

2010 ENGINE

Engine Mechanical - 2.8L, 3.0L, 3.2L, or 3.6L - Repair Instructions - Off Vehicle - Equinox & Terrain

DRIVE BELT TENSIONER REMOVAL

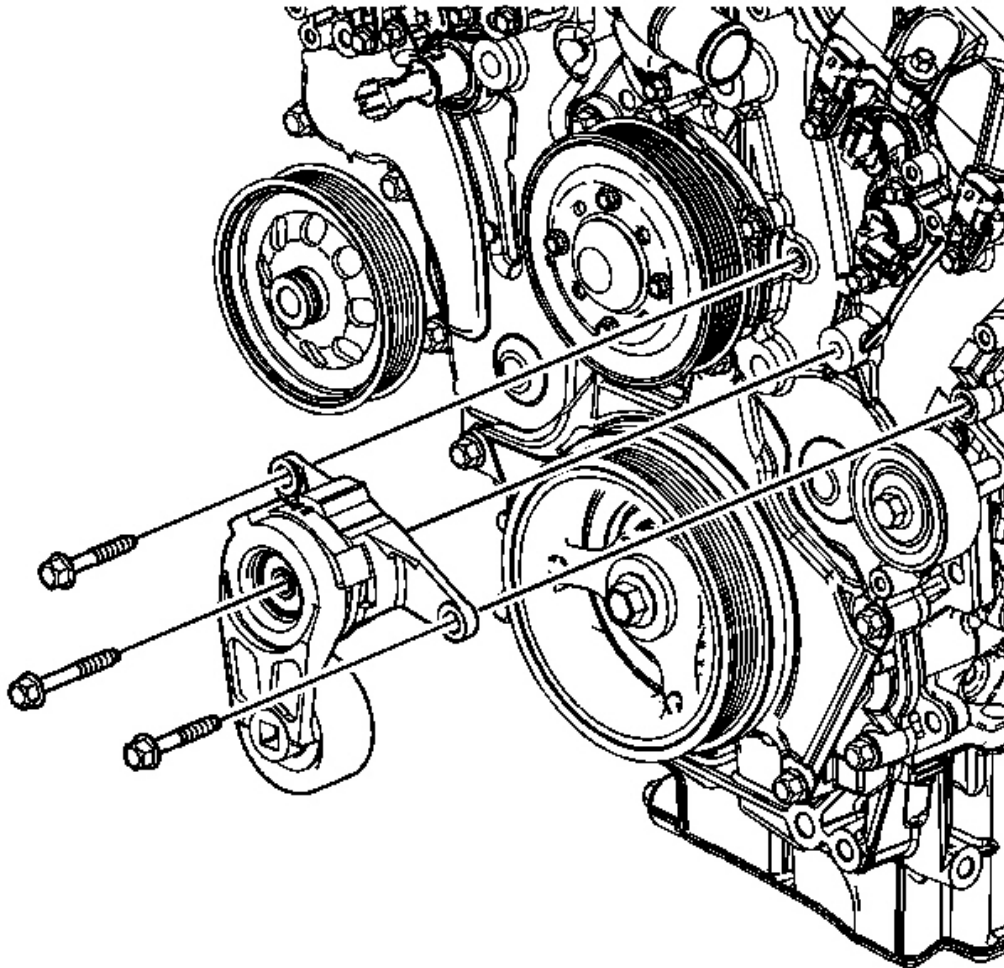


Fig. 1: View Of Left Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

OIL LEVEL INDICATOR AND TUBE REMOVAL (LF1 OR LFW)

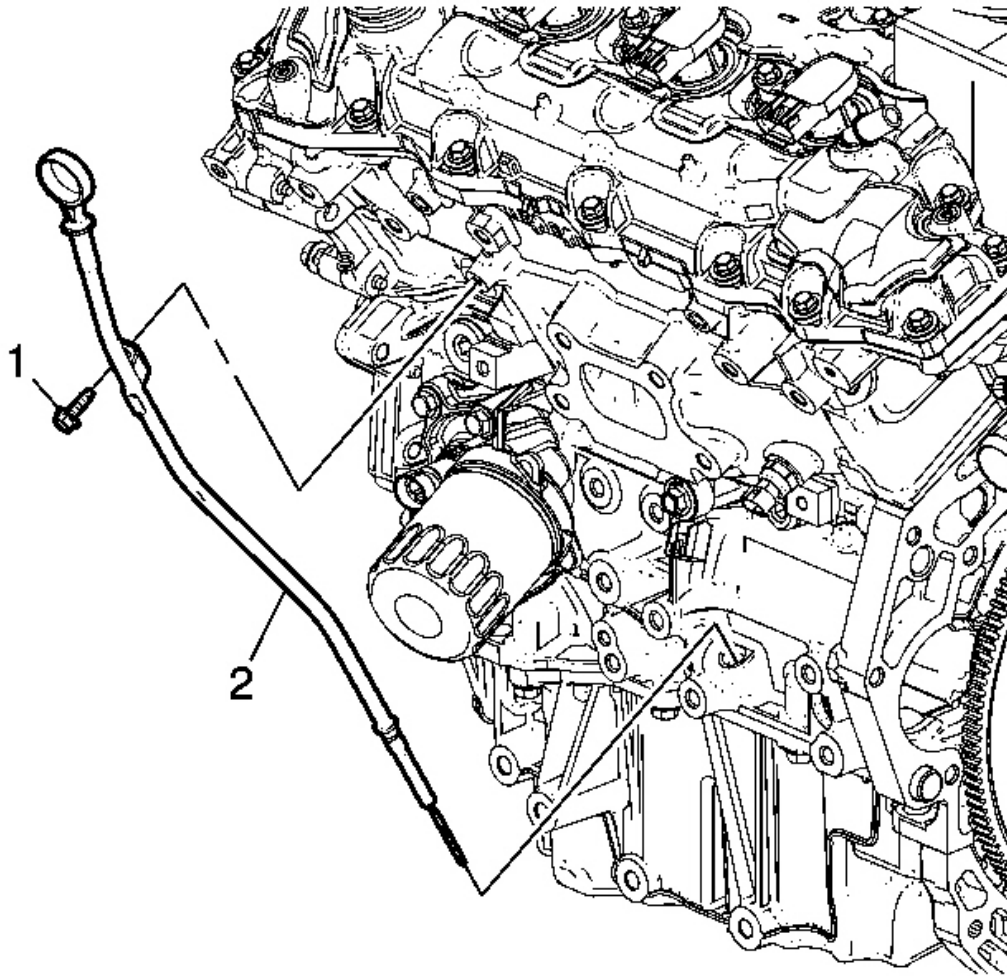


Fig. 2: Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. 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.

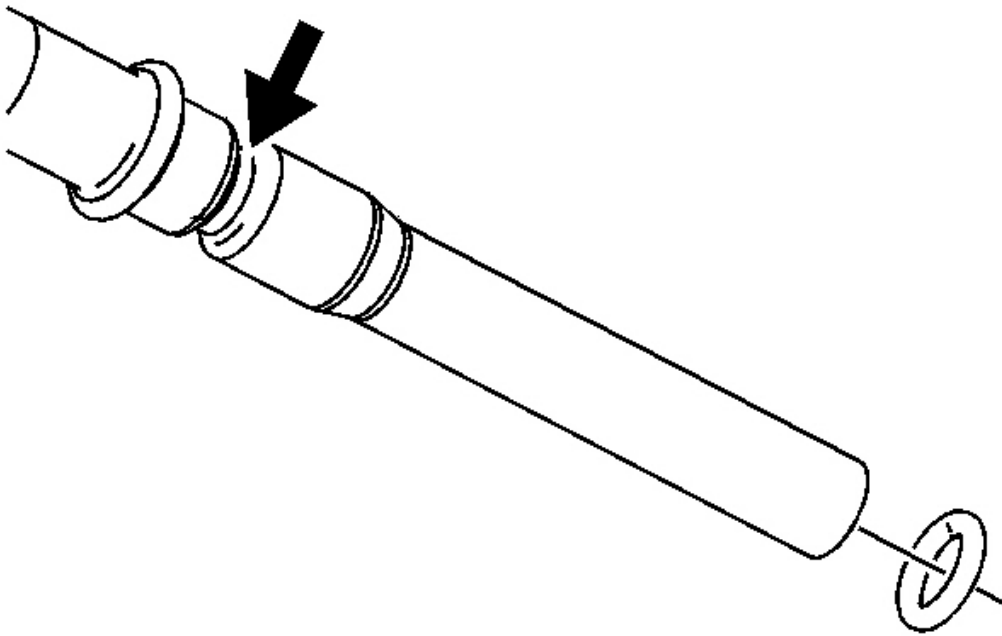


Fig. 3: View Of Oil Level Indicator Tube O-Ring
Courtesy of GENERAL MOTORS CORP.

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

OIL FILTER ADAPTER REMOVAL

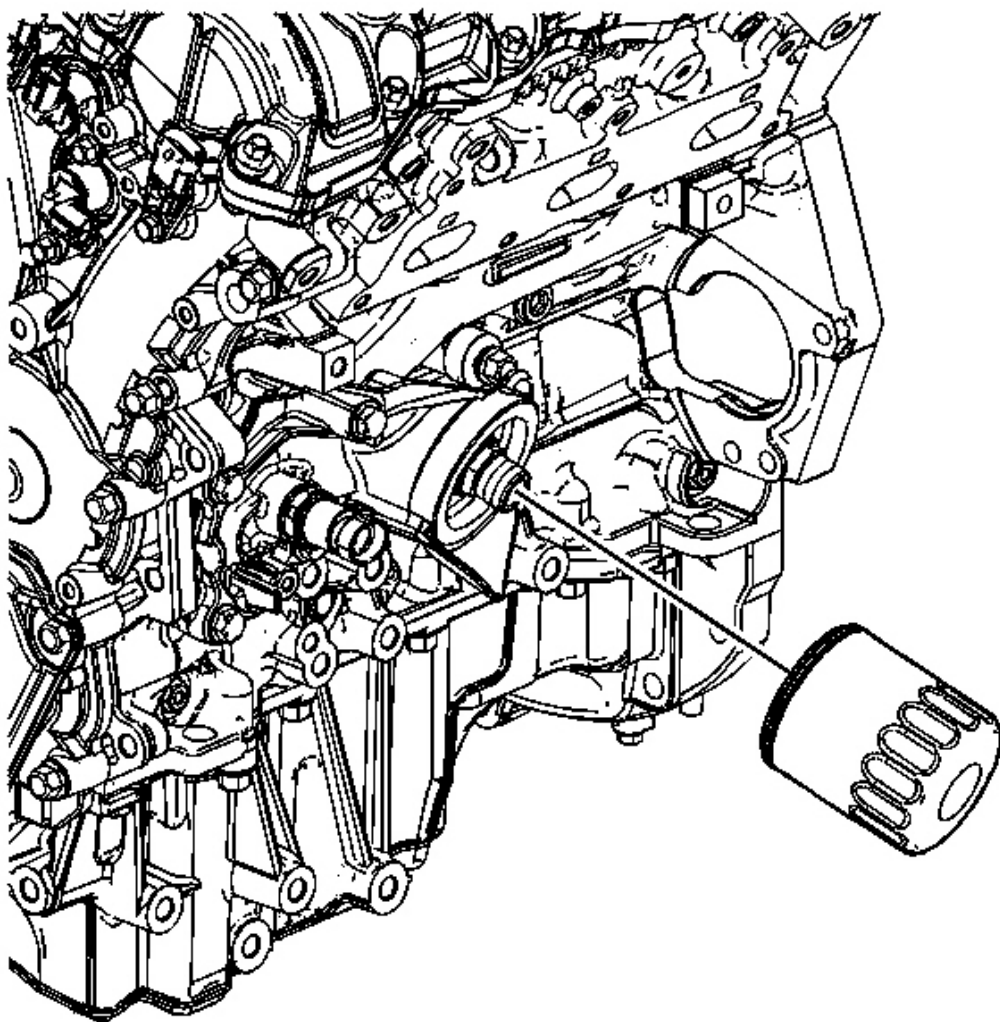


Fig. 4: Removing/Installing Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Remove and properly dispose of the oil filter.

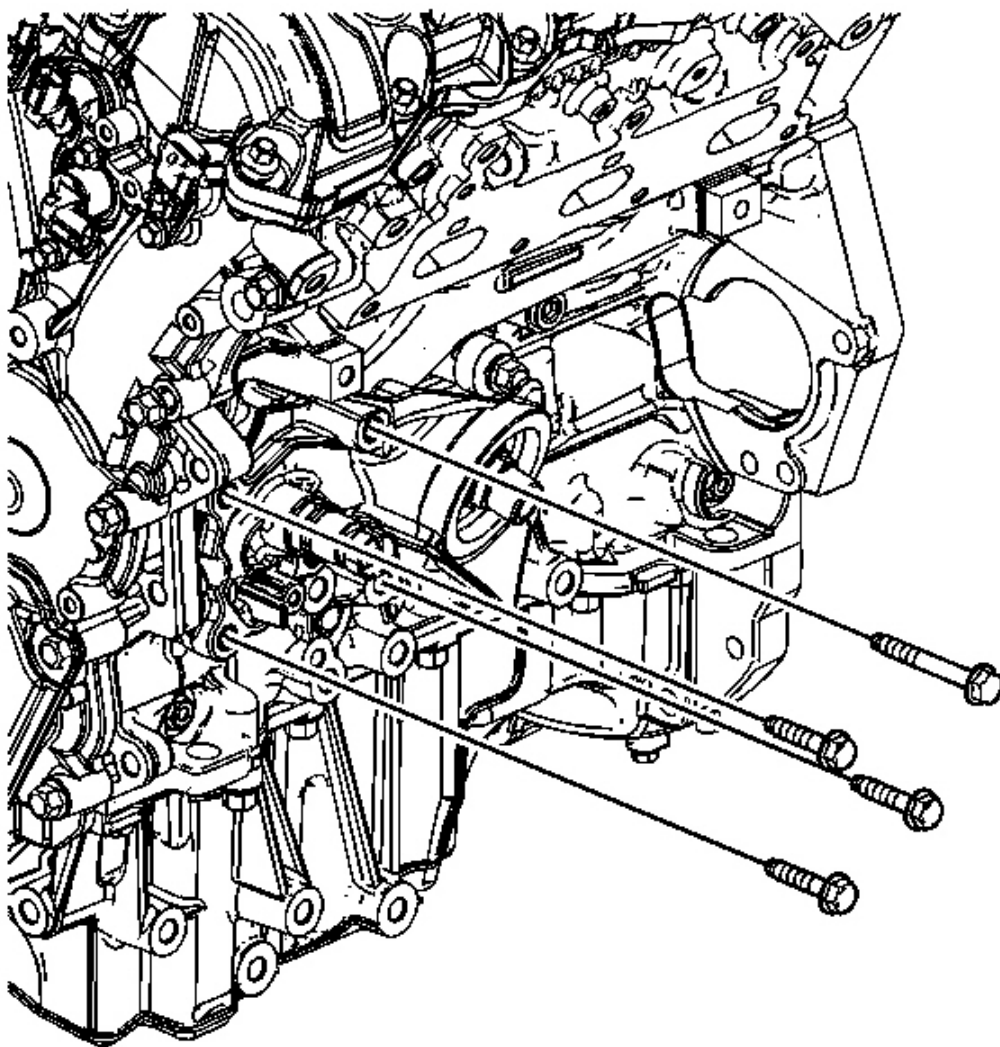


Fig. 5: View Of Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter adapter bolts from the engine block.

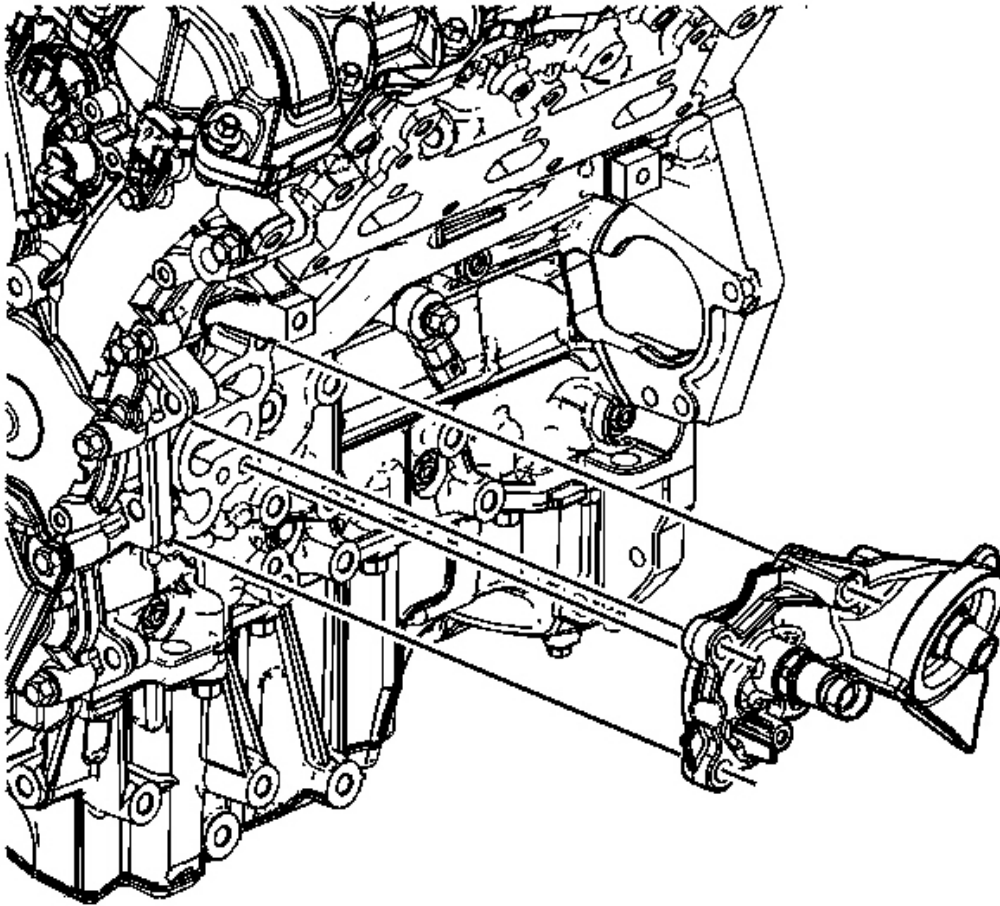


Fig. 6: Removing/Installing Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter adapter.

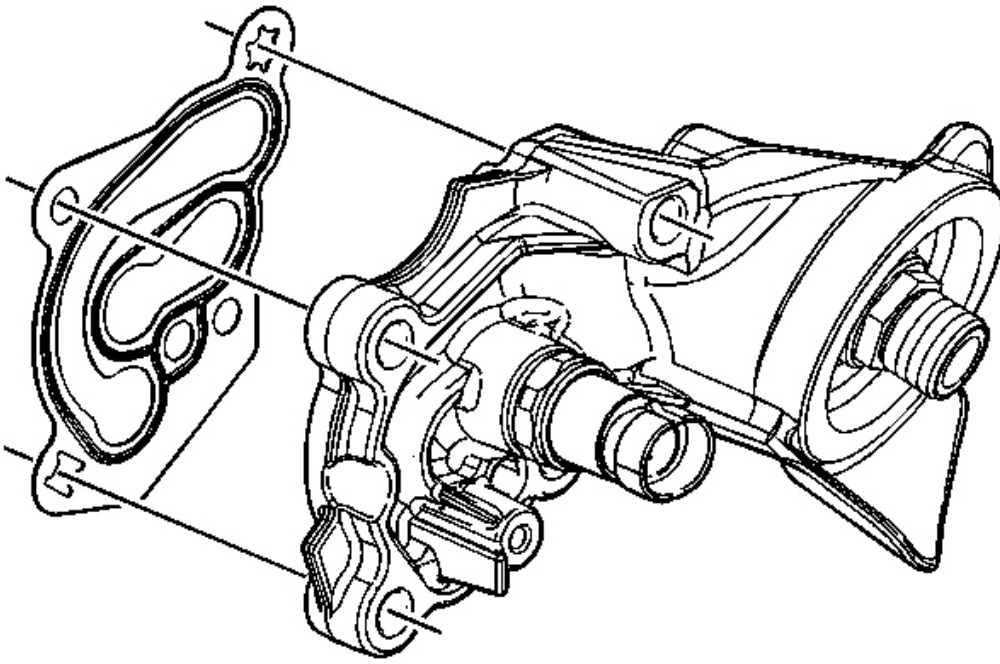


Fig. 7: View Of Oil Filter Adapter & Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the oil filter adapter gasket.

INTAKE MANIFOLD REMOVAL (LF1 OR LFW)

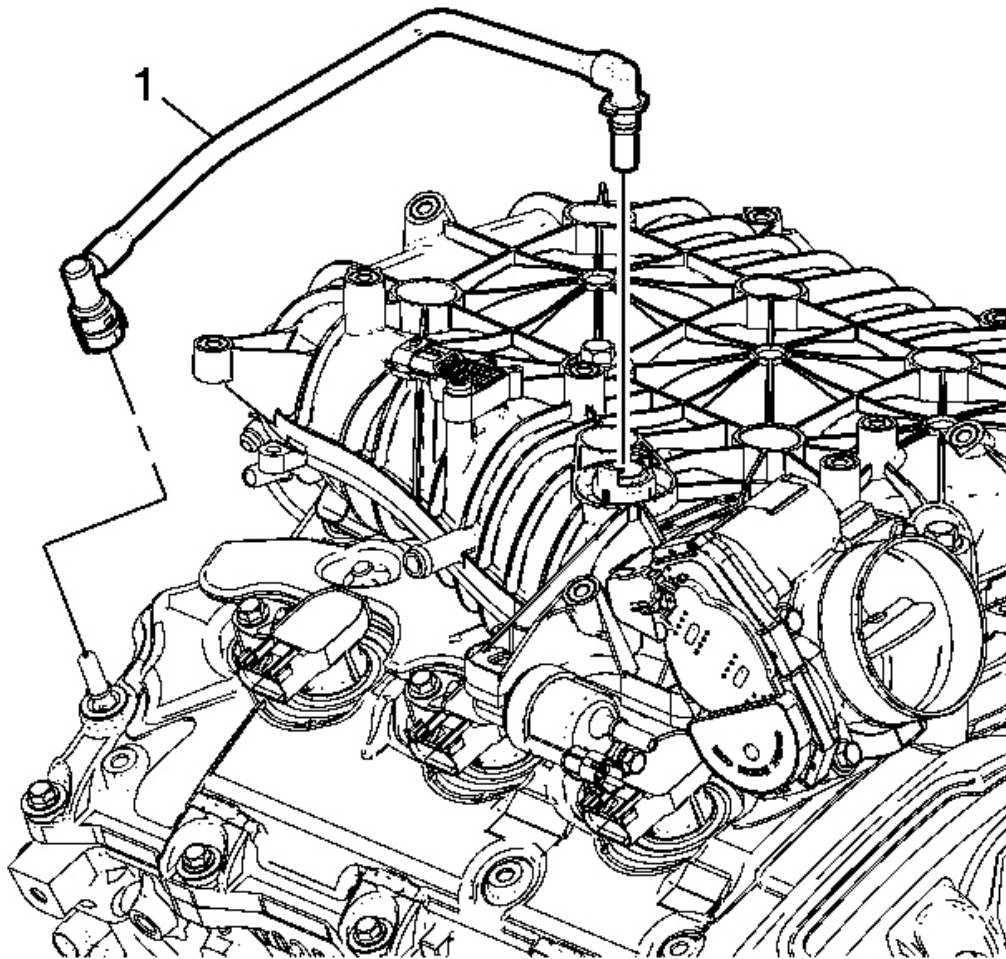


Fig. 8: Positive Crankcase Ventilation (PCV) Tube Assembly
Courtesy of GENERAL MOTORS CORP.

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

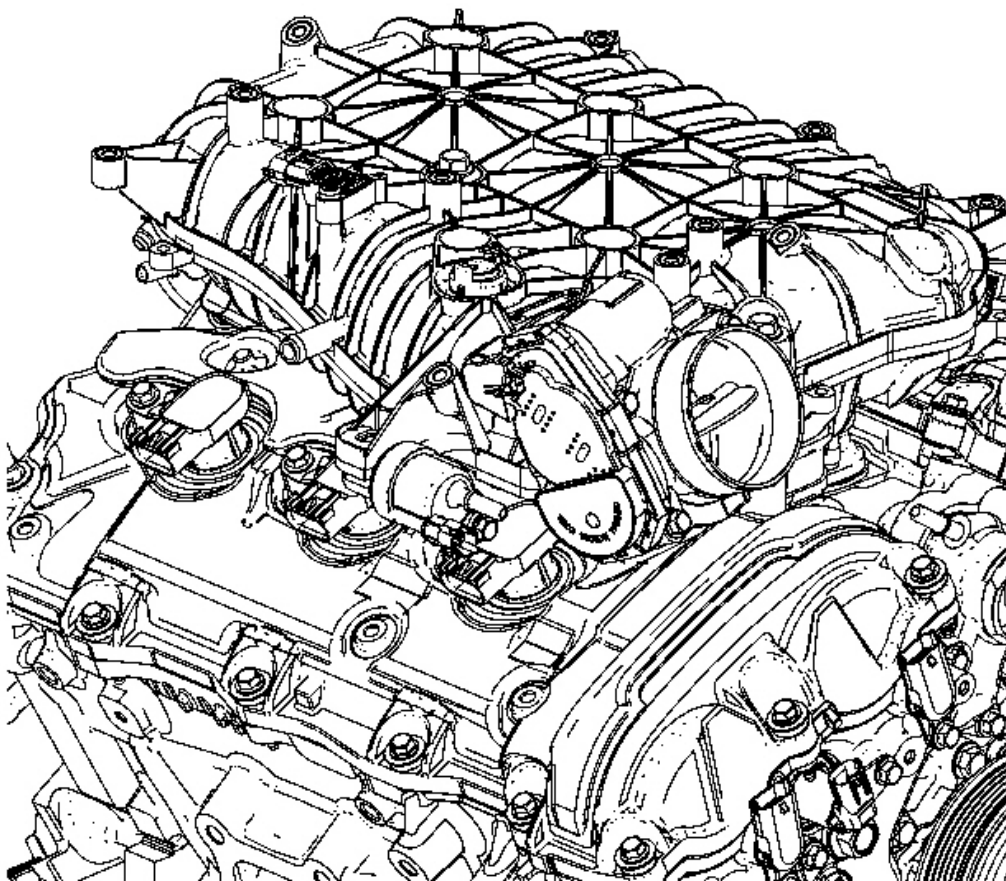


Fig. 9: Upper Intake Manifold & EVAP Solenoid
Courtesy of GENERAL MOTORS CORP.

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

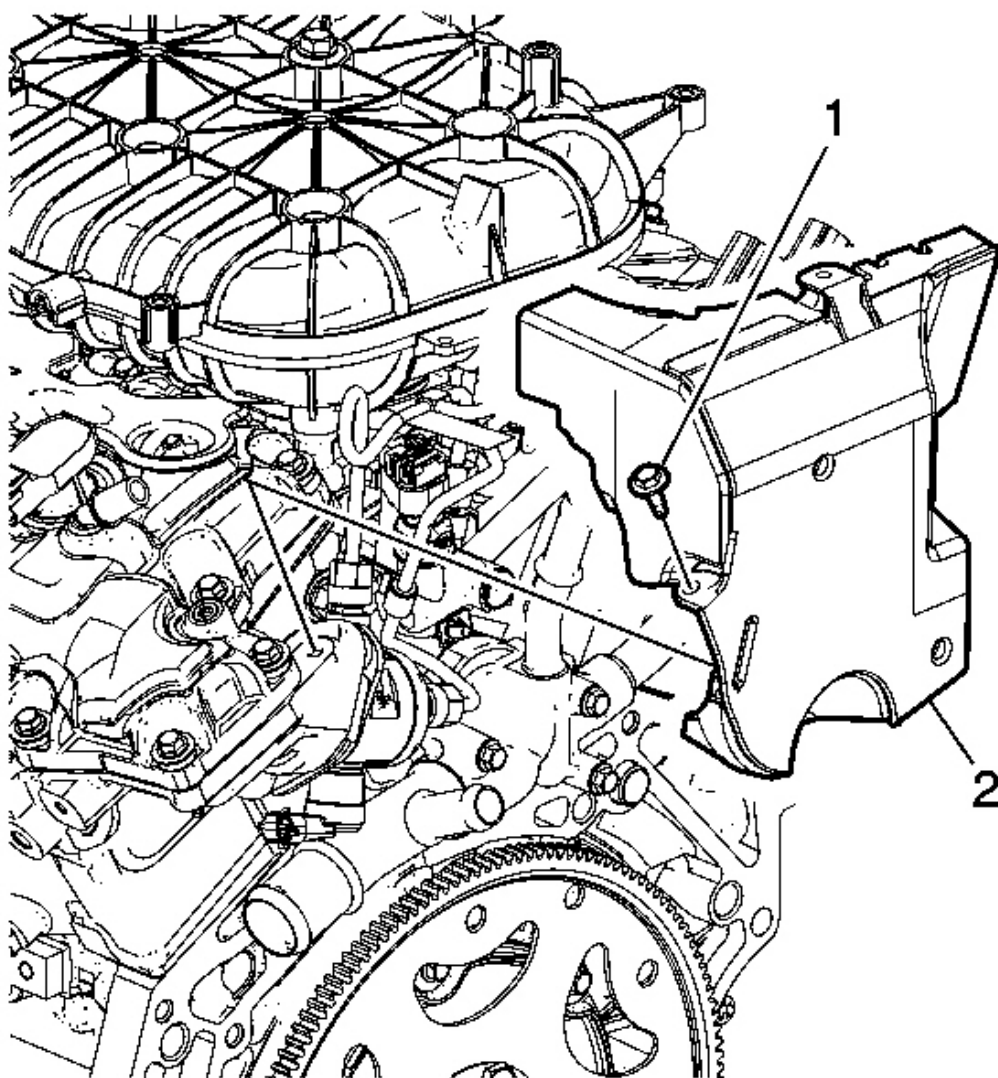


Fig. 10: Fuel Pump Cover

Courtesy of GENERAL MOTORS CORP.

3. Remove the fuel pump cover bolt (1).
4. Remove the fuel pump cover (2).

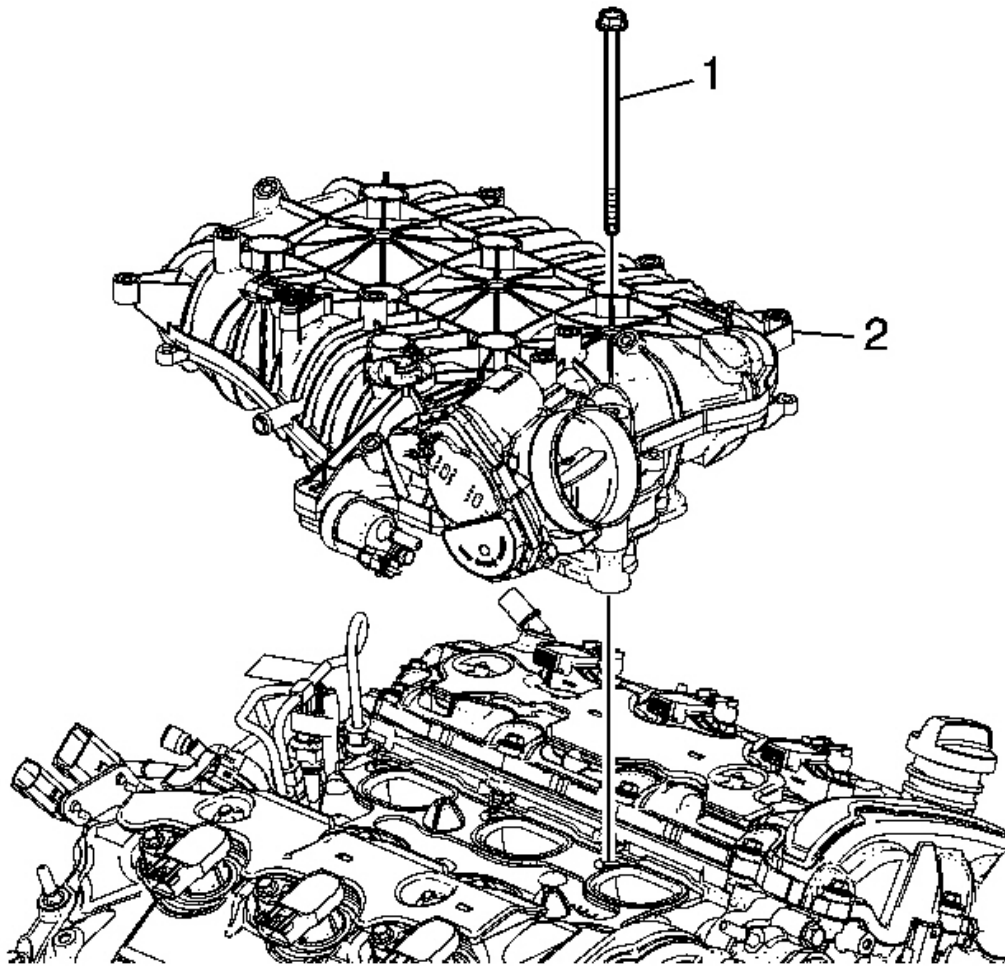


Fig. 11: Intake Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake manifold bolts (1).
6. Remove the intake manifold assembly (2).

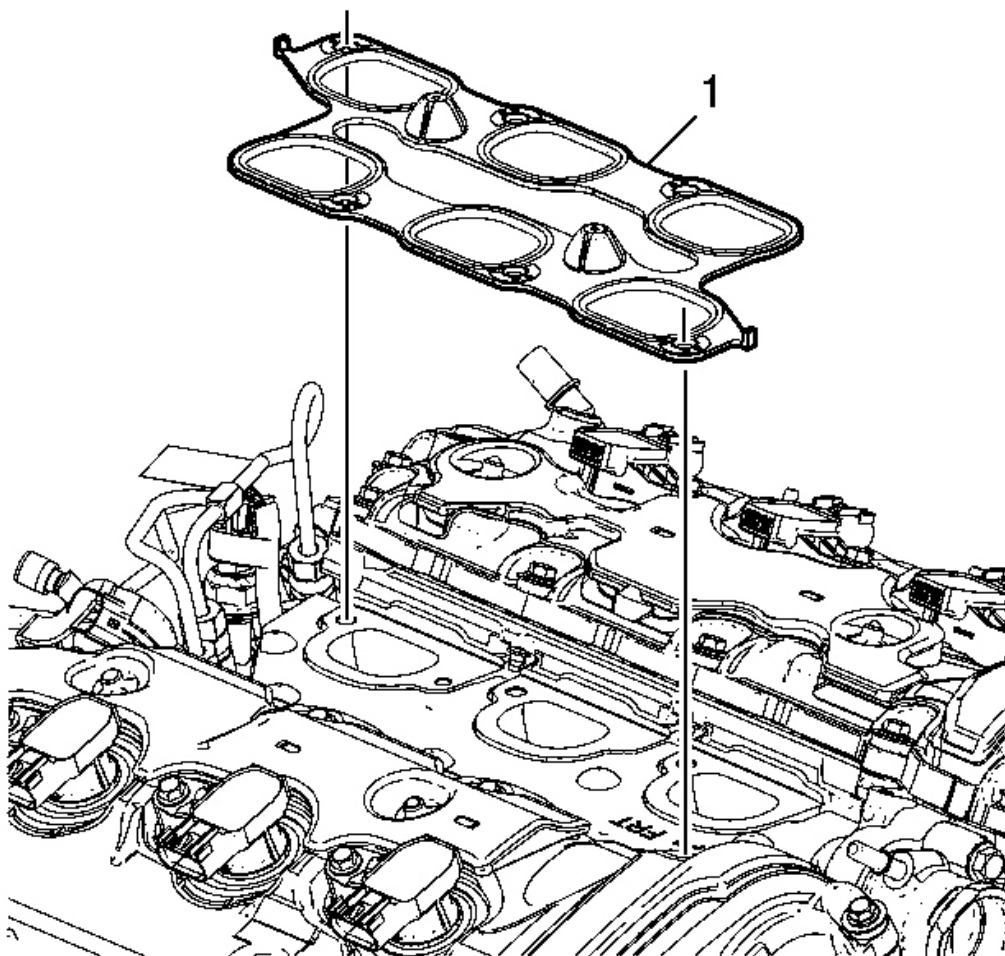


Fig. 12: Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove and discard the intake manifold gasket (1).

WATER OUTLET REMOVAL

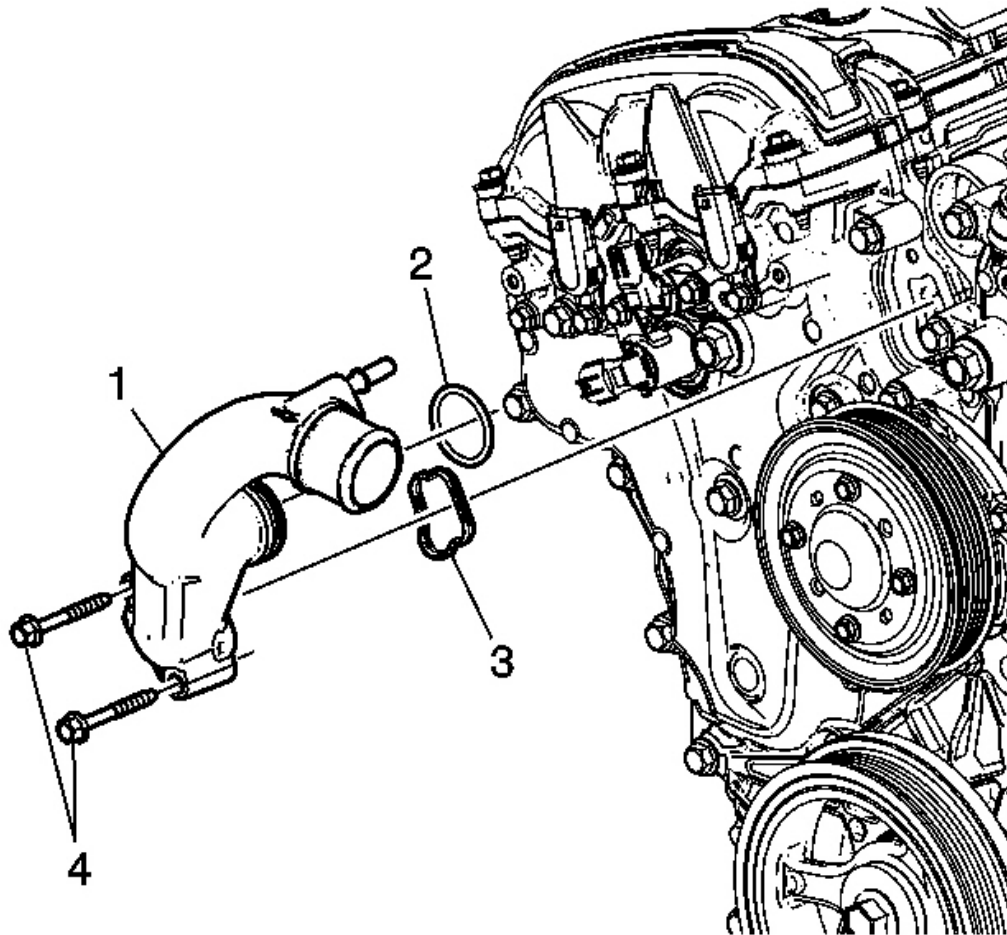


Fig. 13: Water Outlet Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the water outlet bolts (4).
2. Remove the water outlet (1).
3. Remove the water outlet seals (2) and (3).

ENGINE COOLANT THERMOSTAT HOUSING REMOVAL

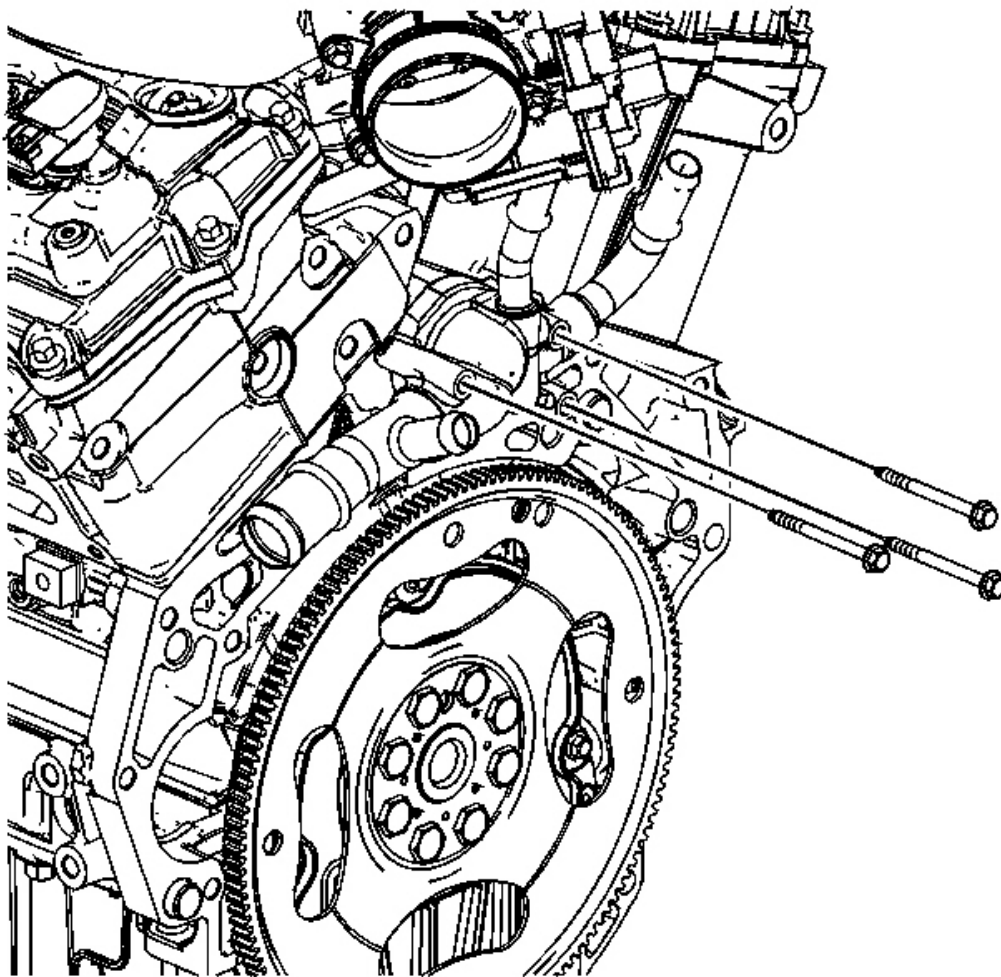


Fig. 14: View Of Thermostat Housing Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the thermostat housing bolts.

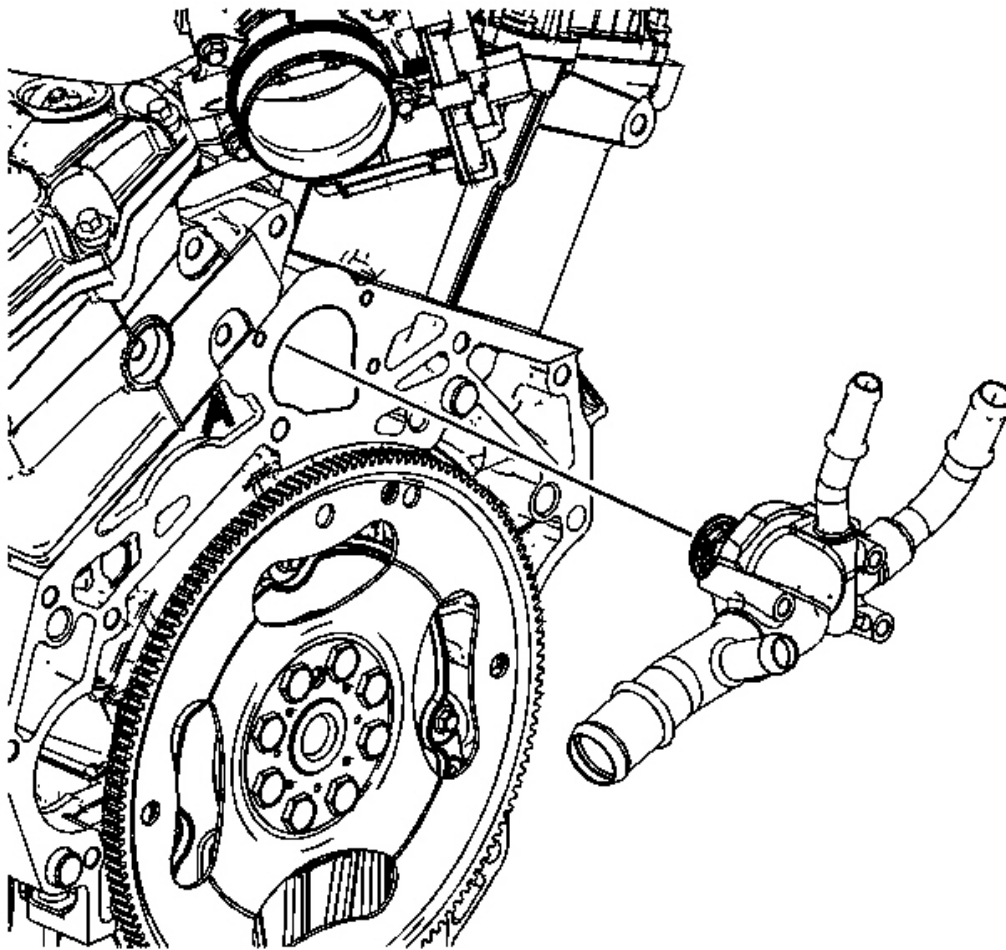


Fig. 15: View Of Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

2. Remove the thermostat housing.

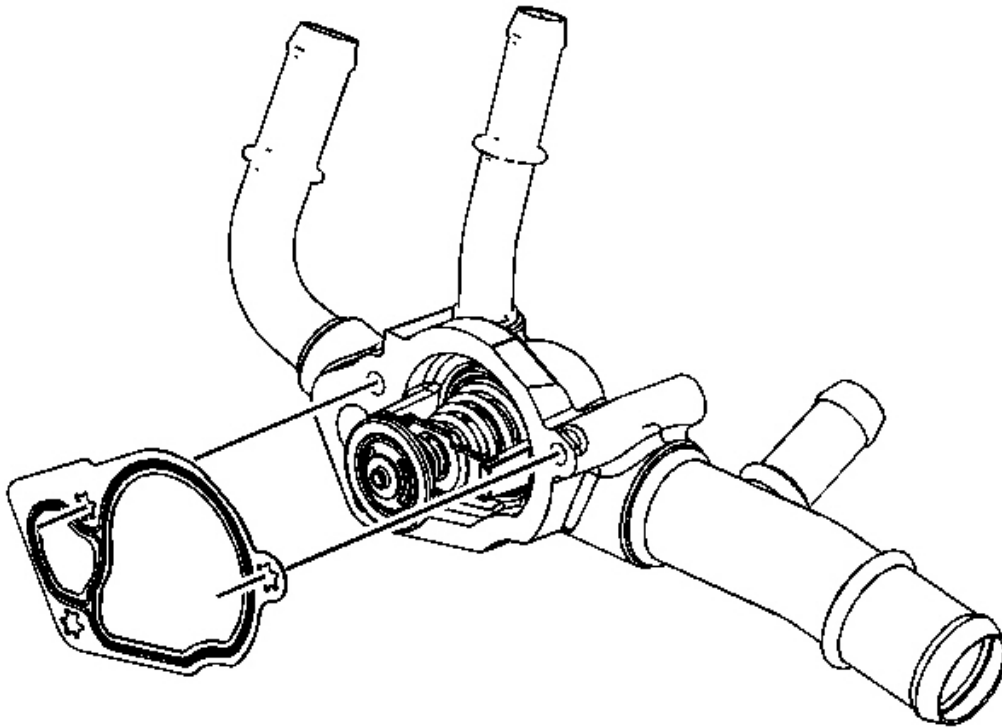


Fig. 16: View Of Thermostat Housing Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the thermostat housing gasket.

CRANKSHAFT BALANCER REMOVAL

Special Tools

- **EN 38416-2:** Crankshaft Button
- **EN 41816:** Crankshaft Balancer Remover
- **EN 46106:** Flywheel Holding Tool

For equivalent regional tools, refer to **Special Tools** .

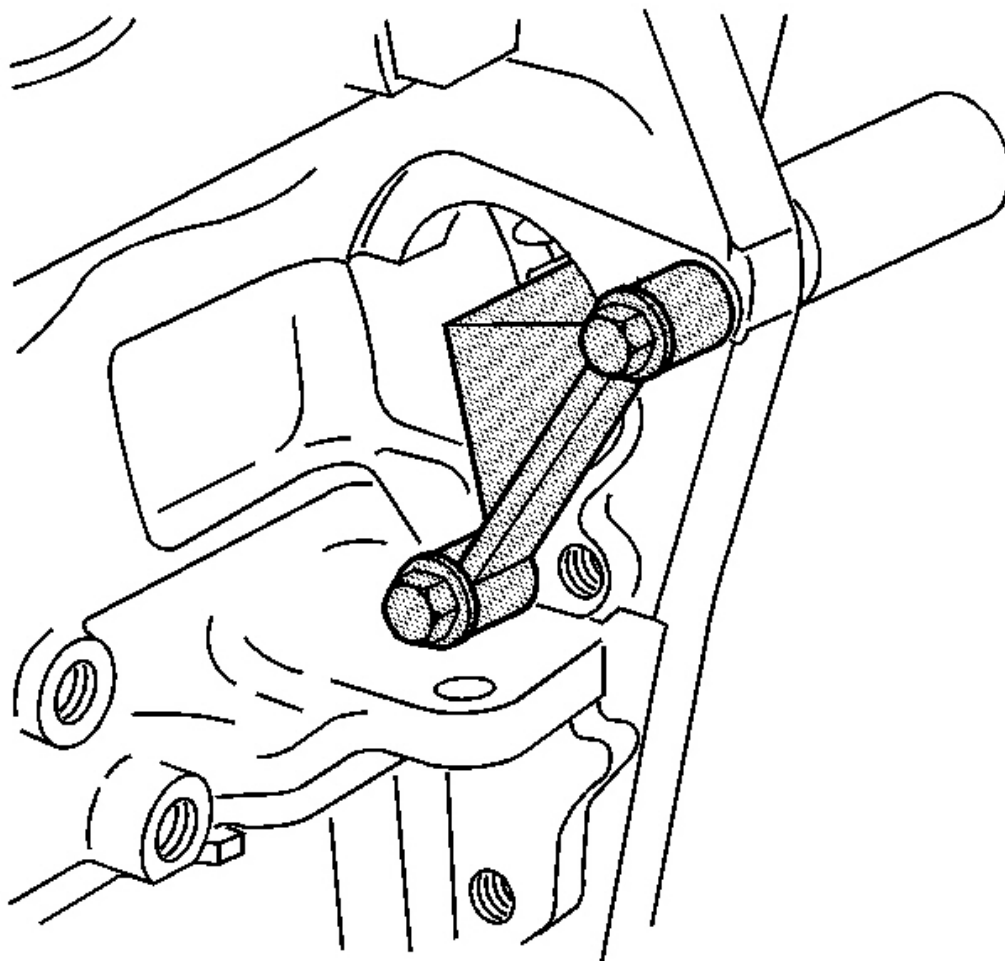


Fig. 17: View Of Tool EN 46106
Courtesy of GENERAL MOTORS CORP.

1. Install the **EN 46106** through the starter mounting hole. See **Special Tools** .

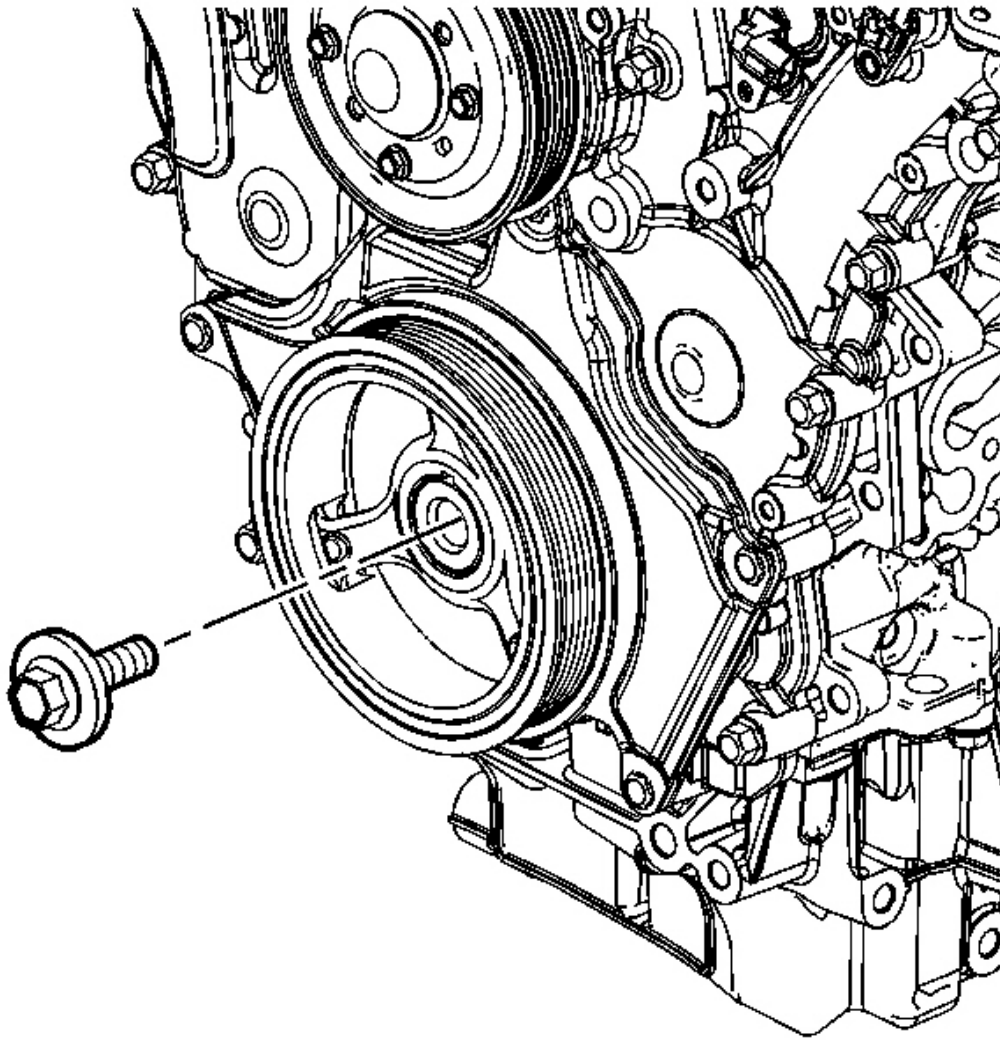


Fig. 18: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove and discard the crankshaft balancer bolt.

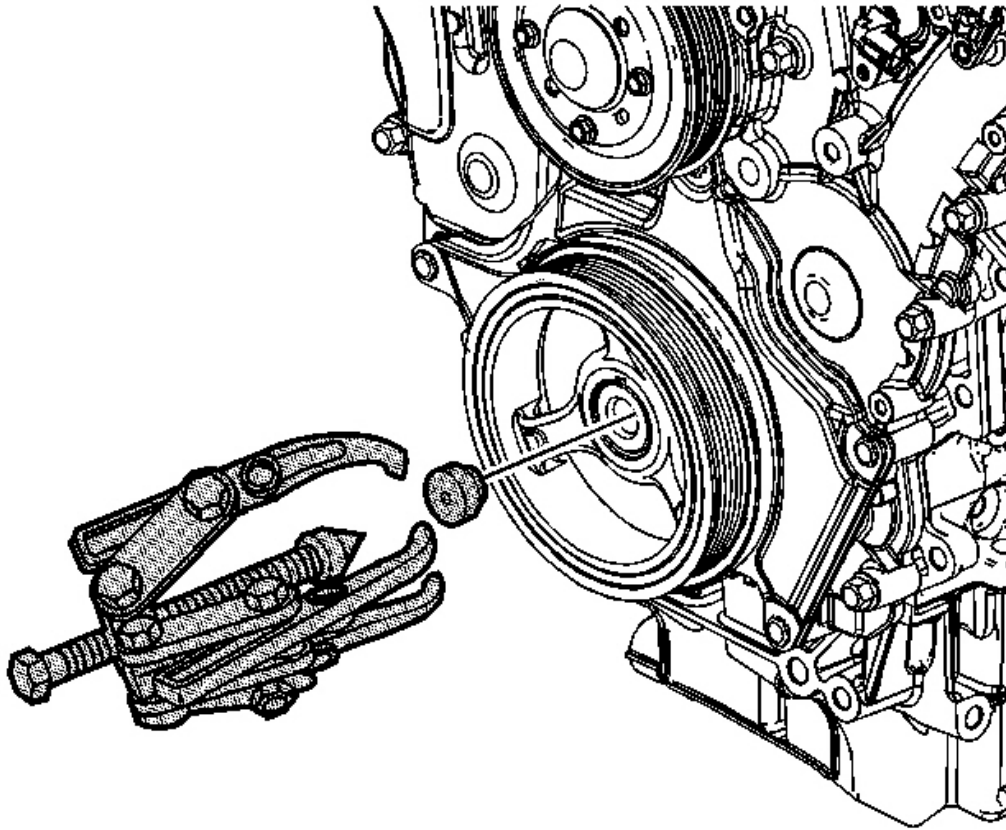


Fig. 19: View Of Crankshaft Balancer Remover
Courtesy of GENERAL MOTORS CORP.

3. Install the **EN 38416-2**: button in the nose of the crankshaft.
4. Install the **EN 41816**: remover in order to remove the crankshaft balancer.
5. Tighten the center bolt of the **EN 41816**: remover in order to pull the crankshaft balancer off of the crankshaft.
6. Remove the **EN 41816**: remover from the crankshaft balancer.

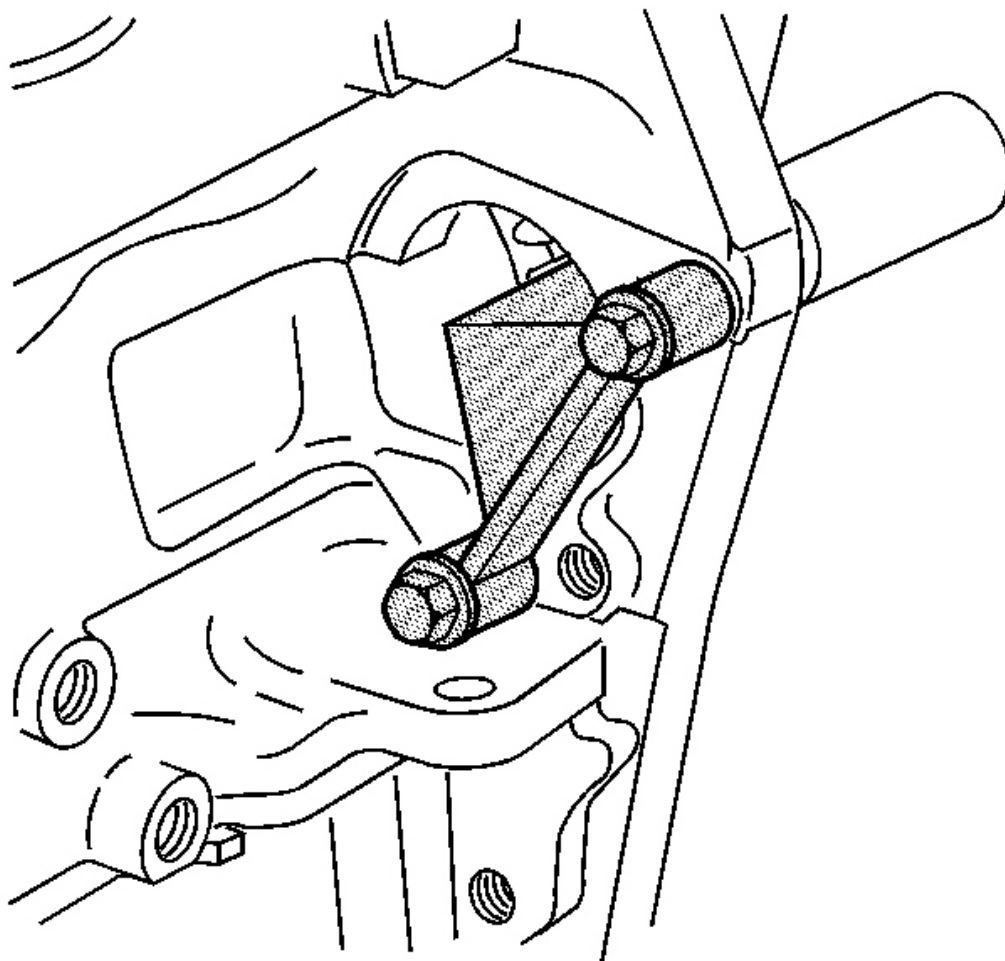


Fig. 20: View Of Tool EN 46106
Courtesy of GENERAL MOTORS CORP.

7. Remove the **EN 46106**: tool.

ENGINE FLYWHEEL REMOVAL

SPECIAL TOOLS

EN 46106 Flywheel Holding Tool. See **Special Tools** .

REMOVAL

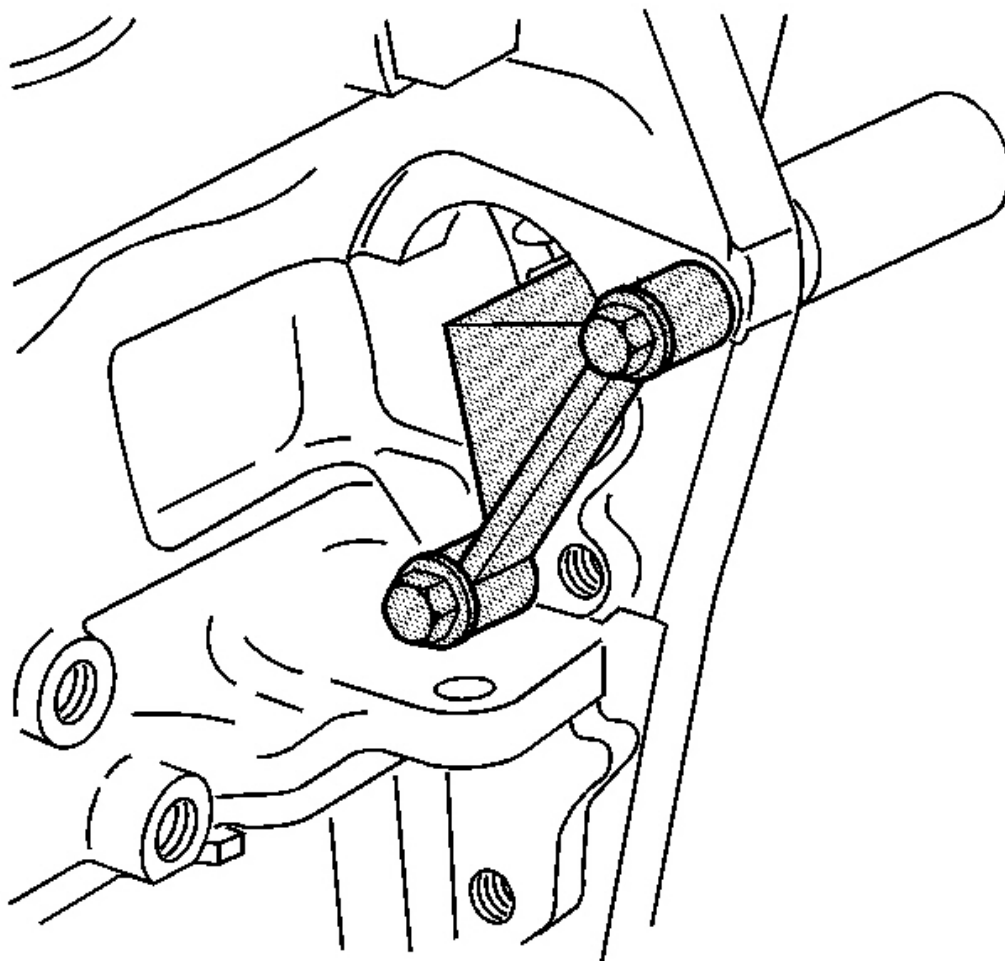


Fig. 21: View Of Tool EN 46106
Courtesy of GENERAL MOTORS CORP.

1. Install the **EN 46106** through the starter mounting hole. See **Special Tools** .

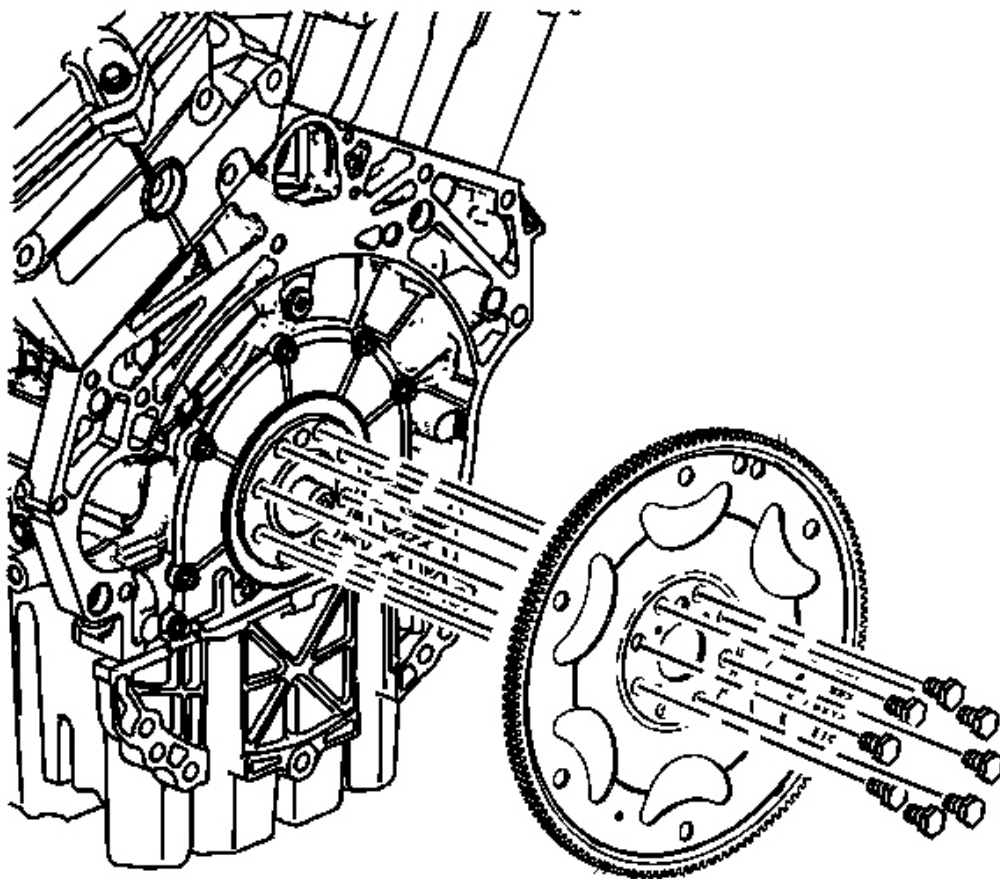


Fig. 22: View Of Engine Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine flywheel bolts and discard.
3. Remove the engine flywheel from the crankshaft.

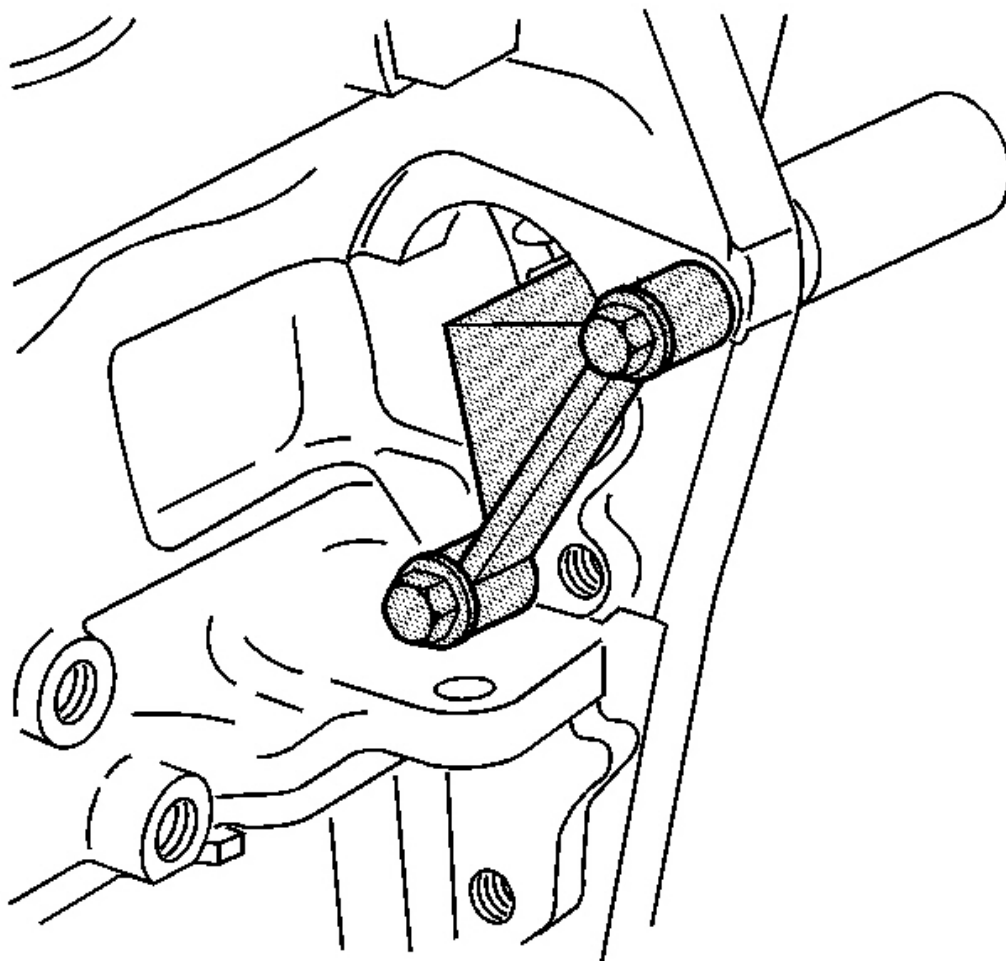


Fig. 23: View Of Tool EN 46106
Courtesy of GENERAL MOTORS CORP.

4. Remove the EN 46106 . See Special Tools .

CAMSHAFT COVER REMOVAL - LEFT SIDE

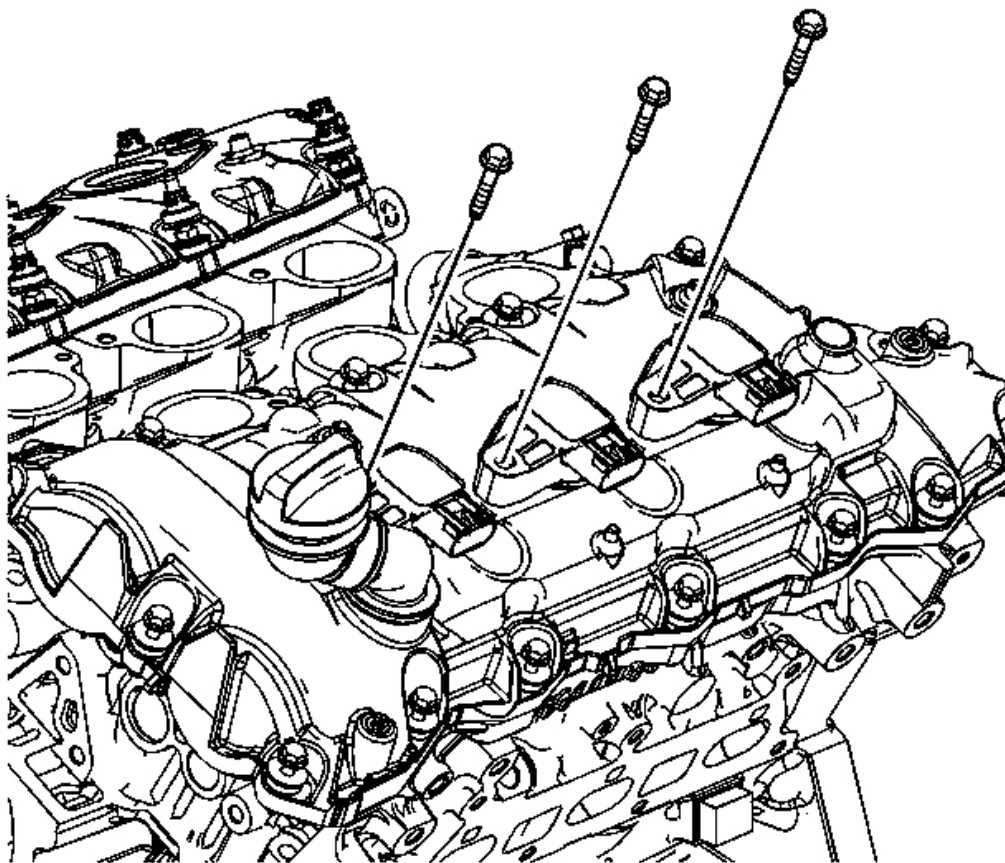


Fig. 24: Removing/Installing Ignition Coil Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition coil bolts.

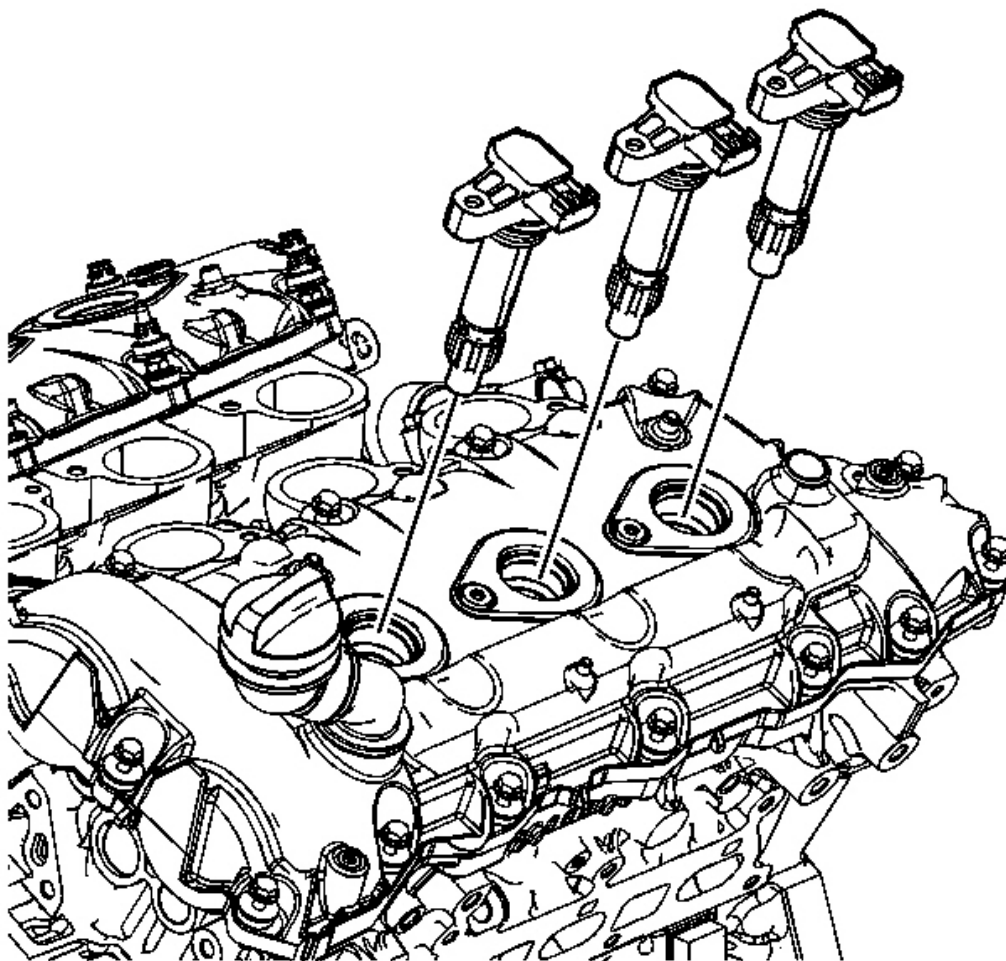


Fig. 25: Removing/Installing Ignition Coils
Courtesy of GENERAL MOTORS CORP.

2. Remove the ignition coils.

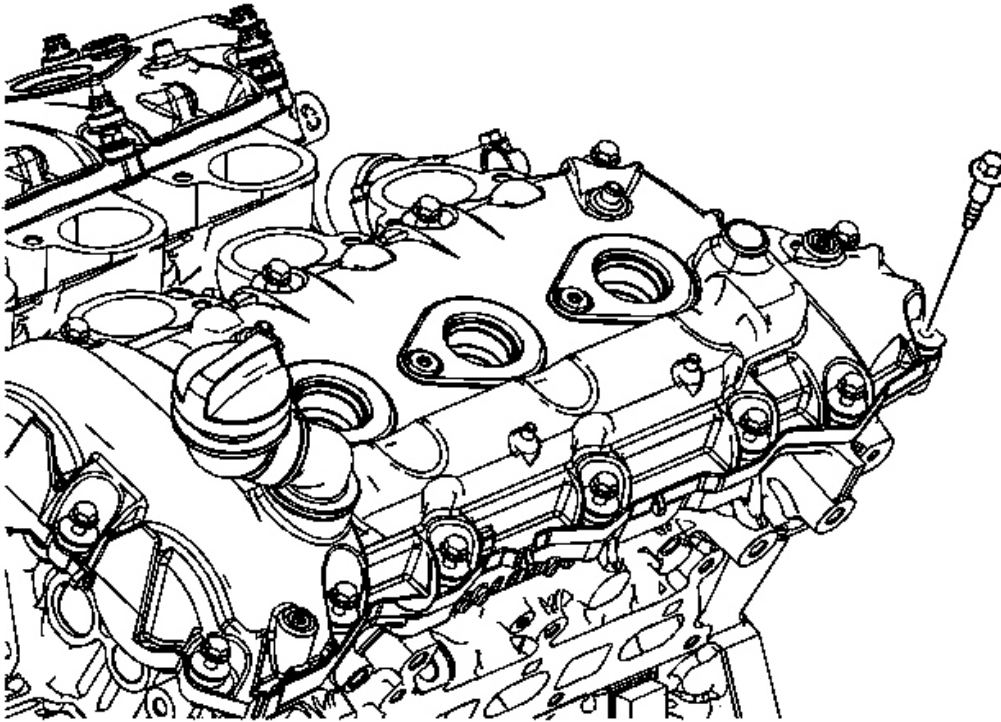


Fig. 26: View Of Left Camshaft Cover Bolt
Courtesy of GENERAL MOTORS CORP.

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

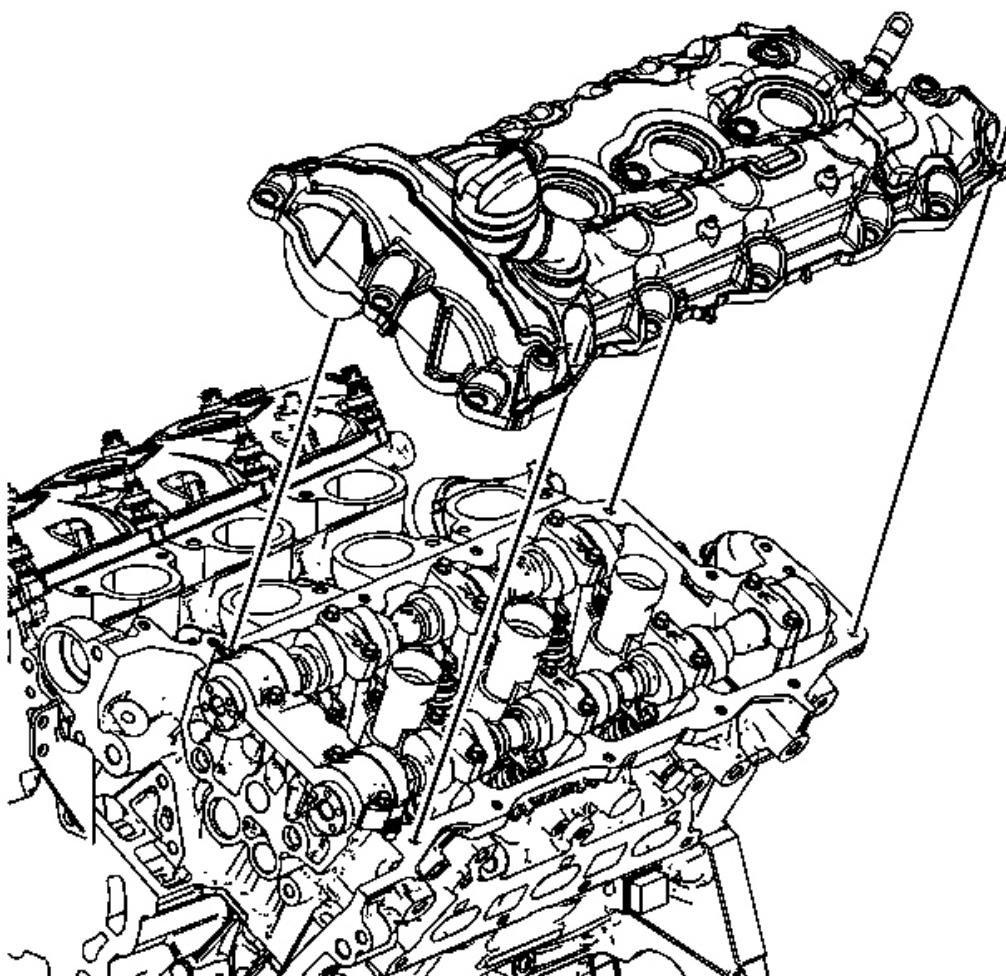


Fig. 27: View of Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the left camshaft cover from the left cylinder head.

CAMSHAFT COVER REMOVAL - RIGHT SIDE

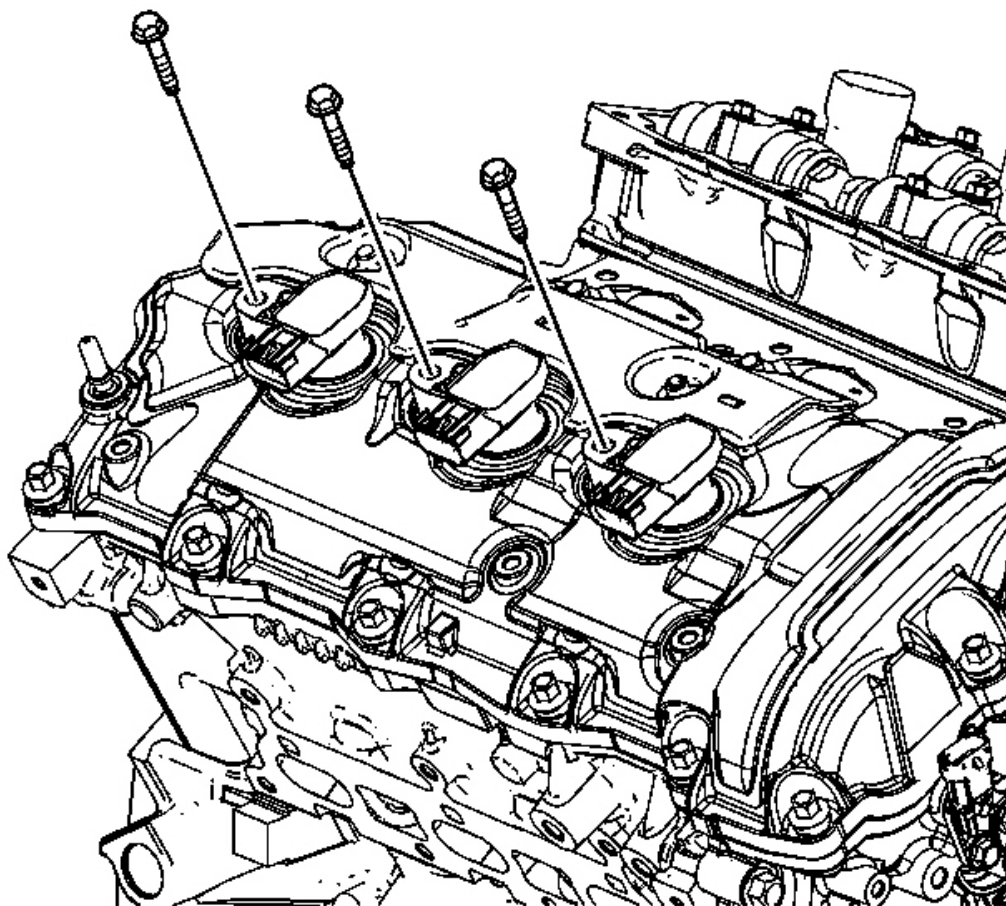


Fig. 28: View Of Ignition Coil Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition coil bolts.

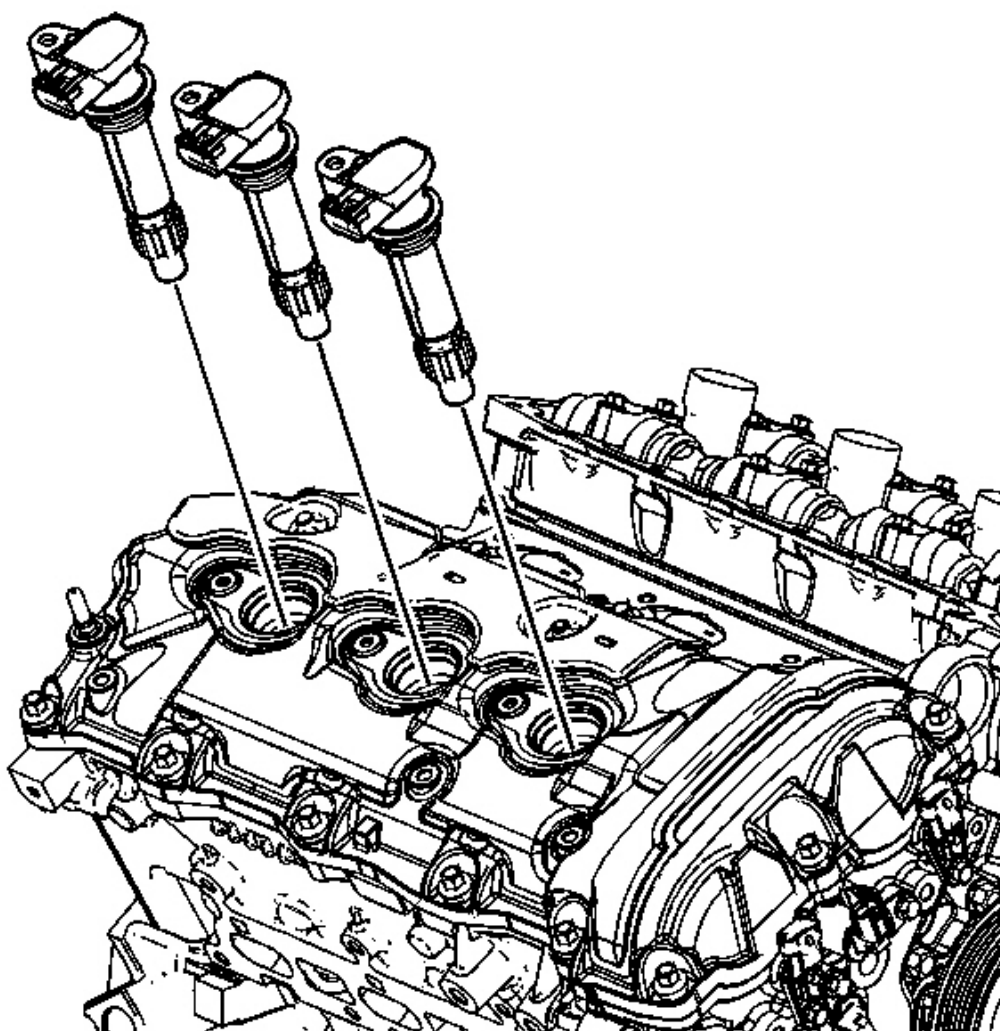


Fig. 29: View Of Ignition Coils
Courtesy of GENERAL MOTORS CORP.

2. Remove the ignition coils.

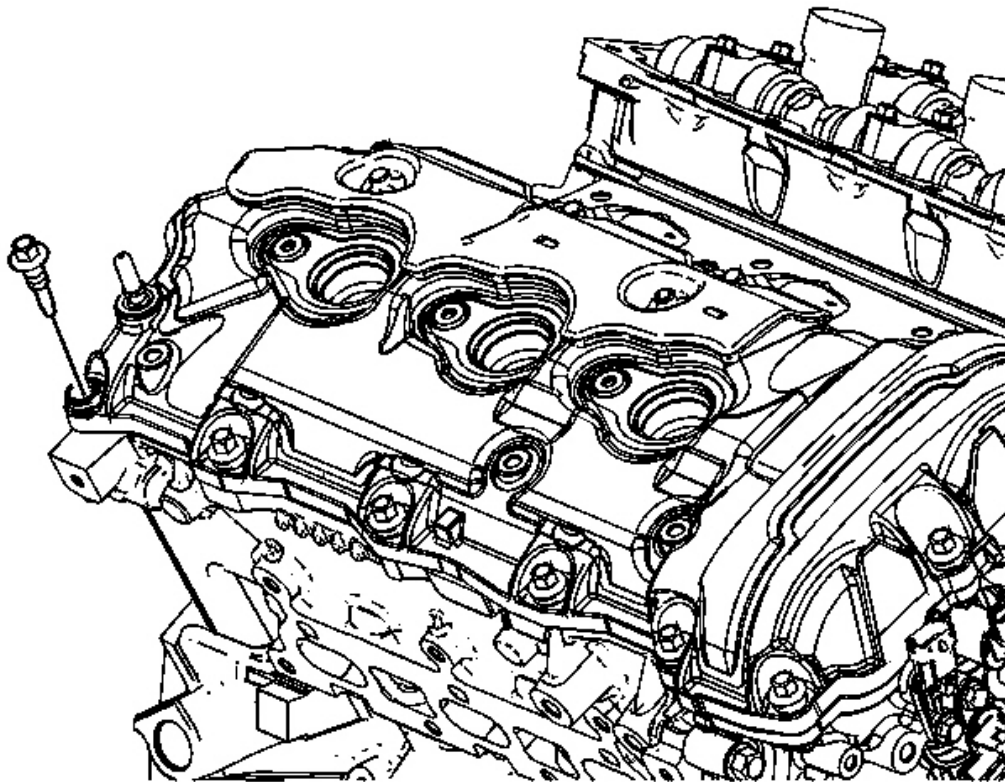


Fig. 30: View Of Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

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

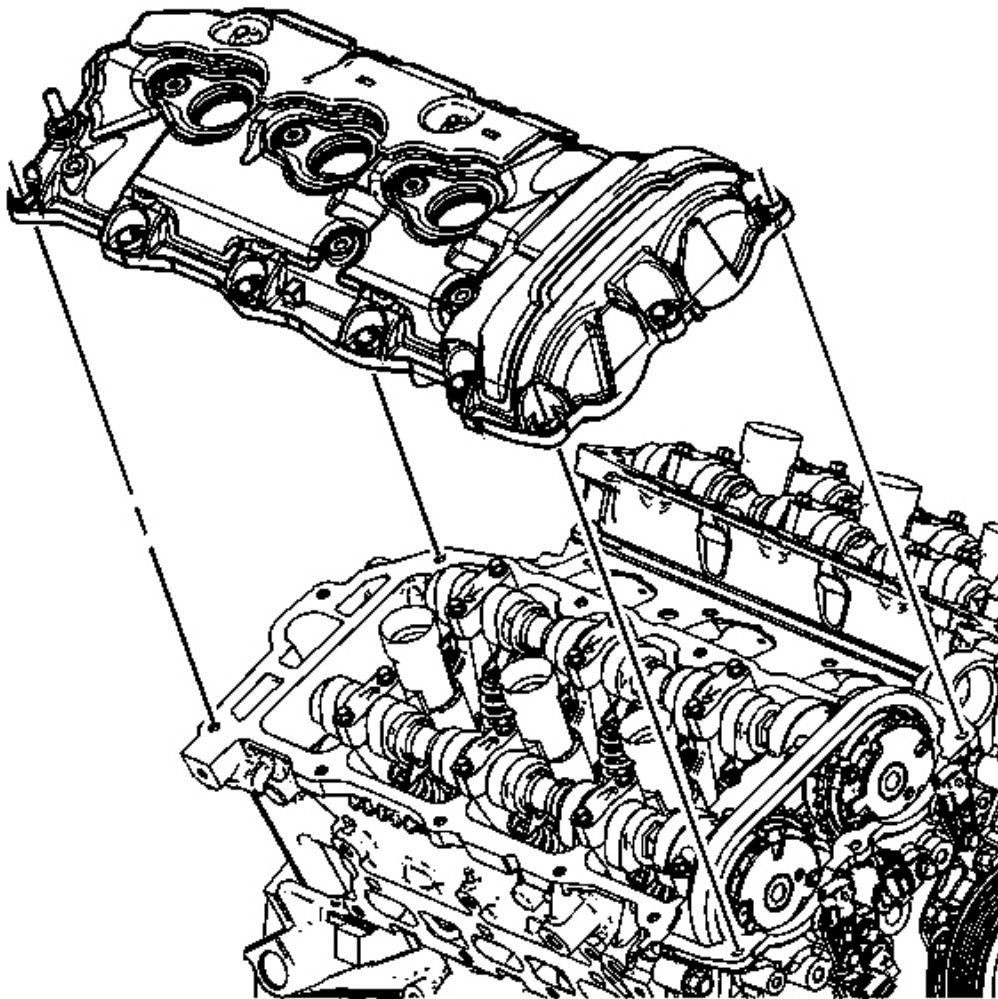


Fig. 31: View Of Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

5. Remove the right camshaft cover from the right cylinder head.

WATER PUMP REMOVAL

TOOLS REQUIRED

EN 46104 Water Pump Pulley Holding Tool

REMOVAL

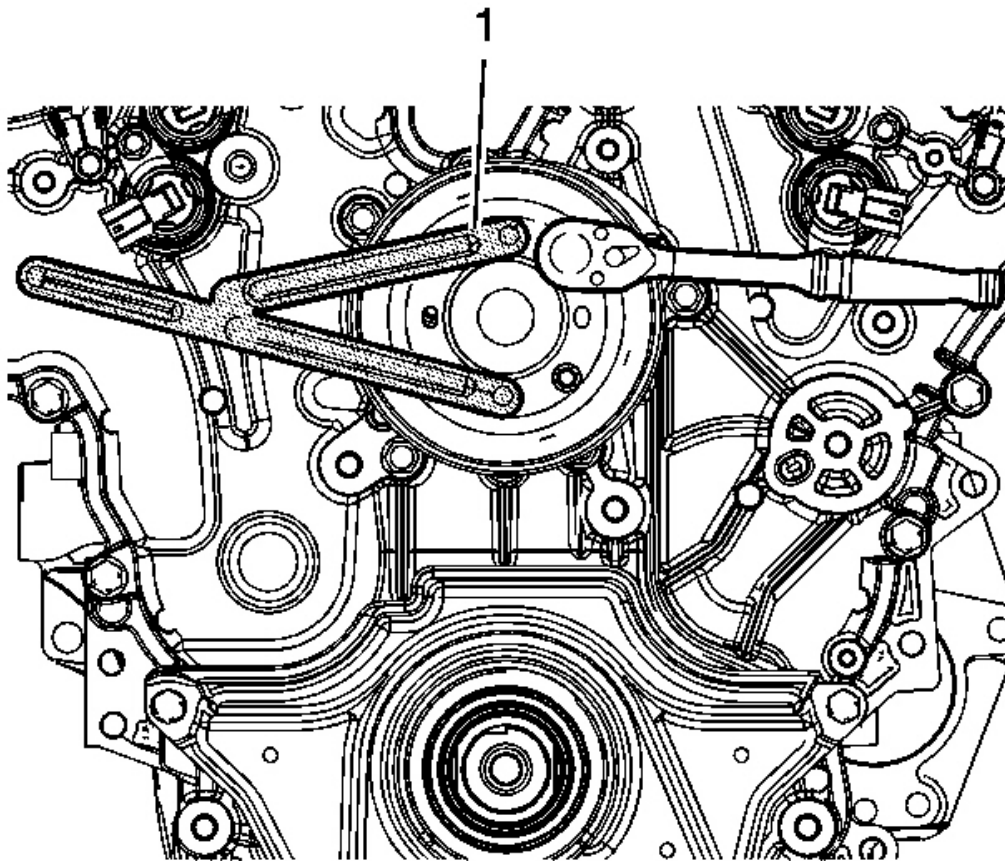


Fig. 32: View Of EN 46104

Courtesy of GENERAL MOTORS CORP.

1. Install the **EN 46104** (1) onto the water pump pulley.

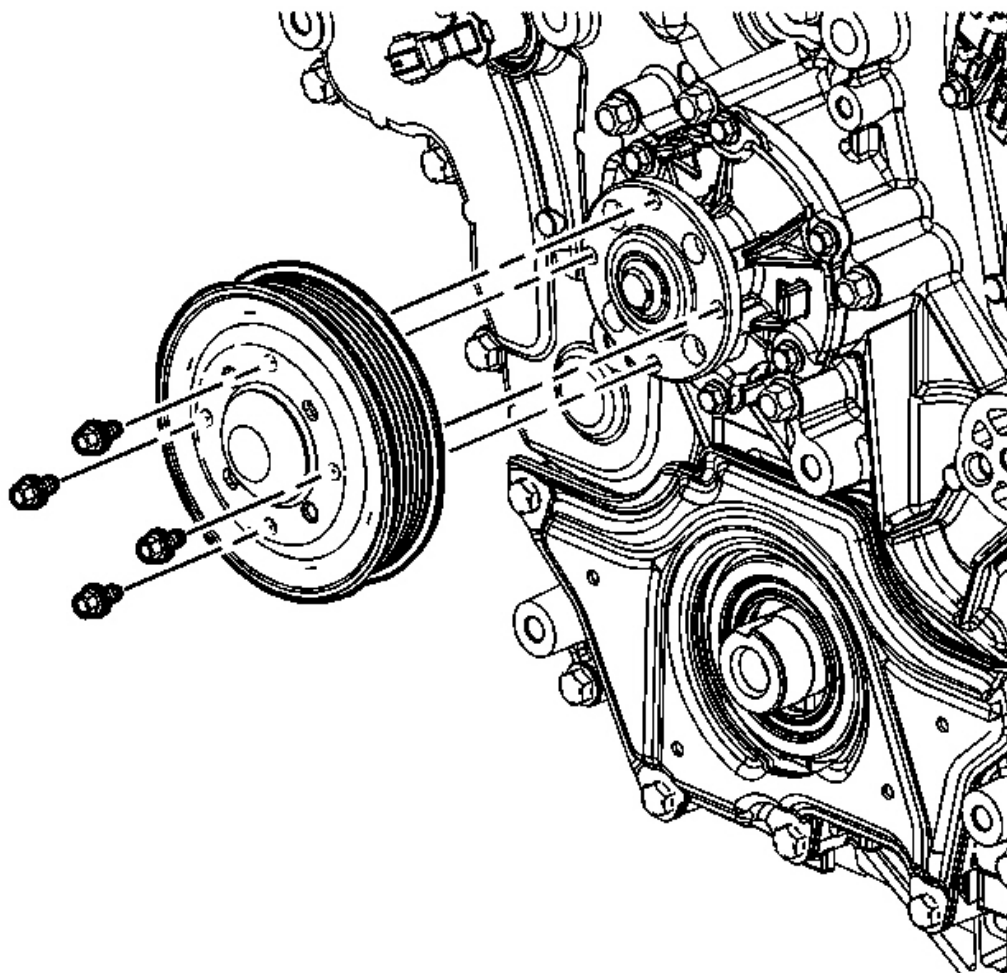


Fig. 33: View Of Water Pump Pulley Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the water pump pulley bolts.
3. Remove the water pump pulley.

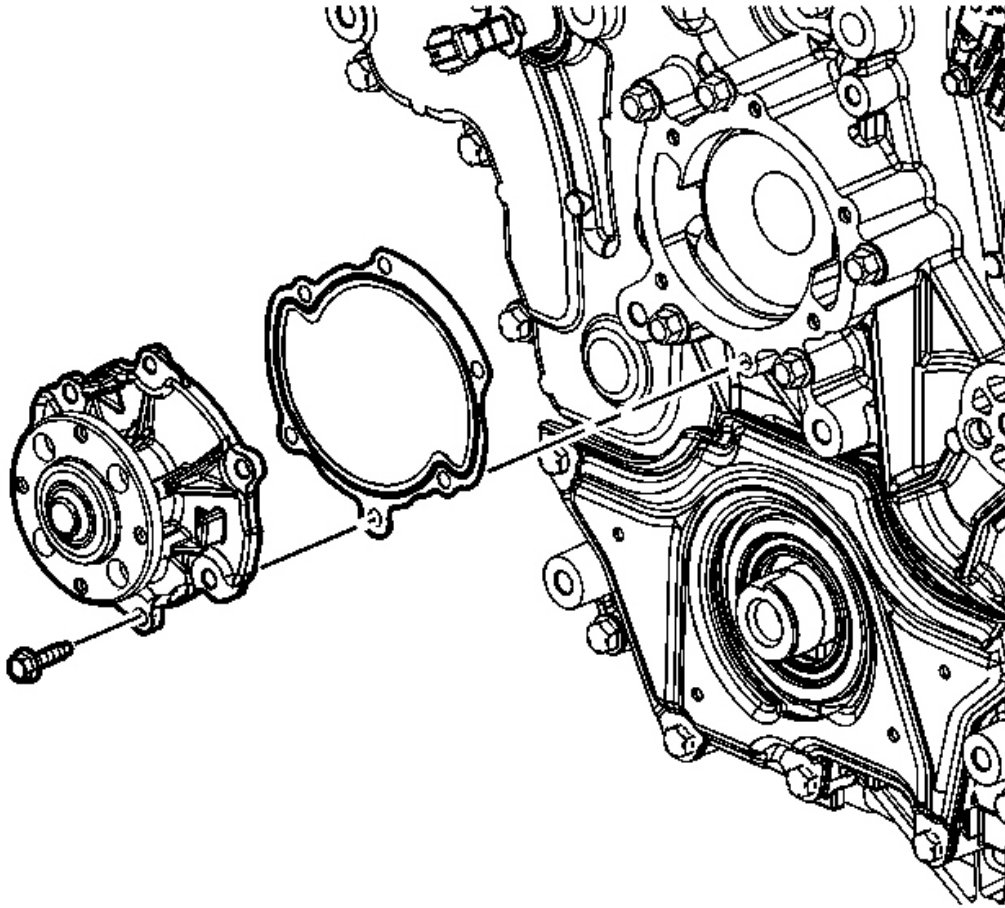


Fig. 34: View Of Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the water pump bolts.
5. Remove the water pump from the front cover.
6. Remove the water pump gasket.

ENGINE FRONT COVER REMOVAL

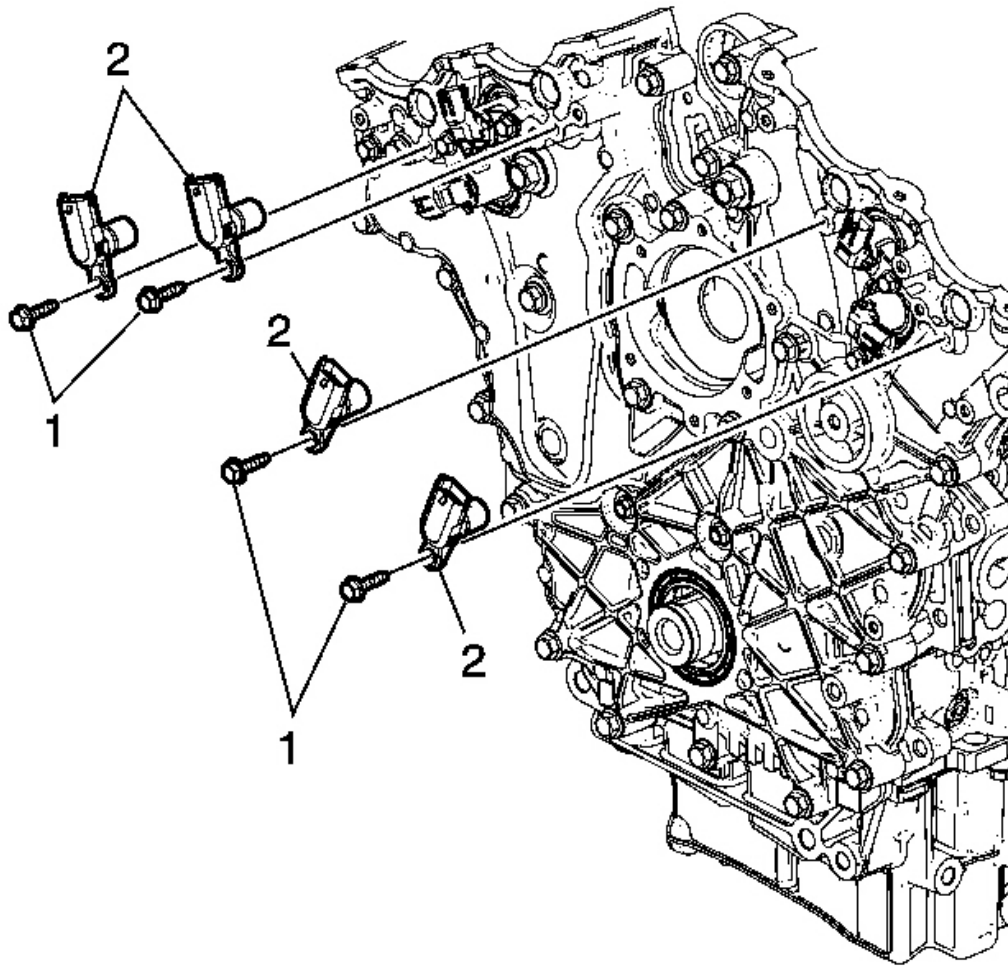


Fig. 35: Placing Camshaft Position Sensors
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position sensor bolts (1).
2. Remove the camshaft position sensors (2).

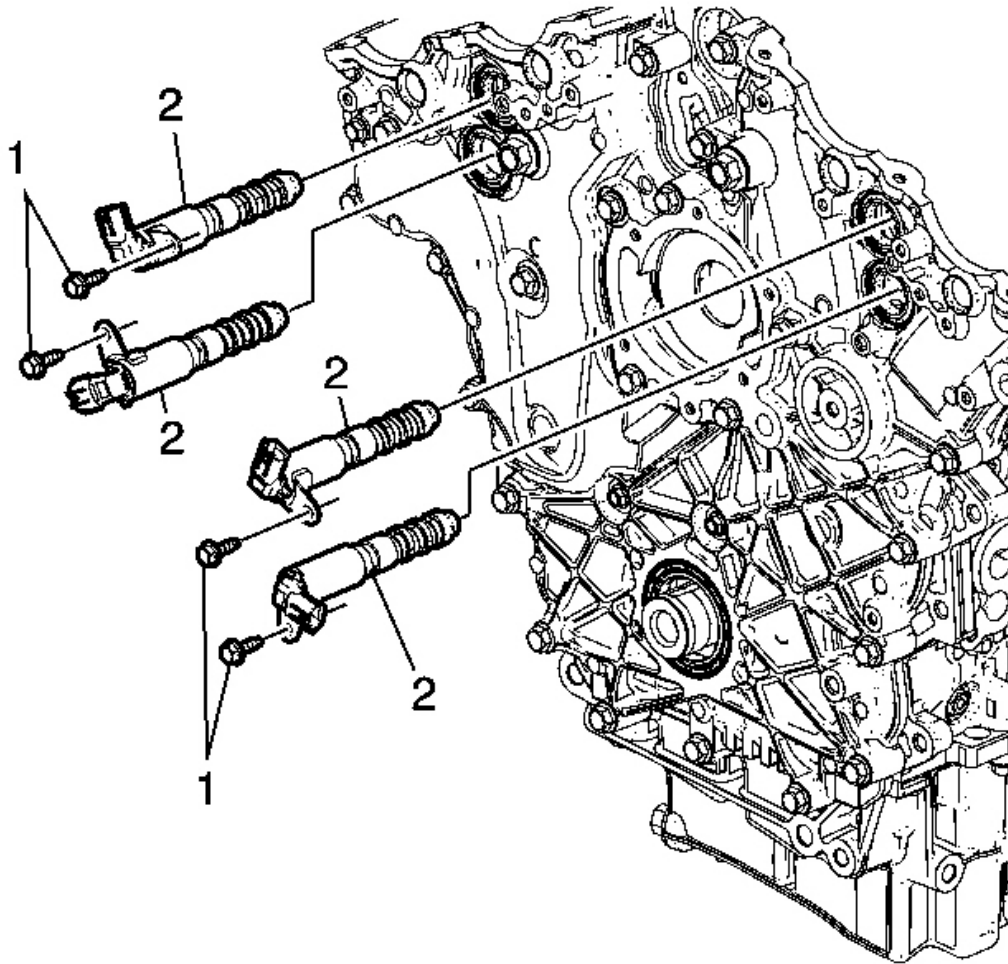


Fig. 36: Placing Camshaft Position Actuator Valves
Courtesy of GENERAL MOTORS CORP.

3. 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.

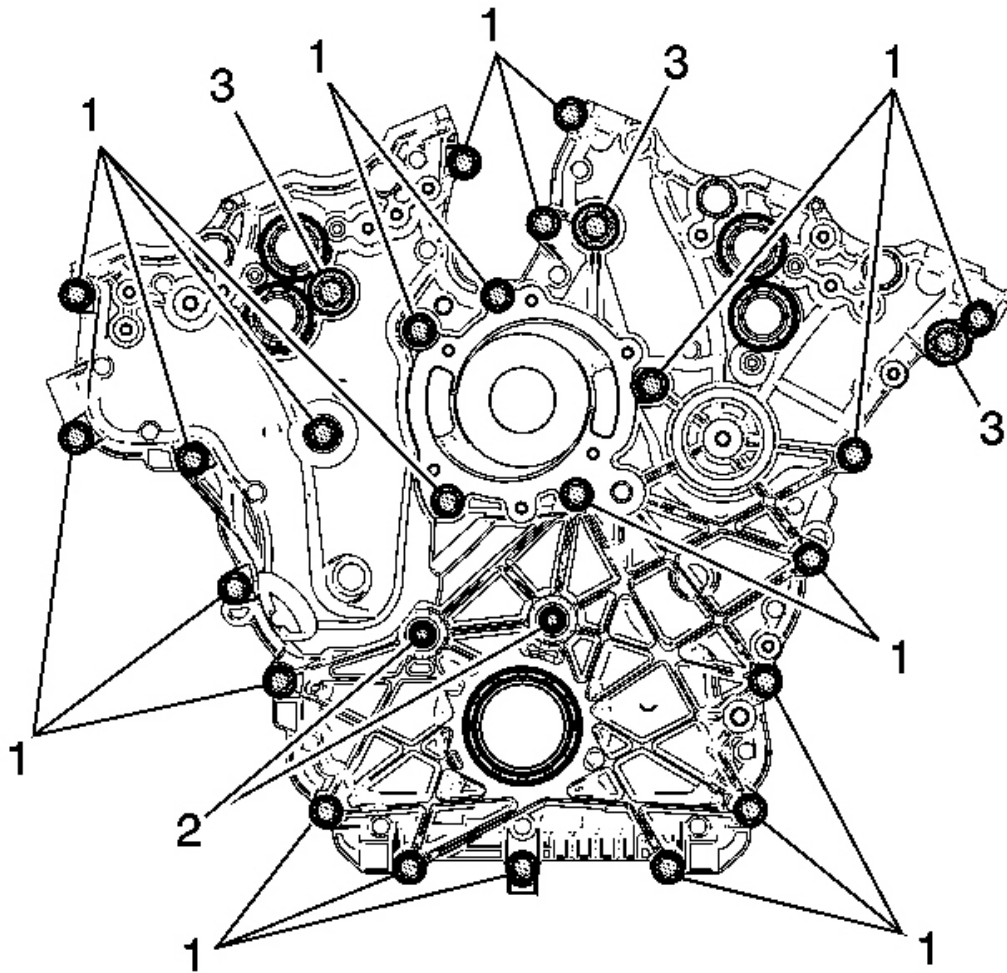


Fig. 37: Identifying Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

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.

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

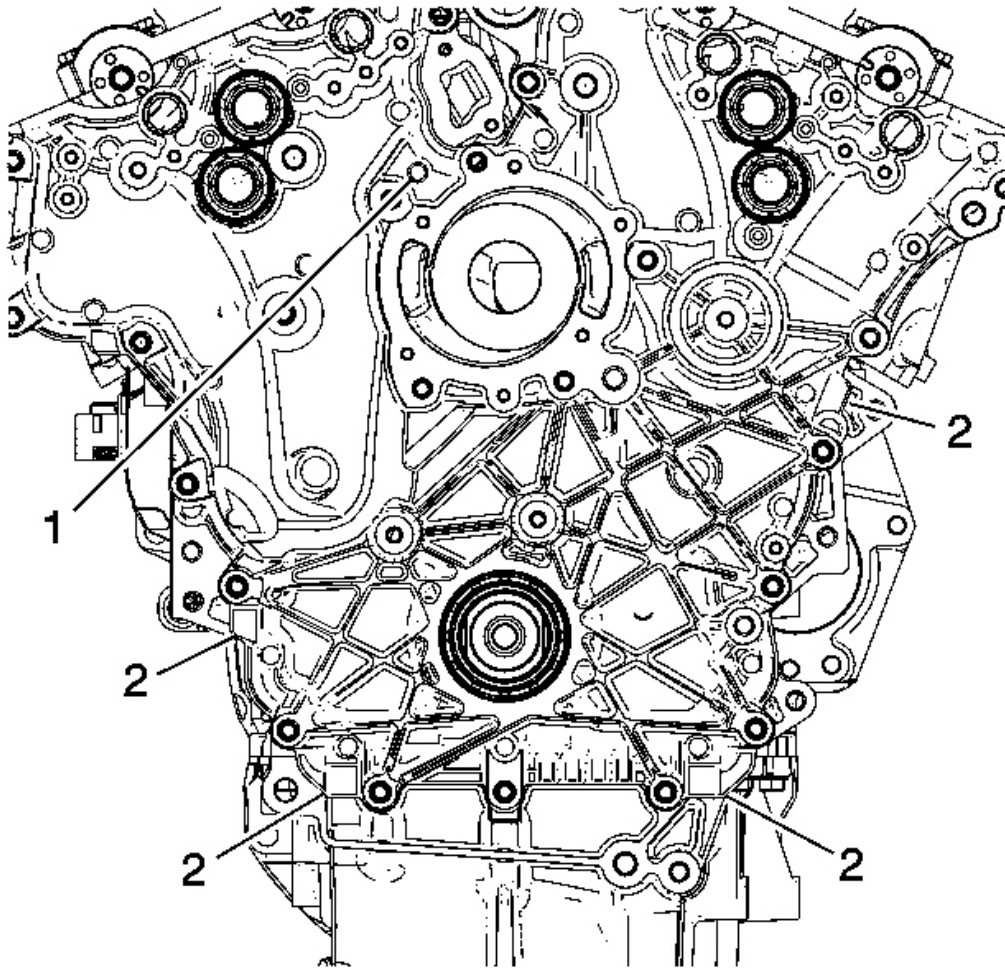


Fig. 38: Locating Jackscrew Hole
Courtesy of GENERAL MOTORS CORP.

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.

6. Loosely install a 10 x 1.5 mm bolt in the jackscrew hole (1).
7. Using the pry points (2) located at the edge of the front cover and the jackscrew, separate the room temperature vulcanizing (RTV) sealant.

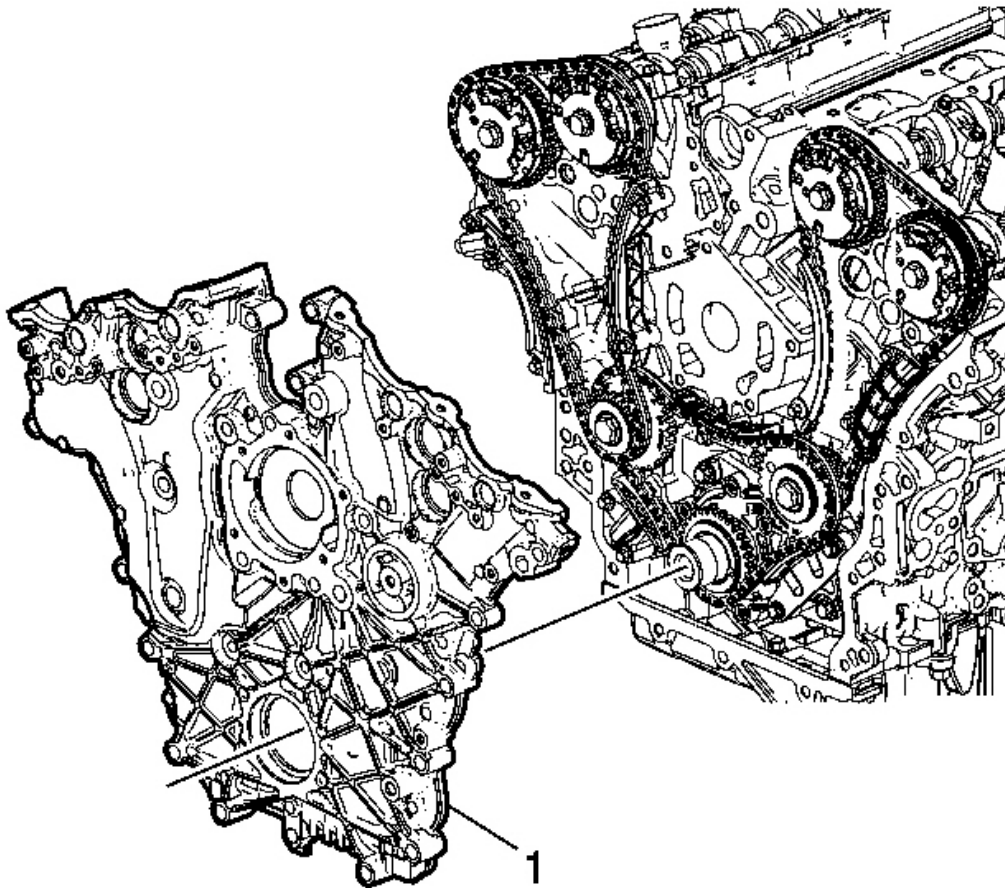


Fig. 39: Engine Front Cover

Courtesy of GENERAL MOTORS CORP.

8. Remove the engine front cover (1).

SECONDARY TIMING CHAIN TENSIONER REMOVAL - RIGHT SIDE

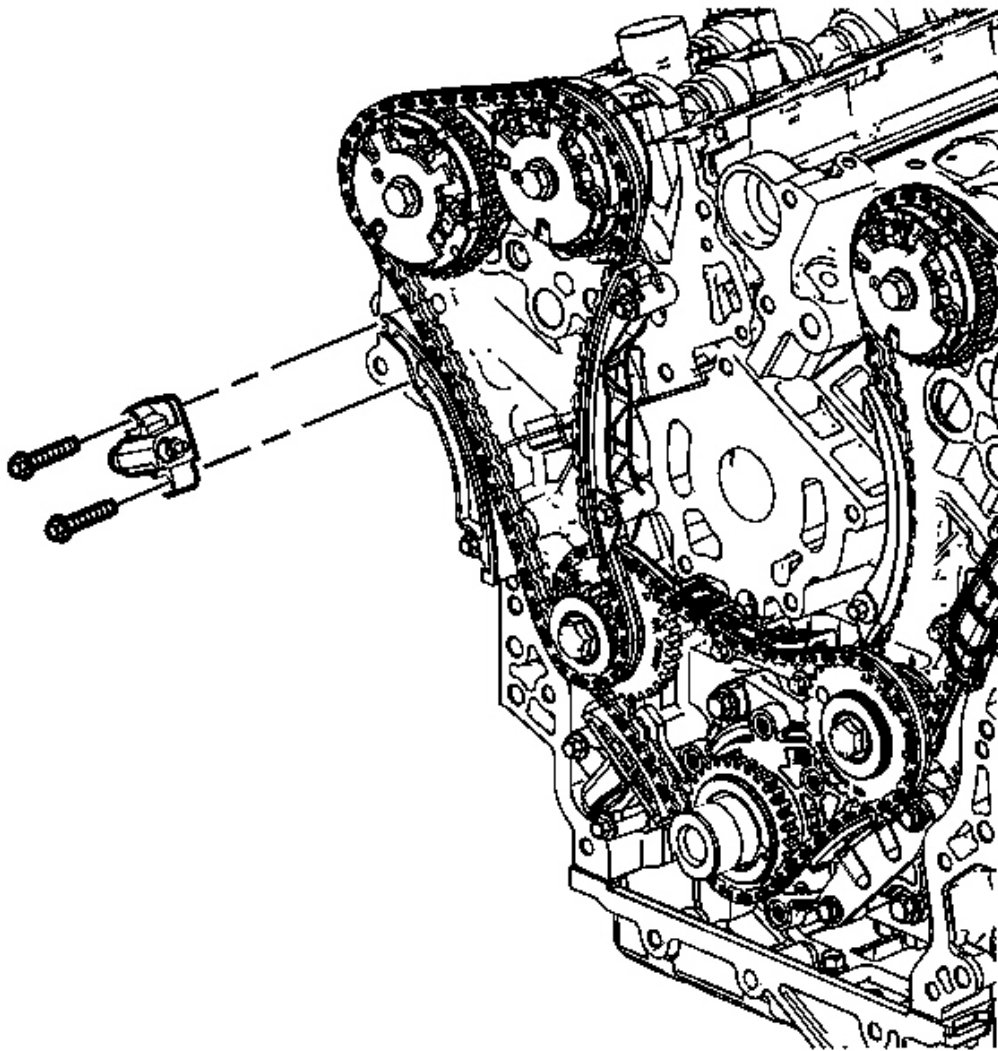


Fig. 40: View Of Secondary Camshaft Drive Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft drive chain tensioner bolts.
2. Remove the right secondary camshaft drive chain tensioner.

