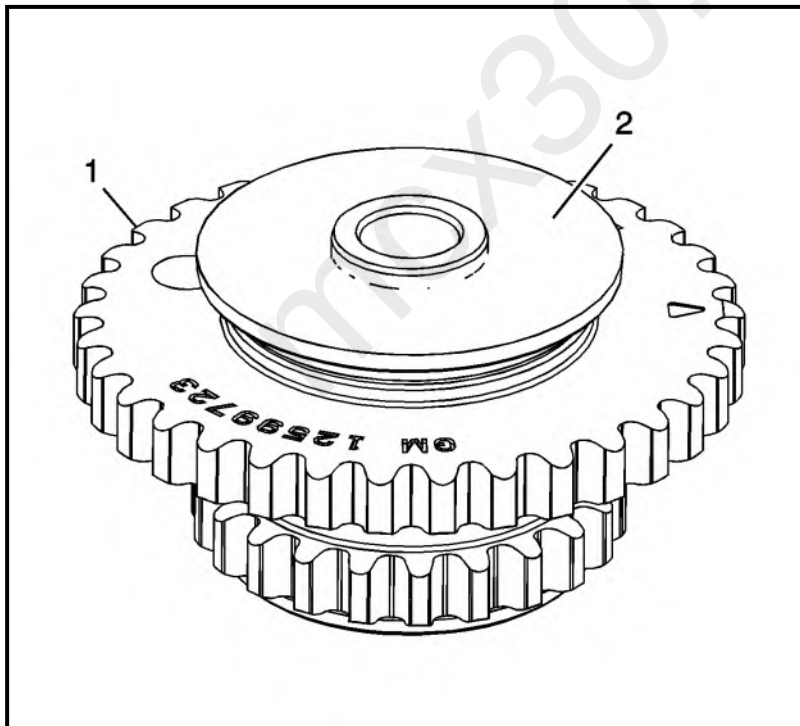
1.



Inspect the front of the right intermediate sprocket for the following:

- Damage to the right secondary camshaft drive chain sprocket (1)
- Damage to the hub bearing (2) - Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy, or feels rough when rotated, replace the intermediate sprocket.
- Damage to the bolt flange seating/sealing surface (3)

2.



Inspect the back of the right intermediate sprocket for the following:

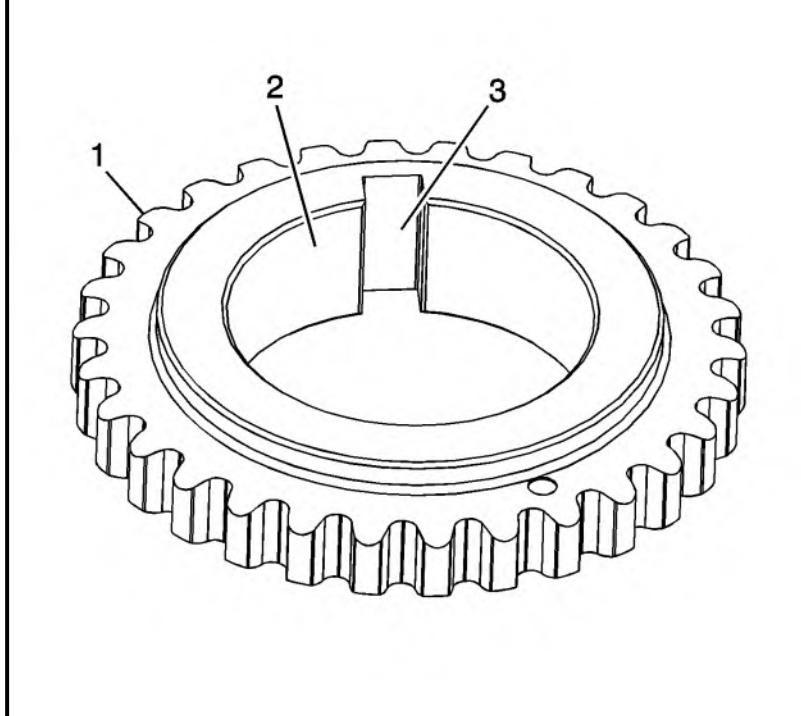
- Damage to the primary camshaft drive chain sprocket (1)
- Damage to the bearing hub-to-engine block sealing surface (2)

3. Replace a damaged right intermediate sprocket.

Crankshaft Sprocket with Primary Inverted Tooth (IT) Chain

1.



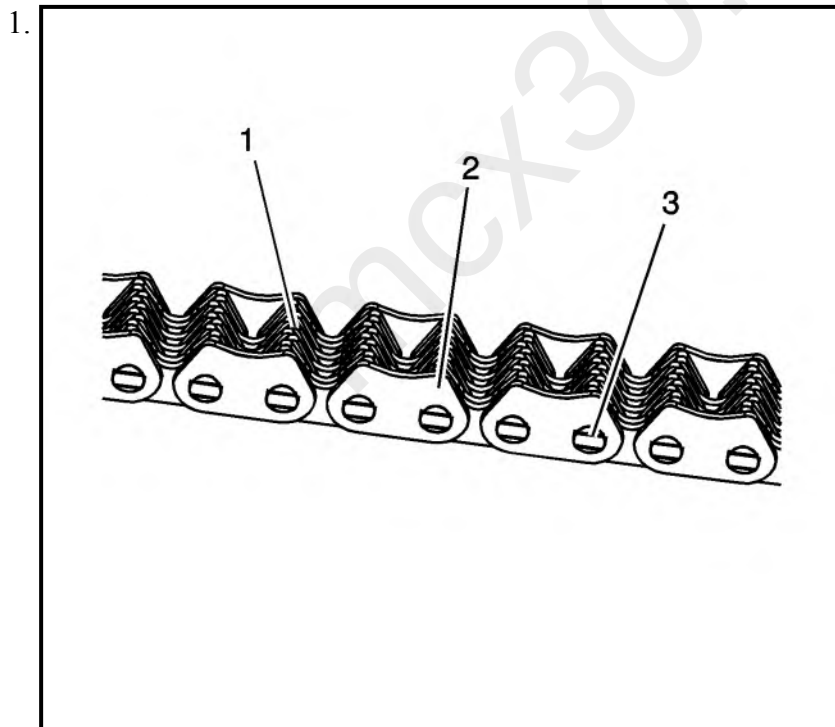


Inspect the crankshaft sprocket for the following:

- Sprocket damage (1)
- Bore damage (2)
- Keyway damage (3)

2. Replace a damaged crankshaft sprocket.

Secondary Timing Chains with Inverted Tooth (IT) Chain

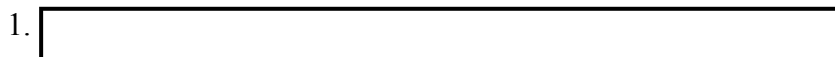


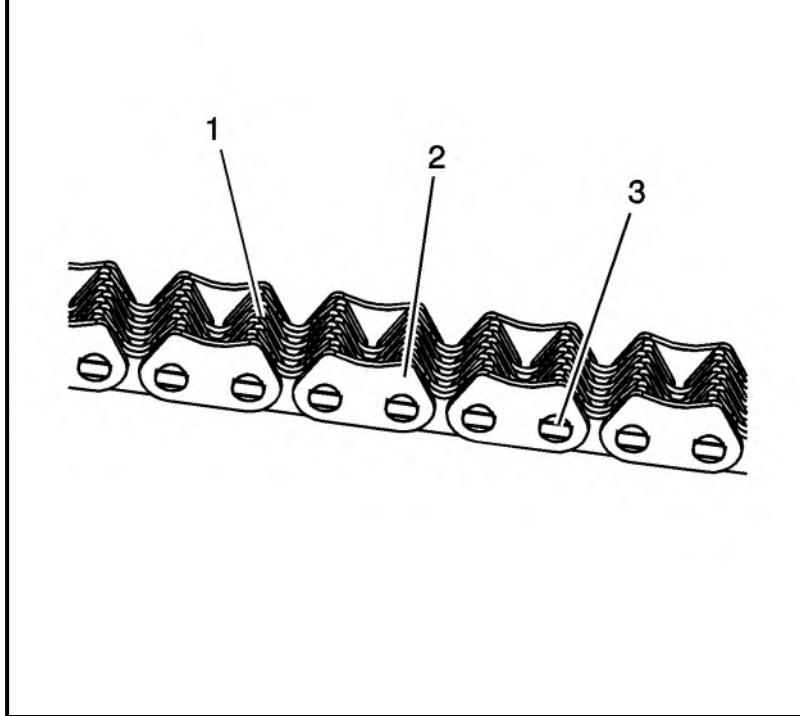
Inspect the secondary timing chain for the following:

- Binding or worn links (1)
- Loose links (2)
- Loose pins (3)

2. Replace a damaged secondary timing chain.

Primary Timing Chain with Inverted Tooth (IT) Chain



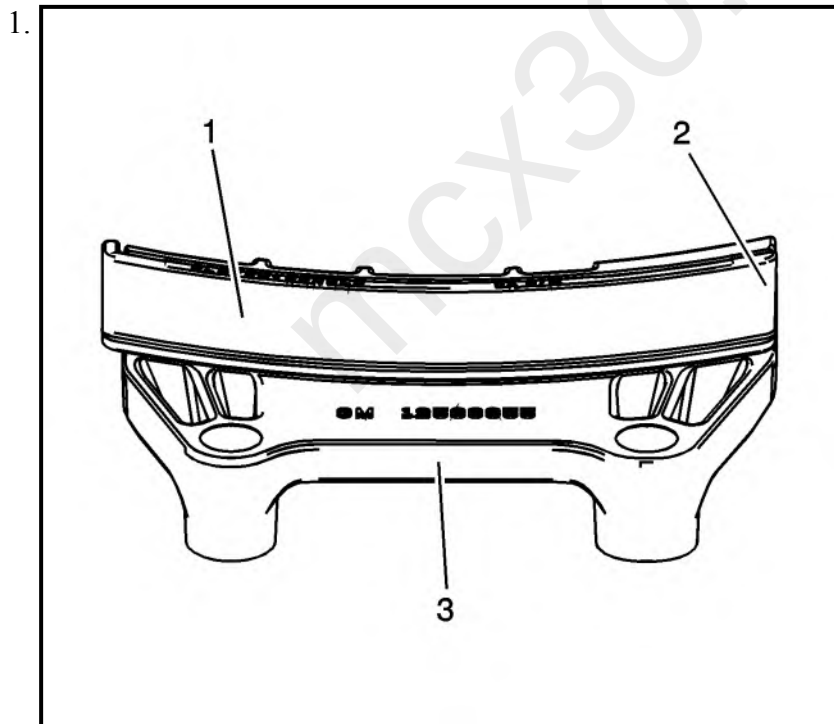


Inspect the primary timing chain for the following:

- Binding or worn links (1)
- Loose links (2)
- Loose pins (3)

2. Replace a damaged primary timing chain.

Primary Timing Chain Upper Guide

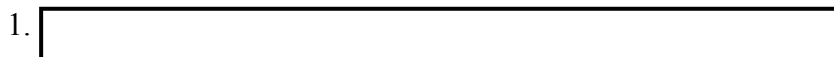


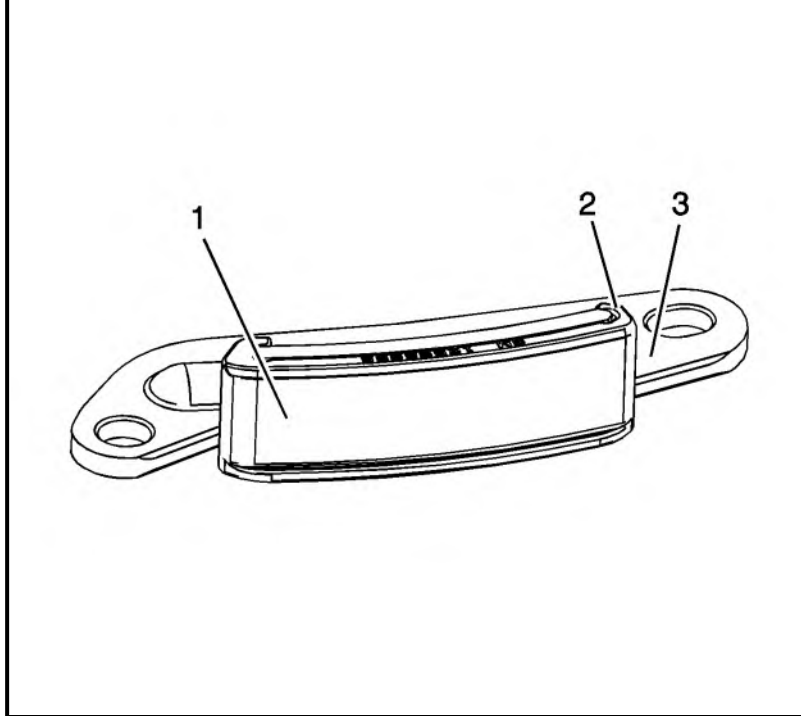
Inspect the primary timing chain upper guide for the following:

- Worn guide surface (1)
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged primary timing chain upper guide.

Primary Timing Chain Lower Guide



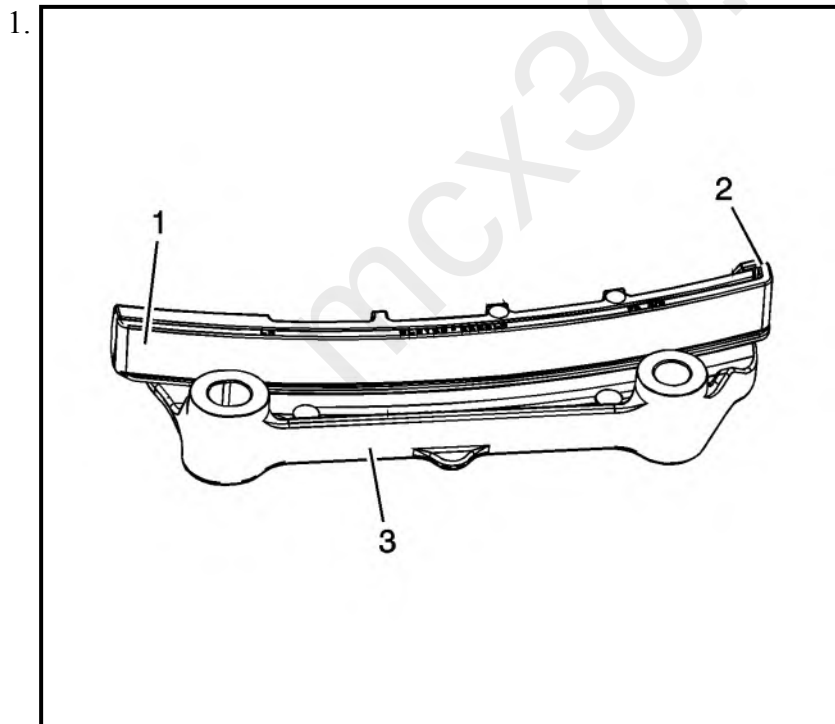


Inspect the primary timing chain lower guide for the following:

- Worn guide surface (1)
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged primary timing chain lower guide.

Left Secondary Timing Chain Guide

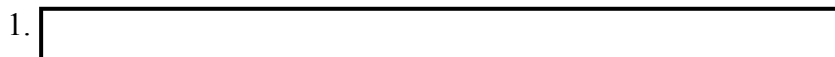


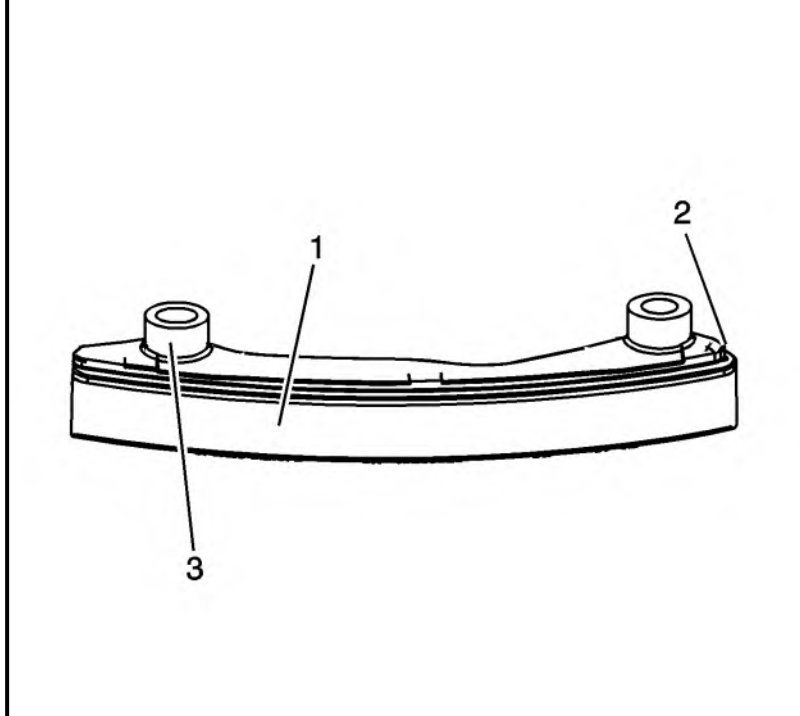
Inspect the left secondary timing chain guides for the following:

- Worn guide surface (1)
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged left secondary timing chain guide.

Right Secondary Timing Chain Guide





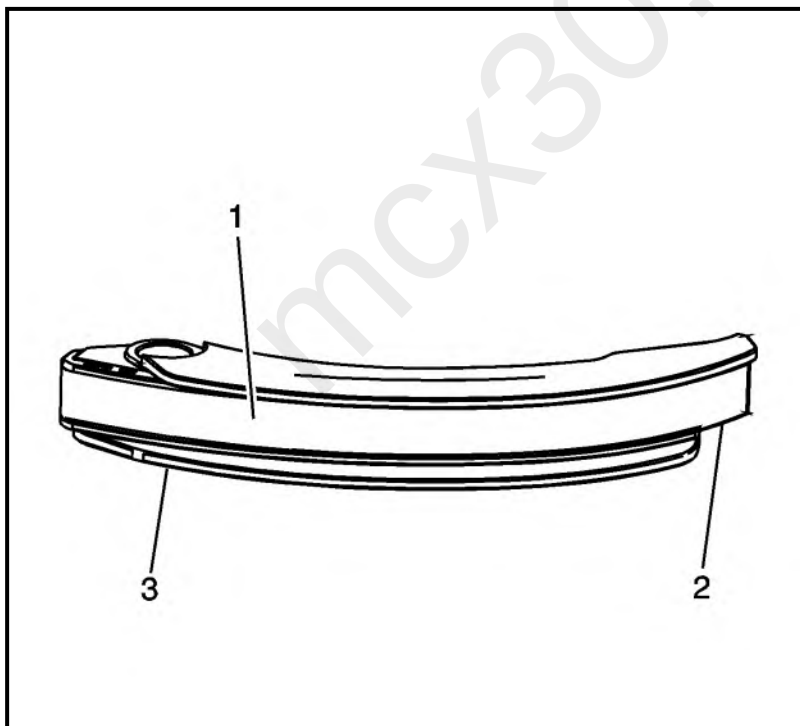
Inspect the right secondary timing chain guides for the following:

- Worn guide surface (1)
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)

2. Replace a damaged right secondary timing chain guide.

Left Secondary Timing Chain Shoe

1.

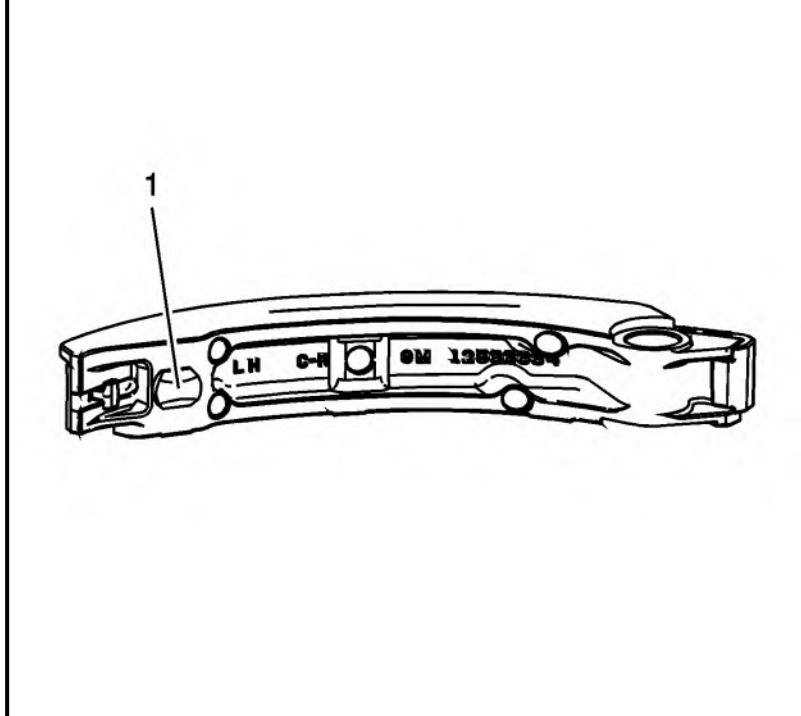


Inspect the front of the left secondary timing chain shoe for the following:

- Worn shoe surface (1)
- Cracked or broken shoe surface (2)
- Cracked or damaged shoe (3)

2.

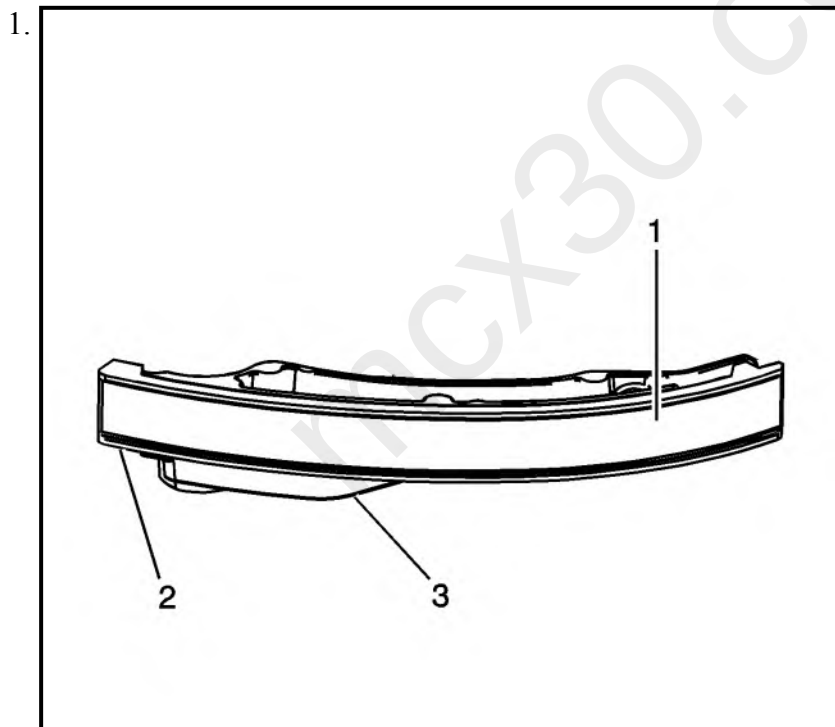




Inspect the back of the left secondary timing chain shoe for a damaged, worn, or missing left secondary timing chain tensioner contact pad (1).

3. Replace a damaged left secondary timing chain shoe.

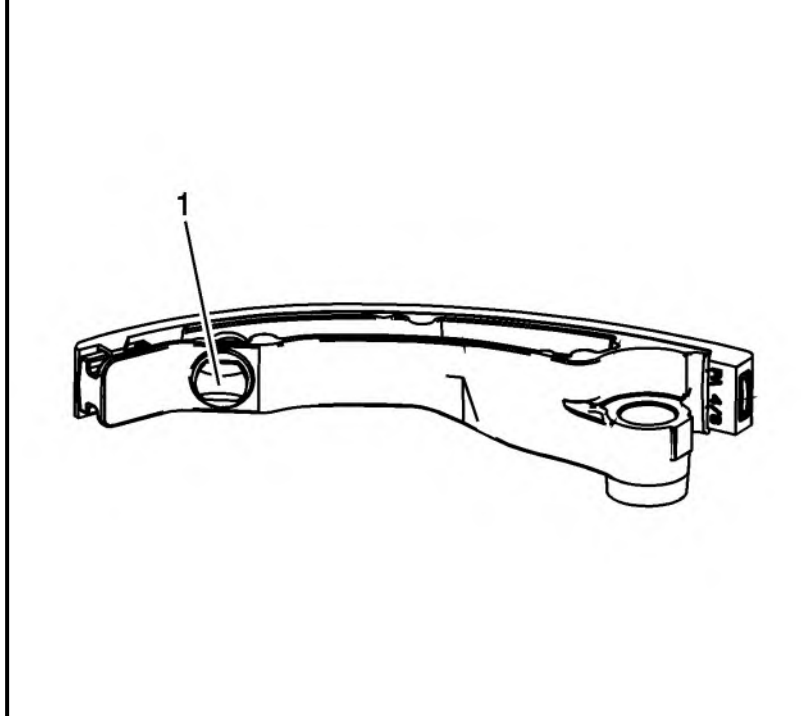
Right Secondary Timing Chain Shoe



Inspect the front of the right secondary timing chain shoe for the following:

- Worn shoe surface (1)
- Cracked or broken shoe surface (2)
- Cracked or damaged shoe (3)

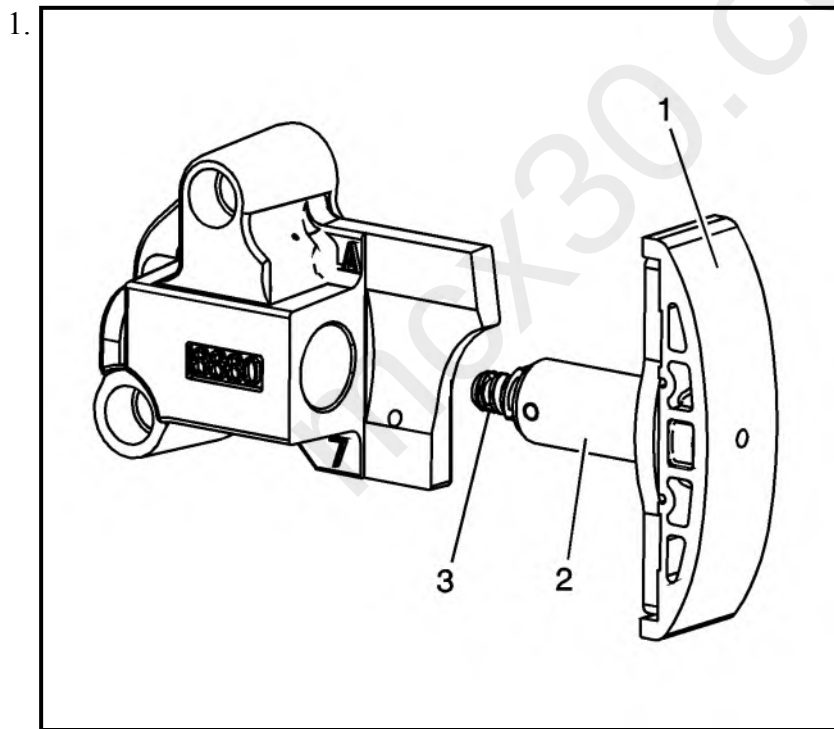




Inspect the back of the right secondary timing chain shoe for a damaged, worn, or missing right secondary timing chain tensioner contact pad (1).

3. Replace a damaged right secondary timing chain shoe.

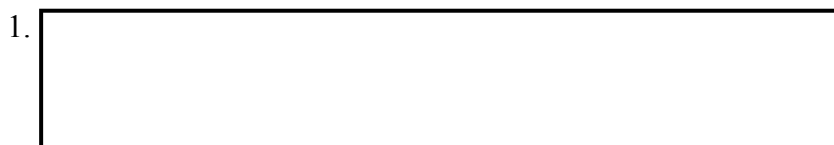
Primary Timing Chain Tensioner

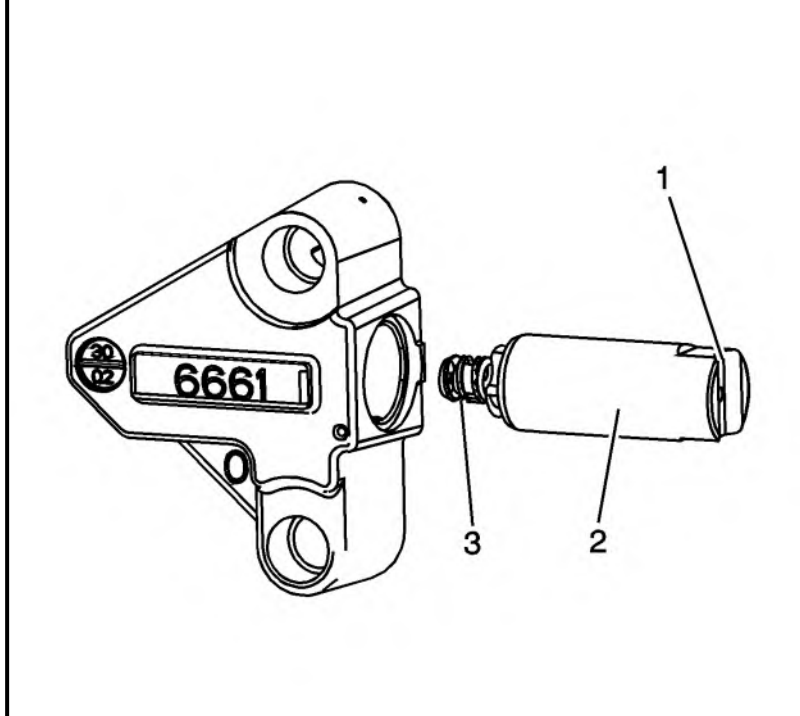


Inspect the primary timing chain tensioner for worn primary timing chain tensioner shoe surface (1).

2. Inspect the primary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to [Camshaft Timing Chain Components Installation](#).
3. Replace a damaged primary timing chain tensioner.

Left Secondary Timing Chain Tensioner

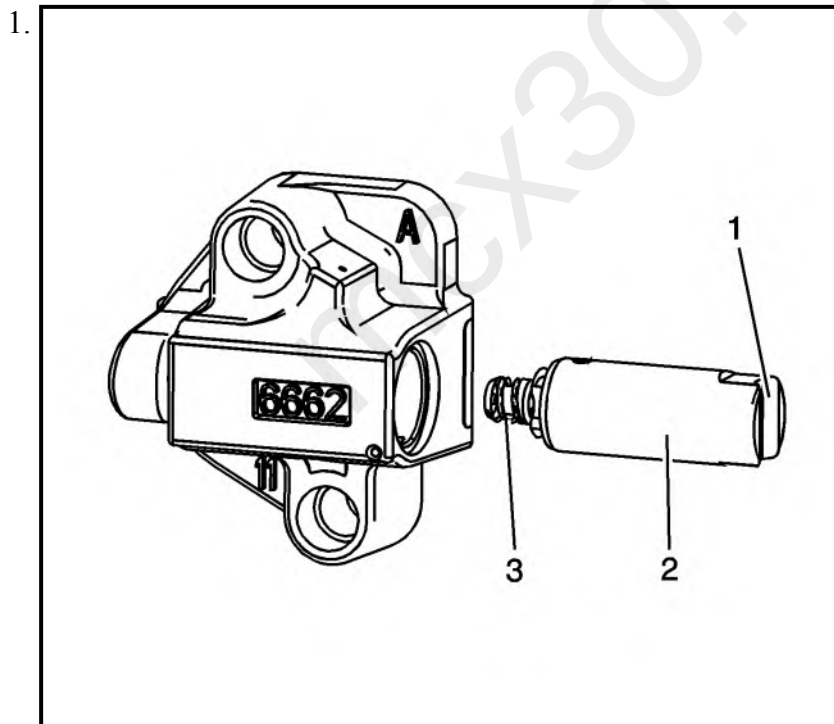




Inspect the left secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).

2. Inspect the left secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to [Camshaft Timing Chain Components Installation](#).
3. Replace a damaged left secondary timing chain tensioner.

Right Secondary Timing Chain Tensioner

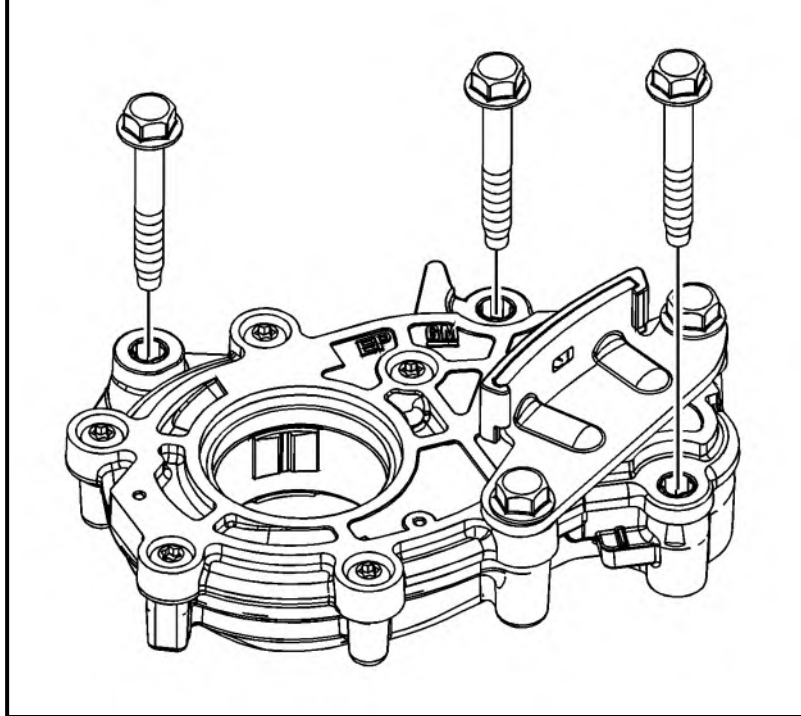


Inspect the right secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).

2. Inspect the right secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to [Camshaft Timing Chain Components Installation](#).
3. Replace a damaged right secondary timing chain tensioner.

OIL PUMP DISASSEMBLE

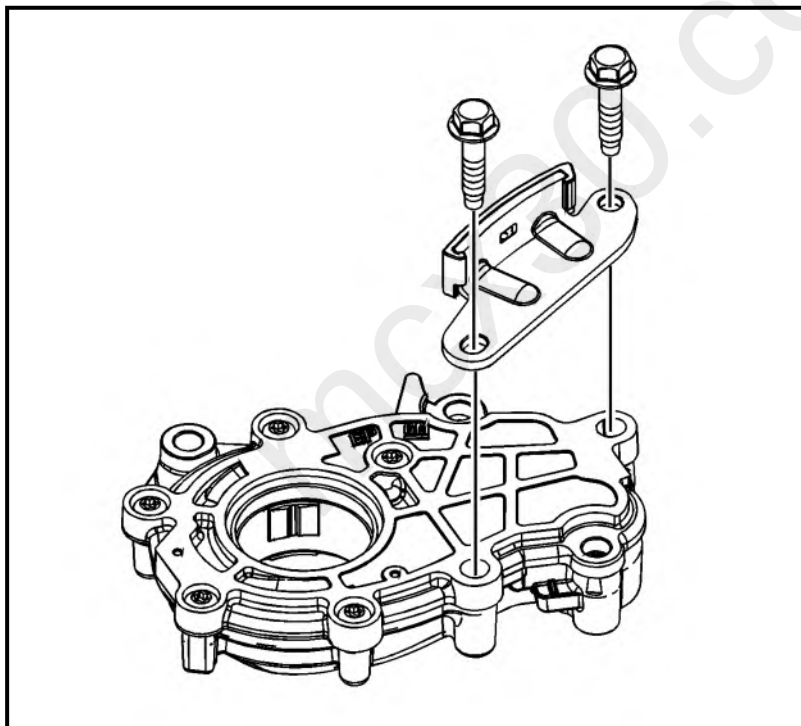




There are no serviceable components within the oil pump. Disassemble the pump
IMPORTANT: only to diagnose an oiling concern. A disassembled oil pump must not be reused.
A disassembled oil pump must be replaced.

Remove the oil pump mounting bolts.

2.

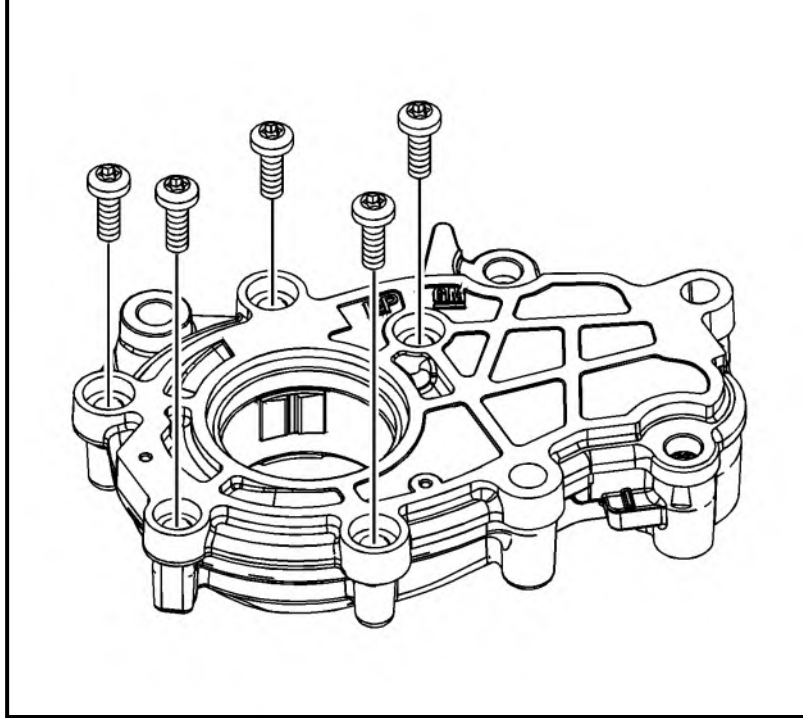


Remove the primary camshaft drive chain lower guide bolts.

3. Remove the primary camshaft drive chain lower guide.

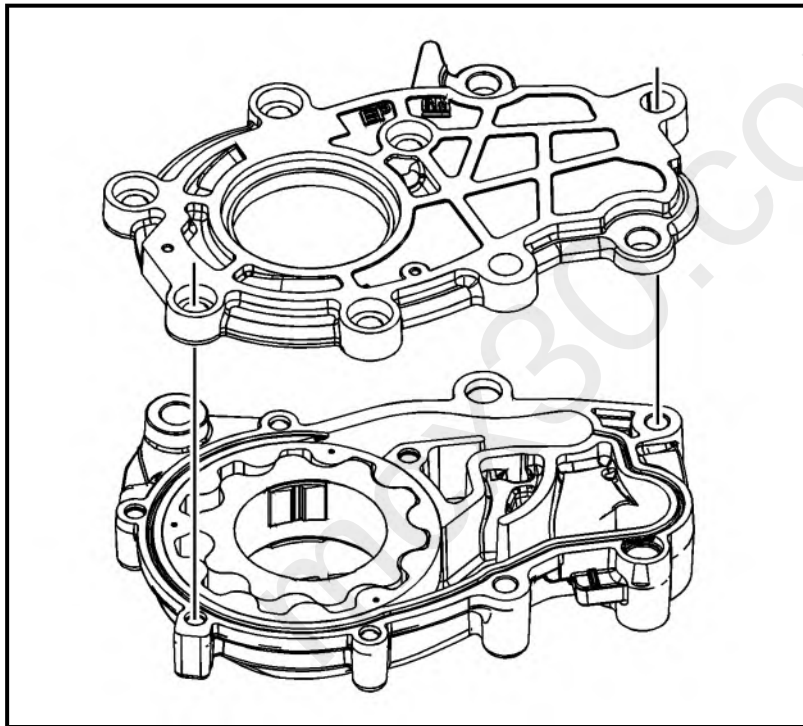
4.





Remove the bolts holding the oil pump cover to the oil pump housing.

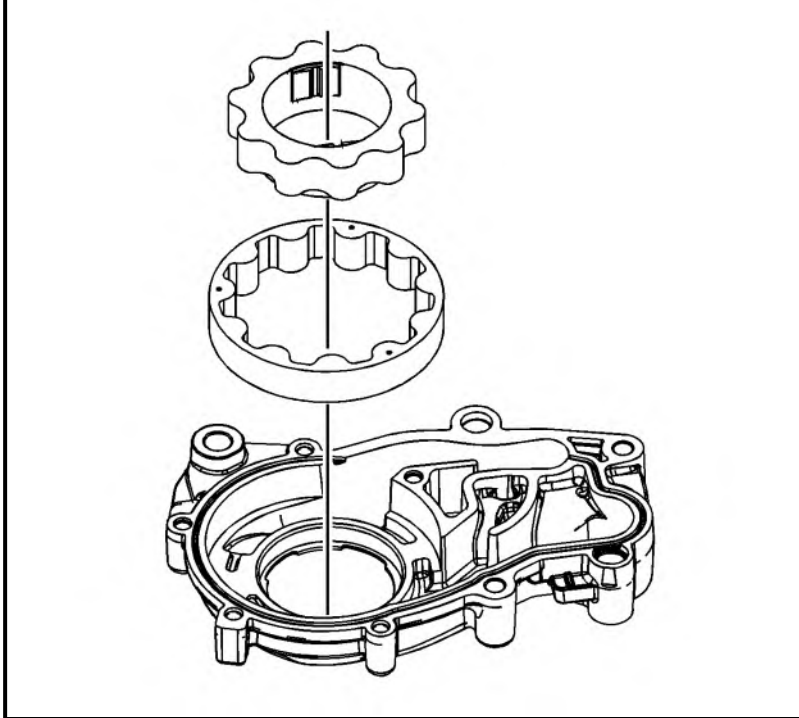
5.



Remove the oil pump cover from the oil pump housing.

6.

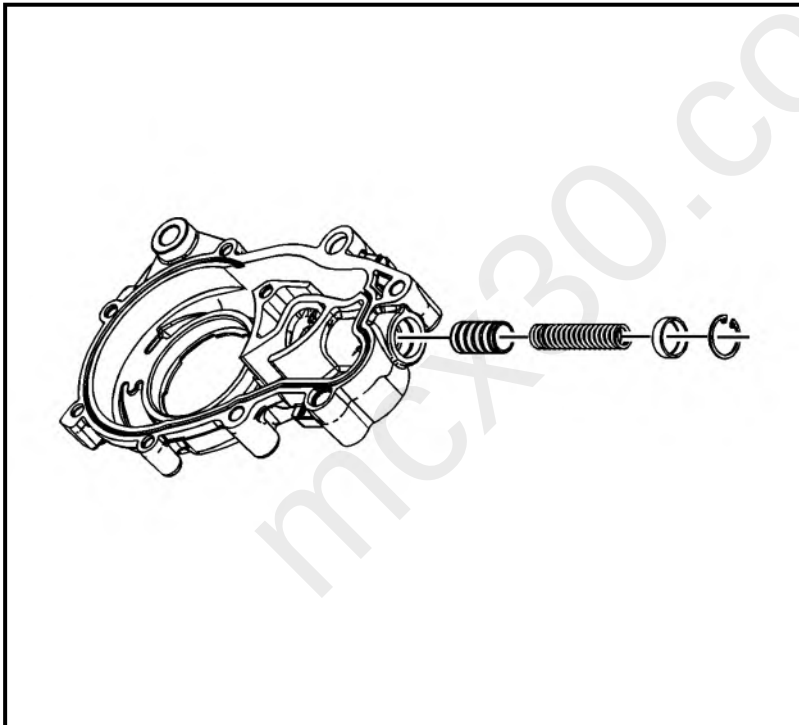




Remove the inner oil pump drive gear.

7. Remove the outer oil pump driven gear.

8.



Remove the clip, holding the cap, for the oil relief valve components.

9. Remove the cap, spring, and plunger from the oil pump housing.

OIL PUMP CLEANING AND INSPECTION

Cleaning Procedure

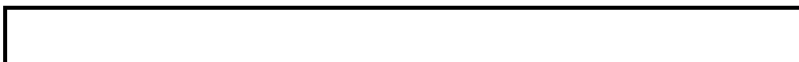
1. Clean the oil pump components with non-corrosive solvent.

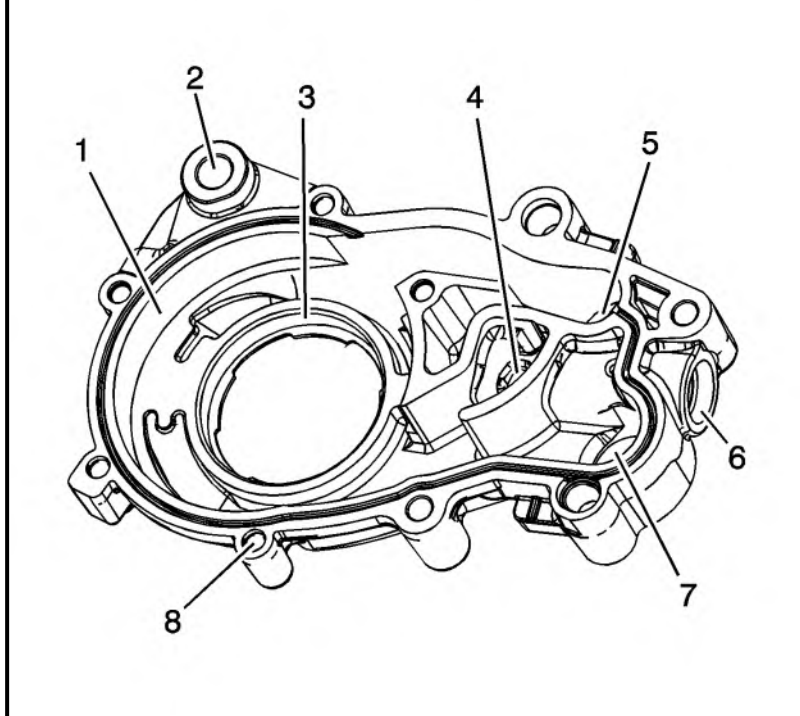
WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the oil pump components with compressed air.

Inspection Procedure

1.



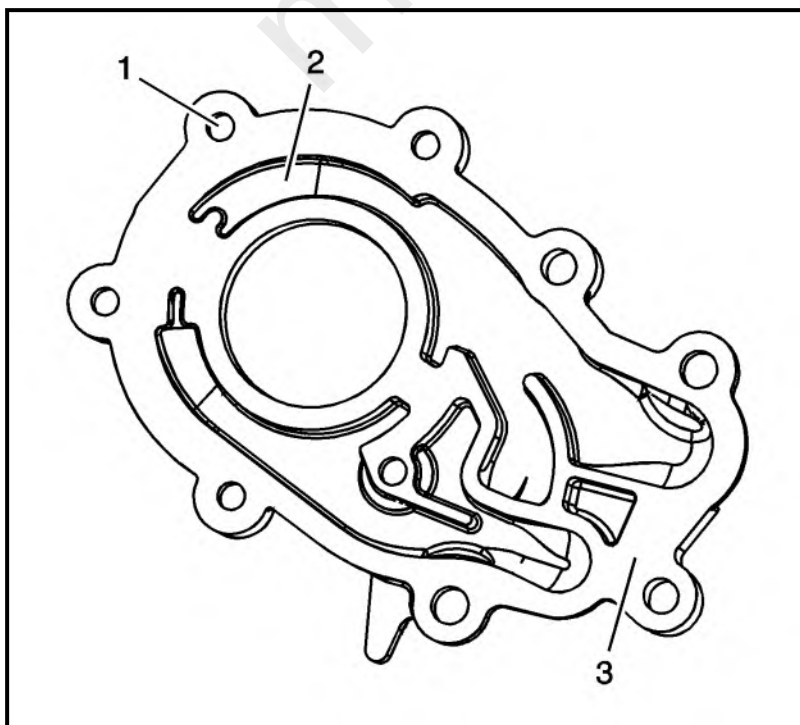


NOTE: There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.

Inspect the oil pump housing for the following:

- Damage, scoring, or debris on the housing surface for the driven gear (1)
- Damage to the oil pump mounting bosses (2)
- Damage, scoring, or debris on the housing surface for the drive gear (3)
- Damage, scoring, or debris in the oil pump relief valve port (4)
- Damage, scoring, or debris in the oil pump intake port (5)
- Damage, scoring, or debris in the oil pump relief valve bore (6)
- Damage, scoring, or debris in the oil pump output port (7)
- Damage to the threads in the oil pump housing for the oil pump cover bolts (8)

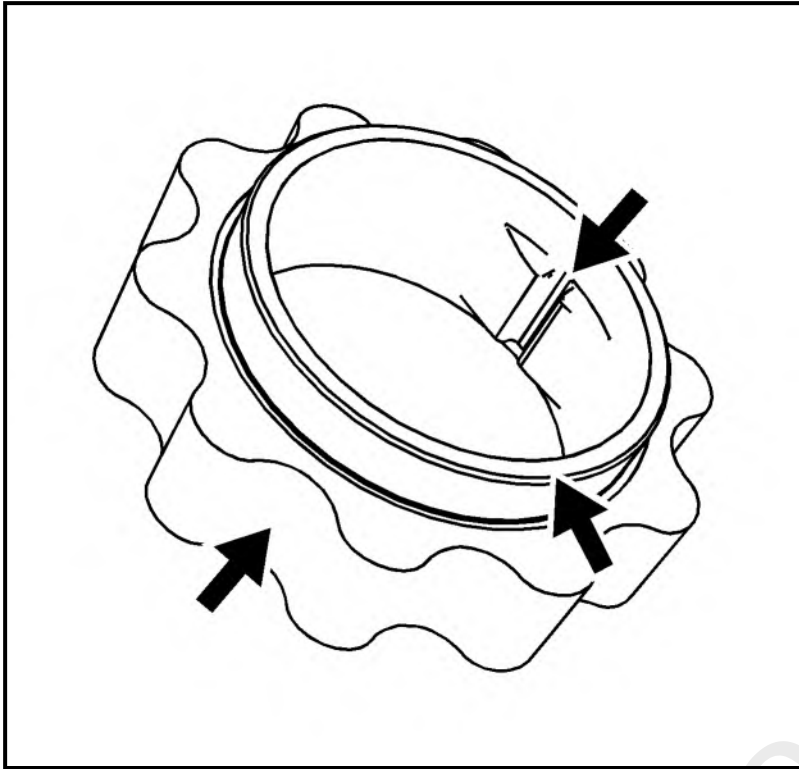
2.



Inspect the oil pump cover for the following conditions:

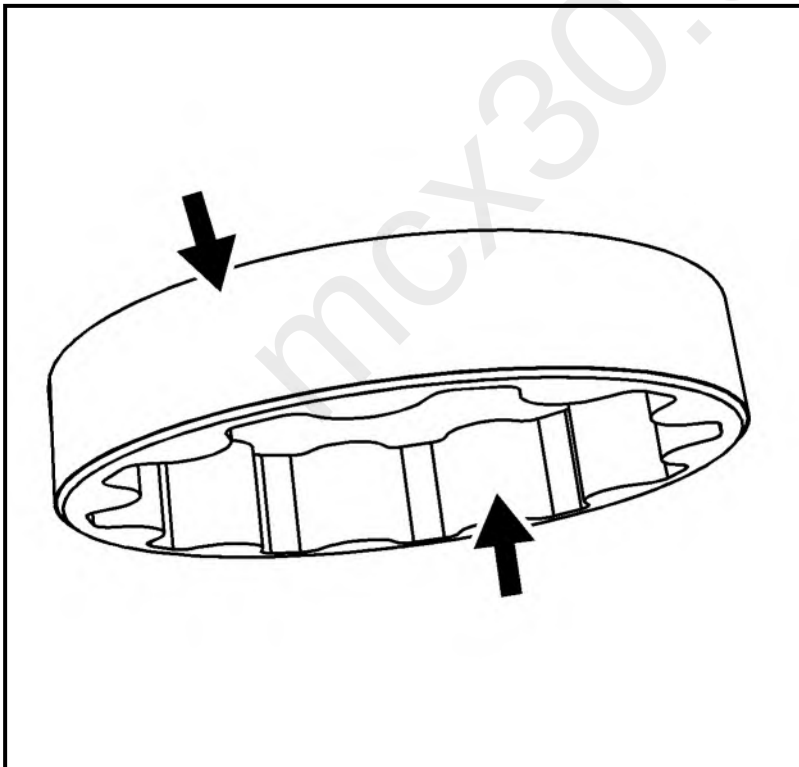
- Damage to the oil pump cover mounting bosses (1)
- Damage, scoring, or debris in the oil pump cover oil passages (2)
- Damage to the sealing surface between the oil pump cover and the oil pump housing (3)

3.



Inspect the inner drive gear for damage. If inner diameter damage is found, ensure the crankshaft is also inspected.

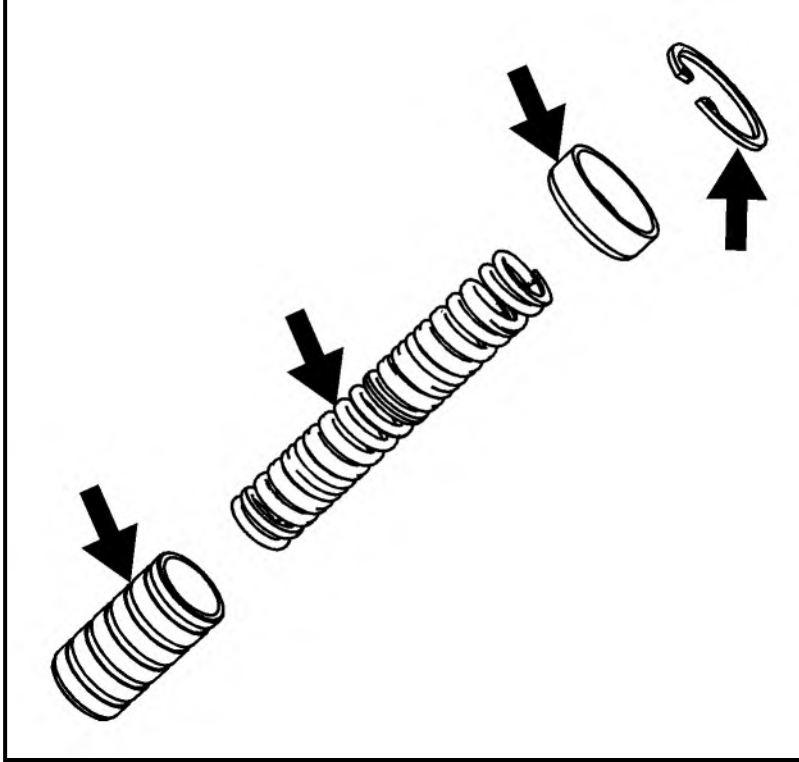
4.



Inspect the outer driven gear for damage.

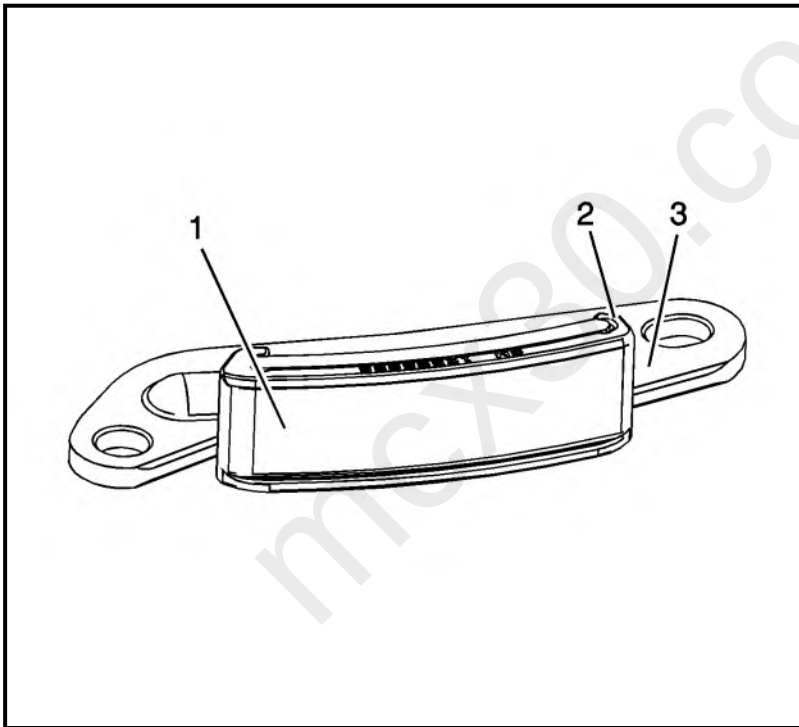
5.





Inspect the oil pump relief valve components for debris or damage.

6.

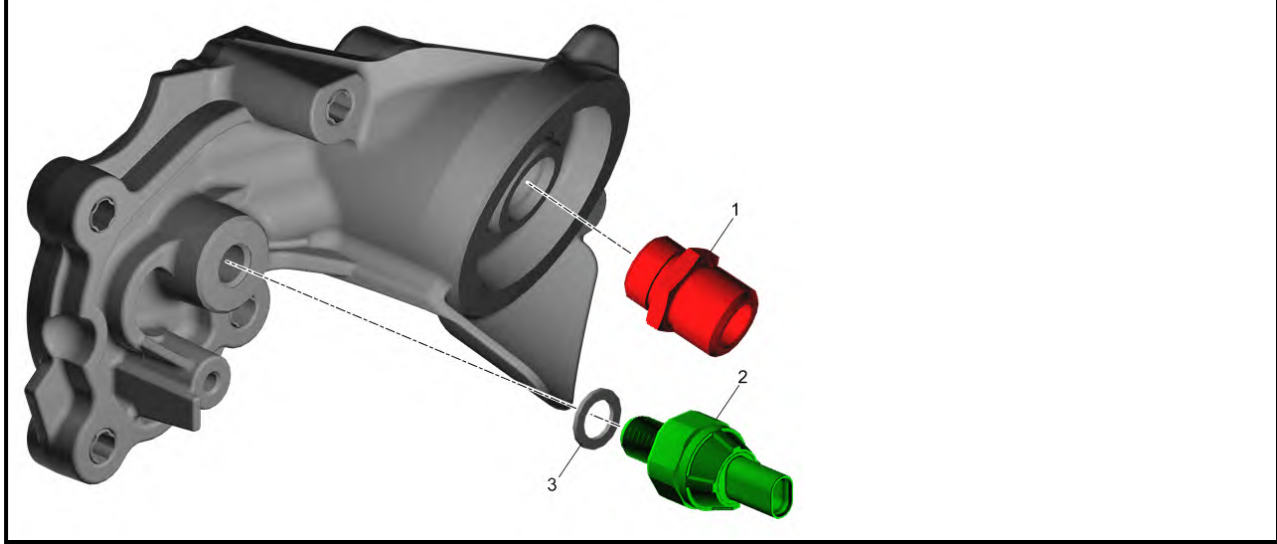


Inspect the primary camshaft drive chain lower guide for damage (1 - 3).

7. If debris or damage is present within the oil pump, further inspection of all of the engine components is necessary.

OIL FILTER ADAPTER DISASSEMBLE





Callout	Component Name
1	Oil Filter Fitting
2	Engine Oil Pressure Sensor
3	Engine Oil Pressure Sensor Seal

OIL FILTER ADAPTER CLEANING AND INSPECTION

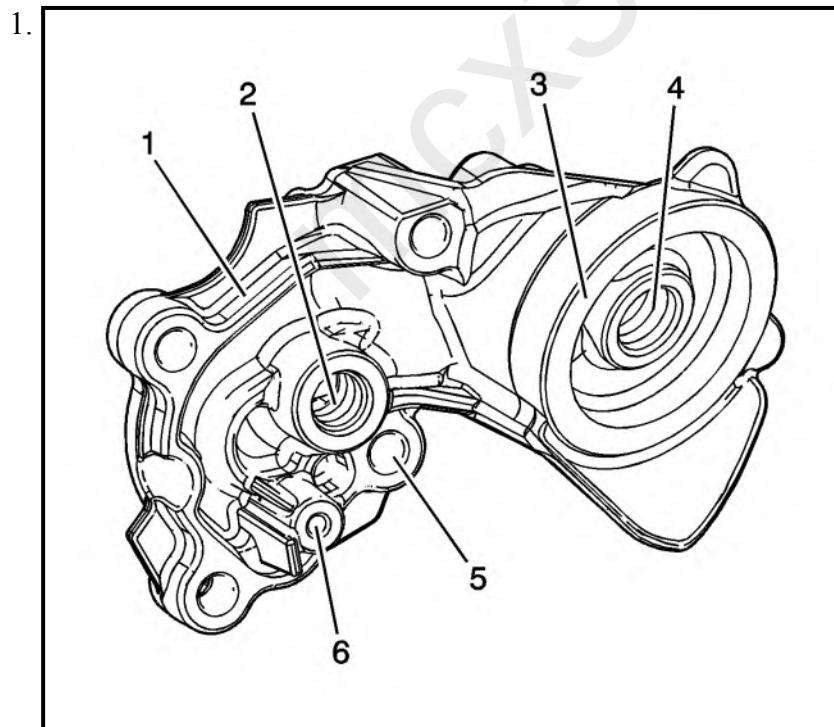
Cleaning Procedure

1. Clean the oil filter adapter components with non-corrosive solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the oil filter adapter components with compressed air.

Inspection Procedure

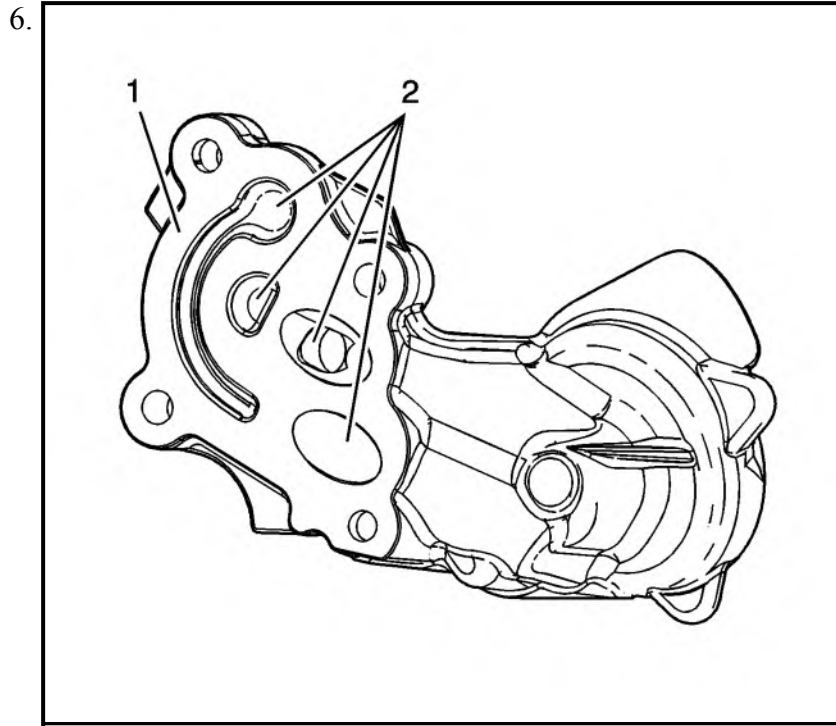


NOTE: The internal parts of the oil filter adapter housing are not serviced separately. If wear or damage is noted, replace the entire oil filter adapter assembly.

Inspect the oil filter adapter housing for cracks, casting imperfections or damage (1).

2. Inspect the threads for the oil pressure sender (2) or the bracket (6) for damage.

3. Inspect the oil filter sealing surface (3) for damage.
4. Inspect the threads for the oil filter fitting (4) for damage.
5. Inspect the mounting holes (5) for damage.



Inspect the oil filter adapter housing gasket sealing surface (1) for damage.

7. Inspect the oil filter adapter housing passages (2) for damage or blockage.
8. Repair or replace the oil filter adapter housing as necessary.

OIL FILTER ADAPTER ASSEMBLE

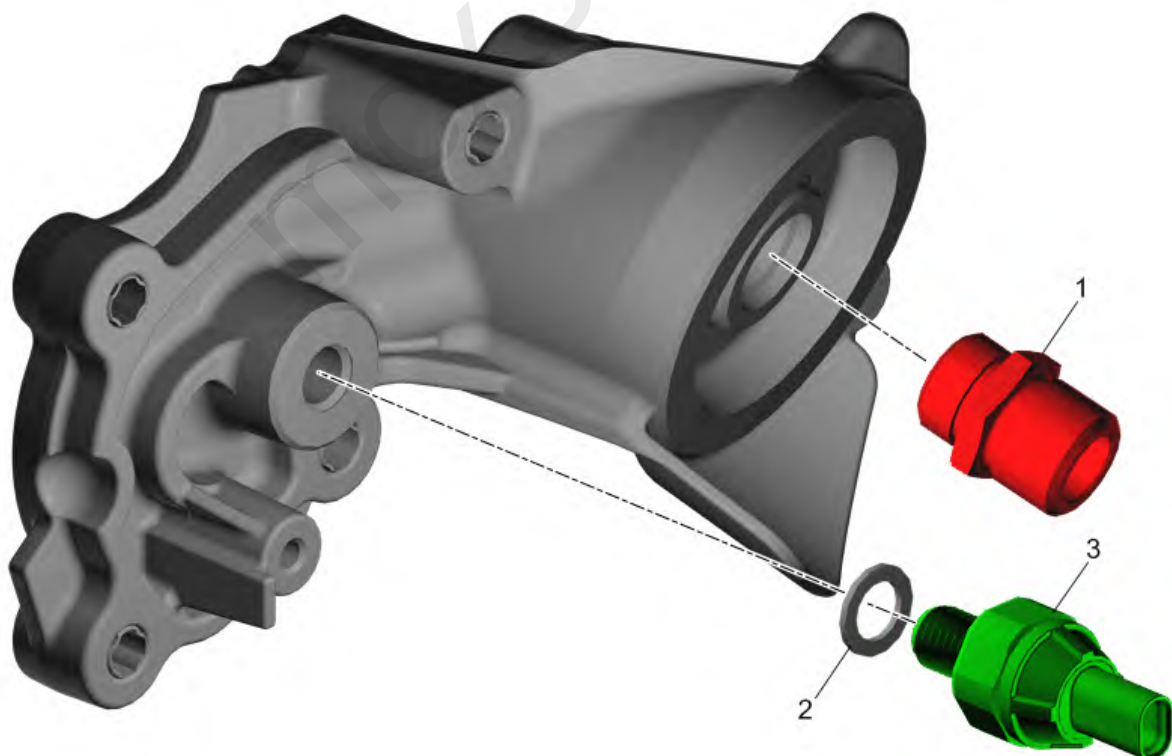


Fig. 6: Exploded View Of Oil Filter Adapter
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
1	Oil Filter Fitting CAUTION: Refer to Fastener Caution . Tighten 50 N.m (37 lb ft)
2	Engine Oil Pressure Sensor Seal
3	Engine Oil Pressure Sensor Tighten 20 N.m (15 lb ft)

OIL PAN DISASSEMBLE

Oil Pan Baffle and Plug Disassemble

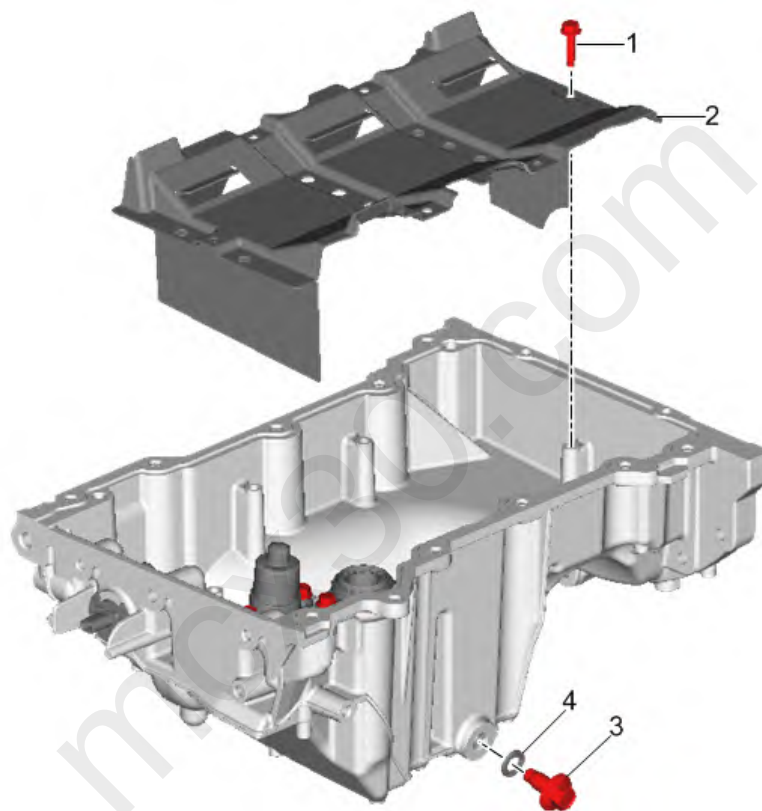


Fig. 7: Exploded View Of Oil Pan Baffle And Plug Components

Courtesy of GENERAL MOTORS COMPANY

Oil Pan Baffle and Plug Disassemble

Callout	Component Name
1	Oil Pan Baffle Bolt [6x]
2	Oil Pan Baffle
3	Oil Pan Drain Plug
4	Oil Pan Drain Plug Seal

Oil Pump Suction Pipe and Oil Level Indicator Switch Disassemble

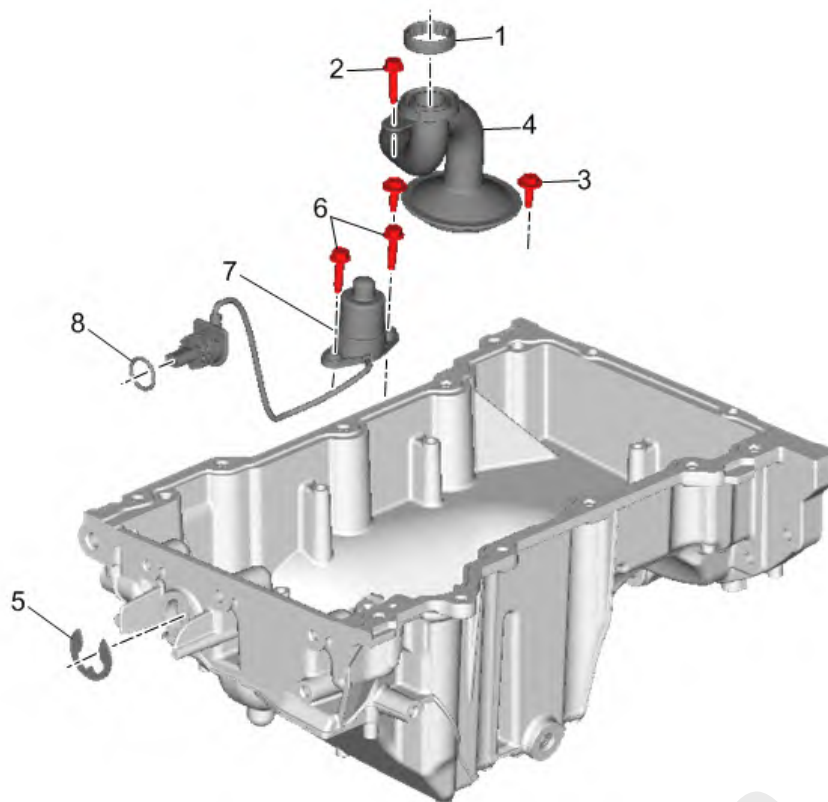


Fig. 8: Exploded View Of Oil Pump Suction Pipe and Oil Level Indicator Switch Components
 Courtesy of GENERAL MOTORS COMPANY

Oil Pump Suction Pipe and Oil Level Indicator Switch Disassemble

Callout	Component Name
1	Oil Pump Suction Pipe Seal NOTE: Remove and DISCARD the seal.
2	Oil Pump Suction Pipe Bolt
3	Oil Pump Suction Pipe Bolt [2x]
4	Oil Pump Suction Pipe
5	Engine Oil Level Switch Clip
6	Engine Oil Level Indicator Switch Bolt [2x]
7	Engine Oil Level Indicator Switch
8	Engine Oil Level Indicator Switch O-Ring Seal NOTE: Remove and DISCARD the seal.

OIL PAN CLEANING AND INSPECTION

Special Tools

EN-28410 Gasket Remover

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

Cleaning Procedure

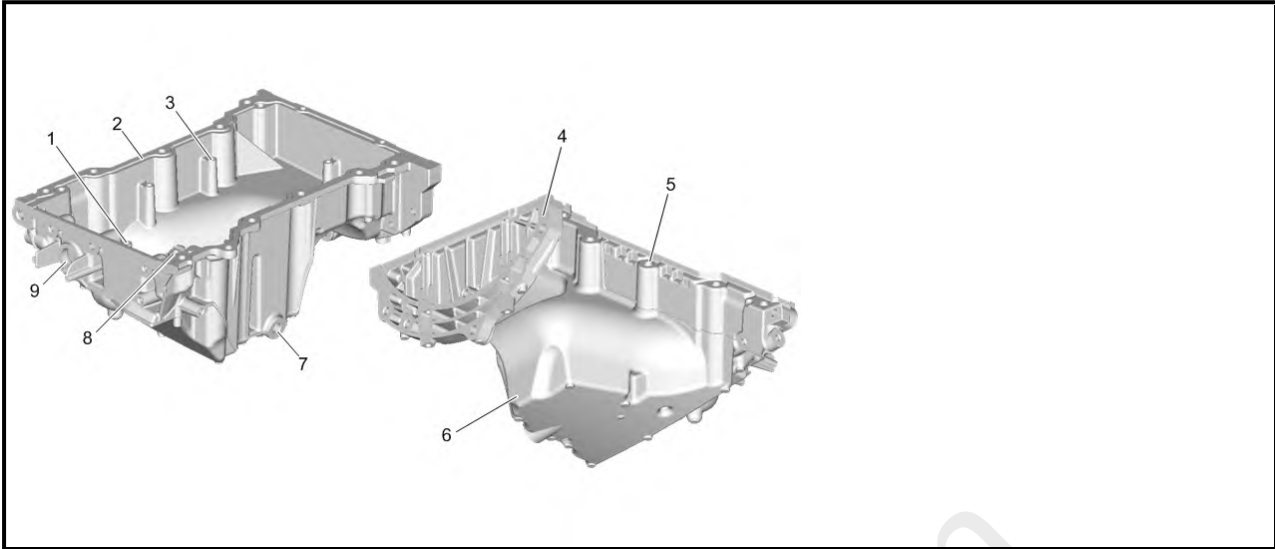
1. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)
2. Remove any old thread sealant, gasket material or sealant using EN-28410 remover.
3. Clean the oil pan and oil pan components in solvent.

4. Clean out debris from the bolt holes.

WARNING: Refer to Safety Glasses Warning .

5. Dry the oil pan and oil pan components with compressed air.

Inspection Procedure Oil Pan



1. Inspect the oil pan for the following conditions:

- Damage to the engine oil level switch mounting holes (1)
- Gouges or damage to the oil pan sealing surfaces (2)
- Damage to the oil pan baffle mounting bosses (3)
- Damage to the brace mounting bosses (4)
- Damage to the oil pan mounting holes (5)
- Gouges or damage to the oil pan surfaces (6)
- Damage to the oil pan drain plug hole (7)
- Damage to the oil pump suction pipe mounting bosses (8)
- Damage to the engine oil level switch hole (9)

2. Repair or replace the oil pan and/or oil pan components as necessary.

OIL PUMP SUCTION PIPE AND SCREEN CLEANING AND INSPECTION

Cleaning Procedure

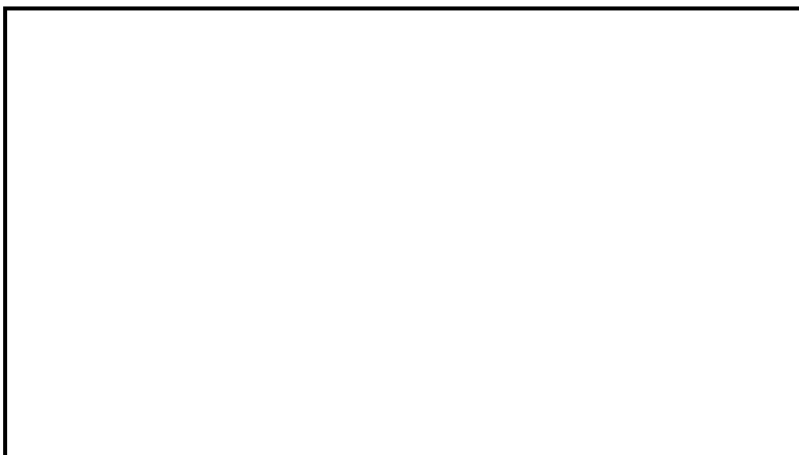
1. Clean the oil pump pipe and screen with solvent.

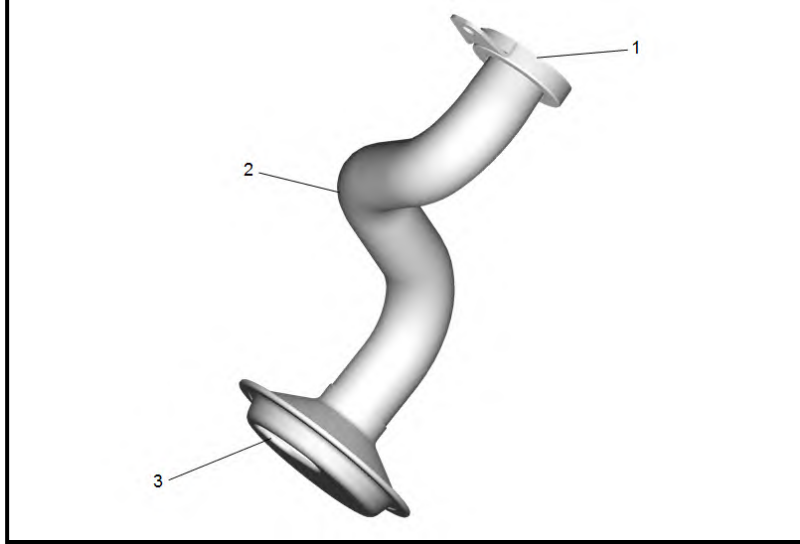
WARNING: Refer to Safety Glasses Warning .

2. Dry the oil pump pipe and screen with compressed air.

Inspection Procedure

1.





Inspect the mounting surface (1) for possible leakage paths.

2. Inspect the oil pump pipe tube (2) for cracks, imperfections and/or damage.

3. Inspect the oil pump screen (3) for blockage, foreign material, tears, cracks and/or damage.

OIL PAN ASSEMBLE

Oil Pump Suction Pipe and Oil Level Indicator Switch Assemble

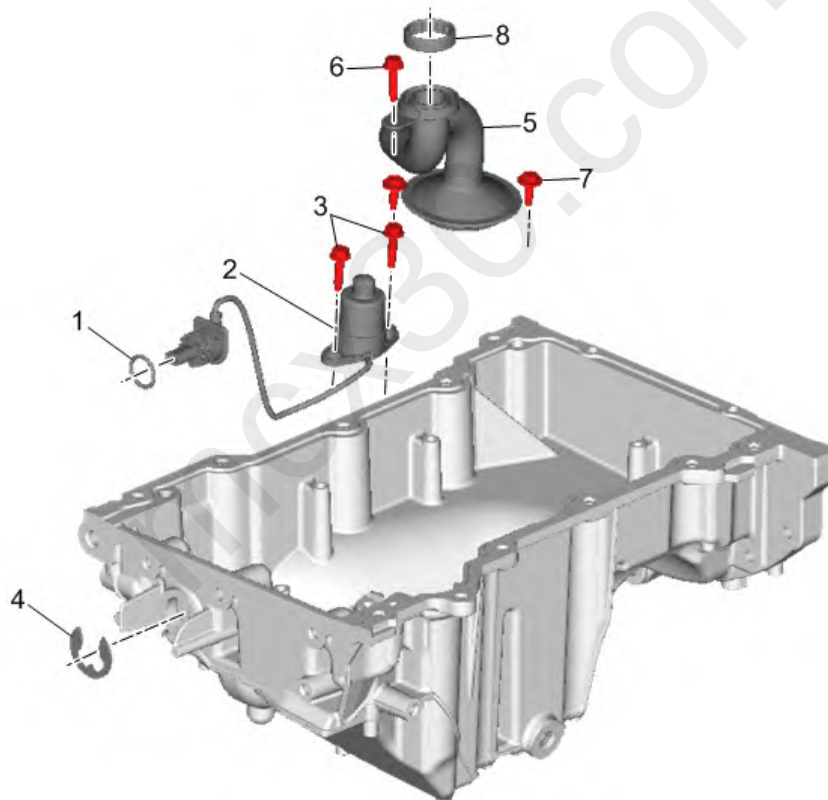


Fig. 9: Exploded View Of Oil Pump Suction Pipe And Oil Level Indicator Switch Components
 Courtesy of GENERAL MOTORS COMPANY

Oil Pump Suction Pipe and Oil Level Indicator Switch Assemble

Callout	Component Name
1	Engine Oil Level Indicator Switch O-Ring Seal NOTE: Install a NEW seal.
2	Engine Oil Level Indicator Switch

Callout	Component Name
3	Engine Oil Level Indicator Switch Bolt [2x] CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
4	Engine Oil Level Switch Clip
5	Oil Pump Suction Pipe
6	Oil Pump Suction Pipe Bolt Tighten 10 N.m (89 lb in)
7	Oil Pump Suction Pipe Bolt [2x] Tighten 10 N.m (89 lb in)
8	Oil Pump Suction Pipe Seal NOTE: Install a NEW seal.

Oil Pan Baffle and Plug Assemble

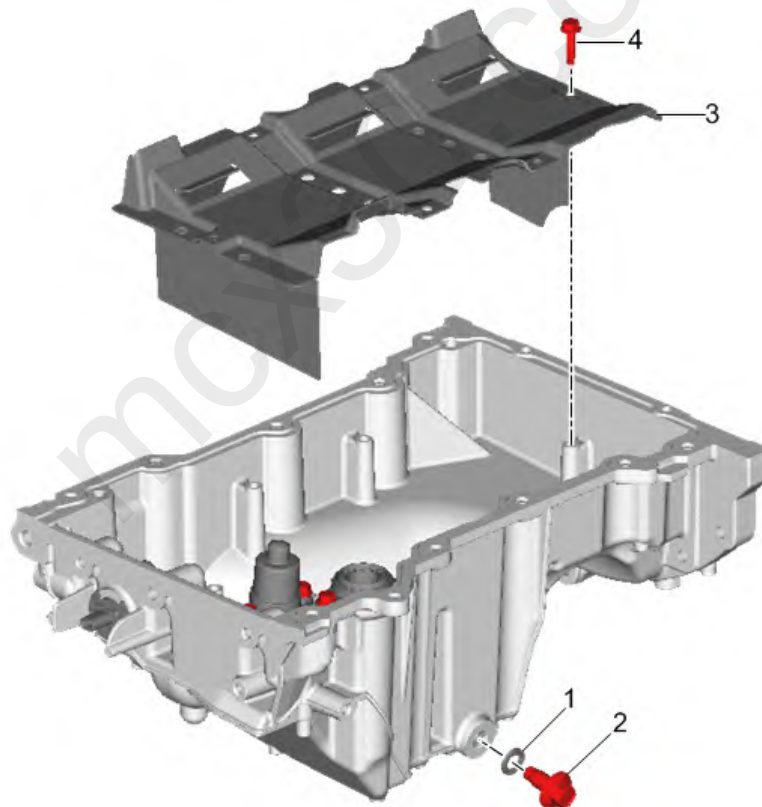


Fig. 10: Exploded View Of Oil Pan Baffle And Plug Components

Courtesy of GENERAL MOTORS COMPANY

Oil Pan Baffle and Plug Assemble

Callout	Component Name
1	Oil Pan Drain Plug Seal NOTE: Install a NEW seal.

Callout	Component Name
2	Oil Pan Drain Plug CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
3	Oil Pan Baffle
4	Oil Pan Baffle Bolt [6x] Tighten 10 N.m (89 lb in)

ENGINE FRONT COVER DISASSEMBLE

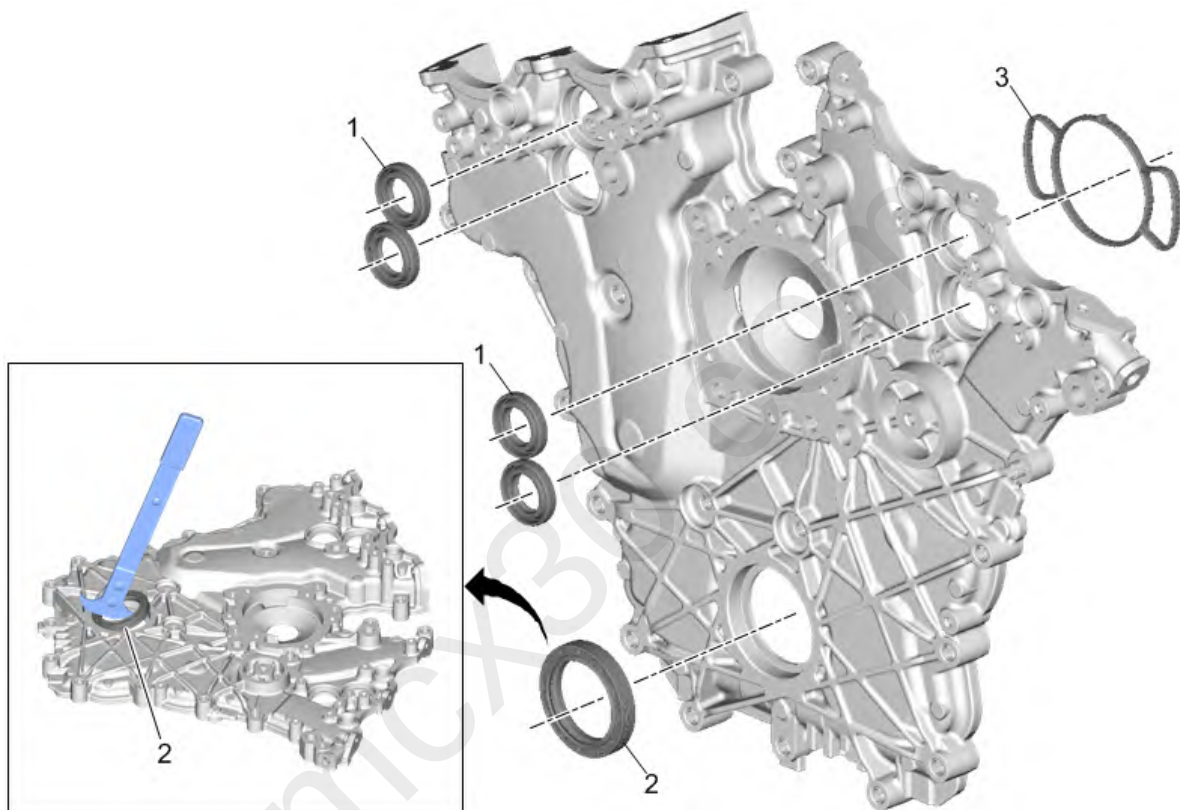


Fig. 11: Exploded View Of Engine Front Cover Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve Seal [4x] NOTE: Remove and DISCARD the seal.
2	Crankshaft Front Oil Seal Procedure 1. Remove - Crankshaft Front Oil Seal EN-45000 Seal Remover Special Tools EN-45000 Seal Remover Equivalent regional tools: Special Tools

Callout	Component Name
3	Engine Front Cover Gasket NOTE: Remove and DISCARD the gasket.

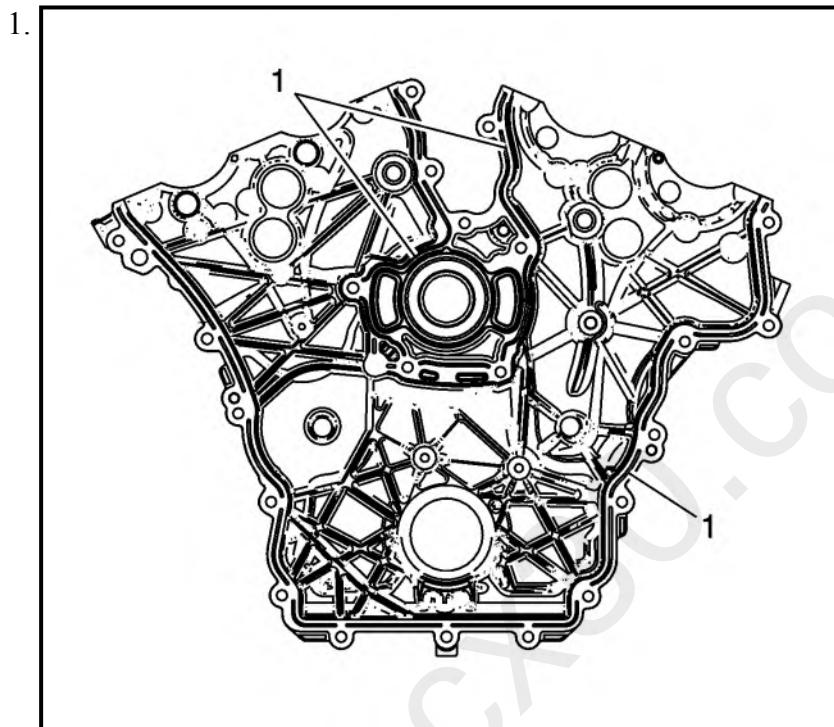
ENGINE FRONT COVER CLEANING AND INSPECTION

Special Tools

EN - 28410 Gasket Remover

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

Cleaning Procedure



Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

Remove any RTV sealant (1) from the engine front cover using **EN - 28410** remover.

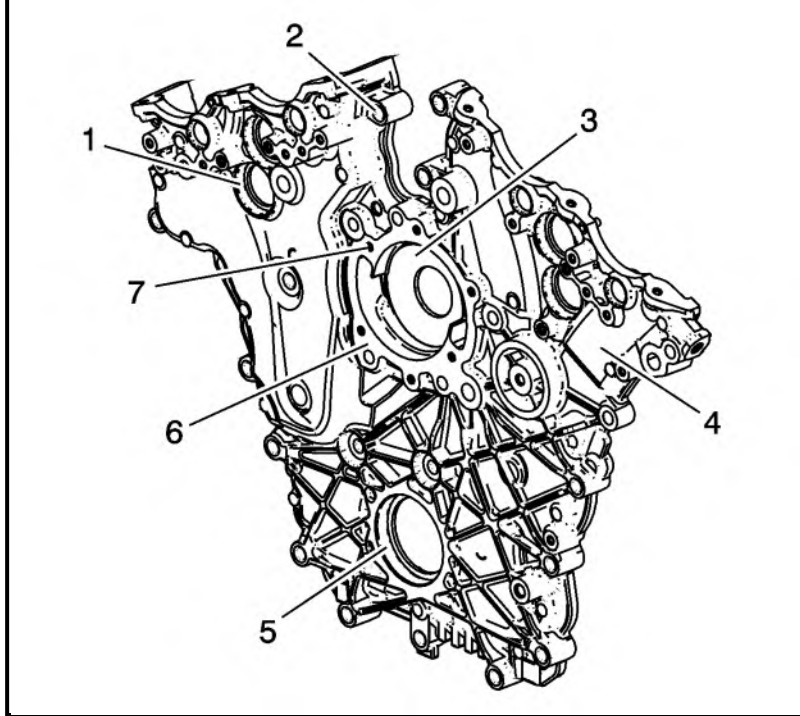
2. Clean out debris from the bolt holes.
3. Clean the engine front cover in solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

4. Dry the engine front cover with compressed air.

Inspection Procedure

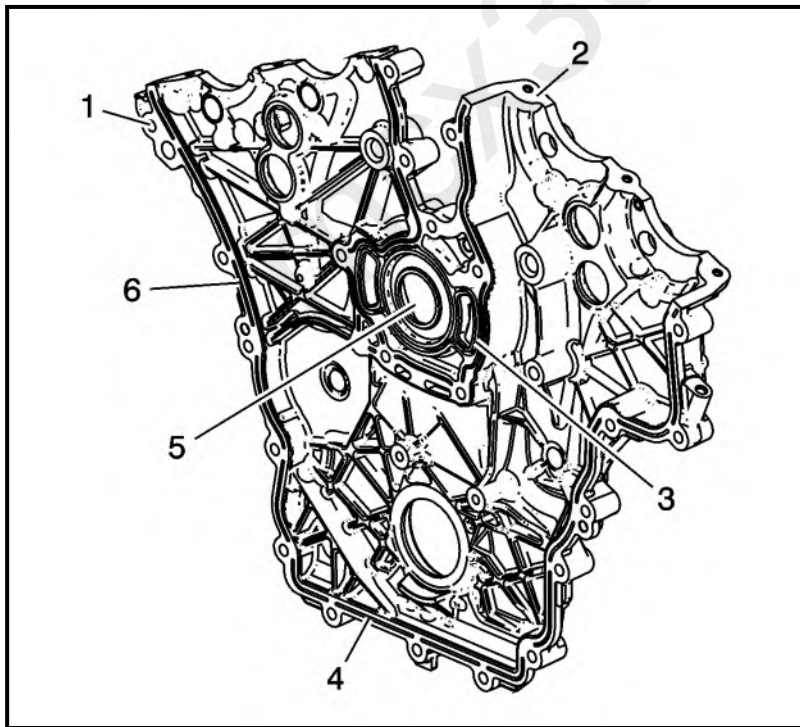




Inspect the exterior of the engine front cover for the following conditions:

- Damage to the water pump bolt hole threads (7)
- Gouges or damage to the water pump sealing surfaces (6)
- Damage to the crankshaft front oil seal bore (5)
- Damage to the camshaft position actuator valve oil seal bores (1)
- Damage to the engine front cover bolt holes (2)
- Damage and/or corrosion to the engine coolant passage (3)
- Dents or damage to the exterior (4)

2.



Inspect the interior of the engine front cover for the following conditions:

- Gouges or damage to the engine front cover sealing surfaces to the engine block (6), oil pan (4), and/or camshaft covers (2)
- Damage and/or corrosion to the engine coolant passage (5)
- Damage to the crankshaft front oil seal bore
- Gouges or damage to the O-ring sealing areas

- Gouges or damage to the water pump seal area (3)
- Damage to the engine front cover bolt holes (1)

3. Repair or replace the engine front cover as necessary.

ENGINE FRONT COVER ASSEMBLE

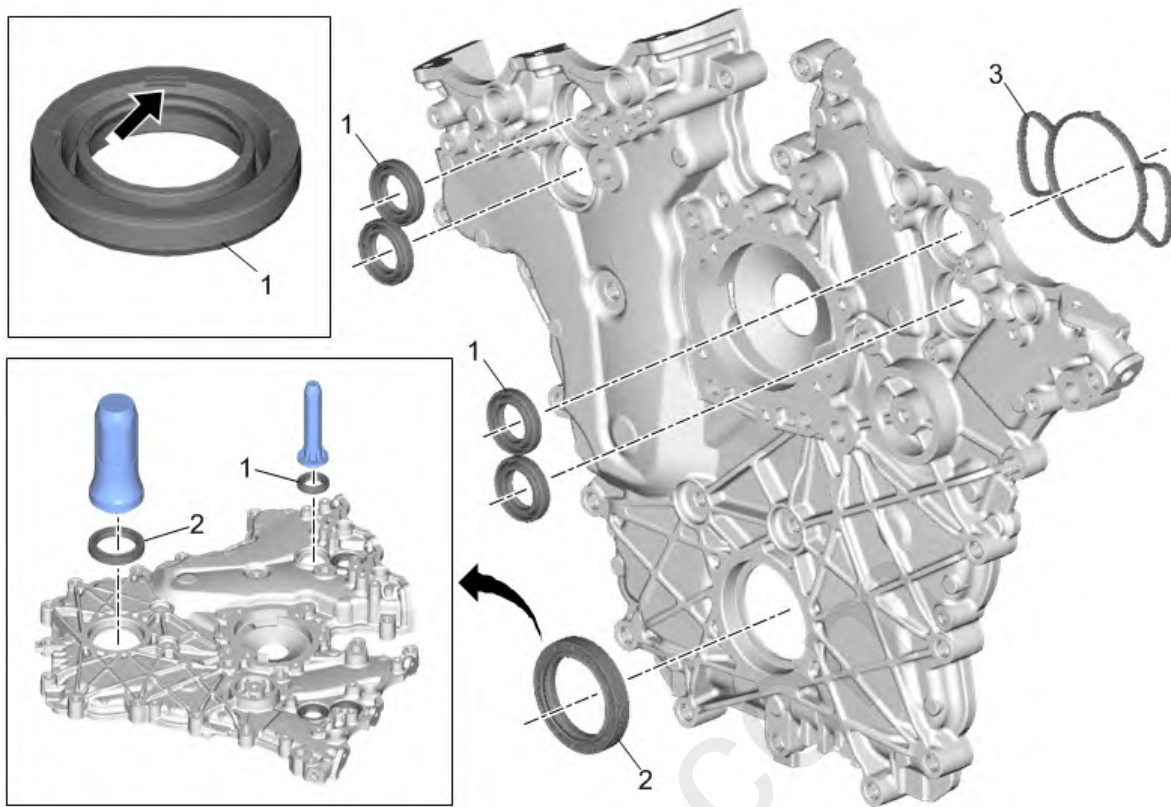


Fig. 12: Exploded View Of Engine Front Cover Components

Courtesy of GENERAL MOTORS COMPANY

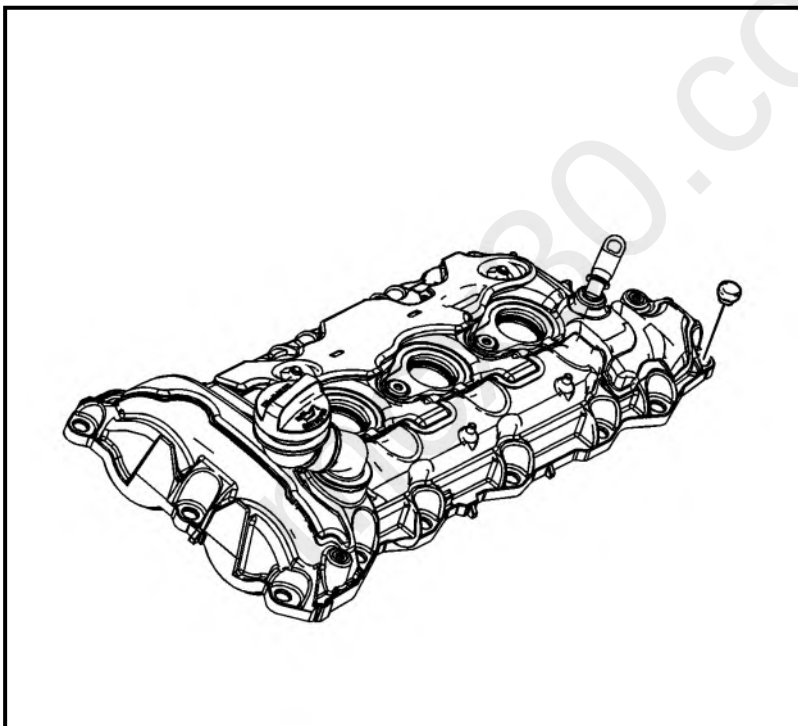
Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve Seal [4x] Procedure 1. Place the seal into position with the notches in the seal down. The notches will face inboard when properly installed. 2. Install - Camshaft Position Actuator Solenoid Valve Seal EN-46103 Camshaft Actuator Valve Seal Installer NOTE: Install a NEW seal. Do NOT reuse the old seal. Special Tools EN-46103 Camshaft Actuator Valve Seal Installer Equivalent regional tools: <u>Special Tools</u>

Callout	Component Name
2	Crankshaft Front Oil Seal Procedure 1. Install - Crankshaft Front Oil Seal EN-29184 Oil Seal Installer NOTE: Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal. Special Tools EN-29184 Oil Seal Installer Equivalent regional tools: Special Tools
3	Engine Front Cover Gasket NOTE: Install a NEW gasket. Do NOT reuse the old gasket.