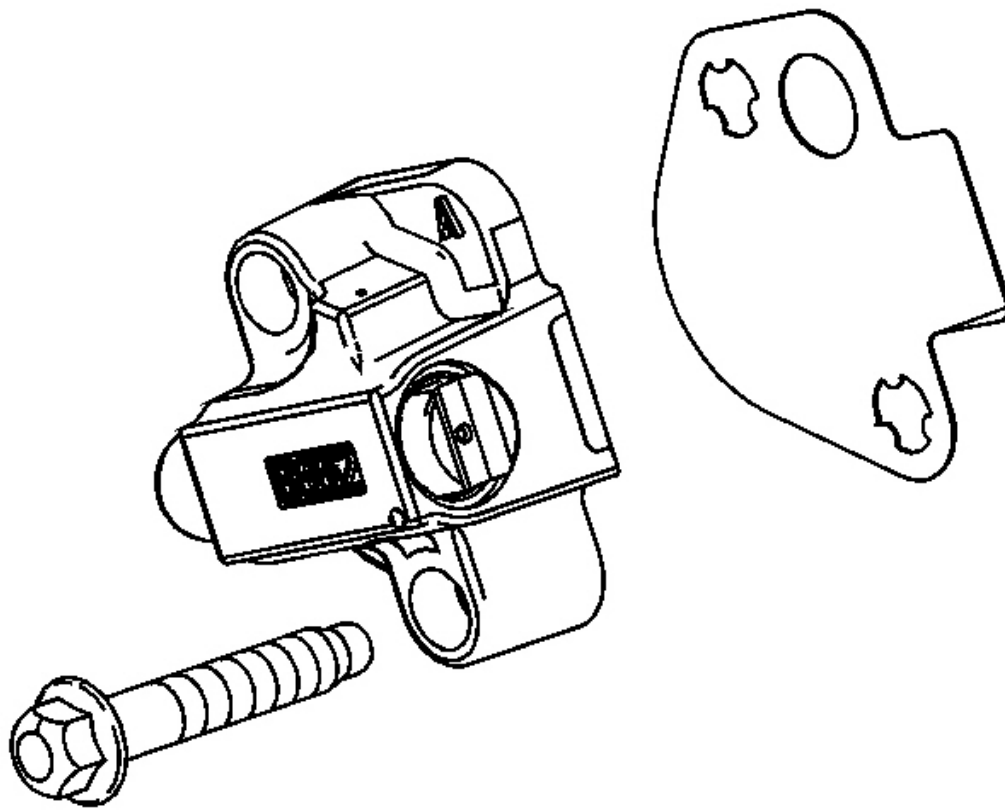


Fig. 41: Identifying Right Secondary Camshaft Drive Chain Tensioner Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the right secondary camshaft drive chain tensioner gasket.
4. Inspect the right secondary camshaft drive chain tensioner mounting surface on the right cylinder head for burrs or any defects that would degrade the sealing of the NEW right secondary camshaft drive chain tensioner gasket.

SECONDARY CAMSHAFT DRIVE CHAIN SHOE REMOVAL - RIGHT SIDE

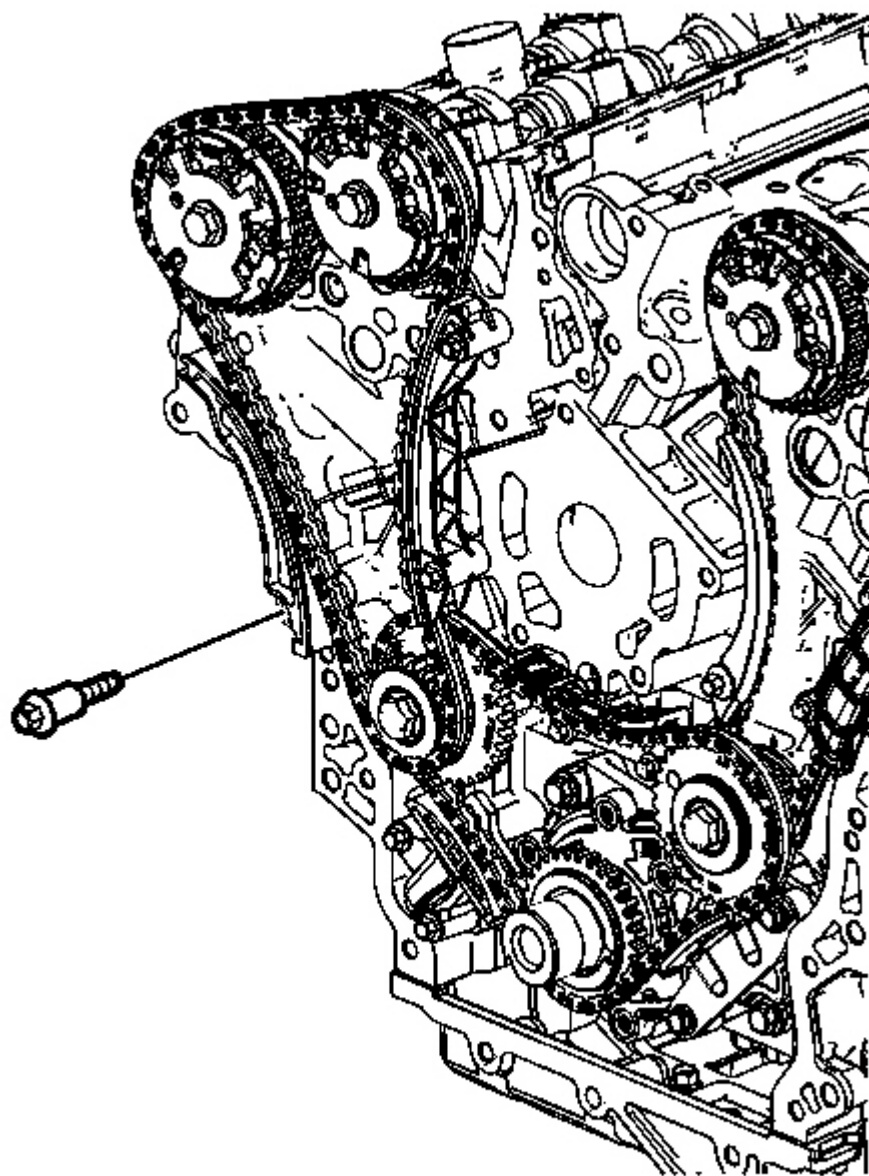


Fig. 42: View Of Right Secondary Camshaft Drive Chain Shoe Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft drive chain shoe bolt.

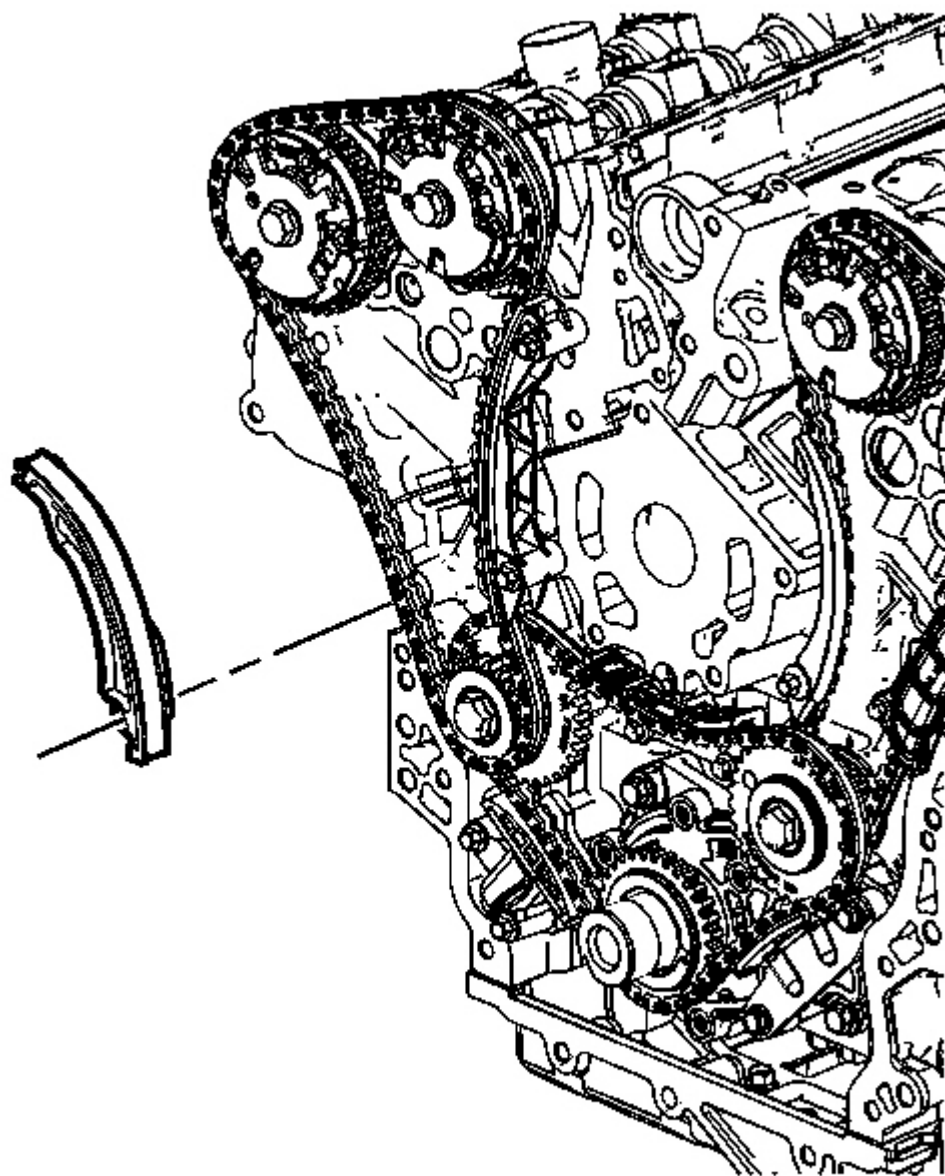


Fig. 43: View Of Right Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

2. Remove the right secondary camshaft drive chain shoe.

SECONDARY TIMING CHAIN GUIDE REMOVAL - RIGHT SIDE

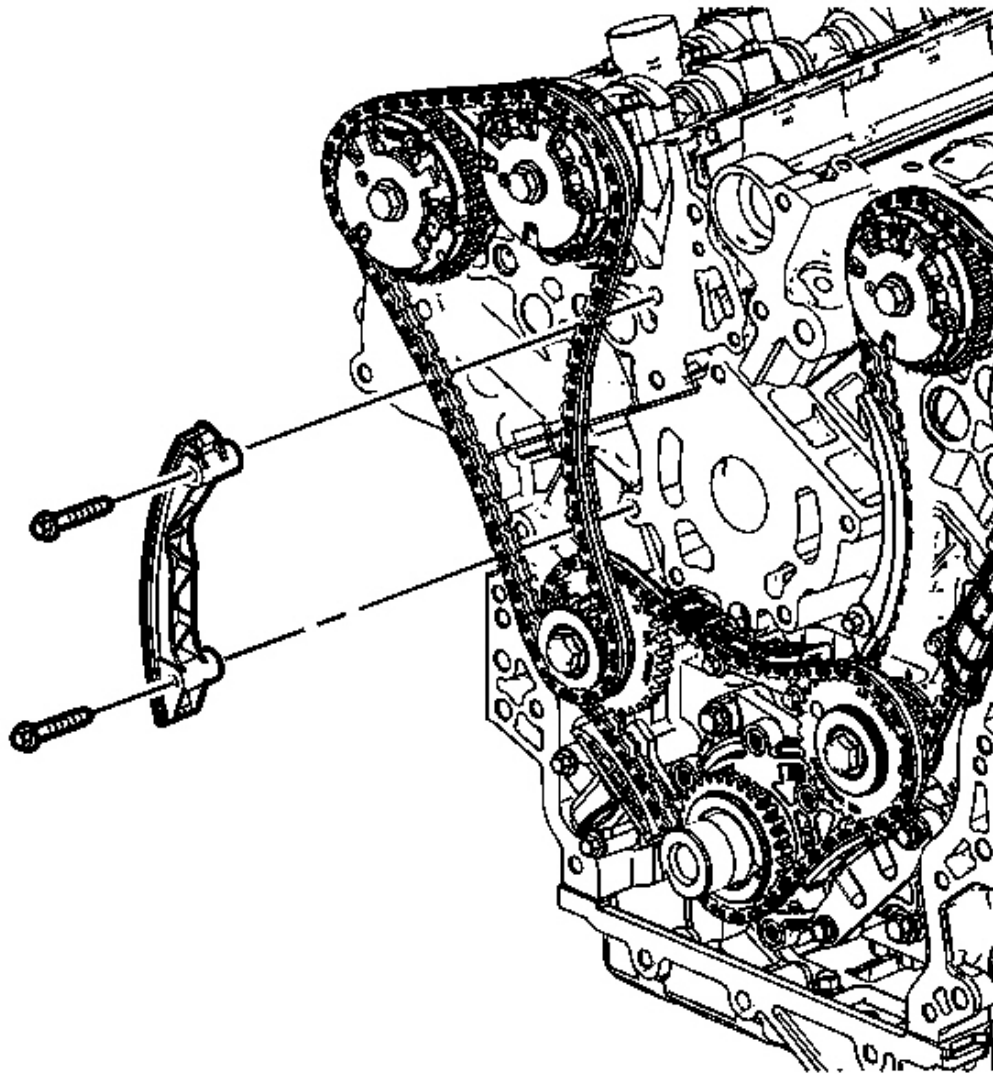


Fig. 44: View Of Right Secondary Camshaft Drive Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft drive chain guide bolts.
2. Remove the right secondary camshaft drive chain guide.

SECONDARY CAMSHAFT INTERMEDIATE DRIVE CHAIN REMOVAL - RIGHT SIDE

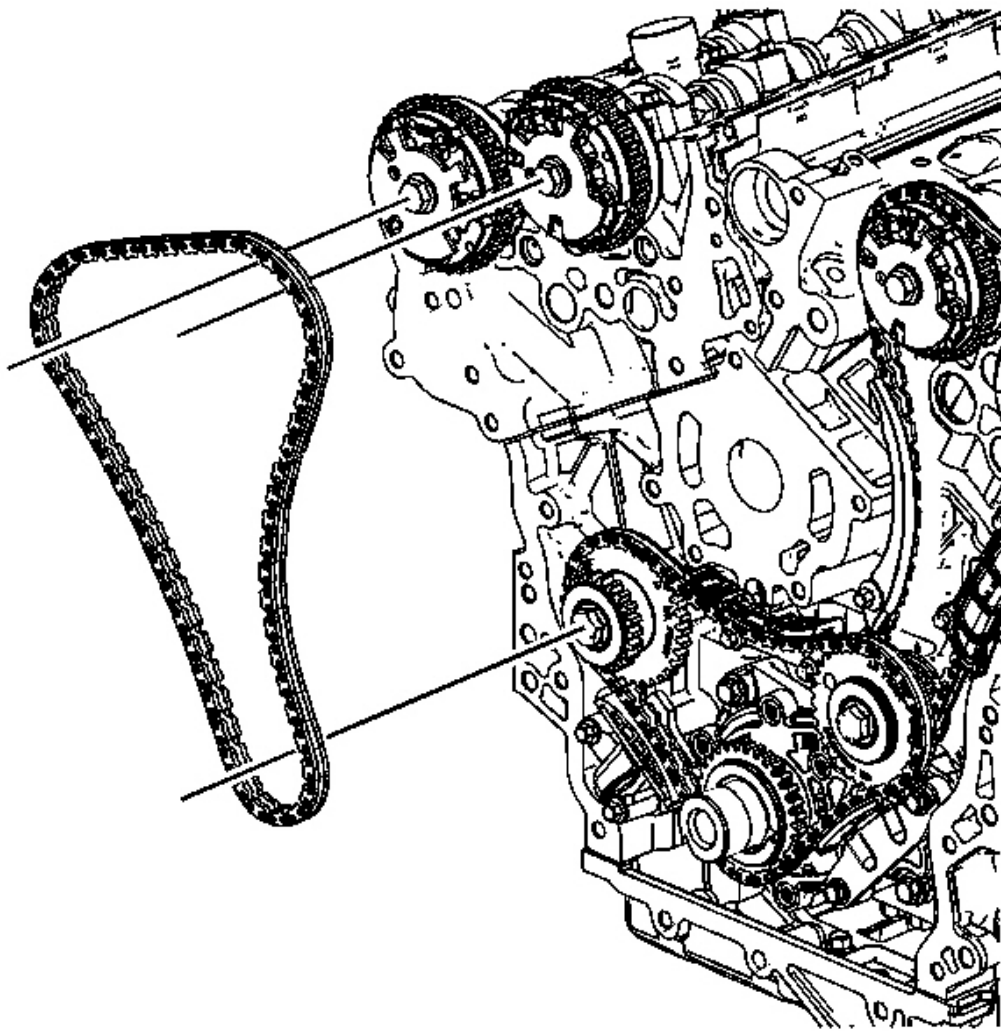


Fig. 45: View Of Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

Remove the right secondary camshaft drive chain from the right camshaft position actuators and the right camshaft intermediate drive chain idler sprocket.

PRIMARY CAMSHAFT INTERMEDIATE DRIVE CHAIN TENSIONER REMOVAL

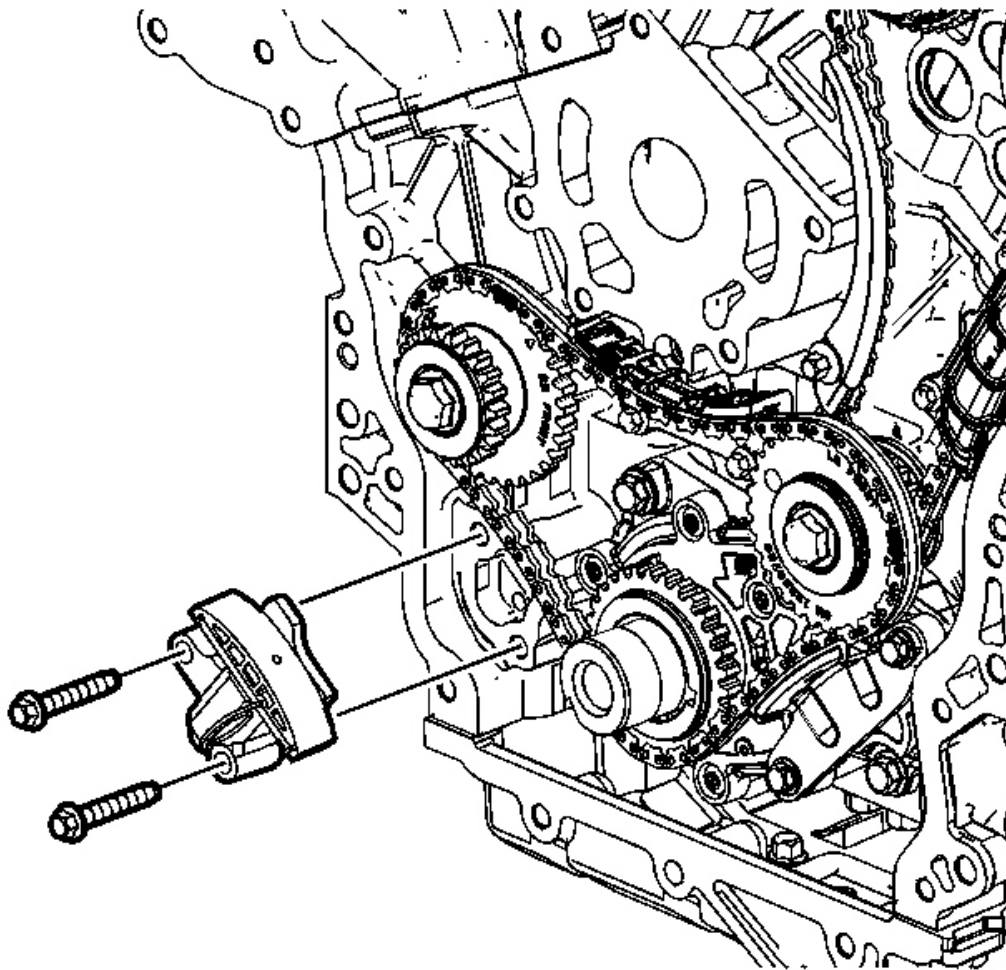


Fig. 46: View Of Primary Camshaft Drive Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the primary camshaft drive chain tensioner bolts.
2. Remove the primary camshaft drive chain tensioner.

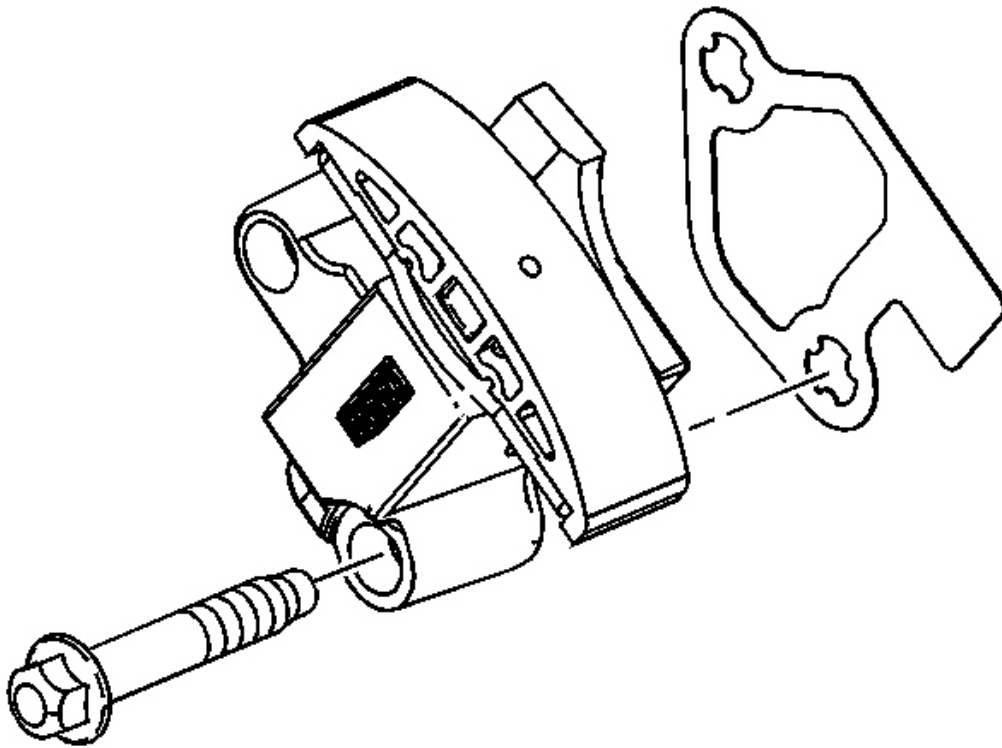


Fig. 47: Identifying Primary Camshaft Drive Chain Tensioner Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the primary camshaft drive chain tensioner gasket.
4. 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.

PRIMARY TIMING CHAIN GUIDE REMOVAL - UPPER

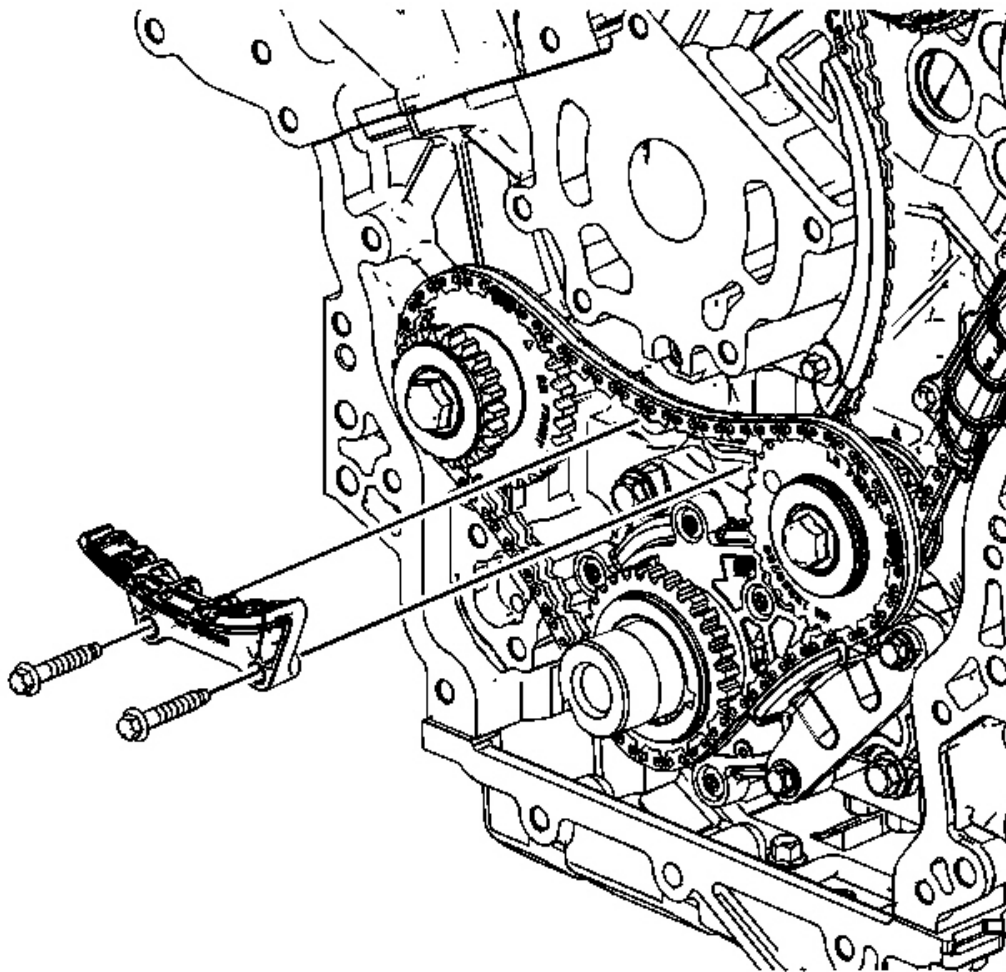


Fig. 48: View Of Primary Camshaft Drive Chain Upper Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the primary camshaft drive chain upper guide bolts.
2. Remove the primary camshaft drive chain upper guides.

PRIMARY TIMING CHAIN GUIDE REMOVAL - LOWER

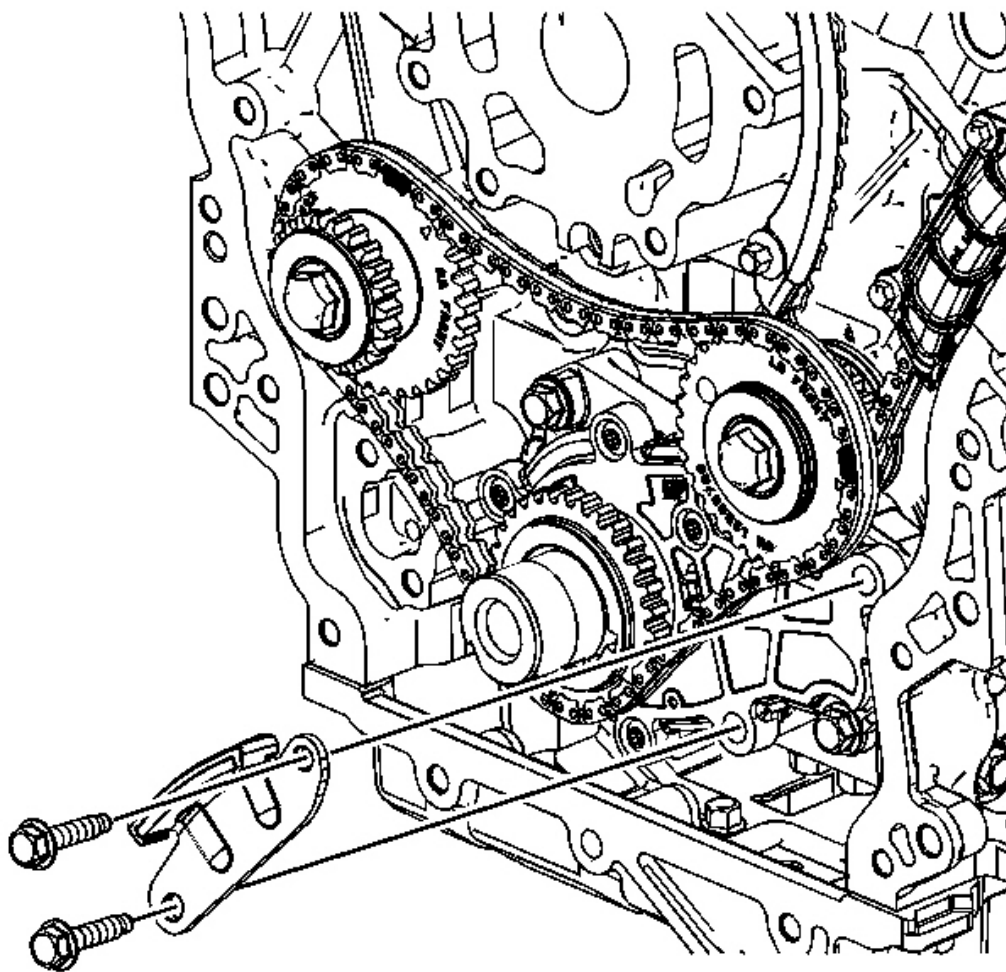


Fig. 49: View Of Primary Camshaft Drive Chain Lower Guide Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the primary camshaft drive chain lower guide bolts.
2. Remove the primary camshaft drive chain lower guide.

PRIMARY CAMSHAFT INTERMEDIATE DRIVE CHAIN REMOVAL

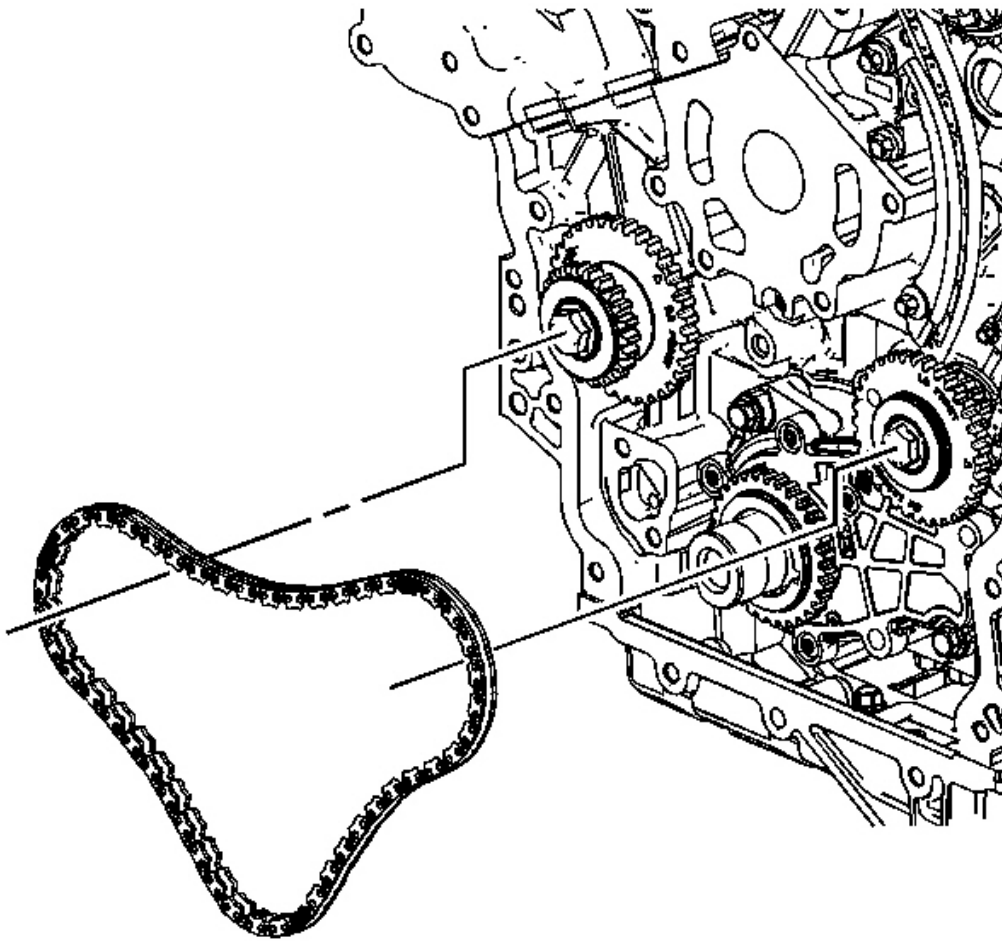


Fig. 50: View Of Primary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

Remove the primary camshaft drive chain.

TIMING CHAIN IDLER SPROCKET REMOVAL - RIGHT SIDE

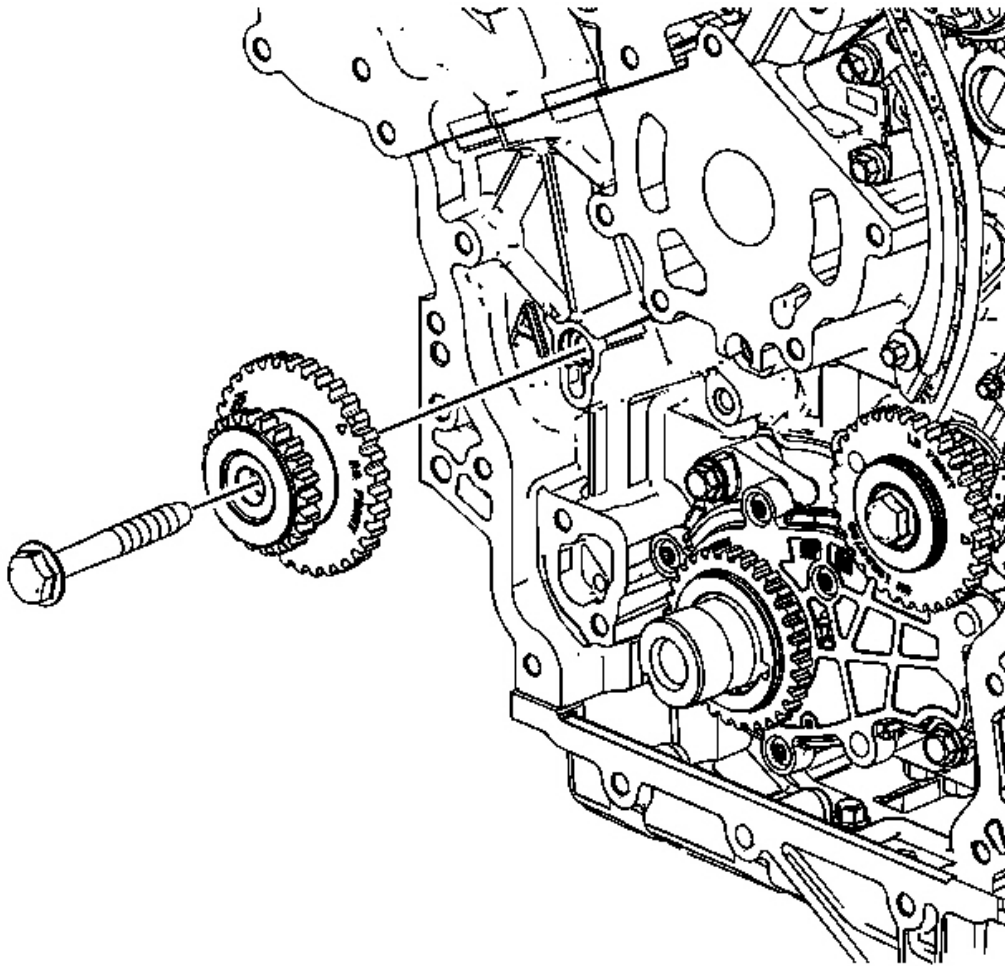


Fig. 51: View Of Camshaft Intermediate Drive Chain Idler & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the right camshaft intermediate drive chain idler bolt.
2. Remove the right camshaft intermediate drive chain idler.

SECONDARY TIMING CHAIN TENSIONER REMOVAL - LEFT SIDE

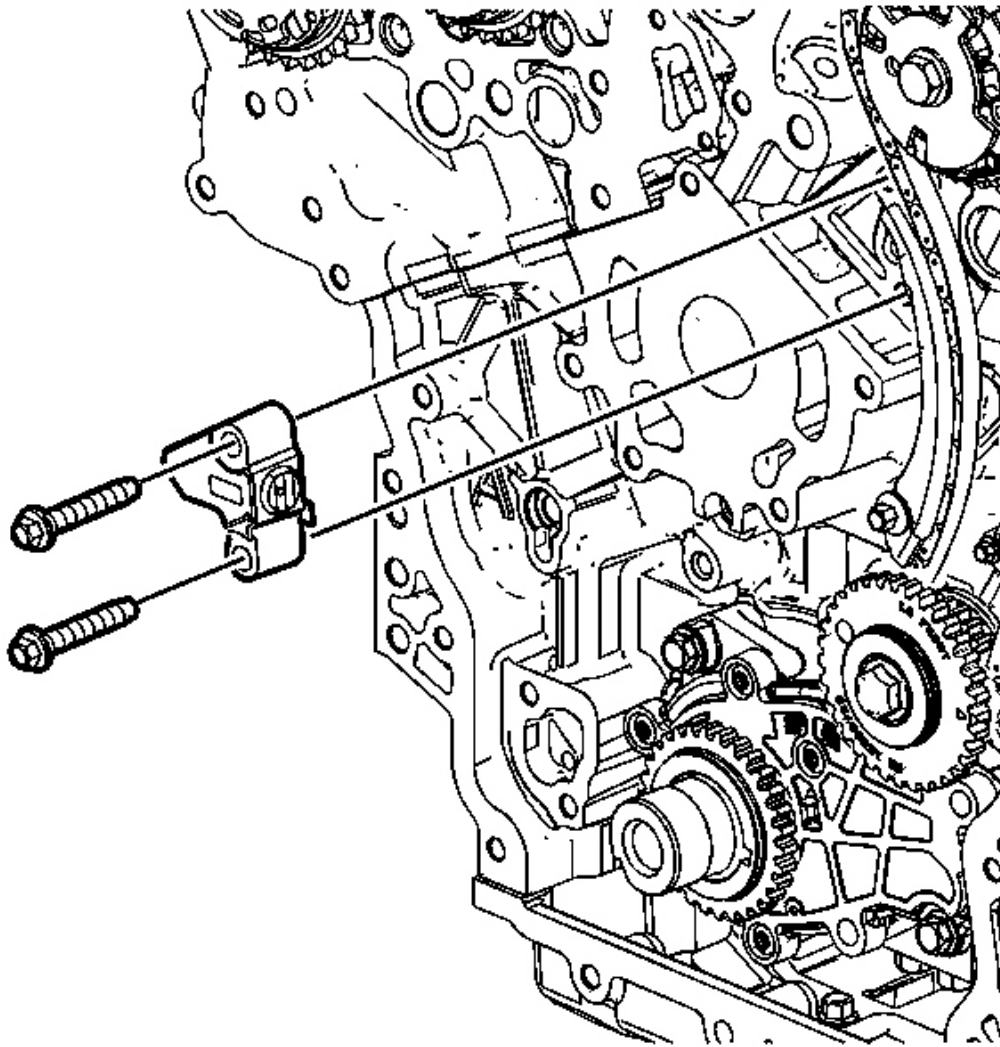


Fig. 52: View Of Secondary Camshaft Drive Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft drive chain tensioner bolts.
2. Remove the left secondary camshaft drive chain tensioner.

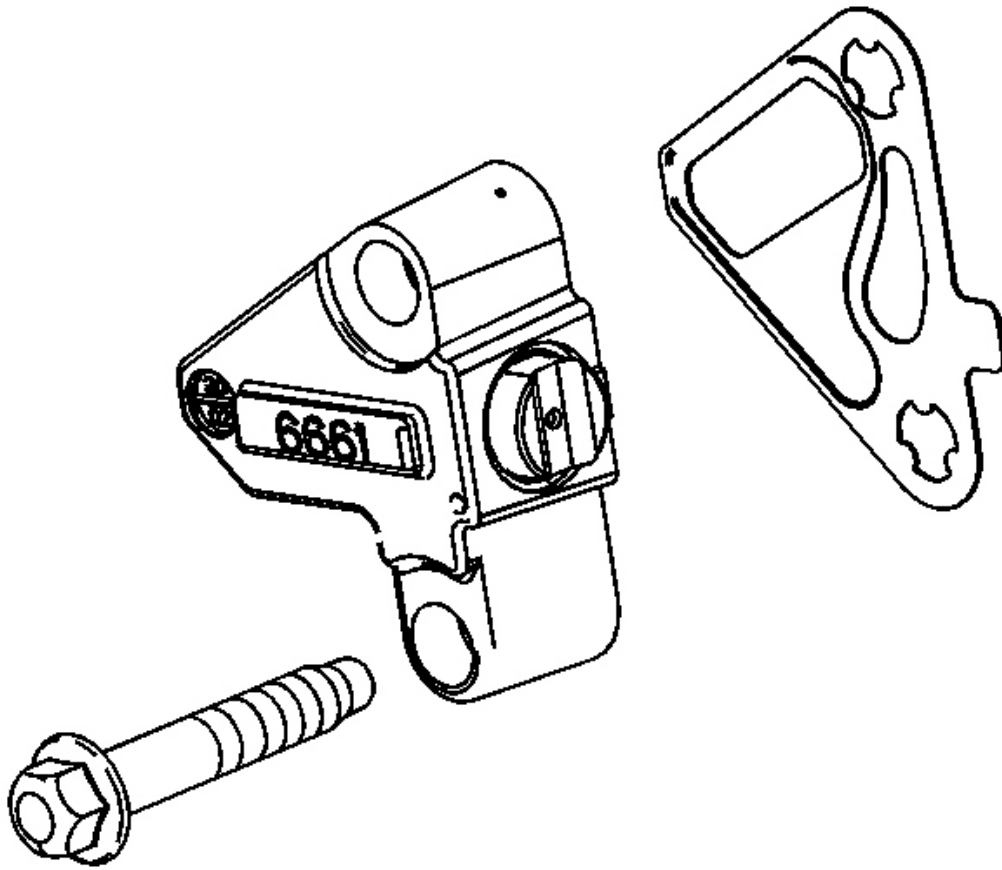


Fig. 53: View Of Left Secondary Camshaft Drive Chain Tensioner Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the left secondary camshaft drive chain tensioner gasket.
4. Inspect the left secondary camshaft drive chain tensioner mounting surface on the left cylinder head for burrs or any defects that would degrade the sealing of the NEW left secondary camshaft drive chain tensioner gasket.

SECONDARY CAMSHAFT DRIVE CHAIN SHOE REMOVAL - LEFT SIDE

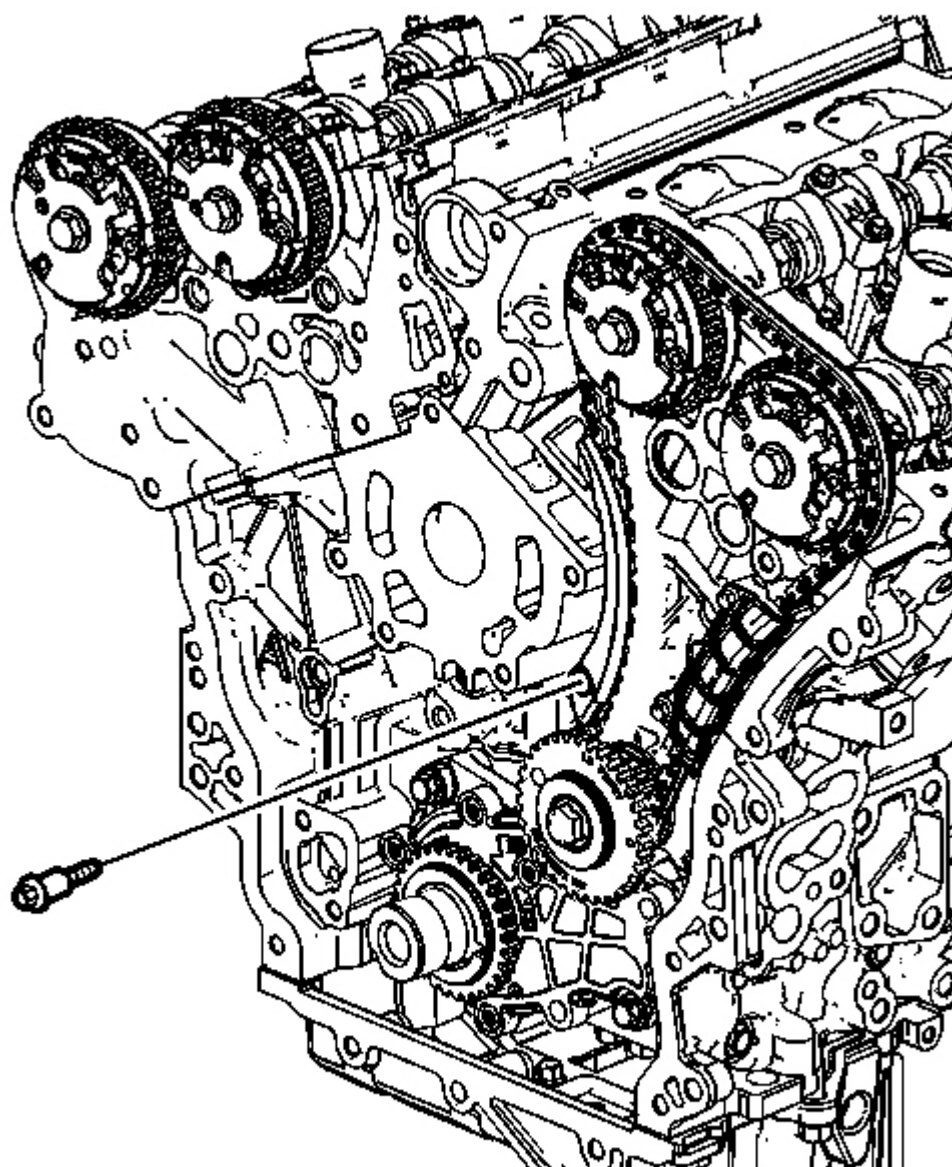


Fig. 54: View Of Left Secondary Camshaft Drive Chain Shoe Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft drive chain shoe bolt.

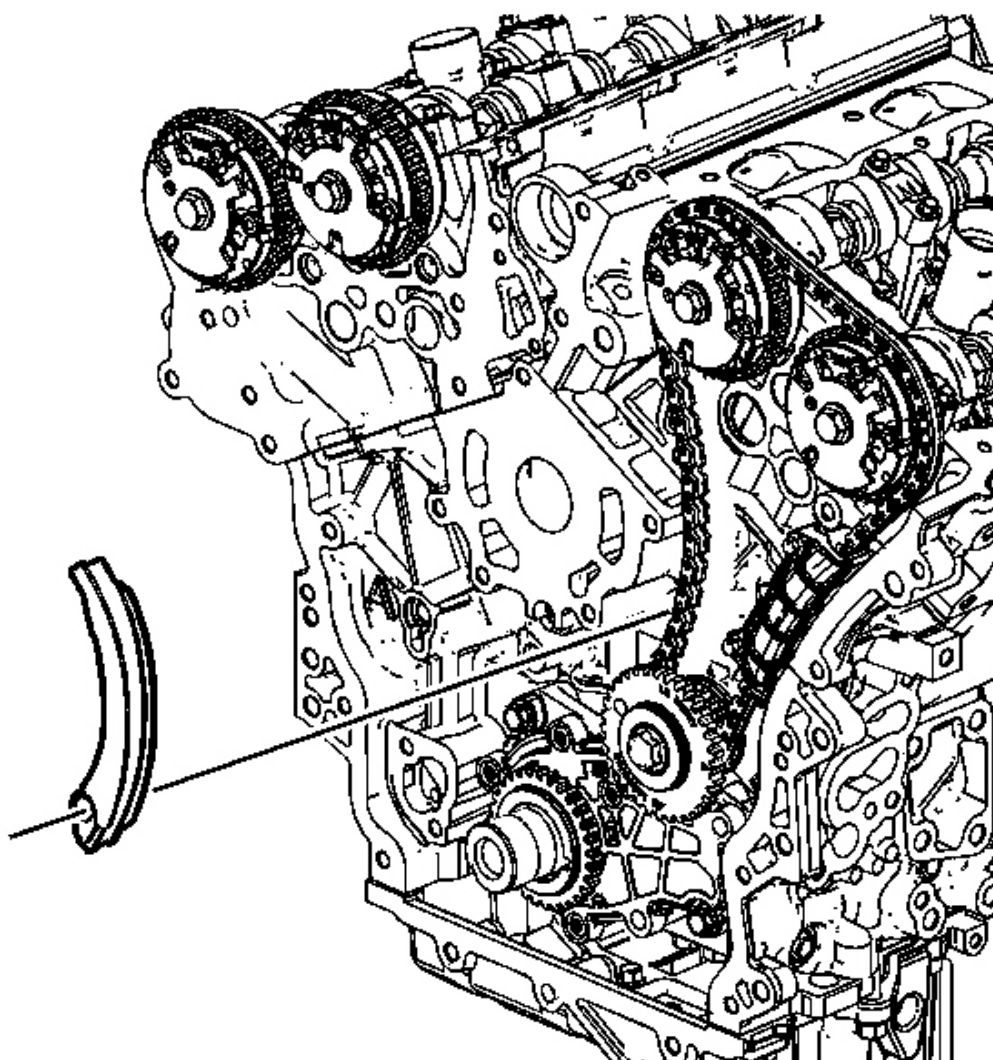


Fig. 55: View Of Left Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

2. Remove the left secondary camshaft drive chain shoe.

SECONDARY TIMING CHAIN GUIDE REMOVAL - LEFT SIDE

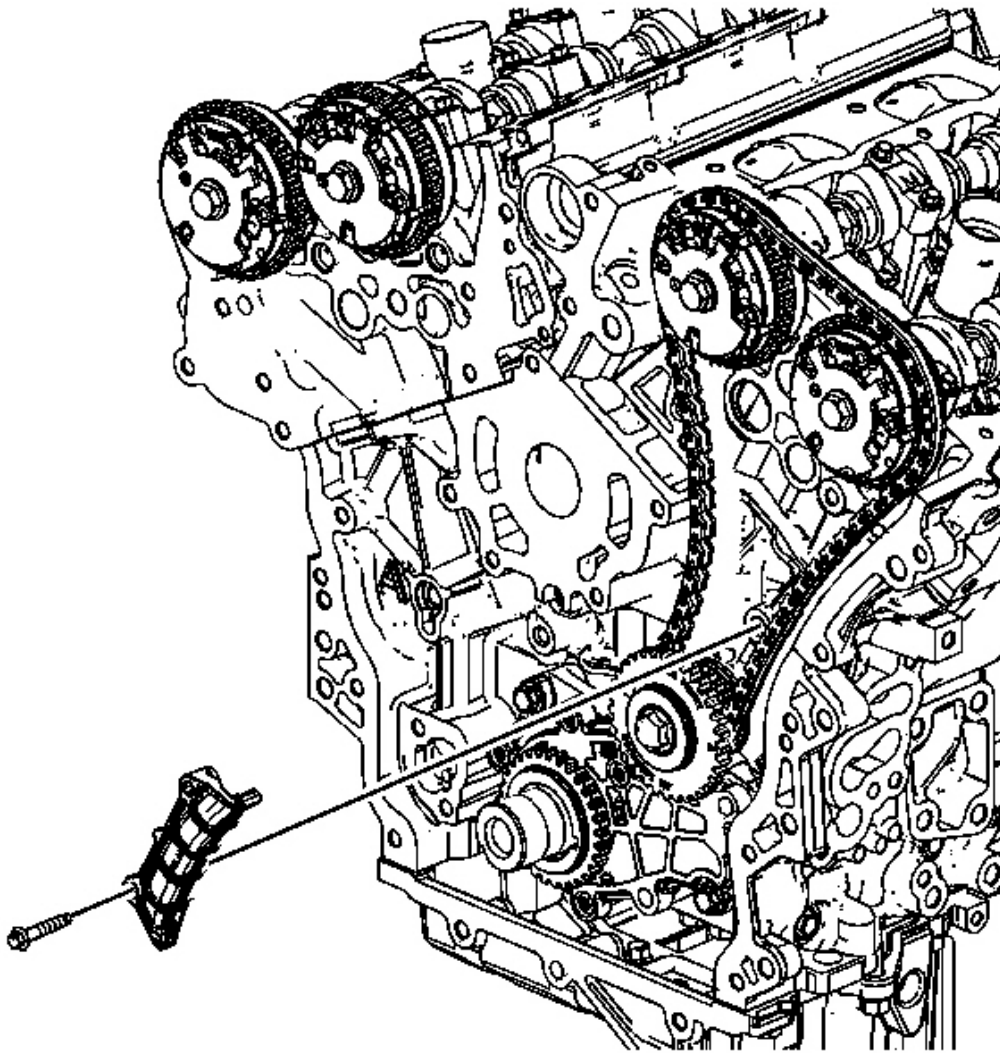


Fig. 56: View Of Secondary Camshaft Drive Chain Guide Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft drive chain guide bolts.
2. Remove the left secondary camshaft drive chain guide.

SECONDARY CAMSHAFT INTERMEDIATE DRIVE CHAIN REMOVAL - LEFT SIDE

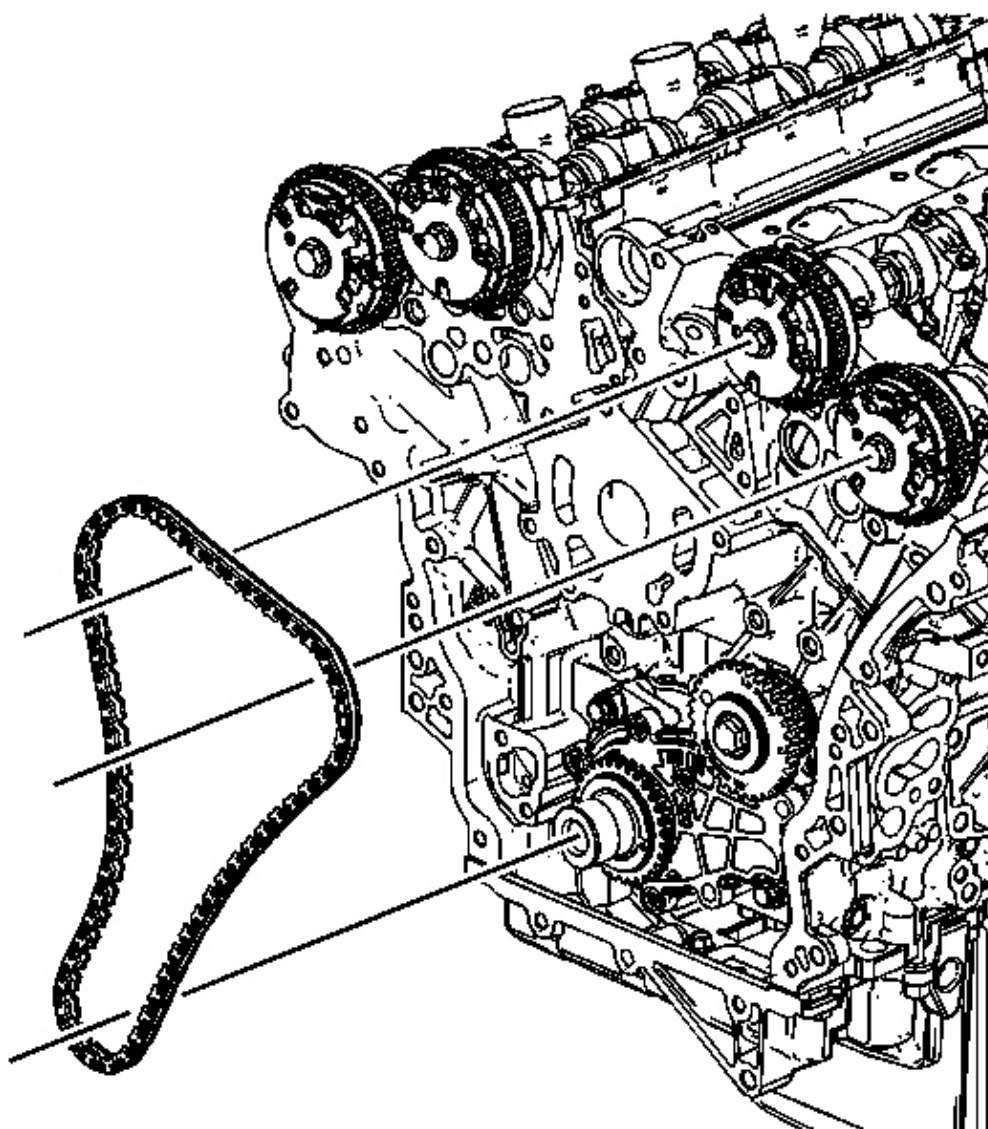


Fig. 57: View Of Left Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

Remove the left secondary camshaft drive chain from the left camshaft position actuators and the left camshaft intermediate drive chain idler sprocket.

TIMING CHAIN IDLER SPROCKET REMOVAL - LEFT SIDE

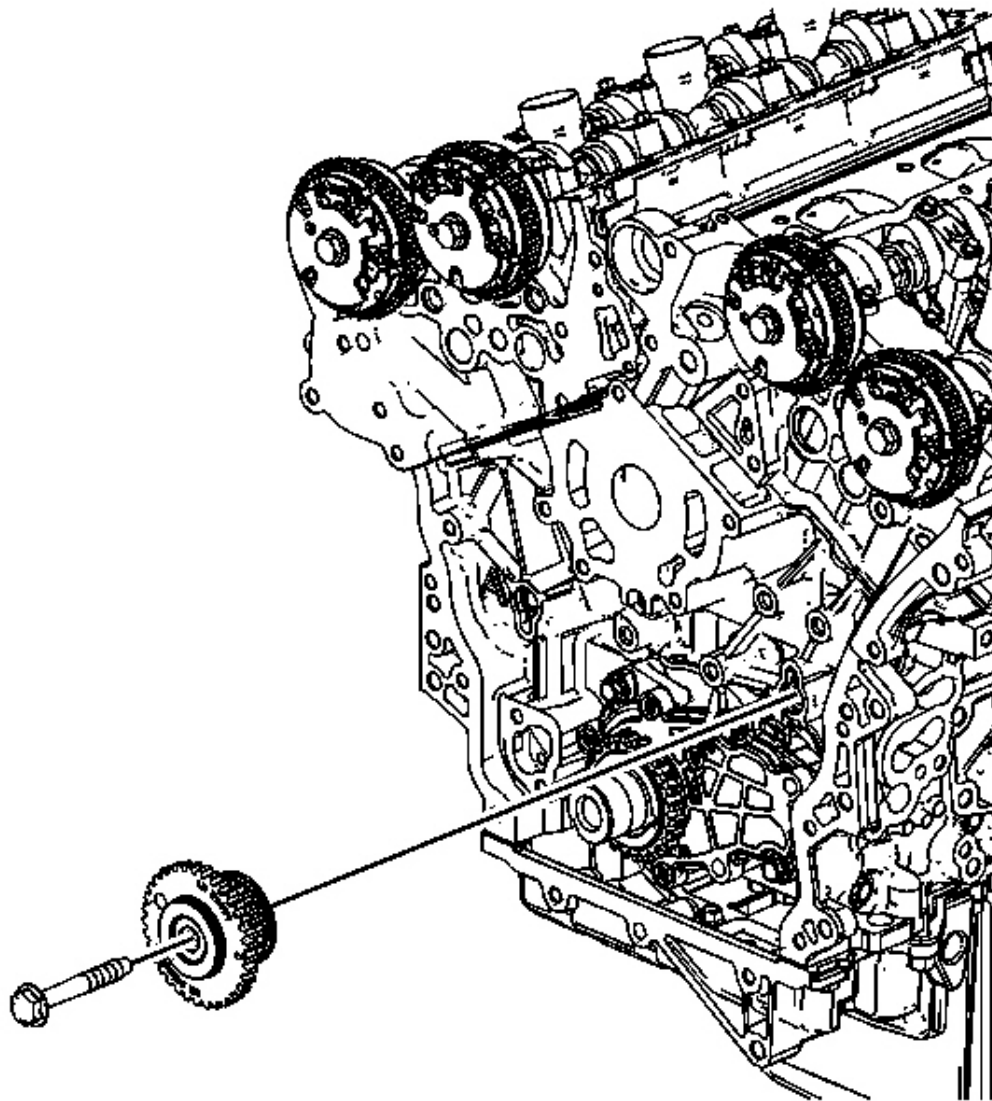


Fig. 58: View Of Left Camshaft Intermediate Drive Chain Idler & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the left camshaft intermediate drive chain idler bolt.
2. Remove the left camshaft intermediate drive chain idler.

CRANKSHAFT SPROCKET REMOVAL

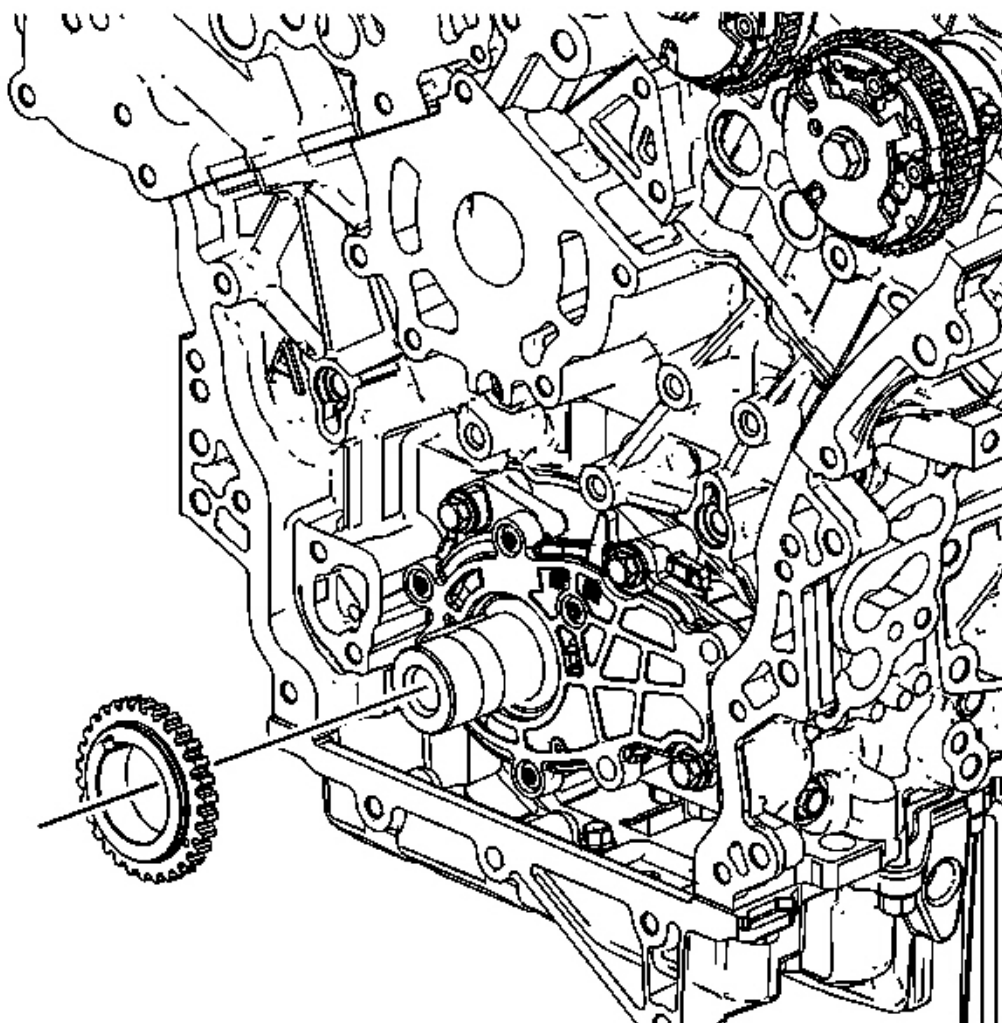


Fig. 59: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

Remove the crankshaft sprocket from the nose of the crankshaft.

CAMSHAFT POSITION ACTUATOR REMOVAL - LEFT SIDE EXHAUST

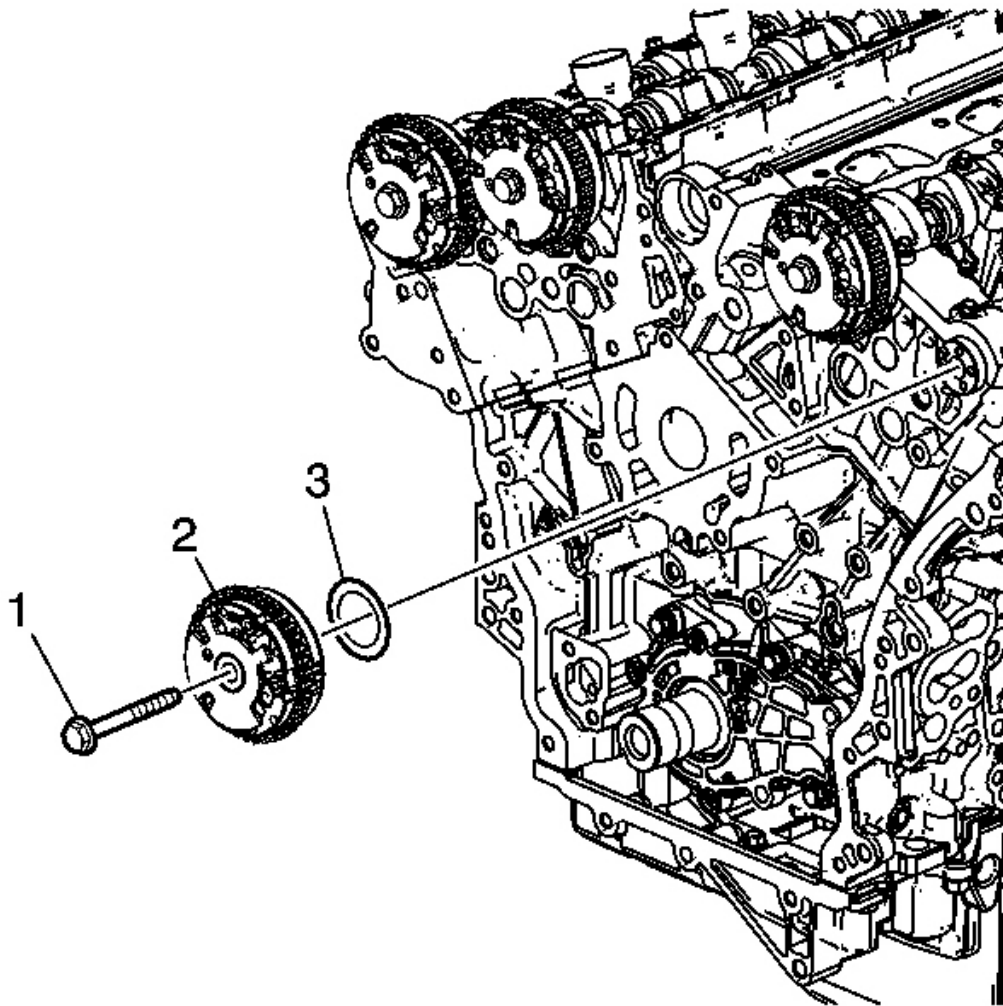


Fig. 60: View Of Exhaust Camshaft Position Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

1. 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

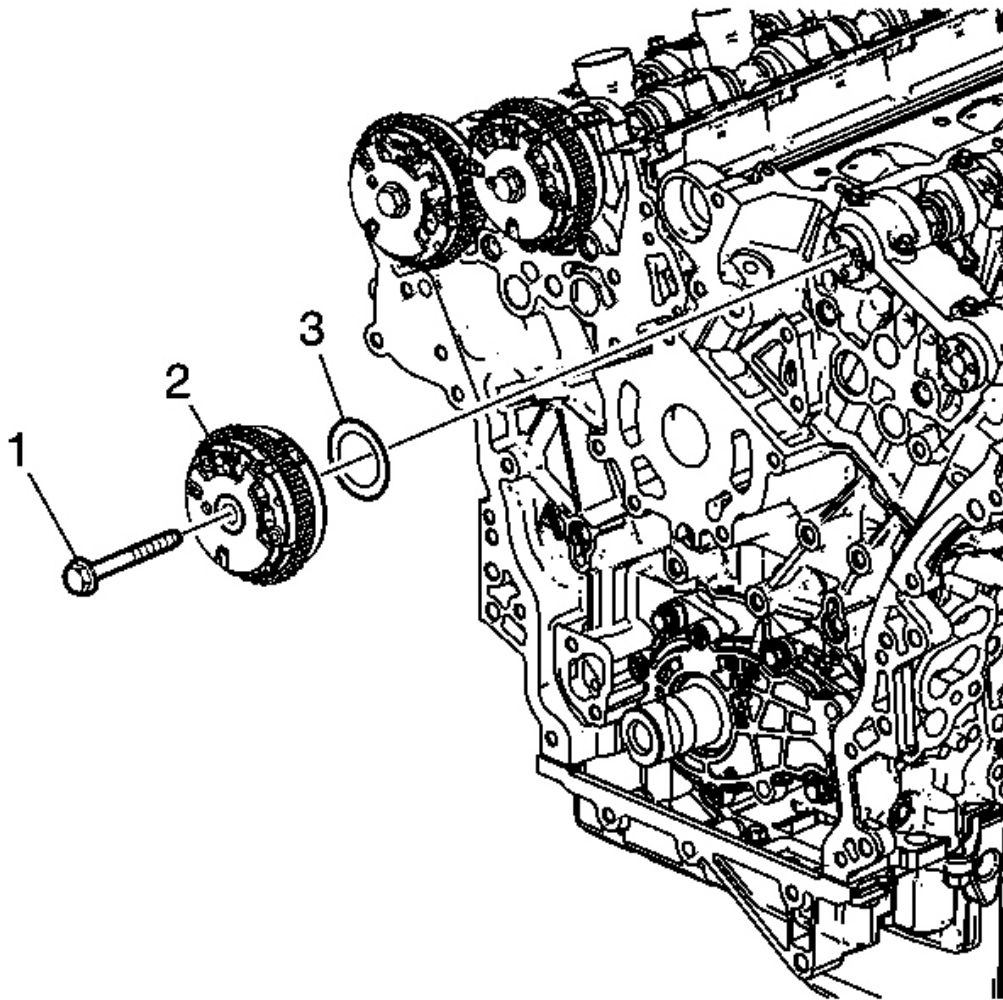


Fig. 61: View Of Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

1. 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

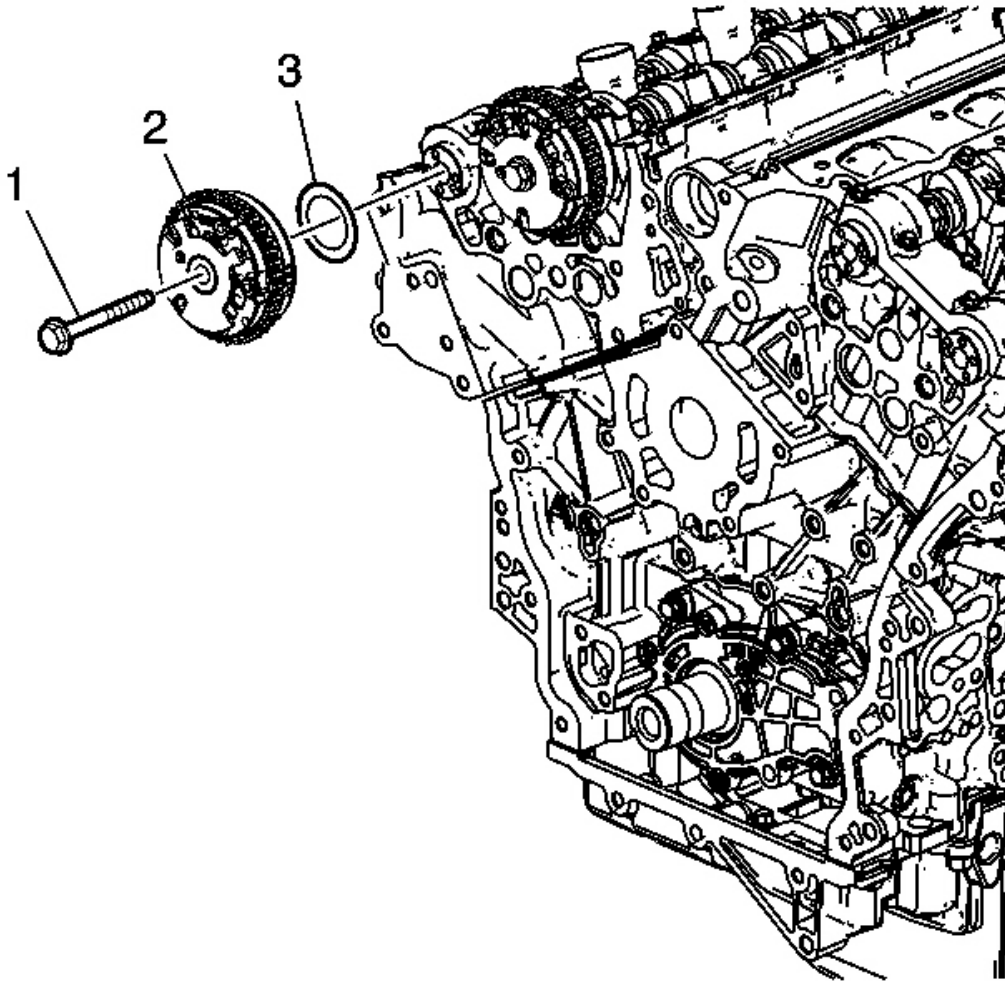


Fig. 62: Identifying Camshaft Position Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

1. 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

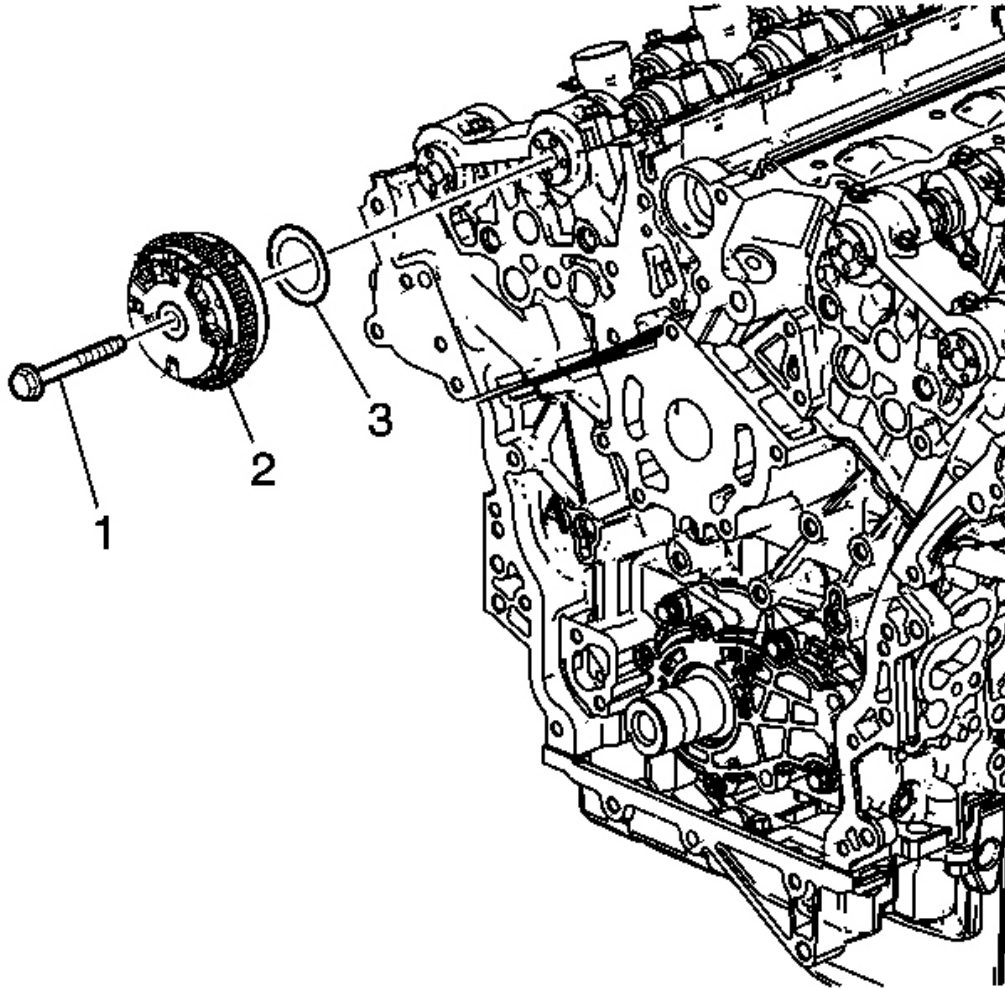


Fig. 63: Identifying Right Side Intake Camshaft Position Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

1. 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 (LF1 OR LFW)

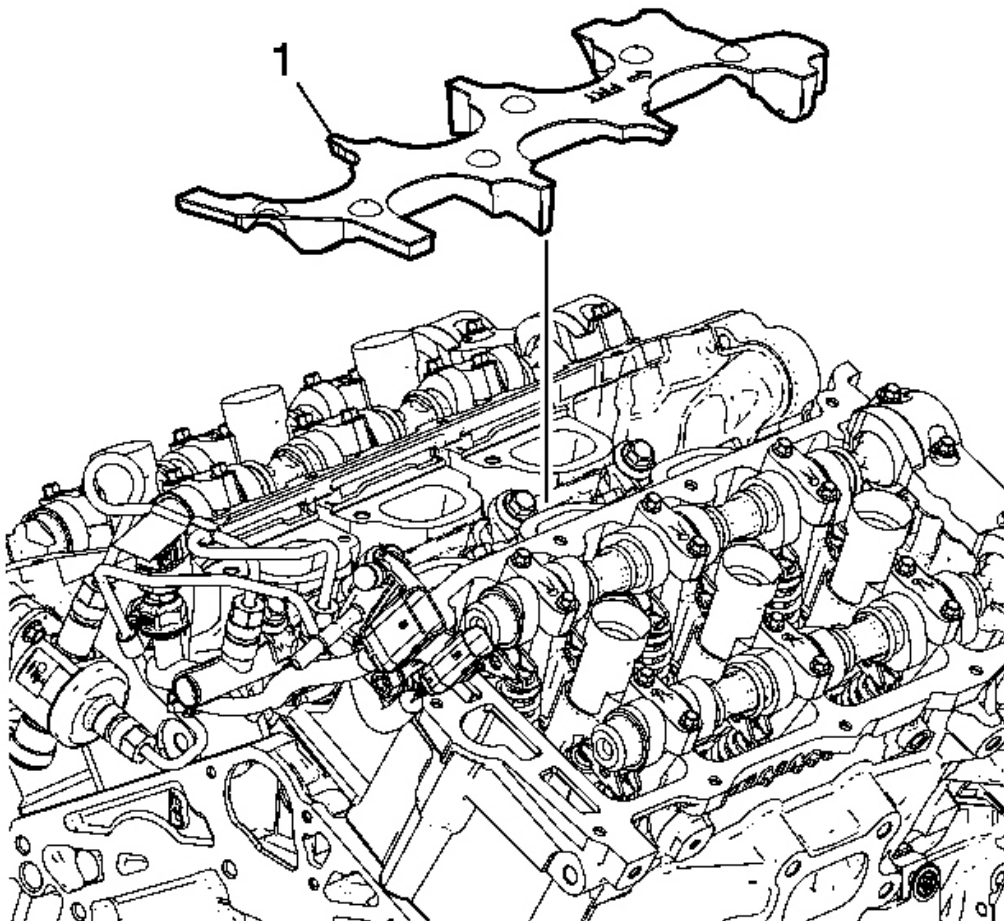


Fig. 64: Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS CORP.

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

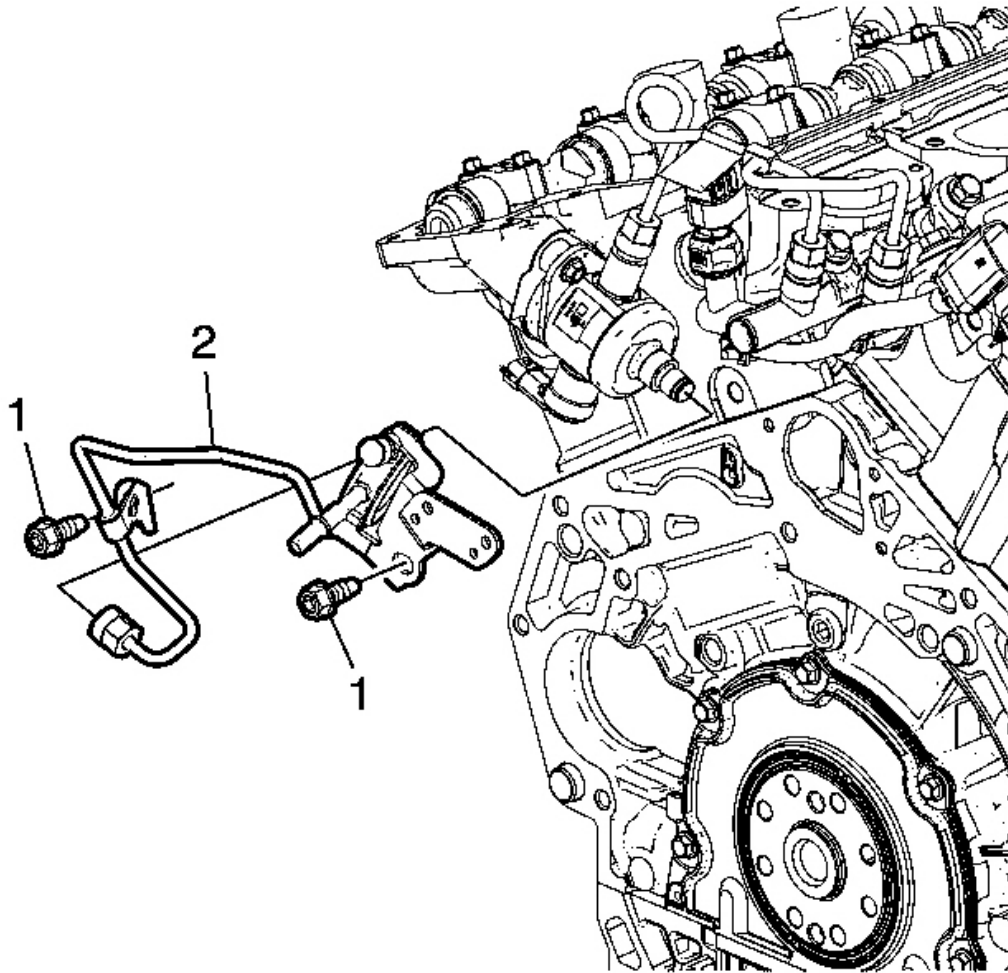


Fig. 65: Fuel Feed Pipe Components
Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel rail wiring connectors from the fuel feed pipe bracket.
3. Remove the fuel feed pipe bolts (1).
4. Remove and discard the fuel feed pipe (2).

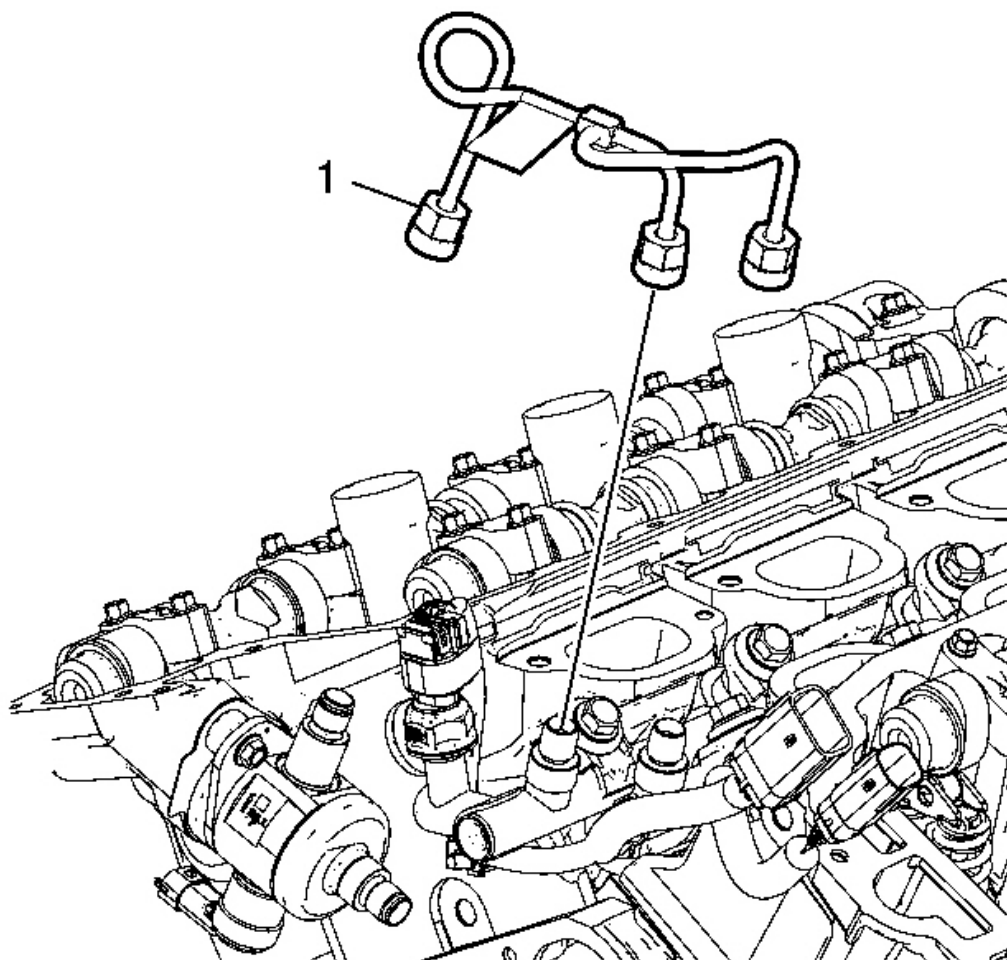


Fig. 66: Fuel Rail Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the high pressure LH to RH fuel rail crossover pipe (1).

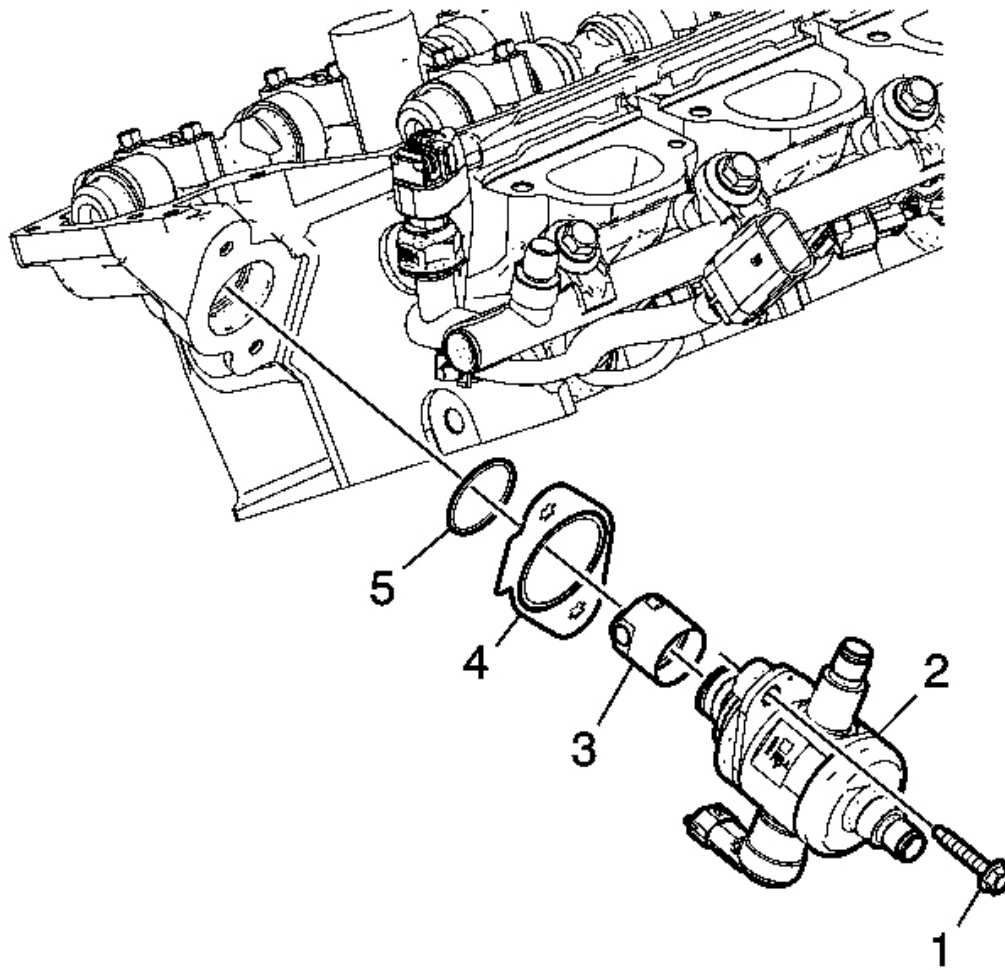


Fig. 67: High Pressure Fuel Pump Components
Courtesy of GENERAL MOTORS CORP.

6. Remove and discard high pressure fuel pump bolts (1).
7. Remove the high pressure fuel pump (2).
8. Remove the valve lifter follower (3).
9. Remove and discard the high pressure fuel pump gasket (4).
10. Remove and discard the high pressure fuel pump O-ring (5).

CAMSHAFT REMOVAL - LEFT SIDE

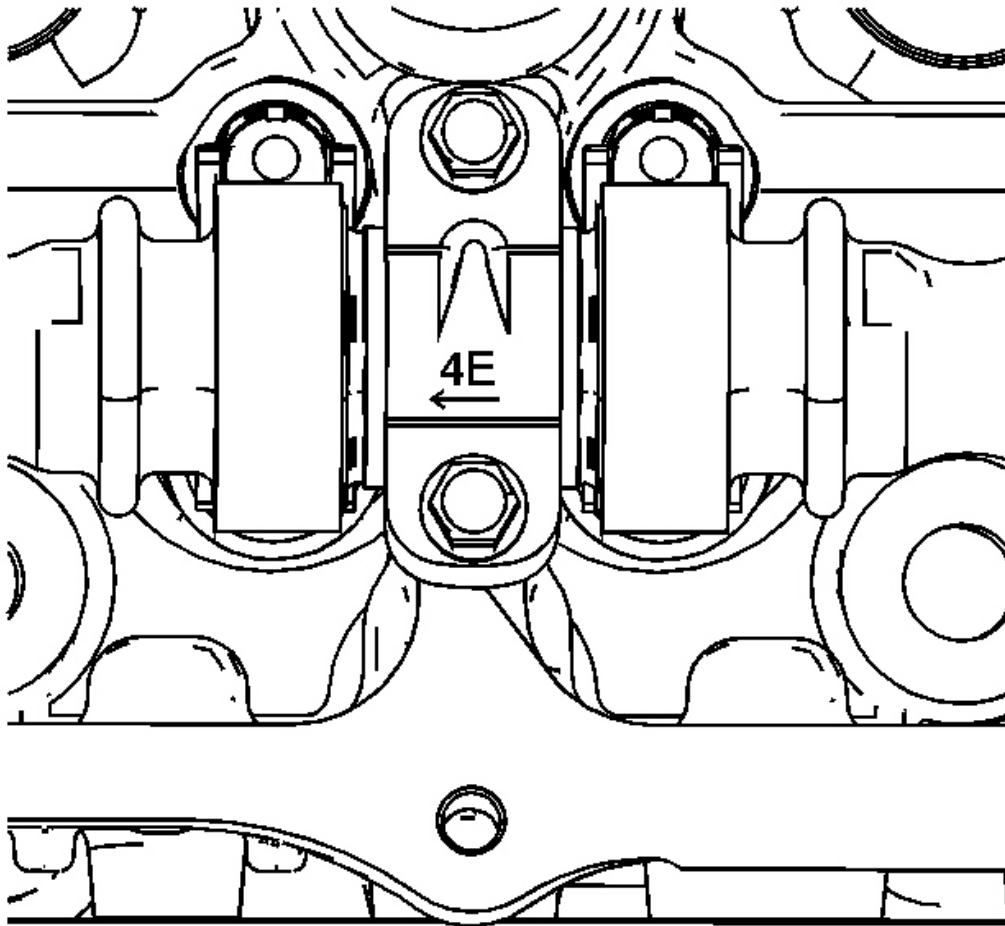


Fig. 68: Identifying Markings On Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. 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.

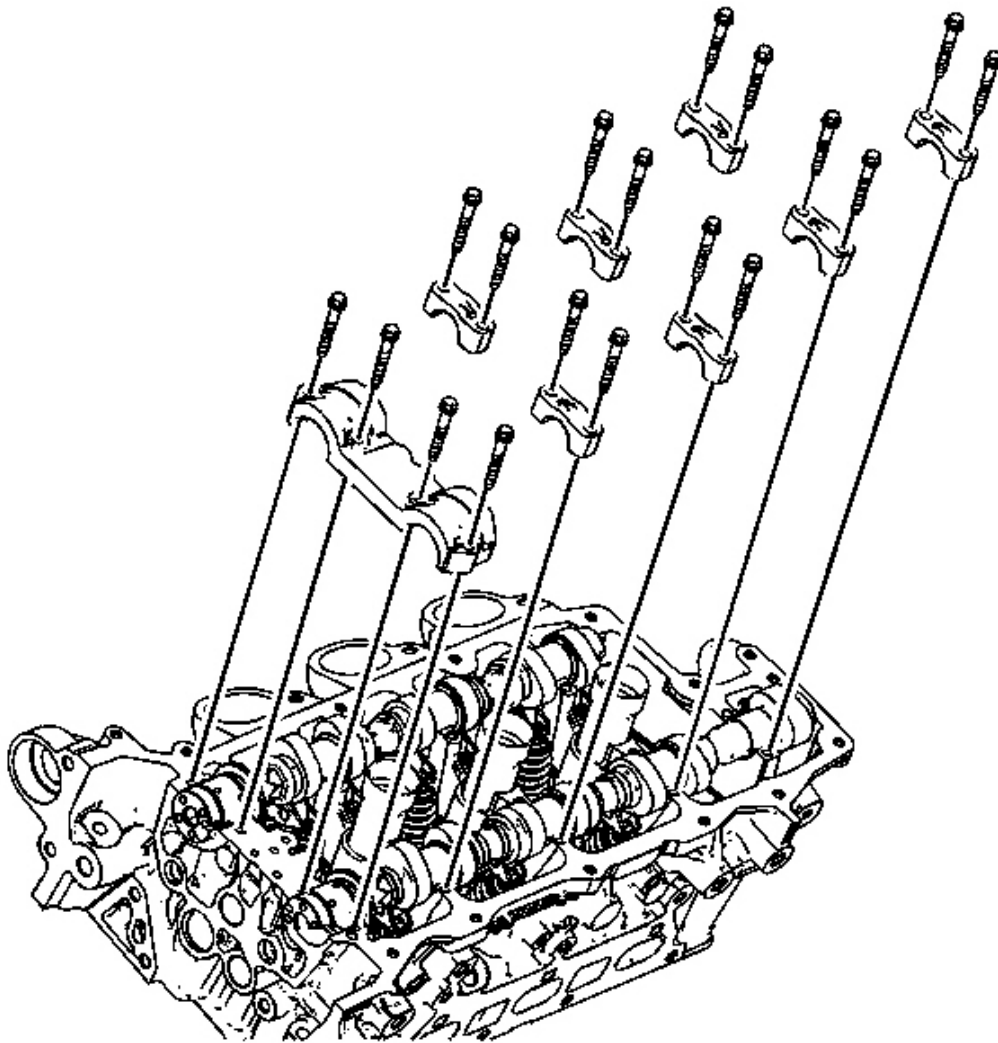


Fig. 69: Removing/Installing Camshaft Bearing Thrust Caps
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft bearing cap bolts.
3. Remove the camshaft bearing caps.

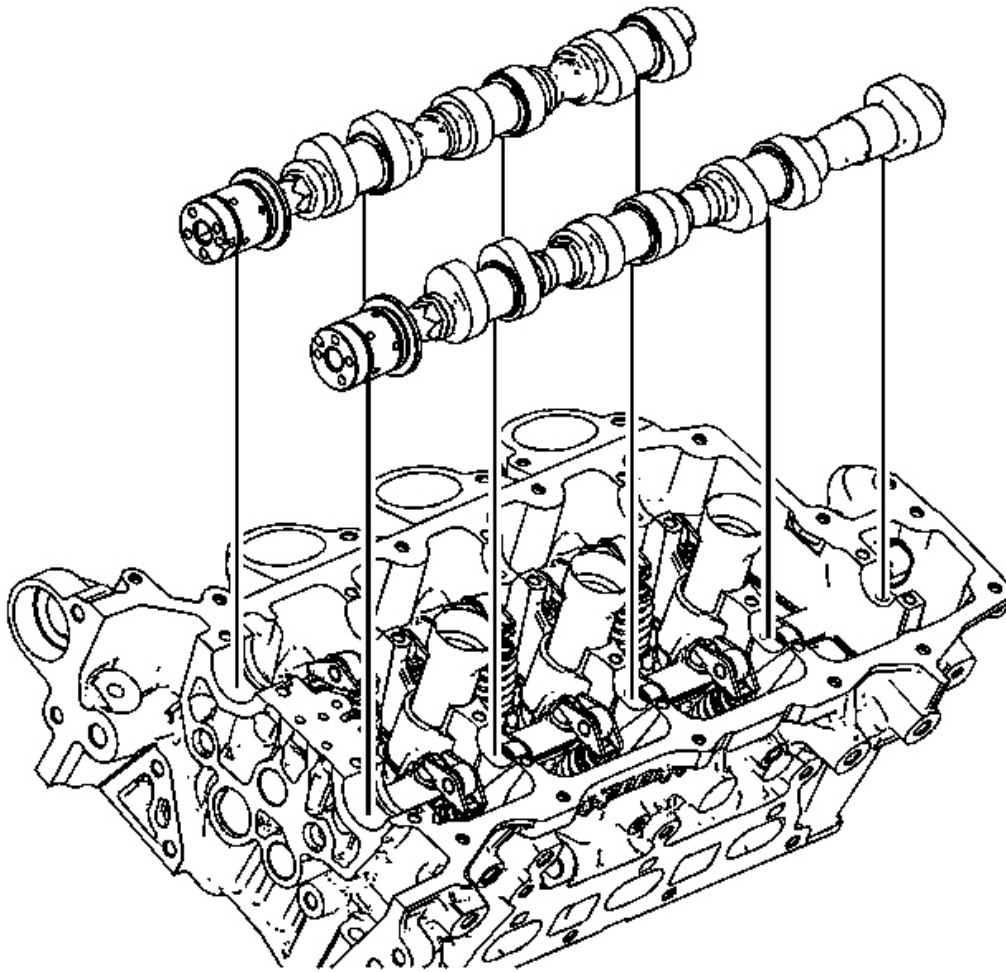


Fig. 70: View of Camshafts and Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

4. Remove the camshafts.
5. Replace the camshaft bearing caps and bolts.

FUEL RAIL REMOVAL

Refer to **Cylinder Head Disassemble (LF1 or LFW)** .

VALVE ROCKER ARM REMOVAL - LEFT SIDE

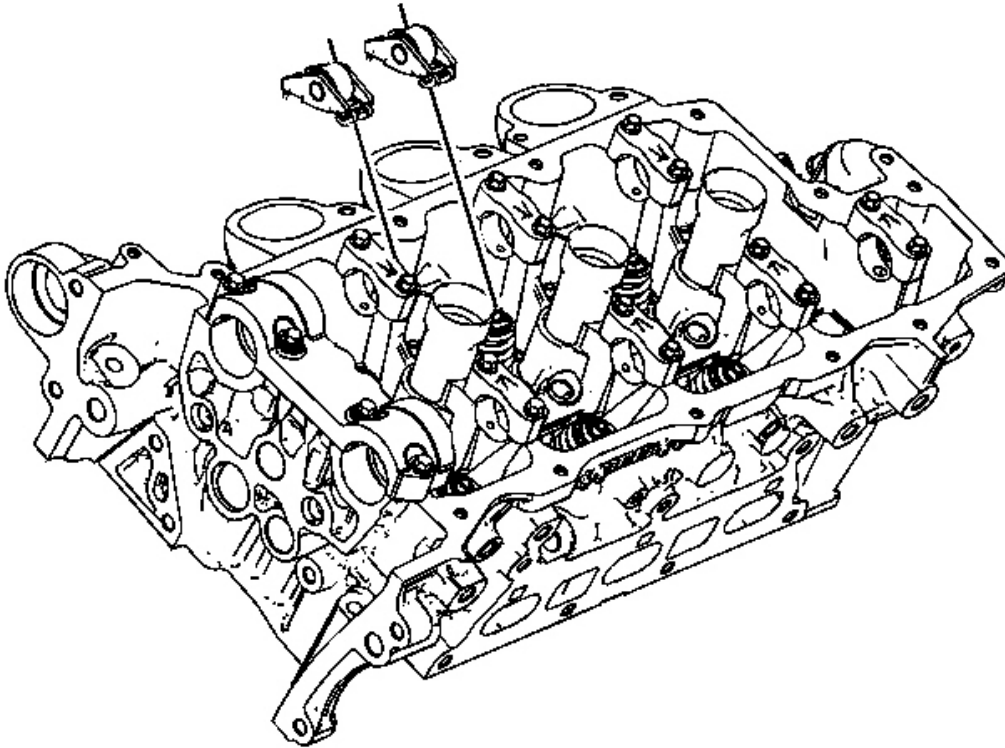


Fig. 71: View of Rocker Arm Assembly
Courtesy of GENERAL MOTORS CORP.

Remove the valve rocker arms from the cylinder head. 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

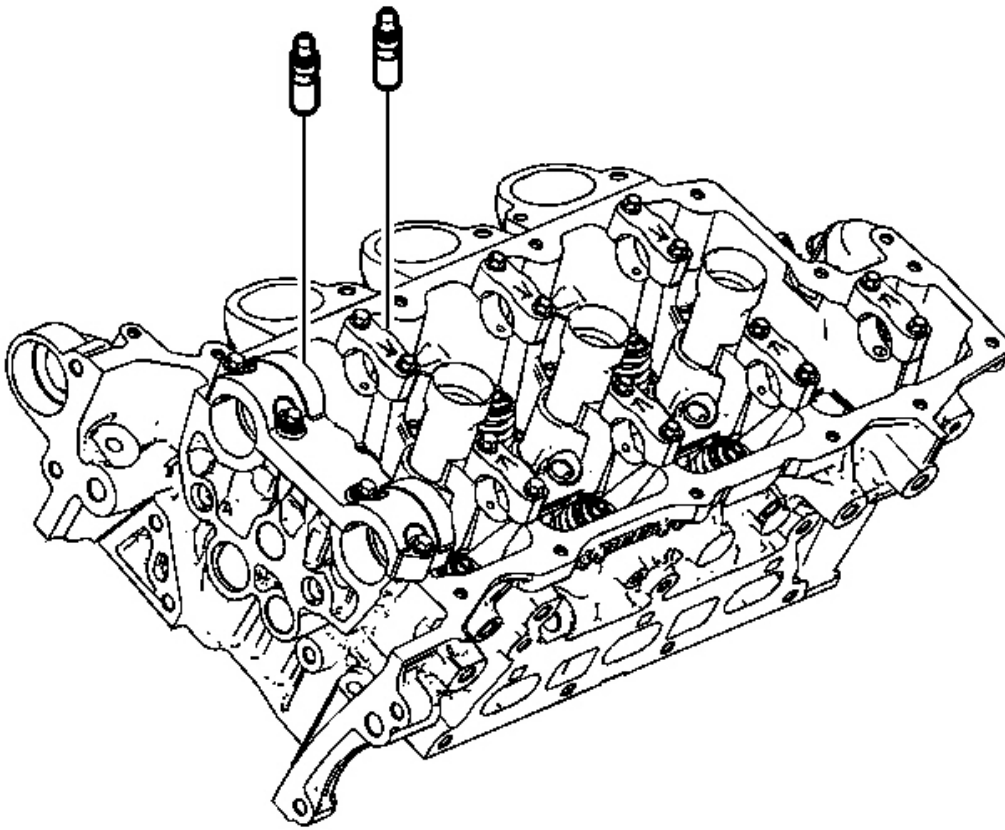


Fig. 72: Valve Lifter - Left Side

Courtesy of GENERAL MOTORS CORP.

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.

Remove the valve lifters (SHLAs) from the cylinder head. If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

CYLINDER HEAD REMOVAL - LEFT SIDE (LF1 OR LFW)

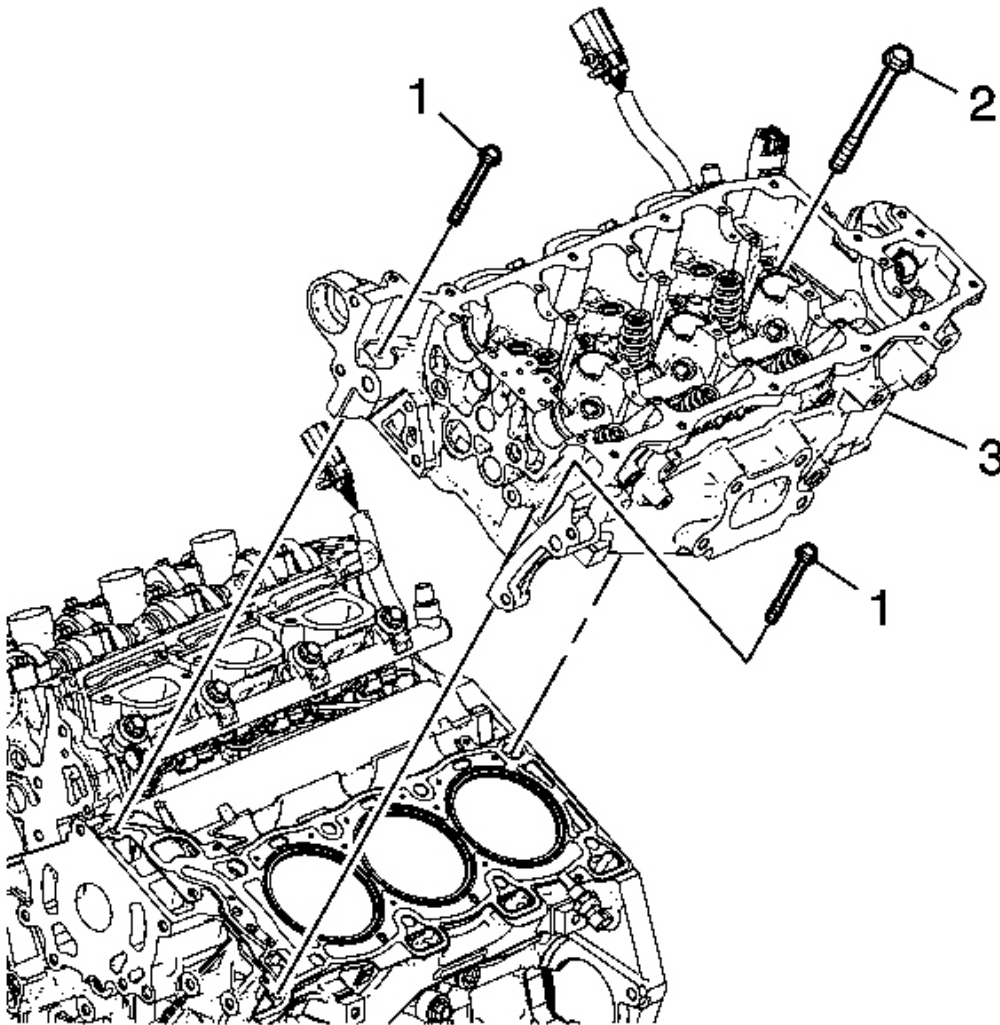


Fig. 73: Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the two front M8 left cylinder head bolts (1).
2. Remove the left cylinder head bolts (2).
3. Remove the left cylinder head (3).

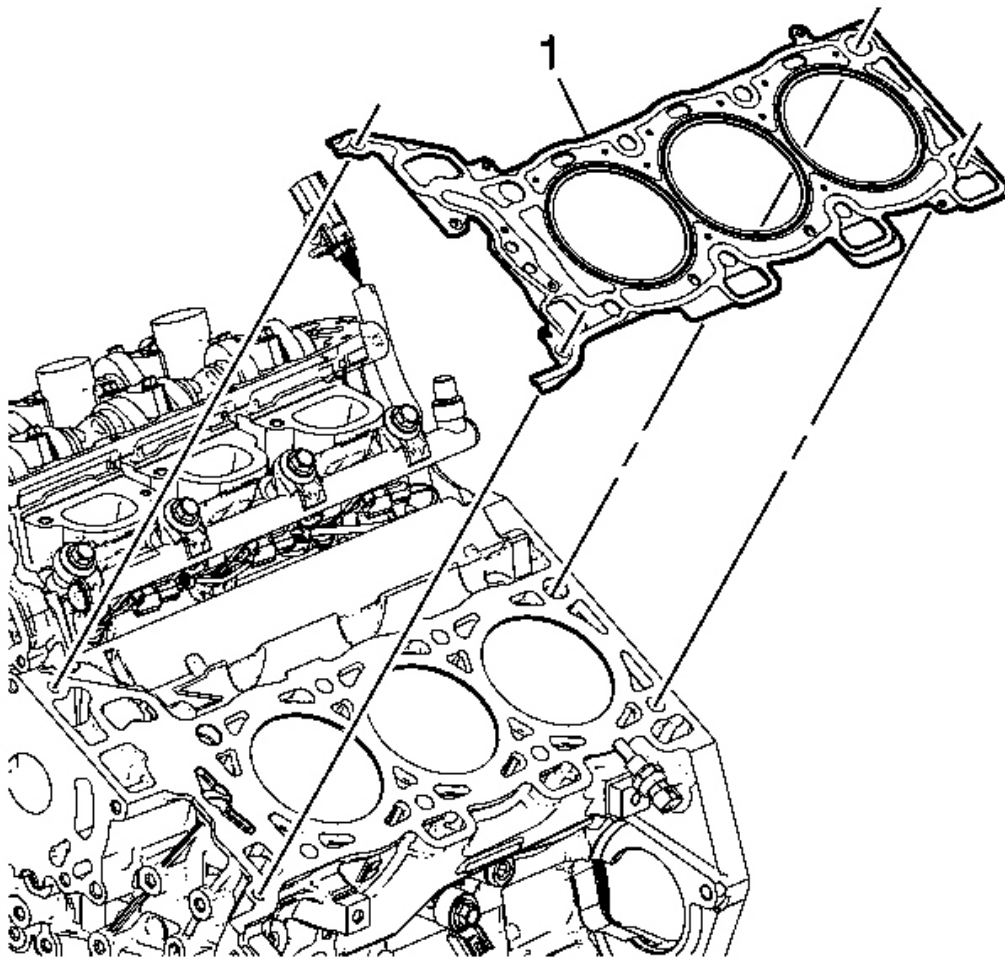


Fig. 74: Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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

CAMSHAFT REMOVAL - RIGHT SIDE

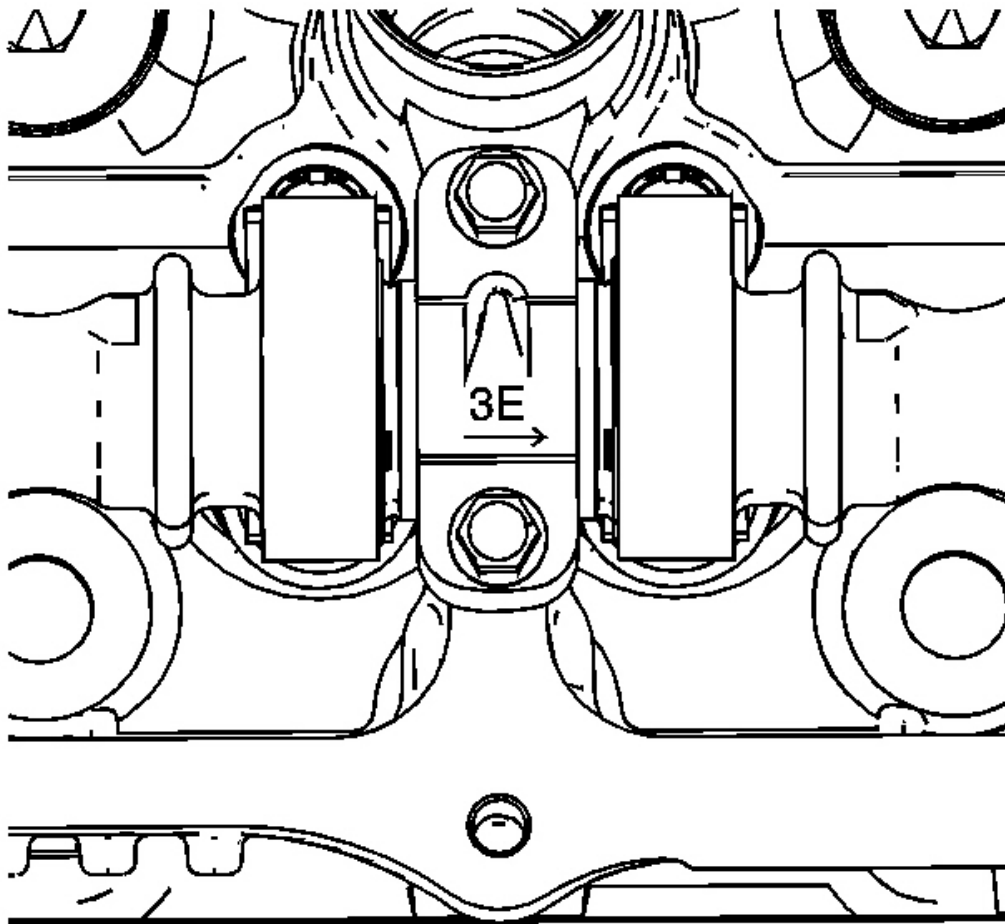


Fig. 75: Identifying Markings On Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. 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.

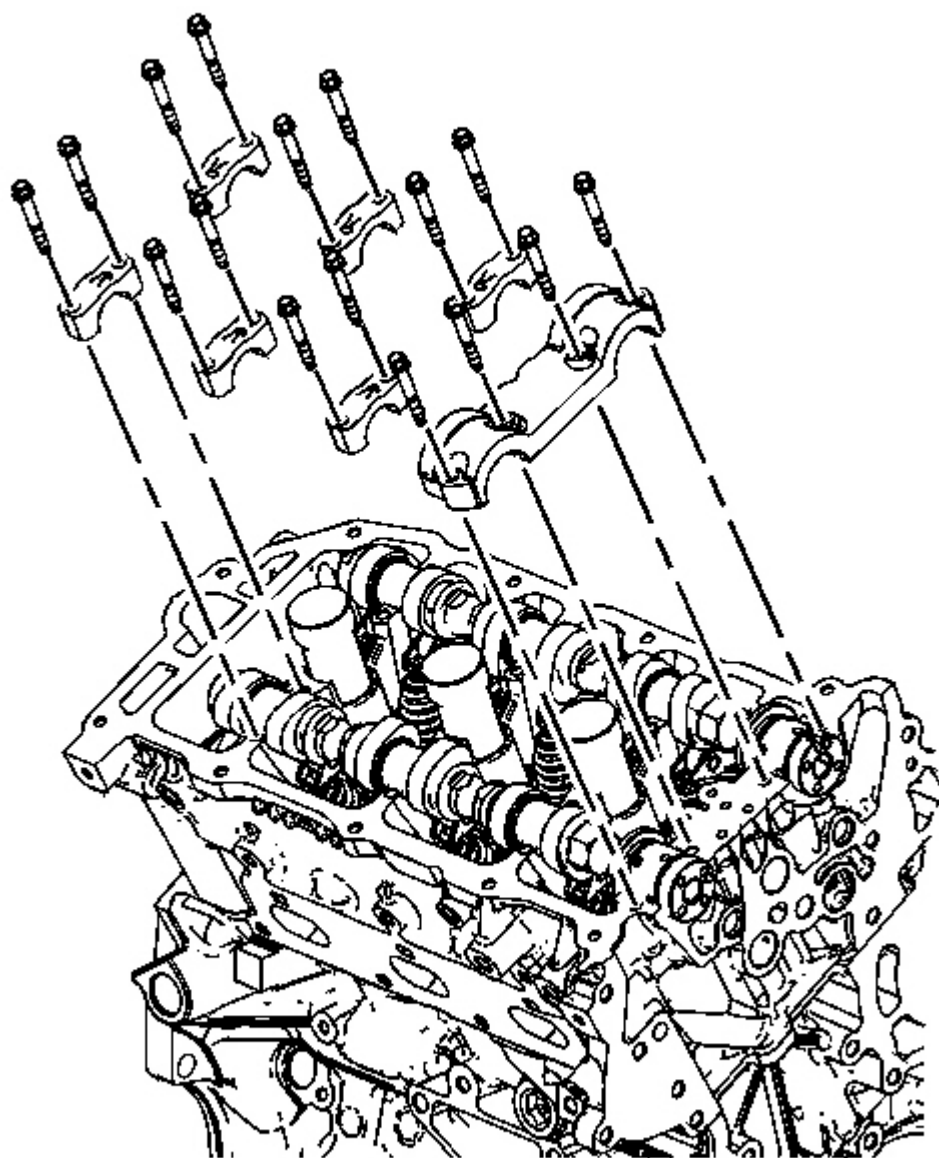


Fig. 76: View Of Camshaft Bearing Caps & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft bearing cap bolts.
3. Remove the camshaft bearing caps.

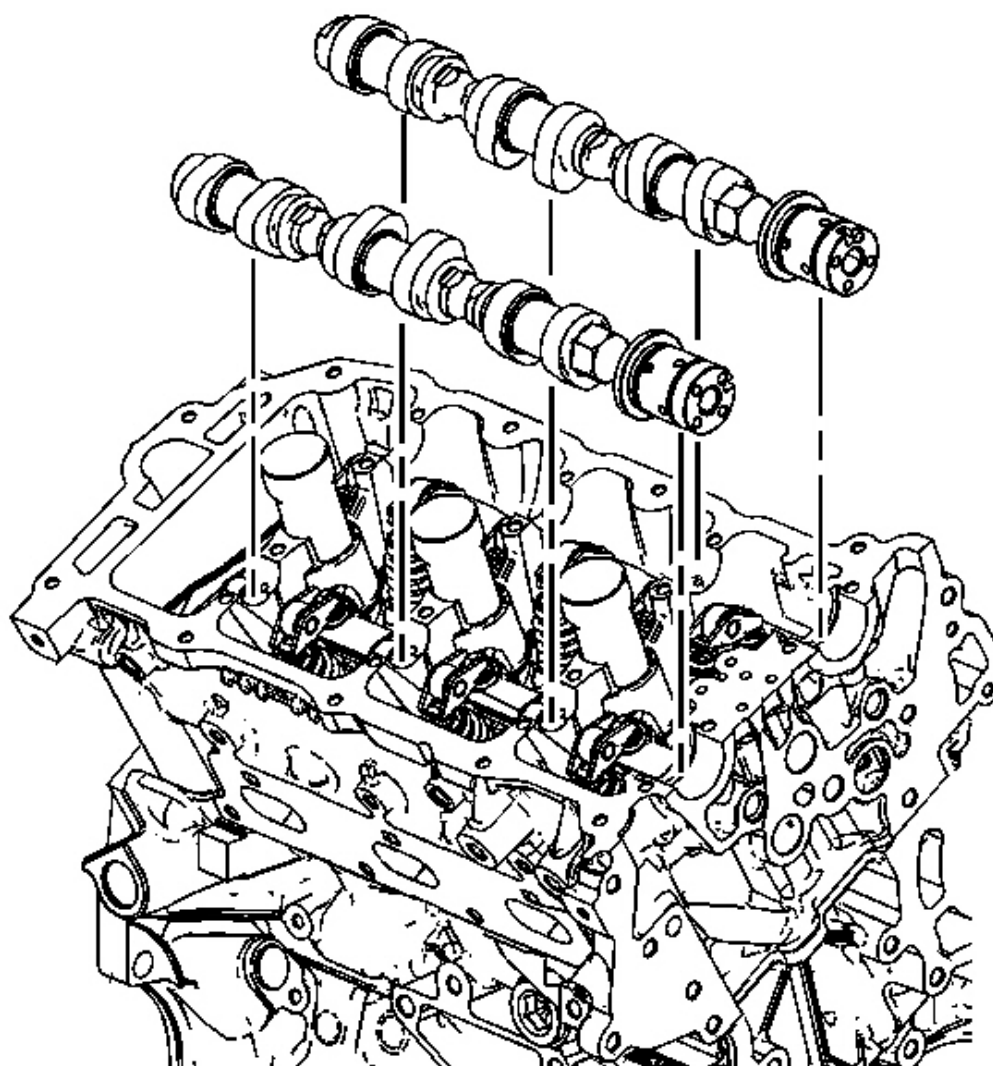


Fig. 77: Locating Camshafts

Courtesy of GENERAL MOTORS CORP.

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

4. Remove the camshafts.
5. Replace the camshaft bearing caps and bolts.

VALVE ROCKER ARM REMOVAL - RIGHT SIDE

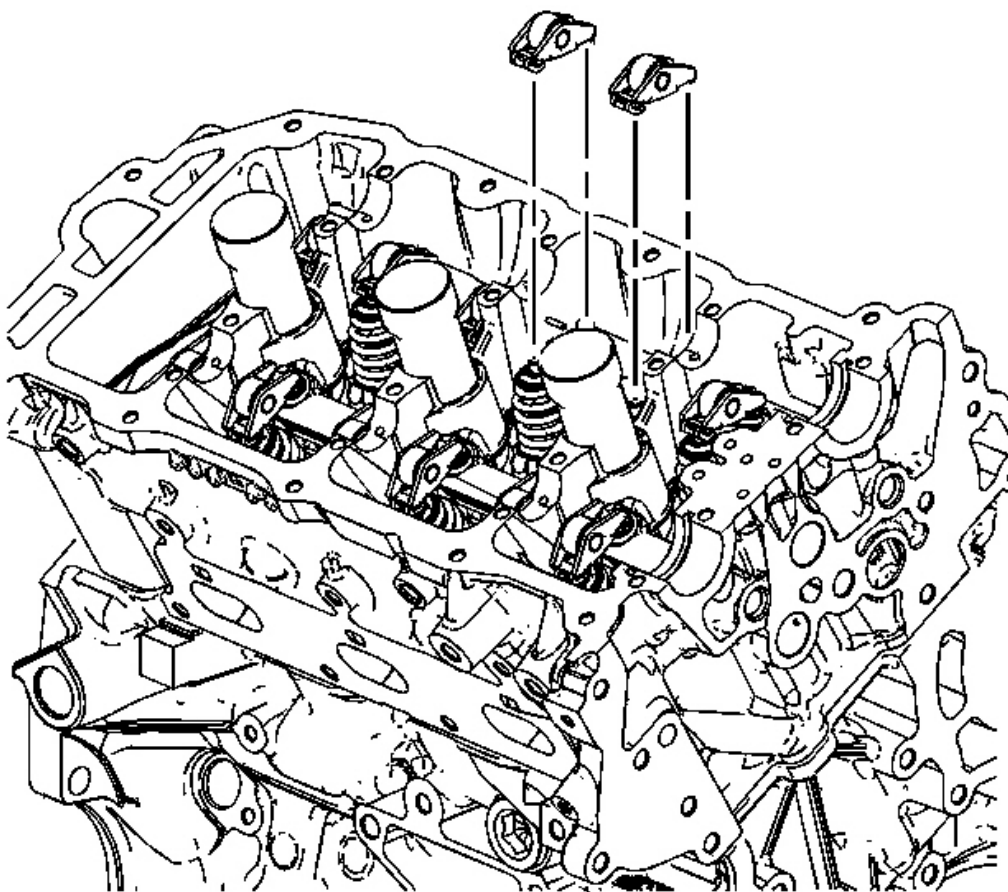


Fig. 78: Valve Rocker Arms

Courtesy of GENERAL MOTORS CORP.

Remove the valve rocker arms from the cylinder head. 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

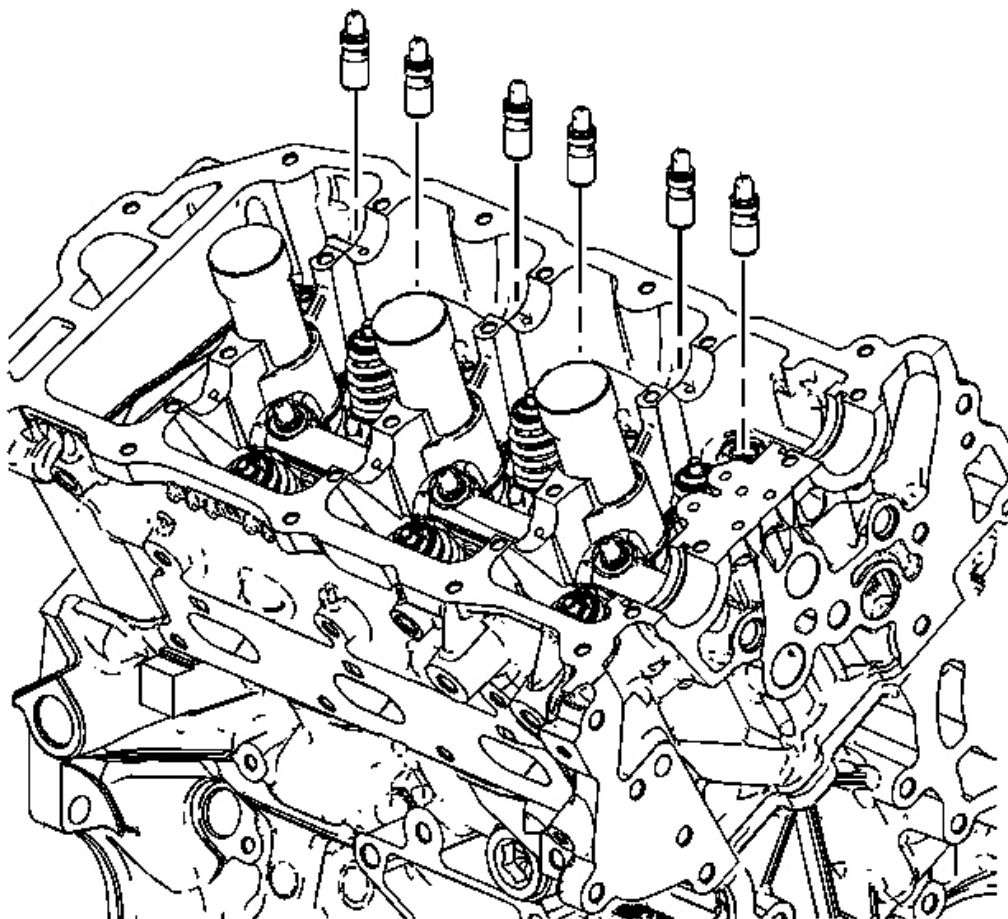


Fig. 79: View Of Stationary Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- 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.

Remove the valve lifters (SHLAs) from the cylinder head. If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

CYLINDER HEAD REMOVAL - RIGHT SIDE (LF1 OR LFW)

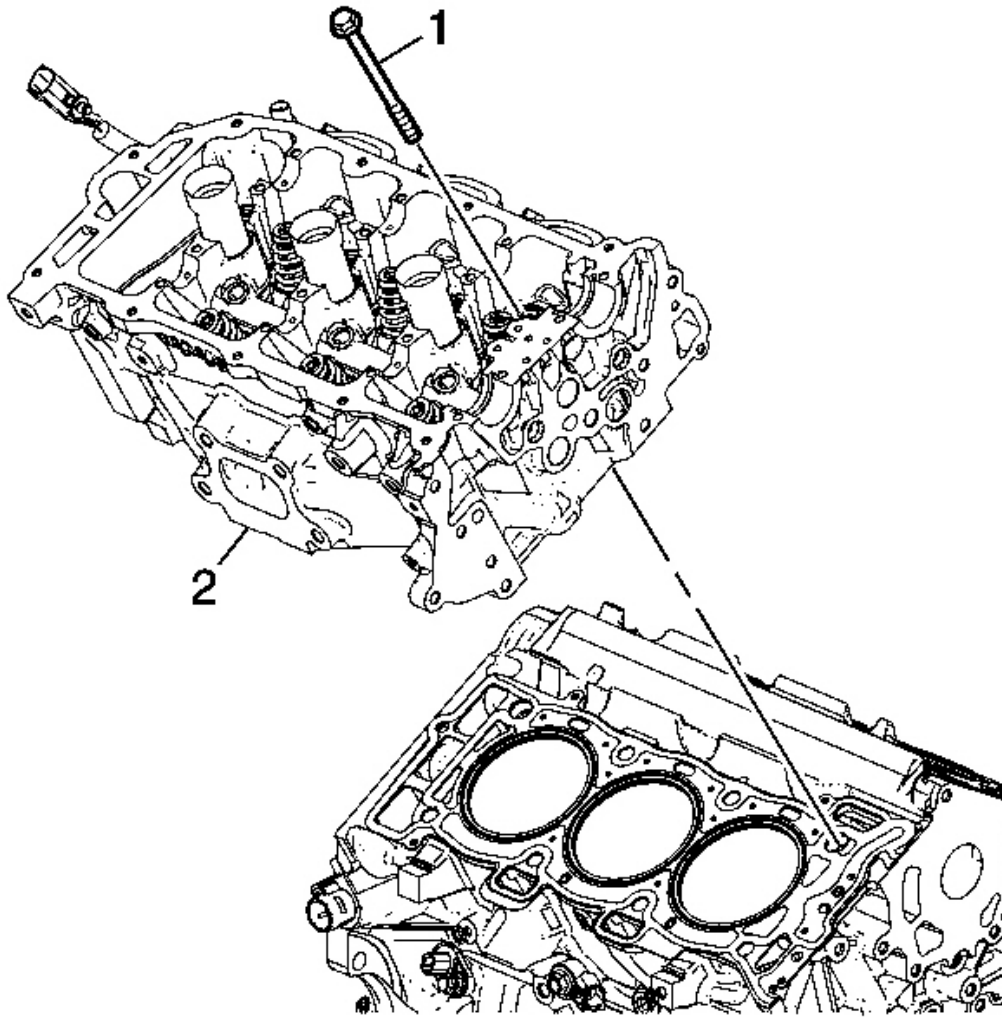


Fig. 80: Right Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the right cylinder head bolts (1).
2. Remove the right cylinder head (2).

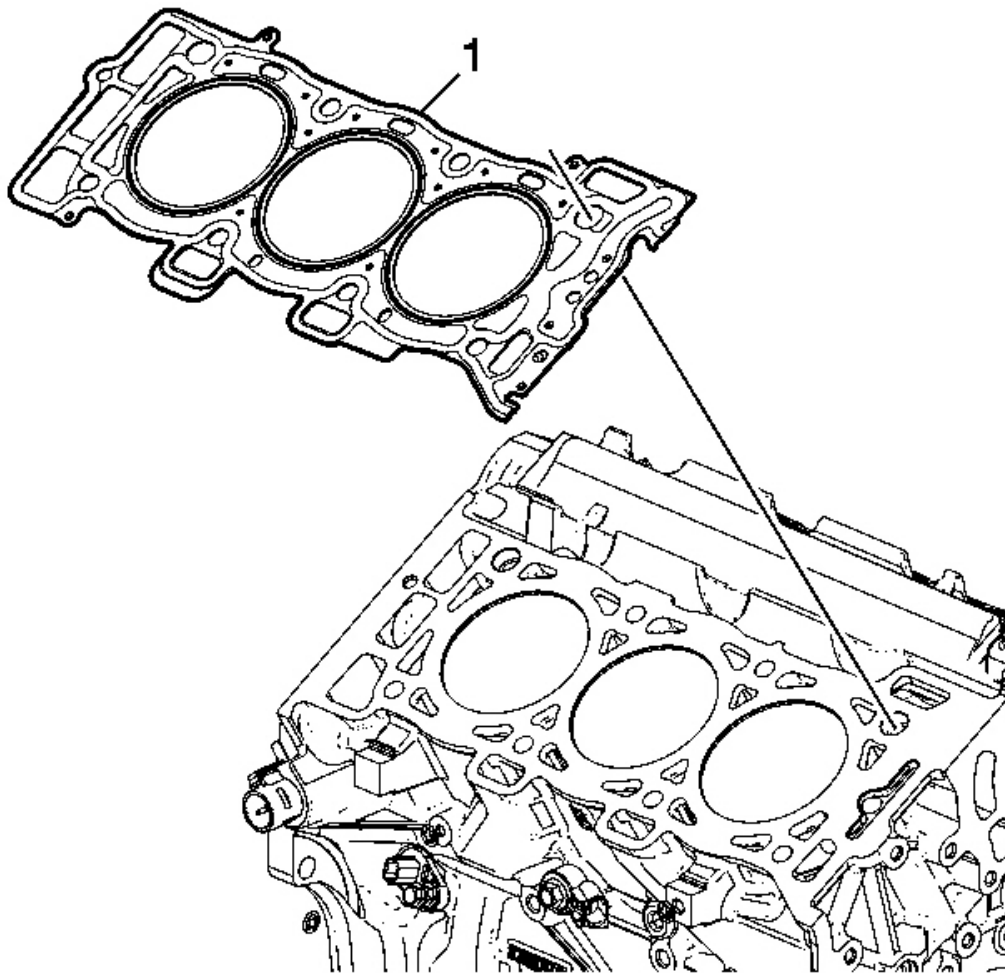


Fig. 81: Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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

OIL PAN REMOVAL

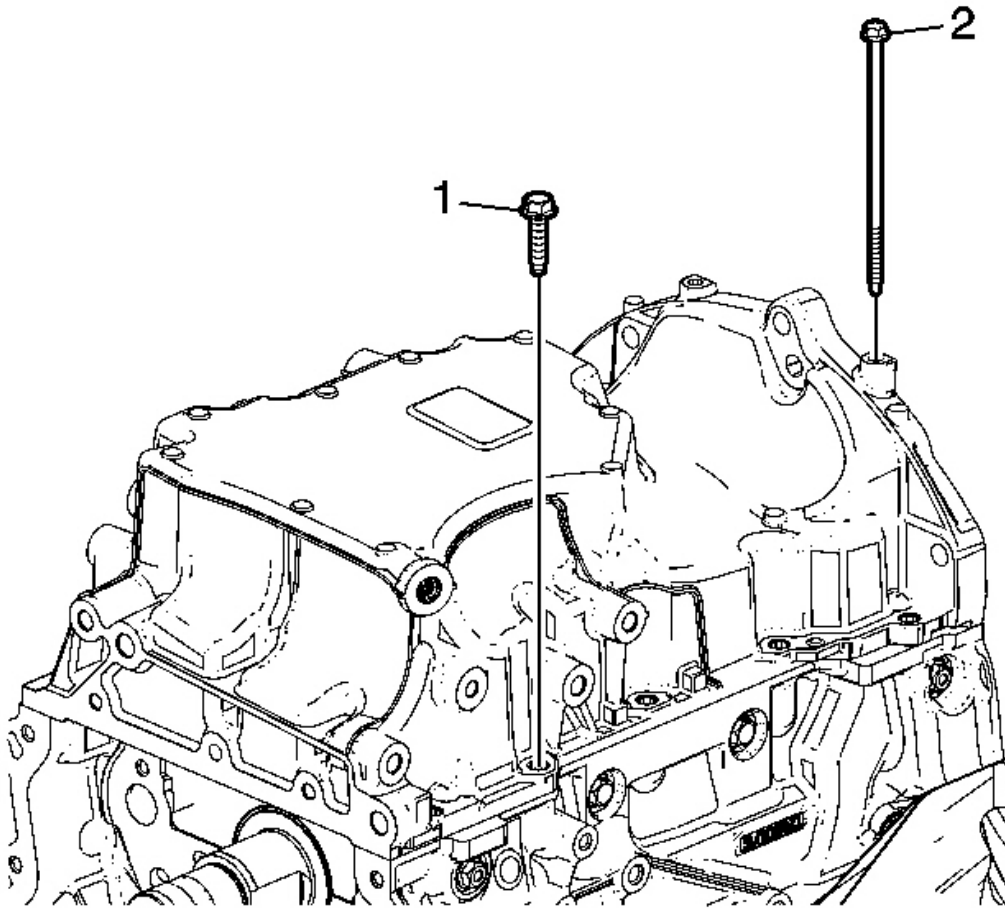


Fig. 82: Oil Pan Bolts

Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan bolts (1) and (2).
2. Using the pry points located at the edge of the oil pan separate the RTV sealant.

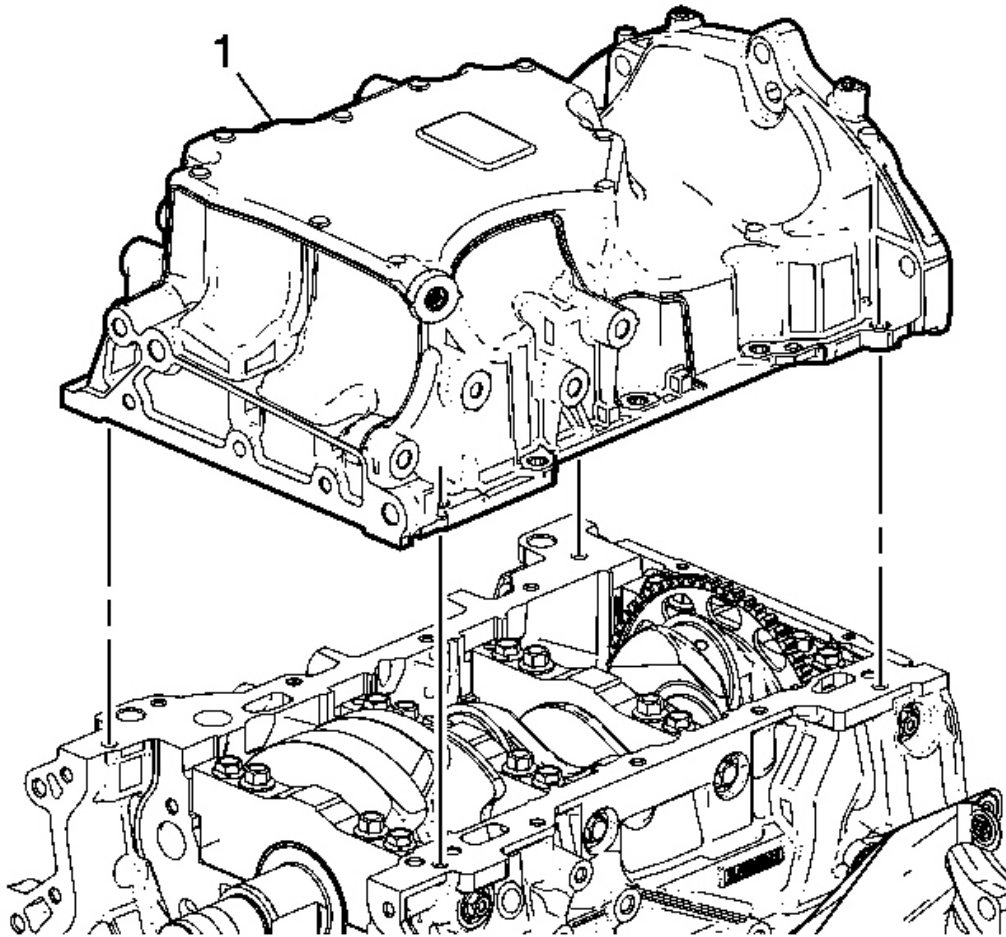


Fig. 83: Oil Pan

Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan (1) from the block.

OIL PUMP REMOVAL

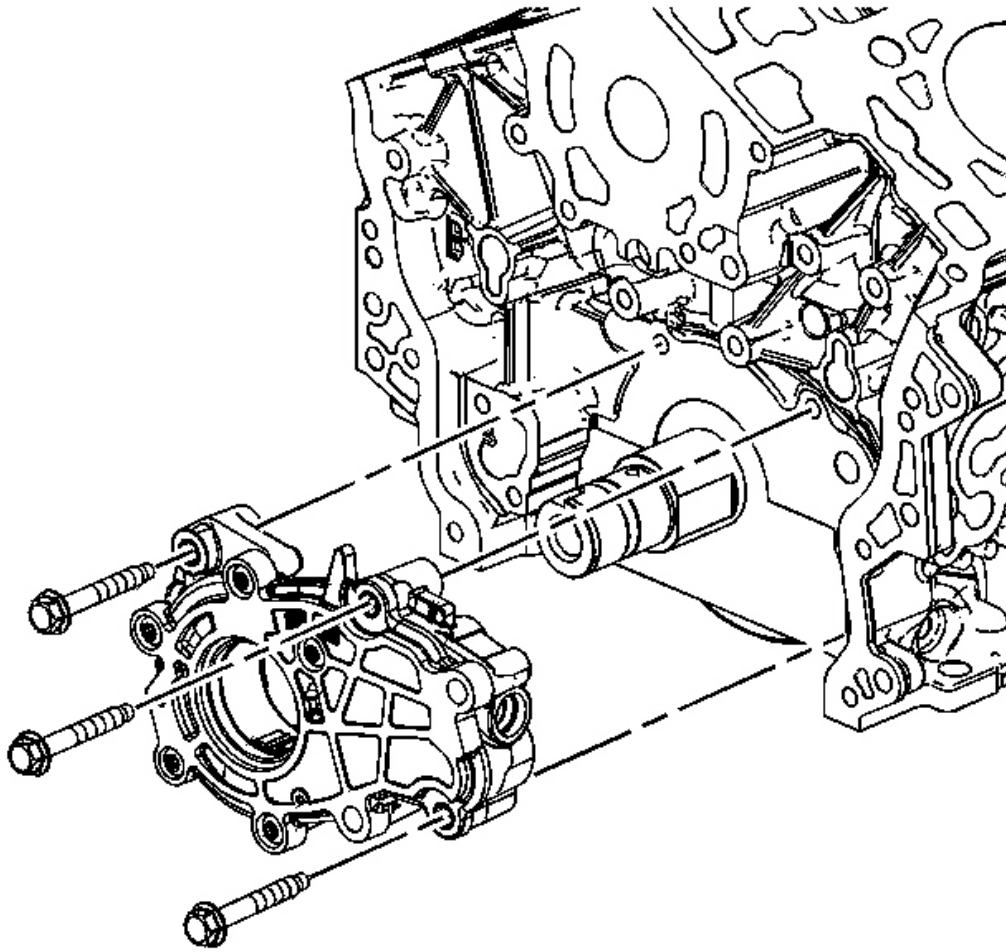


Fig. 84: Oil Pump Bolts

Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump bolts.
2. Remove the oil pump.

CRANKSHAFT REAR OIL SEAL AND HOUSING REMOVAL

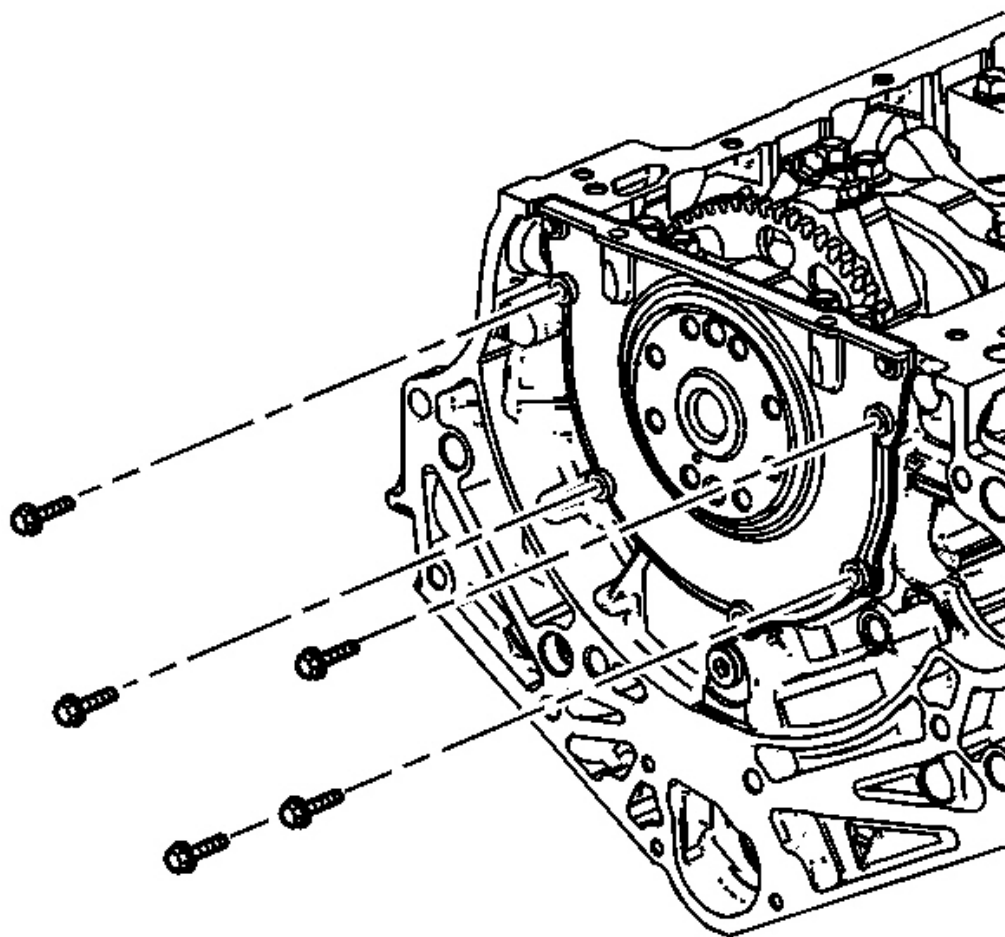


Fig. 85: View Of Crankshaft Rear Oil Seal Housing Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft rear oil seal housing bolts.

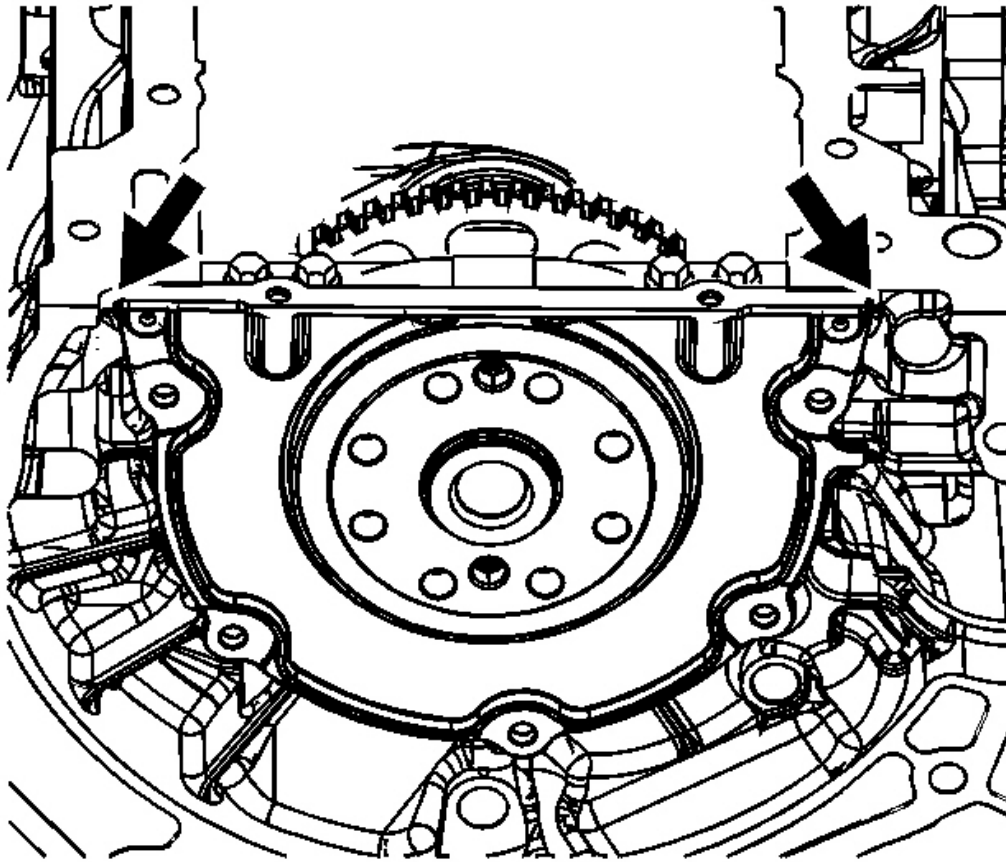


Fig. 86: Identifying Pry Points On Edge Of The Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

2. Use the pry points located at the edge of the crankshaft rear oil seal housing to separate the RTV sealant.

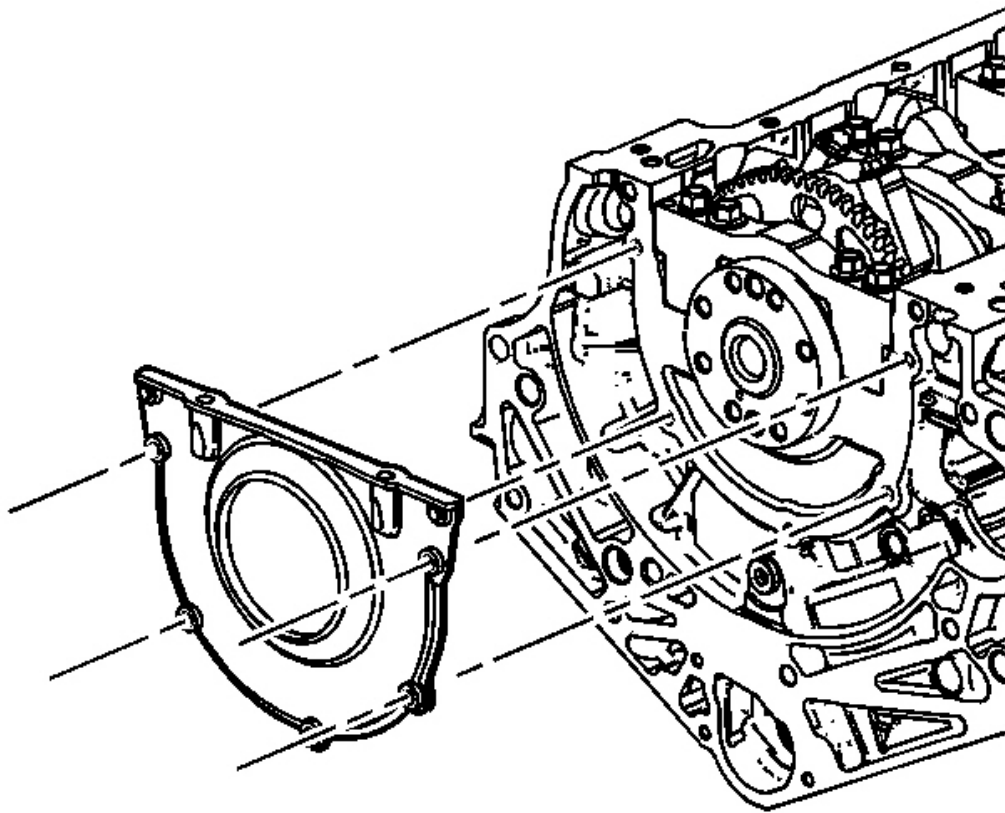


Fig. 87: View Of Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

3. 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** .

REMOVAL

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 (LF1)** .
 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.

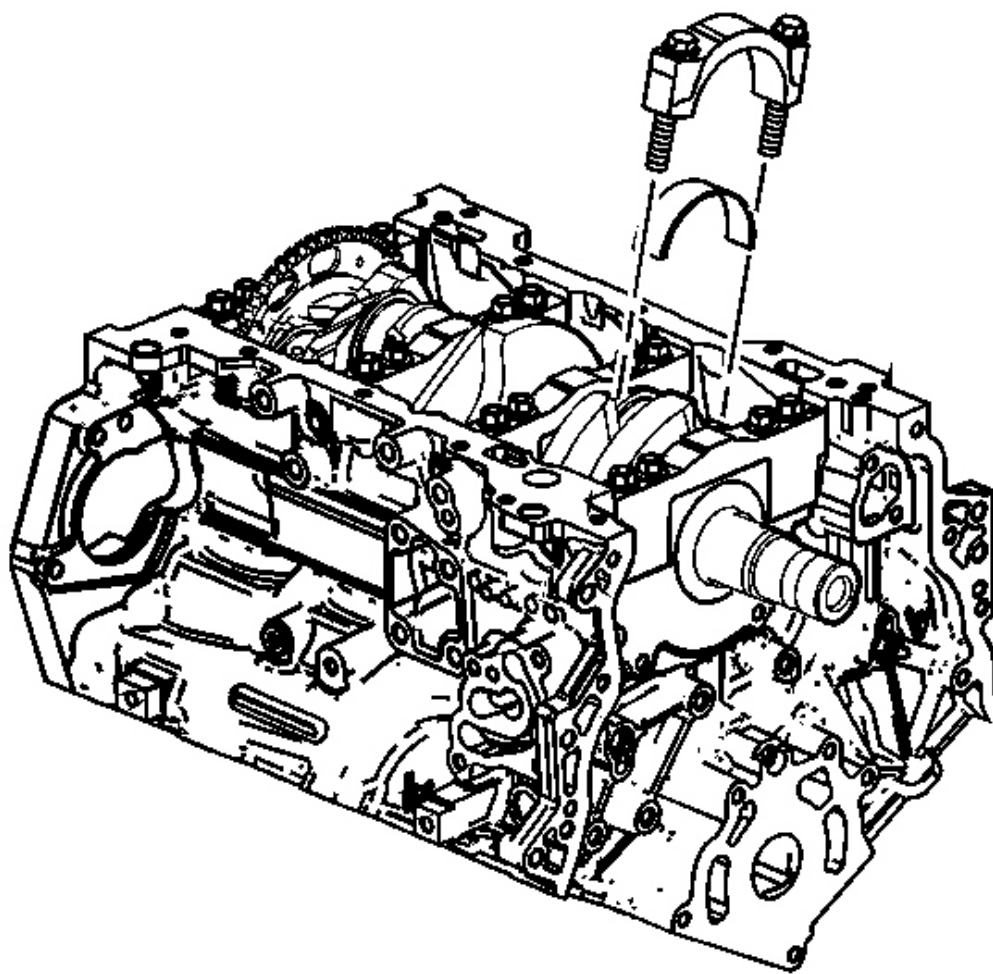


Fig. 88: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

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.

4. Remove the connecting rod bolts.

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

5. Remove the connecting rod cap.

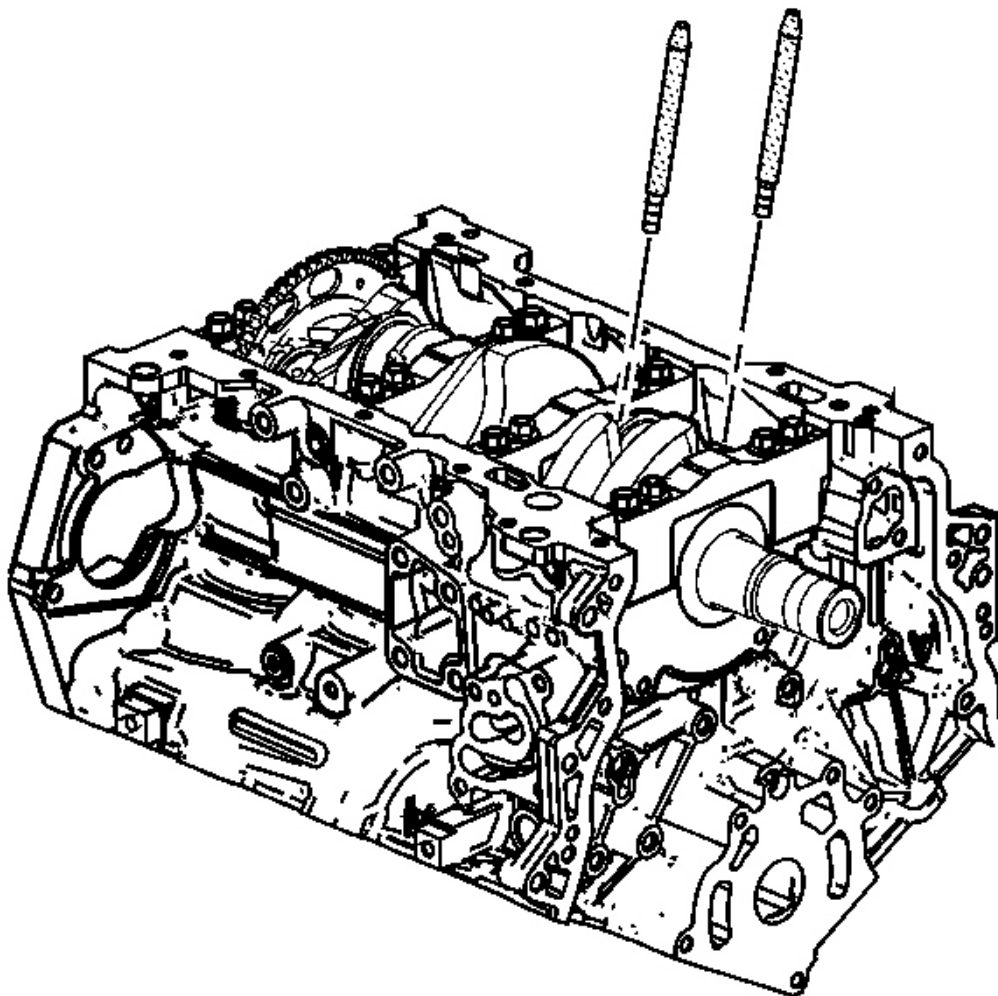


Fig. 89: View Of EN 46121
Courtesy of GENERAL MOTORS CORP.

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

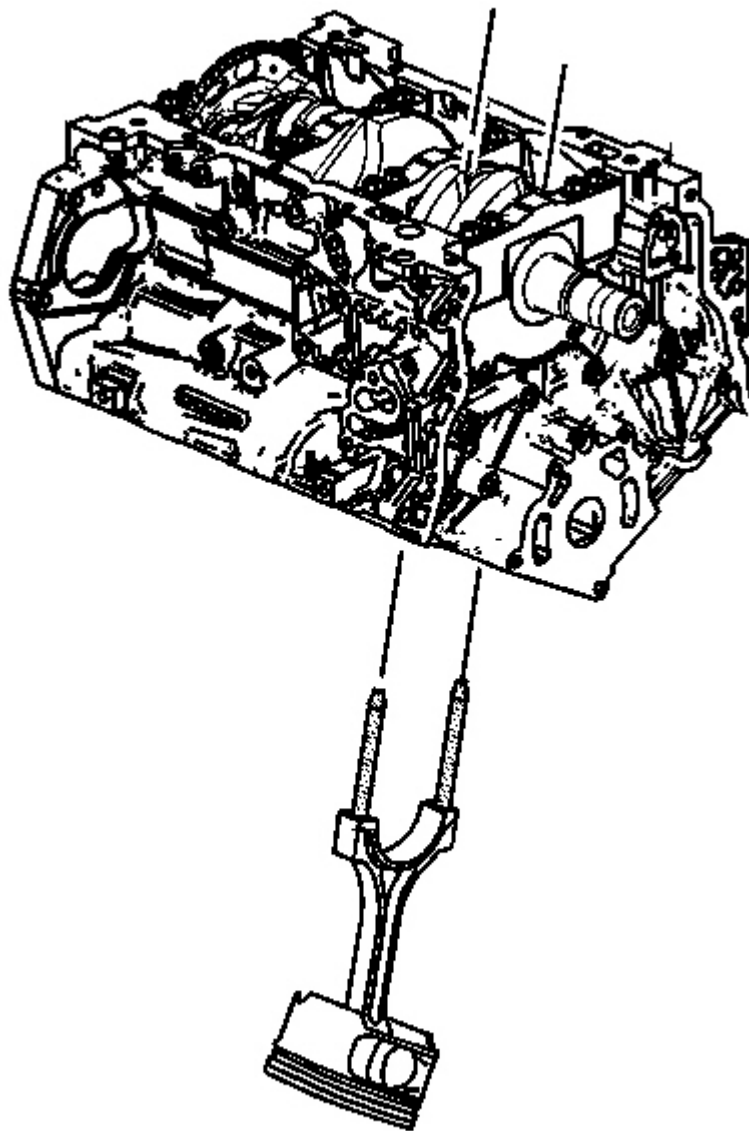


Fig. 90: View Of Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS CORP.

7. 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.

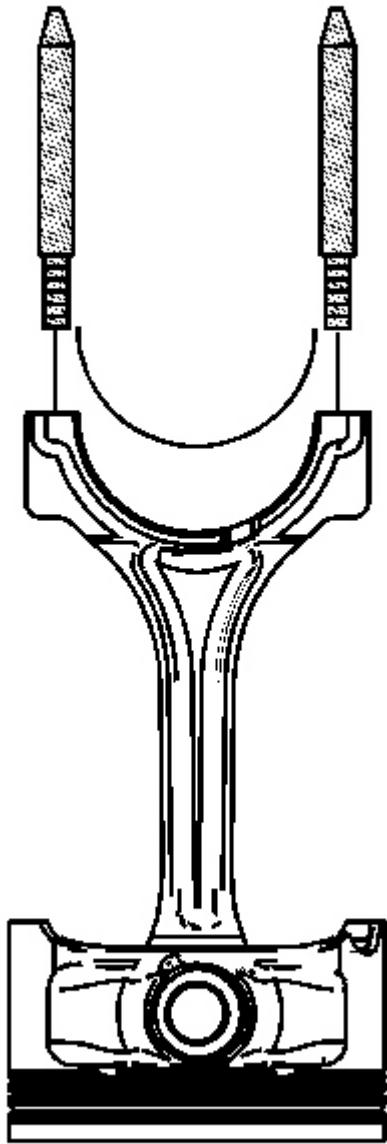


Fig. 91: View Of Piston/Connecting Rod Installation Tool
Courtesy of GENERAL MOTORS CORP.

8. Remove the **EN 46121**: set from the connecting rod bolt holes.
9. Remove the upper connecting rod bearing from the connecting rod.

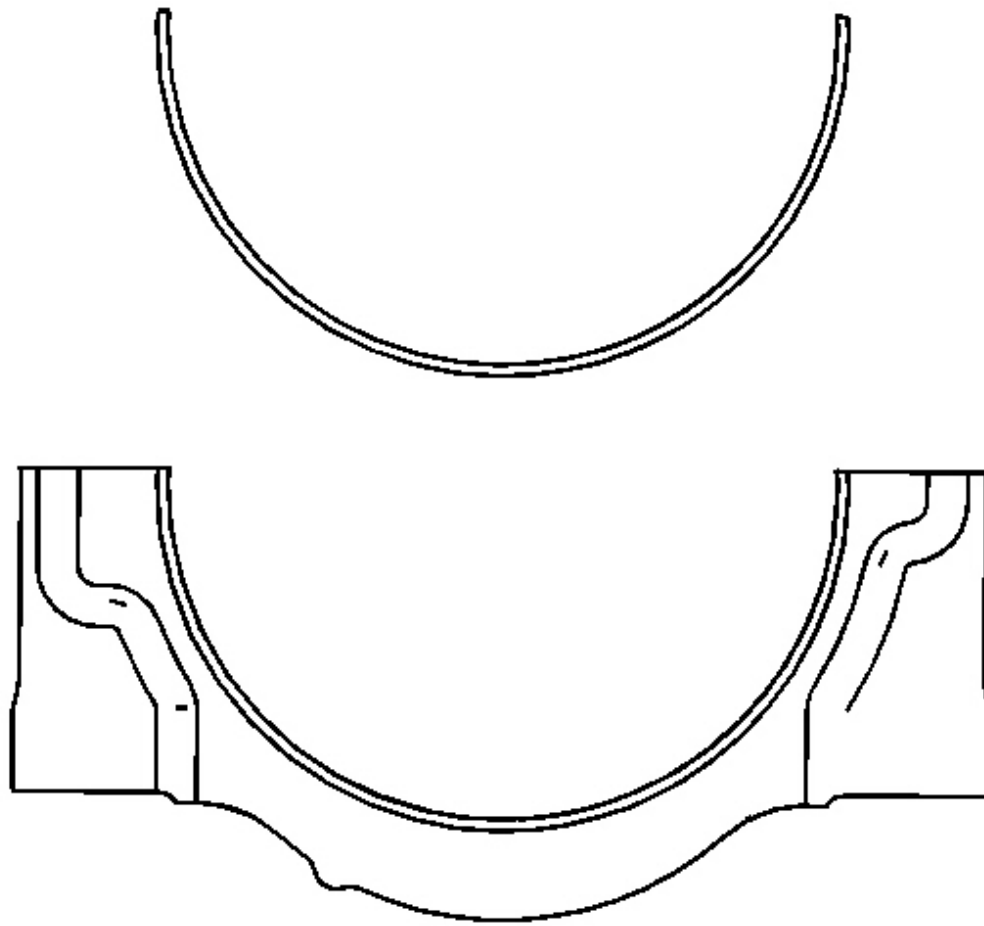


Fig. 92: View Of Lower Connecting Rod Cap & Bearing
Courtesy of GENERAL MOTORS CORP.

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

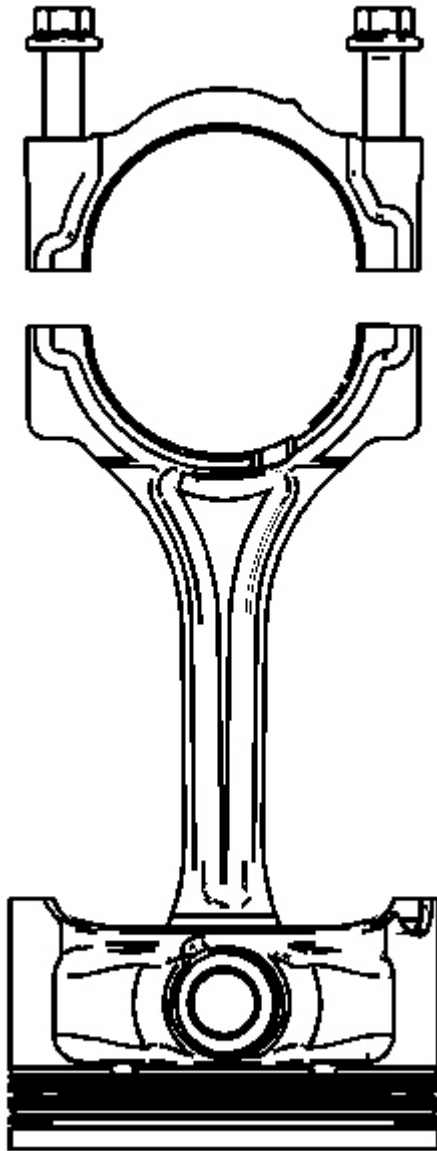


Fig. 93: View Of Connecting Rod Cap, Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS CORP.

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 (LF1)** .
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 (LF1)** .
5. Replace the thrust bearing or crankshaft as necessary.

CRANKSHAFT REMOVAL

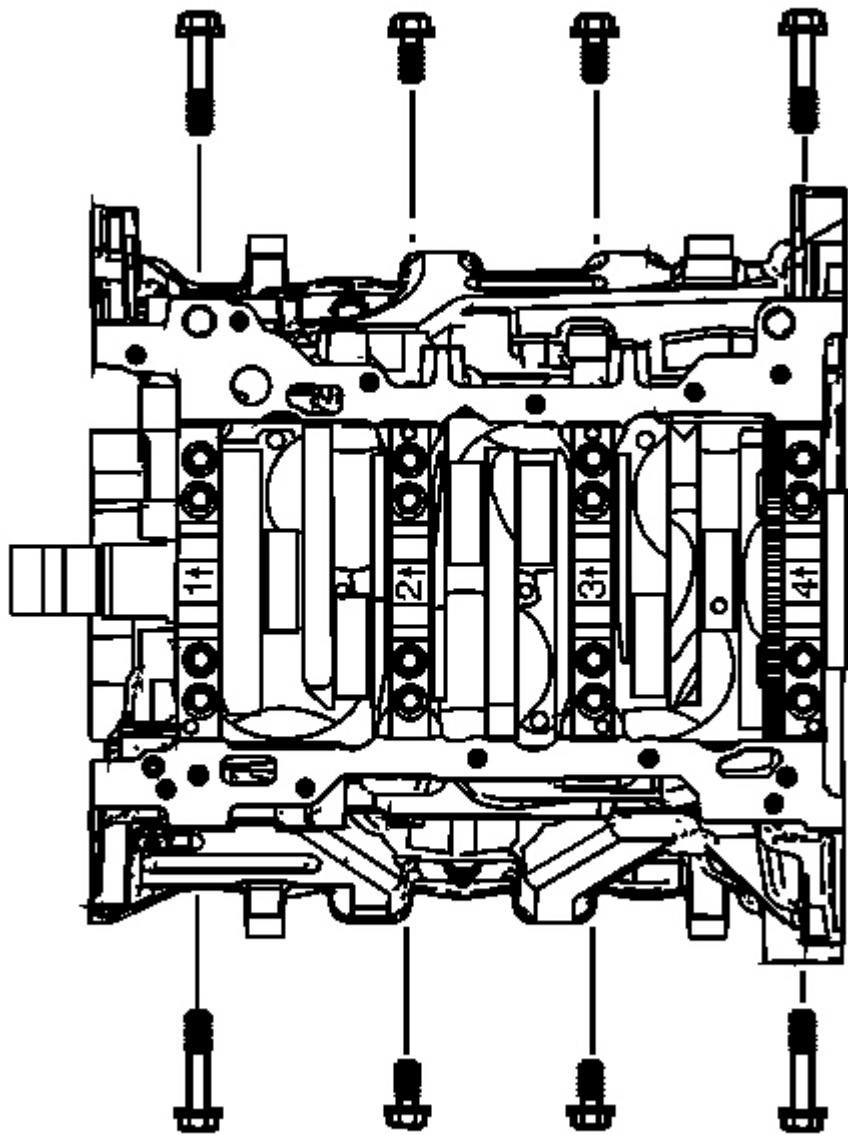


Fig. 94: Identifying Crankshaft Main Bearing Cap Side Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft bearing cap side bolts.
2. Remove the crankshaft bearing cap outer bolts.
3. Remove the crankshaft bearing cap inner bolts.

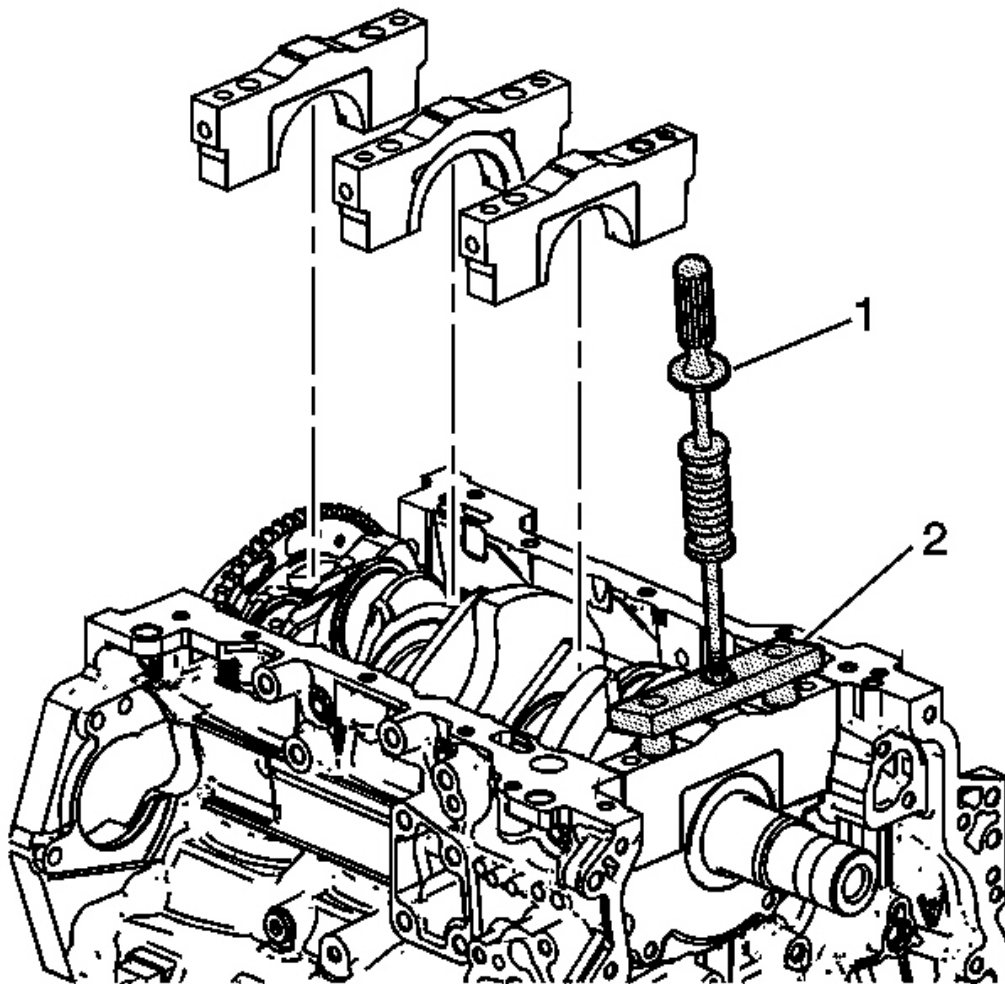


Fig. 95: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

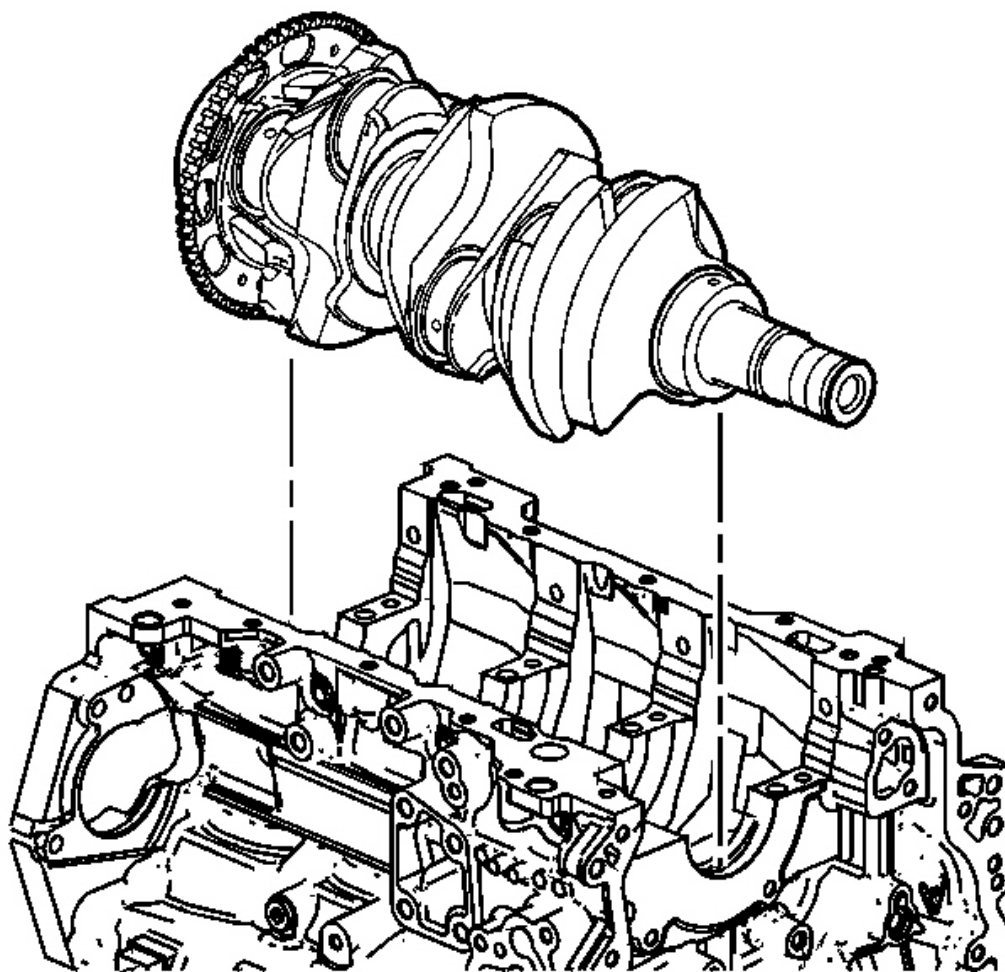


Fig. 96: View Of Crankshaft

Courtesy of GENERAL MOTORS CORP.

5. Using two hands, lift the crankshaft straight up from the engine block.
6. Place the crankshaft in a secure place.

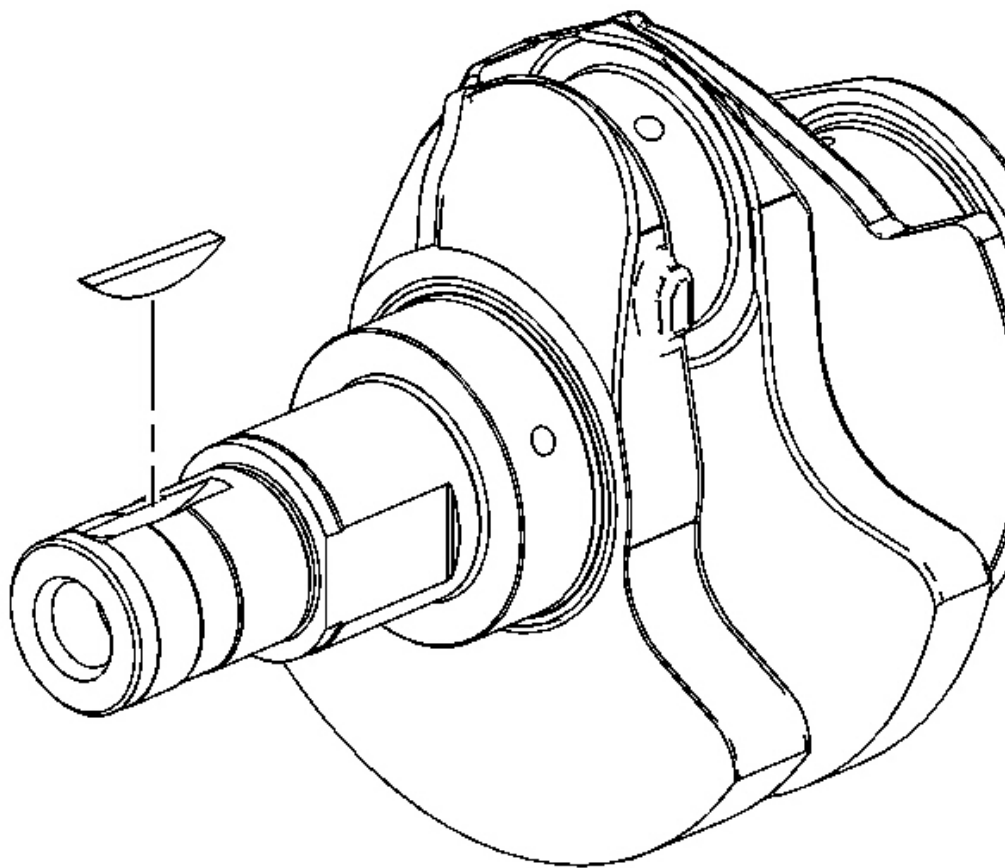


Fig. 97: Locating Crankshaft Sprocket Drive Pin
Courtesy of GENERAL MOTORS CORP.

7. 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.

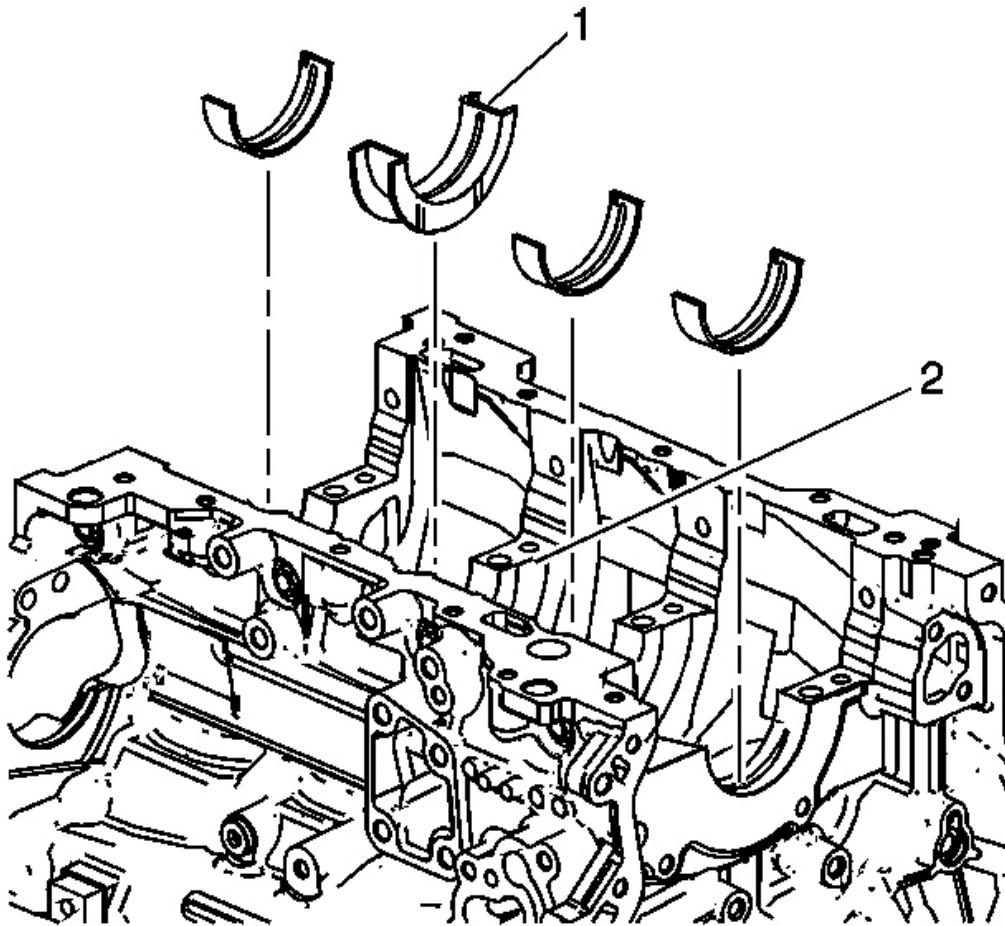


Fig. 98: Locating Thrust Bearing In Number 3 Journal
Courtesy of GENERAL MOTORS CORP.

2. 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.

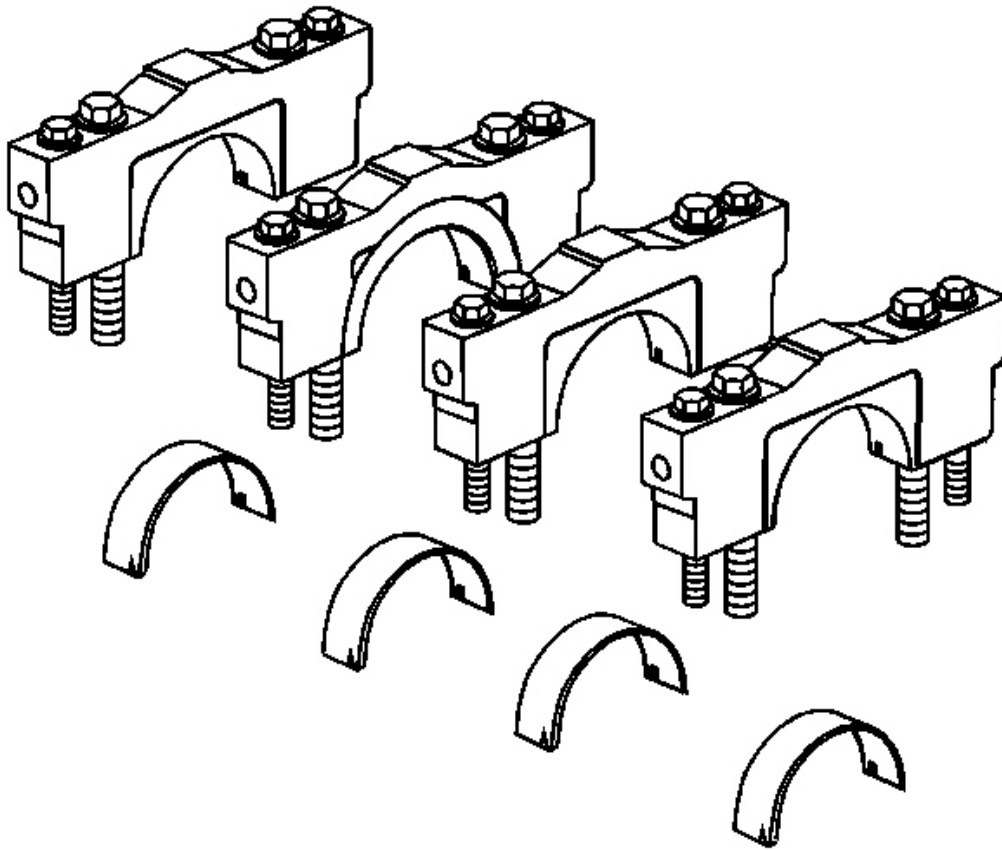


Fig. 99: View Of Crankshaft Bearing Caps & Lower Bearing Halves
Courtesy of GENERAL MOTORS CORP.

4. 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

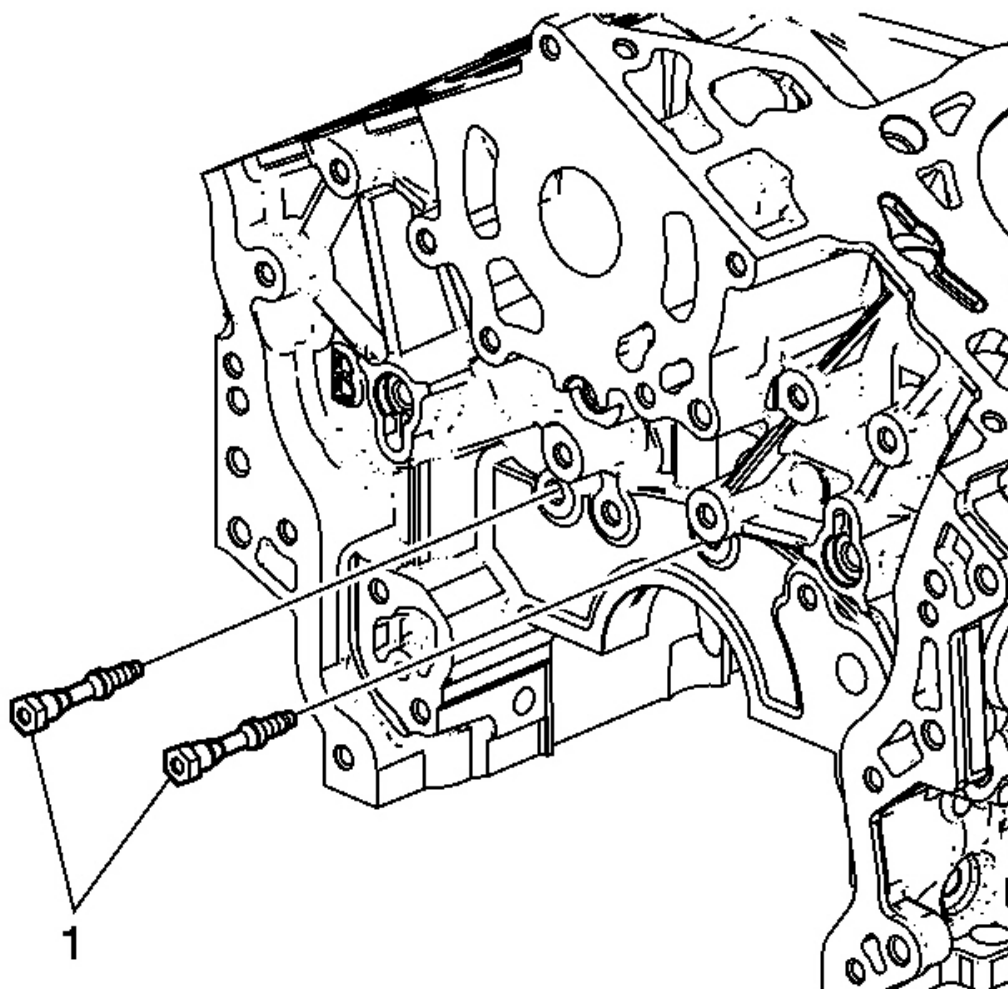


Fig. 100: Engine Front Cover Studs
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover studs (1).

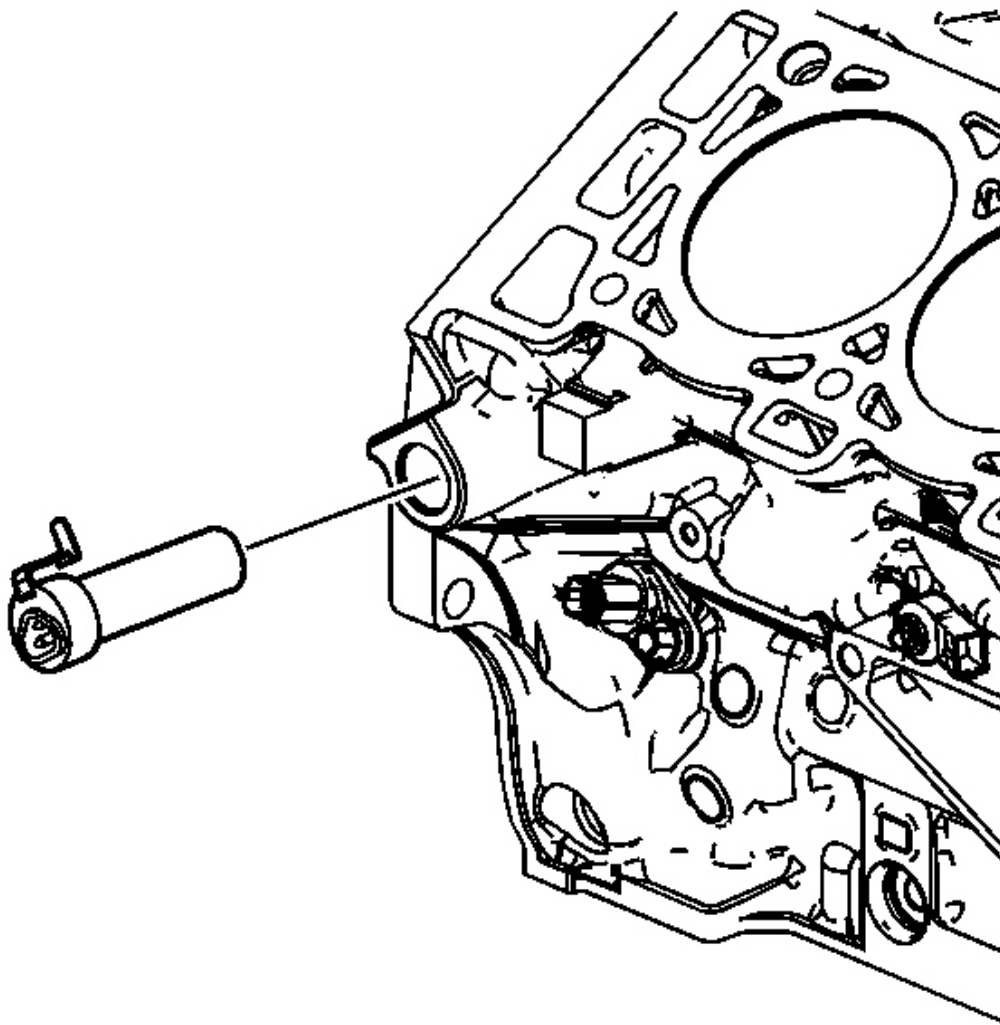


Fig. 101: View Of Block Heater Cartridge
Courtesy of GENERAL MOTORS CORP.

2. Remove the block heater cartridge, if equipped.

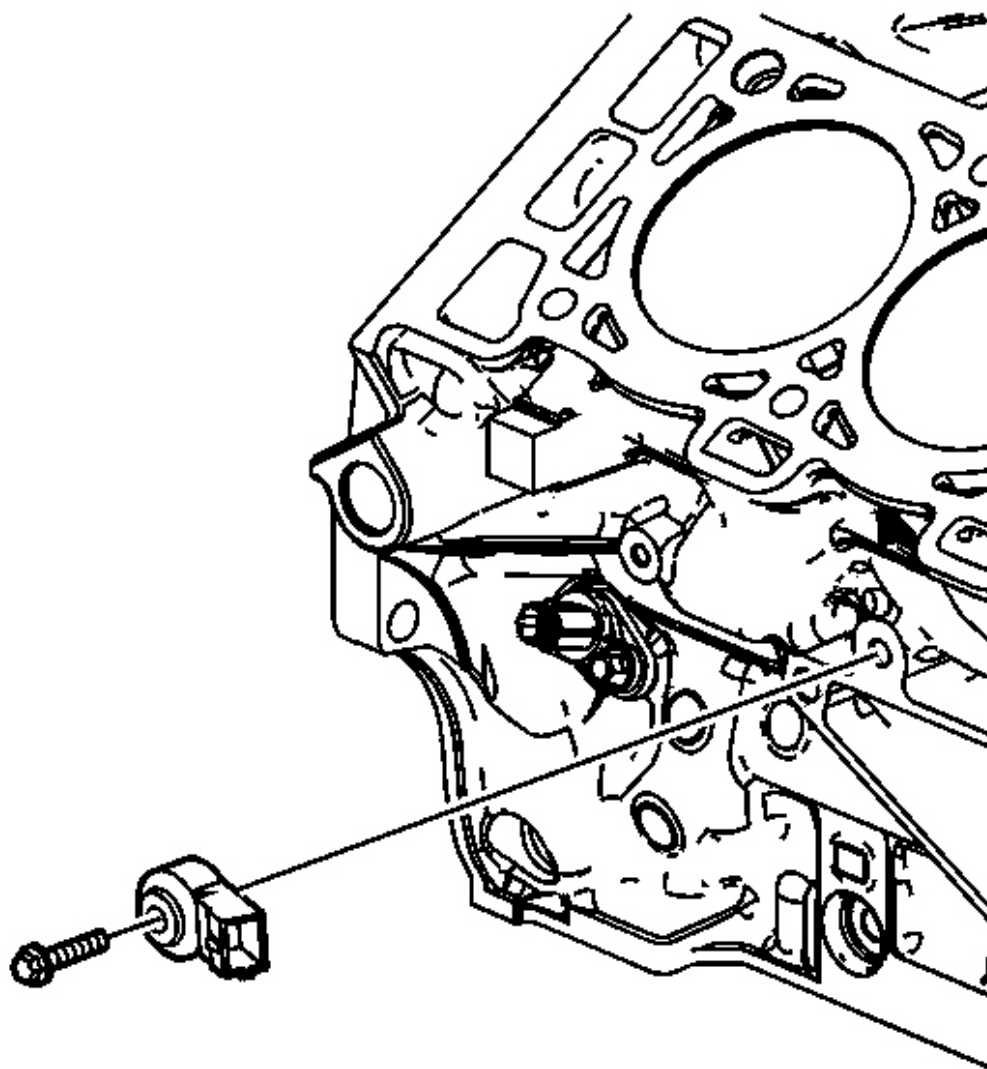


Fig. 102: View Of Right Knock Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the right knock sensor bolt.
4. Remove the right knock sensor.

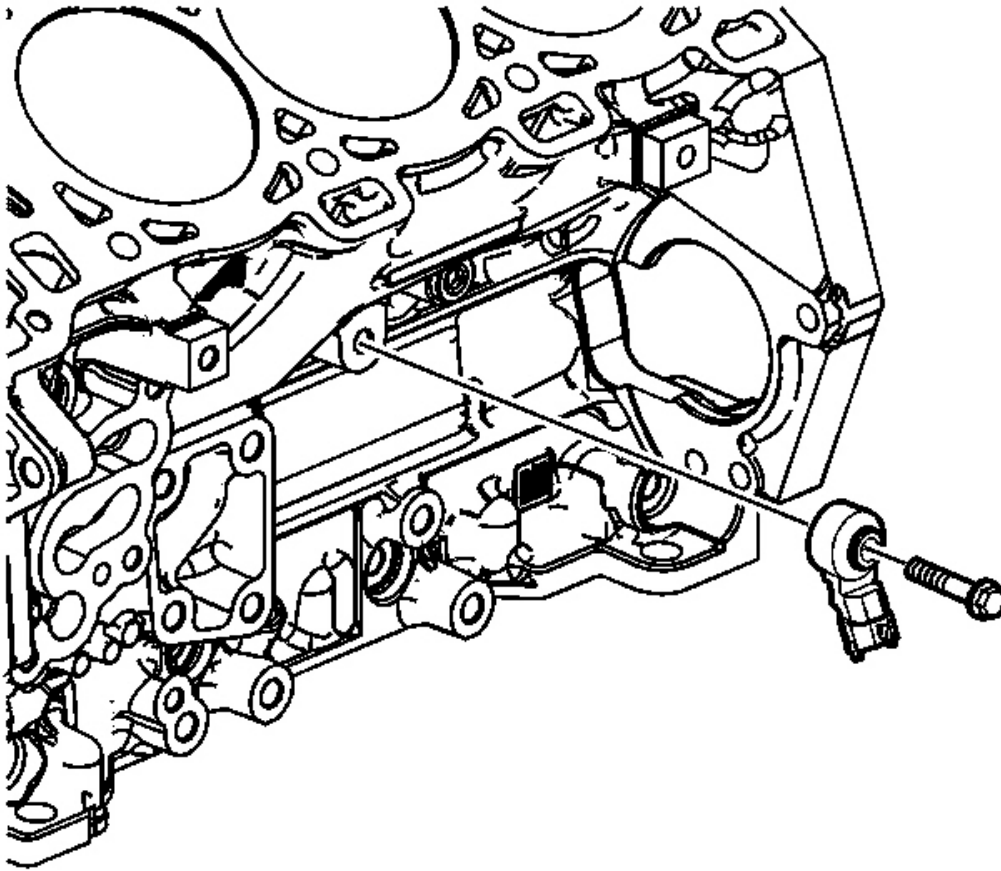


Fig. 103: View Of Left Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the left knock sensor bolt.
6. Remove the left knock sensor.

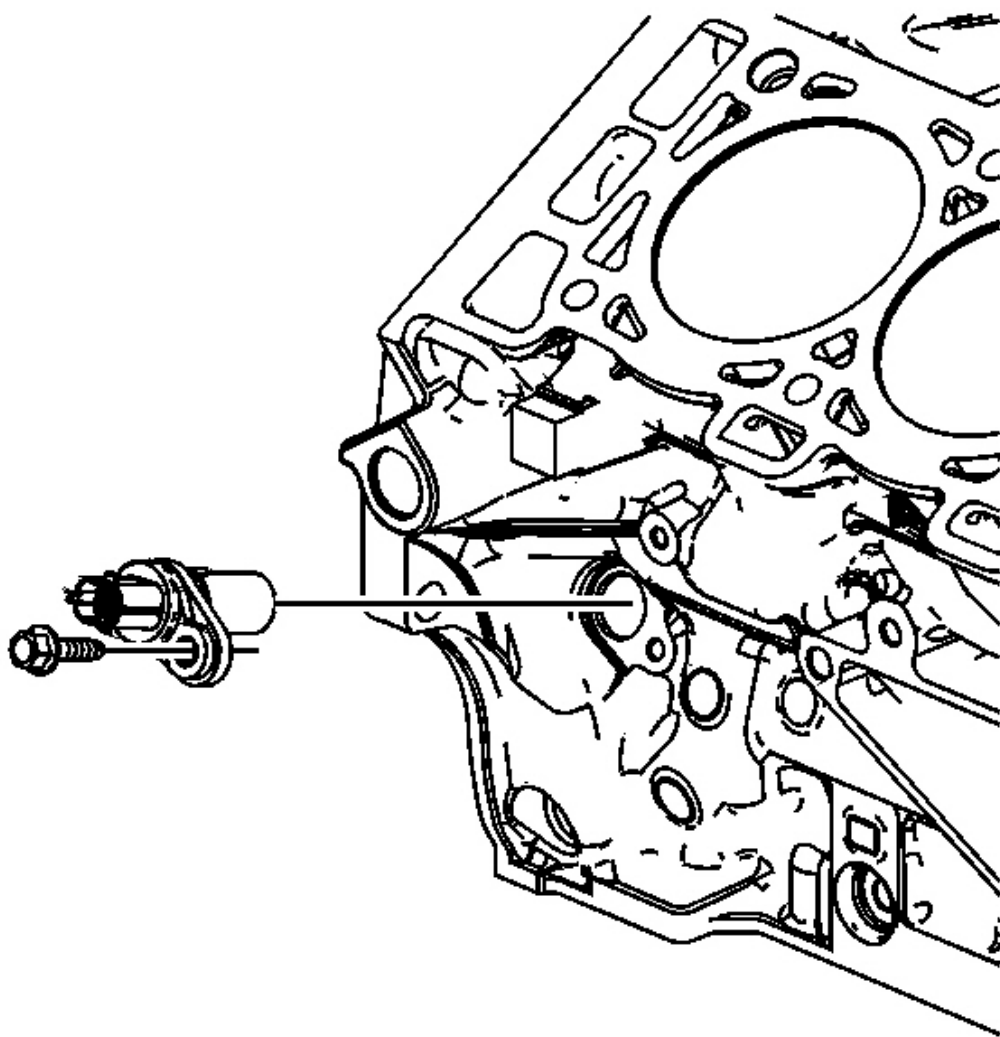


Fig. 104: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft position sensor bolt.
8. Remove the crankshaft position sensor.

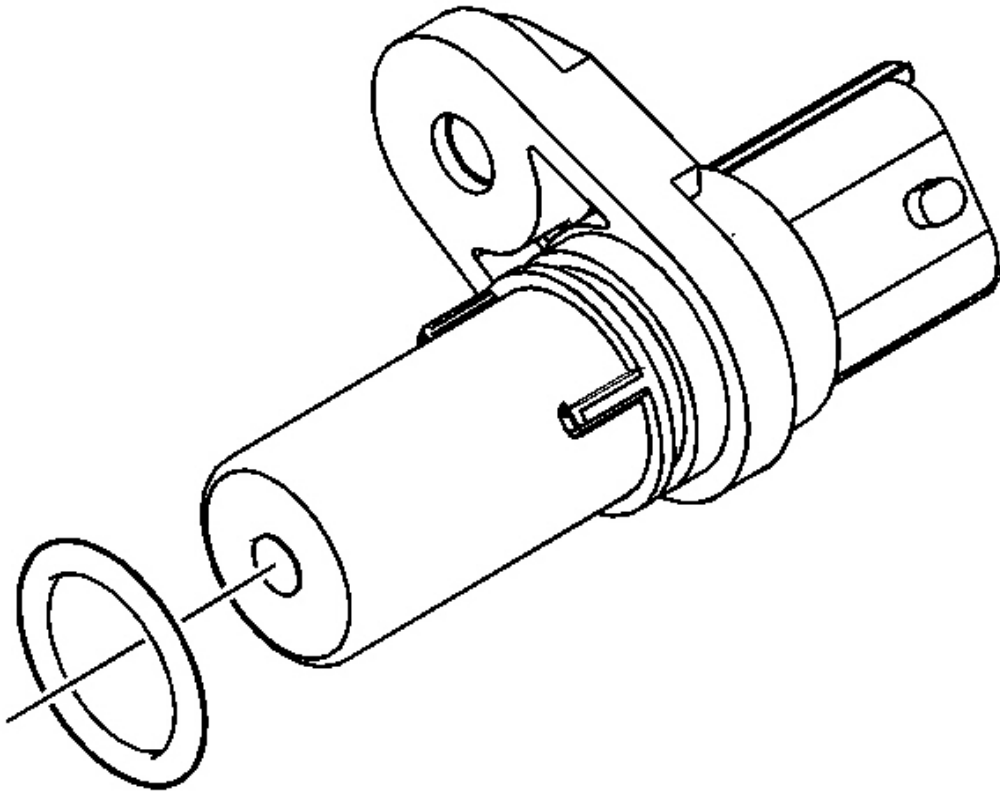


Fig. 105: View Of Crankshaft Position Sensor O-Ring
Courtesy of GENERAL MOTORS CORP.

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

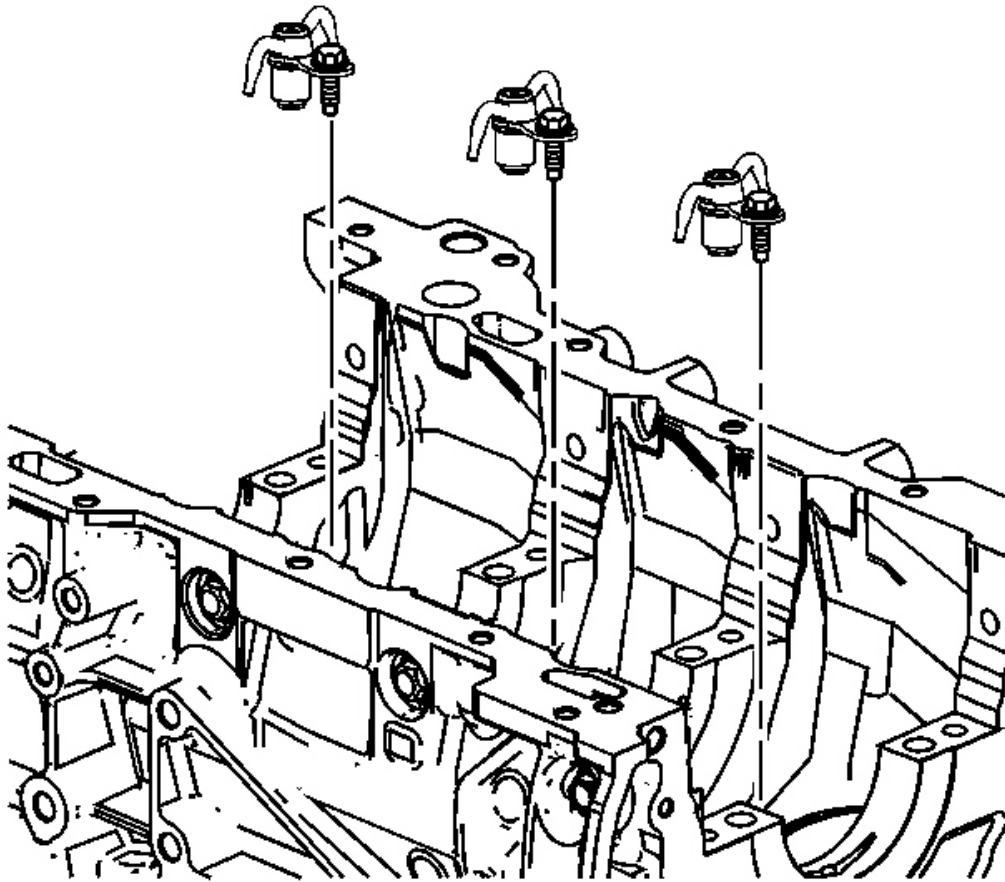


Fig. 106: View Of Oil Jets & Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove oil jet bolts.
11. Remove oil jets.

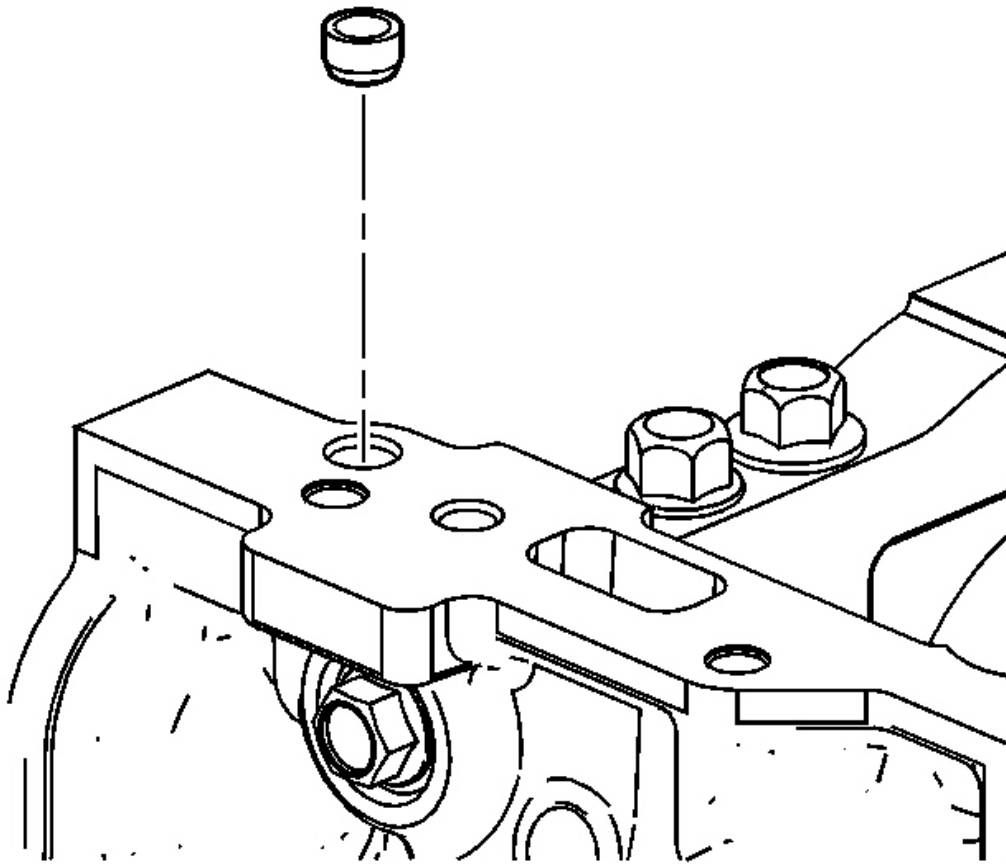


Fig. 107: Right Front Oil Pan Rail Oil Gallery Expansion Plug
Courtesy of GENERAL MOTORS CORP.

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

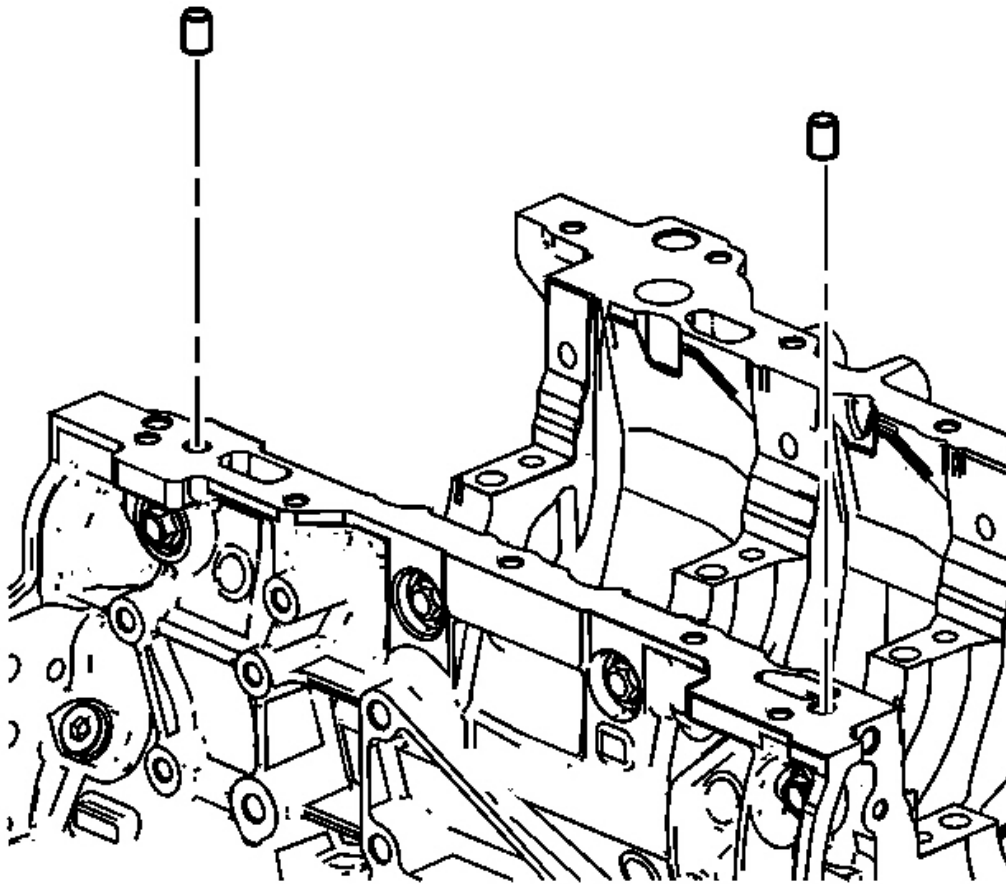


Fig. 108: Cylinder Block-To-Oil Pan Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

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

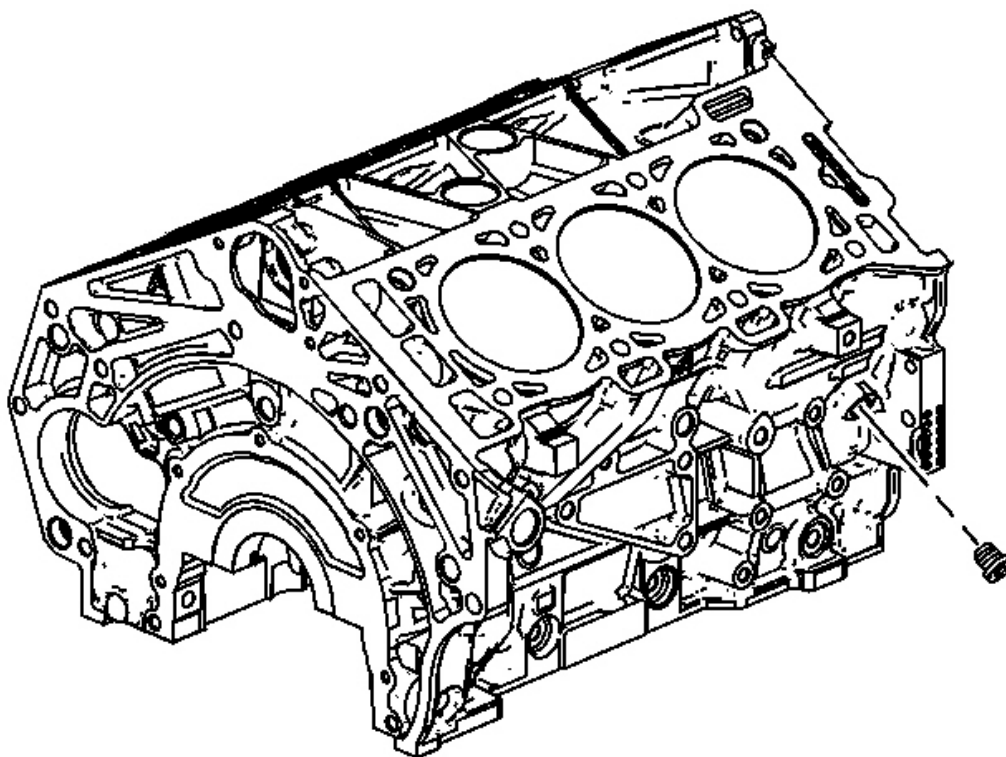


Fig. 109: View Of M14 Right Side Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

14. Remove the M14 right side oil gallery threaded plug.

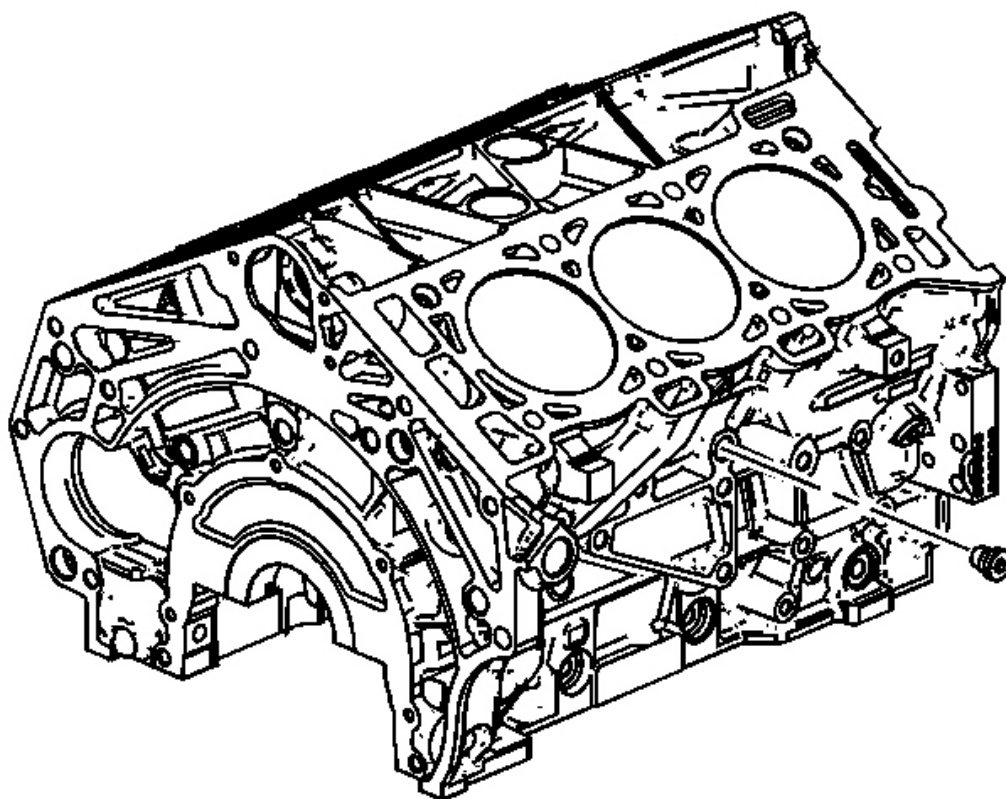


Fig. 110: Right Side Coolant Drain Threaded Plug
Courtesy of GENERAL MOTORS CORP.

15. Remove the M14 right side coolant drain threaded plug.

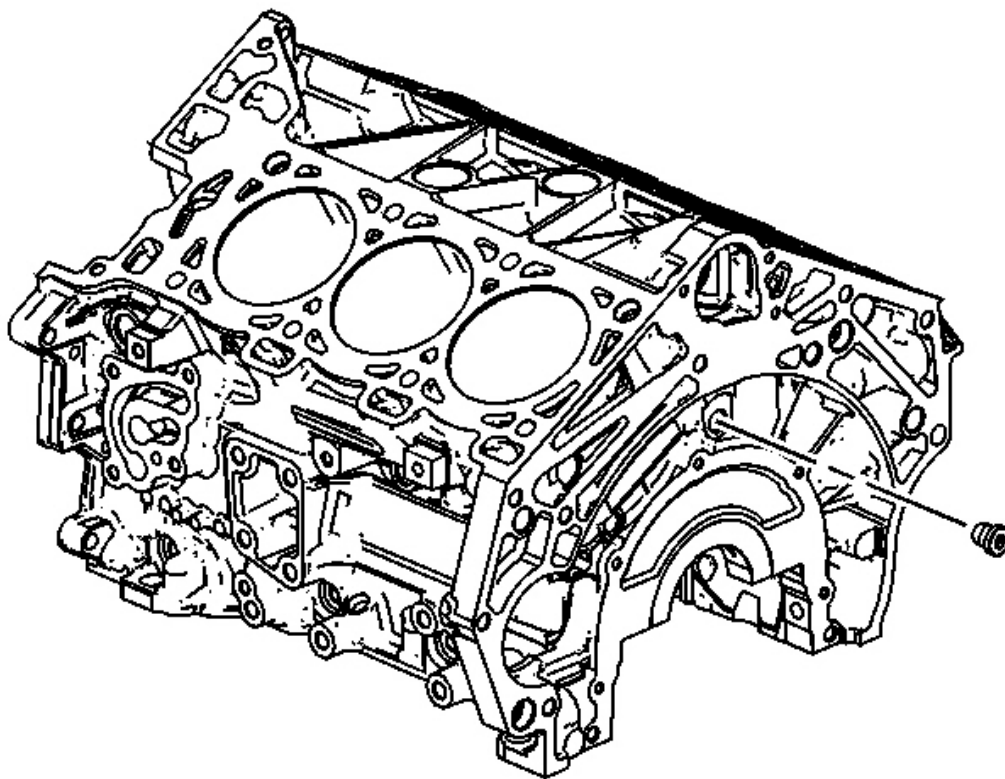


Fig. 111: M14 Rear Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

16. Remove the M14 rear oil gallery threaded plug.

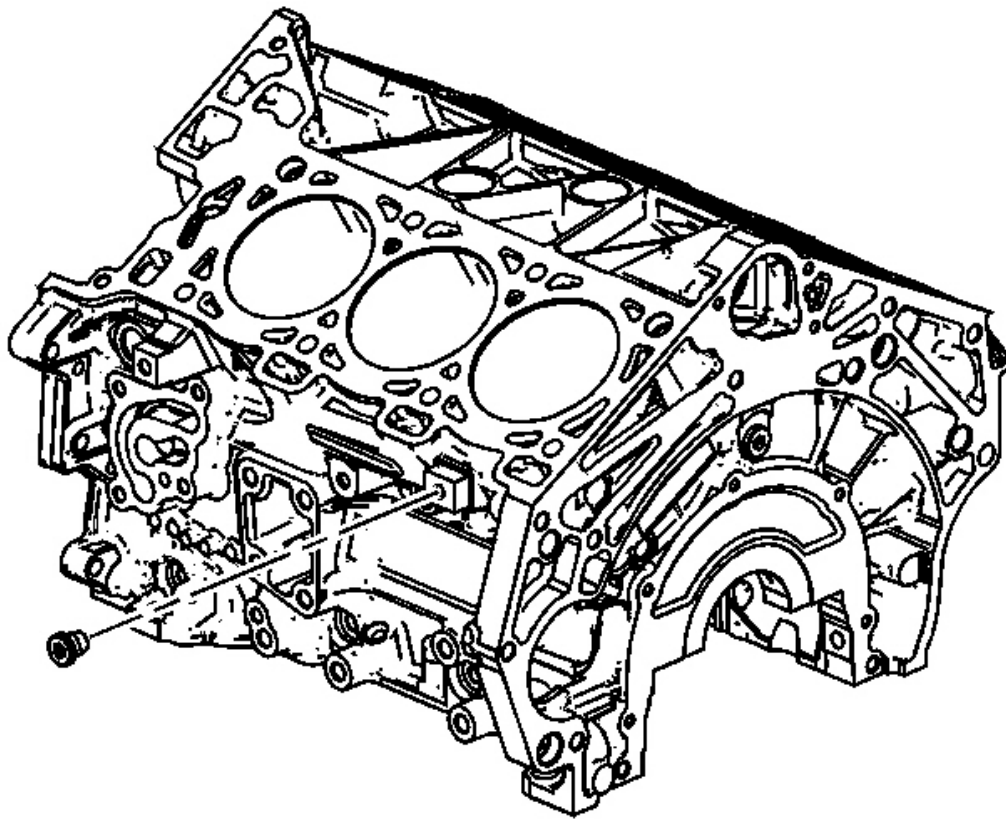


Fig. 112: View Of M14 Left Side Coolant Drain Threaded Plug
Courtesy of GENERAL MOTORS CORP.

17. Remove the M14 left side coolant drain threaded plug.

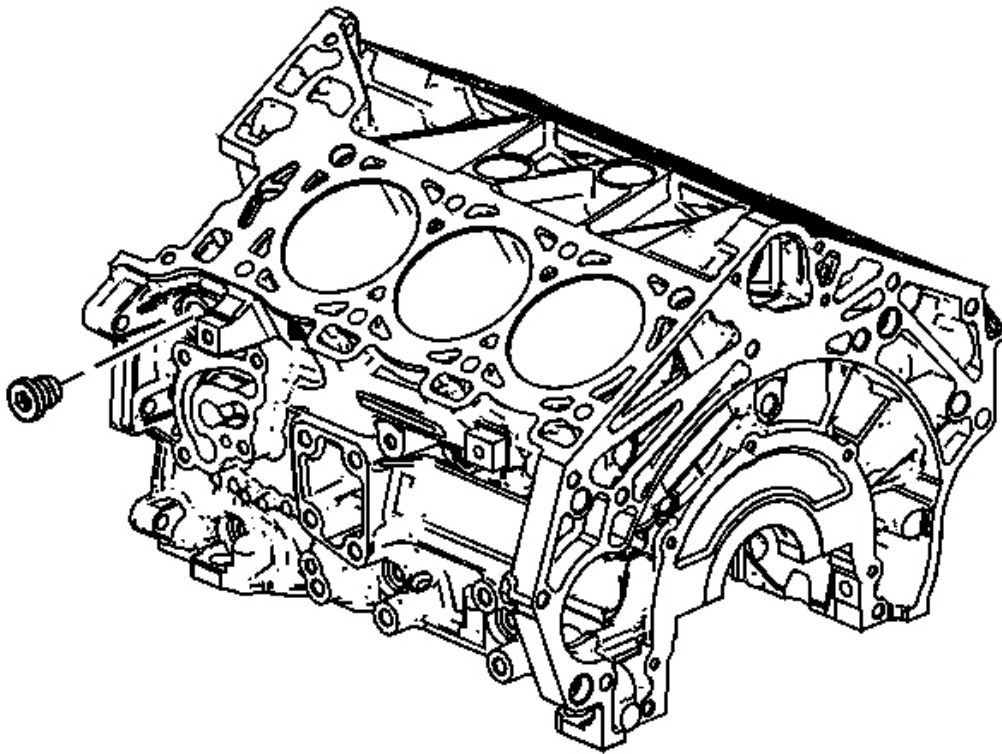


Fig. 113: Removing/Installing M20 Left Side Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

18. Remove the M20 left side oil gallery threaded plug.

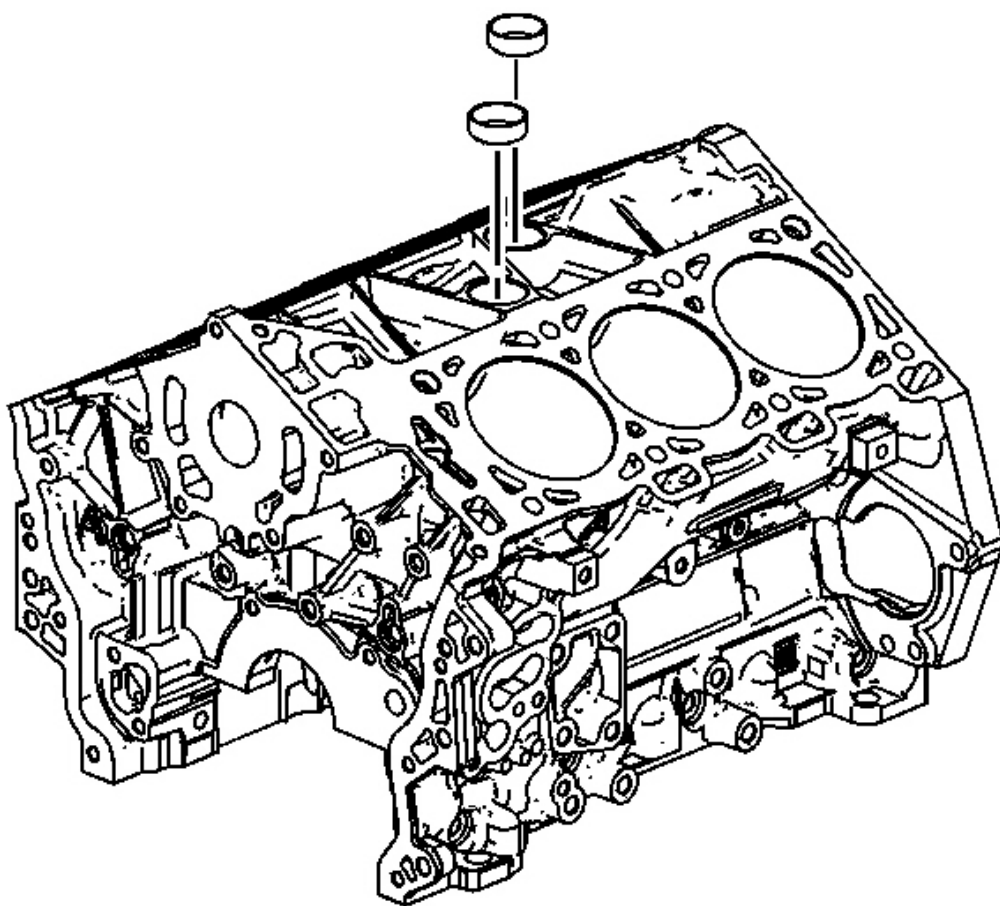


Fig. 114: Removing & Installing Coolant Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

19. Remove the coolant expansion plugs.

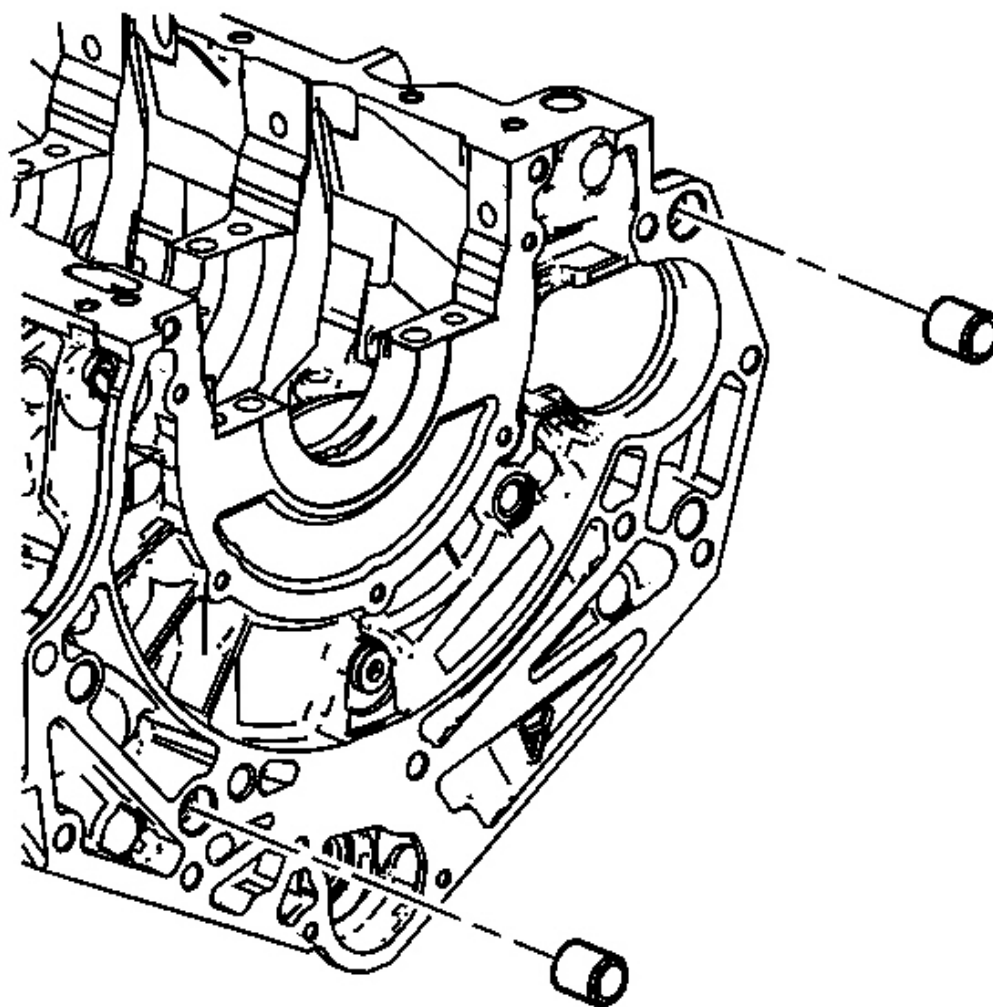


Fig. 115: Cylinder Block-To-Transmission Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

20. Remove the cylinder block-to-transmission alignment dowels.

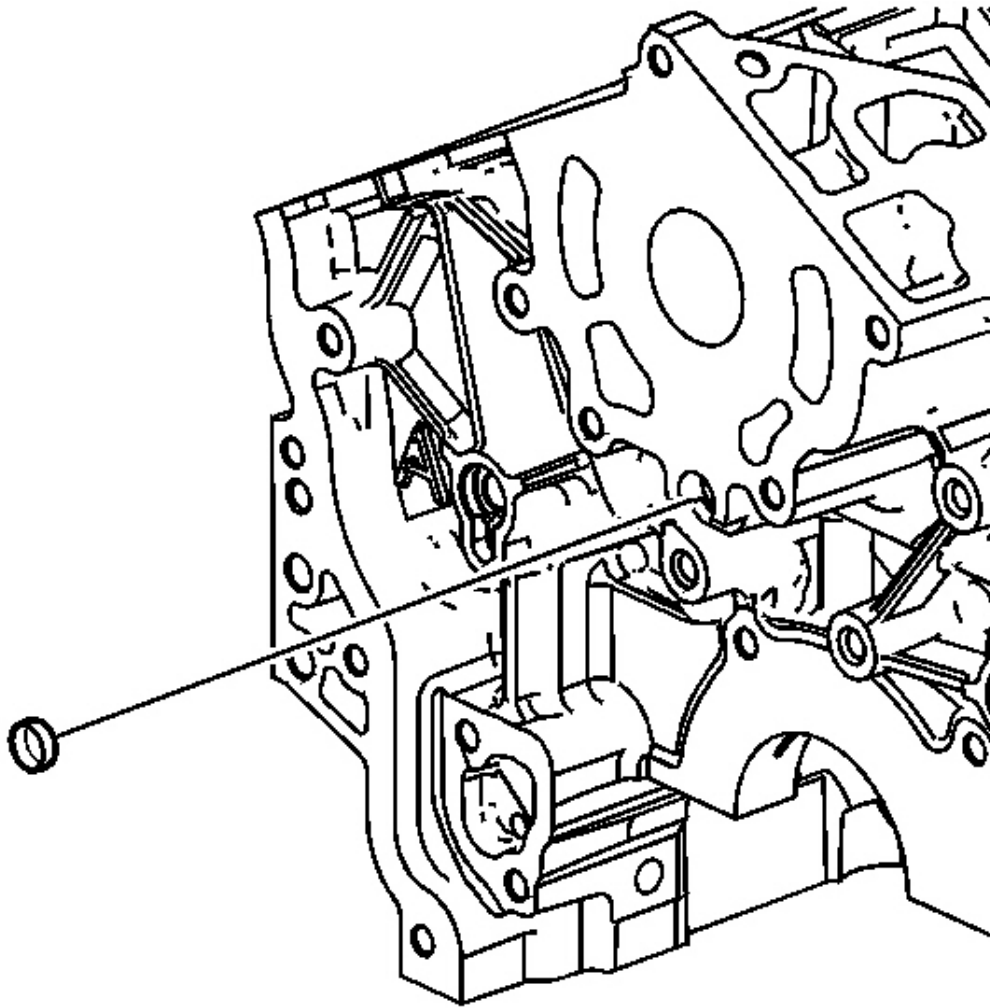


Fig. 116: View Of Front Oil Gallery Expansion Plug
Courtesy of GENERAL MOTORS CORP.

21. Remove the front oil gallery expansion plug.

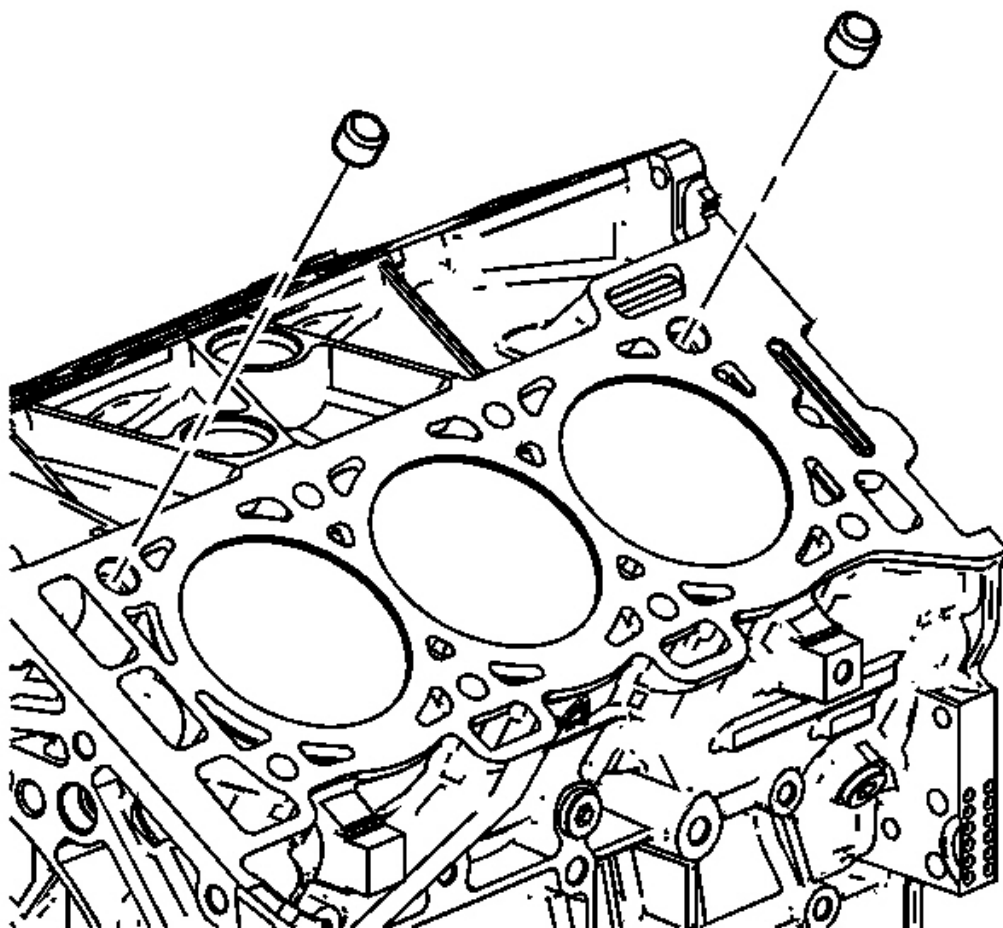


Fig. 117: Cylinder Block-To-Cylinder Head Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

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

For equivalent regional tools, refer to **Special Tools** .

CLEANING PROCEDURE

1. Remove any old thread sealant, gasket material or sealant using **EN 28410:** remover.
2. Clean all the following areas with solvent:
 - Sealing surfaces
 - Cooling passages
 - Oil passages
 - Bearing journals
3. Clean all threaded and through holes with solvent.

WARNING: Refer to Safety Glasses Warning .

4. Dry the engine block with compressed air.

VISUAL INSPECTION

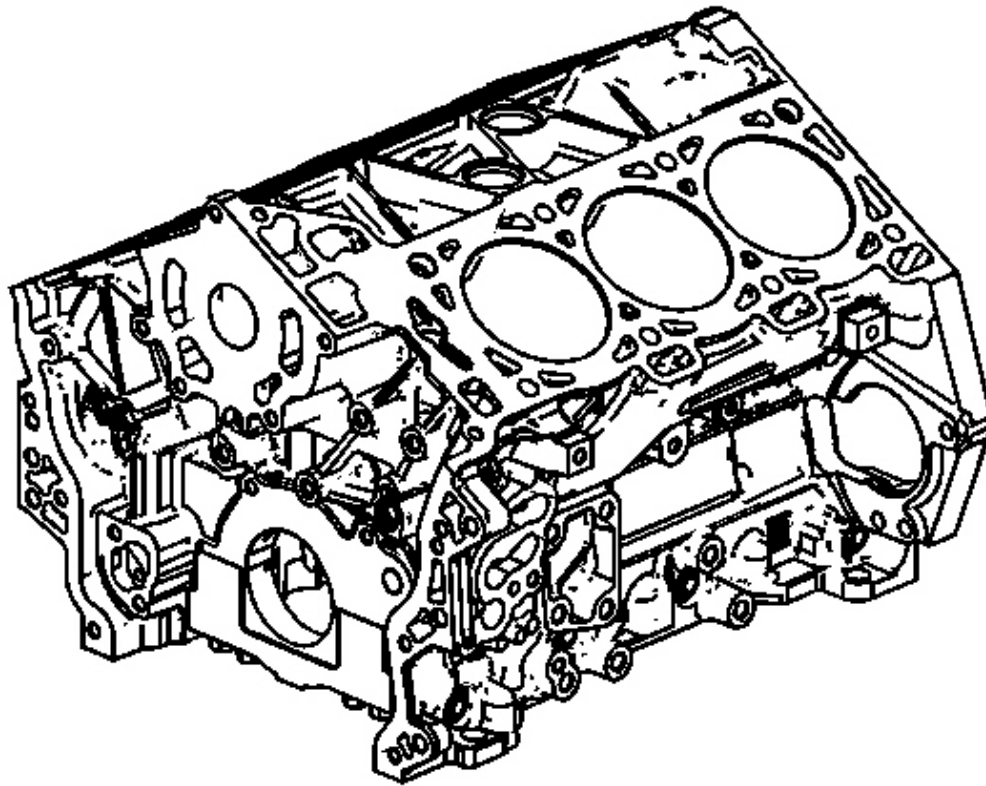


Fig. 118: View Of Engine Block
Courtesy of GENERAL MOTORS CORP.

1. 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 cylinder block assembly 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 cylinder block assembly 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. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the cylinder block assembly must be replaced.
7. Inspect the engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.