CAMSHAFT COVER DISASSEMBLE

Left Camshaft Cover

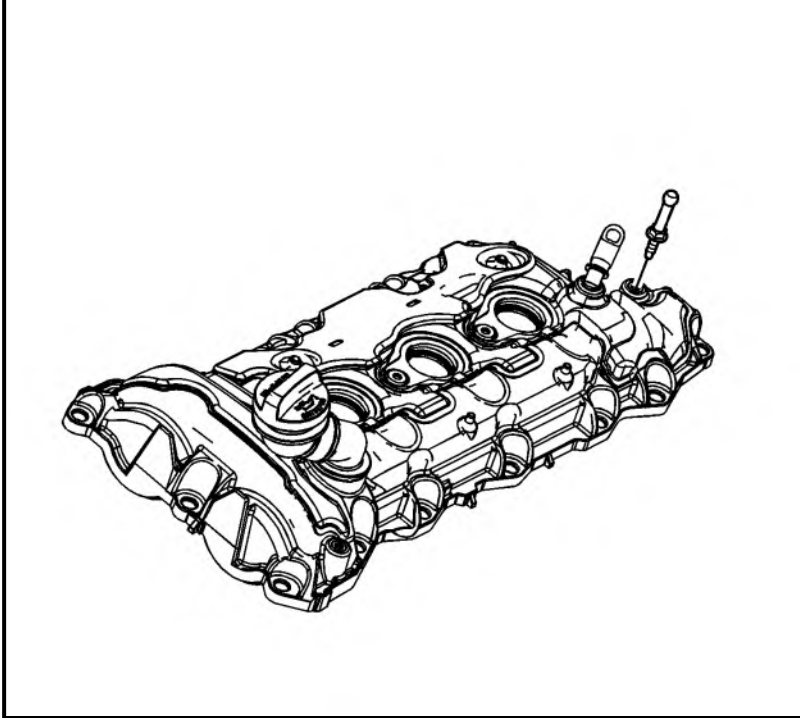
1.



Remove and discard the left camshaft cover bolt grommets.

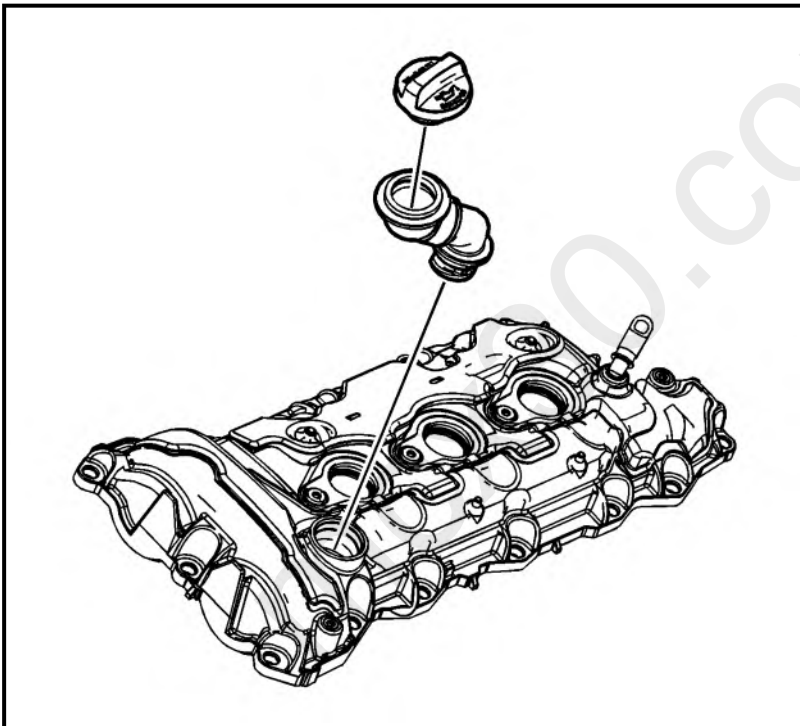
2.





Remove the fuel injector sight shield ballstud.

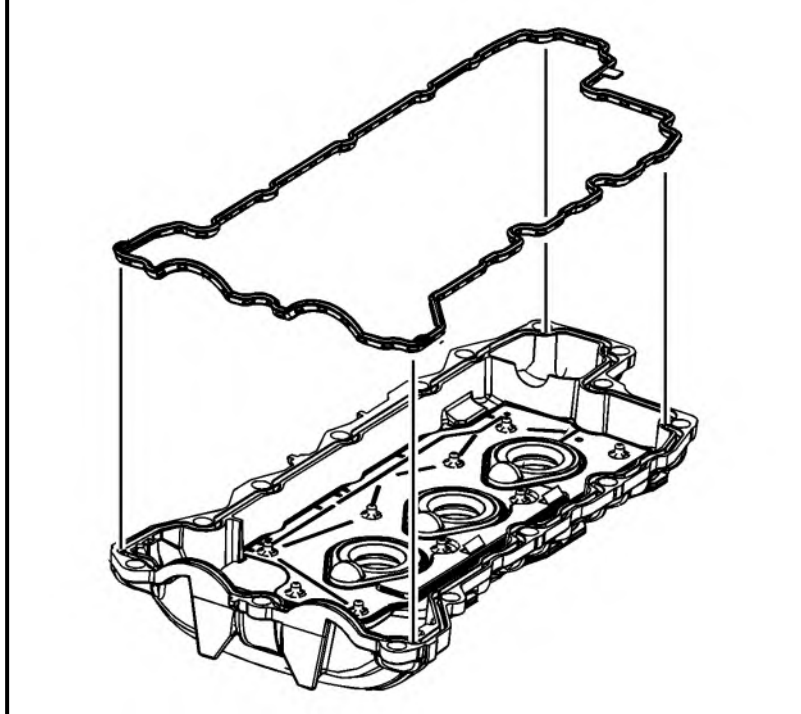
3.



Remove the oil fill cap.

4.

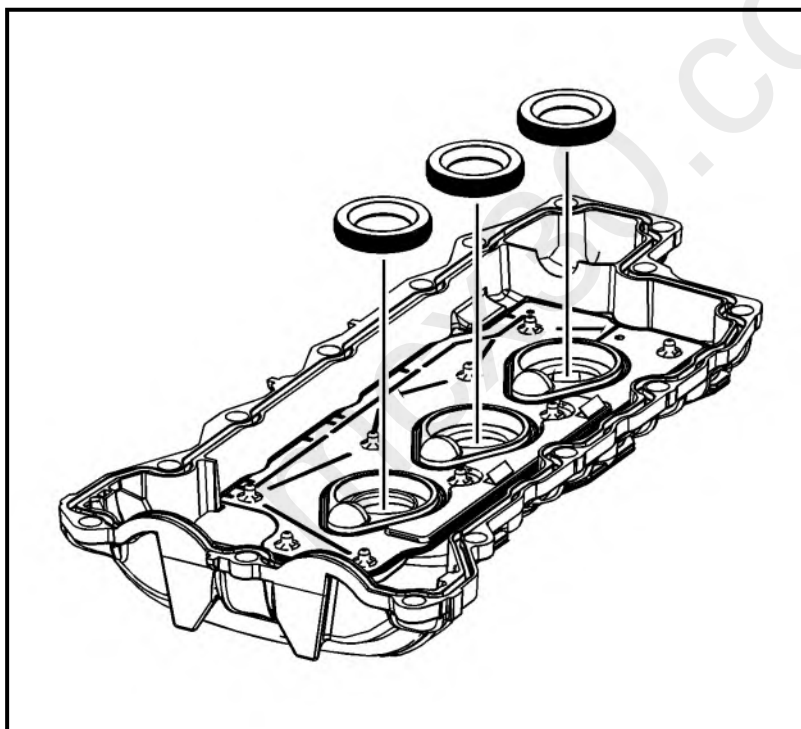




NOTE: Do not reuse the camshaft cover gasket and spark plug shield tube seals.

Remove and discard the left camshaft cover gasket.

5.

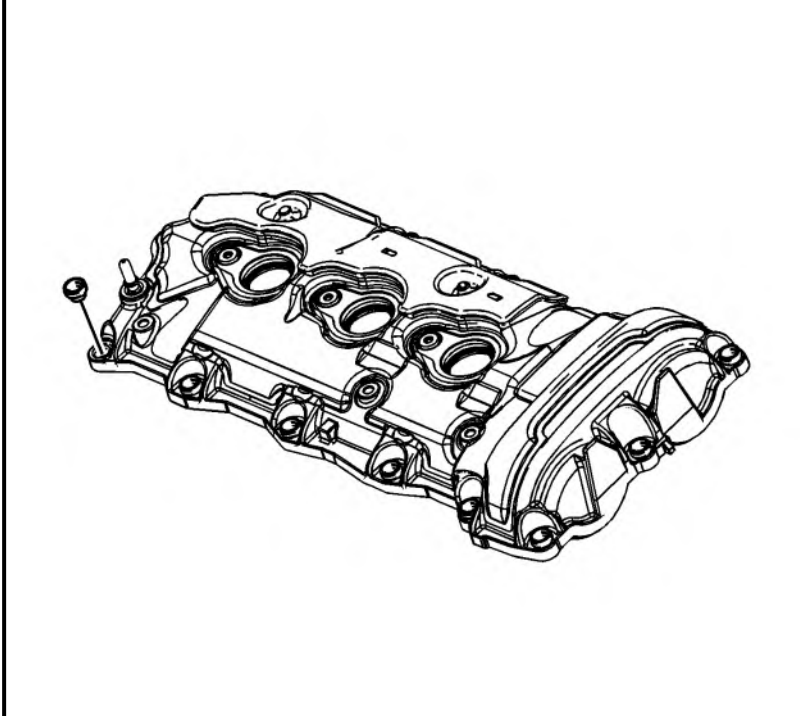


Remove and discard the left spark plug shield tube seals.

Right Camshaft Cover

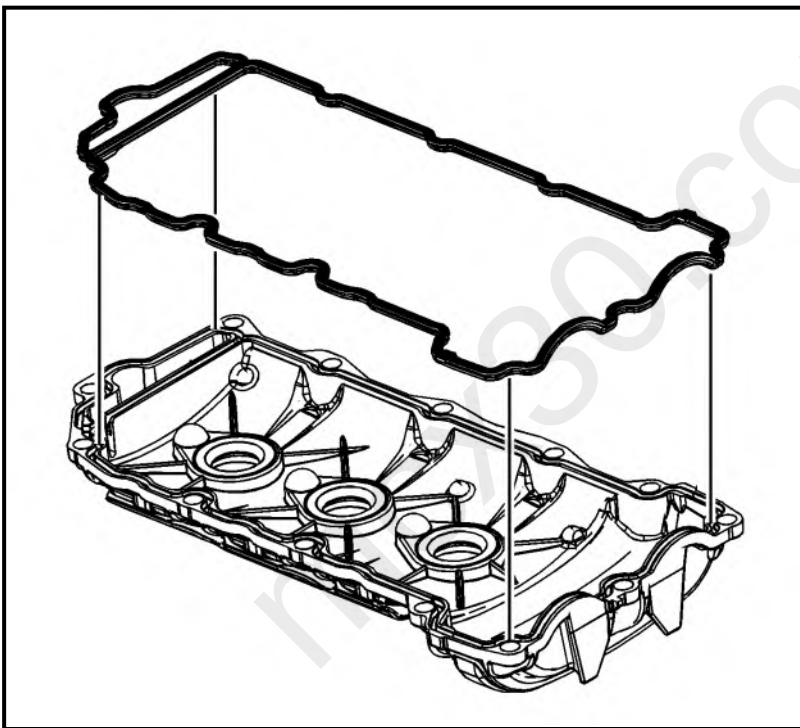
1.





Remove and discard the right camshaft cover bolt grommets.

2.

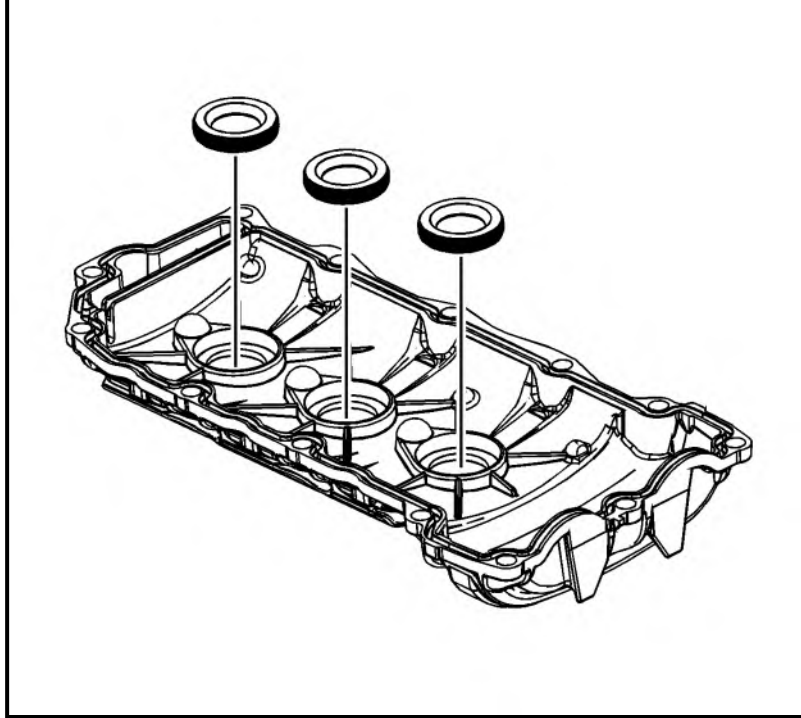


NOTE: Do not reuse the camshaft cover gasket and spark plug shield tube seals.

Remove and discard the right camshaft cover gasket.

3.





Remove and discard the right spark plug shield tube seals.

CAMSHAFT COVER CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the camshaft covers in solvent.

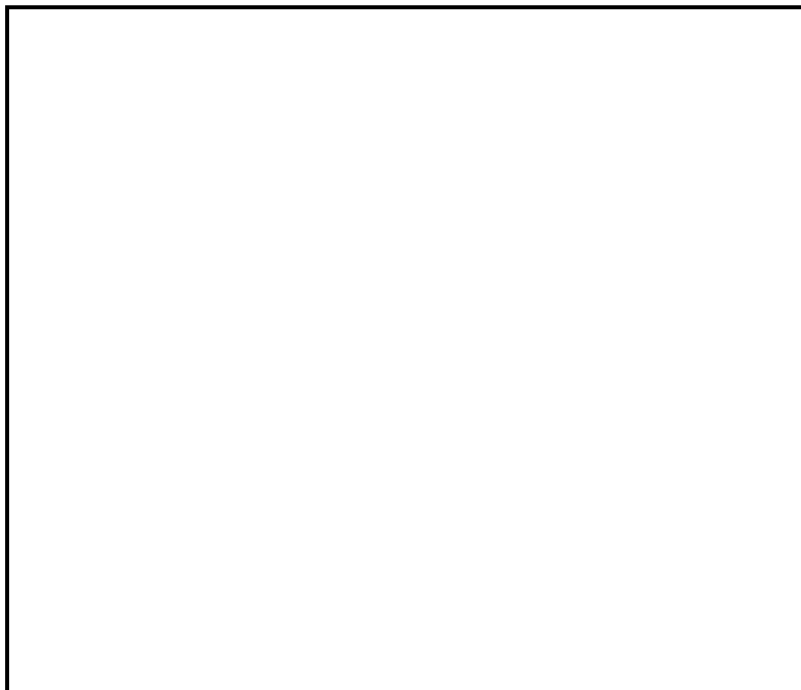
WARNING: Refer to **Safety Glasses Warning**.

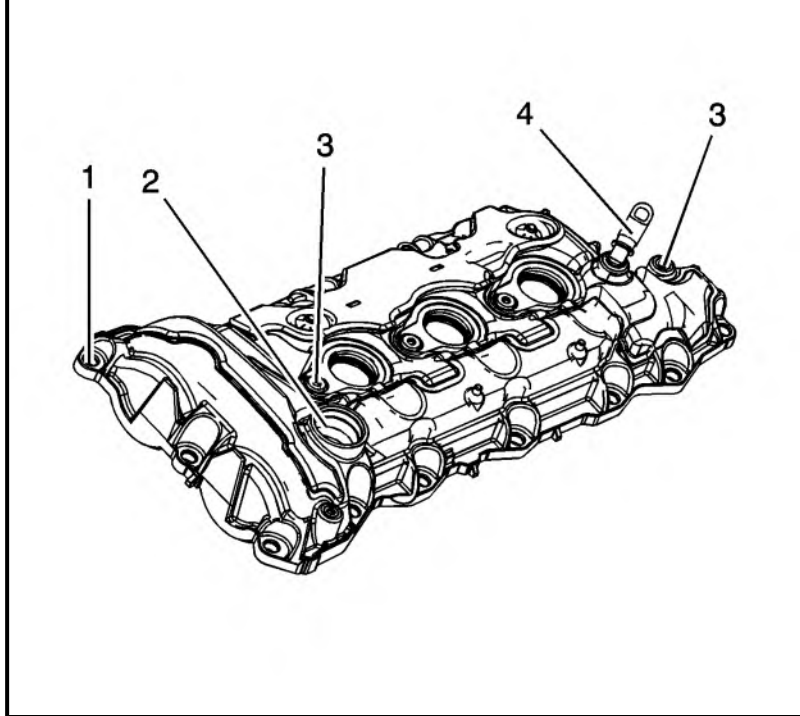
2. Dry the camshaft covers with compressed air.

Inspection Procedure

1. Inspect each camshaft cover for the dents or damage to the exterior. A dented or damaged camshaft cover may:
 - Leak engine oil
 - Affect crankcase ventilation
 - Interfere with the camshafts
 - Interfere with the ignition coil sealing
 - Allow water or condensation to enter the engine

2.

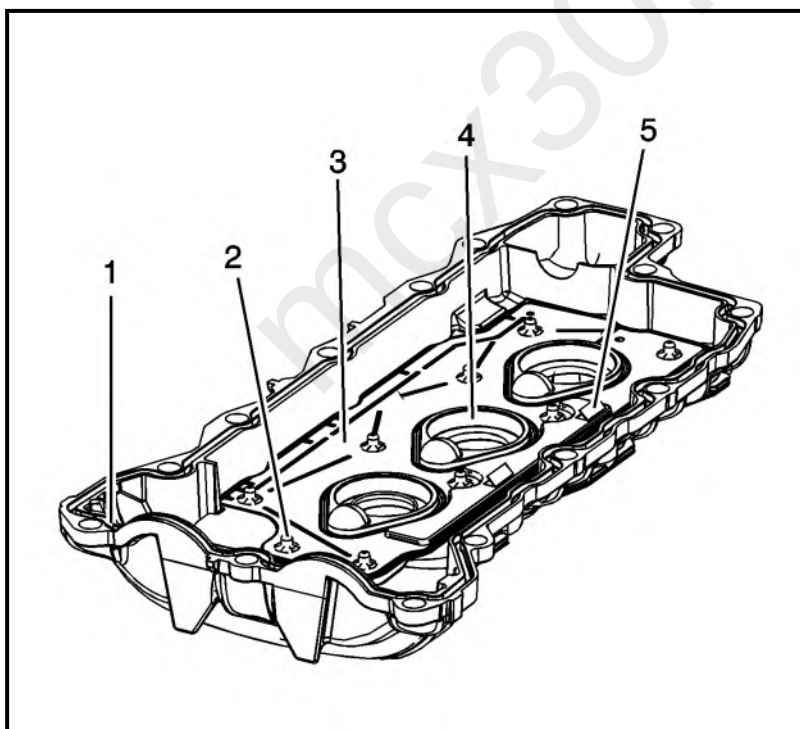




Inspect the exterior of the left camshaft cover for the following conditions:

- Damage to the camshaft cover bolt holes (1)
- Damage to the oil fill hole (2)
- Damage to the mounting holes (3) for the ignition coil assembly and fuel injector sight shield ballstud.
- Damage to the positive crankcase ventilation (PCV) hose connector (4) - A damaged PCV hose connector is replaceable.

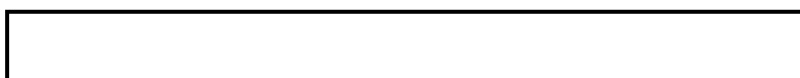
3.

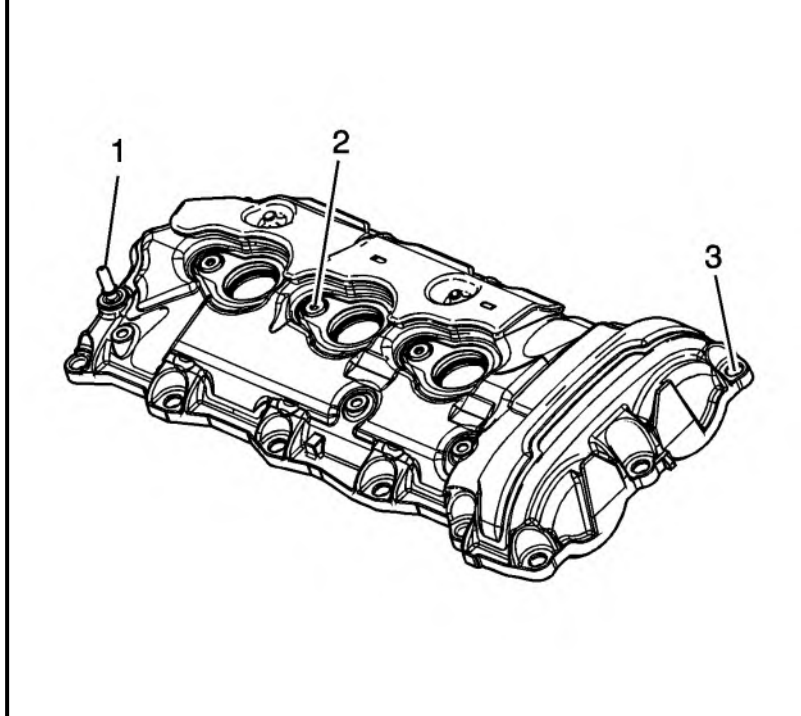


Inspect the interior of the left camshaft cover for the following conditions:

- Gouges or damage to the camshaft cover sealing groove (1)
- Damaged, loose or missing baffle fasteners (2)
- Damaged, loose or missing baffle (3)
- Gouges or damage to the spark plug shield seal bore (4)
- Restrictions to the ventilation system (5)

4.

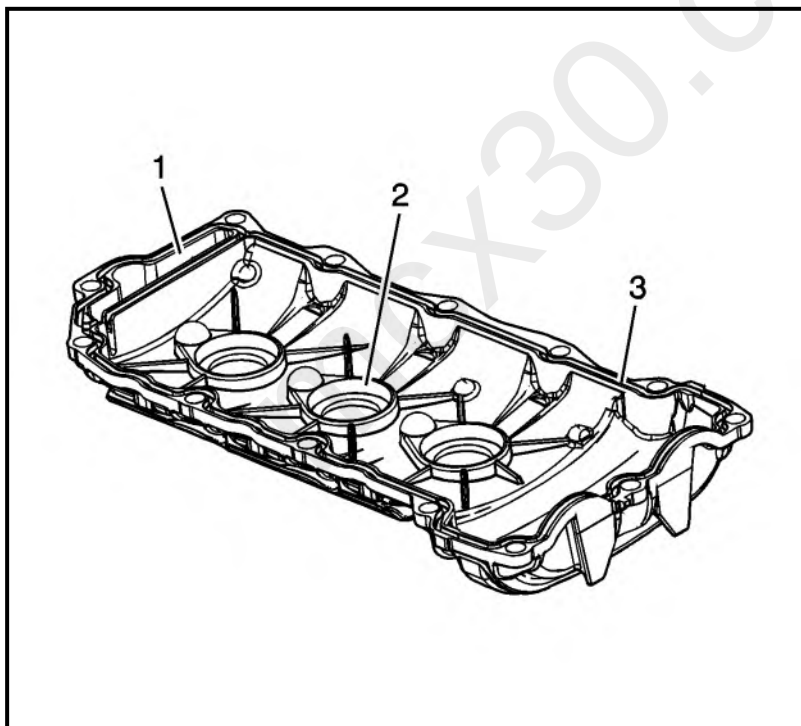




Inspect the exterior of the right camshaft cover for the following conditions:

- Damage to the PCV orifice (1) - A damaged PCV orifice can be replaced. Refer to PCV Orifice Replacement.
- Damage to the mounting holes (2) for the ignition coil assembly
- Damage to the camshaft cover bolt holes (3)

5.



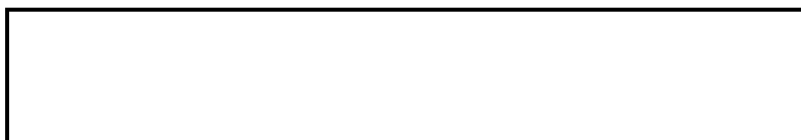
Inspect the interior of the right camshaft cover for the following conditions:

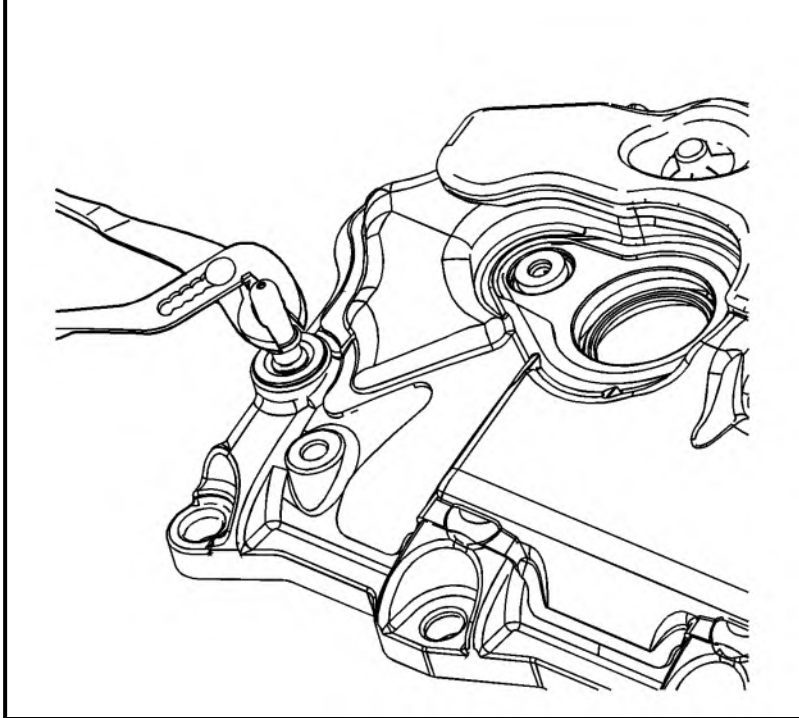
- Restrictions to the ventilation system (1)
- Gouges or damage to the spark plug shield seal bore (2)
- Gouges or damage to the camshaft cover sealing groove (3)

6. Repair or replace the camshaft cover or covers as necessary.

PCV Orifice Replacement

1.

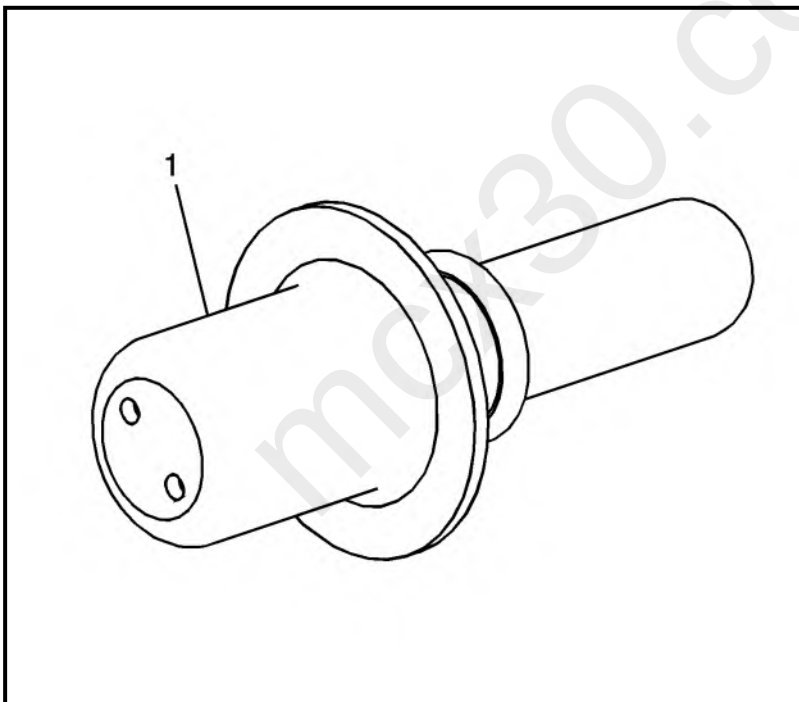




NOTE: If the PCV orifice is damaged or plugged and cannot be cleaned out, the PCV orifice can be replaced.

Remove the old PCV orifice by gripping the neck of the orifice with pliers and twisting and pulling out of the right camshaft cover.

2.

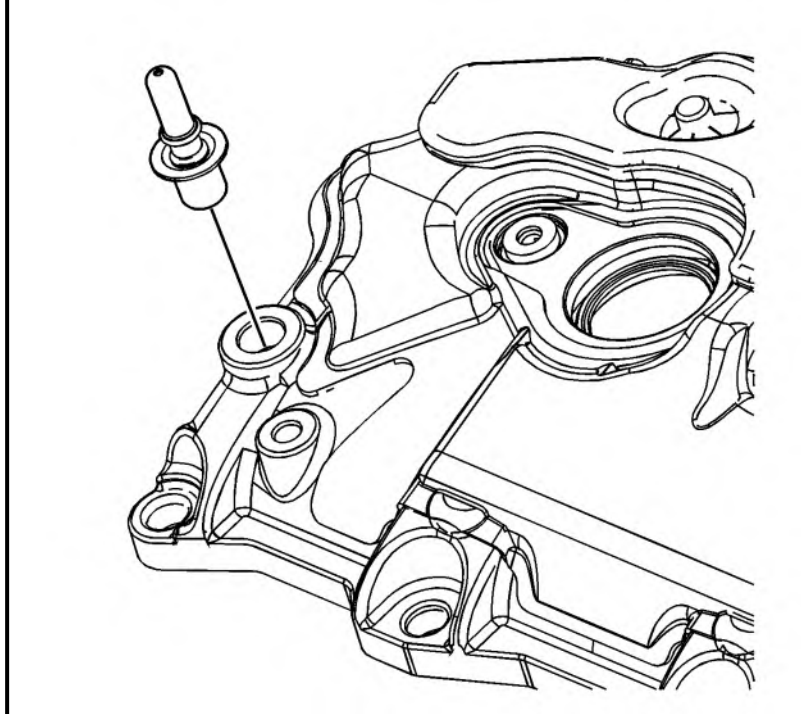


Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

3. Apply sealant to the NEW PCV orifice (1). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

4.

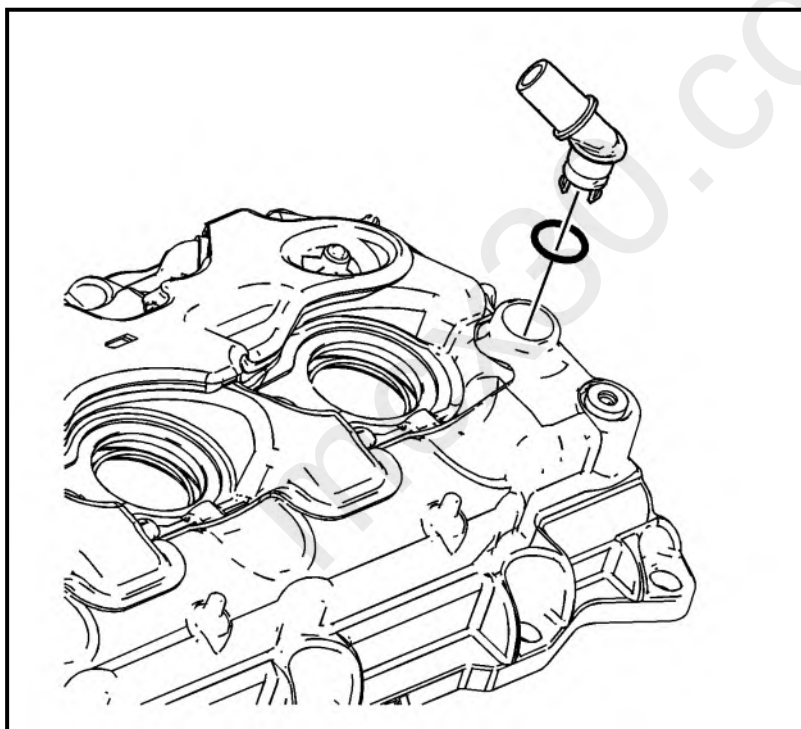




Install the NEW PCV orifice into the right camshaft cover. After insertion, twist the PCV orifice in order to eliminate any vertical leak paths in the sealant.

PCV Fitting Replacement

1.



NOTE: If the PCV fitting is damaged or plugged and cannot be cleaned out, the PCV fitting can be replaced.

Remove the old PCV fitting.

2. Install the new PCV fitting with a NEW O-ring.

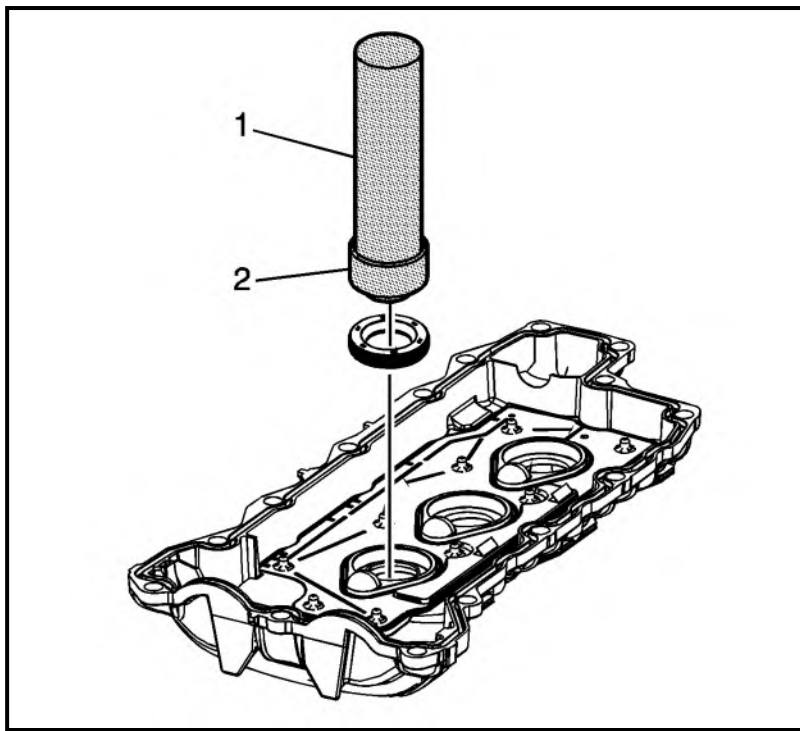
CAMSHAFT COVER ASSEMBLE

Special Tools

- **DT 5590** Bearing and Seal Driver
- **J-25254-A** Oil Seal Installer

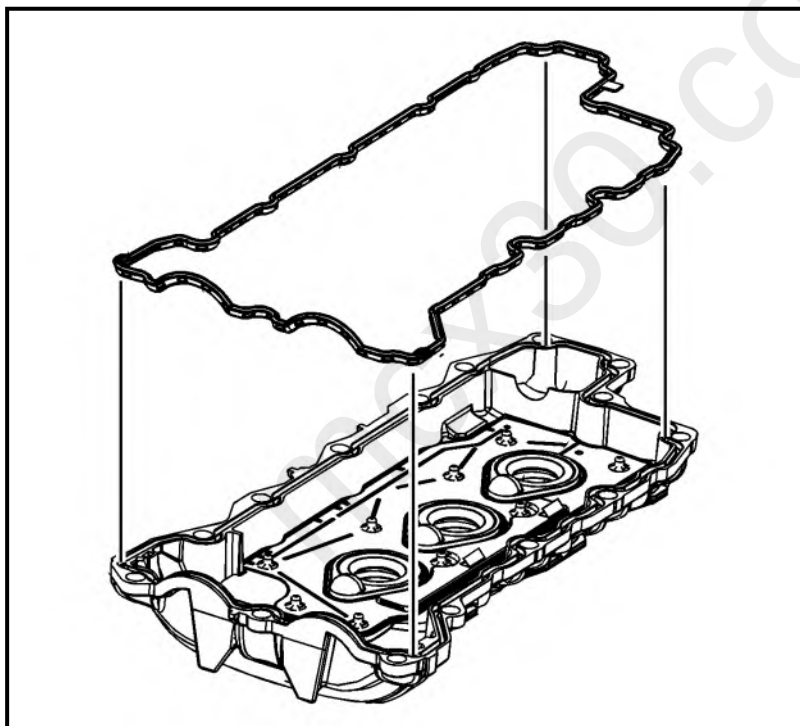
For equivalent regional tools, refer to [Special Tools](#) .

1.



Install the NEW left spark plug shield tube seals using the **DT 5590** driver (1) and **J-25254-A** installer (2).

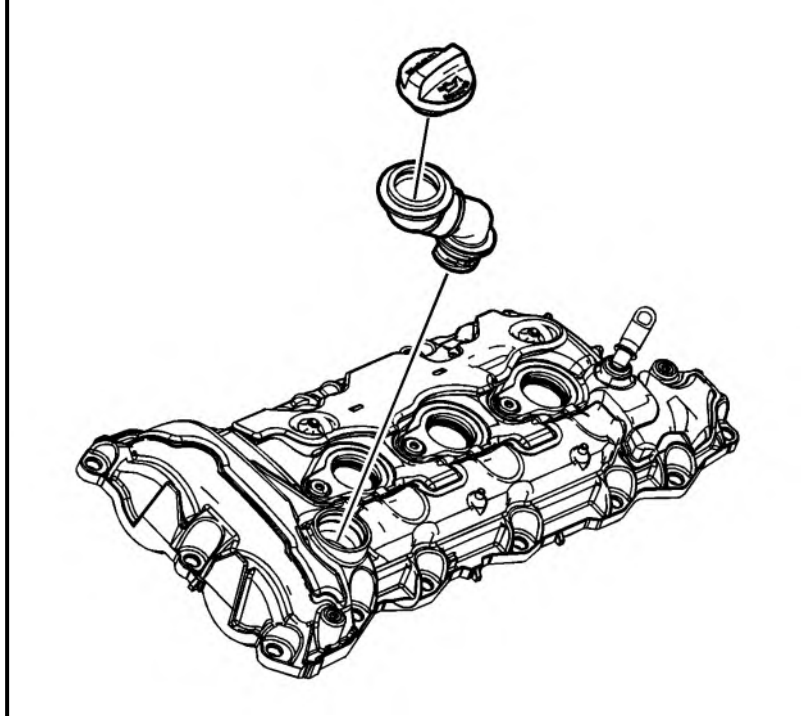
2.



Install the NEW left camshaft cover gasket.

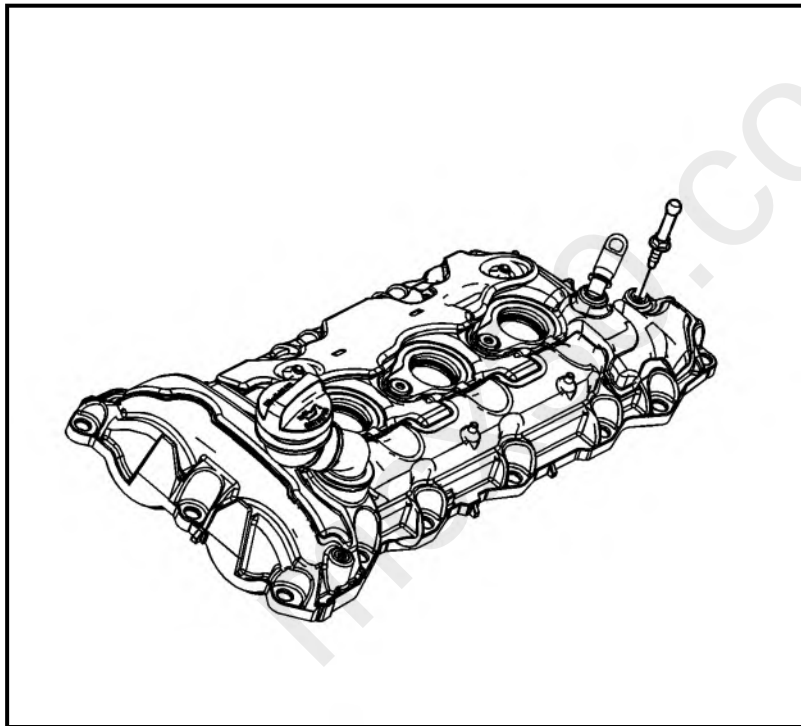
3.





Install the oil fill cap.

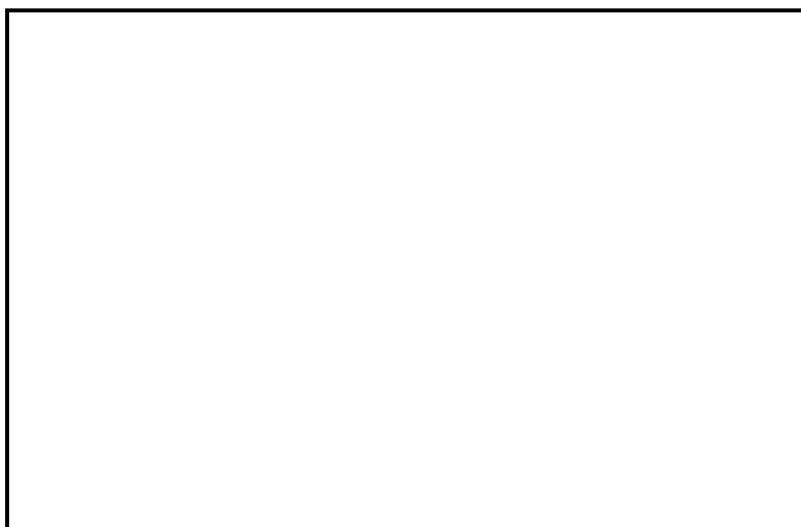
4.

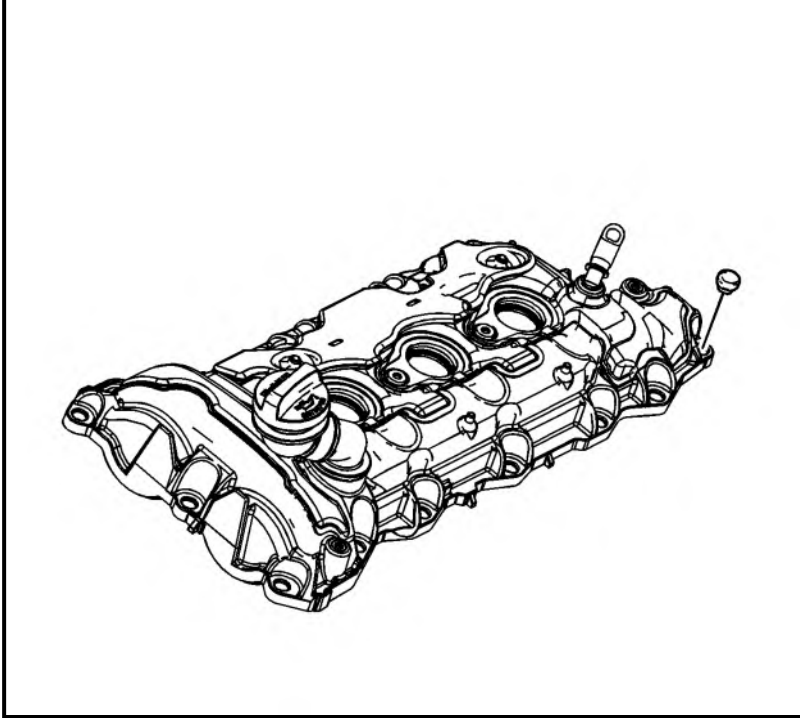


CAUTION: Refer to [Fastener Caution](#) .

Install the fuel injector sight shield cover ballstud and tighten to 10 N.m (89 lb in).

5.

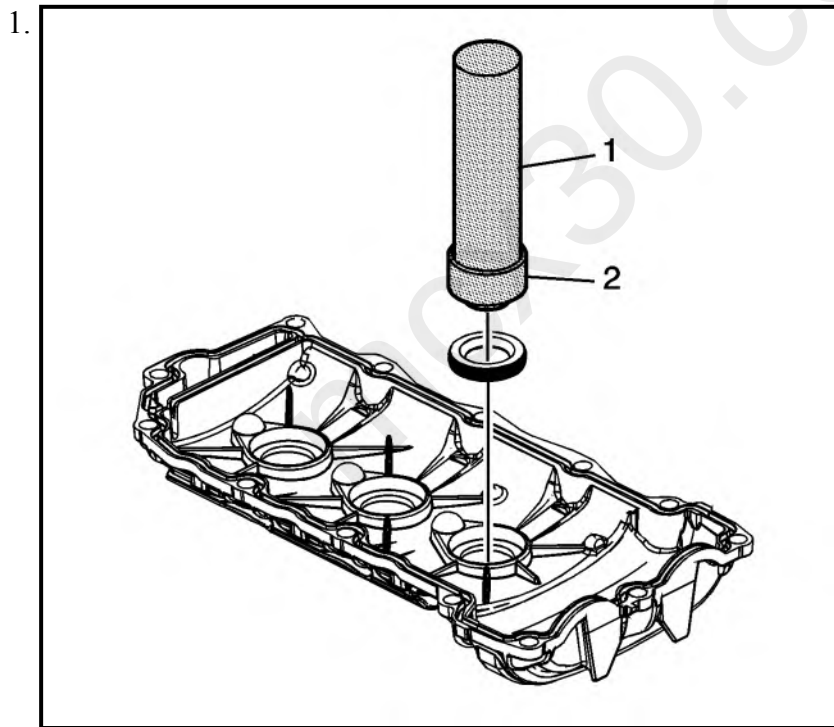




NOTE: The camshaft cover bolt grommet must be installed into the camshaft cover bolt hole before installing the camshaft cover bolt.

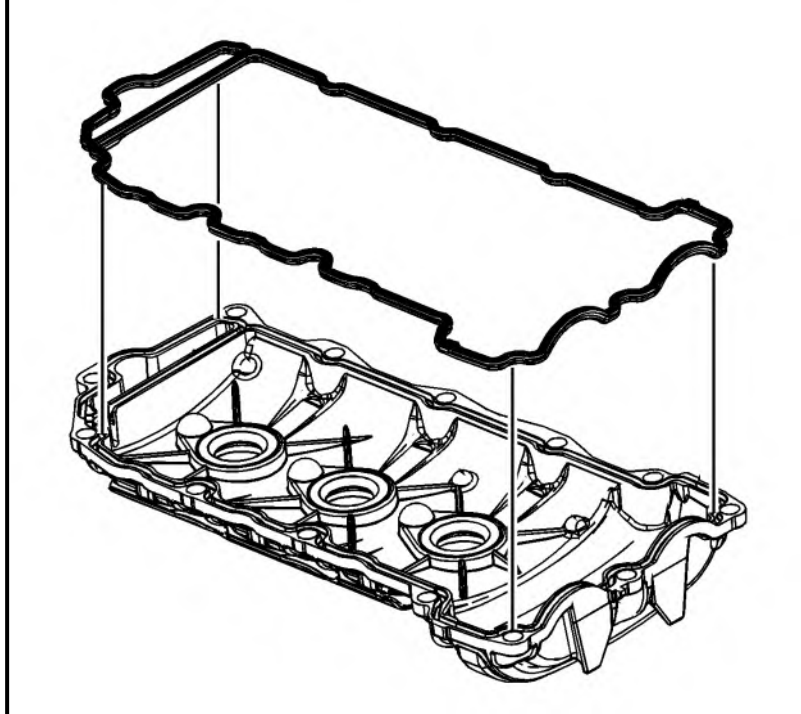
Install the NEW left camshaft cover bolt grommets.

Right Camshaft Cover



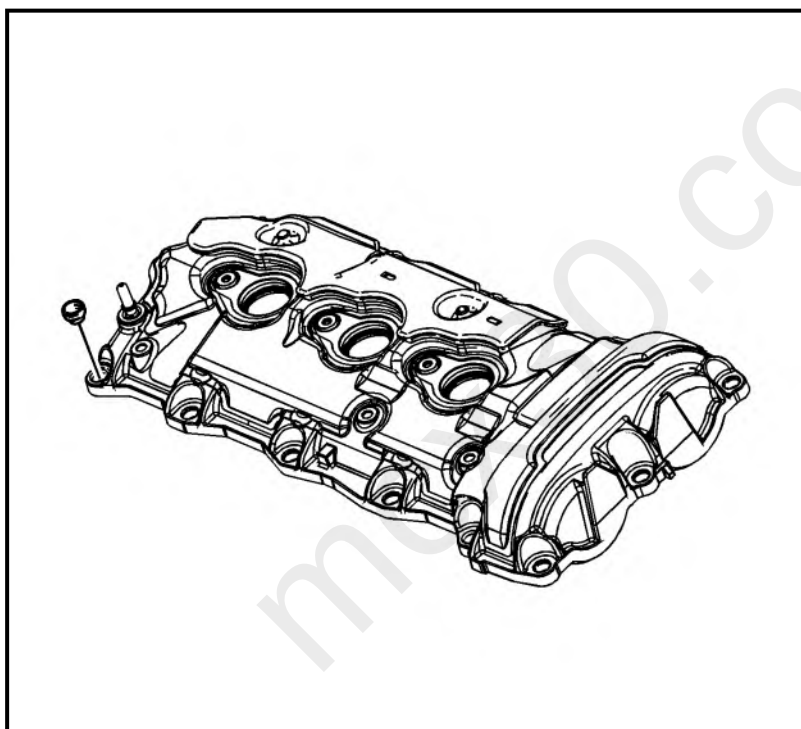
Install the NEW right spark plug shield tube coil seals using the **DT 5590** driver (1) and **J-25254-A** installer (2).





Install the NEW right camshaft cover gasket.

3.



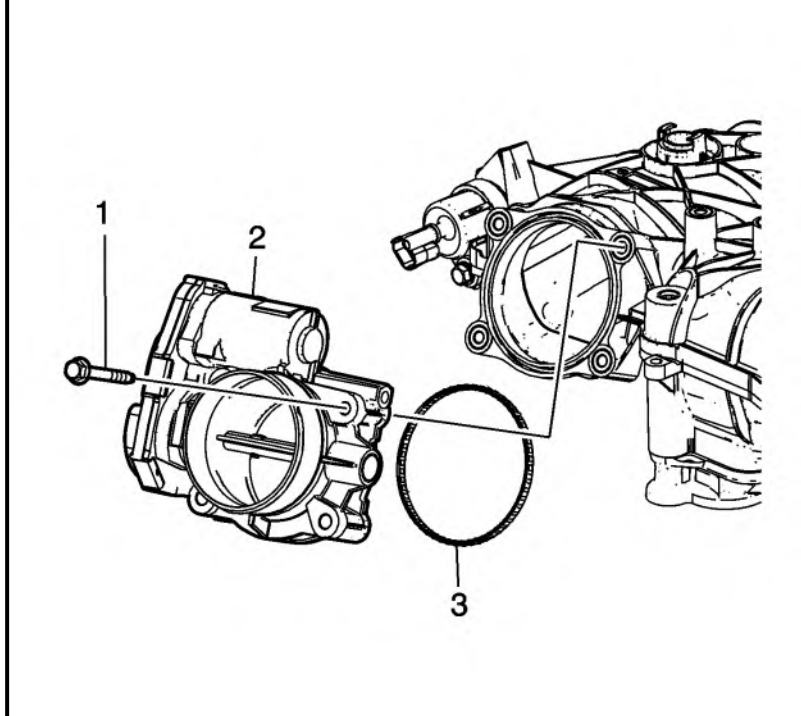
NOTE: The camshaft cover bolt grommet must be installed into the camshaft cover bolt hole before installing the camshaft cover bolt.

Install the NEW right camshaft cover bolt grommets.

INTAKE MANIFOLD DISASSEMBLE

1.

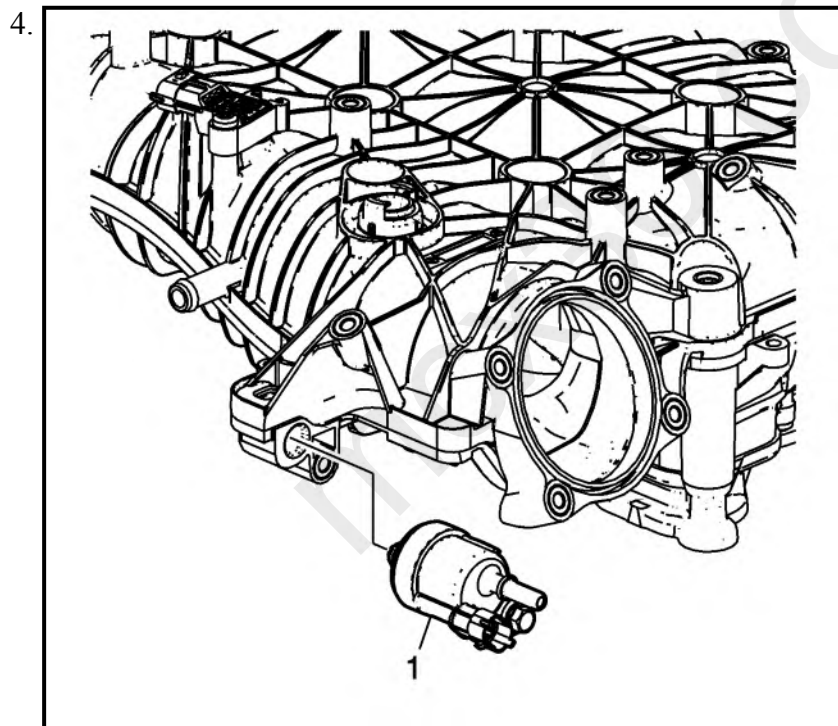




Remove the throttle body bolts (1).

2. Remove the throttle body (2).

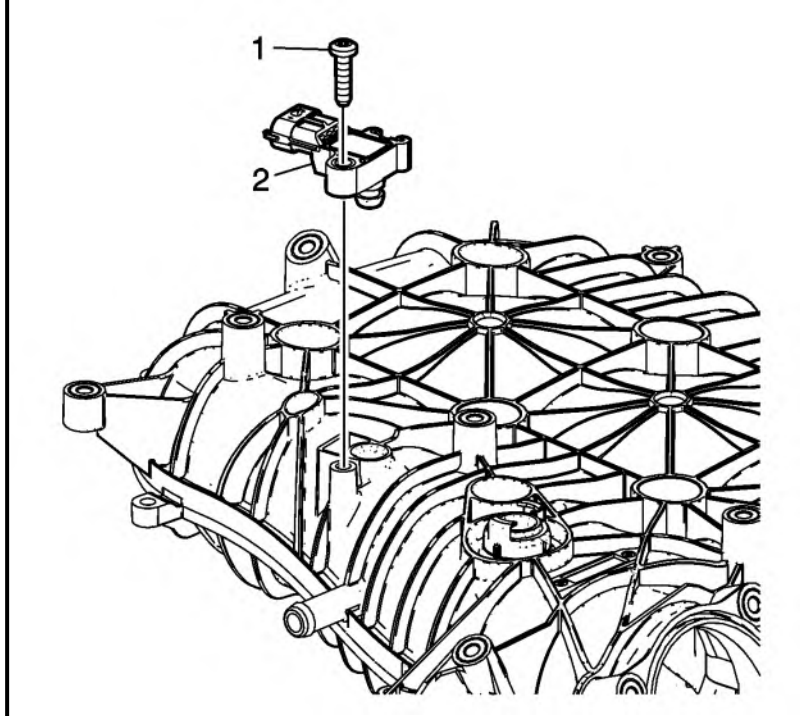
3. Remove and discard the throttle body seal (3).



Loosen the evaporative (EVAP) solenoid bolt.

5. Remove the EVAP solenoid (1).

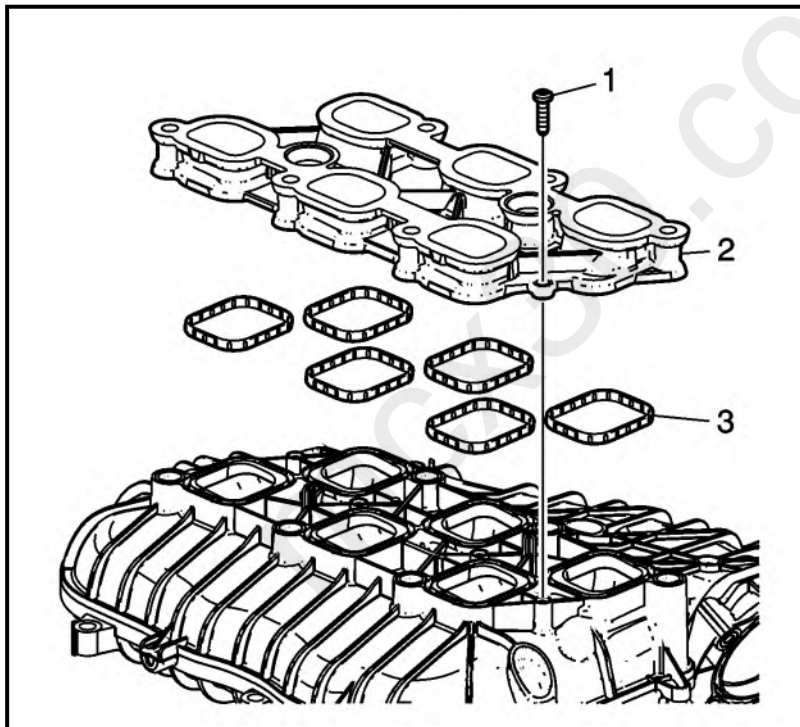




Remove the manifold absolute pressure (MAP) sensor bolt (1).

7. Remove the MAP sensor (2).

8.

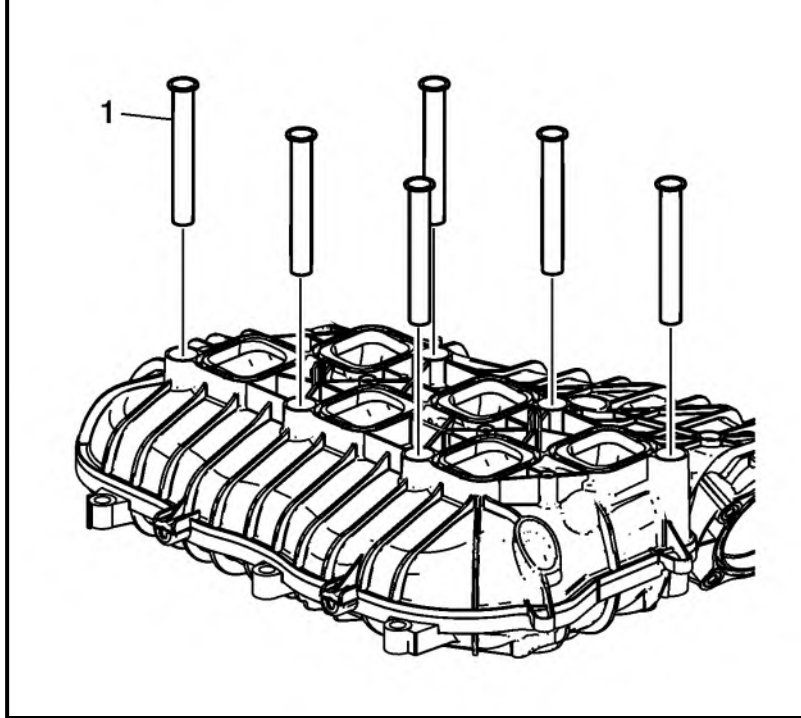


Remove the lower intake manifold bolts (1) and lower intake manifold (2).

9. Remove and discard the lower intake manifold gaskets (3).

10.





Remove and discard the plastic compression limiters (1).

INTAKE MANIFOLD CLEANING AND INSPECTION

Intake Manifold Cleaning Procedure

1. Remove any remaining gasket and/or gasket material from the following:
 - Throttle body
 - Intake manifold
2. Clean the following intake manifold areas in solvent.
 - Intake manifold gasket sealing areas
 - Intake manifold passages
 - Brake booster hose passage
 - Evaporative emission (EVAP) solenoid passage
 - Positive crankcase ventilation (PCV) vacuum hose passages

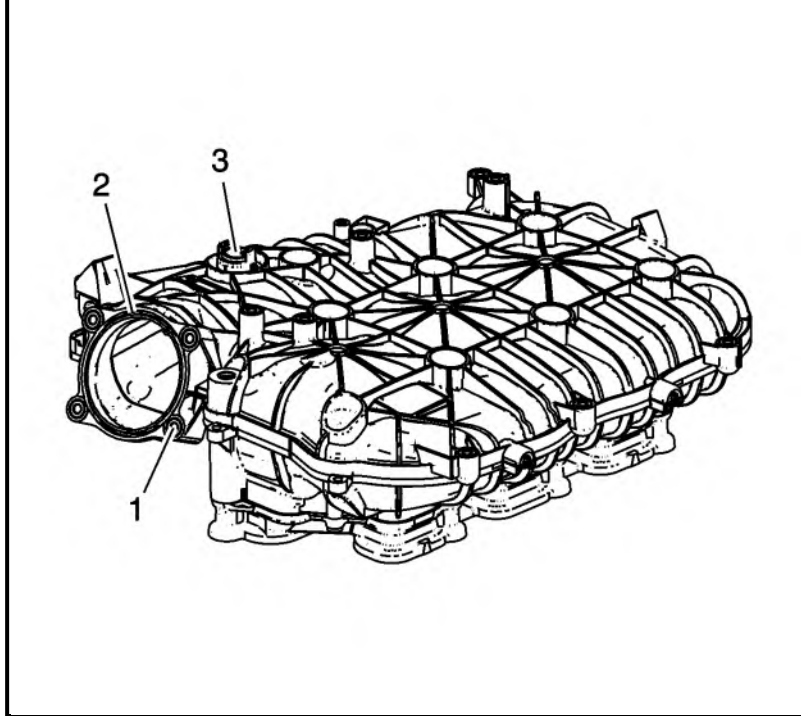
WARNING: Refer to [Safety Glasses Warning](#) .

3. Dry the intake manifold and throttle body with compressed air.

Inspection Procedure

1.

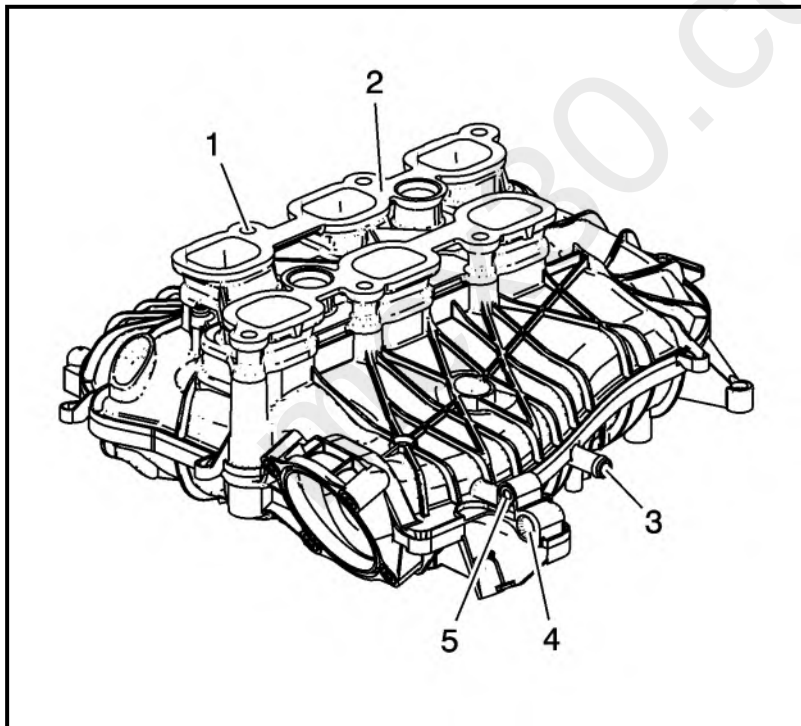




Inspect the intake manifold for the following conditions:

- Damage to the throttle body bolt holes (1)
- Damage, debris or restrictions to the PCV system hose ports (3)
- Damage to the gasket sealing surface for the throttle body (2)

2.

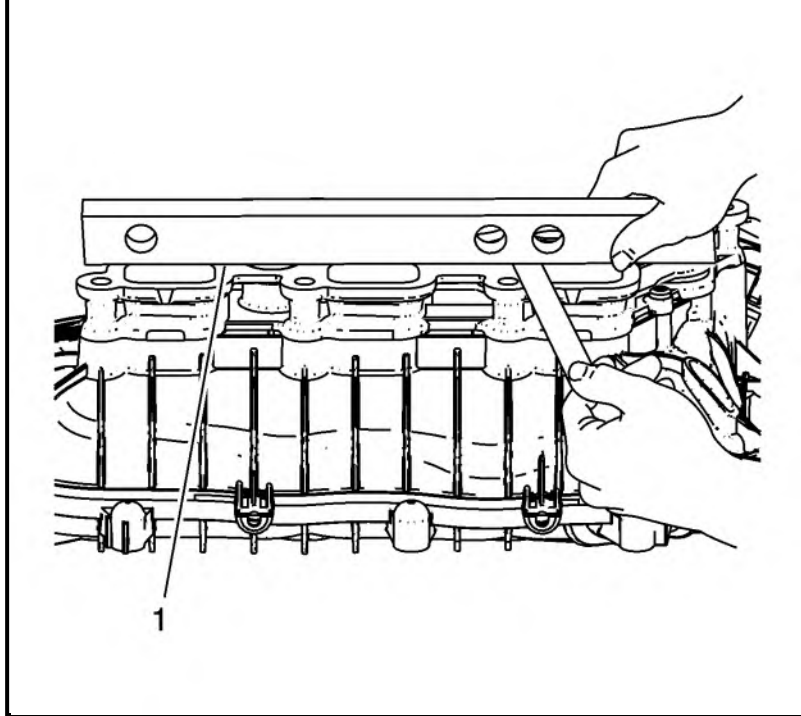


Inspect the intake manifold for the following conditions:

- Damage, debris or restrictions to the brake vacuum booster hose port (3)
- Damage to the intake manifold bolt bosses (1)
- Damage to the EVAP purge solenoid mounting boss (5)
- Damage, debris or restrictions to the EVAP purge solenoid port (4)
- Gouges or damage to the intake manifold sealing surfaces (2)

3.

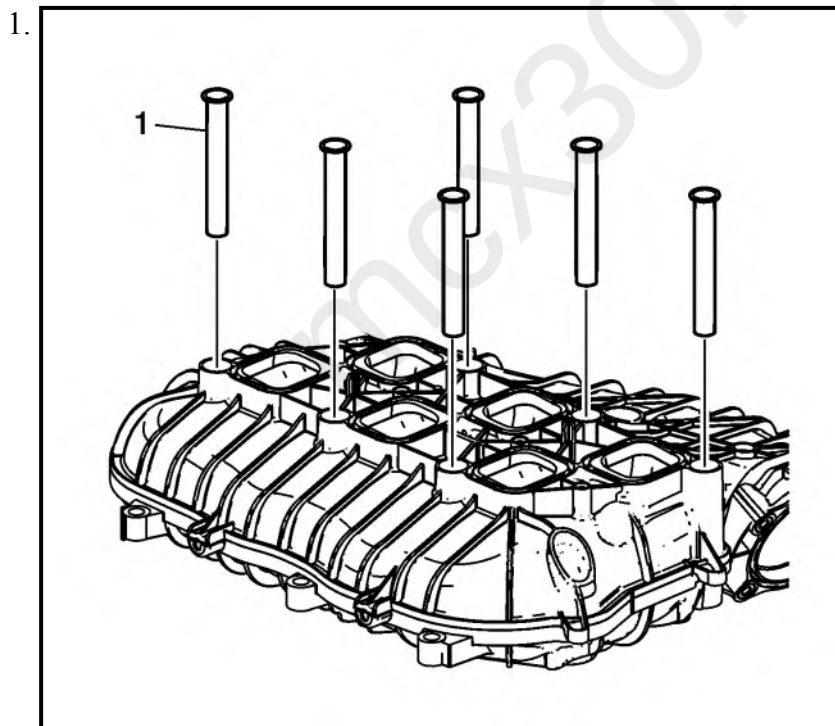




Inspect the intake manifold sealing surface (1) for warpage.

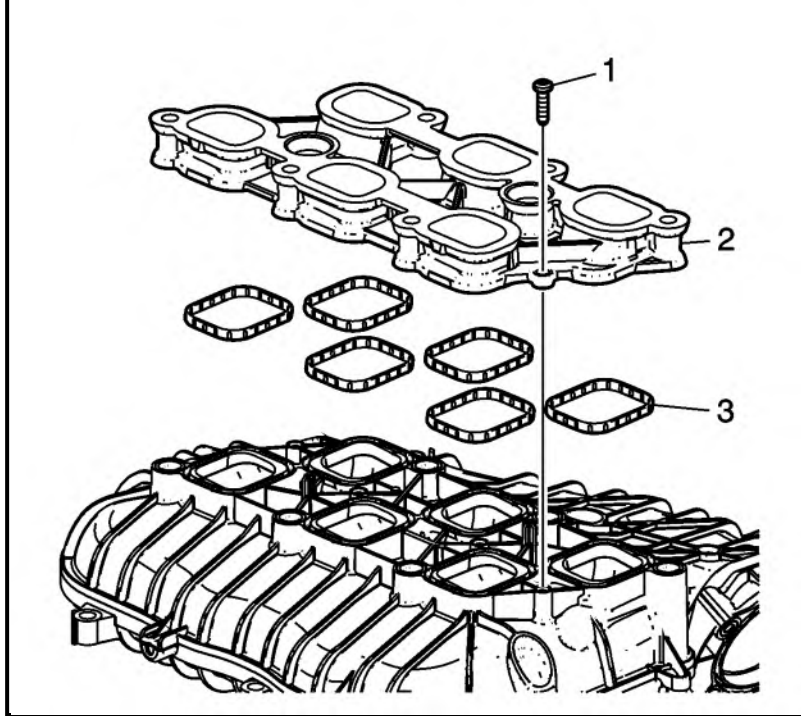
1. Locate a straight edge across the intake manifold sealing surface.
2. Insert a feeler gauge between the intake manifold and the straight edge. An intake manifold with warpage in excess of 0.50 mm (0.020 in) must be replaced.
4. Repair or replace the intake manifold as necessary.

INTAKE MANIFOLD ASSEMBLE



Install the NEW plastic compression limiters (1).





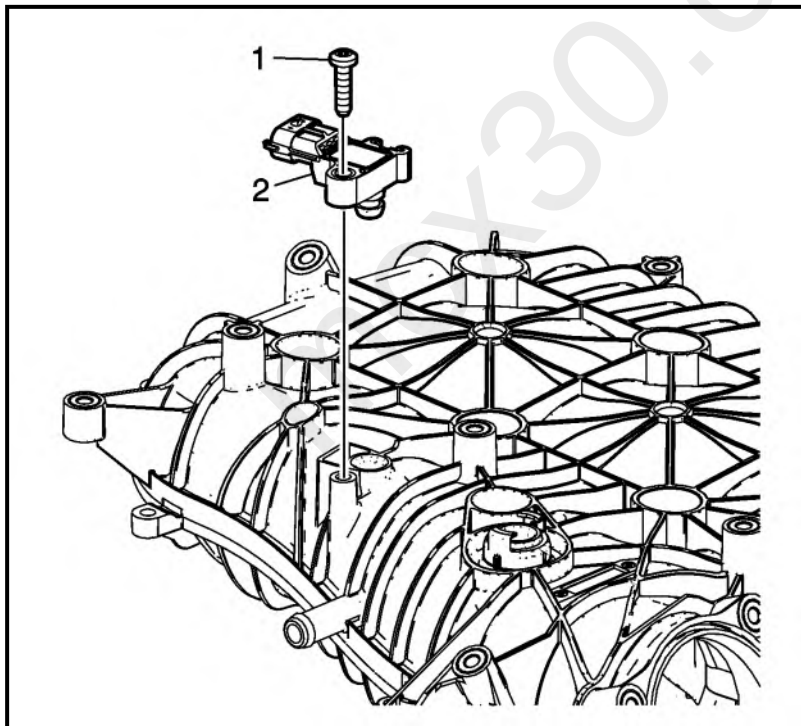
Install the NEW lower intake manifold gaskets (3).

3. Install the lower intake manifold (2) and bolts (1).

CAUTION: Refer to [Fastener Caution](#) .

4. Tighten the lower intake manifold bolts (1) to 7 N.m (62 lb in).

5.

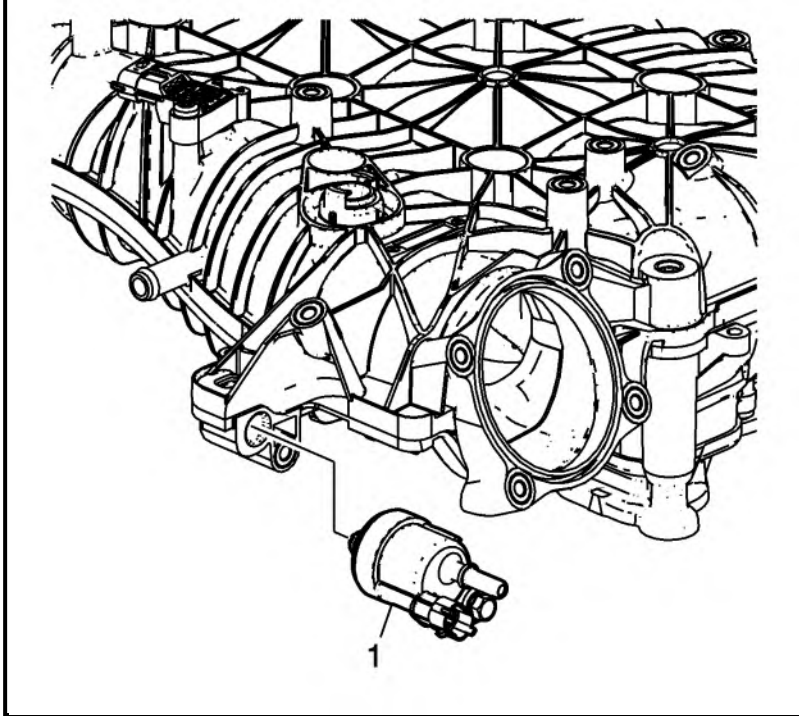


Install the MAP sensor (2).

6. Install the MAP sensor bolt (1) and tighten to 4 N.m (35 lb in).

7.

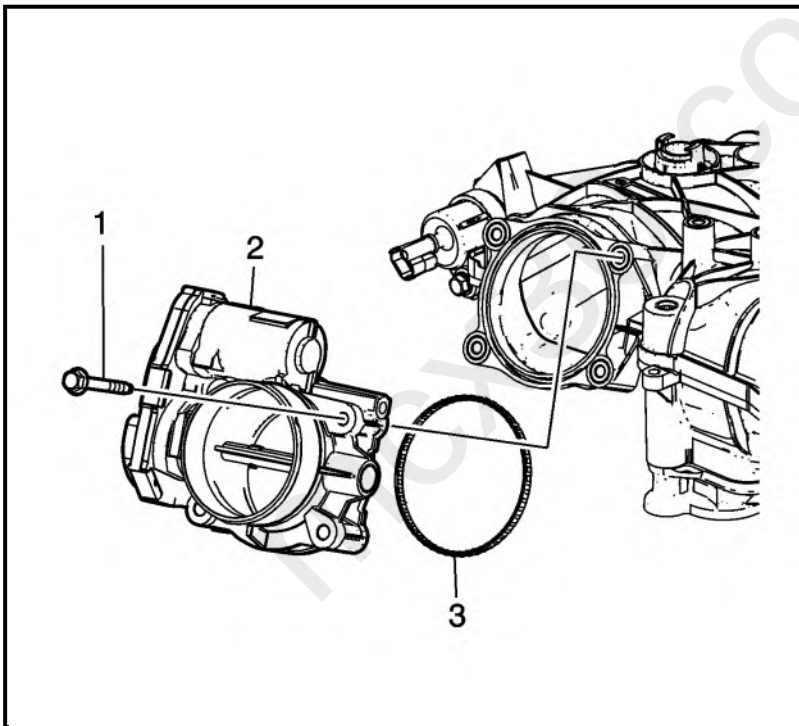




Install the EVAP solenoid (1).

8. Tighten the EVAP solenoid bolt to 10 N.m (89 lb in).

9.



Install the NEW throttle body seal (3).

10. Install the throttle body (2).

11. Install the throttle body bolts (1) and tighten to 10 N.m (89 lb in).

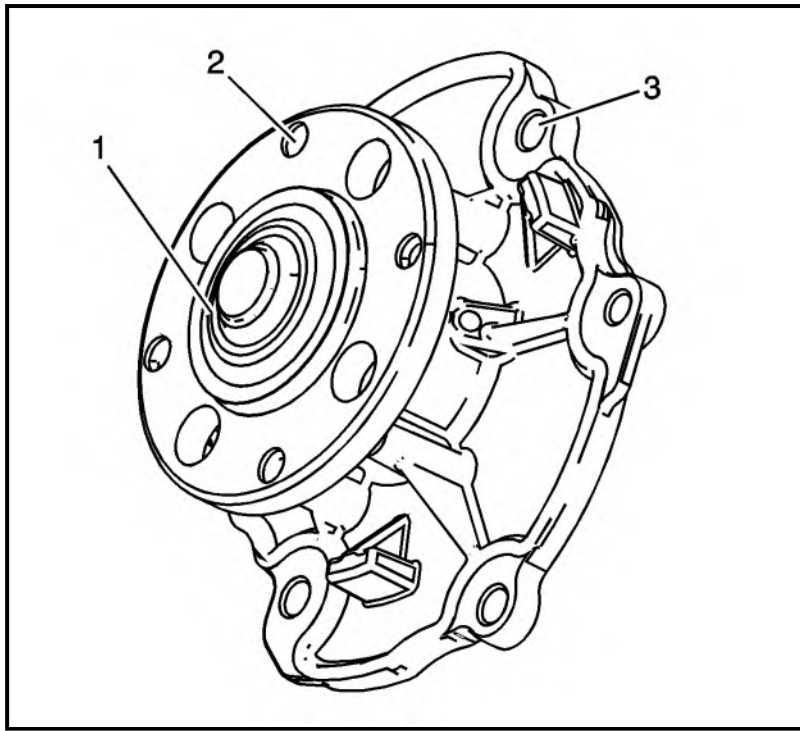
WATER PUMP CLEANING AND INSPECTION

Cleaning Procedure

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

1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all excess dirt and debris from the water pump housing.

1.

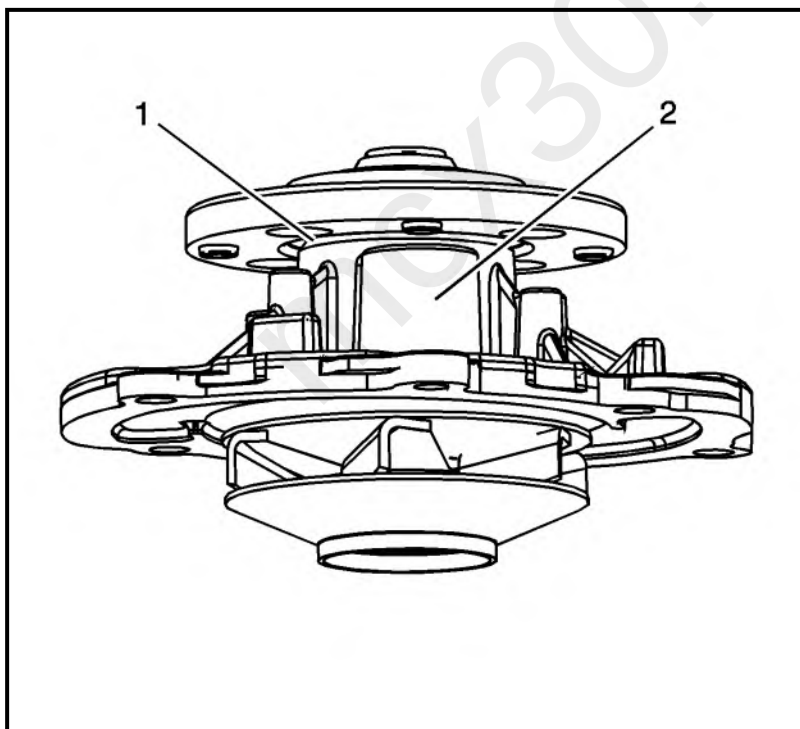


Rotate the water pump hub (1). The water pump hub and impeller should turn straight and smoothly. If the hub wobbles, is noisy, or feels rough when rotated, replace the water pump.

2. Inspect the exterior of the water pump for the following:

- Damage to the water pump hub bolt threads (2) for the water pump pulley
- Damage to the water pump bolt holes (3)

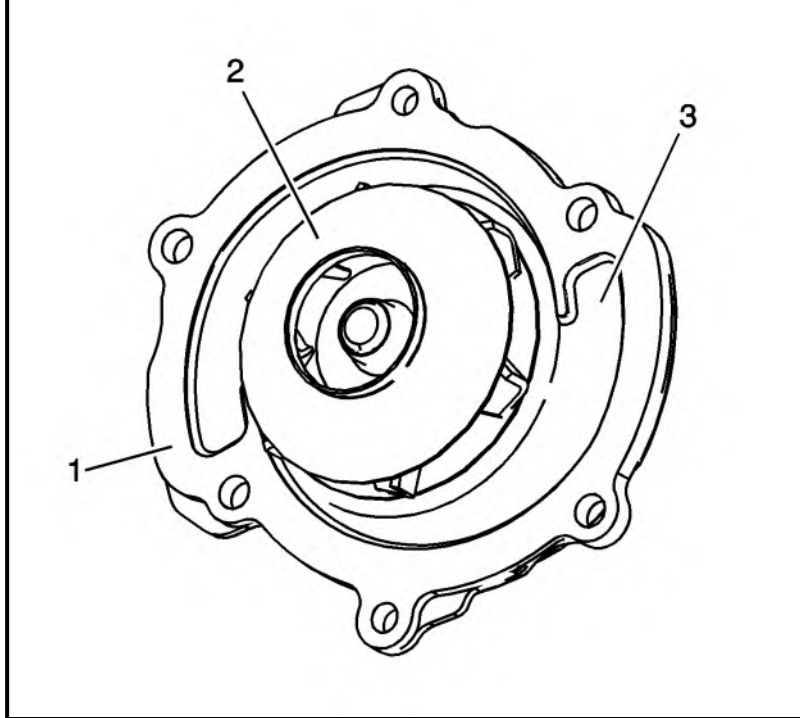
3.



Examine the water pump shaft (1) and the weep hole reservoir (2) in the water pump body for signs of leakage. If coolant leakage is evident, replace the water pump.

4.





Inspect the interior of the water pump for the following:

- Damage to the water pump gasket sealing surface (1)
- Damage, corrosion or restrictions to the water pump impeller (2)
- Damage, corrosion or restrictions to the coolant passages (3)

5. Repair or replace the water pump as necessary.

THREAD REPAIR

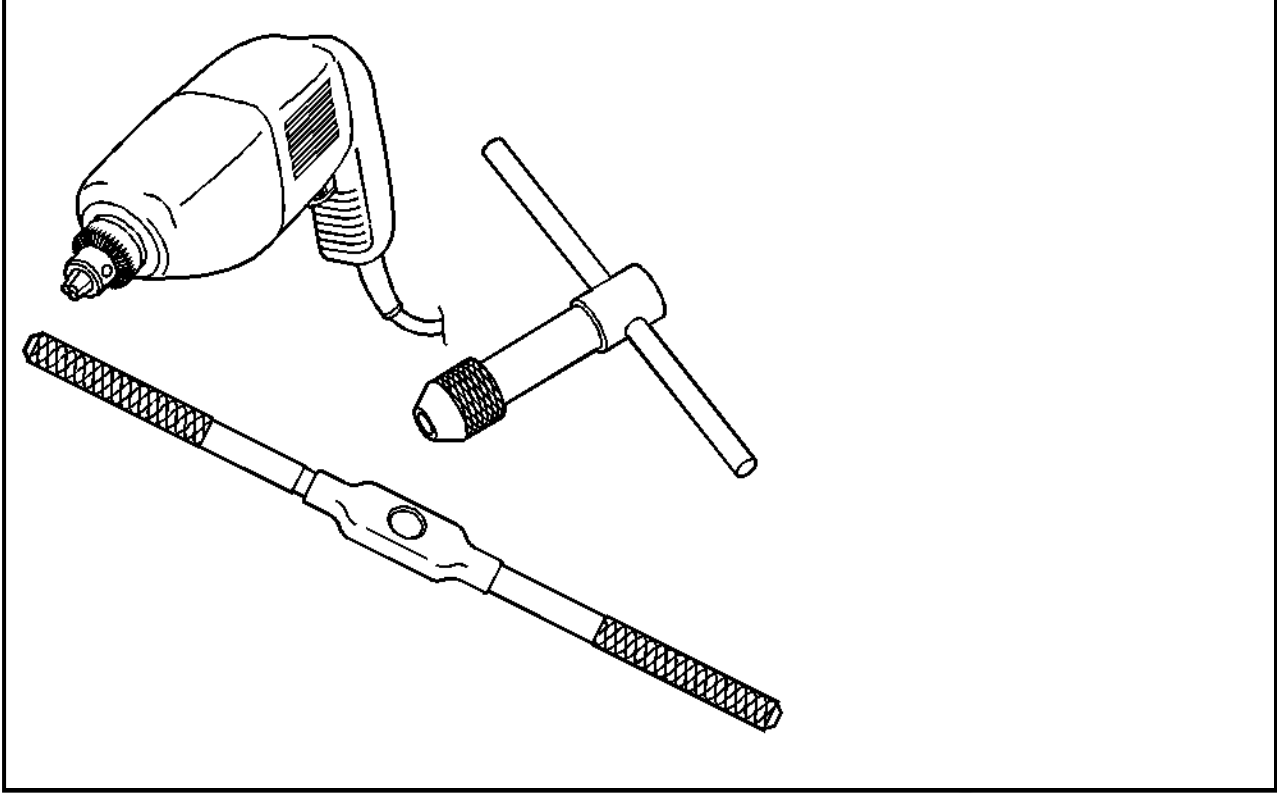
Special Tools

- **EN 42385-700** High Feature Thread Repair Kit
- **EN 42385-2000** Thread Insert Kit
- **EN 43965** Thread Repair Extension Kit

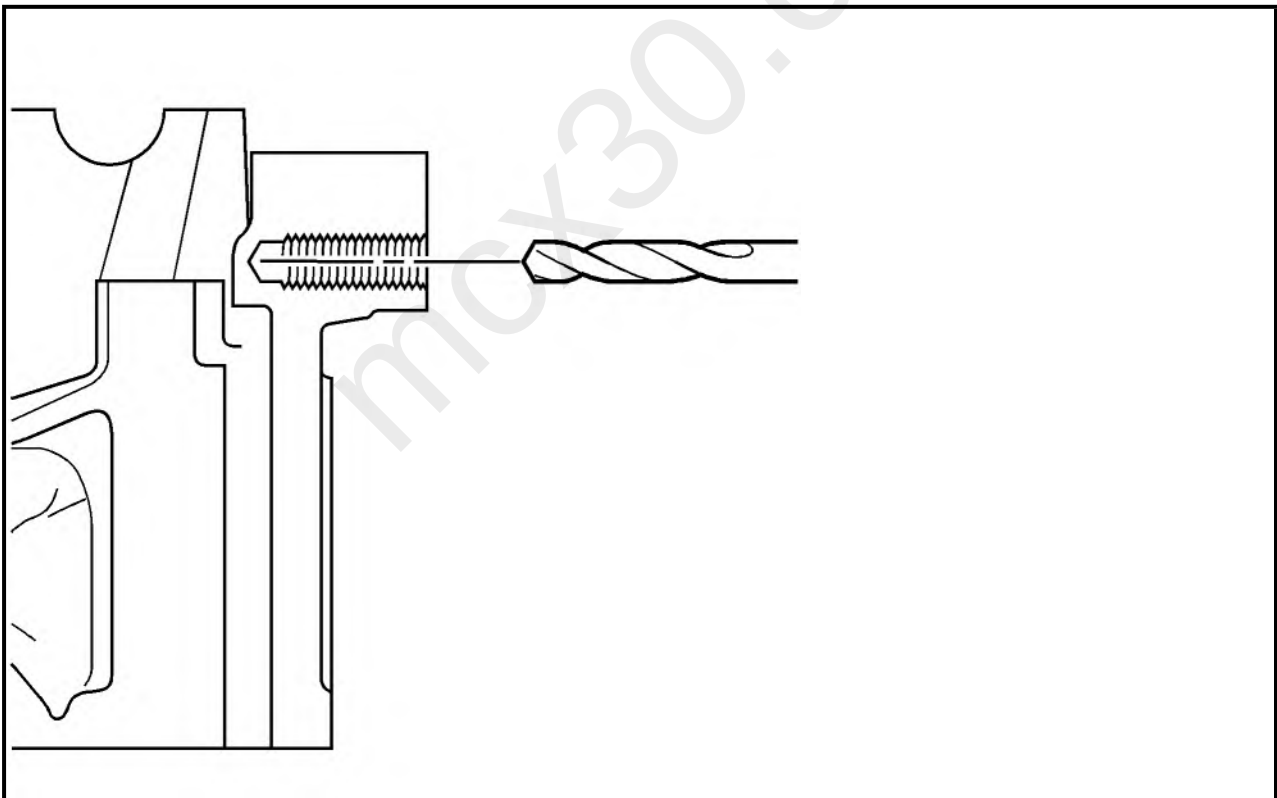
For equivalent regional tools, refer to [**Special Tools**](#) .

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert. During the insert installation process, the installation driver tool cold-rolls the bottom internal threads and expands the bottom external threads of the insert into the base material. This action mechanically locks the insert into place.



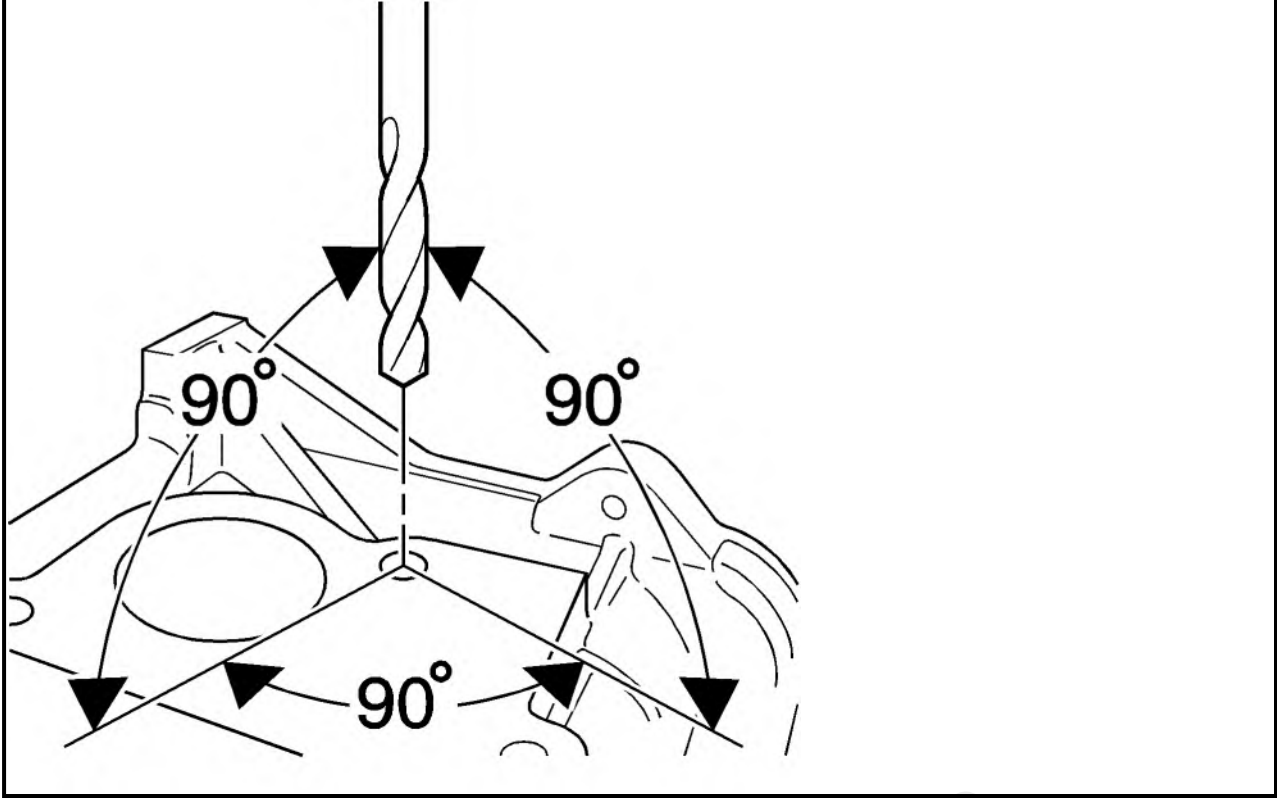


The drill bit and counter bore tool from the tool kit **EN 42385-700** kit and **EN 42385-2000** insert kit is designed for use with either a suitable tap wrench or drill motor. Limited access and larger hole repair may process better using a tap wrench. An extension from kit **EN 43965** extension kit may also be necessary to drive the thread repair tooling dependent on access to the hole being repaired. Use only a tap wrench when tapping the hole and during installation of the insert.

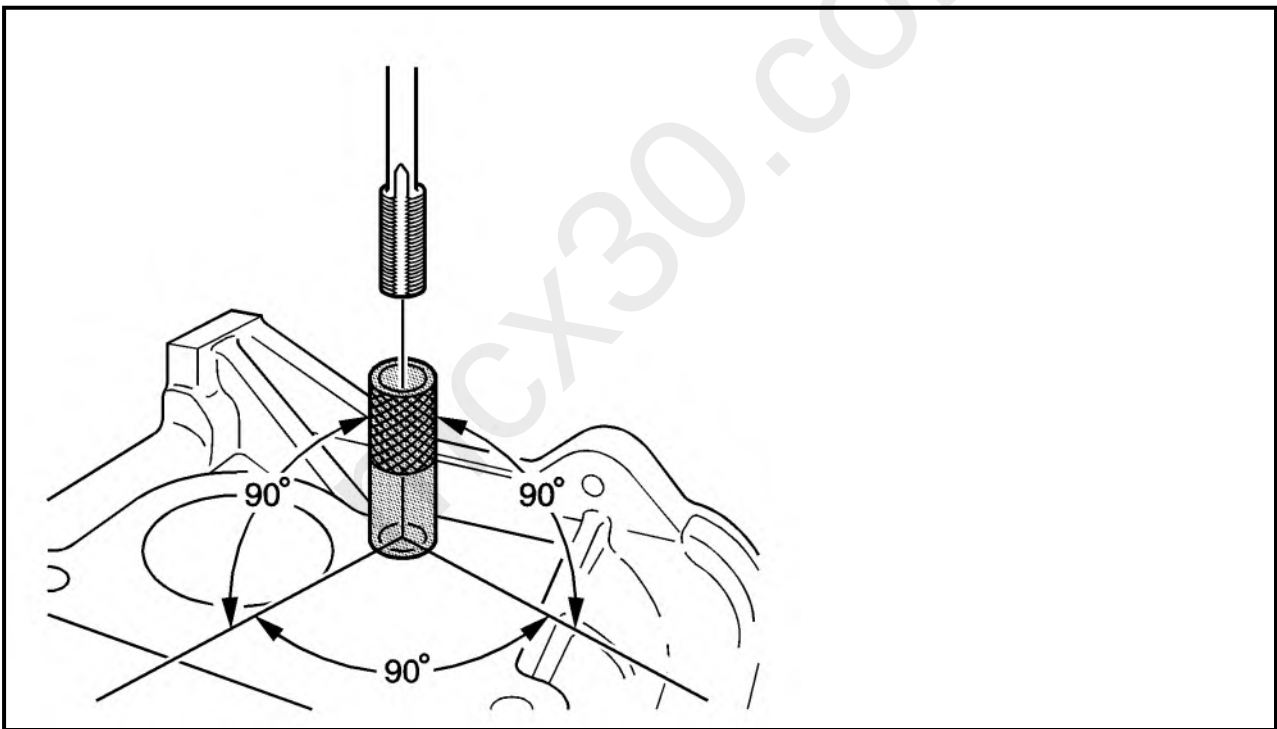


It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.





During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.

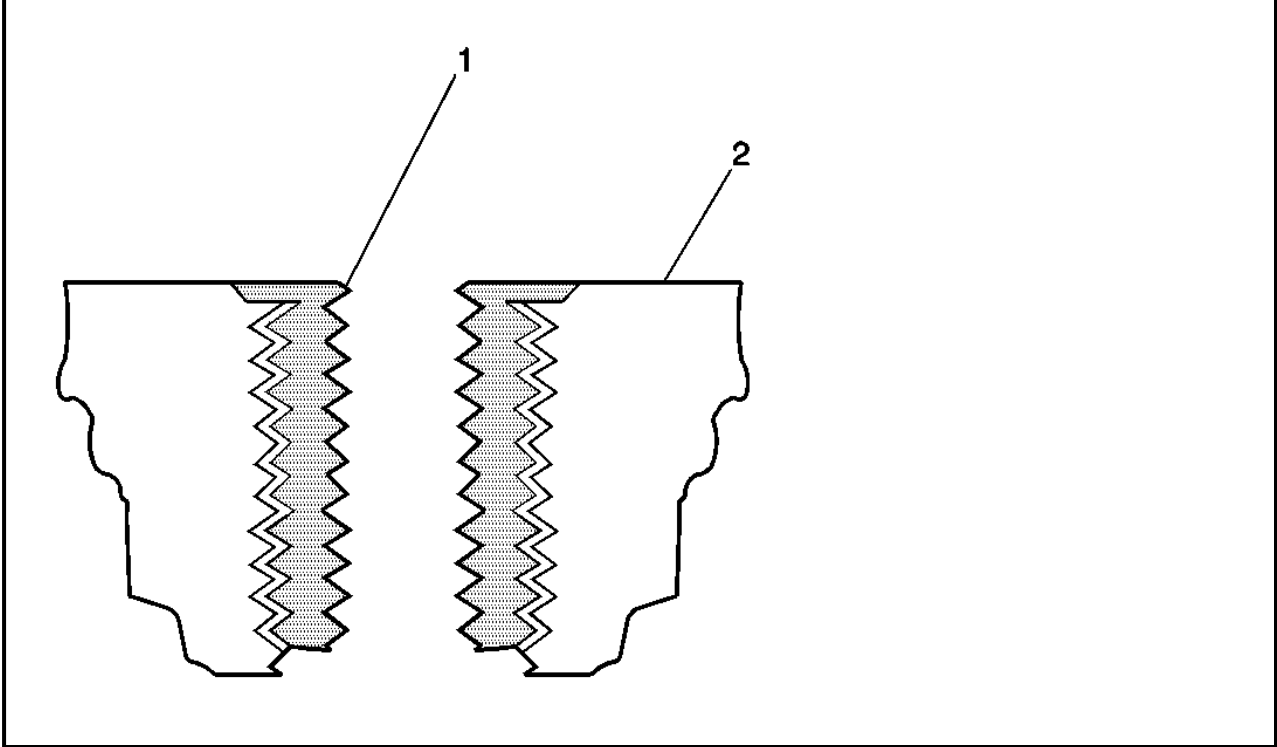


If the threaded hole being repaired has a base surface perpendicular to the hole centerline, tapping guides are available to aid in tapping the hole.

Tap Size	Tap Guide	Tap Size	Tap Guide	Tap Size	Tap Guide
-	EN 42385-	-	EN 42385-	-	EN 42385-
6 x 1.0	729	10 x 1.5	731	14 x 1.5	736
8 x 1.25	730	12 x 1.5	732	20 x 1.5	737

Standard Thread Repair - Flush Hole

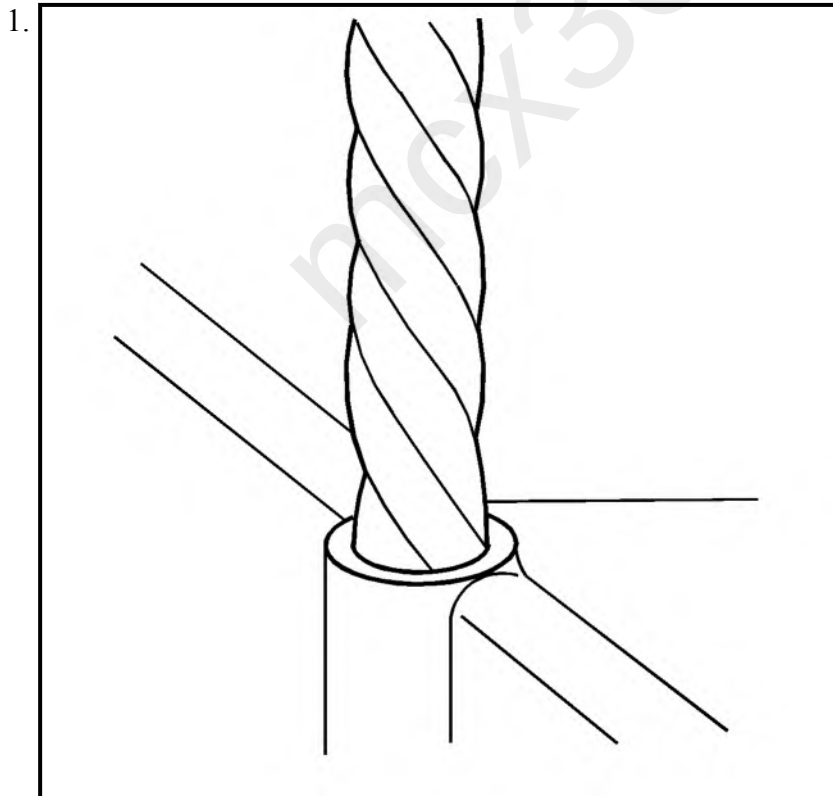




WARNING: Refer to [Safety Glasses Warning](#) .