8. Repair any damaged threaded holes. Refer to Thread Repair Specifications and Thread Repair .

MEASURING CYLINDER BORE DIAMETER

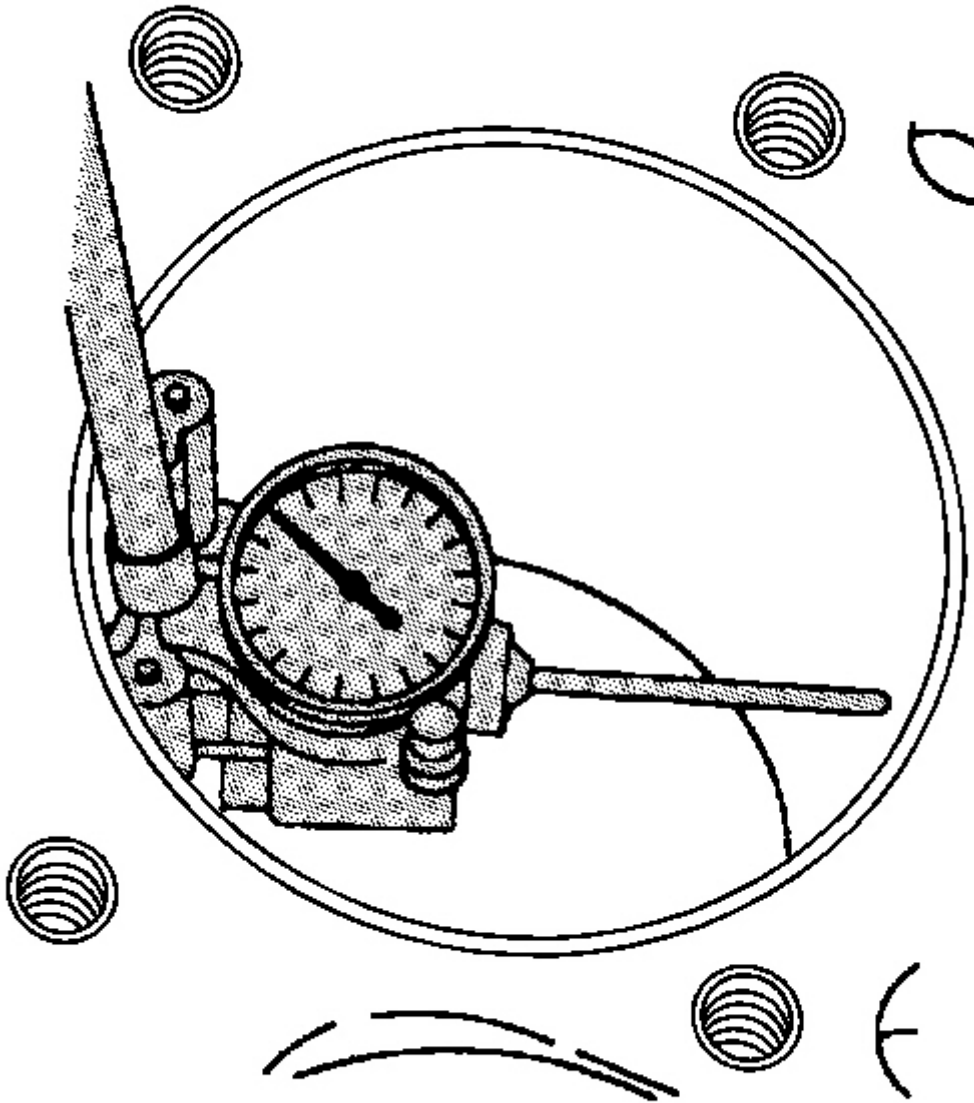


Fig. 119: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

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 (LF1)** . If the cylinder diameter exceeds the specifications, the cylinder 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 (LF1)** . If the cylinders exceed the specifications, the cylinder 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 (LF1)** . If the cylinders exceed these specifications, the cylinder 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

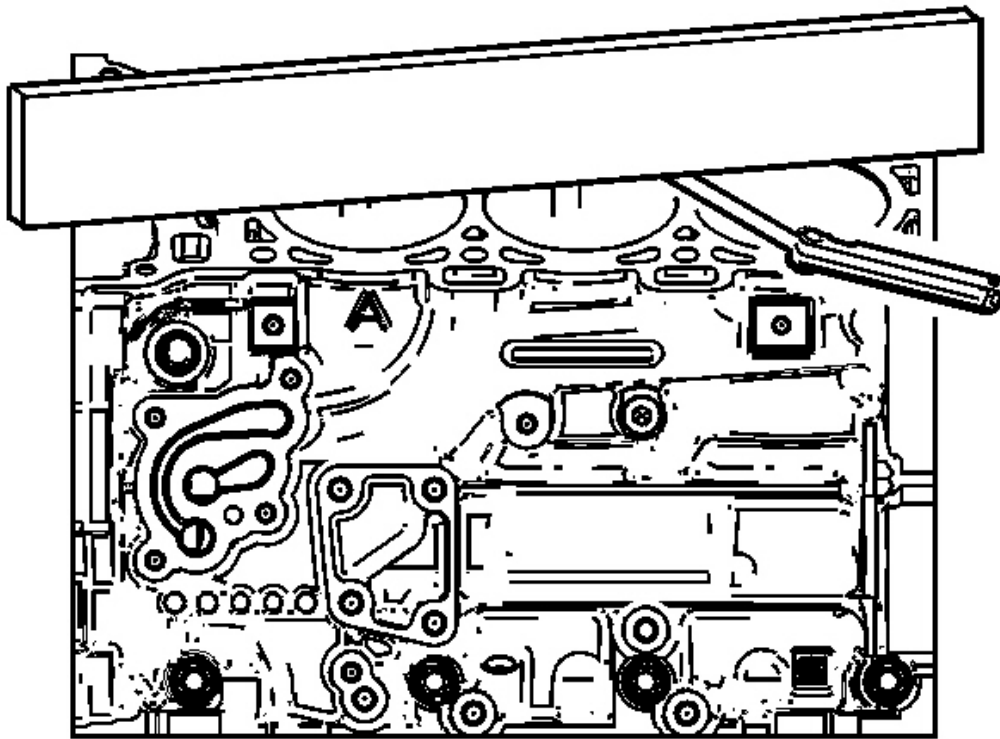


Fig. 120: Measuring Deck Flatness
Courtesy of GENERAL MOTORS CORP.

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 cylinder block deck face surface.
4. Measure the clearance between the straight-edge and the cylinder 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 cylinder 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 cylinder 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 cylinder 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

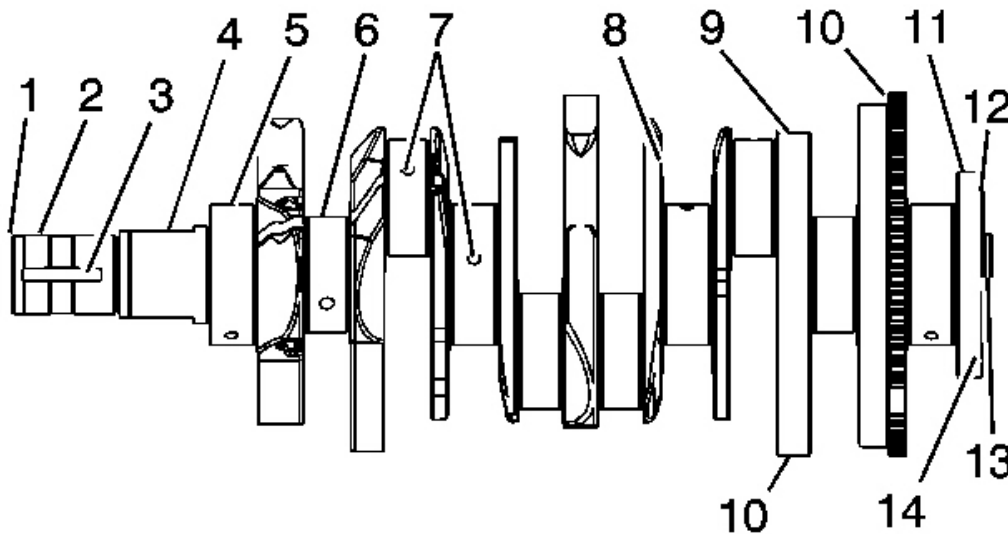


Fig. 121: Identifying Crankshaft Inspection Areas
 Courtesy of GENERAL MOTORS CORP.

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

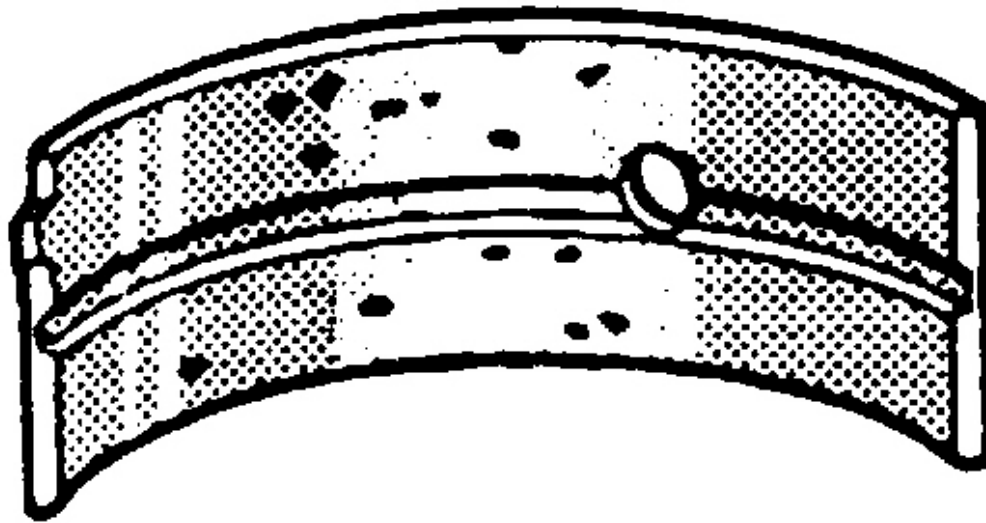


Fig. 122: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

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

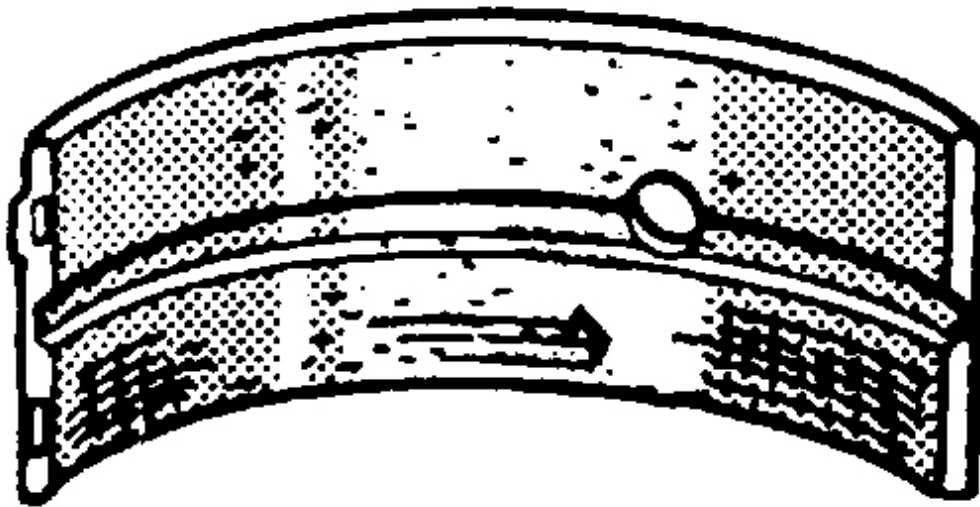


Fig. 123: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

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.

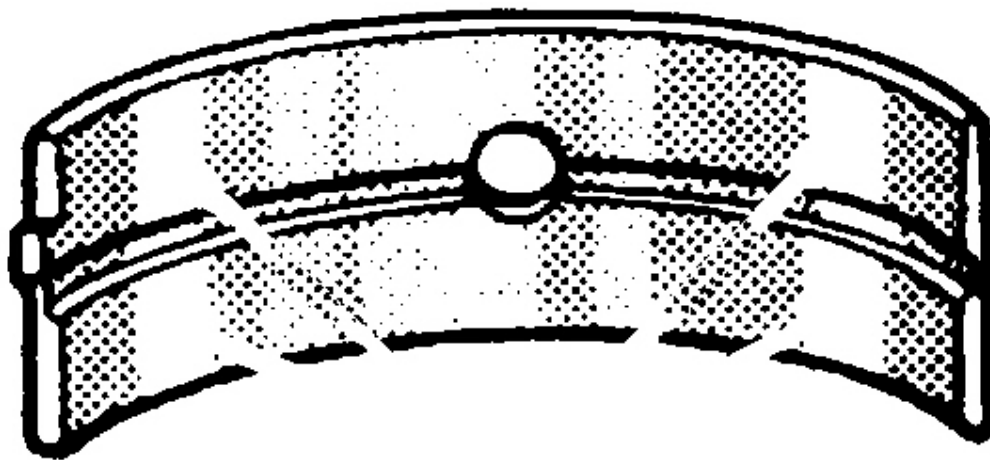


Fig. 124: Identifying Improper Seating
Courtesy of GENERAL MOTORS CORP.

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**

Measure

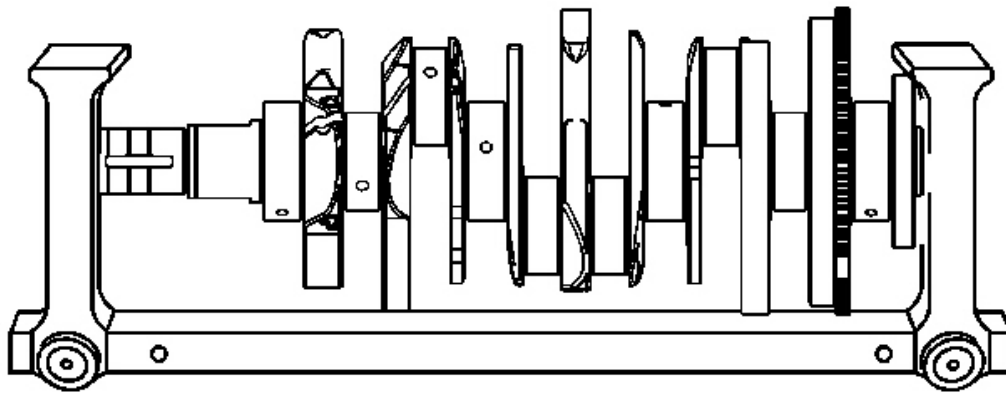


Fig. 125: View Of Crankshaft & Support
Courtesy of GENERAL MOTORS CORP.

1. Using a suitable fixture, support the crankshaft.

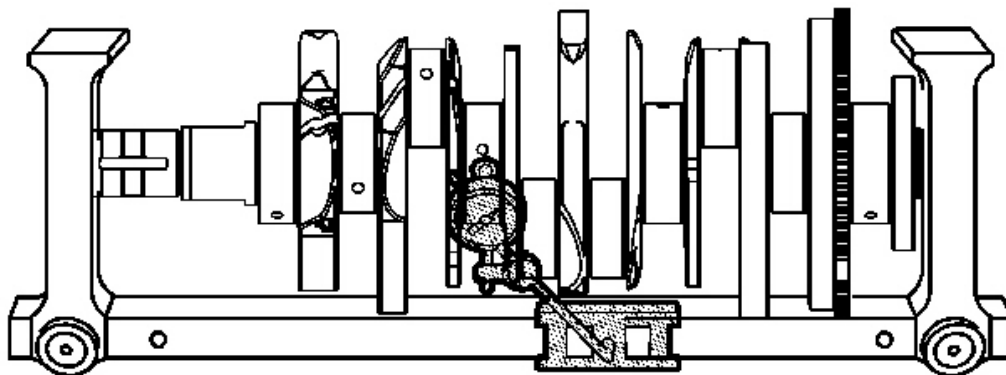


Fig. 126: View of Tool J 7872 & Crankshaft
Courtesy of GENERAL MOTORS CORP.

2. Install the **GE 7872:** indicator.
3. Measure the crankshaft runout using the **GE 7872:** indicator. Refer to **Engine Mechanical Specifications (LF1)** .

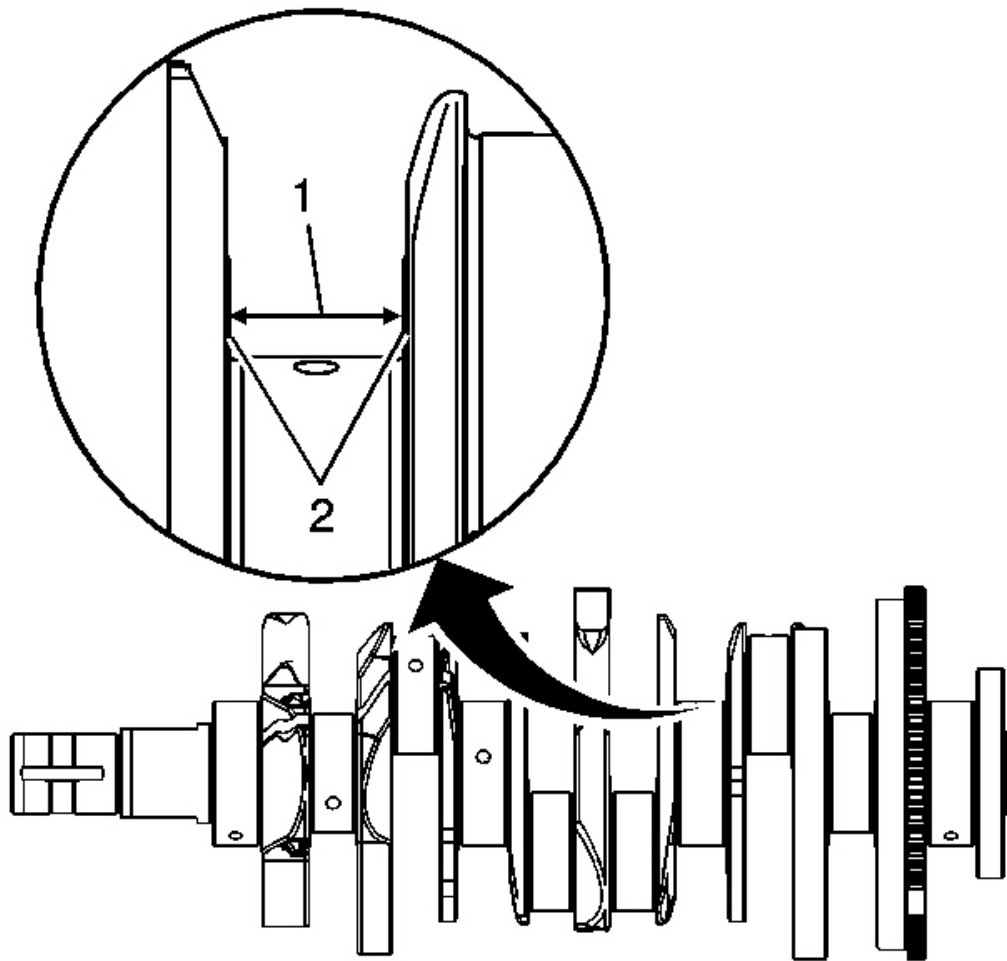


Fig. 127: Identifying Crankshaft Thrust Wall Width & Surface
Courtesy of GENERAL MOTORS CORP.

4. Measure the crankshaft thrust wall width (1) for wear using an inside micrometer. Refer to **Engine Mechanical Specifications (LF1)** .
5. Measure the crankshaft thrust wall surface (2) for runout using the **GE 7872:** indicator. Refer to **Engine Mechanical Specifications (LF1)** .
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.

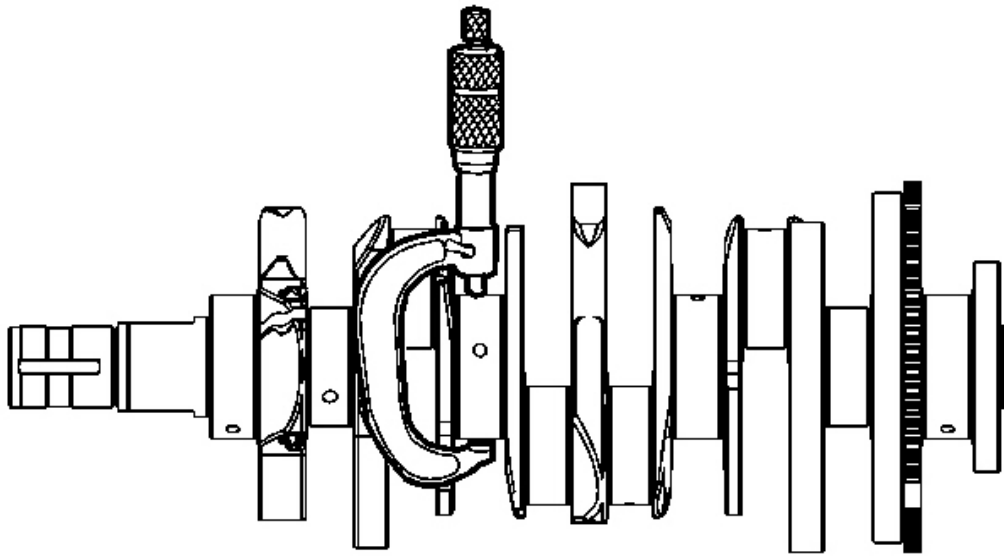


Fig. 128: Inspecting Crankshaft Main Journals
Courtesy of GENERAL MOTORS CORP.

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

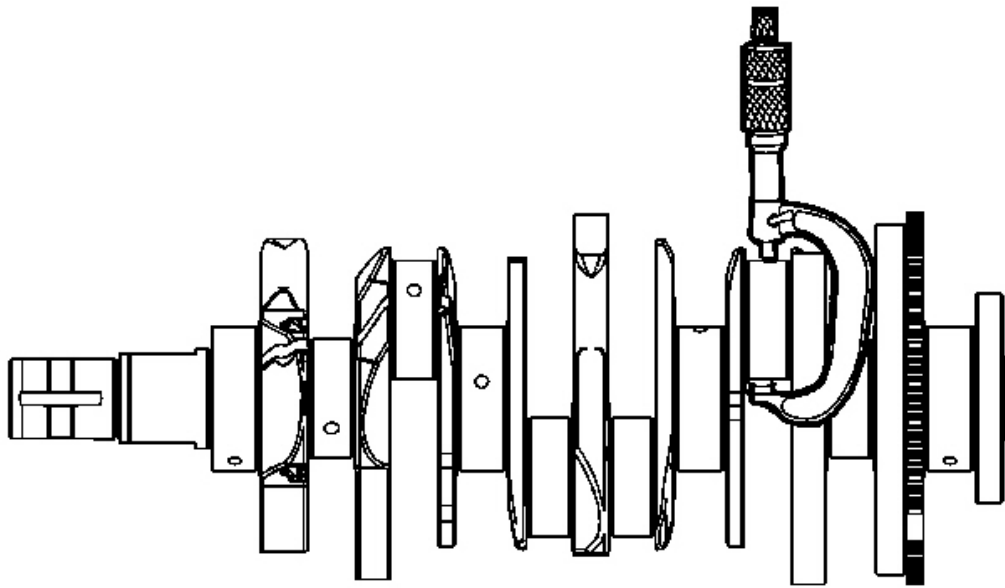


Fig. 129: Inspecting Crankpins
Courtesy of GENERAL MOTORS CORP.

8. Inspect the crankpins for undersize using an outside micrometer.
9. Compare your measurements with those listed in the **Engine Mechanical Specifications (LF1)** . 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.

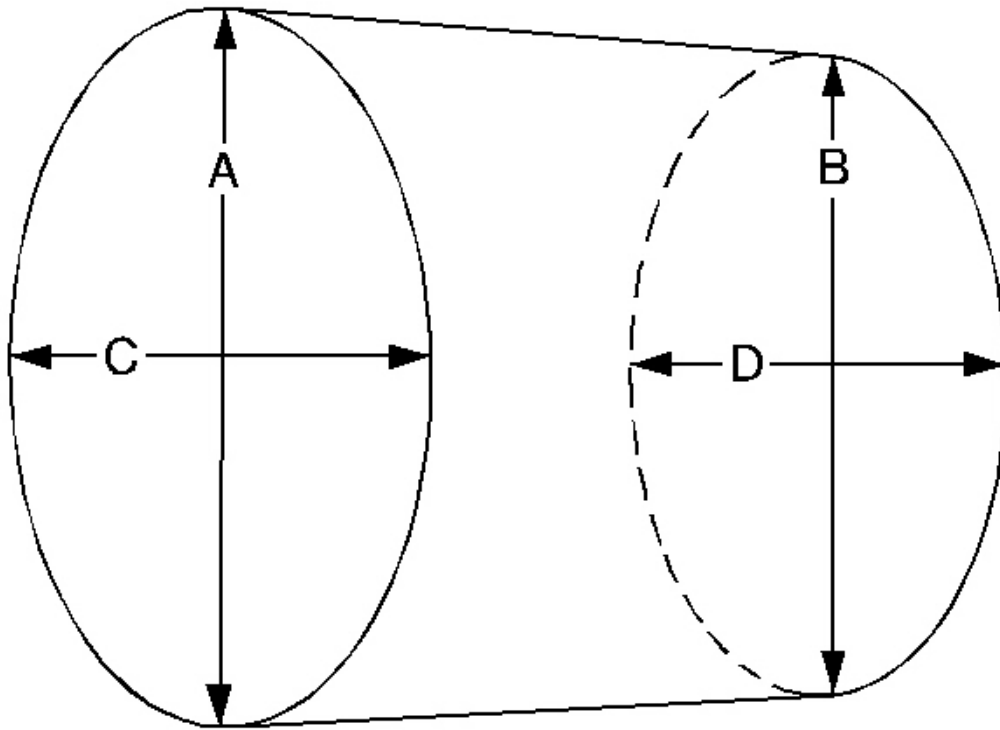


Fig. 130: Identifying Out-Of-Round Measurements
Courtesy of GENERAL MOTORS CORP.

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.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

CLEANING PROCEDURE

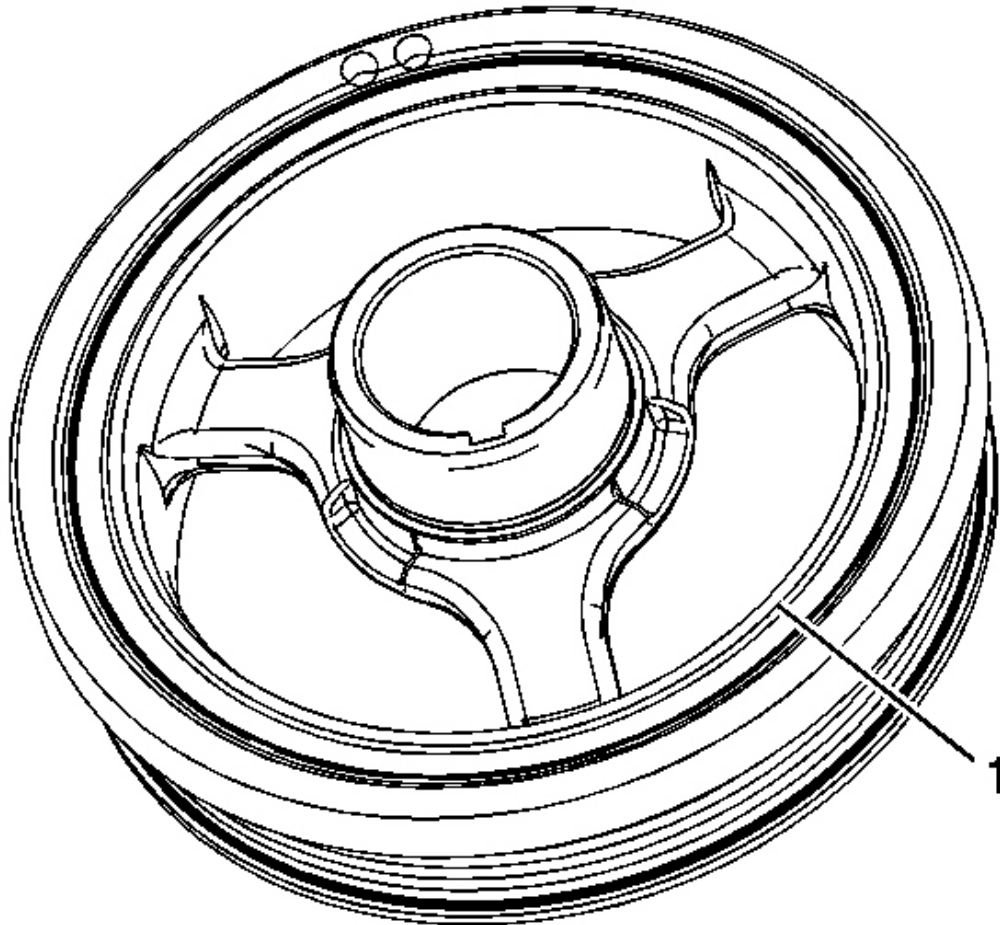


Fig. 131: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. 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

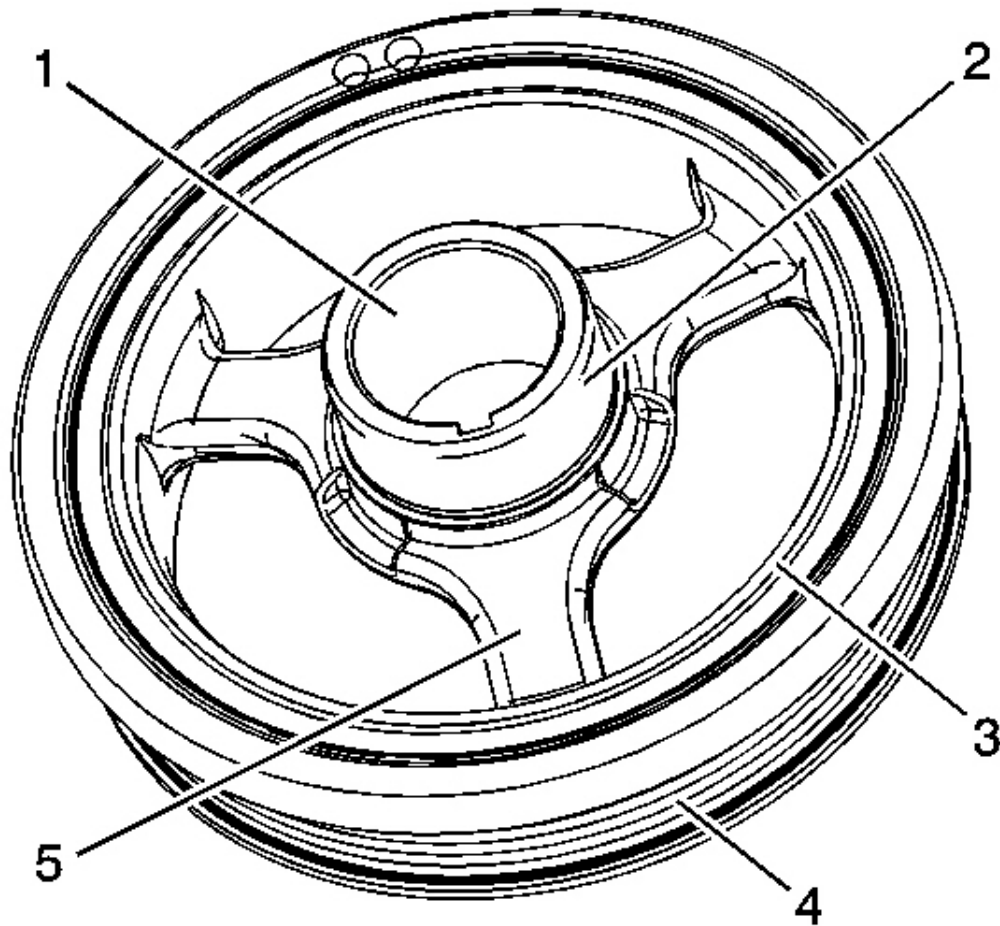


Fig. 132: Identifying Crankshaft Balancer Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. 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.

2010 ENGINE

Engine Mechanical - 2.8L, 3.0L, 3.2L, or 3.6L - Repair Instructions - Off Vehicle - Equinox & Terrain

ENGINE FLYWHEEL CLEANING AND INSPECTION

CLEANING PROCEDURE

NOTE: In order to maintain the proper component balance, contact surface taper and heat transfer, manual transmission flywheels are NOT to be machined.

1. Clean the engine flywheel in solvent.

WARNING: Refer to Safety Glasses Warning .

2. Dry the engine flywheel with compressed air.

INSPECTION PROCEDURE

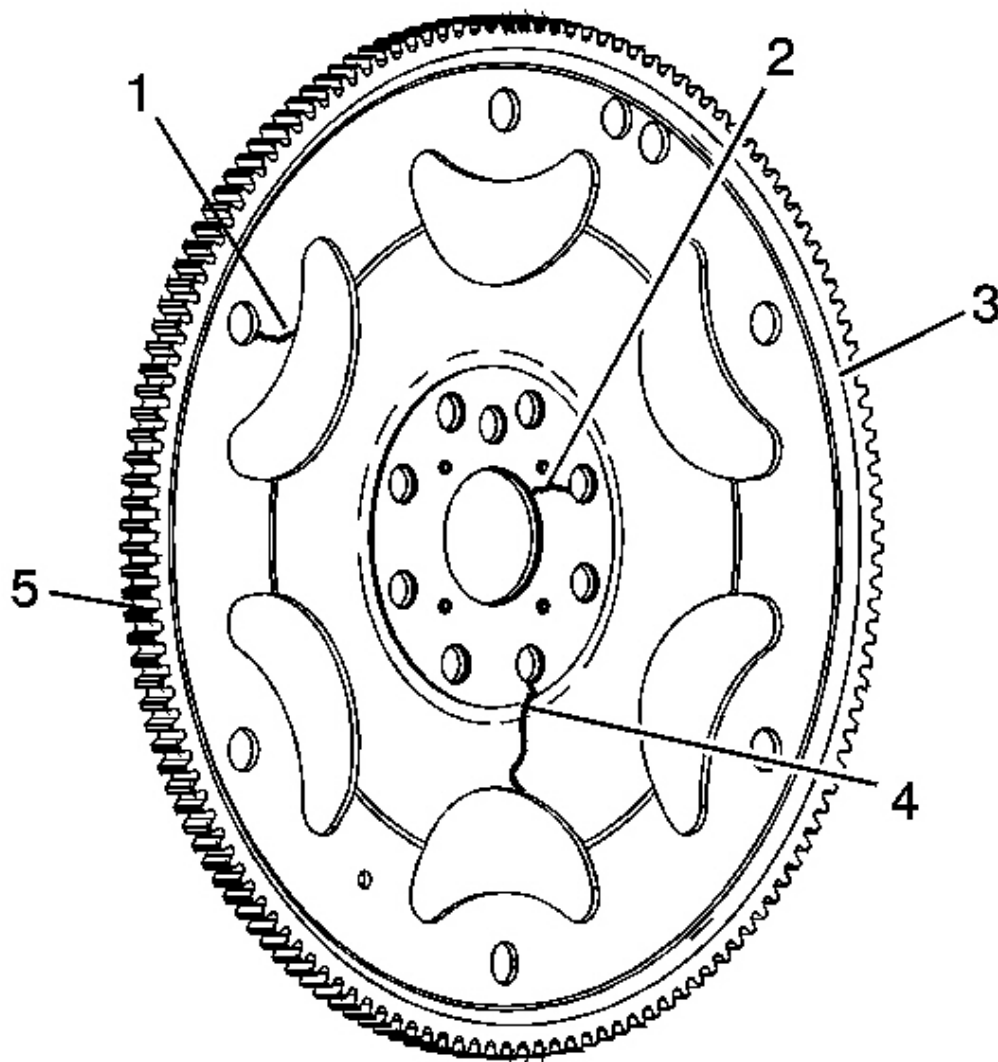


Fig. 1: Identifying Engine Flywheel Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Inspect the engine flywheel for the following conditions:
 - Stress cracks around the engine flywheel-to-torque converter mounting bolt hole locations (1) and/or engine flywheel-to-crankshaft (2, 4)

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

- Cracks at welded areas that retain the ring gear onto the engine flywheel (3)
 - Damaged or missing ring gear teeth (5)
2. Replace the engine flywheel as necessary.

PISTON AND CONNECTING ROD DISASSEMBLE

SPECIAL TOOLS

EN-46745: Piston Pin Clip Remover/Installer

For equivalent regional tools, refer to **Special Tools** .

DISASSEMBLE

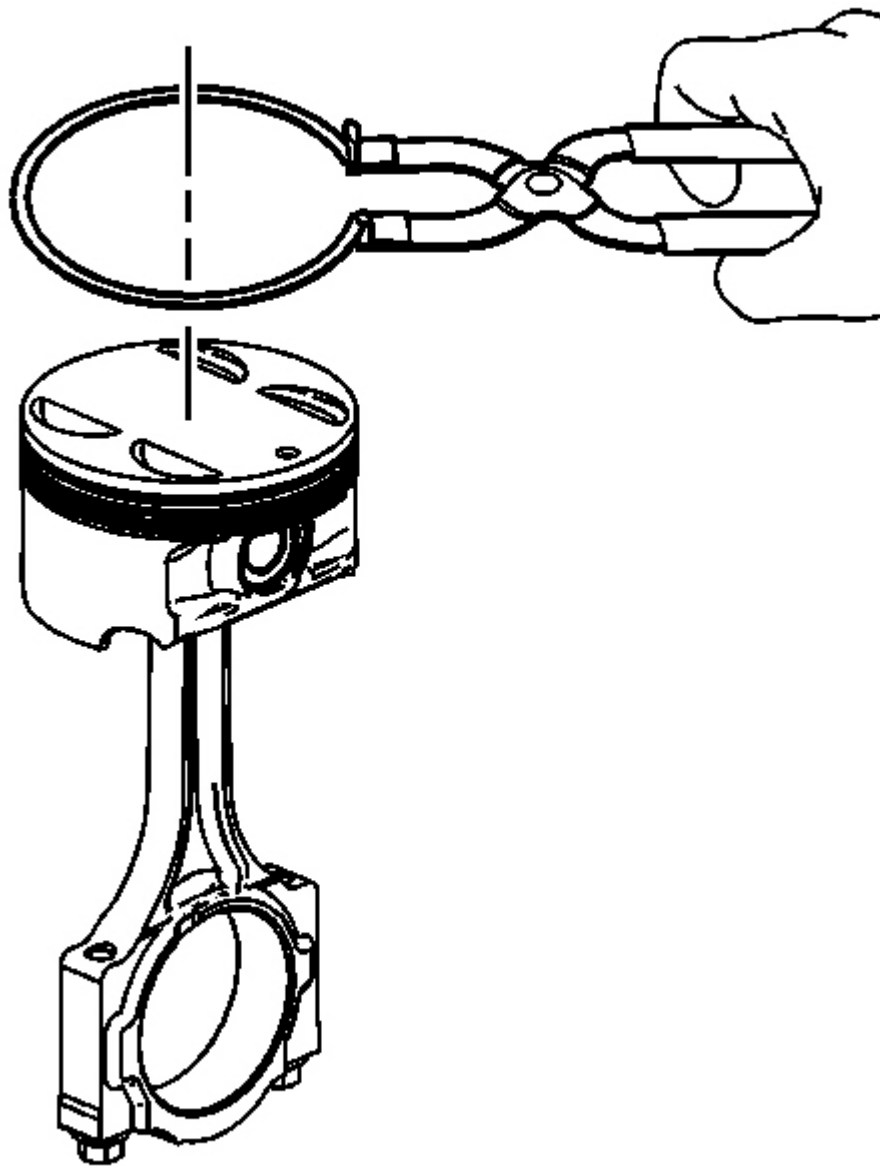


Fig. 2: View Of Piston Ring Expander
Courtesy of GENERAL MOTORS CORP.

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.

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

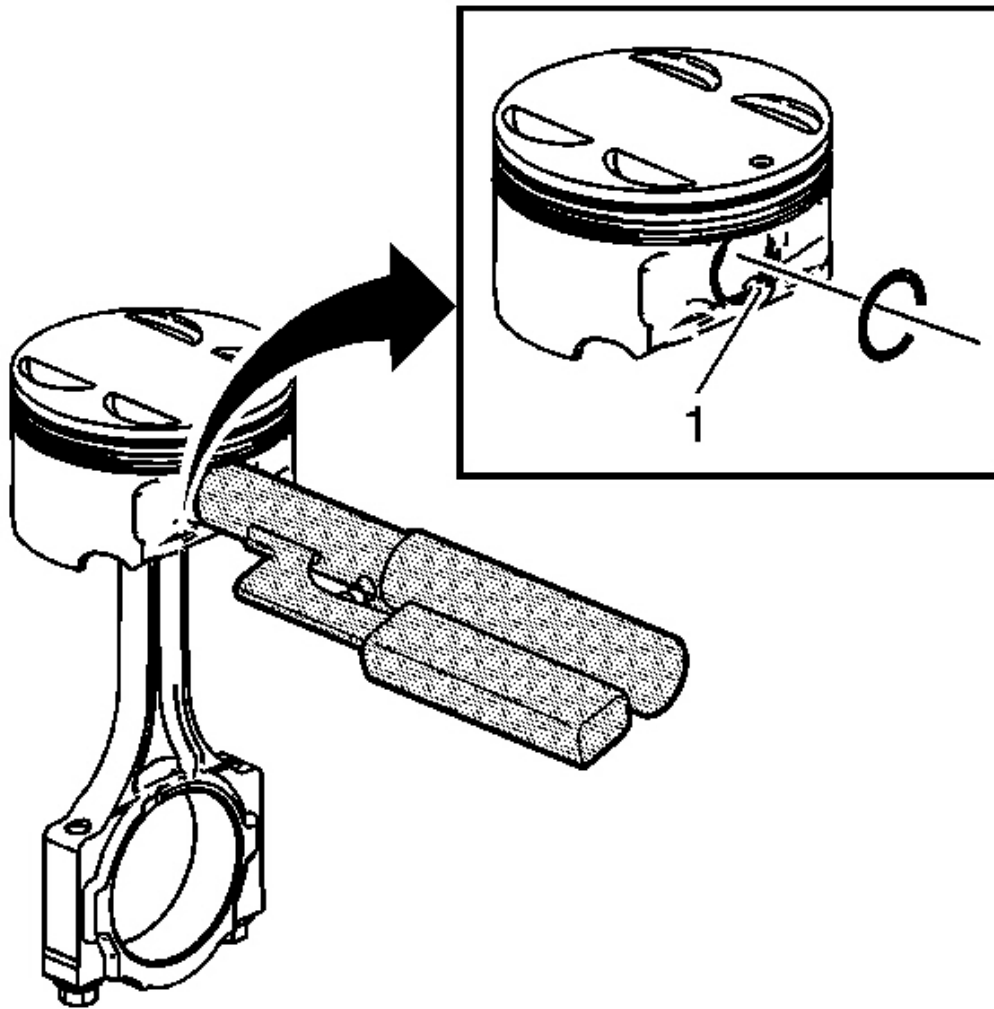


Fig. 3: Identifying Piston Pin Retainers Removal Access Notch
Courtesy of GENERAL MOTORS CORP.

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.

2. 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.

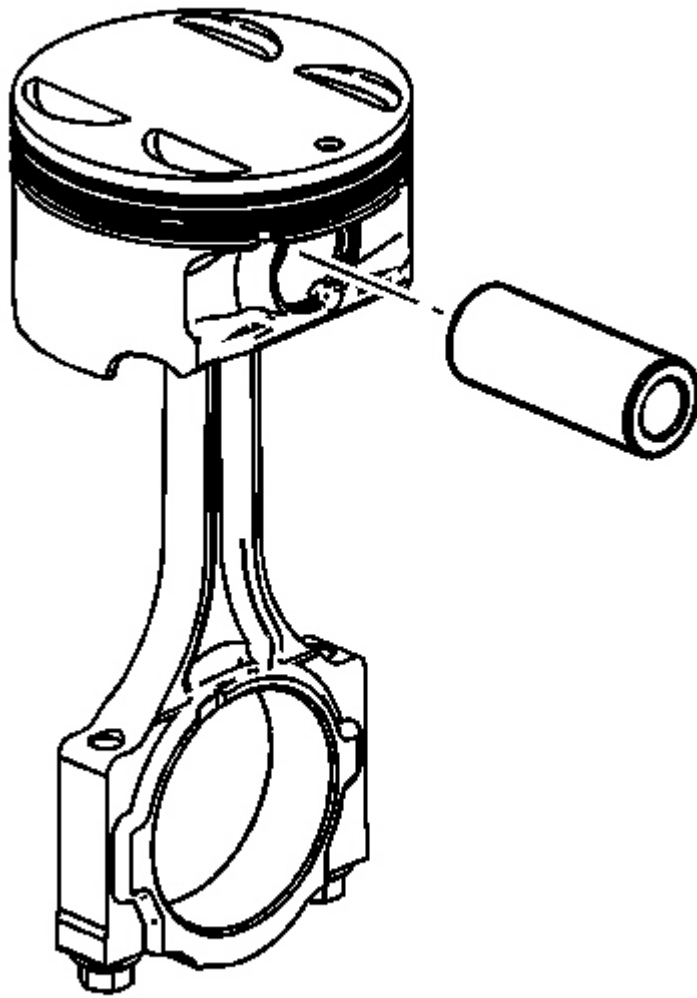


Fig. 4: View Of Piston Pin
Courtesy of GENERAL MOTORS CORP.

3. 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

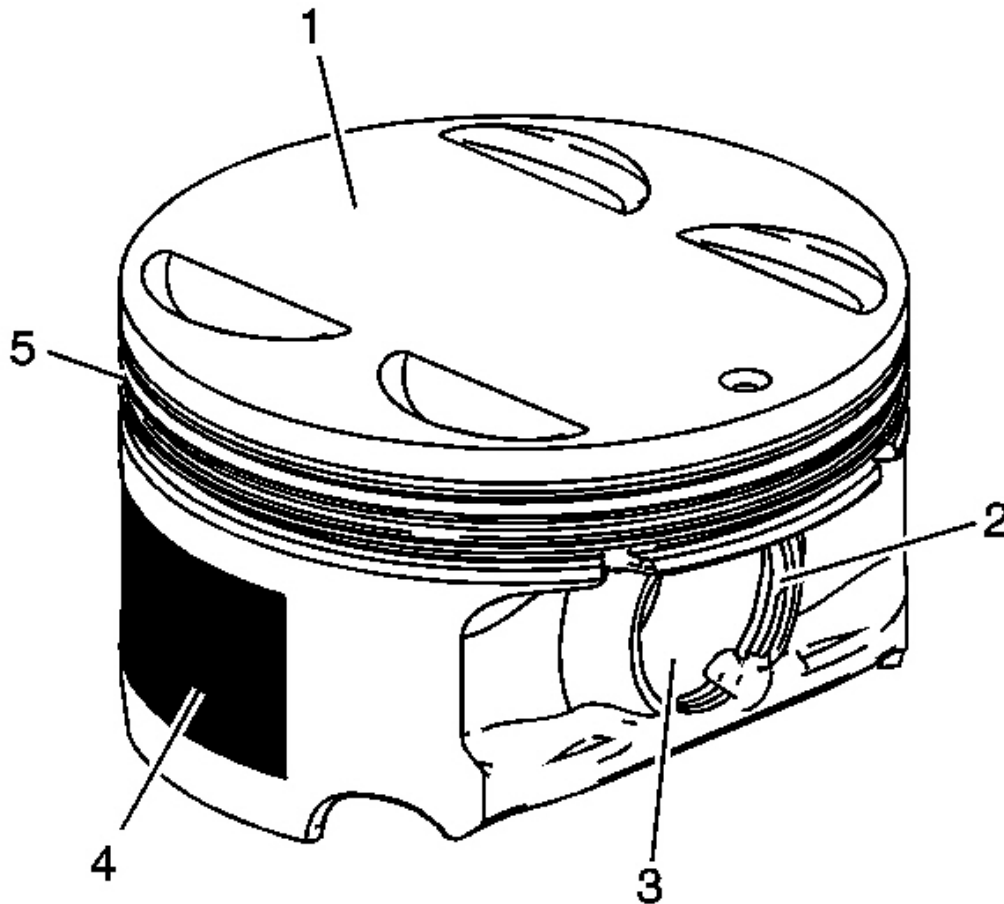


Fig. 5: Piston Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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

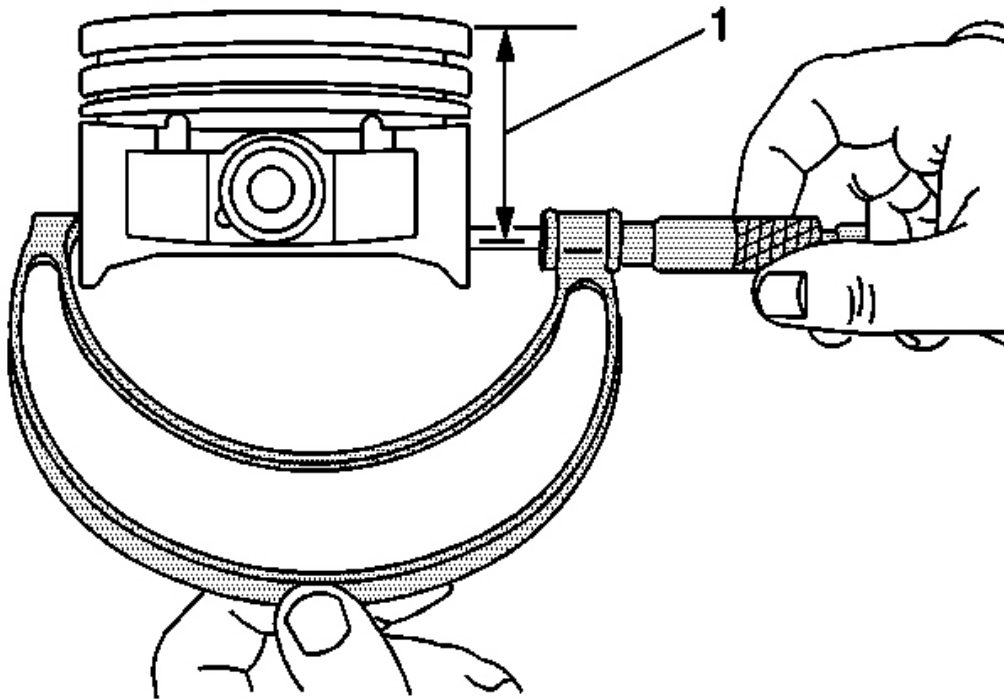


Fig. 6: Measuring Piston Width
Courtesy of GENERAL MOTORS CORP.

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 (LF1)** .
4. If the clearance obtained through measurement is greater than the provided specifications and the cylinder bores are within specification, replace the piston.

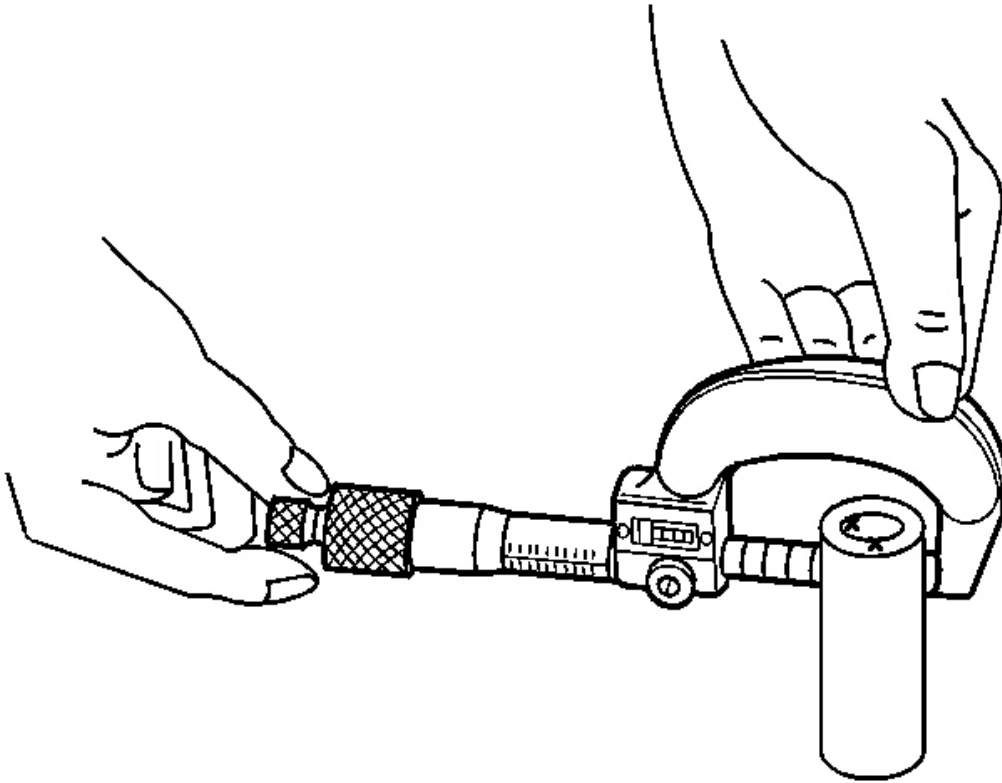


Fig. 7: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

2. 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.

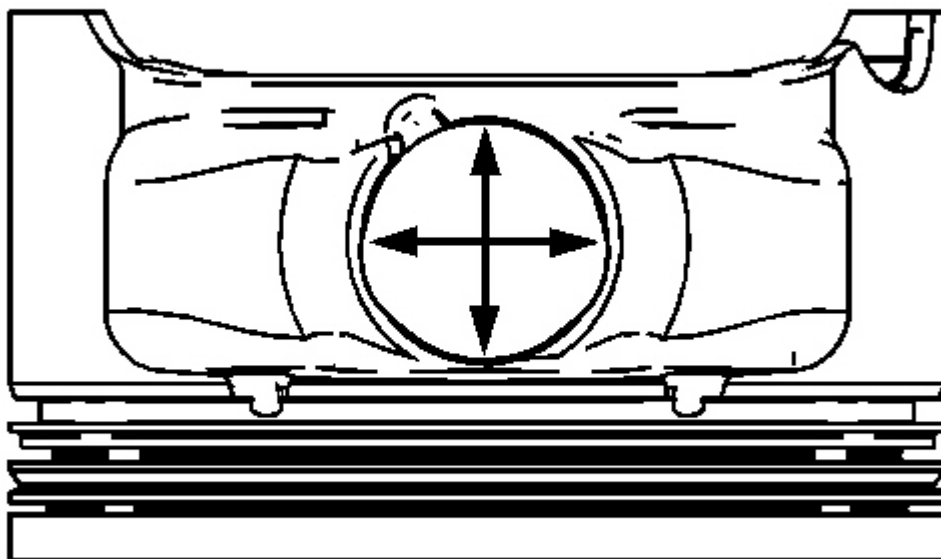


Fig. 8: Checking Piston Pin Bore Dimensions
Courtesy of GENERAL MOTORS CORP.

3. 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 (LF1)**.
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

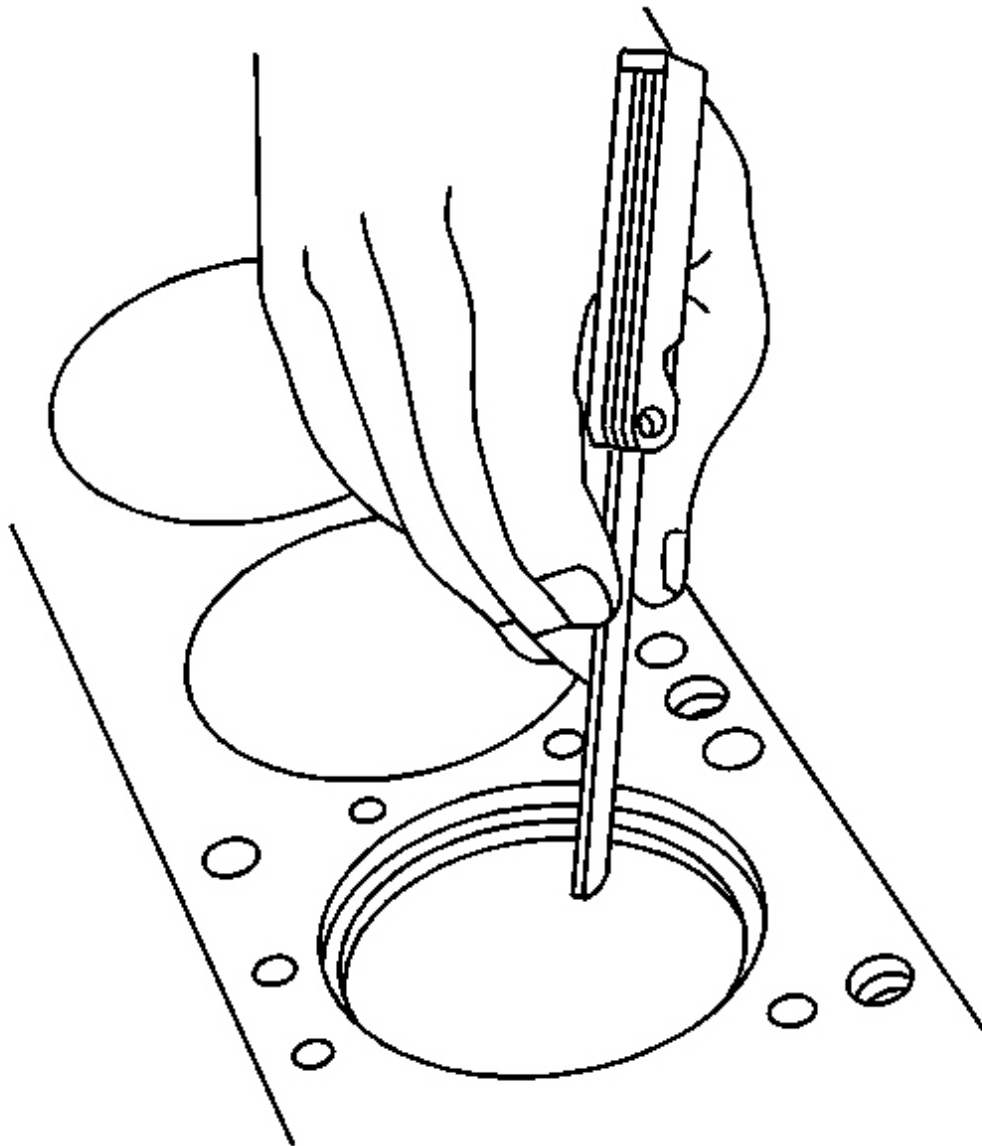


Fig. 9: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

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 (LF1)** .
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.

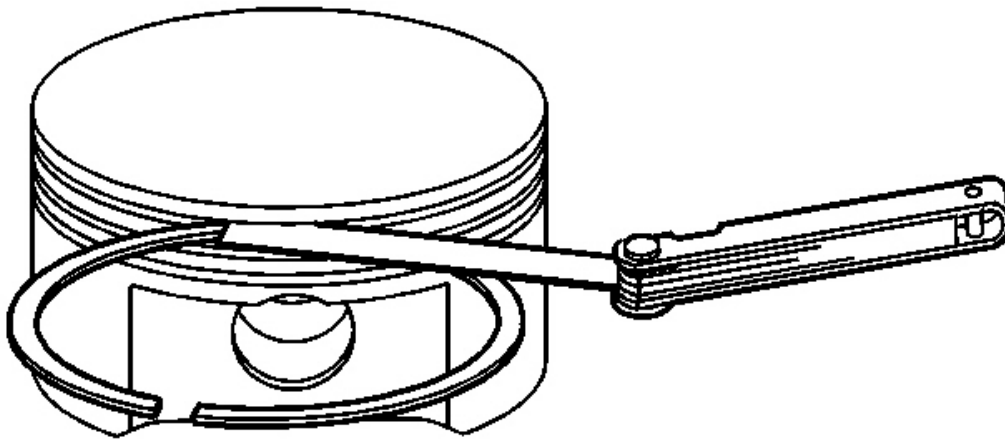


Fig. 10: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

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 (LF1)** .
 4. If the clearance is greater than specifications, replace the piston rings.

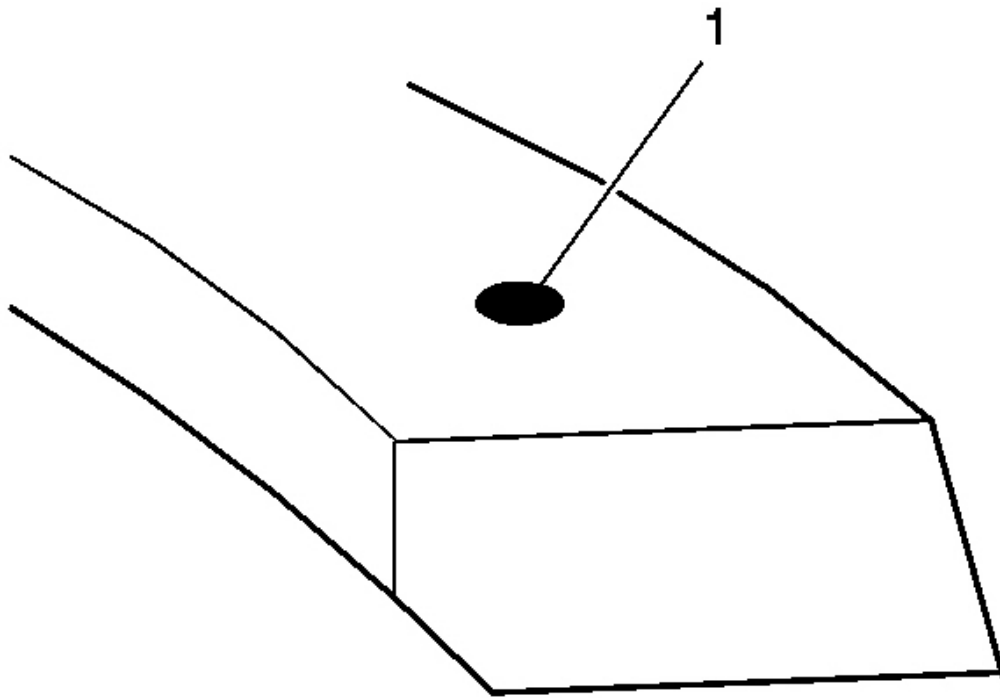


Fig. 11: View Of Lower Compression Piston Ring Mark
Courtesy of GENERAL MOTORS CORP.

3. 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

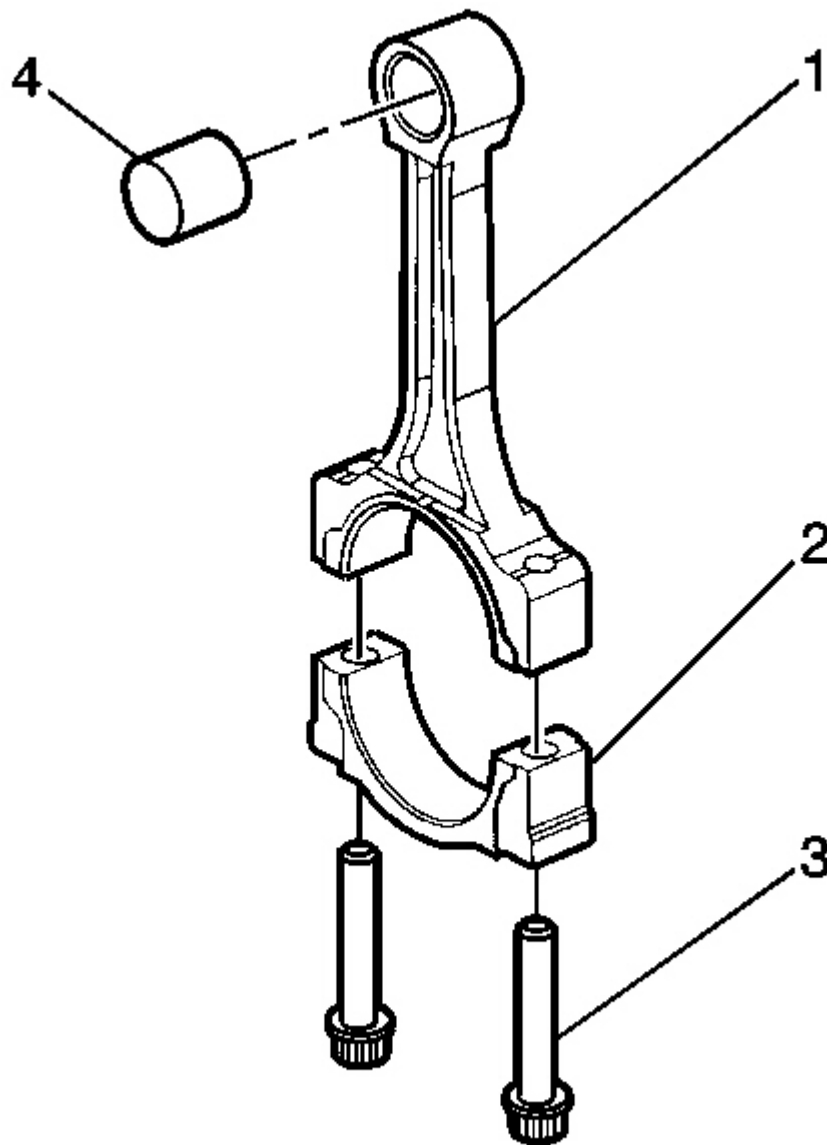


Fig. 12: Inspecting Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

1. 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

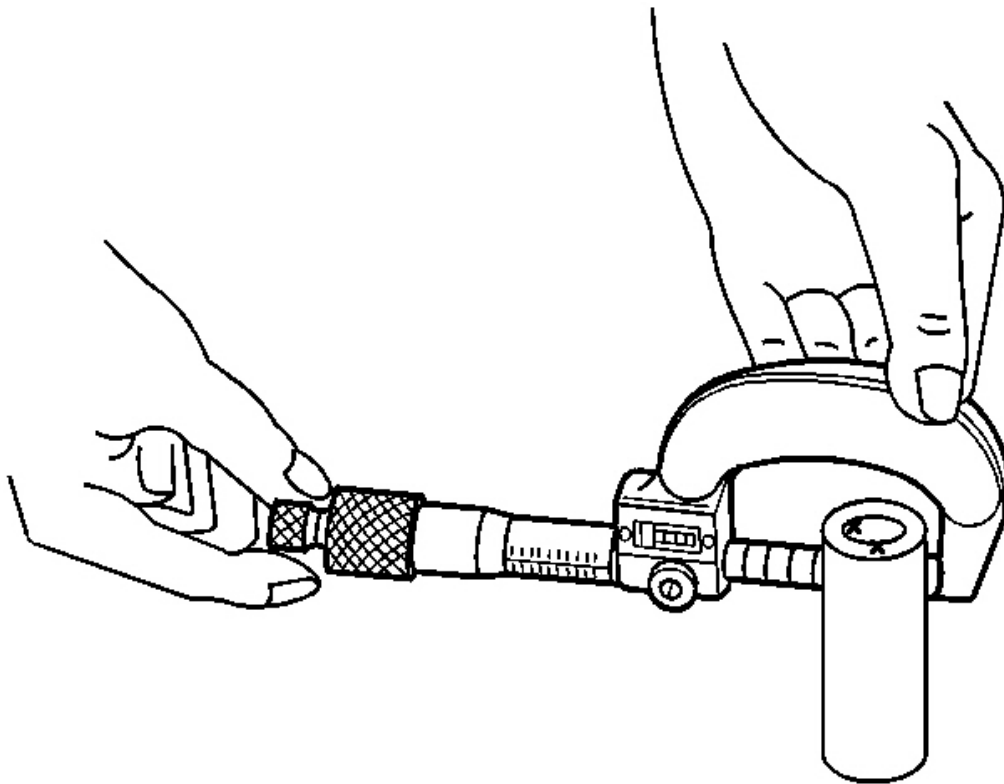


Fig. 13: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

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

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

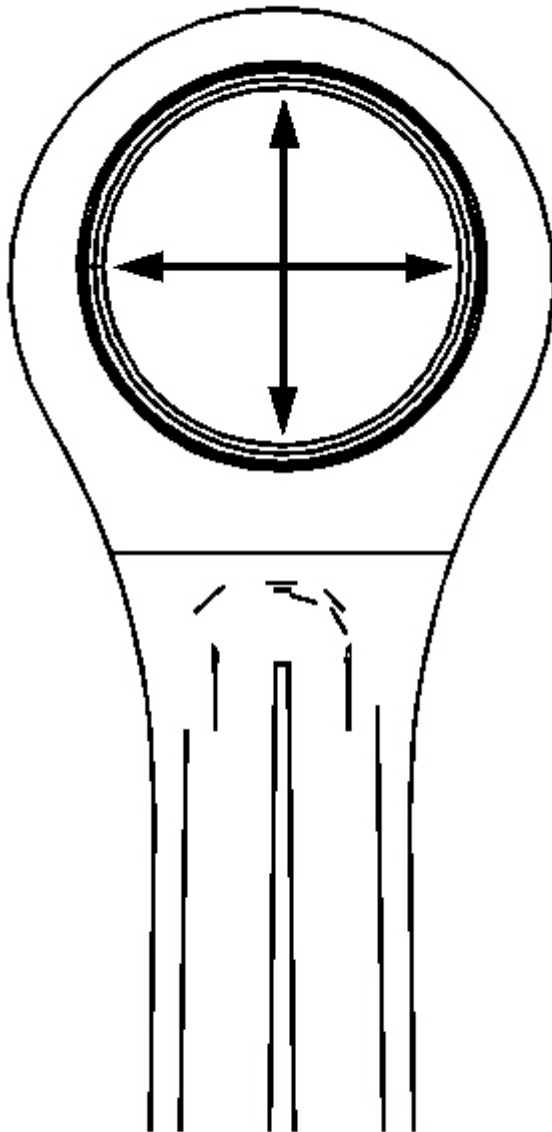


Fig. 14: Checking Connecting Rod Piston Pin Bore Dimensions

Courtesy of GENERAL MOTORS CORP.

2. 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 (LF1)** .
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

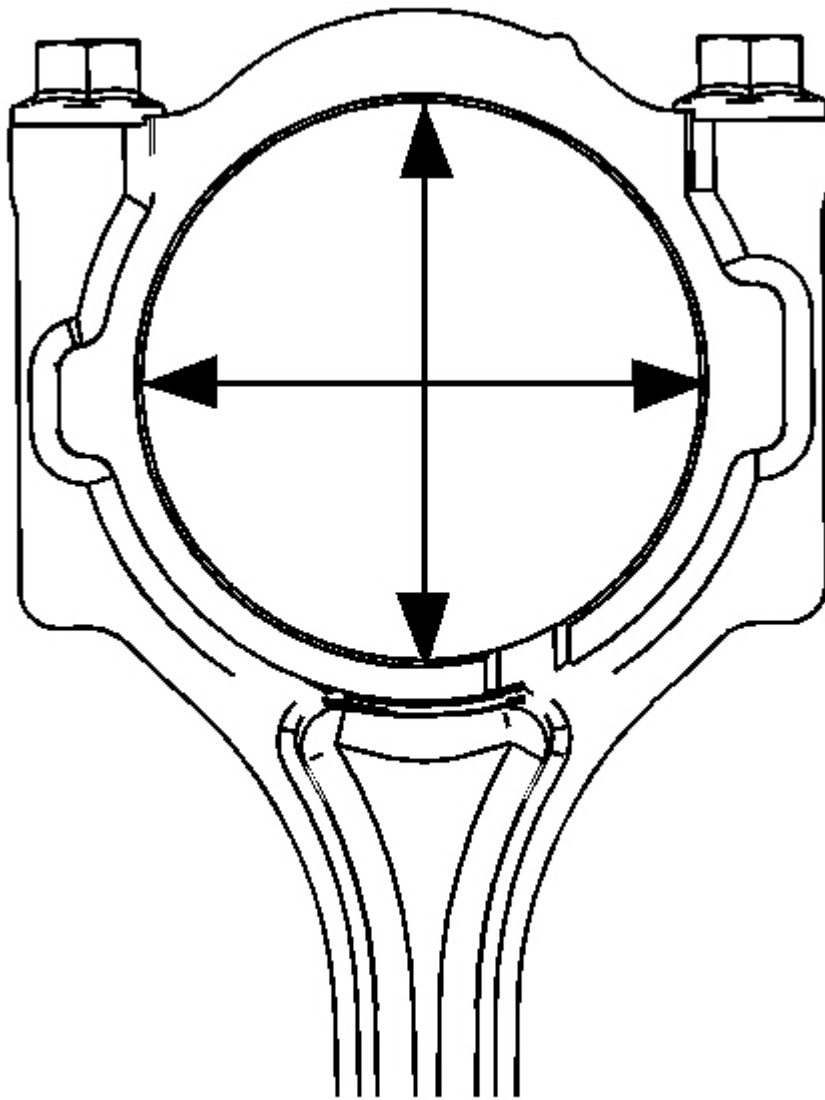


Fig. 15: Measuring Connecting Rod Crankshaft Bearing Bore
Courtesy of GENERAL MOTORS CORP.

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

1. Using an inside micrometer, measure the connecting rod crankshaft bearing bore.
2. Compare the bore measurements with the **Engine Mechanical Specifications (LF1)** .

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-46745: Piston Pin Clip Remover/Installer

For equivalent regional tools, refer to **Special Tools** .

PISTON AND PISTON PIN INSTALLATION PROCEDURE

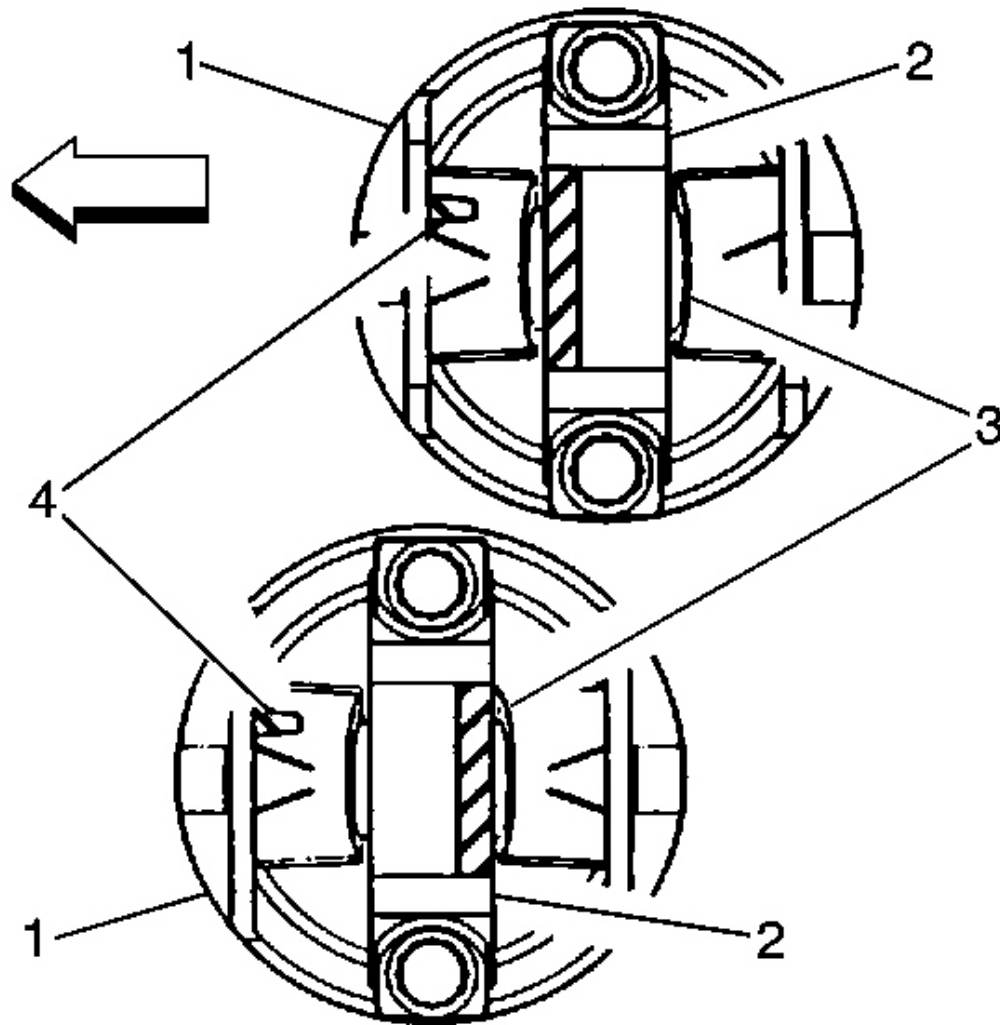


Fig. 16: Identifying Piston & Connecting Rod Locating Marks
Courtesy of GENERAL MOTORS CORP.

1. Properly orient the piston (1) on the connecting rod (2) as follows:
 - The locating mark (4) cast into the underside of the piston should point towards the front of the engine.
 - The locating notch (3) on the connecting rod cap should be pointing towards the rear of the engine on odd-numbered cylinders and towards the front of the engine on even-numbered cylinders.
2. Lubricate the piston pin bores in the piston and connecting rod. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended lubricant.

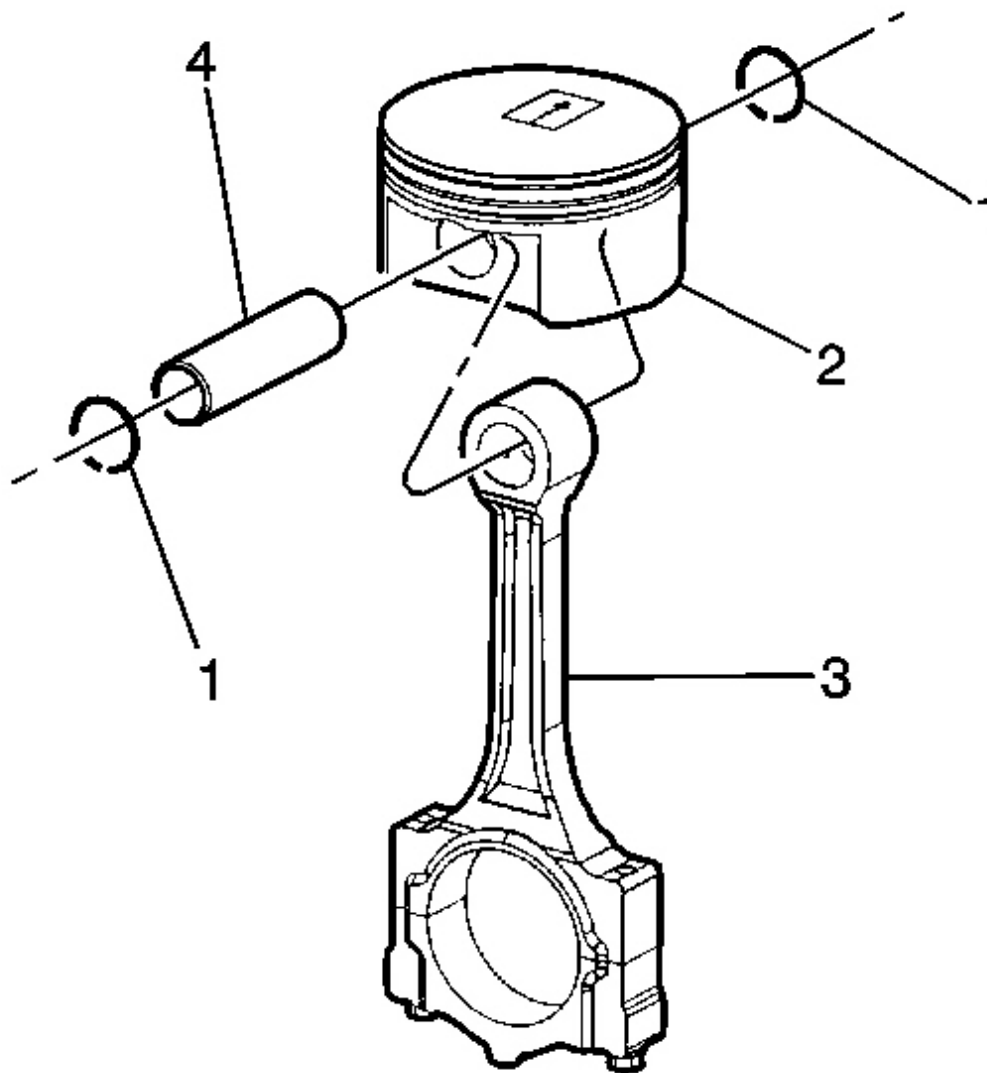


Fig. 17: Exploded View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

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

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.
6. Ensure that the piston pin retainers are fully seated in their grooves.
7. Repeat these procedures for the remaining pistons.

PISTON RING INSTALLATION PROCEDURE

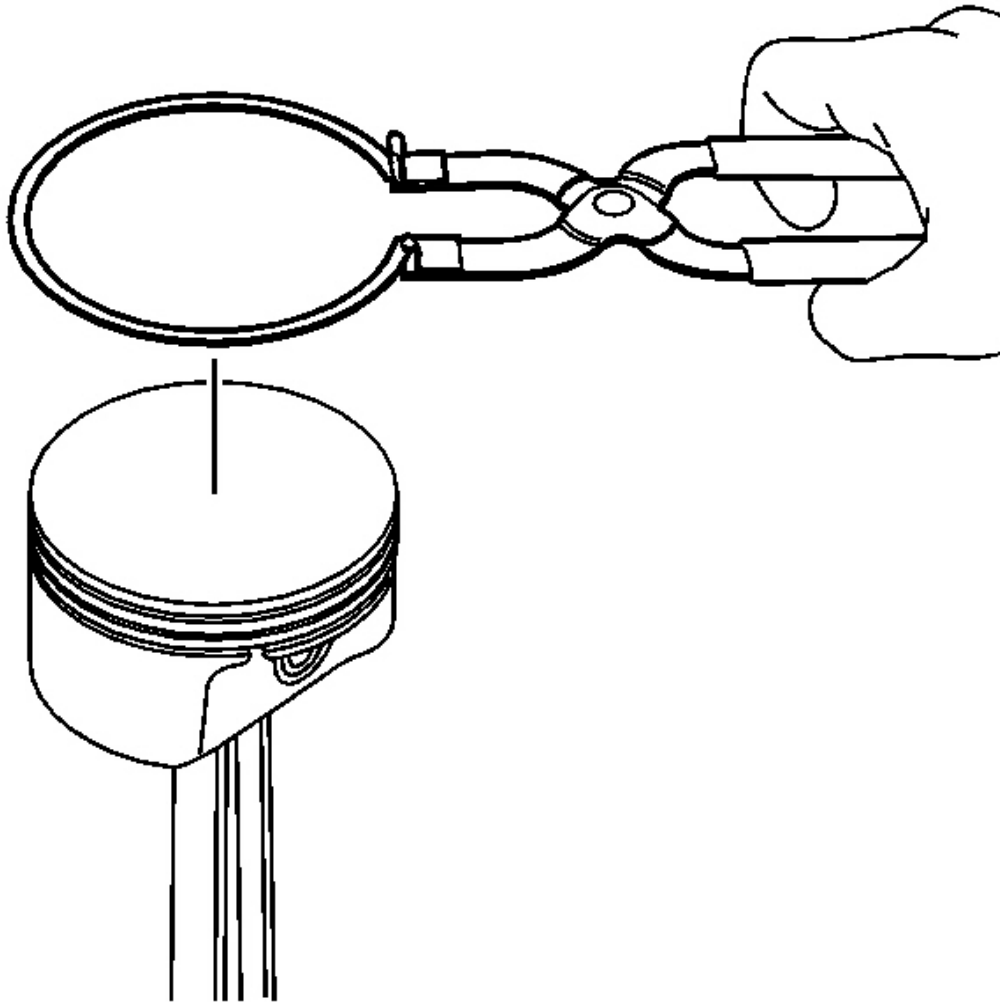


Fig. 18: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

CAUTION: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

1. Install the piston rings using a piston ring installer.

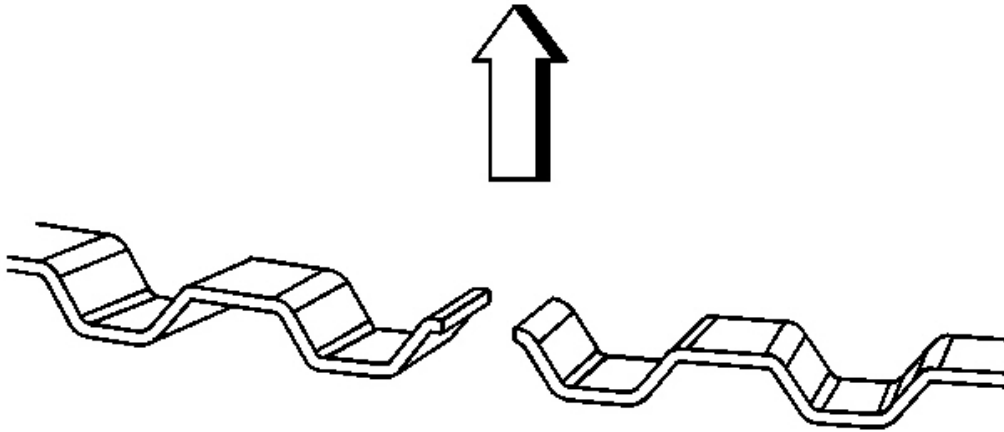


Fig. 19: Aligning Oil Control Ring Expander
Courtesy of GENERAL MOTORS CORP.

2. 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.

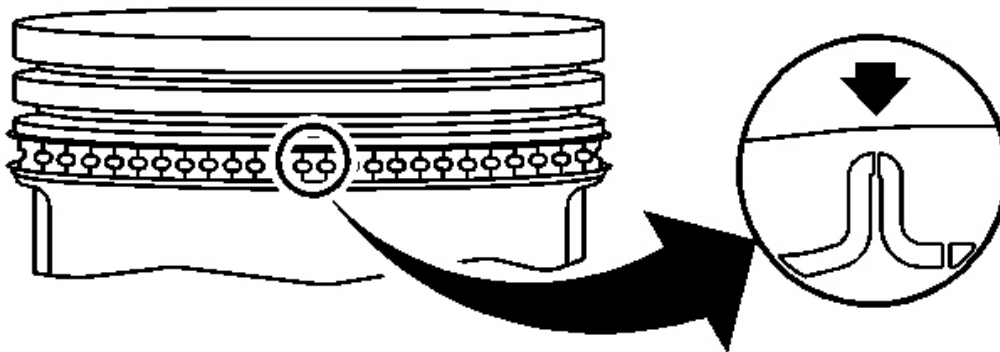


Fig. 20: View Of Lower Oil Control Piston Ring Spacer
Courtesy of GENERAL MOTORS CORP.

3. Install the oil control piston ring spacer onto the piston.

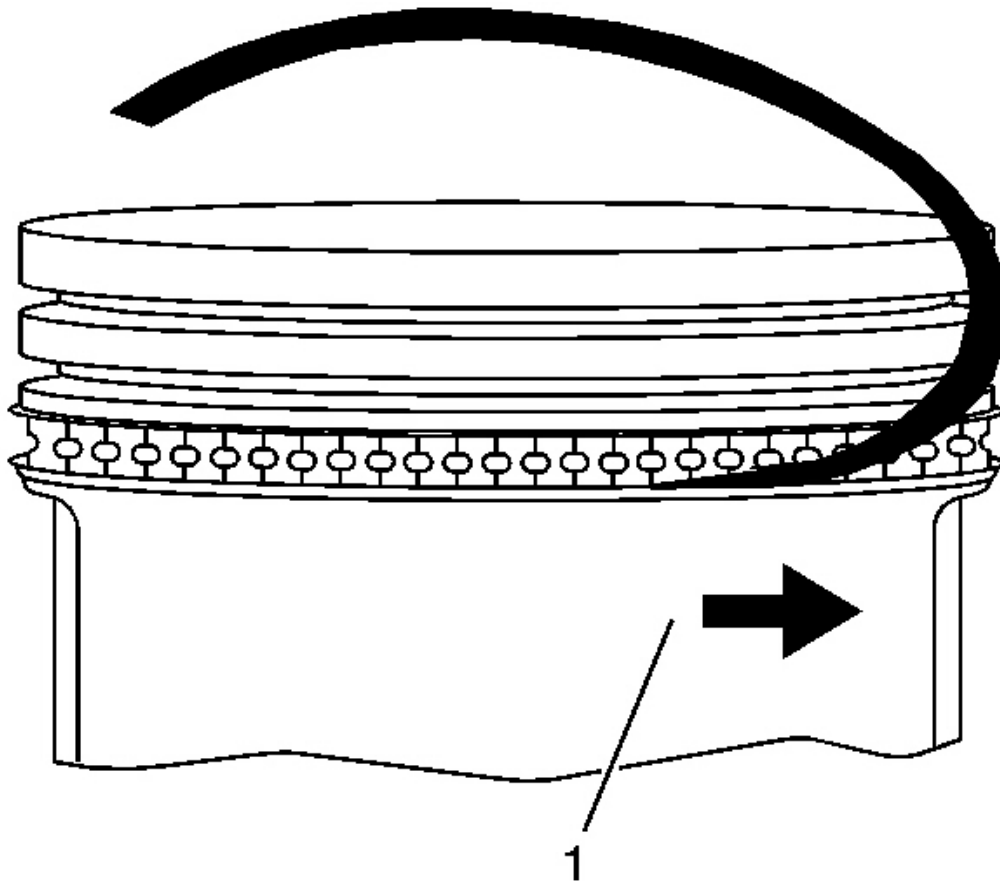


Fig. 21: View Of Lower Oil Control Piston Ring
Courtesy of GENERAL MOTORS CORP.

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

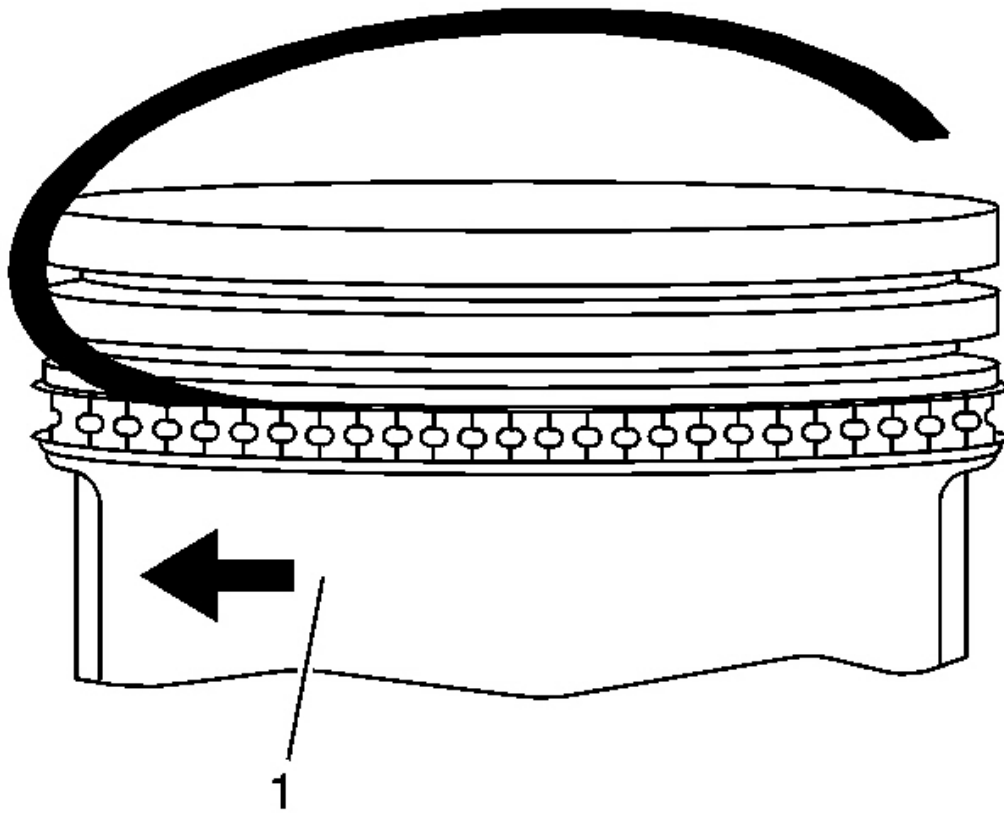


Fig. 22: View Of Upper Oil Control Piston Ring
Courtesy of GENERAL MOTORS CORP.

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

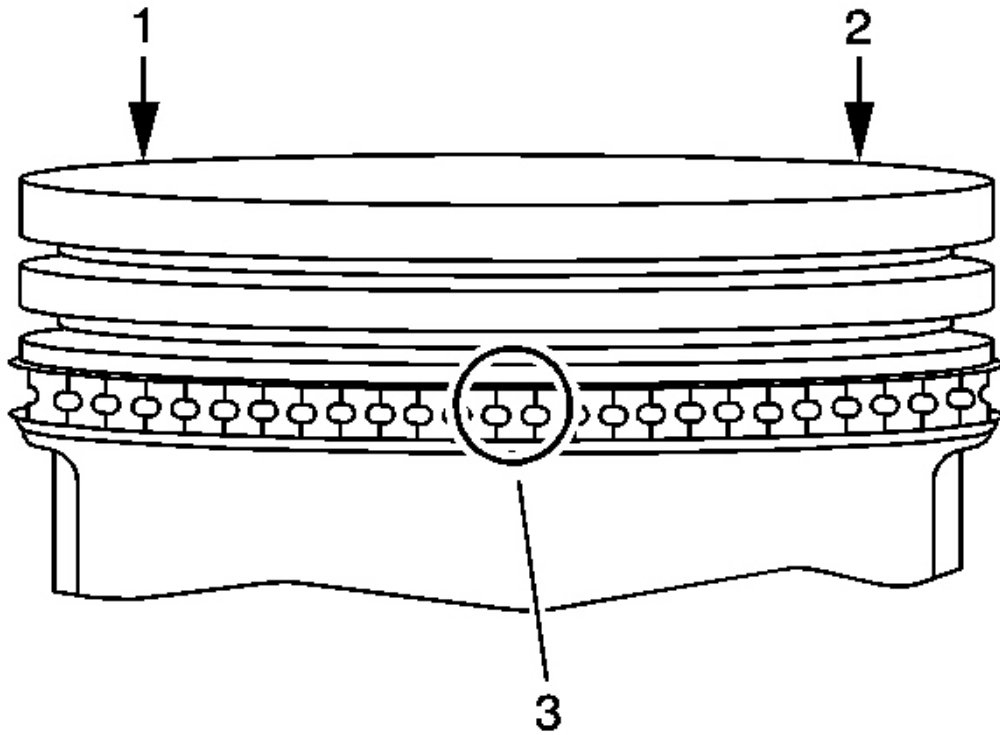


Fig. 23: View Of Oil Control Piston Rings
Courtesy of GENERAL MOTORS CORP.

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

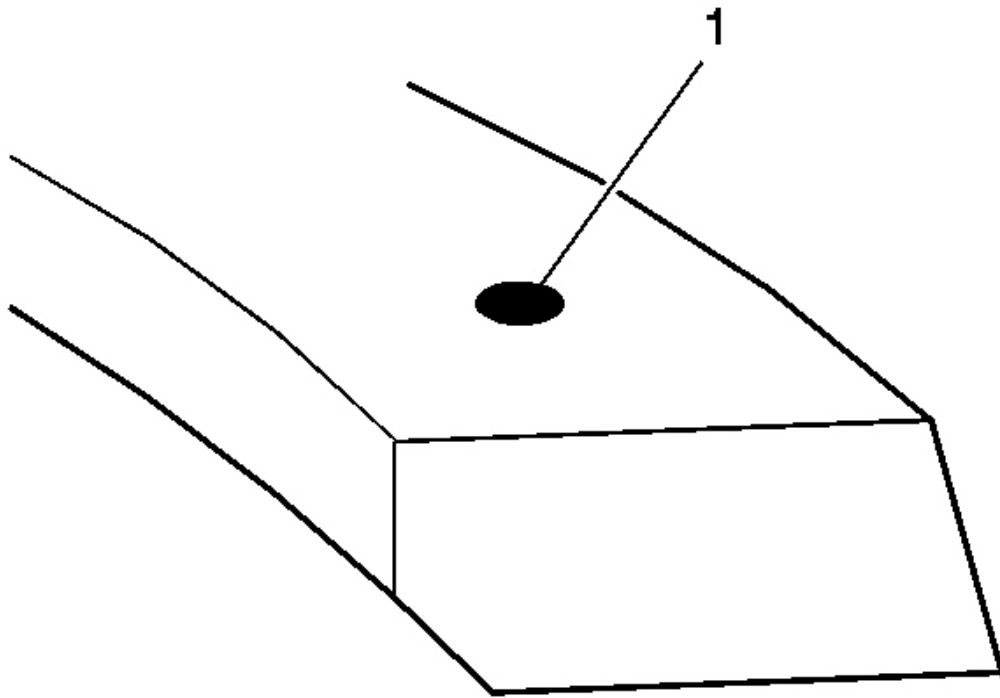


Fig. 24: View Of Lower Compression Piston Ring Mark
Courtesy of GENERAL MOTORS CORP.

7. Install the lower compression piston ring onto the piston (1).

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

8. Install the upper compression piston ring onto the piston.

The top compression ring may be installed with either side up.

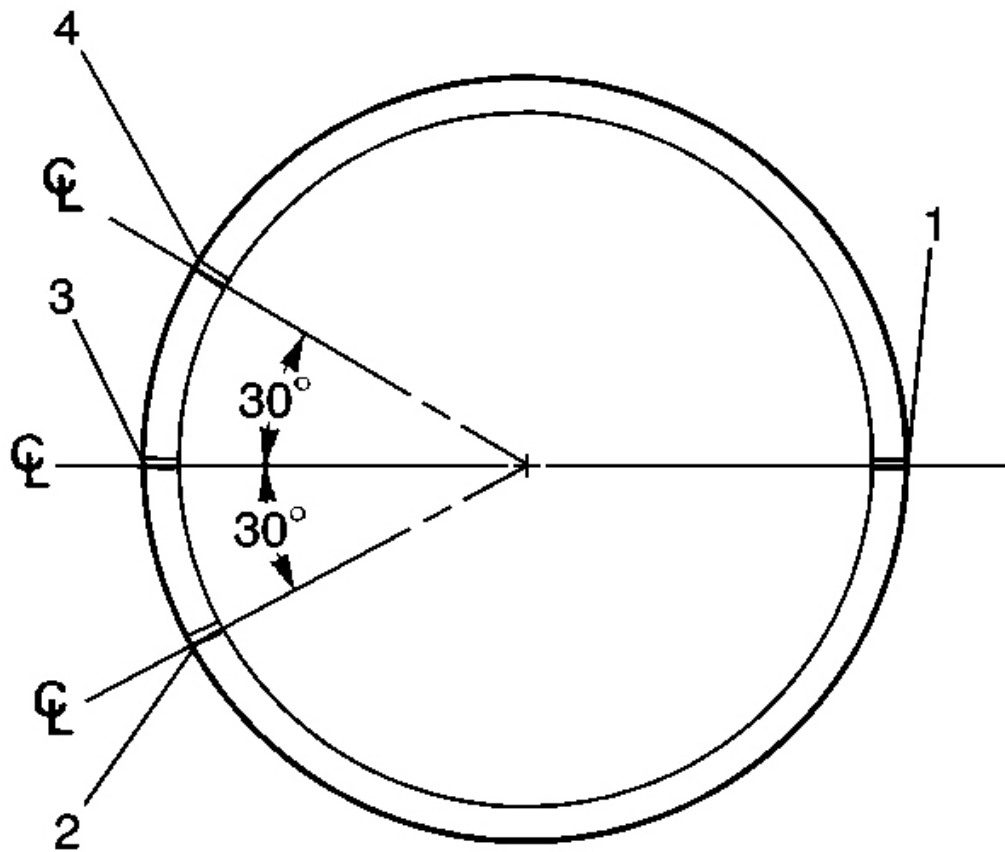


Fig. 25: Identifying Proper Oil Control Ring Gap Positioning
Courtesy of GENERAL MOTORS CORP.

9. Once the rings are installed, set the ring gaps for the oil control, second and top rings in the positions shown:
 1. Oil control ring expander and second compression ring gaps position 1.
 2. Upper oil control ring gap position 2.
 3. Top compression ring gap position 3.
 4. Lower oil control ring gap position 4.

CONNECTING ROD BEARING INSTALLATION PROCEDURE

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

1. Clean the connecting rod and the connecting rod cap bearing bore with a lint-free cloth.

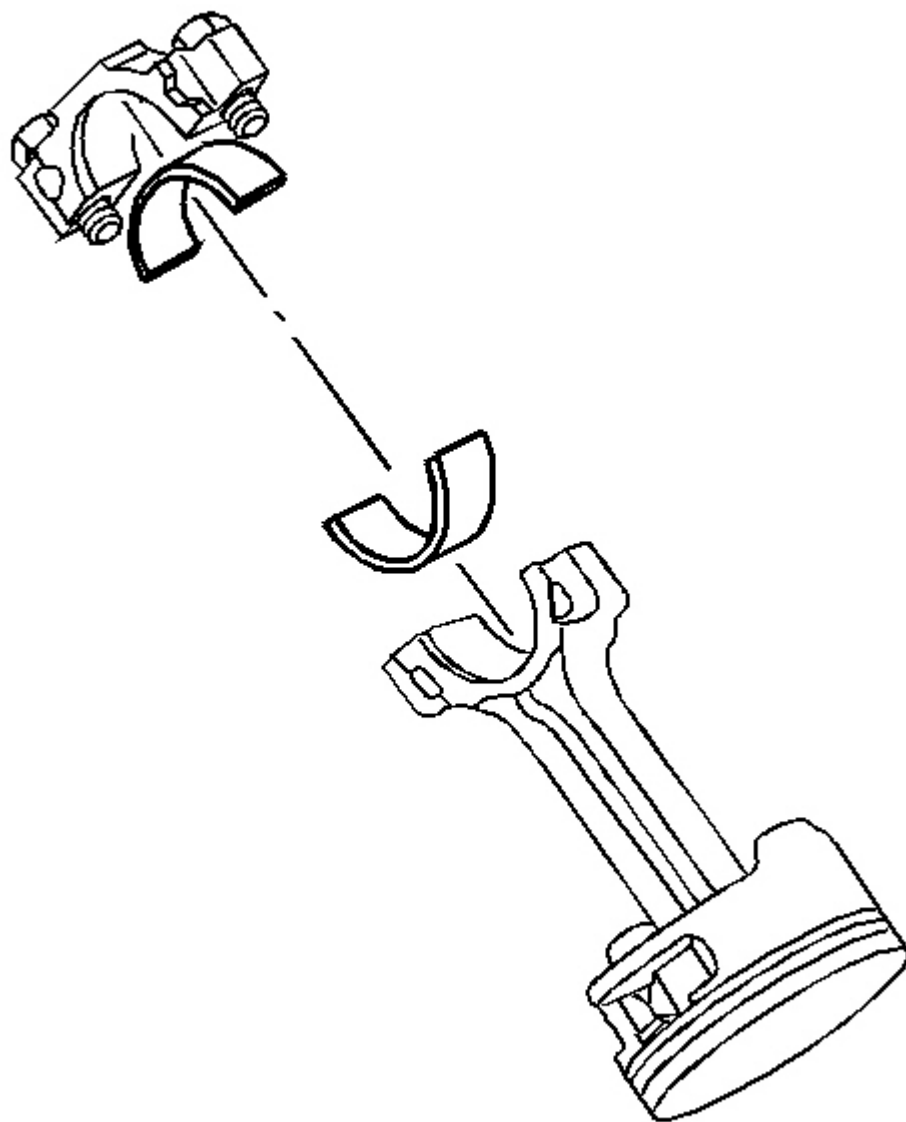


Fig. 26: View Of Piston, Connecting Rod, Bearing Cap, Bearing Halves & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Clean all the oil from behind the connecting rod bearing halves.
3. Install new upper connecting rod bearings 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 new lower connecting rod bearings into position in the connecting rod cap. 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 (LF1 OR LFW)

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

For equivalent regional tools, refer to **Special Tools** .

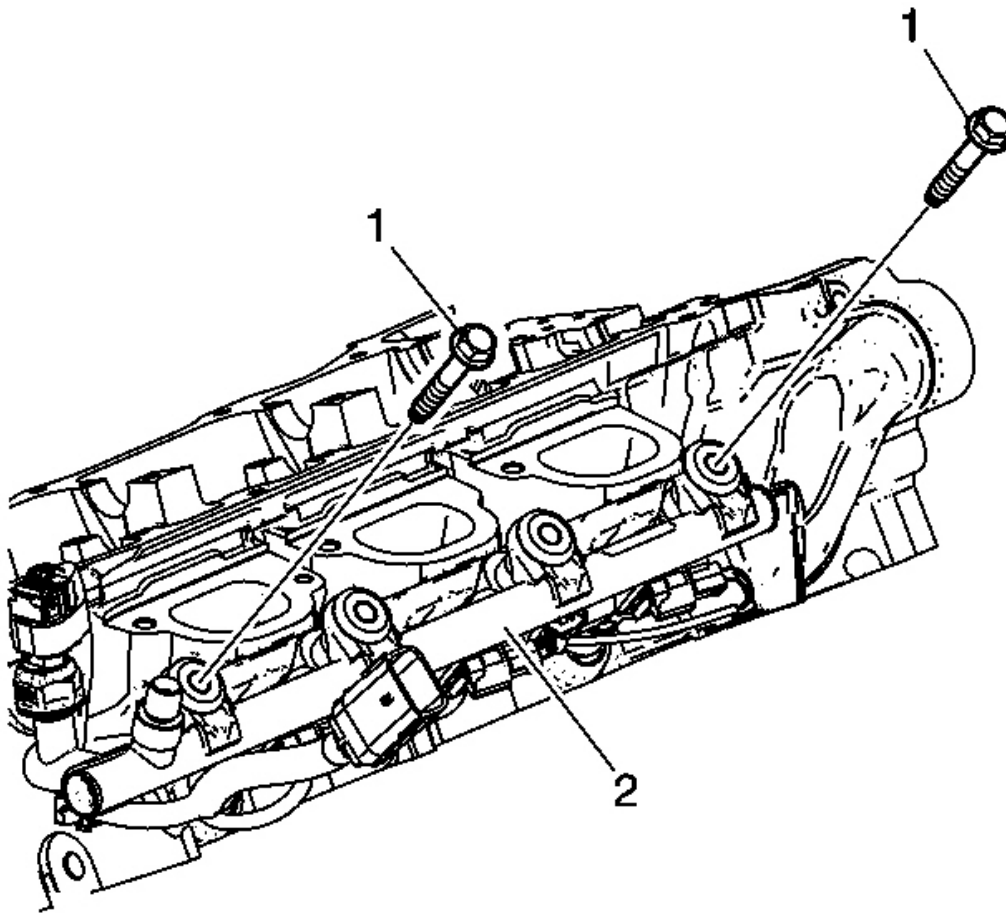


Fig. 27: Fuel Rail Bolts

Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel rail bolts (1).

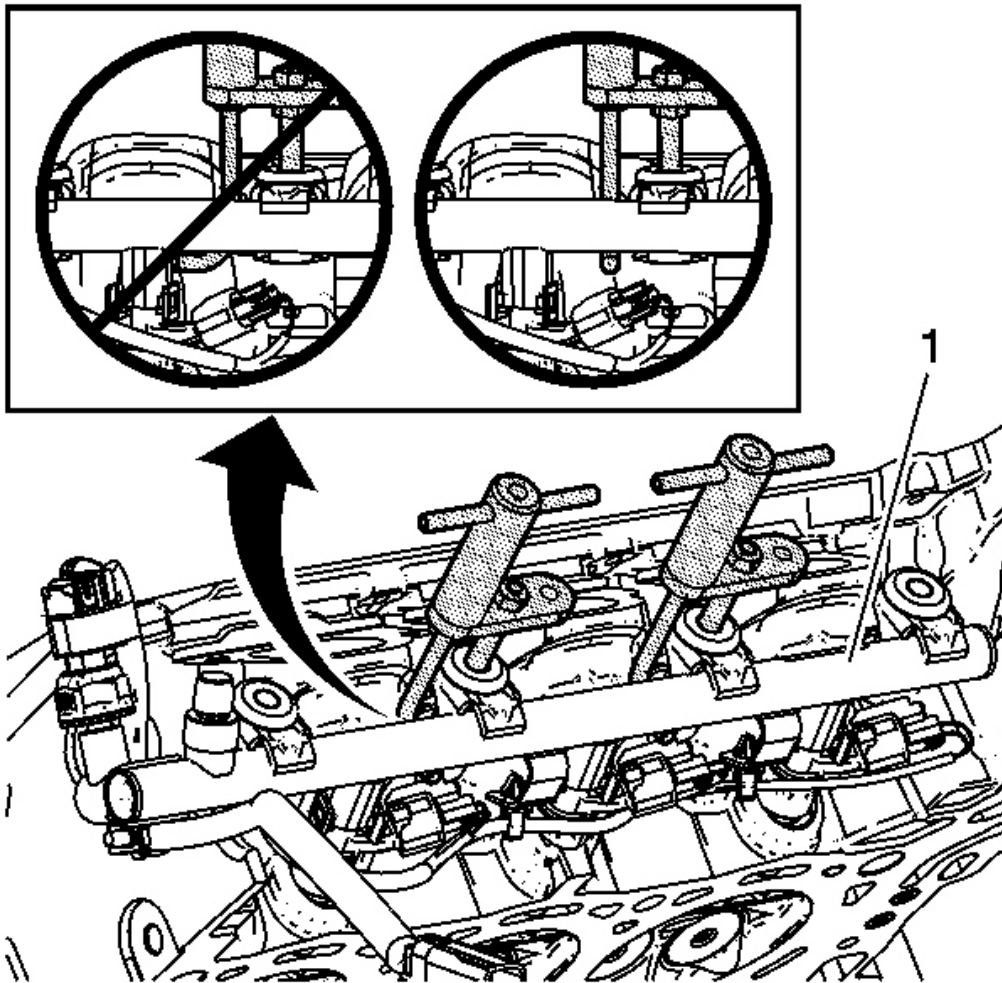


Fig. 28: Removing Fuel Rail And Injectors
Courtesy of GENERAL MOTORS CORP.

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

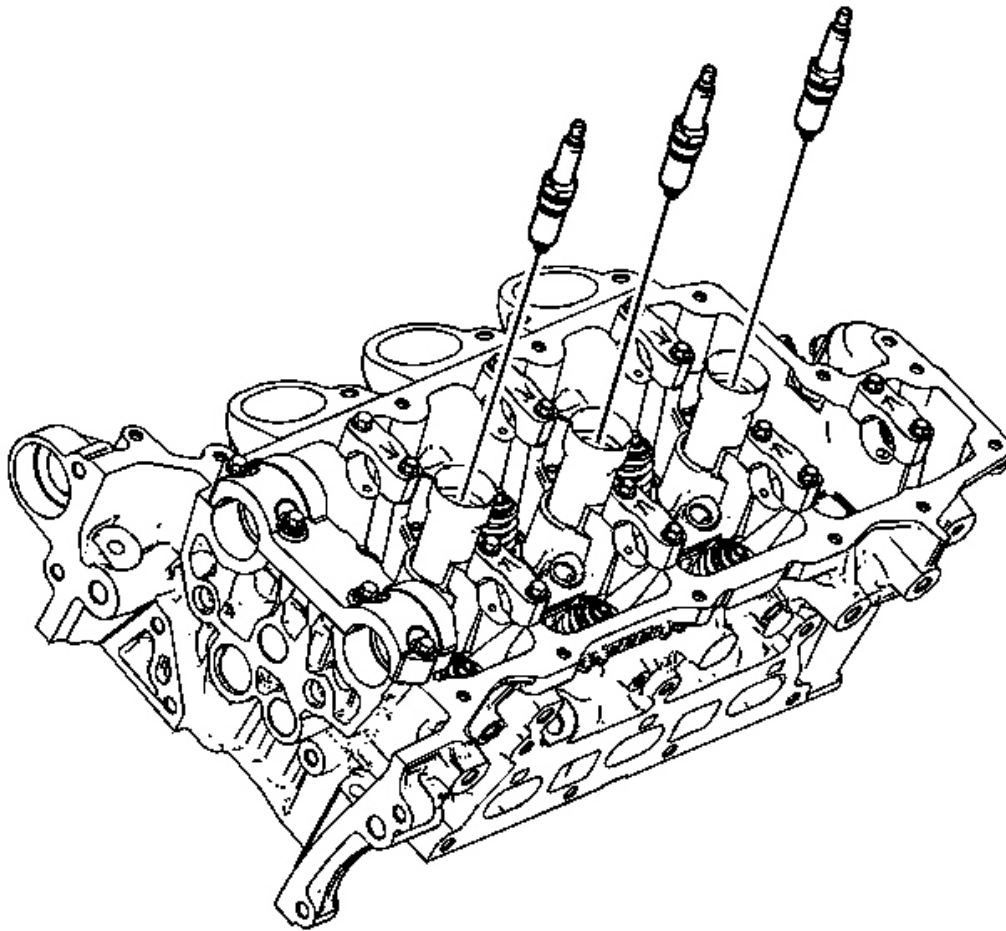


Fig. 29: Spark Plugs

Courtesy of GENERAL MOTORS CORP.

3. Remove the spark plugs.

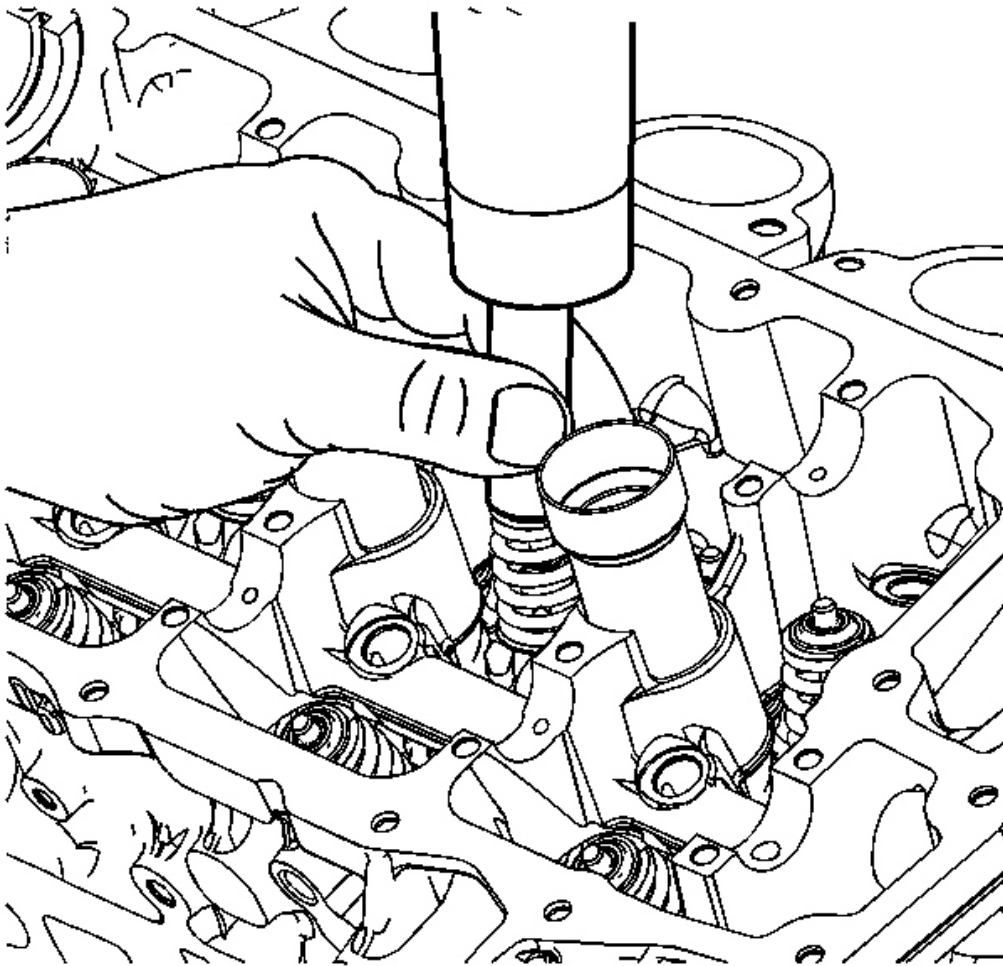


Fig. 30: Loosening Valve Keepers
Courtesy of GENERAL MOTORS CORP.

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

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

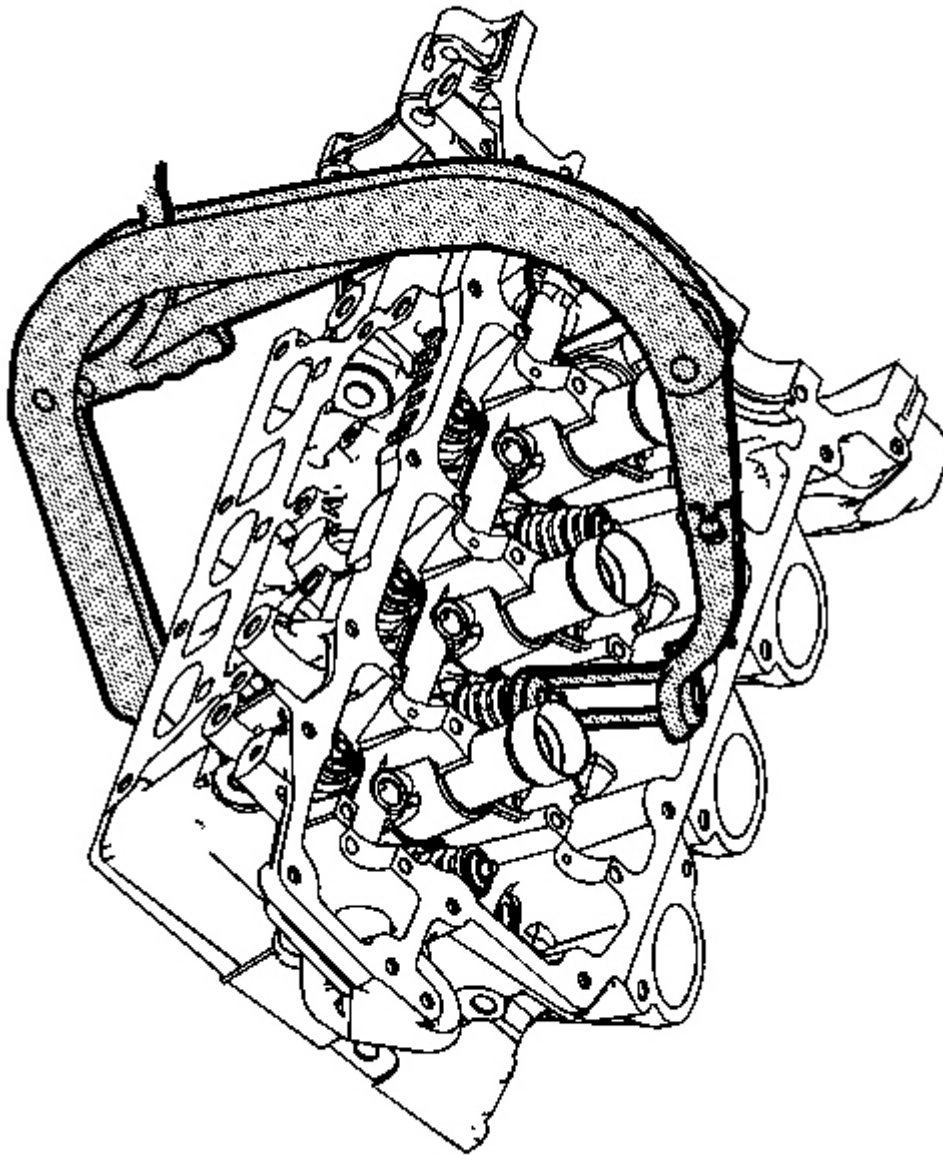


Fig. 31: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

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.

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

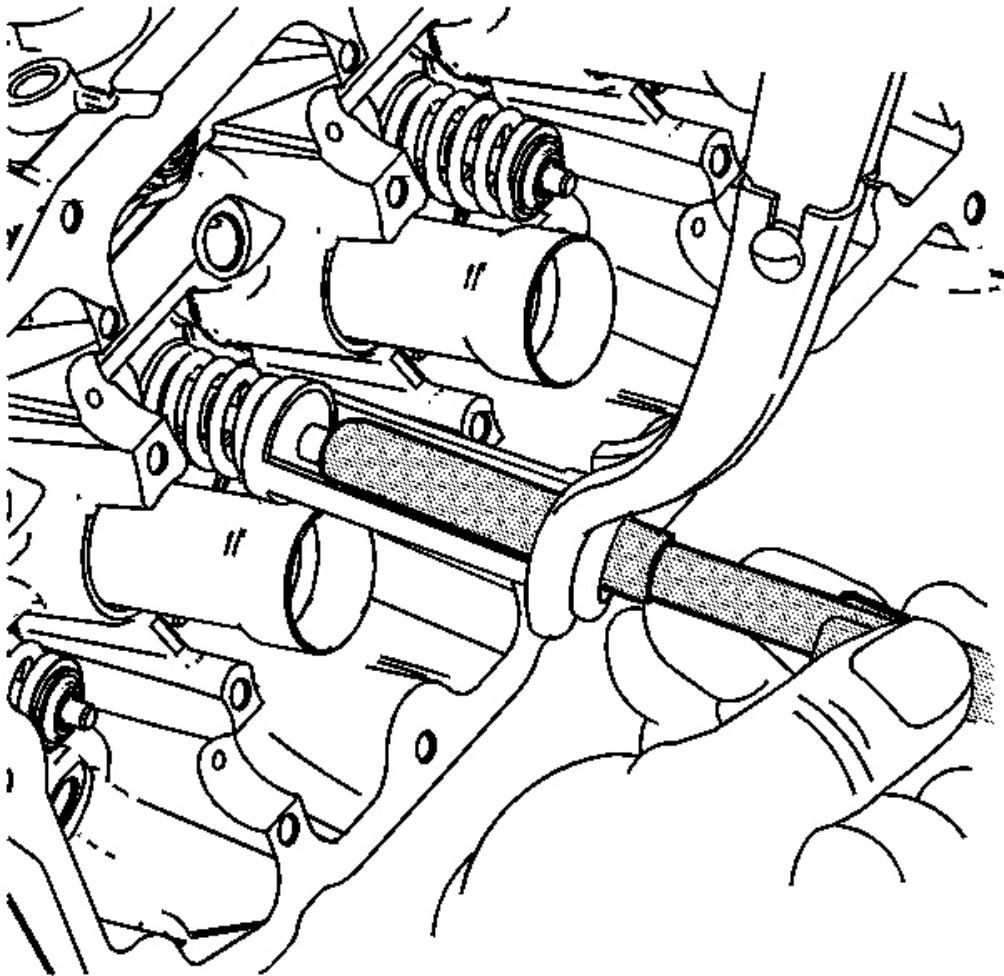


Fig. 32: Removing/Installing Valve Keepers
Courtesy of GENERAL MOTORS CORP.

6. 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.

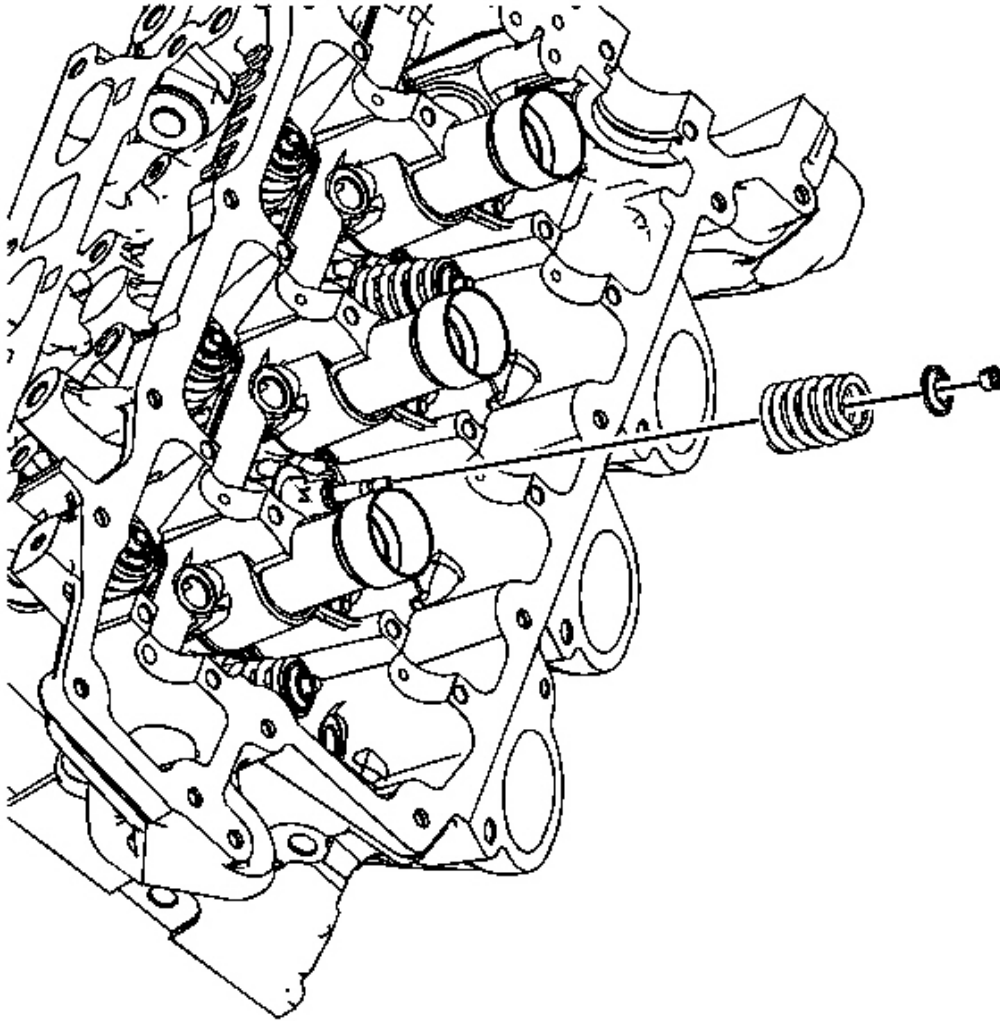


Fig. 33: View Of Valve Spring & Retainer
Courtesy of GENERAL MOTORS CORP.

8. Remove the valve spring retainer.
9. Remove the valve spring.

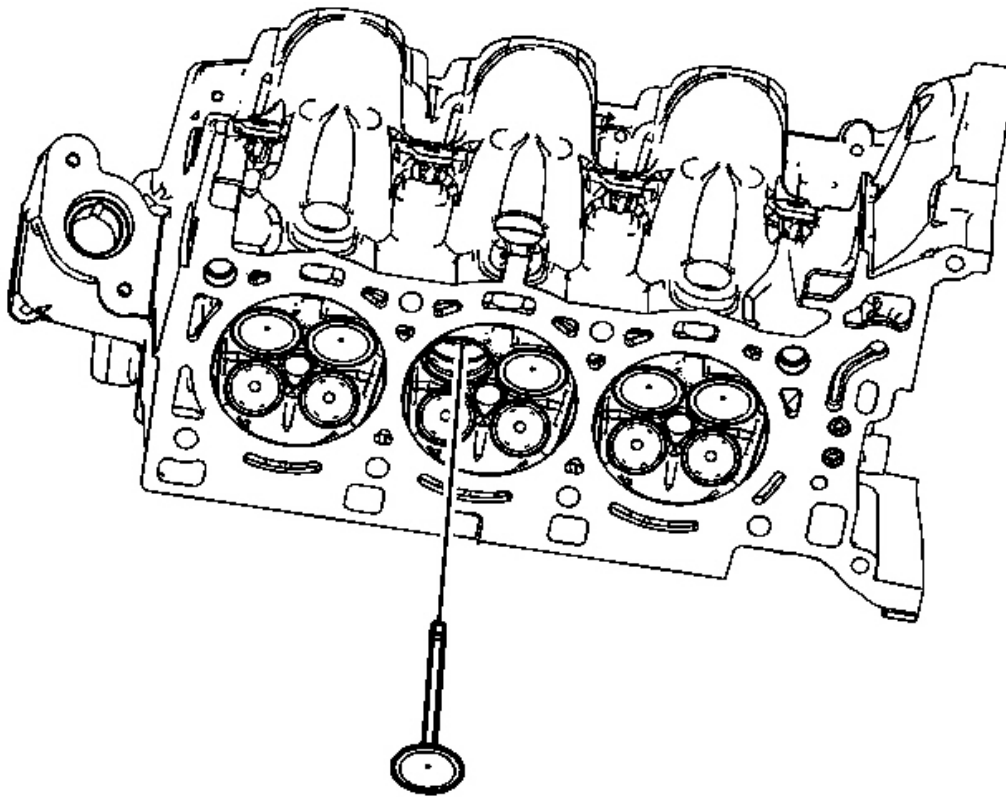


Fig. 34: Removing/Installing valve
Courtesy of GENERAL MOTORS CORP.

10. Remove the valve.

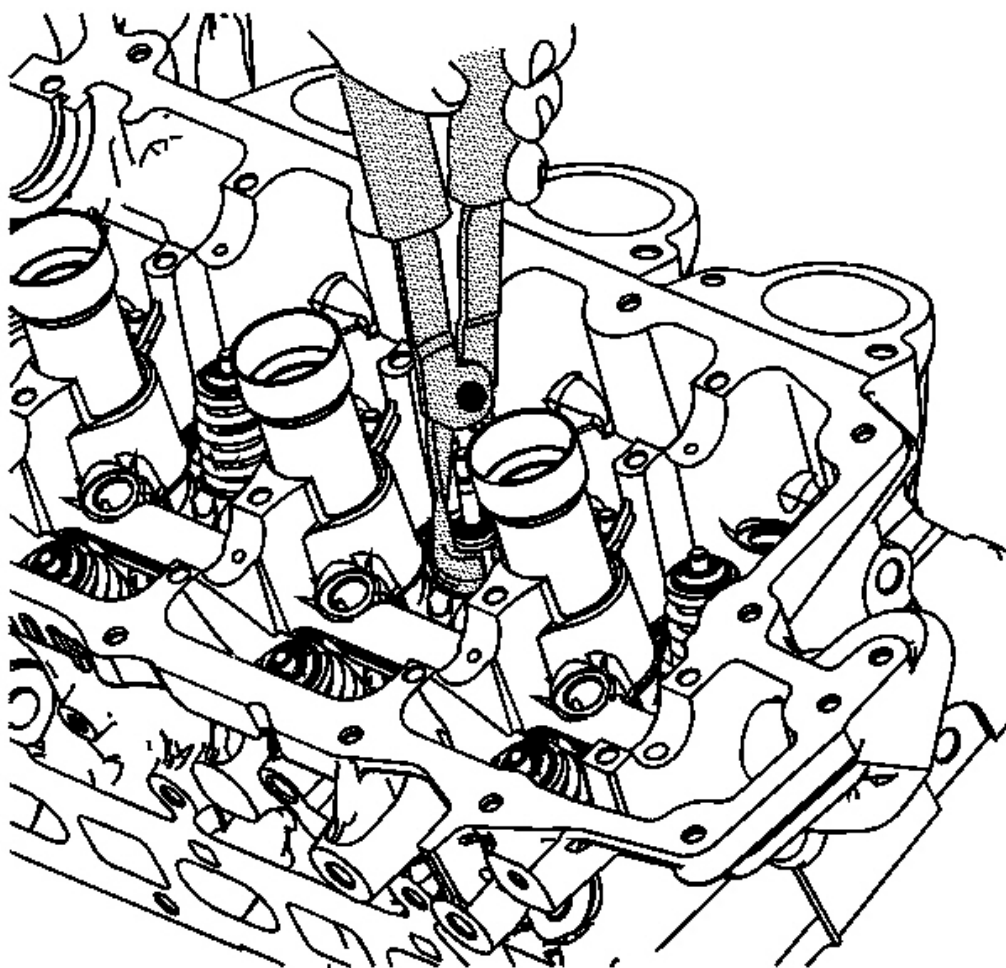


Fig. 35: Removing/Installing Valve Stem Oil Seals
Courtesy of GENERAL MOTORS CORP.

NOTE: **NEVER** reuse a valve stem oil seal.

11. Remove the valve stem oil seal using the **EN 46116**: remover/installer and discard.
12. Repeat these procedures for the remaining valves.

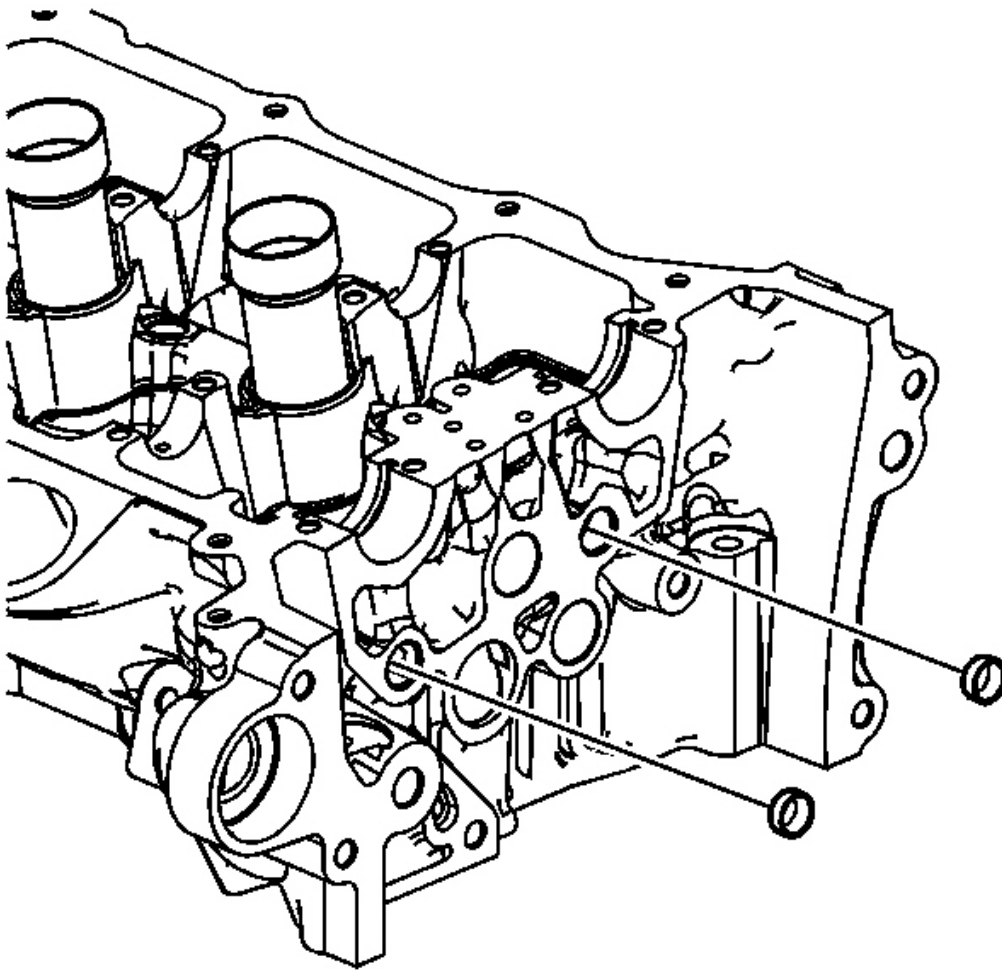


Fig. 36: Cylinder Head Oil Gallery Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

13. Remove the cylinder head oil gallery expansion plugs.

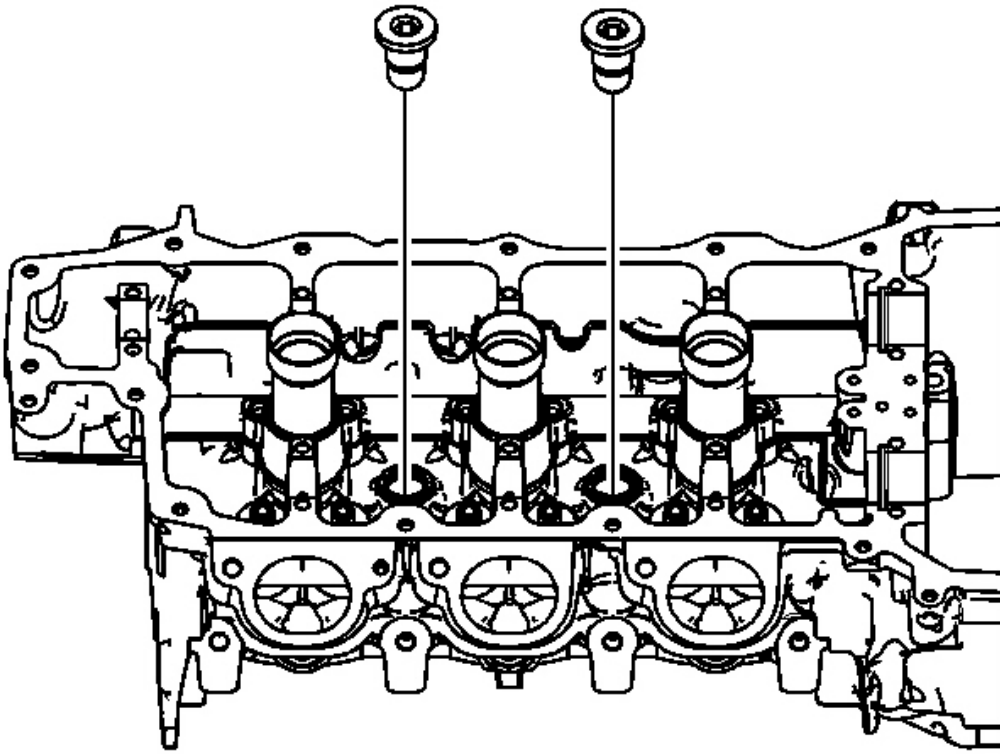


Fig. 37: View Of Cylinder Head Coolant Threaded Plugs
Courtesy of GENERAL MOTORS CORP.

14. Remove the cylinder head coolant threaded plugs.

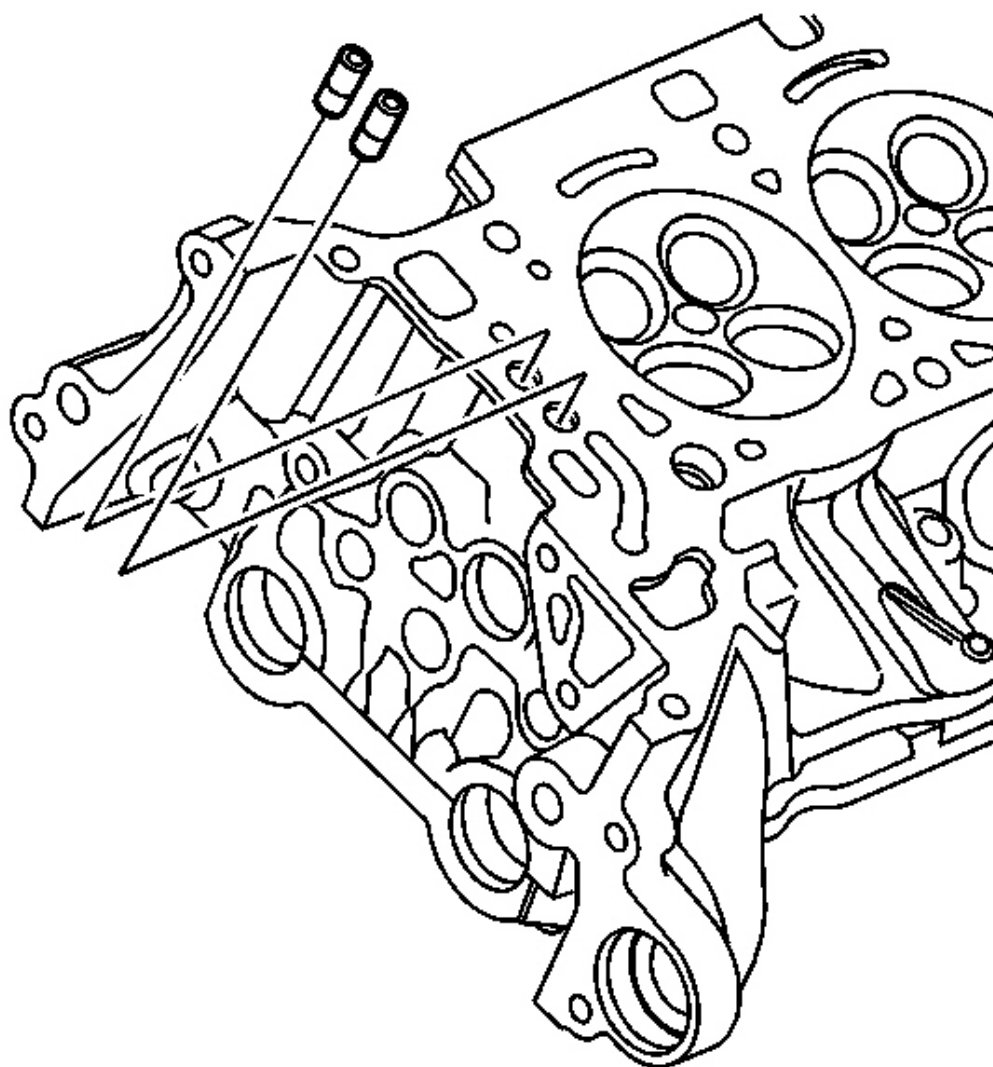


Fig. 38: View Of Camshaft Position Actuator Oil Feed Check Valves
Courtesy of GENERAL MOTORS CORP.

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.

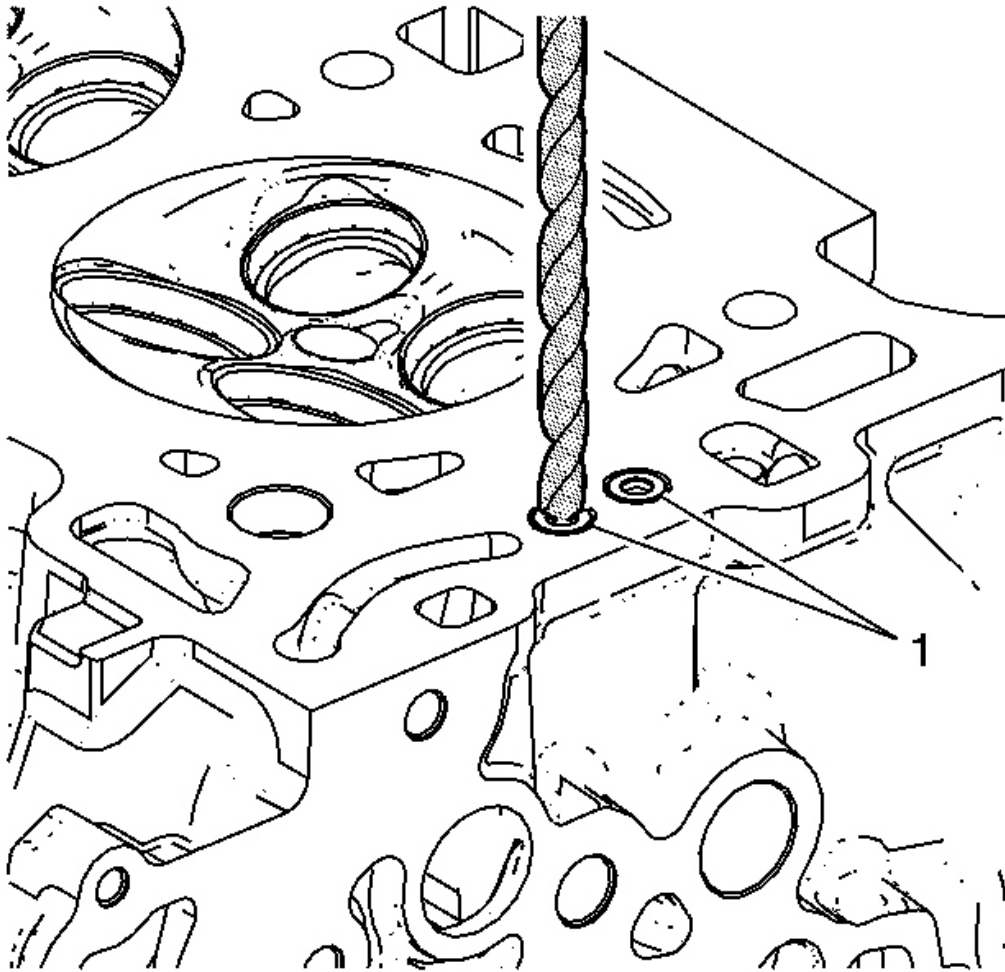


Fig. 39: Drilling Out Top Portion Of Check Valve
Courtesy of GENERAL MOTORS CORP.

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.

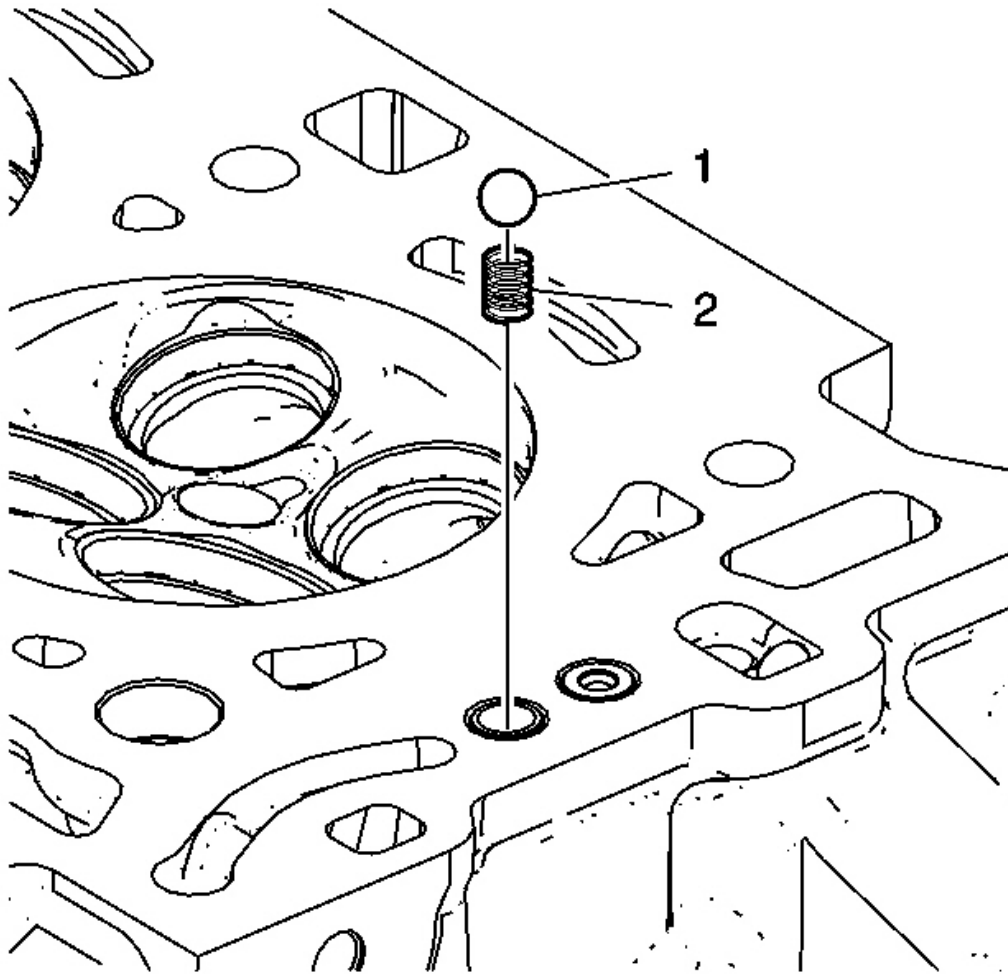


Fig. 40: Identifying Check Ball & Check Ball Spring
Courtesy of GENERAL MOTORS CORP.

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

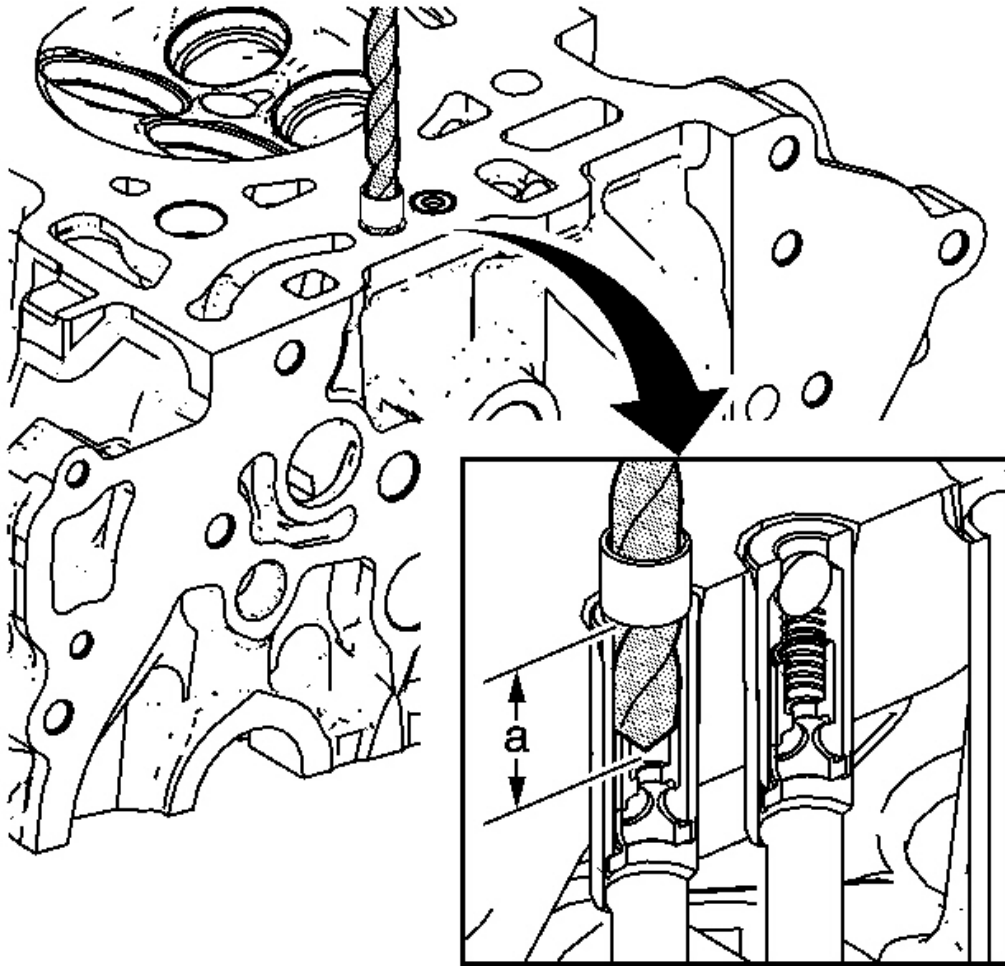


Fig. 41: Drilling Remainder Of Check Valve Sleeve
Courtesy of GENERAL MOTORS CORP.

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.

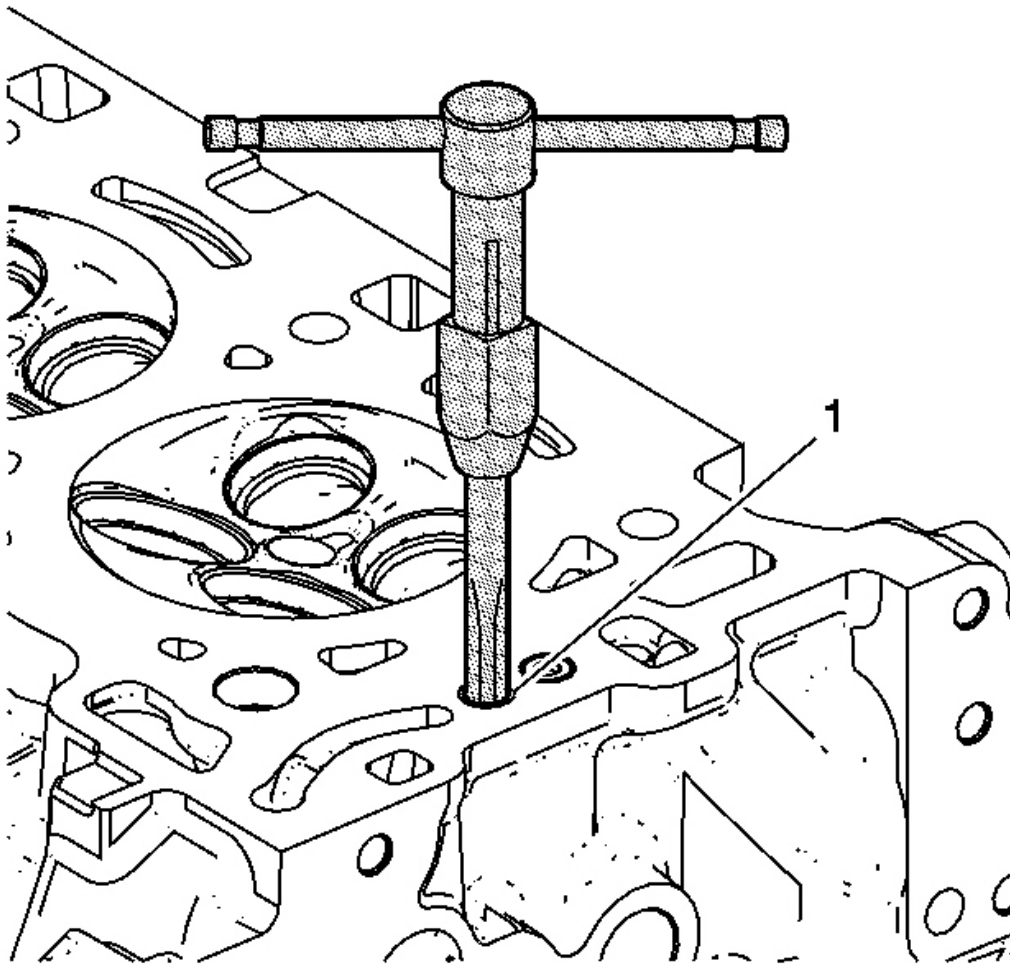


Fig. 42: Tapping Drilled Out Portion Of Check Valve
Courtesy of GENERAL MOTORS CORP.

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.

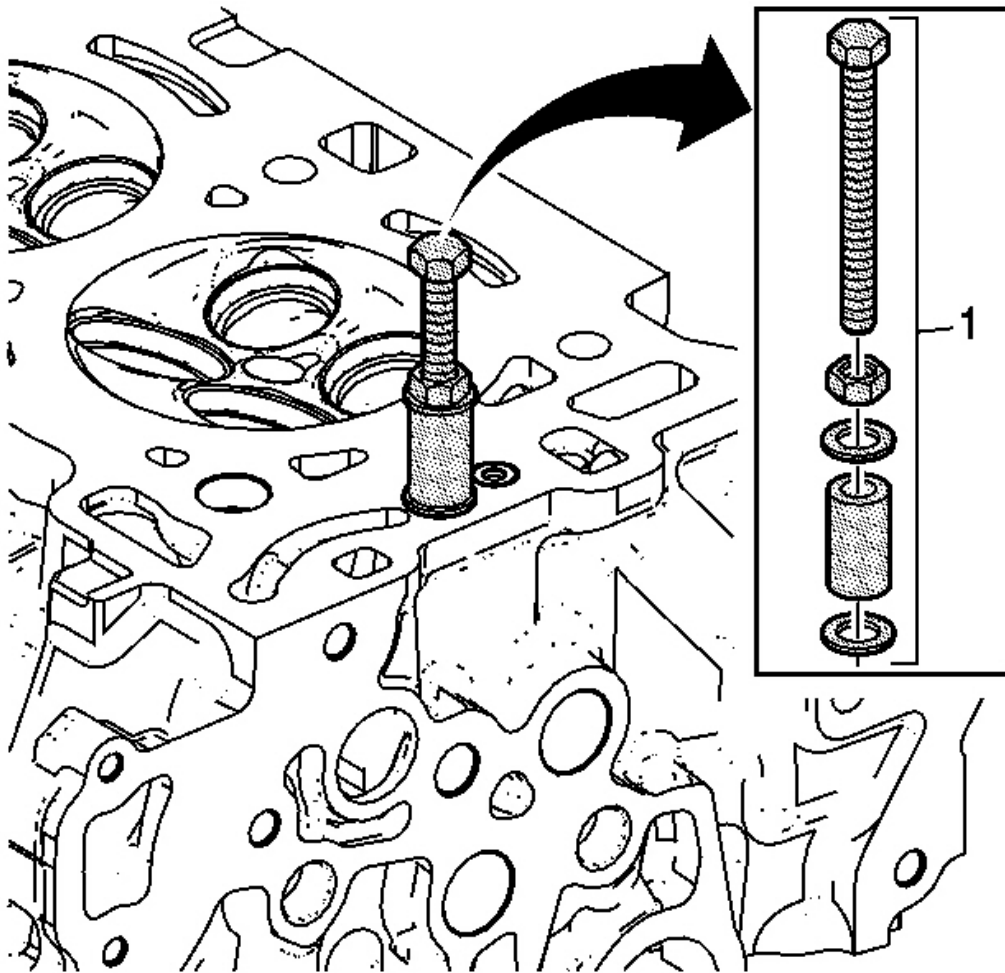


Fig. 43: Assembling Bolt, Nut, Washers & Collar EN-46122-2
Courtesy of GENERAL MOTORS CORP.

21. 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.

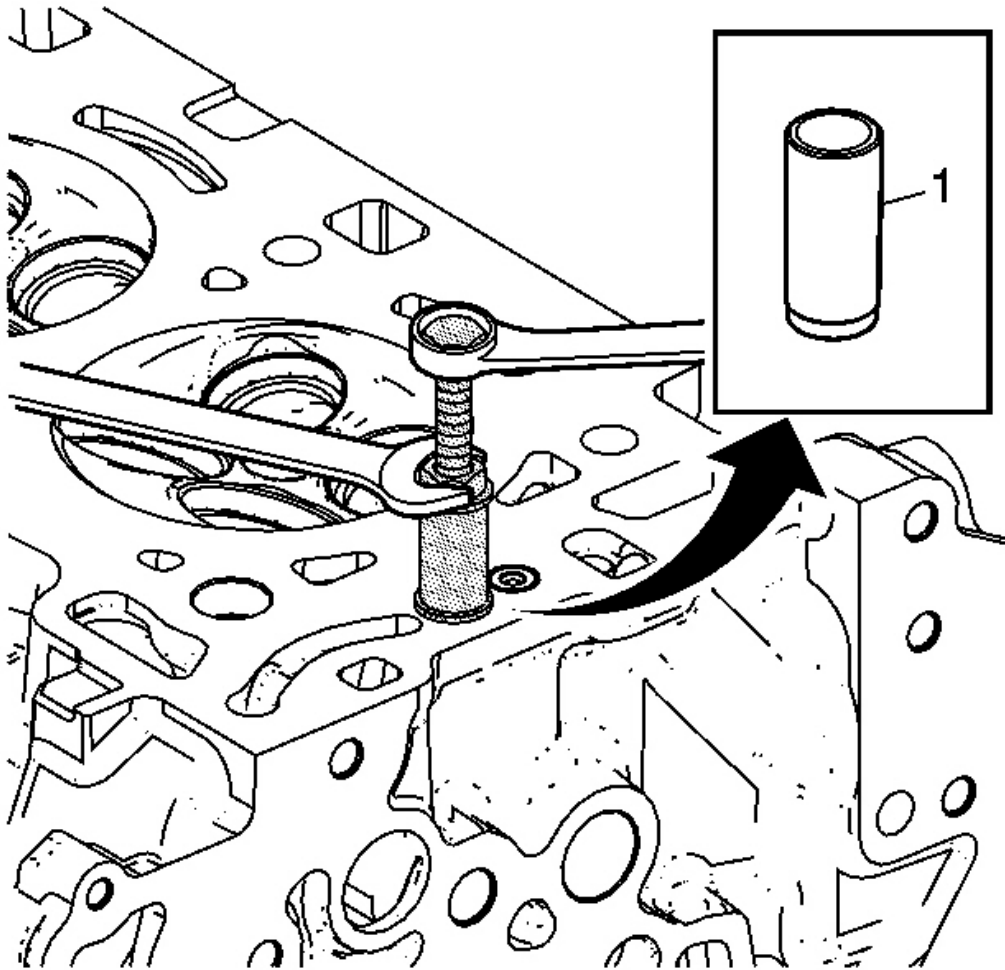


Fig. 44: Removing Check Valve Sleeve
Courtesy of GENERAL MOTORS CORP.

23. 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
- **EN 28410:** Gasket Remover

- **EN 42096:** Valve Guide Reamer
- **EN 47909:** Injector Bore and Sleeve Cleaning Kit
- **J 8358:** Carbon Removal Brush

For equivalent regional tools, refer to **Special Tools** .

CLEANING PROCEDURE

1. Remove any old thread sealant, gasket material or sealant using **EN 28410:** remover.
2. Clean all cylinder head surfaces with non-corrosive solvent.

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

3. Blow out all the oil galleries using compressed air.
4. Remove any carbon deposits from the combustion chambers using the **J 8358:** brush.
5. Clean any debris or build-up from the lifter pockets.

VISUAL INSPECTION

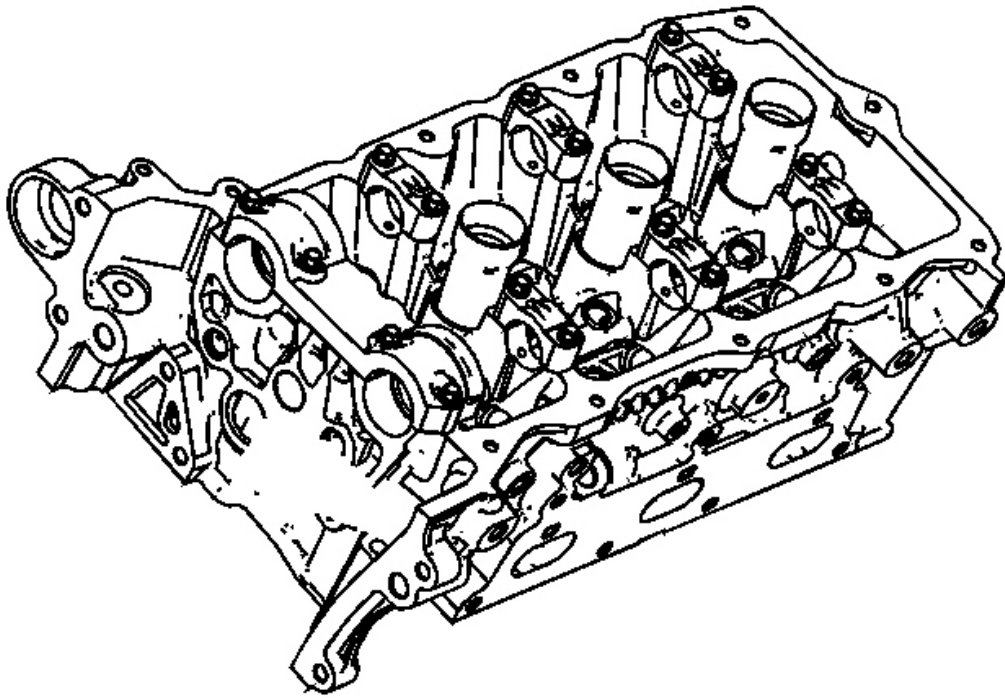


Fig. 45: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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.

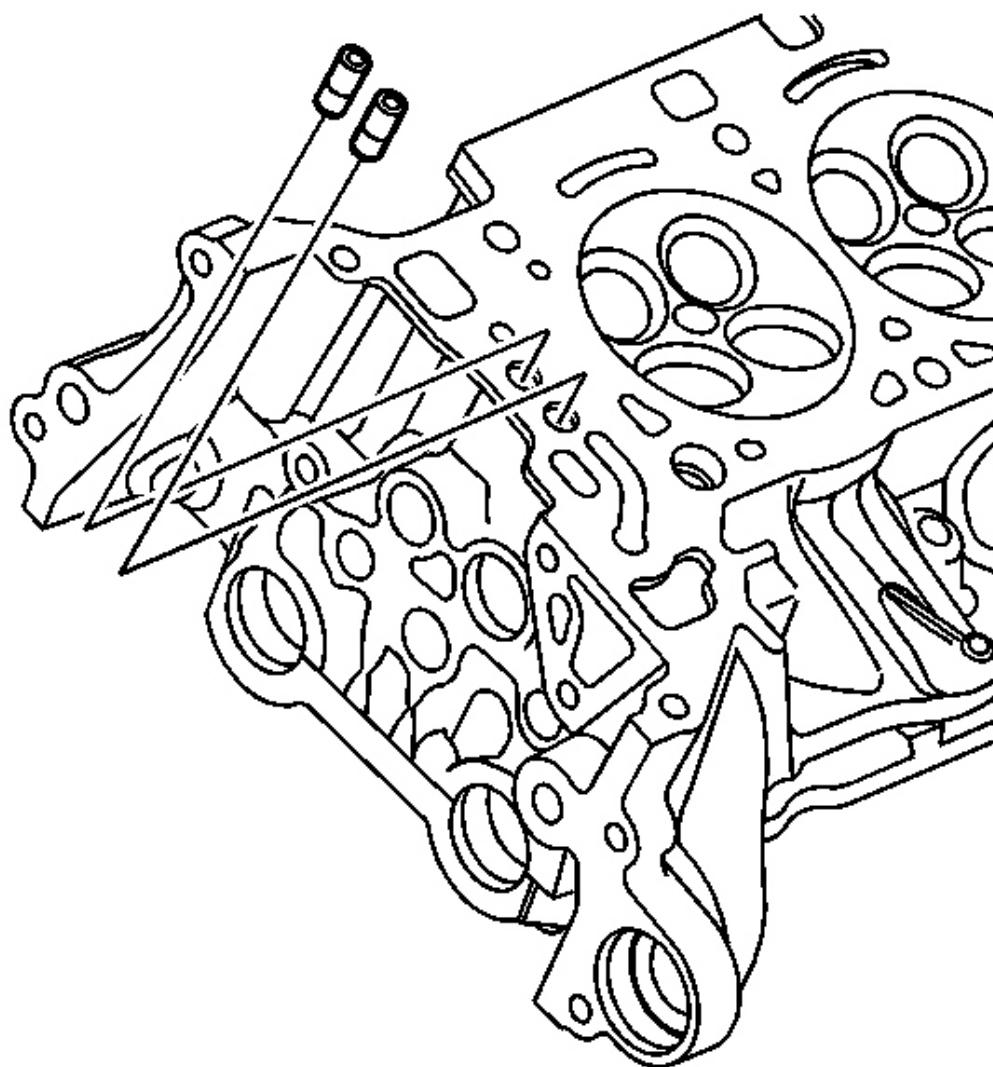


Fig. 46: View Of Camshaft Position Actuator Oil Feed Check Valves
Courtesy of GENERAL MOTORS CORP.

5. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced. Refer to **Cylinder Head Disassemble (LF1 or LFW)**.

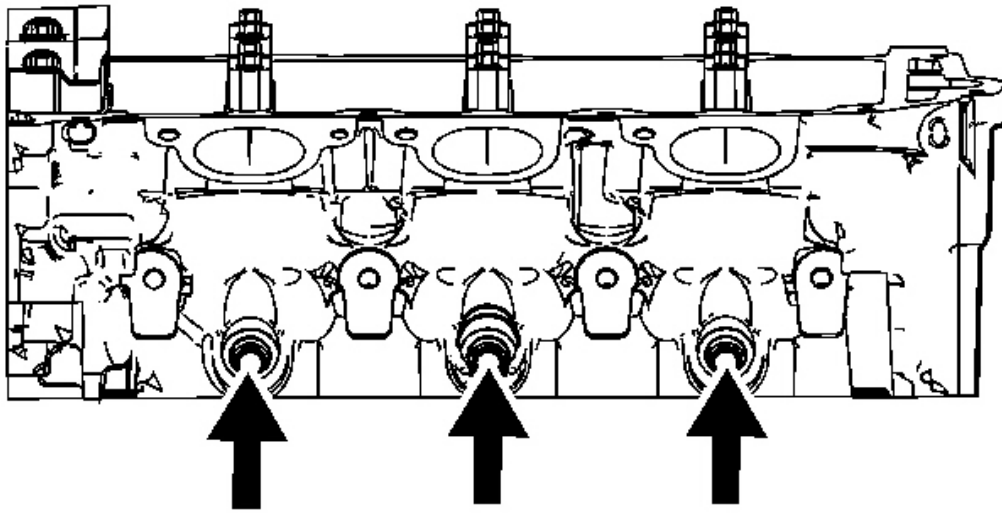


Fig. 47: Fuel Rail injector Bores
Courtesy of GENERAL MOTORS CORP.

6. Inspect the fuel rail injector bores and clean with **EN-47909**: 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

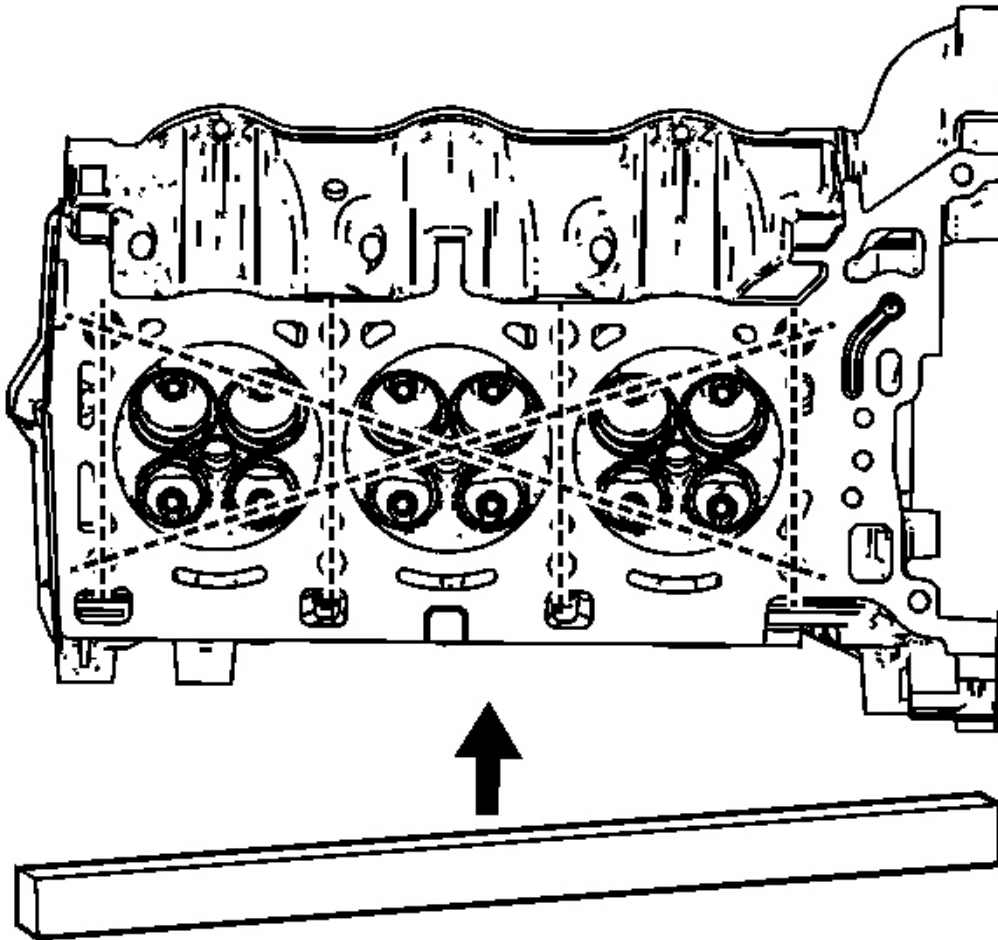


Fig. 48: Measuring Deck Flatness
Courtesy of GENERAL MOTORS CORP.

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

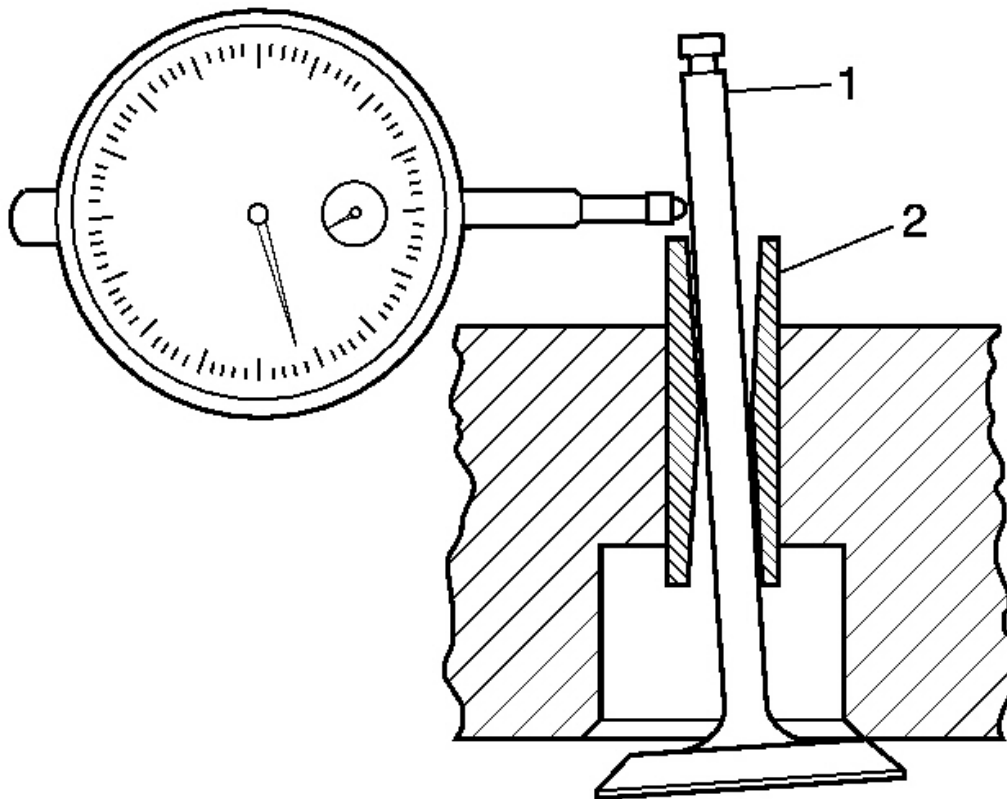


Fig. 49: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

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**: 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. Refer to **Engine Mechanical Specifications (LF1)** for proper clearance.
 - 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**: 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

For equivalent regional tools, refer to **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

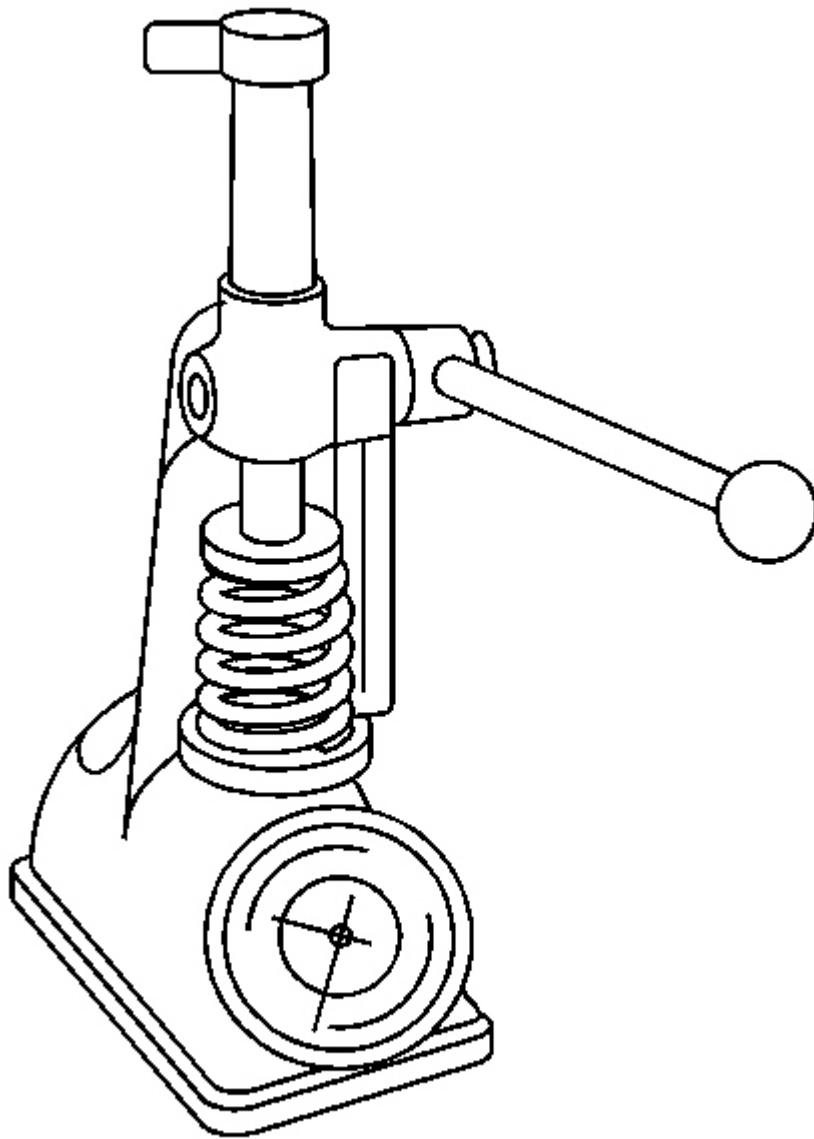


Fig. 50: View Of J 22738-B
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve spring tension using the **EN 22738-B**: tester. Refer to **Engine Mechanical Specifications (LF1)** .
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 (GASOLINE)

CYLINDER HEAD IDENTIFICATION

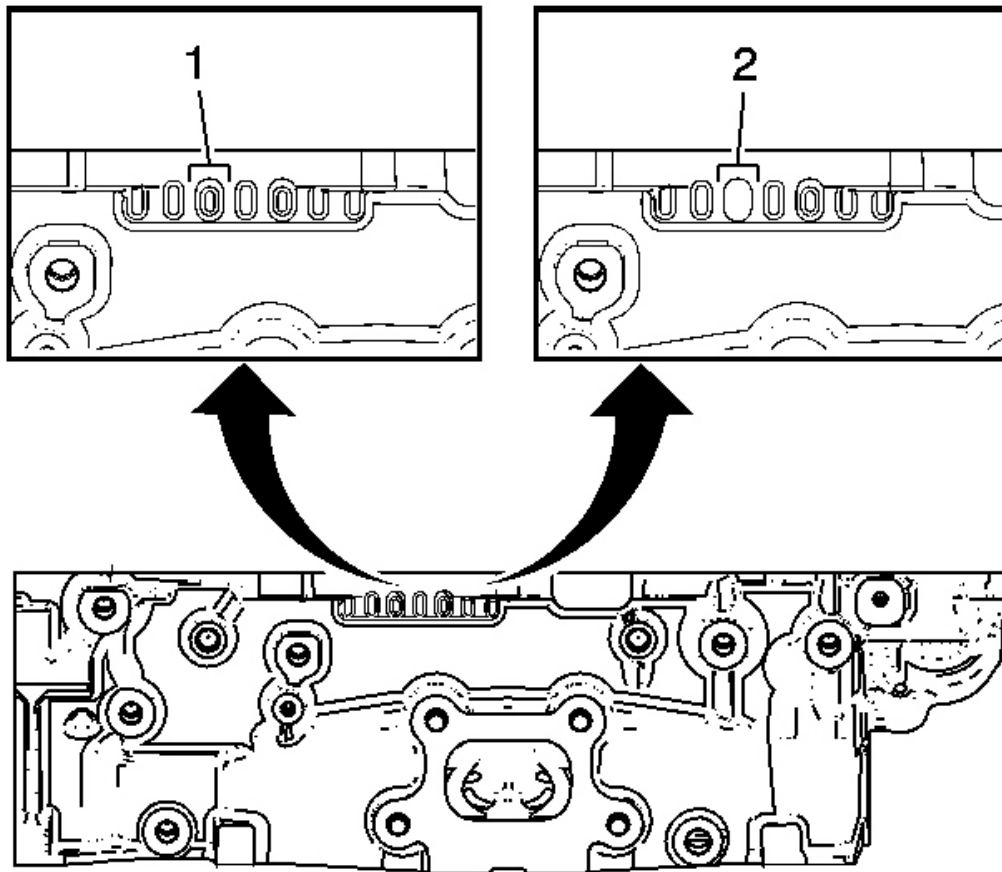


Fig. 51: Identifying Gas Or E85-Compatible Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Prior to performing the valve and seat grinding procedure, determine whether you have a gas or E85-compatible cylinder head by examining the 7 digit bump code on the exhaust side of the cylinder head.
2. The third digit of the bump code on a gas cylinder head is a high bump (1).
3. The third digit of the bump code on an E85-compatible cylinder head is machined off (2). Refer to **Valve and Seat Grinding (Gasoline)** or **Valve and Seat Grinding (FlexFuel)** for an E85-compatible cylinder head.

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

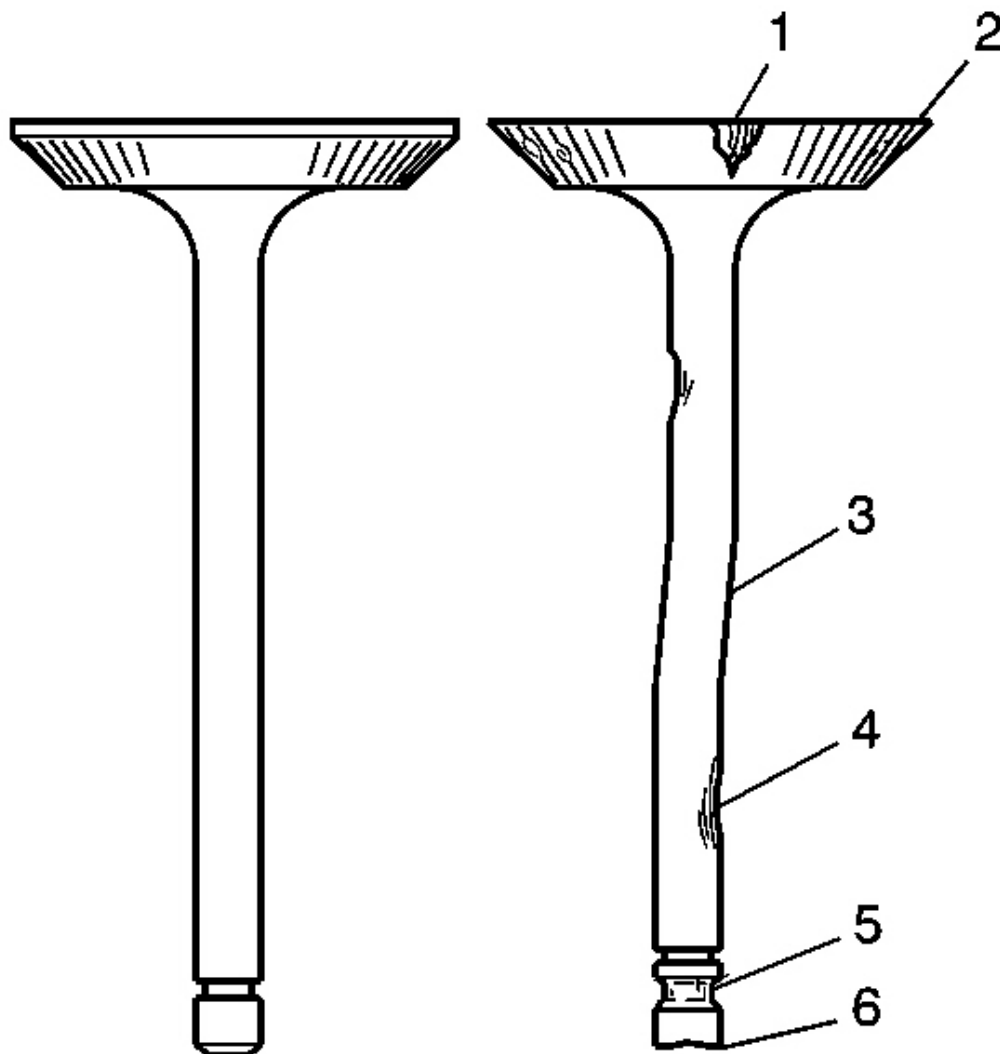


Fig. 52: Identifying Valve Damage
Courtesy of GENERAL MOTORS CORP.

1. 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 AND RECONDITIONING 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 or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.

VALVE SEAT WIDTH MEASUREMENT PROCEDURE

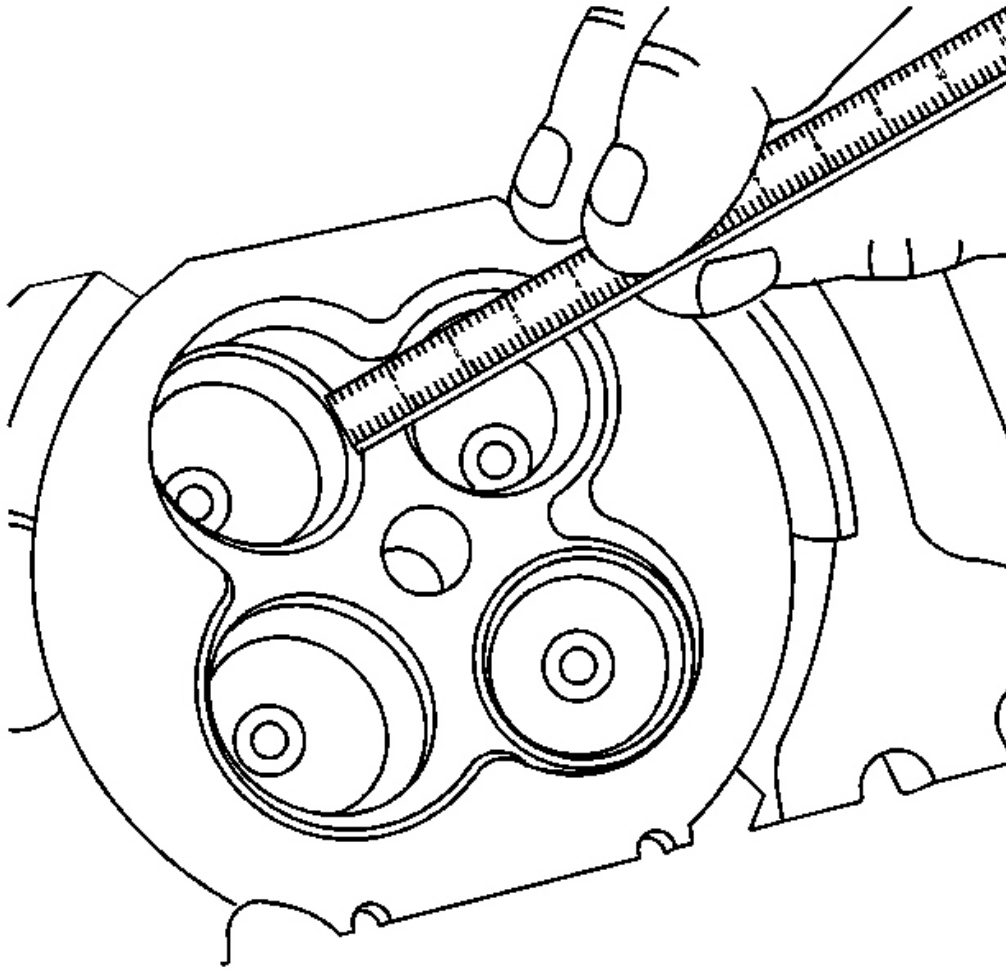


Fig. 53: Checking Valve Seat Width
Courtesy of GENERAL MOTORS CORP.

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

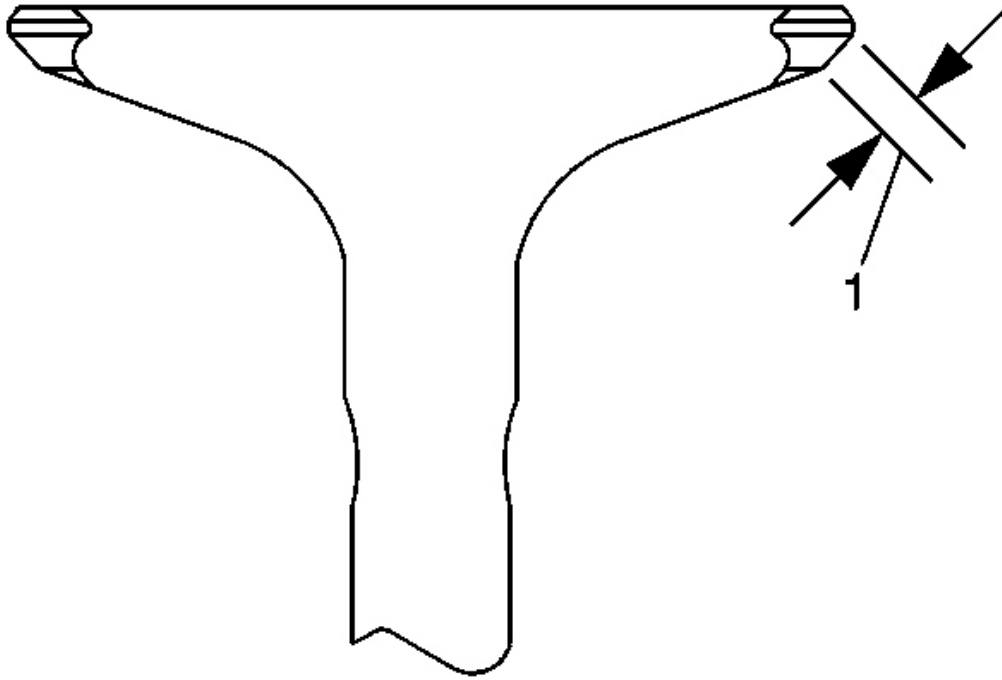


Fig. 54: Measuring Seat Width On Valve Face
Courtesy of GENERAL MOTORS CORP.

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 seat must be reconditioned to move the contact area away from the margin.

3. Compare your measurements with the specifications listed in Engine Mechanical Specifications (LF1).
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 grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. 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 (LF1).
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

VALVE MARGIN MEASUREMENT PROCEDURE

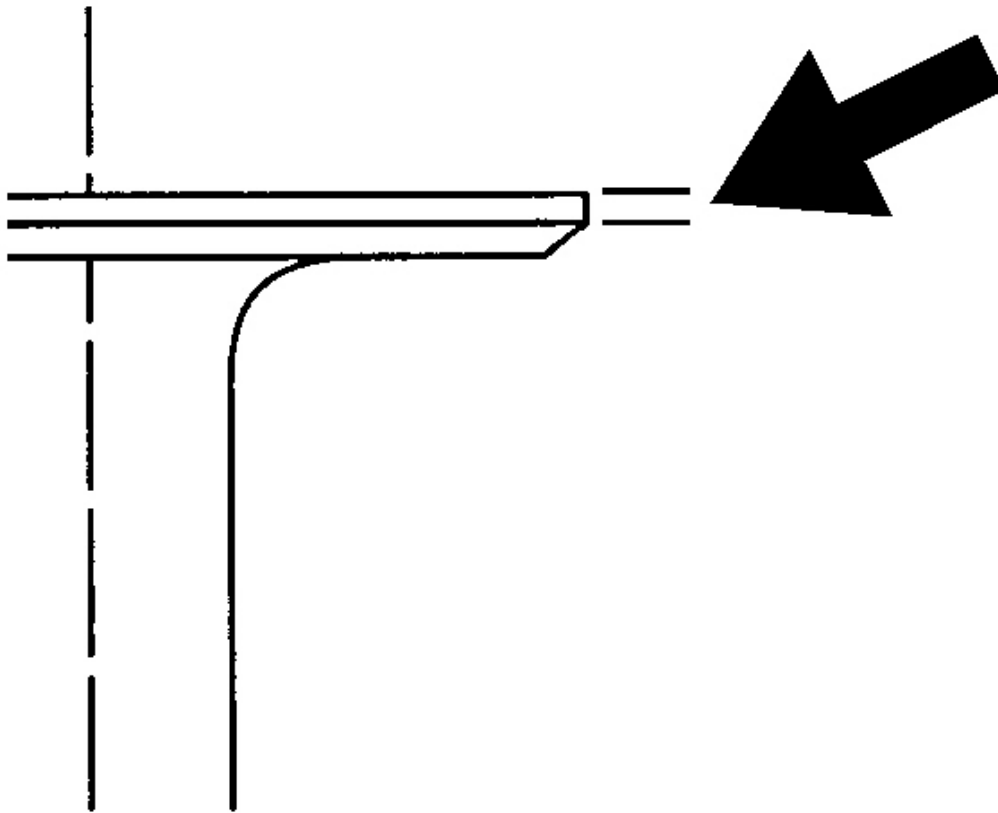


Fig. 55: View Of Valve Margin Measurement
Courtesy of GENERAL MOTORS CORP.

1. 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 and do not require refacing, 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.**

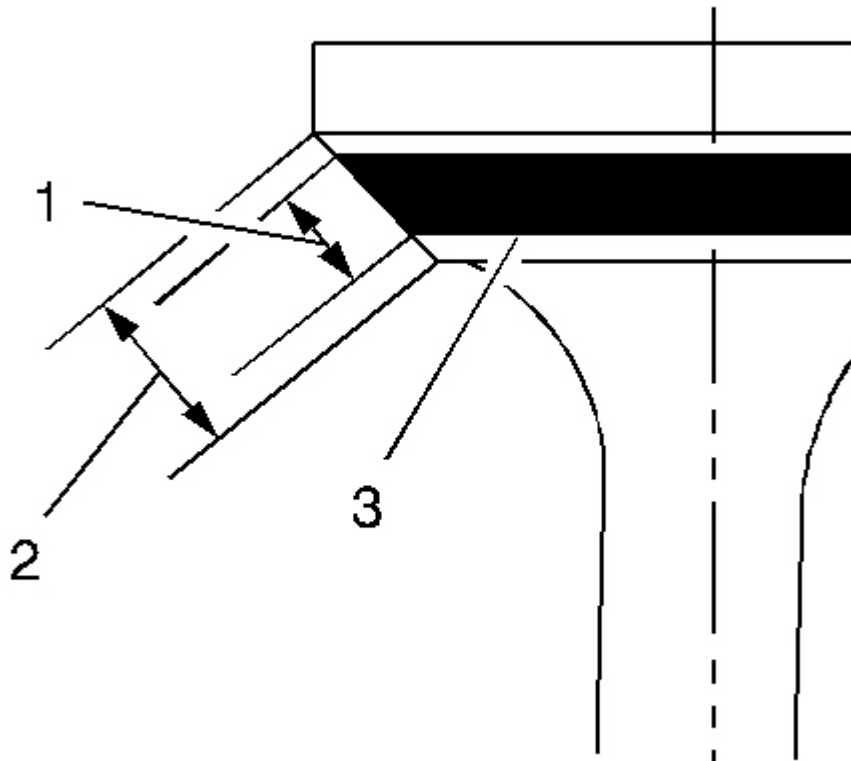


Fig. 56: View Of Valve Contact Face Measurements
Courtesy of GENERAL MOTORS CORP.

1. 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 refaced or replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

VALVE AND SEAT RECONDITIONING PROCEDURE

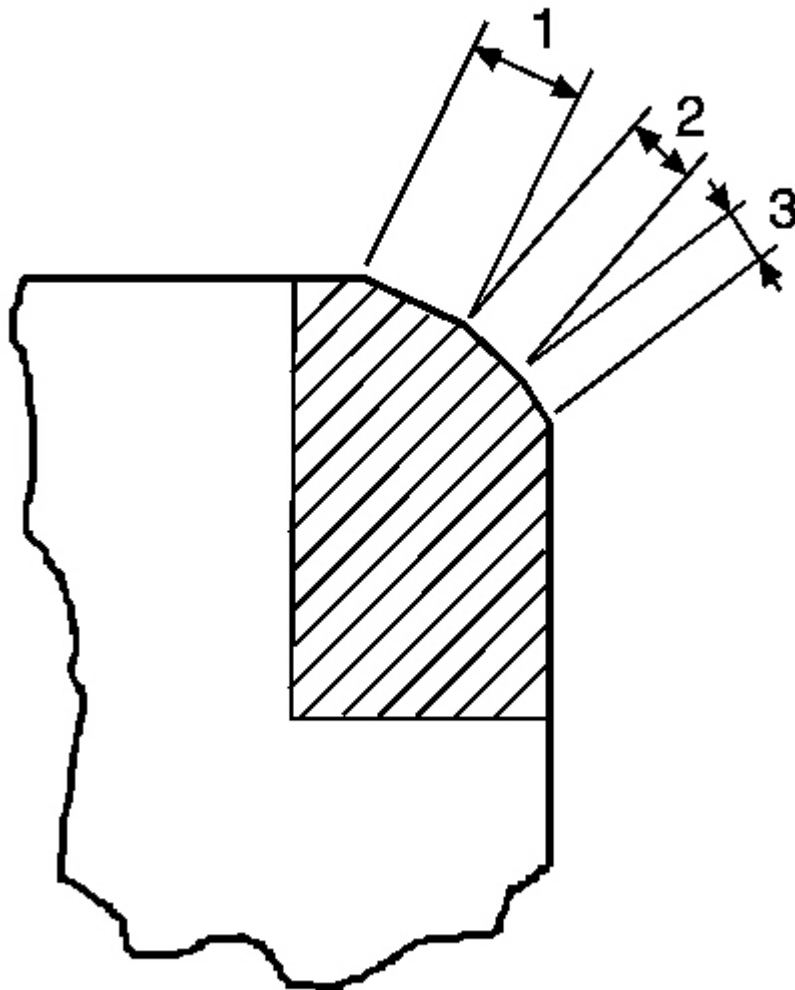


Fig. 57: Illustrating Valve Seat Proper Angles
Courtesy of GENERAL MOTORS CORP.

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 build up of carbon on the seats.
- It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.

1. Grind the valve seats (2) to the proper angle specification listed in **Engine Mechanical Specifications (LF1)**.

2. Using the proper angle specification listed in **Engine Mechanical Specifications (LF1)** , 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 (LF1)** , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in **Engine Mechanical Specifications (LF1)** .
4. If the original valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications (LF1)** . Measure the valve margin again after grinding using the Valve Margin Measurement Procedure. Replace the valve if the margin is out of specification. New valves do not require grinding.
5. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
6. Install the valve in the cylinder head.
 - If you are using refaced valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.

NOTE: **Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.**

- If you are using new valves, do not lap the valves under any condition.
7. 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.
 8. 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

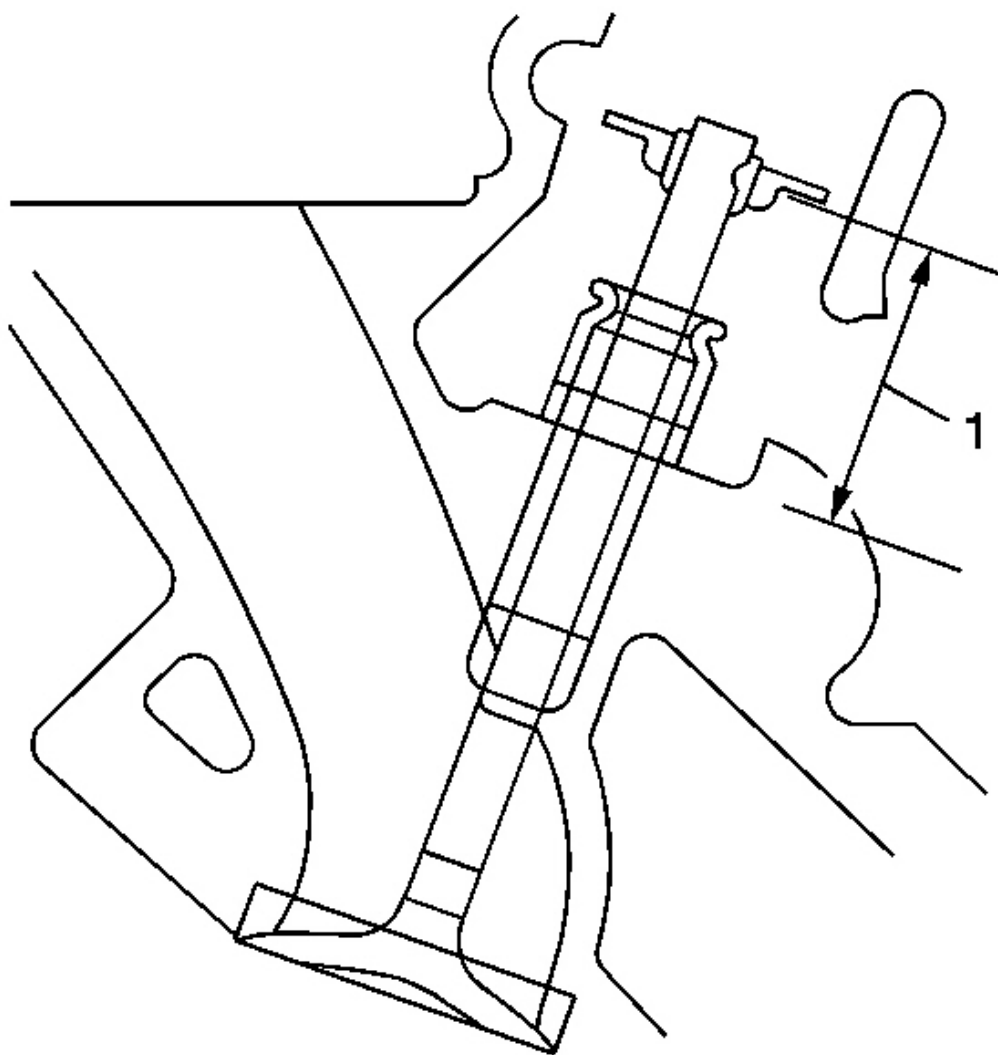


Fig. 58: Measuring Valve Stem Height
Courtesy of GENERAL MOTORS CORP.

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

1. 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 (LF1)** .
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.

VALVE AND SEAT GRINDING (FLEXFUEL)

CYLINDER HEAD IDENTIFICATION

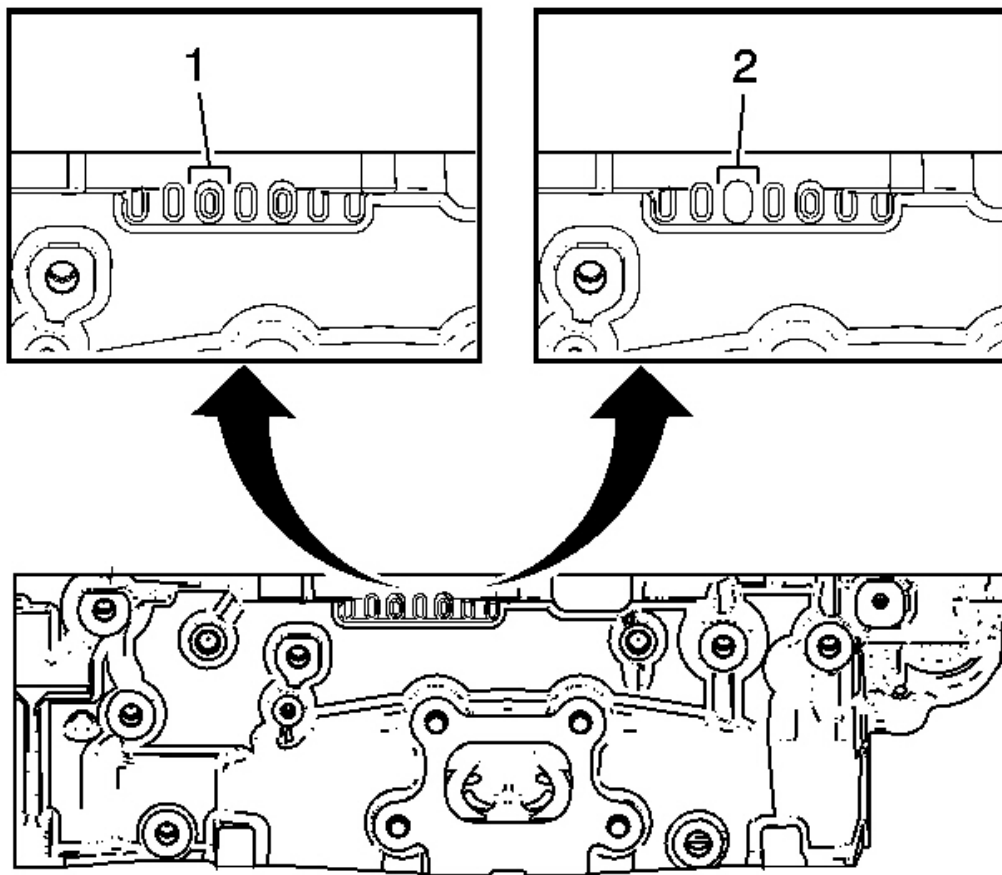


Fig. 59: Identifying Gas Or E85-Compatible Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Prior to performing the valve and seat grinding procedure, determine whether you have a gas or E85-compatible cylinder head by examining the 7 digit bump code on the exhaust side of the cylinder head.
2. The third digit of the bump code on a gas cylinder head is a high bump (1). Refer to **Valve and Seat Grinding (Gasoline)** or **Valve and Seat Grinding (FlexFuel)** for a gas cylinder head.
3. The third digit of the bump code on an E85-compatible cylinder head is machined off (2).

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

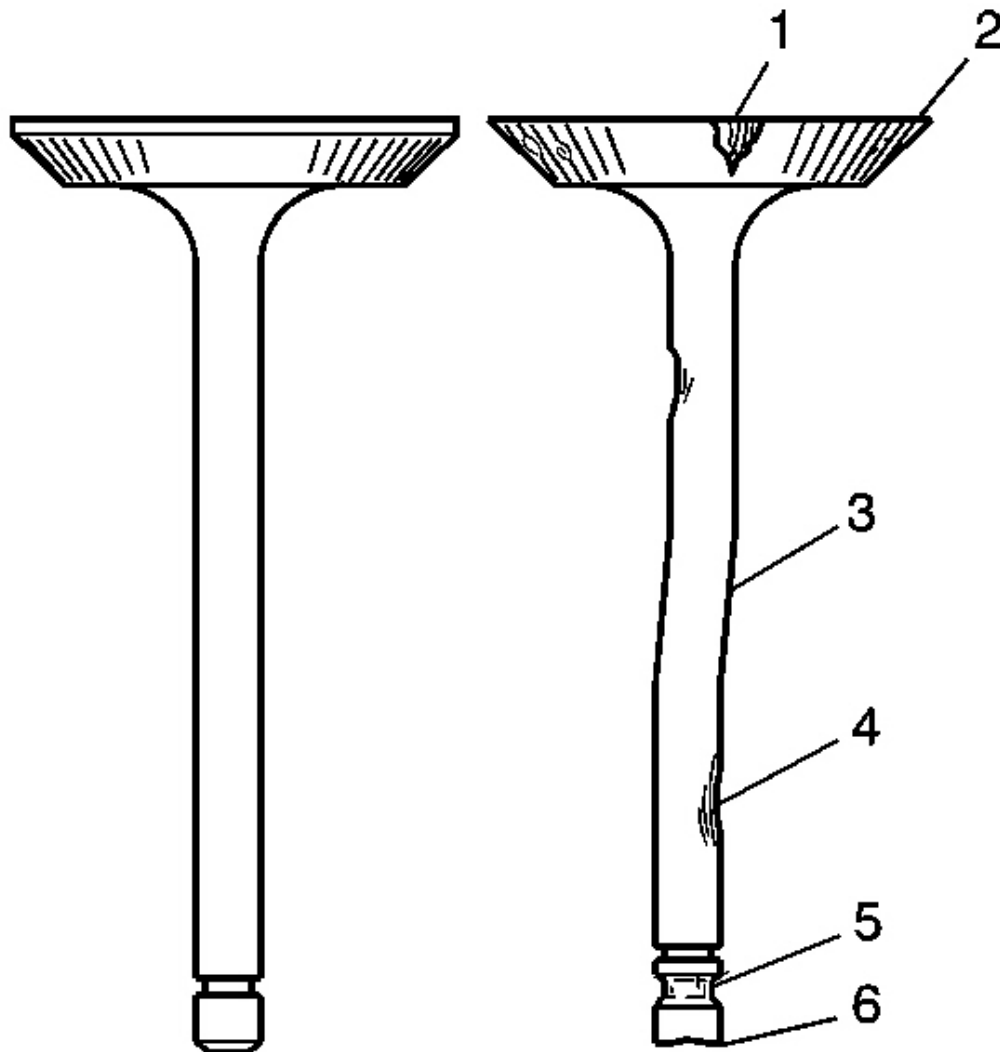


Fig. 60: Identifying Valve Damage

Courtesy of GENERAL MOTORS CORP.

1. 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

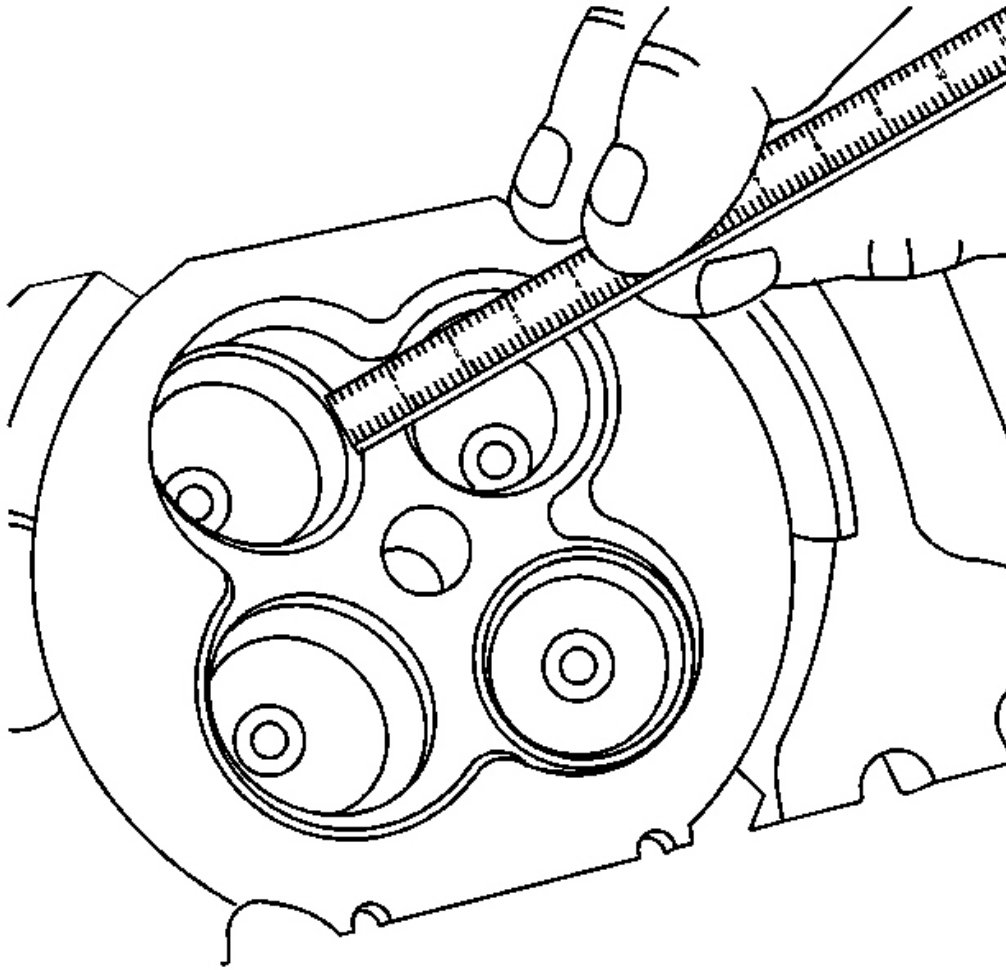


Fig. 61: Checking Valve Seat Width
Courtesy of GENERAL MOTORS CORP.

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

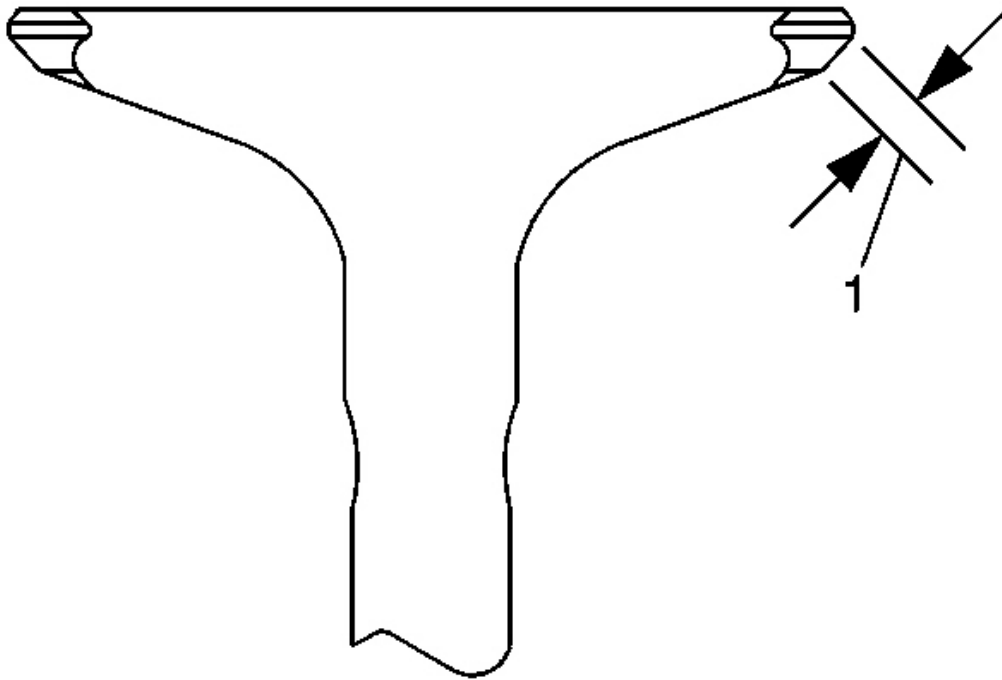


Fig. 62: Measuring Seat Width On Valve Face
Courtesy of GENERAL MOTORS CORP.

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 (LF1)** .
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 (LF1).
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

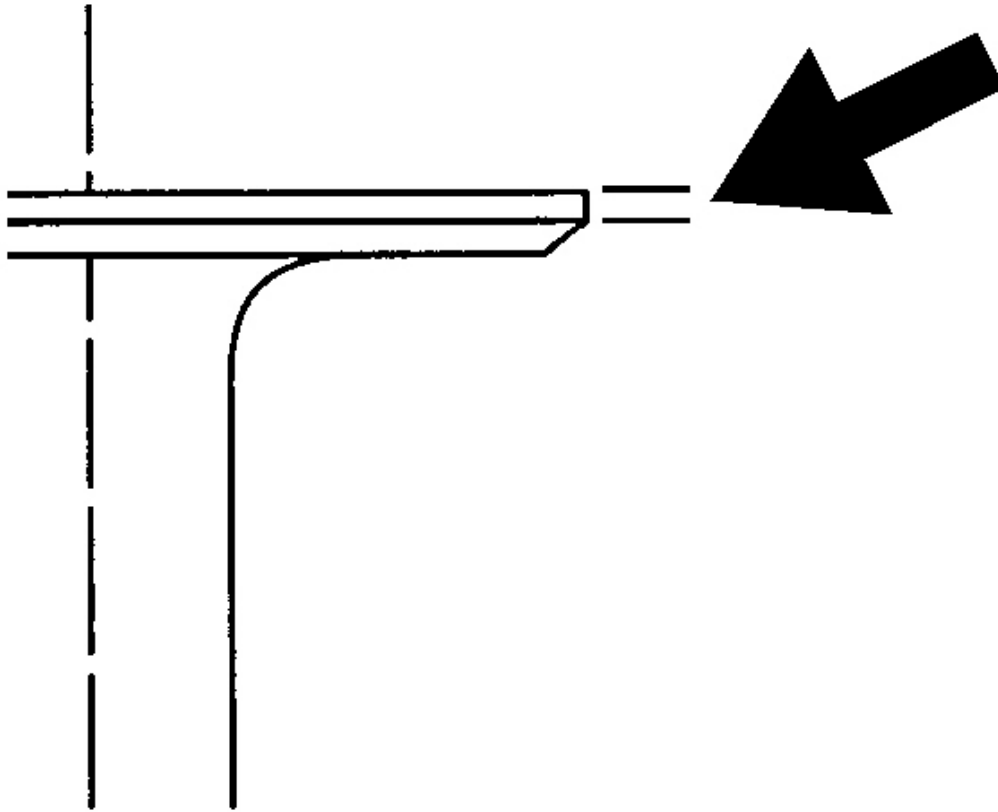


Fig. 63: View Of Valve Margin Measurement
Courtesy of GENERAL MOTORS CORP.

1. 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.

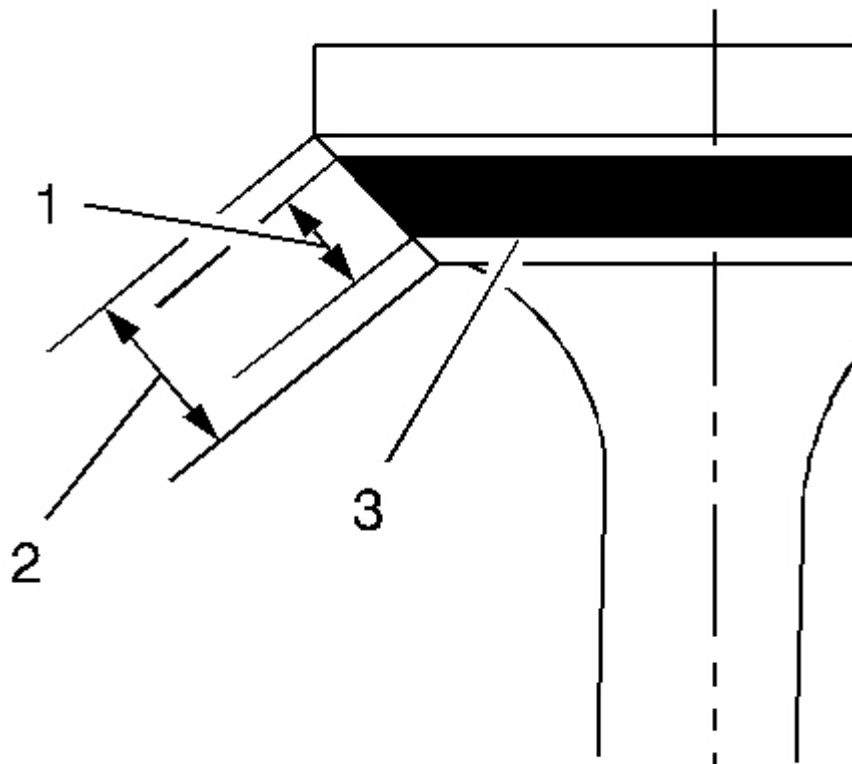


Fig. 64: View Of Valve Contact Face Measurements
Courtesy of GENERAL MOTORS CORP.

1. 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

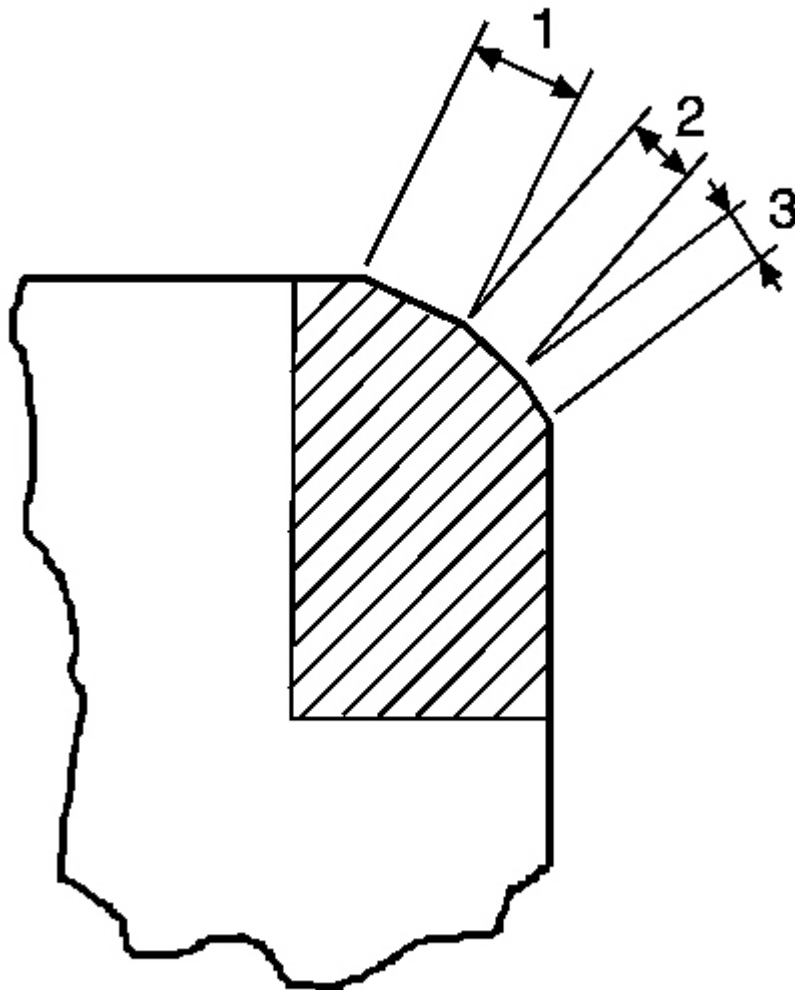


Fig. 65: Illustrating Valve Seat Proper Angles
Courtesy of GENERAL MOTORS CORP.

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.

1. Grind the valve seats (2) to the proper angle specification listed in **Engine Mechanical Specifications (LF1)**.
2. Using the proper angle specification listed in **Engine Mechanical Specifications (LF1)**, 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 (LF1)** , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in **Engine Mechanical Specifications (LF1)** .
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

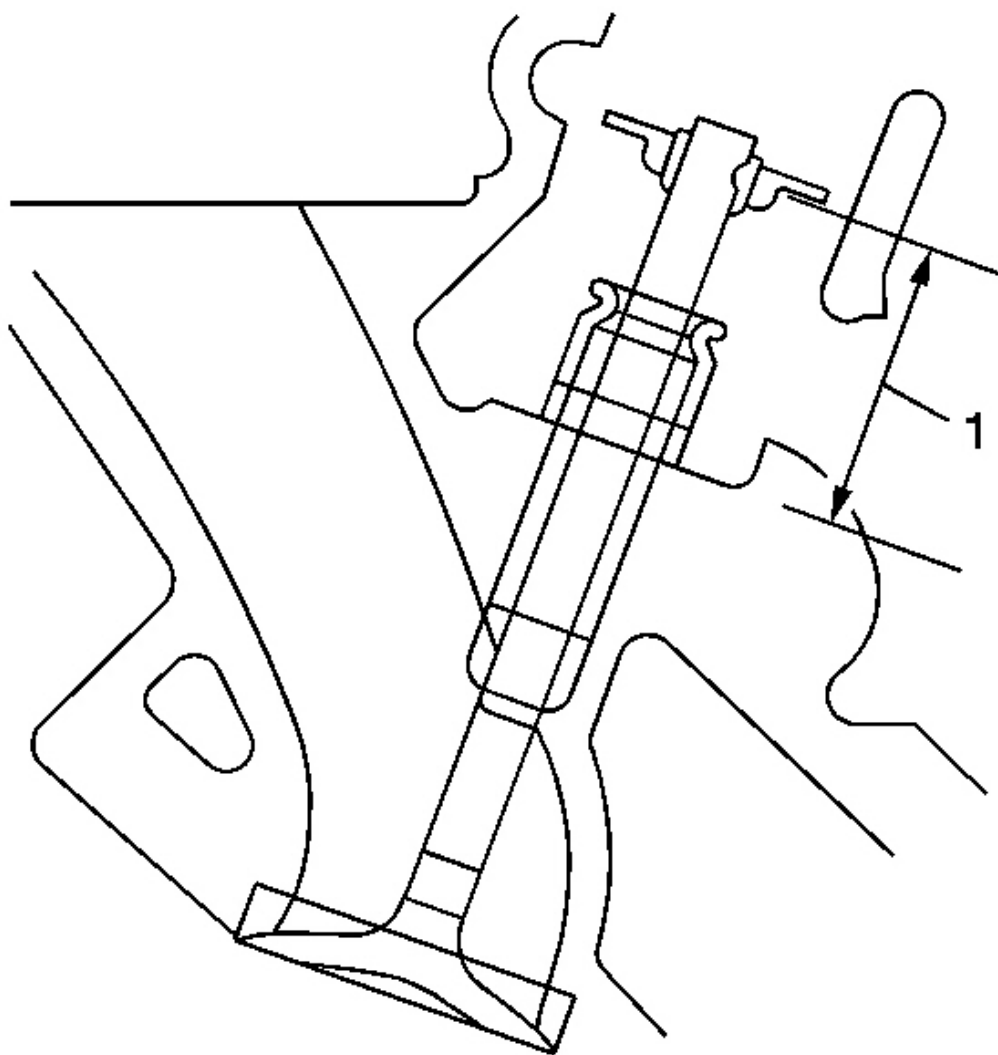


Fig. 66: Measuring Valve Stem Height
Courtesy of GENERAL MOTORS CORP.

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

1. 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 (LF1)** .
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 (LF1 OR LFW)

Special Tools

- **EN 49245:** Injector Seal Installer Kit
- **EN 49247:** Injector Retaining Clip Installer

For equivalent regional tools, refer to **Special Tools** .

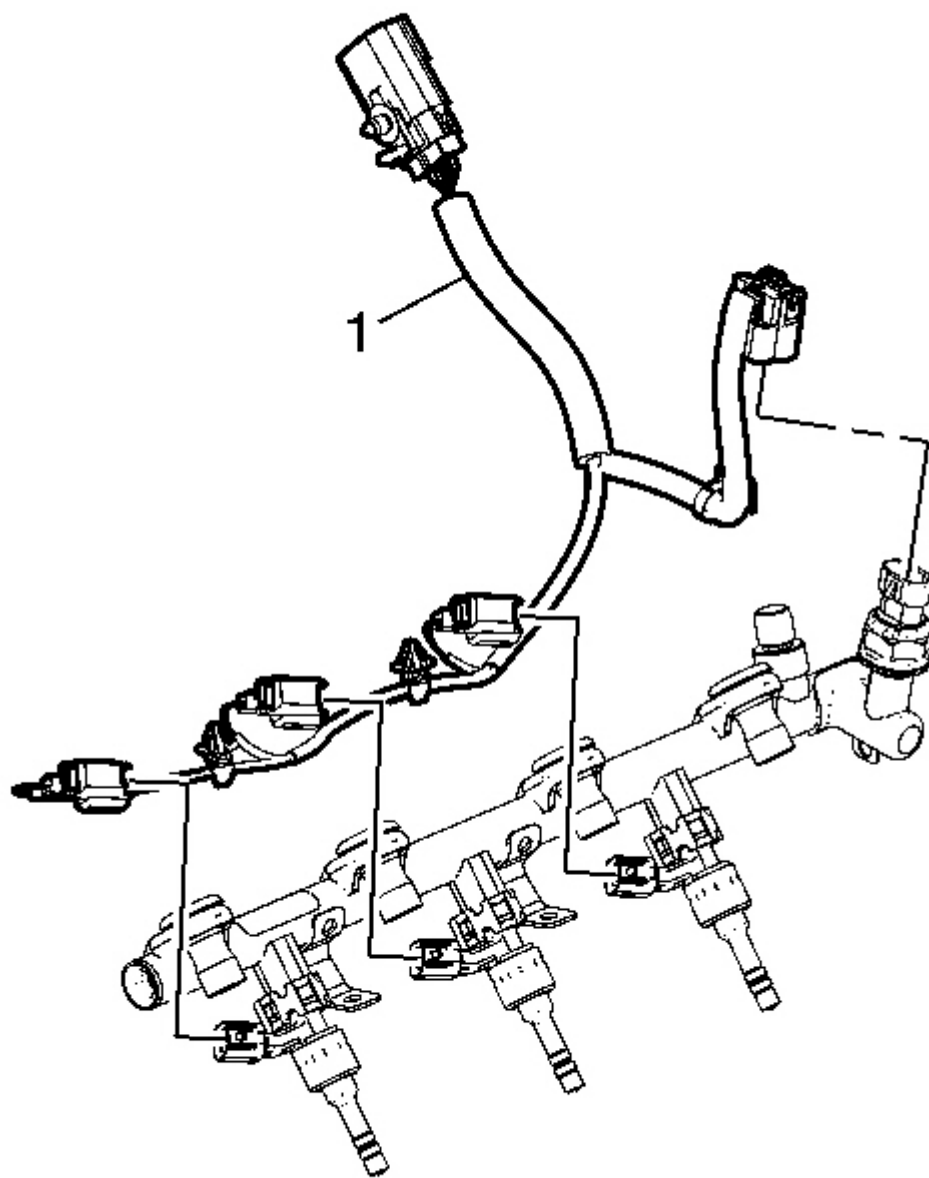


Fig. 67: Fuel Rail Wiring Harness
Courtesy of GENERAL MOTORS CORP.

1. Disconnect and remove the fuel rail wiring harness (1).

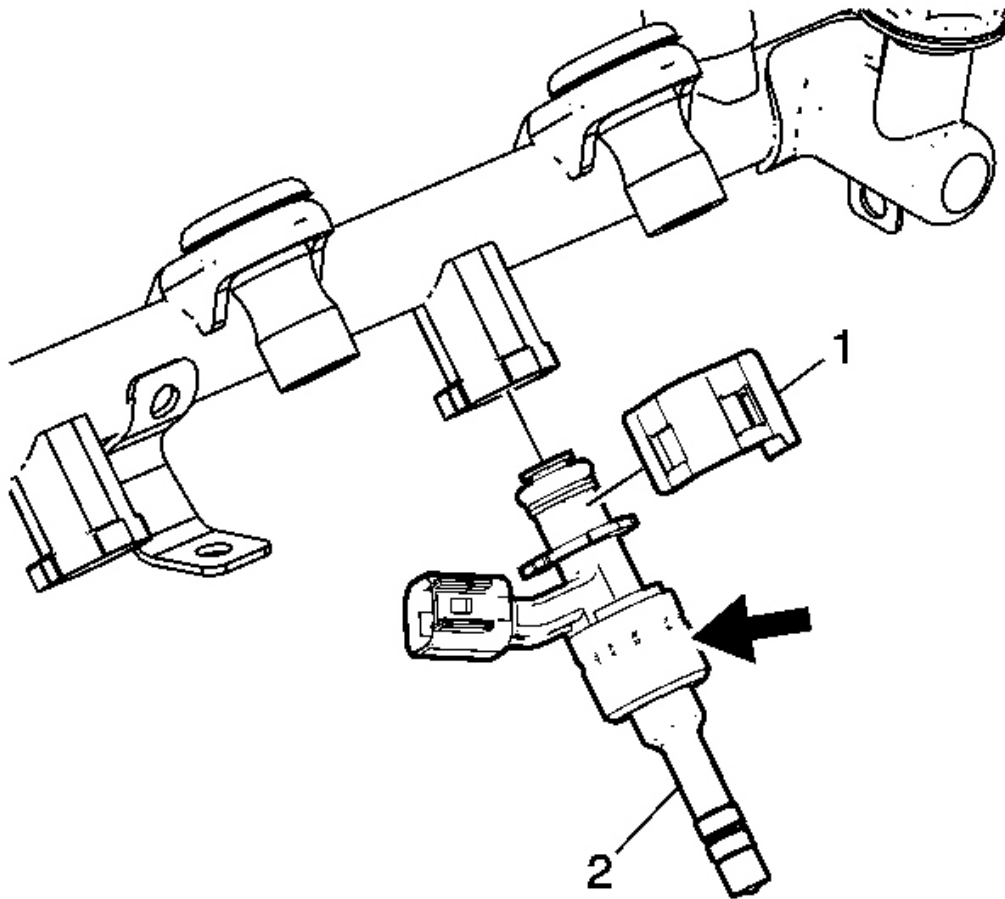


Fig. 68: Fuel Injector Retainer

Courtesy of GENERAL MOTORS CORP.

2. Taking care not to touch or apply force to the injector tip or electrical connector, remove the fuel injector retainer (1) by spreading both sides at the same time. A large, sturdy snap ring plier can help with this. Discard the retainer.
3. Holding the largest diameter/body of the injector only, indicated by arrow in graphic, and using a slight twisting motion, remove the fuel injector (2) from the fuel rail.

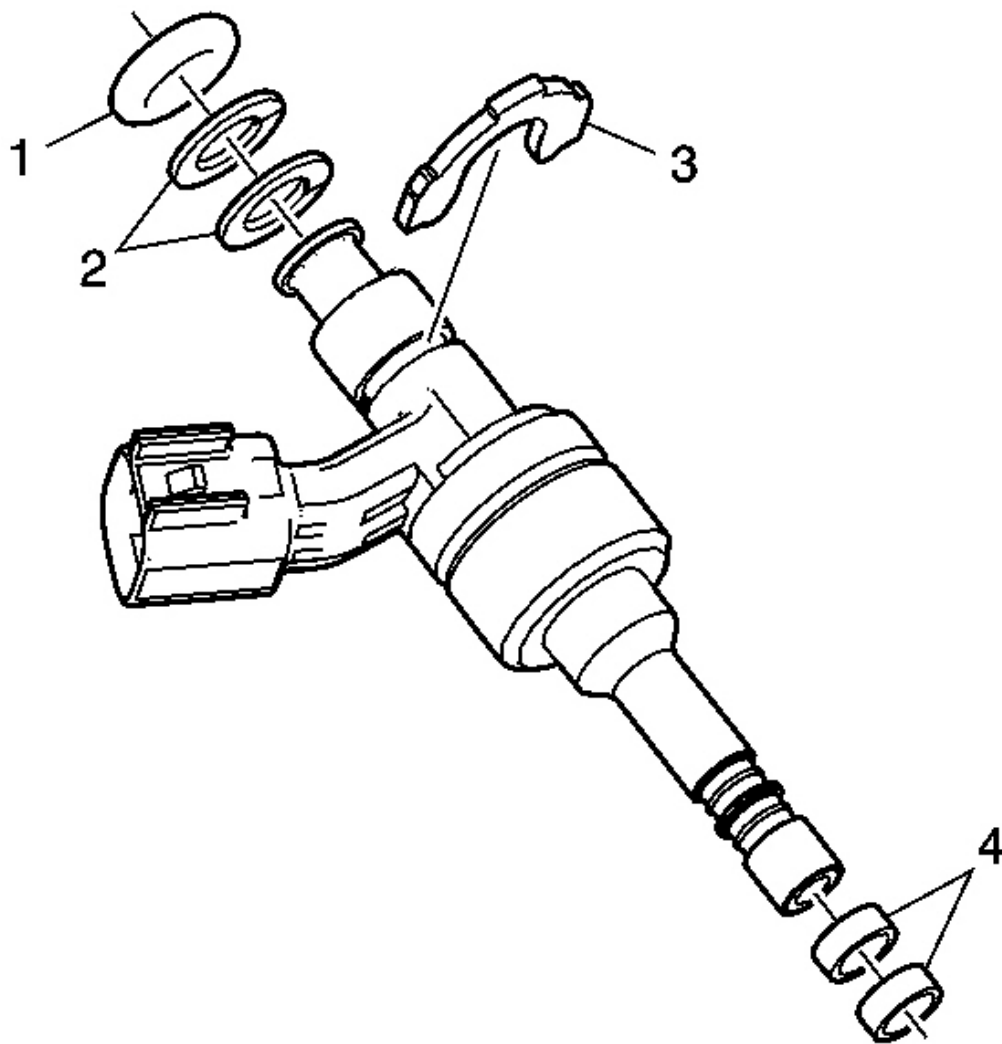


Fig. 69: Fuel Injector Components
Courtesy of GENERAL MOTORS CORP.

4. Using pliers, remove the fuel injector bushing (3) straight out from injector body. Discard bushing (3). Remove and discard the fuel injector O-ring (1) and plastic spacers (2).
5. Remove and discard the fuel injector seals (4).

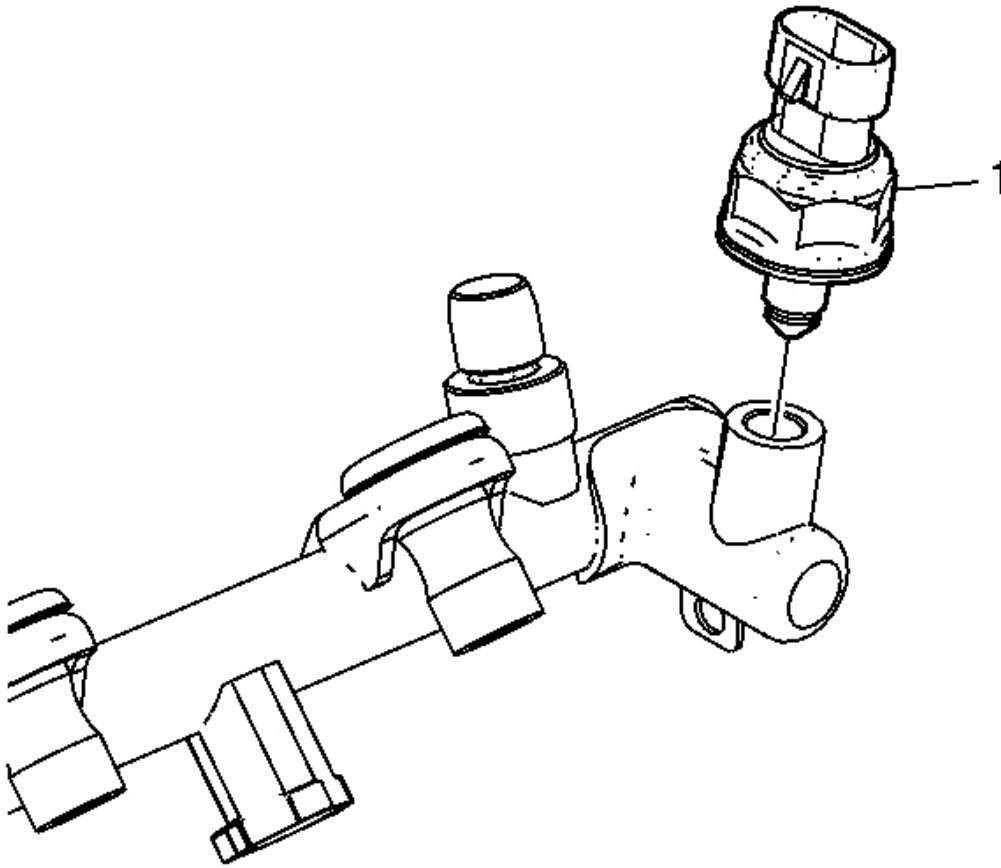


Fig. 70: Fuel Pressure Sensor

Courtesy of GENERAL MOTORS CORP.

NOTE: Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.

6. Remove the fuel pressure sensor (1).

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

7. Clean the exterior of the fuel rail and injectors with solvent.

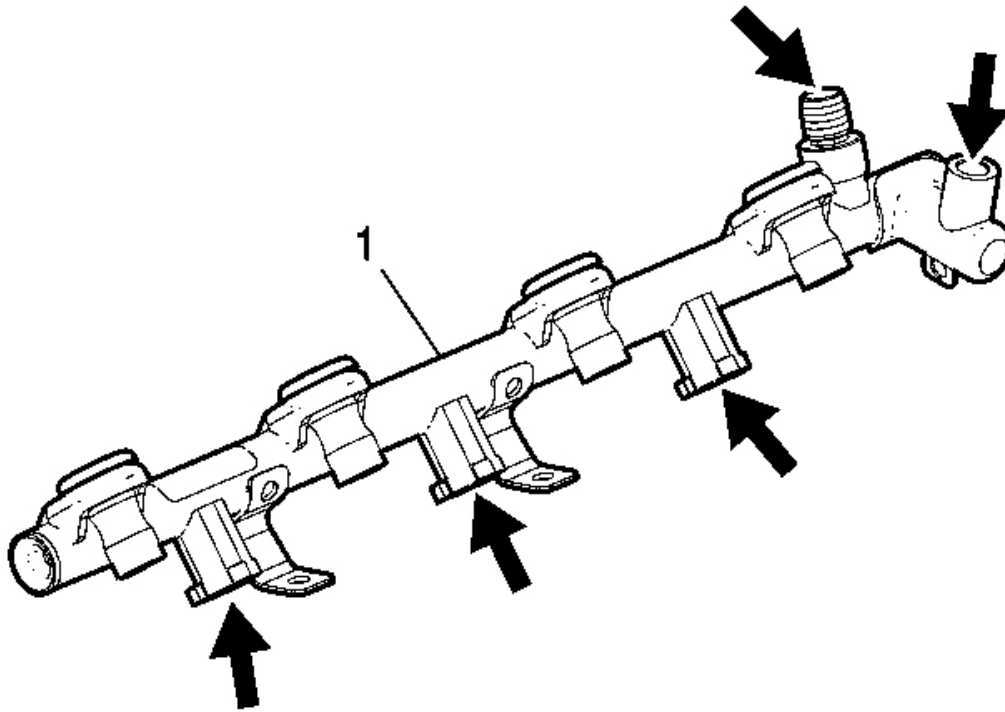


Fig. 71: Fuel Rail

Courtesy of GENERAL MOTORS CORP.

8. Inspect the fuel rail (1) and components 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

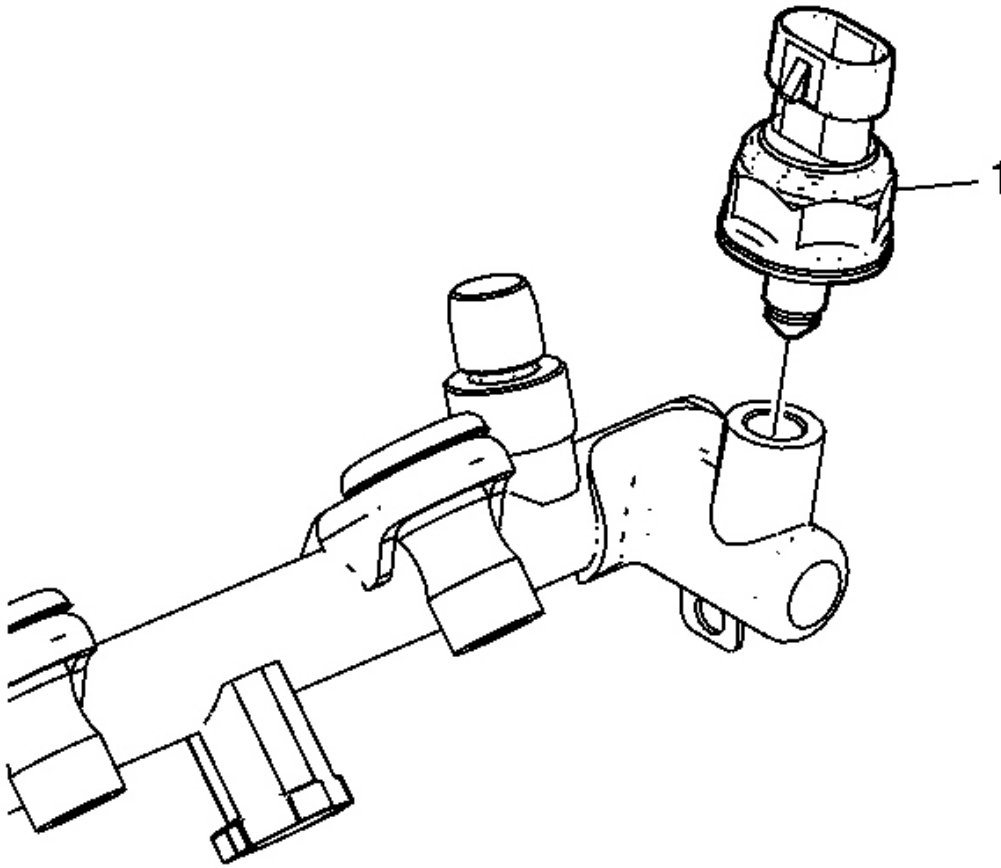


Fig. 72: Fuel Pressure Sensor

Courtesy of GENERAL MOTORS CORP.

NOTE: Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.

9. Install the fuel pressure sensor (1).

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

- Lubricate the threads and the sealing area in the fuel rail with silicon free engine oil GM P/N 12345610, Canadian P/N 993193, or equivalent.
- Lubricate the threads and the sealing area on the fuel pressure sensor with silicon free engine oil GM P/N 12345610, Canadian P/N 993193, or equivalent.

- Install the fuel pressure sensor hand tight.
- Remove the fuel pressure sensor and re-lubricate.

CAUTION: Refer to Fastener Caution .