NOTE: The use of a cutting type fluid is recommended when performing the drilling, counterboring and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cutting fluid.

When installed to the proper depth, the flange (1) of the insert will be seated against the counterbore of the drilled/tapped hole and just below the surface (2) of the base material.



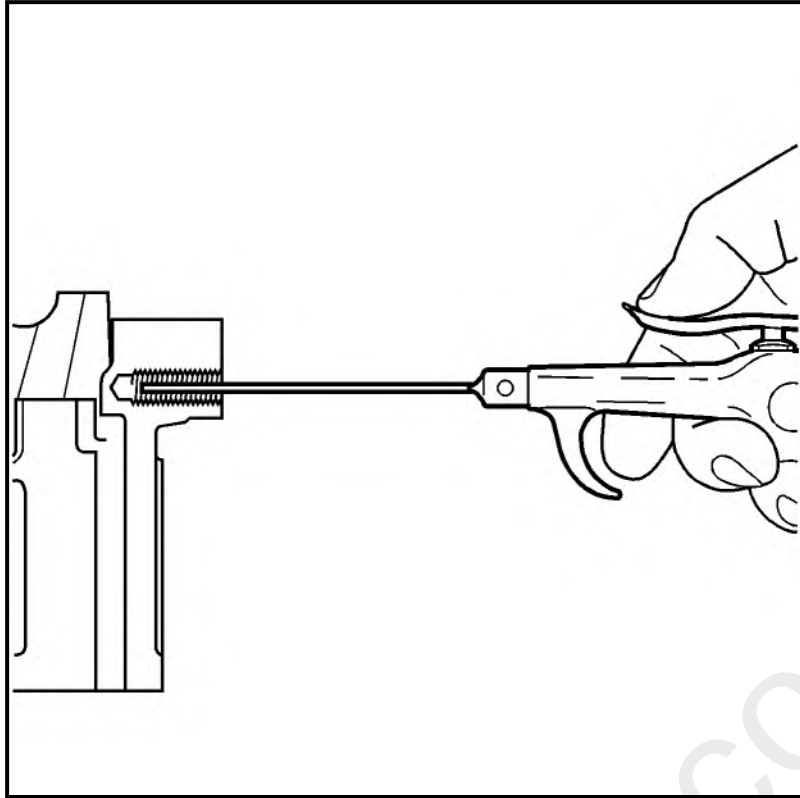
- NOTE:**
- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
 - Do NOT drill any further than the original hole depth.

Drill out the threads of the damaged hole.

Specifications

- 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).

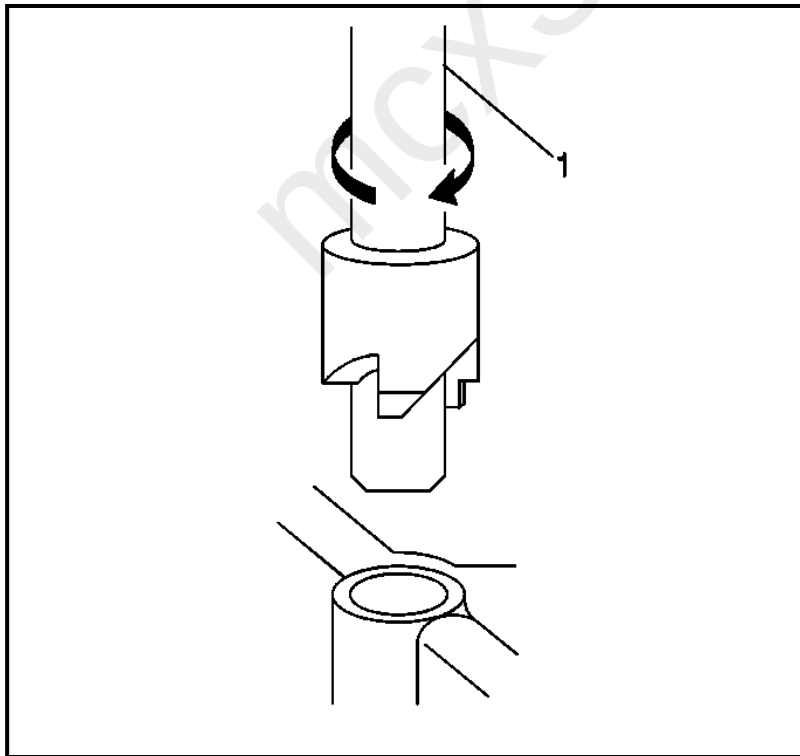
2.



NOTE: All chips must be removed from the drilled hole prior to tapping.

Using compressed air, clean out any chips.

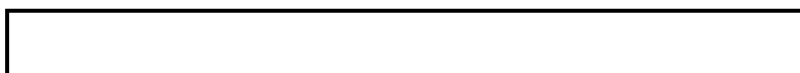
3.

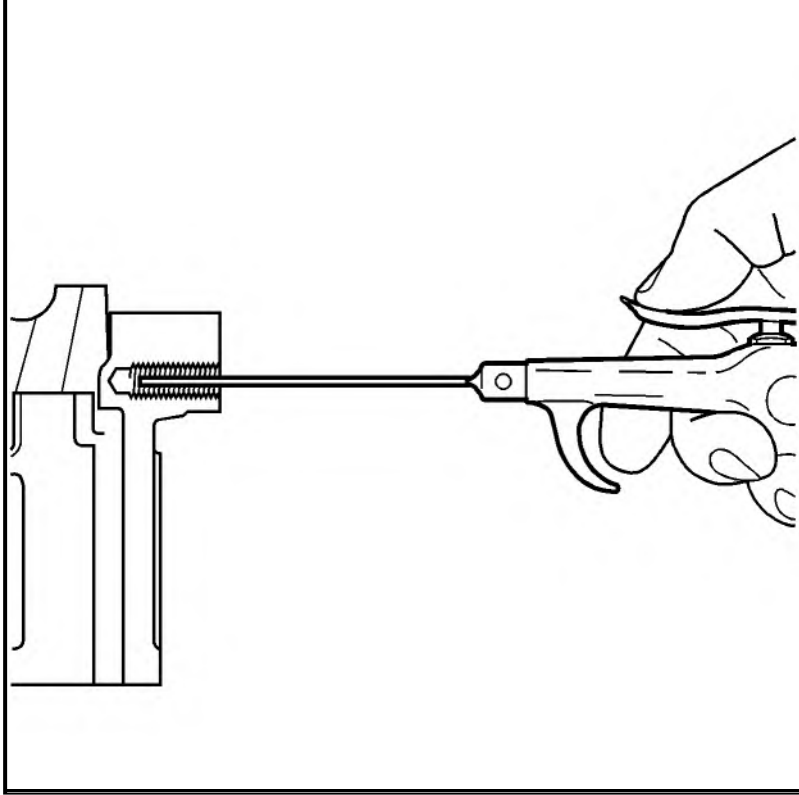


NOTE: A properly counterbored hole will show a slight burnishing on the surface of the base material for 360 degrees around the drilled hole.

Counterbore the drilled hole to the full depth permitted by the tool (1).

4.

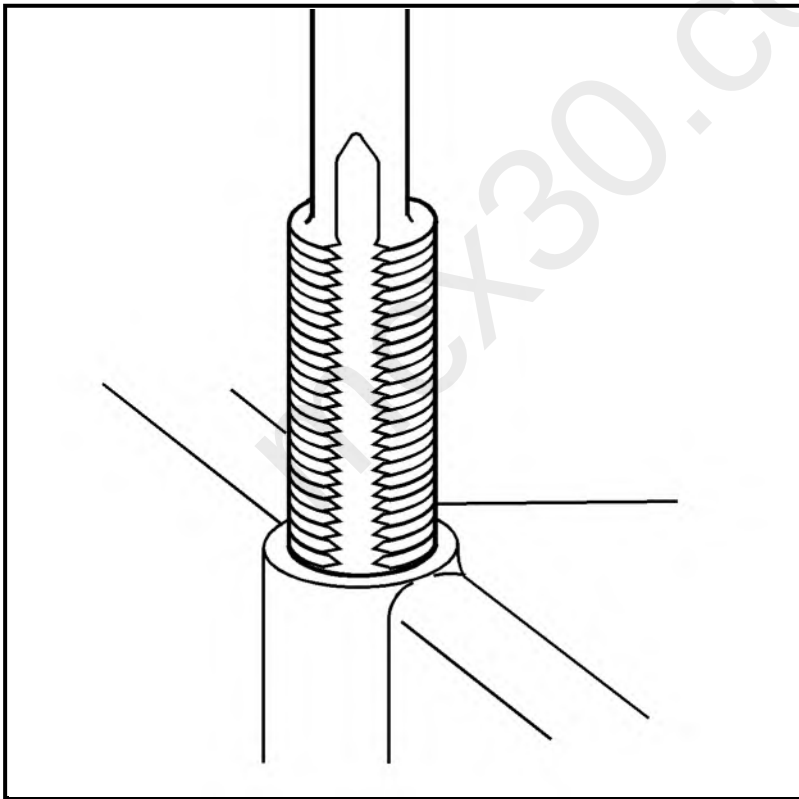




NOTE: All chips must be removed from the drilled hole prior to tapping.

Using compressed air, clean out any chips.

5.



NOTE:

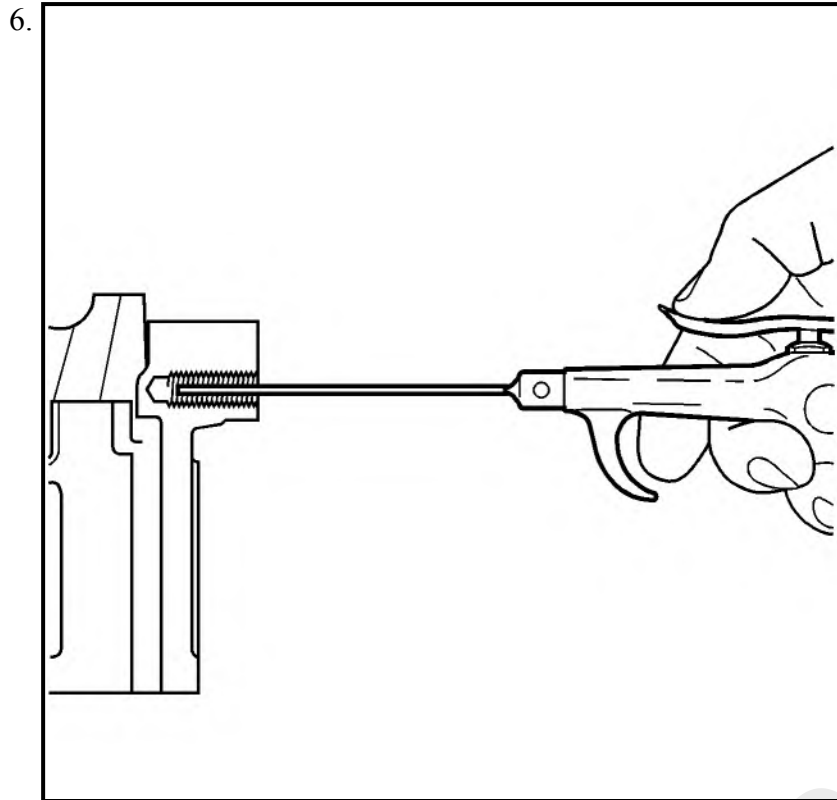
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.

Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

Specifications

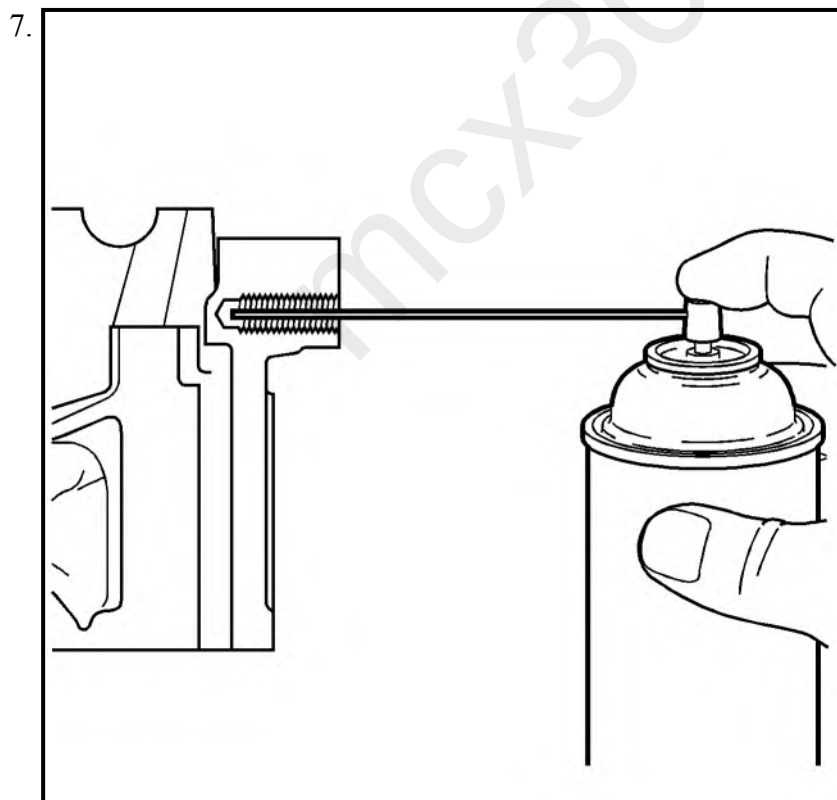
- M6 inserts require a minimum tap depth of 15 mm (0.59 in).

- 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).

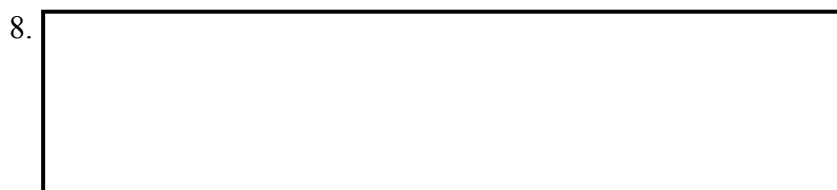


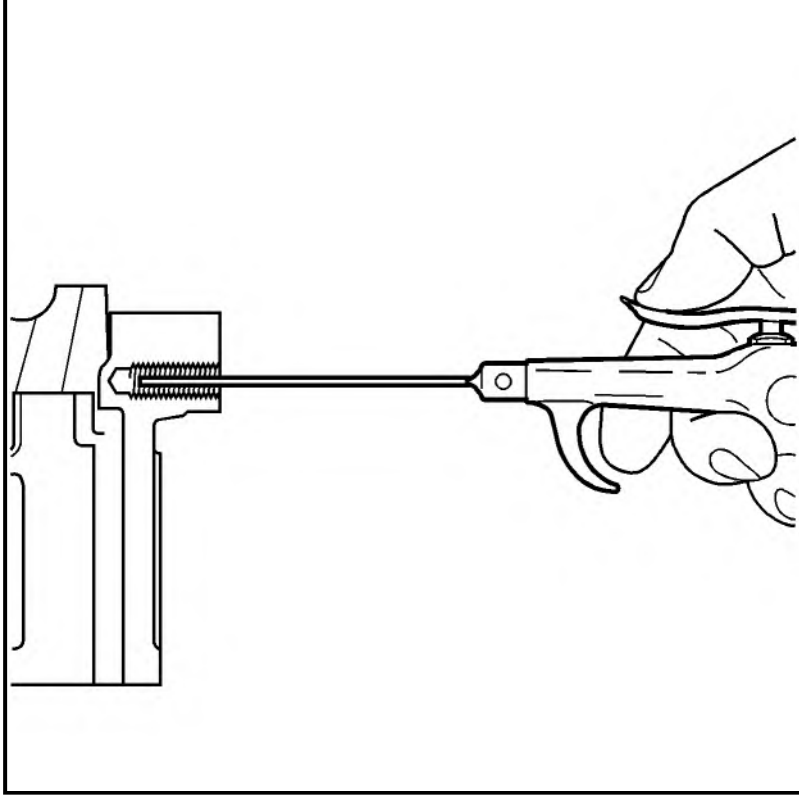
NOTE: All chips must be removed from the tapped hole prior to insert installation.

Using compressed air, clean out any chips.



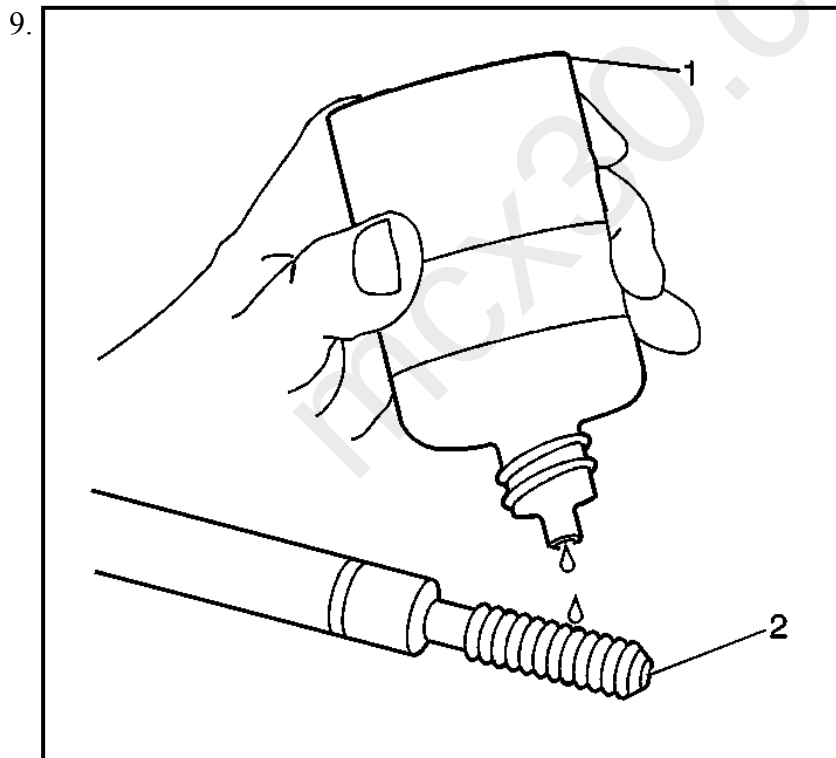
Spray cleaner into the tapped hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cleaner.





NOTE: All chips must be removed from the tapped hole prior to insert installation.

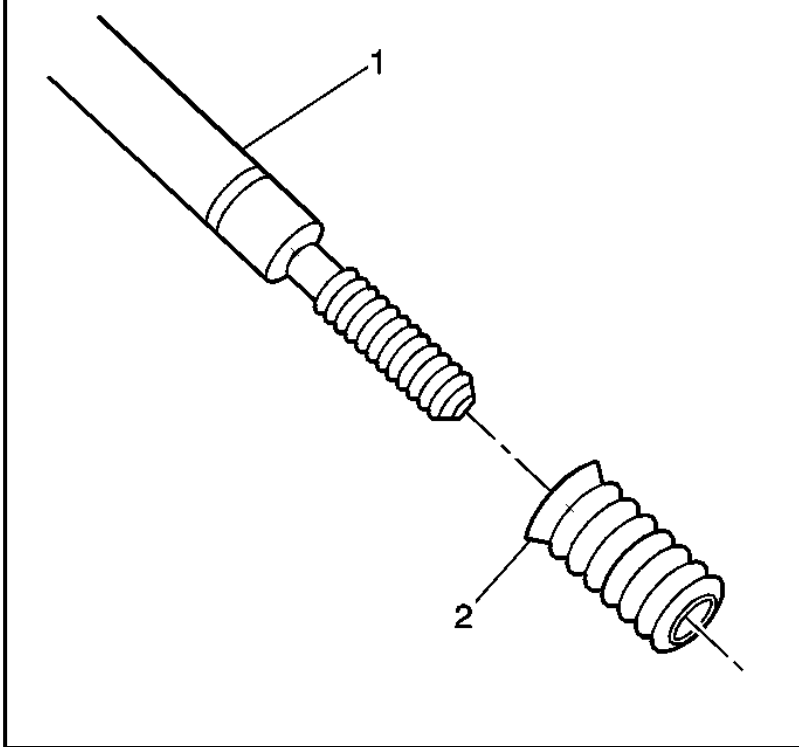
Using compressed air, clean out any chips.



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

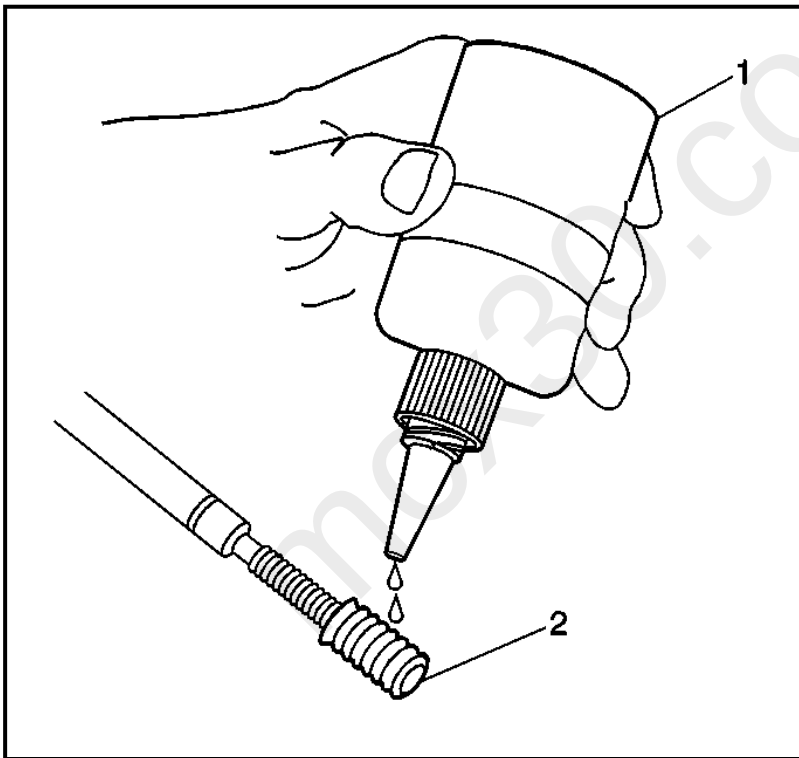
Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1).





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

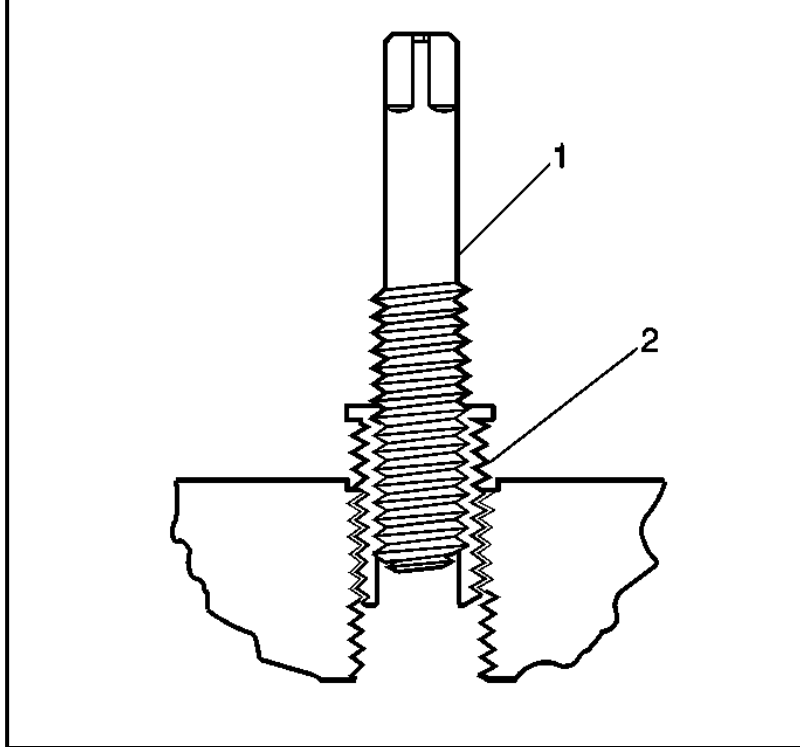
11.



Apply threadlock sealant, EN 42385-109, LOCTITE 277^Å,^Å® or equivalent (1) to the insert OD threads (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

12.



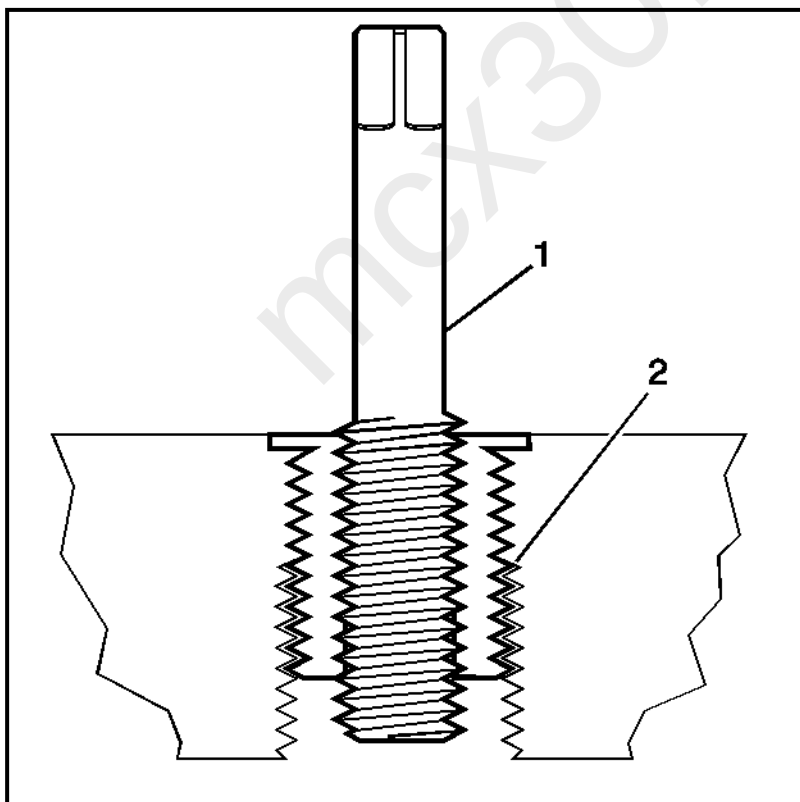


Install the insert (2) into the tapped hole by hand only.

NOTE: If the insert will not thread down until the flange contacts the counterbored surface, remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

13. Install the insert until the flange (2) of the insert contacts the counterbored surface.

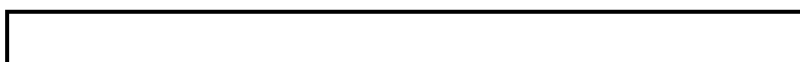
14.

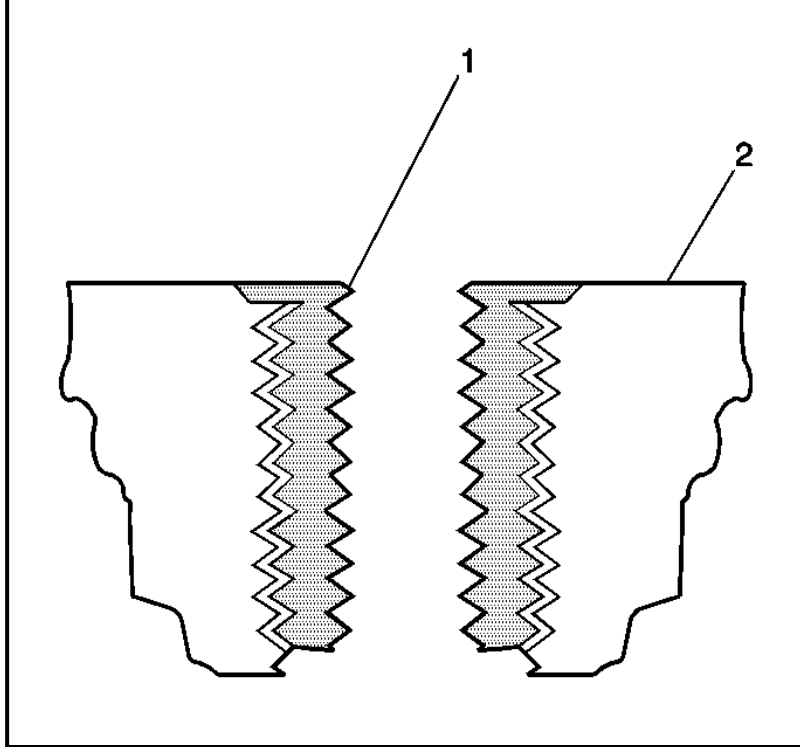


NOTE: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

Continue to rotate the driver installation tool (1) through the insert (2).

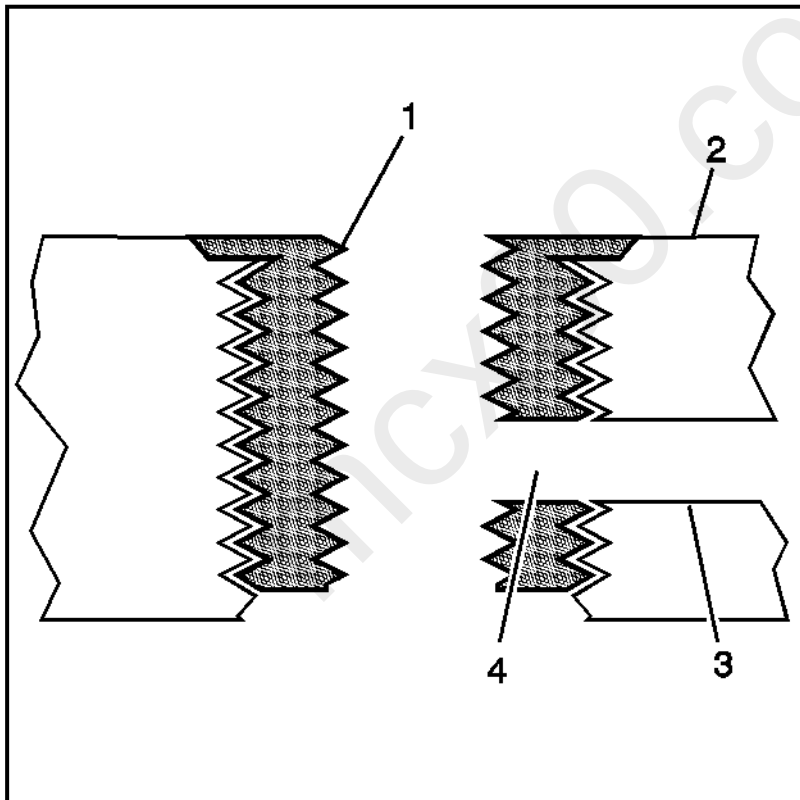
15.





Inspect the insert for proper installation into the tapped hole. A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

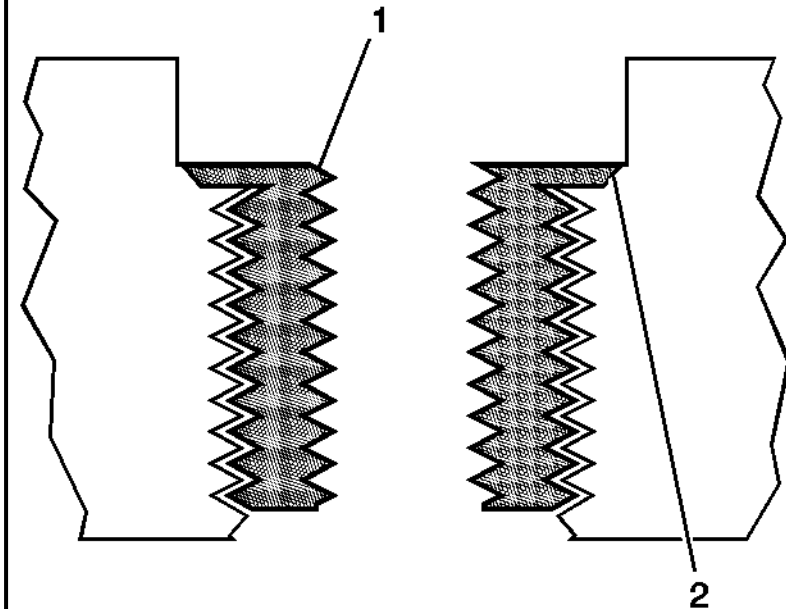
16.



Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

Recessed Thread Repair



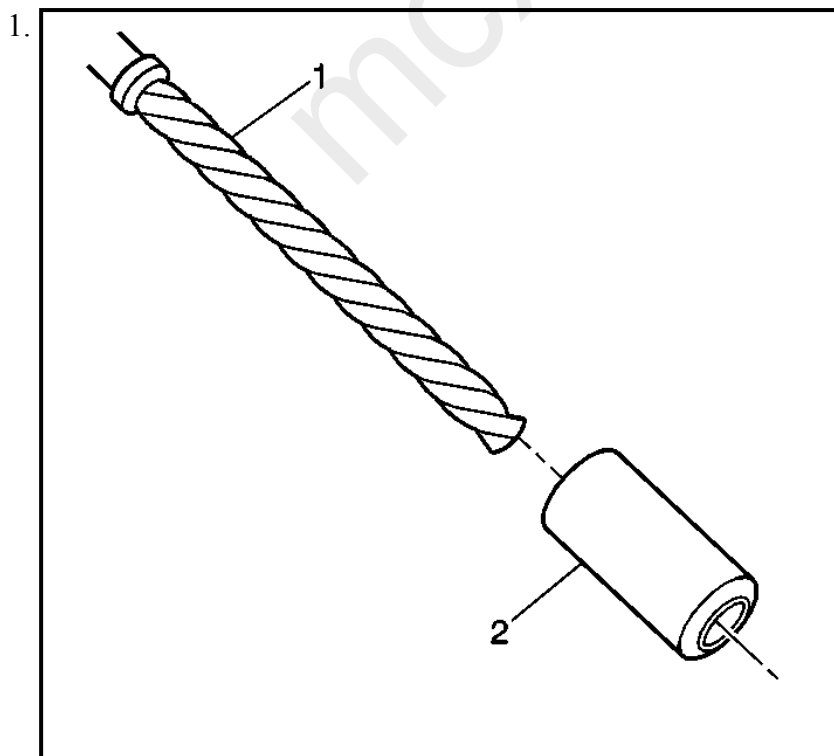


WARNING: Refer to [Safety Glasses Warning](#) .

NOTE:

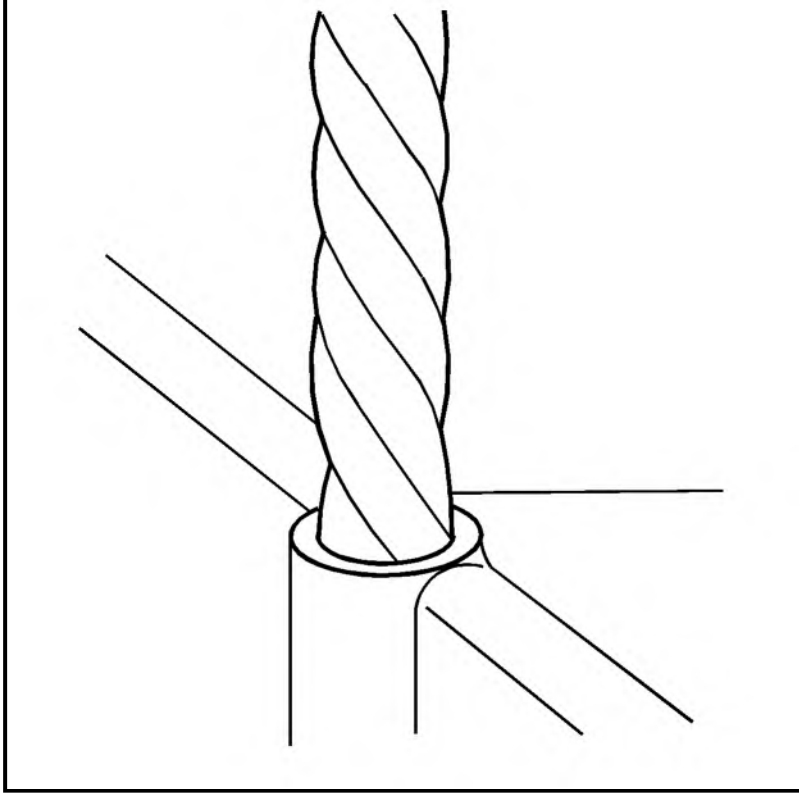
- The use of a cutting type fluid, WD 40[®] or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cutting fluid.
- Do NOT remove the original stop collar from a counterbore drill.

When installed to the proper depth, the flange of the insert (1) will be seated against the counterbore (2) of the drilled/tapped hole.



Install a stop collar (2) on the counterbore drill (1), if required.



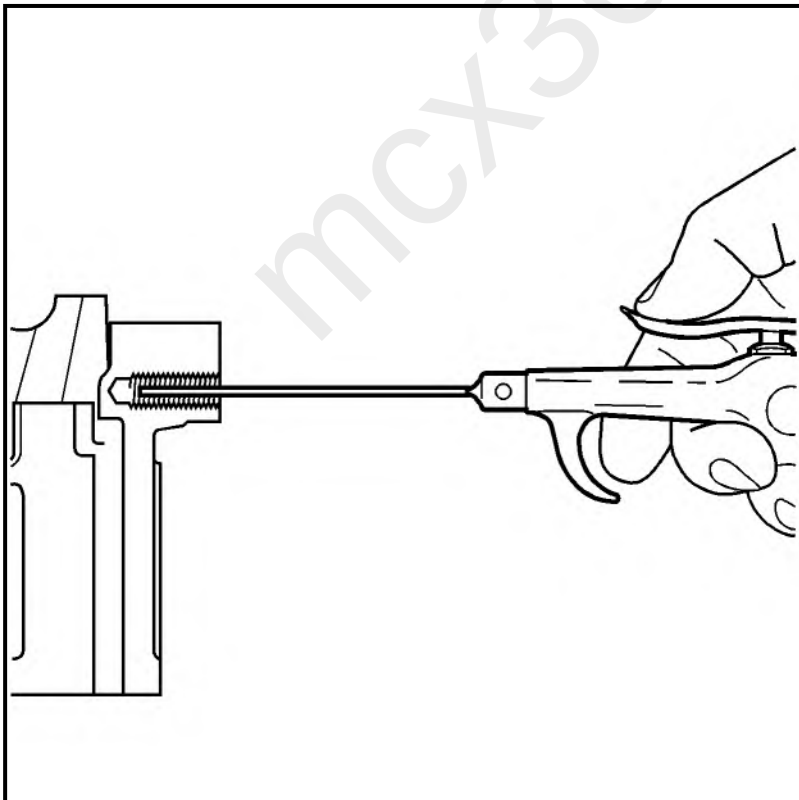


NOTE:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the surface of the base material.

Drill out the threads of the damaged hole.

3.

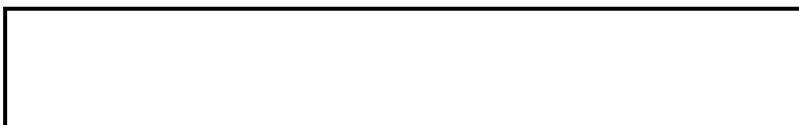


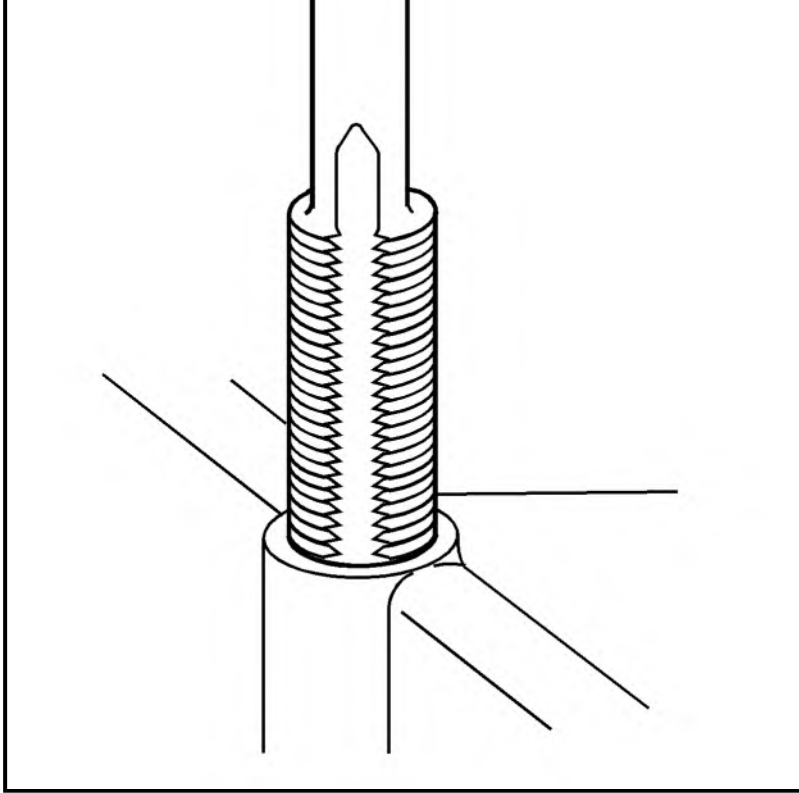
NOTE:

All chips must be removed from the drilled hole prior to tapping.

Using compressed air, clean out any chips.

4.



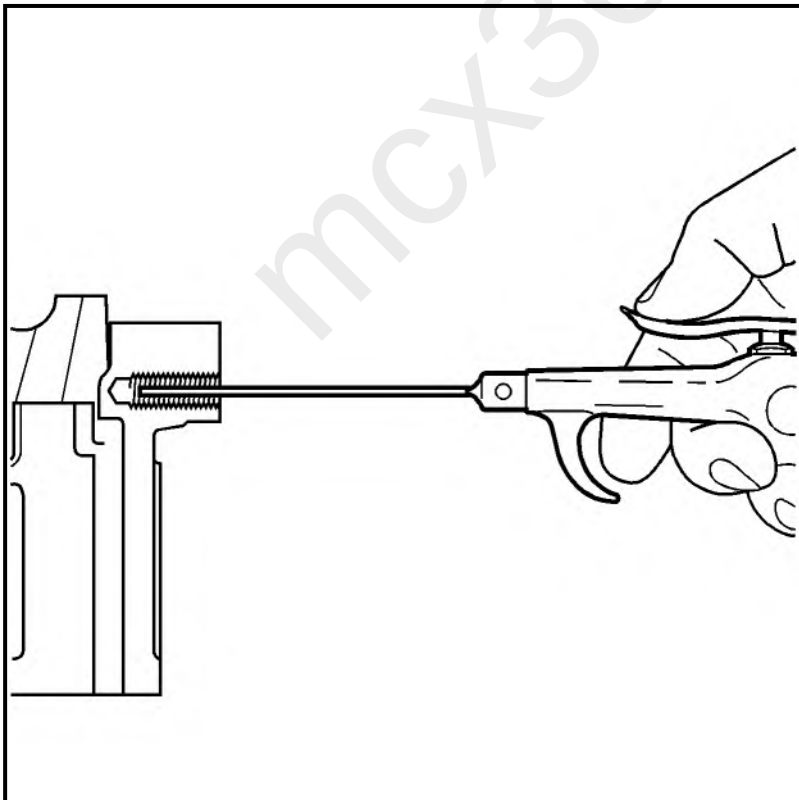


NOTE:

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.

Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

5.



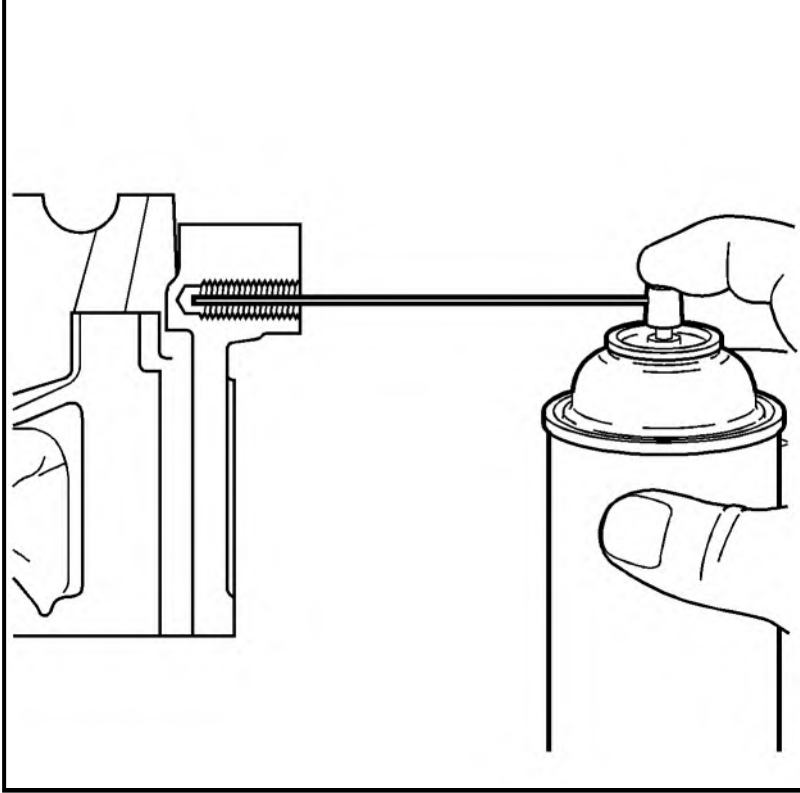
NOTE:

All chips must be removed from the tapped hole prior to insert installation.

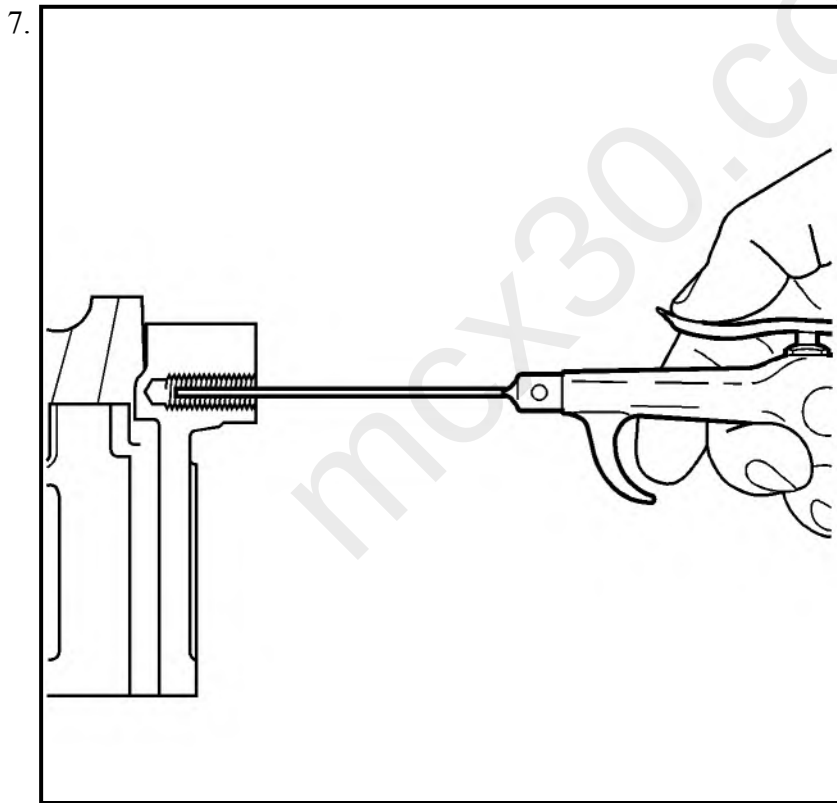
Using compressed air, clean out any chips.

6.



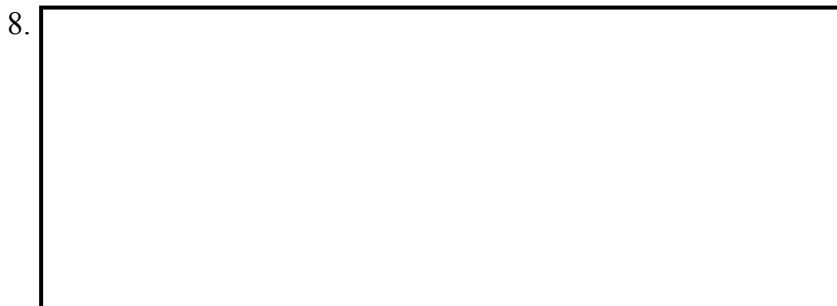


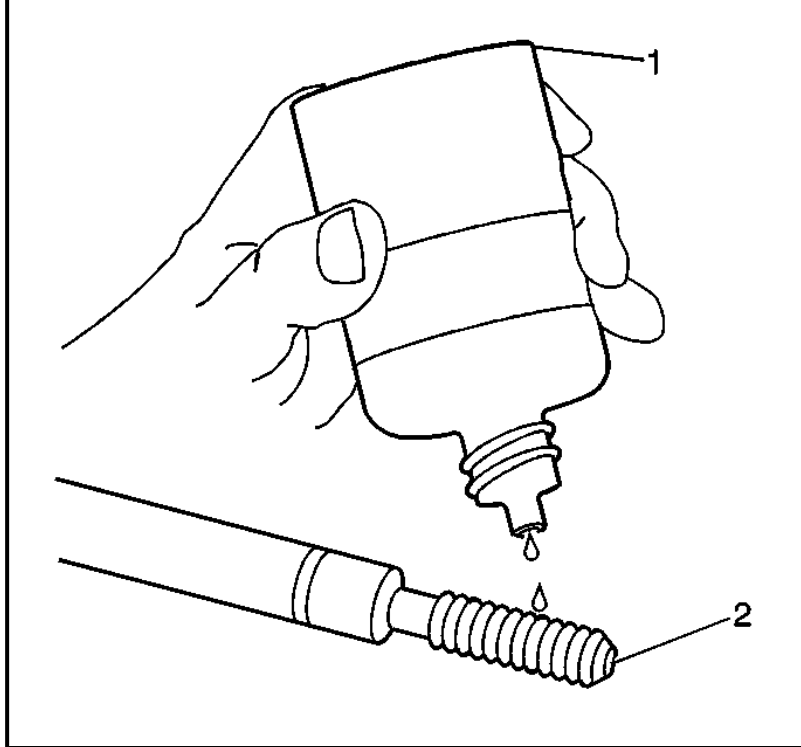
Spray cleaner into the tapped hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cleaner.



NOTE: All chips must be removed from the tapped hole prior to insert installation.

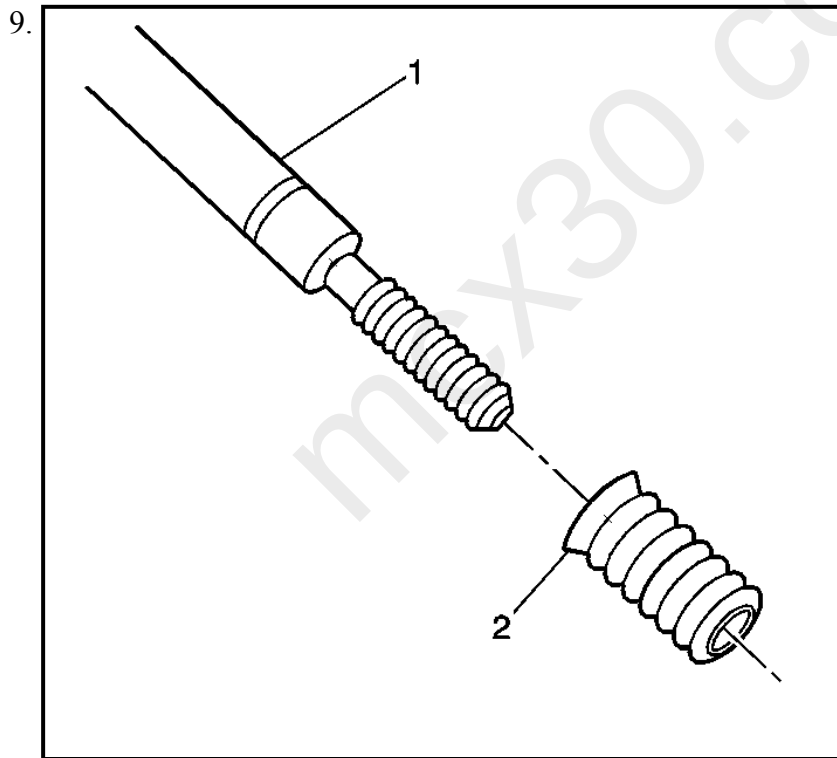
Using compressed air, clean out any chips.





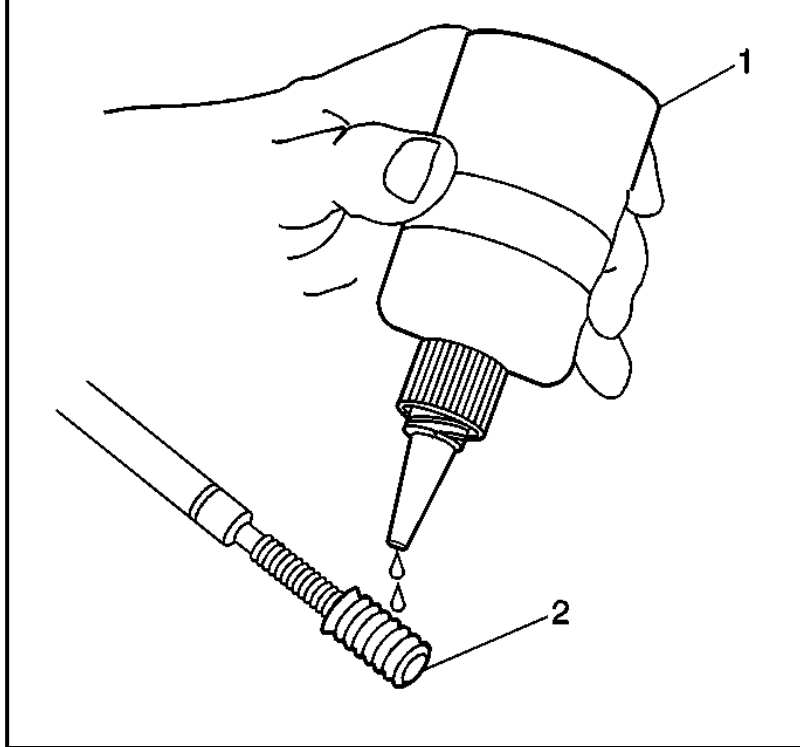
NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1).



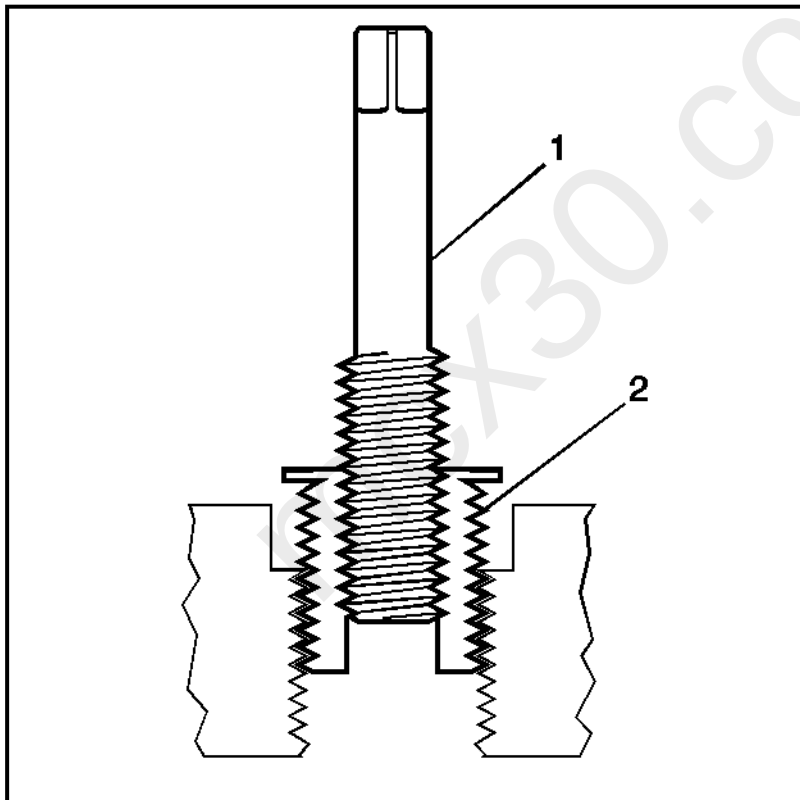
Install the insert (2) onto the driver installation tool (1).





Apply threadlock sealant, EN 42385-109, LOCTITE 277^Å,^Å or equivalent (1) to the insert OD threads (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

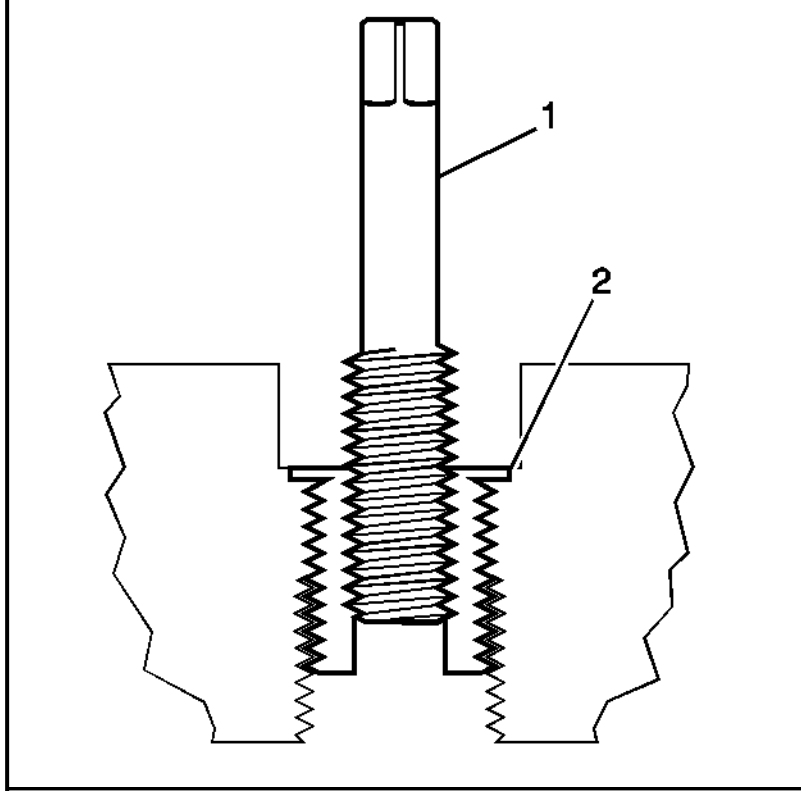
11.



Install the insert (2) into the tapped hole by hand only.

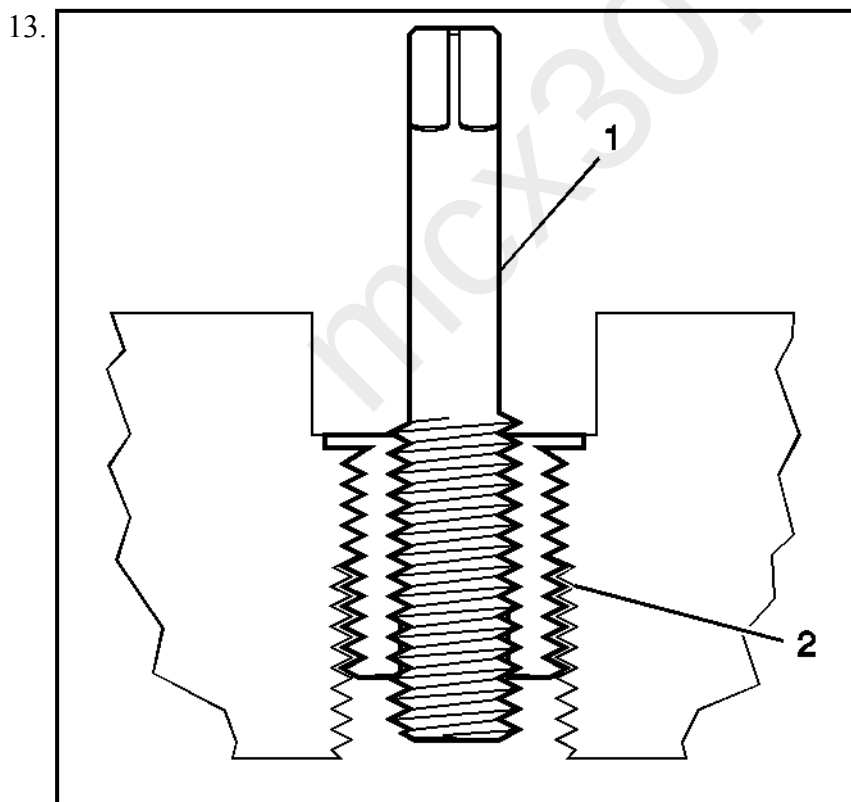
12.





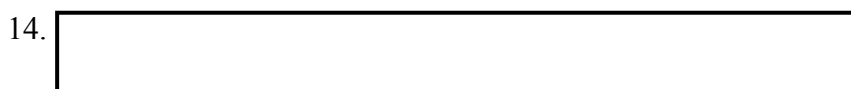
NOTE: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

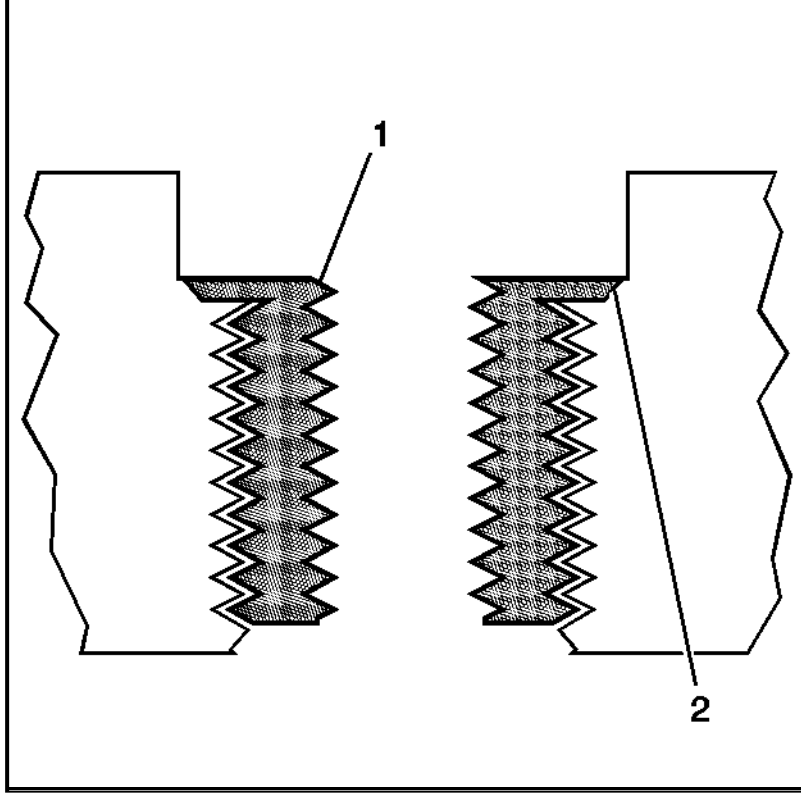
Install the insert until the flange (2) of the insert contacts the counterbored surface.



NOTE: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

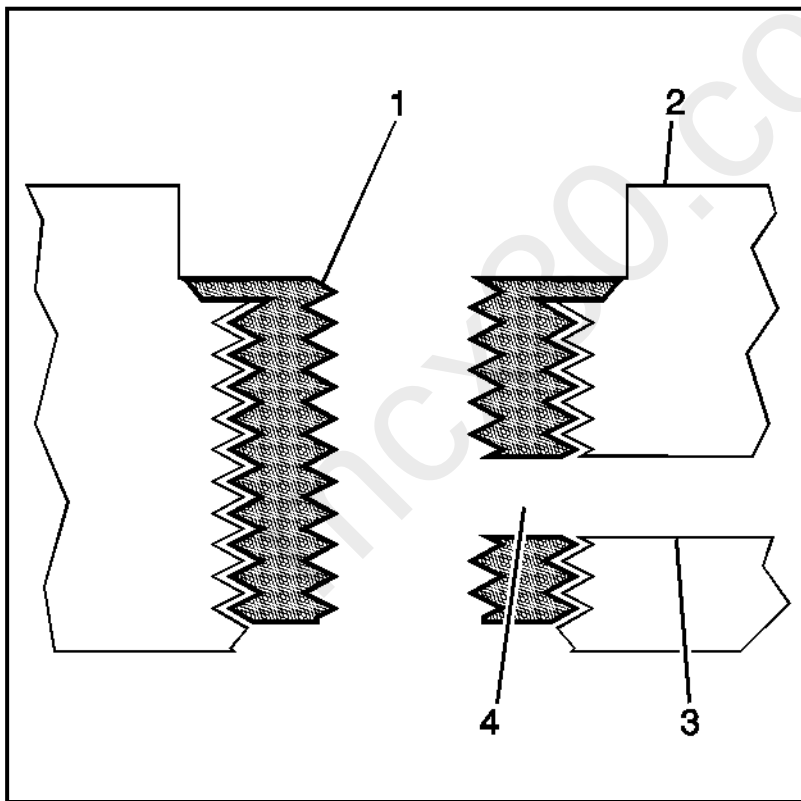
Continue to rotate the driver installation tool (1) through the insert (2).





Inspect the insert (1) for proper installation (2) into the tapped hole.

15.

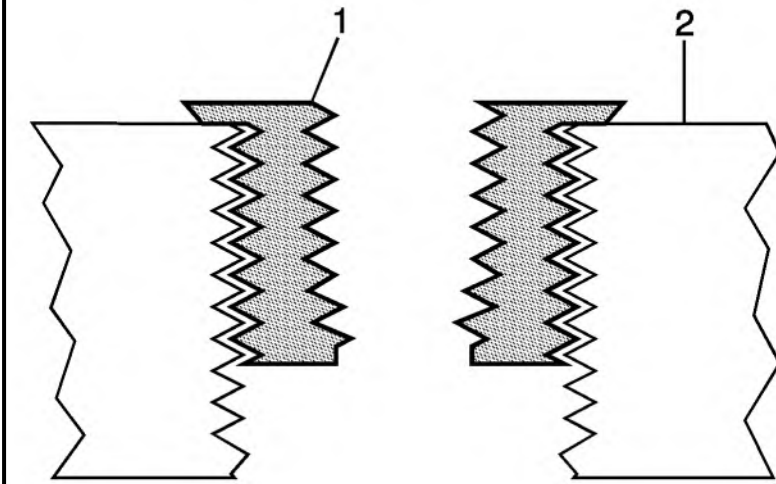


Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

Tapered Pipe Thread Repair

The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.

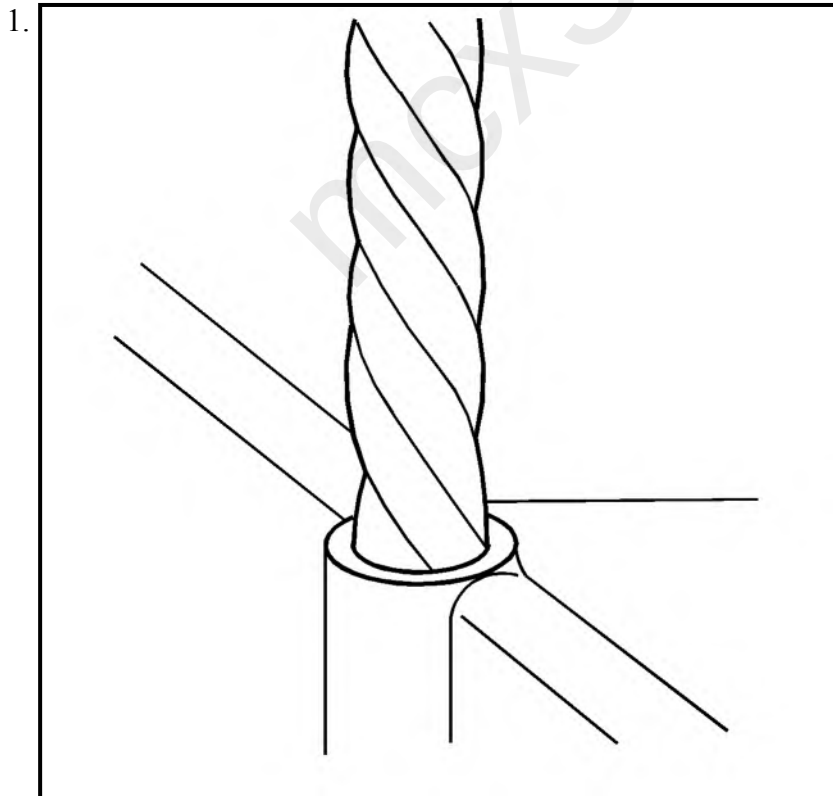




WARNING: Refer to [Safety Glasses Warning](#) .

NOTE: The use of a cutting type fluid, WD 40[®] or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cutting fluid.

When installed to the proper depth, the flange (1) of the insert will be seated against surface (2) of the base material of the drilled/tapped hole.

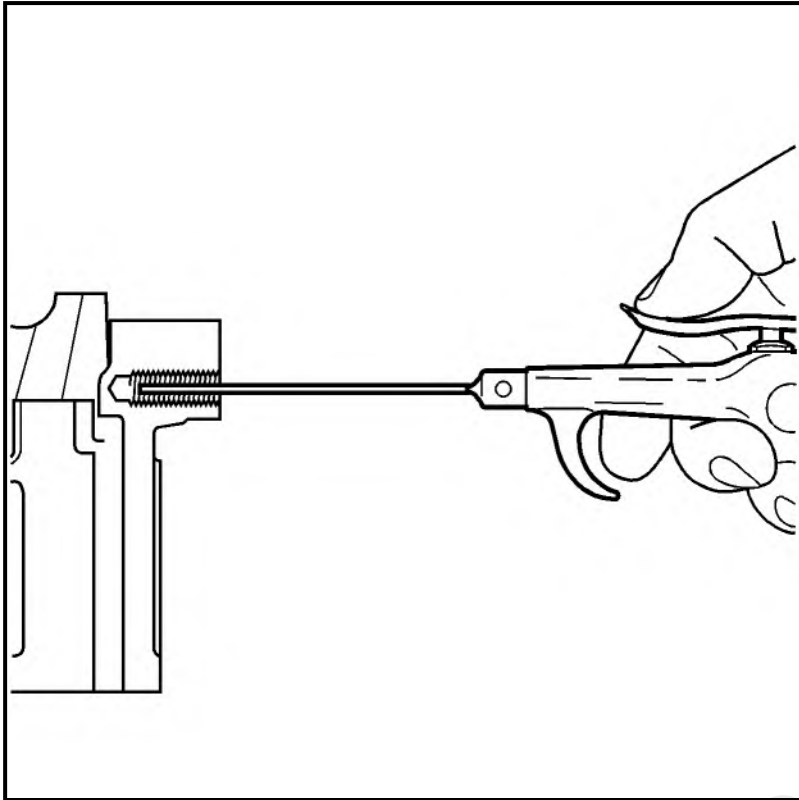


NOTE:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the surface of the base material.

Drill out the threads of the damaged hole.

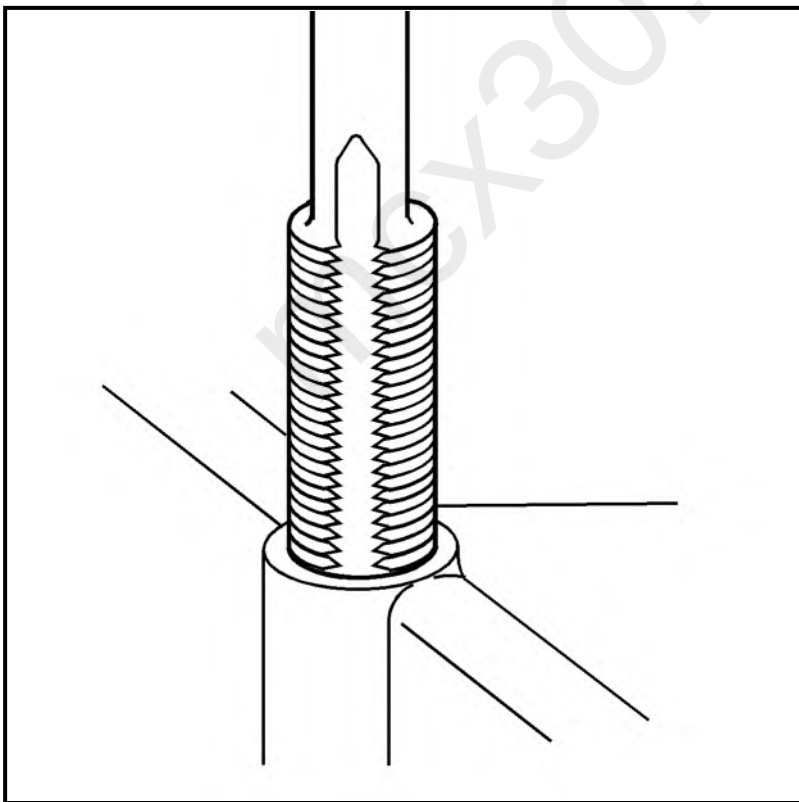
2.



NOTE: All chips must be removed from the drilled hole prior to tapping.

Using compressed air, clean out any chips.

3.

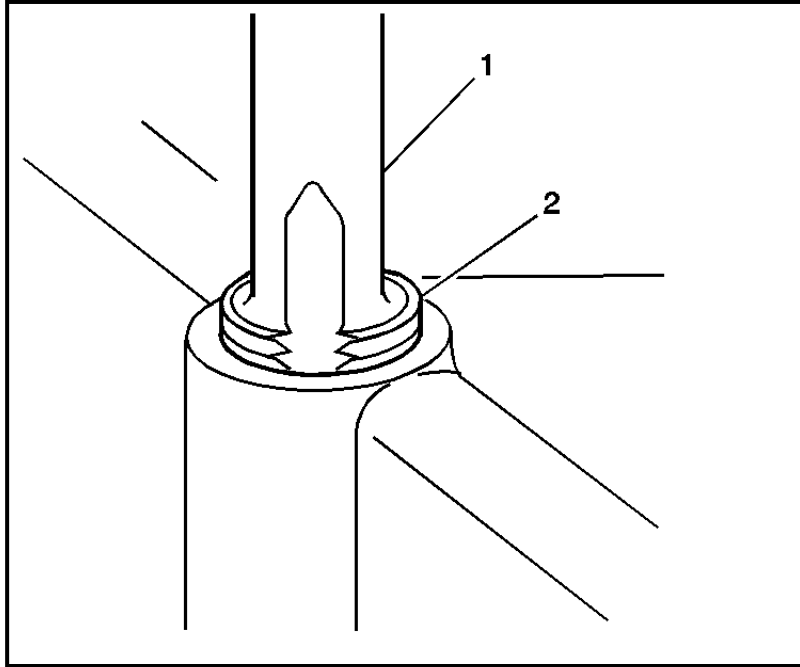


NOTE:

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.

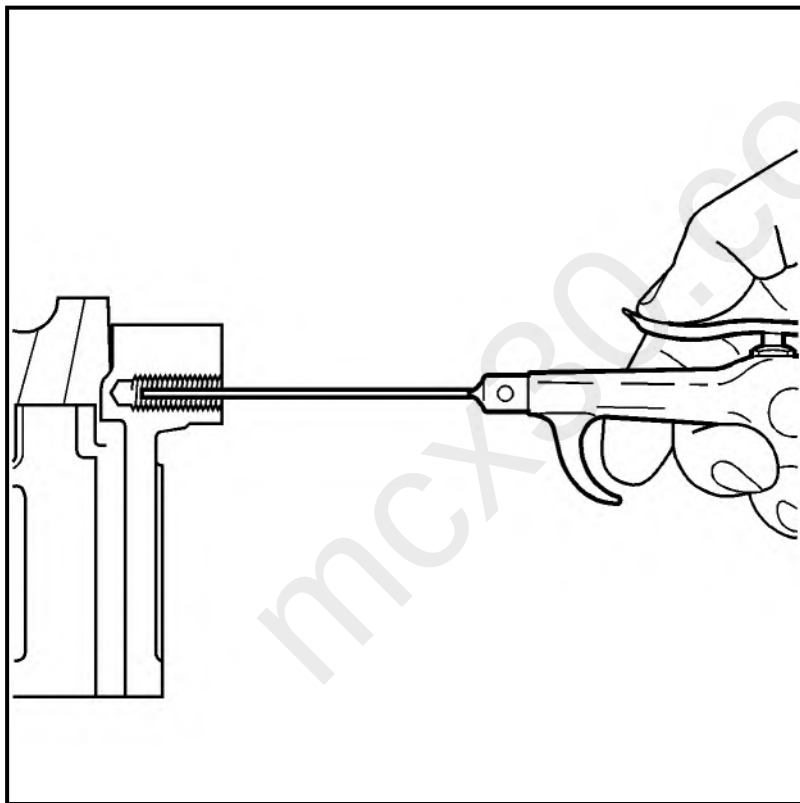
Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

4.



Tap the drilled hole until the threads at the top of the tap (2) are down to the surface of the base material.

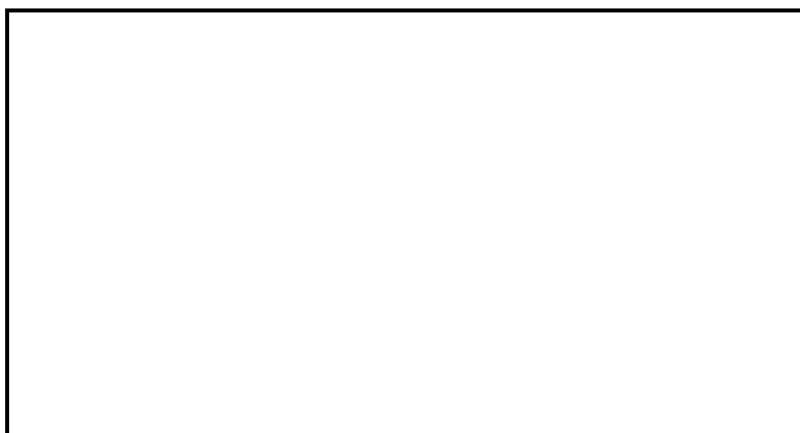
5.

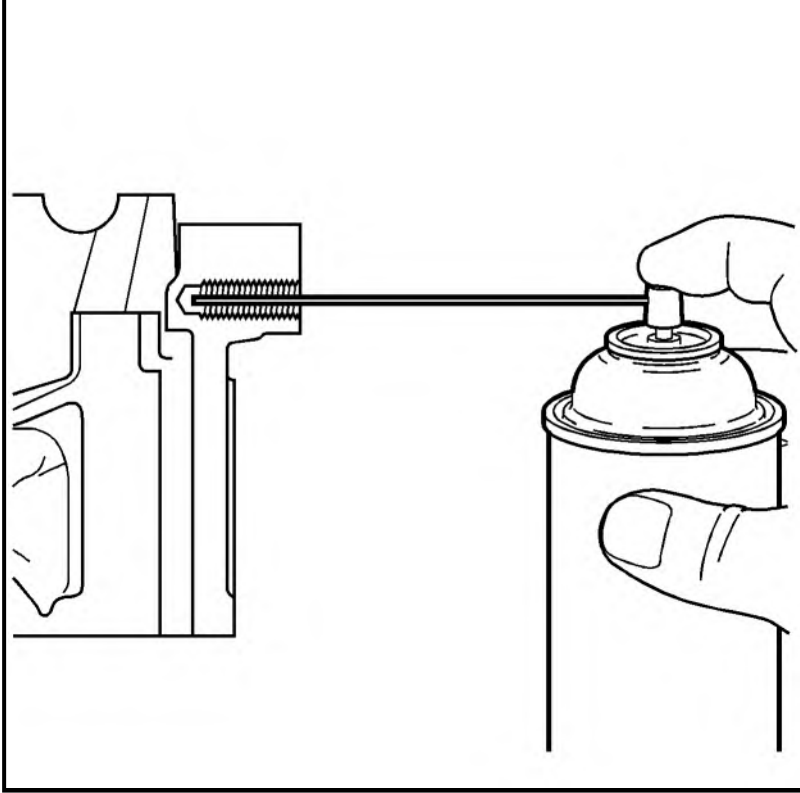


NOTE: All chips must be removed from the tapped hole prior to insert installation.

Using compressed air, clean out any chips.

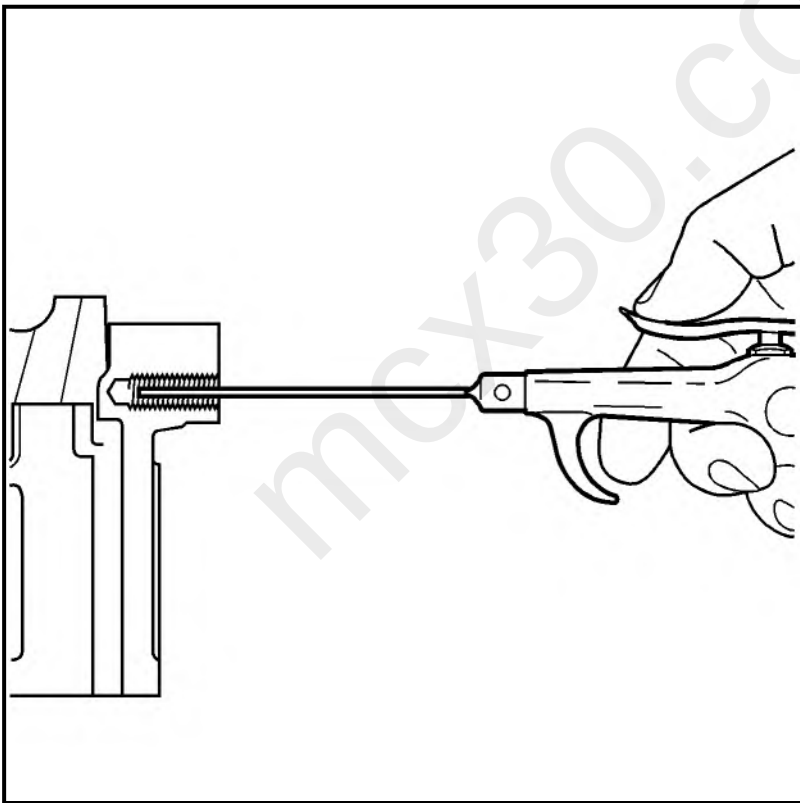
6.





Spray cleaner into the tapped hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cleaner.

7.

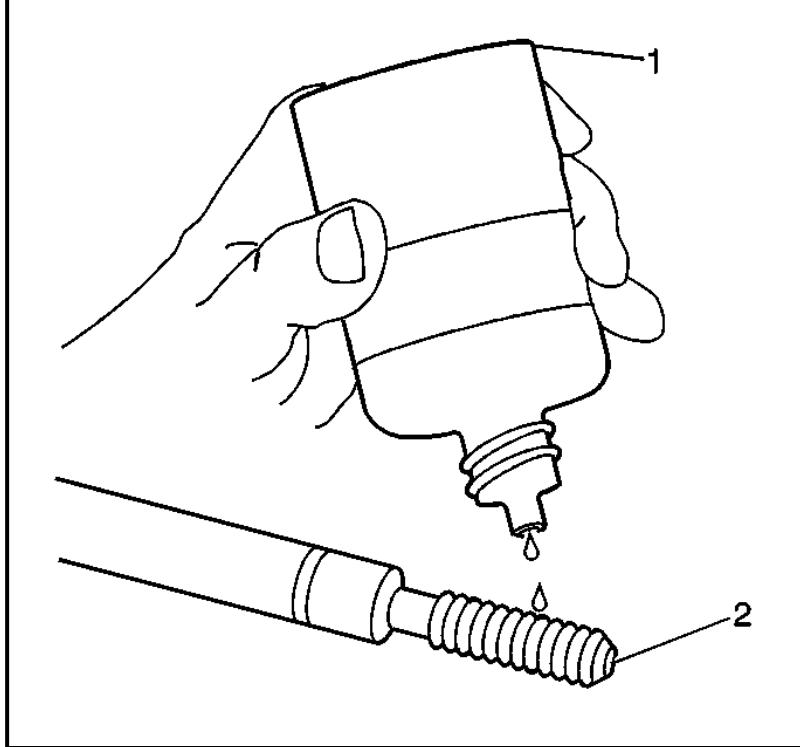


NOTE: All chips must be removed from the tapped hole prior to insert installation.

Using compressed air, clean out any chips.

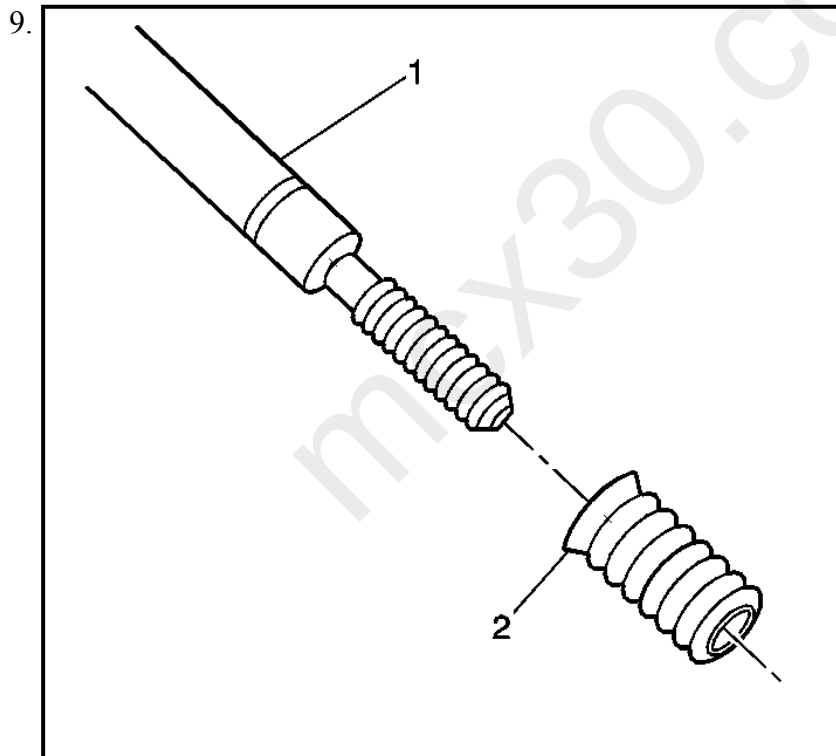
8.





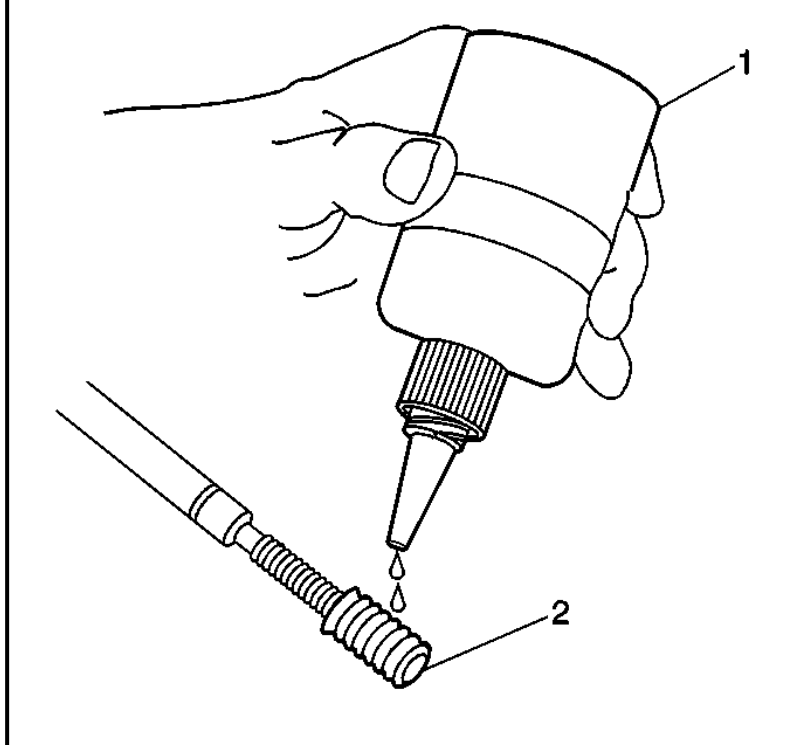
NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1).



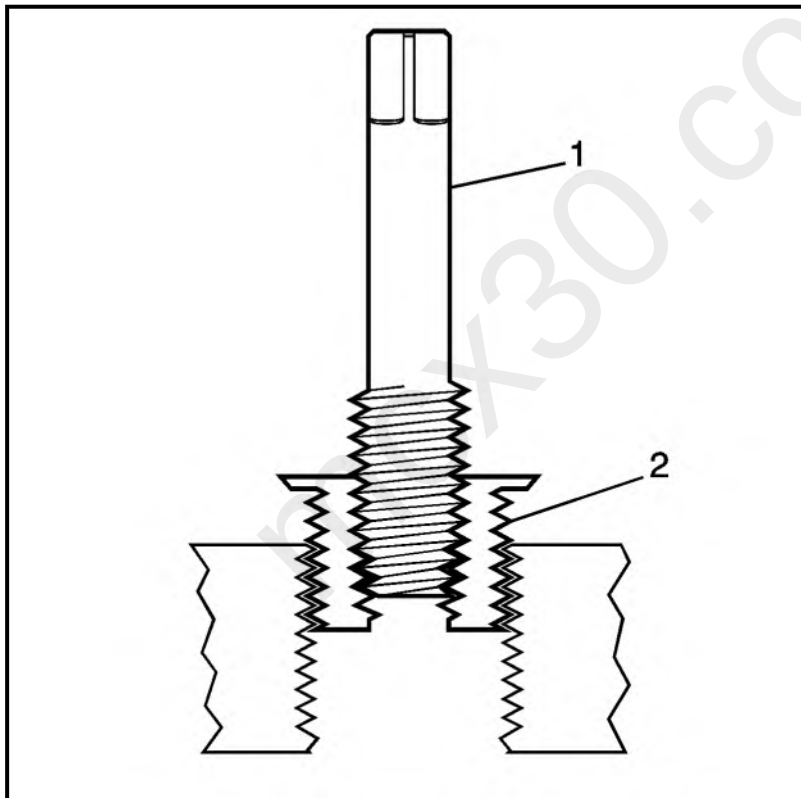
Install the insert (2) onto the driver installation tool (1).





Apply threadlock sealant, EN 42385-109, LOCTITE 277^Å,^Å or equivalent (1) to the insert OD threads (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

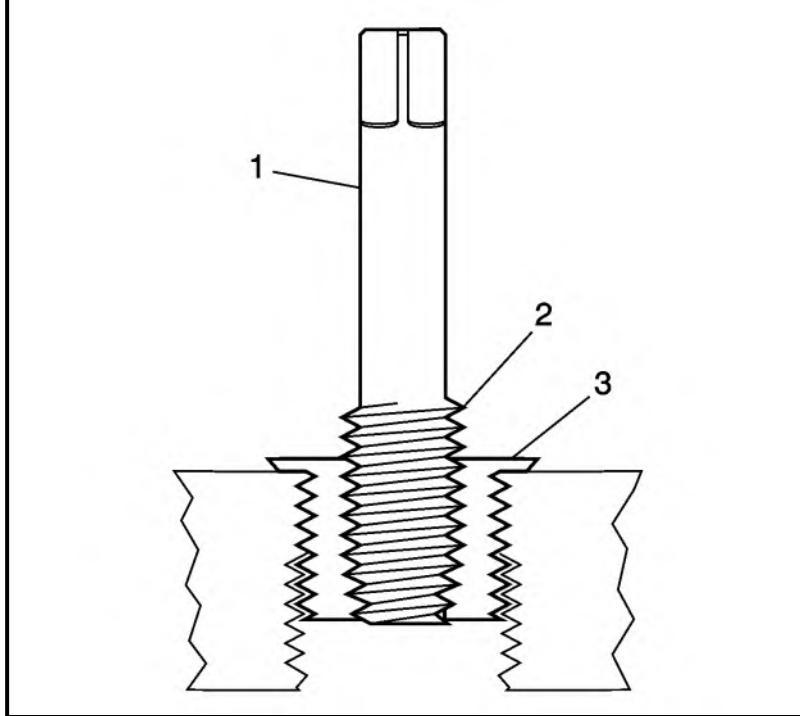
11.



Install the insert (2) into the tapped hole by hand only.

12.



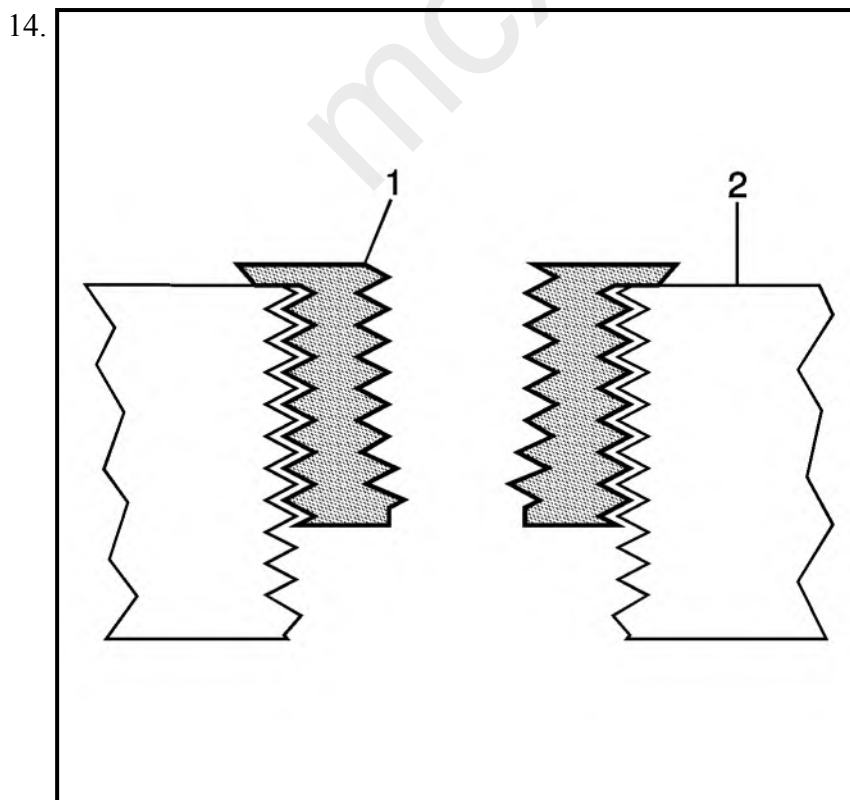


NOTE: If the insert will not thread down until the flange contacts the surface of the base material remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

Install the insert until the flange of the insert (3) contacts the surface of the base material.

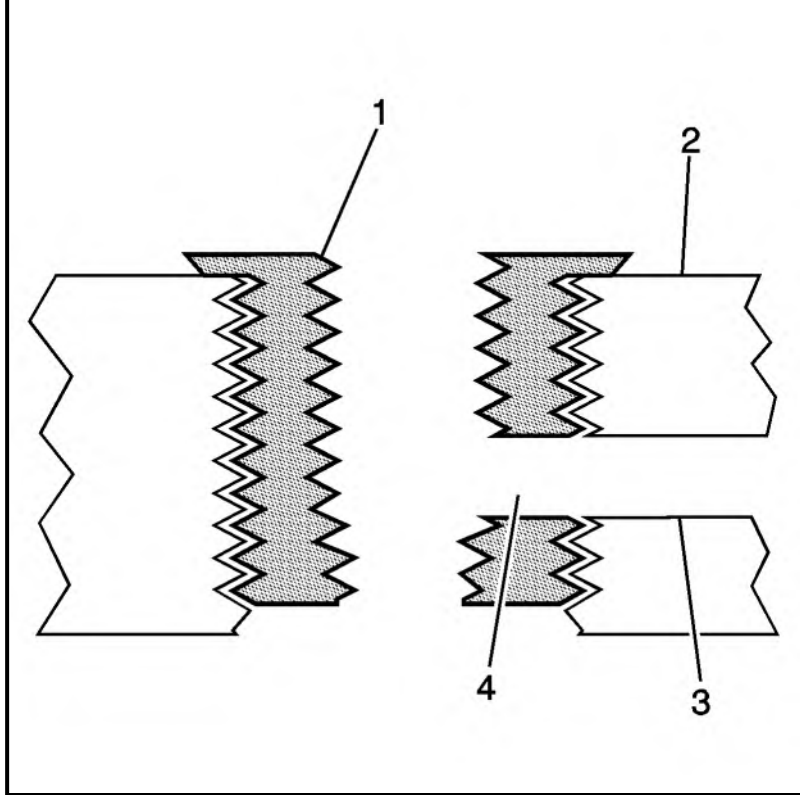
NOTE: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) until the top of the threaded section (2) is level with the top of the insert (3).



Inspect the insert (1) for proper installation (2) into the tapped hole.

15.



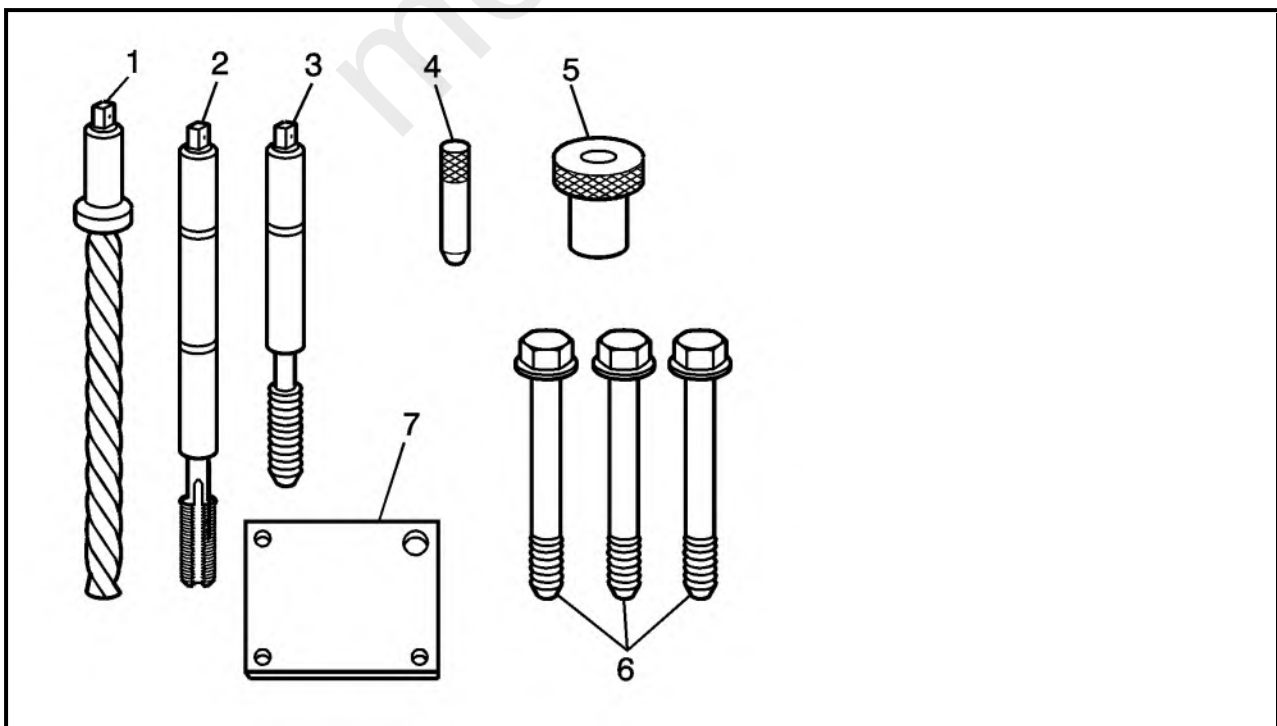
Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

Cylinder Head Bolt Hole Thread Repair

Special Tools

- EN 42385-700 High Feature Thread Repair Kit
- EN 42385-2000 Thread Insert Kit

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



The cylinder head bolt hole thread repair tooling are in the kits **EN 42385-2000** insert kit and **EN 42385-700** kit. The cylinder head bolt hole thread repair components consist of the following:

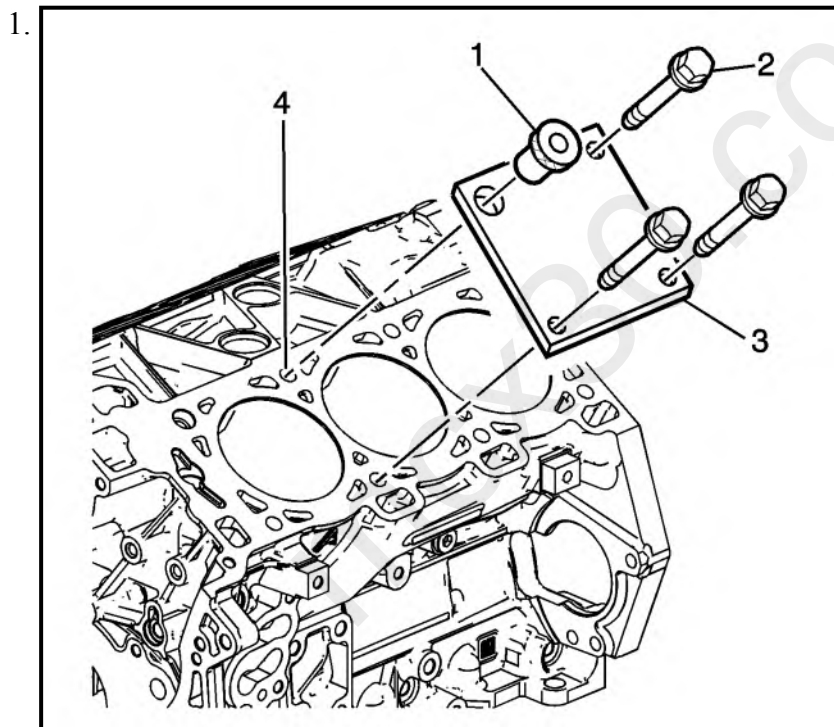
- EN 42385-723 Drill (1)
- EN 42385-724 Tap (2)
- EN 42385-725 Installation driver (3)
- EN 42385-303 Alignment pin (4)
- EN 42385-302 Bushing (5)
- EN 42385-733 Bolts (6)
- EN 42385-401 Fixture plate (7)

WARNING: Refer to [Safety Glasses Warning](#) .