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

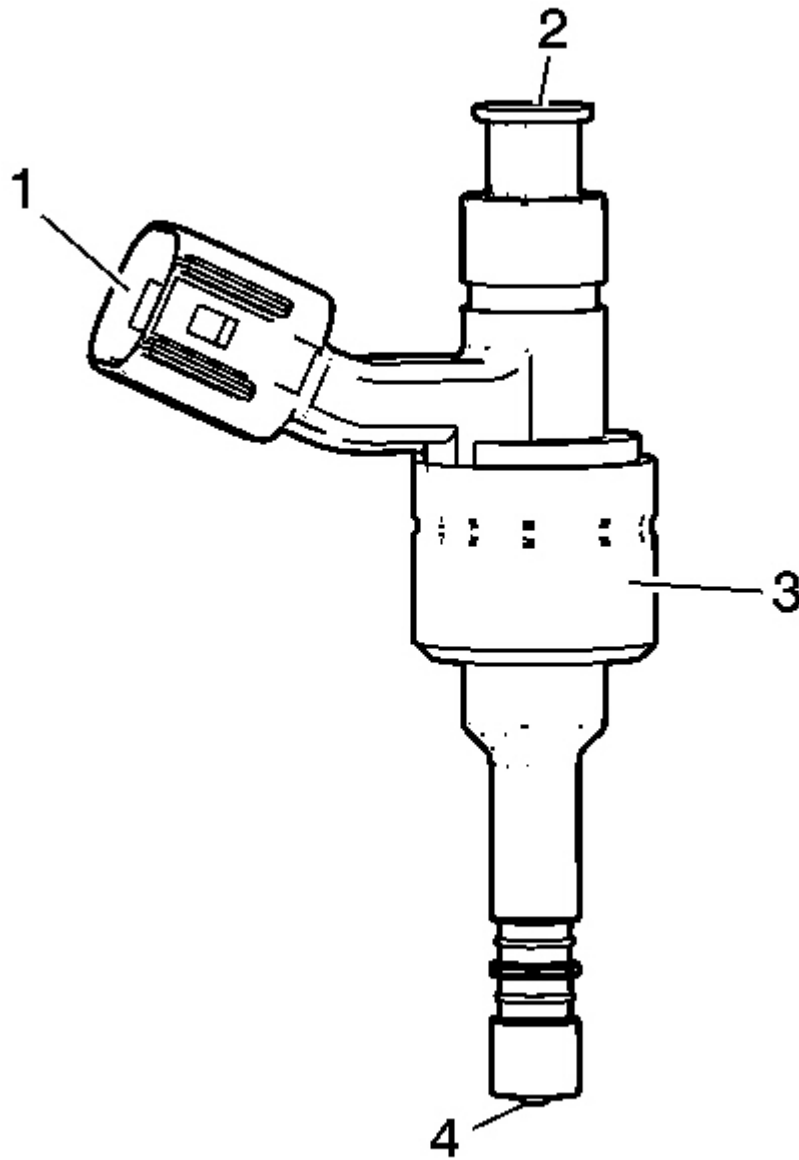


Fig. 73: Fuel Injector Components
Courtesy of GENERAL MOTORS CORP.

10. 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)

11. Replace the fuel rail or injector if any damage is found. Do not attempt to repair a fuel rail or injector.

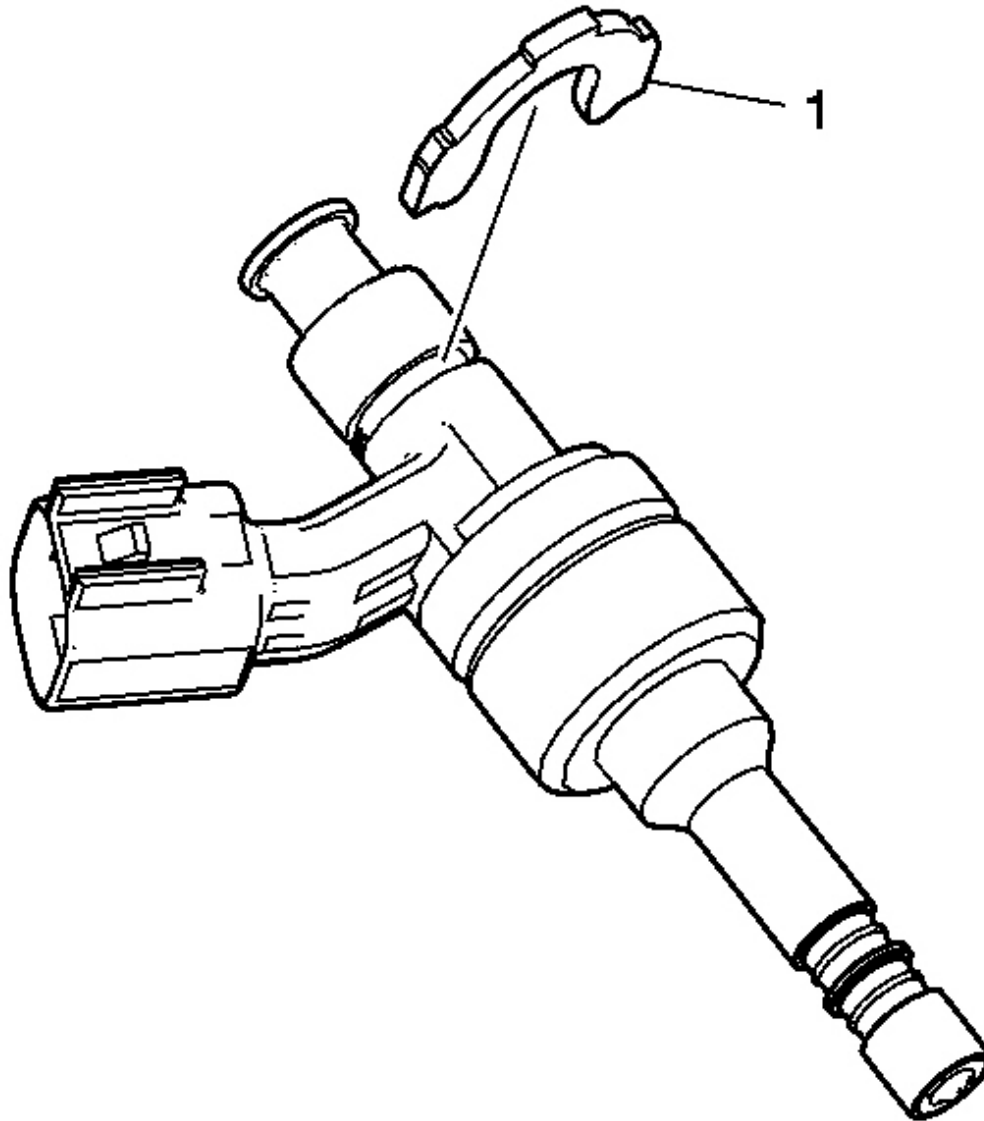


Fig. 74: Fuel Injector Bushing
Courtesy of GENERAL MOTORS CORP.

NOTE: The fuel injector bushing (1) is to be installed BEFORE O-ring or backup rings are installed.

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

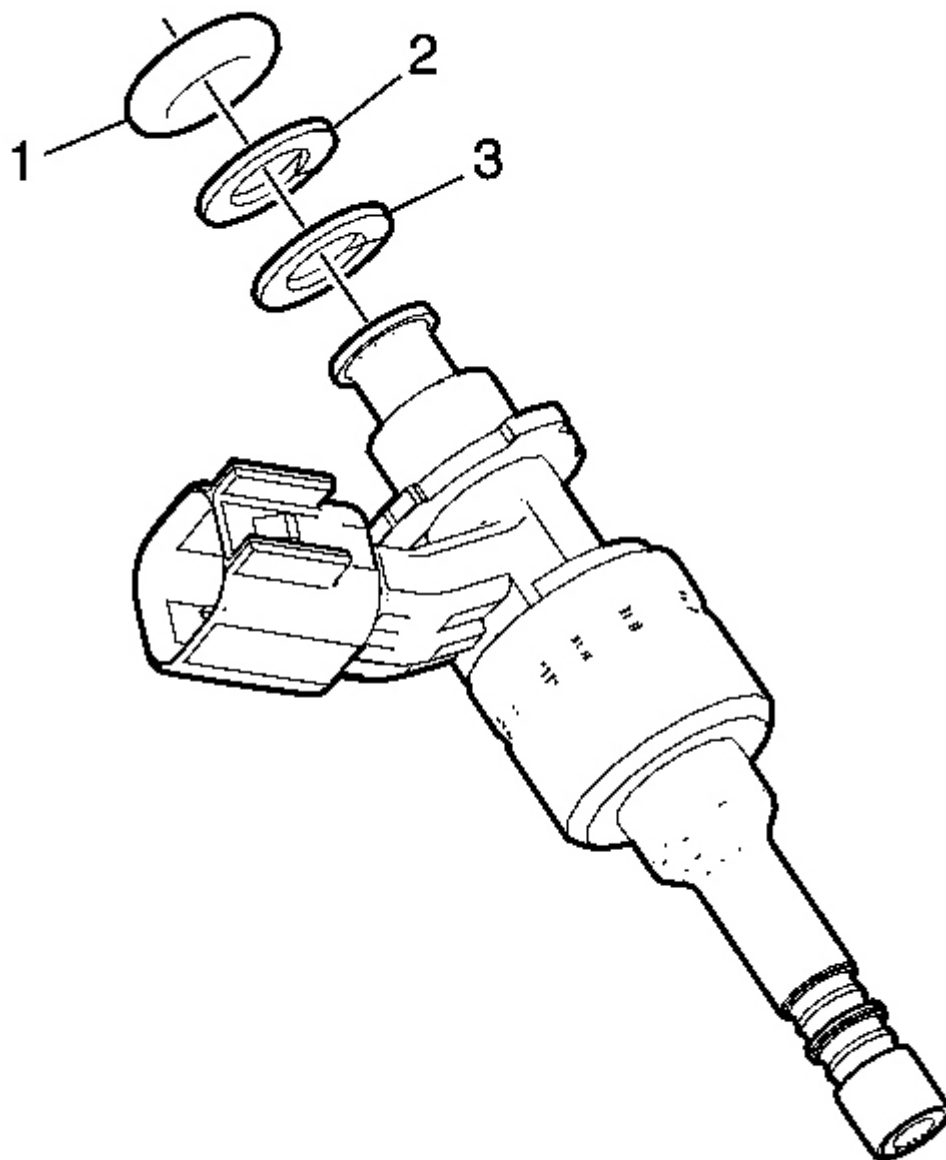


Fig. 75: Injector O-Ring & Spacers

Courtesy of GENERAL MOTORS CORP.

13. Install the NEW white plastic spacer (3) on the fuel injector first.
14. Install the brown plastic spacer (2) second.
15. Lubricate the NEW O-ring (1) with 5W30 engine oil.

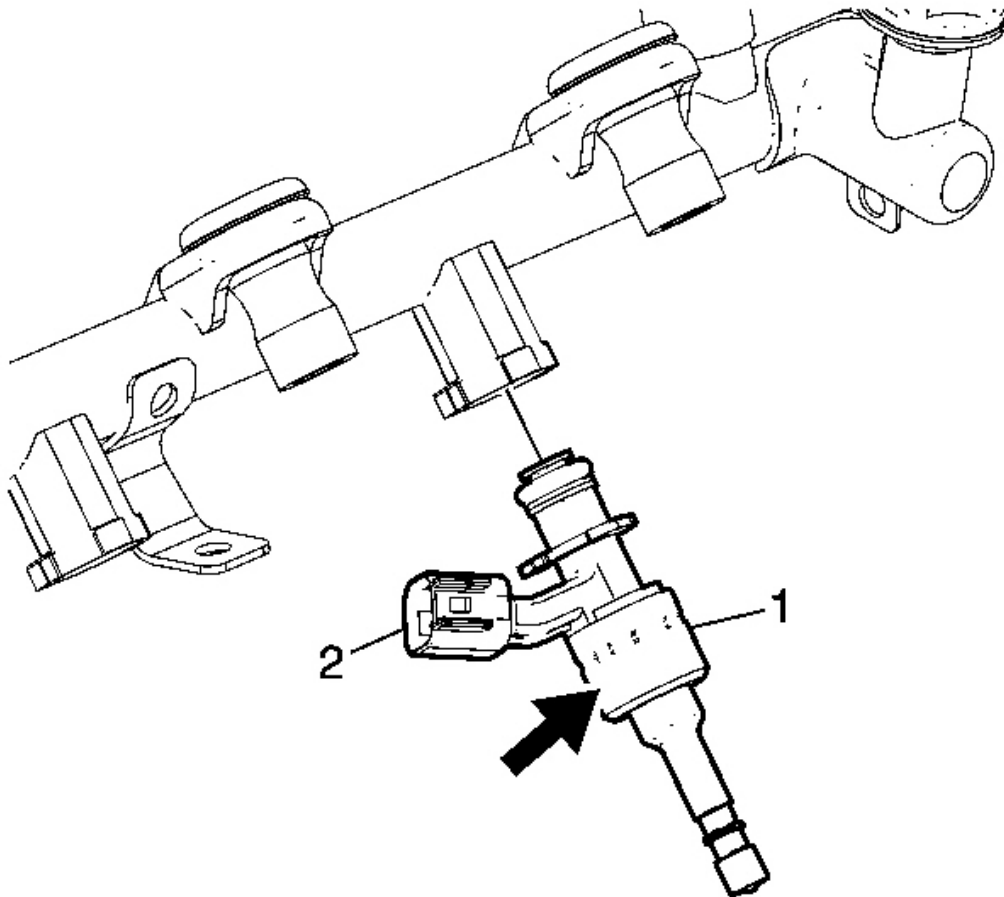


Fig. 76: Injector Assembly

Courtesy of GENERAL MOTORS CORP.

NOTE: Do NOT install the Teflon injector tip/bore seals until AFTER the injectors are installed on the fuel rail.

16. 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).

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

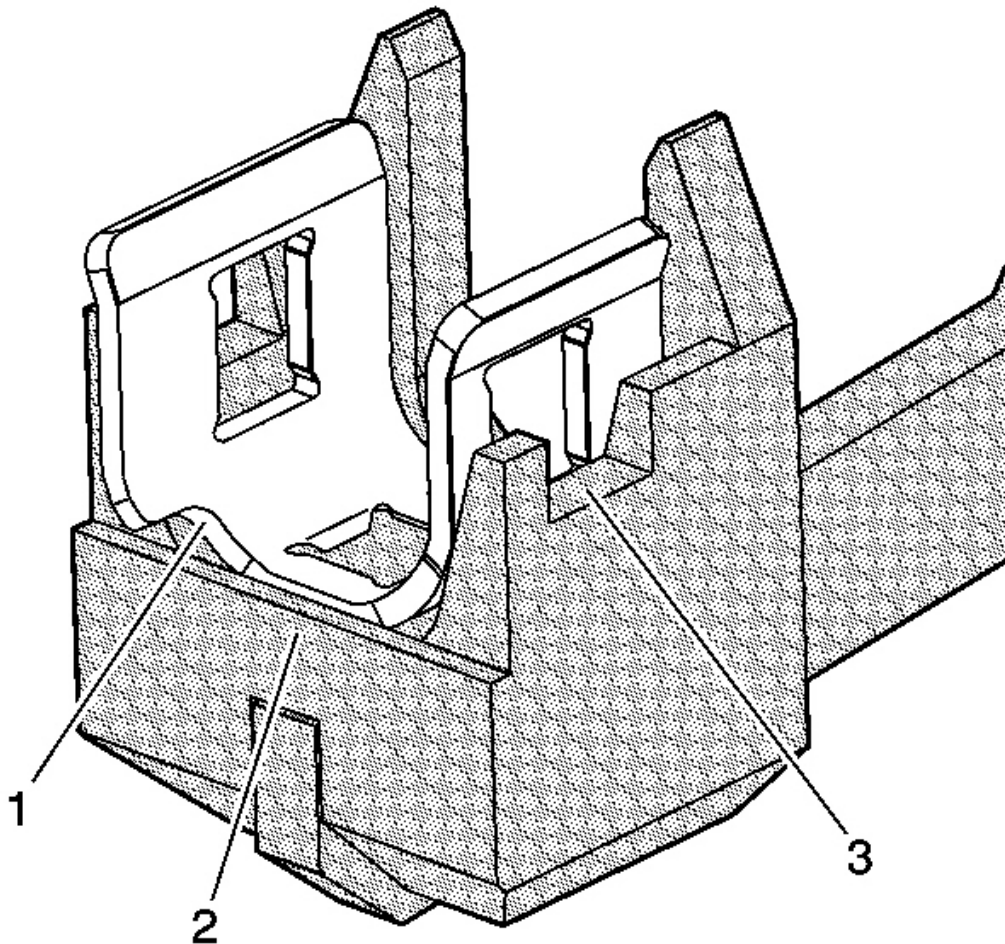


Fig. 77: Retainer Installer

Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure the retainer is set properly into EN 49247: installer.

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

18. Install the fuel injector retainer onto the **EN 49247:** installer.

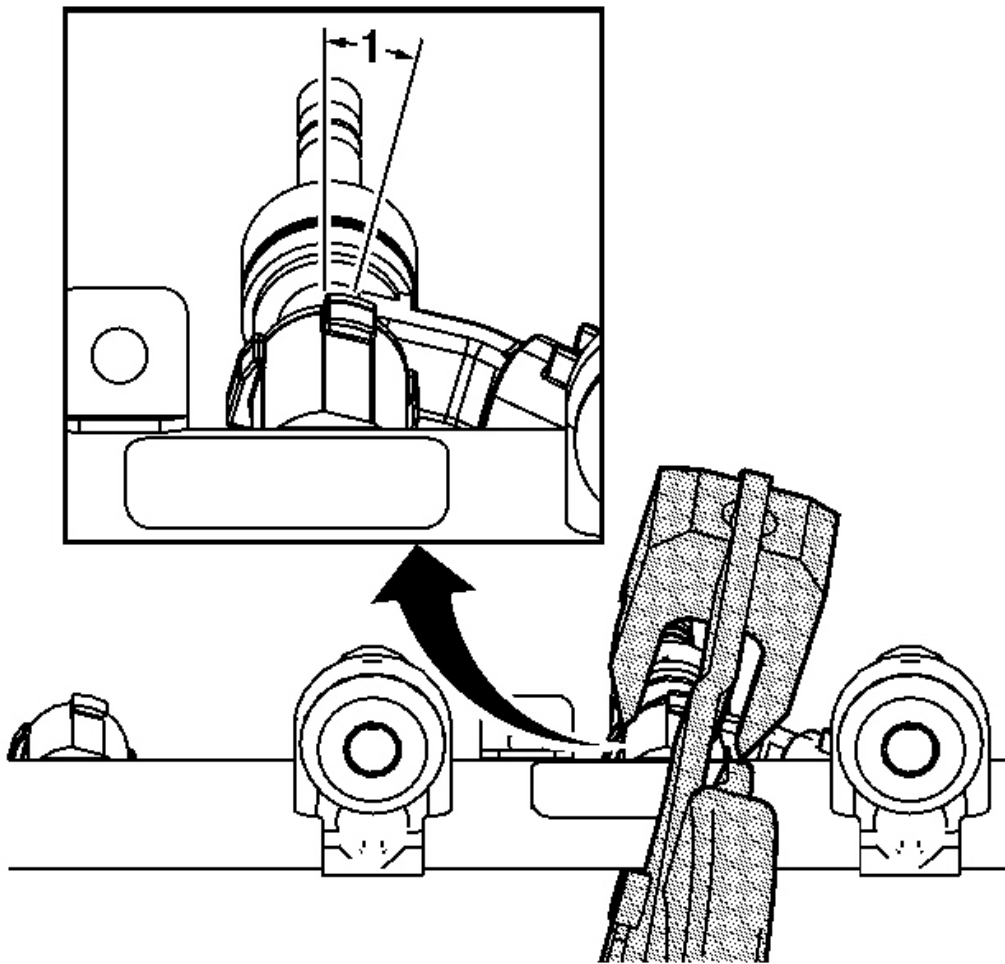


Fig. 78: Installing The Retainer Properly
Courtesy of GENERAL MOTORS CORP.

19. Note the following points when preparing to use the **EN 49247**: installer.

There is a 15-degree angle of rotation (1) with the fuel rail flanges relative to the fuel rail. You must hold the **EN 49247**: installer at a similar angle to ensure installing the retainer properly.

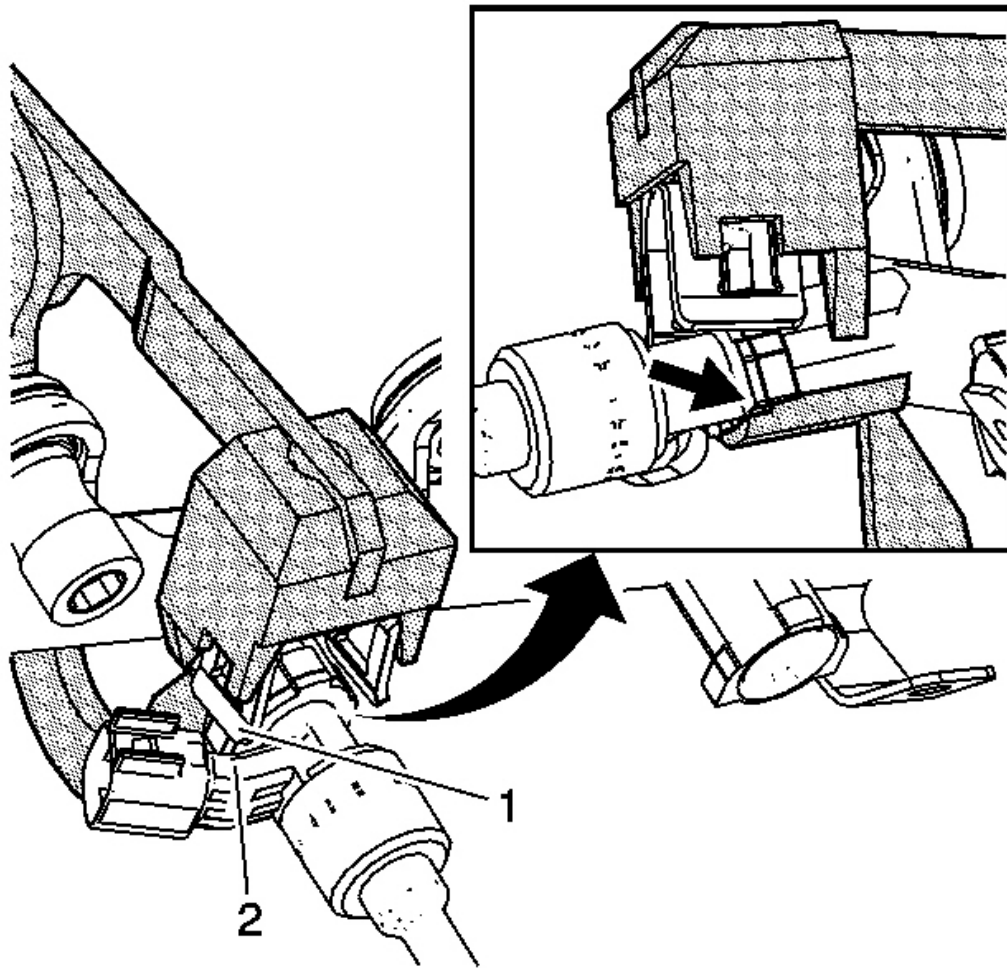


Fig. 79: Positioning Retainer Installer
Courtesy of GENERAL MOTORS CORP.

20. The retainer (1) should almost touch the electrical connector (2), and the base of the **EN 49247:** installer should be positioned as shown before you begin to squeeze the tool to complete the installation. This will help ensure the retainer is properly located relative to the injector and fuel rail flanges.

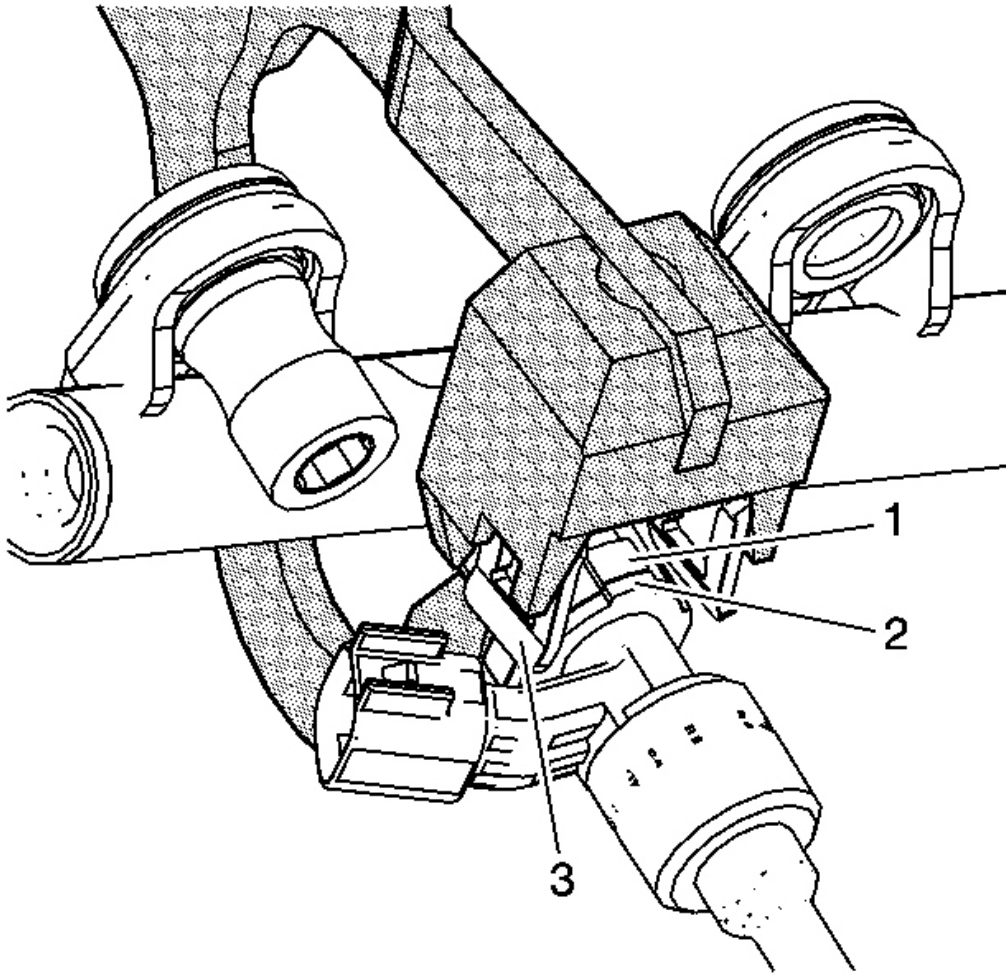


Fig. 80: Installing Fuel Injector Retainer
Courtesy of GENERAL MOTORS CORP.

21. Holding the injector bushing (2) and fuel rail flanges (1) in alignment, and holding the injector assembly firmly against the fuel rail so there is no gap between (1) and (2), install the fuel injector retainer (3).

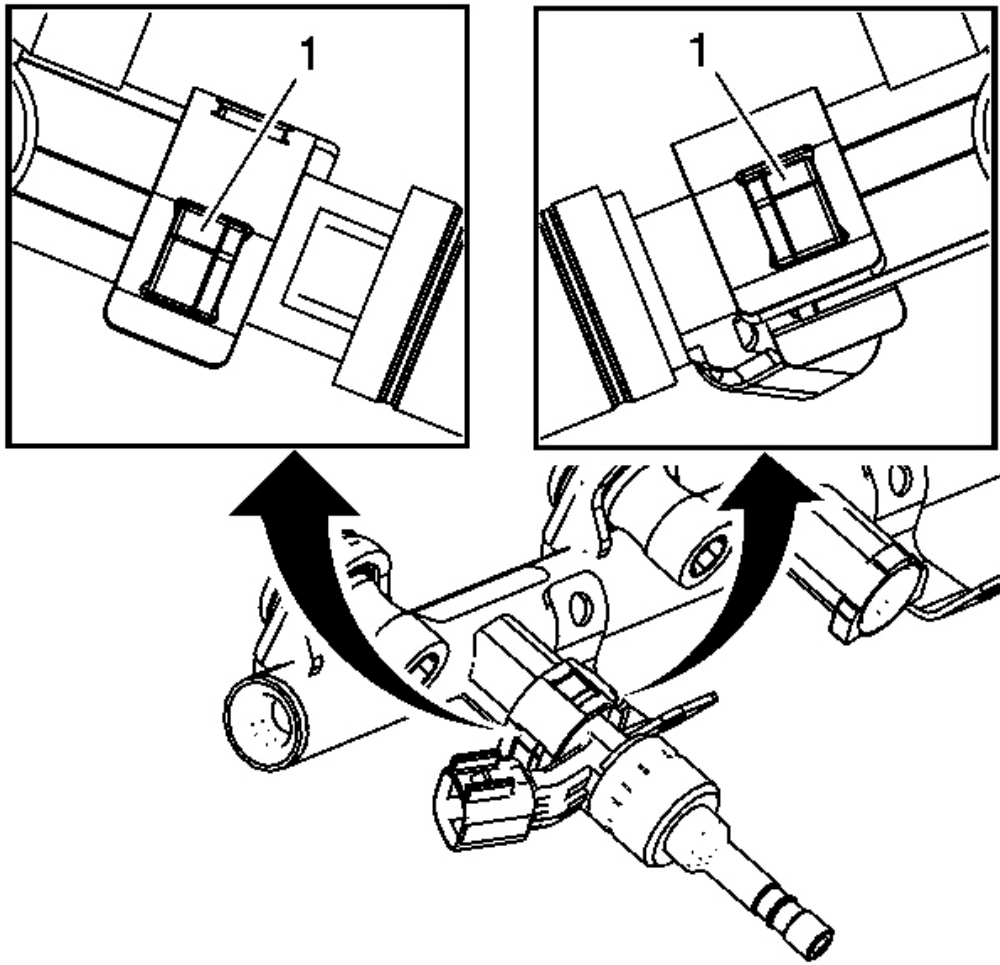


Fig. 81: Fuel Rail Flanges

Courtesy of GENERAL MOTORS CORP.

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.

22. Ensure all 3 fuel injector bushing tabs and fuel rail flanges (1) are properly and completely captured by the fuel injector retainer.
23. Repeat for remaining injectors until all are installed and retained in fuel rail.

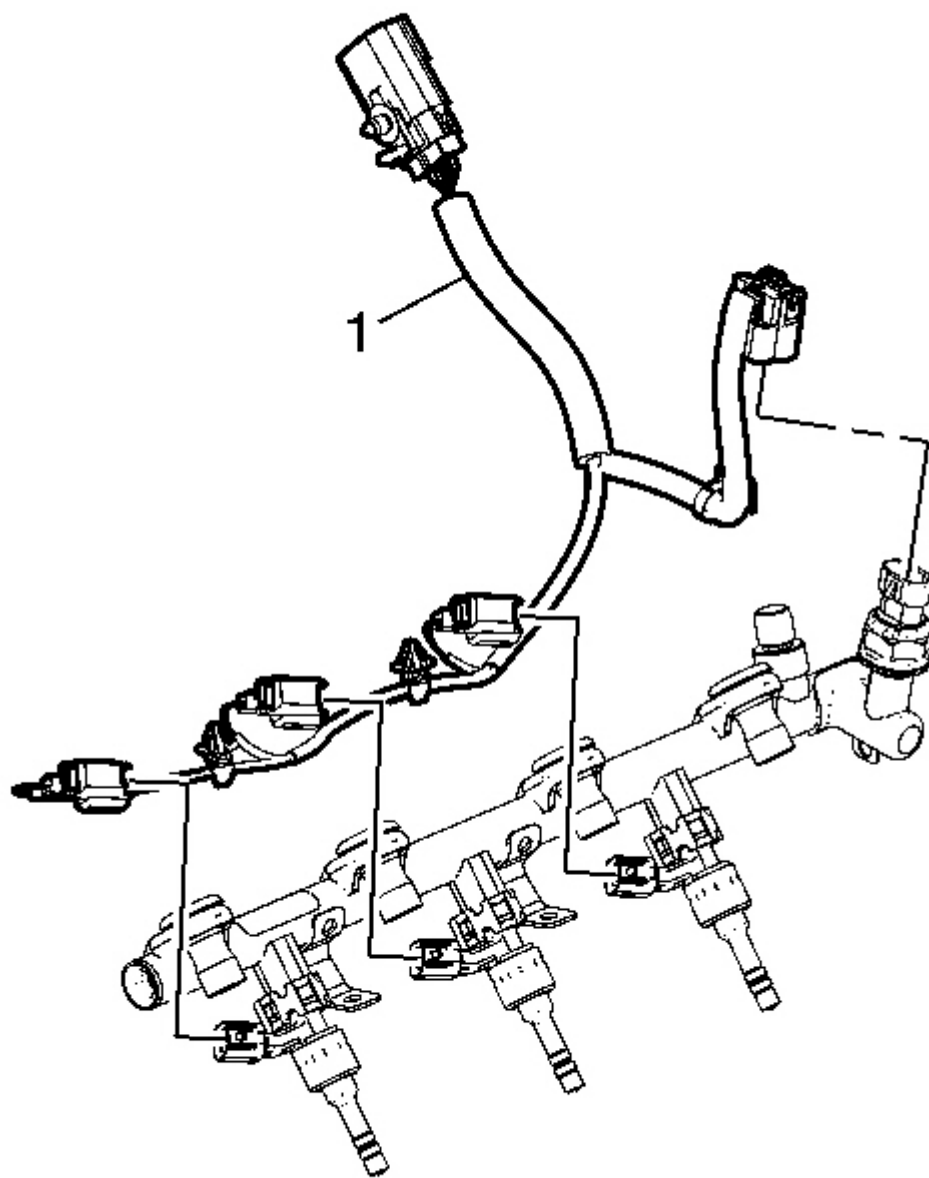


Fig. 82: Fuel Rail Wiring Harness
Courtesy of GENERAL MOTORS CORP.

24. Install the fuel rail wiring harness (1).

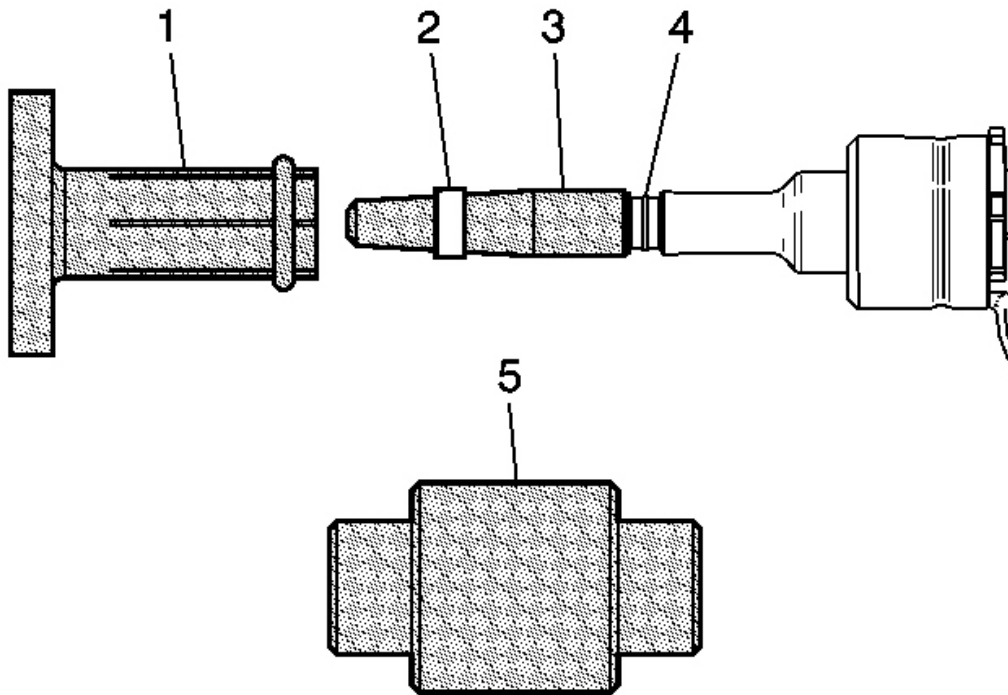


Fig. 83: Installing Seals With Long Protector
Courtesy of GENERAL MOTORS CORP.

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

25. Install **EN 49245-1:** long protector (3) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a NEW seal (2) on **EN-49245-1:** long protector.
26. Using **EN-49245-3:** pusher (1), install the seal into the second recessed area (4) of the fuel injector.

NOTE: The **EN-49245-4:** sizer is two sided, and either direction will size the seal correctly.

27. Compress the seal with your fingers, then resize the seal using the **EN-49245-4:** sizer (5).

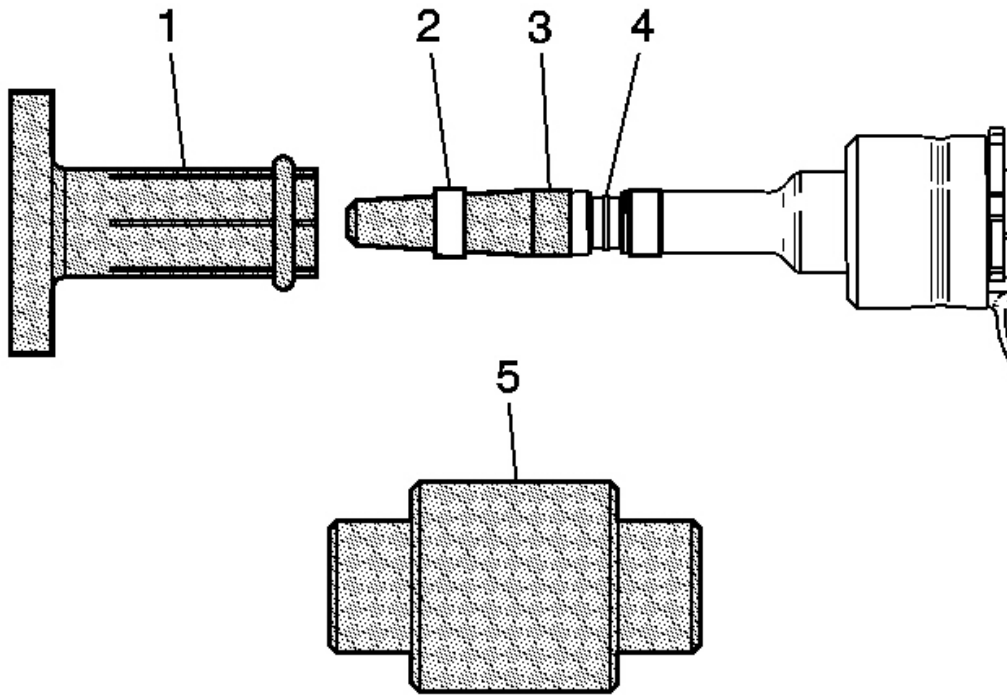


Fig. 84: Installing Seals With Short Protector
Courtesy of GENERAL MOTORS CORP.

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

28. Install **EN-49245-2:** short protector (3) onto the fuel injector tip. Place a NEW seal (2) on **EN-49245-2:** short protector.
29. Using **EN-49245-3:** pusher (1), install the seal into the first recessed area (4) of the fuel injector.

NOTE: The **EN-49245-4:** sizer is two sided, and either direction will size the seal correctly.

30. Compress the seal with your fingers, then resize the seal using the **EN-49245-4:** sizer (5).

CYLINDER HEAD ASSEMBLE (LF1 OR LFW)

Special Tools

- **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
- **J 8062:** Valve Spring Compressor - Head Off

For equivalent regional tools, refer to **Special Tools** .

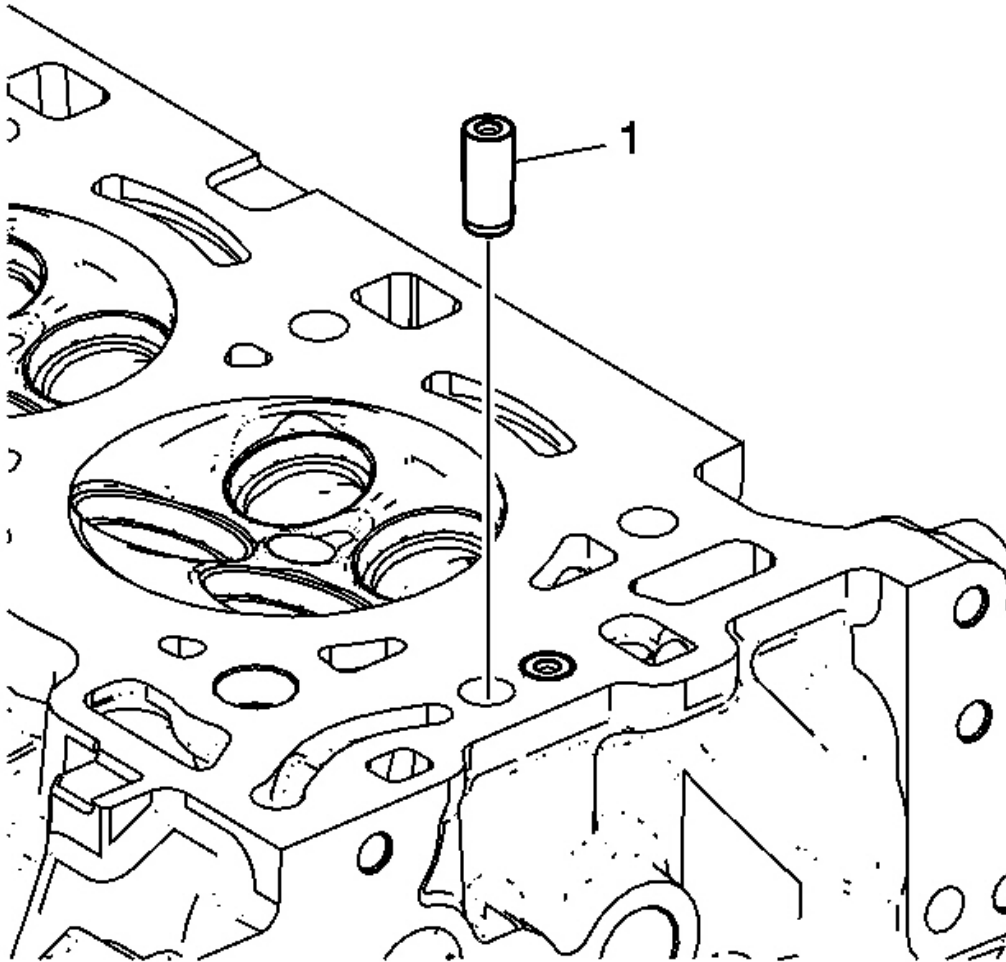


Fig. 85: Check Valve

Courtesy of GENERAL MOTORS CORP.

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.

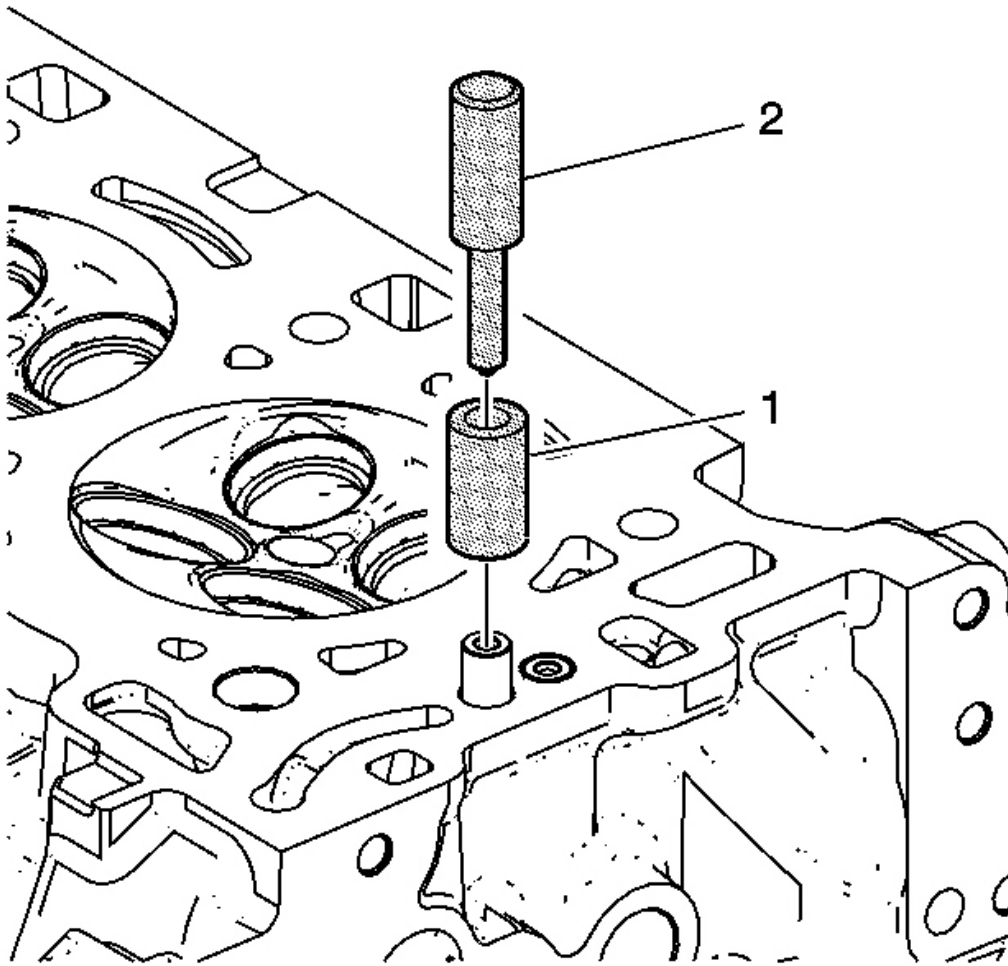


Fig. 86: Tapping Check Valve Into Place
Courtesy of GENERAL MOTORS CORP.

3. 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.

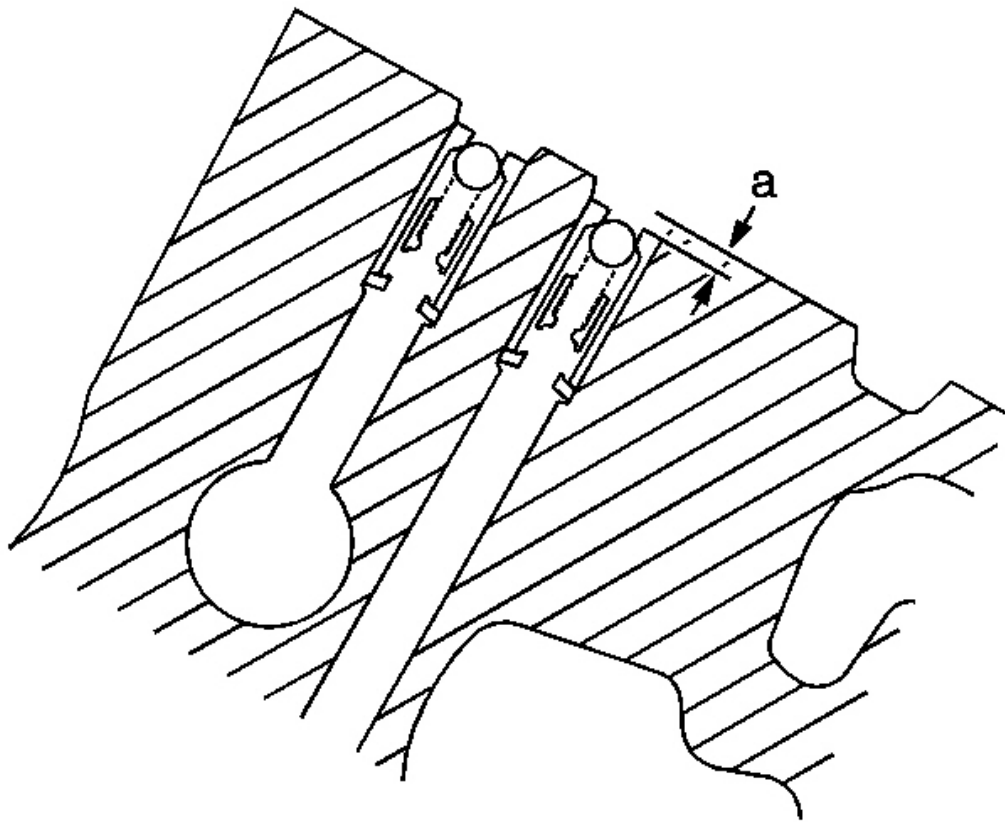


Fig. 87: Inspecting Camshaft Position Actuator Oil Feed Check Valve
Courtesy of GENERAL MOTORS CORP.

5. 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).

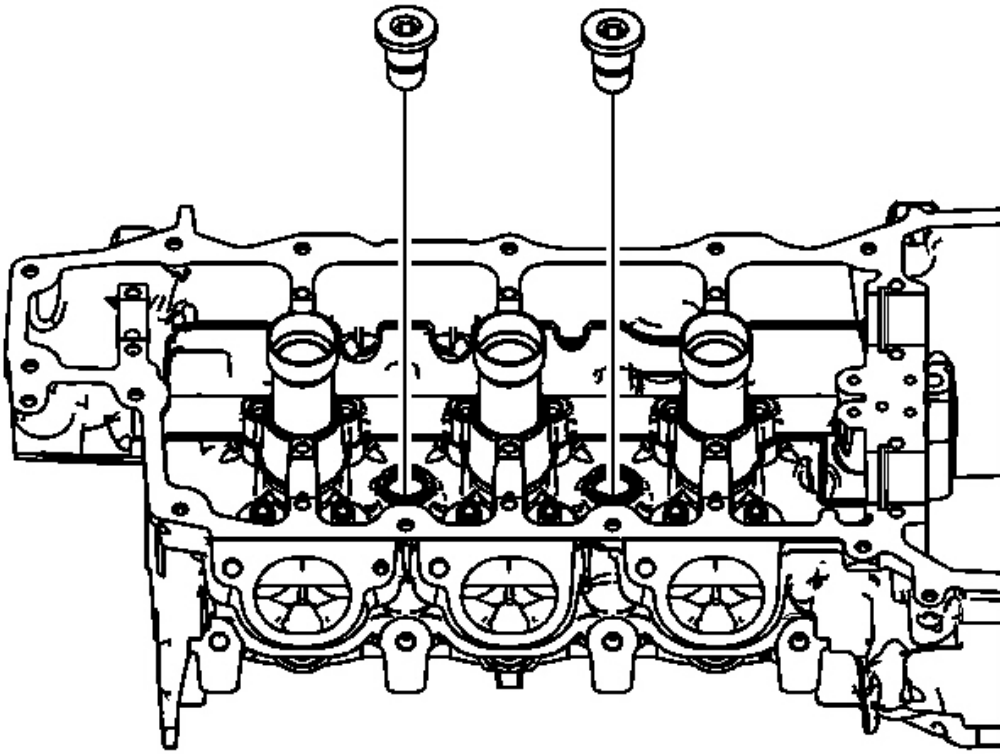


Fig. 88: View Of Cylinder Head Coolant Threaded Plugs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Install the cylinder head coolant threaded plugs and tighten to 31 N.m (23 lb ft).

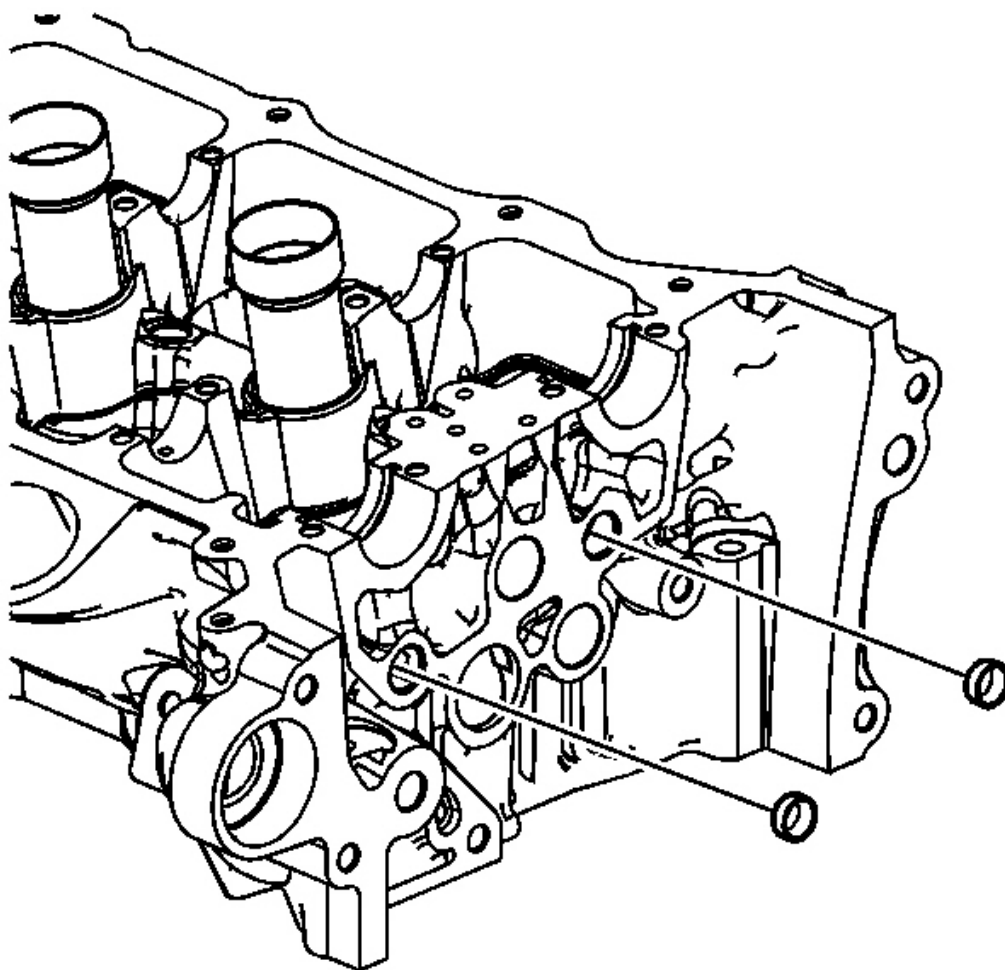


Fig. 89: Cylinder Head Oil Gallery Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head oil gallery expansion plugs.

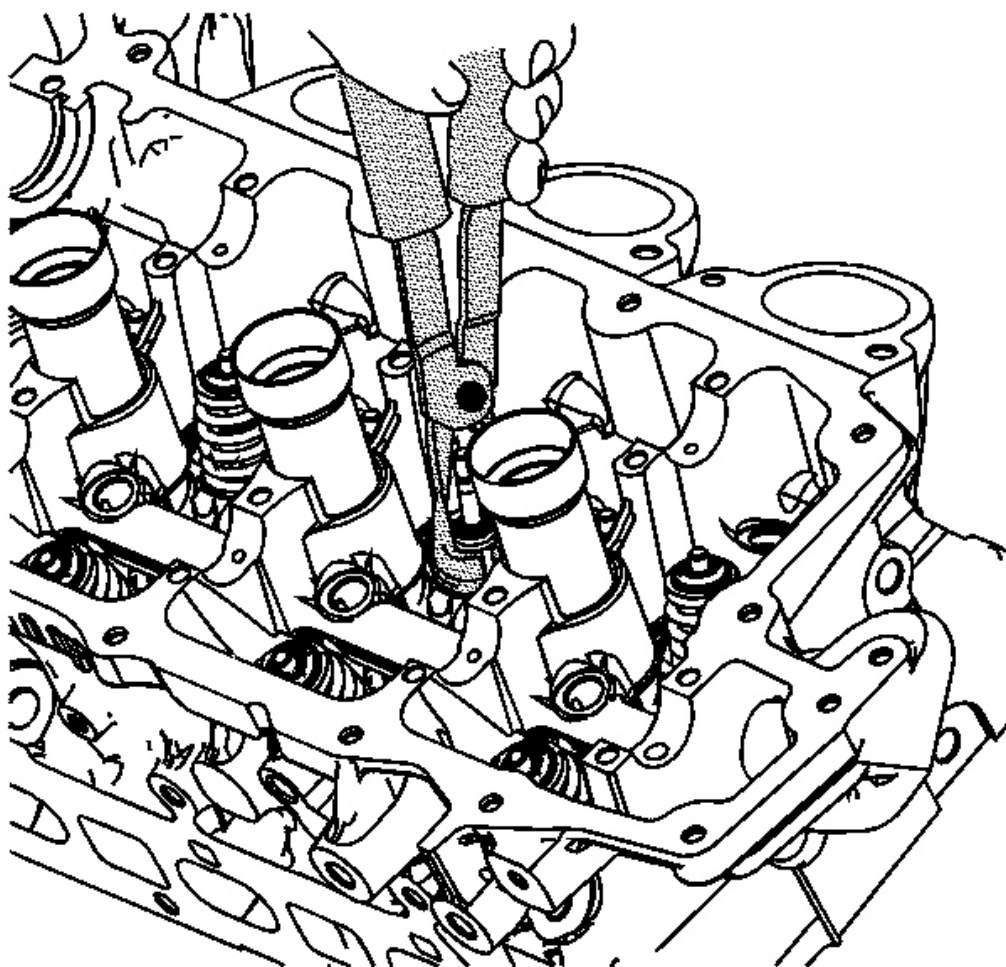


Fig. 90: Removing/Installing Valve Stem Oil Seals
Courtesy of GENERAL MOTORS CORP.

8. 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 GM P/N 12345501 (Canadian P/N 992704) or equivalent.

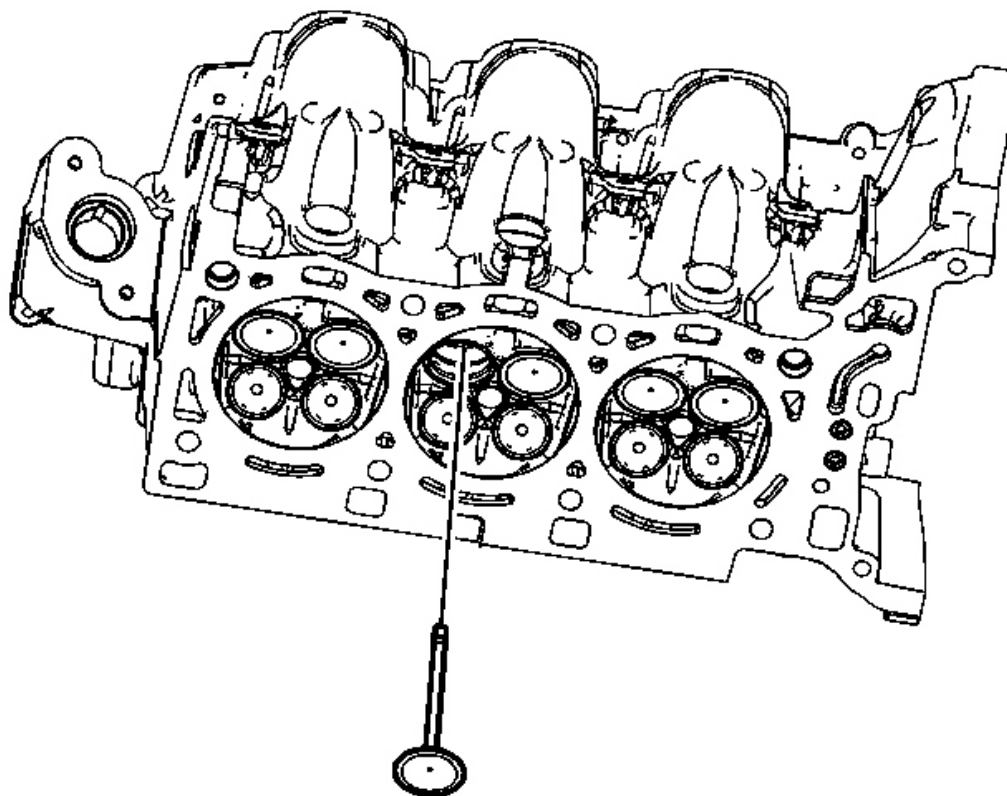


Fig. 91: Removing/Installing valve
Courtesy of GENERAL MOTORS CORP.

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

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

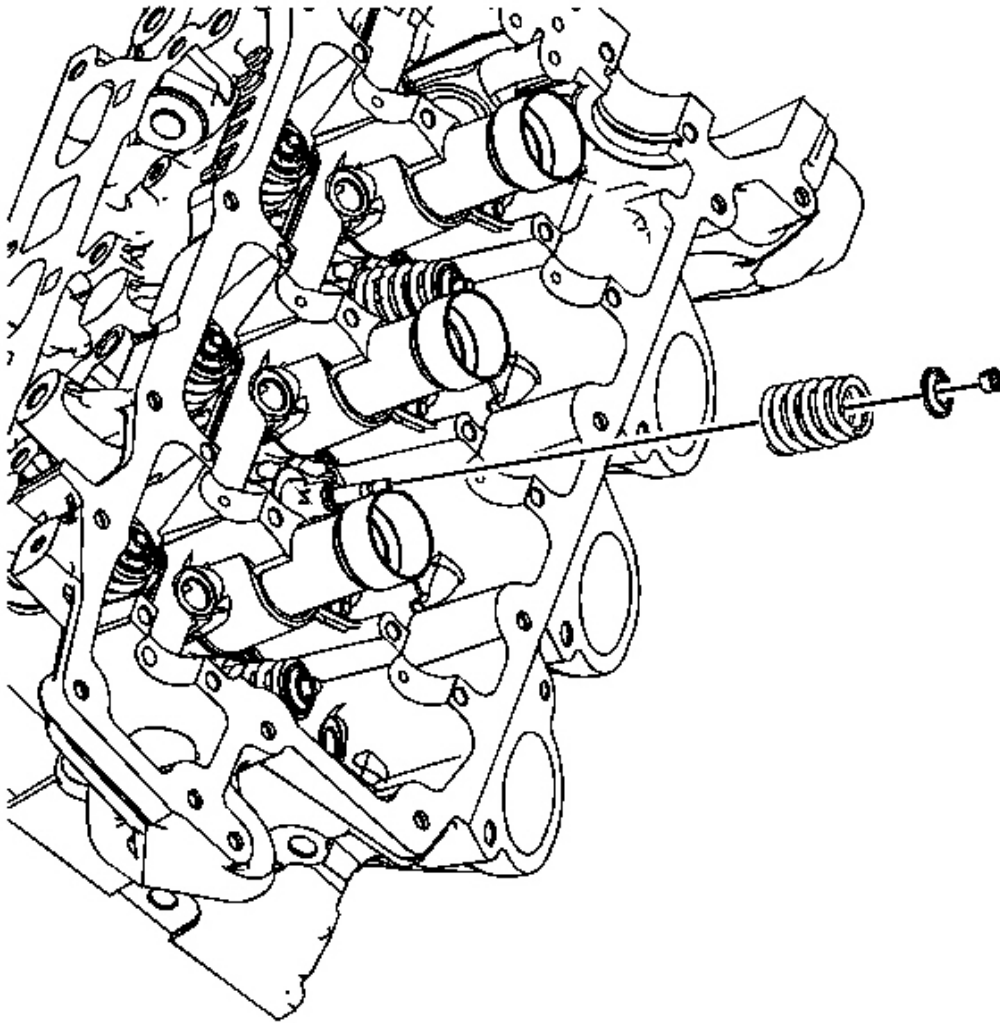


Fig. 92: View Of Valve Spring & Retainer
Courtesy of GENERAL MOTORS CORP.

13. Position the valve spring on the spring seat.
14. Place the valve spring retainer onto the valve spring.

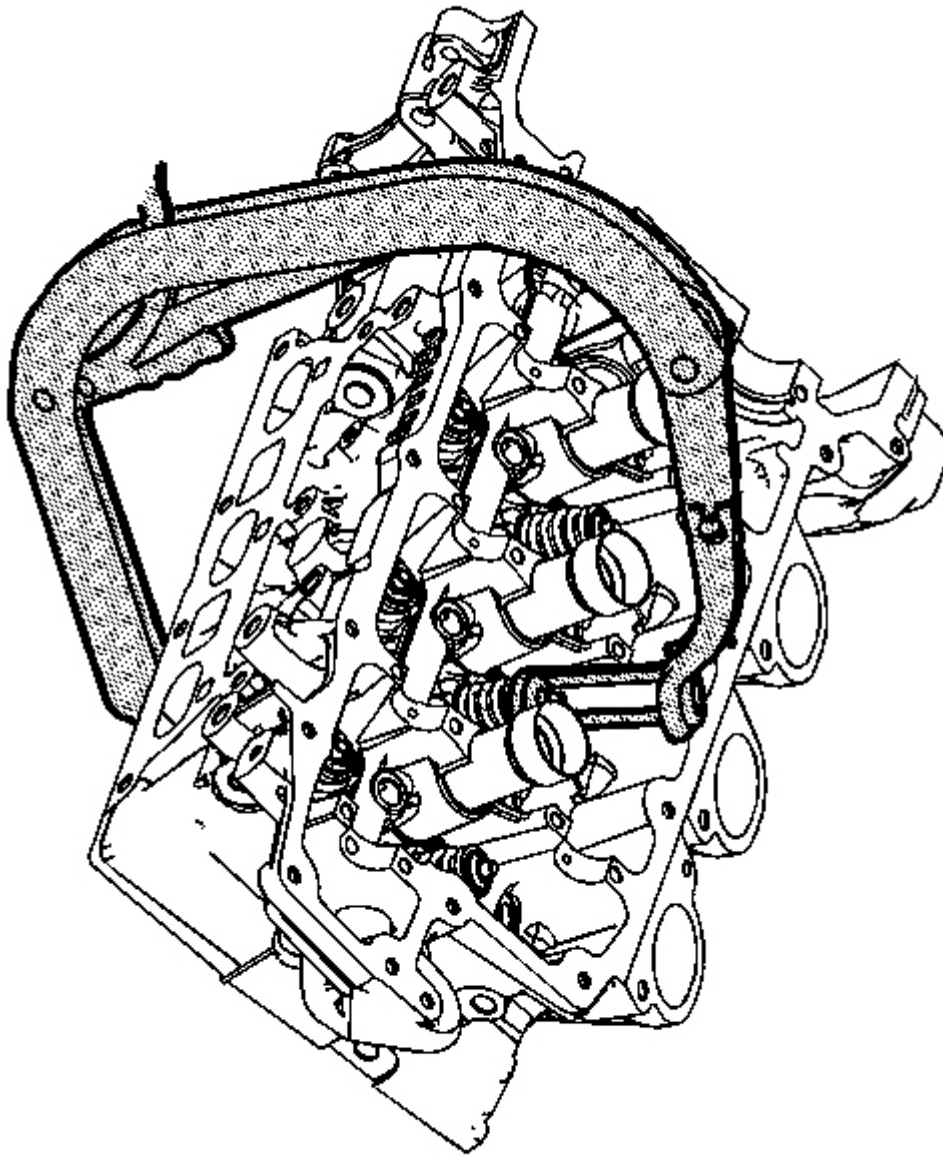


Fig. 93: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

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.

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

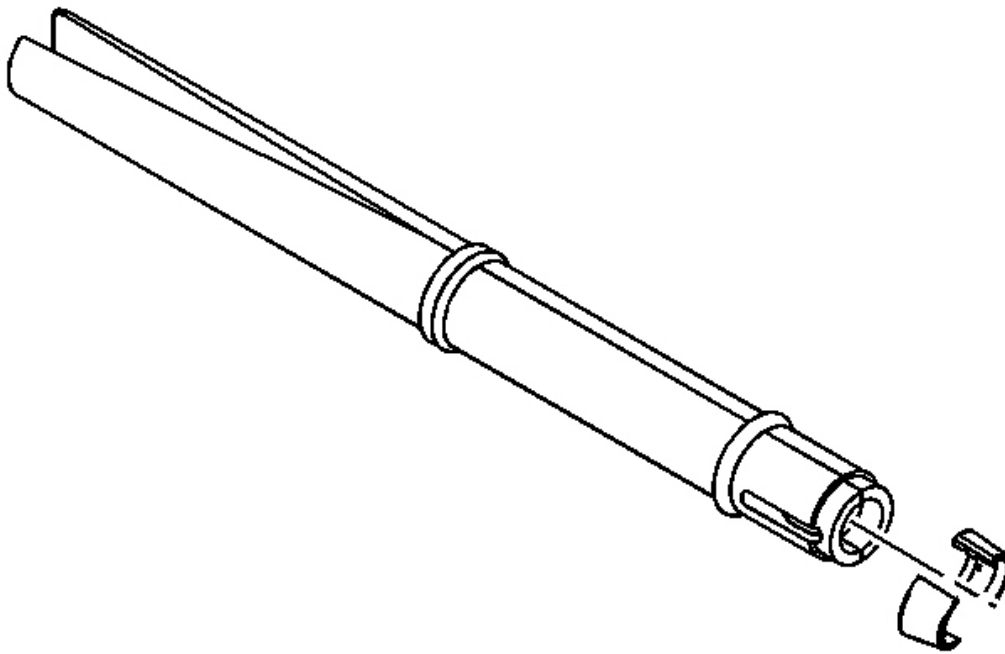


Fig. 94: Installing Valve Keepers
Courtesy of GENERAL MOTORS CORP.

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.

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

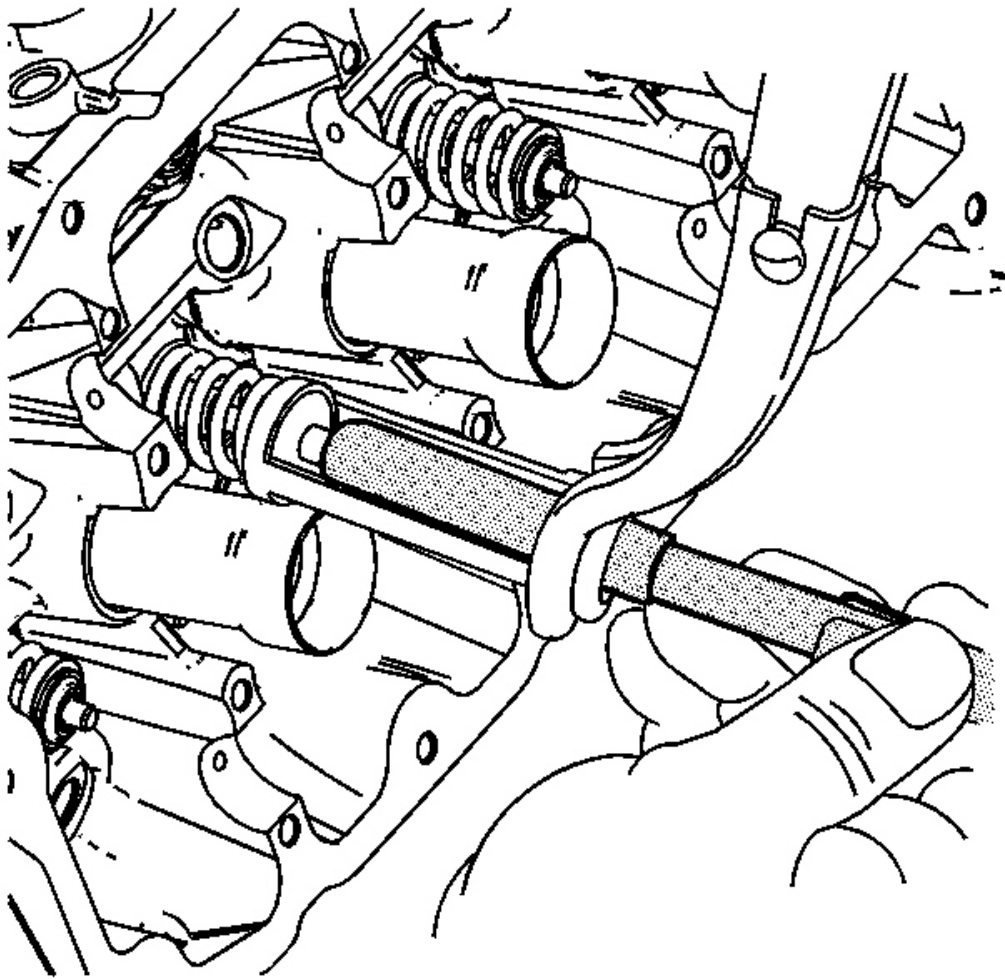


Fig. 95: Placing Keepers

Courtesy of GENERAL MOTORS CORP.

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 **J 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.

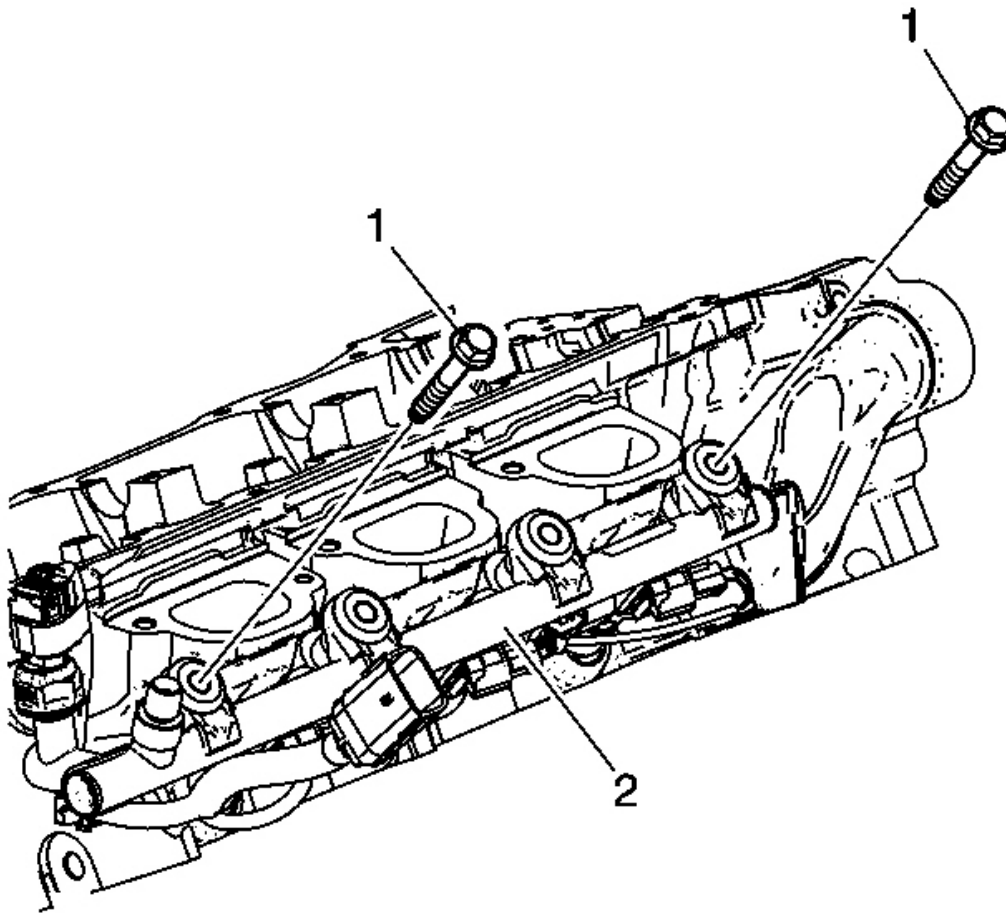


Fig. 96: Fuel Rail Bolts

Courtesy of GENERAL MOTORS CORP.

19. 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.

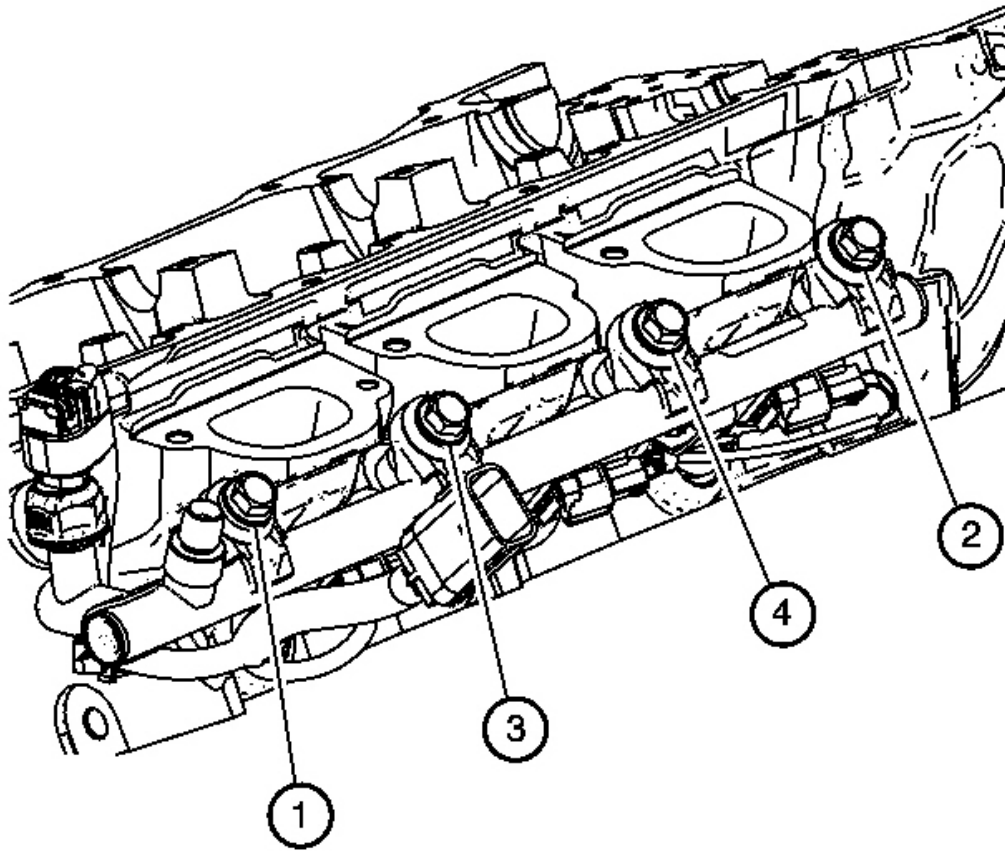


Fig. 97: Identifying Fuel Rail Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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

CAMSHAFT CLEANING AND INSPECTION

SPECIAL TOOLS

GE 7872: Magnetic Base Dial Indicator

For equivalent regional tools, refer to **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

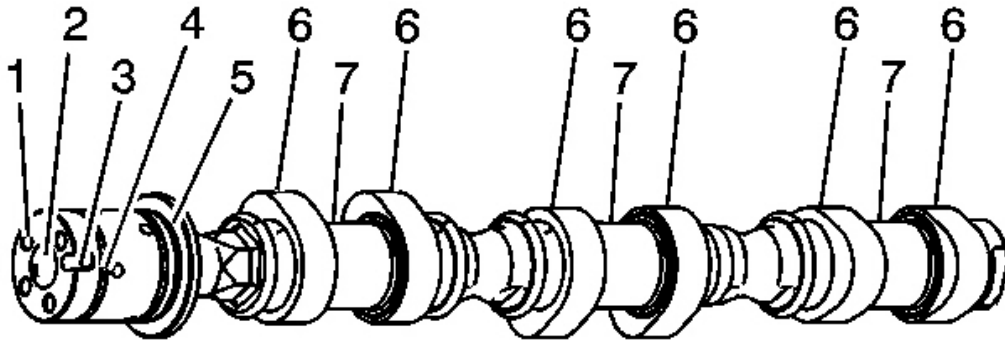


Fig. 98: Identifying Camshaft Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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

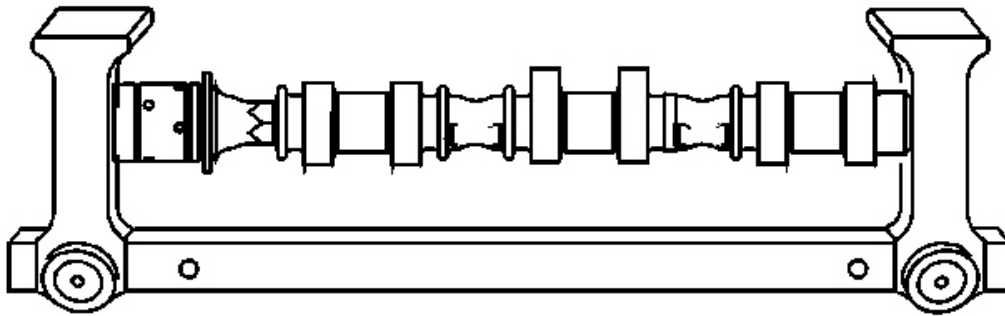


Fig. 99: Supporting Camshaft In Fixture
 Courtesy of GENERAL MOTORS CORP.

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

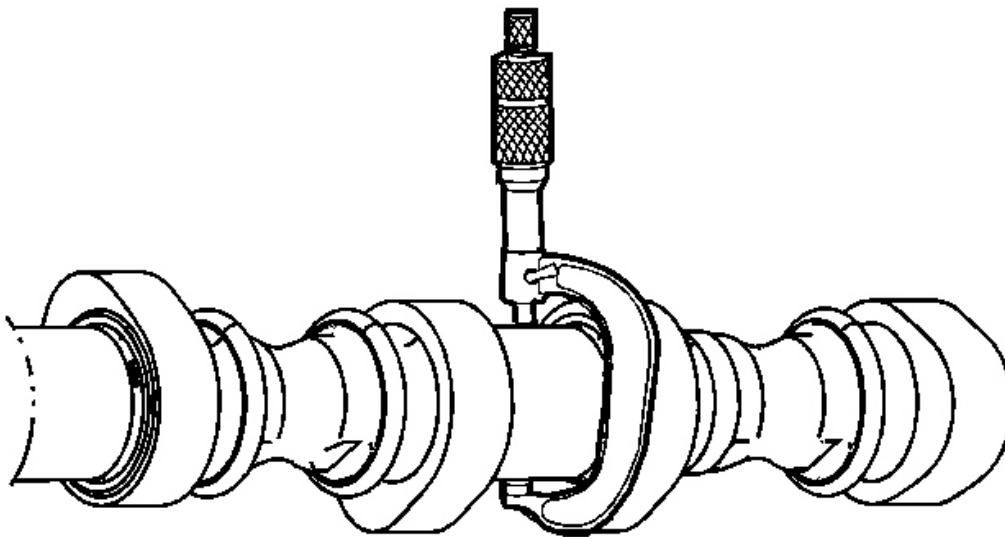


Fig. 100: Measuring Camshaft Journals
 Courtesy of GENERAL MOTORS CORP.

2. Measure the camshaft journals for diameter and out-of-round using an outside micrometer. Refer to **Engine Mechanical Specifications (LF1)** .

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

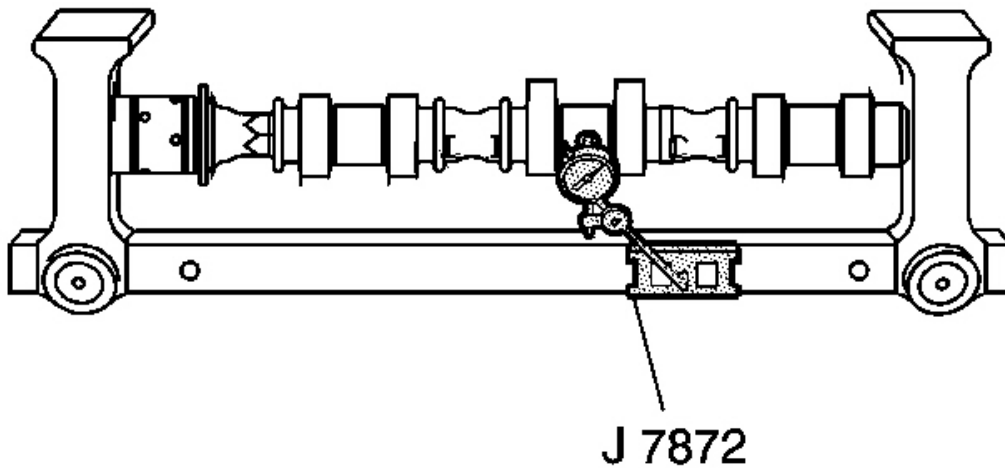


Fig. 101: Checking Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

3. Measure the camshaft runout using the **GE 7872:** indicator. Refer to **Engine Mechanical Specifications (LF1)**.

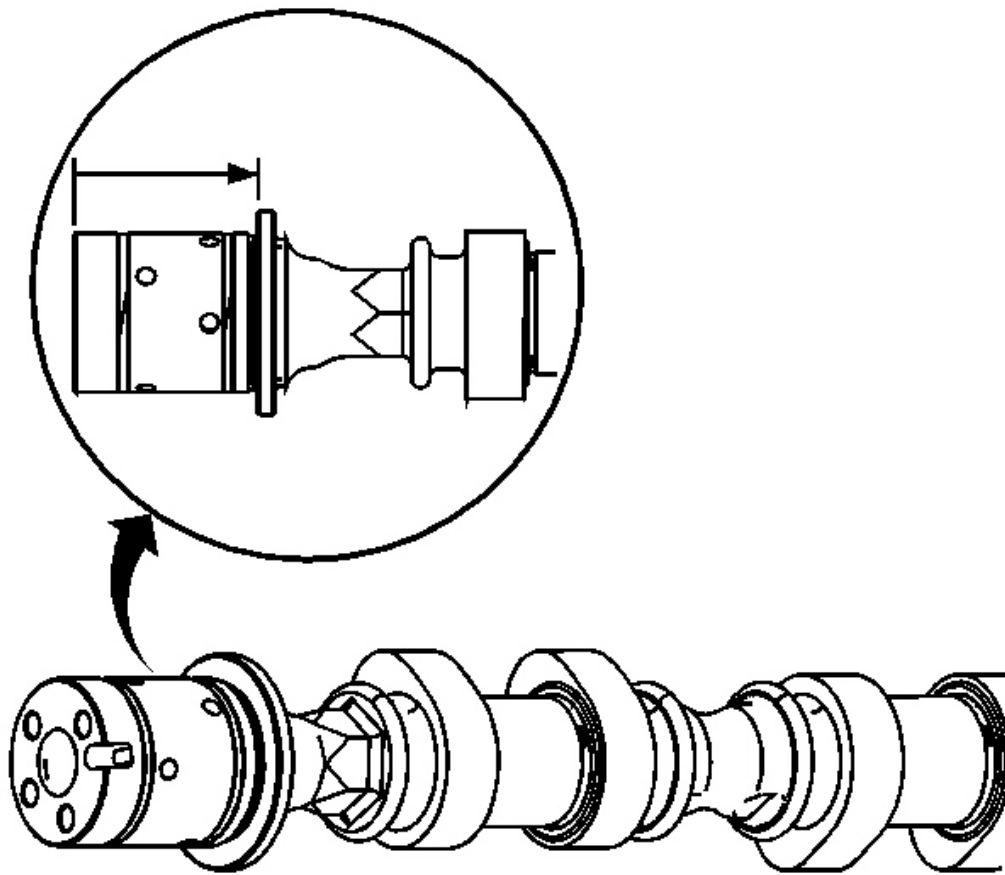


Fig. 102: Measuring Camshaft Thrust
Courtesy of GENERAL MOTORS CORP.

4. Measure the camshaft thrust width for wear using a depth micrometer. Refer to **Engine Mechanical Specifications (LF1)** .

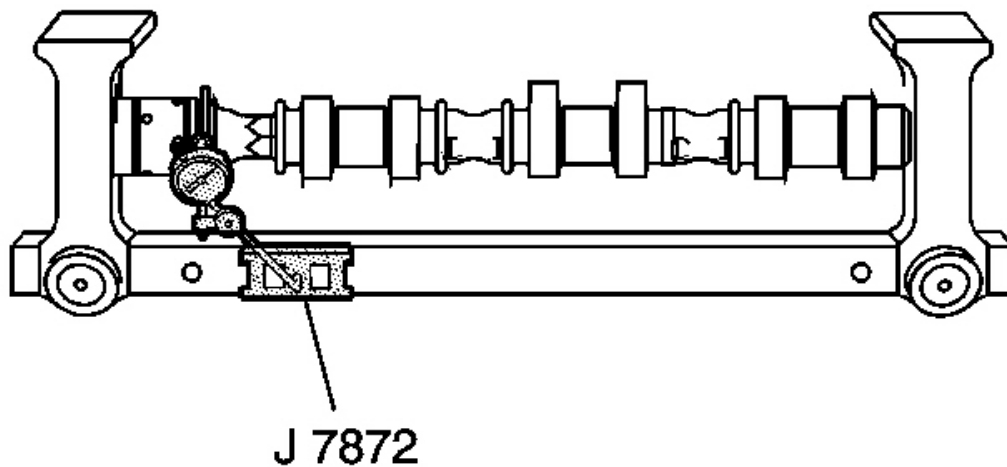


Fig. 103: Measuring Camshaft Thrust Wall Surface For Runout
 Courtesy of GENERAL MOTORS CORP.

5. Measure the camshaft thrust wall surface for runout using **GE 7872**: indicator. Refer to **Engine Mechanical Specifications (LF1)** .
6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.

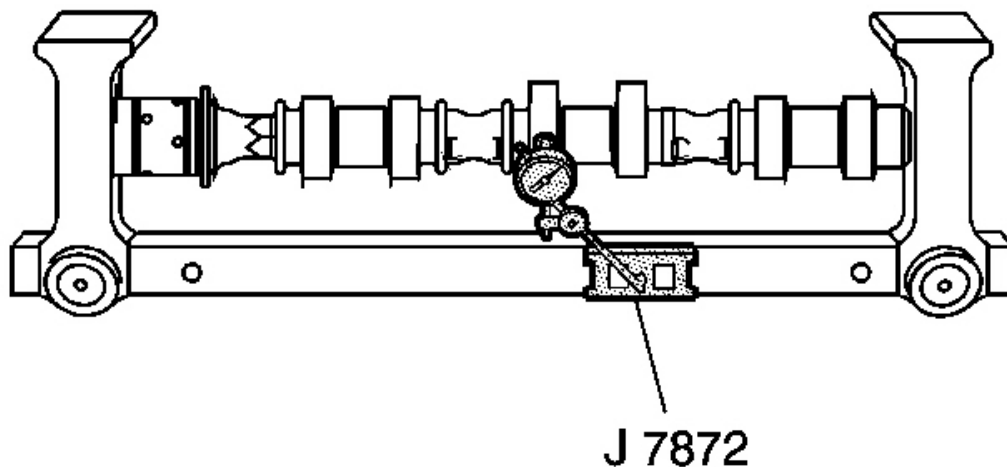


Fig. 104: Measuring Camshaft Lobes For Wear
Courtesy of GENERAL MOTORS CORP.

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

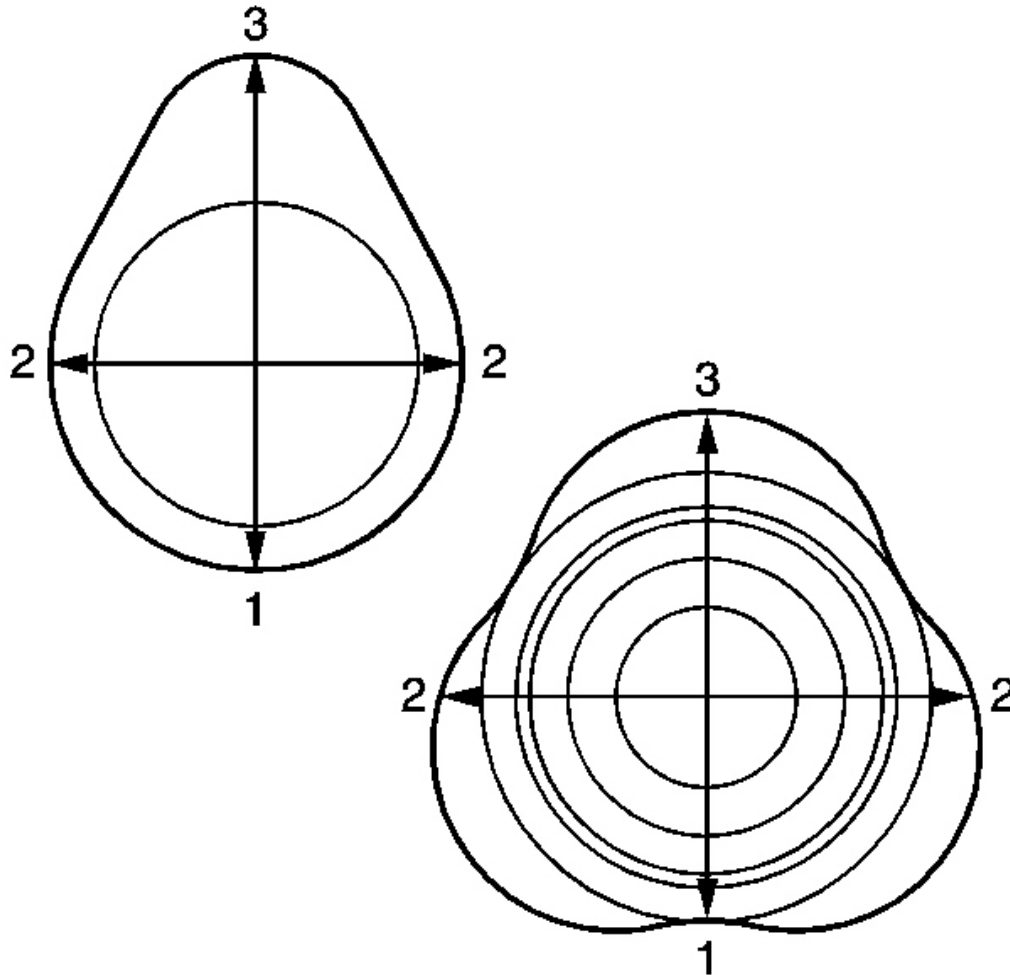


Fig. 105: View of Lobe Diagram
Courtesy of GENERAL MOTORS CORP.

8. 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. Refer to **Engine Mechanical Specifications (LF1)**.
 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

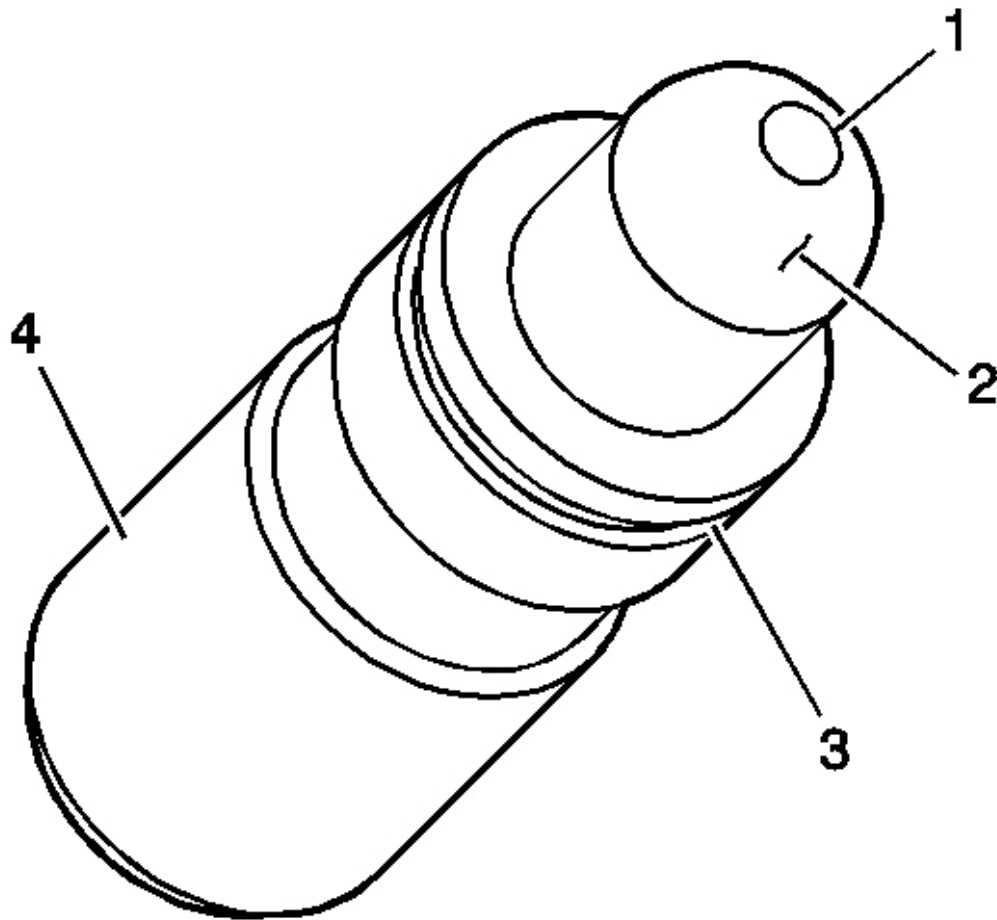


Fig. 106: Valve Lifter
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Valve Lifter Priming Caution .

1. 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

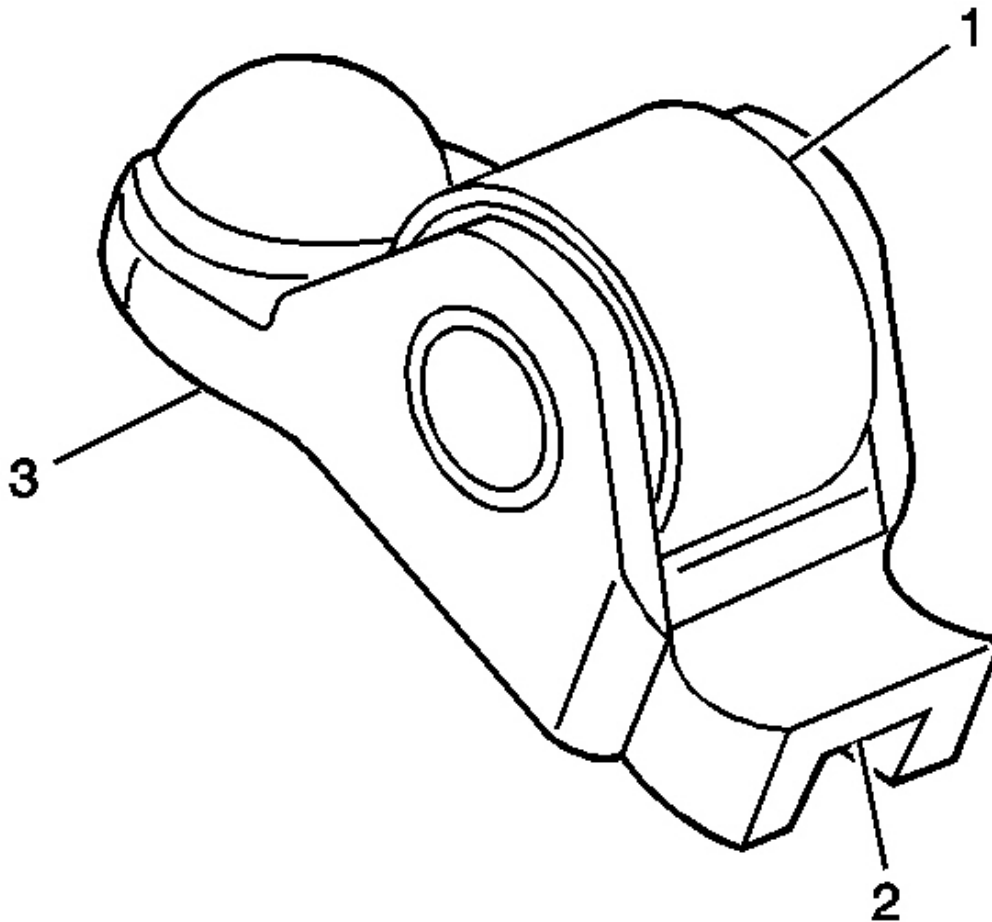


Fig. 107: Identifying Camshaft Follower Roller
Courtesy of GENERAL MOTORS CORP.

1. 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.

VISUAL INSPECTION

Camshaft Thrust Washers

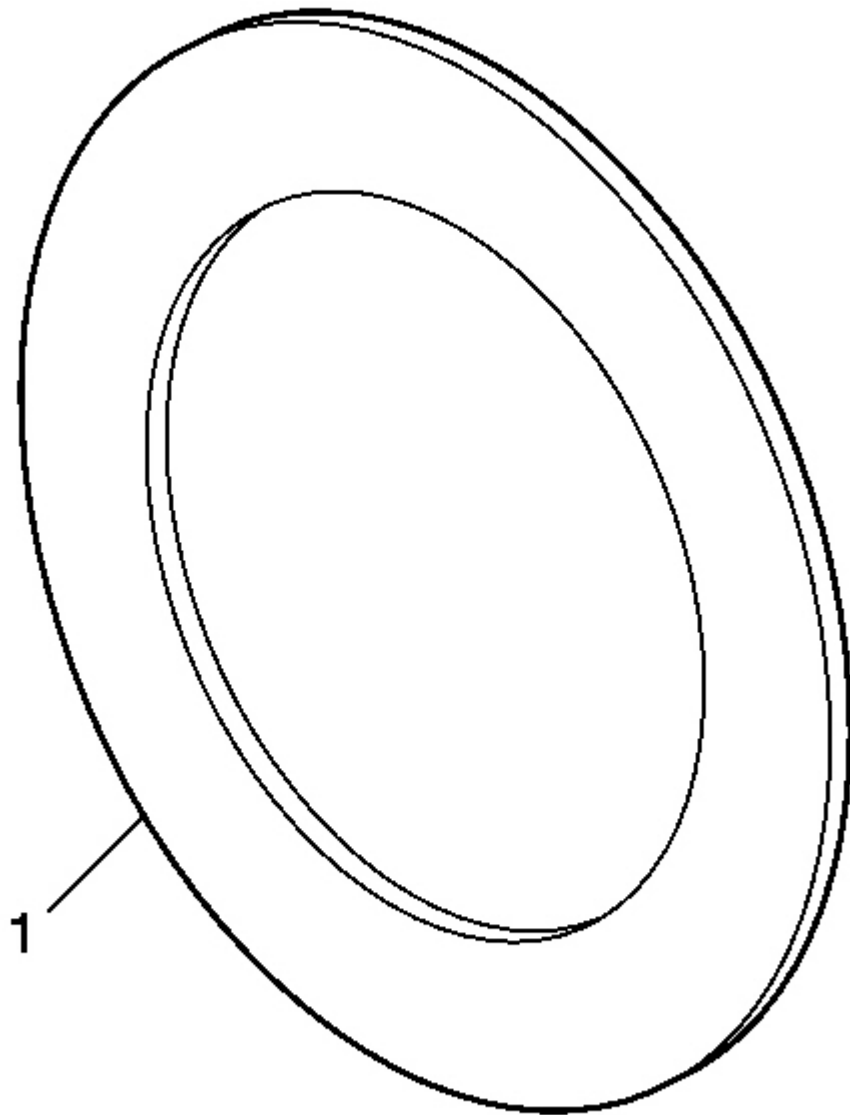


Fig. 108: Camshaft Thrust Washer
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft thrust washers for deep scoring or uneven wear (1).
2. Replace as necessary.

Camshaft Position Actuators

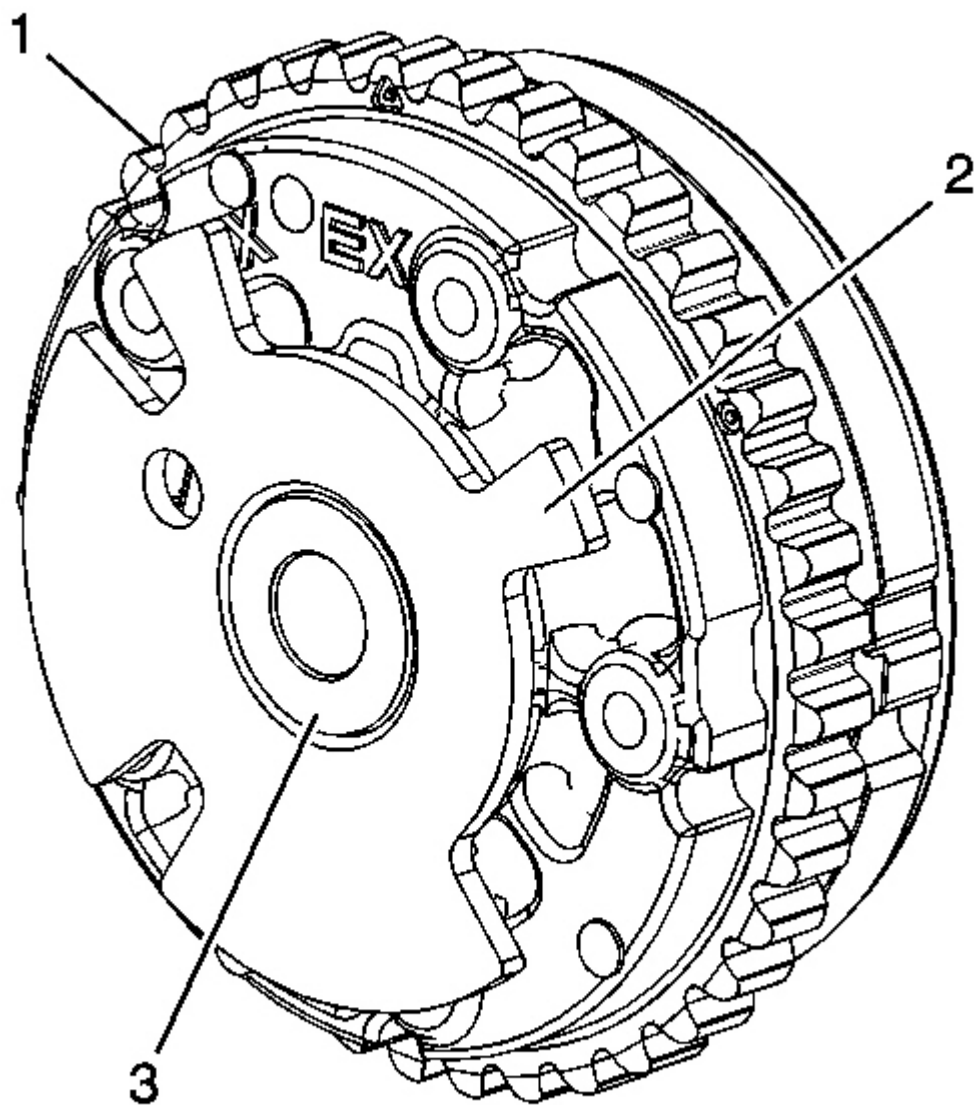


Fig. 109: Identifying Camshaft Position Actuator Damage
Courtesy of GENERAL MOTORS CORP.

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

1. 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)

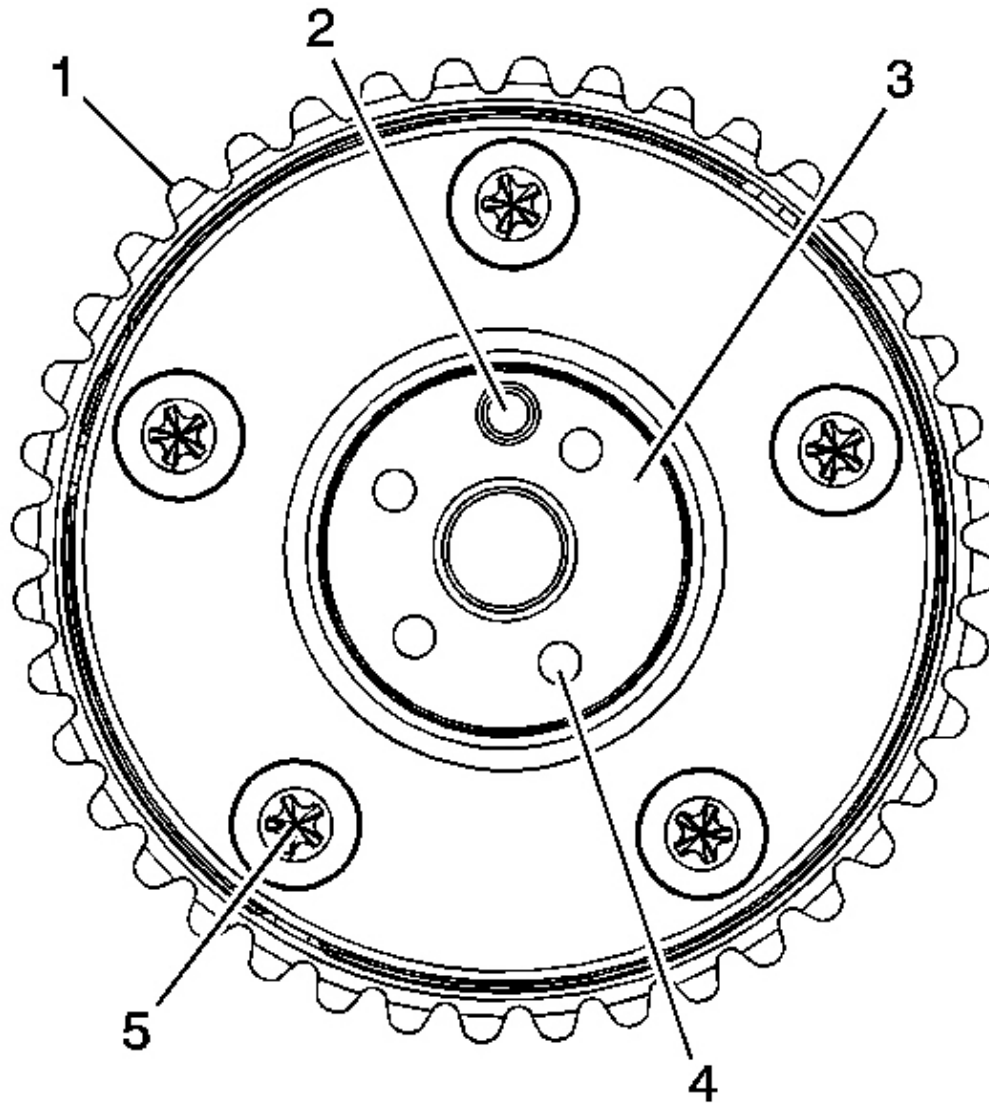


Fig. 110: Identifying Exhaust Camshaft Position Actuator Damage
Courtesy of GENERAL MOTORS CORP.

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)

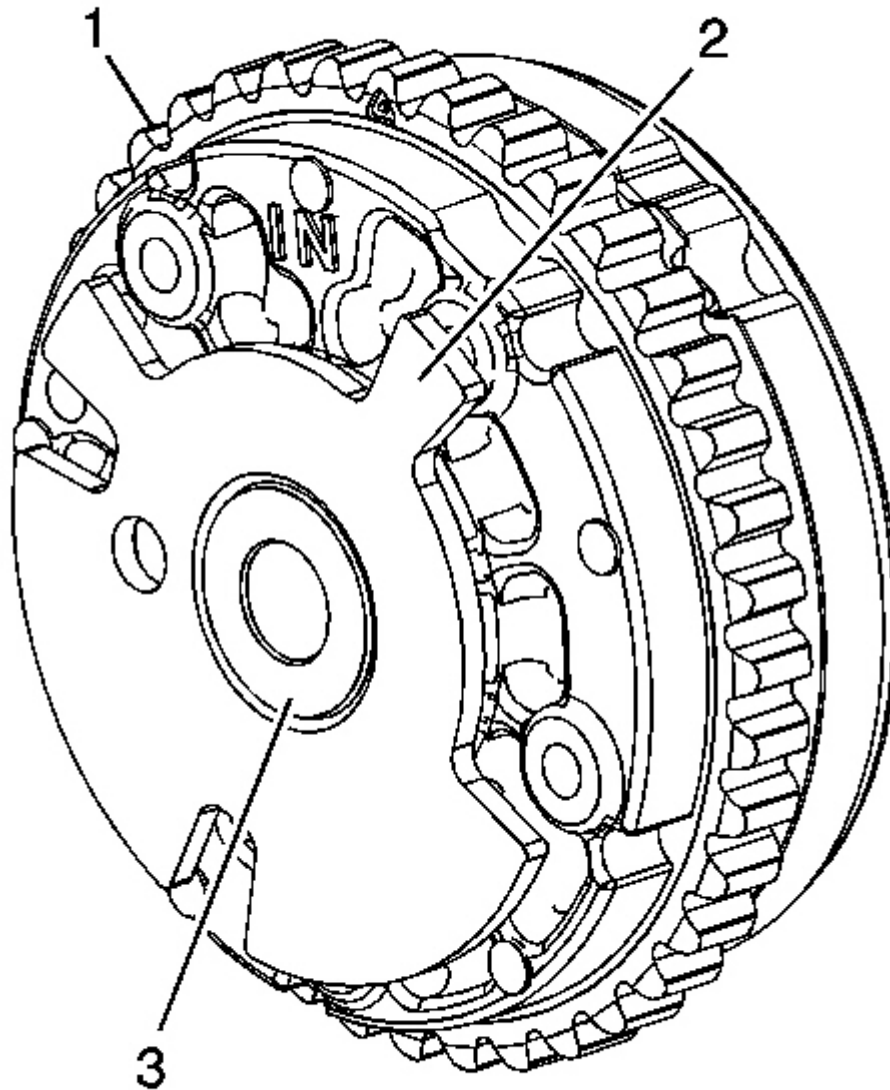


Fig. 111: Identifying Left Intake Camshaft Position Actuator Damage
Courtesy of GENERAL MOTORS CORP.

3. 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)

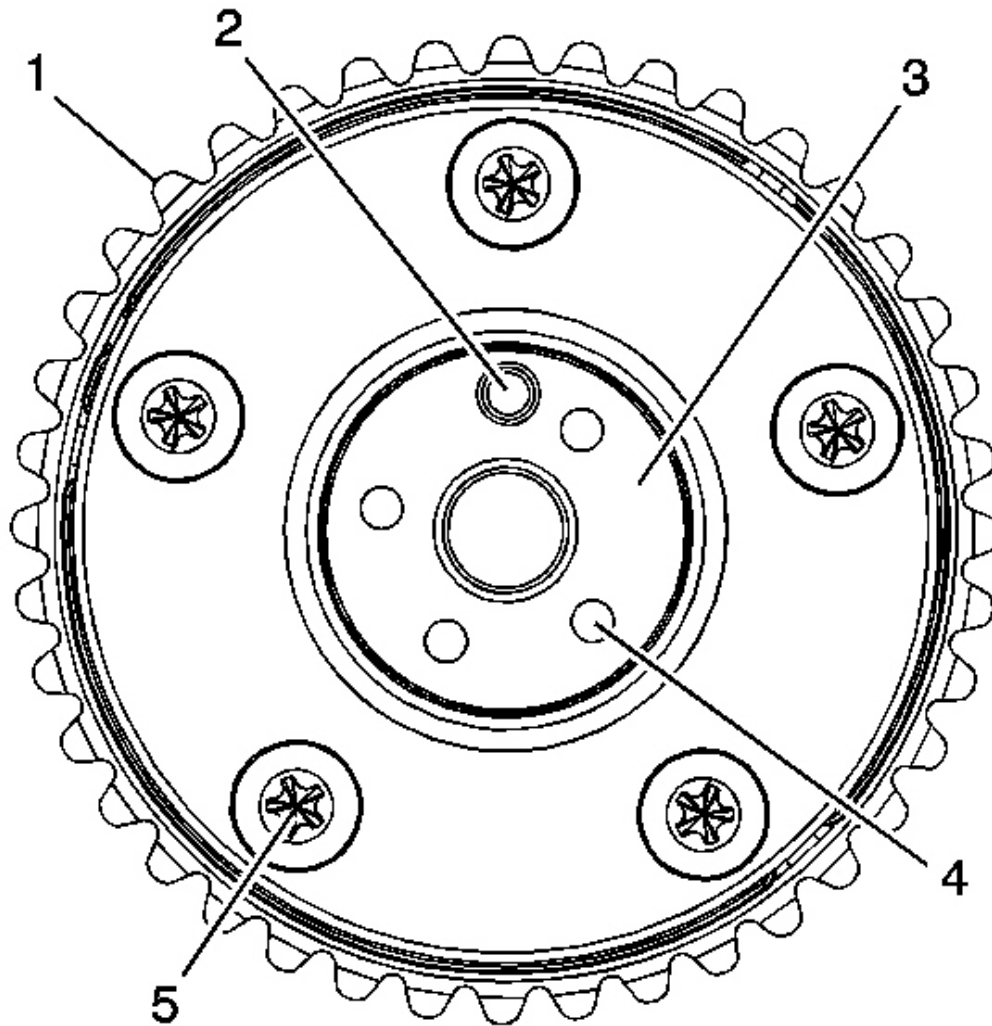


Fig. 112: Identifying Back Of Left Intake Camshaft Position Actuator Damage
Courtesy of GENERAL MOTORS CORP.

4. 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)

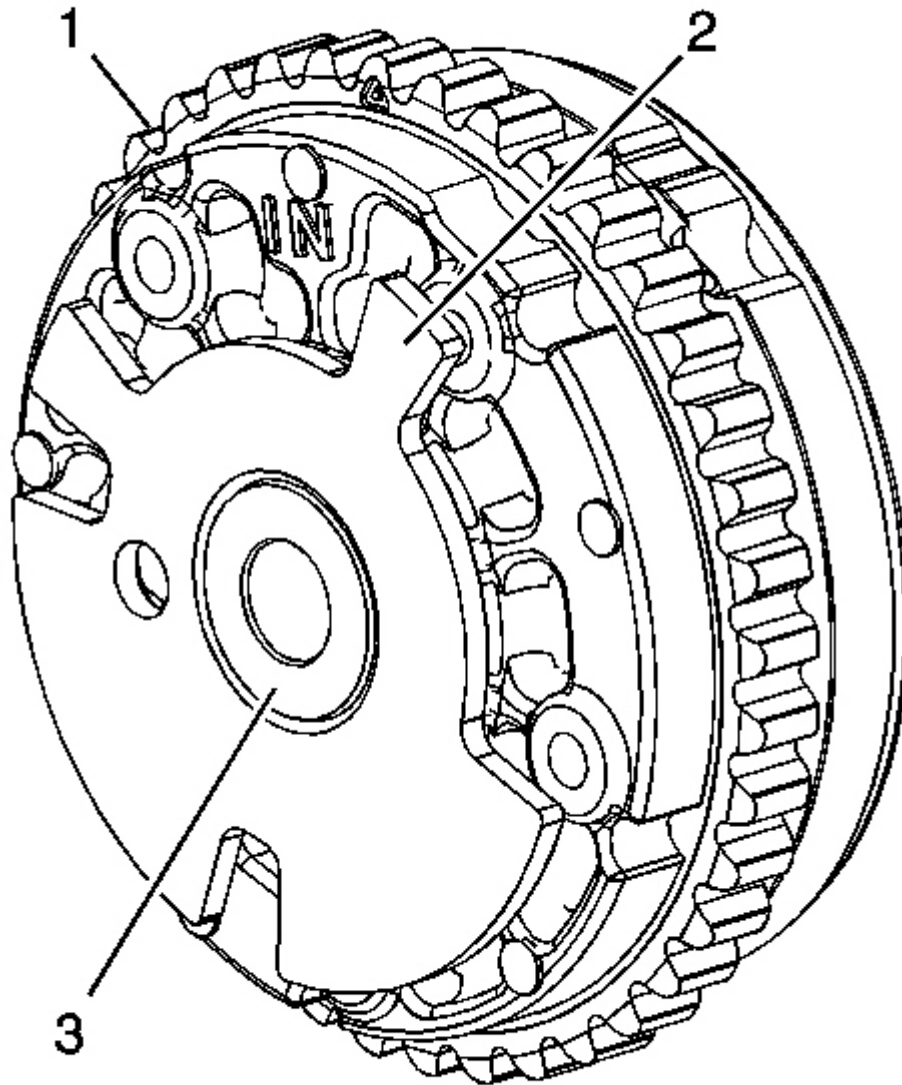


Fig. 113: Identifying Right Intake Camshaft Position Actuator Damage
Courtesy of GENERAL MOTORS CORP.

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)

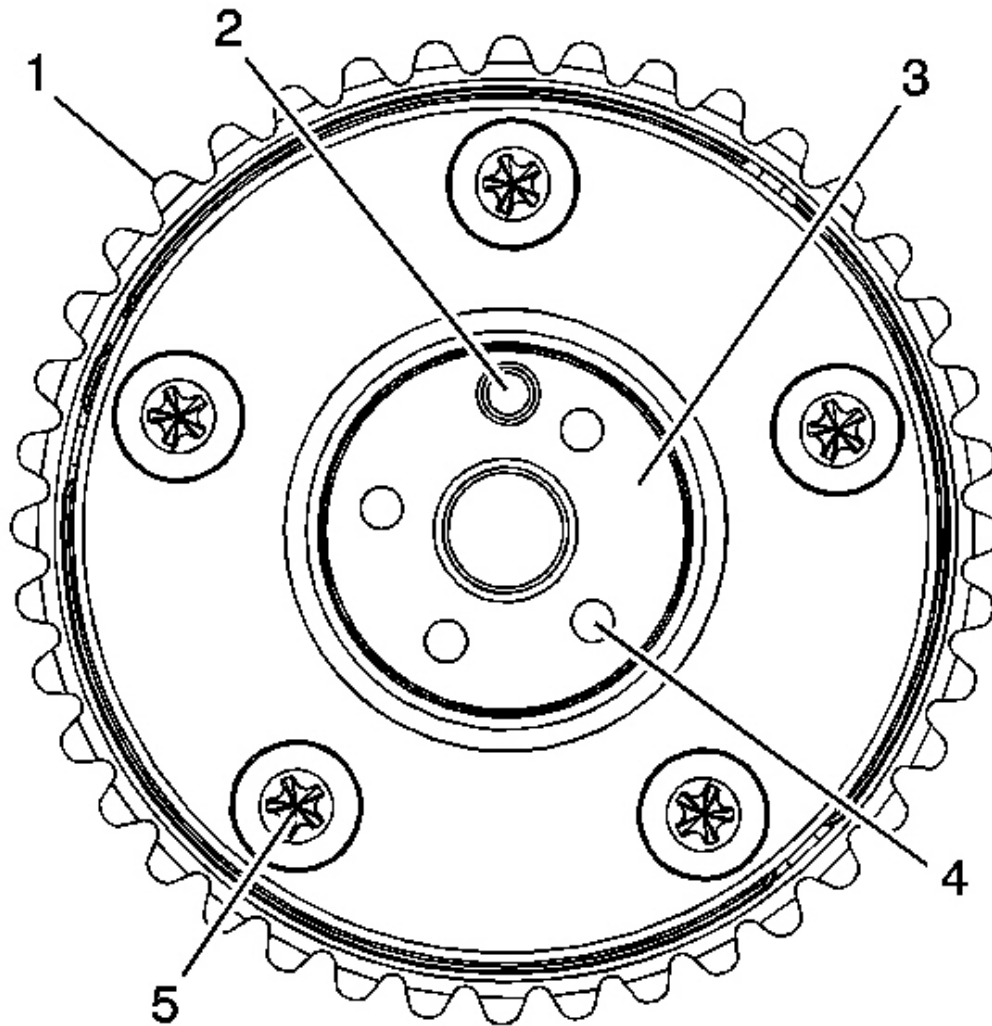


Fig. 114: Identifying Back Of Right Intake Camshaft Position Actuator Damage
Courtesy of GENERAL MOTORS CORP.

6. 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

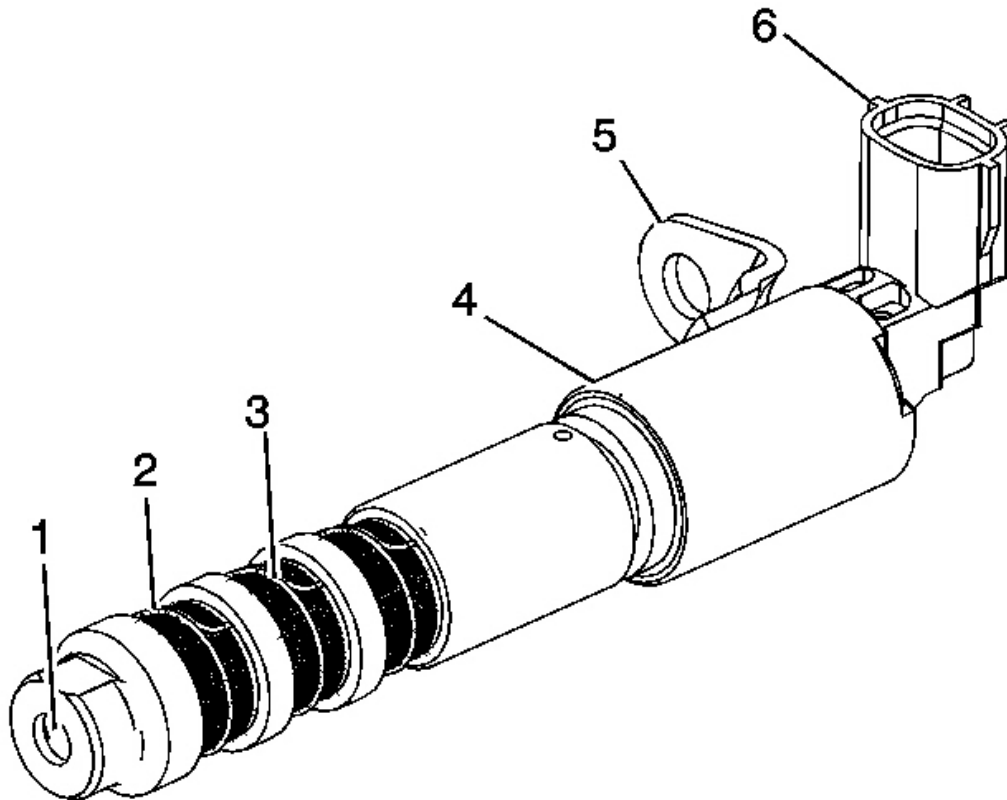


Fig. 115: Identifying Camshaft Position Actuator Oil Control Valves Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. 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

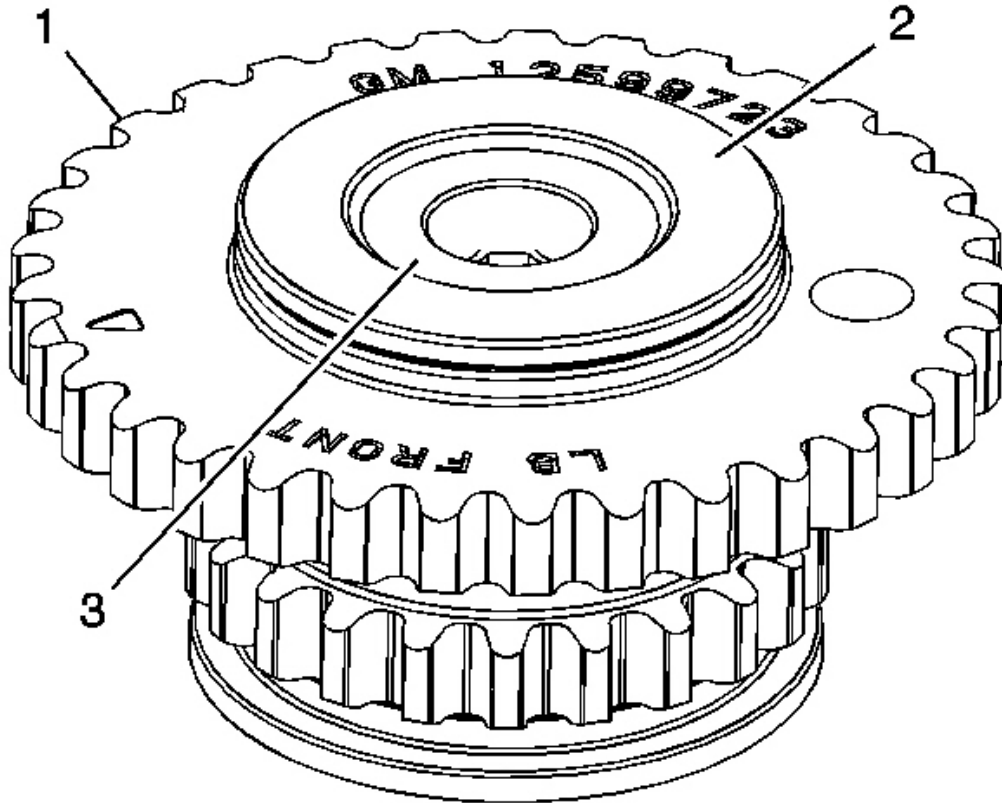


Fig. 116: Inspecting Front Of Left Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

1. 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)

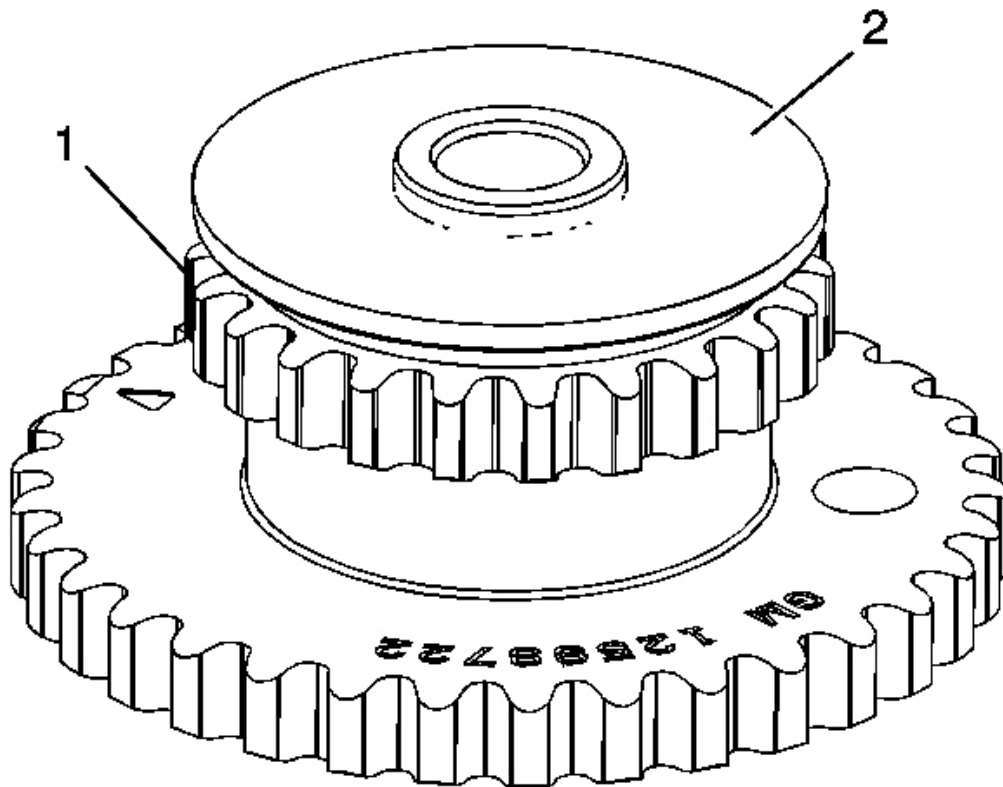


Fig. 117: Inspecting Back Of Left Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

2. 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

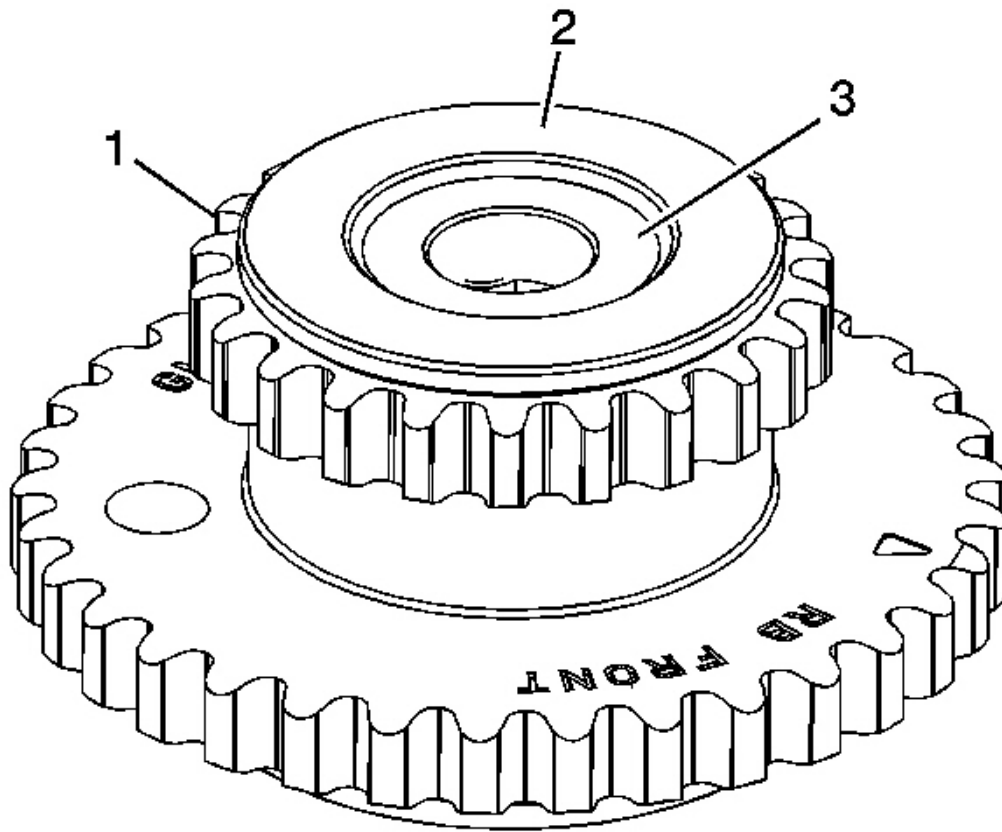


Fig. 118: Inspecting Front Of Right Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

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)

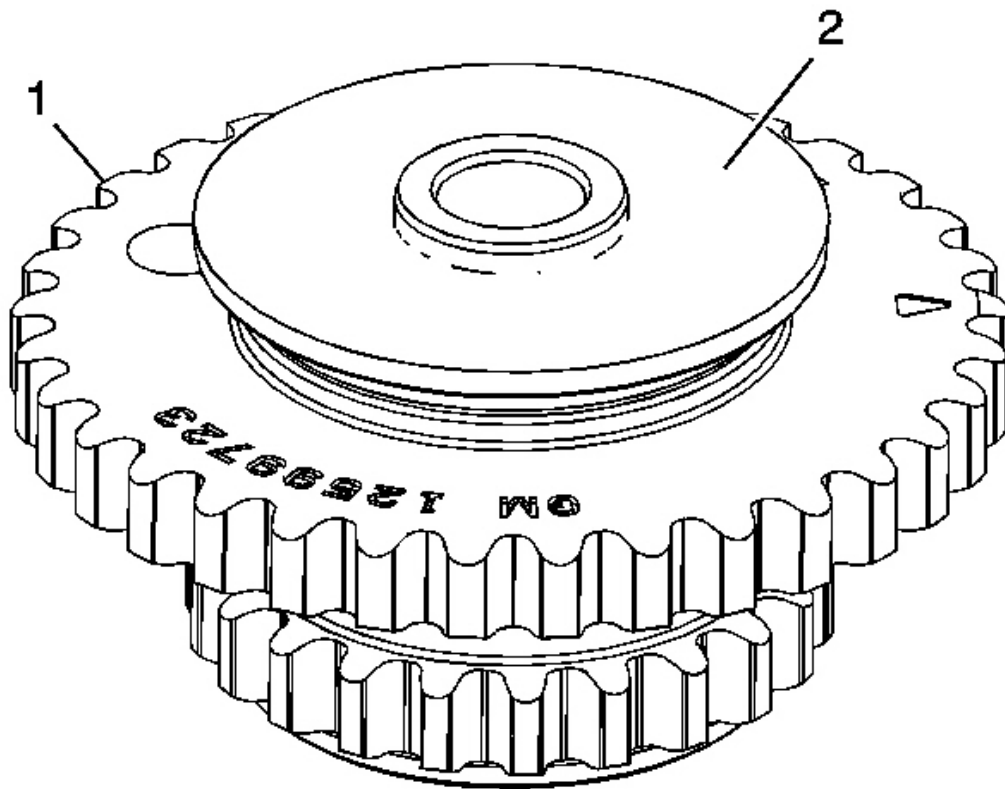


Fig. 119: Inspecting Back Of Right Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

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

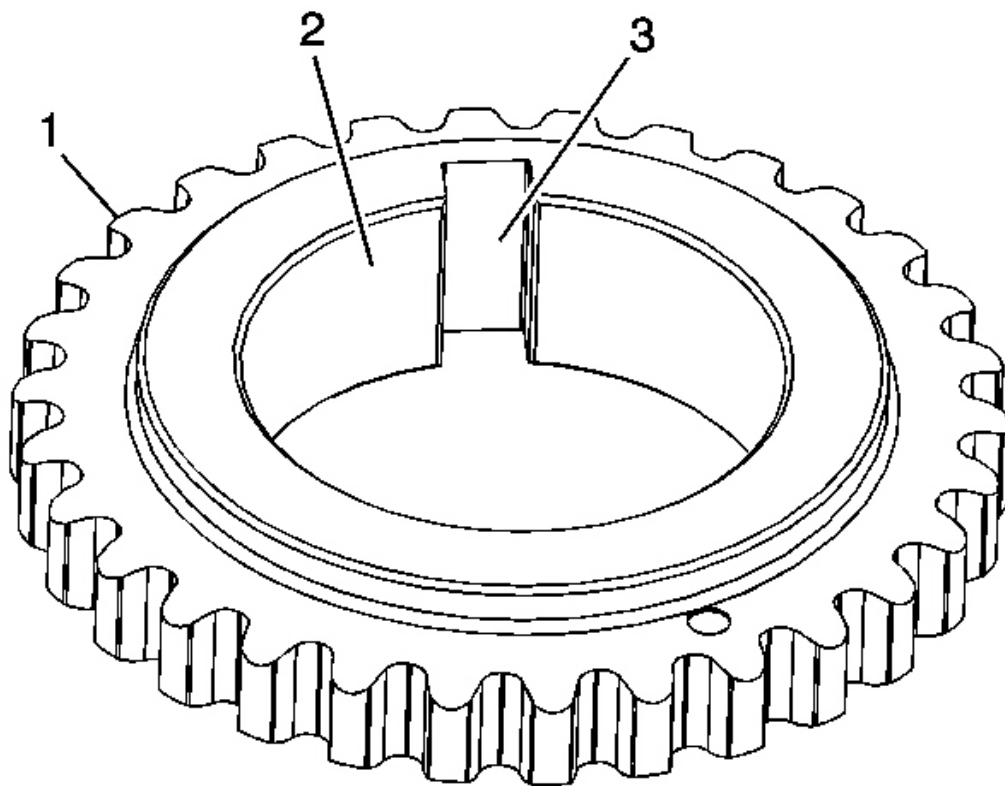


Fig. 120: Inspecting Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

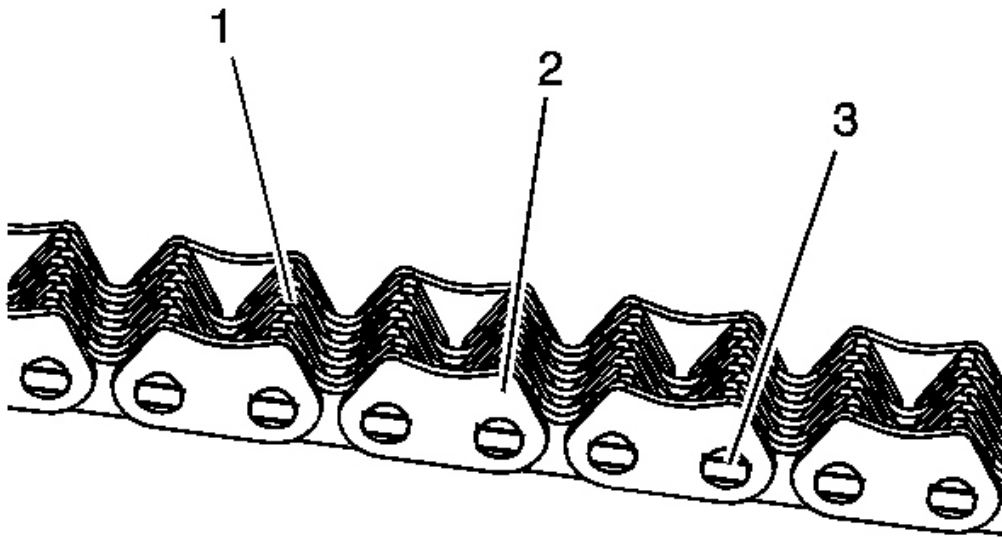


Fig. 121: Inspecting Secondary Timing Chain
Courtesy of GENERAL MOTORS CORP.

1. 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

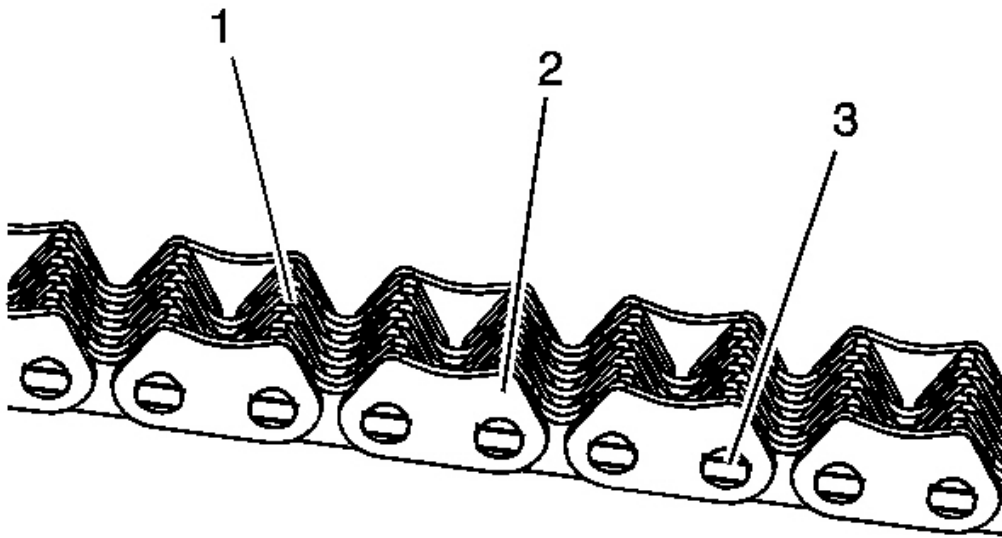


Fig. 122: Inspecting Primary Timing Chain
Courtesy of GENERAL MOTORS CORP.

1. 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

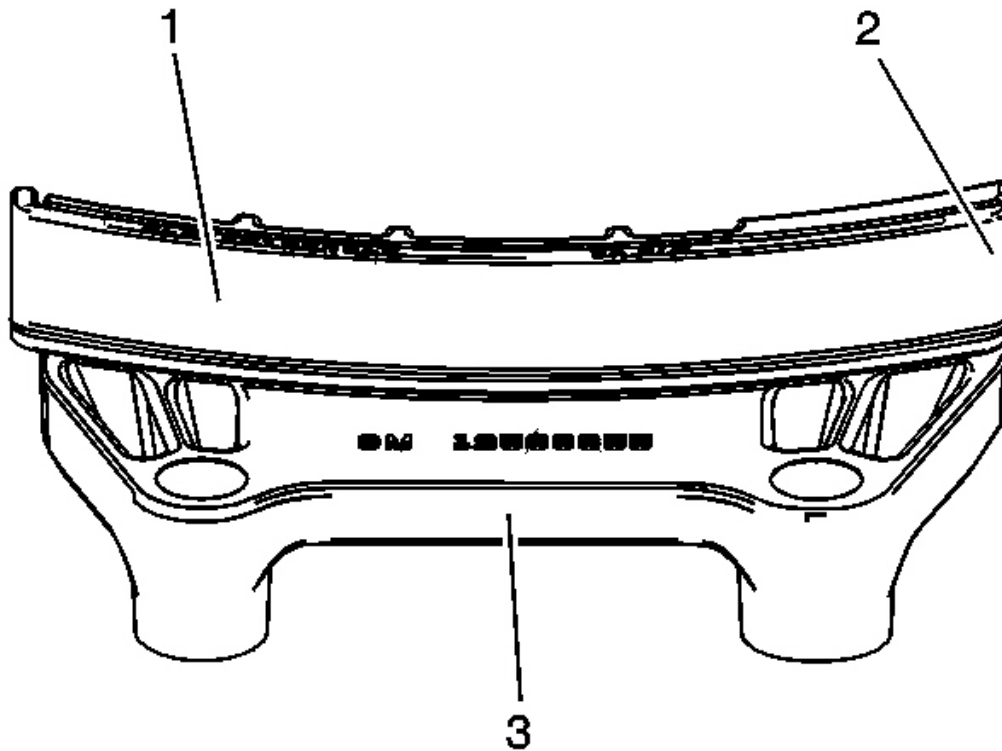


Fig. 123: Checking Primary Timing Chain Upper Guide
Courtesy of GENERAL MOTORS CORP.

1. 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

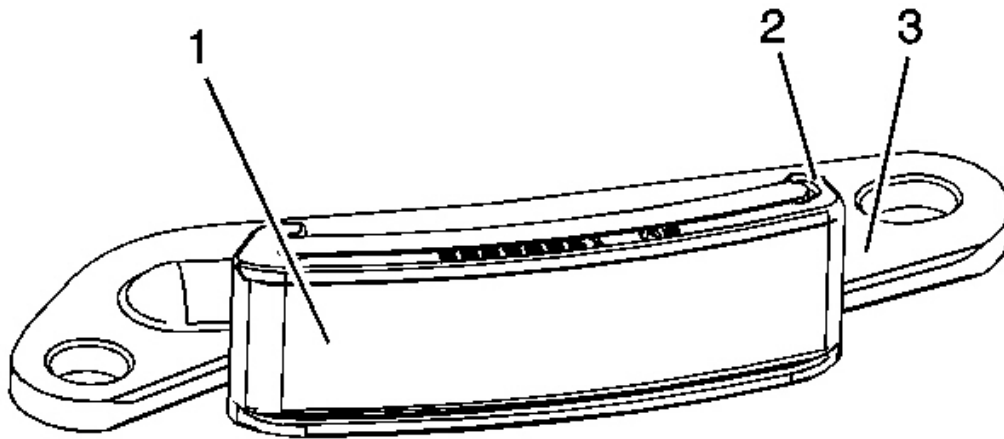


Fig. 124: Inspecting Primary Timing Chain Lower Guide
Courtesy of GENERAL MOTORS CORP.

1. 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

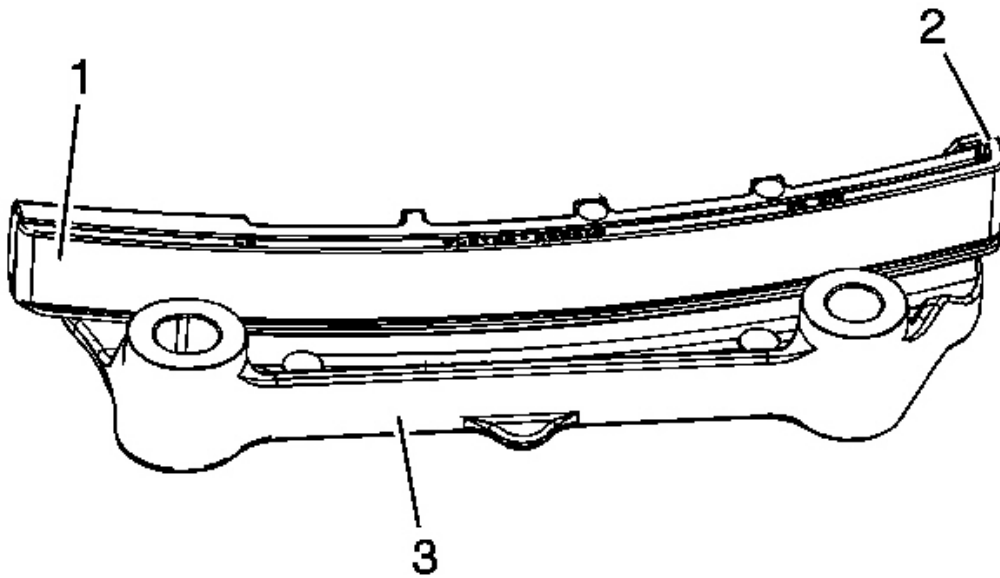


Fig. 125: Inspecting Left Secondary Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. 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

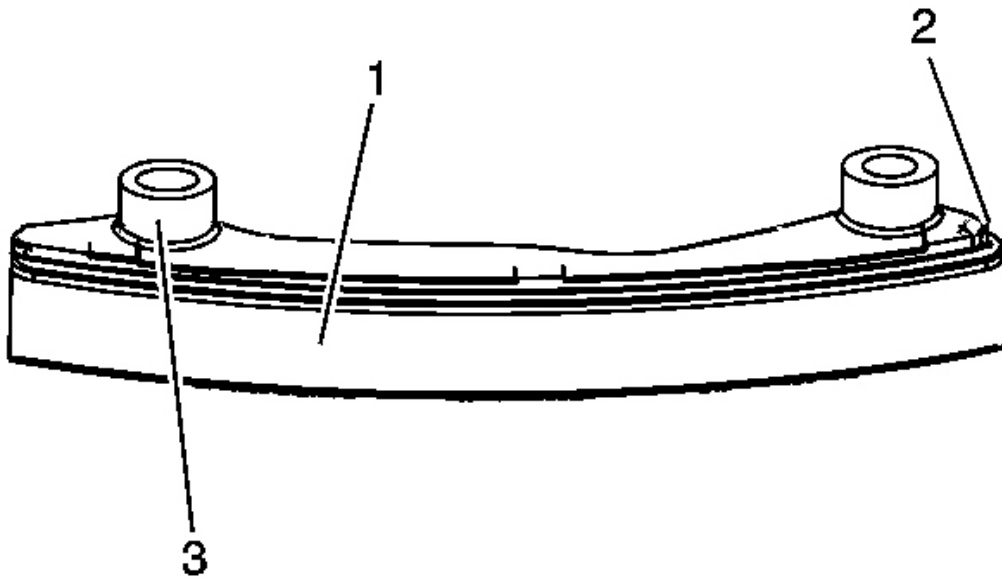


Fig. 126: Inspecting Right Secondary Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. 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

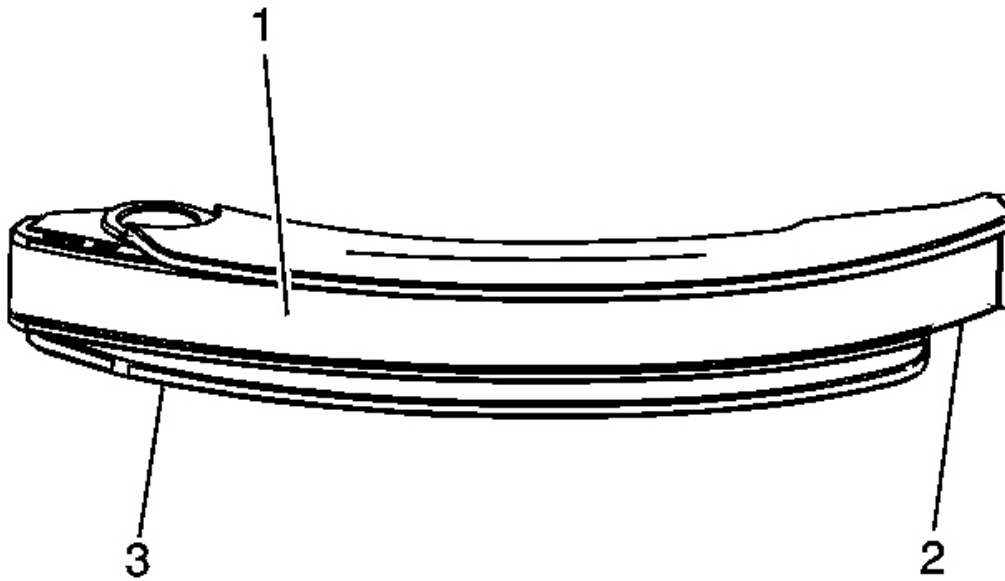


Fig. 127: Inspecting Front Of Left Secondary Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

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)

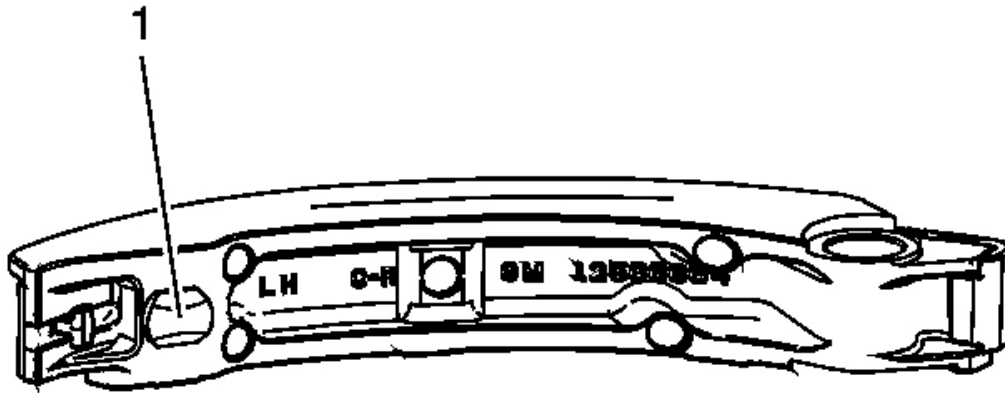


Fig. 128: Inspecting Left Secondary Timing Chain Tensioner Contact Pad
Courtesy of GENERAL MOTORS CORP.

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

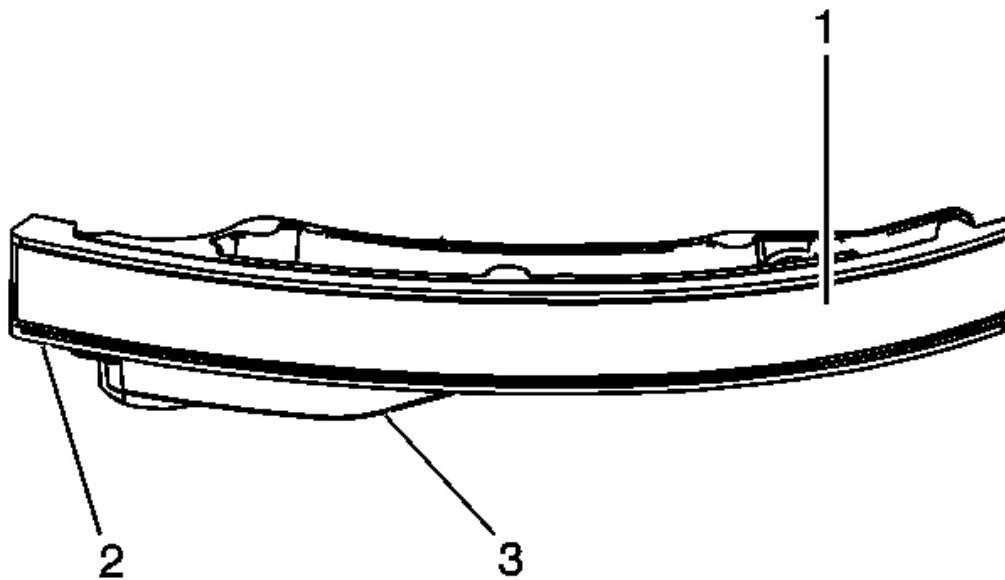


Fig. 129: Inspecting Front Of Right Secondary Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

1. 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)

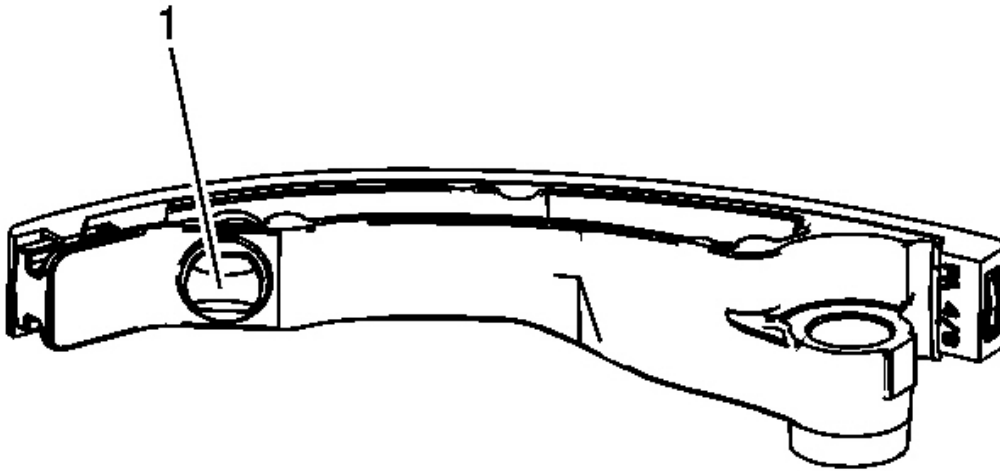


Fig. 130: Inspecting Right Secondary Timing Chain Tensioner Contact Pad
Courtesy of GENERAL MOTORS CORP.

2. 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

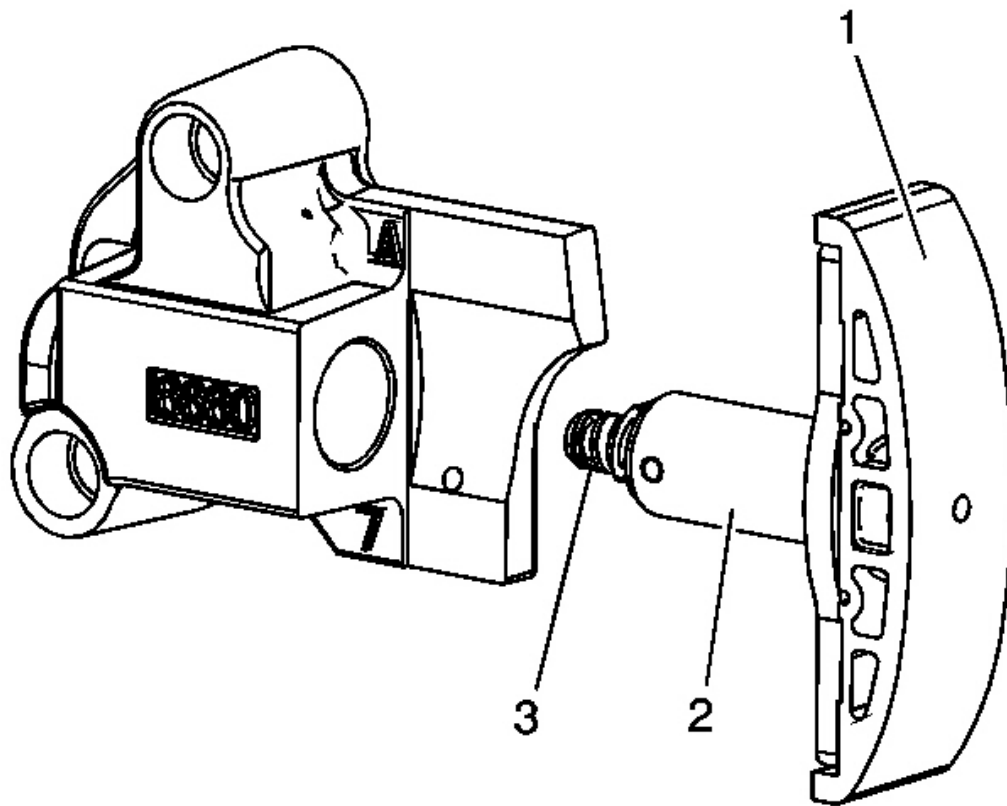


Fig. 131: Checking Primary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. 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 **Primary Camshaft Intermediate Drive Chain Tensioner Installation**.
3. Replace a damaged primary timing chain tensioner.

Left Secondary Timing Chain Tensioner

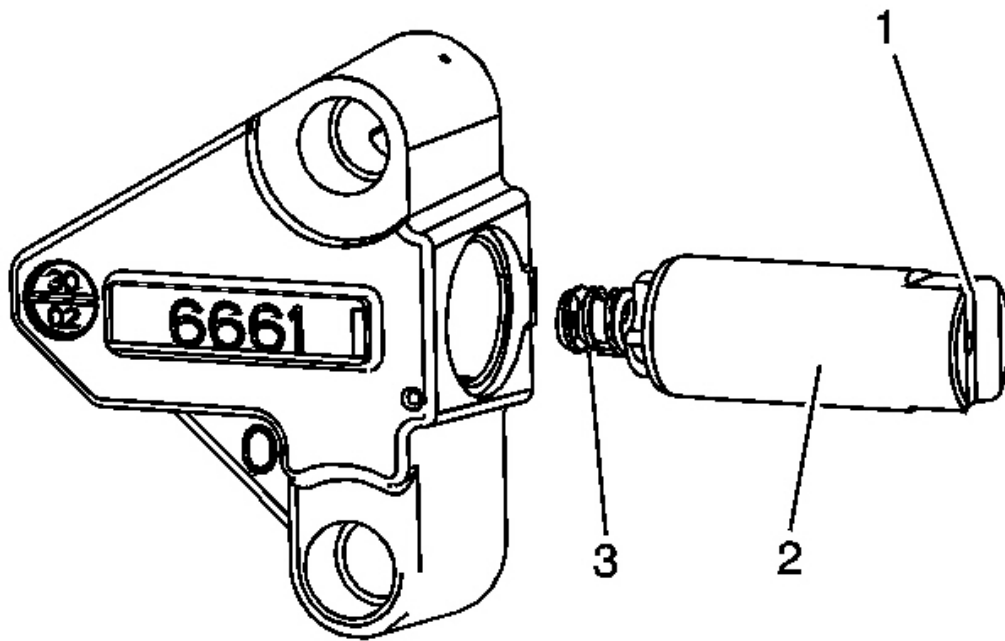


Fig. 132: Checking Left Secondary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. 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 **Secondary Timing Chain Tensioner Installation - Left Side** .
3. Replace a damaged left secondary timing chain tensioner.

Right Secondary Timing Chain Tensioner

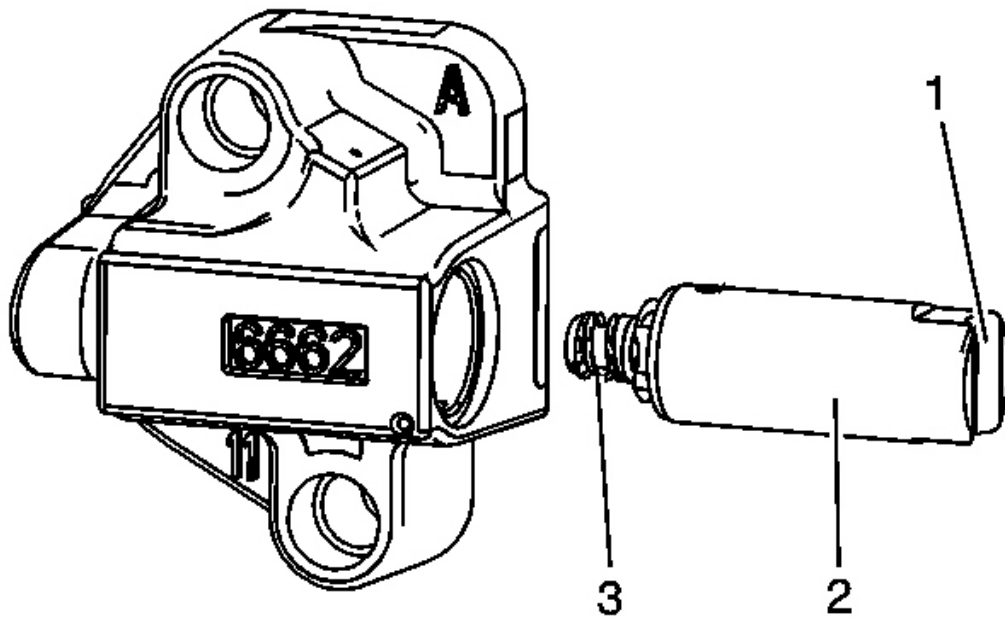


Fig. 133: Inspecting Right Secondary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. 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 **Secondary Timing Chain Tensioner Installation - Right Side** .
3. Replace a damaged right secondary timing chain tensioner.

OIL PUMP DISASSEMBLE

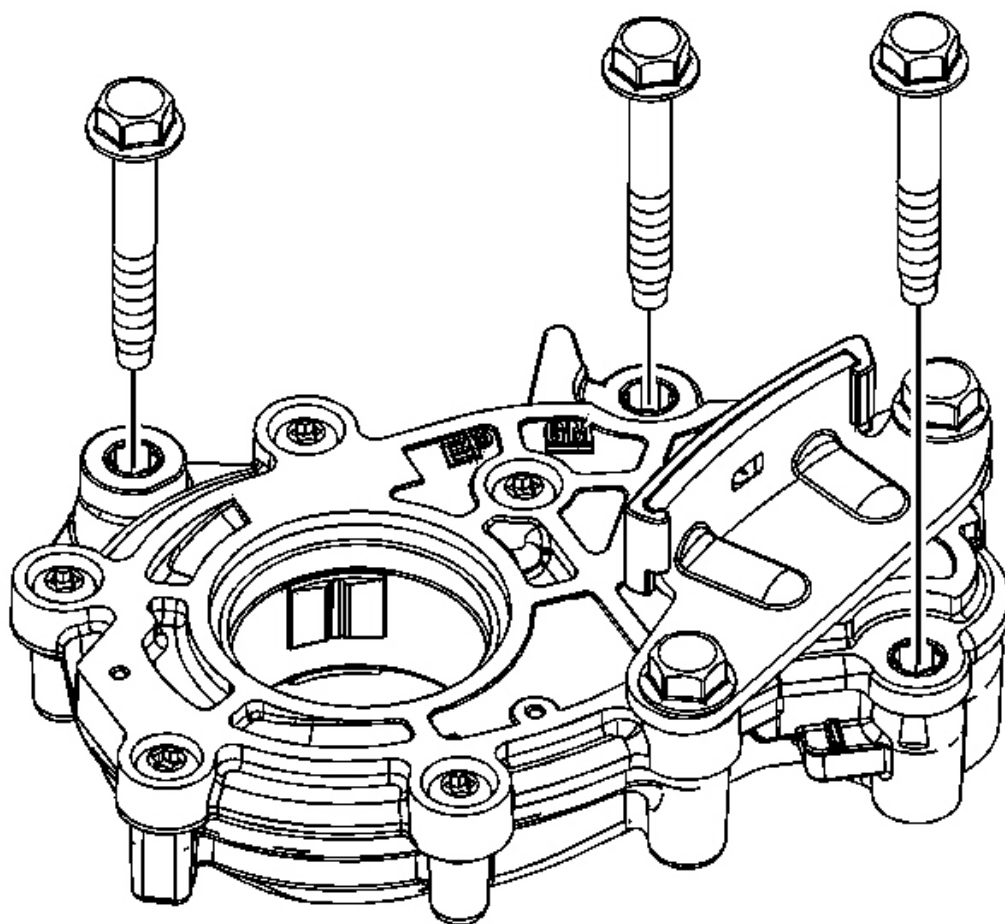


Fig. 134: Identifying Oil Pump Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

1. Remove the oil pump mounting bolts.

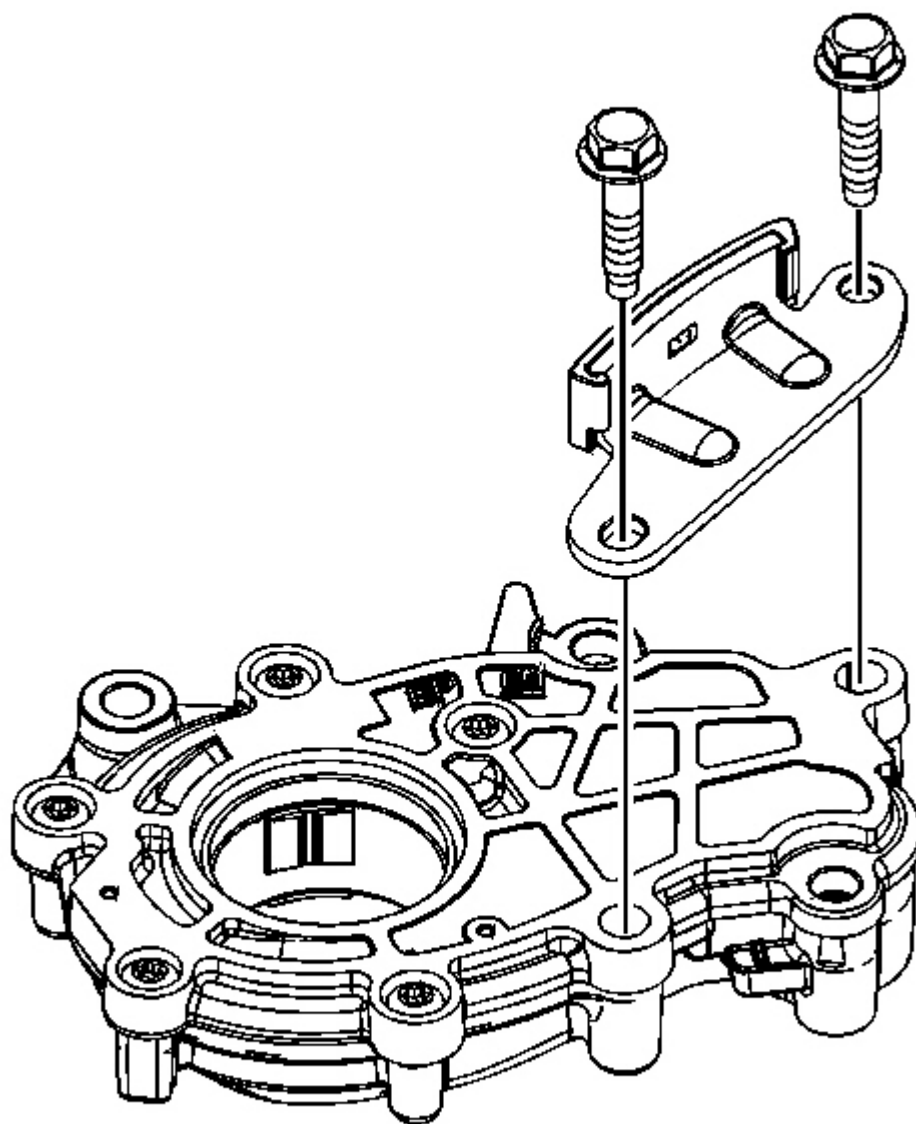


Fig. 135: Primary Camshaft Drive Chain Lower Guide
Courtesy of GENERAL MOTORS CORP.

2. Remove the primary camshaft drive chain lower guide bolts.
3. Remove the primary camshaft drive chain lower guide.

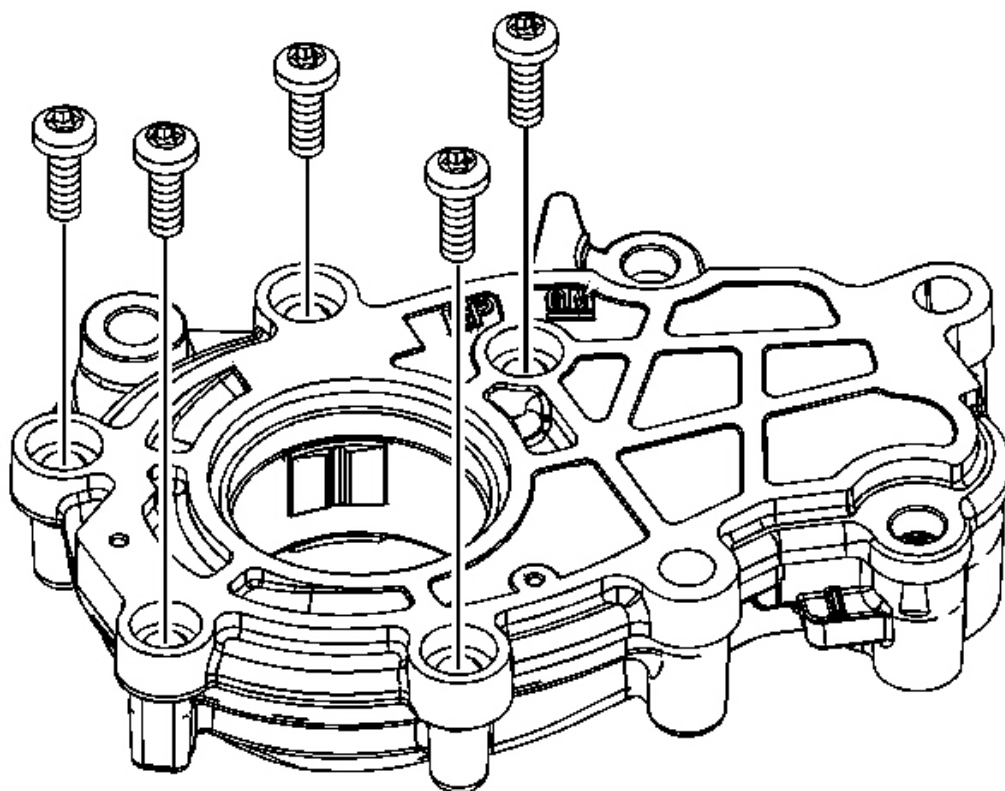


Fig. 136: Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

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

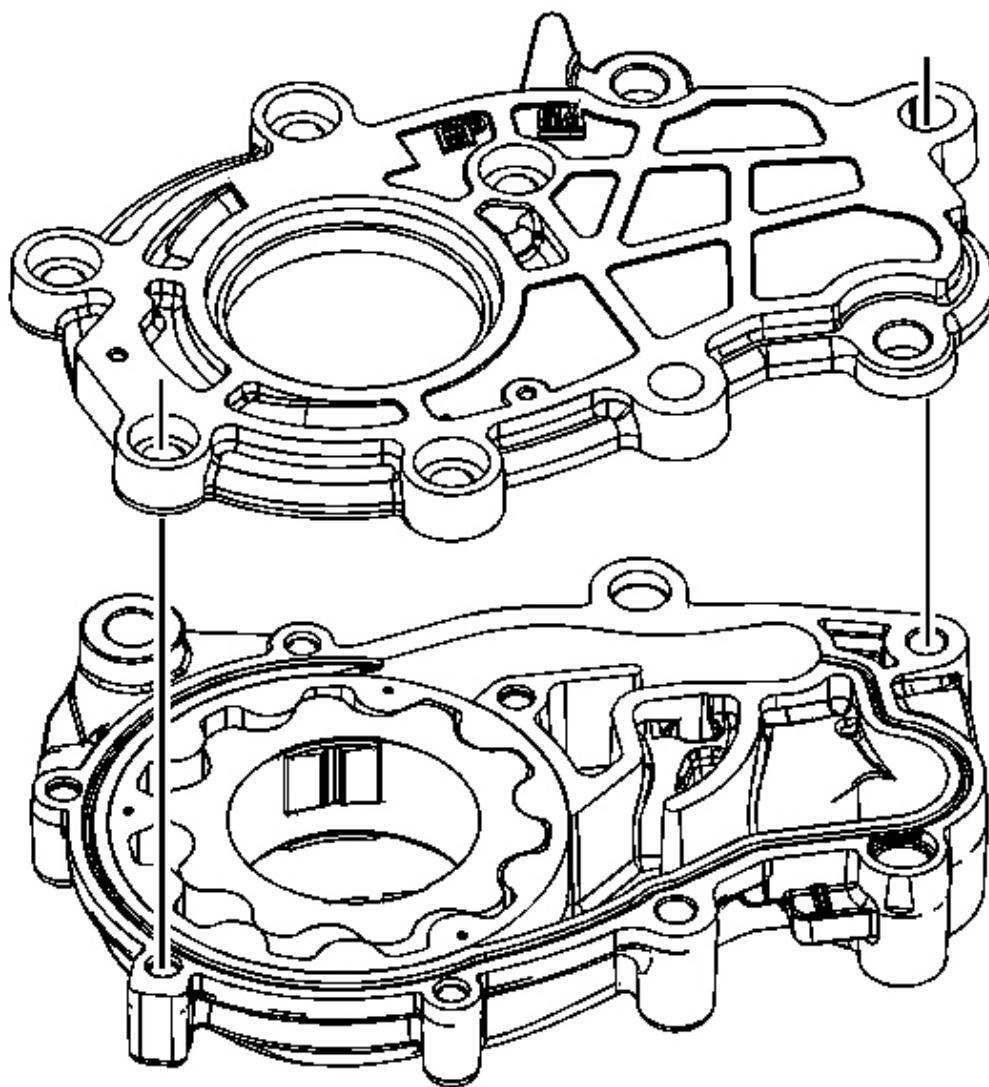


Fig. 137: Oil Pump Cover & Oil Pump Housing
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump cover from the oil pump housing.

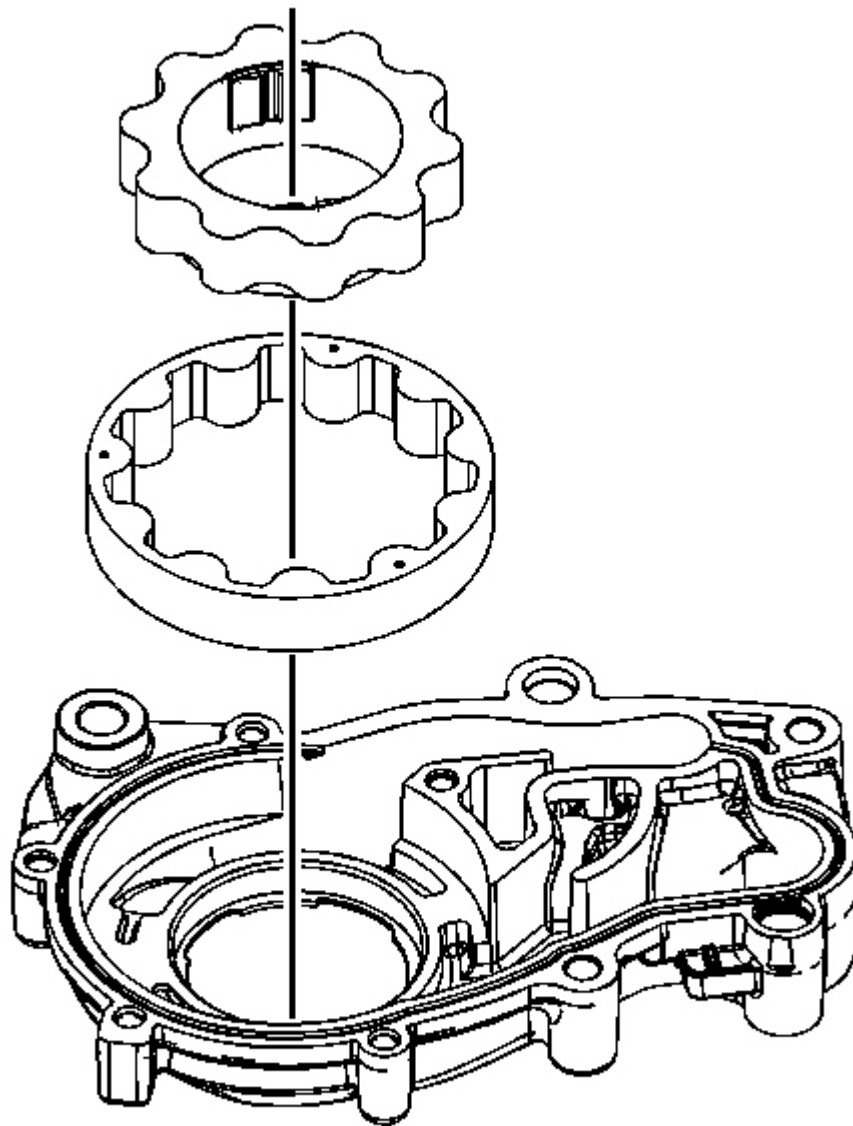


Fig. 138: Identifying Oil Pump Gears
Courtesy of GENERAL MOTORS CORP.

6. Remove the inner oil pump drive gear.
7. Remove the outer oil pump driven gear.

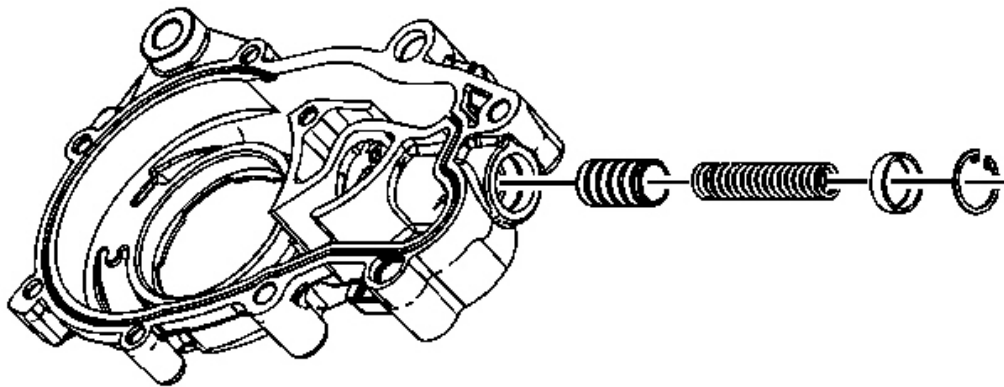


Fig. 139: View Of Oil Pressure Relief Valve Components
Courtesy of GENERAL MOTORS CORP.

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

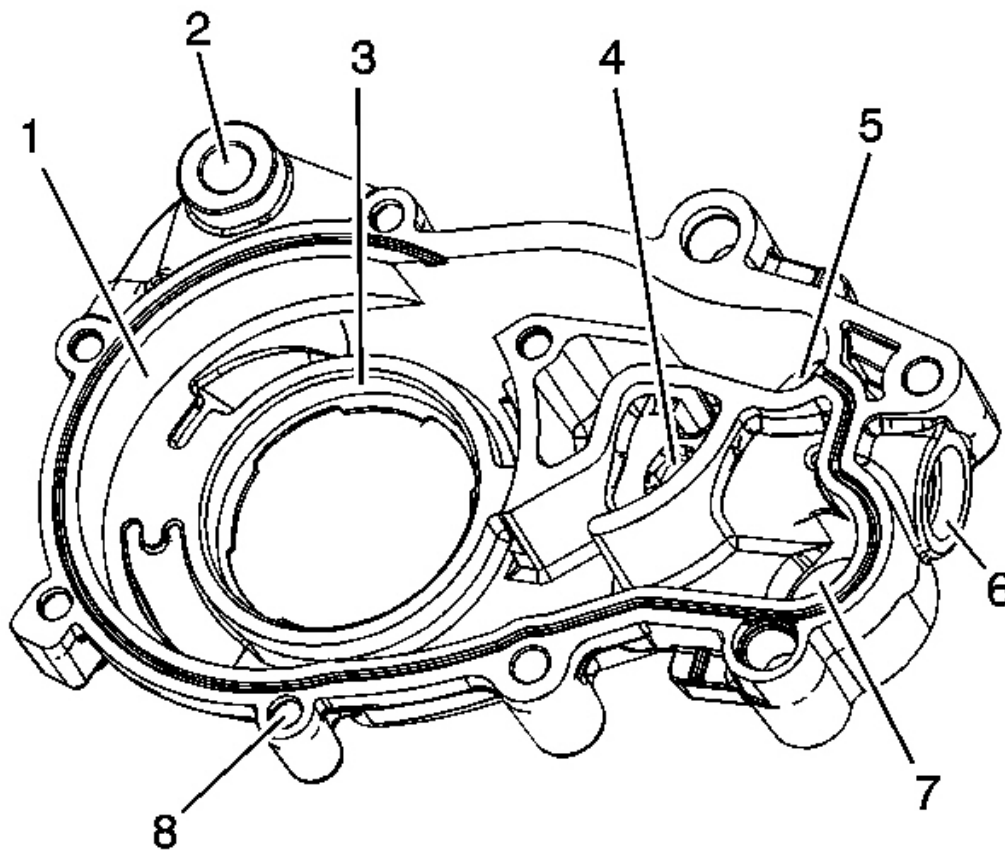


Fig. 140: Oil Pump Housing Check Points
Courtesy of GENERAL MOTORS CORP.

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.

1. 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)

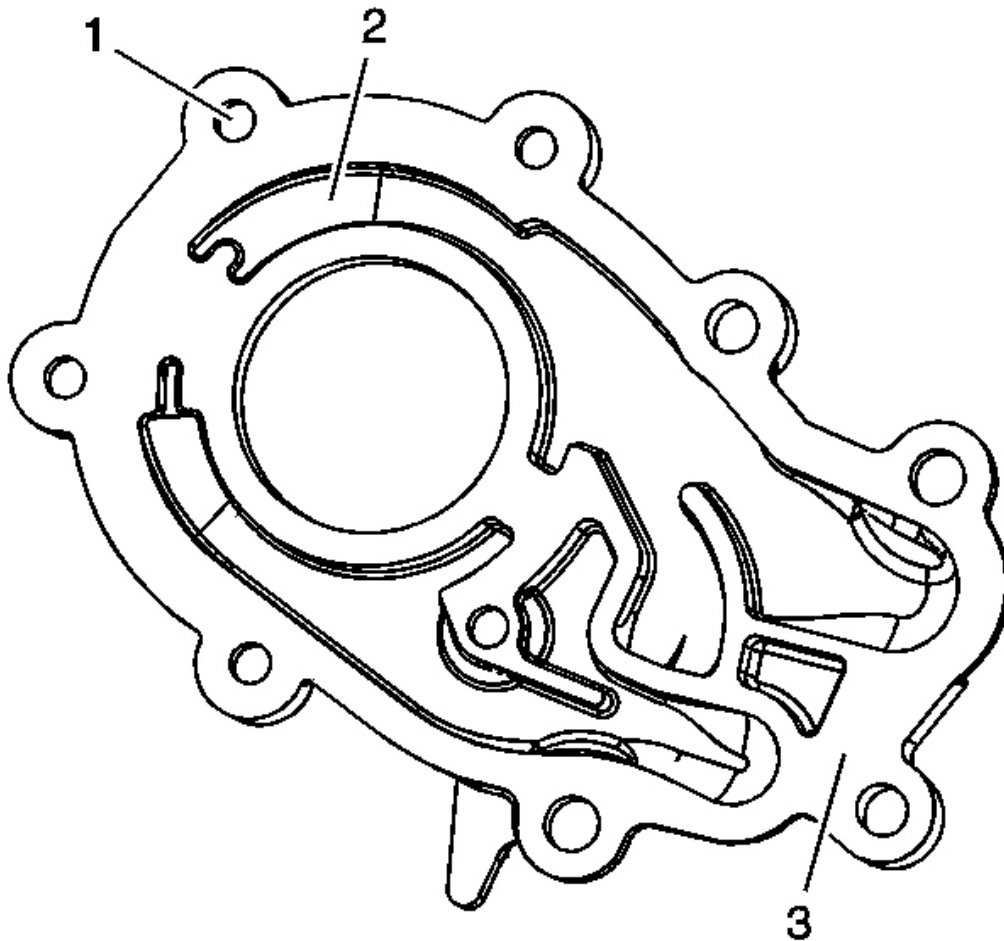


Fig. 141: Inspecting Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

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)

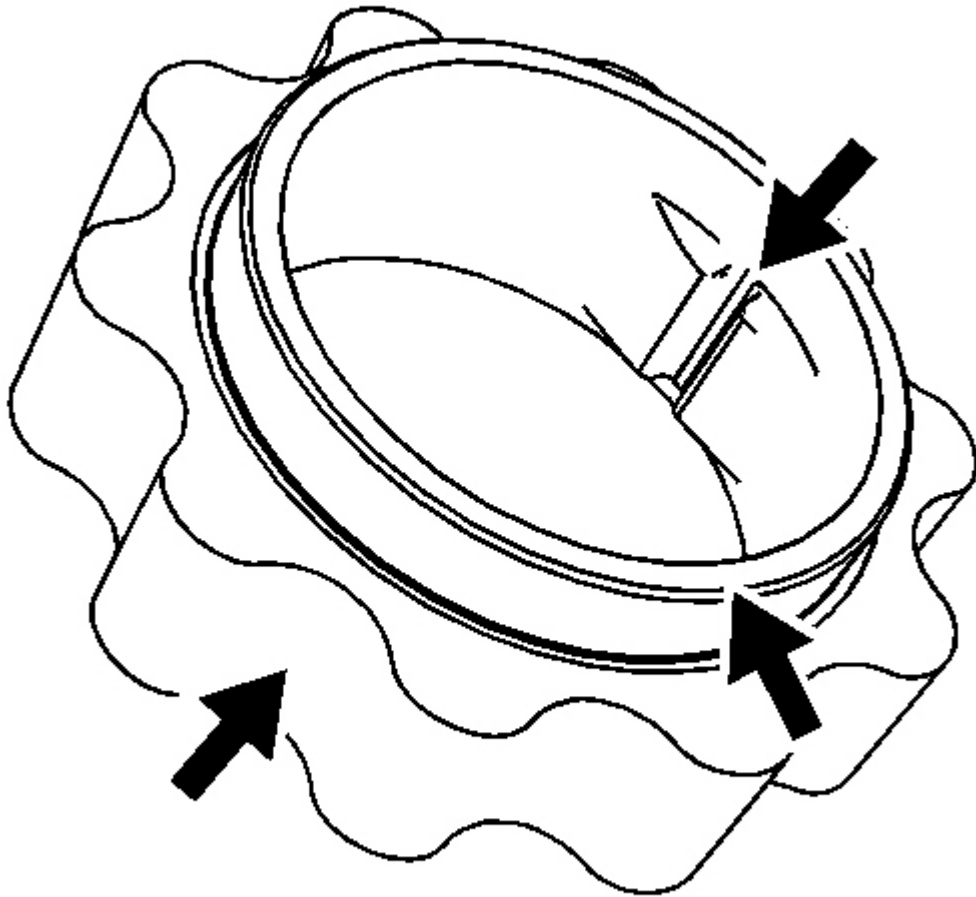


Fig. 142: Locating Inspection Areas On Inner Drive Gear
Courtesy of GENERAL MOTORS CORP.

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

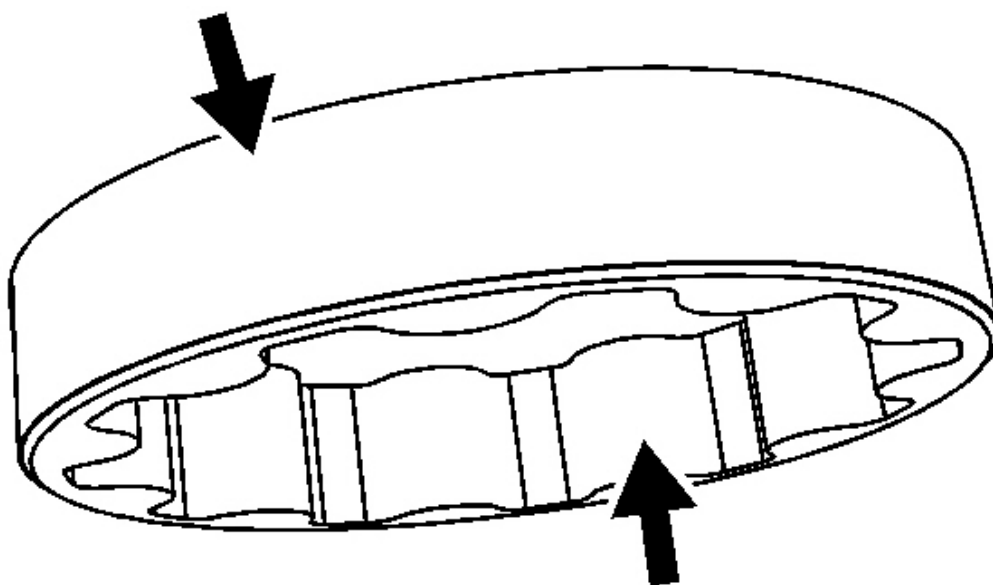


Fig. 143: Checking Outer Driven Gear
Courtesy of GENERAL MOTORS CORP.

4. Inspect the outer driven gear for damage.

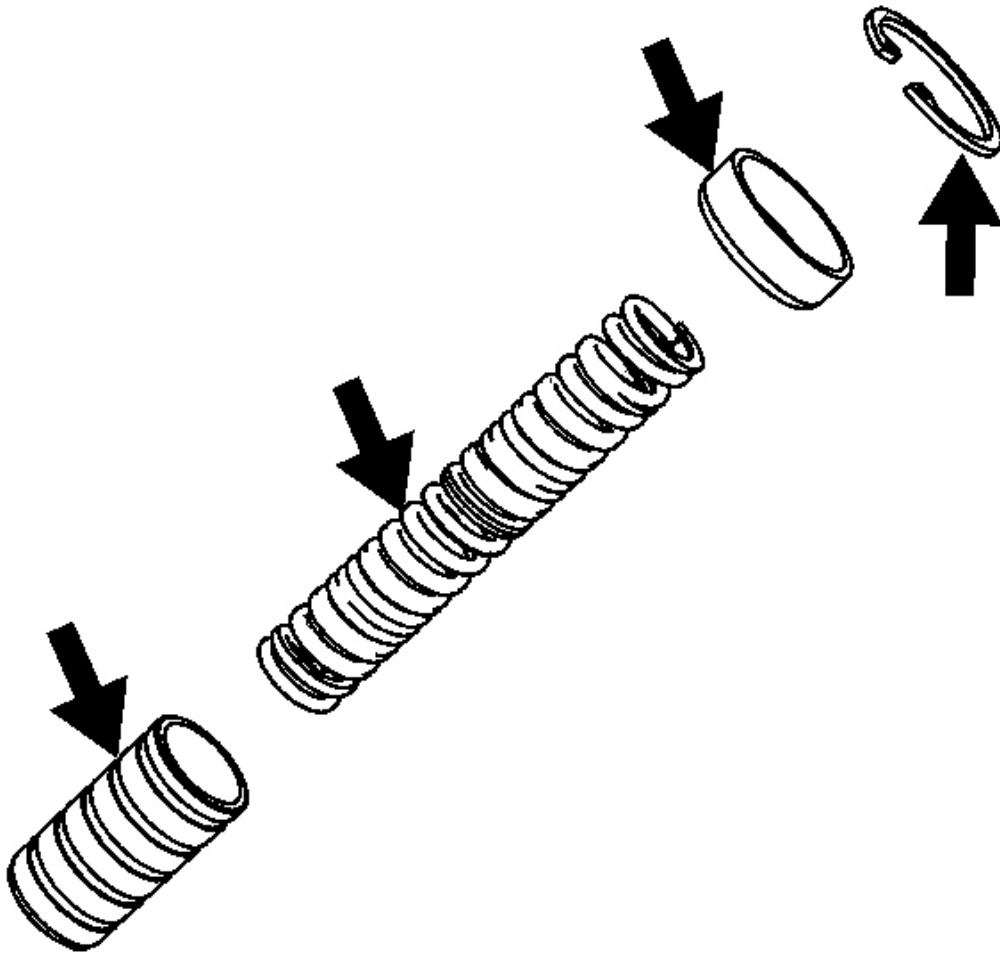


Fig. 144: Inspecting Oil Pump Relief Valve Components
Courtesy of GENERAL MOTORS CORP.

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

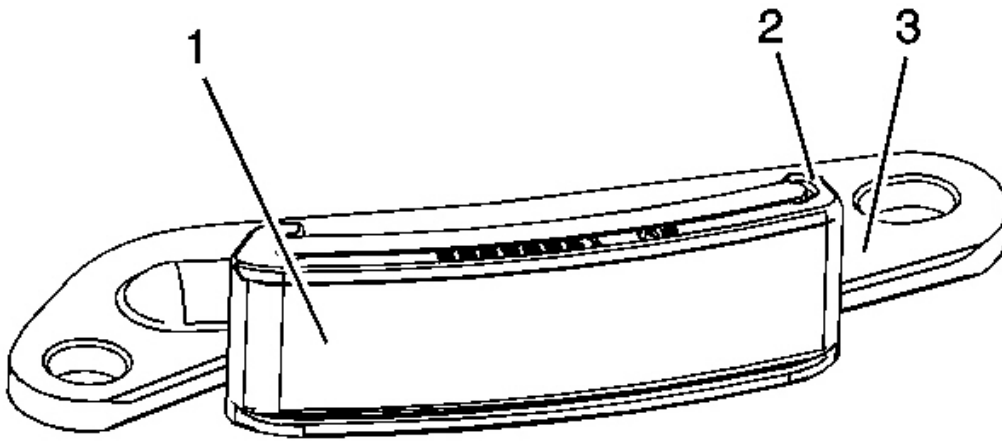


Fig. 145: Inspecting Primary Camshaft Drive Chain Lower Guide
Courtesy of GENERAL MOTORS CORP.

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

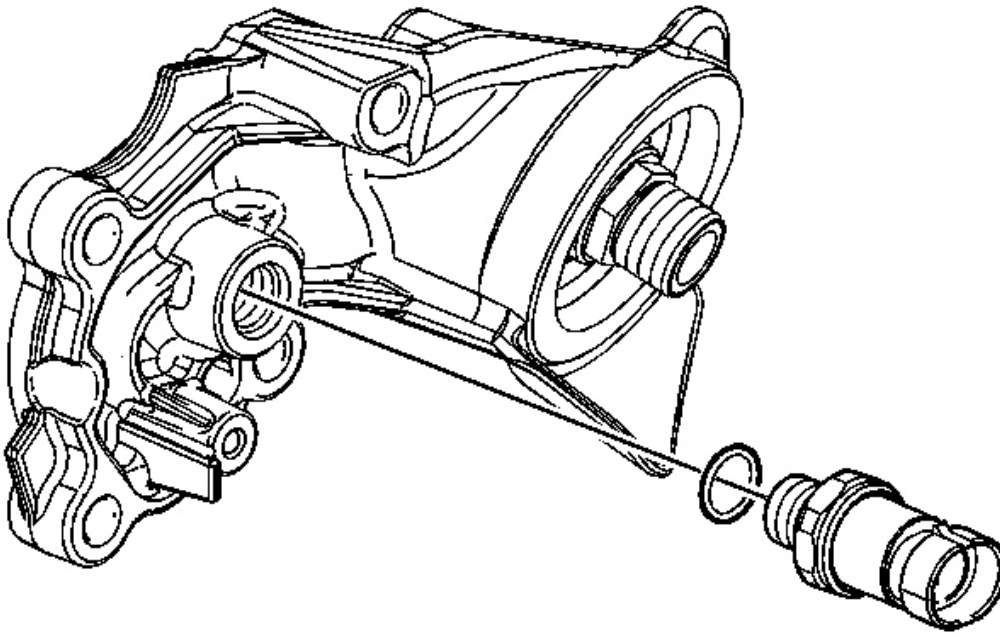


Fig. 146: Oil Pressure Sender
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pressure sender.

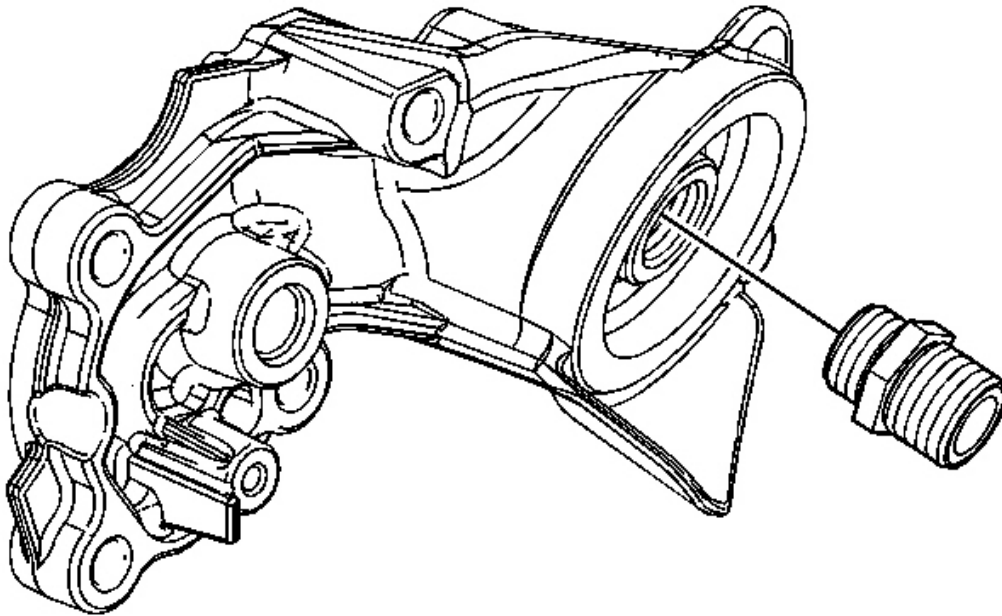


Fig. 147: Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter fitting.

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

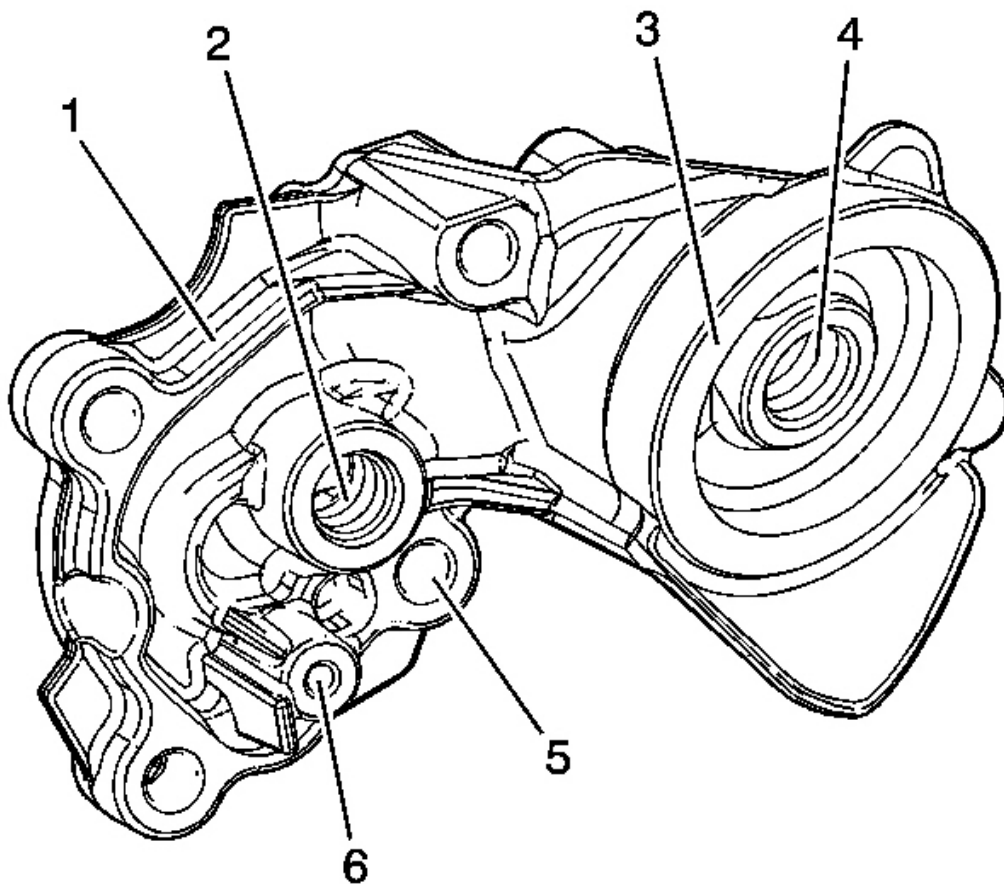


Fig. 148: Identifying Oil Filter Adapter Components
Courtesy of GENERAL MOTORS CORP.

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.

1. 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.

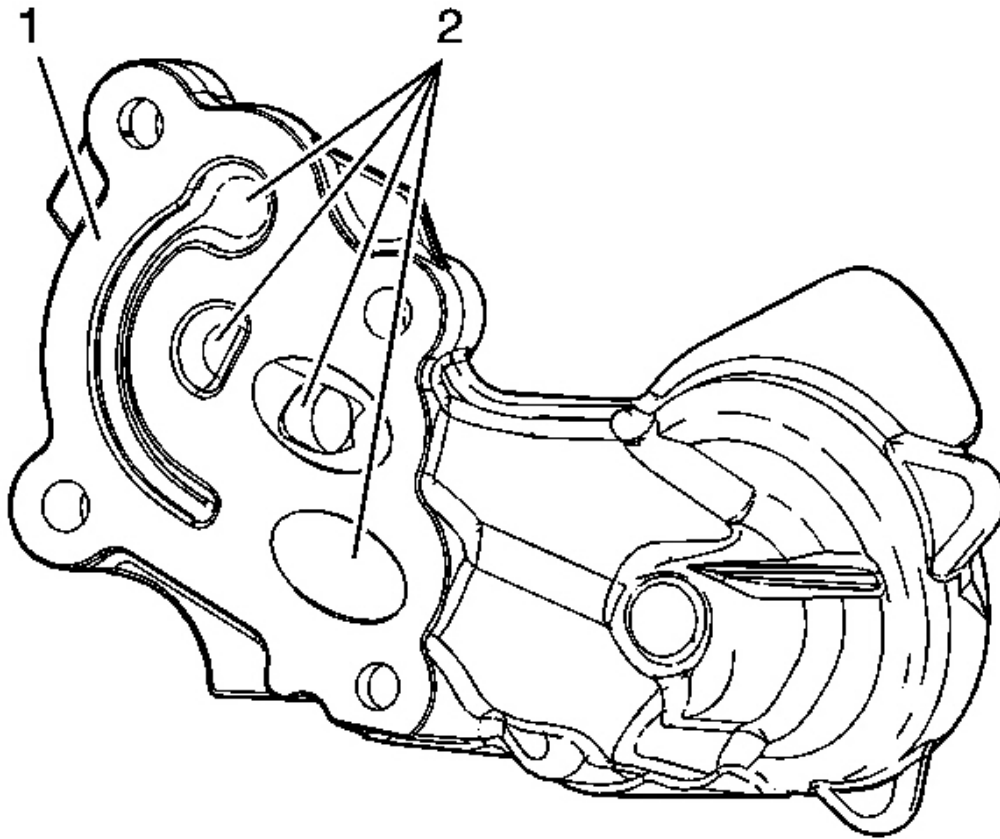


Fig. 149: Inspecting Oil Filter Adapter Housing
Courtesy of GENERAL MOTORS CORP.

6. 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

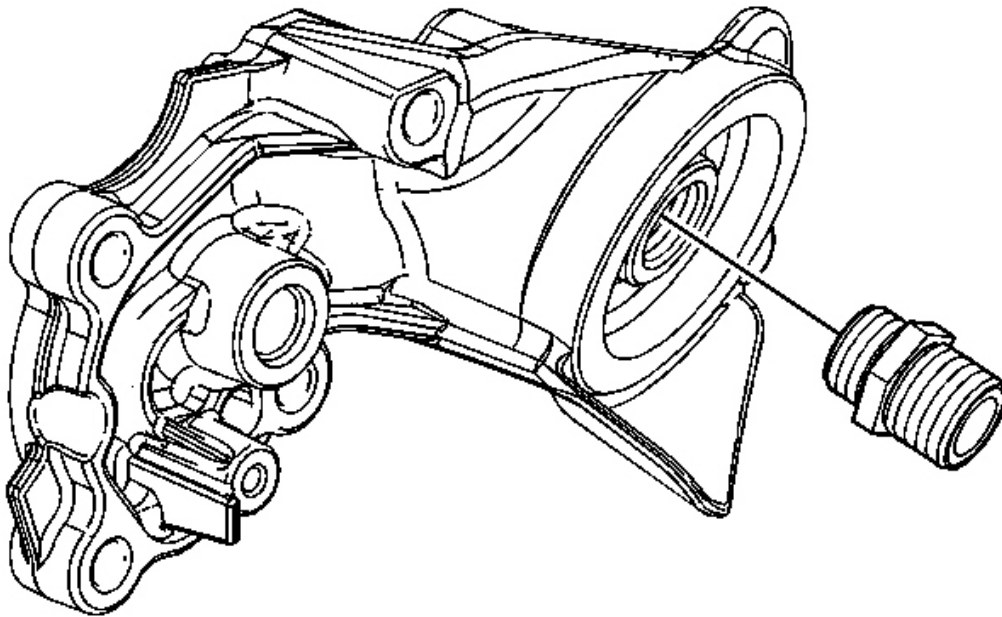


Fig. 150: Oil Filter Fitting

Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the oil filter fitting and tighten to 50 N.m (37 lb ft).

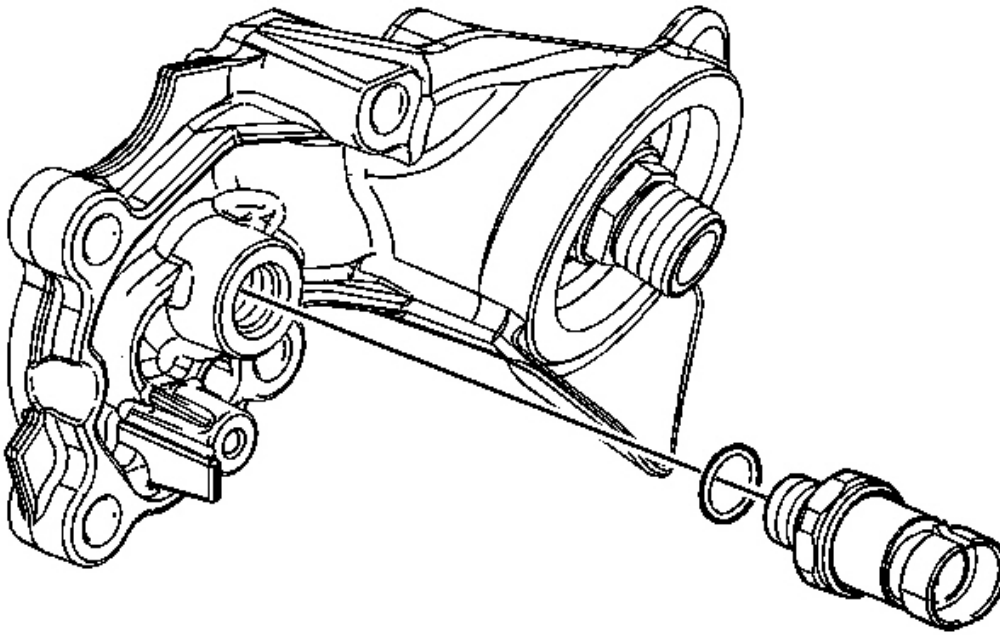


Fig. 151: Oil Pressure Sender
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pressure sender and tighten to 20 N.m (15 lb ft).

OIL PAN DISASSEMBLE

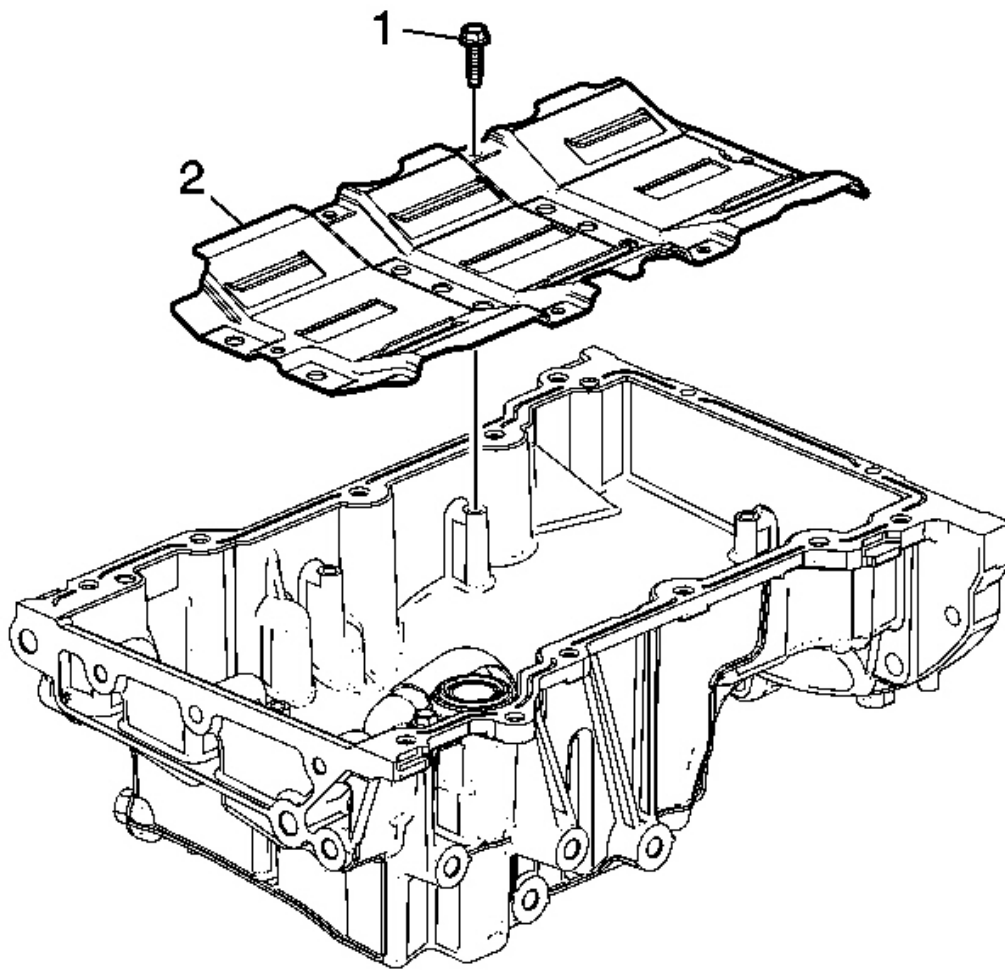


Fig. 152: Oil Pan Scraper & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan scraper bolts (1).
2. Remove the oil pan scraper (2).

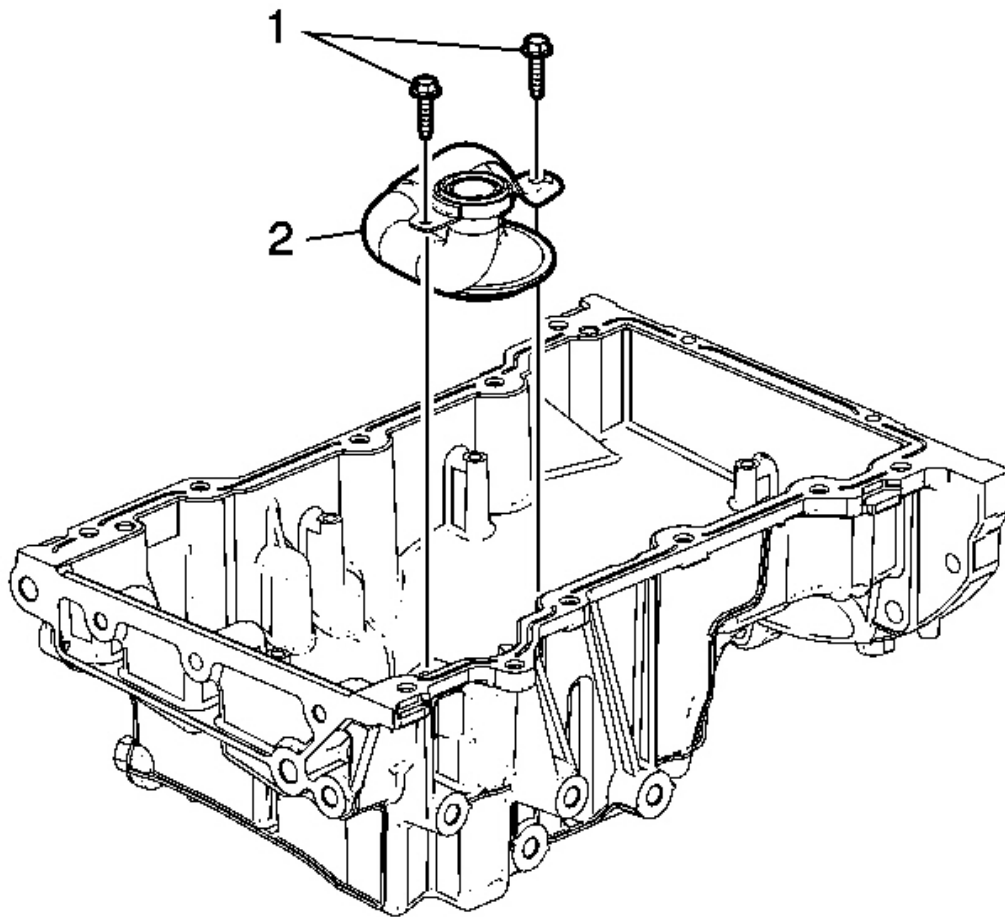


Fig. 153: Oil Suction Pipe & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil suction pipe bolts (1).
4. Remove the oil suction pipe (2).

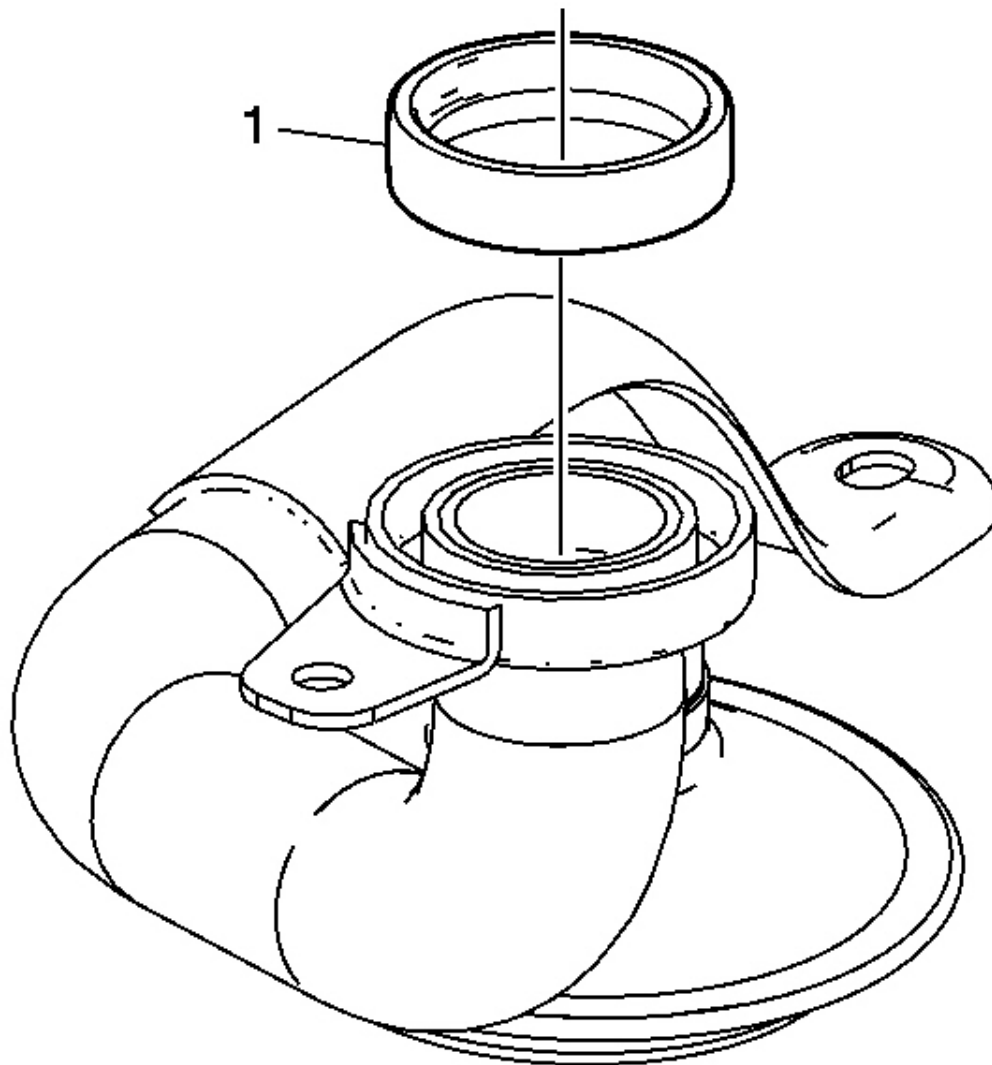


Fig. 154: Oil Suction Pipe O-Ring
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil suction pipe O-ring (1).

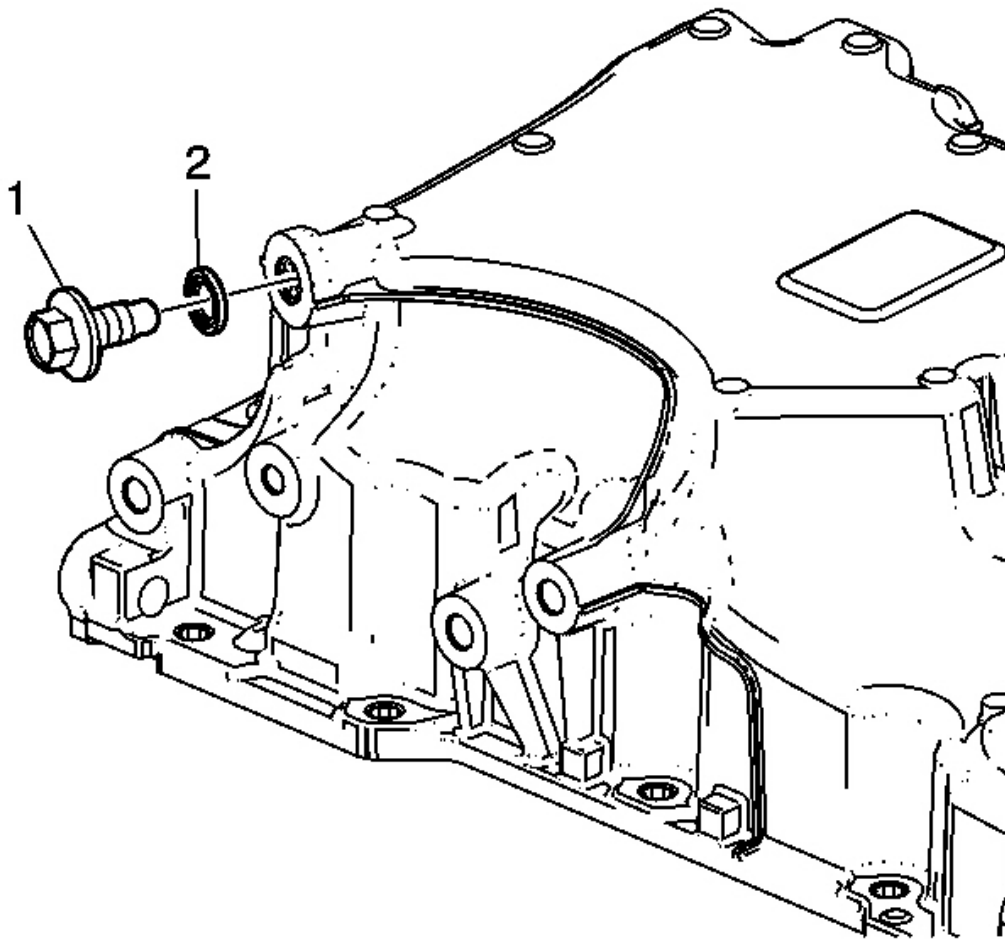


Fig. 155: Oil Pan Drain Plug & Seal
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pan drain plug (1) and seal (2).

OIL PAN CLEANING AND INSPECTION

SPECIAL TOOLS

EN 28410: Gasket Remover

For equivalent regional tools, refer to **Special Tools**

CLEANING PROCEDURE

1. Remove any old thread sealant, gasket material or sealant using **EN 28410:** remover.
2. Clean the oil pan and oil pan components in solvent.
3. Clean out debris from the bolt holes.

WARNING: Refer to Safety Glasses Warning .

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

INSPECTION PROCEDURE

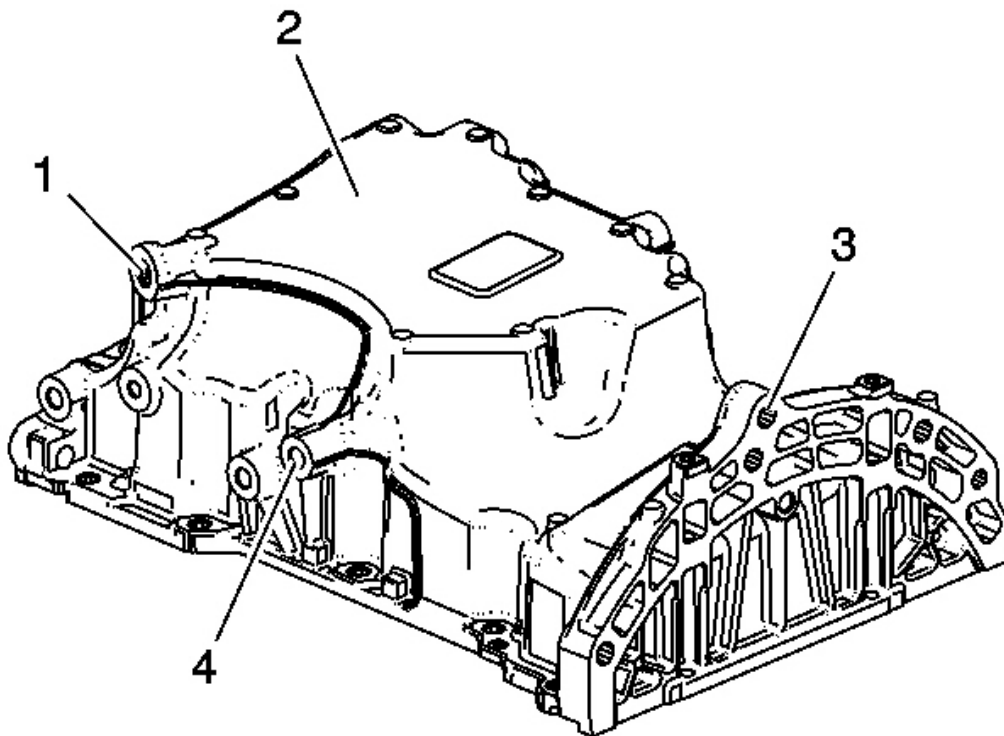


Fig. 156: Exterior Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exterior of the oil pan for the following conditions:
 - Dents or damage to the exterior (2)
 - Damage to the drain plug or drain plug hole (1)
 - Damage to the transaxle brace mounting bosses (4)

- Damage to the transaxle mounting bosses (3)

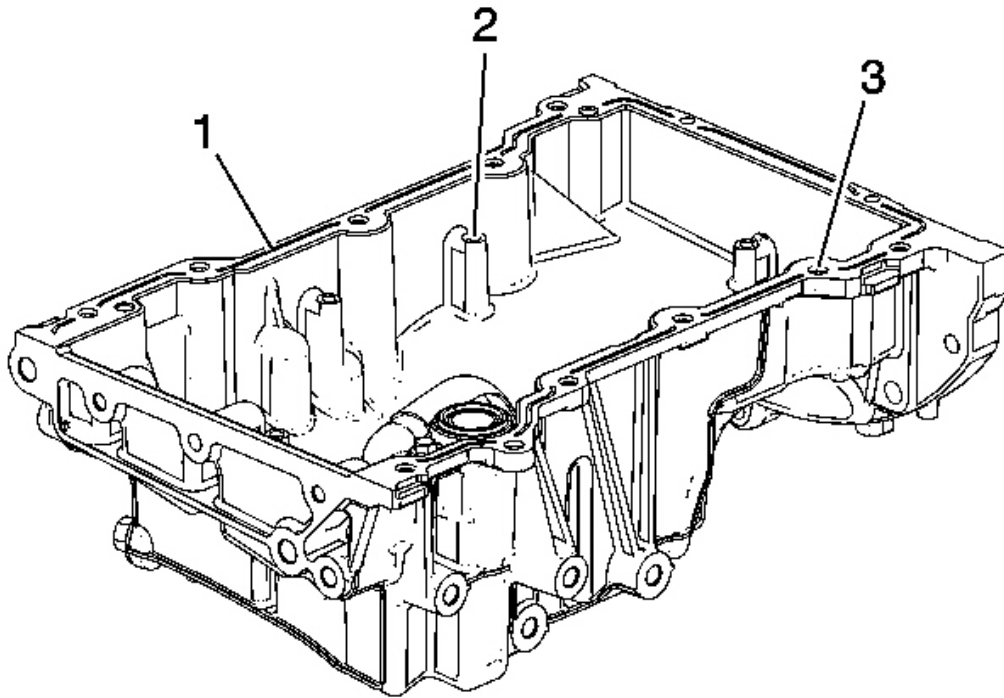


Fig. 157: Interior Of Oil Pan

Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the oil pan for the following conditions:
 - Gouges or damage to the oil pan sealing surfaces (1)
 - Damage to the oil pan scraper mounting holes (2)
 - Damage to the bolt holes (3)
3. 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

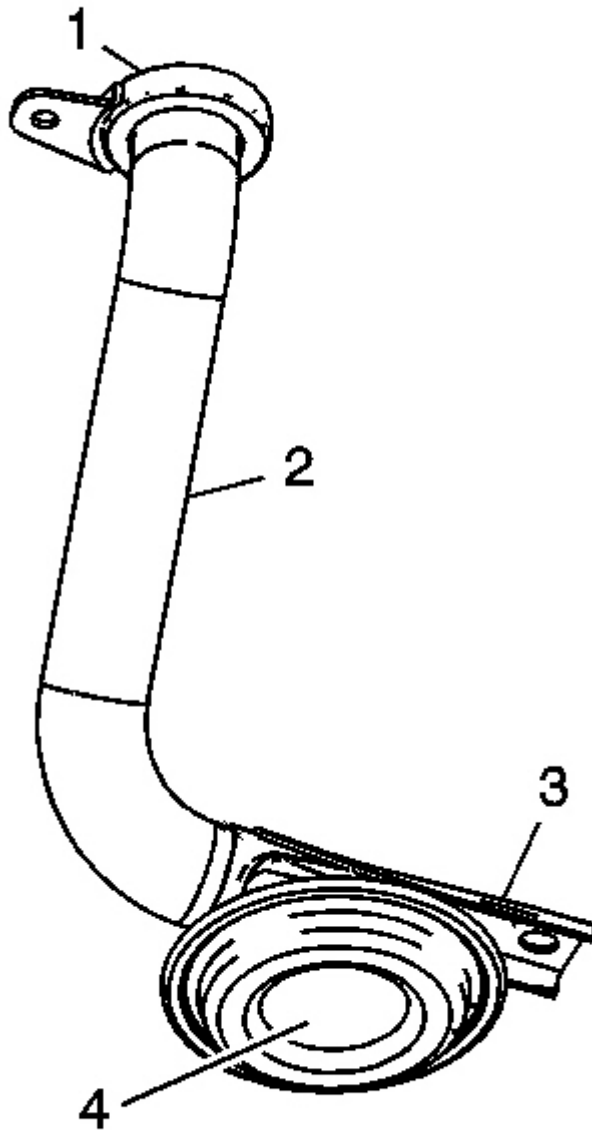


Fig. 158: Inspecting Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

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 pipe support bracket (3) for cracks or damage.
4. Inspect the oil pump screen (4) for blockage, foreign material, tears, cracks and/or damage.

OIL PAN ASSEMBLE

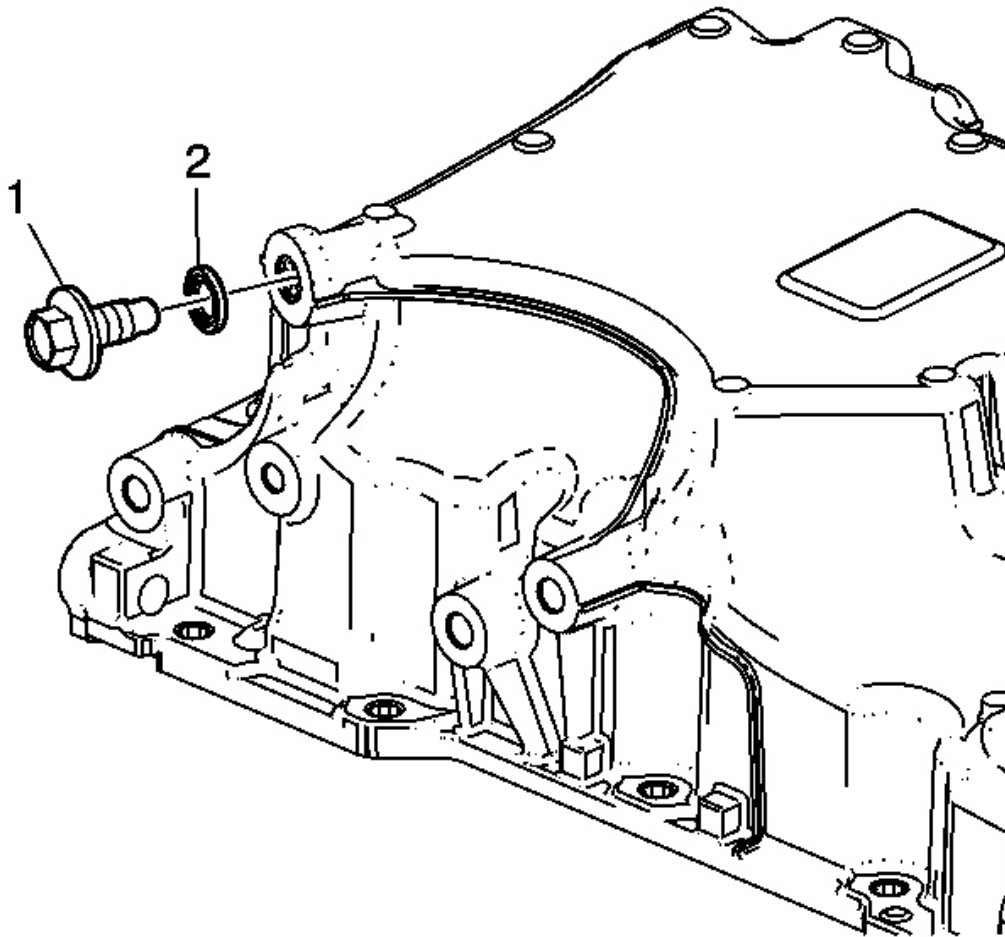


Fig. 159: Oil Pan Drain Plug & Seal
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the oil pan drain plug (1) and NEW O-ring seal (2) and tighten to 25 N.m (18 lb ft).

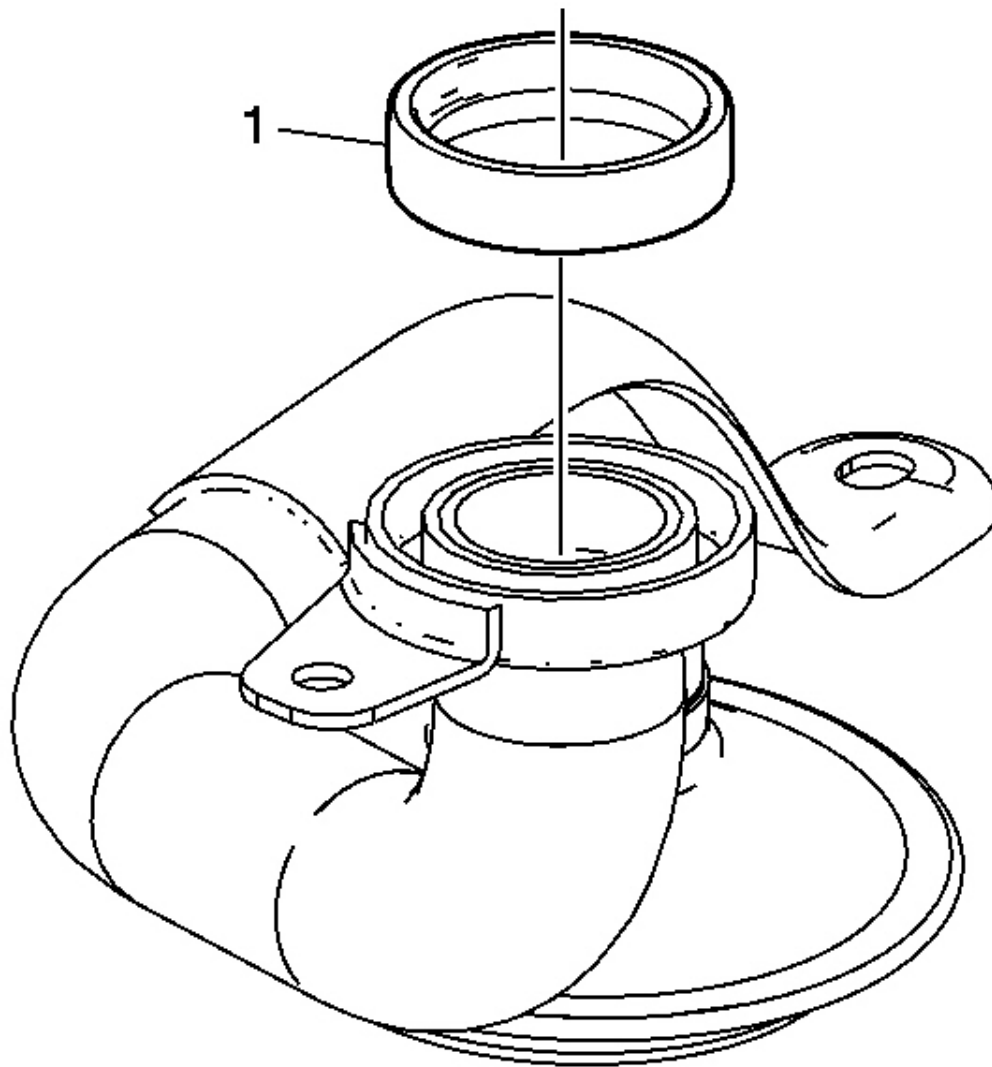


Fig. 160: Oil Suction Pipe O-Ring
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW oil suction pipe O-ring (1).

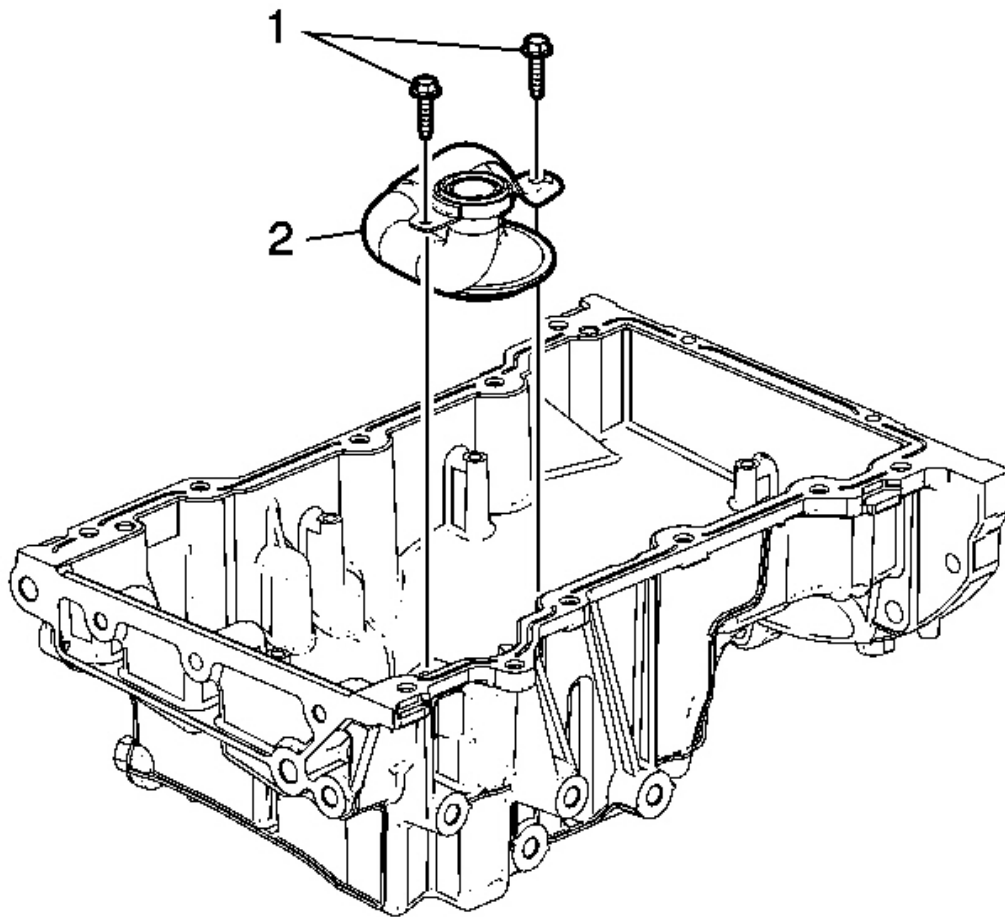


Fig. 161: Oil Suction Pipe & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the oil suction pipe (2).
4. Install the oil suction pipe bolts (1) and tighten to 10 N.m (89 lb in).

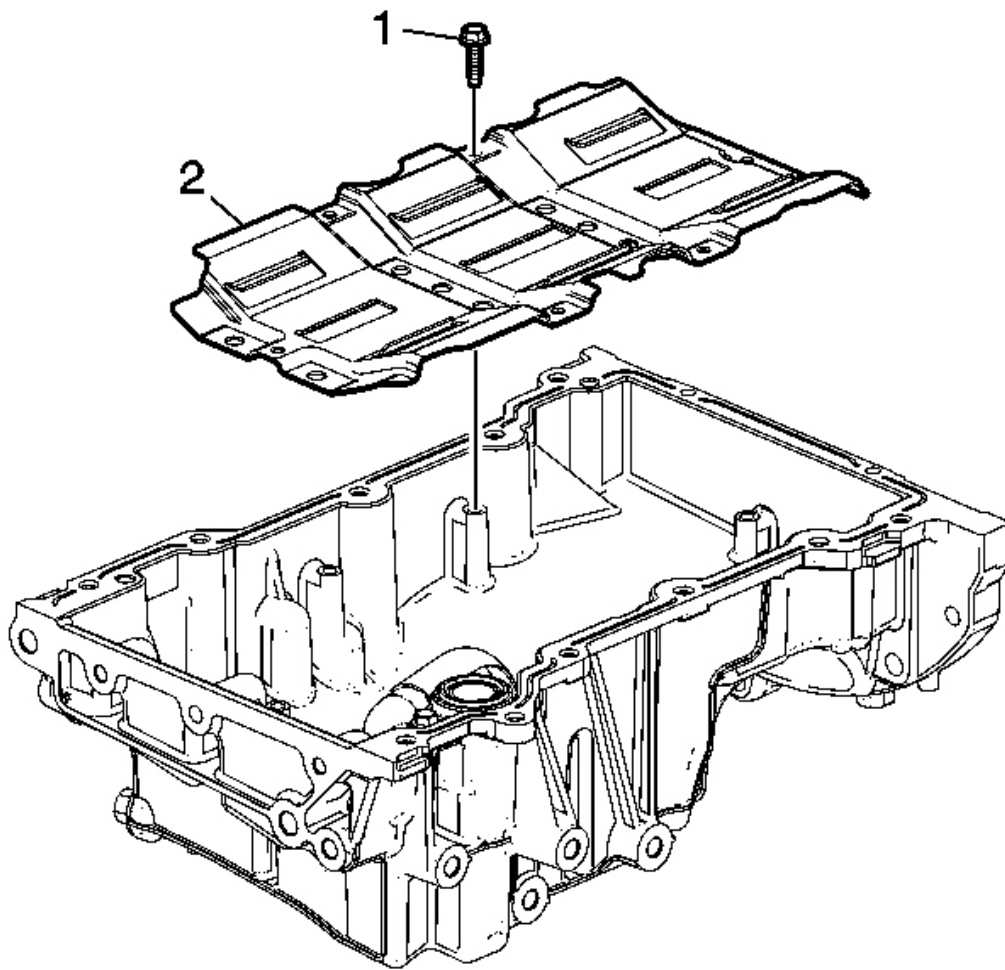


Fig. 162: Oil Pan Scraper & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the oil pan scraper (2).
6. Install the oil pan scraper bolts (1) and tighten to 10 N.m (89 lb in).