NOTE:

- Remove the fixture plate prior to installing the insert with the installer tool.
- The use of a cutting type fluid, WD 40[®]; or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cutting fluid.

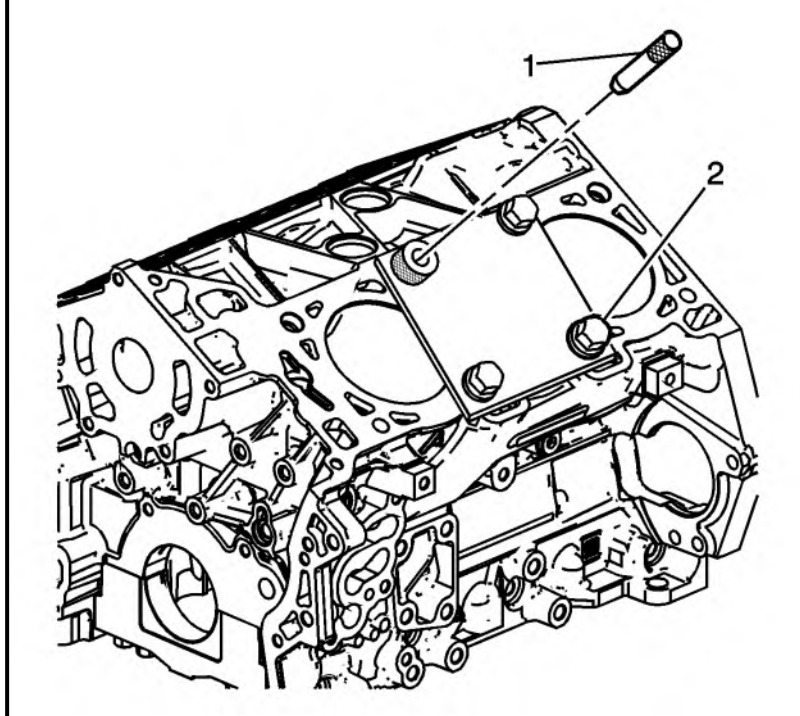
When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.



Position the fixture plate (3) with the bushing (1) installed over the cylinder head bolt hole to be repaired (4).

2. Loosely install the fixture plate bolts (2) into the remaining cylinder head bolt holes.

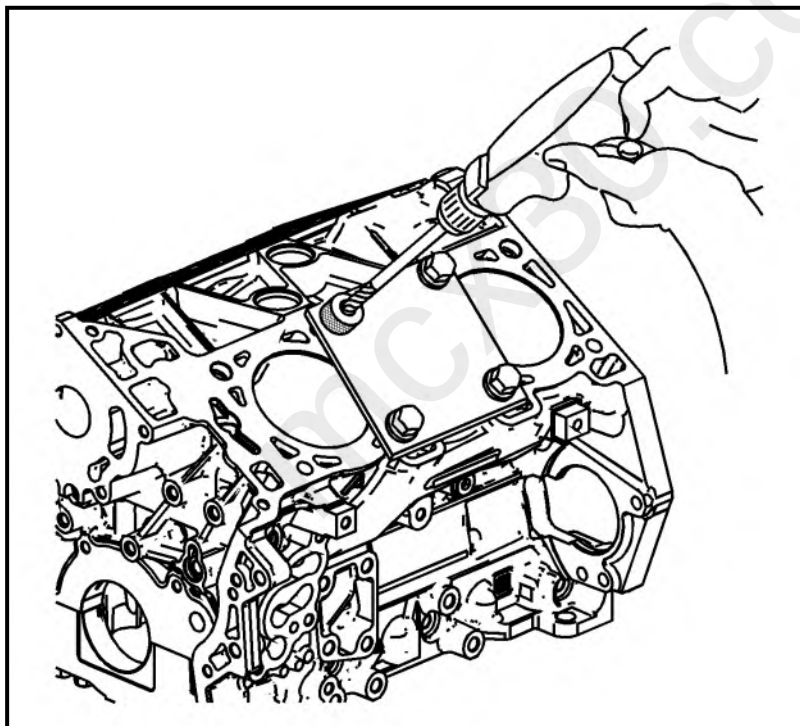




Position the alignment pin (1) through the bushing and into the cylinder head bolt hole.

4. With the alignment pin in the desired cylinder head bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the cylinder head bolt hole.

6.



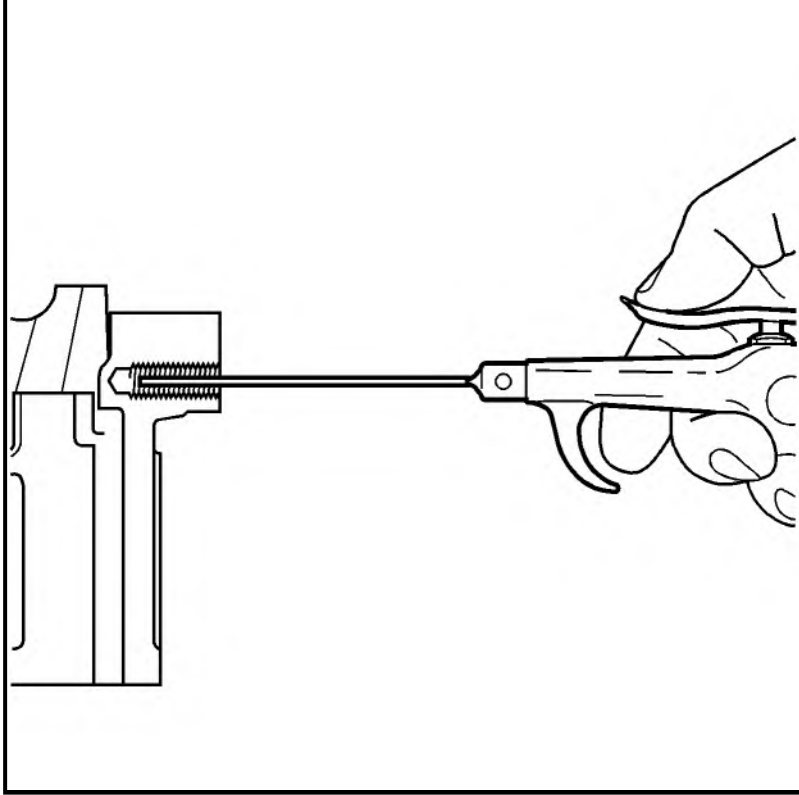
NOTE:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the top of the drill bushing.

Drill out the threads of the damaged hole.

7.

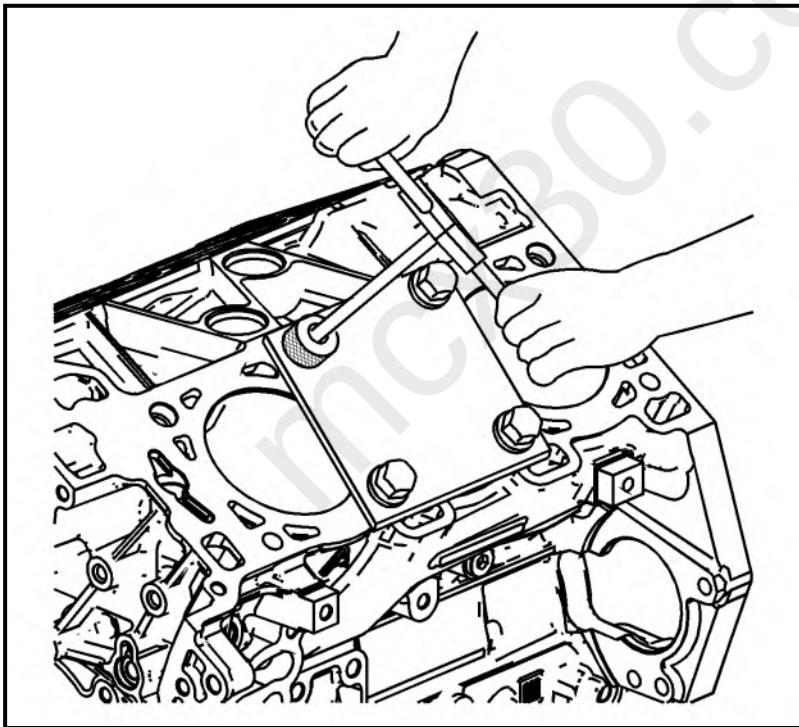




NOTE: All chips must be removed from the drilled hole prior to tapping.

Using compressed air, clean out any chips.

8.



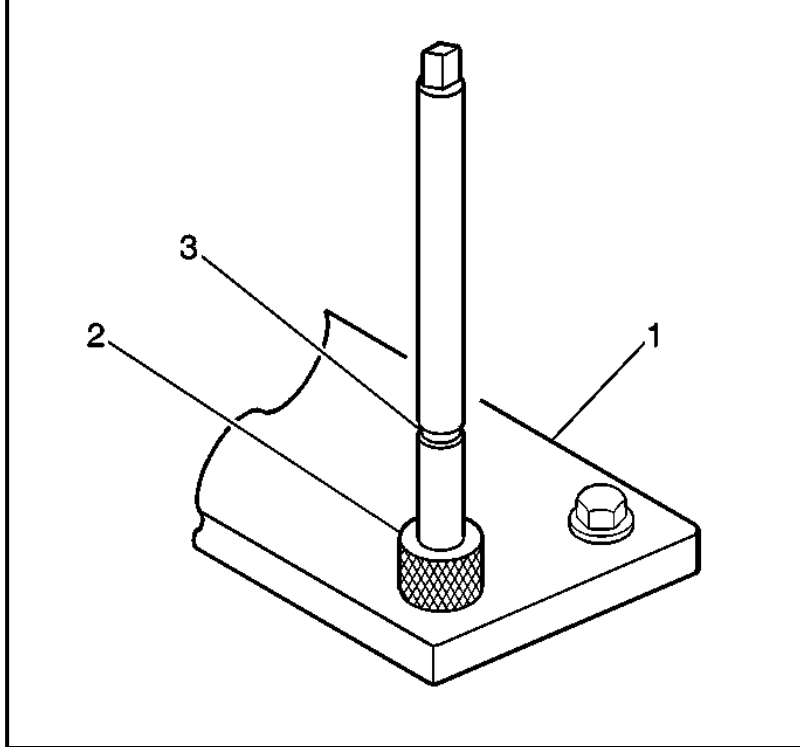
NOTE:

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.

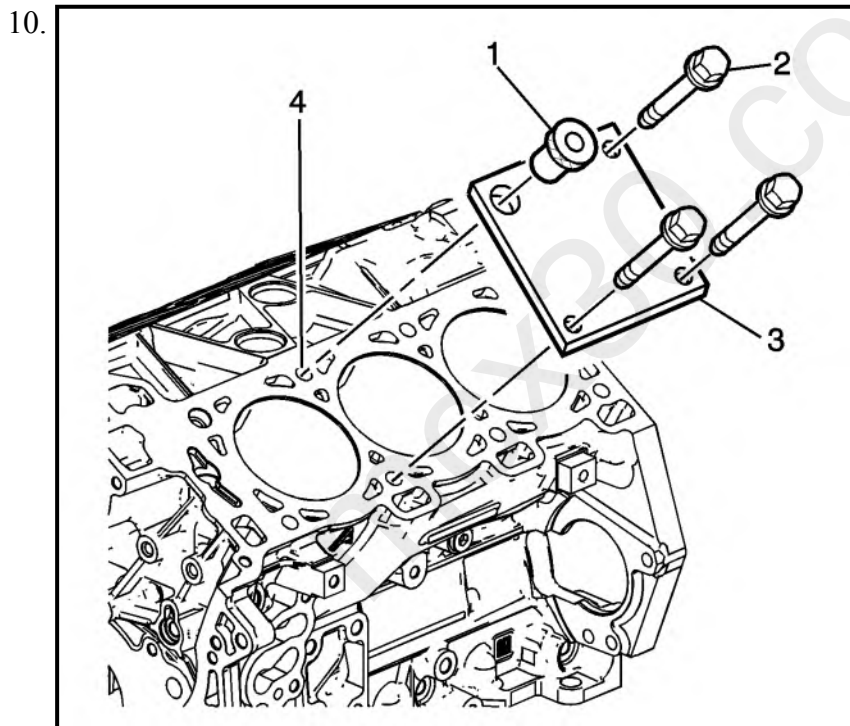
Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

9.





In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

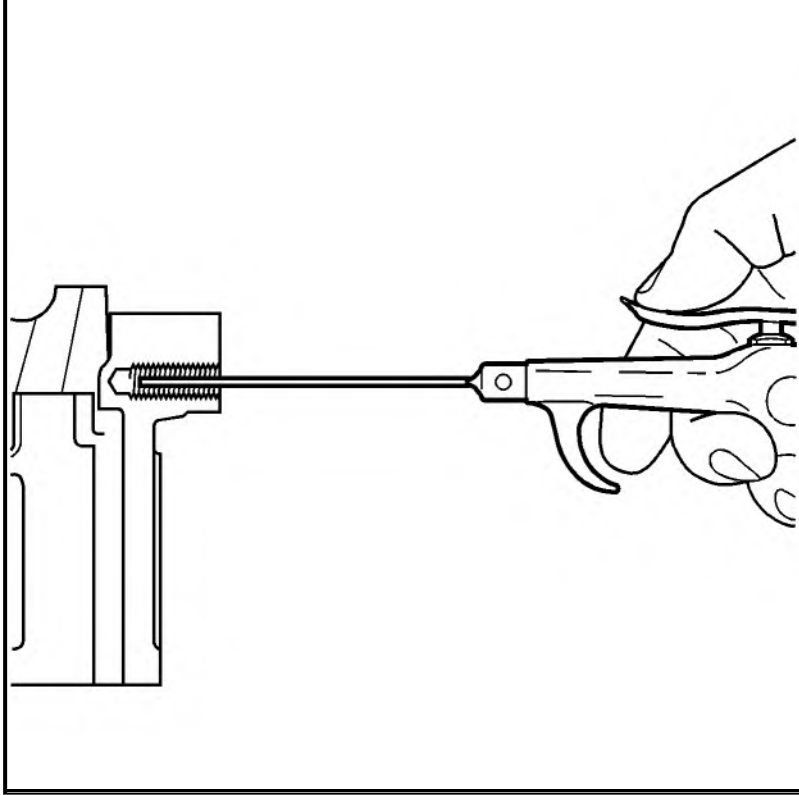


NOTE: Remove the fixture plate prior to installing the insert with the installer tool.

Remove the fixture plate bolts (2).

11. Remove the fixture plate (3) and bushing (1).

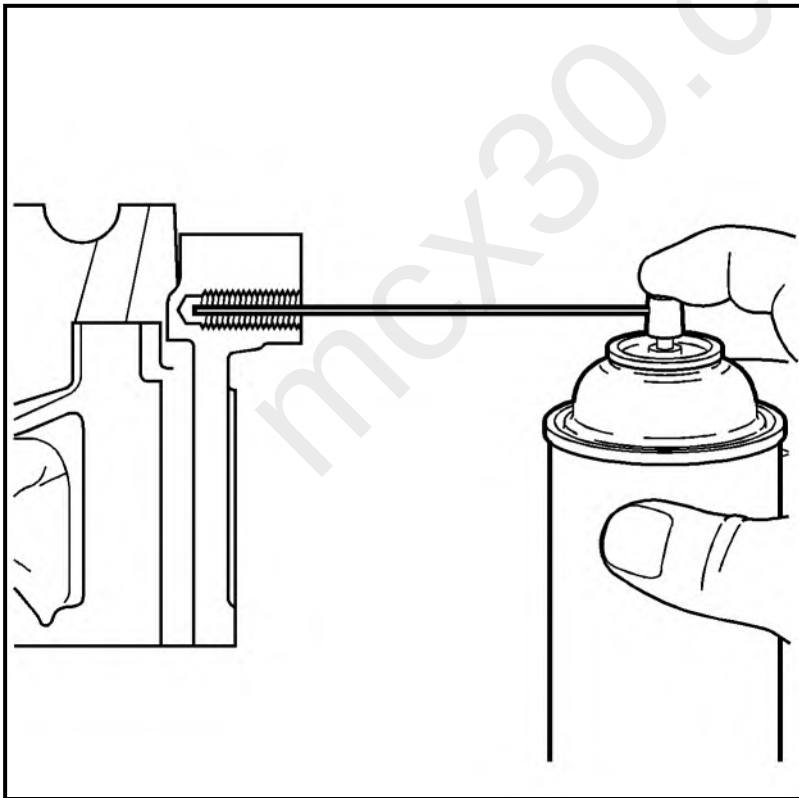




NOTE: All chips must be removed from the tapped hole prior to insert installation.

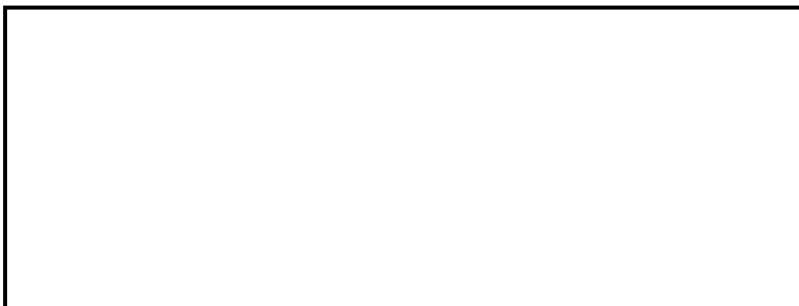
Using compressed air, clean out any chips.

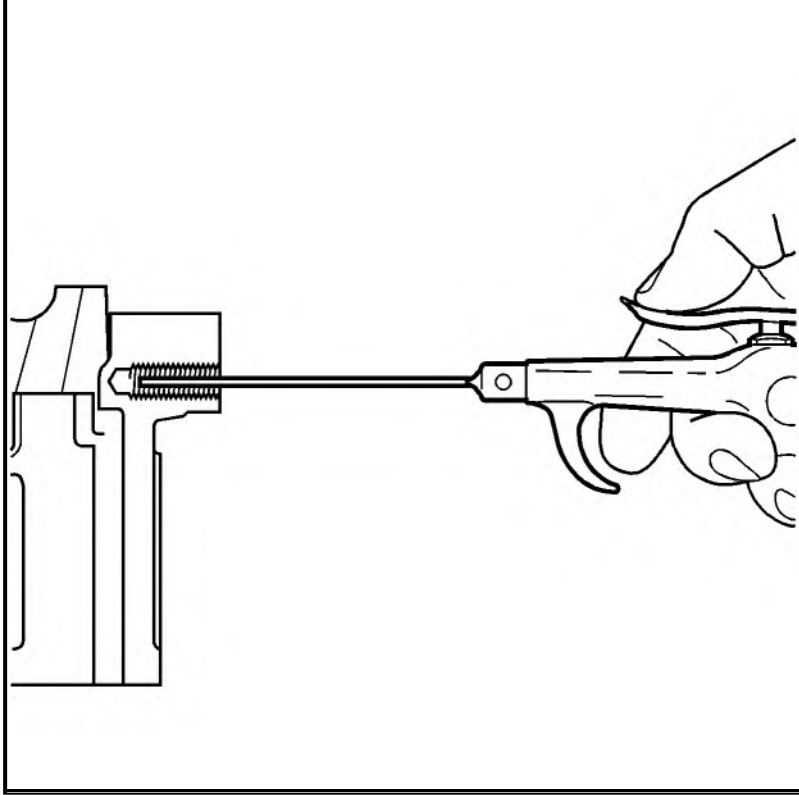
13.



Spray cleaner into the tapped hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cleaner.

14.

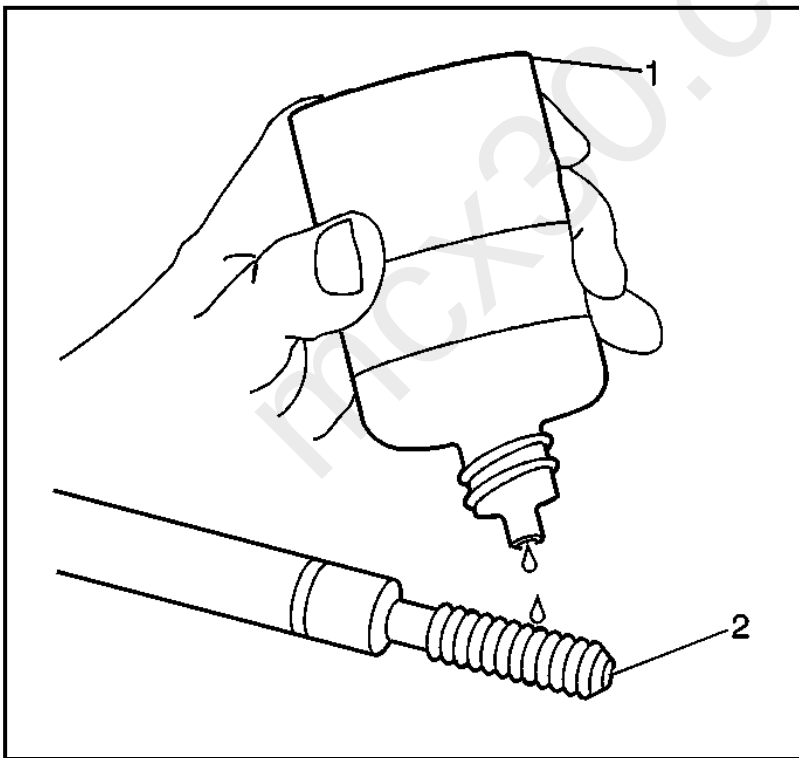




NOTE: All chips must be removed from the tapped hole prior to insert installation.

Using compressed air, clean out any chips.

15.

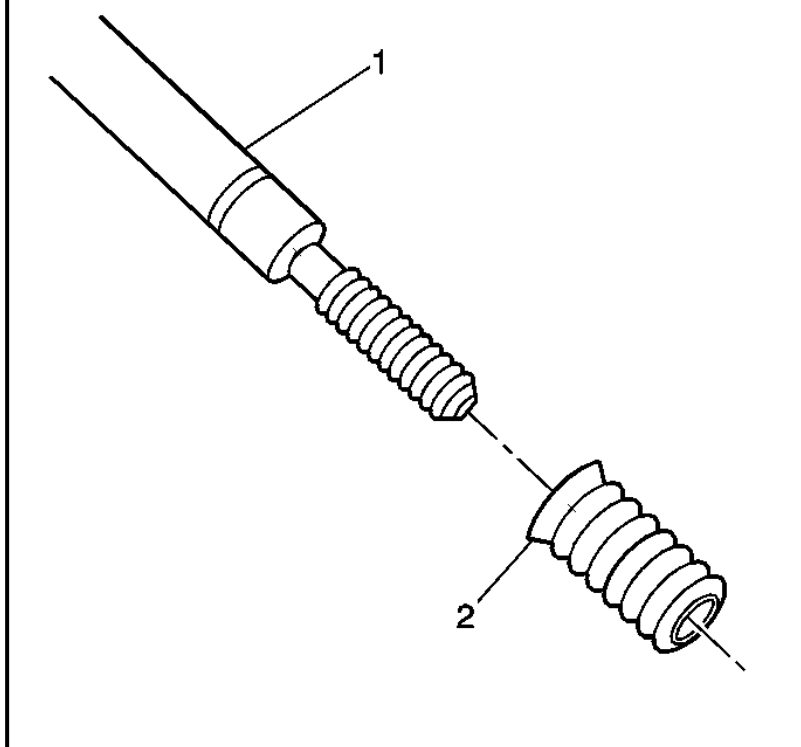


NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1).

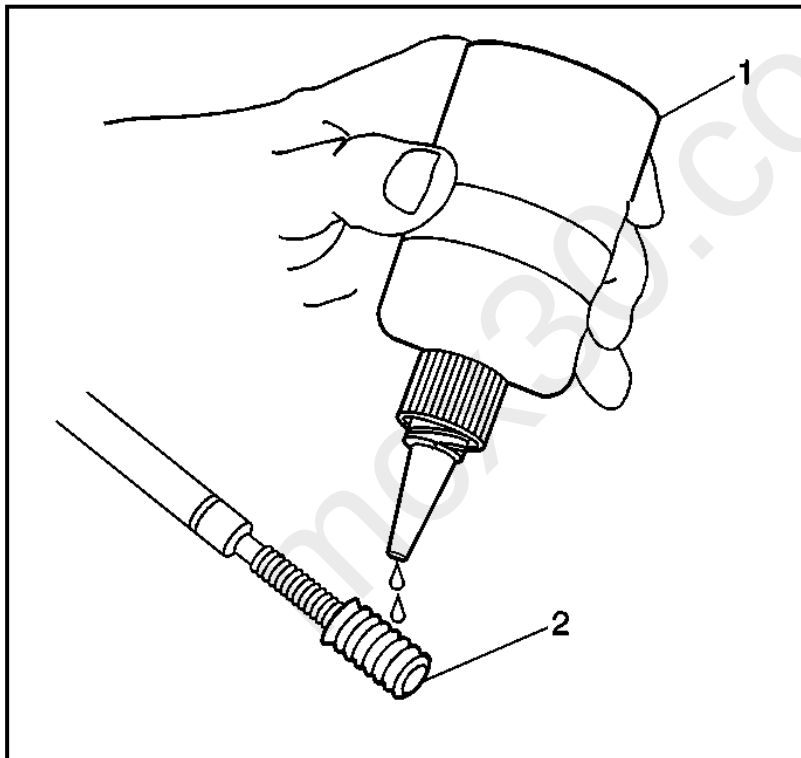
16.





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

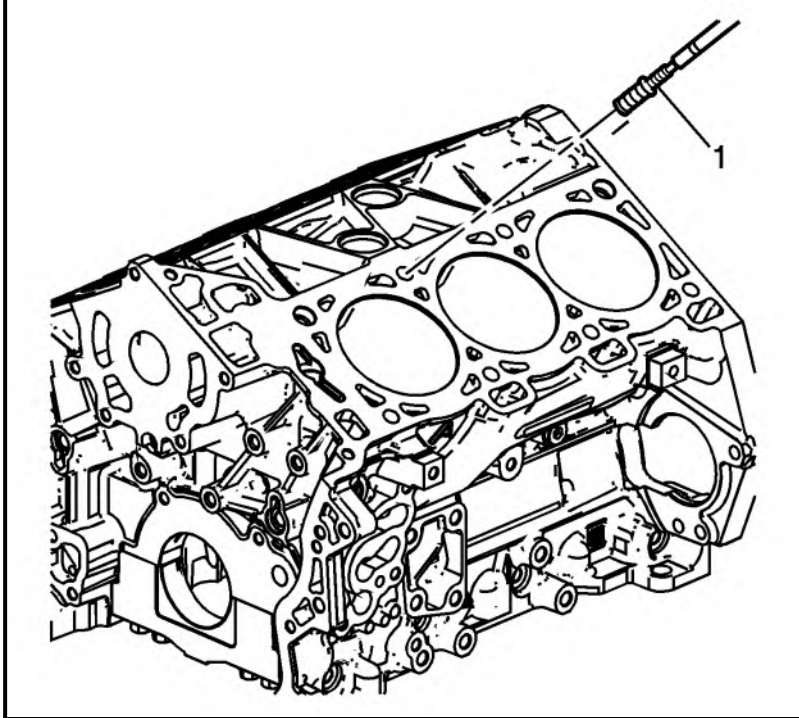
17.



Apply threadlock sealant, EN 42385-109, LOCTITE 277^Å,^Å®; or equivalent (1) to the insert OD threads (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

18.





Install the insert and installation driver (1) into the tapped hole by hand only.

19. Start the insert into the threaded hole.

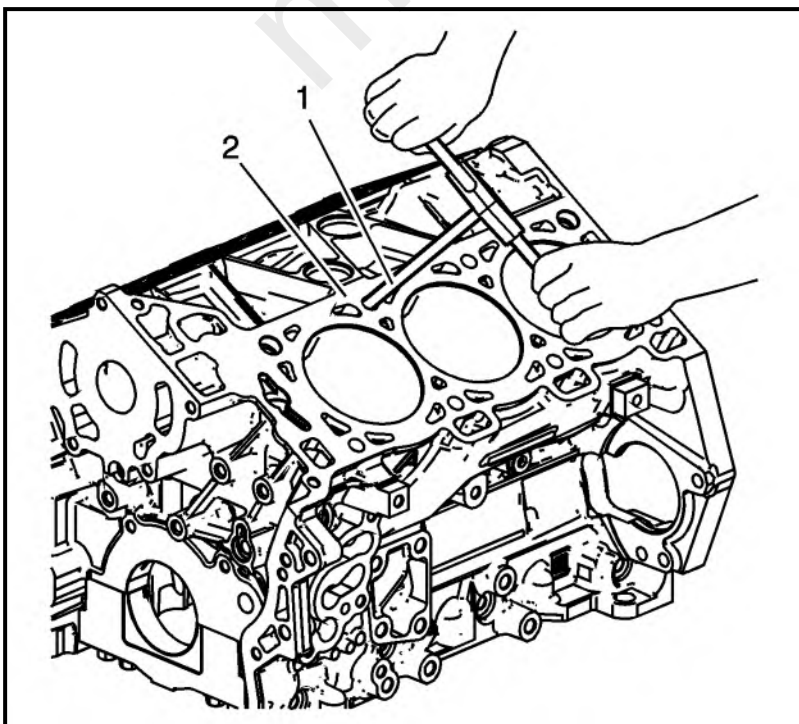
NOTE: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

20. Install the insert until the flange of the insert contacts the counterbored surface.

NOTE: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

21. Continue to rotate the driver installation tool through the insert.

22.



In order to completely form the new threads in the insert, rotate the driver installation tool through the insert until the mark (1) on the driver installation tool aligns with the surface of the engine

block deck (2).

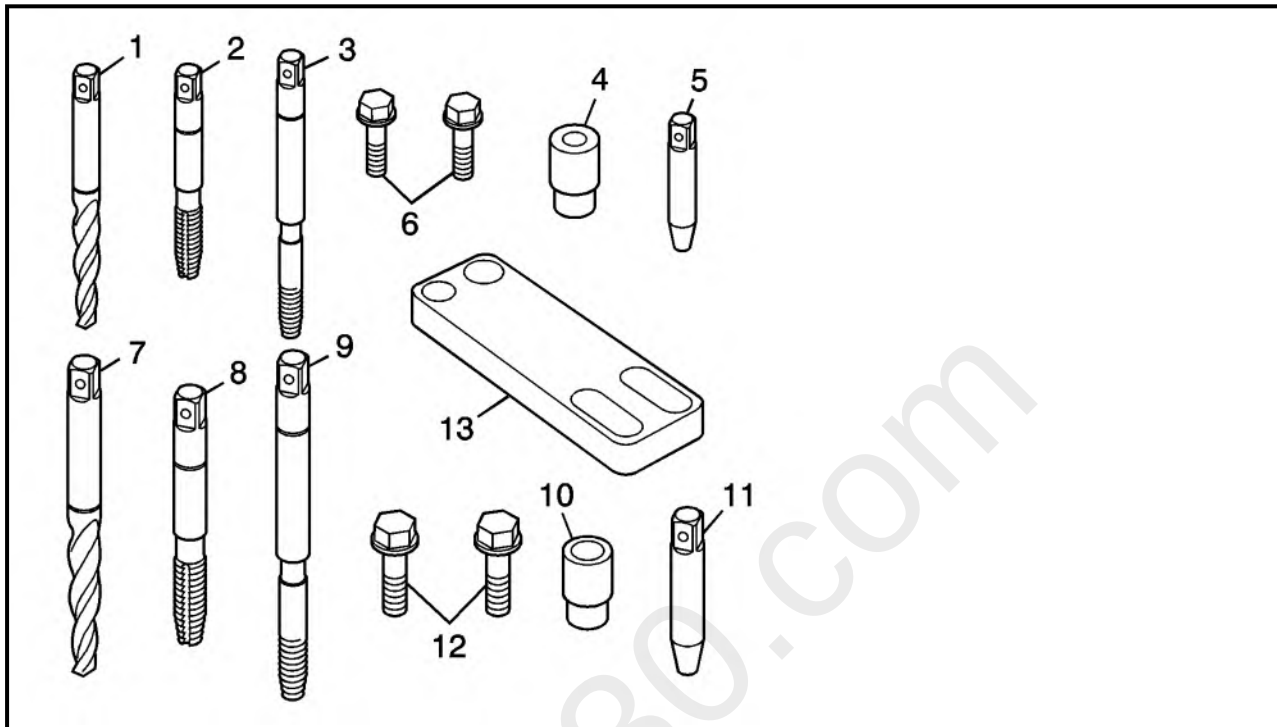
23. Inspect the insert for proper installation into the tapped hole.

Crankshaft Main Bolt Hole Thread Repair

Special Tools

- **EN 42385-700** High Feature Thread Repair Kit
- **EN 42385-2000** Thread Insert Kit

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



NOTE:

- In order to repair some crankshaft main bolt holes it will be necessary to mount the fixture plate upside down.
- Do NOT remove the fixture plate prior to installing the insert with the installation driver. The fixture plate remains in position throughout the thread repair process.

The crankshaft main bearing bolt hole thread repair tooling are in the kits **EN 42385-2000** insert kit and **EN 42385-700** kit. The crankshaft main bearing bolt hole thread repair components consist of the following:

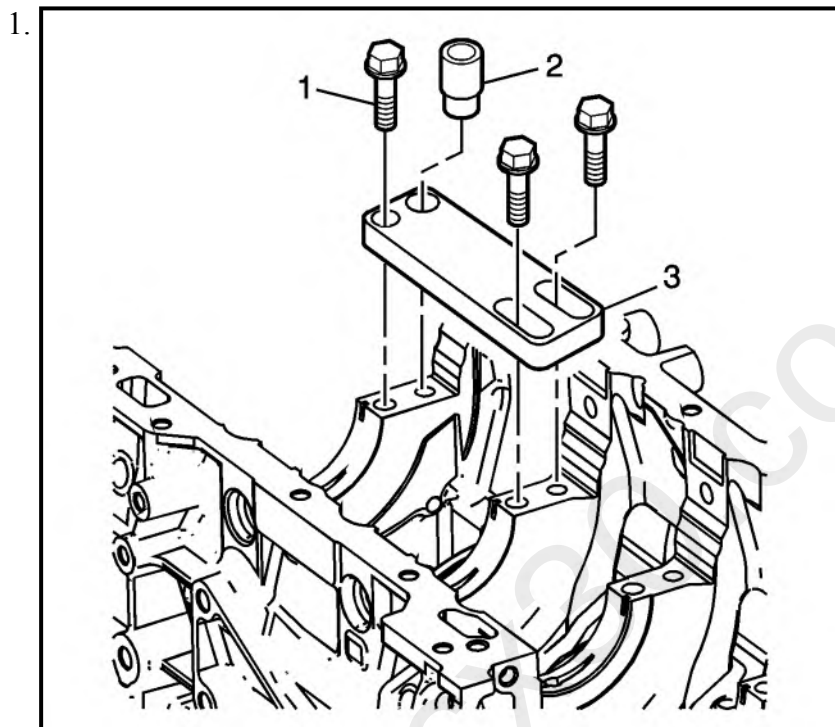
- EN 42385-702 Drill (1) for outboard holes
- EN 42385-703 Tap (2) for outboard holes
- EN 42385-704 Installation driver (3) for outboard holes
- EN 42385-726 Bushing (4) for outboard holes
- EN 42385-727 Alignment pin (5) for outboard holes
- EN 42385-728 Bolts (6) for outboard holes
- EN 42385-720 Drill (7) for inboard holes
- EN 42385-721 Tap (8) for inboard holes
- EN 42385-722 Installation driver (9) for inboard holes
- EN 42385-713 Bushing (10)
- EN 42385-308 Alignment pin (11)
- EN 42385-734 Bolts (12)
- EN 42385-712 Fixture plate (13)

WARNING: Refer to [Safety Glasses Warning](#) .

NOTE:

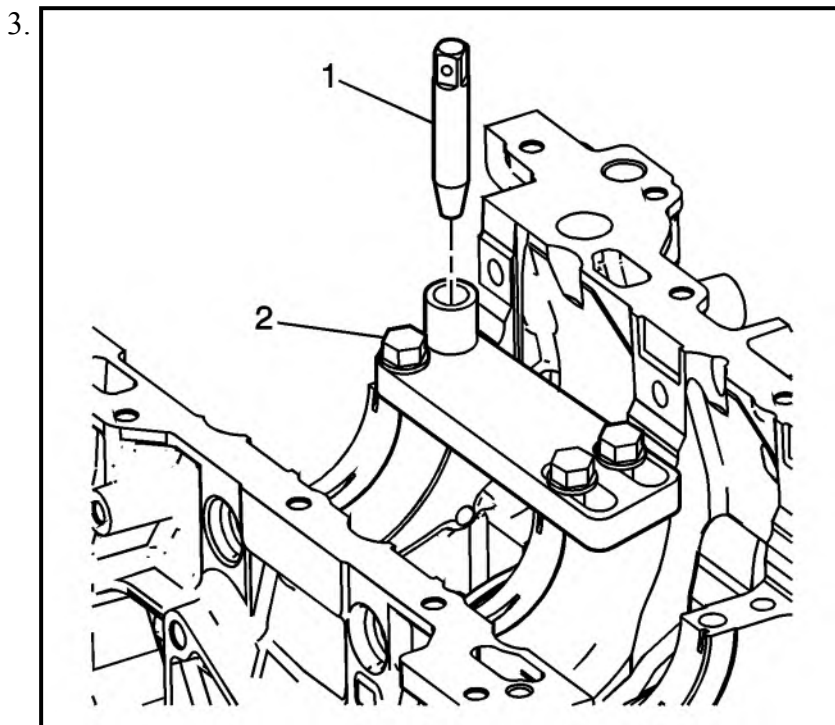
- Ensure the fixture plate is installed during the machining and installation processes of the insert.
- The use of a cutting type fluid, WD 40[®] or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cutting fluid.

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.



Position the fixture plate (3) with the bushing (2) installed over the crankshaft main cap bolt hole to be repaired.

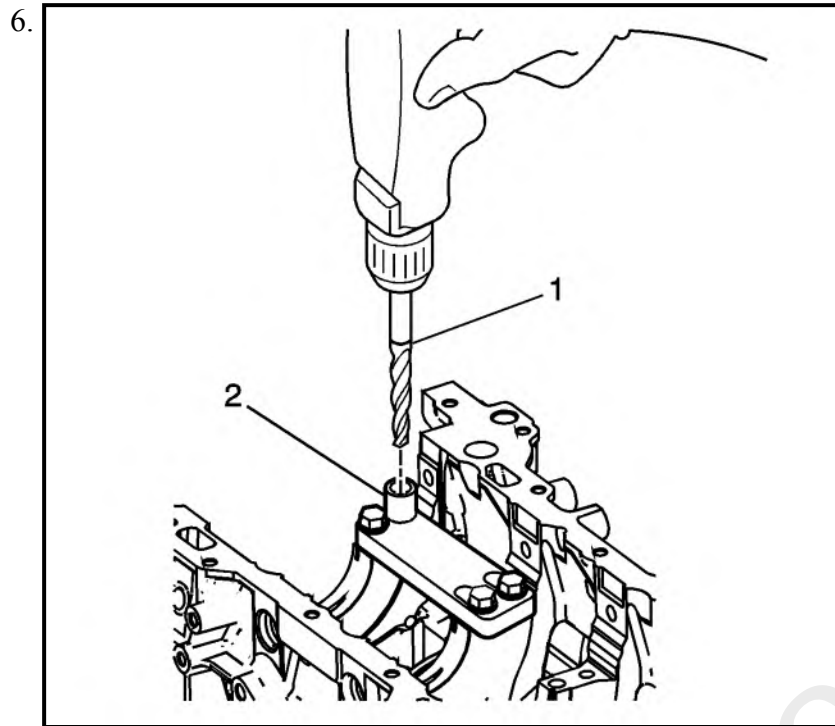
2. Loosely install the fixture plate bolts (1) into the remaining crankshaft main cap bolt holes.



Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.

4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).

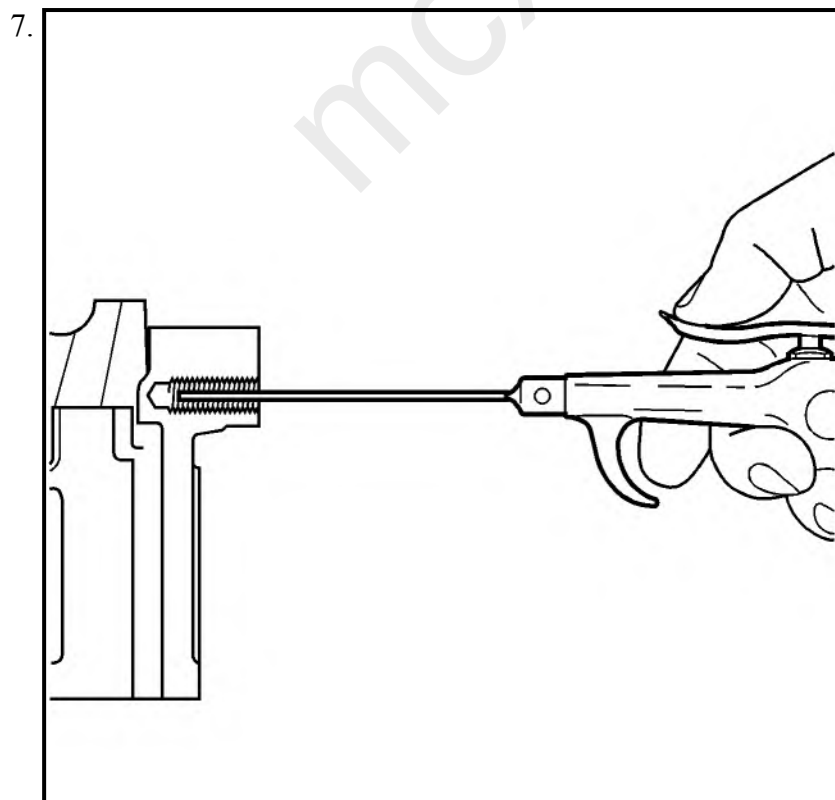
5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.



NOTE:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).

Drill out the threads of the damaged hole.

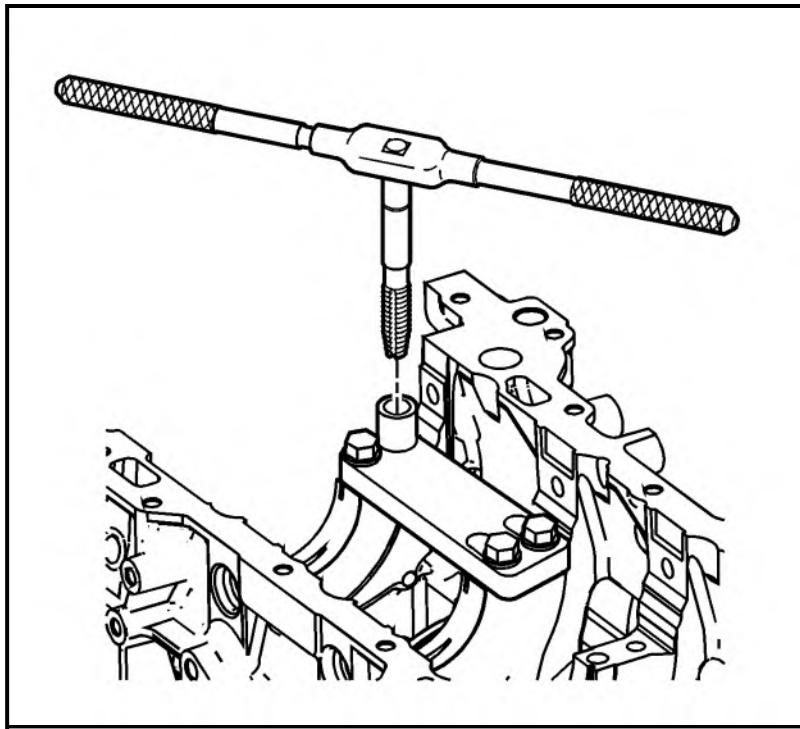


NOTE:

All chips must be removed from the drilled hole prior to tapping.

Using compressed air, clean out any chips.

8.

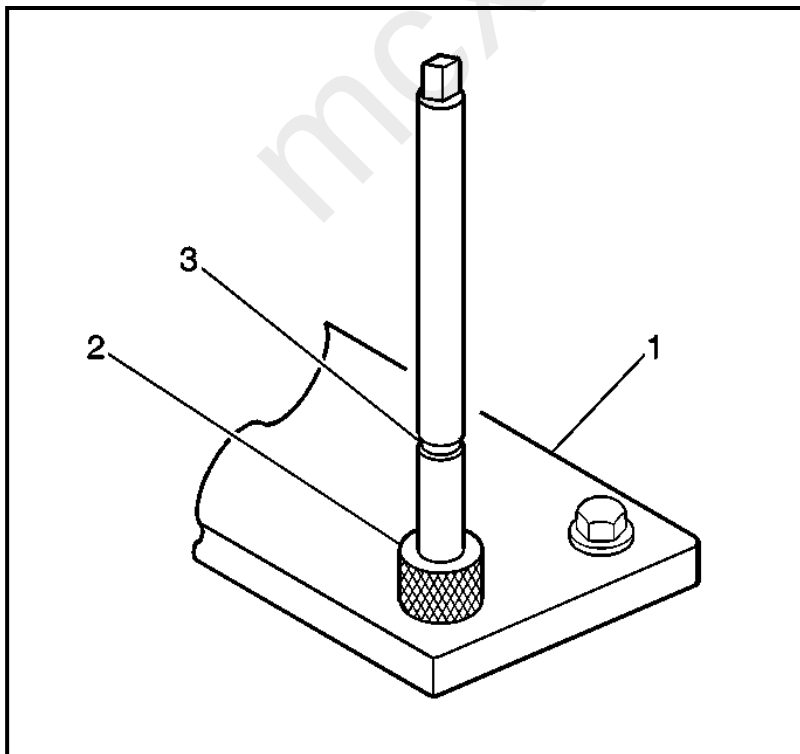


NOTE:

- Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.

Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

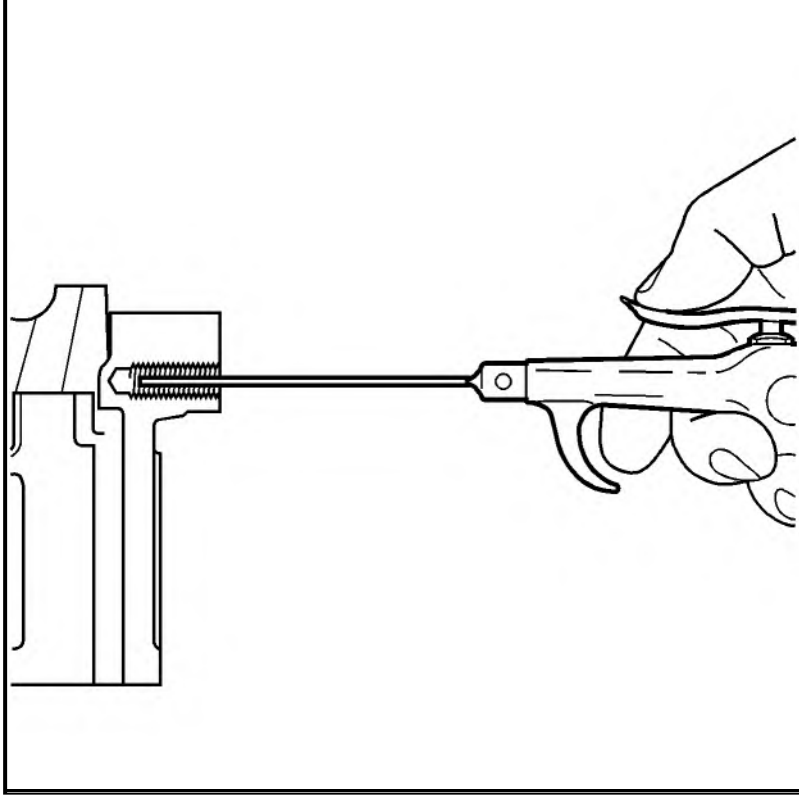
9.



In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

10.

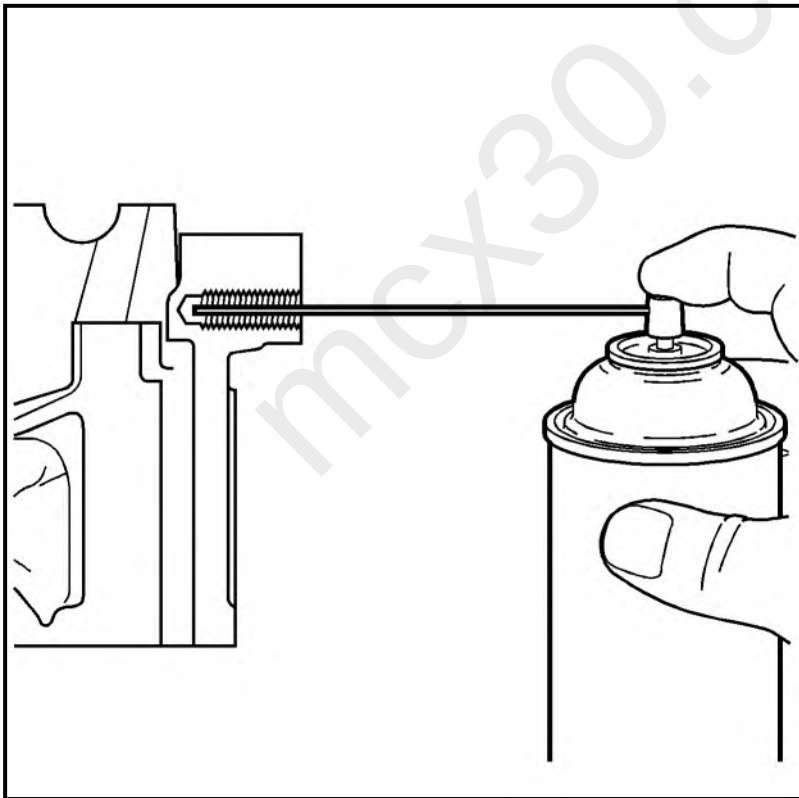




NOTE: All chips must be removed from the tapped hole prior to insert installation.

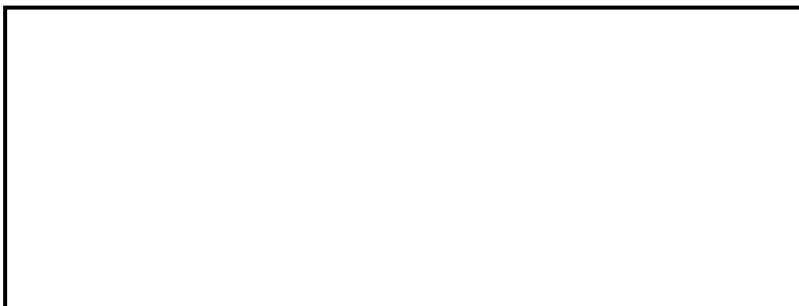
Using compressed air, clean out any chips.

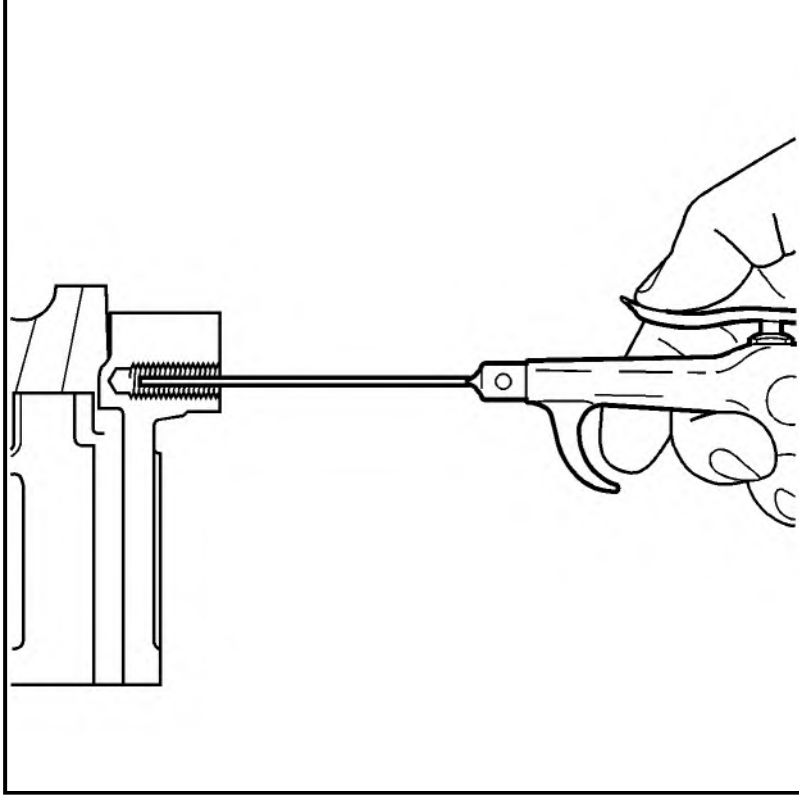
11.



Spray cleaner into the tapped hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cleaner.

12.

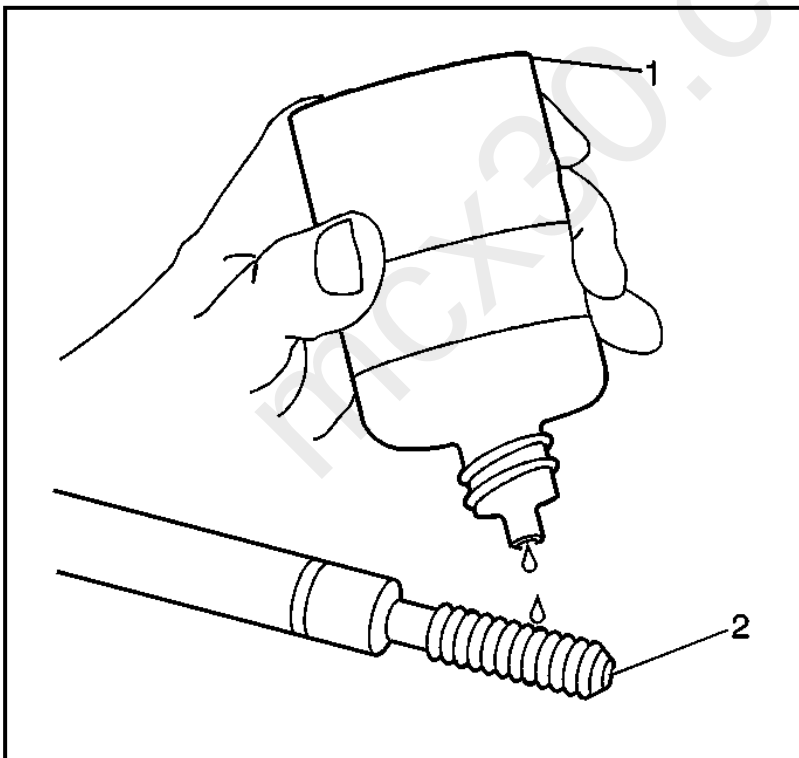




NOTE: All chips must be removed from the tapped hole prior to insert installation.

Using compressed air, clean out any chips.

13.



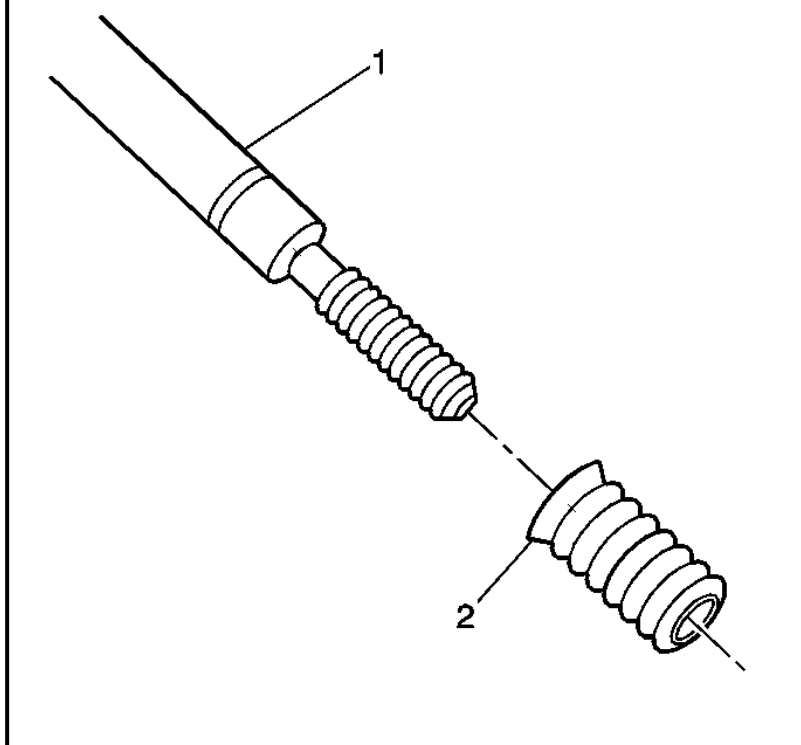
NOTE:

- Do not remove the fixture plate, ensure the fixture plate is installed during the installation process of the insert.
- Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1).

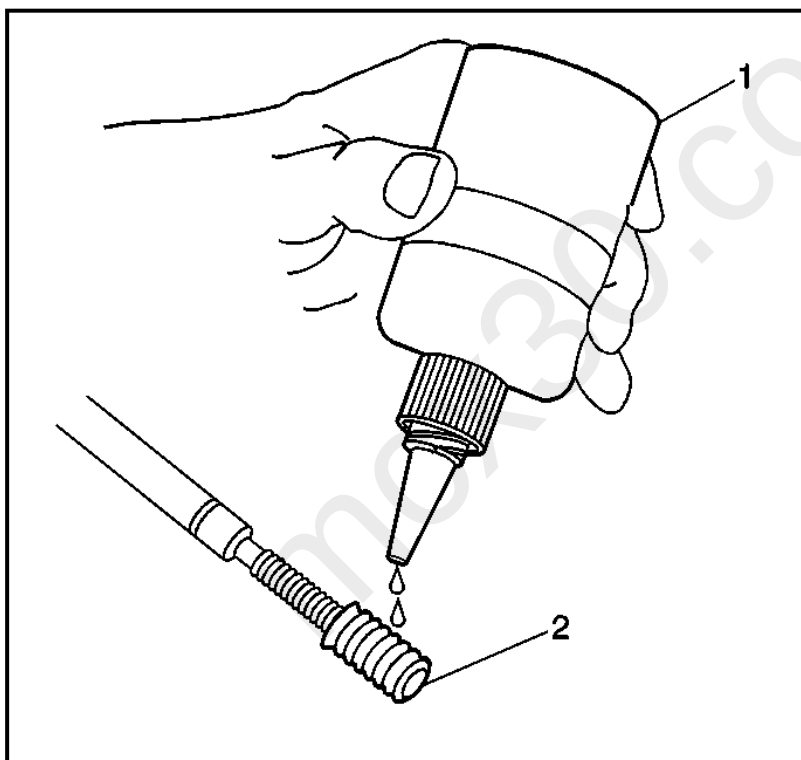
14.





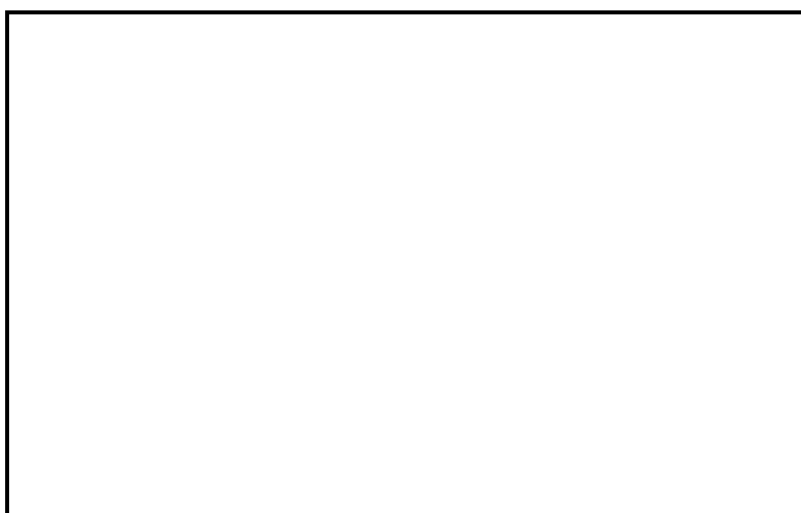
Install the insert (2) onto the driver installation tool (1).

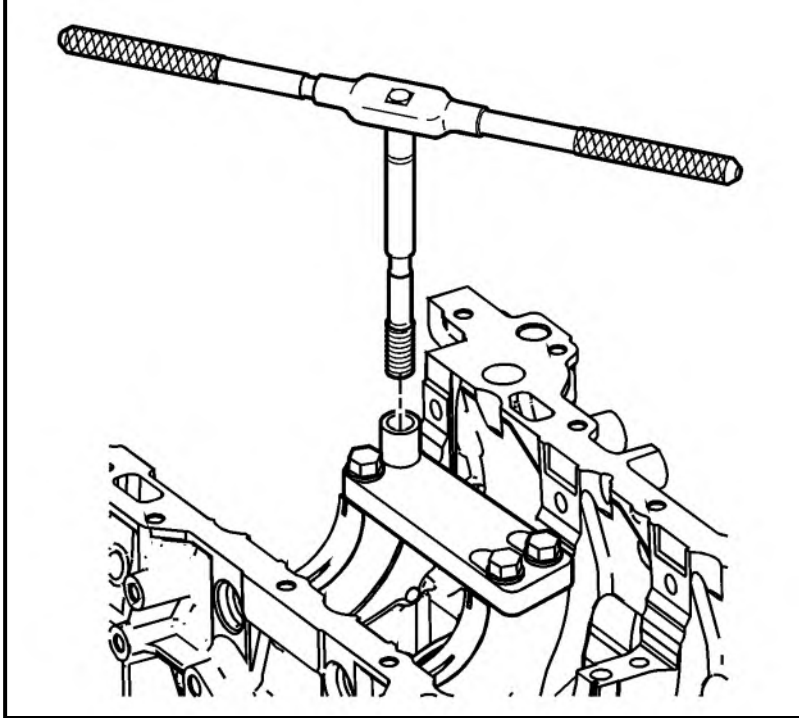
15.



Apply threadlock sealant, EN 42385-109, LOCTITE 277^Å,^Å®, or equivalent (1) to the insert OD threads (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

16.





Install the insert and installation driver into the tapped hole by hand only.

17. Start the insert into the threaded hole.

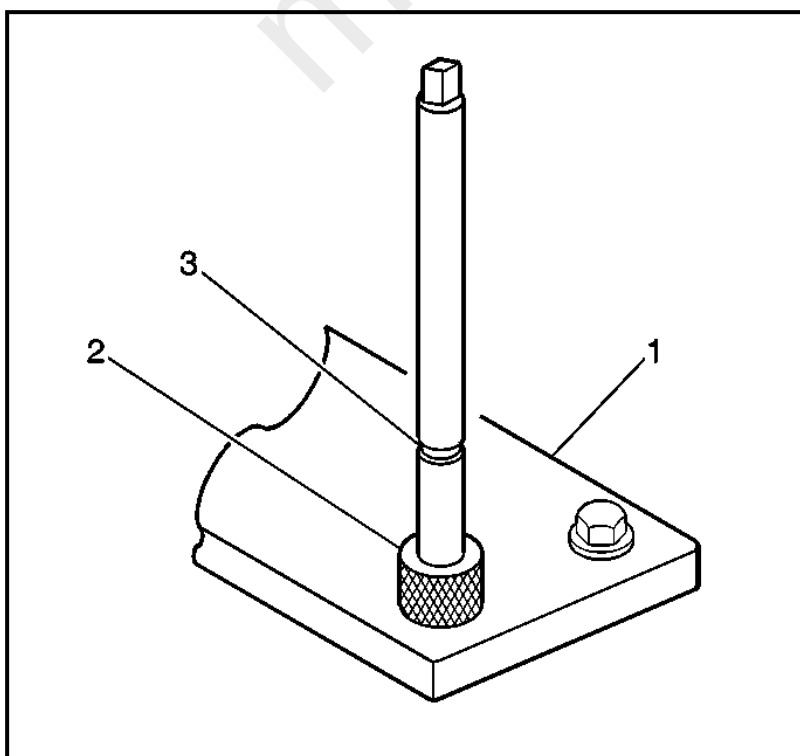
NOTE: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

18. Install the insert until the flange of the insert contacts the counterbored surface.

NOTE: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

19. Continue to rotate the driver installation tool through the insert.

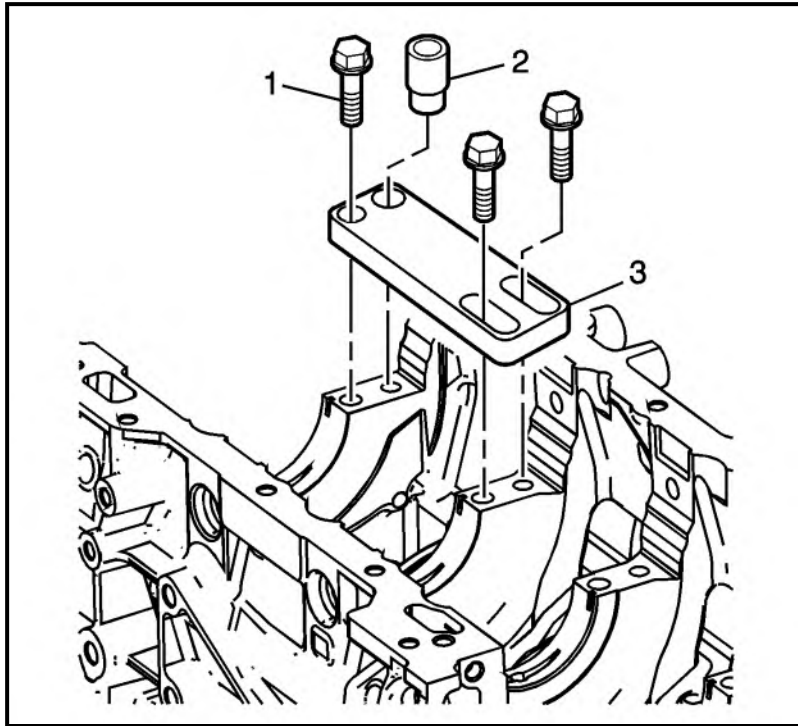
- 20.



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

21. Inspect the insert for proper installation into the tapped hole.

22.

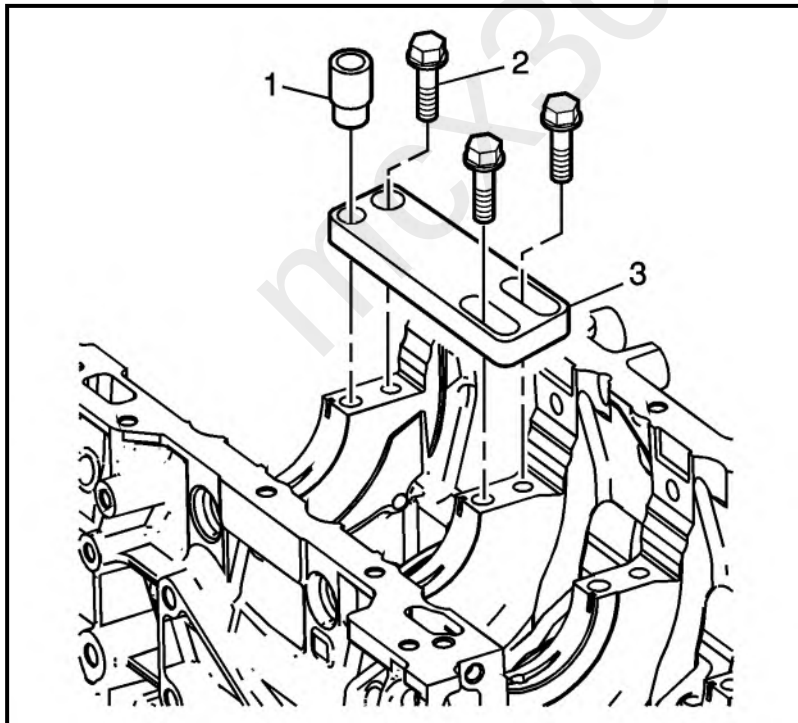


Remove the fixture plate bolts (1).

23. Remove the fixture plate (3) and bushing (2).

Inboard Bolt Holes

1.



WARNING: Refer to [Safety Glasses Warning](#) .

NOTE:

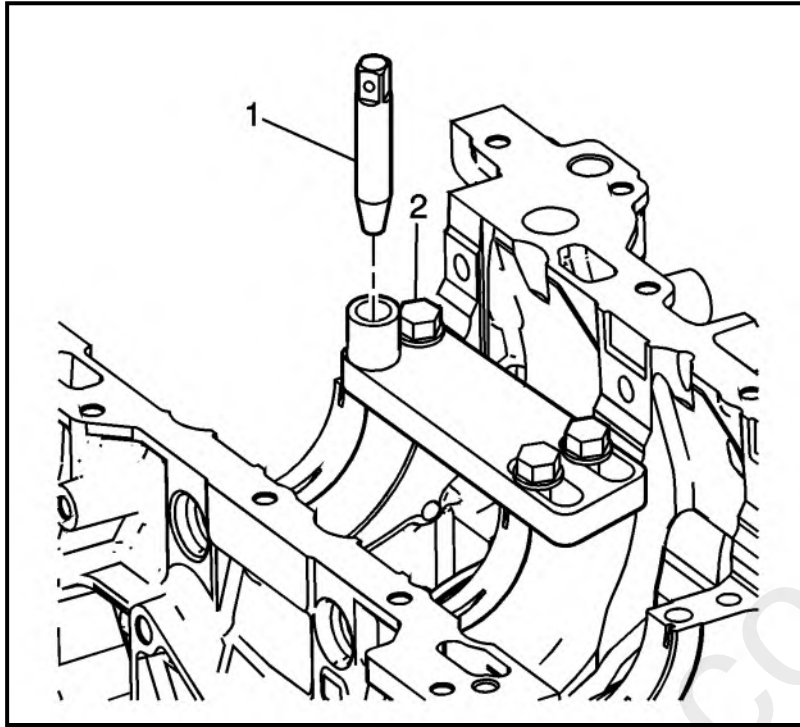
- Ensure the fixture plate is installed during the machining and installation processes of the insert.
- The use of a cutting type fluid, WD 40[®] or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cutting fluid.

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

Position the fixture plate (3) with the bushing (1) installed over the crankshaft main cap bolt hole to be repaired.

2. Loosely install the fixture plate bolts (2) into the remaining crankshaft main cap bolt holes.

3.

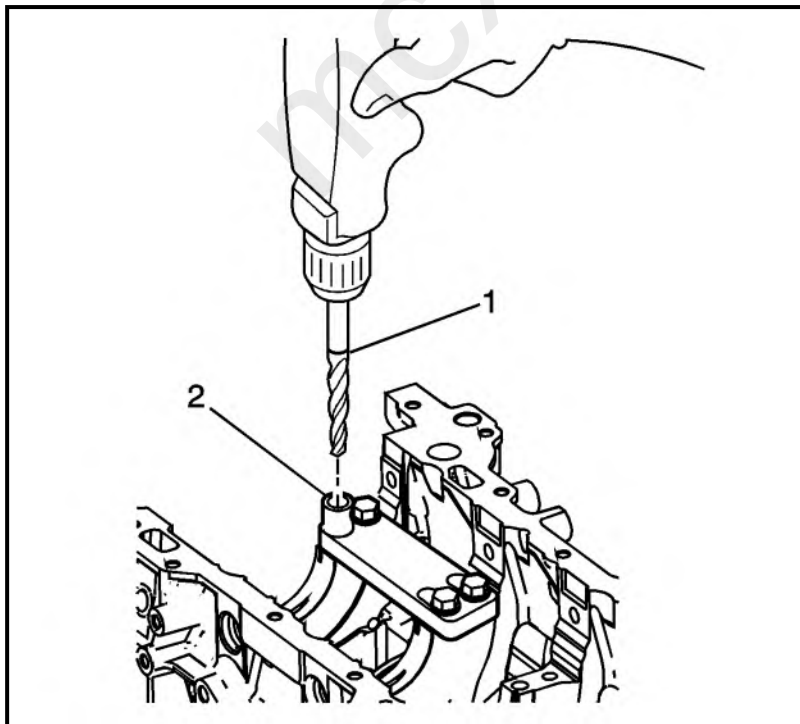


Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.

4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).

5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.

6.

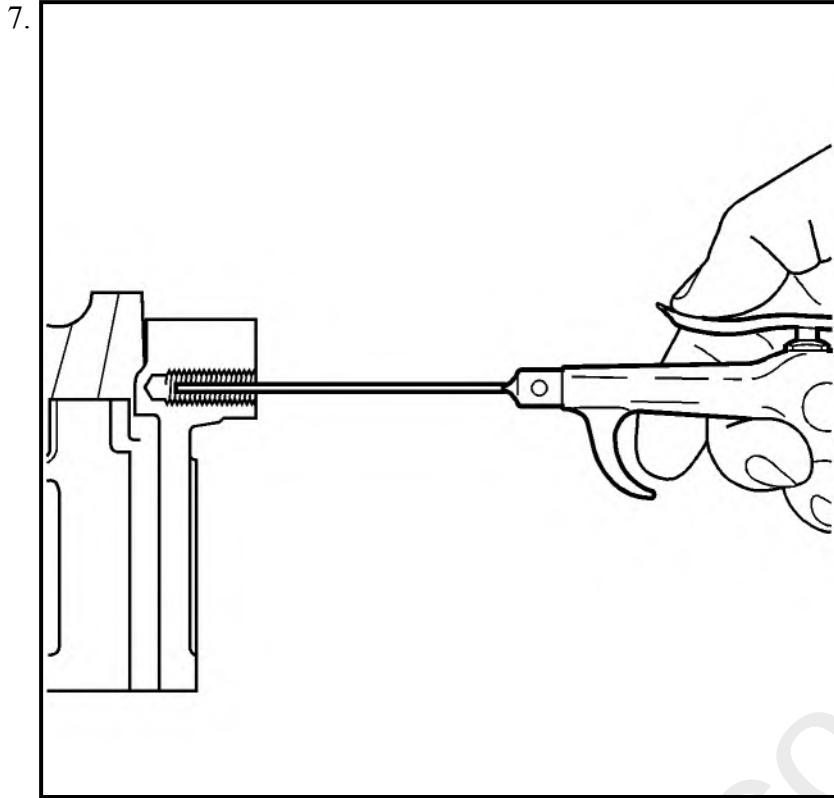


NOTE:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.

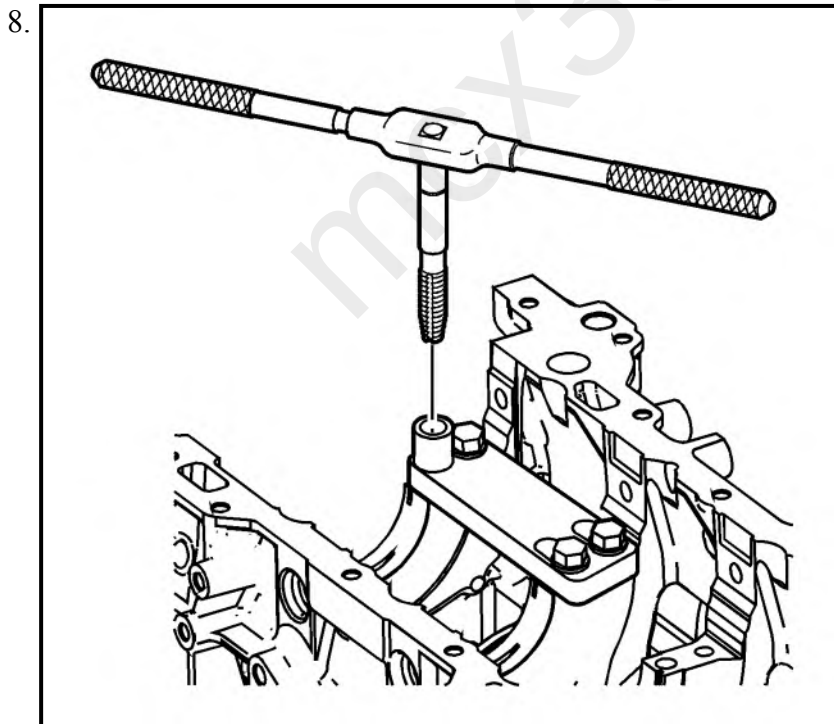
- Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).

Drill out the threads of the damaged hole.



NOTE: All chips must be removed from the drilled hole prior to tapping.

Using compressed air, clean out any chips.

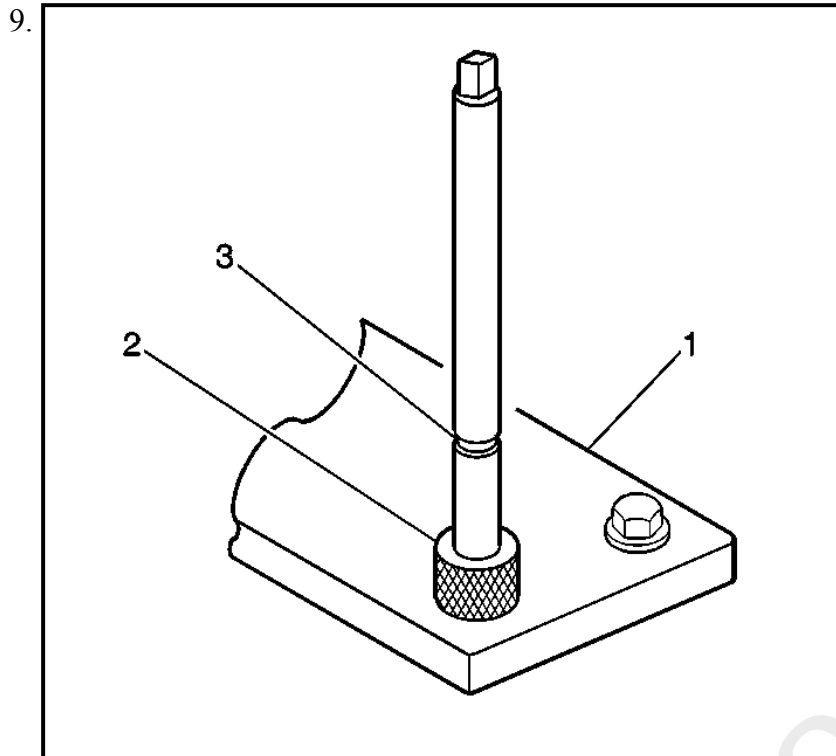


NOTE:

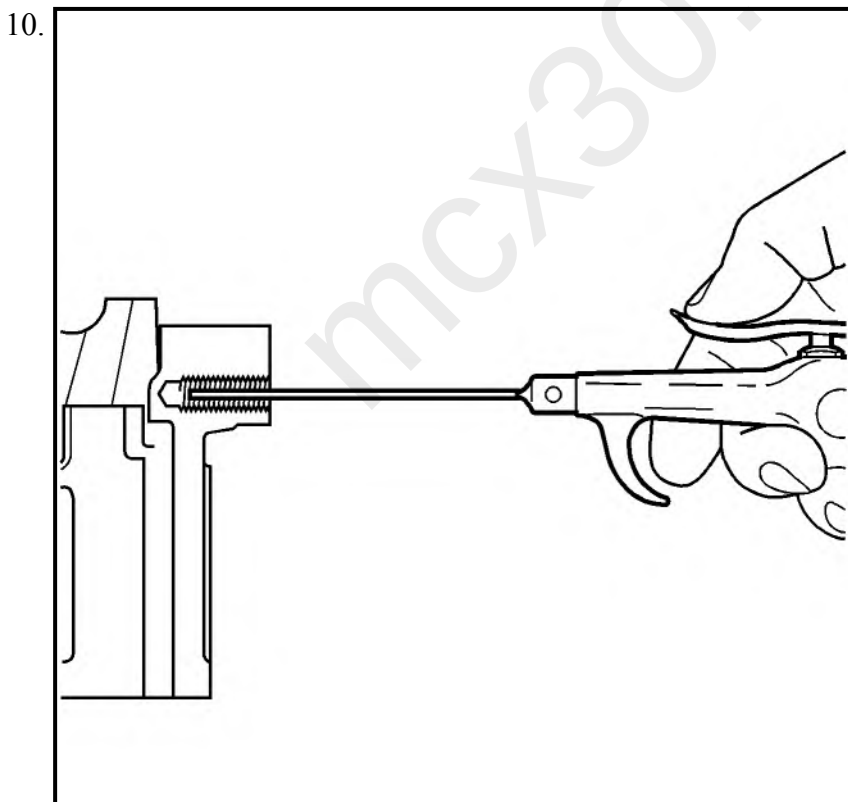
- Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.

- Ensure the tap has created full threads at least to the depth equal to the insert length.

Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

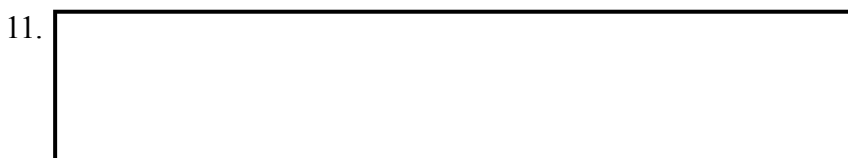


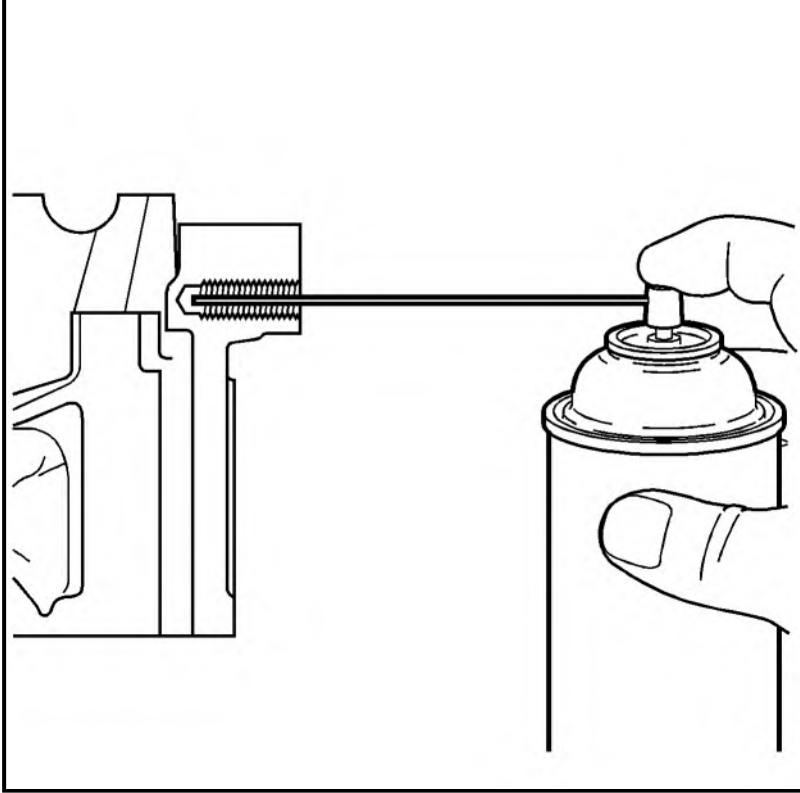
In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).



NOTE: All chips must be removed from the tapped hole prior to insert installation.

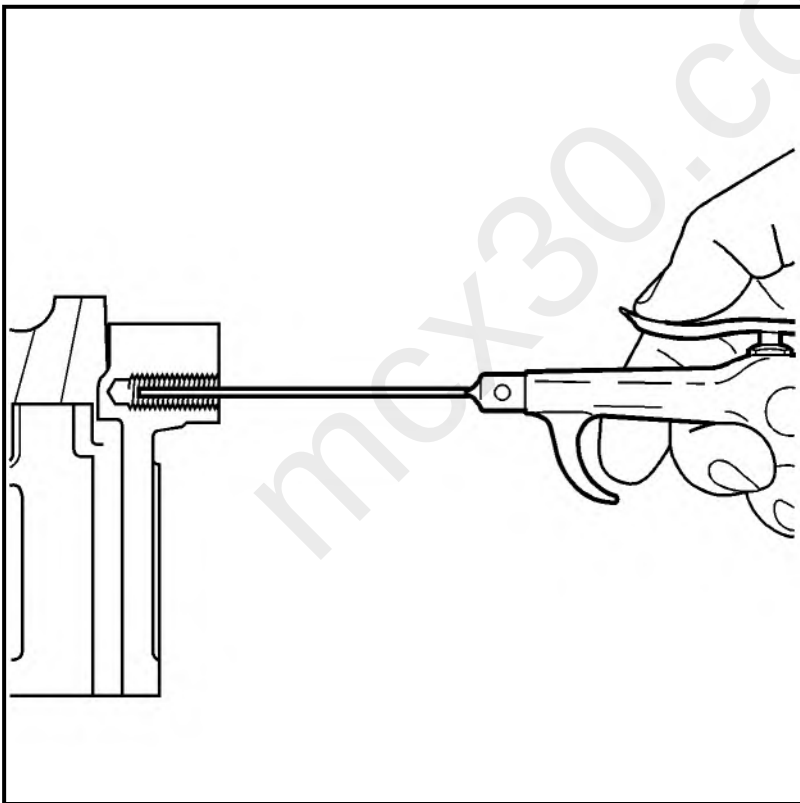
Using compressed air, clean out any chips.





Spray cleaner into the tapped hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended cleaner.

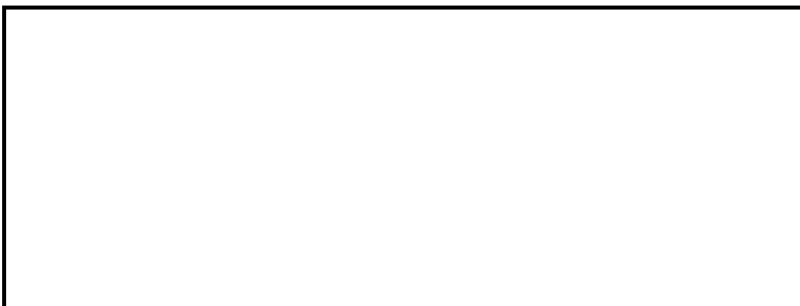
12.

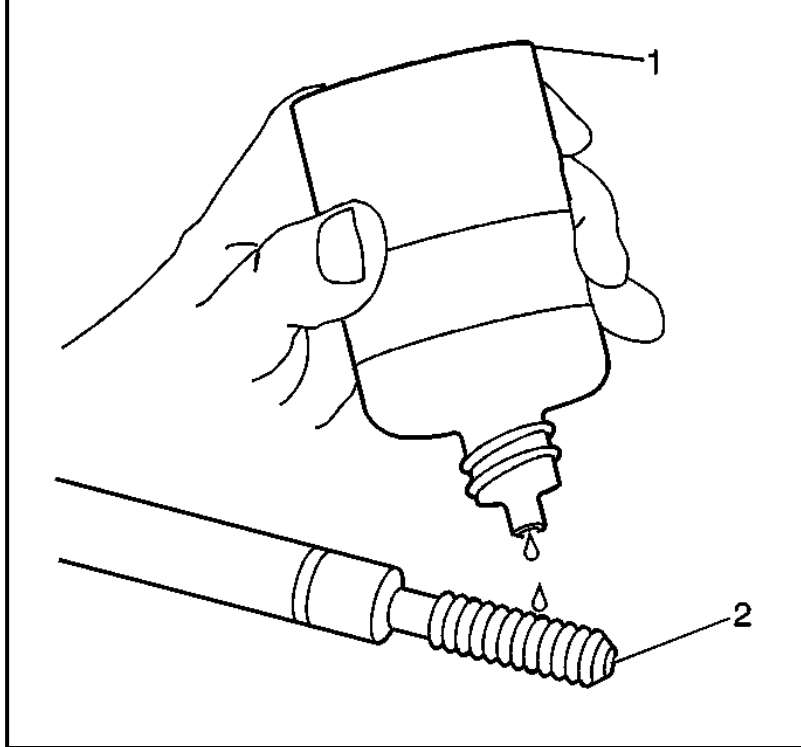


NOTE: All chips must be removed from the tapped hole prior to insert installation.

Using compressed air, clean out any chips.

13.



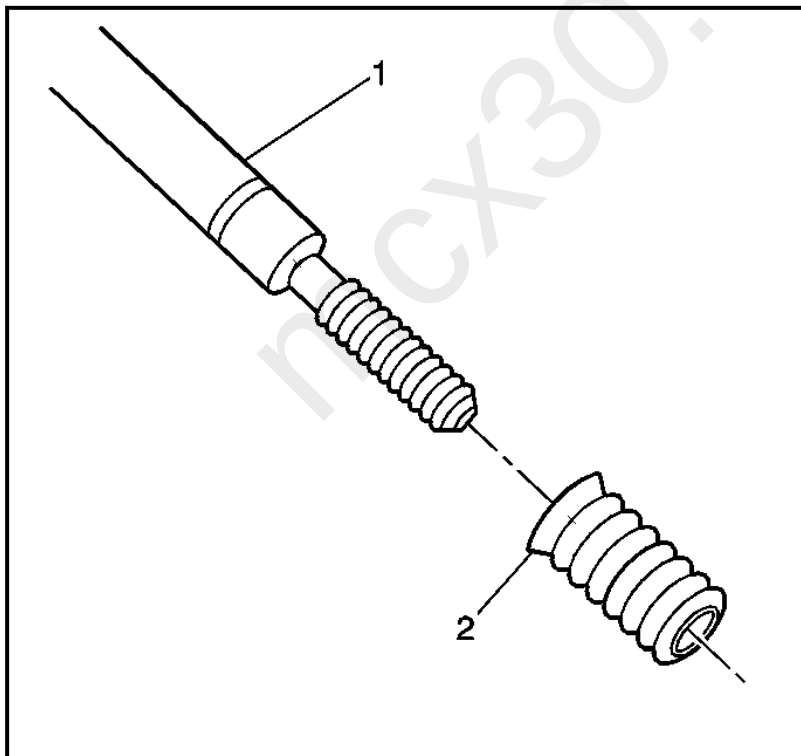


NOTE:

- Do not remove the fixture plate, ensure the fixture plate is installed during the installation process of the insert.
- Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1).

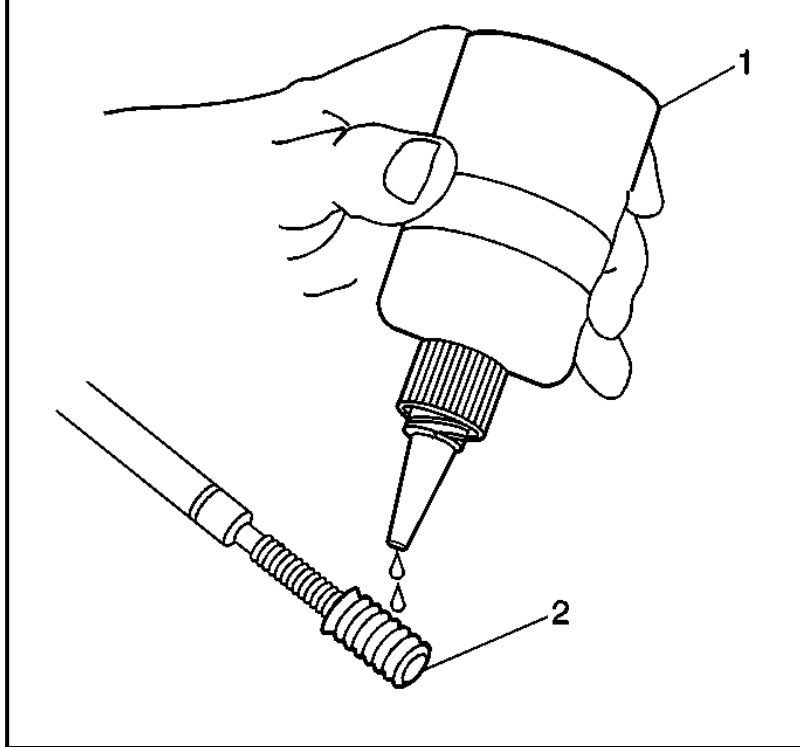
14.



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

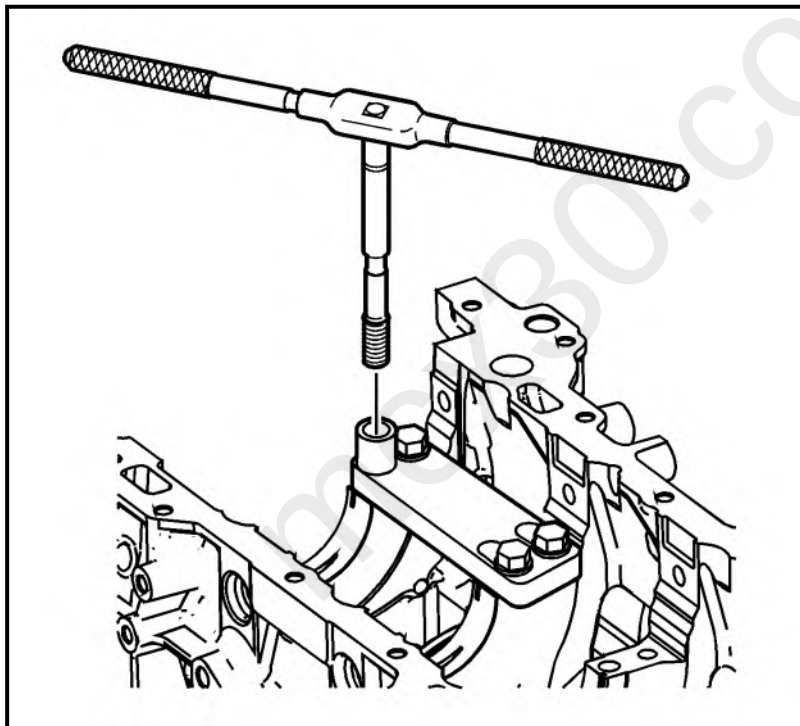
15.





Apply threadlock sealant, EN 42385-109, LOCTITE 277^Å,^Å®, or equivalent (1) to the insert OD threads (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

16.



Install the insert and installation driver into the tapped hole by hand only.

17. Start the insert into the threaded hole.

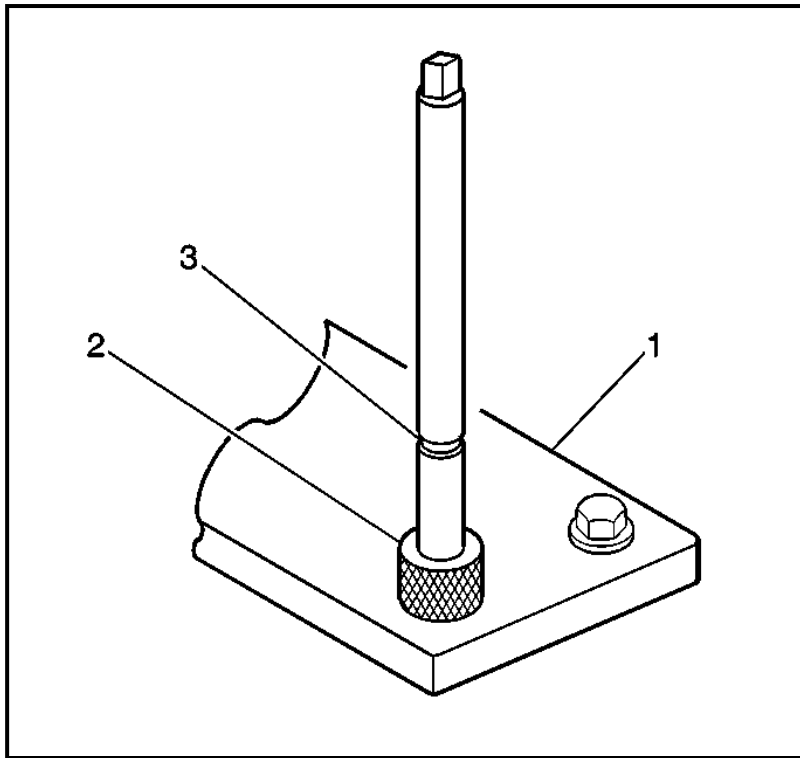
NOTE: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

18. Install the insert until the flange of the insert contacts the counterbored surface.

NOTE: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

19. Continue to rotate the driver installation tool through the insert.

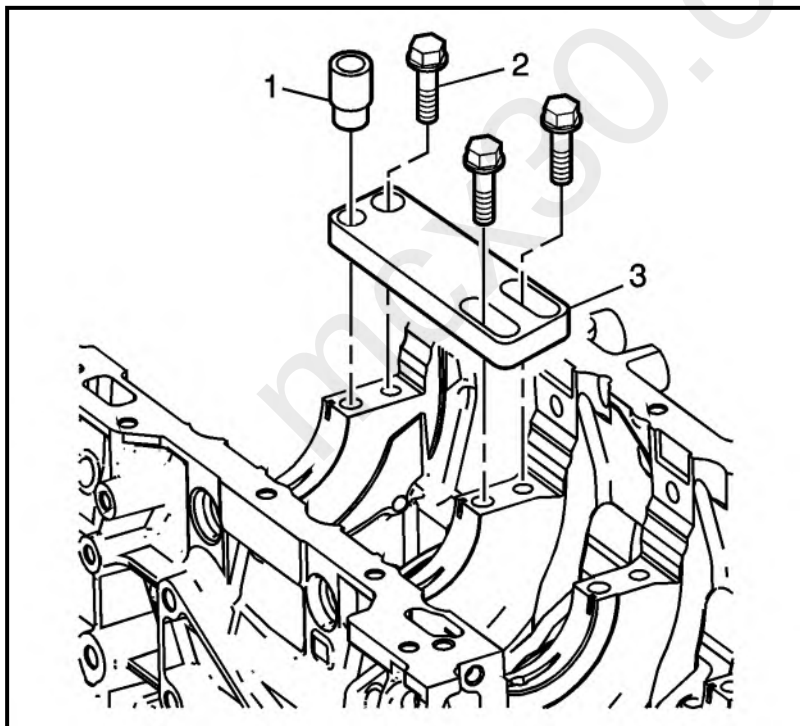
20.



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

21. Inspect the insert for proper installation into the tapped hole.

22.



Remove the fixture plate bolts (2).

23. Remove the fixture plate (3) and bushing (1).

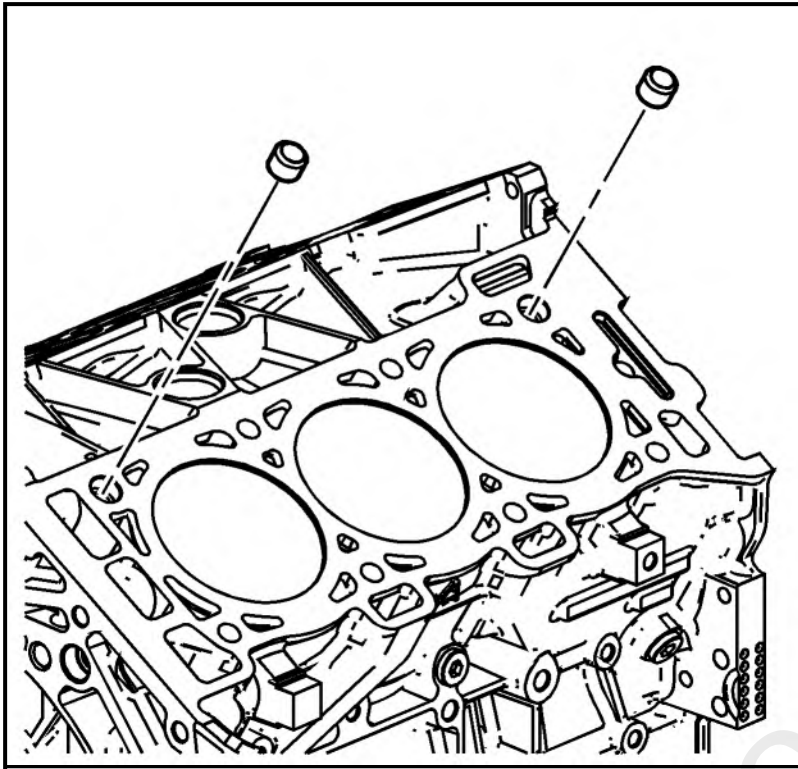
SERVICE PRIOR TO ASSEMBLY

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position, and direction.

- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

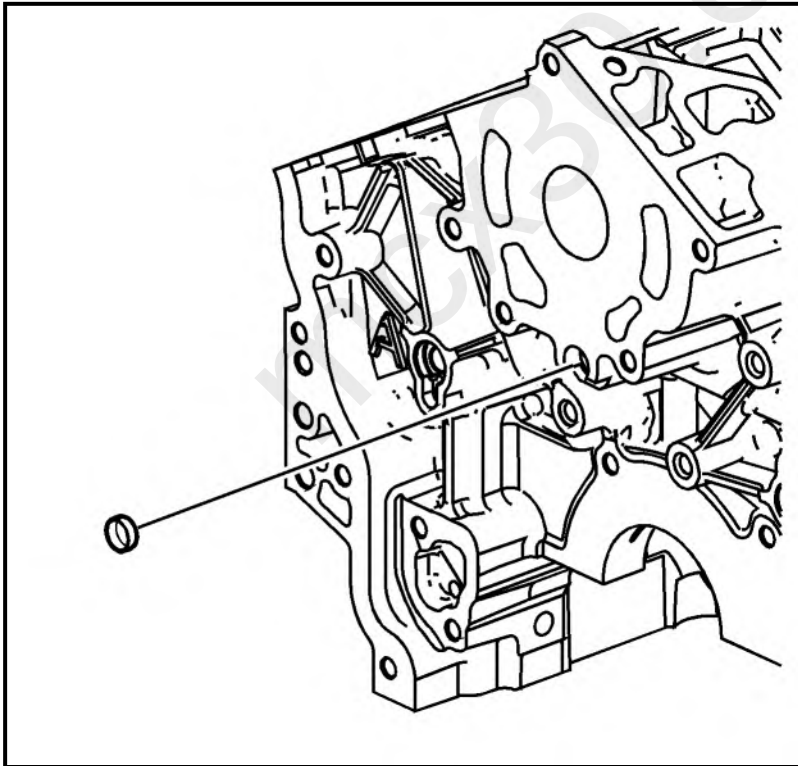
ENGINE BLOCK ASSEMBLE

1.



Install the cylinder block-to-cylinder head alignment dowels.

2.

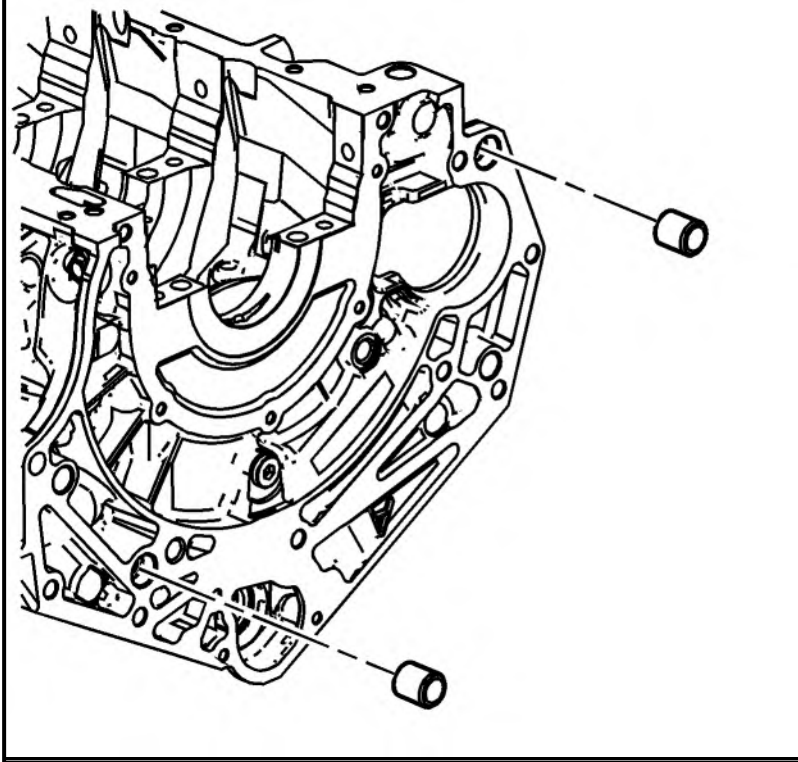


Install the NEW front oil gallery expansion plug.

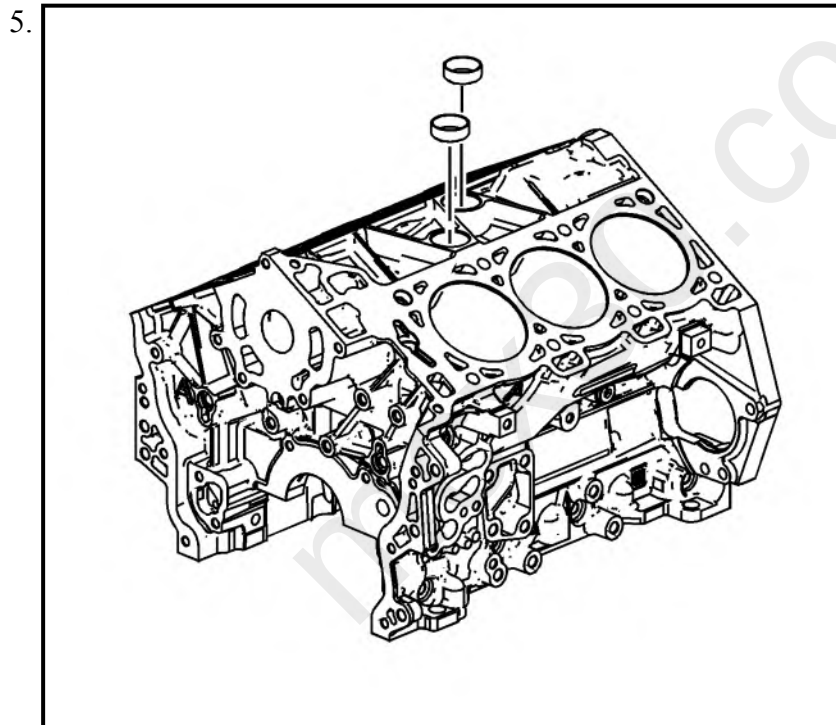
3. Ensure the NEW front oil gallery expansion plug is installed to the proper depth.

4.





Install the cylinder block-to-transmission alignment dowels.



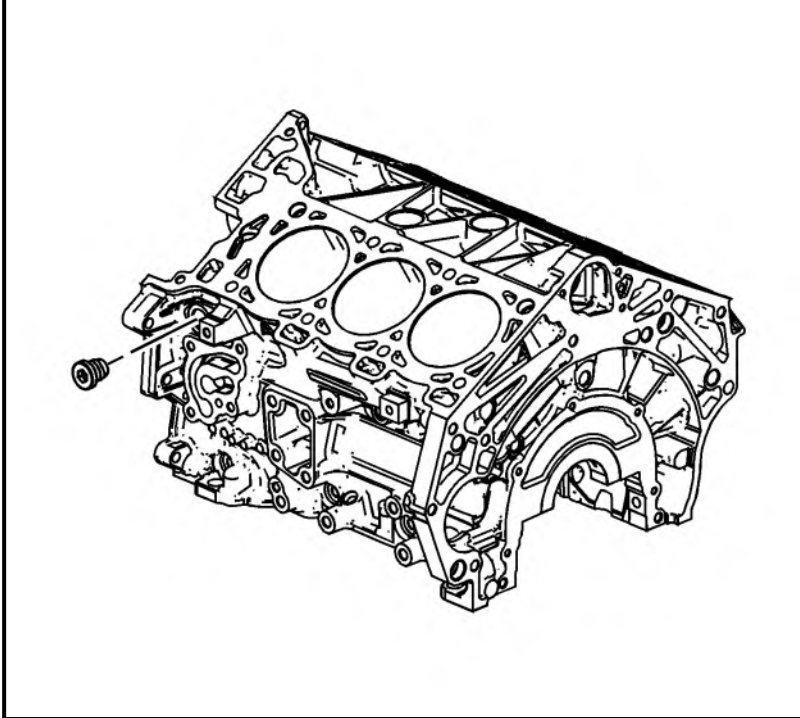
Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

Apply the RTV sealant on the NEW coolant expansion plugs. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

6. Install the NEW coolant expansion plugs.

7. Ensure the NEW coolant expansion plugs are installed to the proper depth.



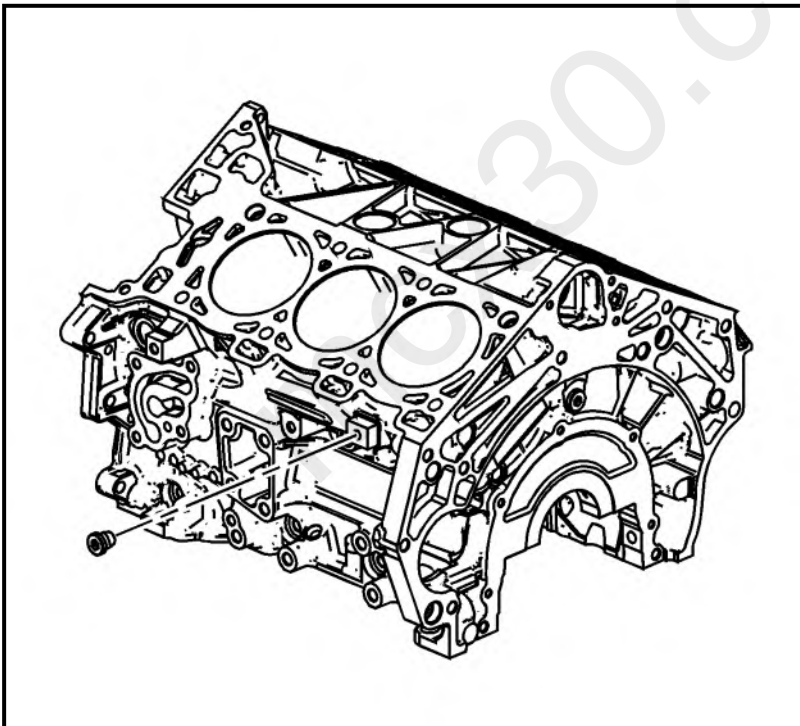


Apply thread sealant on the threads of the M20 left side oil gallery threaded plug. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

CAUTION: Refer to [Fastener Caution](#) .

9. Install the M20 left side oil gallery threaded plug and tighten to 75 N.m (55 lb ft).

10.

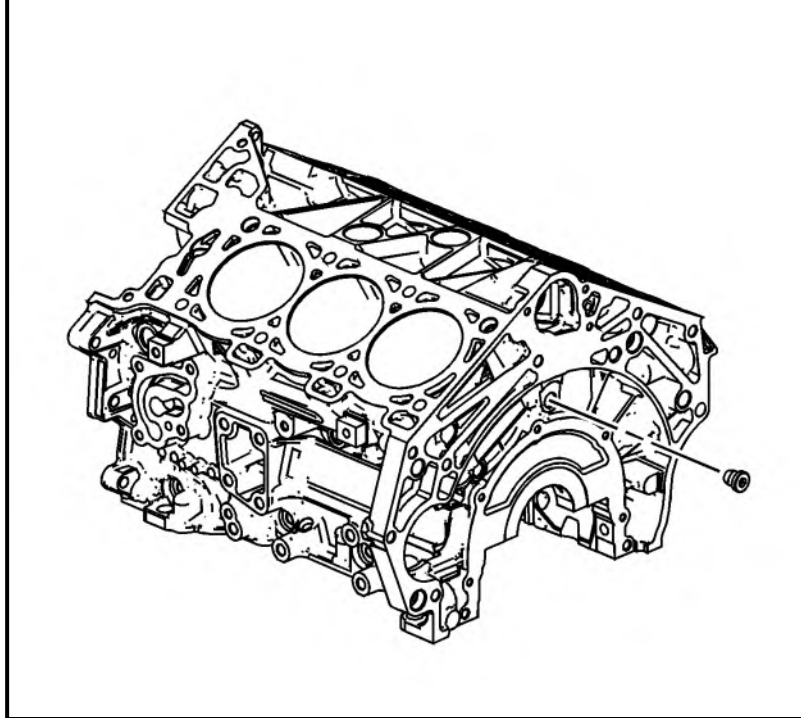


Apply thread sealant on the threads of the M14 left side coolant drain threaded plug. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

11. Install the M14 left side coolant drain threaded plug and tighten to 50 N.m (37 lb ft).

12.

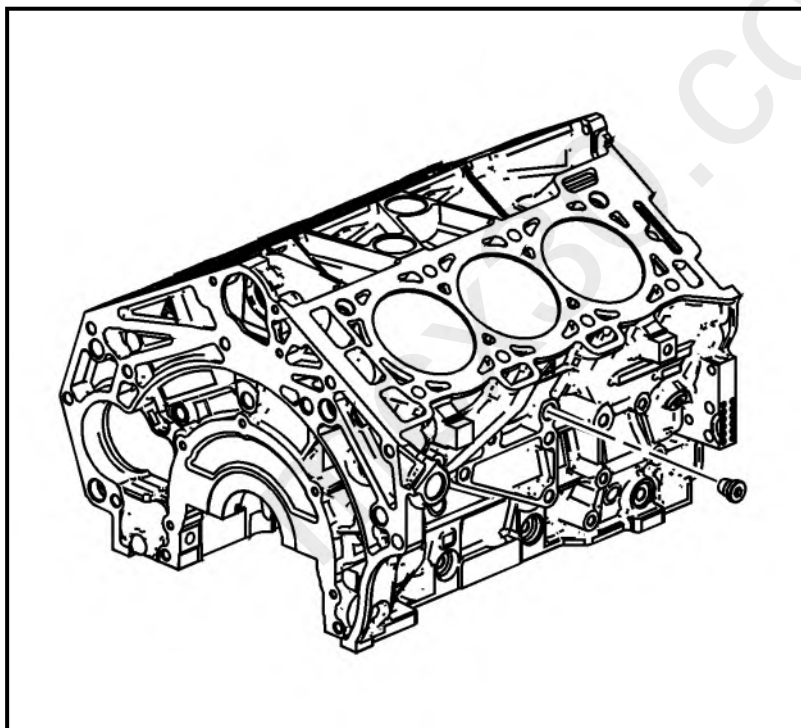




Apply thread sealant on the threads of the M14 rear oil gallery threaded plug. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

13. Install the M14 rear oil gallery threaded plug and tighten to 50 N.m (37 lb ft).

14.

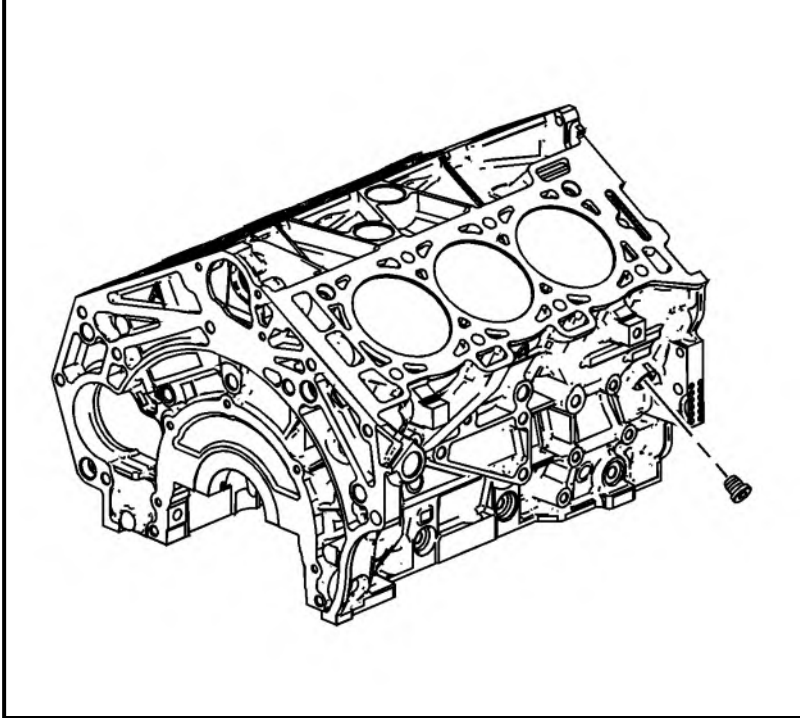


Apply thread sealant on the threads of the M14 right side coolant drain threaded plug. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

15. Install the M14 right side coolant drain threaded plug and tighten to 50 N.m (37 lb ft).

16.

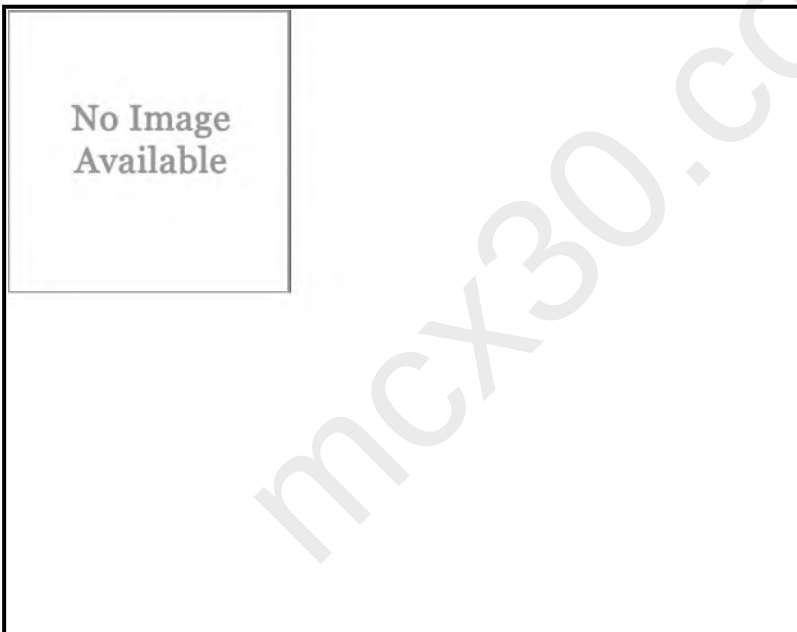




Apply thread sealant on the threads of the M14 right side oil gallery threaded plug. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.

17. Install the M14 right side oil gallery threaded plug and tighten to 50 N.m (37 lb ft).

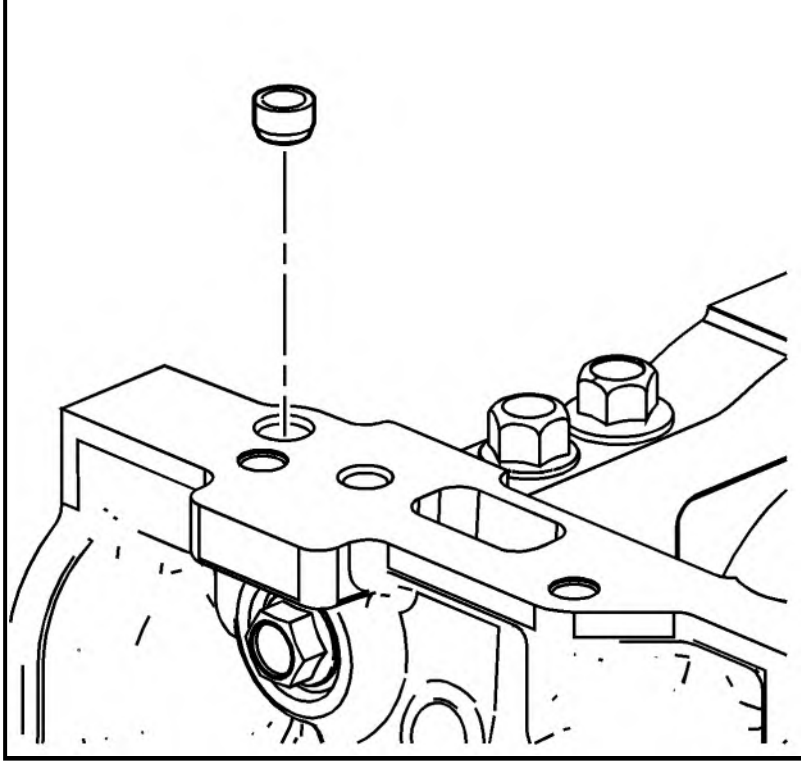
18.



Install the cylinder block-to-oil pan alignment dowels.

19.

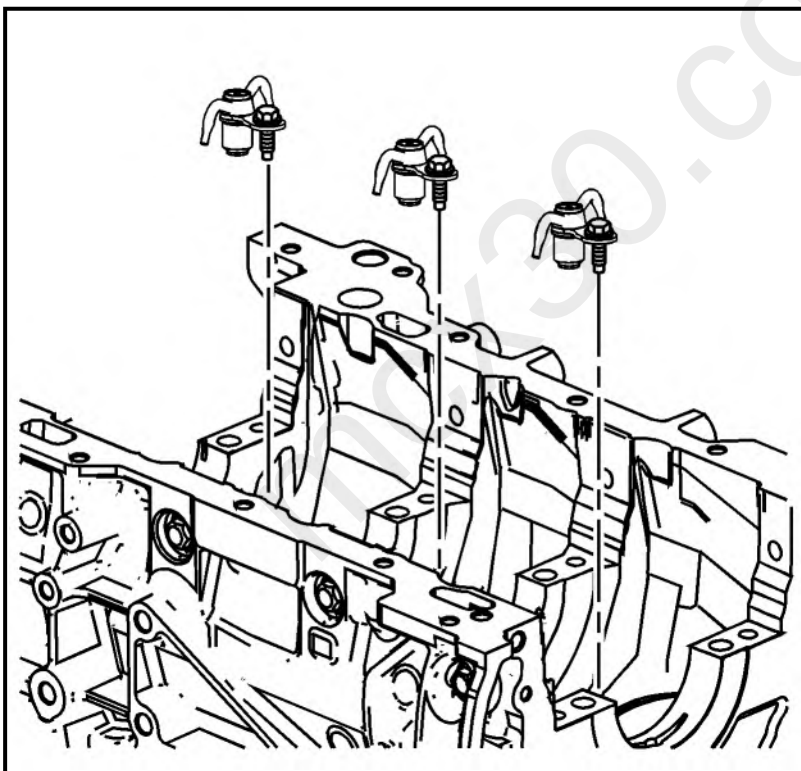




Install the NEW right front oil pan rail oil gallery expansion plug.

20. Ensure the NEW right front oil pan rail oil gallery expansion plug is installed to the proper depth.

21.

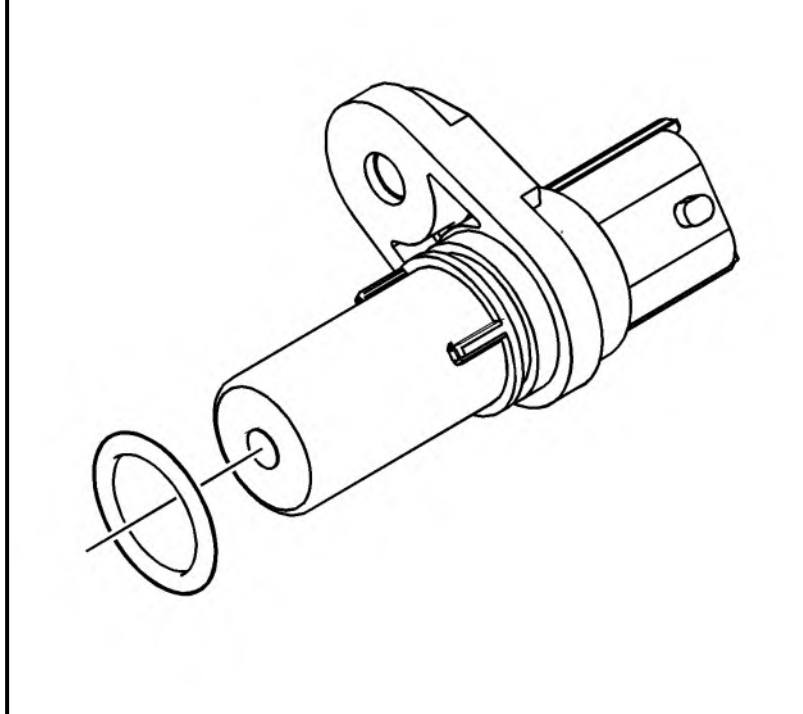


Install the oil jets.

22. Install the oil jet bolts and tighten to 10 N.m (89 lb in).

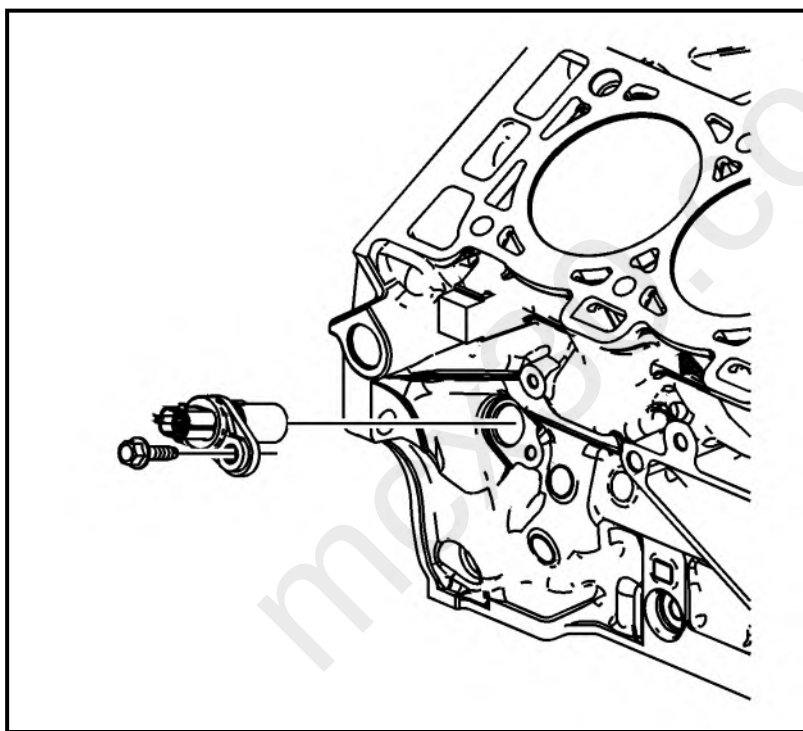
23.





Install the NEW crankshaft position sensor O-ring, if damaged.

24.

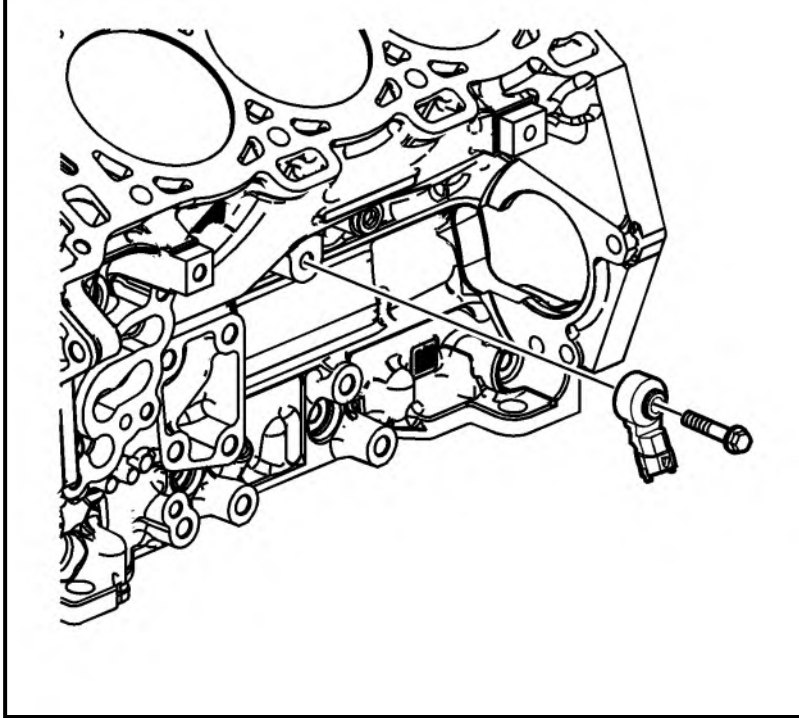


Install the crankshaft position sensor.

25. Install the crankshaft position sensor bolt and tighten to 10 N.m (89 lb in).

26.



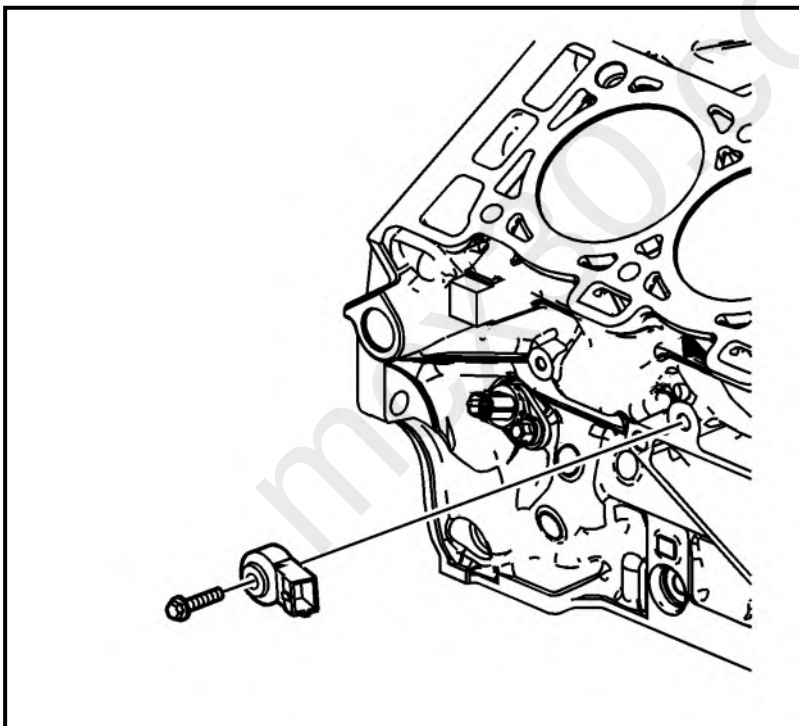


Install the left knock sensor to the cylinder block, as shown.

27. Install the left knock sensor bolt and tighten to 25 N.m (18 lb ft).

28. Ensure proper sensor orientation.

29.



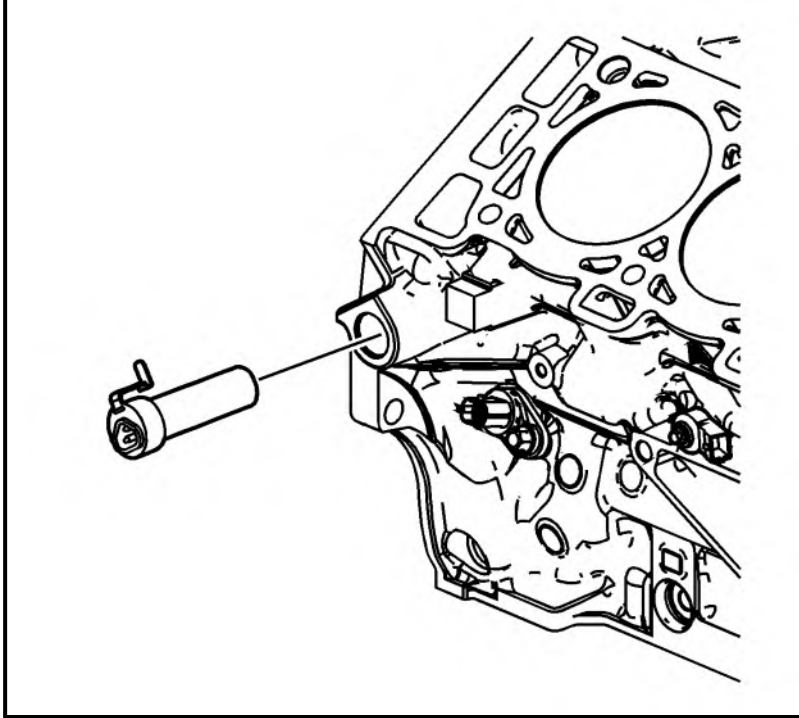
Install the right knock sensor to the cylinder block, as shown.

30. Install the right knock sensor bolt and tighten to 25 N.m (18 lb ft).

31. Ensure proper sensor orientation.

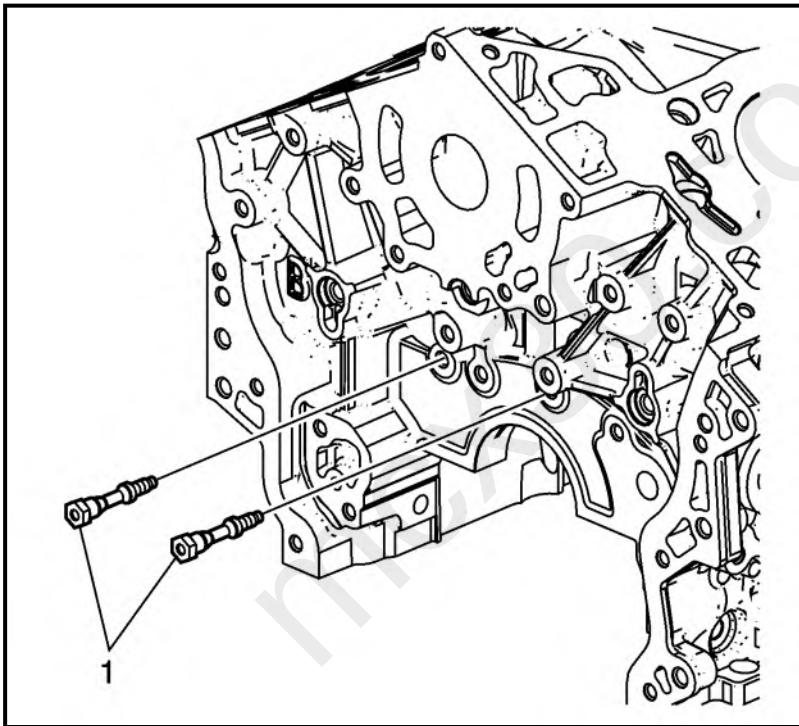
32.





Install the block heater cartridge, if equipped.

33.



Install the engine front cover studs (1) and tighten to 15 N.m (11 lb ft).

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- **GE-6125-1B** Slide Hammer Adapter
- **EN-45059** Angle Meter
- **EN-49102** Crankshaft Bearing Cap Remover

Equivalent regional tools: [Special Tools](#)

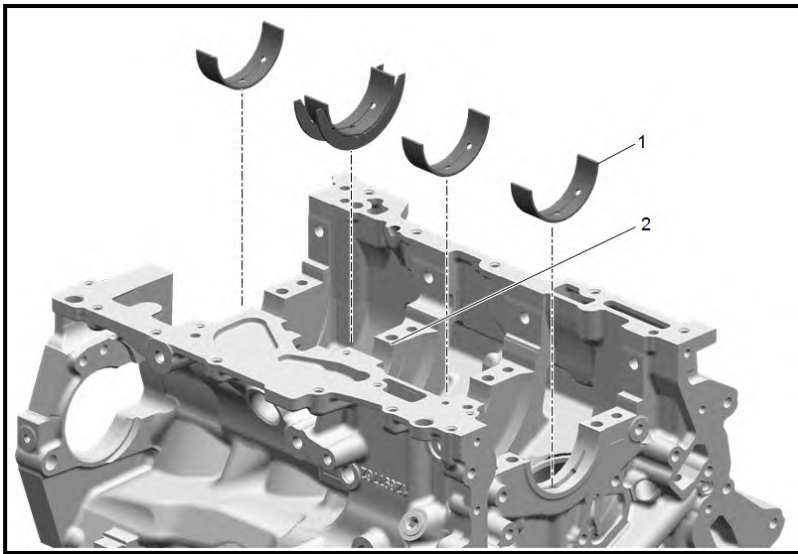
Crankshaft Bearing Installation Procedure

NOTE: If the crankshaft bearings have been used in a running engine, you must replace them with **NEW** crankshaft bearings for reassembly.

1. Clean the crankcase crank bore with a lint-free cloth.

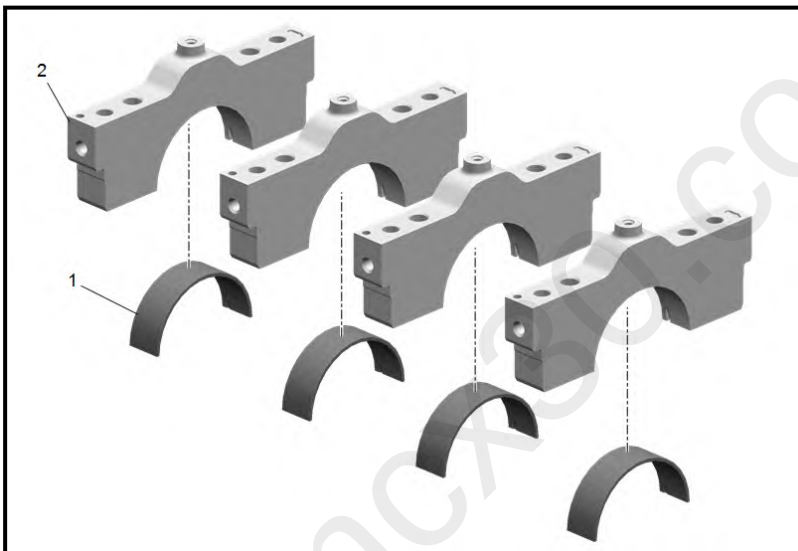
2. Clean all the oil from the backside of new bearing halves.

3.



Install the NEW upper crankshaft bearings (1) into position. The thrust bearing belongs in the number 3 journal (2). Ensure that the upper bearing insert contains the oil transfer hole and groove. Roll the bearing into position so that the lock tang engages the crank slot. The bearing must fit flush with the upper crankcase.

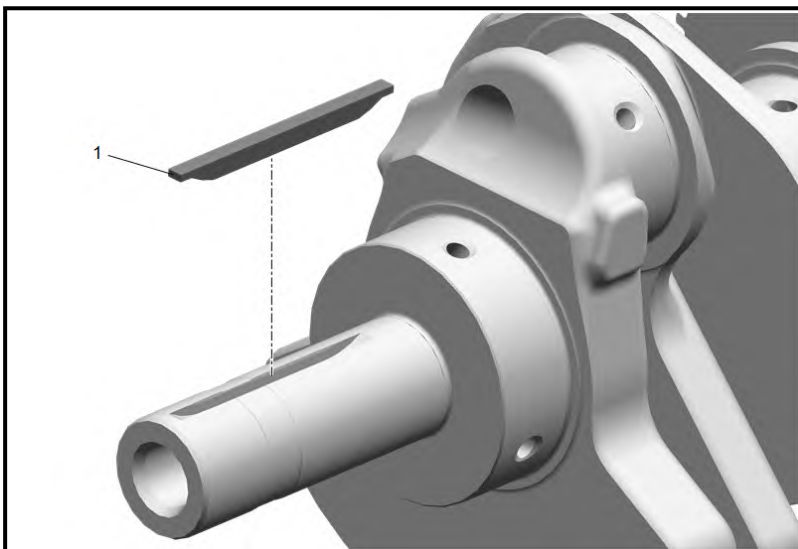
4.



Install the NEW lower crankshaft bearings (1) into position in the main bearing caps(2). The lower crankshaft bearings are identified by NO grooves or holes. The bearings (1) must fit flush with the crankshaft bearing caps (2).

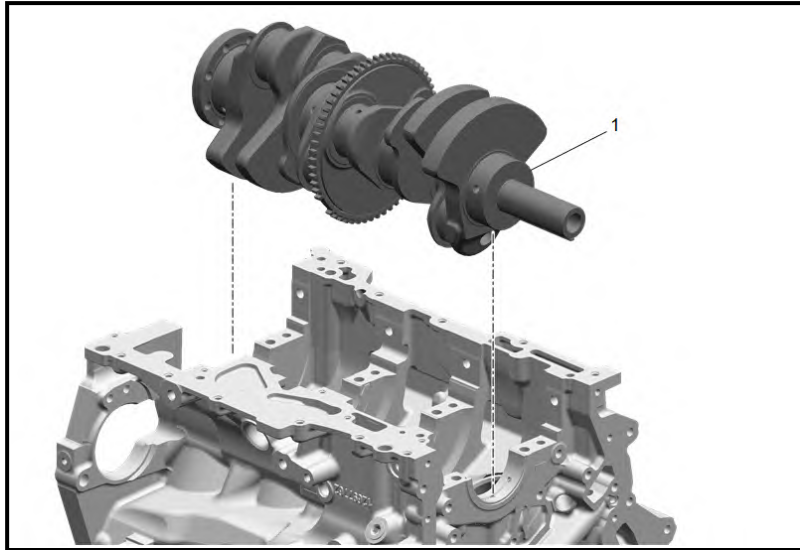
Crankshaft Installation Procedure

1.



If removed, install the crankshaft key (1). Lightly tap the key in place with a small soft face, bronze/plastic, hammer until it bottoms in the keyway.

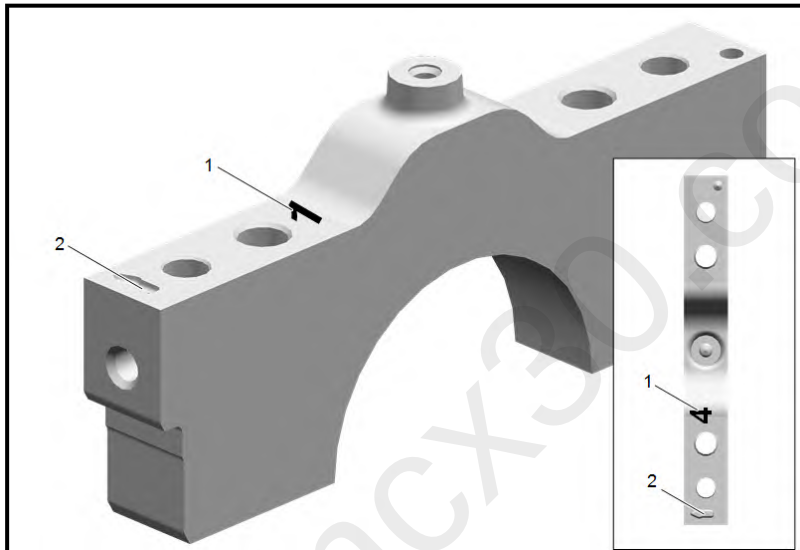
2.



Gently lower the crankshaft (1) into position in the cylinder block.

Crankshaft Bearing Clearance Measurement Procedure

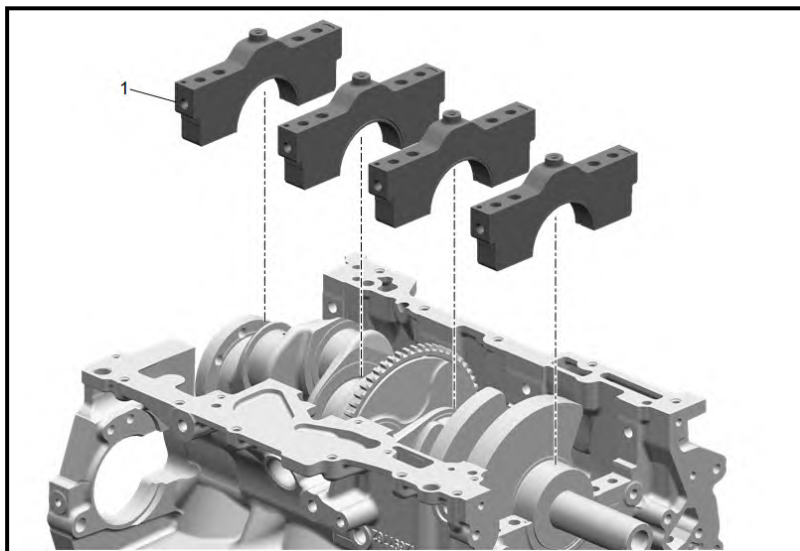
1.



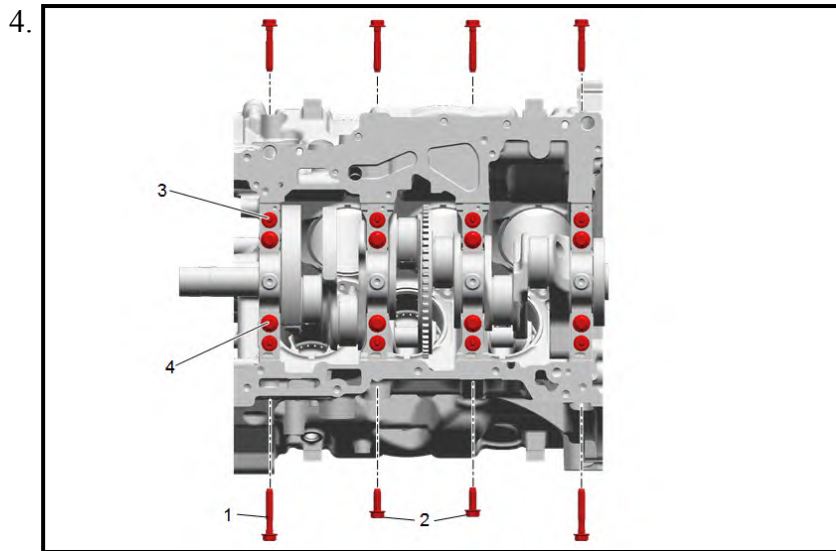
Place a length of fresh, room temperature plastic gaging material all the way across all the crankshaft bearing journals.

2. Identify the proper order of the main bearing caps. The main bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the engine.

3.

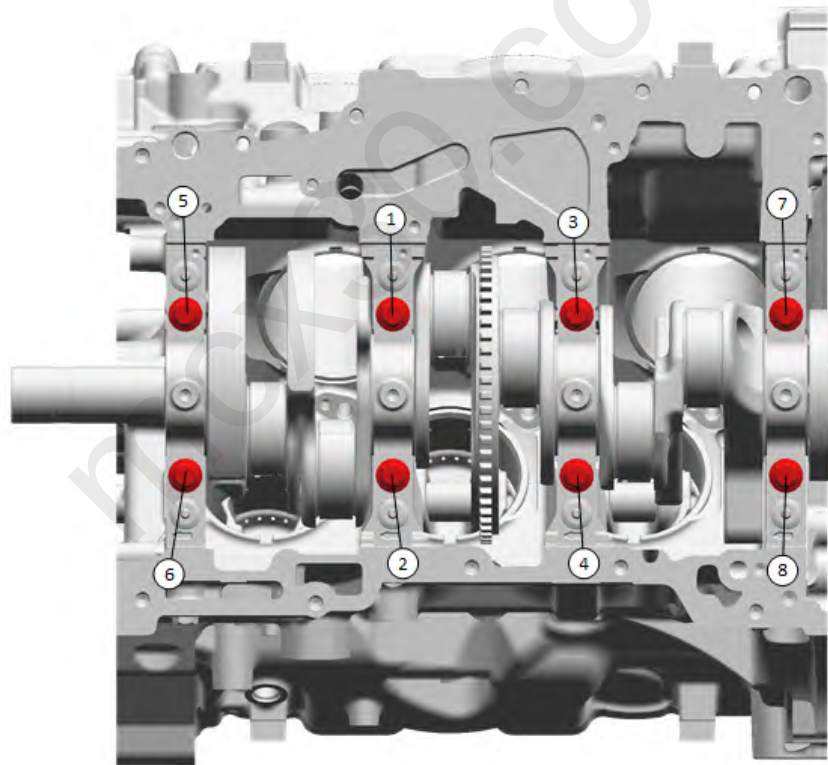


Install the crankshaft main bearing caps.



Loosely install the original short/inner side main cap bolts (2).

5. Loosely install the original long/outer side main cap bolts (1).
6. Loosely install the original inner main cap bolts (4).
7. Loosely install the original outer main cap bolts (3).
8. Tap the crankshaft main bearing caps with a soft-faced hammer.



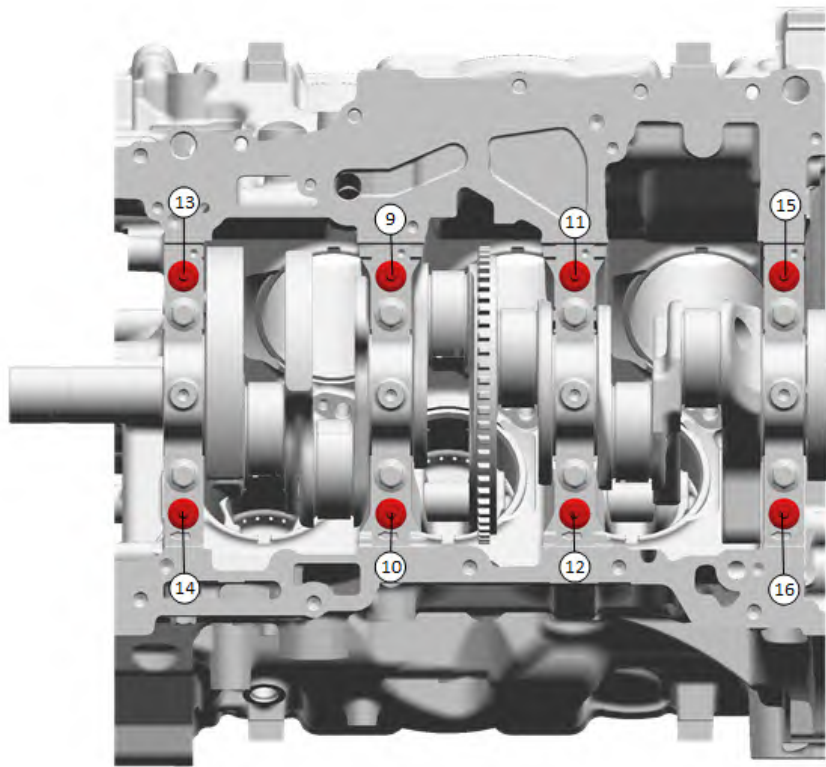
9.

Fig. 13: Crankshaft Main Bearing Inboard Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

Tighten the main caps bolts using the **EN-45059** Angle Meter in the following sequence:

CAUTION: Refer to **Fastener Caution** .

10. Tighten the inboard bolts (1 - 8) first, in two passes.
 1. Tighten the inboard bolts to 20 N.m (15 lb ft) on the first pass.
 2. Tighten the inboard bolts (1 - 8) an additional 80 degrees on the 2nd pass.

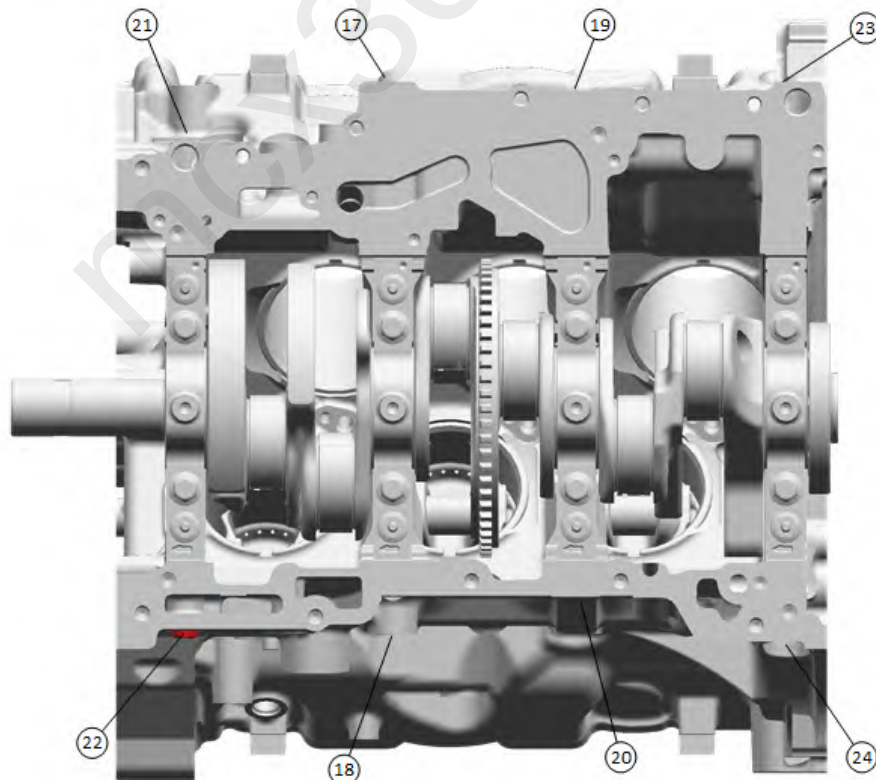


11.

Fig. 14: Outboard Crankshaft Main Bearing Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

Tighten the outboard bolts (9 - 16) second, in two passes.

1. Tighten the outboard bolts to 15 N.m (11 lb ft) on the first pass.
2. Tighten the outboard bolts (9 - 16) an additional 110 degrees on the 2nd pass.



12.

Fig. 15: Short/Inner Main Bearing Bolts And Long/Outer Bolts Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

Tighten the short/inner bolts (17 - 20) third, in two passes.

1. Tighten the short/inner bolts to 30 N.m (22 lb ft) on the first pass.

2. Tighten the short/inner bolts (17 - 20) an additional 60 degrees on the 2nd pass.

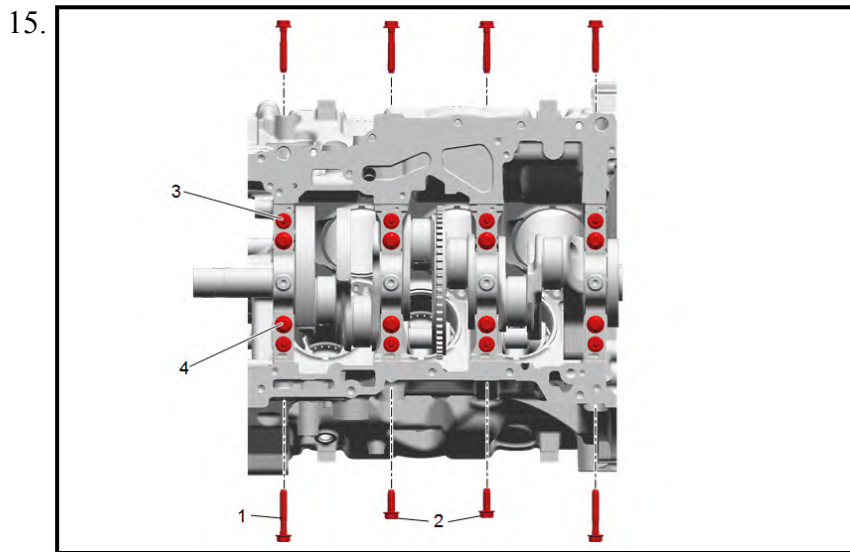
13. Tighten the long/outer bolts (21 - 24) fourth, in two passes.

1. Tighten the long/outer bolts to 30 N.m (22 lb ft) on the first pass.

2. Tighten the long/outer bolts (21 - 24) an additional 60 degrees on the 2nd pass.

NOTE: Do not rotate the crankshaft.

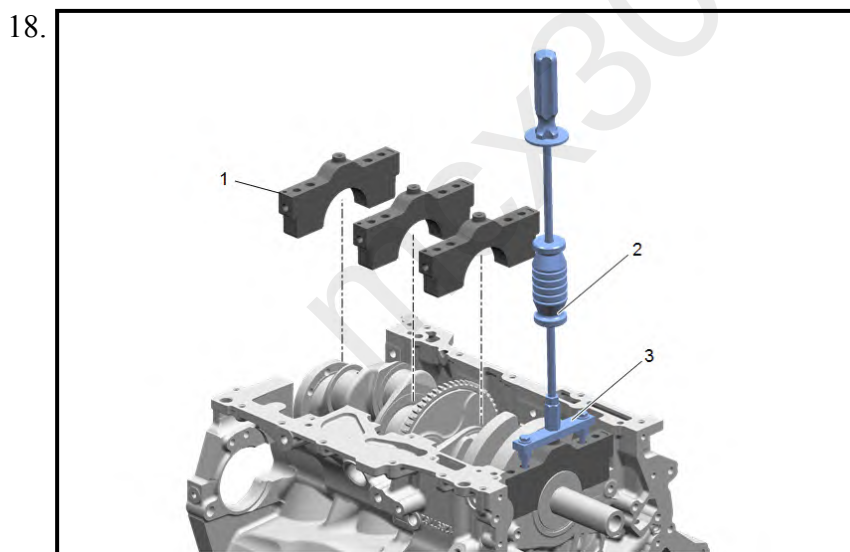
14. After reaching final torque, allow the assembly to sit for 2 minutes.



Remove the crankshaft bearing cap side bolts (1 and 2).

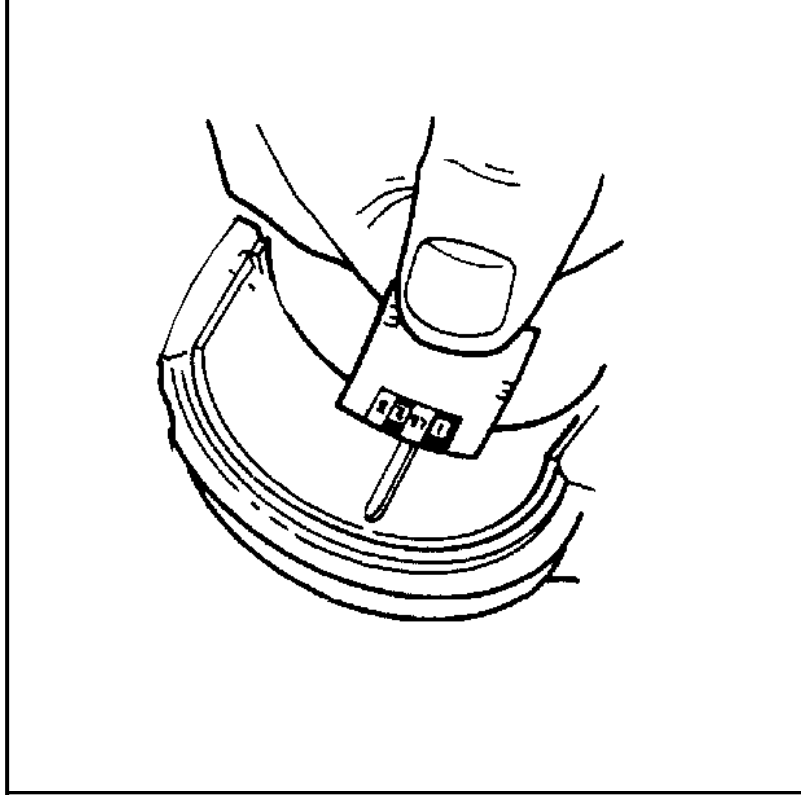
16. Remove the crankshaft bearing cap outer bolts (3).

17. Remove the crankshaft bearing cap inner bolts (4).



Remove the crankshaft bearing caps (1) using the **GE-6125-1B** Slide Hammer Adapter (2) and **EN-49102** Crankshaft Bearing Cap Remover (3).

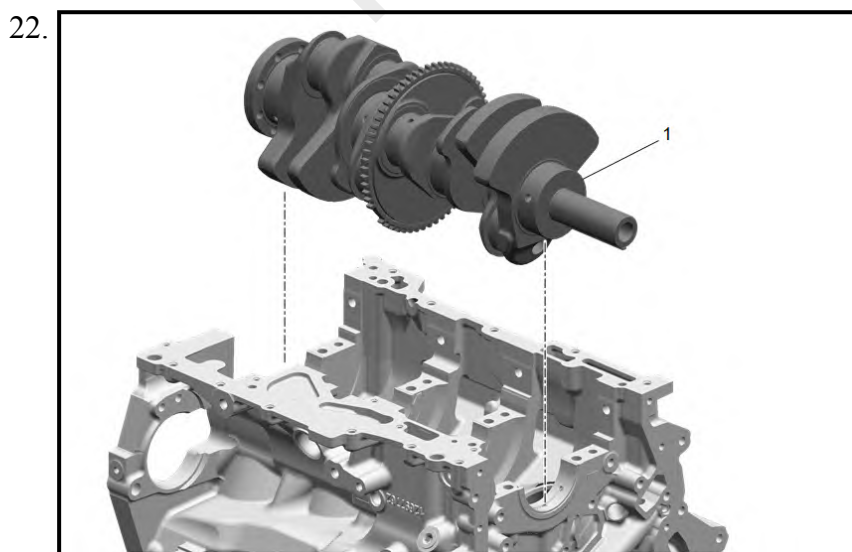




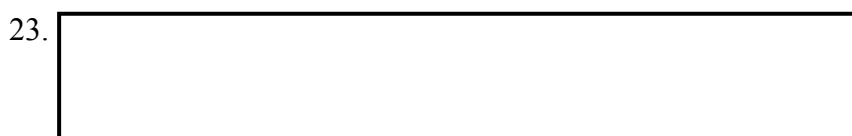
Determine the crankshaft bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container.

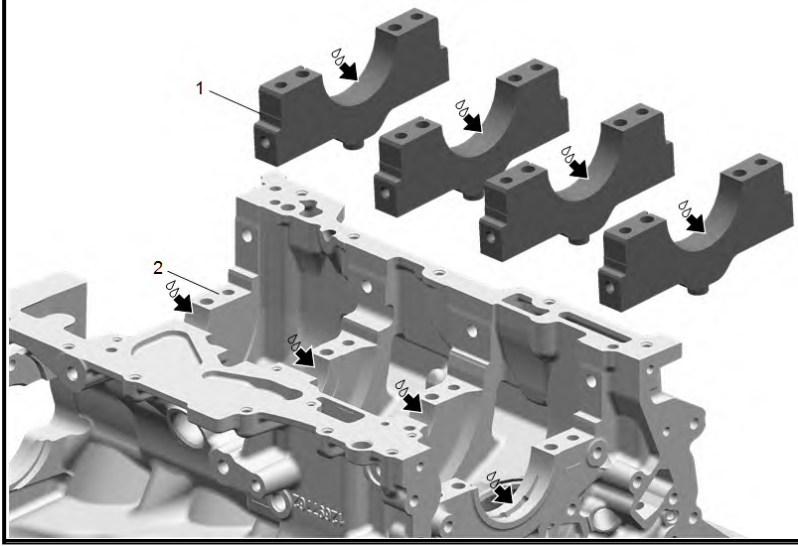
NOTE: The crankshaft bearings **CAN** be reused after checking the clearance if the bearings have never been used in a running engine.

20. Compare your measurements with the [Engine Mechanical Specifications](#) . If the new bearings do not provide the proper crankshaft to bearing clearance, inspect the following:
 1. Re-measure the crankshaft journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.
 2. Re-measure the engine block crankshaft bearing bore diameter to ensure proper size. The engine block crankshaft bearing bore is not machinable and the block must be replaced if out of specification.
21. Clean the plastic gaging material from the crankshaft bearing journals with a soft, lint-free cloth.



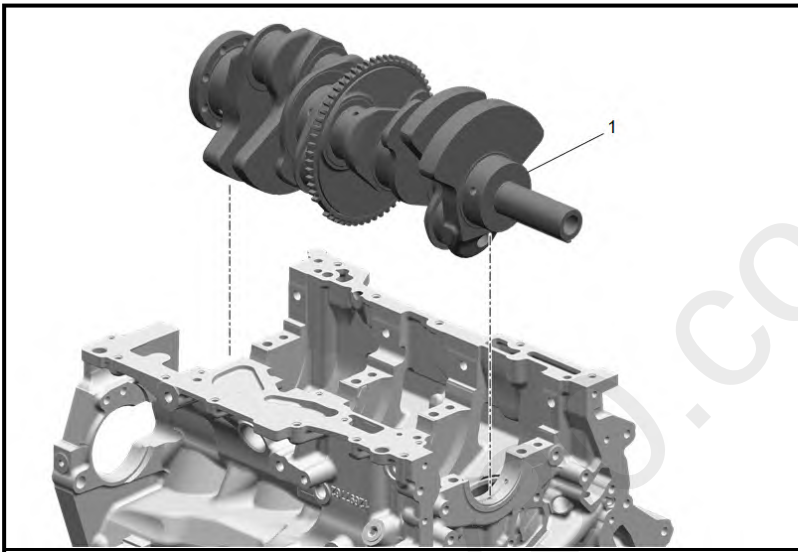
Lift the crankshaft (1) out of the cylinder block.





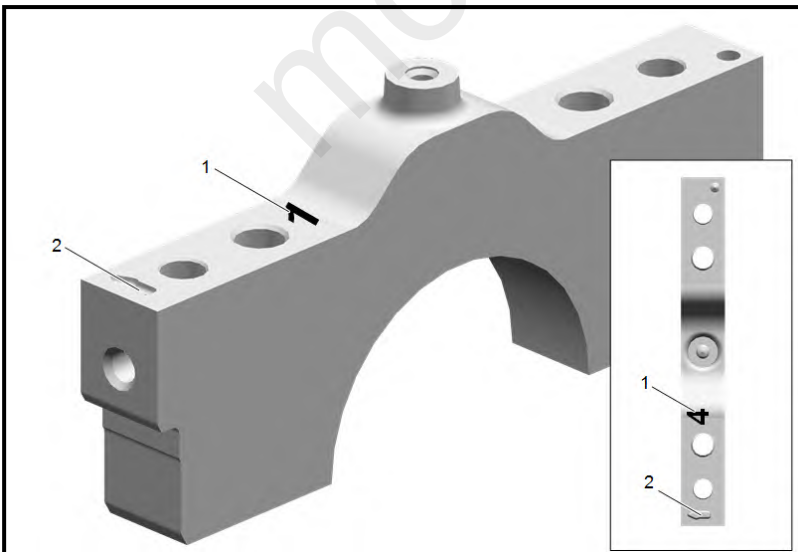
Apply a liberal amount of crankshaft prelube or clean engine oil to the upper (1) and lower (2) bearing surfaces. **Adhesives, Fluids, Lubricants, and Sealers**

24.



Gently lower the crankshaft (1) into position in the cylinder block.

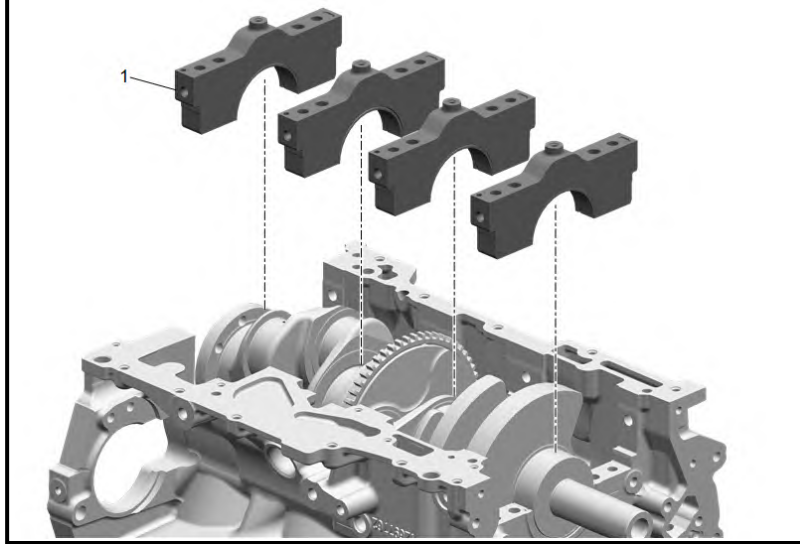
25.



Identify the proper order of the main bearing caps. The main bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the engine.

26.



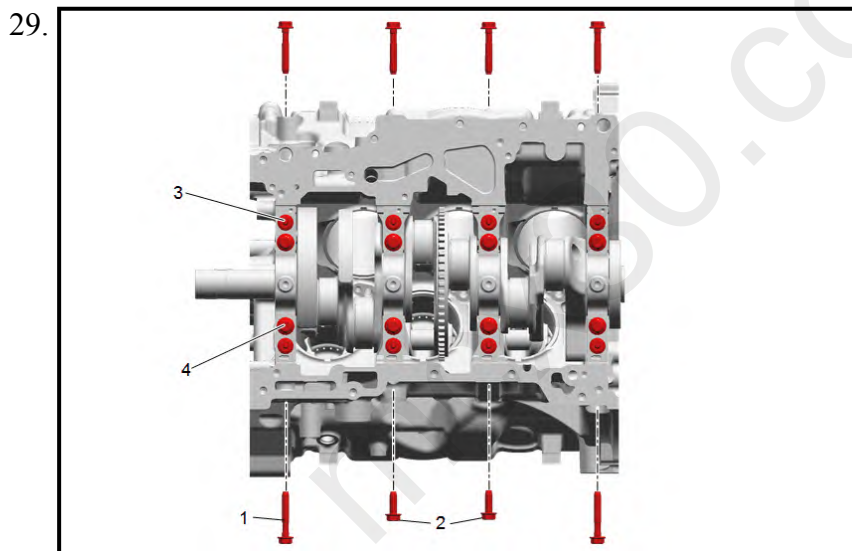


Install the crankshaft main bearing caps (1).

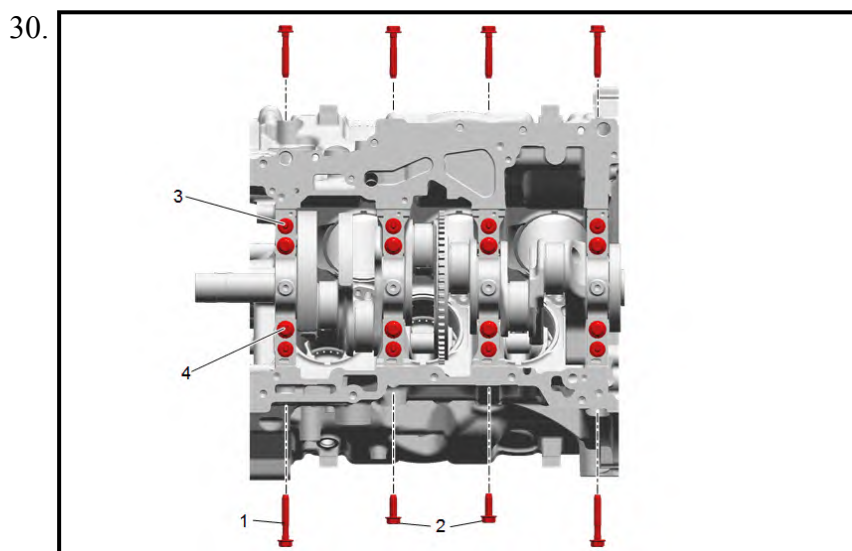
CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

27. Loosely install the NEW inner main cap bolts (4).

28. Loosely install the NEW outer main cap bolts (3).

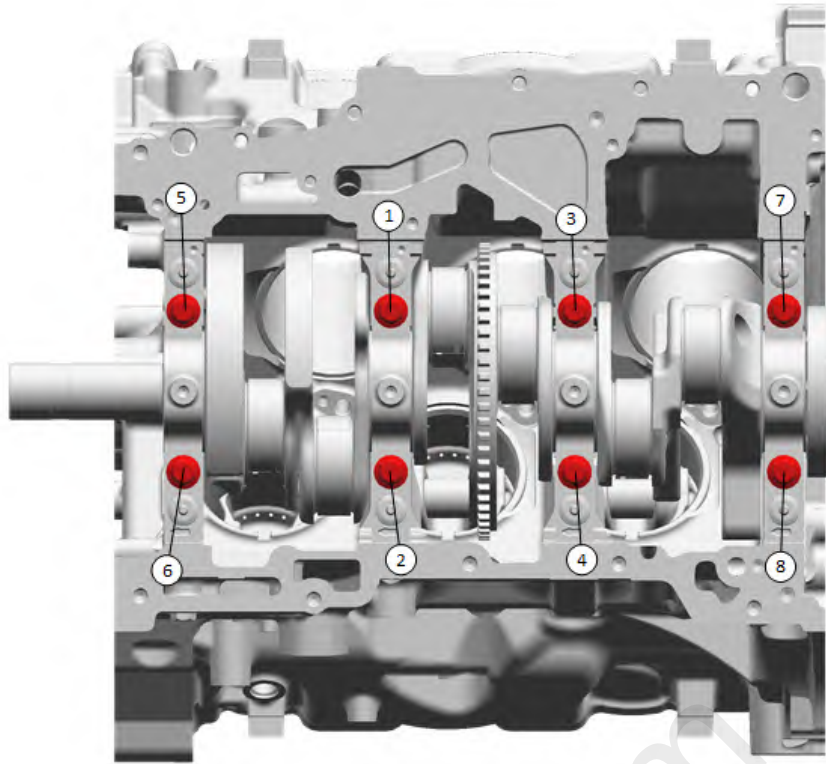


Tap the crankshaft main bearing caps with a soft-faced hammer.



Loosely install the NEW short/inner side main cap bolts (2).

31. Loosely install the NEW long/outer side main cap bolts (1).



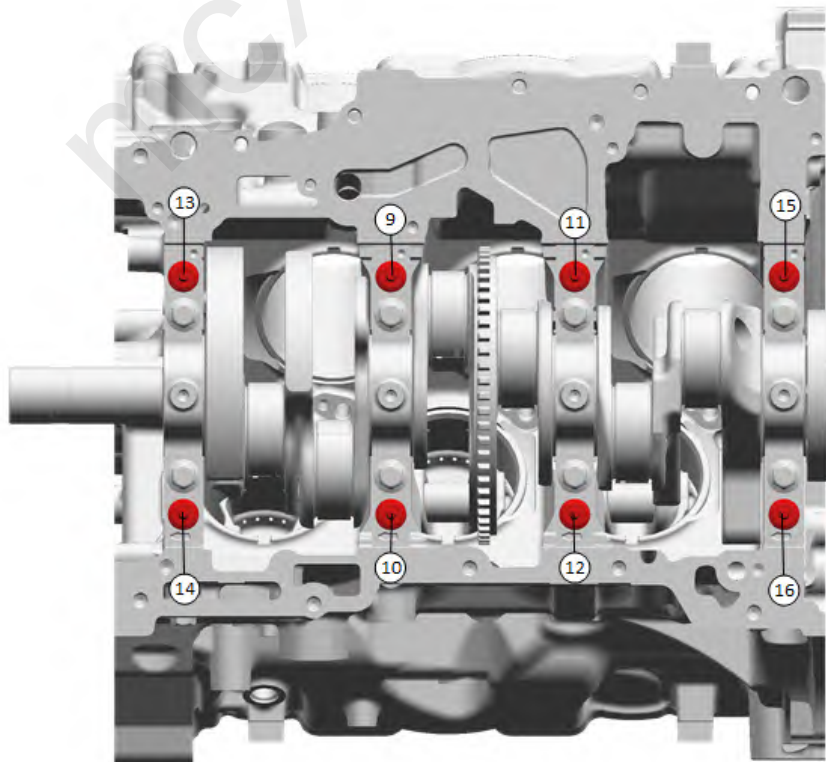
32.

Fig. 16: Crankshaft Main Bearing Inboard Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

Tighten the main cap bolts using the **EN-45059** Angle Meter in the following sequence:

33. Tighten the inboard bolts (1 - 8) first, in two passes.

1. Tighten the inboard bolts to 20 N.m (15 lb ft) on the first pass.
2. Tighten the inboard bolts (1 - 8) an additional 80 degrees on the 2nd pass.

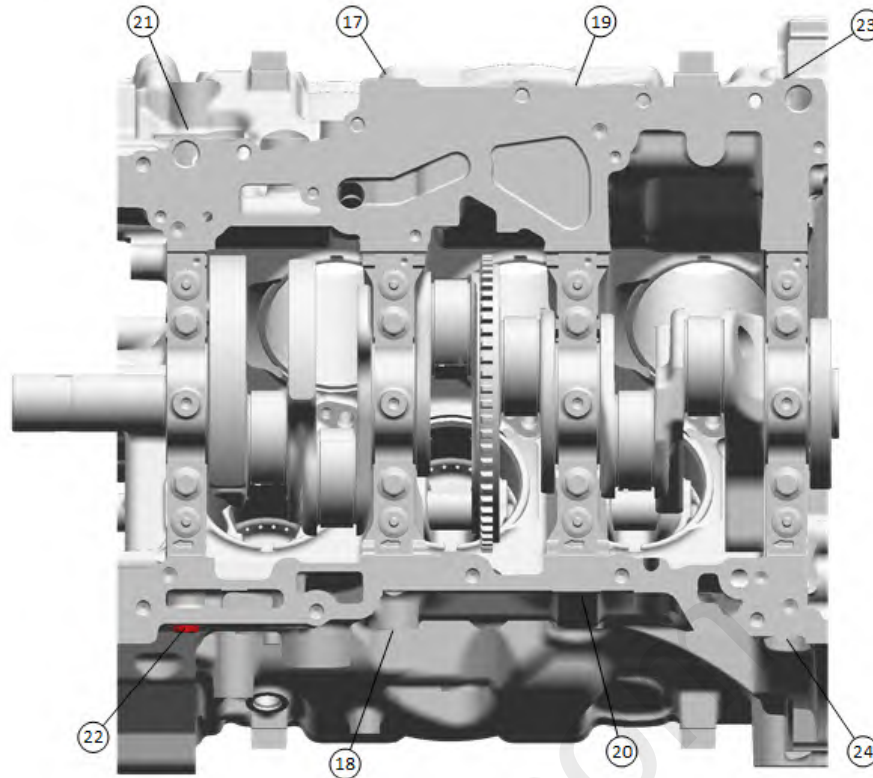


34.

Fig. 17: Outboard Crankshaft Main Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

Tighten the outboard bolts (9 - 16) second, in two passes.

1. Tighten the outboard bolts to 15 N.m (11 lb ft) on the first pass.
2. Tighten the outboard bolts (9 - 16) an additional 110 degrees on the 2nd pass.



35.

Fig. 18: Short/Inner Main Bearing Bolts And Long/Outer Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

Tighten the short/inner bolts (17 - 20) third, in two passes.

1. Tighten the short/inner bolts to 30 N.m (22 lb ft) on the first pass.
 2. Tighten the short/inner bolts (17 - 20) an additional 60 degrees on the 2nd pass.
36. Tighten the long/outer bolts (21 - 24) fourth, in two passes.
1. Tighten the long/outer bolts to 30 N.m (22 lb ft) on the first pass.
 2. Tighten the long/outer bolts (21 - 24) an additional 60 degrees on the 2nd pass.
37. Ensure that the crankshaft turns without binding or noise.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Special Tools

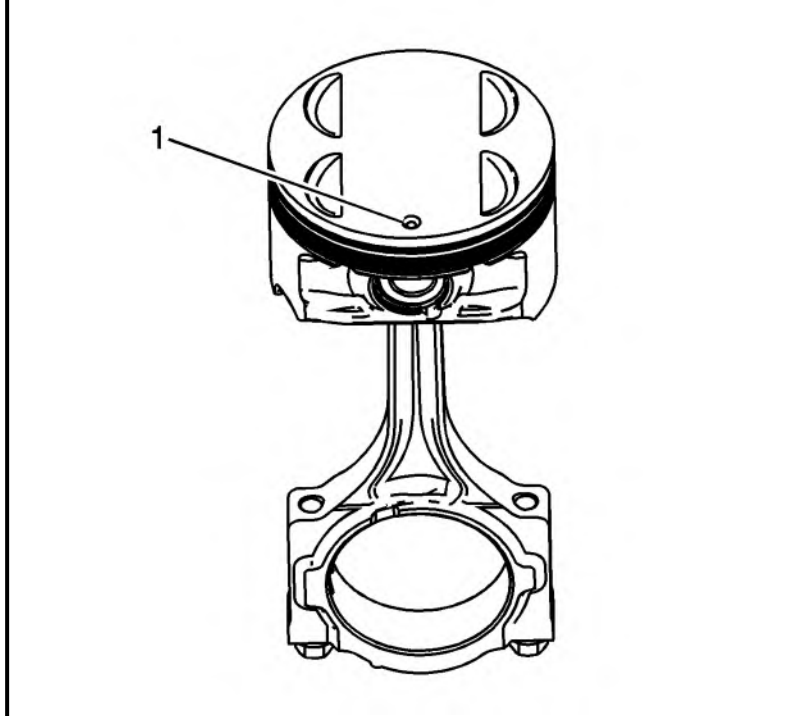
- EN-43690-A Rod Bearing Clearance Checking Tool
- EN-45059 Angle Meter
- EN-46121 Connecting Rod Guide Pin Set
- EN-48589 Crankshaft Rotation Socket

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

Piston and Connecting Rod Assembly Procedure

1.





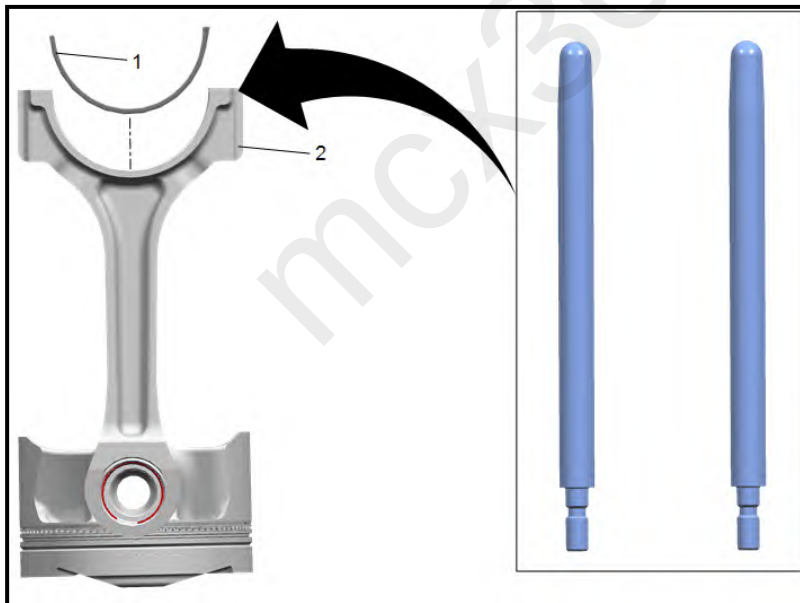
Liberally lubricate the cylinder walls, piston rings and piston skirts with engine oil.

NOTE:

- The piston is directional and must be installed in the engine block in the proper direction. The dot on the top of the piston must face the front of the engine.
- Ensure the Bowl of the piston faces the intake.

2. Select the correctly numbered piston/connecting rod assembly for the cylinder. A dot (1) showing proper piston orientation is located on the top of the piston.

3.



NOTE:

If the connecting rod bearings have been used in a running engine, you must replace them with **NEW** connecting rod bearings for reassembly.

Install the connecting rod bearing into the connecting rod.

4. Install the **EN 46121** pin set into the connecting rod bolt holes.

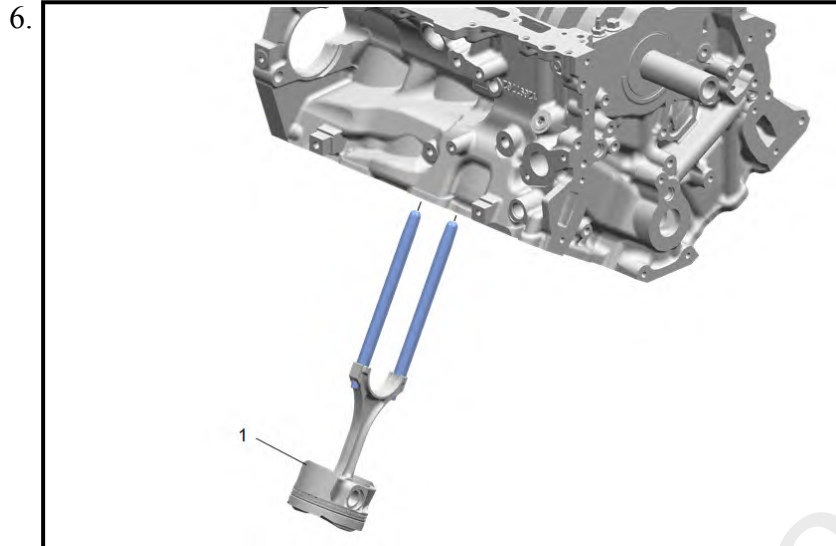
5. Compress the piston rings using the a ring compressor sleeve or equivalent.

NOTE:

When installing a piston into a cylinder, use a ring compressor sleeve or equivalent for best results. The following features should be looked for when selecting a ring compressor sleeve.

1. Hard anodized and Teflon coated for low friction and prolonged wear resistance.
2. Smooth radius that tapers down to the specific bore size.
3. Sleeve should compress the piston rings smoothly and evenly.
4. Using a ring compressor sleeve greatly reduces the difficulty with installing thin high-performance oil rings.

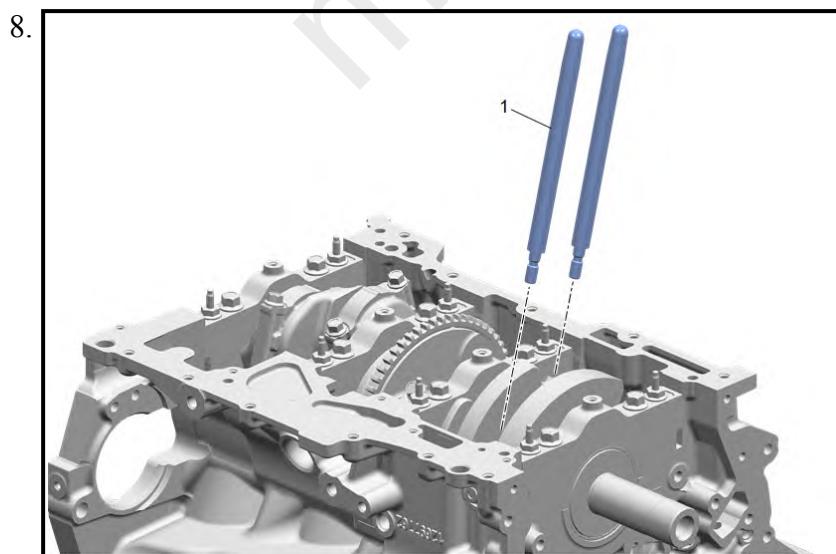
If a ring compressor sleeve is unavailable, a universal ring compressor will work but is more difficult to use.



NOTE: Extreme care must be used when installing the piston and connecting rod in order to be sure the rod does not scrape or nick the cylinder bore, the oil jets, or the crankshaft surfaces.

Using both hands, slowly guide the piston and connecting rod assembly into the cylinder from the top and bottom of the cylinder. DO NOT allow the connecting rod to contact the cylinder wall.

7. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal using the **EN-46121** set while gently tapping the piston into place. Hold the ring compressor sleeve or equivalent against the engine block until all the rings have entered the cylinder bore.



Remove the **EN 46121** pin set from the connecting rod bolt holes.

Connecting Rod Bearing Clearance Measurement Procedure - Using Plastic Gaging

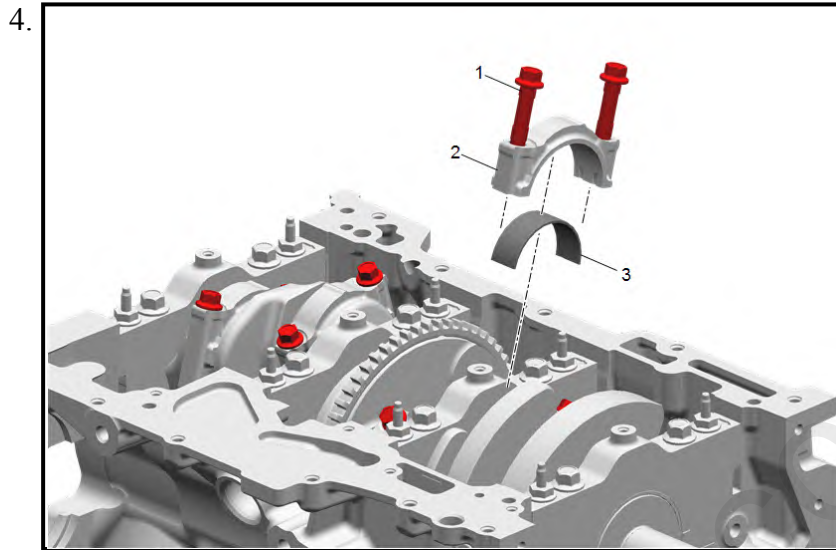
NOTE: Connecting rod bearings that have been run in an engine should **NEVER** be reused.

Before final assembly it is important to check the clearance of the new connecting rod bearings.

1. Place a length of fresh, room temperature plastic gaging material all the way across the connecting rod bearing journal.
2. Install the connecting rod bearing into the connecting rod cap.

NOTE: The connecting rod is non-directional therefore the connecting rod bearing lock tangs can face inboard or outboard.

3. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.



CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

NOTE: Reuse the old connecting rod bolts ONLY for measuring the connecting rod bearing clearance.

Install the connecting rod bolts into the connecting rod cap.

5. Tighten the connecting rod bolts.

1. First Pass

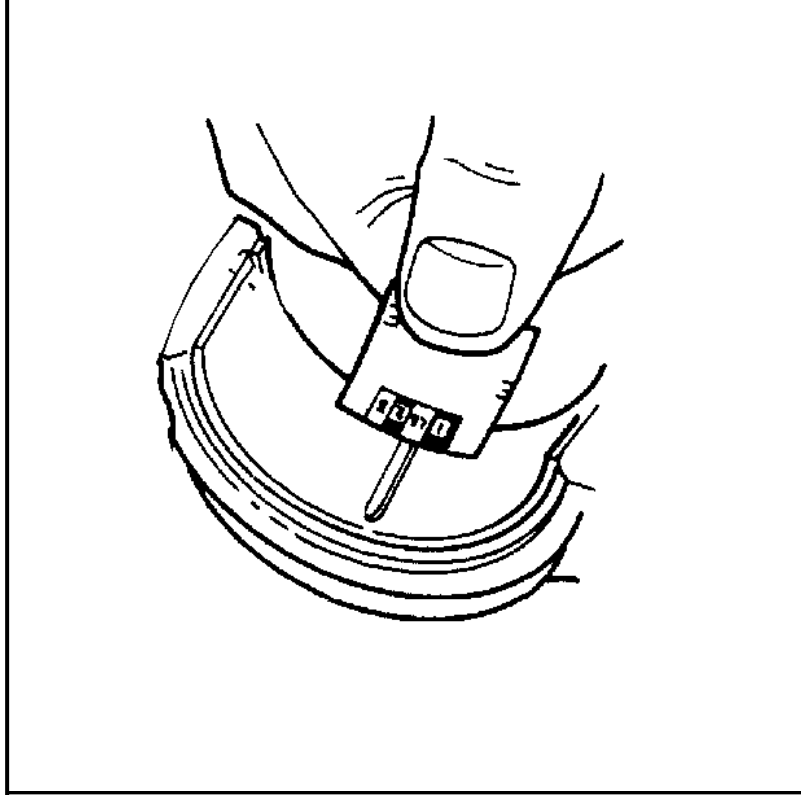
Tighten the connecting rod bolts to 25 N.m (18 lb ft).

2. Final Pass

Tighten the connecting rod bolts an additional 110 degrees using the **EN 45059** meter.

6. Allow the assembly to sit for at least 2 minutes.
7. Remove the connecting rod cap bolts.
8. Remove the connecting rod cap.



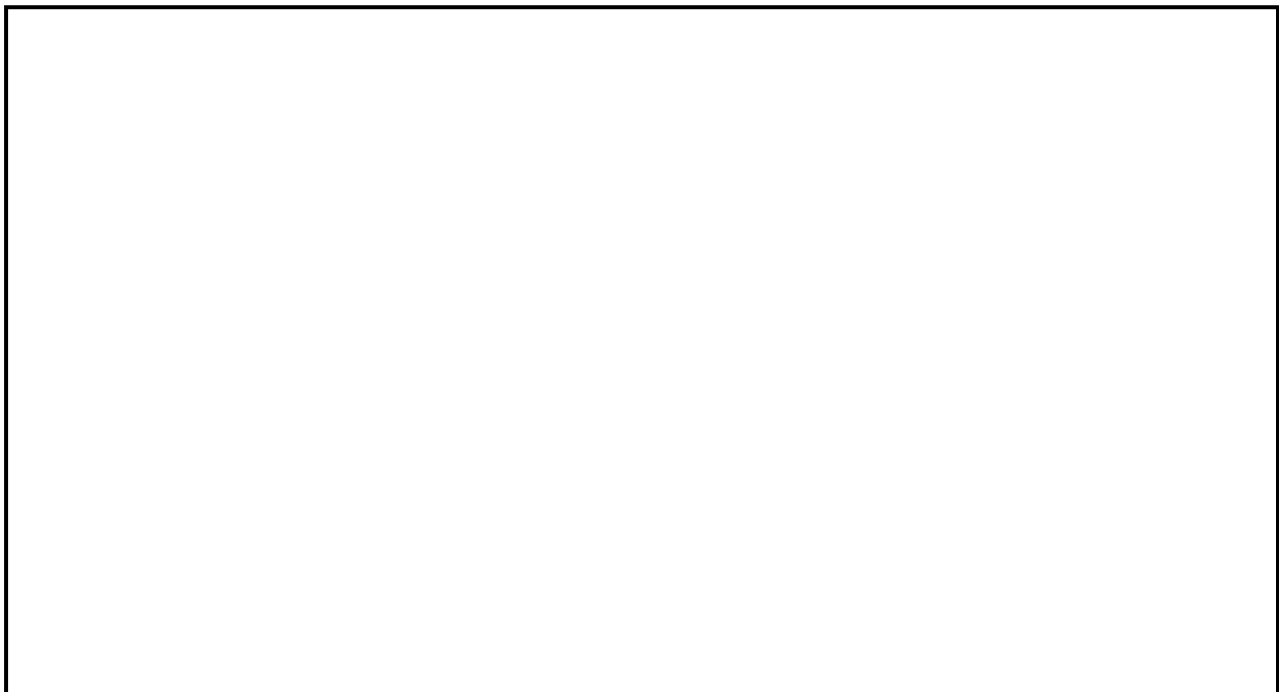


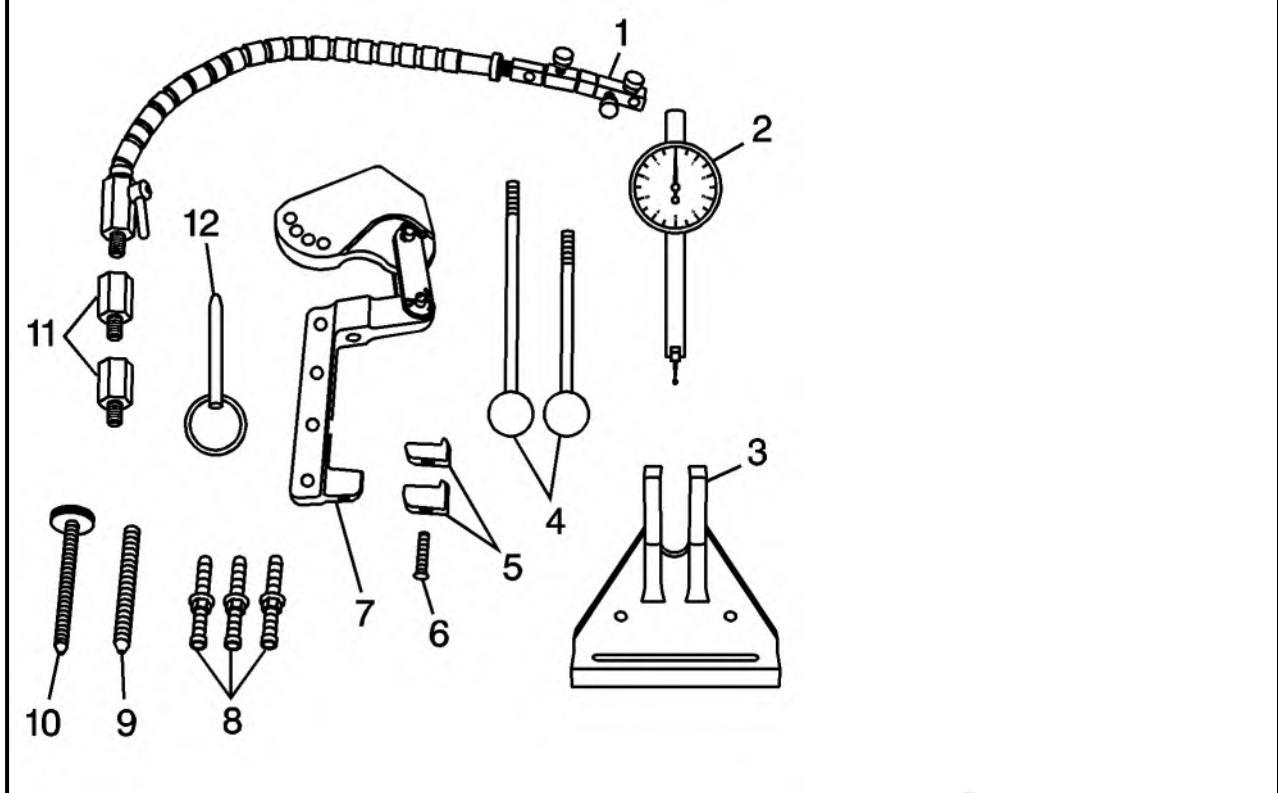
Determine the connecting rod bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container.

10. Compare your measurements with the engine mechanical specifications. If the new bearings do not provide the proper crankshaft to connecting rod bearing clearance, inspect the following:
 1. Re-measure the crankshaft connecting rod journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft connecting rod journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.
 2. Re-measure the connecting rod bearing bore diameter to ensure proper size. The connecting rod is not machinable and the connecting rod must be replaced if out of specification.
11. Clean the plastic gaging material from the connecting rod bearing journals using a soft lint-free cloth.

Connecting Rod Bearing Clearance Measurement Procedure - Using EN-43690-A

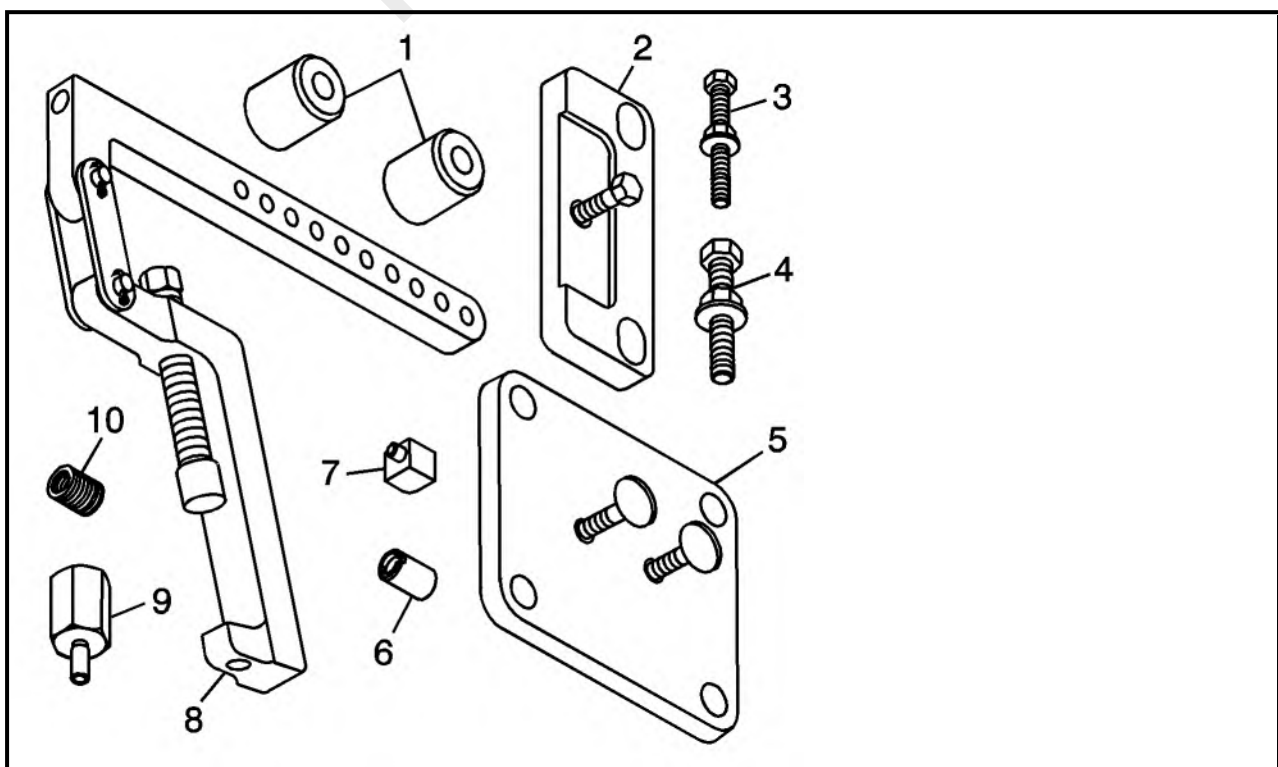
The **EN-43690-A** checking tool has been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.





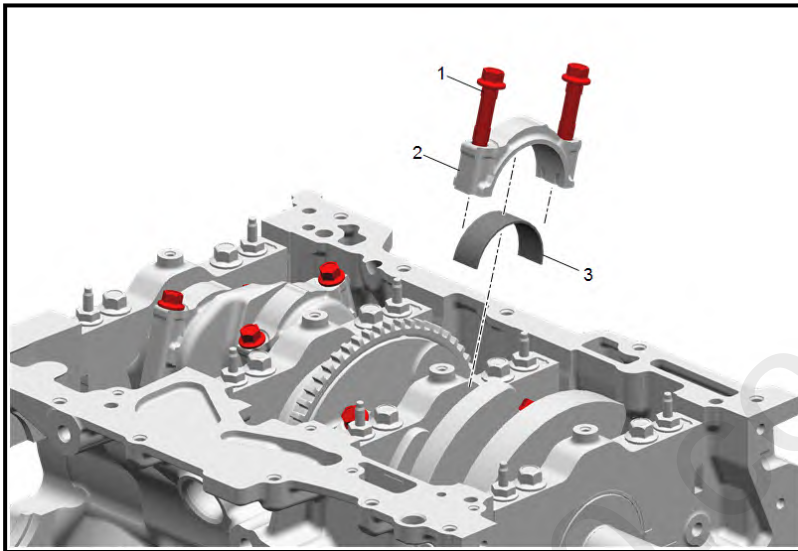
EN 43690-A checking tool

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



- EN 43690-104 Spacer (1)
- EN 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- EN 43690-106 Retainer Plate (5)
- EN 43690-107 Cap (6)
- EN 43690-102 Foot (7)
- EN 43690-101 Pivot Arm Assembly (8)
- EN 43690-103 Adapter (9)
- 505439 Adapter (10)

1.



NOTE: Connecting rod bearings that have been run in an engine should **NEVER** be reused.

Before final assembly it is important to check the clearance of the new connecting rod bearings.

Install the connecting rod bearing into the connecting rod cap.

NOTE: The connecting rod is non-directional therefore the connecting rod bearing lock tangs can face inboard or outboard.

2. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

NOTE: Reuse the old connecting rod bolts **ONLY** for measuring the connecting rod bearing clearance.

3. Install the connecting rod bolts into the connecting rod cap.
4. Tighten the connecting rod bolts.

1. First Pass

Tighten the connecting rod bolts to 25 N.m (18 lb ft).

2. Final Pass

Tighten the connecting rod bolts an additional 110 degrees using the **EN 45059** meter.

5. Rotate the crankshaft until the crankshaft journal and the connecting rod to be measured is in the 12 o'clock position.

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

6. Remove the crankshaft main bolts required to install the retainer plate EN 43690-105.

NOTE: Do not allow the EN 43690-105 retainer plate screw to contact the reluctor ring.

7. Install the EN 43690-105 and crankshaft main bolts.
8. Loosen the connecting rod bolts until the torque reading is zero.
9. Re-tighten the connecting rod bolts.

1. First Pass

Tighten the connecting rod bolts to 25 N.m (18 lb ft).

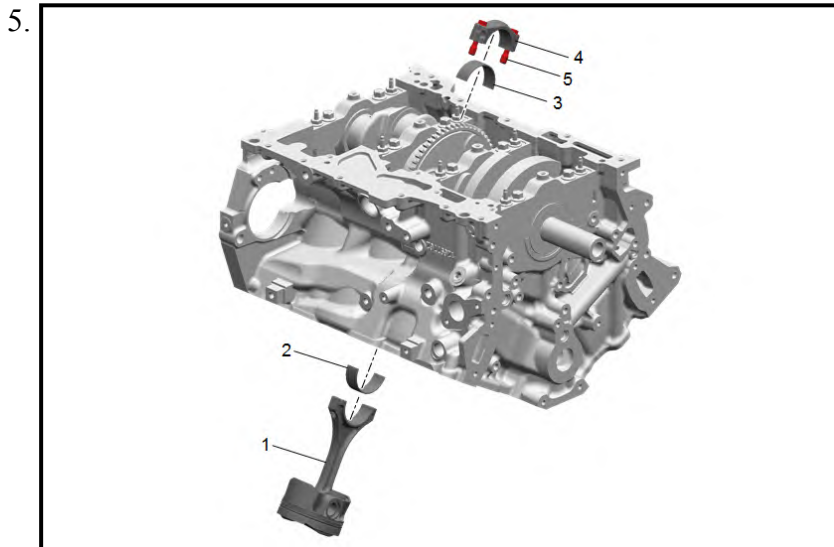
2. Final Pass

Tighten the connecting rod bolts an additional 110 degrees using the **EN 45059** meter.

10. During and after installation, ensure each piston is positioned properly in the correct cylinder. The locating arrow on the top of each piston must be pointing toward the front of the engine.
11. Repeat these procedures for the remaining piston/connecting rod assemblies using the **EN-48589** socket in order to rotate the crankshaft.

Connecting Rod Final Assembly Procedure

1. Guide the connecting rod away from the crankshaft connecting rod journal in order to lubricate the crankshaft connecting rod bearing journal.
2. Apply a liberal amount of crankshaft prelube or clean engine oil to the crankshaft connecting rod bearing journal. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.
3. Guide the connecting rod to the crankshaft connecting rod journal.
4. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.



CAUTION: Do not lubricate the NEW connecting rod bolts. The NEW bolts have

a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

Install the **NEW** connecting rod bolts into the connecting rod cap.

6. Tighten the connecting rod bolts.

1. First Pass

Tighten the connecting rod bolts to 25 N.m (18 lb ft).

2. Final Pass

Tighten the connecting rod bolts an additional 110 degrees using the **EN 45059** meter.

7. During and after installation, ensure each piston is positioned properly in the correct cylinder. The locating arrow on the top of each piston must be pointing toward the front of the engine.

8. Repeat these procedures for the remaining piston/connecting rod assemblies using the **EN 45059** meter in order to rotate the crankshaft.

CRANKSHAFT REAR OIL SEAL AND HOUSING INSTALLATION

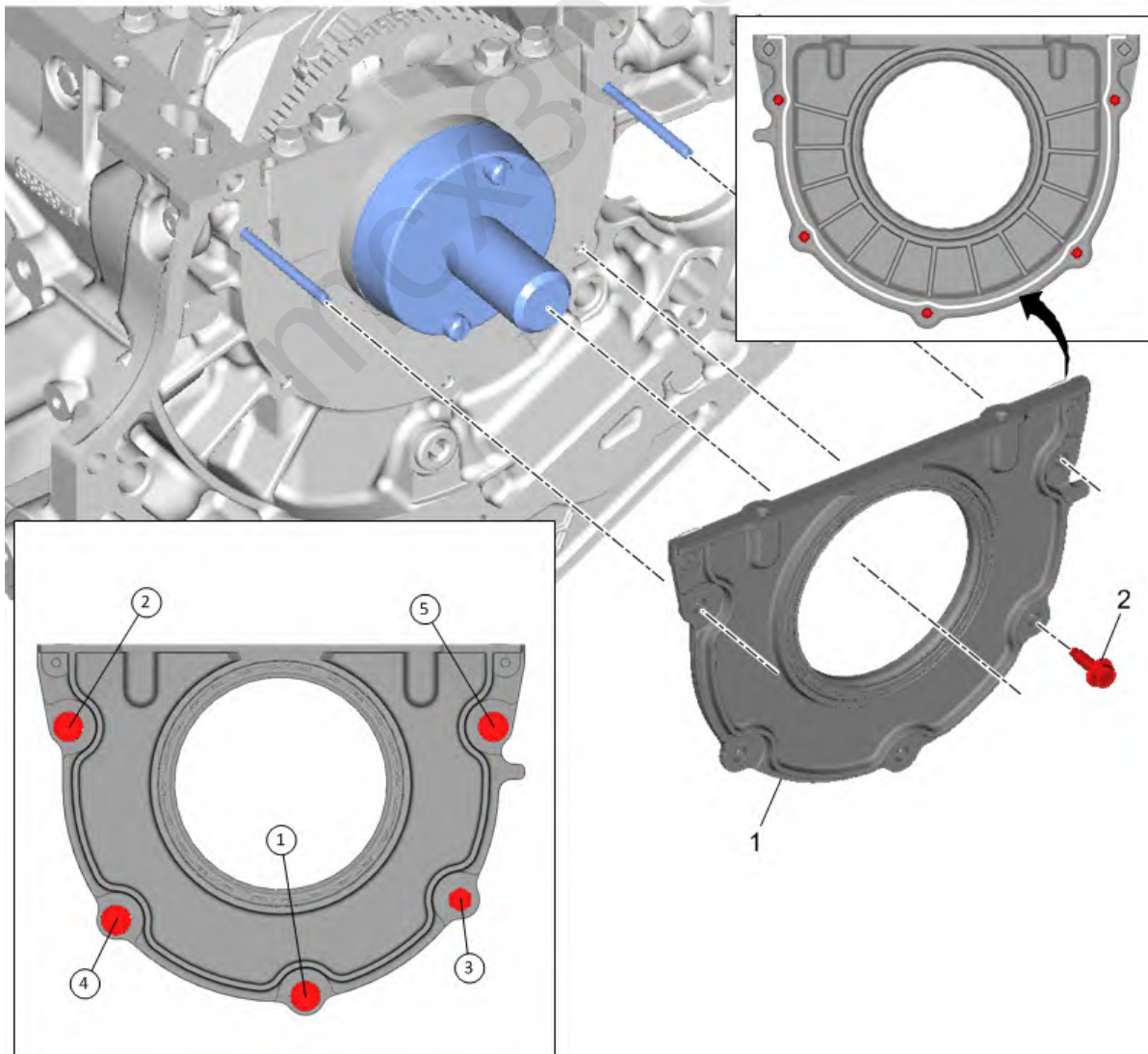


Fig. 19: Exploded View Of Crankshaft Rear Oil Seal and Housing With Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Rear Oil Seal Housing Procedure 1. Install the 6 mm (0.236 in) guides from the EN-46109 pin set into the 2 crankshaft rear oil seal housing corner bolt holes of the engine block. 2. Install the EN-47839 tool with the EN-42183 handle onto the rear of the crankshaft flange. 3. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u> 4. Place a 3 mm (0.118 in) bead of RTV sealant to the NEW crankshaft rear oil seal housing as shown. <u>Adhesives, Fluids, Lubricants, and Sealers</u> NOTE: DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed. 5. Install a NEW crankshaft rear oil seal housing to the engine block. 6. Remove the EN-46109 pin set 6 mm (0.236 in) guides from the engine block. 7. Install the crankshaft rear oil seal housing bolts and tighten in sequence. 8. Remove the EN-47839 tool and EN-42183 handle from the crankshaft flange. Special Tools • EN-42183 Handle • EN-46109 Guide Pin Set • EN-47839 Crankshaft Rear Oil Seal Installation Tool Equivalent regional tools: <u>Special Tools</u> .
2	Crankshaft Rear Oil Seal Housing Bolt CAUTION: Refer to <u>Fastener Caution</u> . Tighten in sequence 10 N.m (89 lb in)

OIL PUMP INSTALLATION

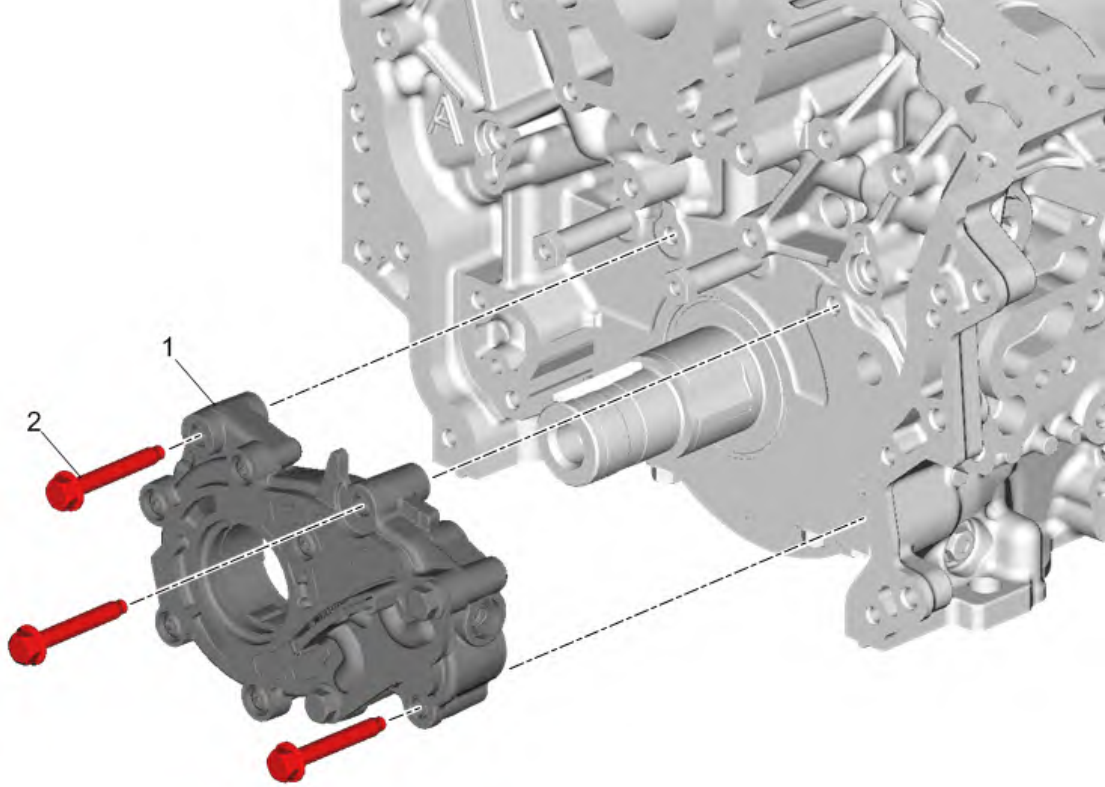


Fig. 20: Exploded View Of Oil Pump Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Procedure 1. Align the oil pump drive gear with the crankshaft flats and install the oil pump to the engine block. 2. Align the pump body with the mounting holes in the cylinder block.
2	Oil Pump Bolt [3x] CAUTION: Refer to Fastener Caution . Tighten 25 N.m (18 lb ft)

OIL PAN INSTALLATION

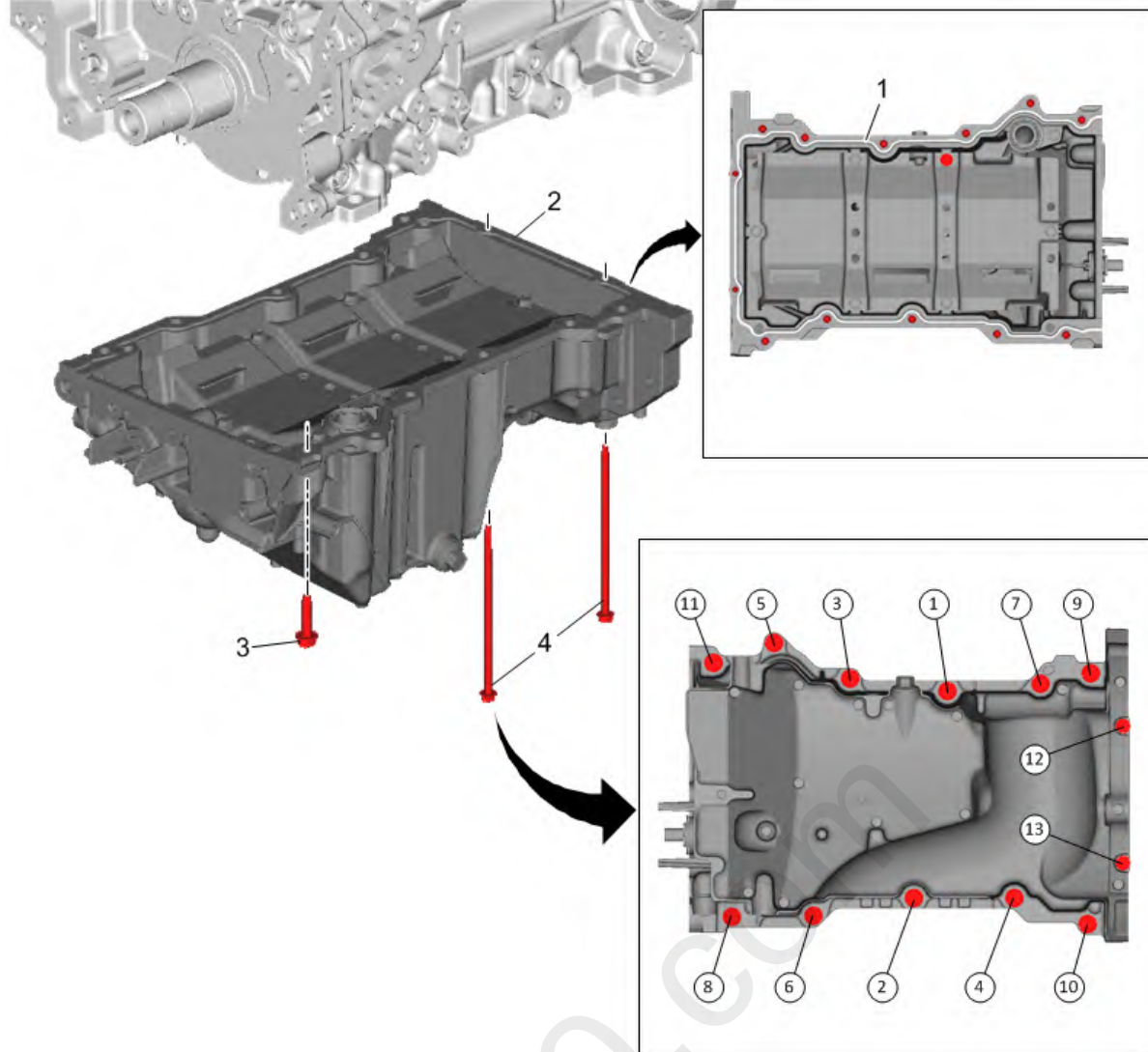


Fig. 21: Exploded View Of Oil Pan With Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Sealant Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Place a 3 mm (0.118 in) bead of RTV sealant on the block pan rail and the crankshaft rear oil seal housing (1). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.
2	Oil Pan
3	Oil Pan Bolt [11x] CAUTION: Refer to Fastener Caution . NOTE: Tighten the oil pan bolts in sequence shown. Tighten 25 N.m (18 lb ft)

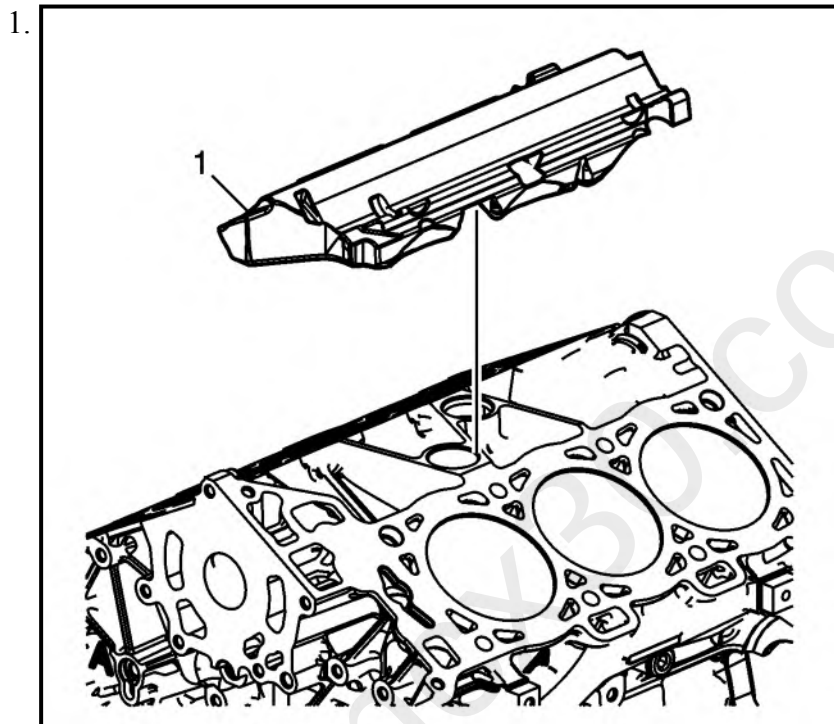
Callout	Component Name
4	Oil Pan Bolt [2x] NOTE: Tighten the oil pan bolts in sequence shown. Tighten 10 N.m (89 lb in)

CYLINDER HEAD INSTALLATION - RIGHT SIDE

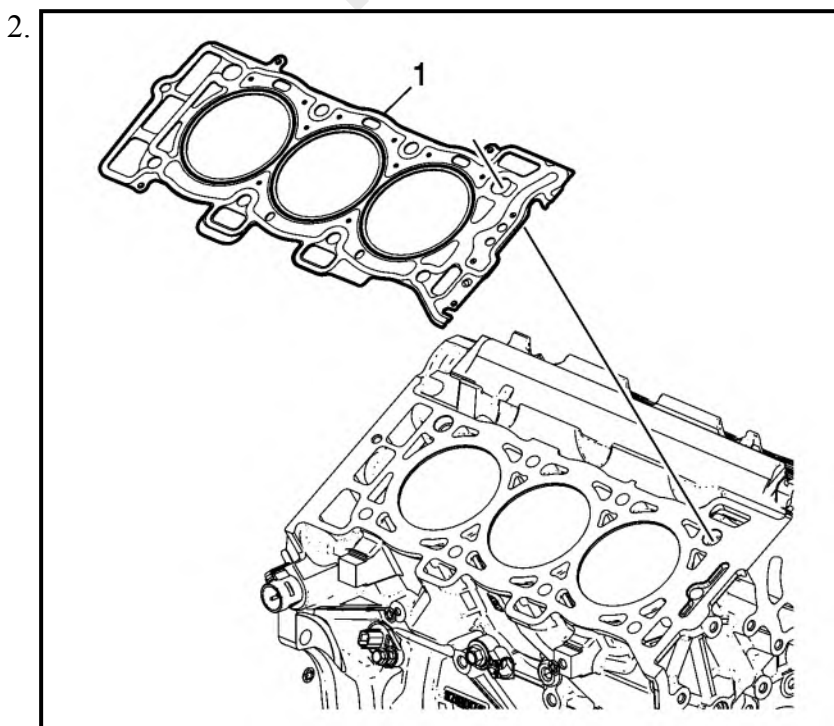
Special Tools

EN - 45059 Angle Meter

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

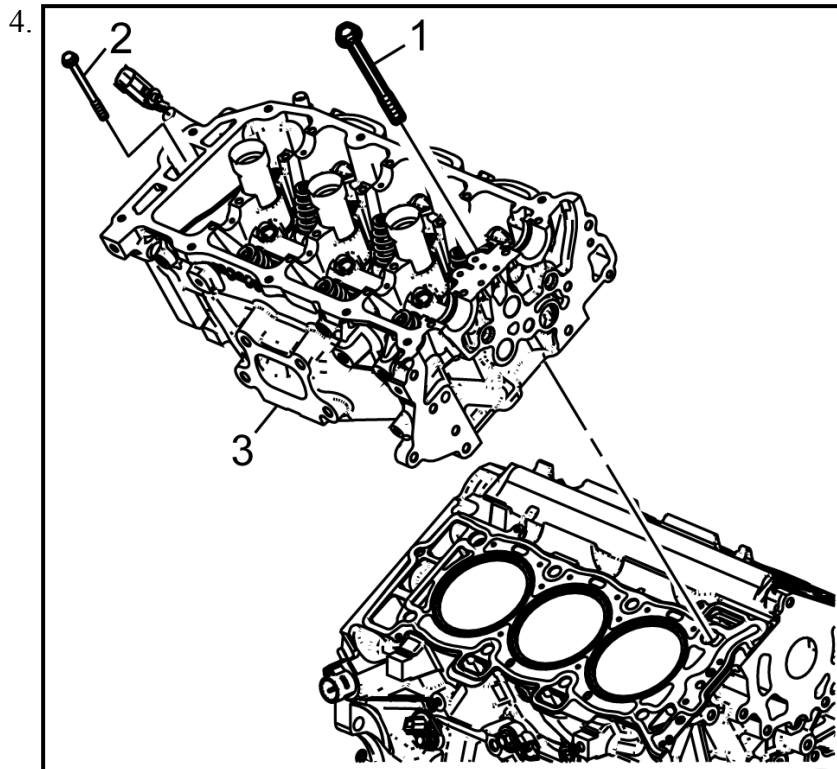


Install the fuel injection fuel rail noise shield-lower (1).



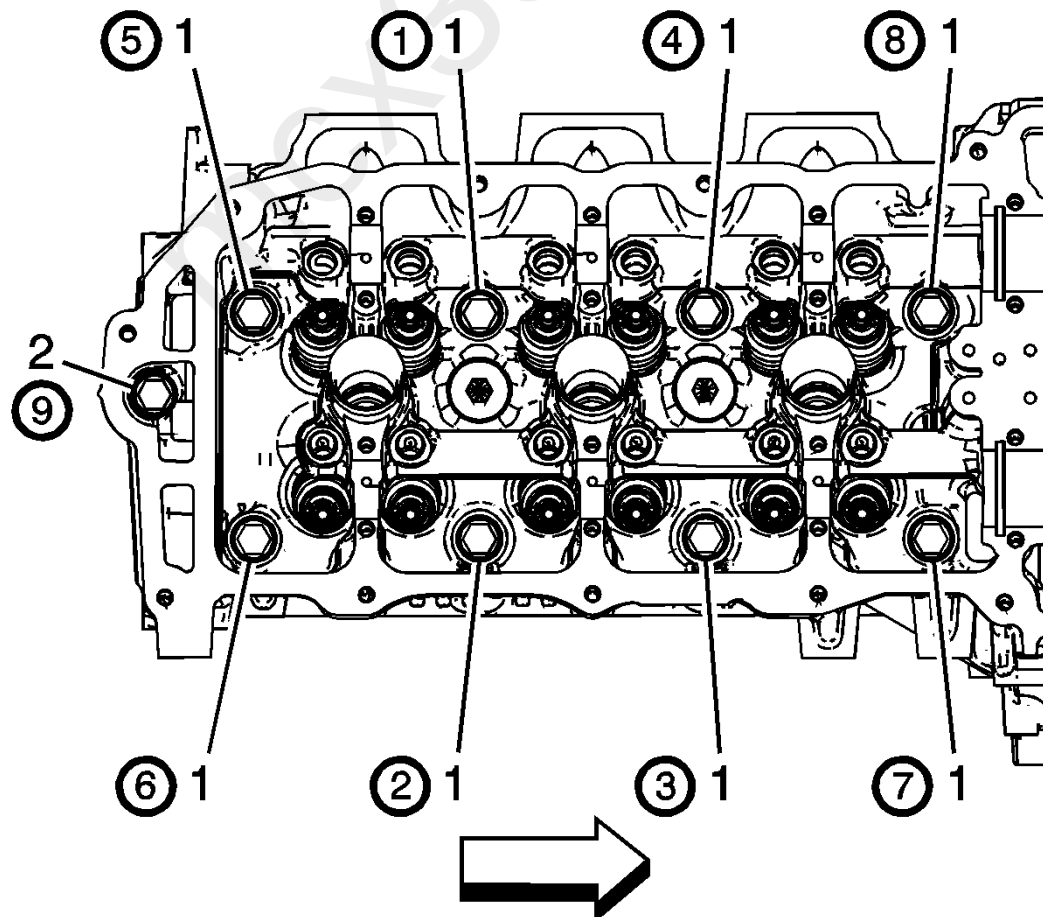
Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face.

3. Install a NEW right cylinder head gasket (1) using the deck face locating pins for retention.



Align the right cylinder head (2) with the deck face locating pins.

5. Place the right cylinder head in position on the deck face.



6.

CAUTION: Refer to [Fastener Caution](#) .

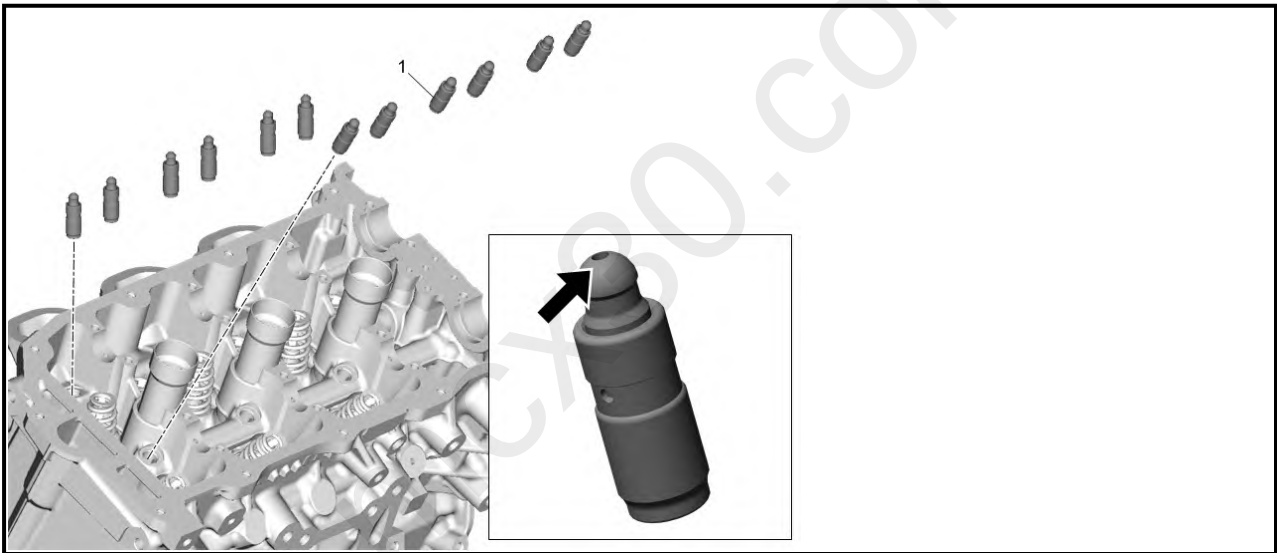
CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

NOTE: **DO NOT** allow oil on the cylinder head bolt bosses.

Install the NEW M11 cylinder head bolts (1).

1. Tighten the M11 cylinder head bolts a first pass in sequence to 30 N.m (22 lb ft).
 2. Tighten the M11 cylinder head bolts a second pass in sequence an additional 150 degrees using the **EN 45059** meter.
7. Install the NEW M8 cylinder head bolt (2).
1. Tighten the M8 cylinder head bolt a first pass to 15 N.m (11 lb ft).
 2. Tighten the M8 cylinder head bolt a second pass an additional 75 degrees using the **EN 45059** meter.

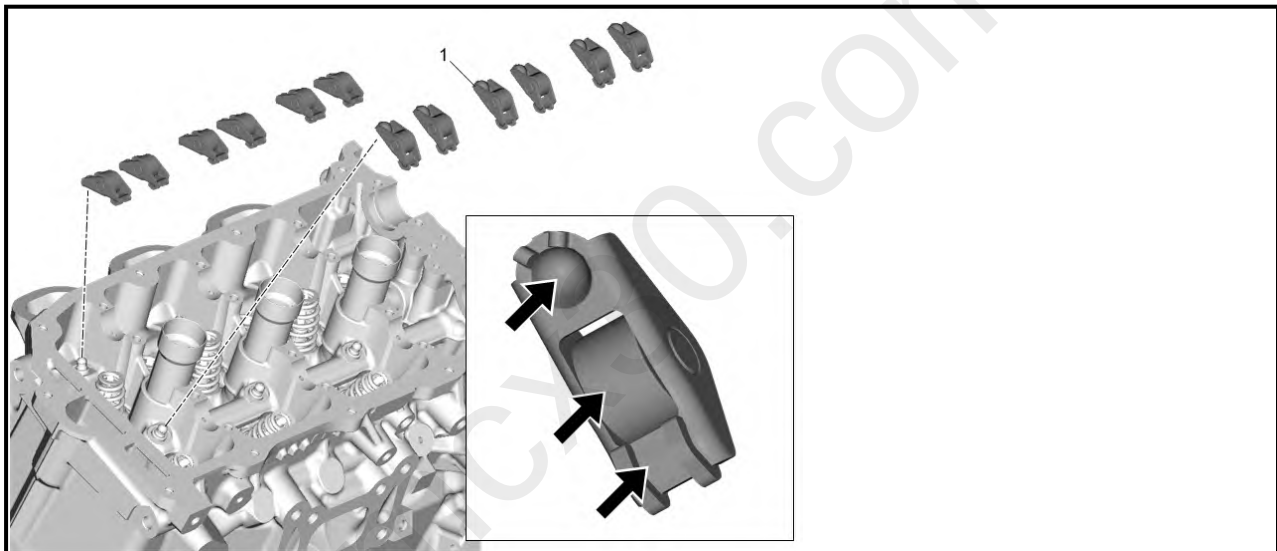
VALVE LIFTER INSTALLATION - RIGHT SIDE



Callout	Component Name

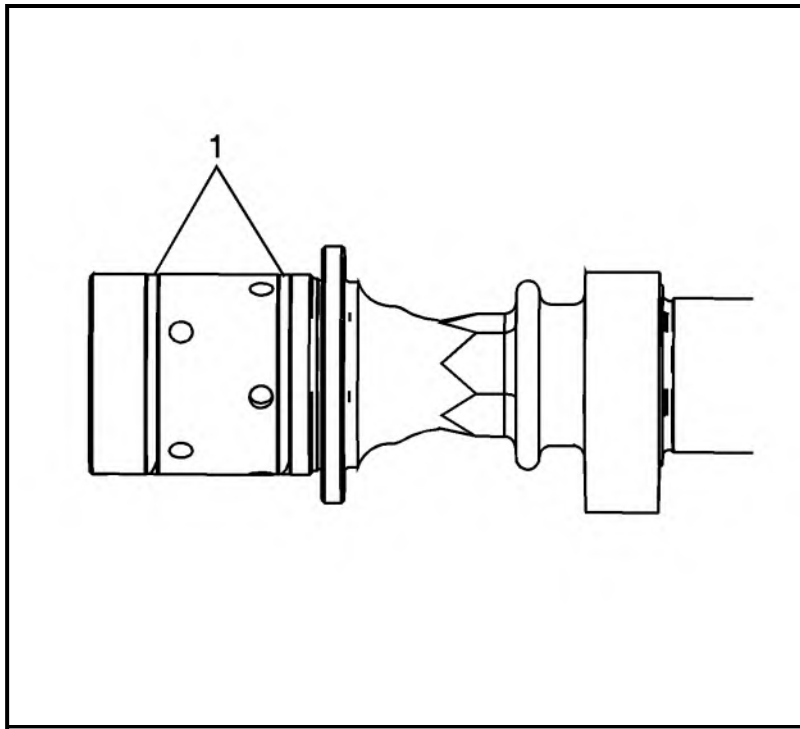
Callout	Component Name
1	Hydraulic Valve Lash Adjuster NOTE: • Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber. • Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill. Procedure 1. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. <u>Adhesives, Fluids, Lubricants, and Sealers</u> Take precautions to prevent scratching the pivot sphere area of the SHLA. 2. Lubricate the SHLA bores in the cylinder head with clean engine oil. 3. Install the SHLAs in the cylinder head. 4. Apply a liberal amount of lubricant to the SHLA pivot spheres.

VALVE ROCKER ARM INSTALLATION - RIGHT SIDE



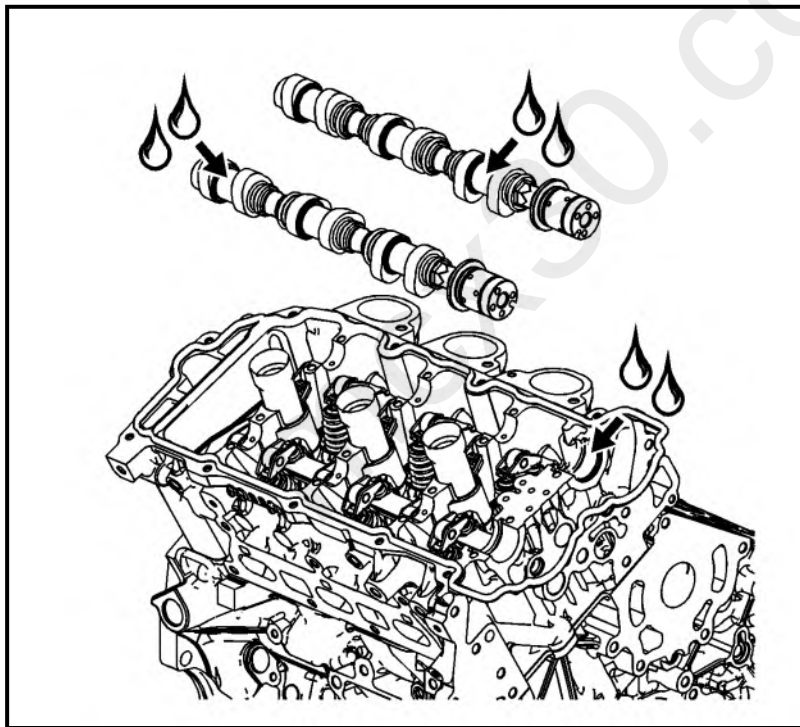
Callout	Component Name
1	Valve Rocker Arm Procedure 1. Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. <u>Adhesives, Fluids, Lubricants, and Sealers</u> NOTE: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location. 2. Place the camshaft followers in position on the valve tip and stationary hydraulic lash adjuster (SHLA). 3. The rounded head end of the follower goes on the SHLA while the flat end goes on the valve tip. 4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

1.



Ensure that the camshaft sealing rings (1) are in place in the camshaft grooves. Camshaft sealing rings must be in place below the surface of the camshaft journal in order to avoid being pinched between the cylinder head and the camshaft caps.

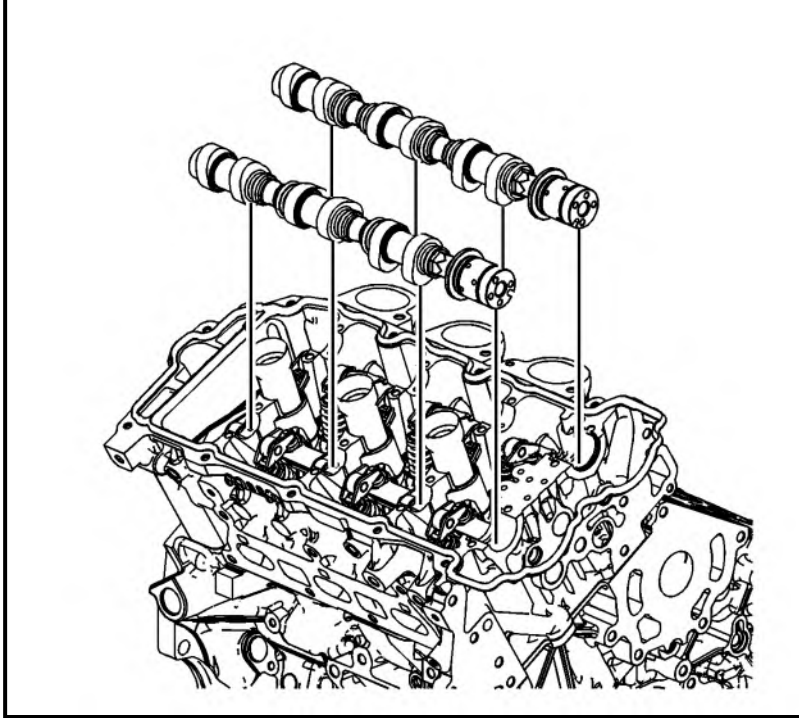
2.



Apply a liberal amount of lubricant to the camshaft journals and the right cylinder head camshaft carriers. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.

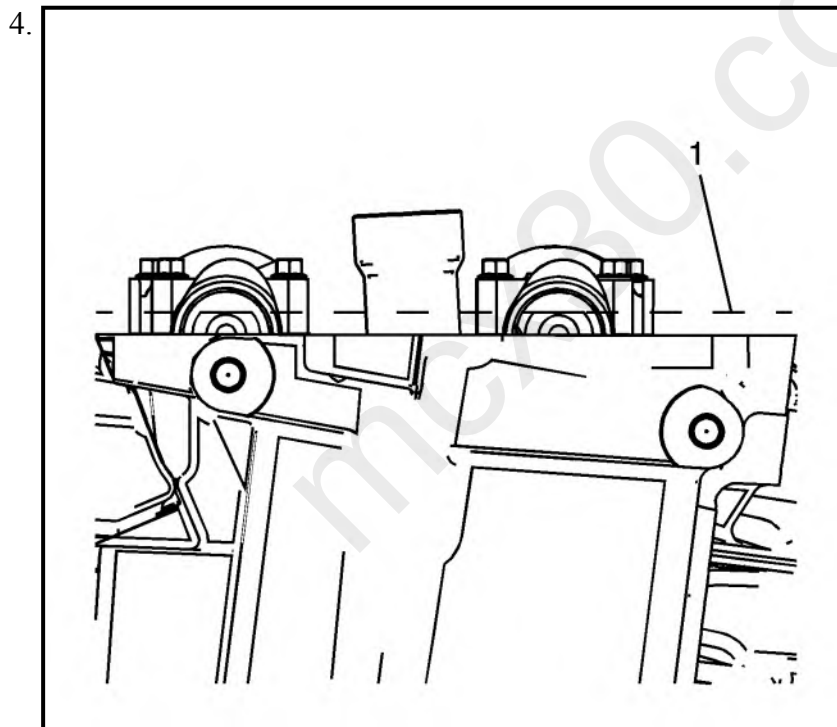
3.





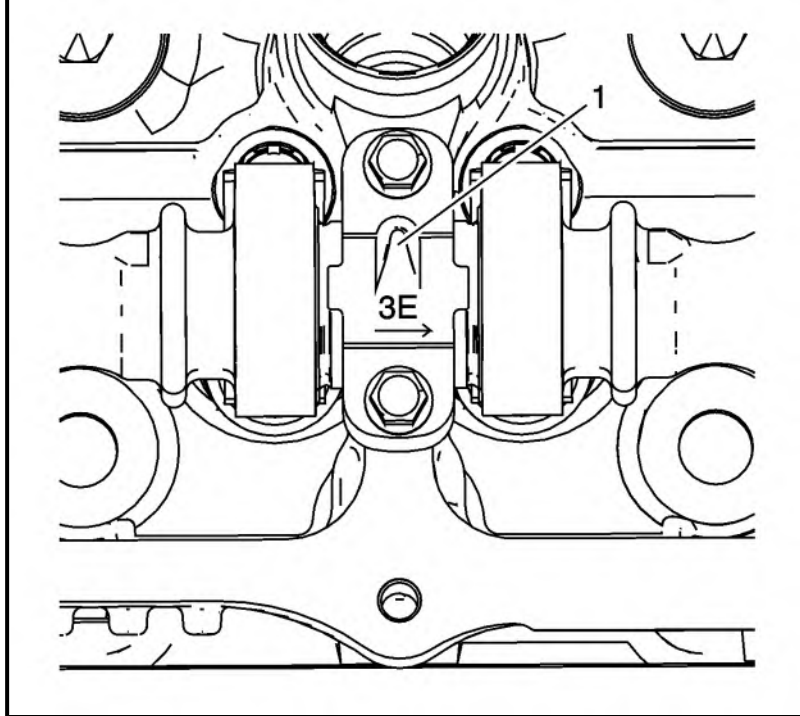
NOTE: The right intake camshaft has a laser inscription marking on the rear of the shaft to identify it as right bank intake (RI).

Place the right intake and right exhaust camshafts in position in the right cylinder head.



Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the right cylinder head camshaft cover rail.



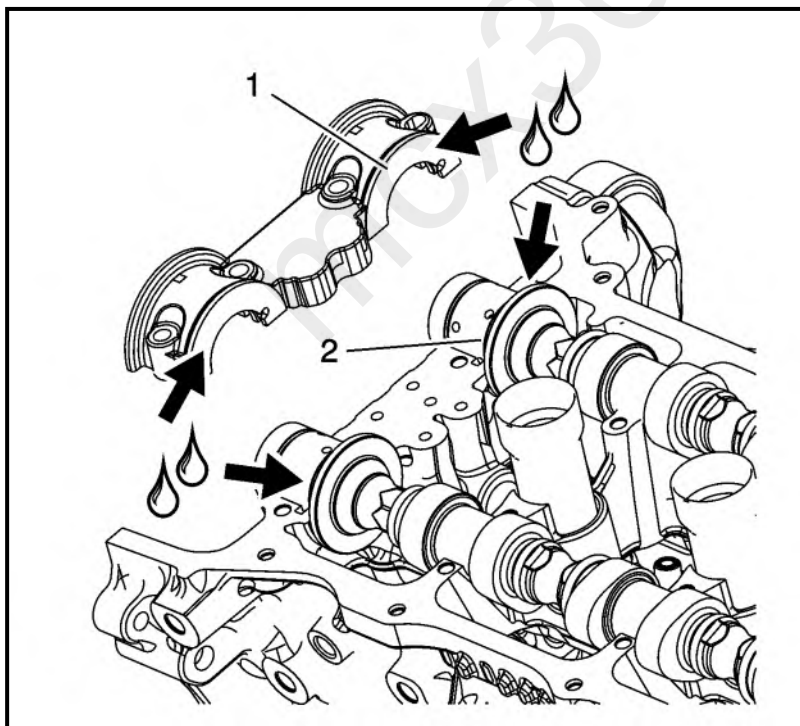


Observe the markings on the right cylinder head camshaft bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:

- The raised feature (1) must always be oriented toward the center of the cylinder head.
- The I indicates the intake camshaft.
- The E indicates the exhaust camshaft.
- The number 1, 3, 5 indicates the cylinder position from the front of the engine.

6. Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.

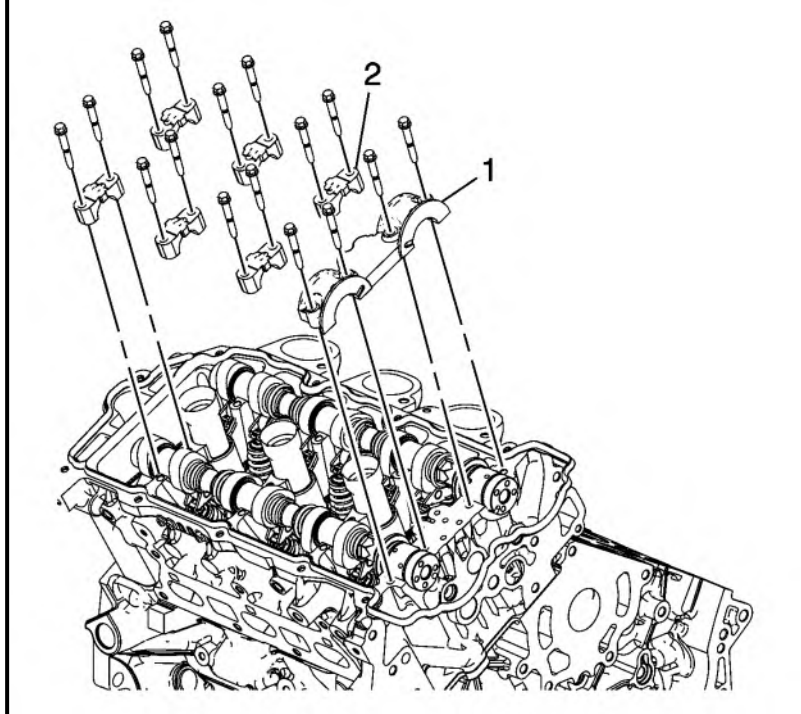
7.



Apply a liberal amount of lubricant to the camshaft bearing cap (1) and camshaft thrust surface (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.

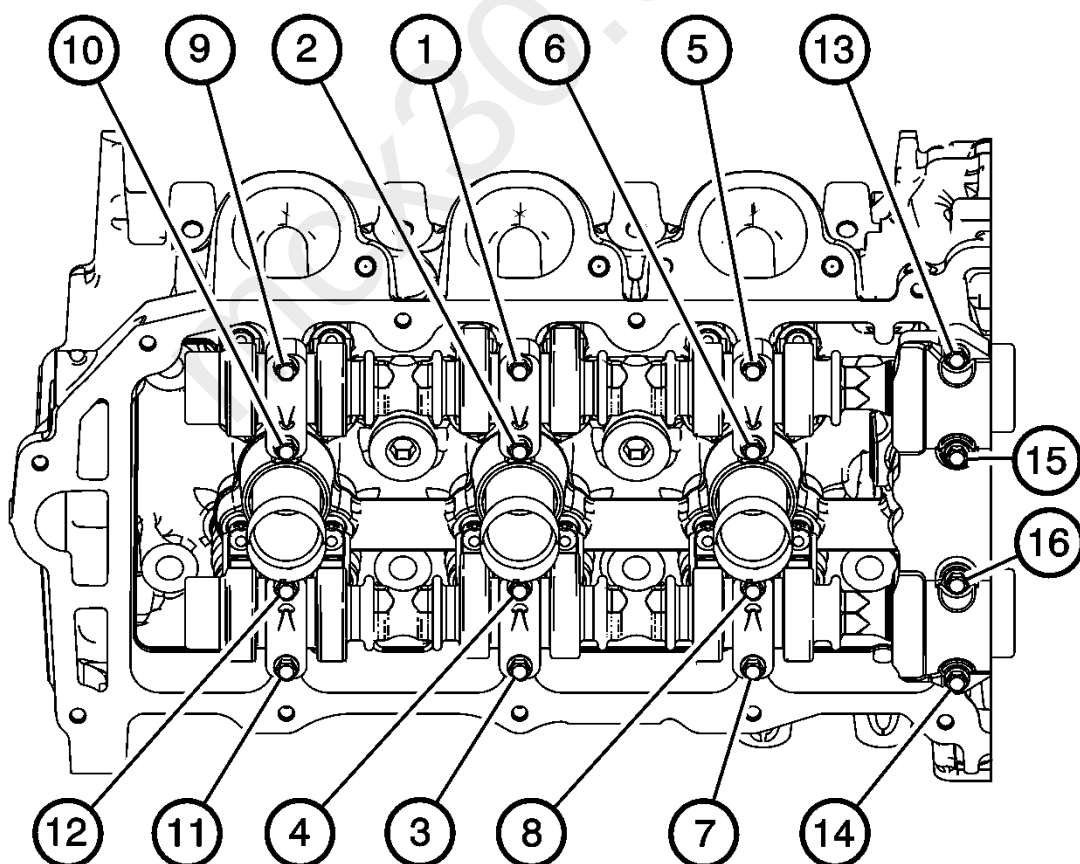
8.





Install the camshaft bearing thrust caps (1) in the first journal of the right cylinder head.

9. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.
10. Hand start all the camshaft bearing cap bolts.



11.

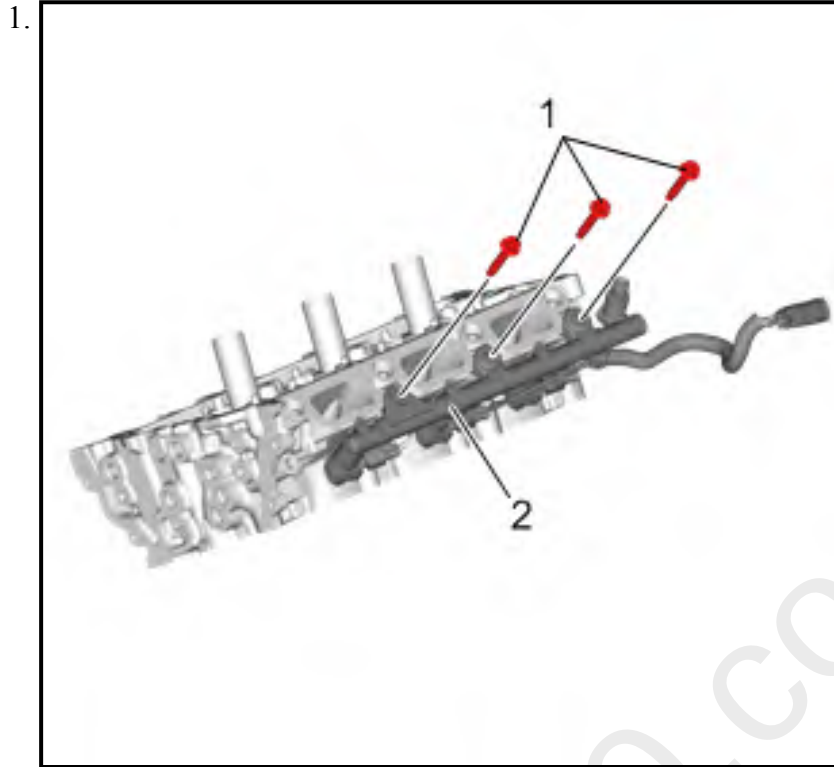
Fig. 23: Camshaft Bearing Cap Bolts Tighten Sequence - Right Side
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

Tighten the camshaft bearing cap bolts in the sequence shown and tighten to 10 N.m (89 lb in).

12. Loosen the center intake camshaft bearing cap bolts (1, 2) and the center exhaust camshaft bearing cap bolts (3, 4).
13. Retighten the center camshaft bearing cap bolts (1, 2, 3, 4) and retighten the camshaft bearing cap bolts to 10 N.m (89 lb in).

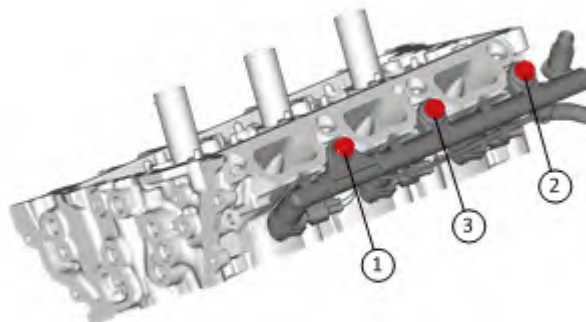
FUEL RAIL INSTALLATION



NOTE: If the fuel rail was removed from the cylinder head, the fuel injector tip seals must be replaced. [Fuel Rail and Injectors Cleaning and Inspection](#)

Install the fuel rail with injectors (2) into the cylinder head evenly.

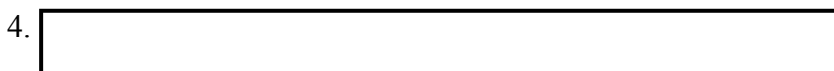
2. Install and hand tighten the three fuel rail bolts (1) to seat the injectors in the injector bores.

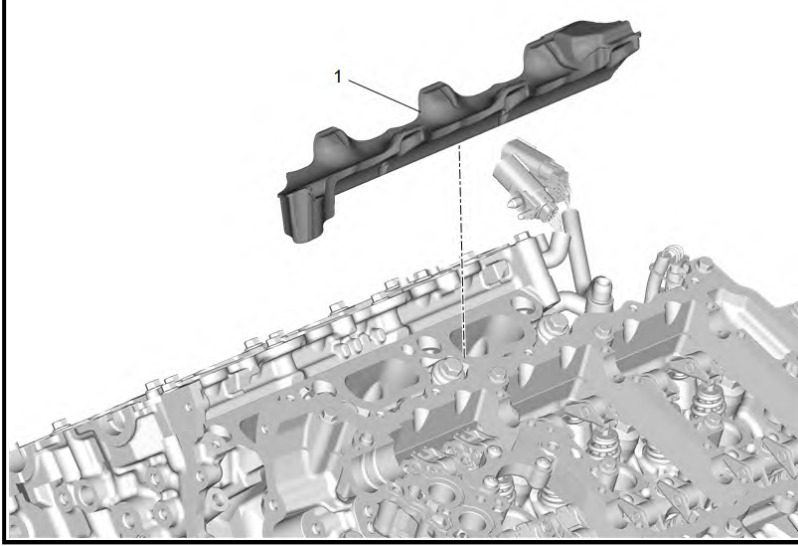


- 3.

Fig. 24: Fuel Rail Bolts With Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

Tighten the fuel rail bolts in the sequence shown to 25 N.m (18 lb ft).





WARNING: The noise cancelling foam component **MUST** be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

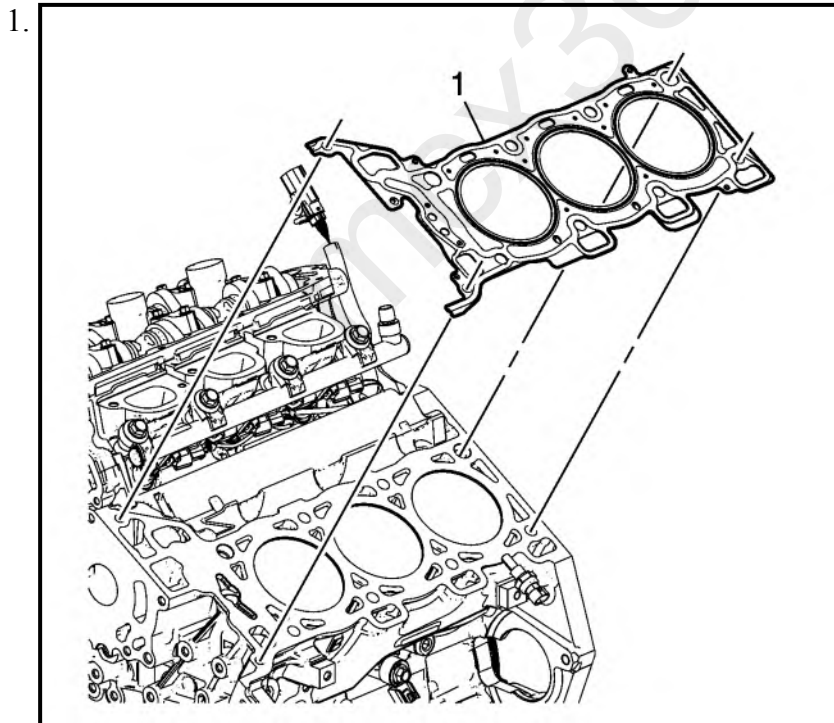
Install fuel injection fuel rail noise shield (1).

CYLINDER HEAD INSTALLATION - LEFT SIDE

Special Tools

EN 45059 Angle Meter

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

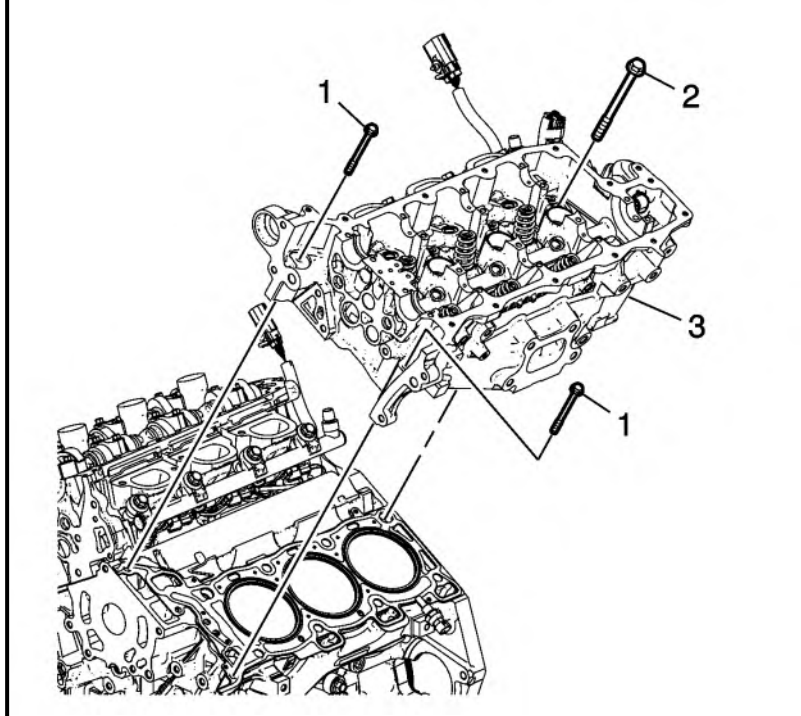


Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face.

2. Install a NEW left cylinder head gasket (1) using the deck face locating pins for retention.

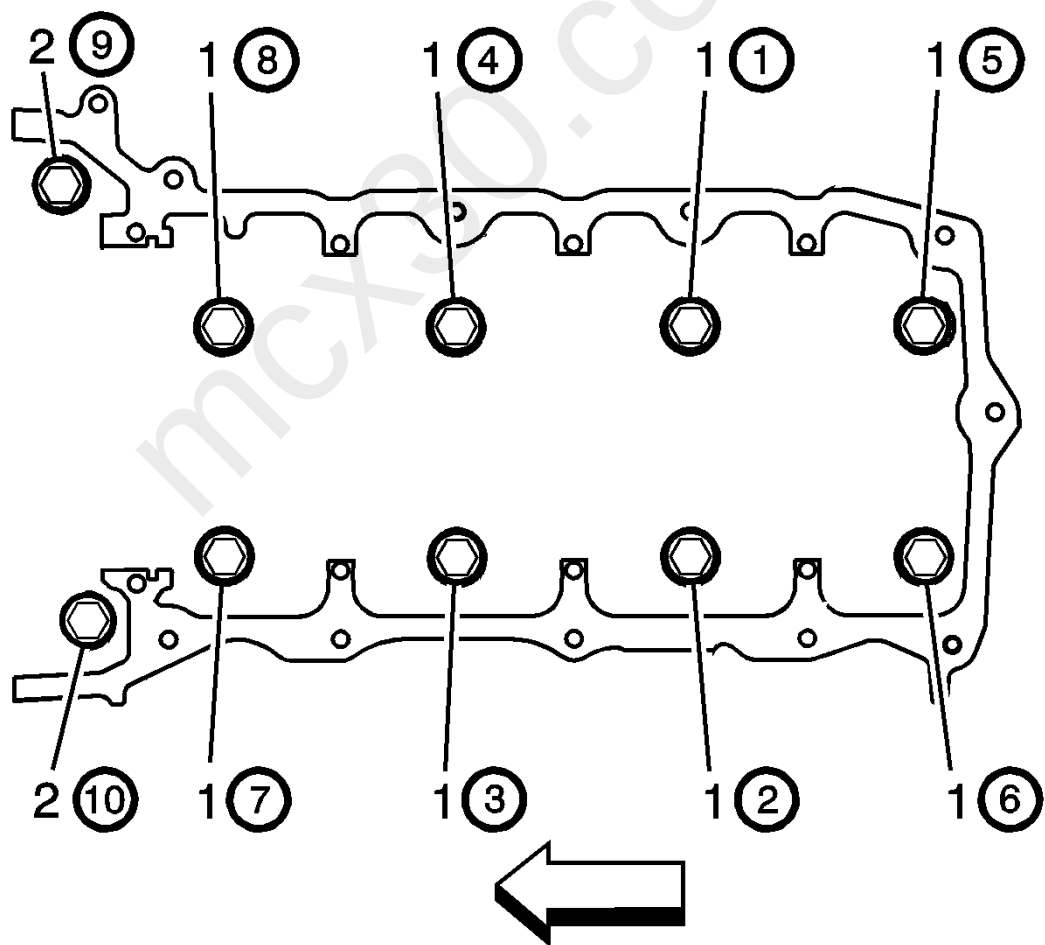
3.





Align the left cylinder head (3) with the deck face locating pins.

4. Place the left cylinder head in position on the deck face.



5.

Fig. 25: Cylinder Head Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners.

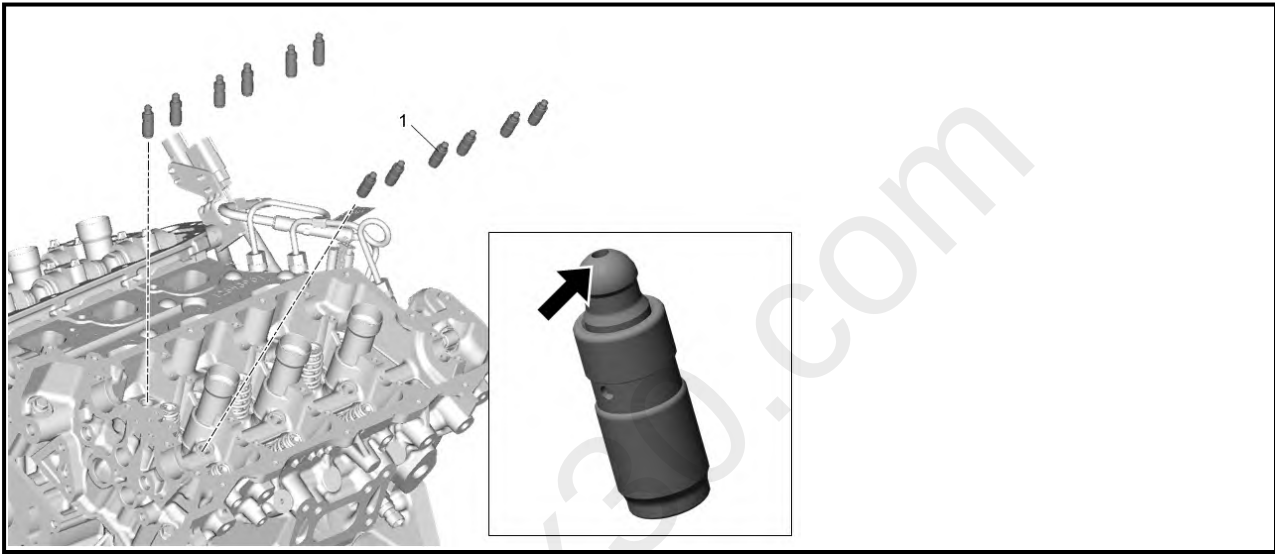
Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

NOTE: DO NOT allow oil on the cylinder head bolt bosses.

Install the NEW M11 cylinder head bolts (1).

1. Tighten the M11 cylinder head bolts a first pass in sequence to 30 N.m (22 lb ft).
 2. Tighten the M11 cylinder head bolts a second pass in sequence an additional 150 degrees using the **EN 45059** meter.
6. Install the 2 NEW front M8 left cylinder head bolts (2).
1. Tighten the M8 cylinder head bolts a first pass to 15 N.m (11 lb ft).
 2. Tighten the M8 cylinder head bolts a second pass in sequence an additional 75 degrees using the **EN 45059** meter.

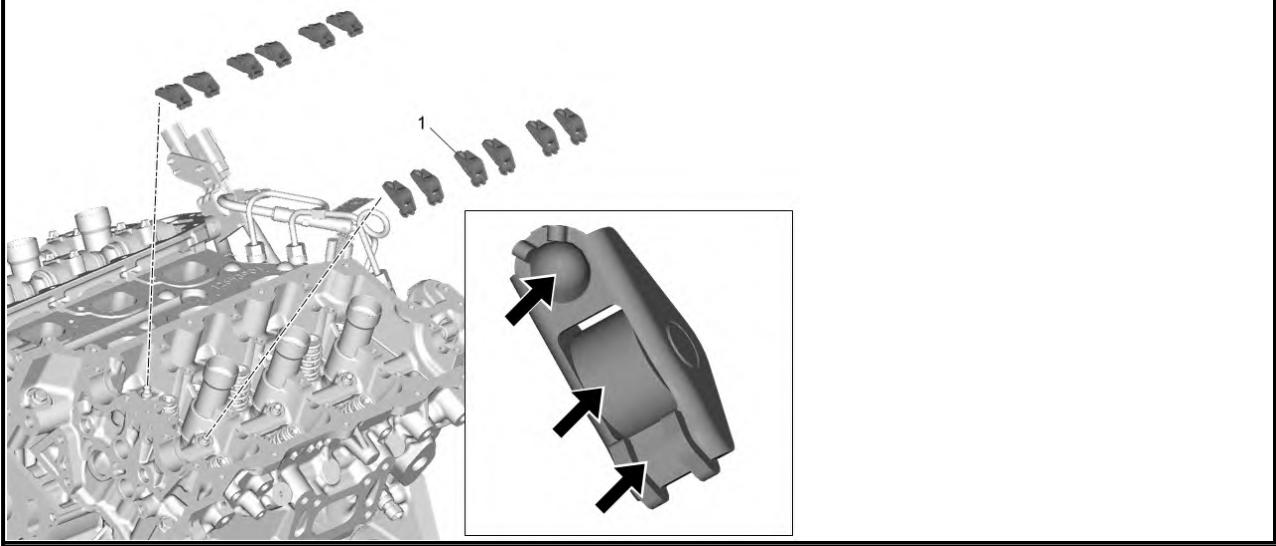
VALVE LIFTER INSTALLATION - LEFT SIDE



Callout	Component Name
1	Hydraulic Valve Lash Adjuster NOTE: • Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber. • Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill. Procedure 1. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Adhesives, Fluids, Lubricants, and Sealers Take precautions to prevent scratching the pivot sphere area of the SHLA. 2. Lubricate the SHLA bores in the cylinder head with clean engine oil. 3. Install the SHLAs in the cylinder head. 4. Apply a liberal amount of lubricant to the SHLA pivot spheres.

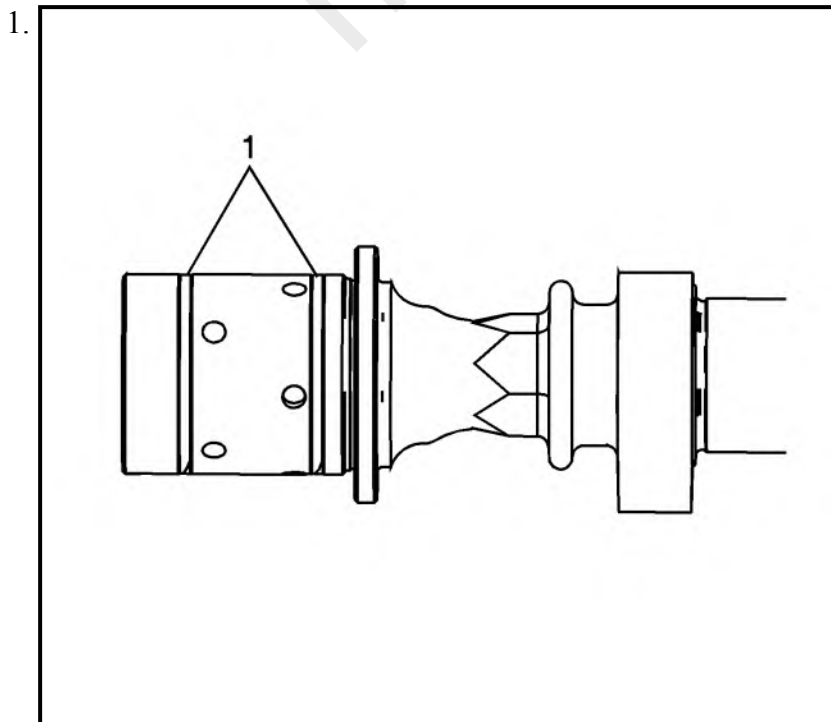
VALVE ROCKER ARM INSTALLATION - LEFT SIDE





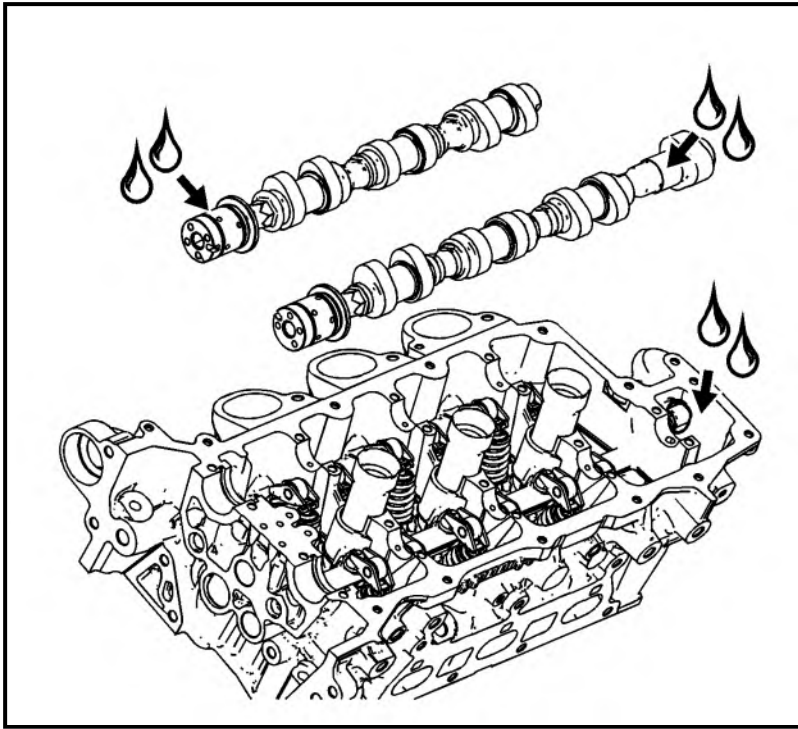
Callout	Component Name
1	Valve Rocker Arm Procedure 1. Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. <u>Adhesives, Fluids, Lubricants, and Sealers</u> NOTE: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location. 2. Place the camshaft followers in position on the valve tip and stationary hydraulic lash adjuster (SHLA). 3. The rounded head end of the follower goes on the SHLA while the flat end goes on the valve tip. 4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

CAMSHAFT INSTALLATION - LEFT SIDE



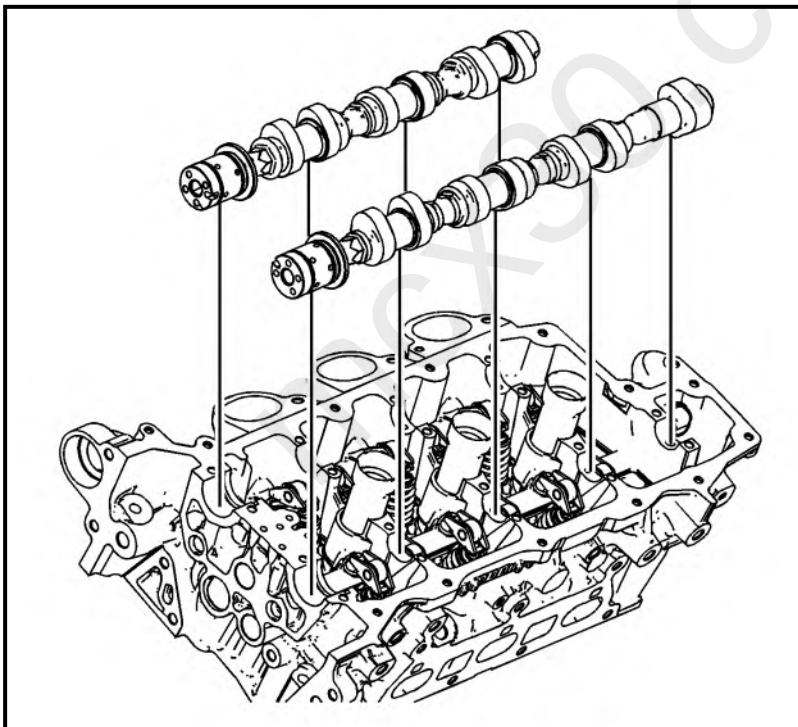
Ensure that the camshaft sealing rings (1) are in place in the camshaft grooves. Camshaft sealing rings must be in place below the surface of the camshaft journal in order to avoid being pinched between the cylinder head and the camshaft caps.

2.



Apply a liberal amount of lubricant to the camshaft journals and the left cylinder head camshaft carriers. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.

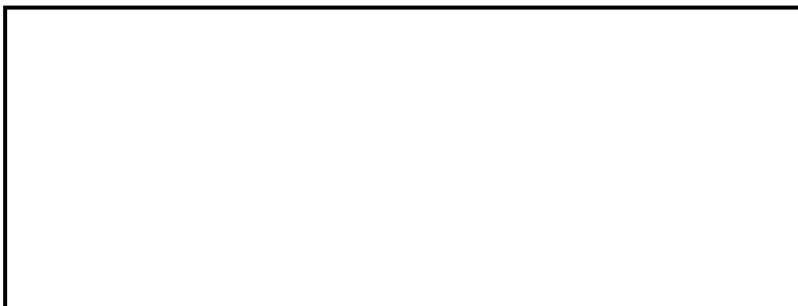
3.

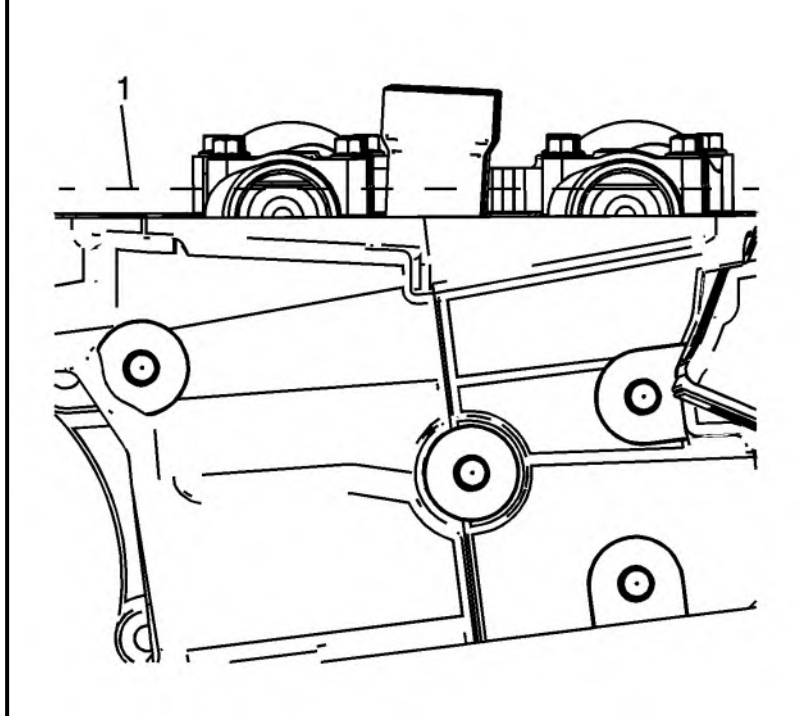


NOTE: The left intake camshaft has a laser inscription marking on the rear of the shaft to identify it as left bank intake (LI).

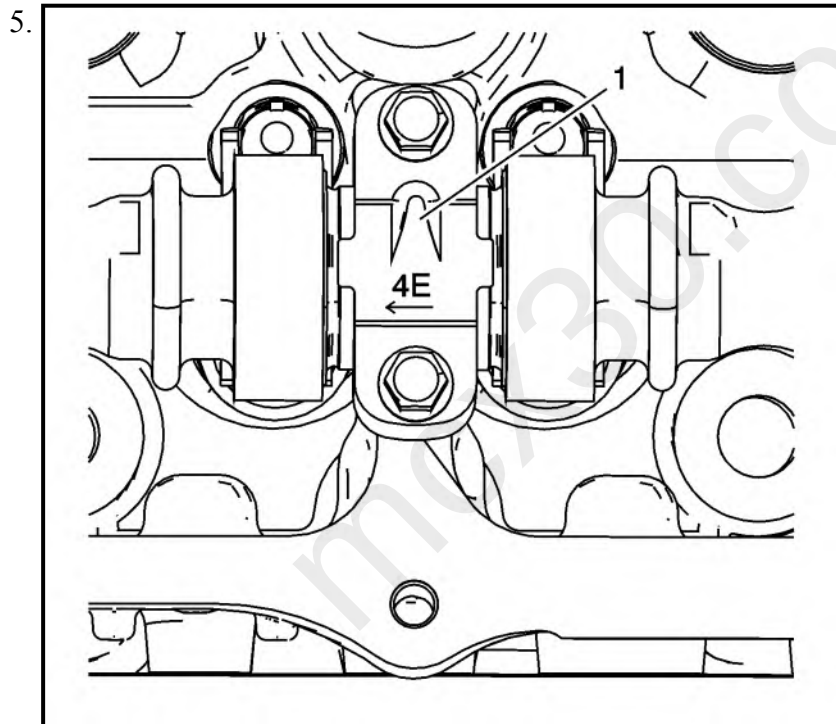
Place the left intake and left exhaust camshafts in position in the left cylinder head.

4.





Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the left cylinder head camshaft cover rail.



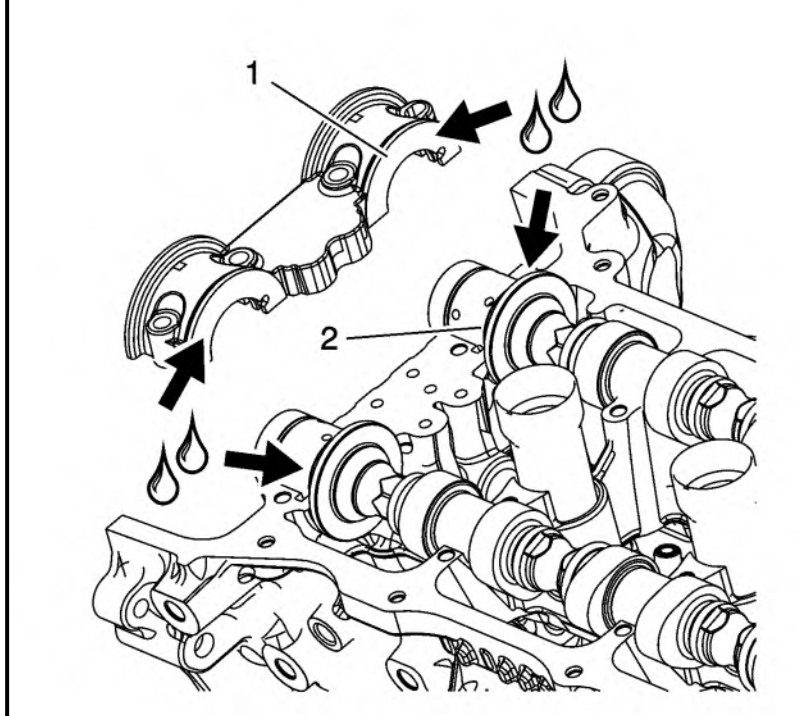
Observe the markings on the left cylinder head camshaft bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:

- The raised feature (1) must always be oriented toward the center of the cylinder head.
- The I indicates the intake camshaft.
- The E indicates the exhaust camshaft.
- The number 2, 4, 6 indicates the cylinder position from the front of the engine.

6. Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.

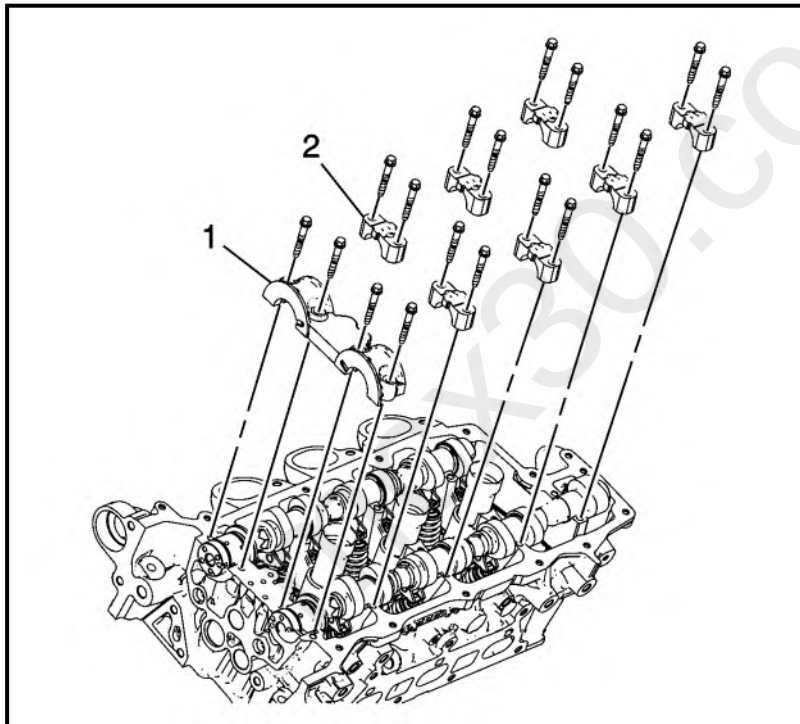
7.





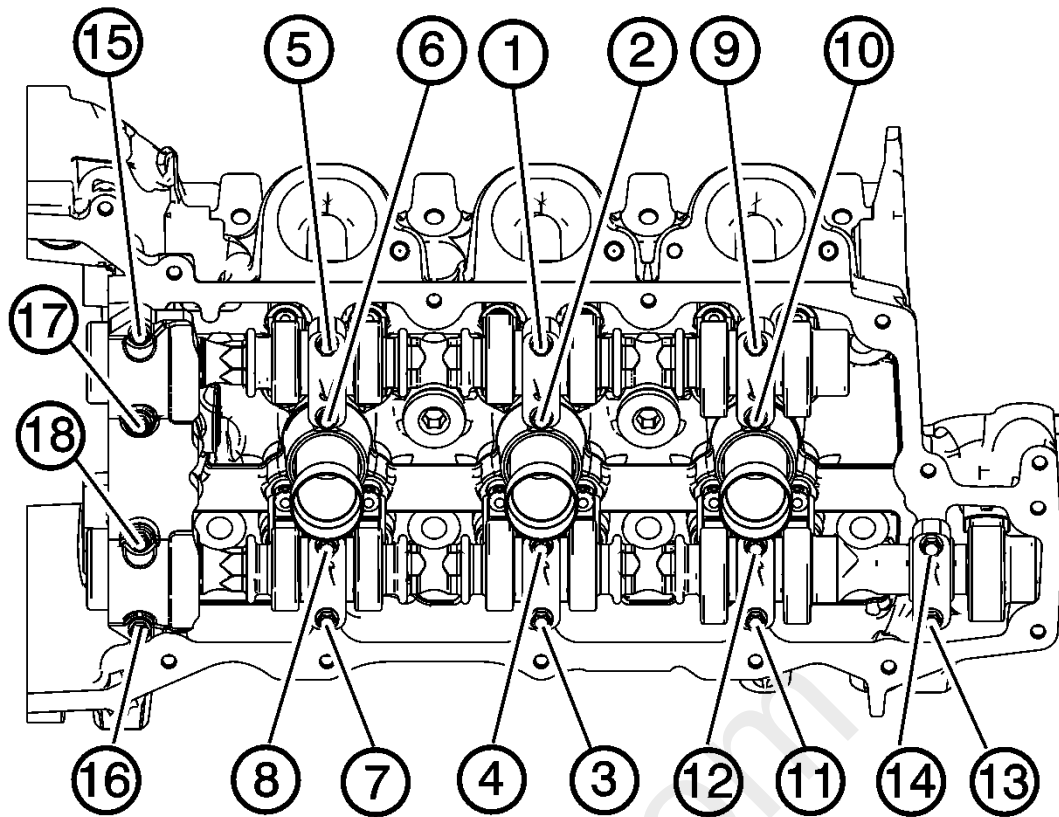
Apply a liberal amount of lubricant to the camshaft bearing cap (1) and camshaft thrust surface (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.

8.



Install the camshaft bearing thrust cap (1) in the first journal of the left cylinder head.

9. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.
10. Hand start all the camshaft bearing cap bolts.



11.

Fig. 26: Camshaft Bearing Cap Bolt Tightening Sequence - Left Side

Courtesy of GENERAL MOTORS COMPANY

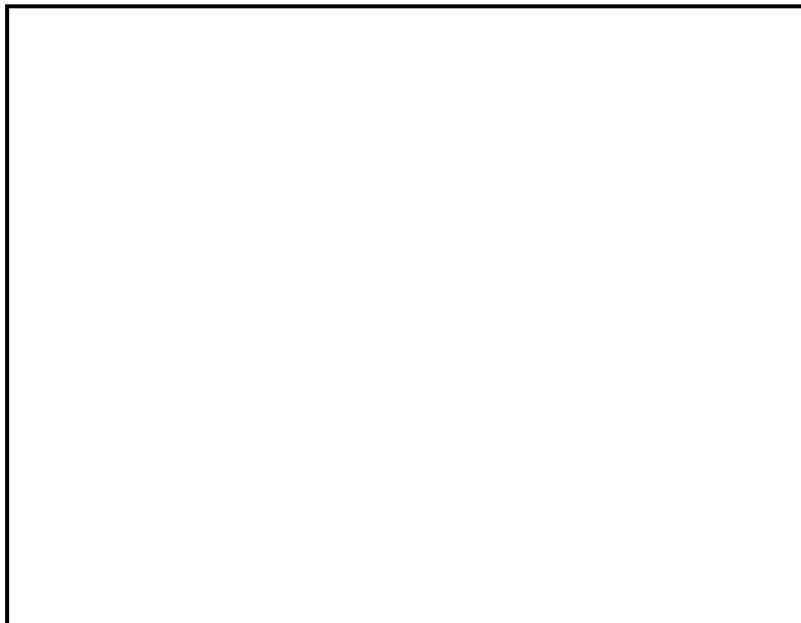
CAUTION: Refer to **Fastener Caution** .

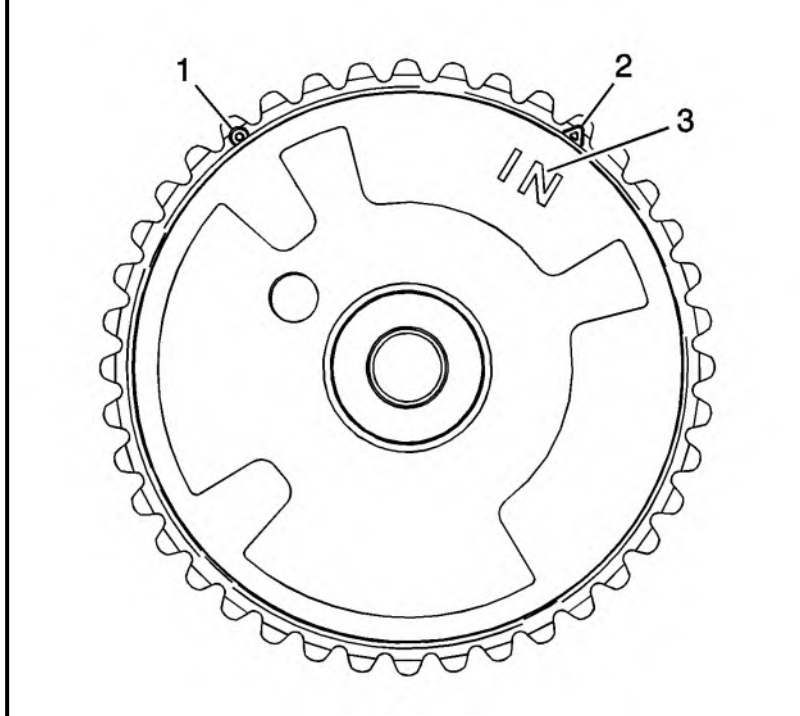
Tighten the camshaft bearing cap bolts in the sequence shown and tighten to 10 N.m (89 lb in).

12. Loosen the center intake camshaft bearing cap bolts 1, 2 and the center exhaust camshaft bearing cap bolts 3, 4.
13. Retighten the center camshaft bearing cap bolts 1, 2, 3, 4 and retighten the camshaft bearing cap bolts to 10 N.m (89 lb in).

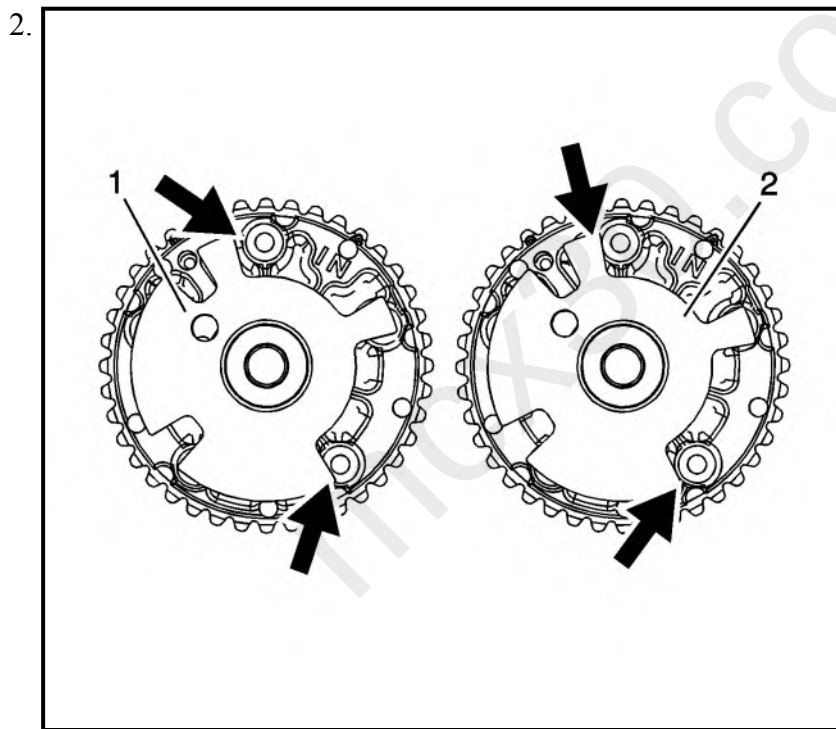
CAMSHAFT POSITION ACTUATOR INSTALLATION - RIGHT SIDE INTAKE

1.





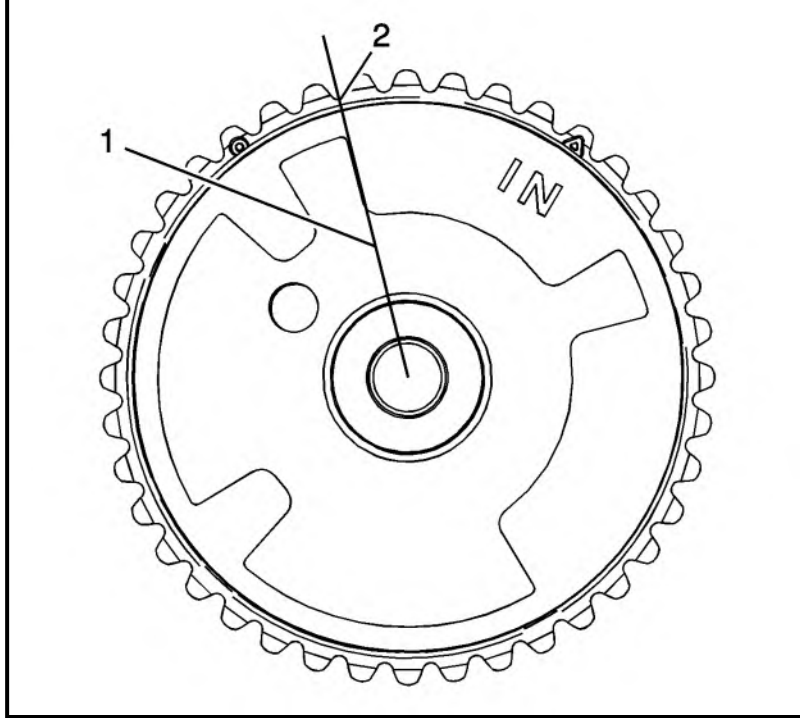
Ensure the proper camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "IN" marking (3). The marking is for an intake camshaft position actuator.



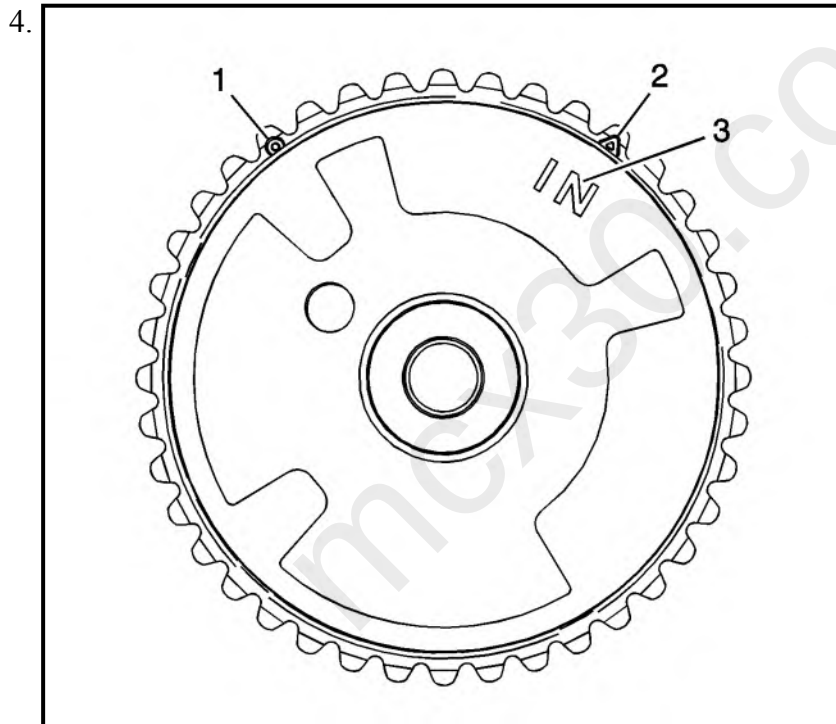
CAUTION: Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.

Ensure the proper camshaft position actuator is being installed. The reluctor wheel on the right intake camshaft position actuator (1) is indexed in a different position compared to the left intake camshaft position actuator (2).





On the right intake camshaft actuator the edge of the reluctor wheel (1) lines up with the valley (2) of the sprocket tooth.

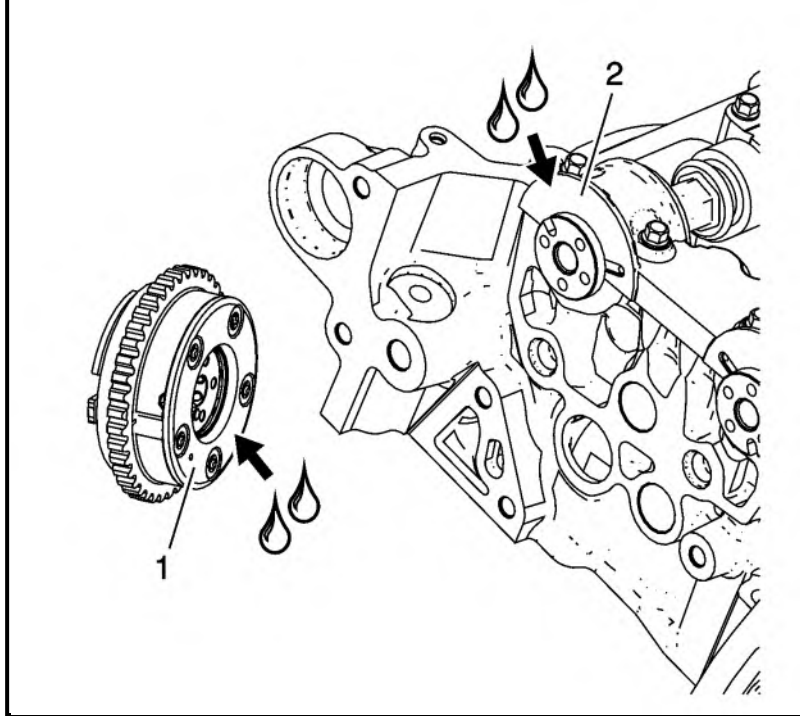


Ensure the proper timing mark is used. Observe the outer ring of the camshaft position actuator for the triangle marking (2). The triangle marking is for alignment to the highlighted timing chain link on the right side of the engine.

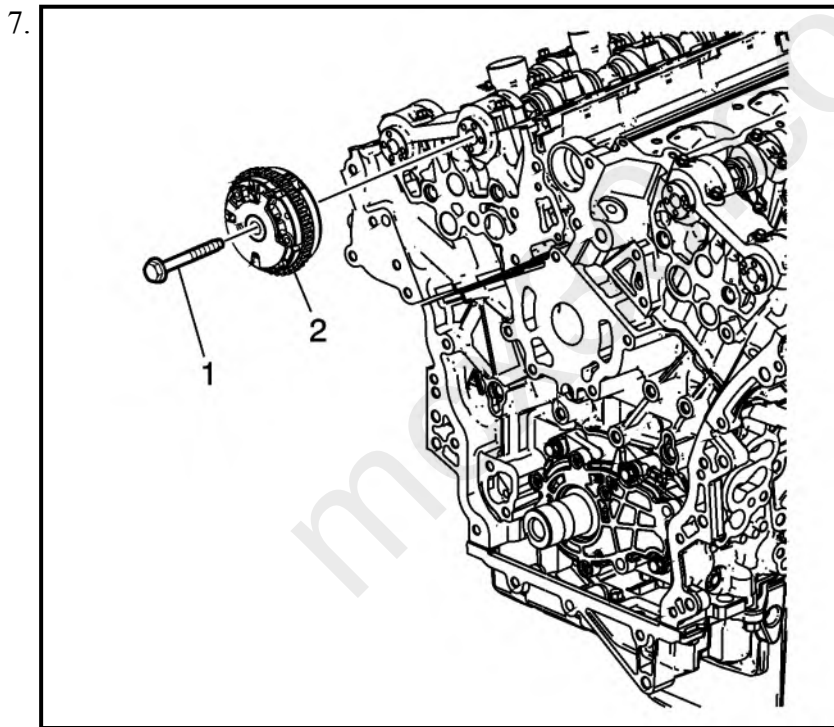
CAUTION: Refer to [Torque Reaction Against Timing Drive Chain Caution](#) .

5. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.





Apply a liberal amount of lubricant to the back of the camshaft position actuator (1) and front of the camshaft bearing cap (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.



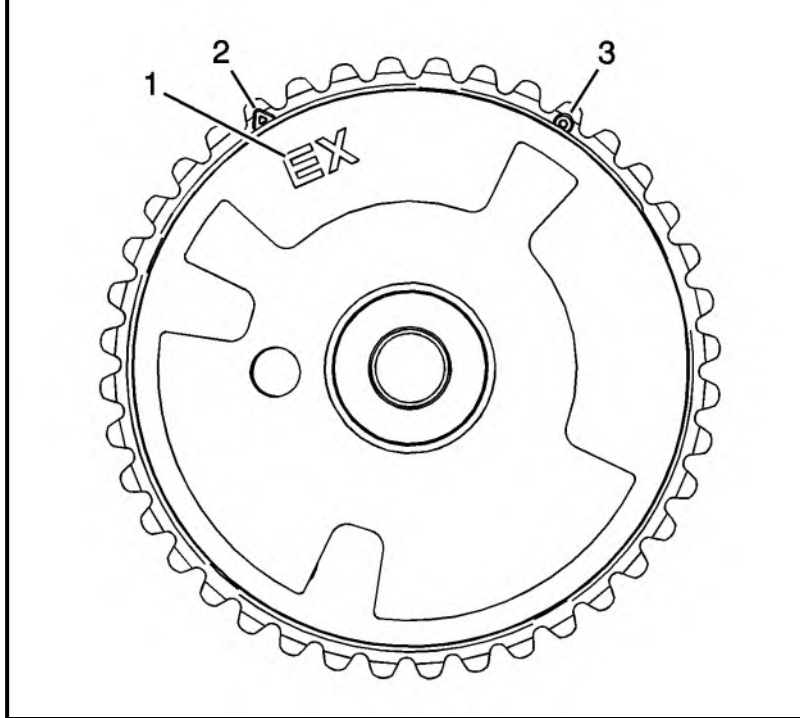
Install the right intake camshaft position actuator (2).

CAUTION: Refer to [Fastener Caution](#) .

8. Install the camshaft position actuator bolt (1) and tighten to 58 N.m (43 lb ft).

CAMSHAFT POSITION ACTUATOR INSTALLATION - RIGHT SIDE EXHAUST



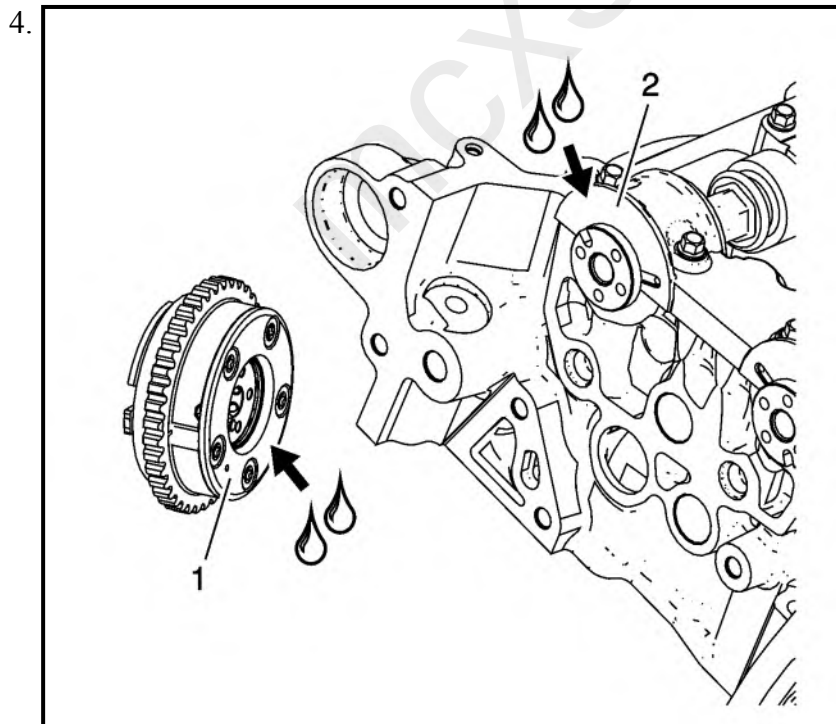


Ensure the proper camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "EX" marking (1). The marking is for an exhaust camshaft position actuator.

2. Ensure the proper timing mark is used. Observe the outer ring of the camshaft position actuator for the triangle marking (2). The marking is for alignment to the highlighted timing chain link on the right side of the engine.

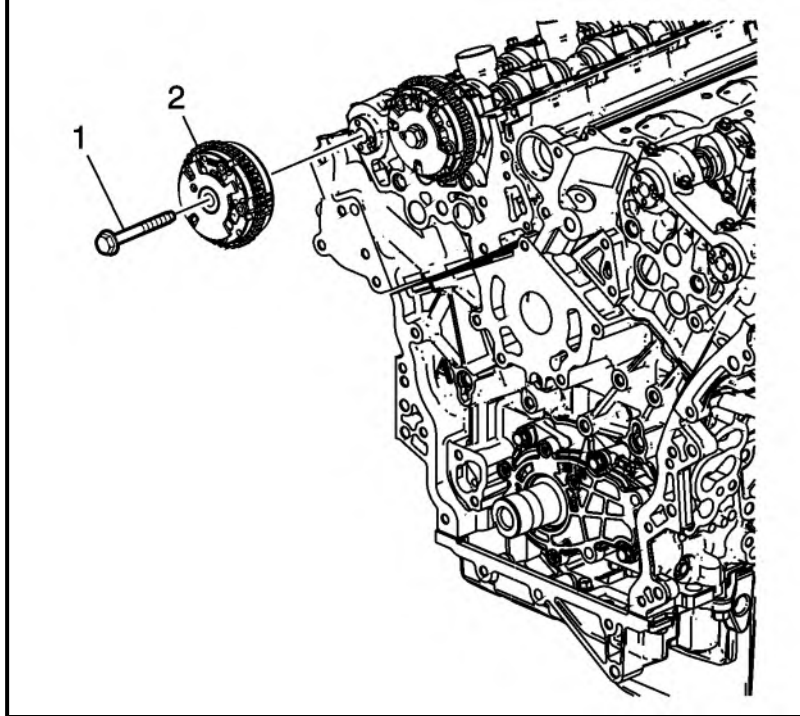
CAUTION: Refer to [Torque Reaction Against Timing Drive Chain Caution](#) .

3. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.



Apply a liberal amount of lubricant to the back of the camshaft position actuator (1) and front of the camshaft bearing cap (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.



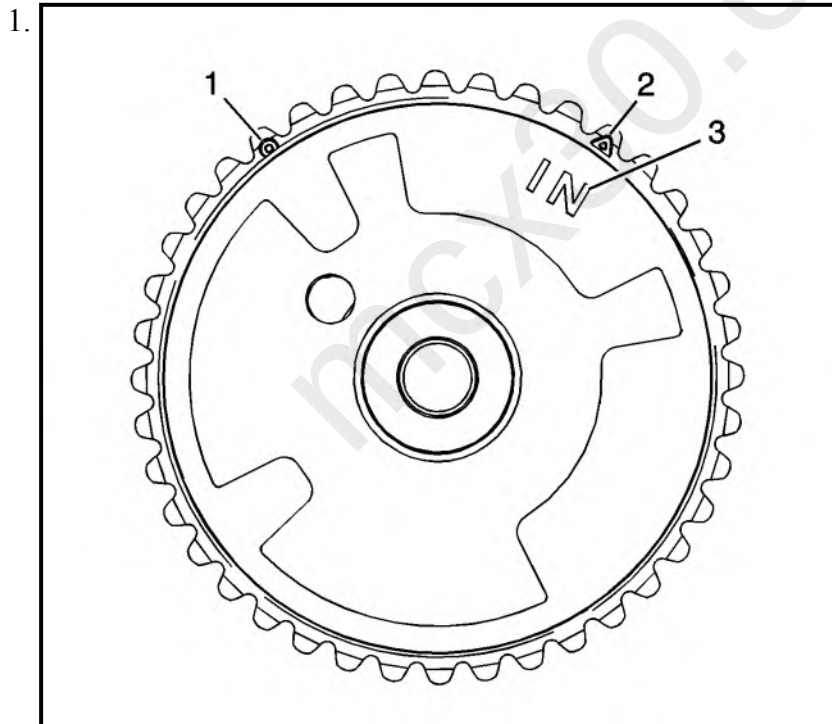


Install the right exhaust camshaft position actuator (2).

CAUTION: Refer to [Fastener Caution](#) .

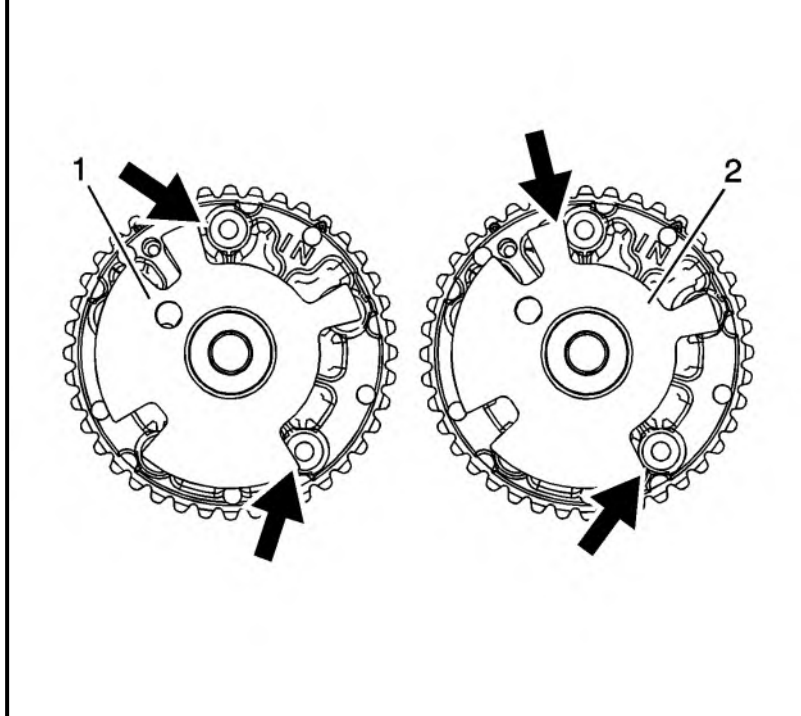
6. Install the camshaft position actuator bolt (1) and tighten to 58 N.m (43 lb ft).

CAMSHAFT POSITION ACTUATOR INSTALLATION - LEFT SIDE INTAKE



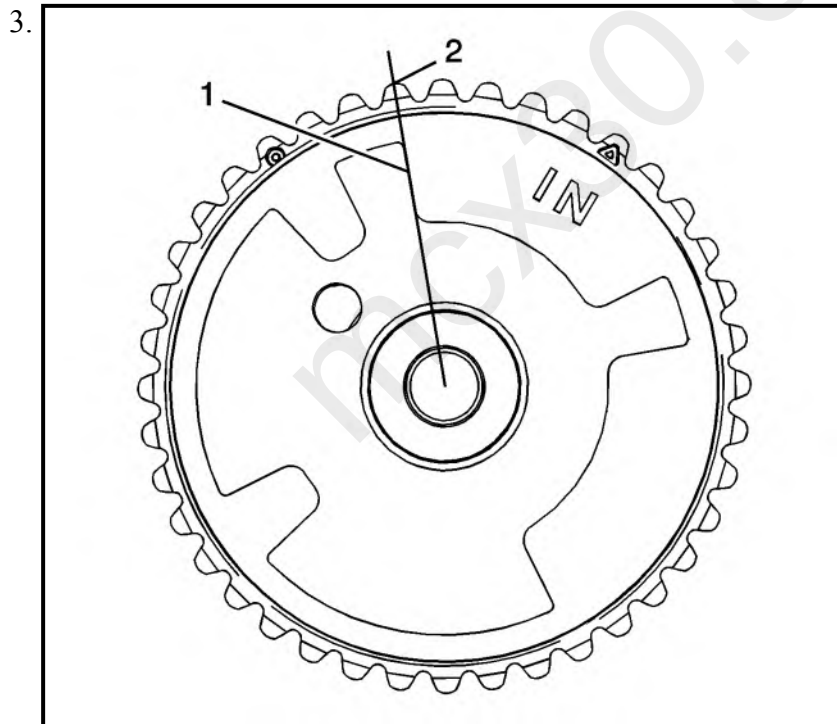
Ensure the proper camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "IN" marking (3). The marking is for an intake camshaft position actuator.





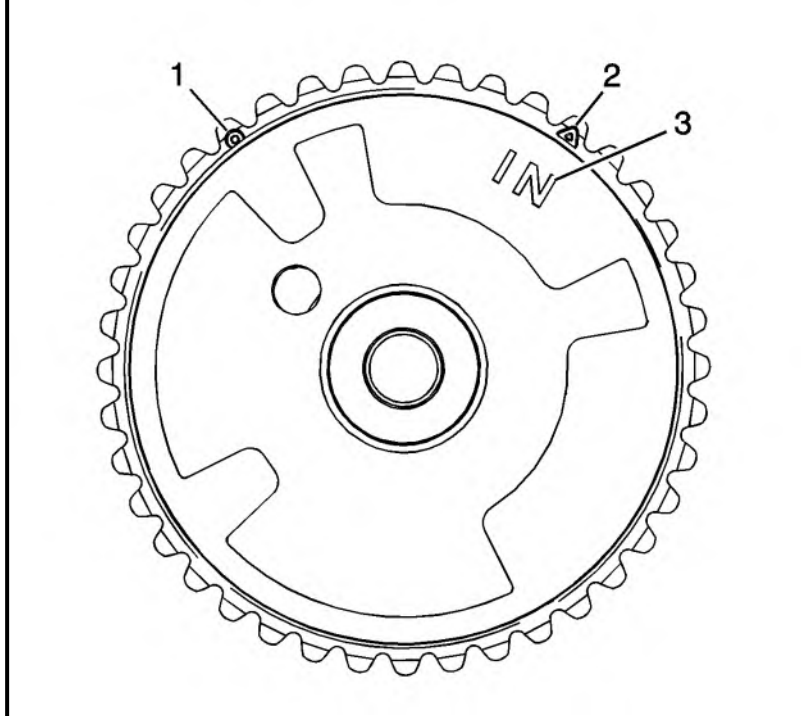
CAUTION: Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.

Ensure the proper camshaft position actuator is being installed. The reluctor wheel on the right intake camshaft position actuator (1) is indexed in a different position compared to the left intake camshaft position actuator (2).



On the left intake camshaft actuator the edge of the reluctor wheel (1) lines up with the peak (2) of the sprocket tooth.

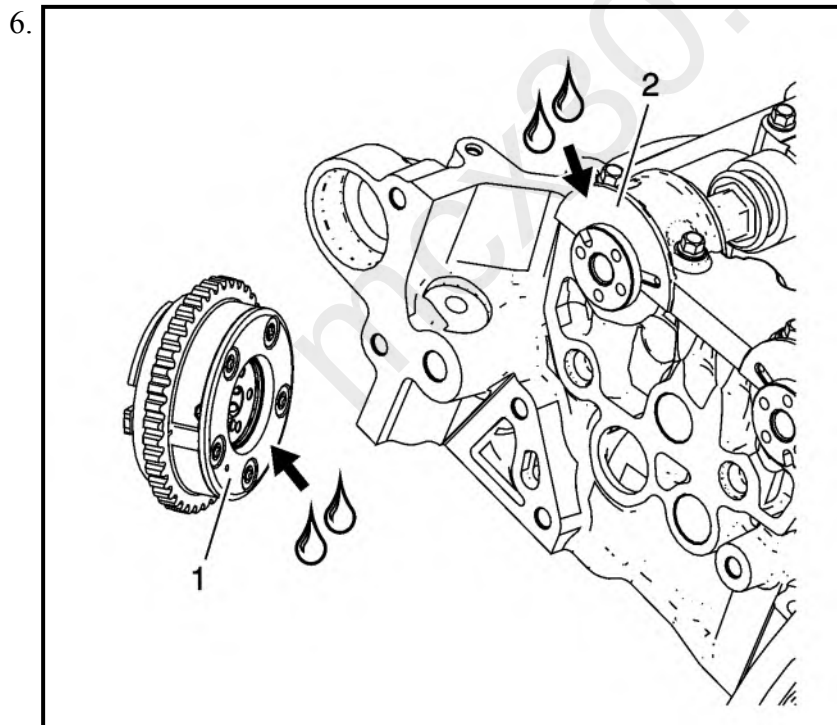




Ensure the proper timing mark is used. Observe the outer ring of the camshaft position actuator for the circle marking (1). The circle marking is for alignment to the highlighted timing chain link on the left side of the engine.

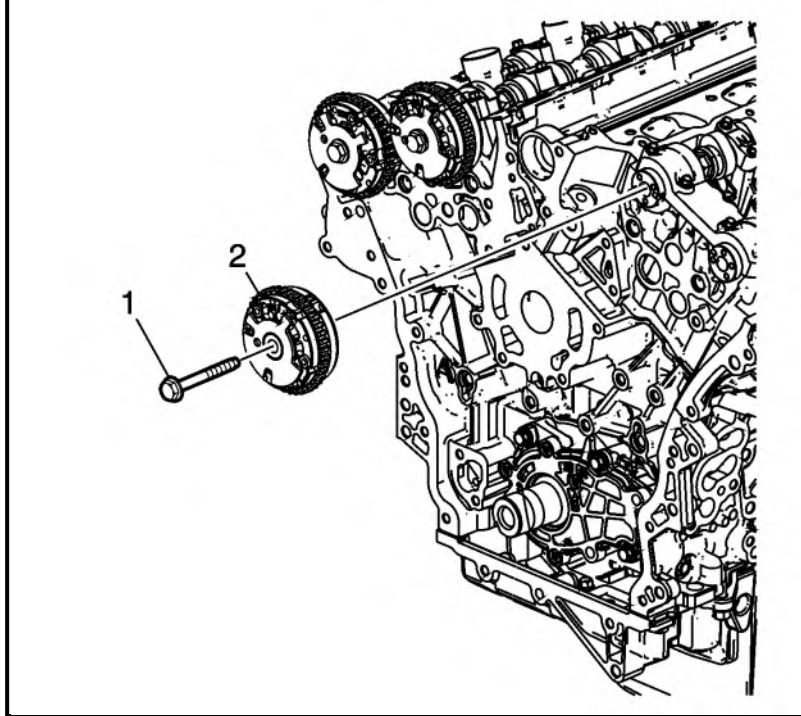
CAUTION: Refer to [Torque Reaction Against Timing Drive Chain Caution](#) .

5. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.



Apply a liberal amount of lubricant to the back of the camshaft position actuator (1) and front of the camshaft bearing cap (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.



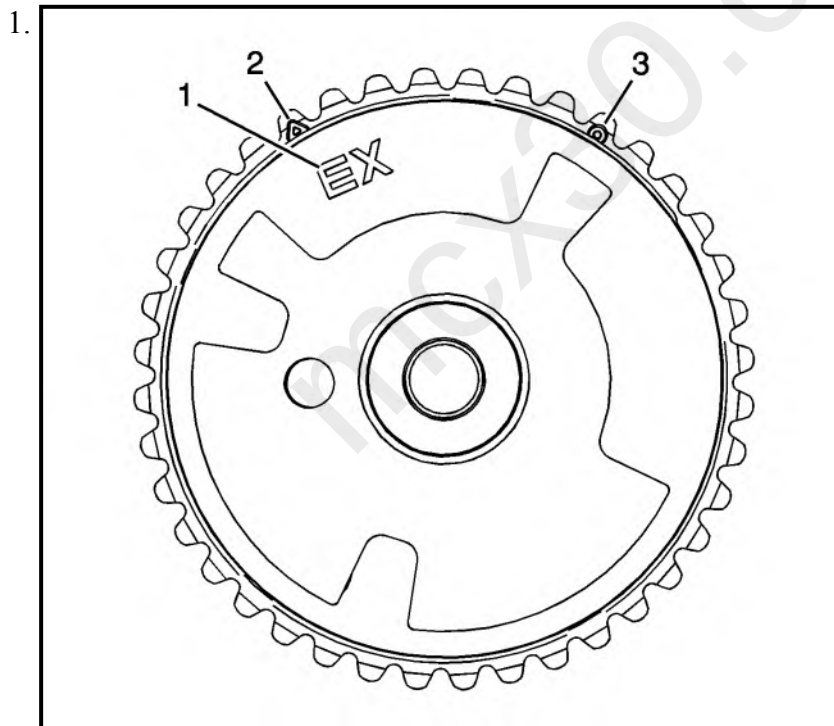


Install the left intake camshaft position actuator (2).

CAUTION: Refer to [Fastener Caution](#) .

8. Install the camshaft position actuator bolt (1) and tighten to 58 N.m (43 lb ft).

CAMSHAFT POSITION ACTUATOR INSTALLATION - LEFT SIDE EXHAUST



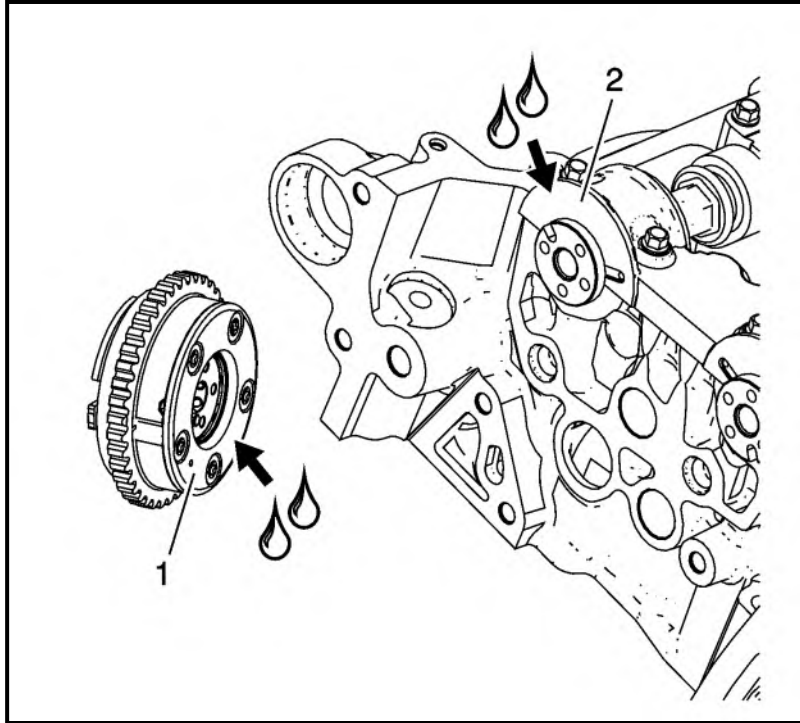
Ensure the proper camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "EX" marking (1). The marking is for an exhaust camshaft position actuator.

2. Ensure the proper timing mark is used. Observe the outer ring of the camshaft position actuator for the circle marking (3). The marking is for alignment to the highlighted timing chain link on the left side of the engine.

CAUTION: Refer to [Torque Reaction Against Timing Drive Chain Caution](#) .

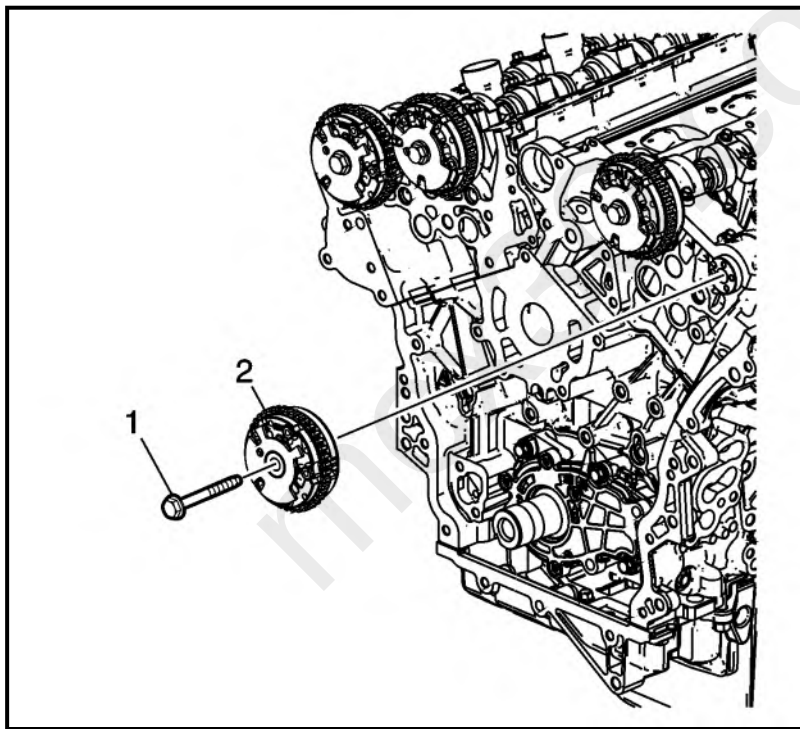
3. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.

4.



Apply a liberal amount of lubricant to the back of the camshaft position actuator (1) and front of the camshaft bearing cap (2). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended lubricant.

5.



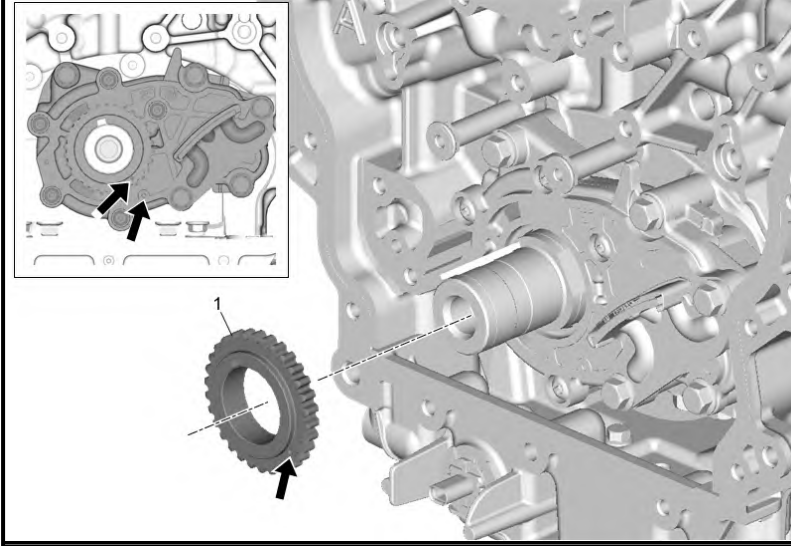
Install the left exhaust camshaft position actuator (2).

CAUTION: Refer to [Fastener Caution](#) .

6. Install the camshaft position actuator bolt (1) and tighten to 58 N.m (43 lb ft).

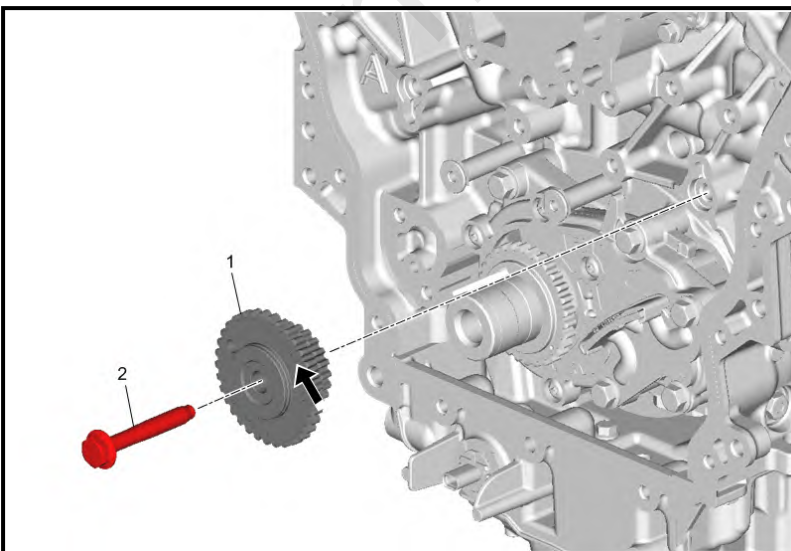
CRANKSHAFT SPROCKET INSTALLATION





Callout	Component Name
1	Crankshaft Sprocket Procedure 1. Ensure the crankshaft sprocket is installed with the timing mark visible. 2. Install the crankshaft sprocket onto the nose of the crankshaft. 3. Align the notch in the crankshaft sprocket with the pin in the crankshaft. 4. Slide the crankshaft sprocket on the crankshaft nose until the crankshaft sprocket contacts the step in the crankshaft. 5. Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark aligned to the stage one timing mark on the oil pump cover using the EN-48589 socket. Refer to: Timing Chain Alignment Diagram Special Tools EN-48589 Crankshaft Rotation Socket Equivalent regional tools: Special Tools

TIMING CHAIN IDLER SPROCKET INSTALLATION - LEFT SIDE

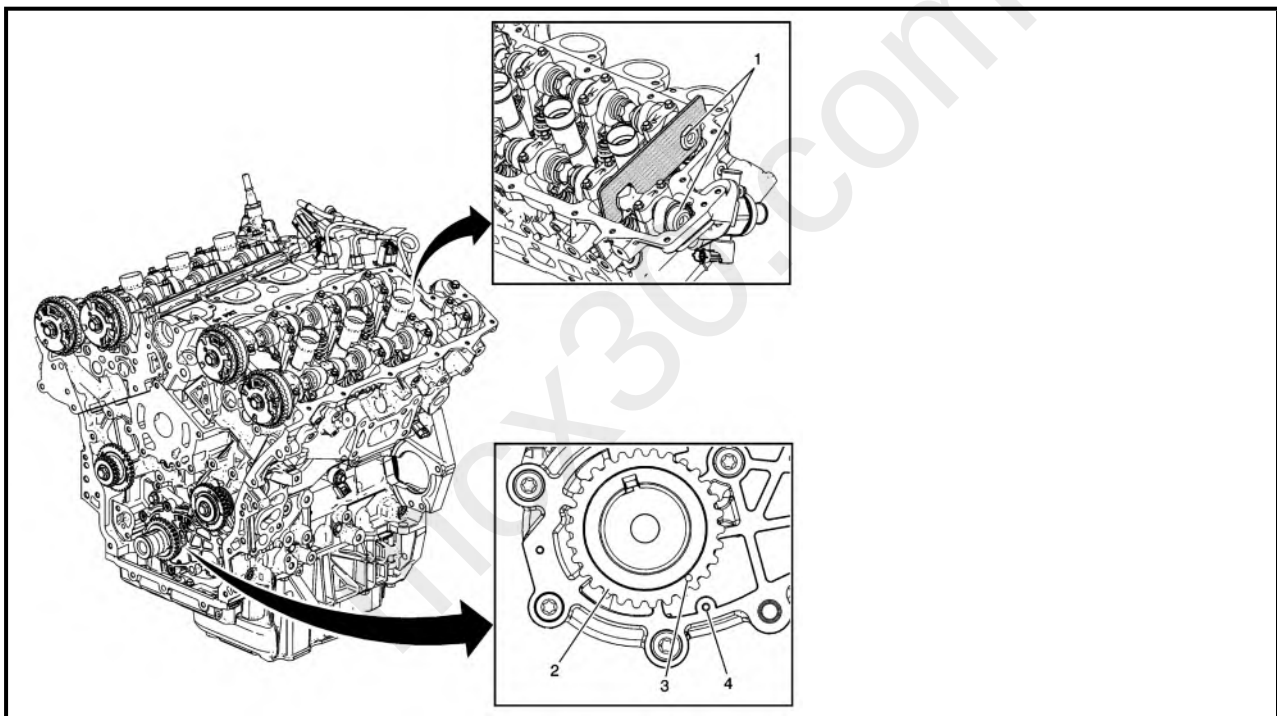


Callout	Component Name

Callout	Component Name
1	Left SideTiming Chain Idler Sprocket Procedure 1. Ensure that the left timing chain idler sprocket is being installed. The recessed hub and the larger sprocket of the left timing chain idler sprocket is installed outward. 2. Place the left camshaft intermediate drive chain idler to the cylinder block.
2	Timing Chain Idler Sprocket Shaft Bolt CAUTION: Refer to Fastener Caution . Tighten 58 N.m (43 lb ft)

CAMSHAFT TIMING CHAIN COMPONENTS INSTALLATION

Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 1

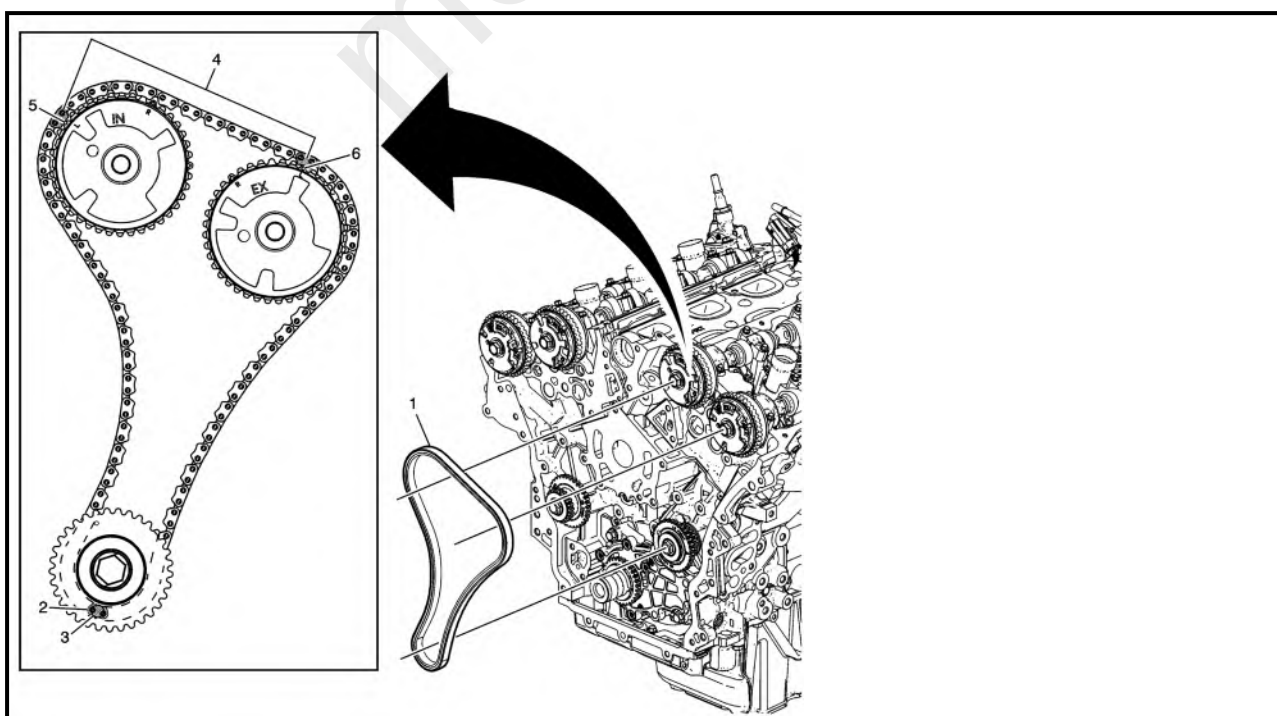


Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 1

Callout	Component Name
NOTE: If you are performing this procedure for the first time, it is recommended that you view video 56510.12V from the common training website before beginning (U.S. Dealers Only). To search for the video number, click on the catalog icon on the home page. Canadian dealers should view Tech Assist video 16038.01W on the LMS website and a related video on GM Global Connect (Library-Service>Technician Review>TAC Talk Video Help). See www.centerlearning.com for more information.	

Callout	Component Name
1	Left Intake and Exhaust Camshaft Procedure NOTE: • There should be no need to rotate the camshaft more than 10 degrees. Using the hex cast into the camshaft rotate the camshaft in order to install the EN-48383 retaining tools. • All camshafts must be locked in place before installation of any camshaft drive chains. 1. Install the EN-48383 - 1 retaining tool onto the rear of the left camshafts. 2. Ensure the EN-48383 - 1 retaining tool is fully seated onto the camshafts. Special Tool EN-48383 Camshaft Retaining Tools Equivalent regional tools: Special Tools .
2	Crankshaft Sprocket NOTE: Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark (3) aligned to the stage one timing mark on the oil pump cover (4) using the EN-48589 socket. Refer to Timing Chain Alignment Diagram . Special Tool EN-48589 Crankshaft Rotation Socket Equivalent regional tools: Special Tools .
3	Crankshaft Sprocket Timing Mark
4	Stage One Timing Mark On The Oil Pump Cover

Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 2

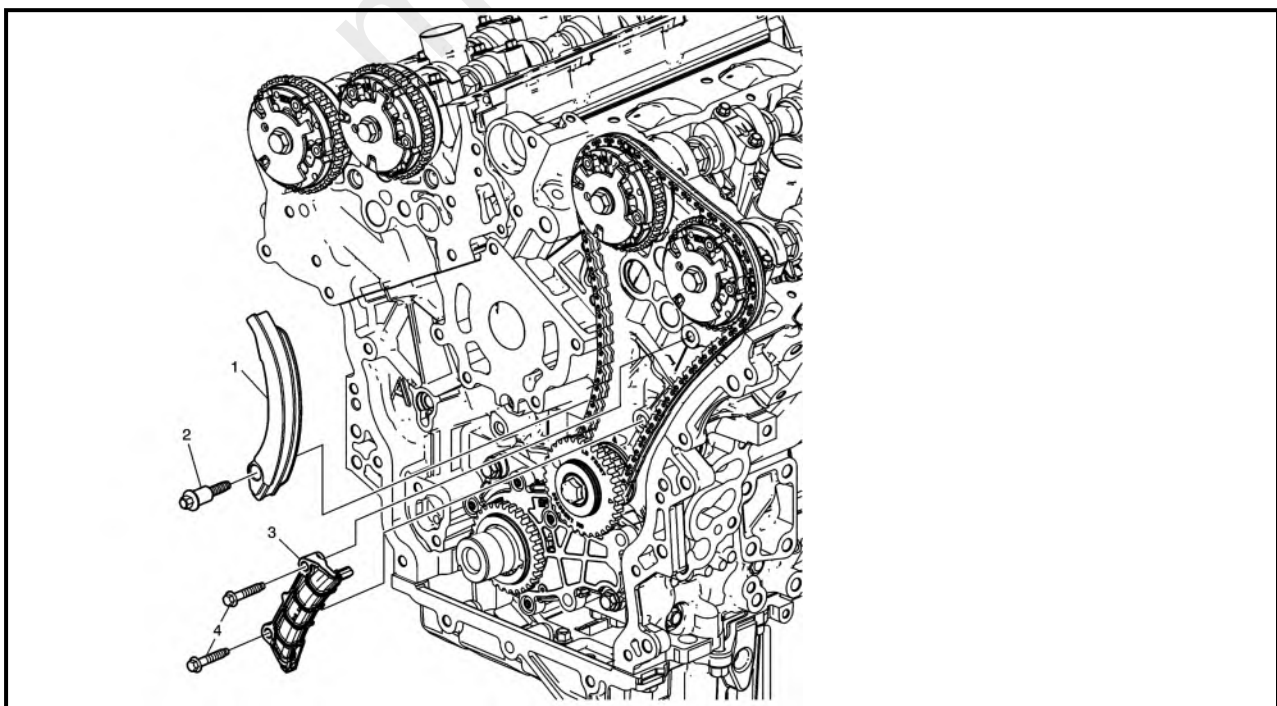


Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 2

Callout	Component Name

Callout	Component Name
NOTE: Ensure that the left (L) camshaft position actuator sprocket alignment circle marks are used during this step.	
1	Secondary Camshaft Intermediate Drive Chain Procedure NOTE: Once the lower timing link is aligned, it may be helpful to hold the drive chain in position using a small flat blade screwdriver through the idler sprocket alignment access hole. 1. Place the left secondary camshaft drive chain around the inner sprocket of the left camshaft intermediate drive chain idler with the camshaft drive chain timing link (2) aligned to the alignment access hole (3) in the left camshaft intermediate drive chain idler outer sprocket. 2. Wrap the secondary camshaft drive chain around both left (L) actuator drive sprockets. 3. Align the left (L) intake camshaft position actuator sprocket alignment circle mark (5) with the camshaft drive chain timing link. 4. Align the left (L) exhaust camshaft position actuator sprocket alignment circle mark (6) with the camshaft drive chain timing link. 5. Once aligned, ensure there are 10 chain links (4) between timing marks for the left (L) camshaft position actuator sprockets.
2	Timing Camshaft Drive Chain
3	Alignment Access Hole
4	10 Chain Links Between Timing Marks for the Left (L) Camshaft Position Actuator Sprockets
5	Left (L) Intake Camshaft Position Actuator Sprocket Alignment Circle Mark
6	Left (L) Exhaust Camshaft Position Actuator Sprocket Alignment Circle Mark

Secondary Camshaft Drive Chain Guide and Shoe Installation - Left

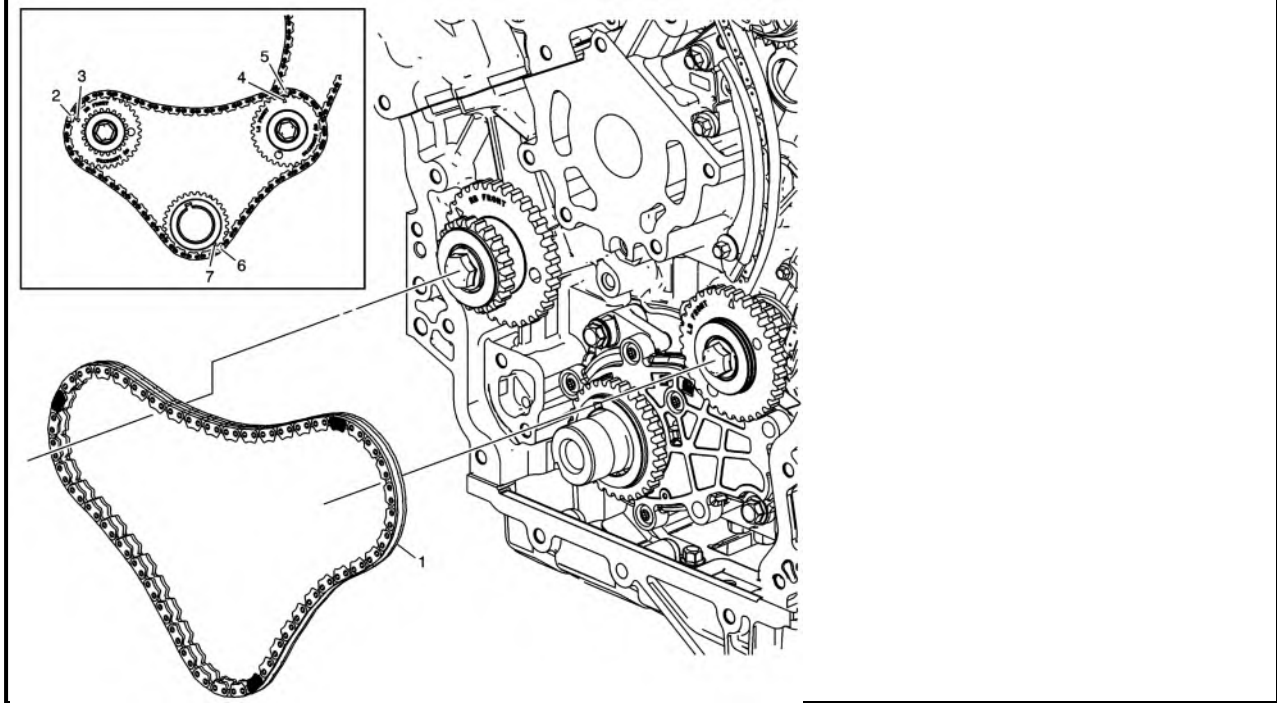


Secondary Camshaft Drive Chain Guide and Shoe Installation - Left

Callout	Component Name

Callout	Component Name
1	Left Secondary Timing Chain Tensioner Plunger. Procedure 1. Reset the left secondary camshaft drive chain tensioner plunger using EN - 45027 tensioner tool. 2. Install left secondary camshaft drive chain tensioner plunger into body. 3. Compress the plunger into the body and lock the left secondary camshaft drive chain tensioner by inserting the EN-46112 tensioner retraction pins into the access hole in the side of the left secondary camshaft drive chain tensioner body. 4. Slowly release pressure on the left secondary camshaft drive chain tensioner. The left secondary camshaft drive chain tensioner should remain compressed. Special Tools • EN-45027 Tensioner Tool • EN-46112 Tensioner Retraction Pins Equivalent regional tools: Special Tools .
2	Left Timing Chain Housing Gasket NOTE: Ensure the left secondary camshaft drive chain tensioner mounting surface on the left cylinder head does not have any burrs or defects that would degrade the sealing of the NEW left secondary camshaft drive chain tensioner gasket.
3	Left Secondary Timing Chain Tensioner
4	Left Secondary Timing Chain Tensioner Bolt Procedure 1. Place the chain tensioner into position and loosely install the bolts to the block. 2. Verify the proper placement of the drive chain tensioner gasket tab (5). 3. Tighten the drive chain tensioner bolts in two passes. 4. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 5. Release the drive chain tensioner by pulling out the EN - 46112 tensioner retraction pins pin (6) and unlocking the tensioner plunger. 6. Verify the left secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One. Tighten • First Pass: 5 N.m (44 lb in) • Final Pass: 25 N.m (18 lb ft)
5	Left Timing Chain Housing Gasket Tab
6	EN - 46112 Pin

Primary Camshaft Intermediate Drive Chain Installation

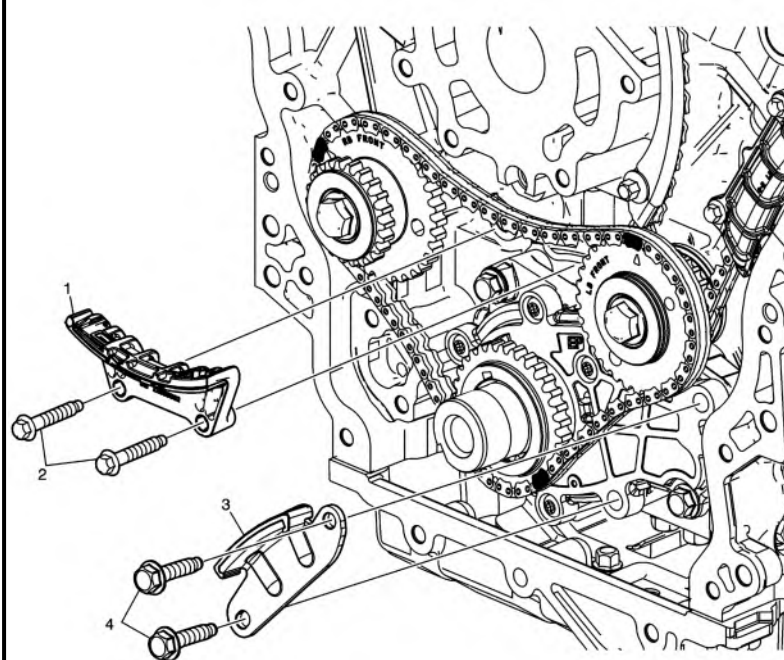


Primary Camshaft Intermediate Drive Chain Installation

Callout	Component Name
1	Primary Camshaft Drive Intermediate Chain Procedure 1. Wrap the primary camshaft drive chain around the large sprockets of each camshaft intermediate drive chain idler and the crankshaft sprocket. 2. The left camshaft intermediate drive chain idler timing mark (2) will align with camshaft drive chain timing link (3). 3. The right camshaft intermediate drive chain idler timing mark (4) will align with camshaft drive chain timing link (5). 4. The crankshaft sprocket timing mark (7) will align with camshaft drive chain timing link (6).
2	Left Camshaft Intermediate Drive Chain Idler Timing Mark
3	Camshaft Drive Chain Timing Link
4	Right Camshaft Intermediate Drive Chain Idler Timing Mark
5	Camshaft Drive Chain Timing Link
6	Camshaft Drive Chain Timing Link
7	Crankshaft Sprocket Timing Mark

Primary Timing Chain Guide Installation - Lower and Upper

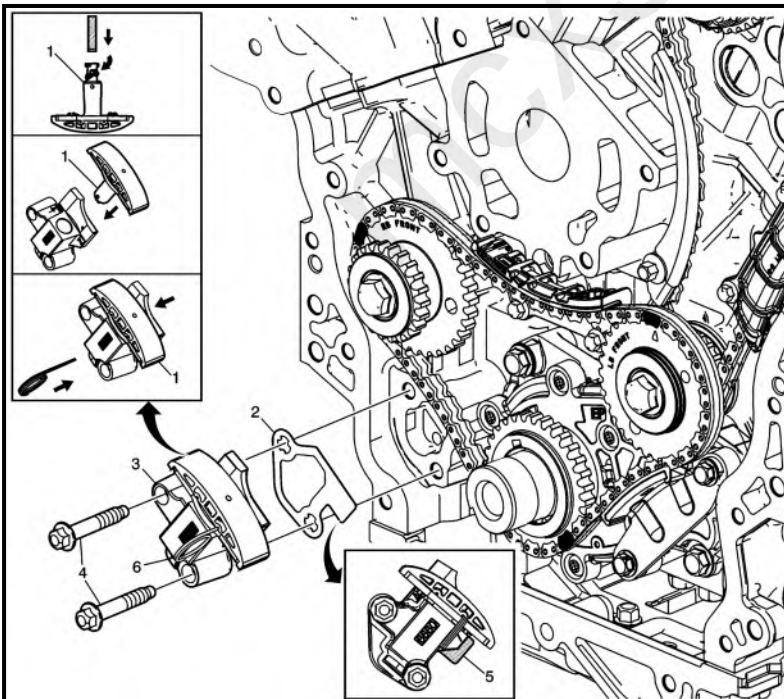




Primary Timing Chain Guide Installation - Lower and Upper

Callout	Component Name
1	Upper Primary Timing Chain Guide
2	Upper Primary Timing Chain Guide Bolt Tighten 25 N.m (18 lb ft)
3	Lower Primary Timing Chain Guide
4	Lower Primary Timing Chain Guide Bolt Tighten 25 N.m (18 lb ft)

Primary Camshaft Intermediate Drive Chain Tensioner Installation

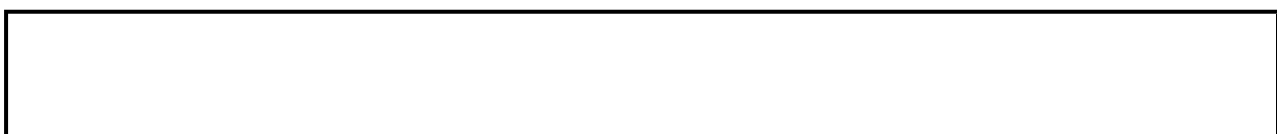


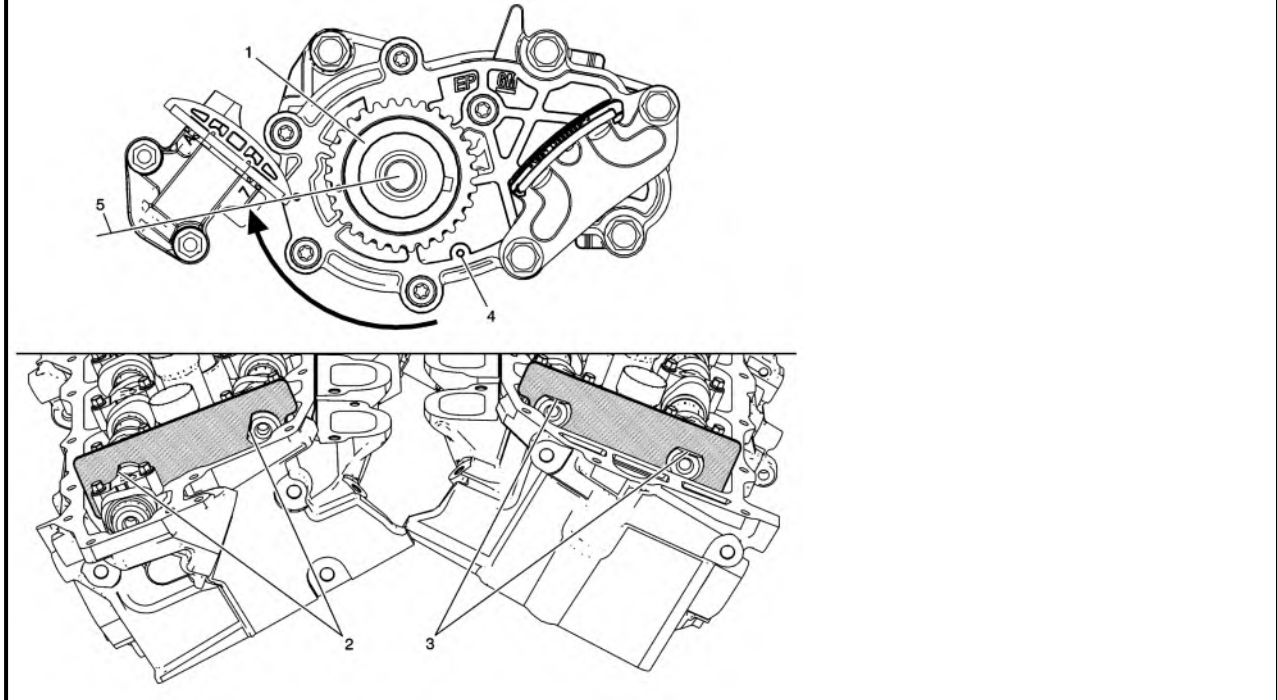
Primary Camshaft Intermediate Drive Chain Tensioner Installation

Callout	Component Name

Callout	Component Name
1	Camshaft Intermediate Drive Chain Tensioner Plunger. Procedure 1. Reset the primary camshaft drive chain tensioner plunger using EN - 45027 tensioner tool. 2. Install primary camshaft drive chain tensioner plunger into body. 3. Compress the plunger into the body and lock the primary camshaft drive chain tensioner by inserting the EN-46112 tensioner retraction pins into the access hole in the side of the primary camshaft drive chain tensioner body. 4. Slowly release pressure on the primary camshaft drive chain tensioner. The primary camshaft drive chain tensioner should remain compressed. Special Tools • EN-45027 Tensioner Tool • EN - 46112 Tensioner Retraction Pins Equivalent regional tools: Special Tools .
2	Timing Chain Housing Gasket NOTE: Ensure the primary camshaft drive chain tensioner mounting surface on the engine block does not have any burrs or defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.
3	Camshaft Intermediate Drive Chain Tensioner
4	Camshaft Intermediate Drive Chain Tensioner Bolt Procedure 1. Place the drive chain tensioner into position and loosely install the bolts to the block. 2. Verify the proper placement of the drive chain tensioner gasket tab (5). 3. Tighten the drive chain tensioner bolts in two passes. 4. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 5. Release the drive chain tensioner by pulling out the EN - 46112 pin (6) and unlocking the tensioner plunger. 6. Verify the primary and left secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One. Tighten • First Pass: 5 N.m (44 lb in) • Final Pass: 25 N.m (18 lb ft)
5	Timing Chain Housing Gasket Tab
6	EN - 46112 Pin

Stage 1 Alignment Position to the Stage 2 Alignment Position



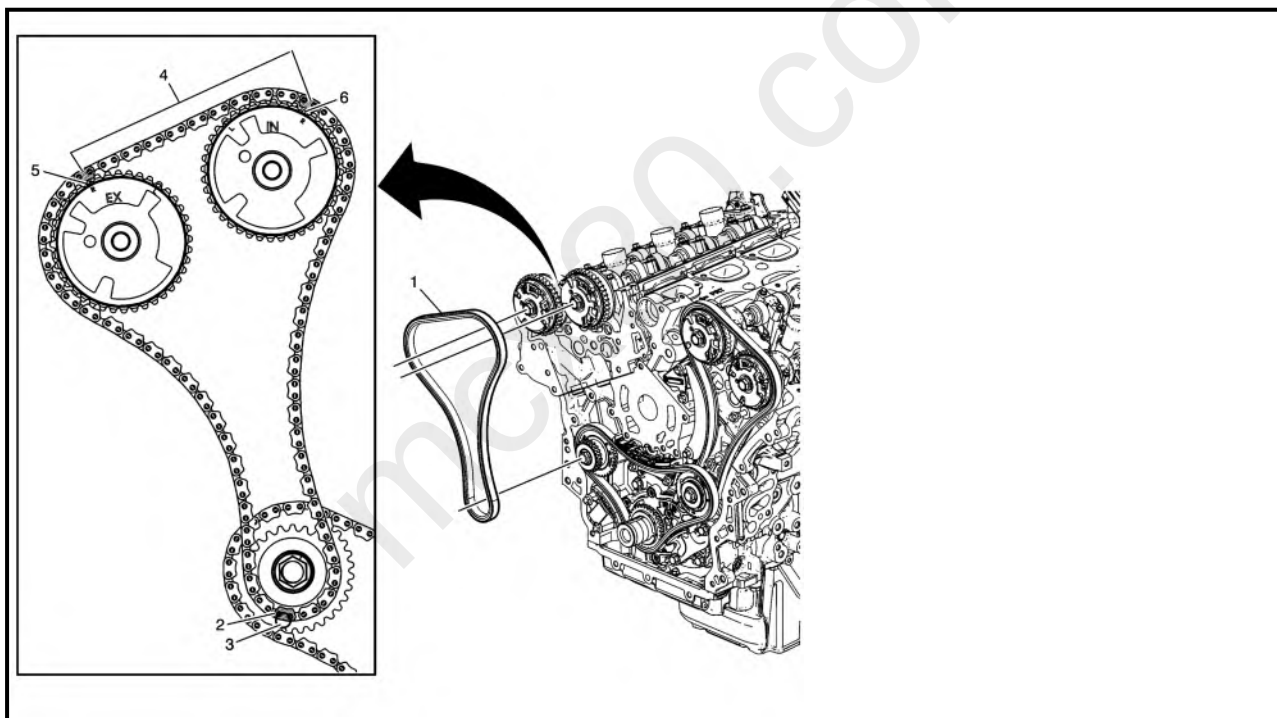


Stage 1 Alignment Position to the Stage 2 Alignment Position

Callout	Component Name
Preliminary Procedure Remove the EN 48383-1 from the rear of the left camshafts.	
1	Crankshaft Sprocket Procedure Using the EN - 48589 crankshaft rotation socket, rotate the crankshaft and crankshaft sprocket from the stage one alignment position (4) to the stage two alignment position (5), 115 crankshaft degrees, in order to install the right secondary camshaft drive chain components. Special Tool EN-48589 Crankshaft Rotation Socket For equivalent regional tools, refer to Special Tools .
2	Left Intake and Exhaust Camshaft Procedure NOTE: • There should be no need to rotate the camshaft more than 10 degrees. Using the hex cast into the camshaft rotate the camshaft in order to install the EN-48383-2 retainer. • All camshafts must be locked in place before installation of any camshaft drive chains. 1. Install the EN-48383-2 retainer onto the rear of the left camshafts. 2. Ensure the EN-48383-2 retainer is fully seated onto the camshafts. Special Tool EN-48383 Crankshaft Rotation Tools Equivalent regional tools: Special Tools .

Callout	Component Name
3	Right Intake and Exhaust Camshaft Procedure NOTE: • There should be no need to rotate the camshaft more than 10 degrees. Using the hex cast into the camshaft rotate the camshaft in order to install the EN-48383-3 retainer. • All camshafts must be locked in place before installation of any camshaft drive chains. 1. Install the EN-48383-3 retainer onto the rear of the right camshafts. 2. Ensure the EN-48383-3 retainer is fully seated onto the camshafts. Special Tools EN - 48383 Crankshaft Rotation Tools Equivalent regional tools: Special Tools .
4	Stage One Alignment Position
5	Stage Two Alignment Position

Secondary Camshaft Intermediate Drive Chain Installation - Right Side

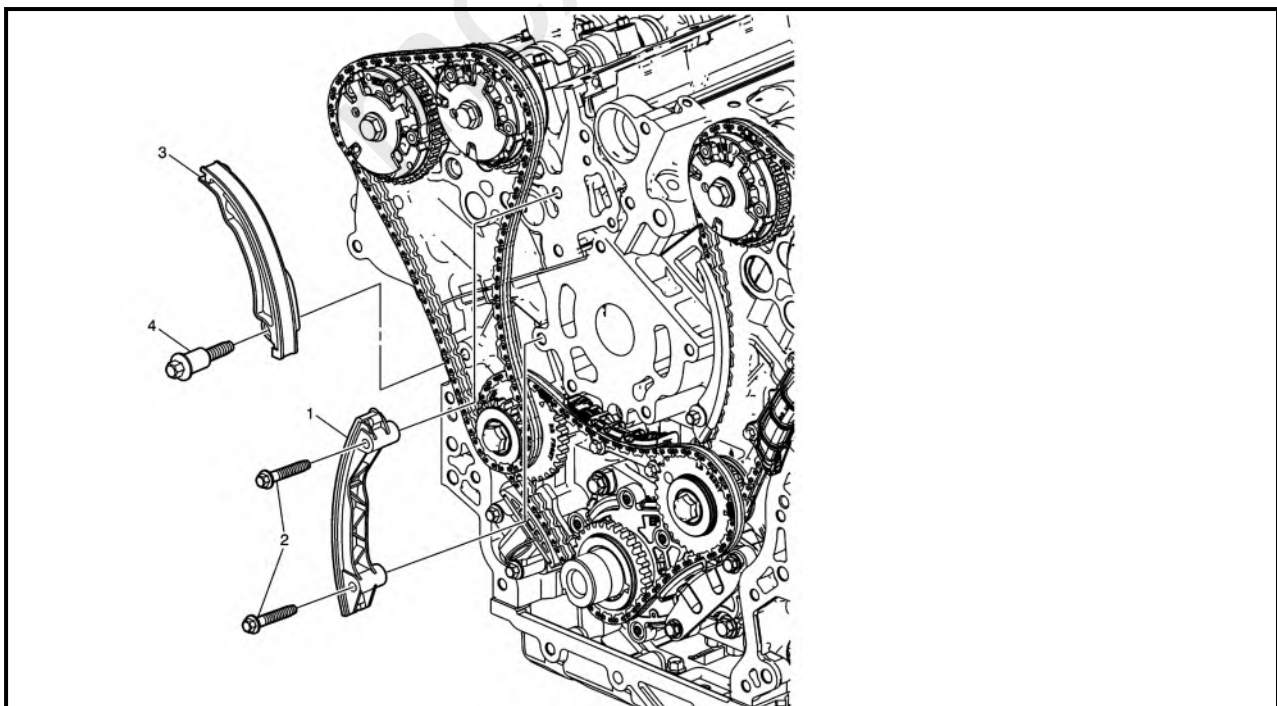


Secondary Camshaft Intermediate Drive Chain Installation - Right Side

Callout	Component Name
NOTE:	Ensure that the right (R) camshaft position actuator sprocket alignment triangle marks are used during this step.

Callout	Component Name
1	Secondary Camshaft Intermediate Drive Chain NOTE: Ensure that the crankshaft is in the stage 2 timing drive assembly position. Procedure 1. Place the secondary camshaft intermediate drive chain around the right camshaft intermediate drive chain idler outer sprocket, aligning the camshaft drive chain timing link (2) with the alignment access hole (3) in the right camshaft intermediate drive chain idler inner sprocket. 2. Wrap the secondary camshaft intermediate drive chain around both right (R) actuator drive sprockets. 3. Align the right (R) intake camshaft position actuator sprocket alignment triangle mark (5) with the camshaft drive chain timing link. 4. Align the right (R) exhaust camshaft position actuator sprocket alignment triangle mark (6) with the camshaft drive chain timing link. 5. Once aligned, ensure there are 10 chain links (4) between timing marks for the right (R) camshaft position actuator sprockets. 6. There will be 22 links between the right camshaft intermediate drive chain idler timing camshaft drive chain link and each right camshaft position actuator sprocket timing camshaft drive chain link.
2	Camshaft Drive Chain Timing Link
3	Alignment Access Hole
4	10 Chain Links Between Timing Marks for the Right (R) Camshaft Position Actuator Sprockets
5	Right (R) Intake Camshaft Position Actuator Sprocket Alignment Triangle Mark
6	Right (R) Exhaust Camshaft Position Actuator Sprocket Alignment Triangle Mark

Secondary Camshaft Drive Chain Guide and Shoe Installation - Right Side

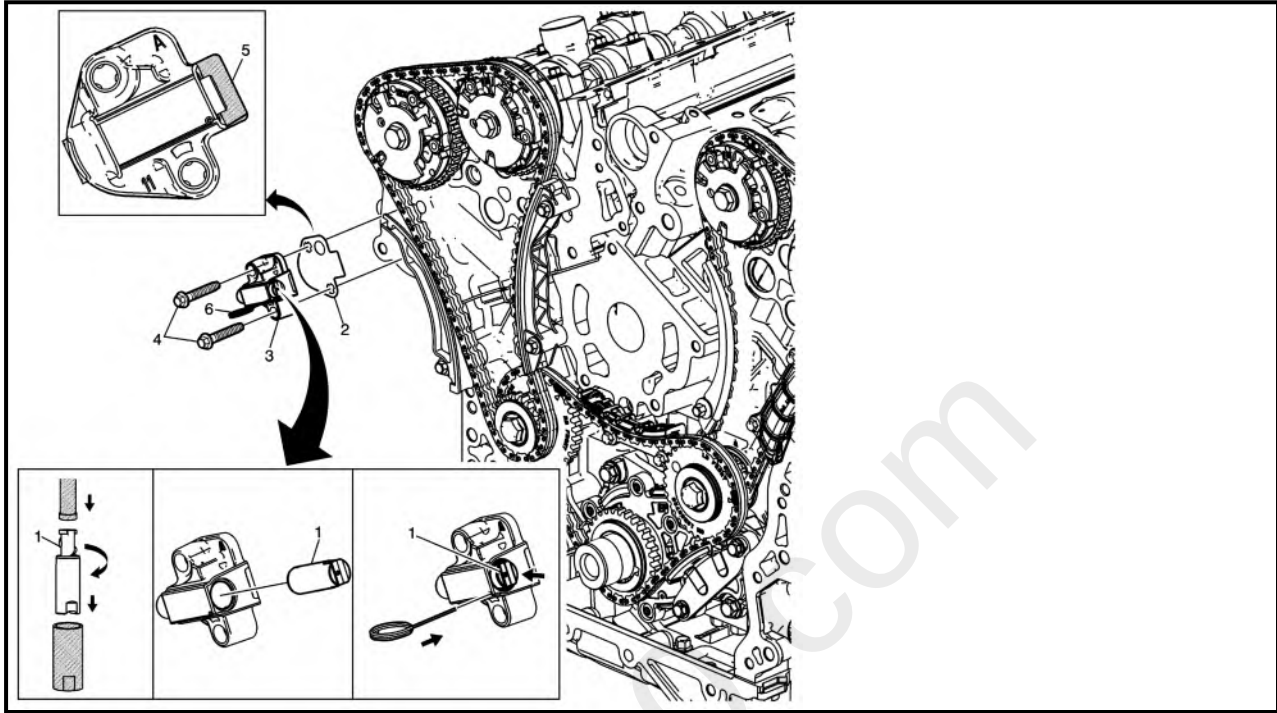


Secondary Camshaft Drive Chain Guide and Shoe Installation - Right Side

Callout	Component Name
1	Right Secondary Timing Chain Guide

Callout	Component Name
2	Right Secondary Timing Chain Guide Bolt Tighten 25 N.m (18 lb ft)
3	Right Pivot Arm Timing Chain Guide
4	Right Pivot Arm Timing Chain Guide Bolt Tighten 25 N.m (18 lb ft)

Secondary Camshaft Drive Chain Tensioner Installation - Right Side



Secondary Camshaft Drive Chain Tensioner Installation - Right Side

Callout	Component Name
1	Right Secondary Timing Chain Tensioner Plunger Procedure 1. Reset the right secondary camshaft drive chain tensioner plunger using EN - 45027 tensioner tool. 2. Install right secondary camshaft drive chain tensioner plunger into body. 3. Compress the plunger into the body and lock the right secondary camshaft drive chain tensioner by inserting the EN - 46112 tensioner retraction pins into the access hole in the side of the right secondary camshaft drive chain tensioner body. 4. Slowly release pressure on the right secondary camshaft drive chain tensioner. The right secondary camshaft drive chain tensioner should remain compressed. Special Tools • EN-45027 Tensioner Tool • EN - 46112 Tensioner Retraction Pins Equivalent regional tools: Special Tools .

Callout	Component Name
2	Right Timing Chain Housing Gasket NOTE: Ensure the right secondary camshaft drive chain tensioner mounting surface on the right cylinder head does not have any burrs or defects that would degrade the sealing of the NEW right secondary camshaft drive chain tensioner gasket.
3	Right Secondary Timing Chain Tensioner
4	Right Secondary Timing Chain Tensioner Bolt Procedure 1. Place the right secondary drive chain tensioner into position and loosely install the bolts to the block. 2. Verify the proper placement of the right secondary drive chain tensioner gasket tab (5). 3. Tighten the drive chain tensioner bolts in two passes. 4. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 5. Release the right secondary drive chain tensioner by pulling out the EN - 46112 pin (6) and unlocking the tensioner plunger. 6. Verify all primary and secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One. 7. Remove EN - 48383 Crankshaft Rotation Tools Tighten • First Pass: 5 N.m (44 lb in) • Final Pass: 25 N.m (18 lb ft) Special Tools • EN-46112 Pin • EN - 48383 Crankshaft Rotation Tools Equivalent regional tools: Special Tools .
5	Right Timing Chain Housing Gasket Tab
6	EN-46112 Pin

FUEL PUMP INSTALLATION

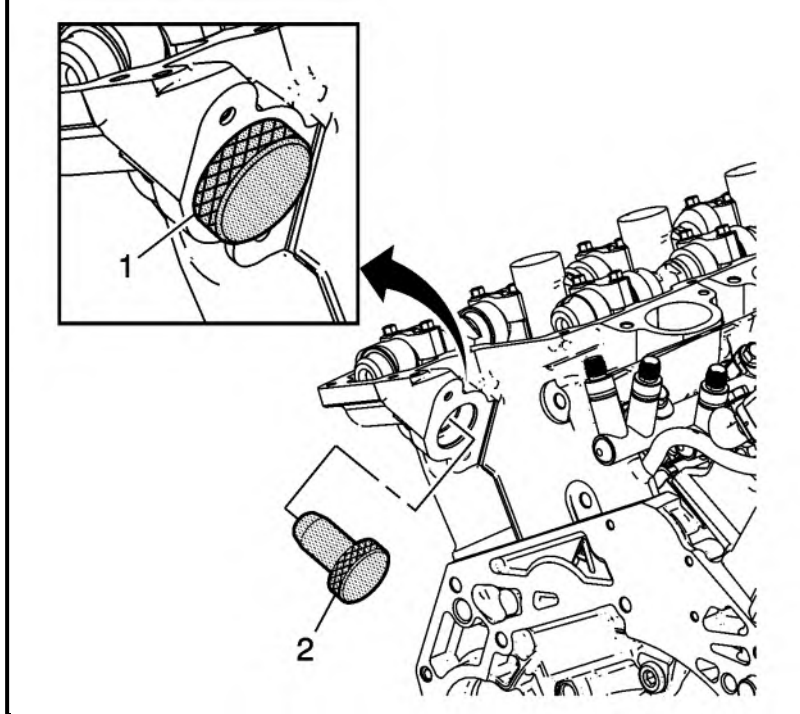
Special Tools

EN - 48896 HP Fuel Pump Installation Alignment Gauge

For equivalent regional tools, refer to **Special Tools** .

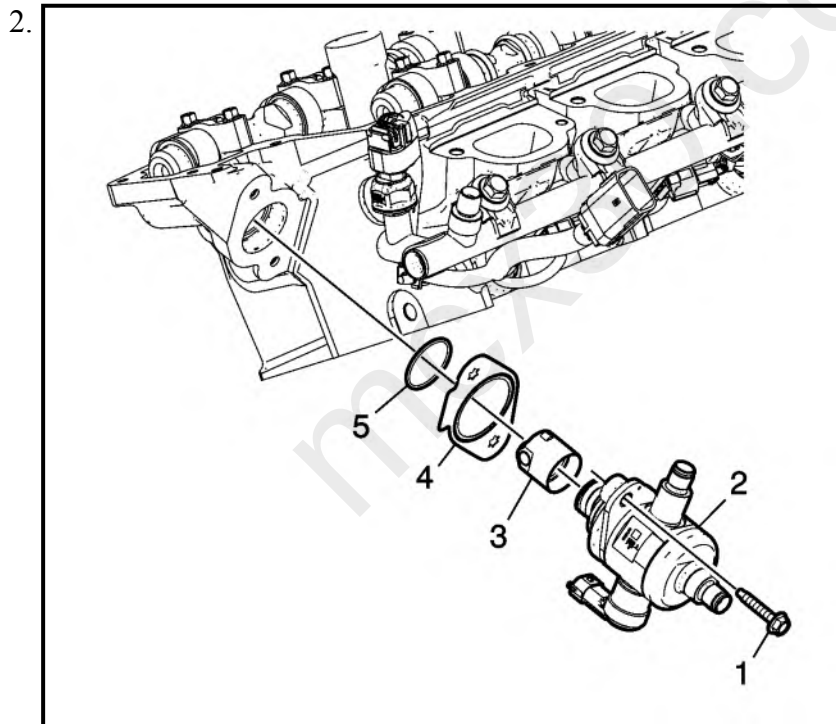
1.





NOTE: The camshaft must be in the base circle position before the high pressure fuel pump is installed.

Use the **EN - 48896** alignment gauge (2) to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the head (1).



Lubricate the high pressure fuel pump cylinder head bore with clean engine oil.

NOTE: Ensure that the high pressure fuel pump roller lifter is oriented properly, the camshaft is at base circle and the number 1 piston is at top dead center (TDC) on the exhaust stroke.

3. Lubricate the high pressure fuel pump roller lifter with clean engine oil and install into the cylinder head bore.
4. Install a NEW high pressure fuel pressure fuel pump gasket (4).

NOTE: If a high pressure pump is replaced on an engine which originally had a pump WITH a gasket, it must be rebuilt WITH a pump kit that includes the gasket; if a high pressure pump is replaced on an

engine which originally had a pump **WITHOUT** a gasket, it must be rebuilt **WITHOUT** a gasket.

5. Lubricate NEW high pressure fuel pump O-ring (5) with one drop of clean engine oil and install.

NOTE: Ensure the plastic bolt retainers are installed in the high pressure fuel pump mounting holes before installing.

6. Install the valve lifter follower (3).

7. Install the high pressure fuel pump (2).

CAUTION: Refer to [Fastener Caution](#) .

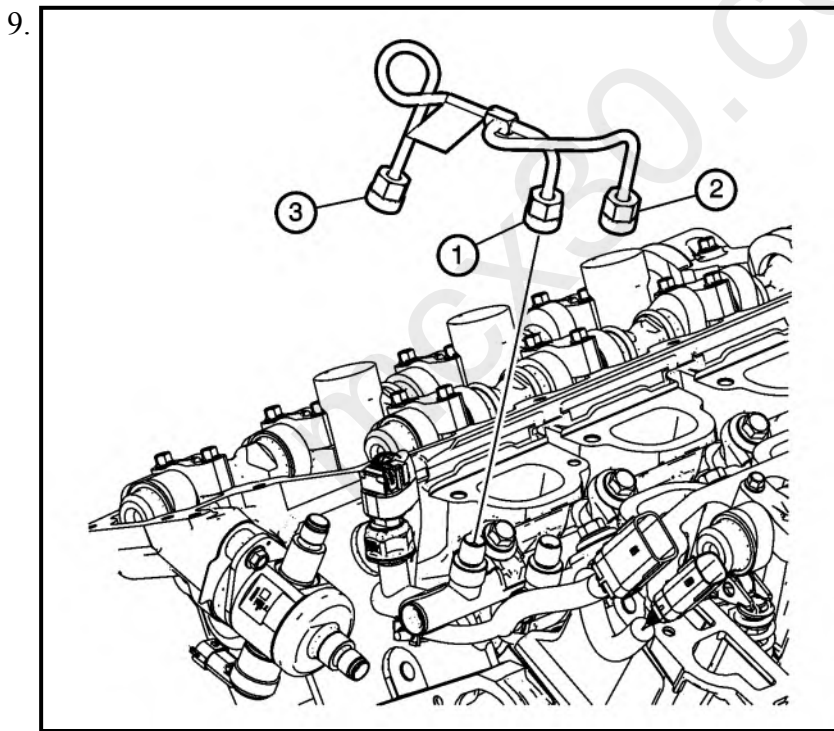
CAUTION: Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage.

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

8. Start and hand-tighten the NEW high pressure fuel pump bolts (1) evenly.

1. Tighten the fuel pump bolts (1) a first pass in sequence to 15 N.m (11 lb ft).

2. Tighten the fuel pump bolts (1) a second pass in an additional 60 degrees.



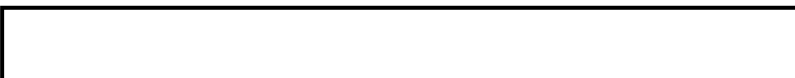
NOTE:

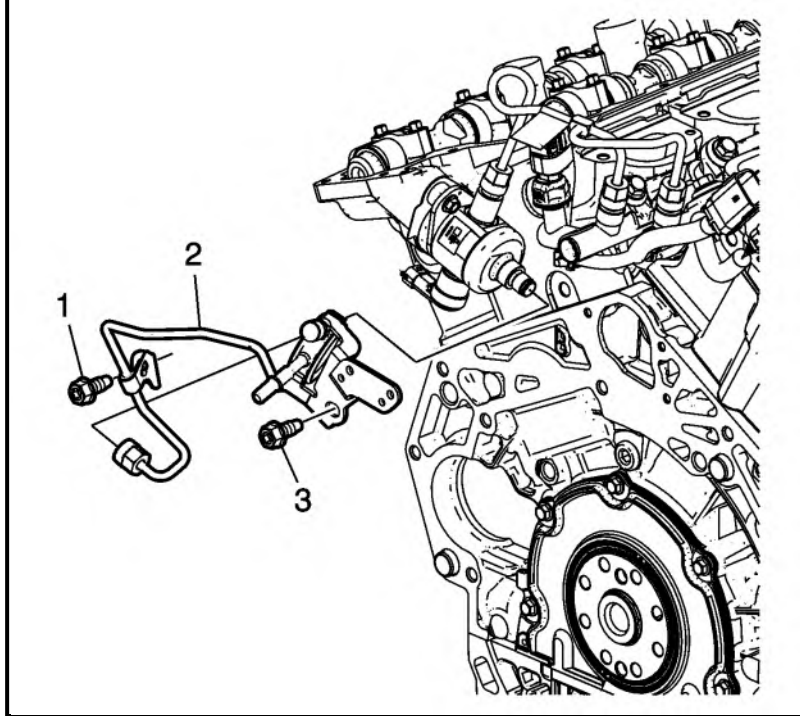
- **DO NOT** reuse the high pressure fuel rail crossover pipe.
- The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow installation and tightening steps exactly.

Install the NEW high pressure LH to RH fuel rail crossover pipe by starting all three fuel crossover pipe fitting nuts (1), (2) and (3) to finger-tight only.

10. Tighten the fuel rail crossover pipe fittings to 28 N.m (21 lb ft) in the following order: (1) left fuel rail, (2) right fuel rail, then (3) fuel pump.

11.

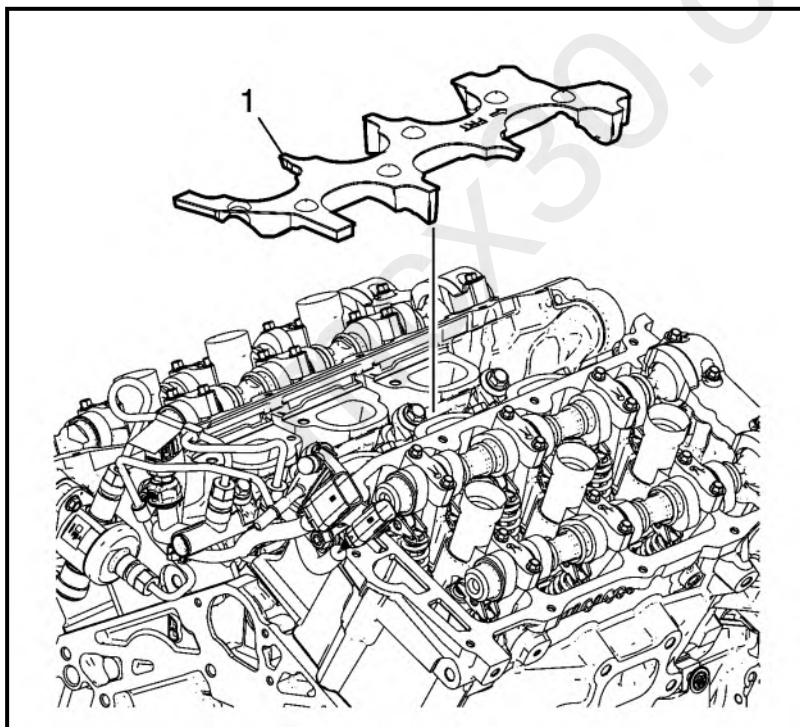




Install the NEW fuel feed pipe (2) by installing the fuel line nut to the fuel pump finger-tight.

12. Install the fuel feed pipe bolts finger tight (1 and 3).
13. Tighten the fuel feed pipe bolts (1 and 3) to 50 N.m (37 lb ft).
14. Tighten the fuel feed pipe fitting nut to 28 N.m (21 lb ft).
15. Install the fuel rail wiring connectors to the fuel feed pipe bracket.

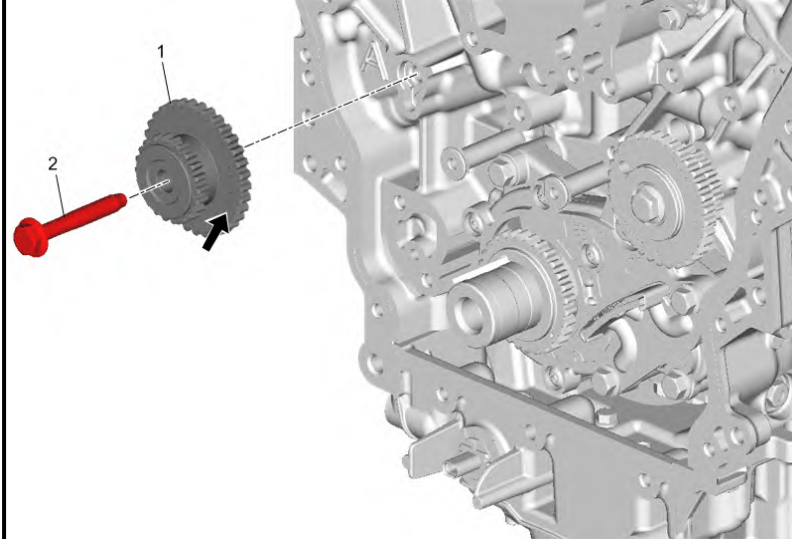
16.



Install the fuel rail noise shield (1).

TIMING CHAIN IDLER SPROCKET INSTALLATION - RIGHT SIDE





Callout	Component Name
1	Right Side Timing Chain Idler Sprocket Procedure 1. Ensure that the right timing chain idler sprocket is being installed. The raised hub and the larger sprocket of the right timing chain idler sprocket is installed towards the block. 2. Place the right timing chain idler sprocket to the cylinder block.
2	Timing Chain Idler Sprocket Shaft Bolt CAUTION: Refer to Fastener Caution . Tighten 58 N.m (43 lb ft)

ENGINE FRONT COVER INSTALLATION

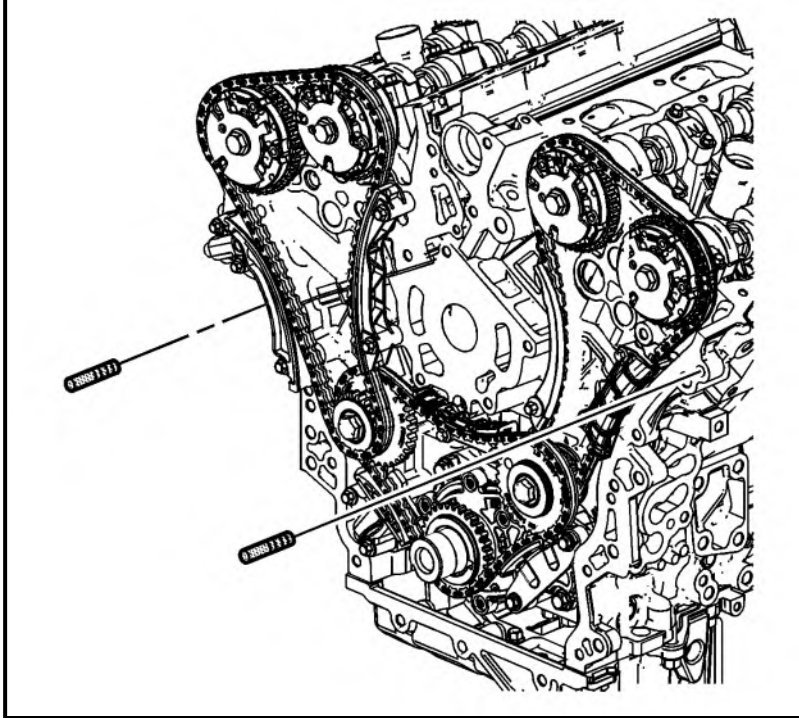
Special Tools

EN - 46109 Guide Pins

For equivalent regional tools, refer to **Special Tools** .

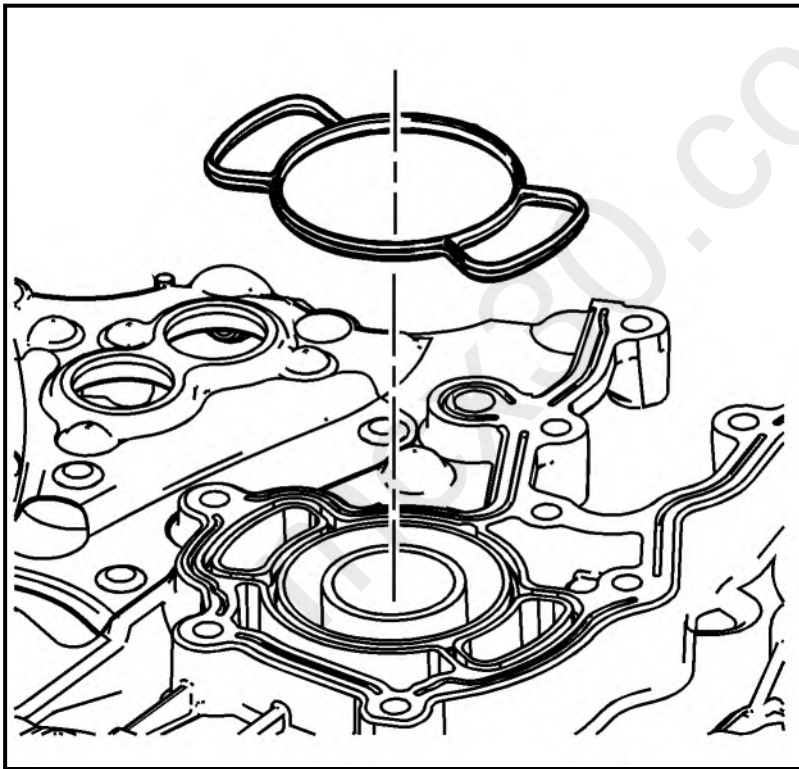
1.





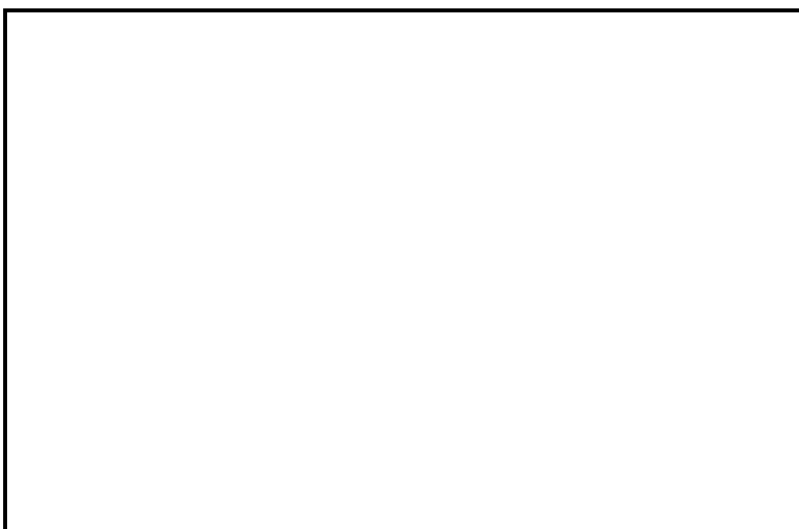
Install the 8 mm (0.315 in) guide from the **EN - 46109** pins into the cylinder block positions as shown.

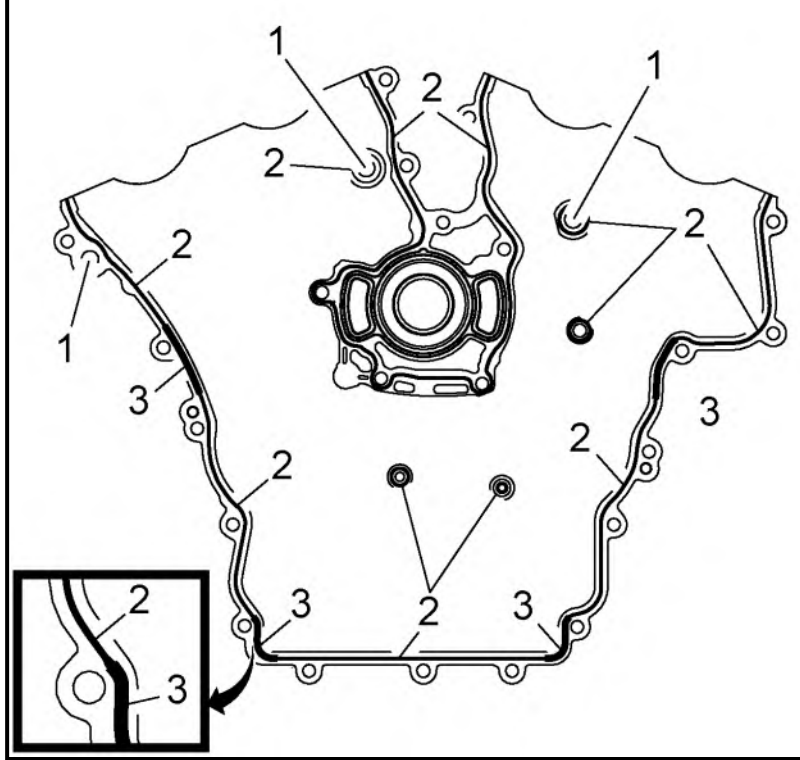
2.



Install the NEW engine front cover to cylinder block seal.

3.



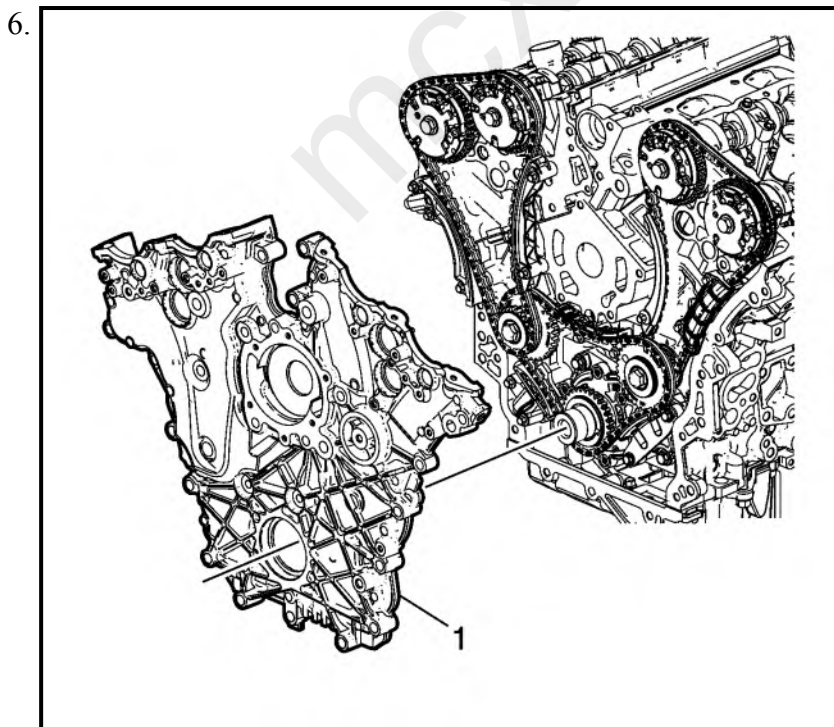


NOTE:

- No RTV sealant should be visible in the M12 bolt holes (1) upon final assembly of front cover to engine.
- Keep the RTV bead path on the outward edge of the t-joints to ensure proper sealant coverage.

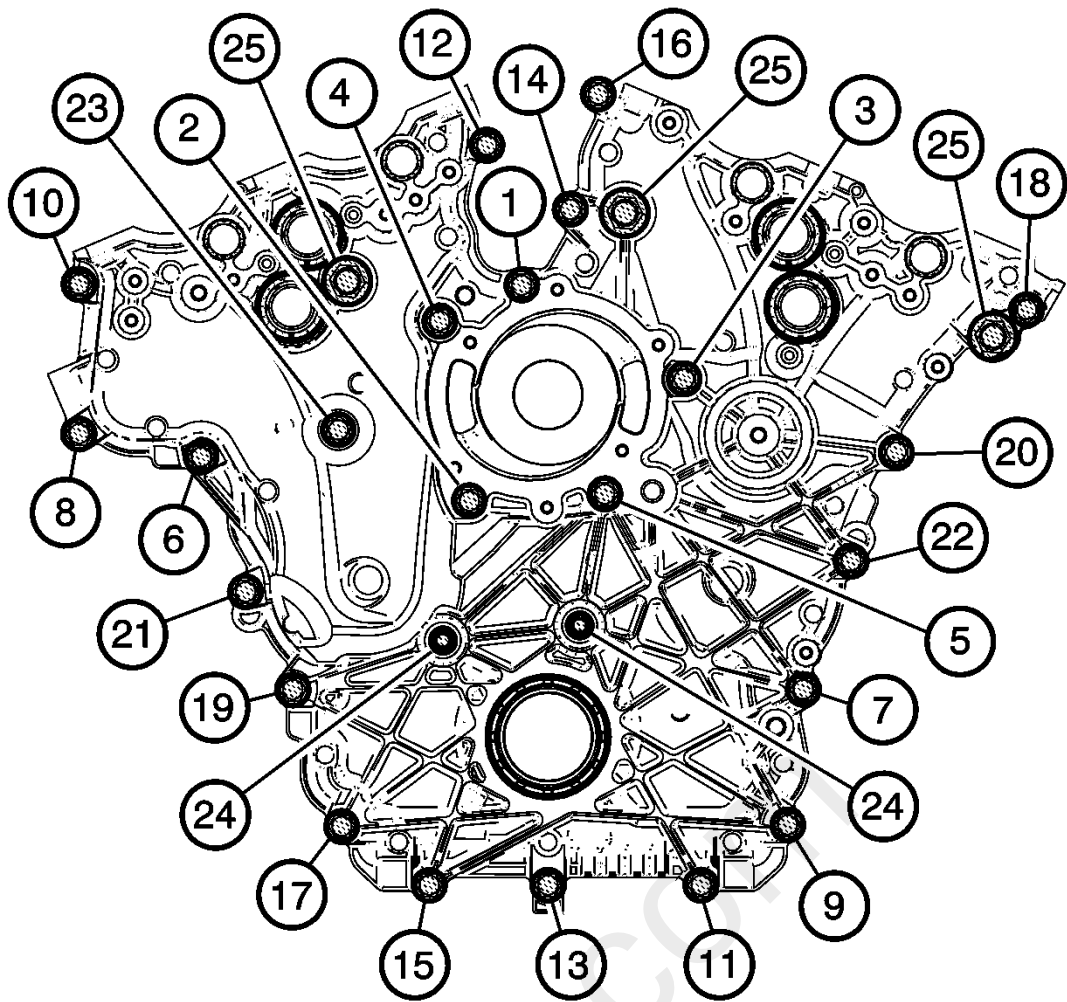
Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

4. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (2).
5. Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (3). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for recommended sealant.



Place the engine front cover (1) onto the EN - 46109 pins and slide into position.

7. Remove the EN - 46109 pins from the cylinder block.
8. Hand start all the engine front cover bolts.



9.

Fig. 27: Engine Front Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

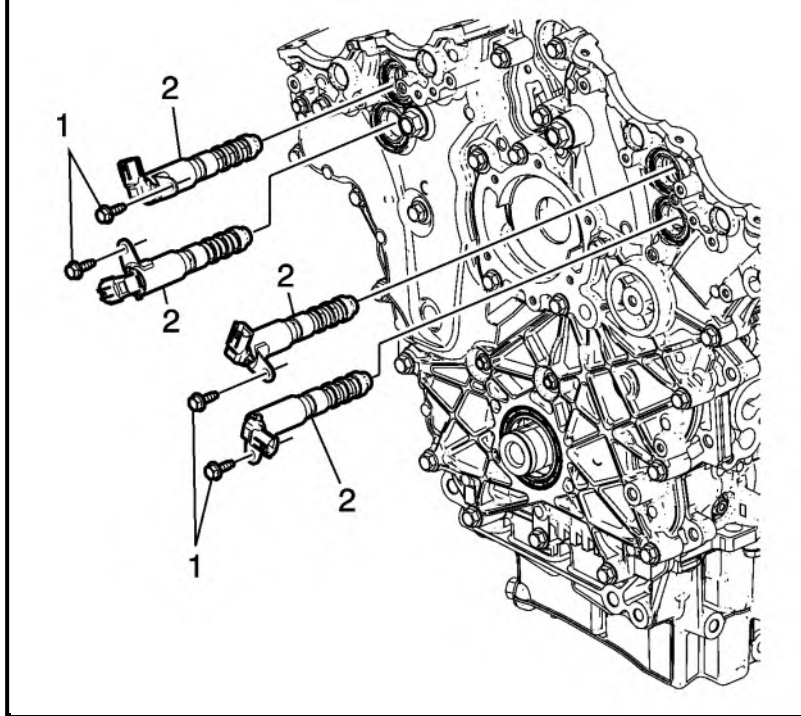
NOTE: Engine front cover bolts in the number (25) location are model dependent and may not apply.

Tighten the engine front cover bolts (1 - 23) in the sequence shown to 20 N.m (15 lb ft).

1. Tighten the engine front cover bolts (1 - 23) a second pass in sequence to 20 N.m (15 lb ft).
2. Tighten the engine front cover bolts (1 - 23) a third pass in sequence an additional 60 degrees.
3. Tighten the engine front cover bolts (24) to 15 N.m (11 lb ft).
4. Tighten the engine front cover bolts (25) to 65 N.m (48 lb ft).

10.

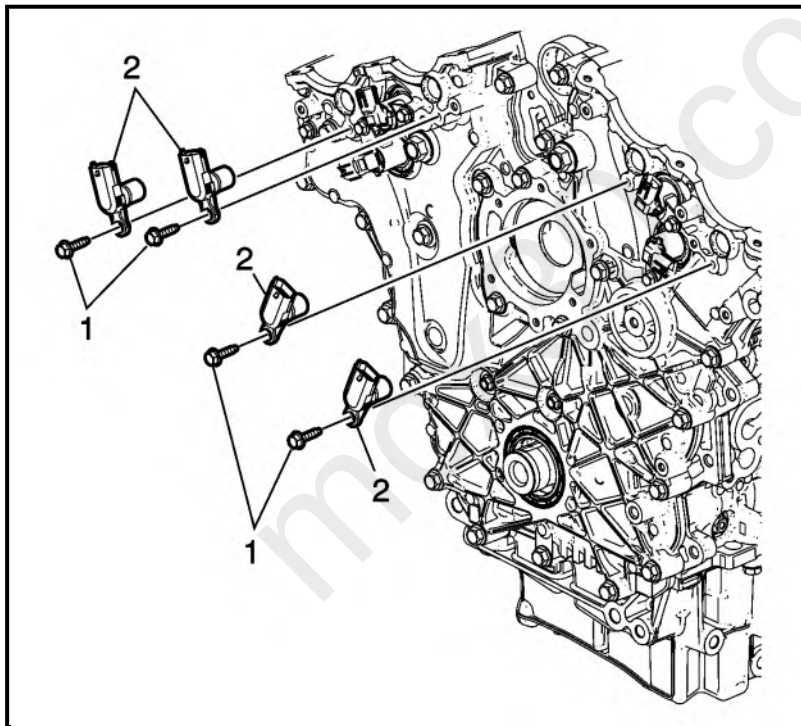




Place the camshaft position actuator valves (2) in position on the front cover.

11. Install the camshaft position actuator valve bolts (1) and tighten to 10 N.m (89 lb in).

12.



NOTE: Inspect the camshaft position sensor O-ring seals. If the seals are damaged, the entire camshaft position sensor must be replaced.

Place the camshaft position sensors (2) in position on the front cover.

13. Install the camshaft position sensor bolts (1) and tighten to 10 N.m (89 lb in).

WATER PUMP INSTALLATION

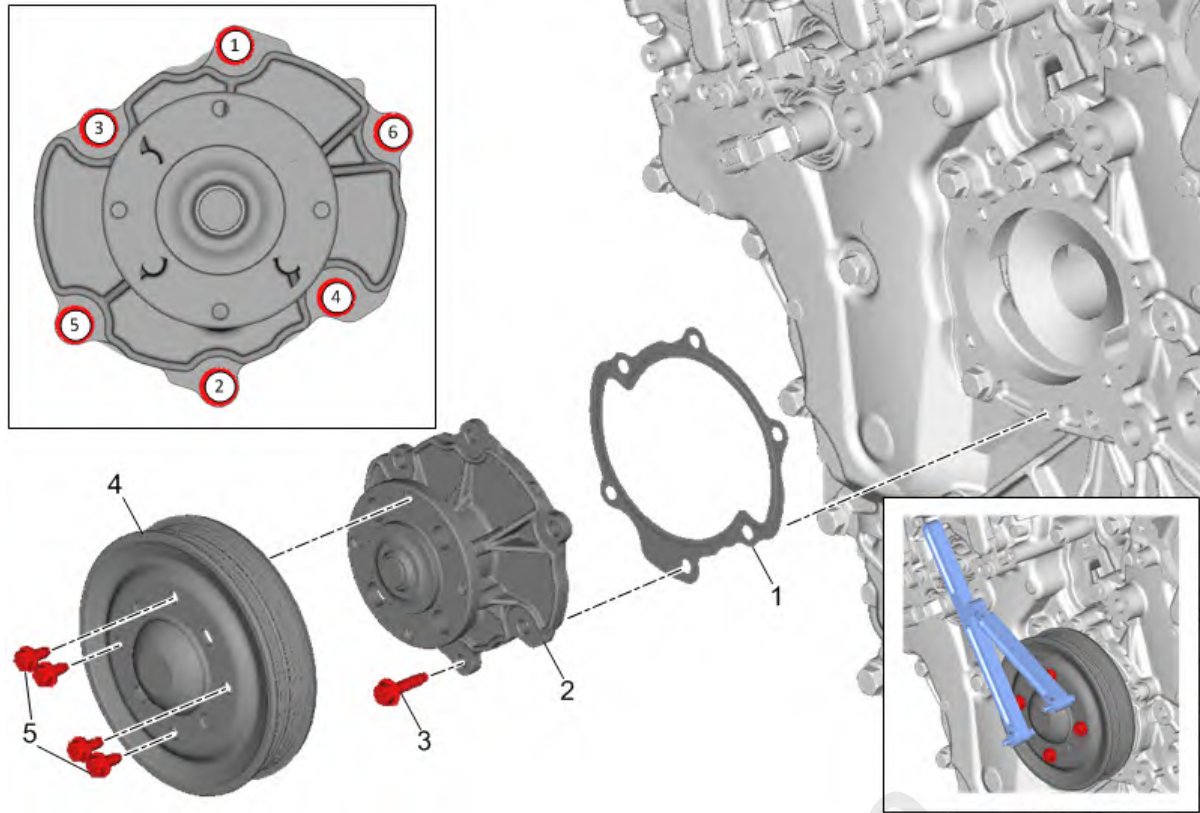


Fig. 28: Exploded View Of Water Pump And Bolts With Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Gasket NOTE: Install a NEW gasket.
2	Water Pump

Callout	Component Name
3	Water Pump Bolt [6x] CAUTION: Refer to Fastener Caution . CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. NOTE: Install NEW bolts. Tighten in sequence • First Pass: 10 N.m (89 lb in) • Second Pass: 10 N.m (89 lb in) • Final Pass: 45 degrees
4	Water Pump Pulley Procedure 1. Install the EN-46104 Water Pump Pulley Holding Tool onto the water pump pulley mounting holes. 2. Install the water pump pulley bolts. 3. Remove the EN-46104 Water Pump Pulley Holding Tool from the water pump pulley. Special Tools EN-46104 Water Pump Pulley Holding Tool Equivalent regional tools: Special Tools
5	Water Pump Pulley Bolt [4x] Tighten 10 N.m (89 lb in)

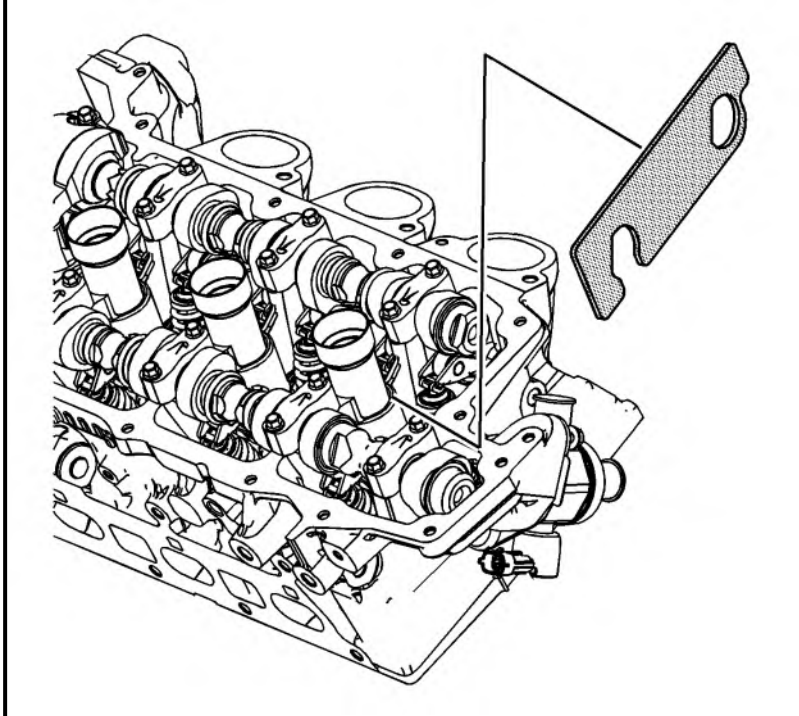
CAMSHAFT COVER INSTALLATION - LEFT SIDE

Special Tools

- **EN-46101** Spark Plug Tube Seal Guide
- **EN-48383** Camshaft Retaining Tools

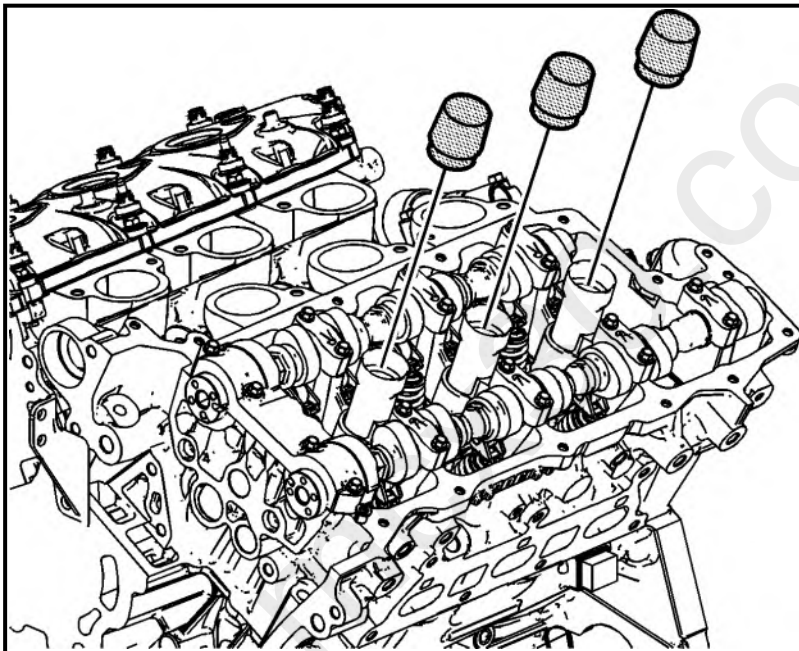
For equivalent regional tools, refer to [Special Tools](#) .

1.



Remove the **EN-48383-2** from the rear of the left camshafts.

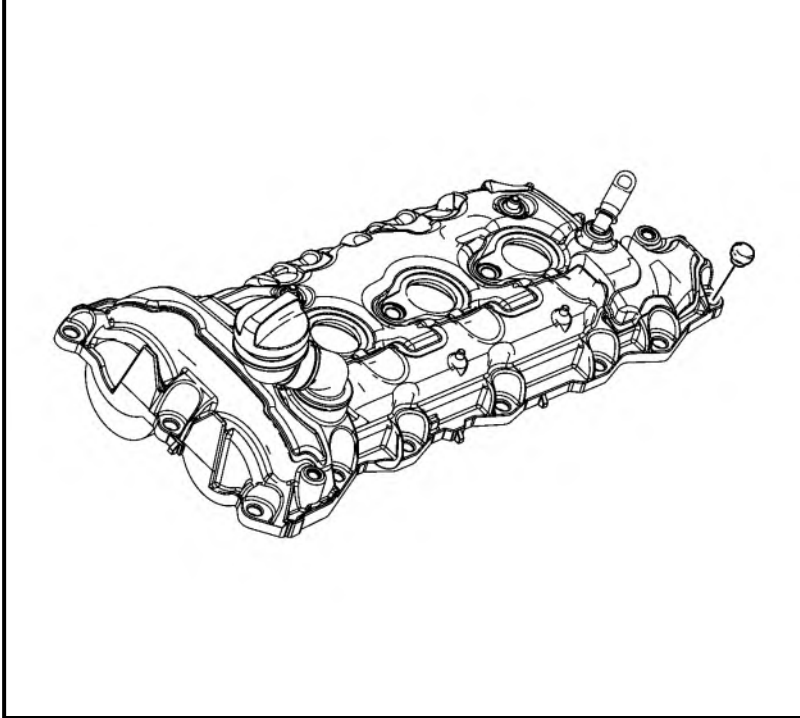
2.



Install the **EN-46101** guide onto the spark plug tubes of the left cylinder head.

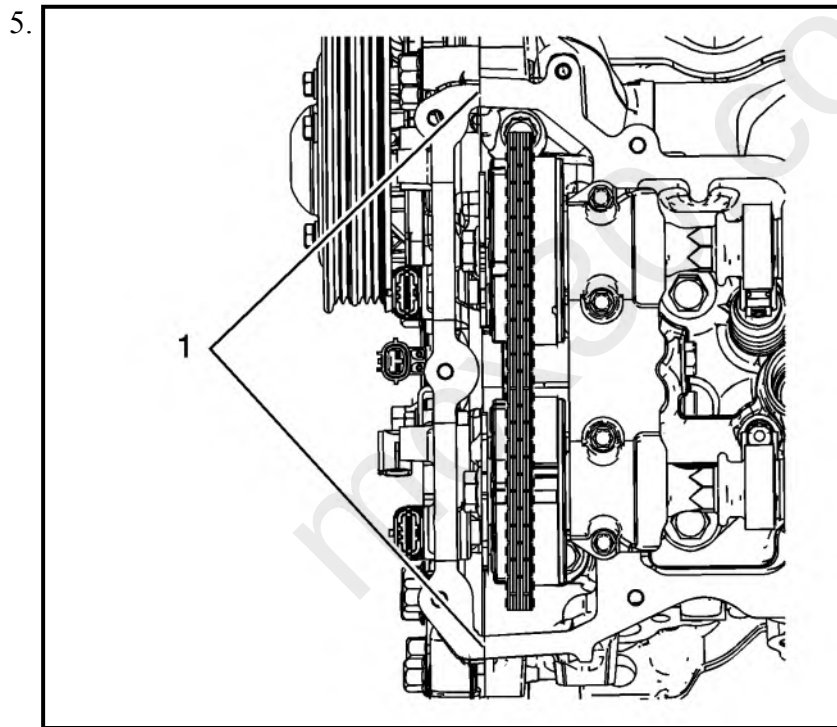
3.





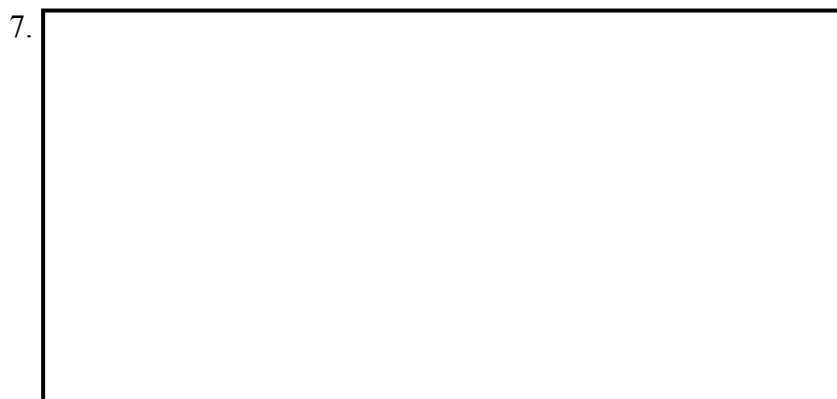
Install the NEW camshaft cover bolt grommets prior to installing the camshaft cover bolts.

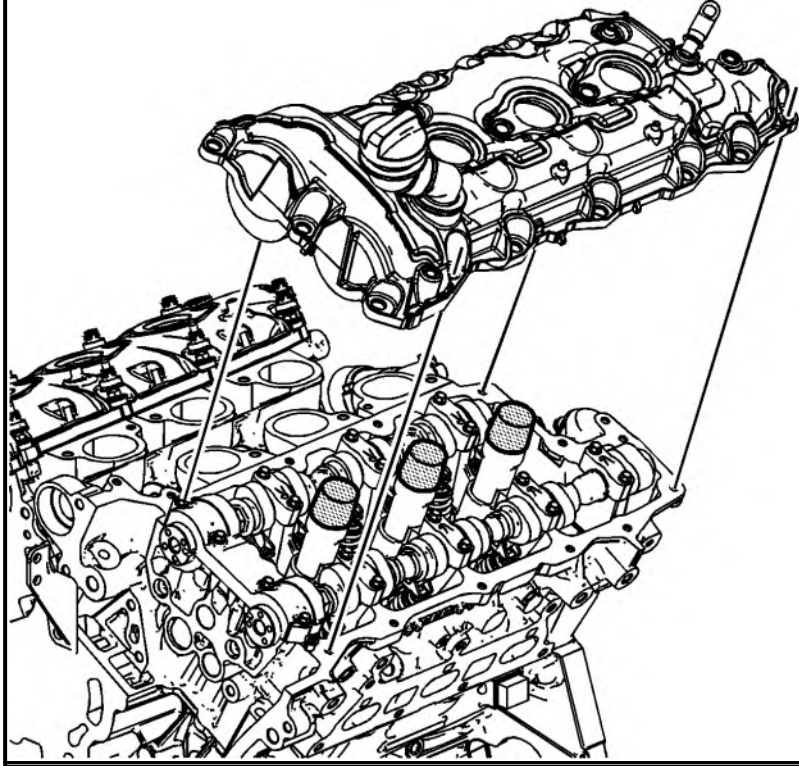
4. Wipe the camshaft cover sealing surface on the left cylinder head with a clean, lint-free cloth.



Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

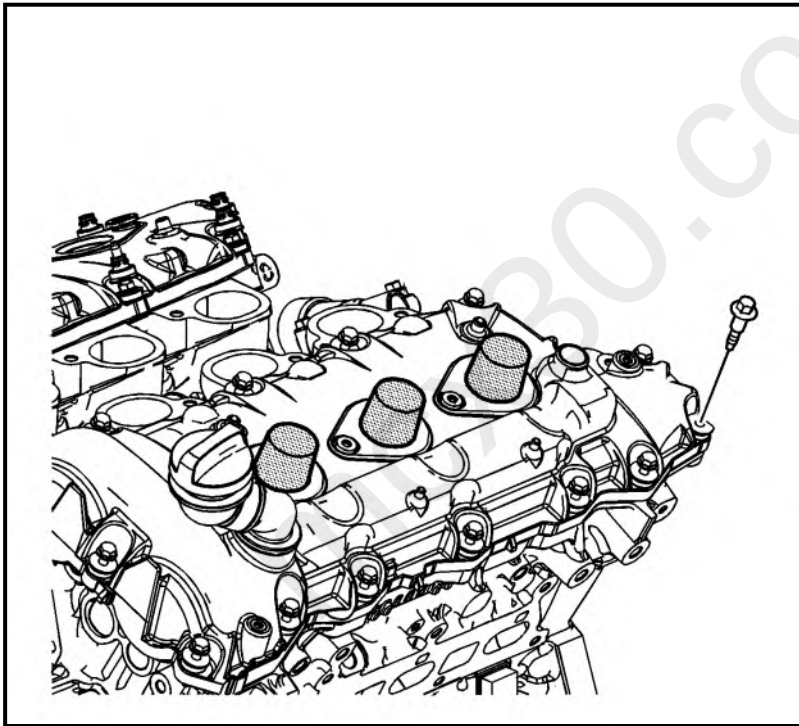
6. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant, on the engine front cover split lines (1). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) .



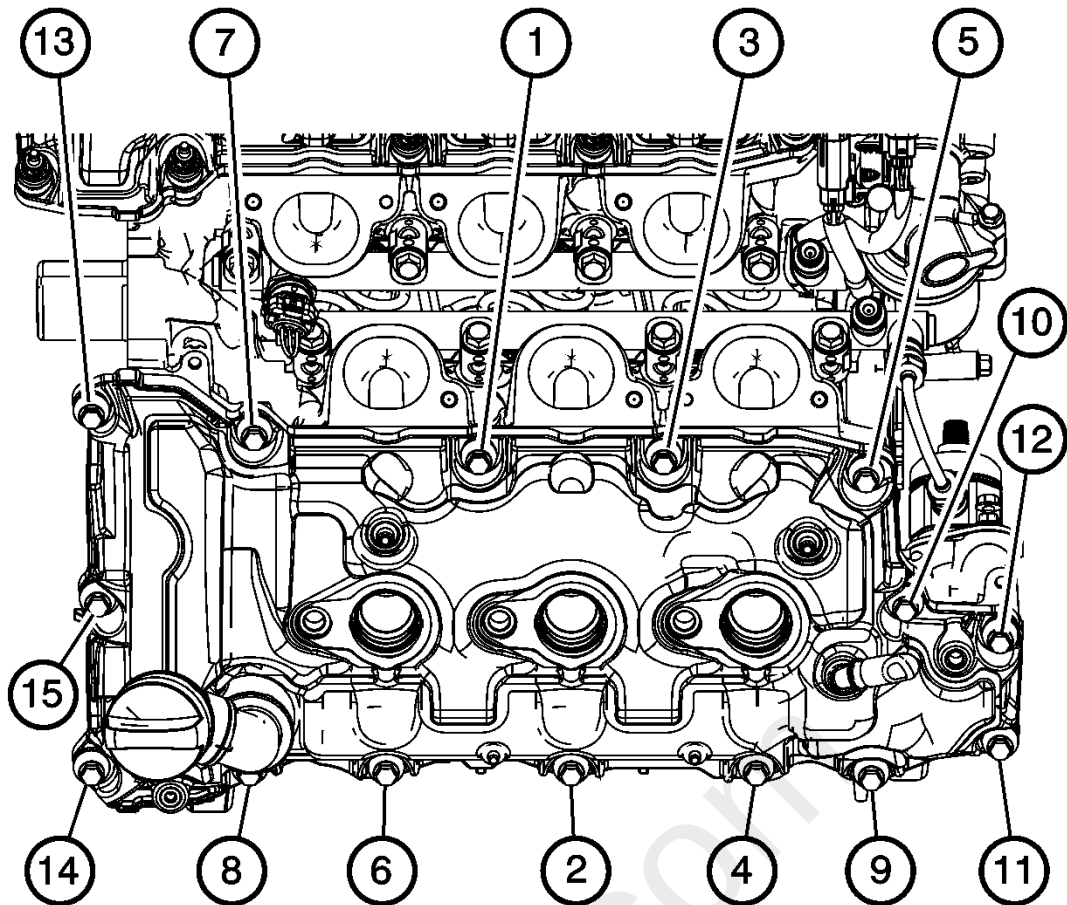


Place the left camshaft cover into position onto the left cylinder head.

8.



Loosely install the left camshaft cover bolts.



9.

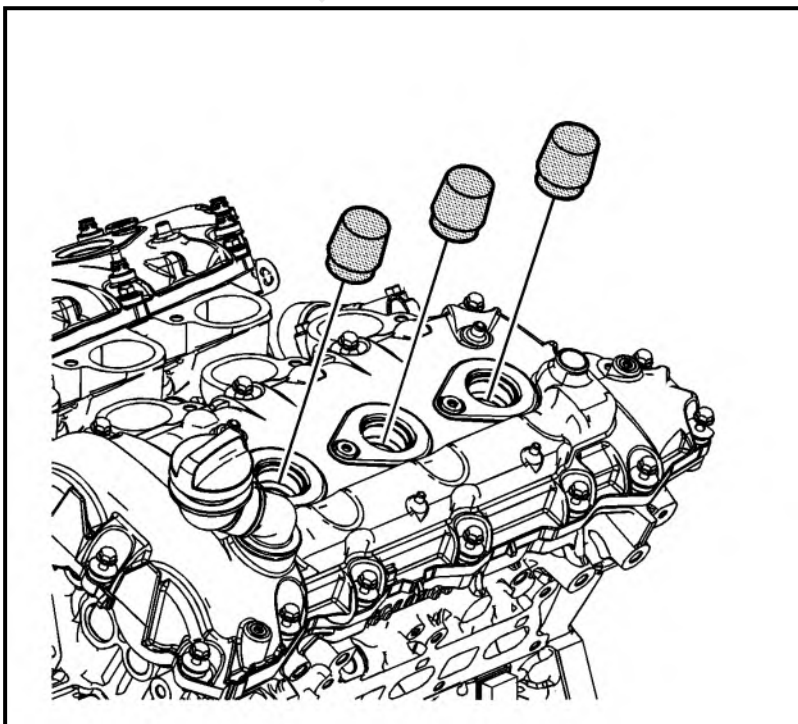
Fig. 29: Camshaft Cover Bolt Tightening Sequence - Left Side
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution**.

Tighten the left camshaft cover bolts in the sequence shown.

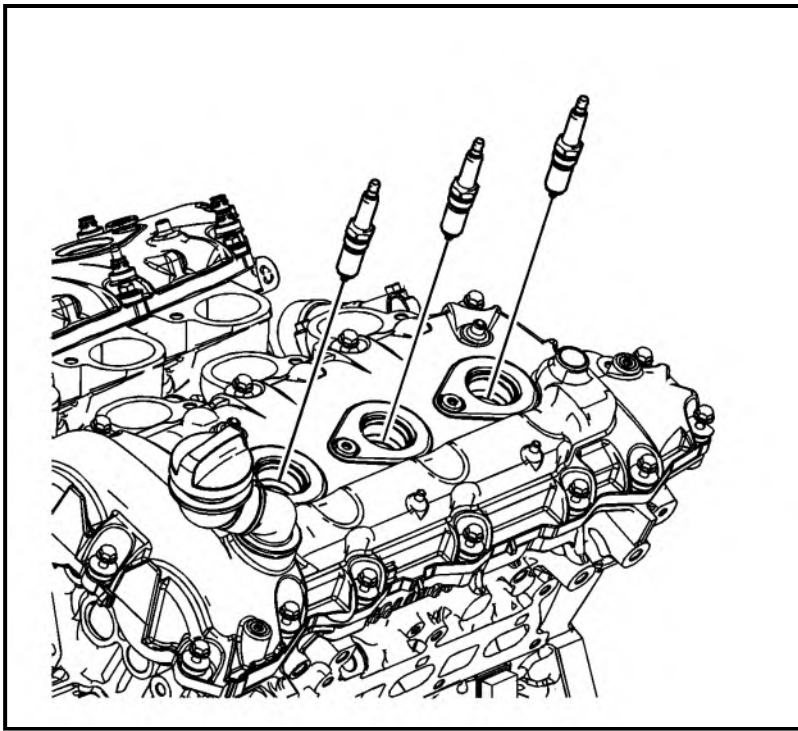
1. Tighten the left camshaft cover bolts in the sequence to 10 N.m (89 lb in).
2. Tighten the left camshaft cover bolts a second pass in the sequence to 10 N.m (89 lb in).

10.



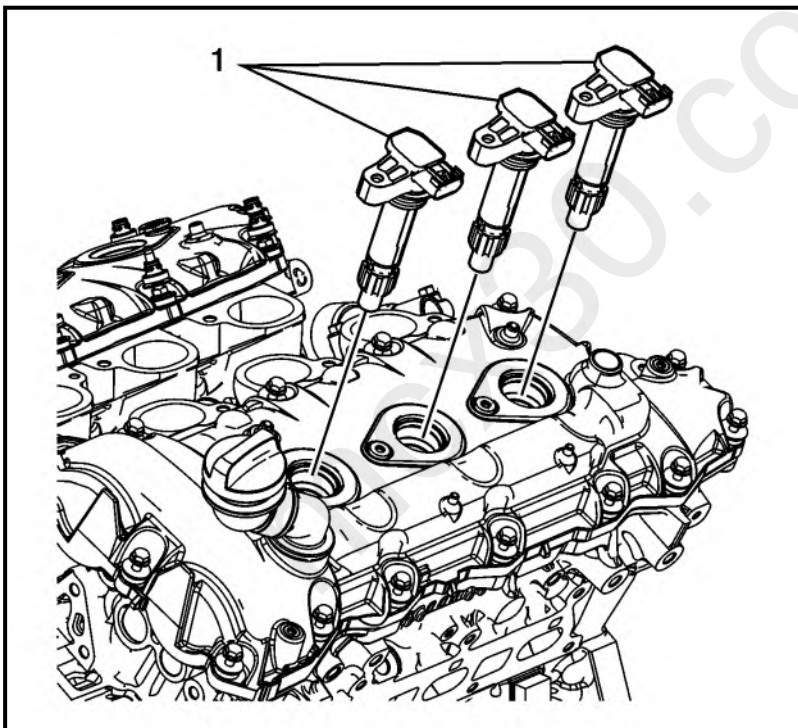
Remove the **EN-46101** guide from the spark plug tubes of the left cylinder head.

11.



Install the NEW spark plugs into the left cylinder head and tighten to 18 N.m (13 lb ft).

12.



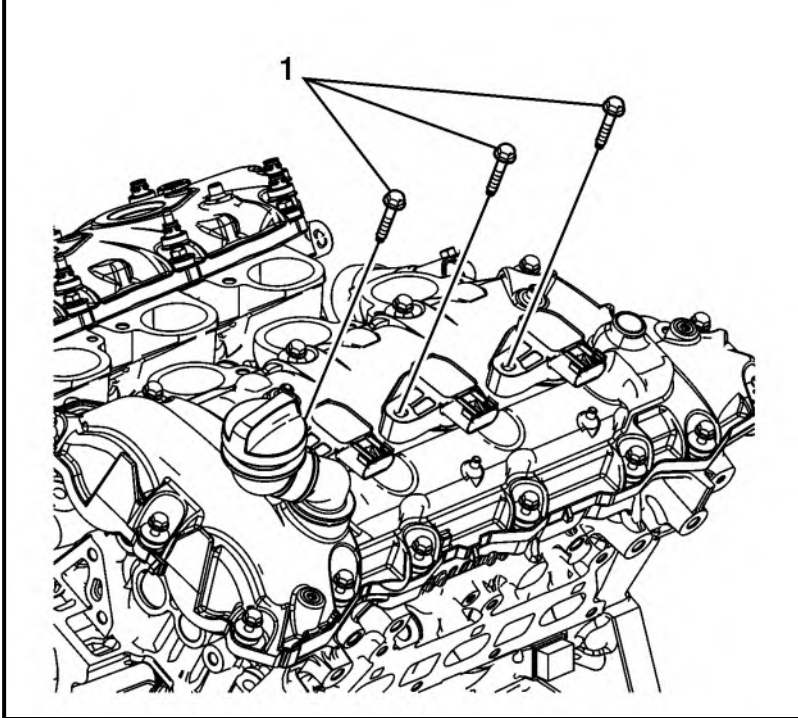
Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure:

1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.

13. Install the ignition coils.

14.





Install the ignition coil bolts and tighten to 10 N.m (89 lb in).

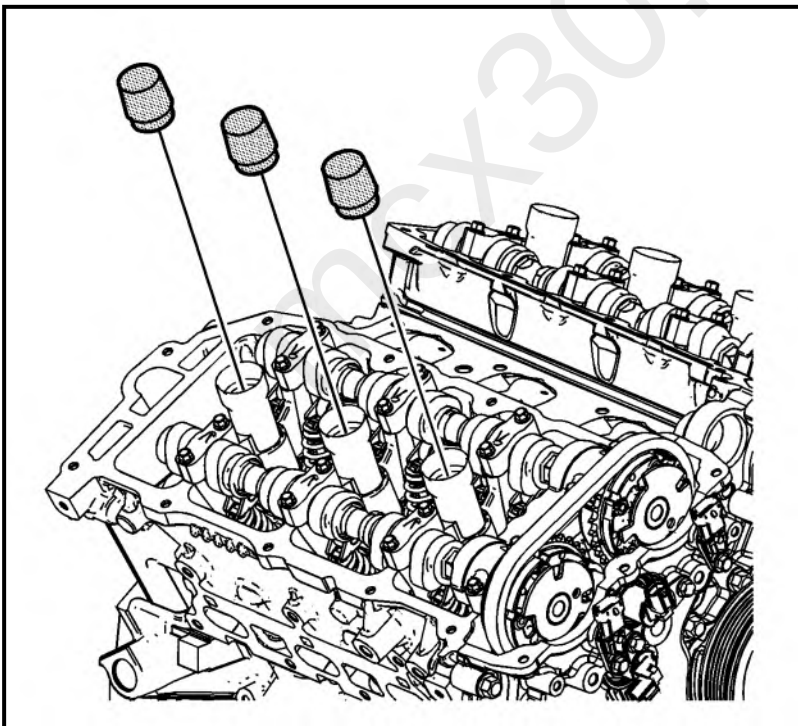
CAMSHAFT COVER INSTALLATION - RIGHT SIDE

Special Tools

EN-46101 Spark Plug Tube Seal Guide

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

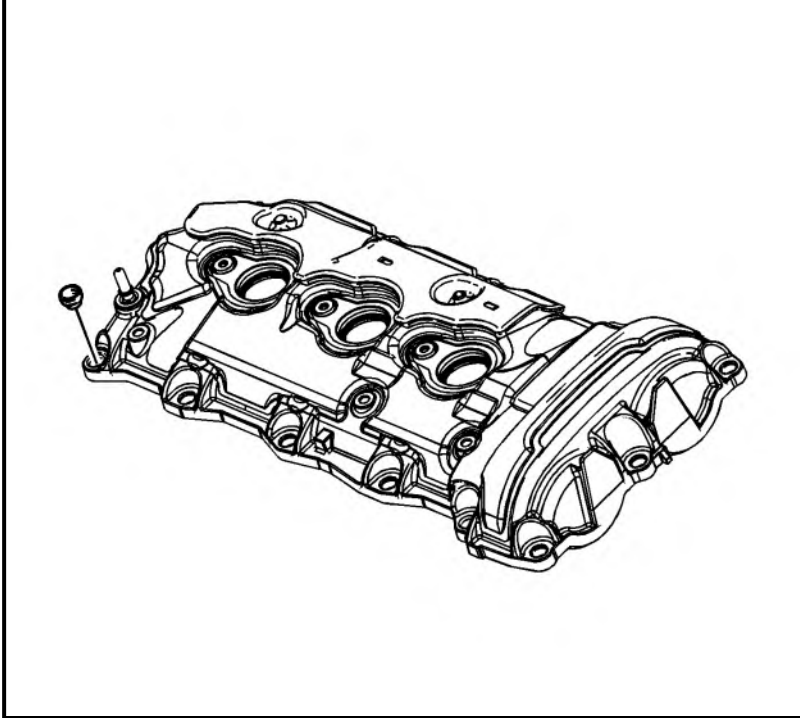
1.



Install the **EN-46101** guide onto the spark plug tubes of the right cylinder head.

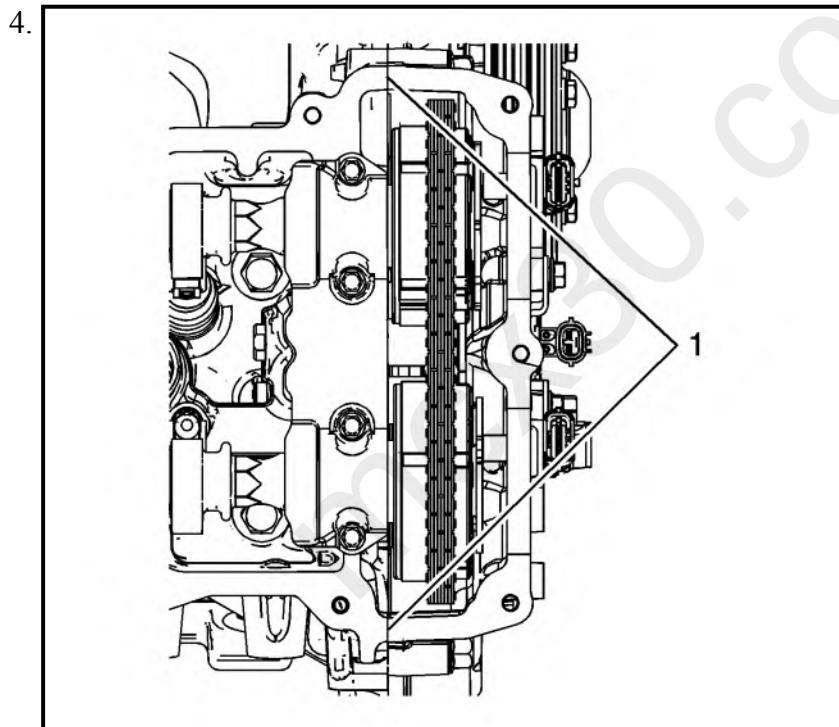
2.





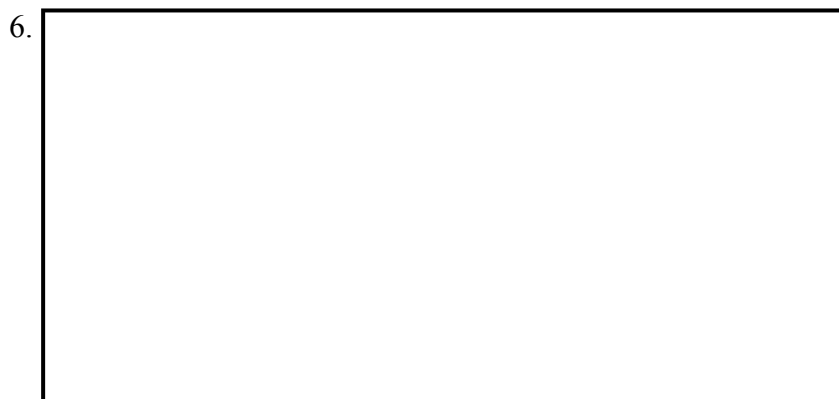
Install the NEW camshaft cover bolt grommets prior to installing the camshaft cover bolts.

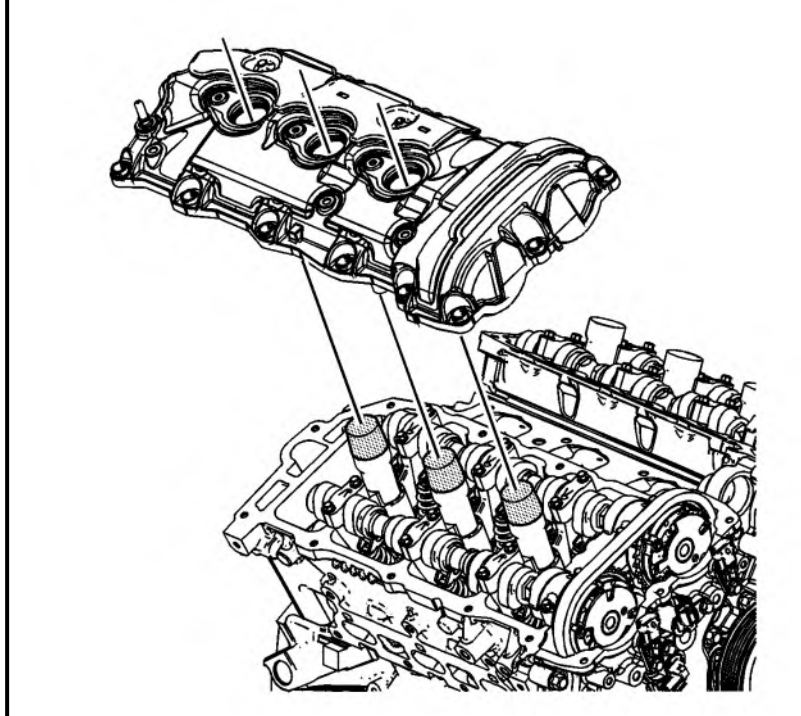
3. Wipe the camshaft cover sealing surface on the right cylinder head with a clean, lint-free cloth.



Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

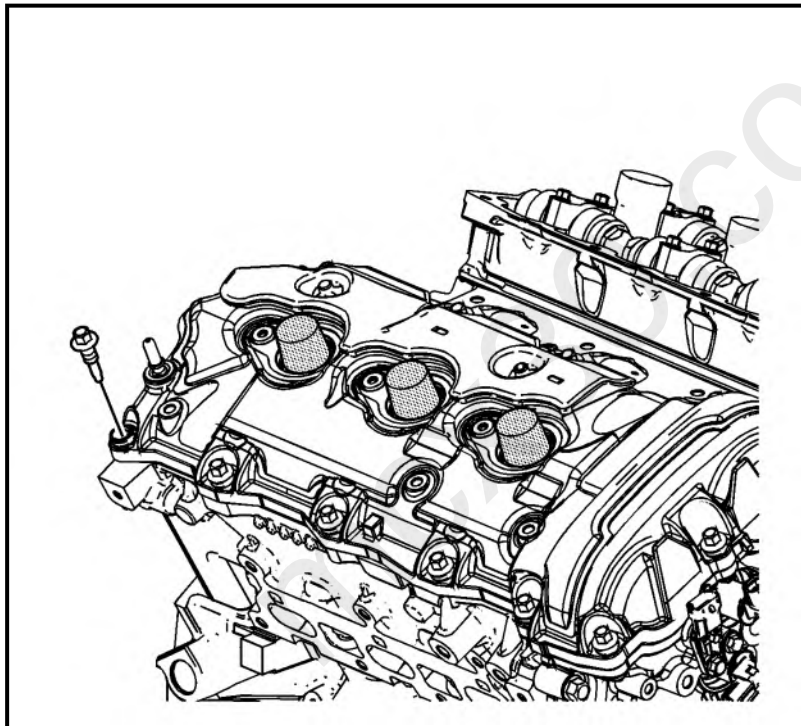
5. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant, on the engine front cover split lines (1). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) .



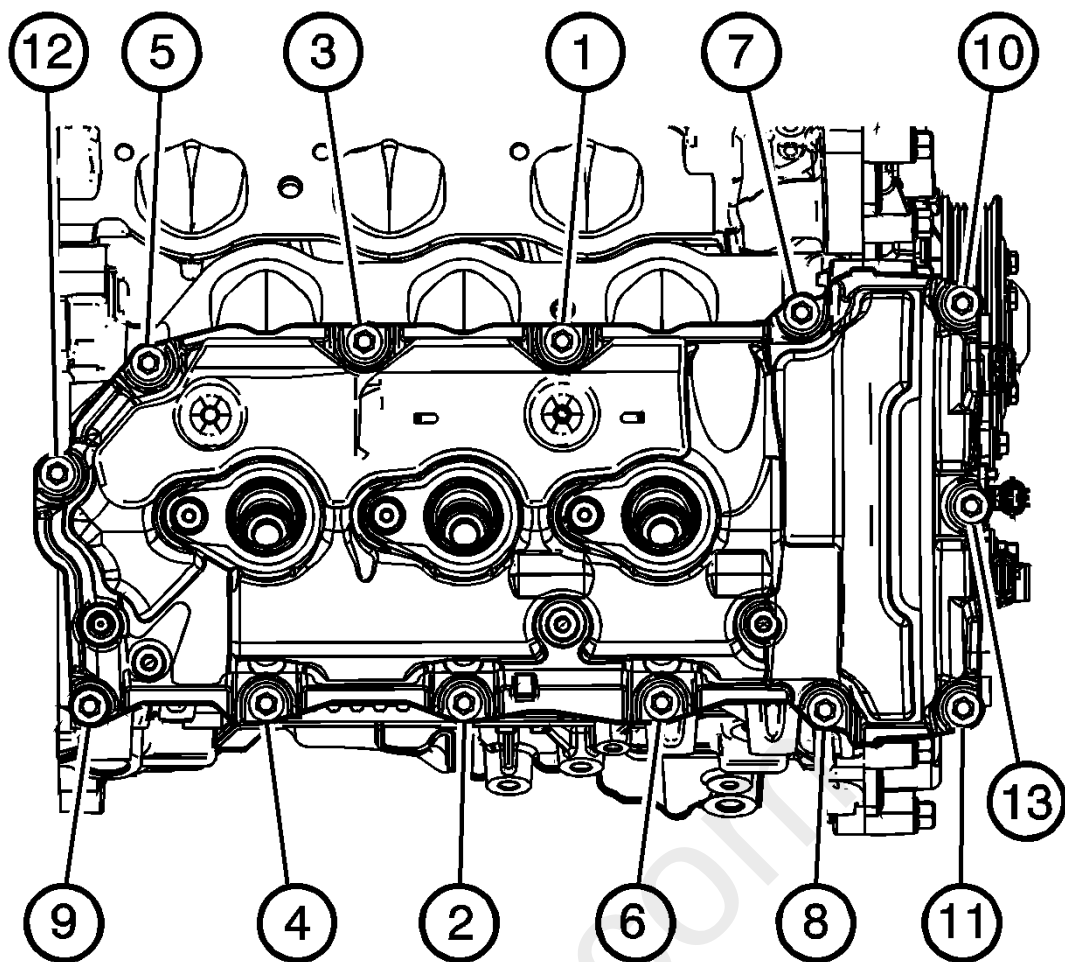


Place the right camshaft cover into position onto the right cylinder head.

7.



Loosely install the right camshaft cover bolts.



8.

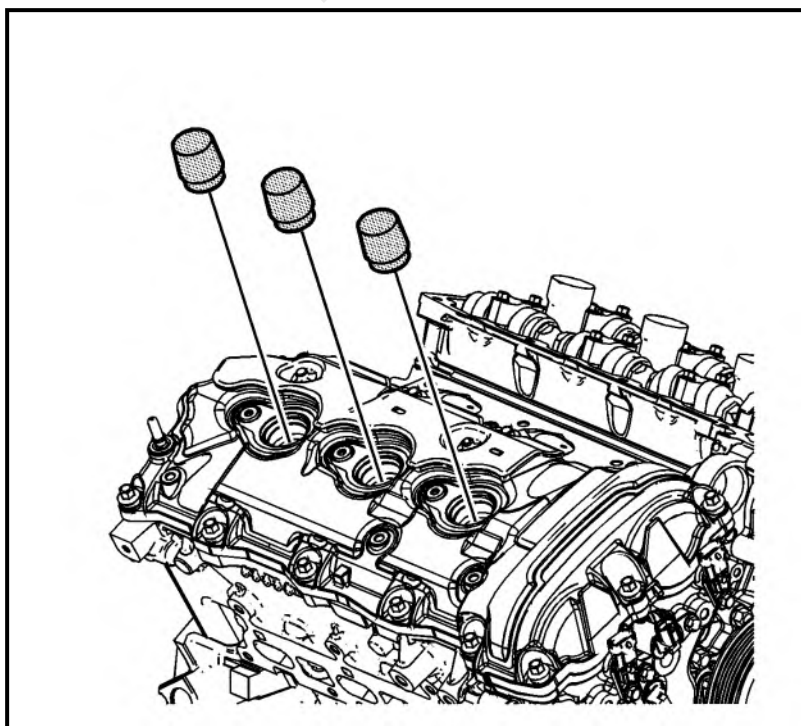
Fig. 30: Right Camshaft Cover Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

Tighten the right camshaft cover bolts in the sequence shown.

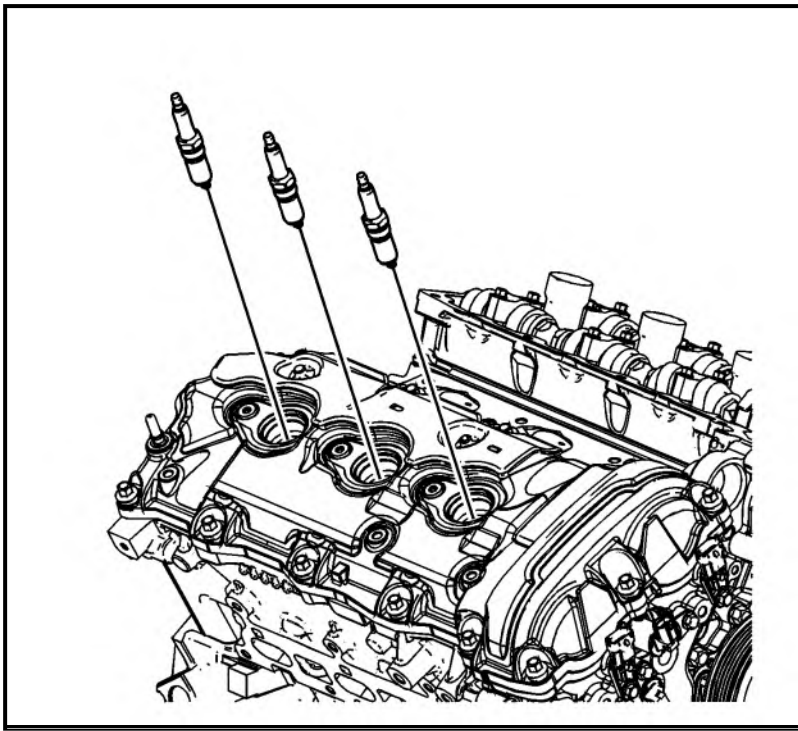
1. Tighten the right camshaft cover bolts to 10 N.m (89 lb in).
2. Tighten the right camshaft cover bolts a second pass to 10 N.m (89 lb in).

9.



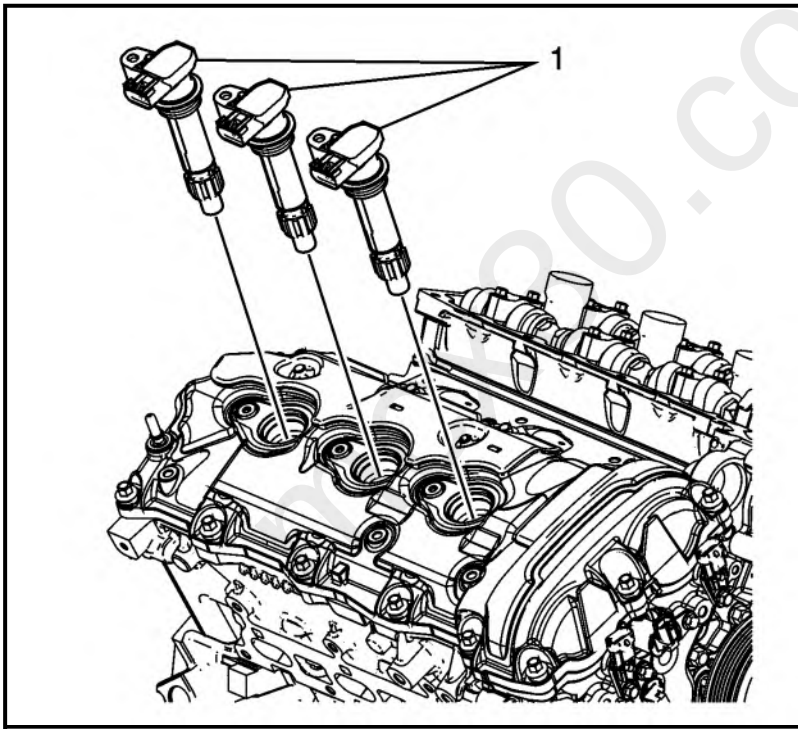
Remove the **EN-46101** guide from the spark plug tubes of the right cylinder head.

10.



Install the NEW spark plugs into the right cylinder head and tighten to 18 N.m (13 lb ft).

11.



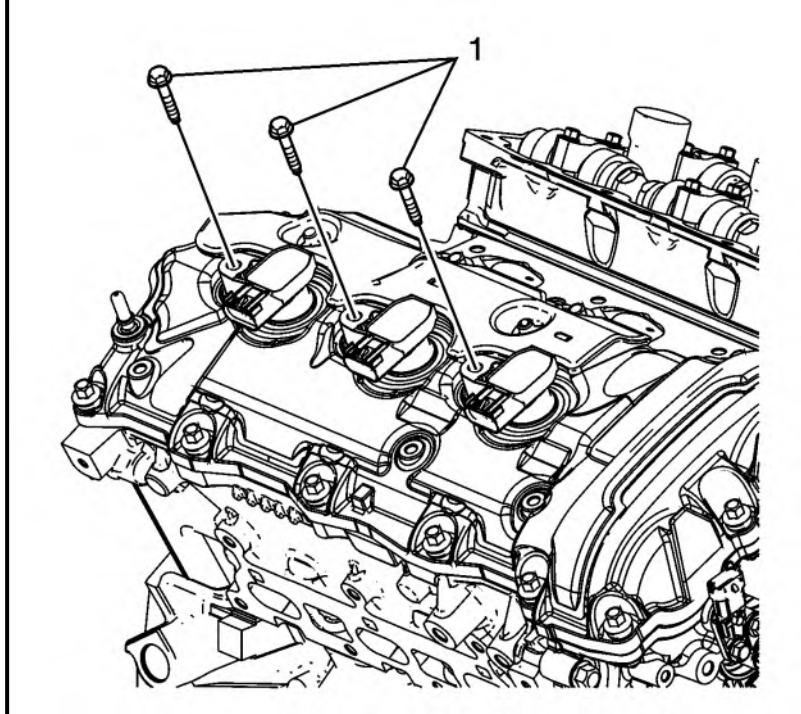
Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure:

1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.

12. Install the ignition coils.

13.

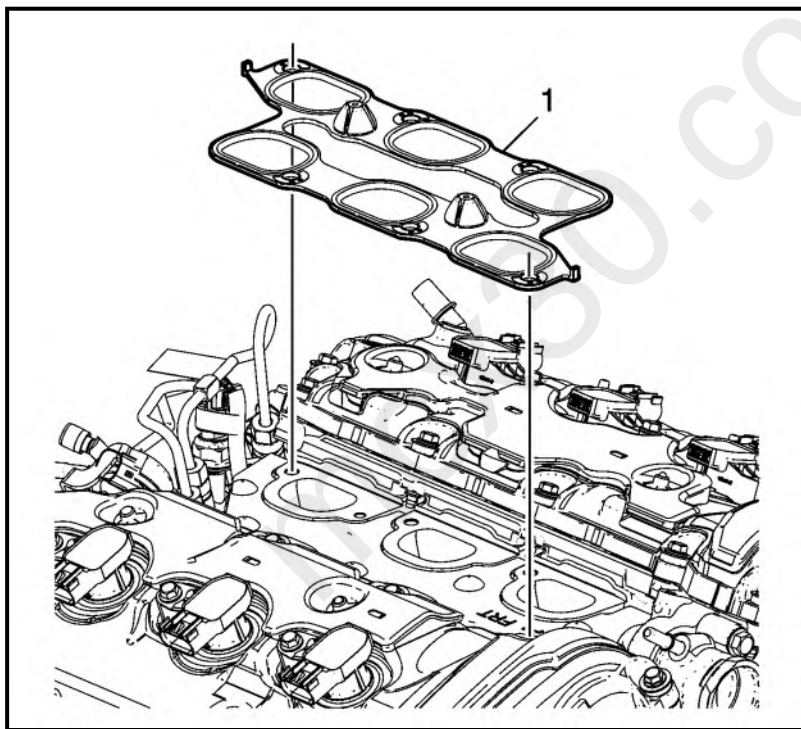




Install the ignition coil bolts and tighten to 10 N.m (89 lb in).

INTAKE MANIFOLD INSTALLATION

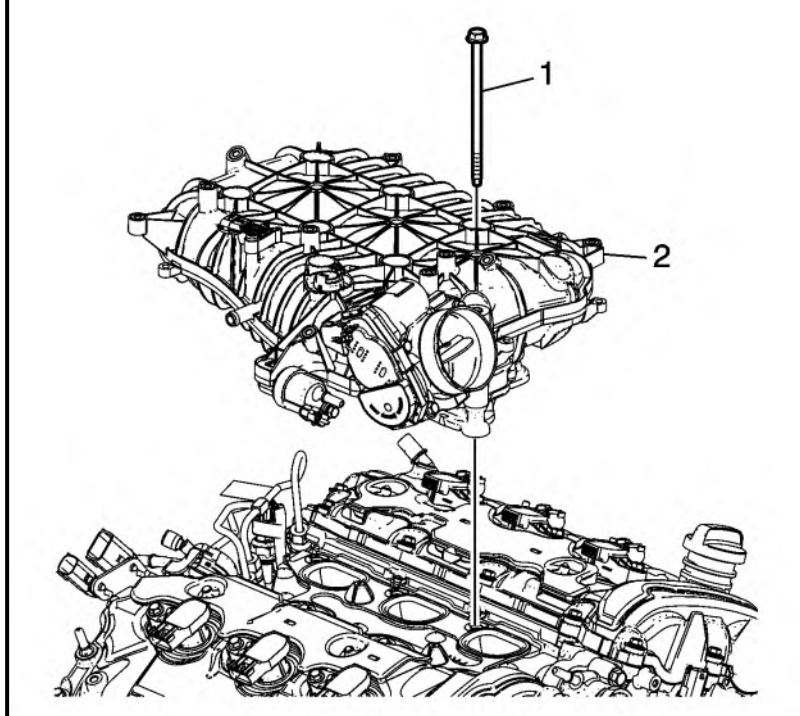
1.



Install the NEW intake manifold gasket (1).

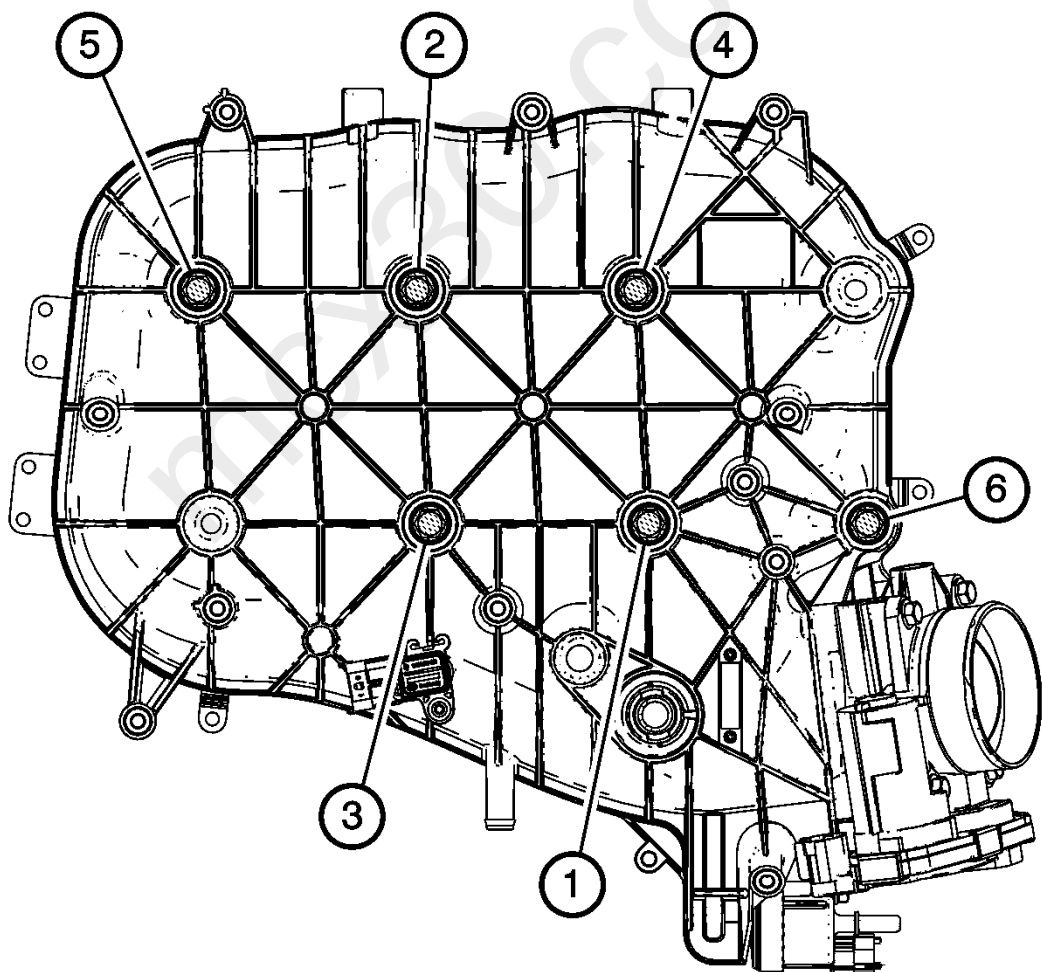
2.





Install the intake manifold assembly (2).

3. Install the intake manifold bolts (1).



4.

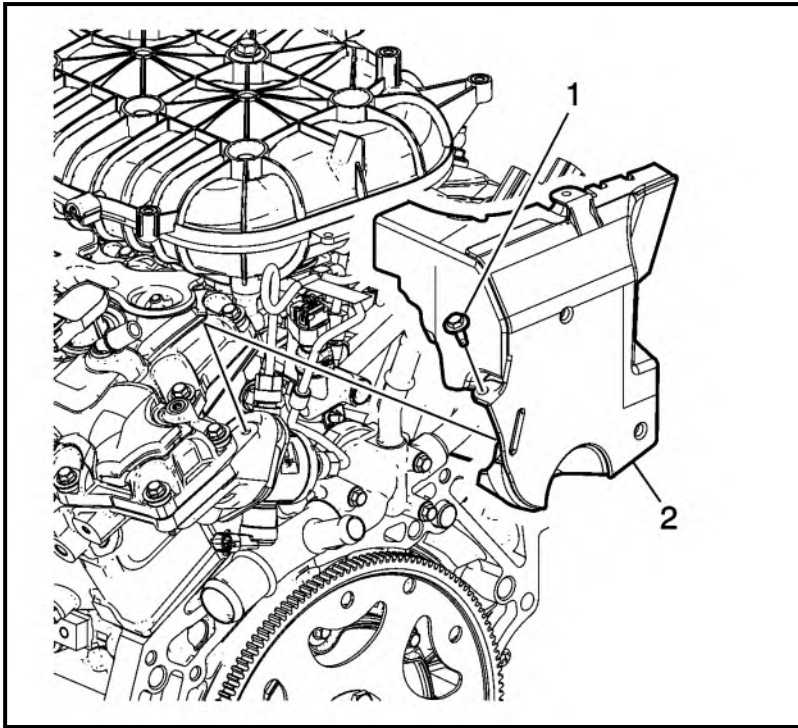
Fig. 31: Intake Manifold Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

Tighten the intake manifold bolts in the sequence shown.

5. Tighten the intake manifold bolts in sequence to 25 N.m (18 lb ft).
6. Tighten the intake manifold bolts a second pass in sequence to 25 N.m (18 lb ft).

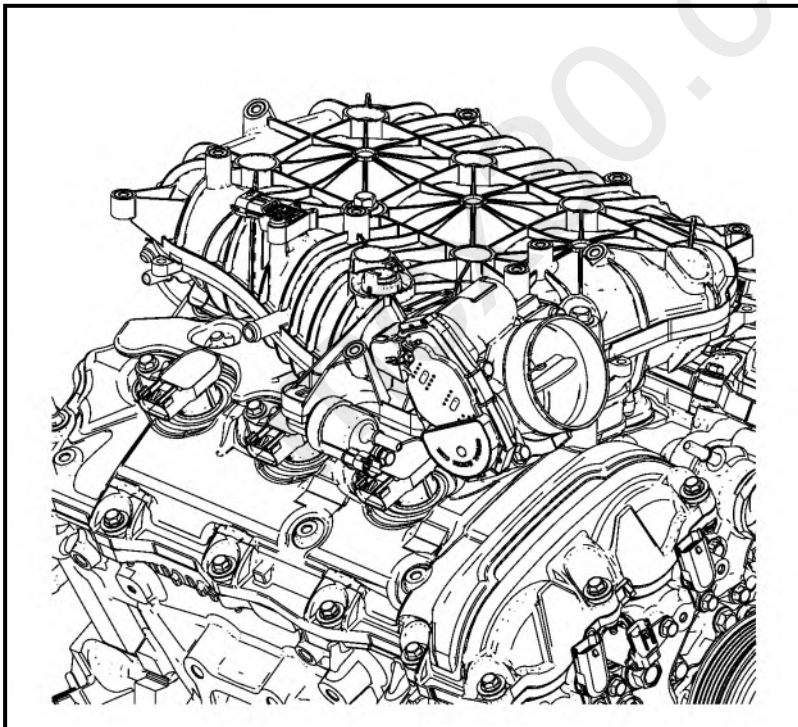
7.



Install the engine rear noise shield (2).

8. Install the engine rear noise shield bolt (1) and tighten to 10 N.m (89 lb in).

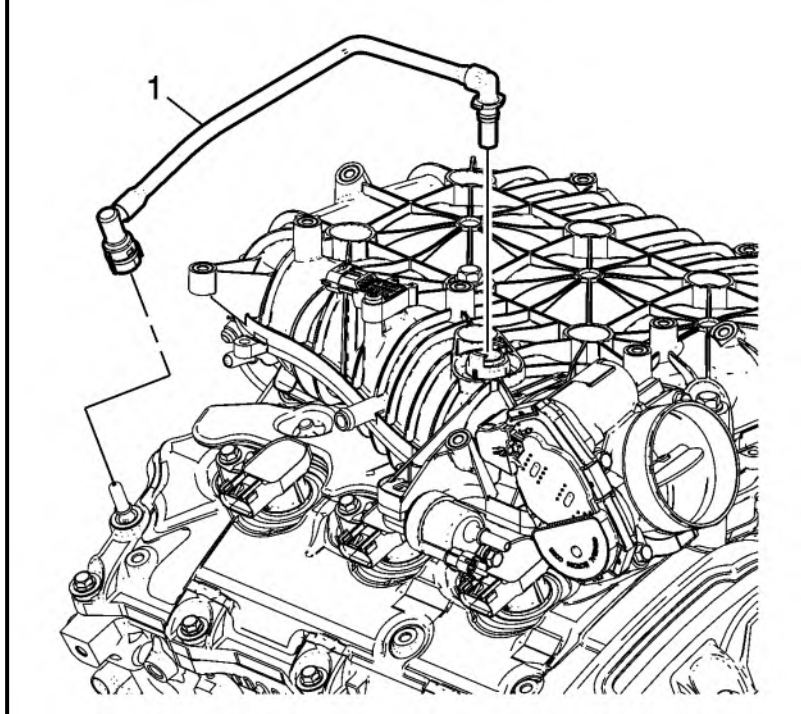
9.



Connect the evaporative (EVAP) hose to the upper intake manifold and EVAP solenoid.

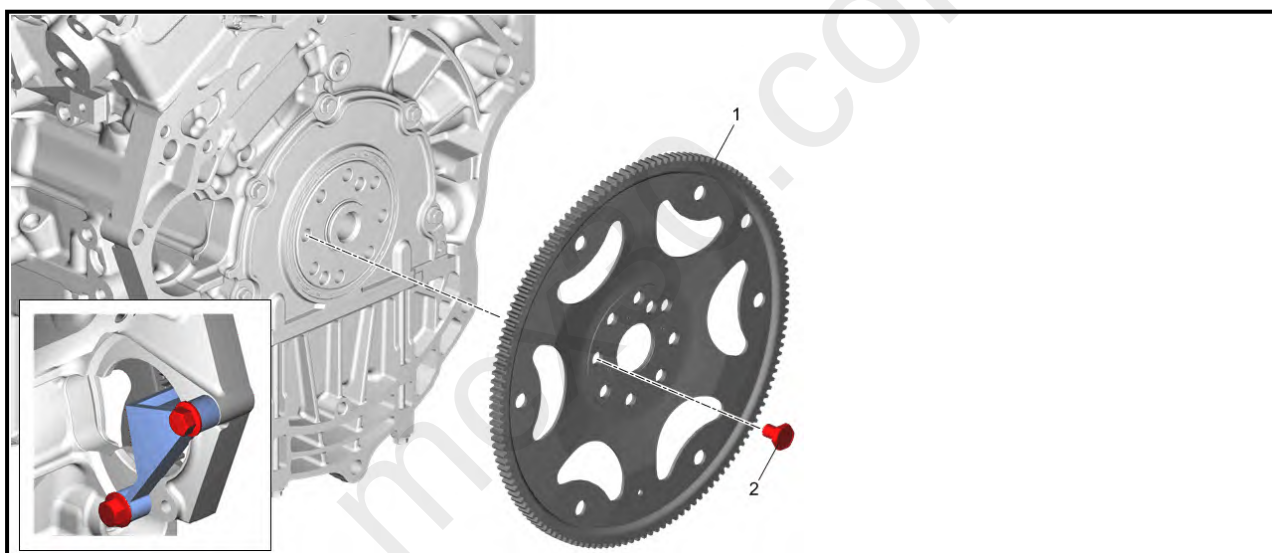
10.





Connect the positive crankcase ventilation (PCV) tube assembly (1) to the upper intake manifold and the right camshaft cover.

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION



Callout	Component Name
1	Automatic Transmission Flex Plate

Callout	Component Name
2	Automatic Transmission Flex Plate Bolt [8x] CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. CAUTION: Refer to Fastener Caution . Procedure 1. Install 2 NEW bolts (2) in location at the top and bottom of the flex plate bolt pattern allowing the flex plate (2) to hang in position. 2. Install the EN-46106 Flywheel Holding Tool through the starter mounting hole. 3. Install the remaining NEW flex plate bolts and tighten to specifications. NOTE: The top starter hole will require a longer bolt and nut to secure the tool. 4. Remove the EN-46106 Flywheel Holding Tool through the starter mounting hole. Tighten 1. First Pass: 30 N.m (22 lb ft) 2. Final Pass: 45 degrees using the EN - 45059 Angle Meter Special Tools • EN-46106 Flywheel Holding Tool • EN-45059 Angle Meter Equivalent regional tools: Special Tools

CRANKSHAFT BALANCER INSTALLATION

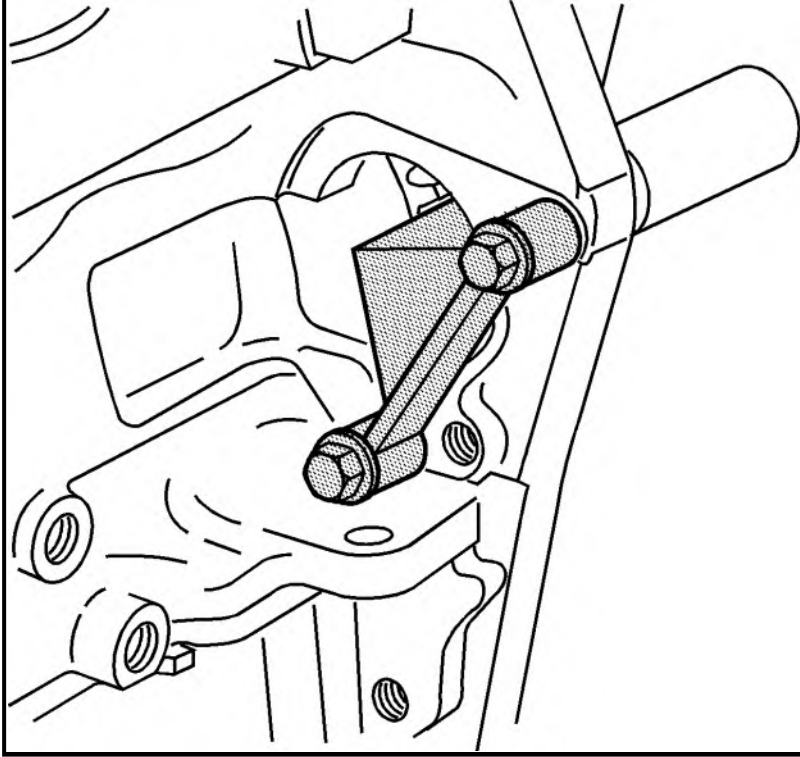
Special Tools

- **EN 46106** Engine Flywheel Holding Tool
- **J 41998-B** Crankshaft Balancer Installer
- **J 45059** Angle Meter

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

1.

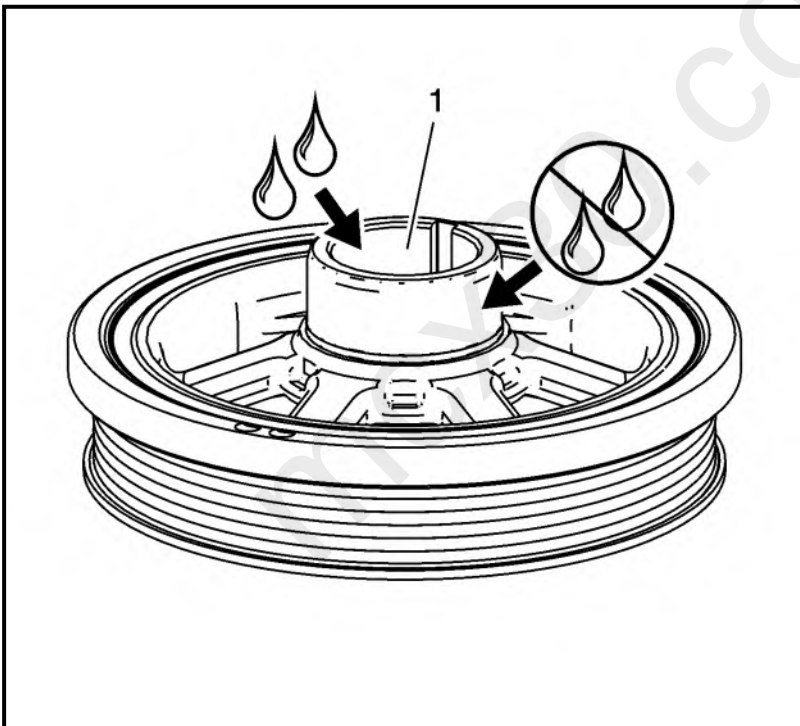




The **EN 46106** tool must be installed onto the flywheel.

2. Use the **J 41998-B** installer, nut, bearing and washer to install the crankshaft balancer.

3.

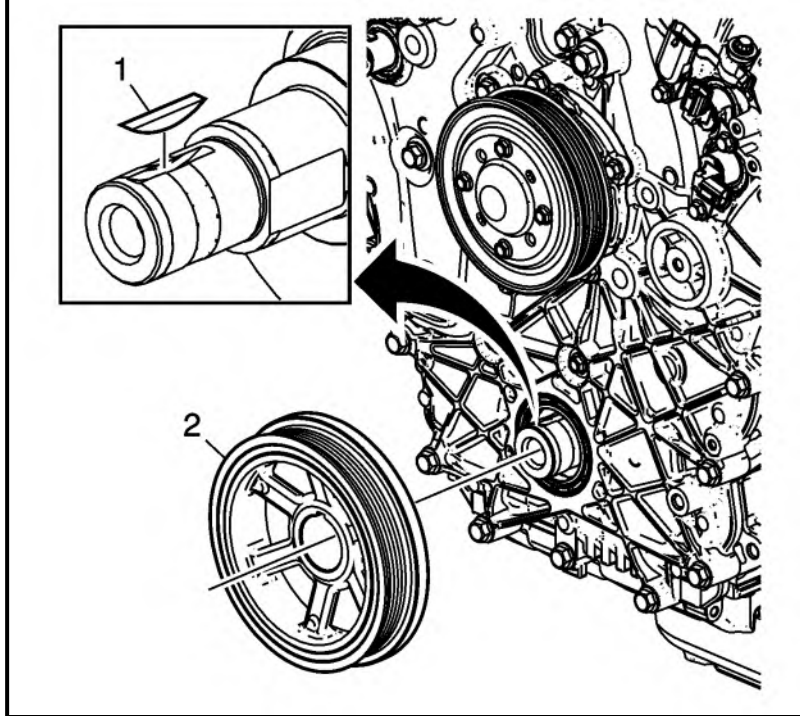


NOTE: Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

Apply lubricant to the inside of the crankshaft balancer hub bore (1).

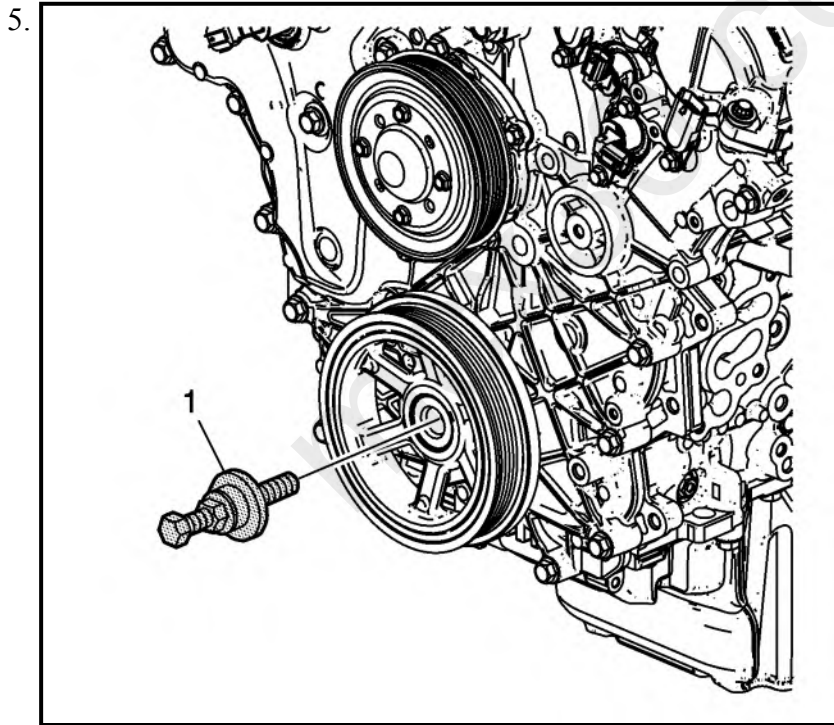
4.





NOTE: Ensure the key (1) located on the top of the crankshaft is correctly installed in the crankshaft. Failure to adhere to this may cause engine damage.

Slide the crankshaft balancer (2) into position on the crankshaft.

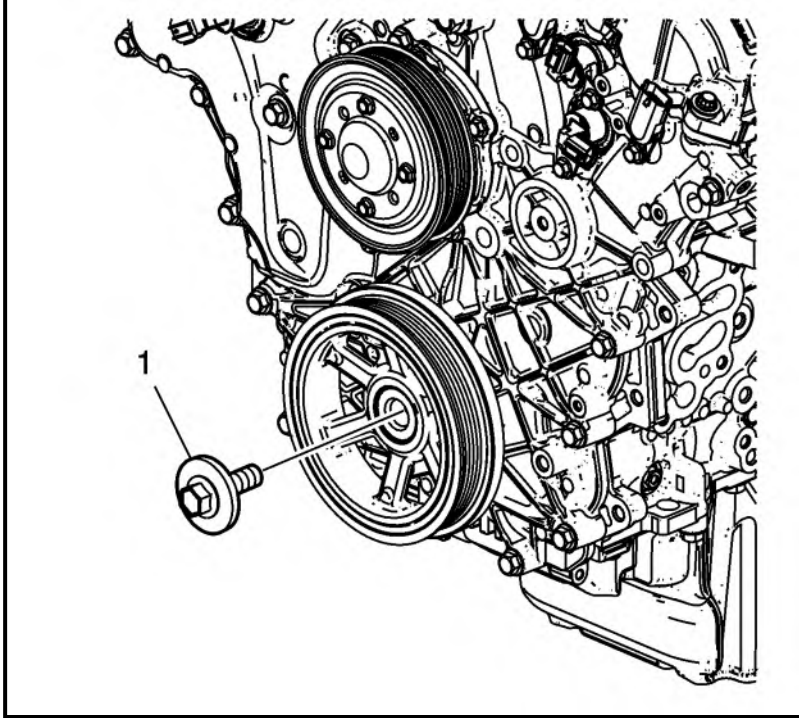


Thread the **J 41998-B** installer (1) in the crankshaft. Ensure you engage at least 10 threads of the **J 41998-B** installer before pressing the crankshaft balancer in place.

6. Push the crankshaft balancer into position by tightening the nut on the **J 41998-B** installer until the large washer bottoms out on the crankshaft end.

7. Remove the **J 41998-B** installer.





Install the NEW crankshaft balancer bolt (1).

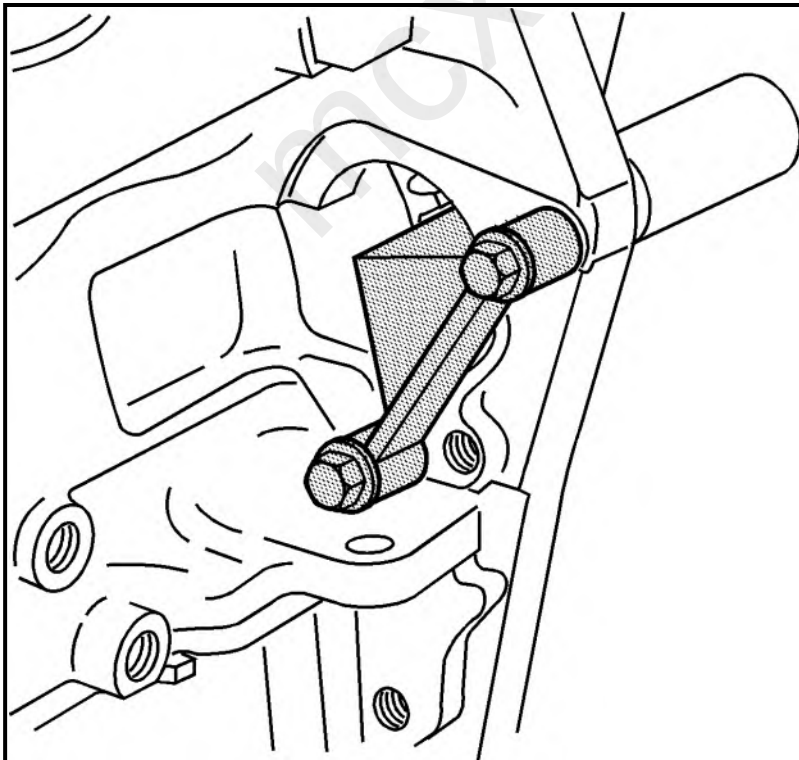
CAUTION: Refer to **Fastener Caution** .

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

9. Tighten the crankshaft balancer bolt.

1. Tighten the crankshaft balancer bolt to 100 N.m (74 lb ft).
2. Tighten the crankshaft balancer bolt an additional 150 degrees using the **J 45059** meter.

10.



Remove the **EN 46106** tool.

OIL FILTER ADAPTER INSTALLATION

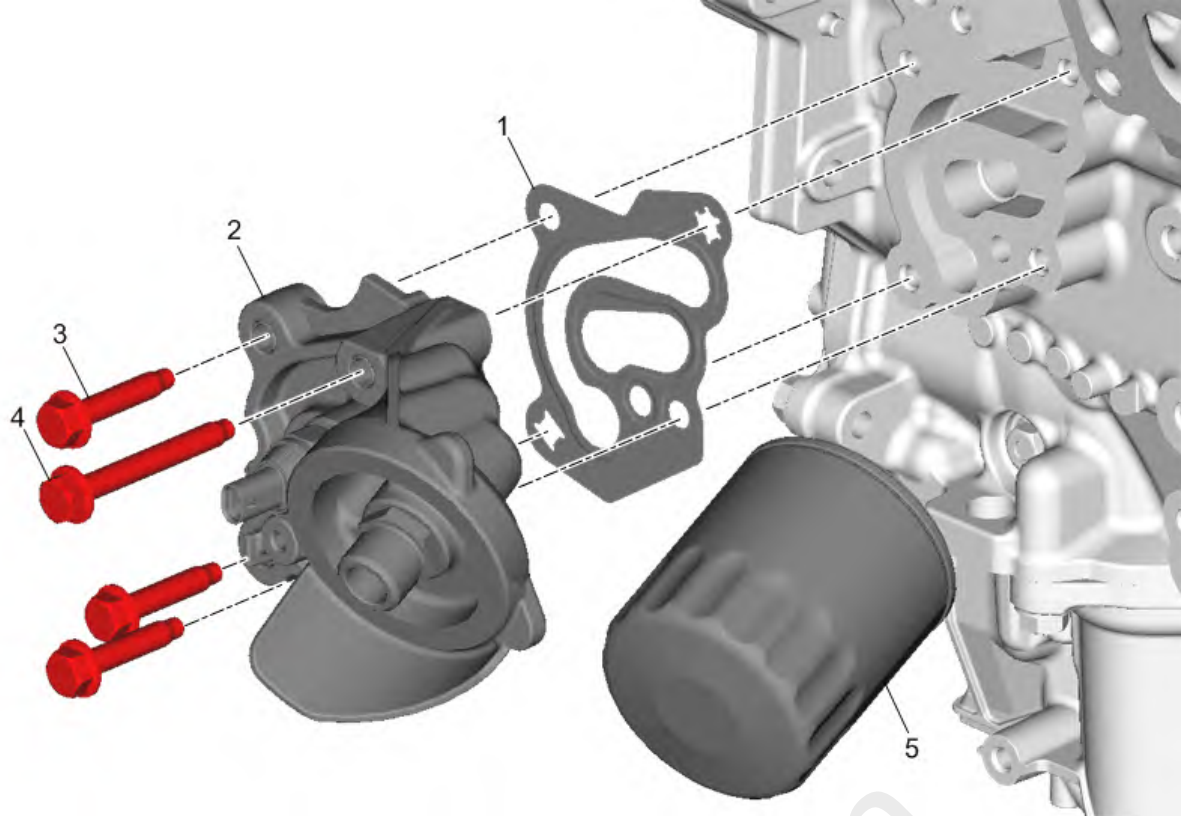


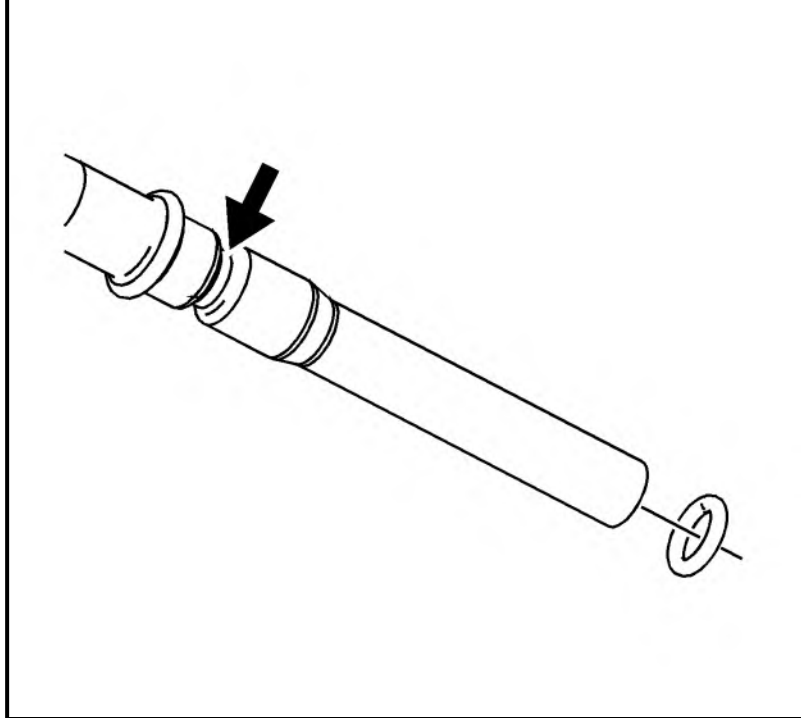
Fig. 32: Exploded View Of Oil Filter Adapter Components

Courtesy of GENERAL MOTORS COMPANY

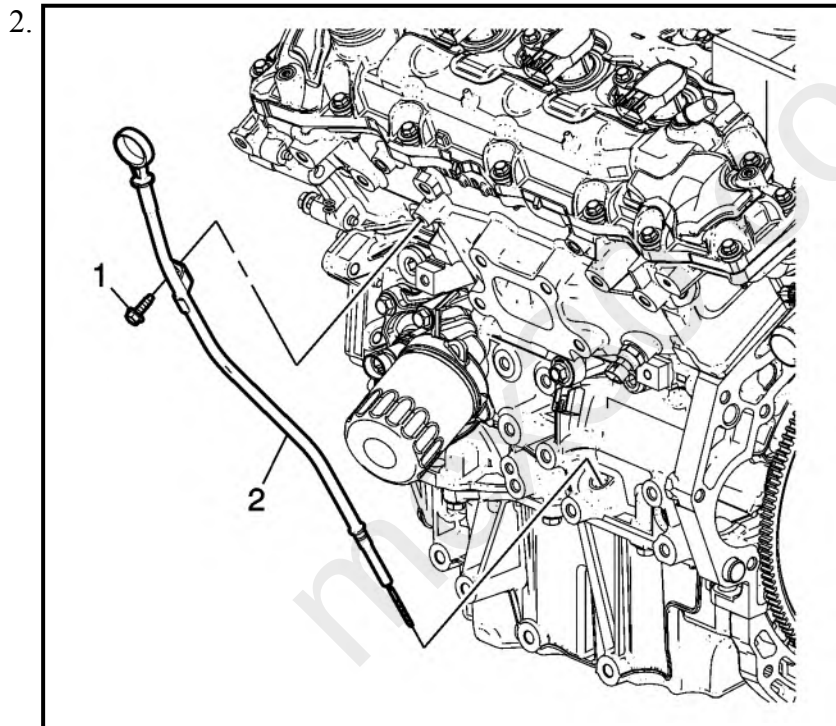
Callout	Component Name
1	Oil Filter Adapter Gasket NOTE: Install a NEW gasket.
2	Oil Filter Adapter
3	Oil Filter Adapter Bolt [3x] CAUTION: Refer to Fastener Caution . Tighten 23 N.m (17 lb ft)
4	Oil Filter Adapter Bolt Tighten 23 N.m (17 lb ft)
5	Oil Filter NOTE: Install a NEW oil filter. Tighten 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange

OIL LEVEL INDICATOR AND TUBE INSTALLATION

1.



Install a NEW O-ring on the oil level indicator tube.



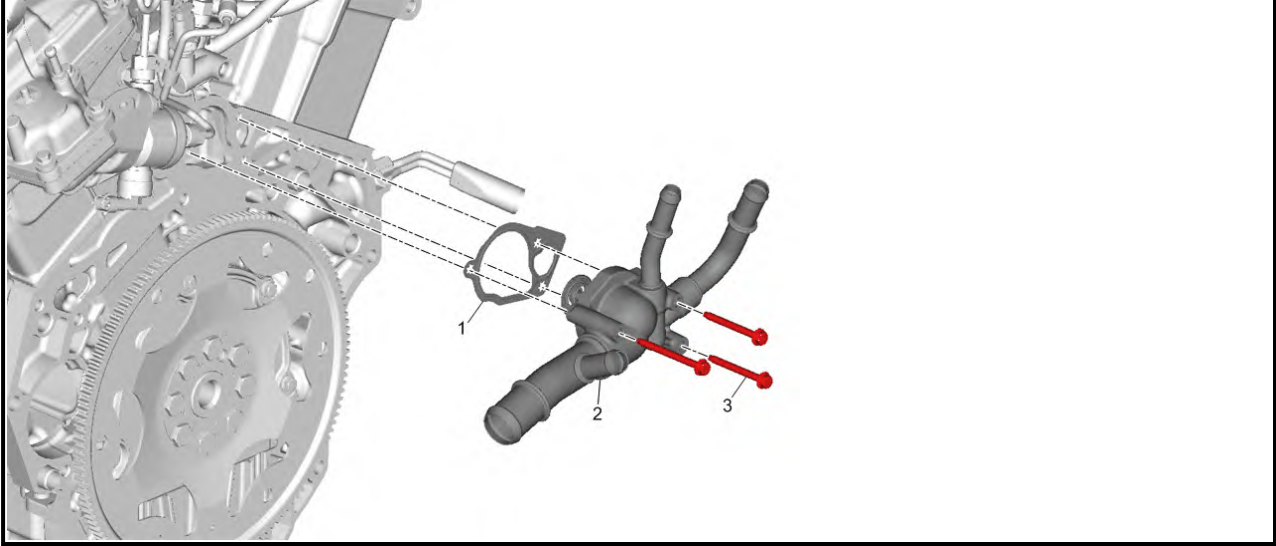
Install the oil level indicator and tube (2) by sliding the tube down through the lower crankcase hole.

CAUTION: Refer to Fastener Caution .

3. Install the oil level indicator tube bracket bolt (1) and tighten to 10 N.m (89 lb in).

ENGINE COOLANT THERMOSTAT HOUSING INSTALLATION





Callout	Component Name
1	Engine Coolant Thermostat Housing Gasket NOTE: Install a NEW gasket.
2	Engine Coolant Thermostat Housing
3	Engine Coolant Thermostat Housing Bolt [3x] CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)

WATER OUTLET INSTALLATION

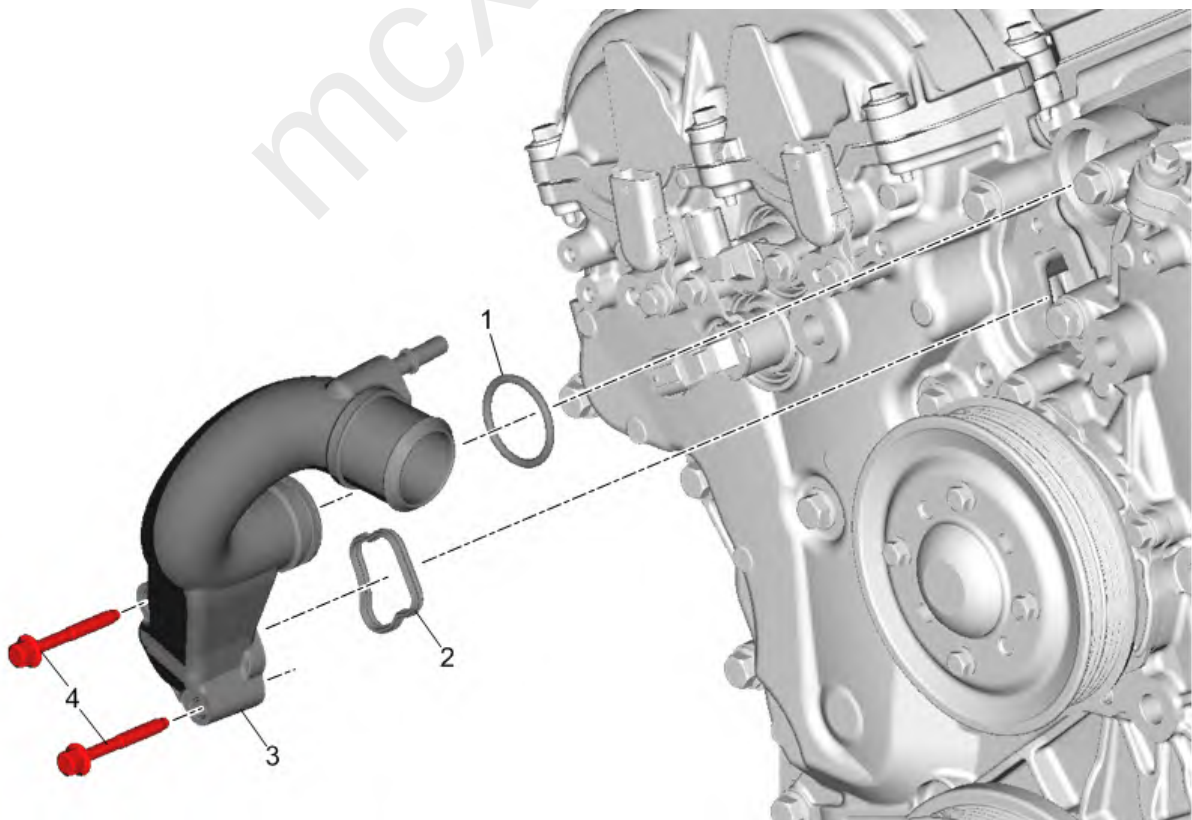


Fig. 33: Exploded View Of Water Outlet Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Outlet O-Ring Seal NOTE: Install a NEW seal.
2	Water Outlet Seal NOTE: Install a NEW seal.
3	Water Outlet
4	Water Outlet Bolt [2x] CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)

DRIVE BELT TENSIONER INSTALLATION

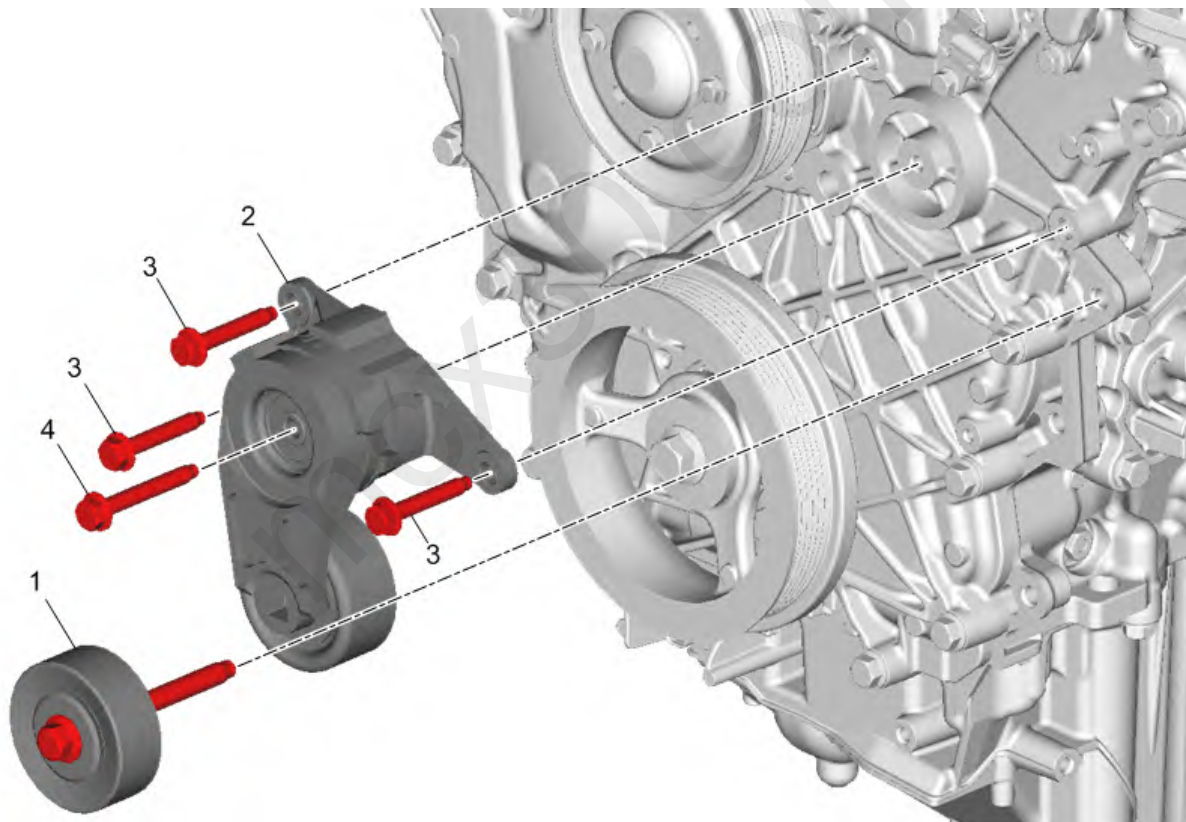


Fig. 34: Exploded View Of Drive Belt Tensioner Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Idler Pulley CAUTION: Refer to Fastener Caution . Tighten 30 N.m (22 lb ft)
2	Drive Belt Tensioner

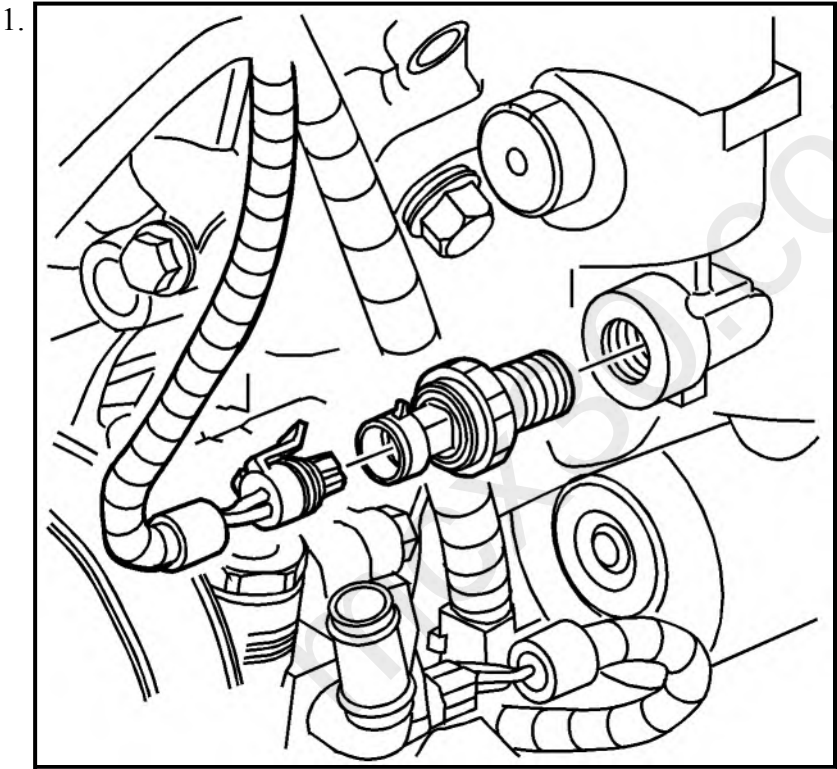
Callout	Component Name
3	Engine Front Cover Bolt [3x] Tighten • First Pass: 20 N.m (15 lb ft) • Final Pass: 60 degrees
4	Drive Belt Tensioner Bolt Tighten 25 N.m (18 lb ft)

ENGINE PRELUBING

Special Tools

- EN-21867-6 Oil Pressure Adapter Fitting
- EN-45299 Engine Preluber

Equivalent regional tools: [Special Tools](#)



NOTE: A constant and continuous flow of clean engine oil is required to properly prime the engine. Be sure to use an approved engine oil.

Remove the oil filter cap.

2. Install a NEW oil filter.
3. Lubricate the threads of the oil filter cap with clean engine oil.

CAUTION: Refer to [Fastener Caution](#) .

4. Install the oil filter cap and tighten to 25 N.m (18 lb ft).
5. Remove the oil pressure sending unit from the oil filter adapter.
6. Install the EN-21867-6 fitting.





Install the flexible hose to the adapter and open the valve.

8. Pump the handle on the **EN-45299** preluber to flow a minimum of 1 - 1.9 liters (1 - 2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
 9. Close the valve and remove the flexible hose and adapter from the engine.
 10. Install the oil pressure sending unit and tighten to 20 N.m (15 lb ft).
 11. Top-off the engine oil to the proper level.
-