ENGINE FRONT COVER DISASSEMBLE

SPECIAL TOOLS

EN 45000: Seal Remover

For equivalent regional tools, refer to **Special Tools**

DISASSEMBLE

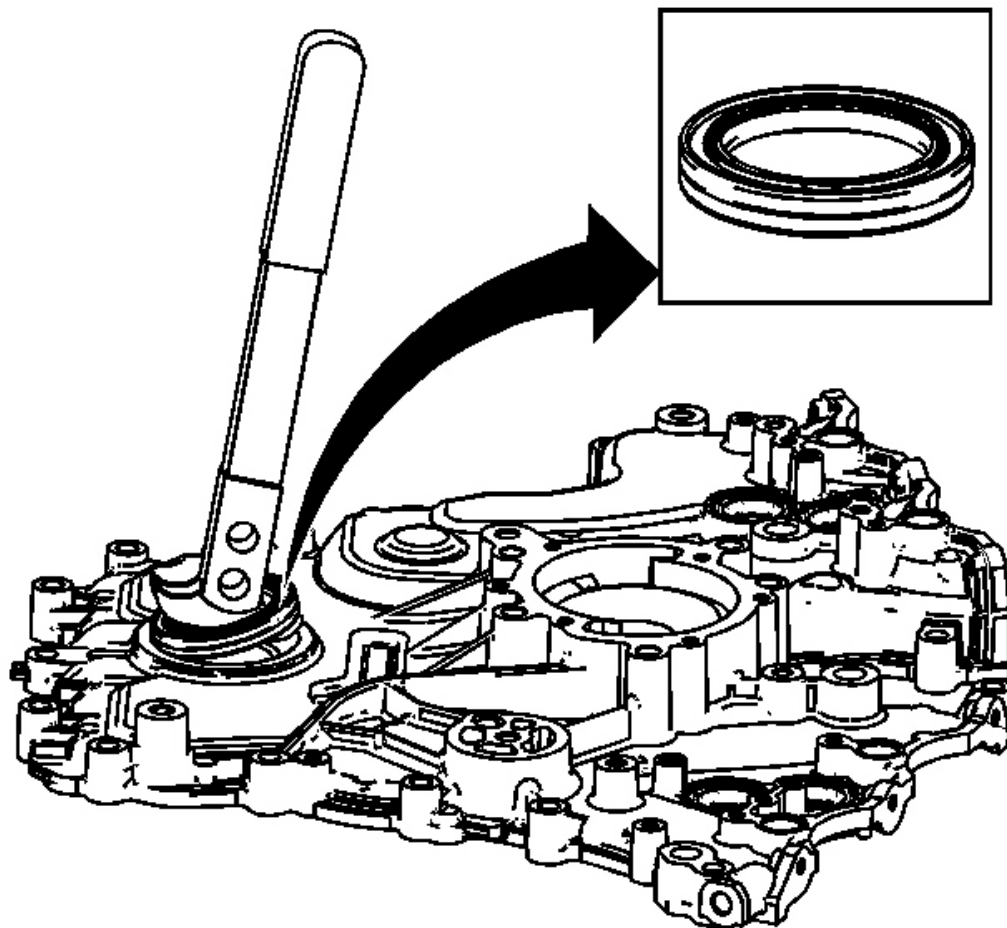


Fig. 163: Removing & Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft front oil seal from the engine front cover using the **EN 45000**: remover.

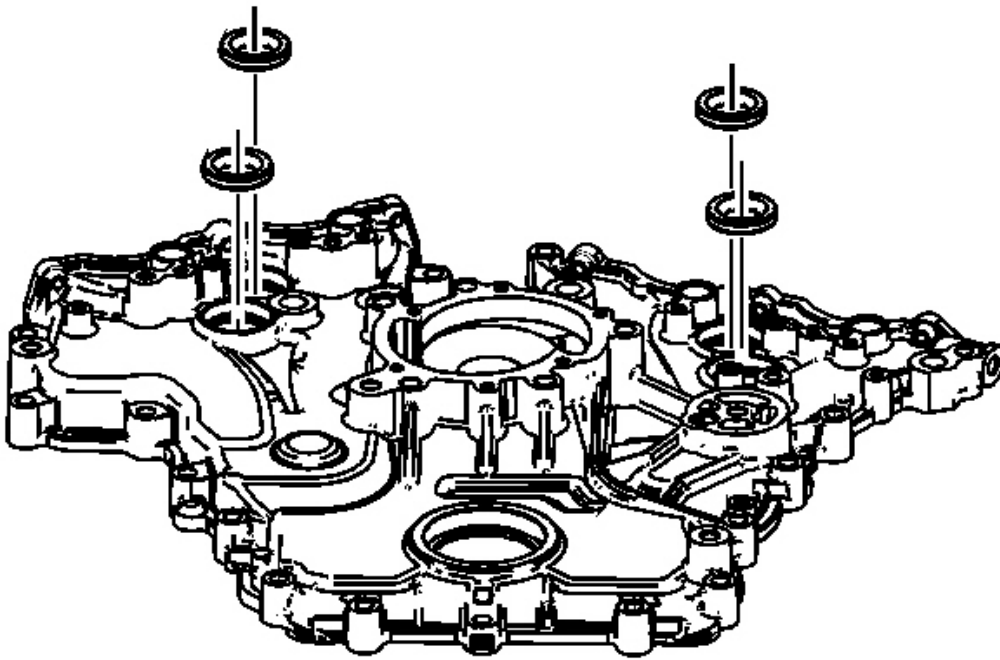


Fig. 164: View Of Camshaft Position Actuator Valve Oil Seals
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft position actuator valve oil seals from the engine front cover.

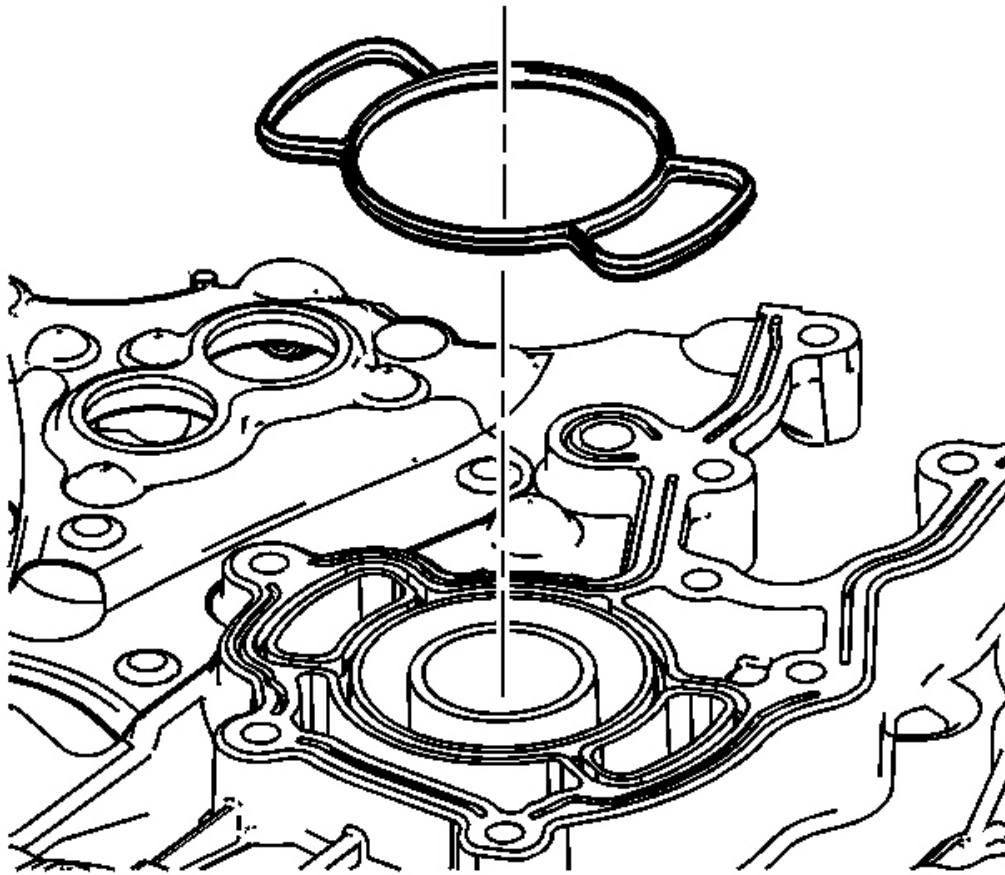


Fig. 165: Identifying Water Pump Seal
Courtesy of GENERAL MOTORS CORP.

3. Remove the water pump seal from the engine front cover.
4. Discard the water pump seal.

ENGINE FRONT COVER CLEANING AND INSPECTION

SPECIAL TOOLS

EN 28410: Gasket Remover

For equivalent regional tools, refer to **Special Tools** .

CLEANING PROCEDURE

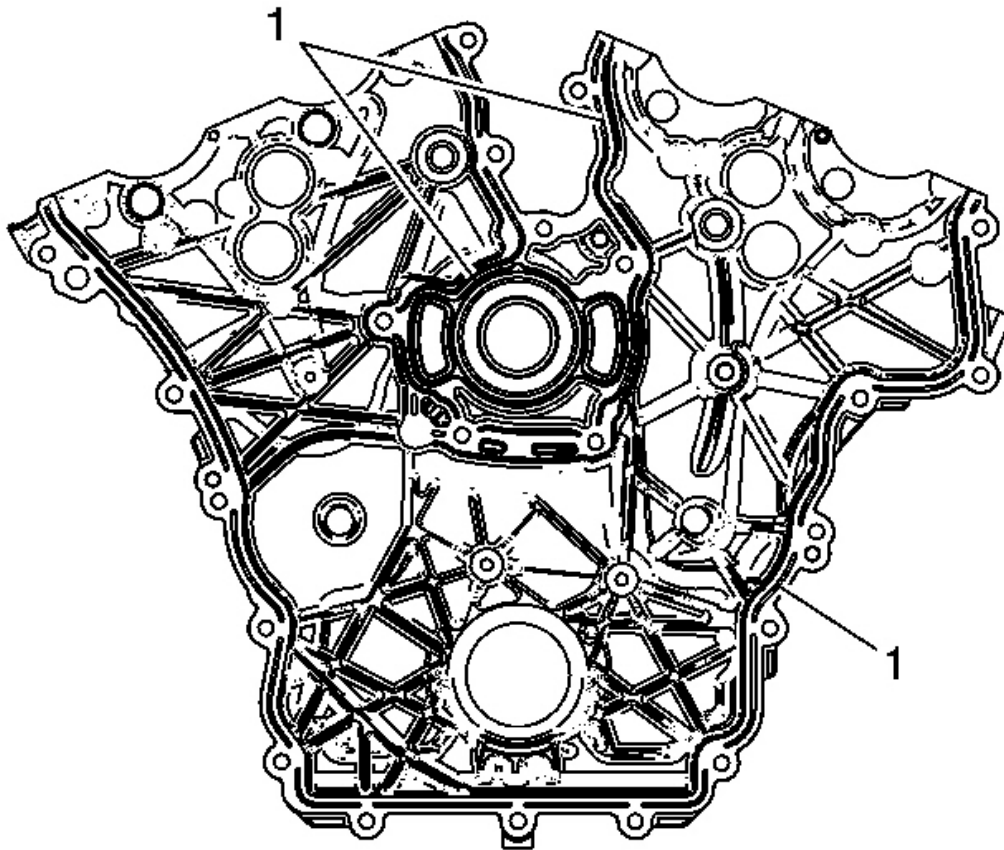


Fig. 166: Locating Sealant On Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. 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

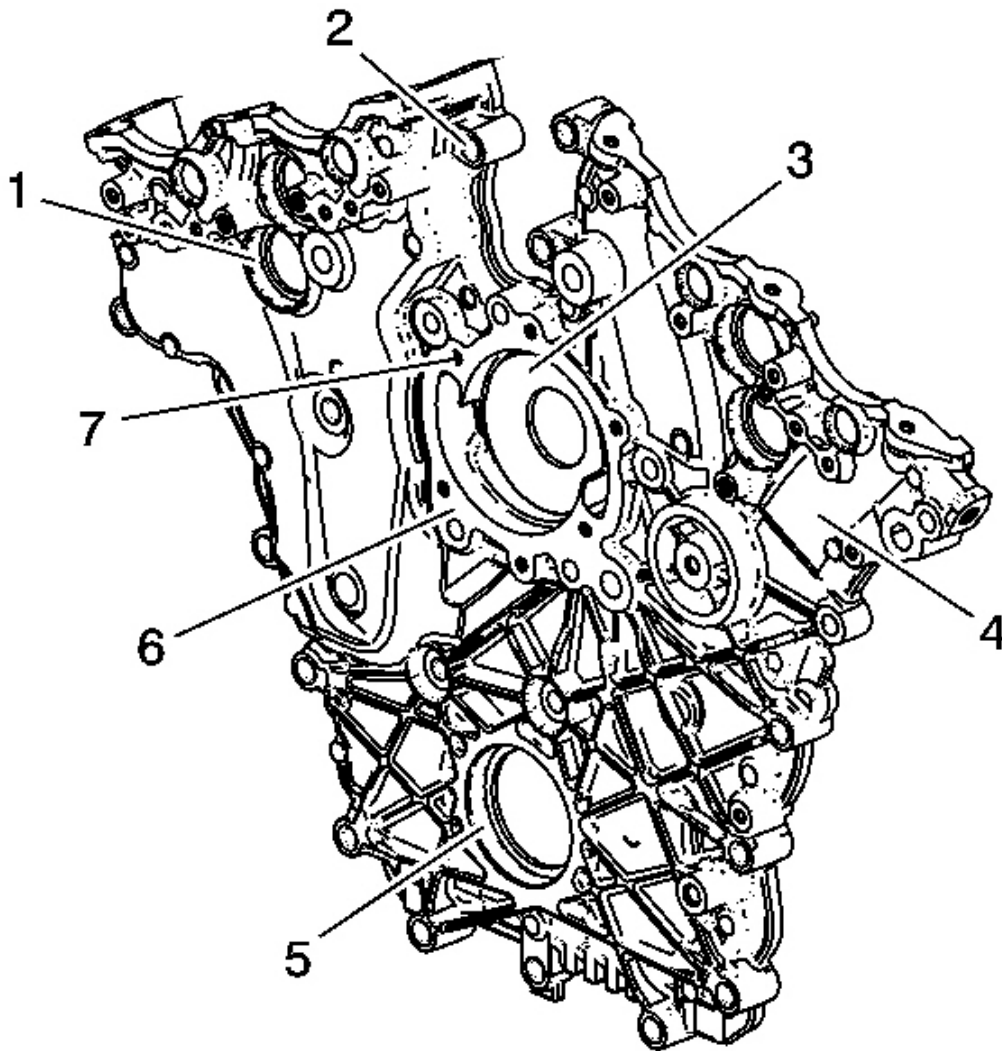


Fig. 167: Exterior Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. 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)

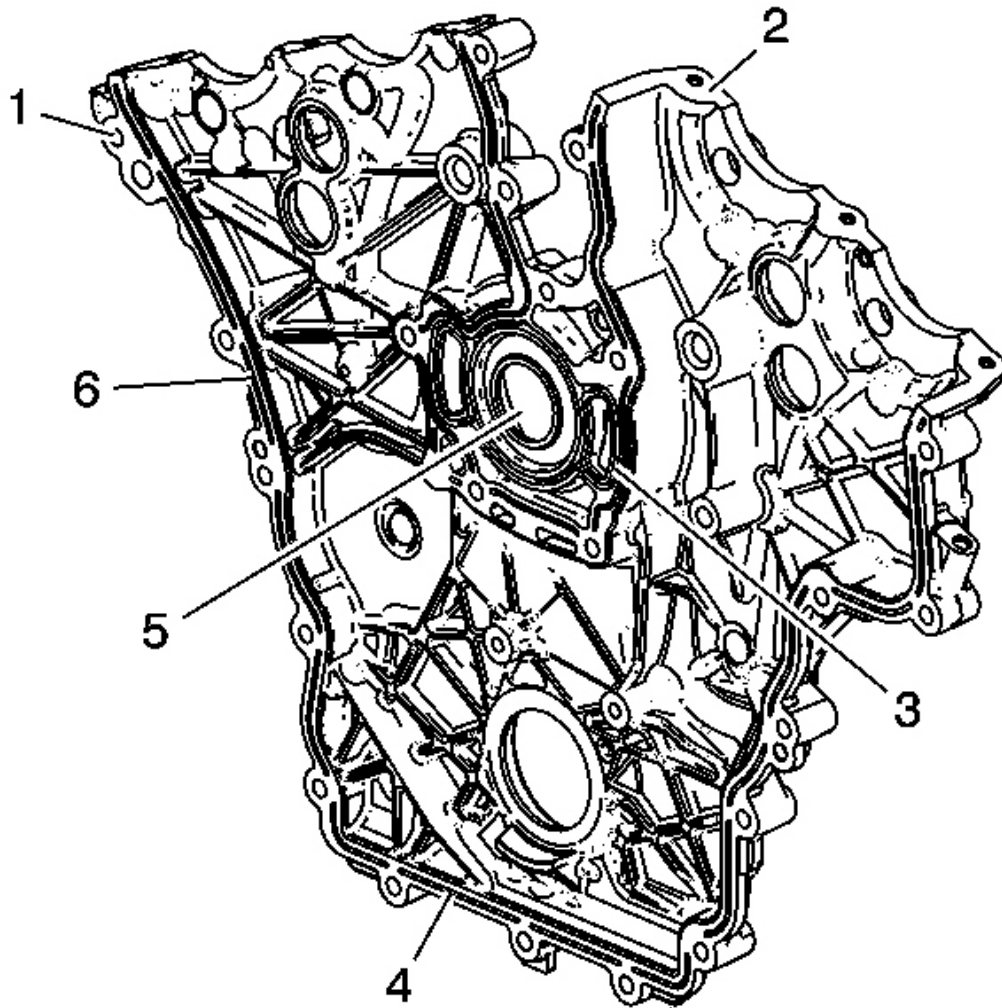


Fig. 168: Interior Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

Special Tools

- **EN 29184:** Oil Seal Installer
- **EN 46103:** Camshaft Actuator Valve Seal Installer

For equivalent regional tools, refer to **Special Tools** .

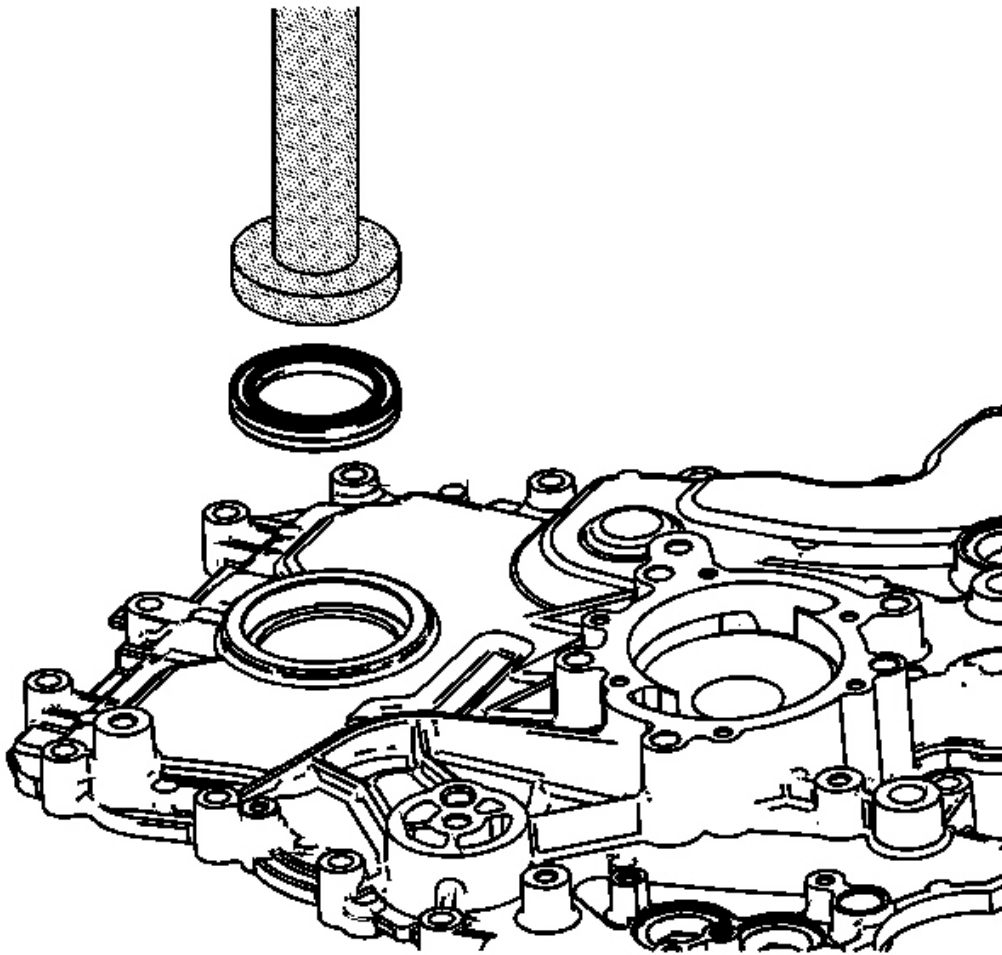


Fig. 169: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

1. Install the NEW crankshaft front oil seal into the engine front cover using the **EN 29184:** installer.

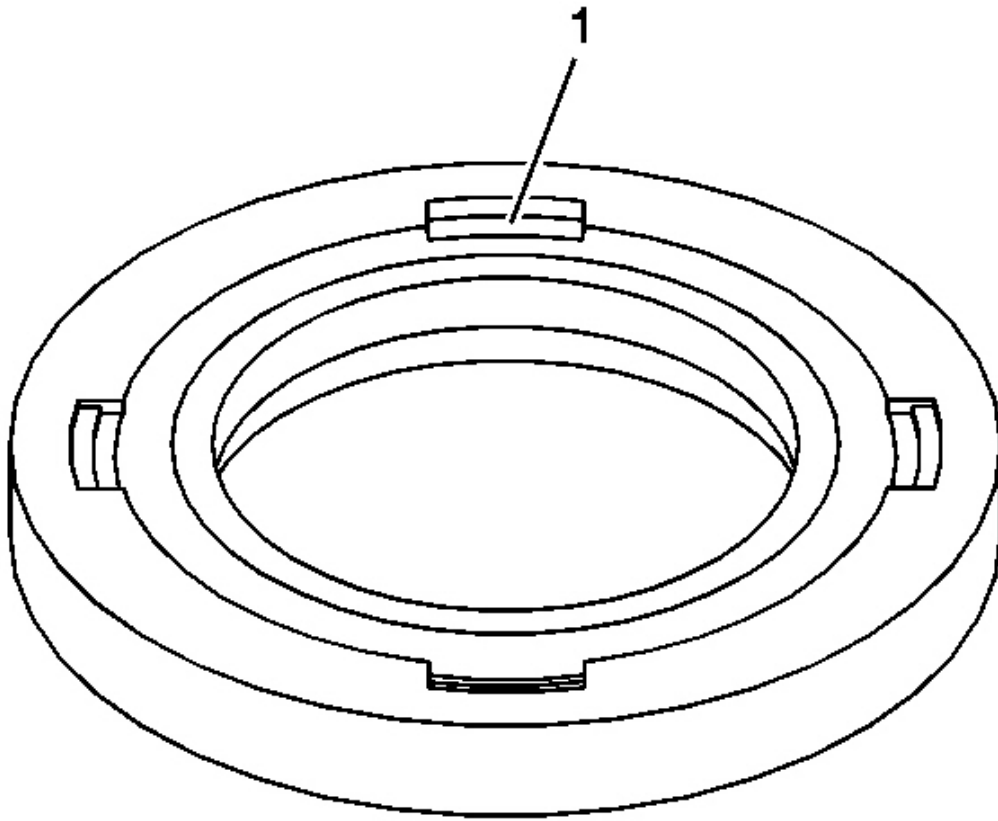


Fig. 170: Crankshaft Front Oil Seal Notches
Courtesy of GENERAL MOTORS CORP.

2. Place the seal into position with the notches (1) in the seal down. The notches (1) will face inboard when properly installed.

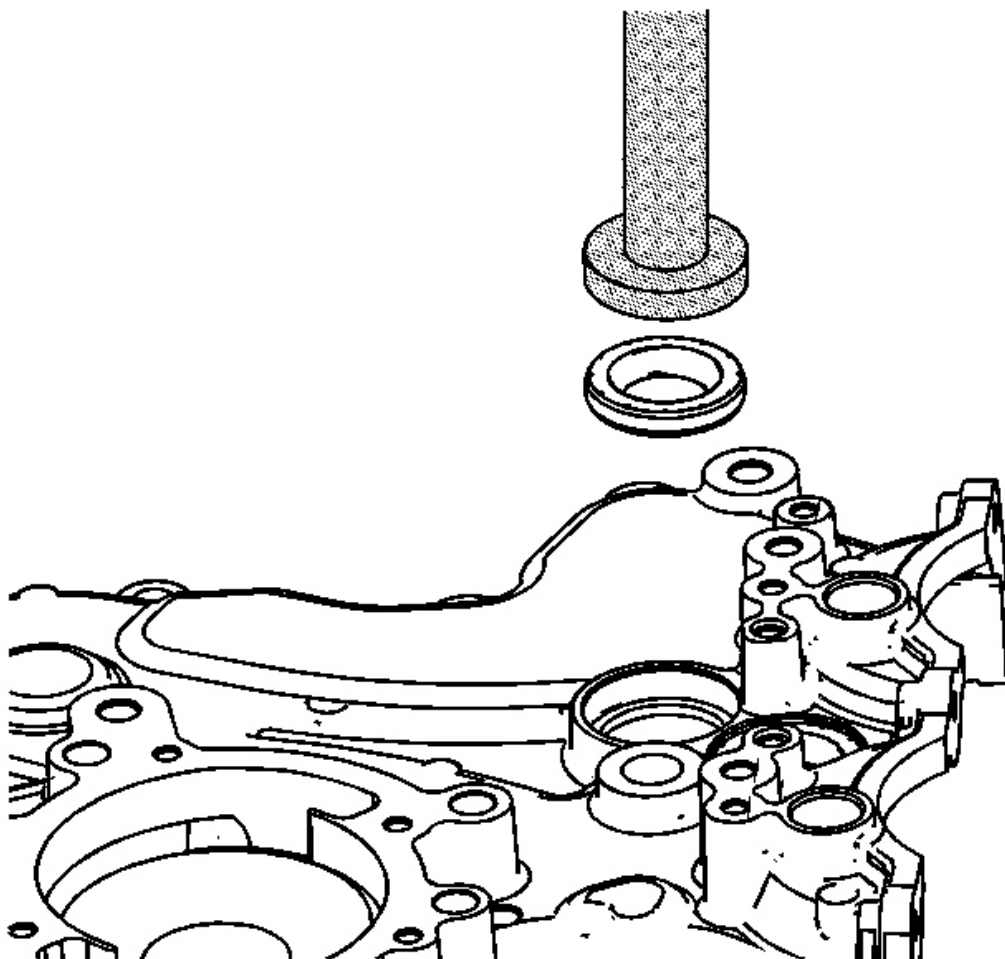


Fig. 171: Installing Camshaft Position Actuator Valve Oil Seals
Courtesy of GENERAL MOTORS CORP.

3. Install the NEW camshaft position actuator valve oil seals into the engine front cover using the **EN 46103**: installer.

CAMSHAFT COVER DISASSEMBLE

LEFT CAMSHAFT COVER

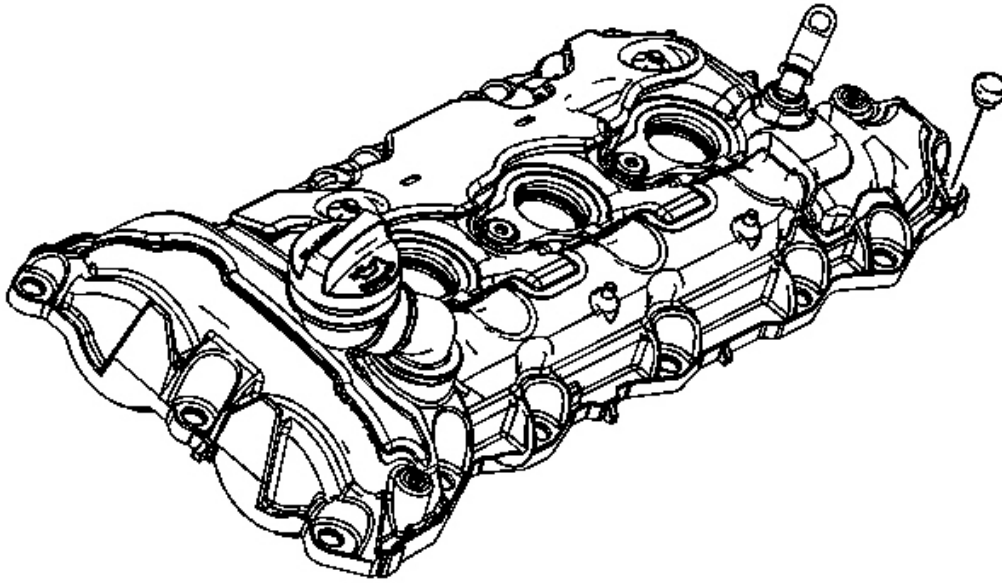


Fig. 172: Left Camshaft Cover Bolt Grommets
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the left camshaft cover bolt grommets.

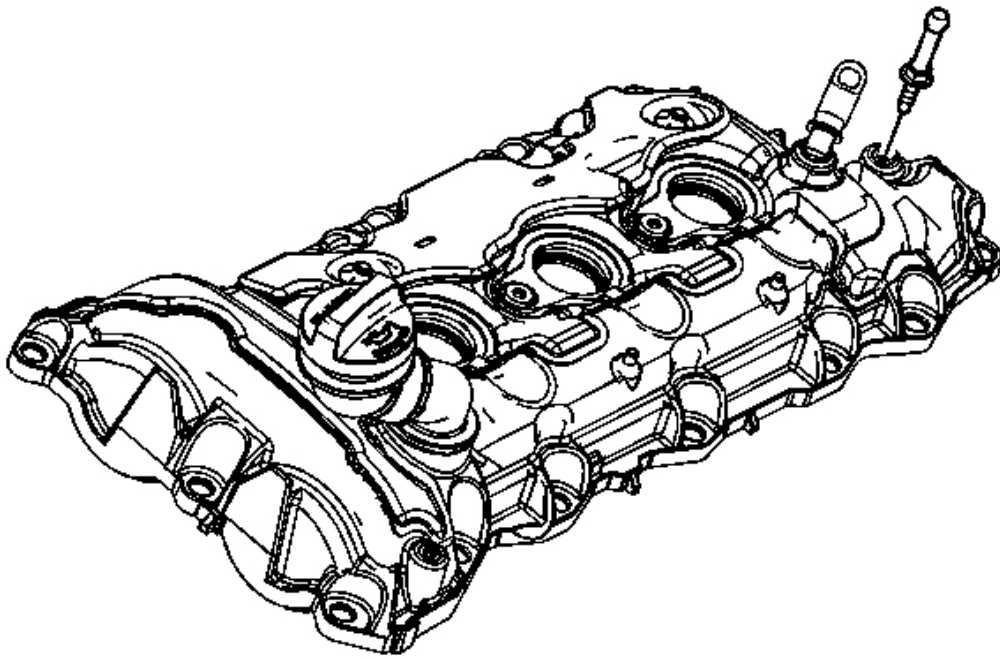


Fig. 173: Fuel Injector Sight Shield Cover Ballstud
Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel injector sight shield ballstud.

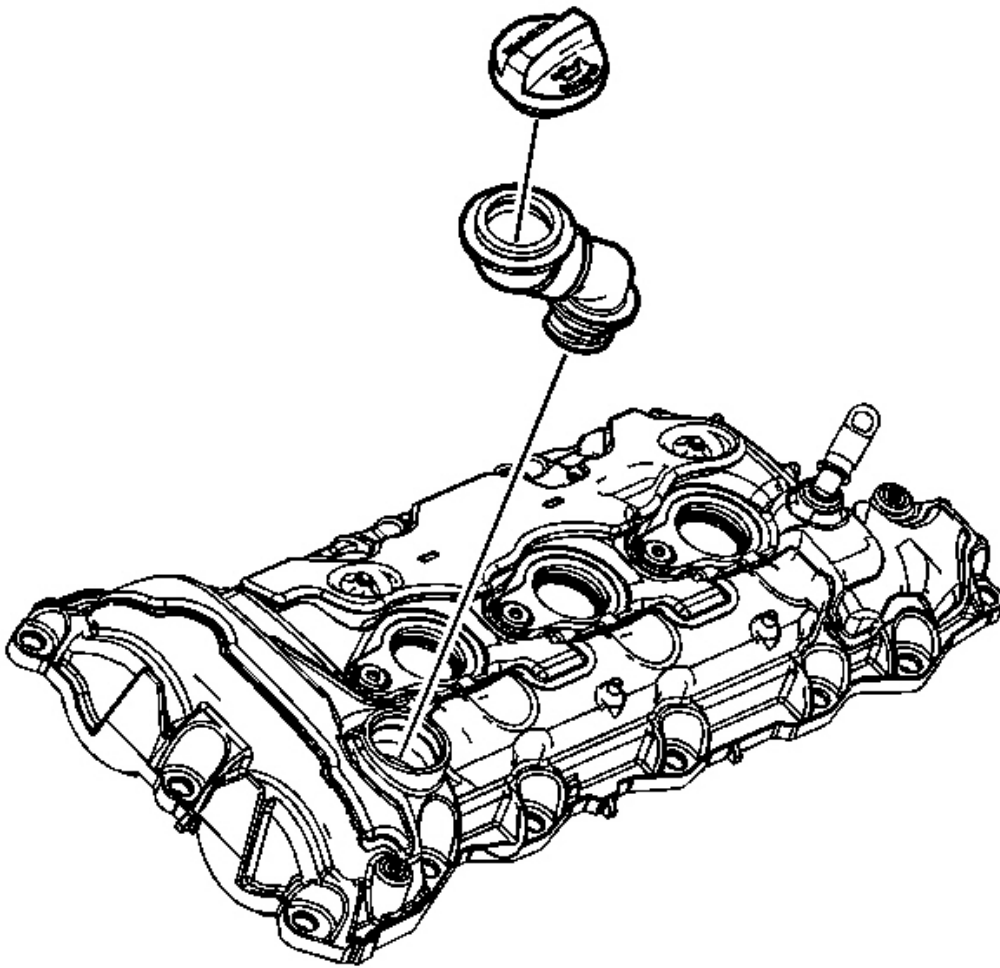


Fig. 174: Oil Filter Cap Assembly
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil fill cap.

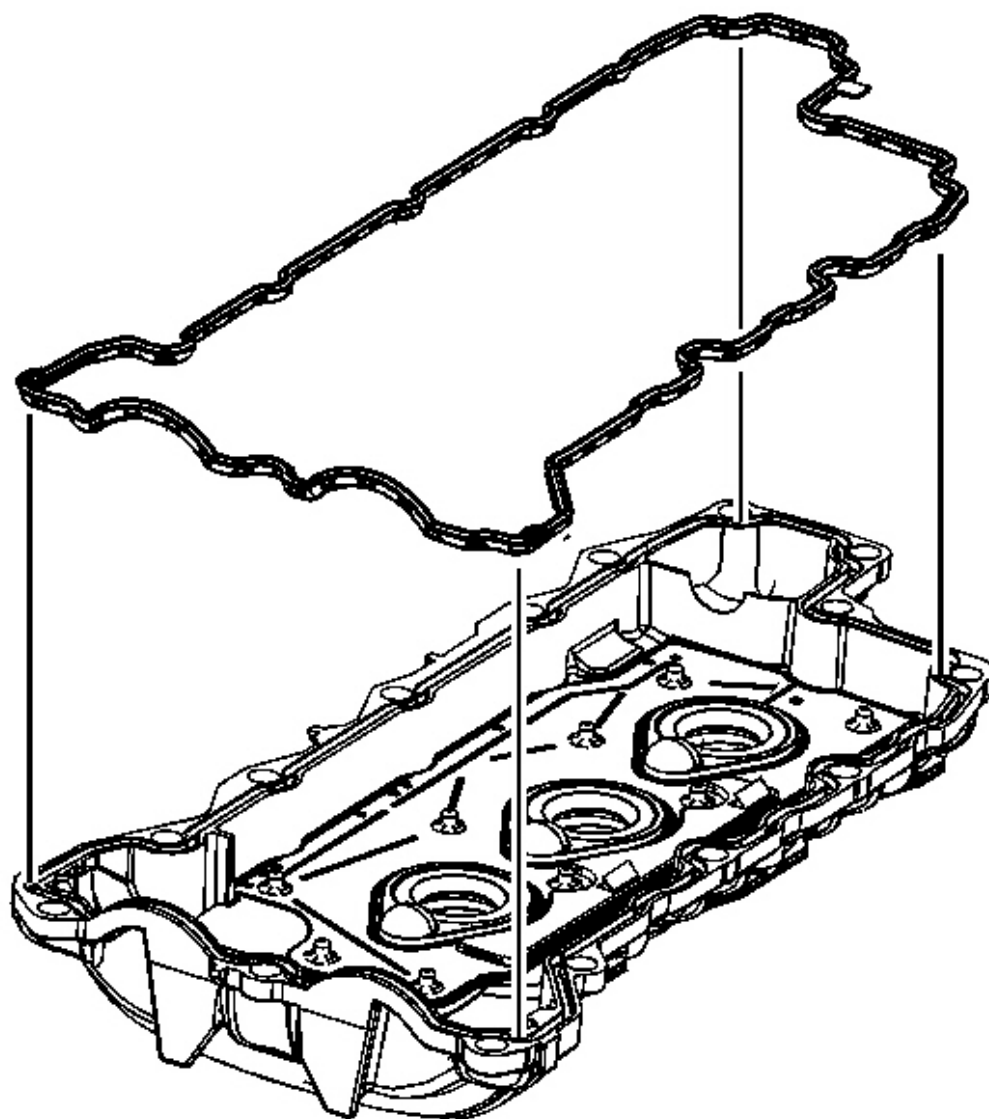


Fig. 175: Left Camshaft Cover Gasket Assembly
Courtesy of GENERAL MOTORS CORP.

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

4. Remove and discard the left camshaft cover gasket.

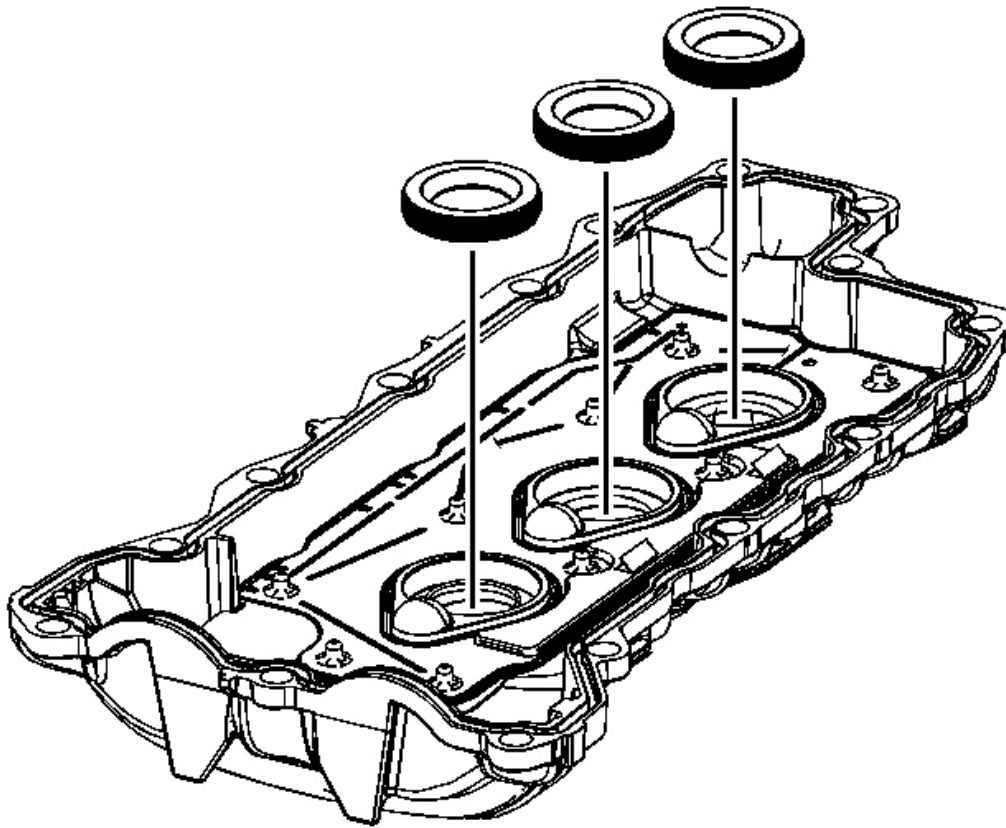


Fig. 176: Right Spark Plug Shield Tube Seals
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the left spark plug shield tube seals.

RIGHT CAMSHAFT COVER

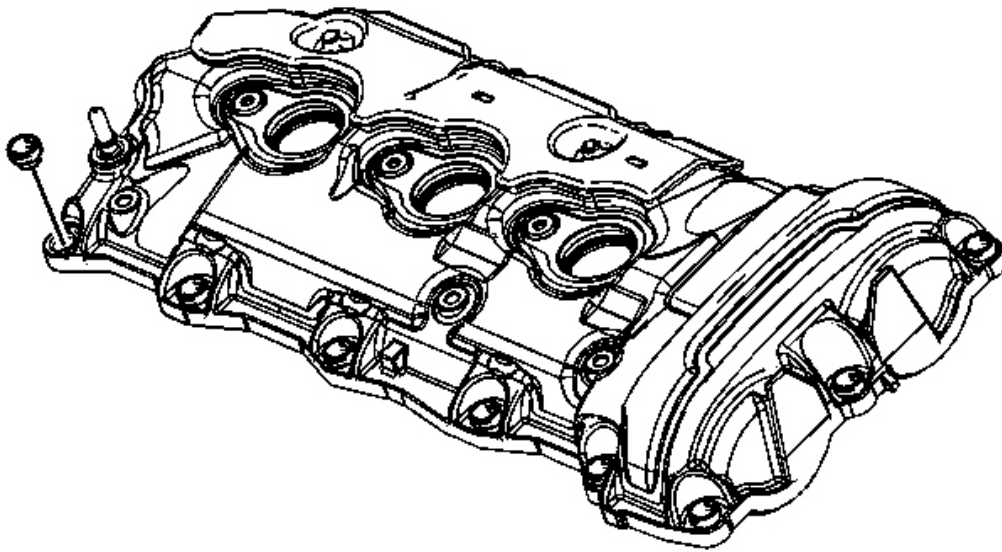


Fig. 177: Right Camshaft Cover Bolt Grommet
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the right camshaft cover bolt grommets.

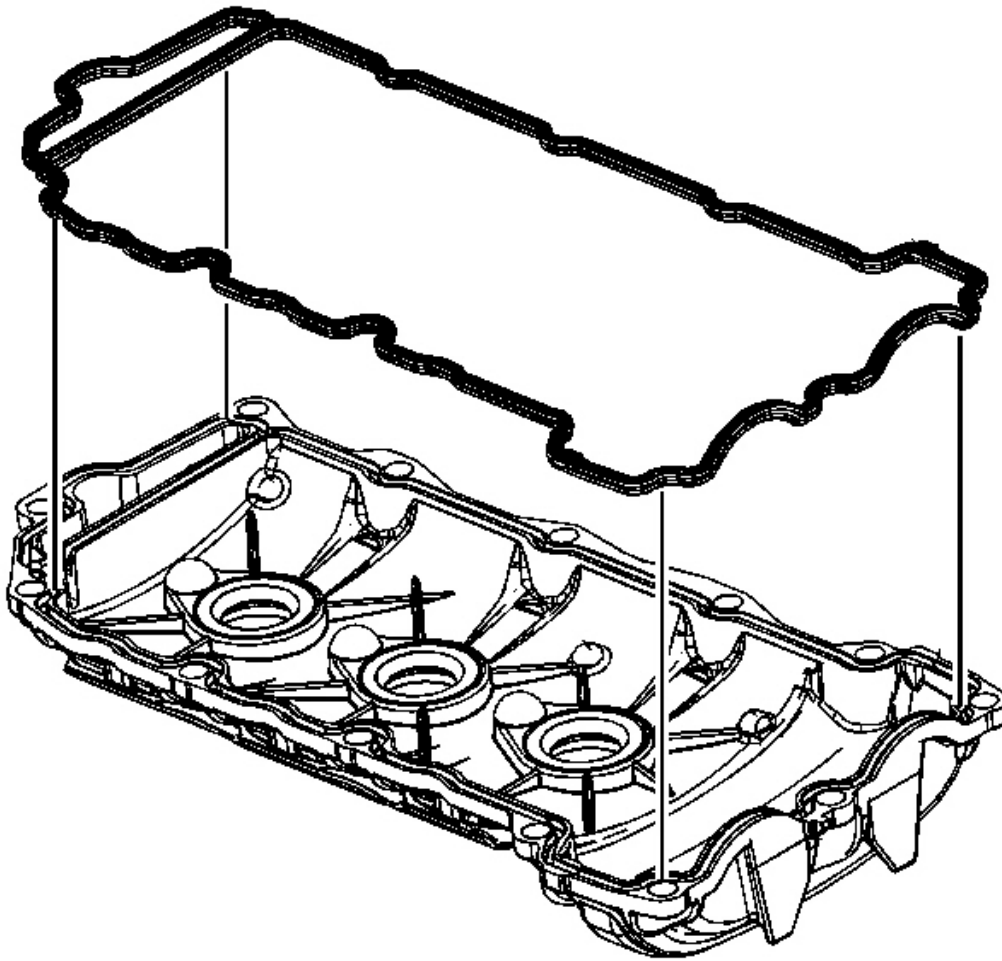


Fig. 178: Right Camshaft Cover Gasket
Courtesy of GENERAL MOTORS CORP.

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

2. Remove and discard the right camshaft cover gasket.

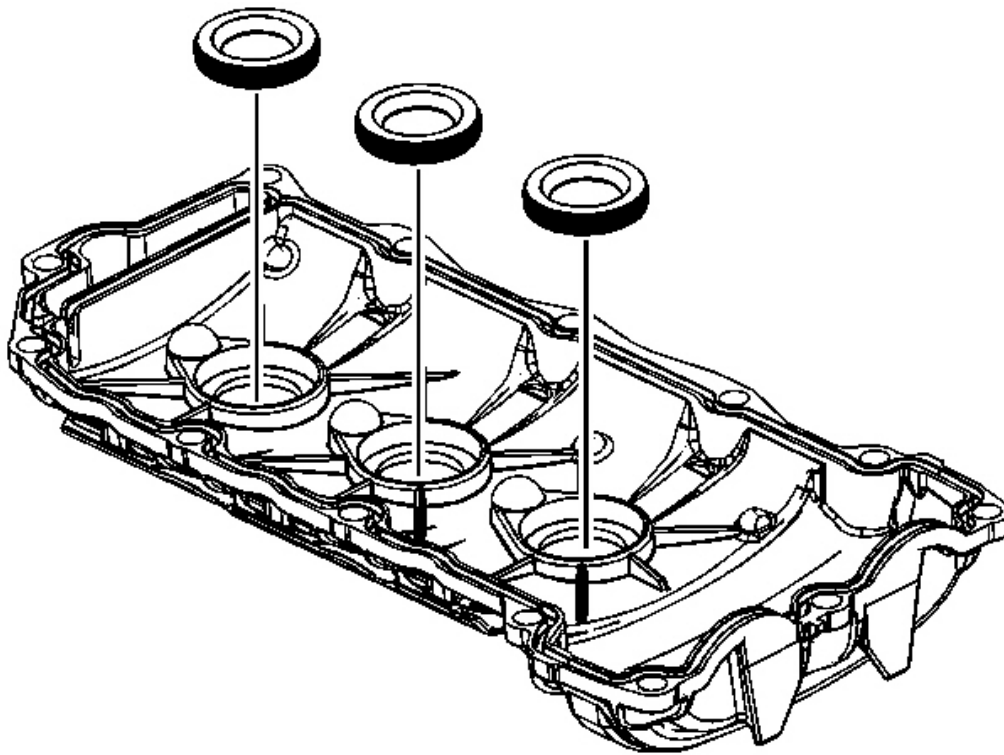


Fig. 179: Right Spark Plug Shield Tube Seals
Courtesy of GENERAL MOTORS CORP.

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
 - Effect crankcase ventilation
 - Interfere with the camshafts
 - Interfere with the ignition coil sealing
 - Allow water or condensation to enter the engine

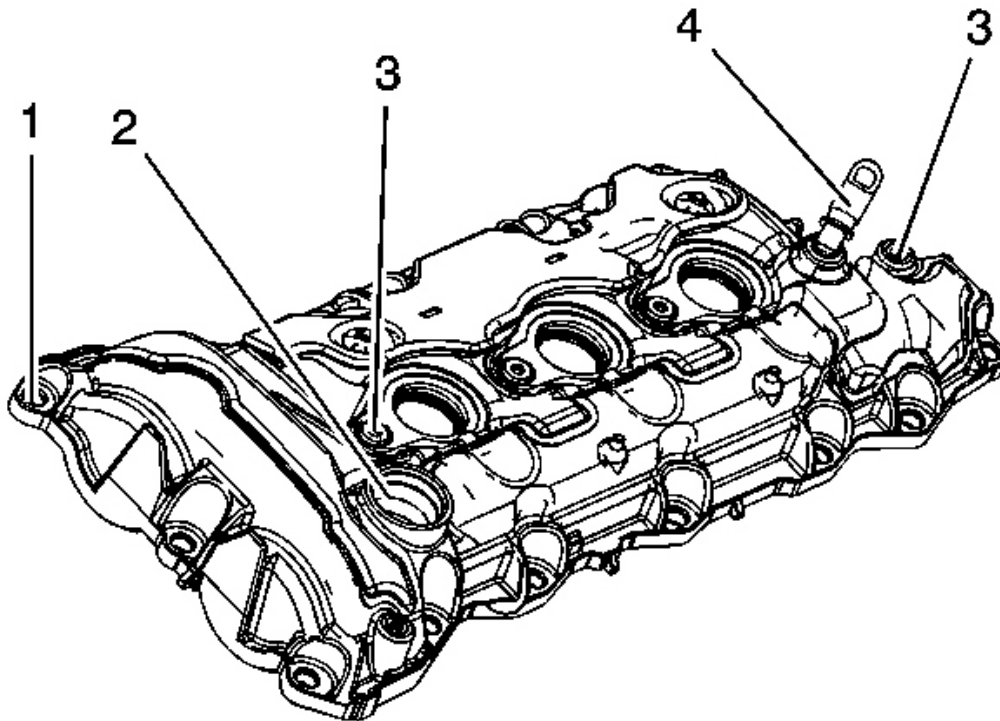


Fig. 180: Identifying Inspection Points Of Left Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

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.

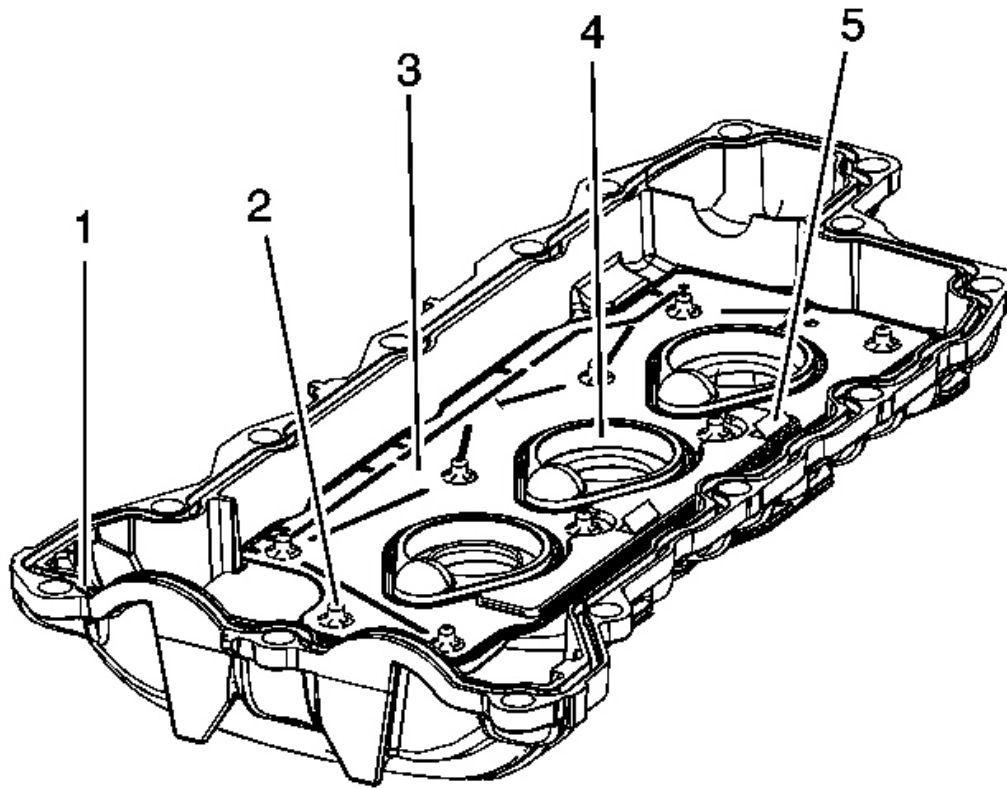


Fig. 181: Identifying Inspection Points Of Left Camshaft Cover Interior
Courtesy of GENERAL MOTORS CORP.

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)

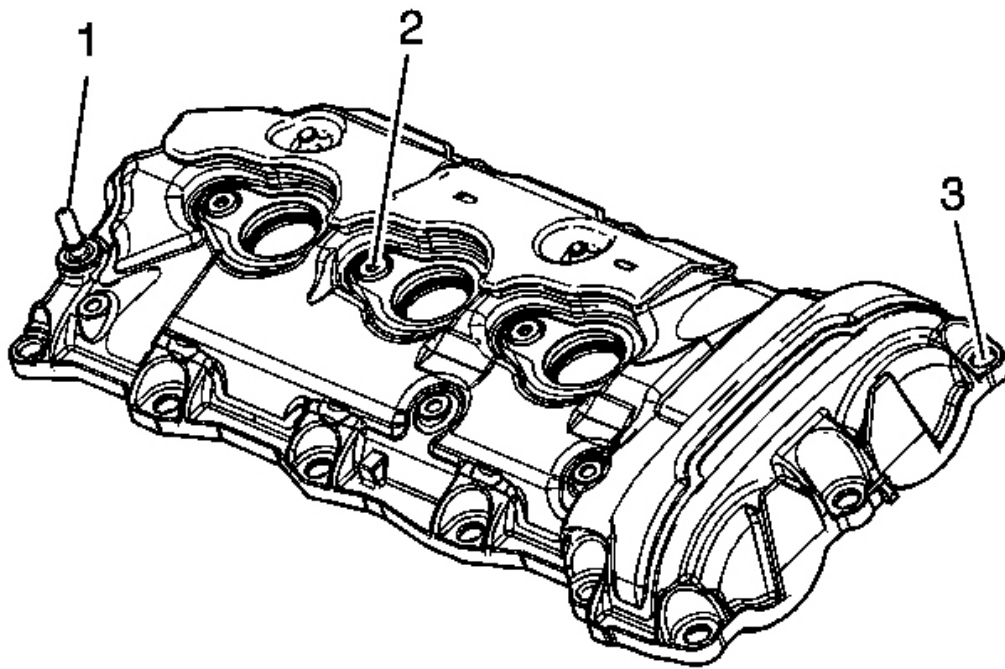


Fig. 182: Inspecting Exterior Of Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

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)

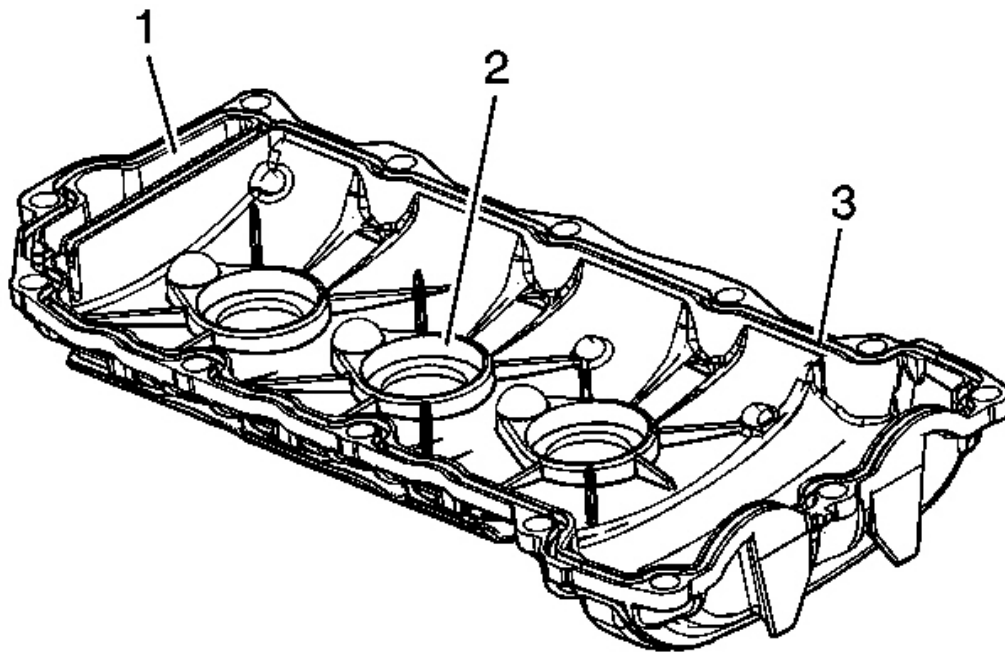


Fig. 183: Inspecting Interior Of Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

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

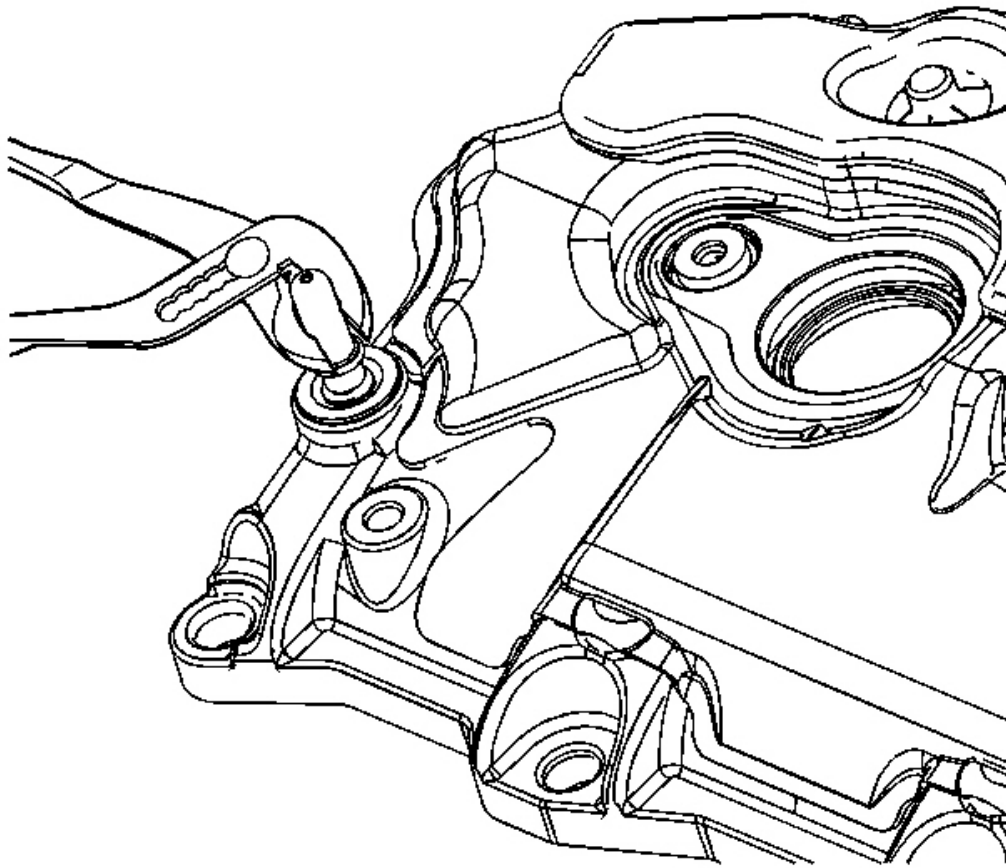


Fig. 184: Removing PCV Orifice
Courtesy of GENERAL MOTORS CORP.

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

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

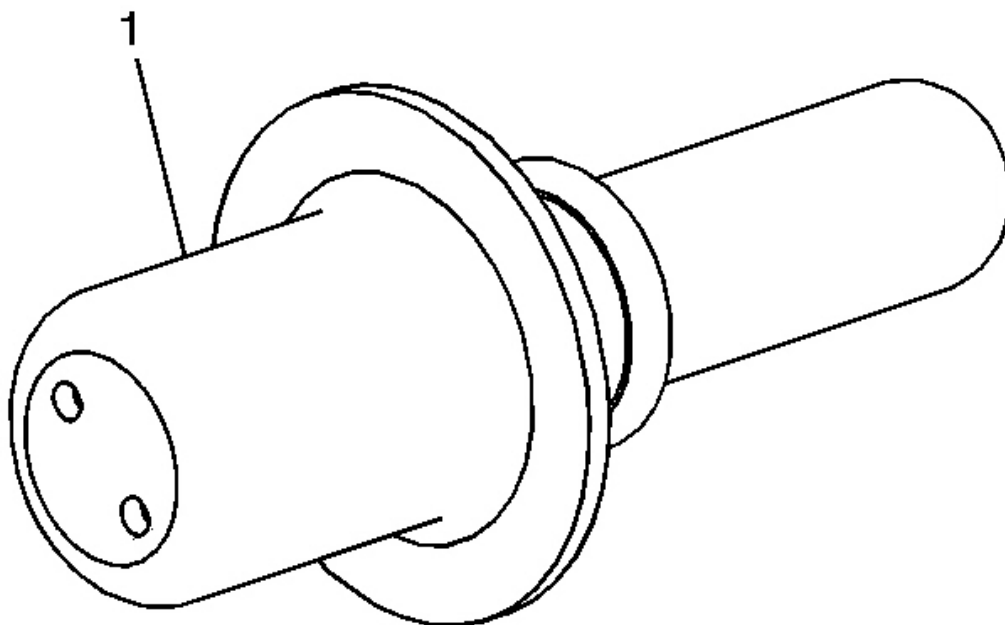


Fig. 185: Identifying Sealant Area On PCV Orifice
Courtesy of GENERAL MOTORS CORP.

2. Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the NEW PCV orifice (1).

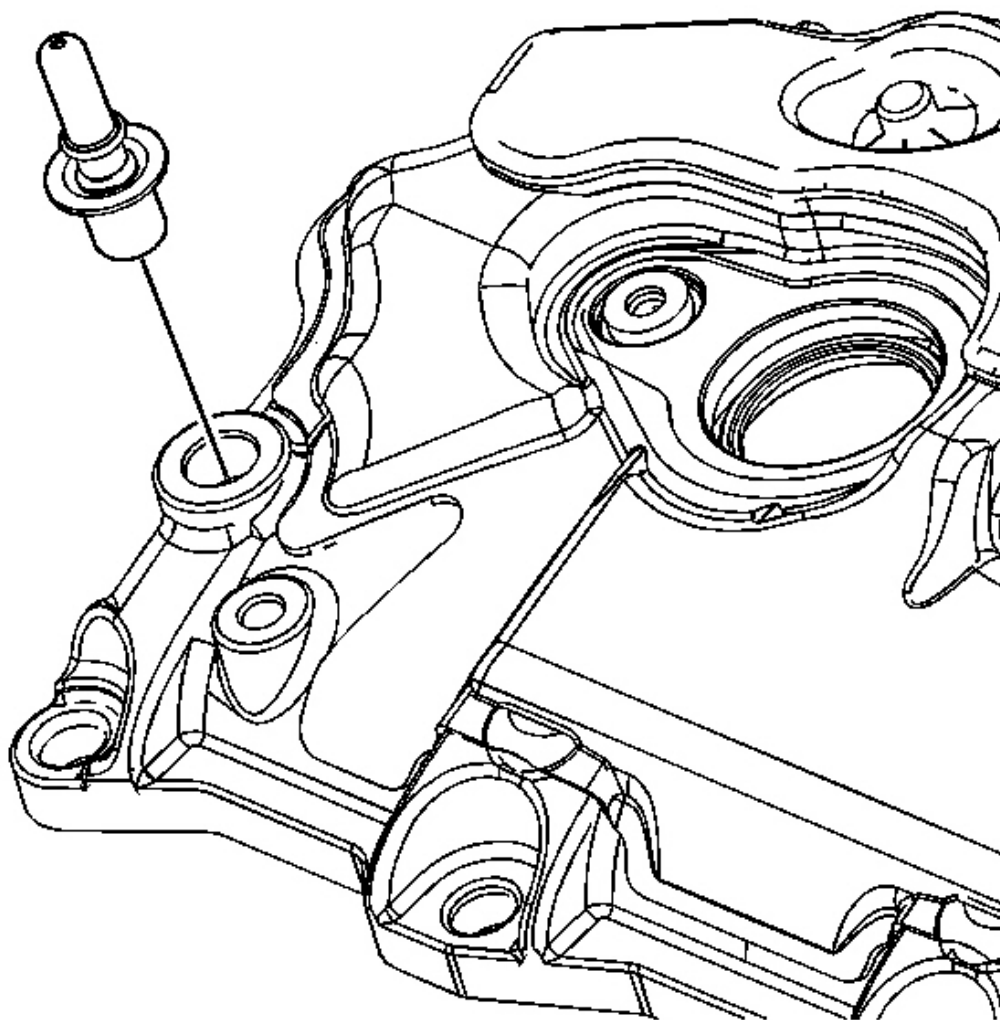


Fig. 186: View Of PCV Orifice & Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

3. 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

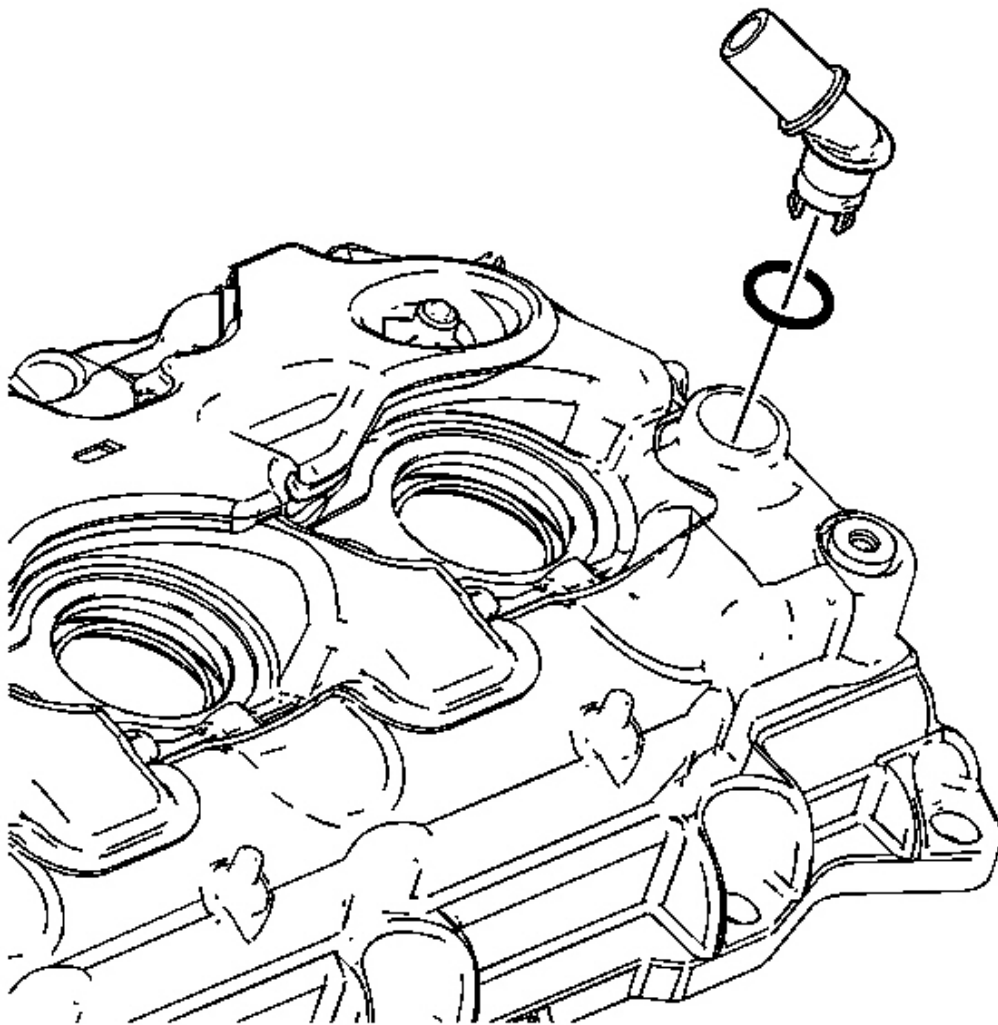


Fig. 187: View Of PCV Fitting & O-Ring
Courtesy of GENERAL MOTORS CORP.

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

1. 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** .

LEFT CAMSHAFT COVER

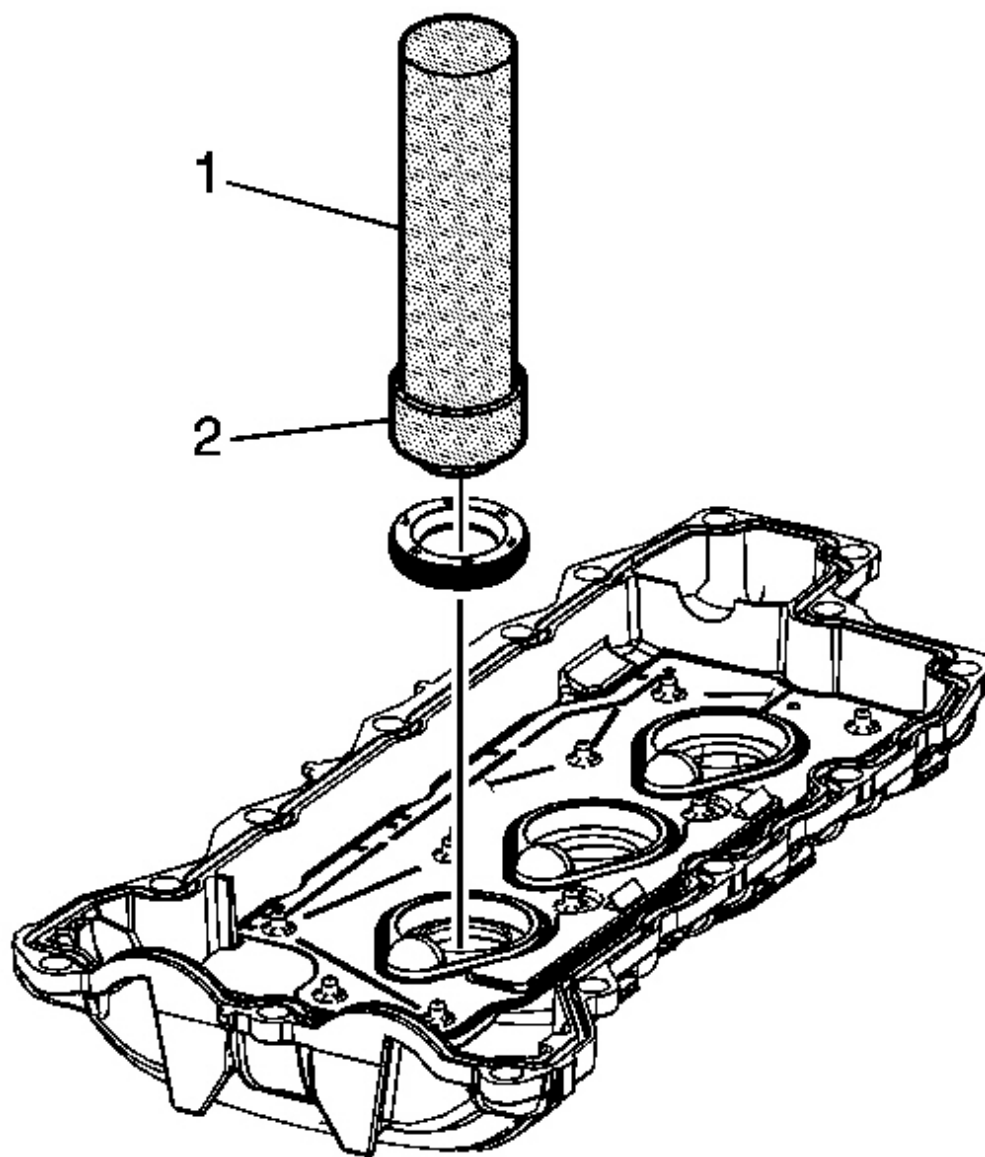


Fig. 188: Installing Left Spark Plug Shield Tube Seals
Courtesy of GENERAL MOTORS CORP.

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

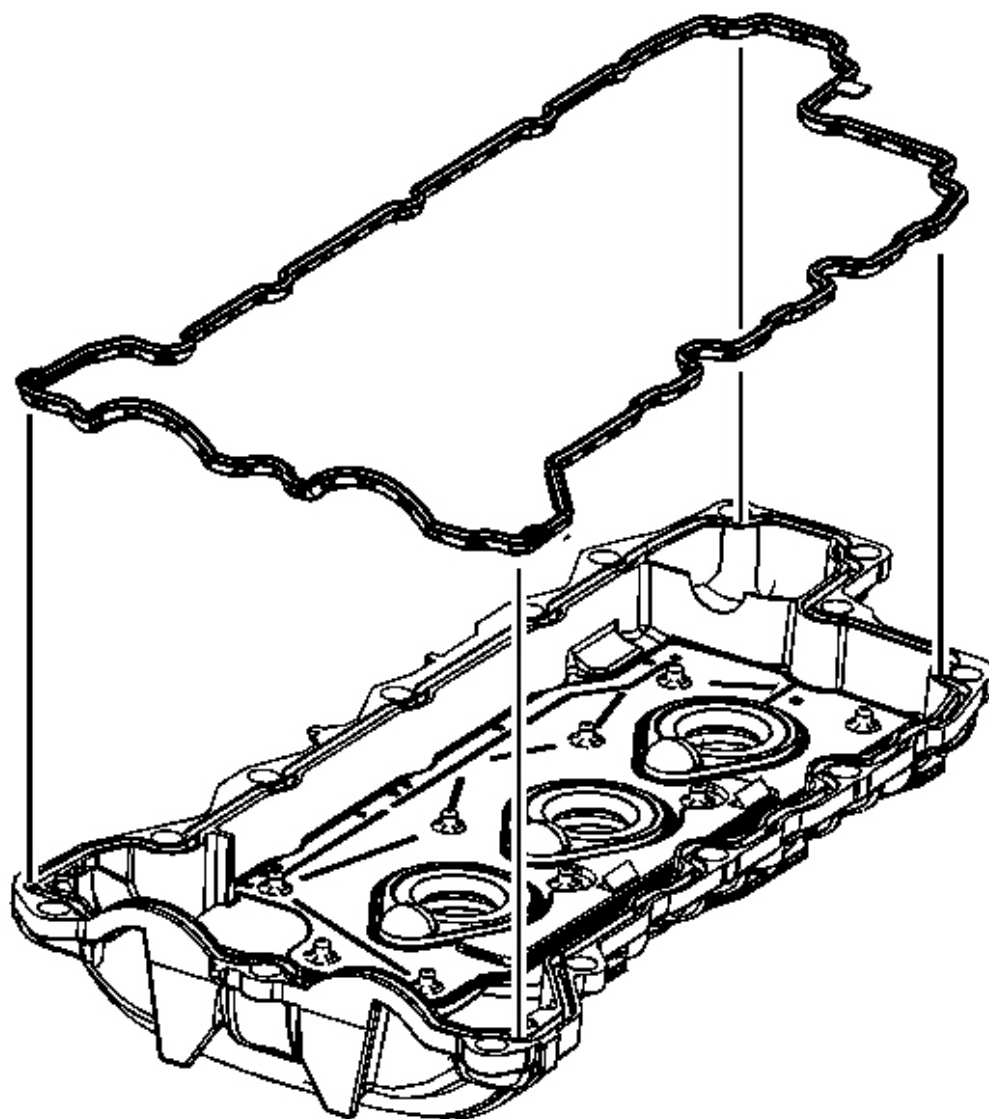


Fig. 189: Left Camshaft Cover Gasket Assembly
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW left camshaft cover gasket.

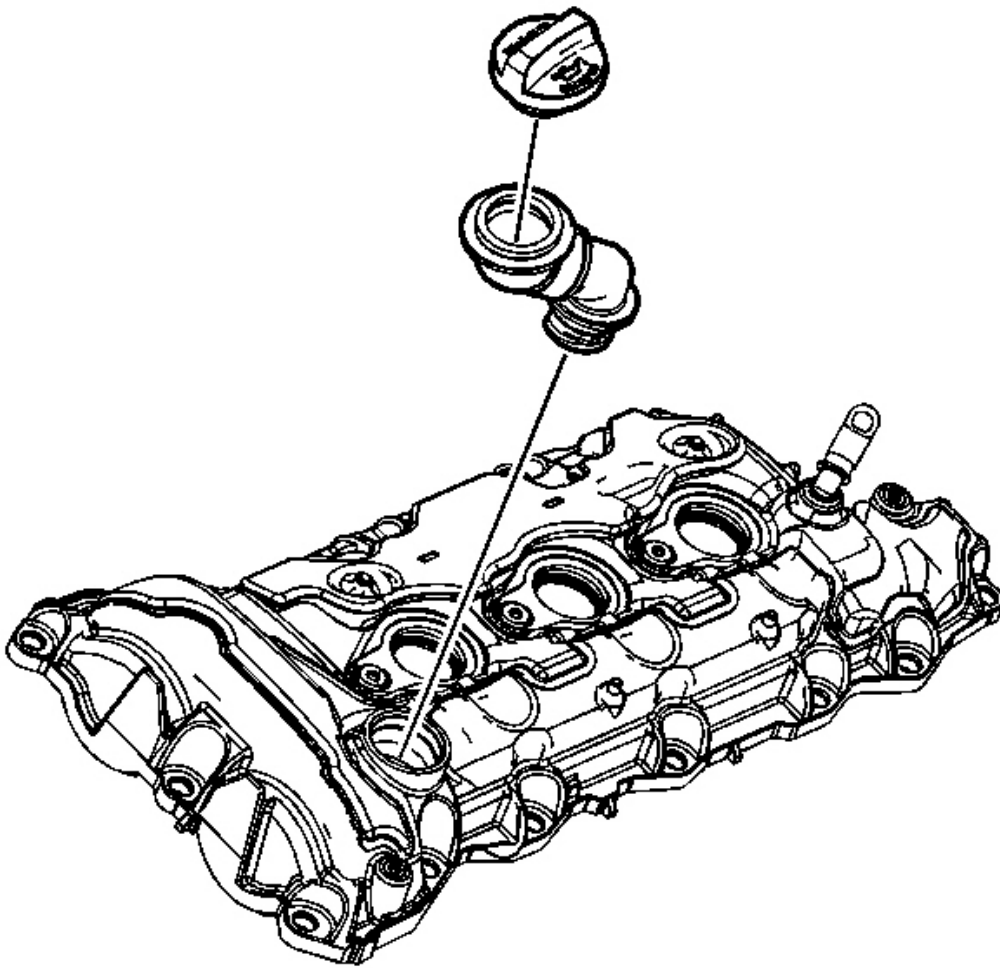


Fig. 190: Oil Filter Cap Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the oil fill cap.

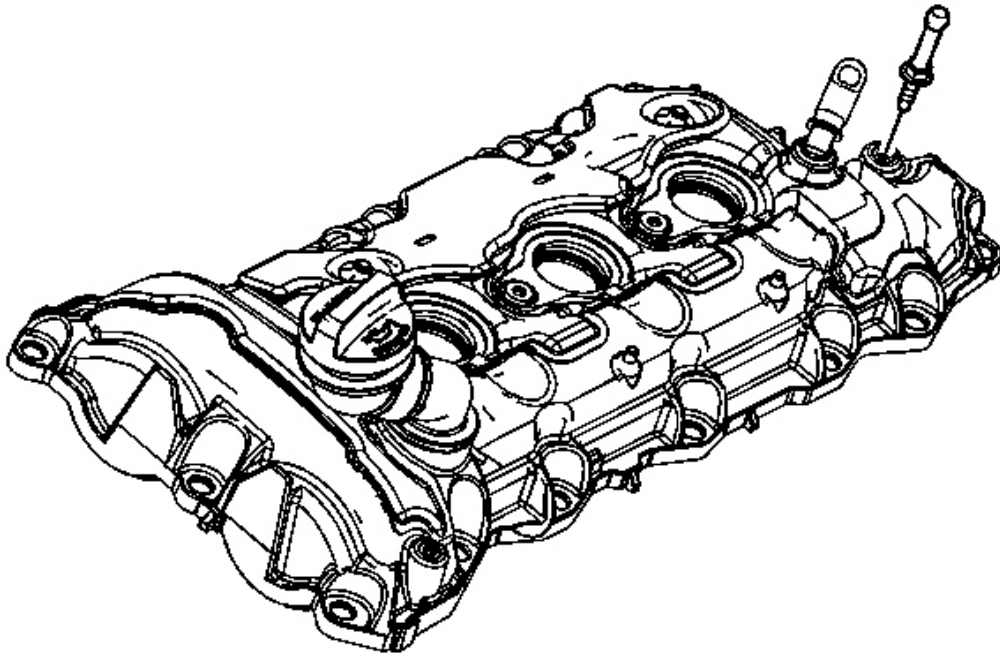


Fig. 191: Fuel Injector Sight Shield Cover Ballstud
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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

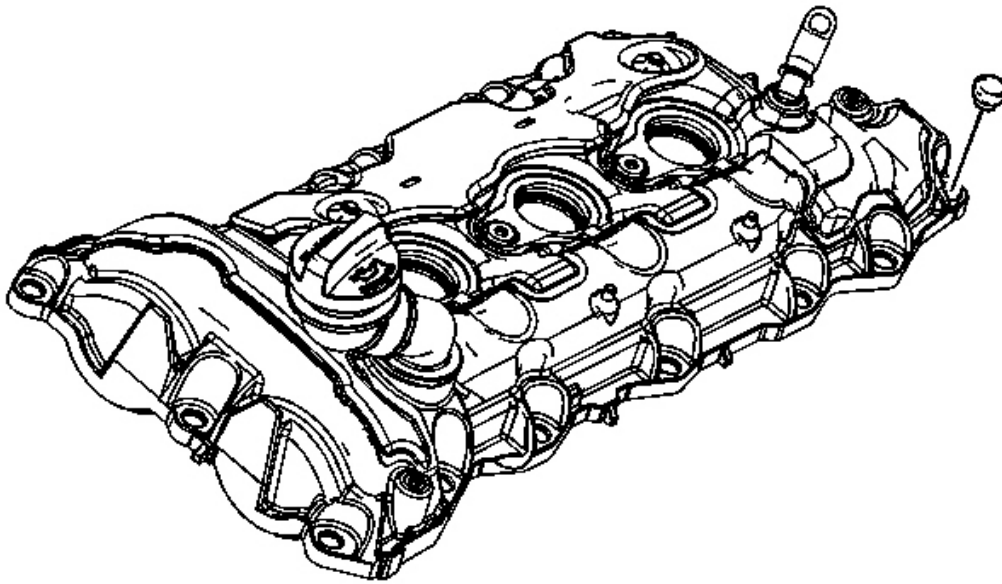


Fig. 192: Left Camshaft Cover Bolt Grommets
Courtesy of GENERAL MOTORS CORP.

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

5. Install the NEW left camshaft cover bolt grommets.

RIGHT CAMSHAFT COVER

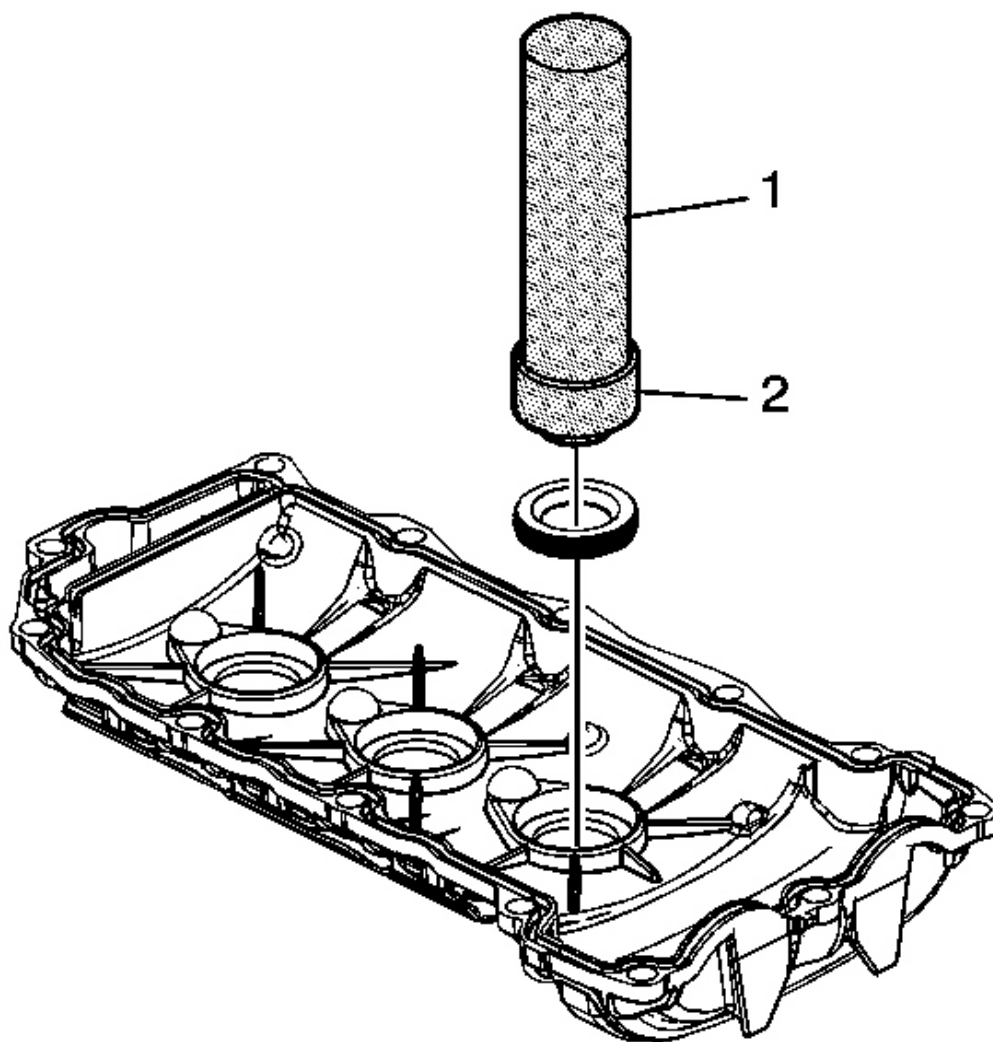


Fig. 193: Installing Right Spark Plug Shield Tube Coil Seals
Courtesy of GENERAL MOTORS CORP.

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

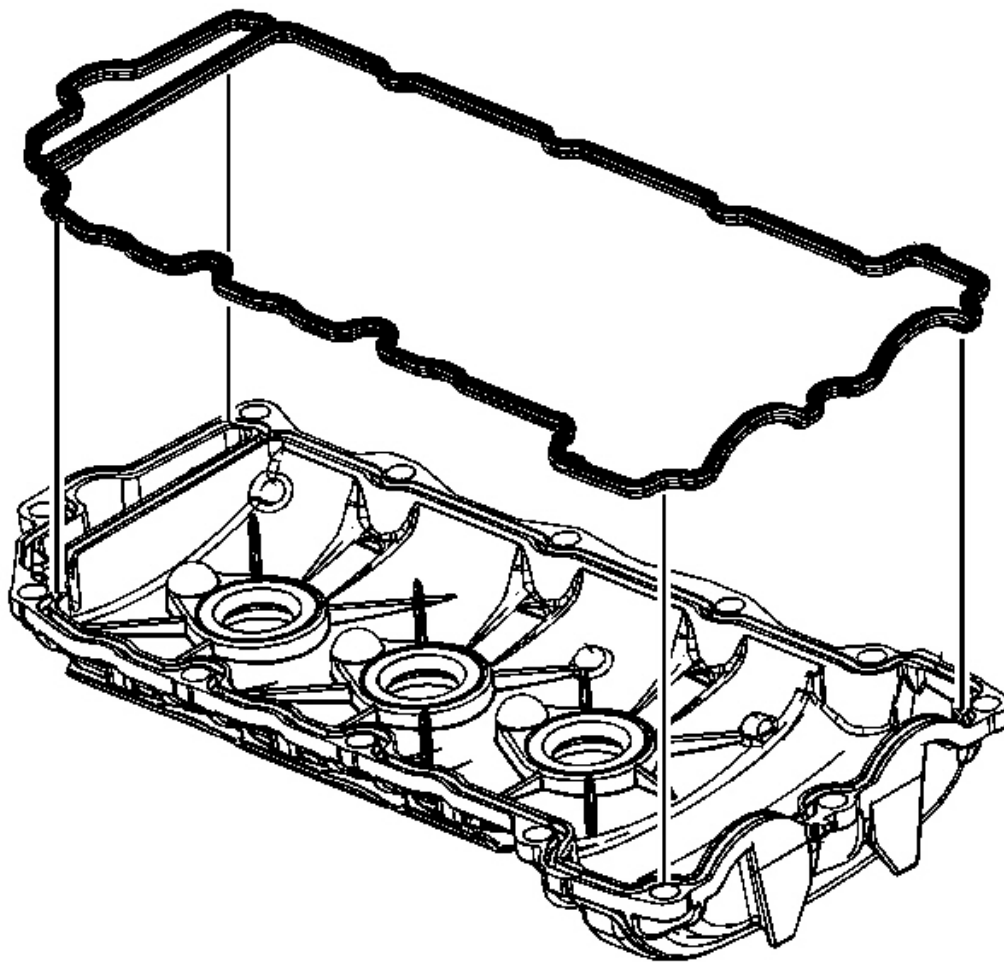


Fig. 194: Right Camshaft Cover Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW right camshaft cover gasket.

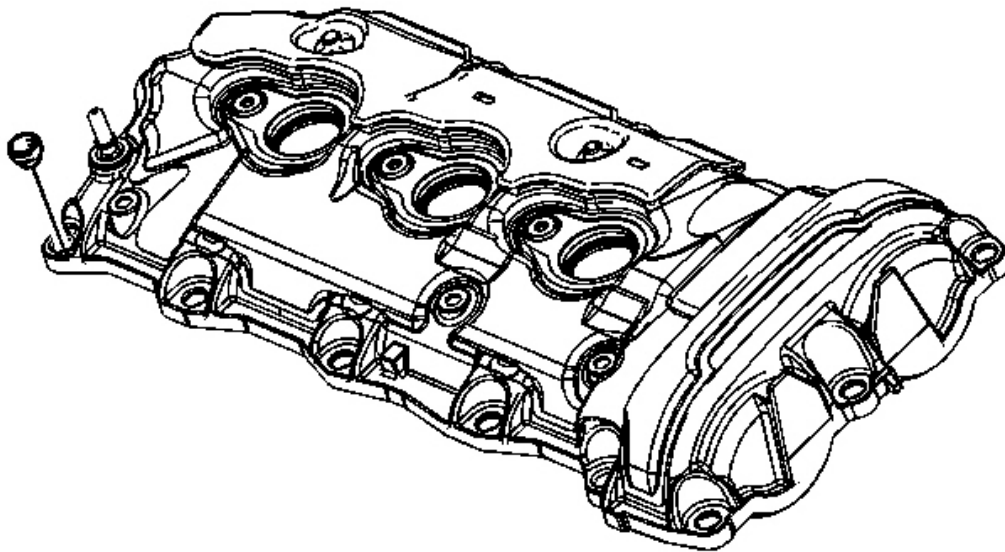


Fig. 195: View Of Right Camshaft Cover Bolt Grommets
Courtesy of GENERAL MOTORS CORP.

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

3. Install the NEW right camshaft cover bolt grommets.

INTAKE MANIFOLD DISASSEMBLE (LF1 OR LFW)

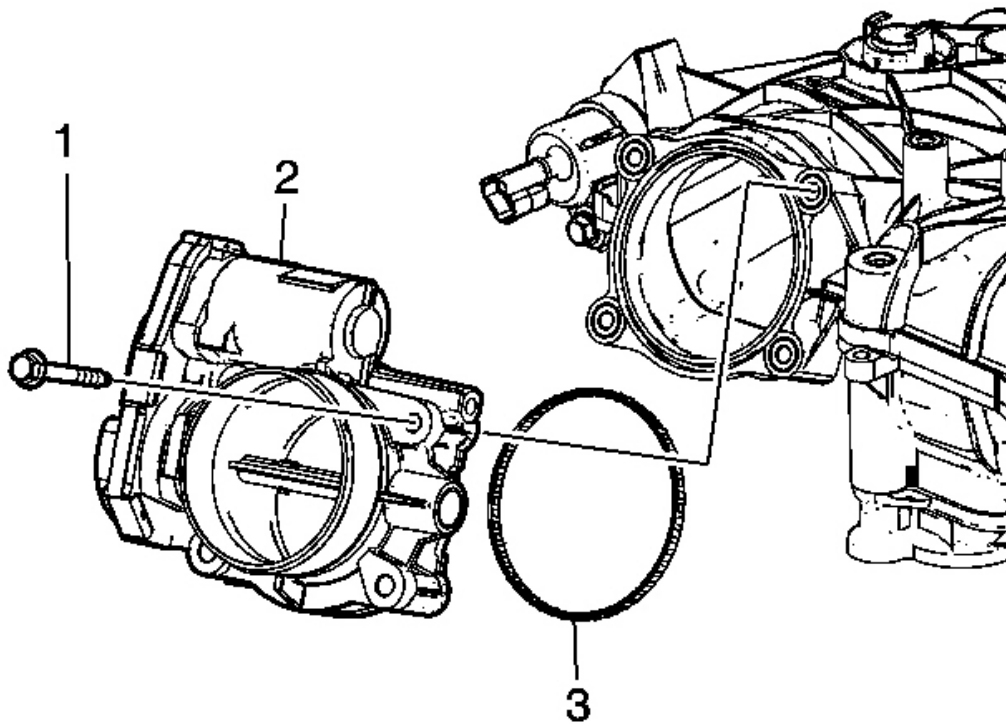


Fig. 196: Throttle Body Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle body bolts (1).
2. Remove the throttle body (2).
3. Remove and discard the throttle body seal (3).

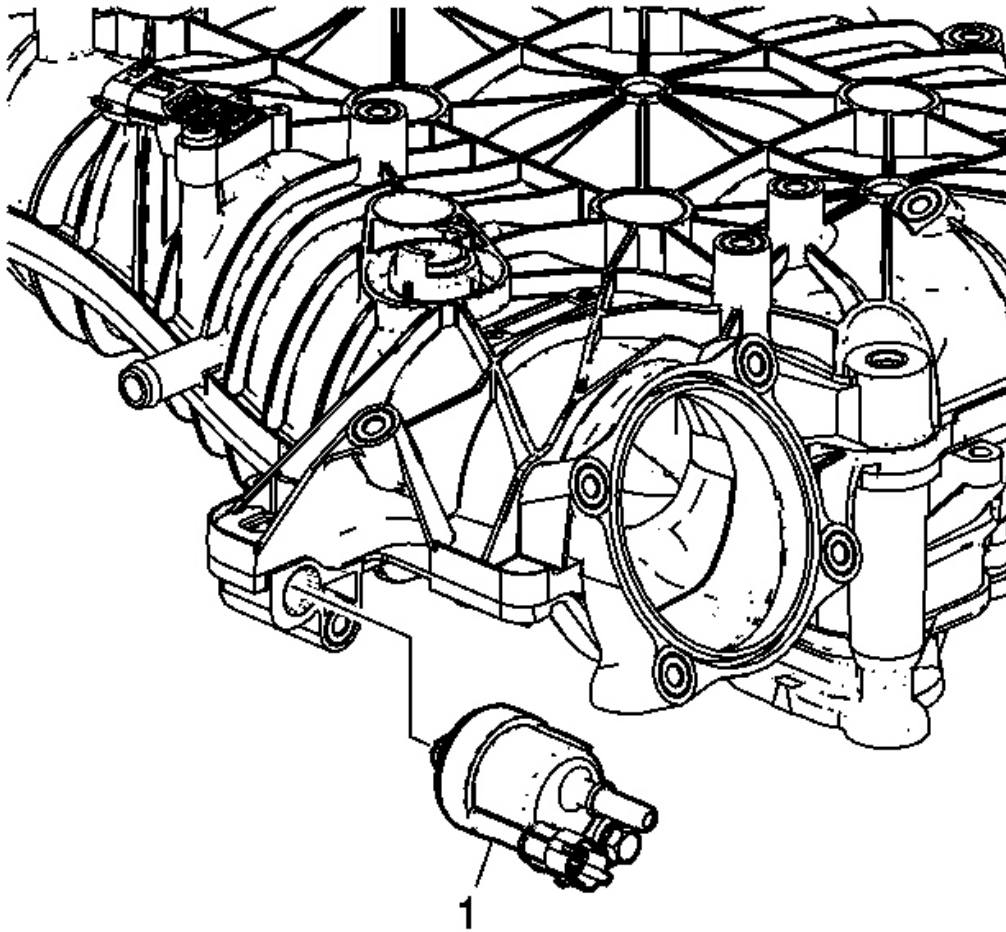


Fig. 197: EVAP Solenoid
Courtesy of GENERAL MOTORS CORP.

4. Loosen the evaporative (EVAP) solenoid bolt.
5. Remove the EVAP solenoid (1).

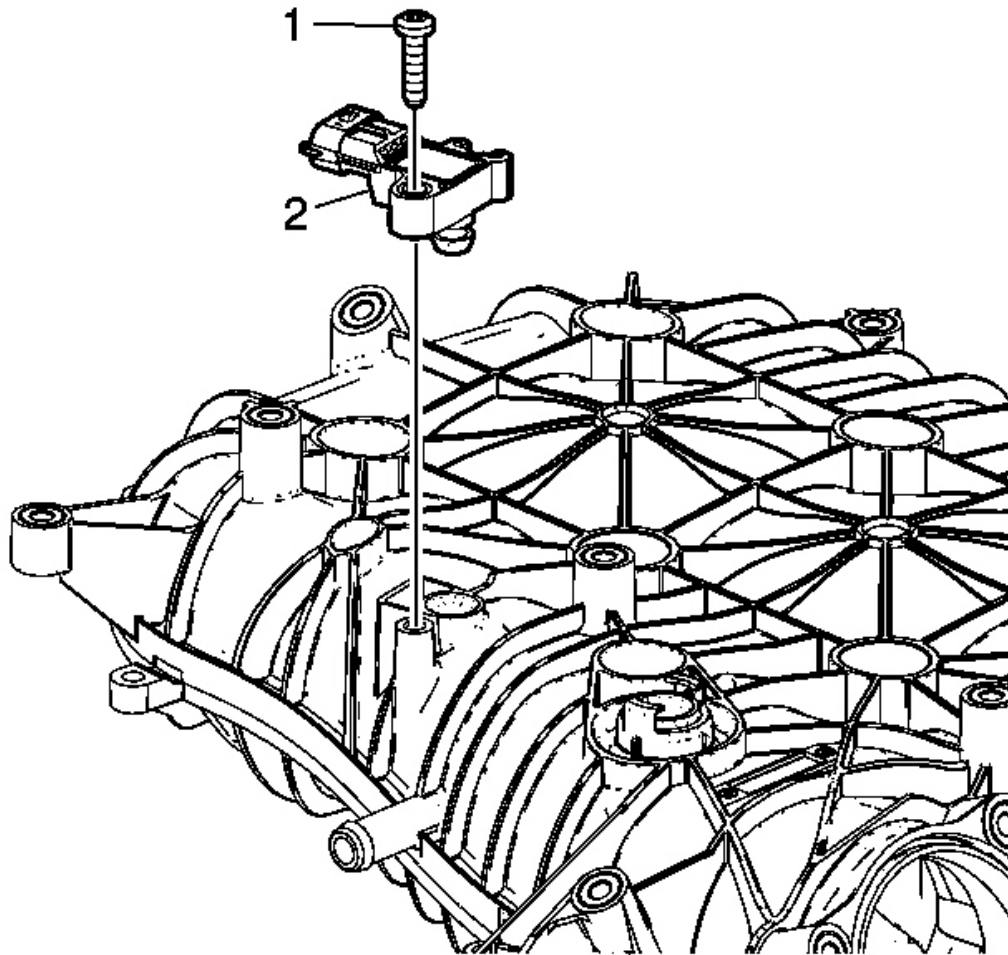


Fig. 198: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

6. Remove the manifold absolute pressure (MAP) sensor bolt (1).
7. Remove the MAP sensor (2).

INTAKE MANIFOLD CLEANING AND INSPECTION (LF1 OR LFW)

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

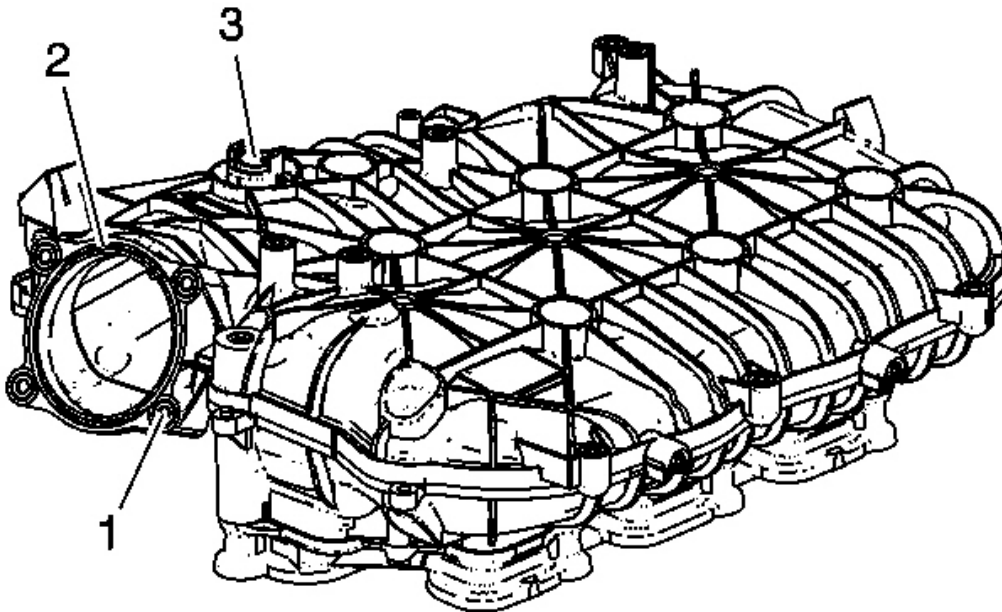


Fig. 199: Inspecting Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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)

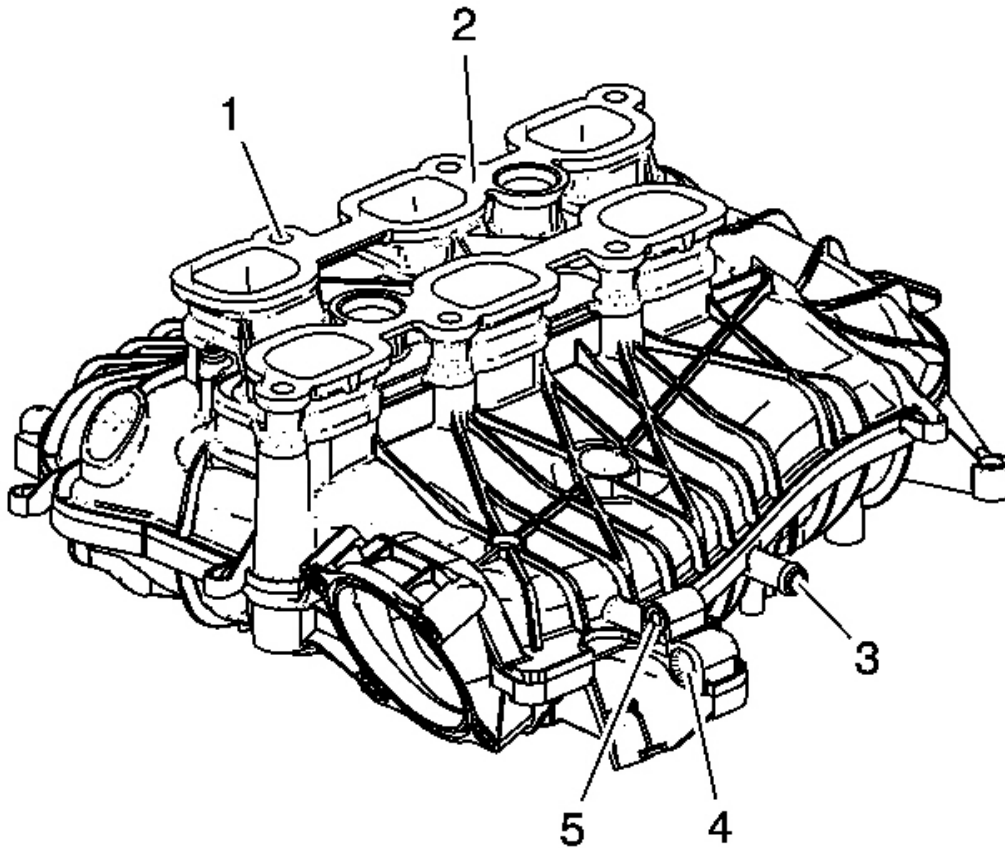


Fig. 200: Inspecting Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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)

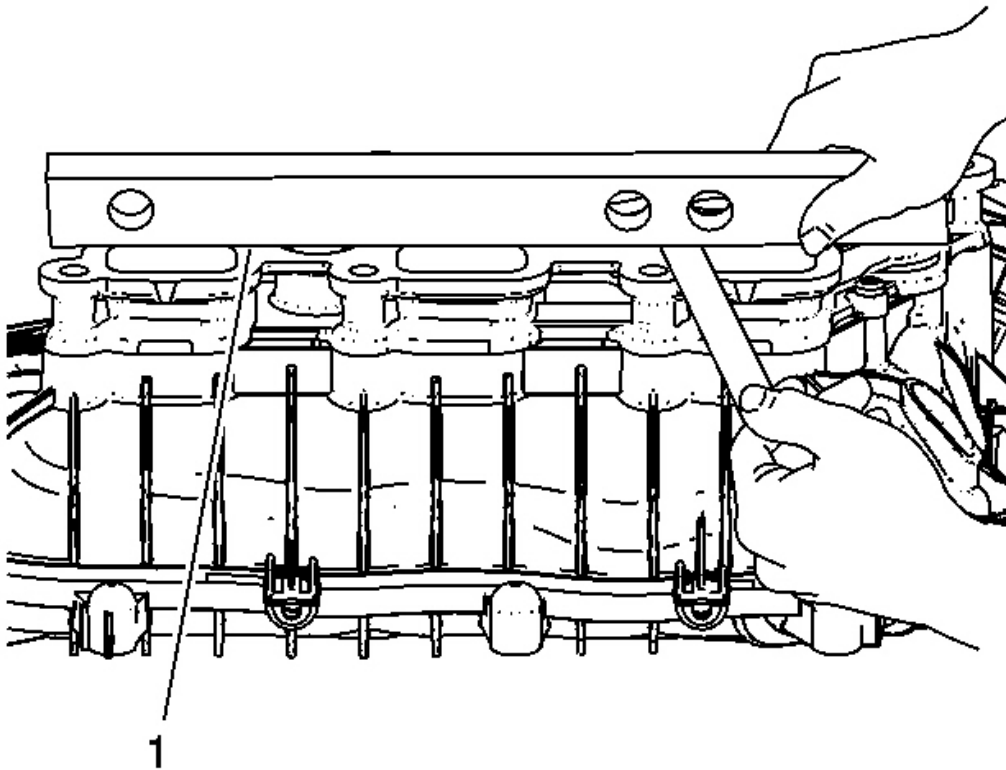


Fig. 201: Inspecting Intake Manifold Sealing Surface
Courtesy of GENERAL MOTORS CORP.

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 ASSEMBLY (LF1 OR LFW)

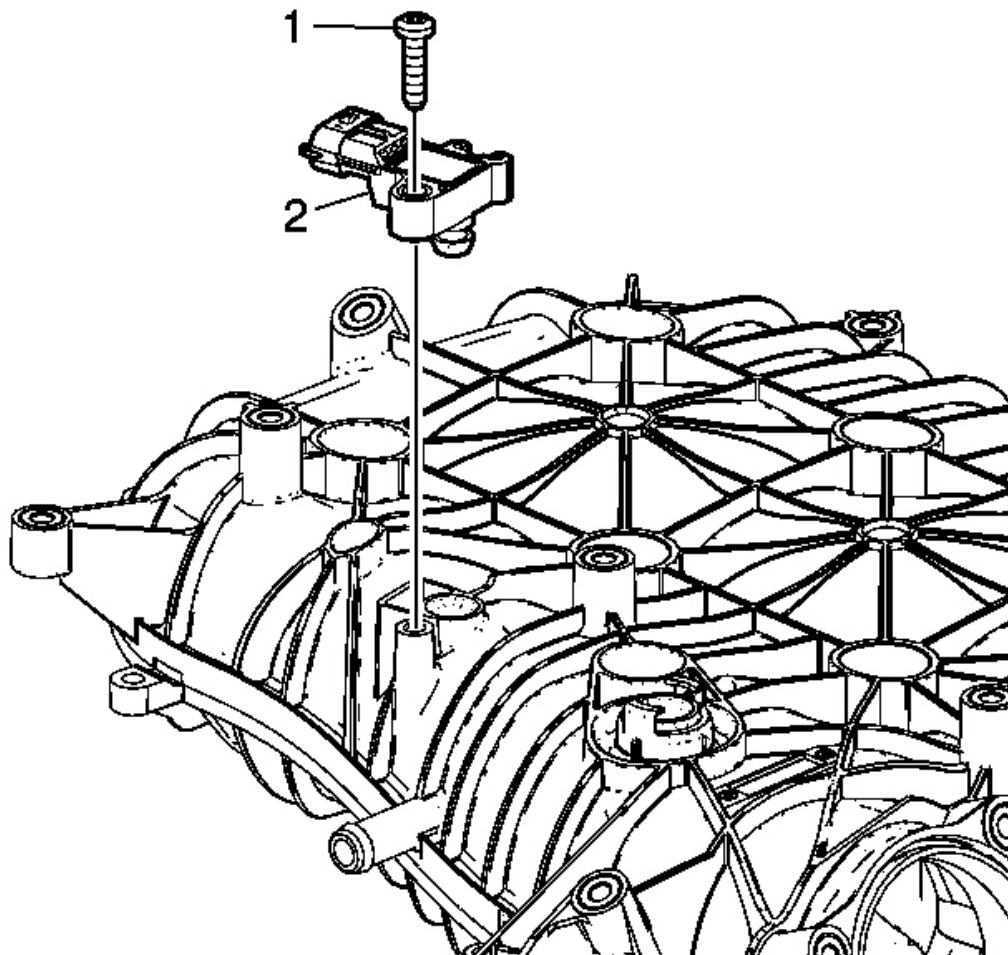


Fig. 202: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

1. Install the MAP sensor (2).
2. Install the MAP sensor bolt (1) and tighten to 4 N.m (35 lb in).

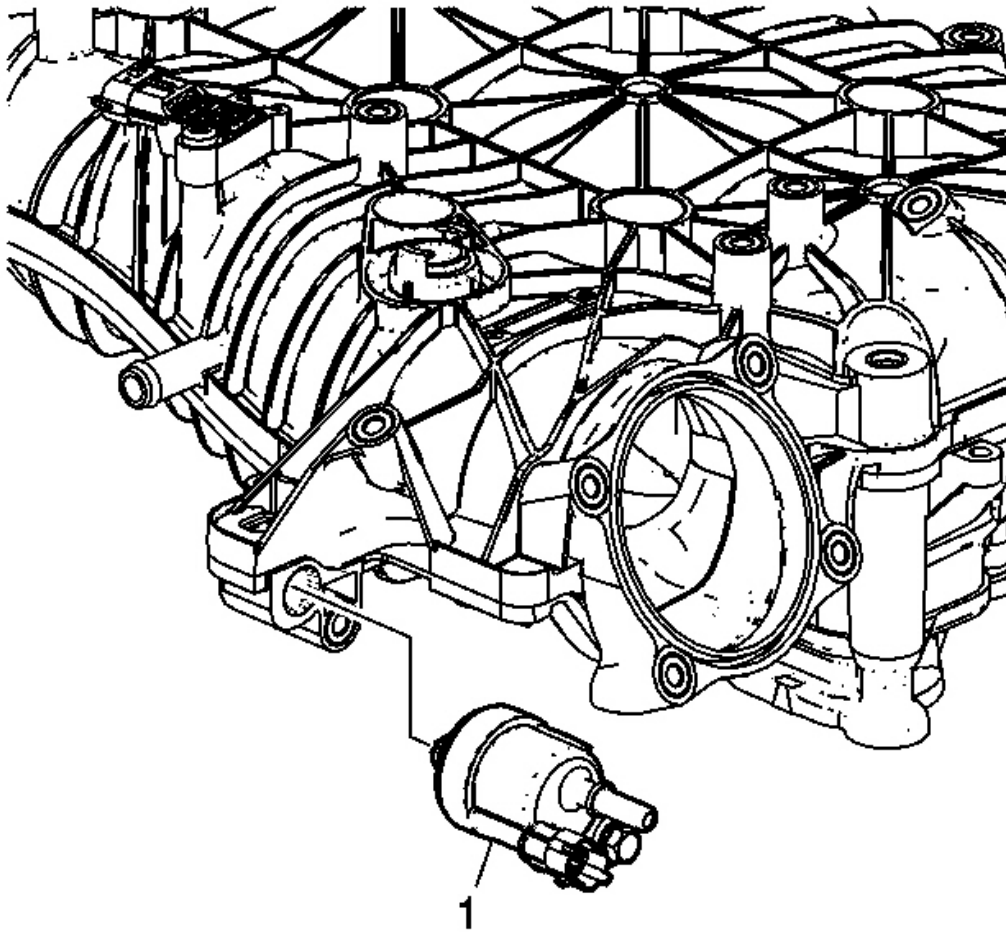


Fig. 203: EVAP Solenoid
Courtesy of GENERAL MOTORS CORP.

3. Install the EVAP solenoid (1).
4. Tighten the EVAP solenoid bolt to 10 N.m (89 lb in).

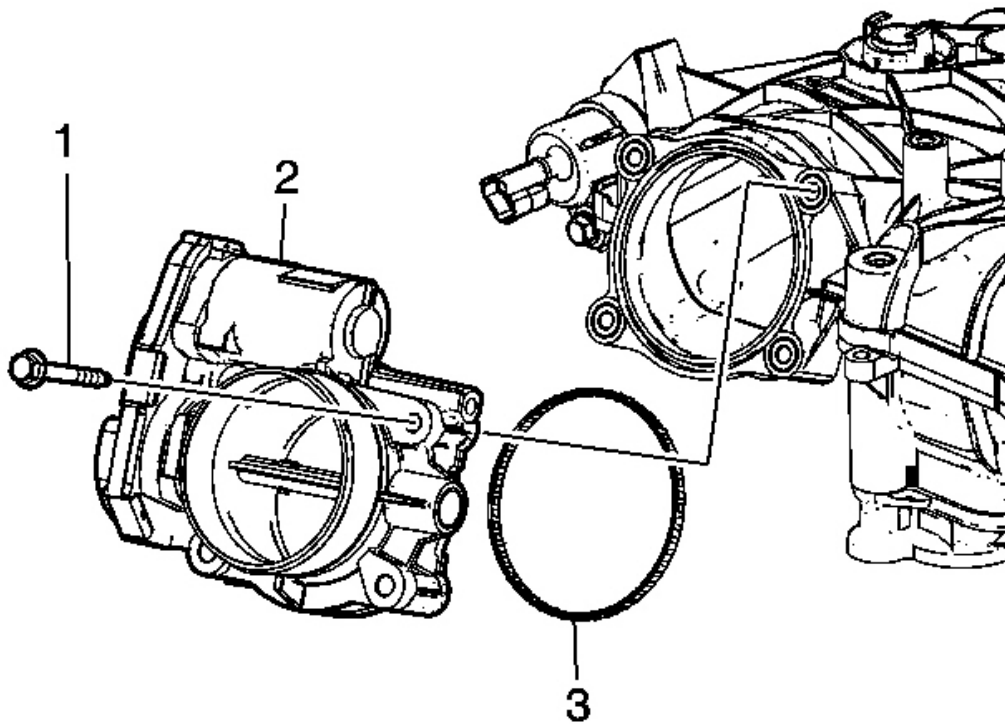


Fig. 204: Throttle Body Components
Courtesy of GENERAL MOTORS CORP.

5. Install the NEW throttle body seal (3).
6. Install the throttle body (2).
7. 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.

INSPECTION PROCEDURE

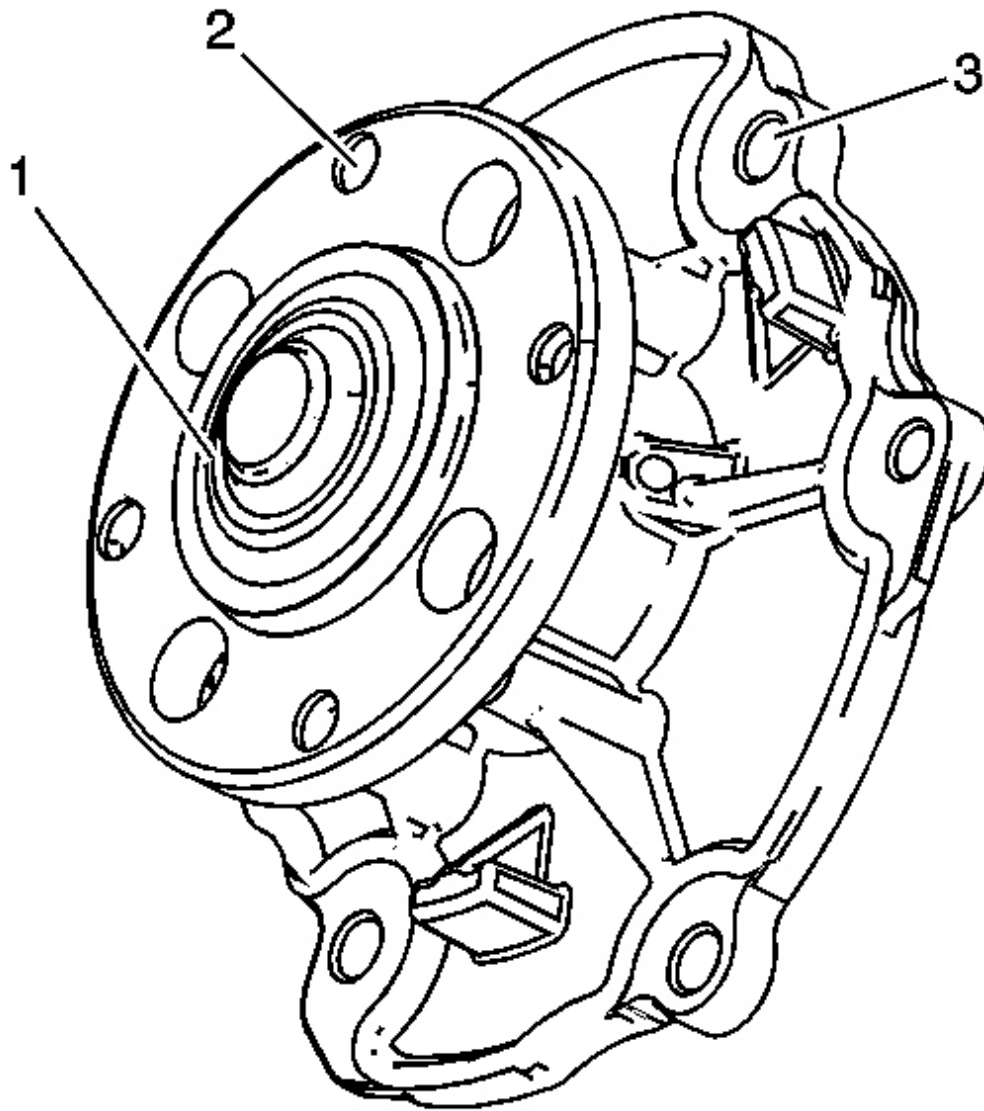


Fig. 205: Inspecting Water Pump & Hub
Courtesy of GENERAL MOTORS CORP.

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)

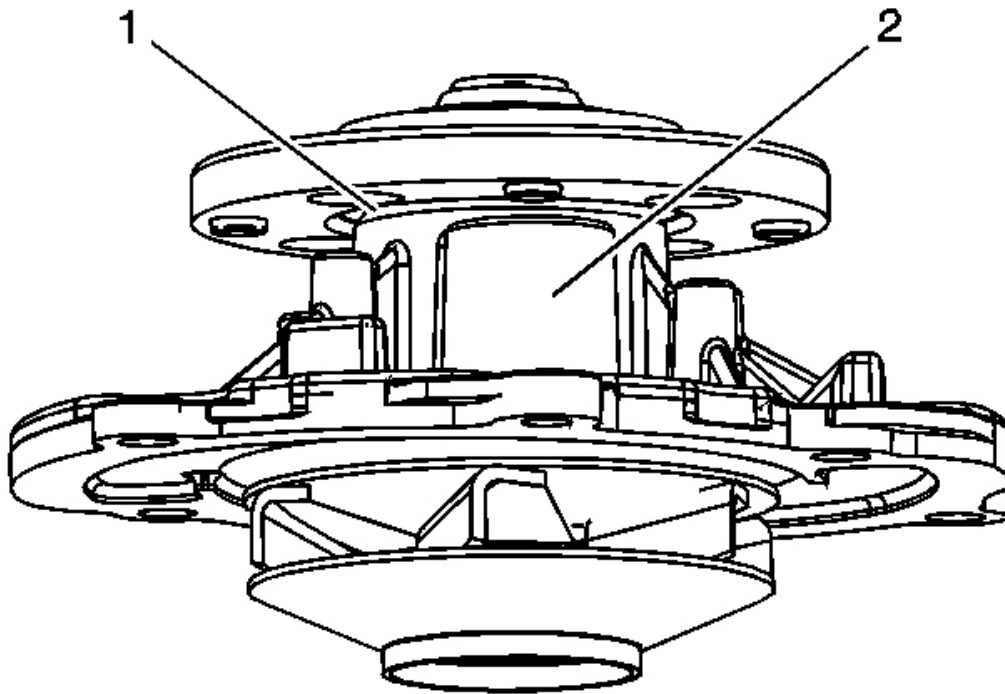


Fig. 206: Checking Water Pump Shaft & Weep Hole For Leakage
Courtesy of GENERAL MOTORS CORP.

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.

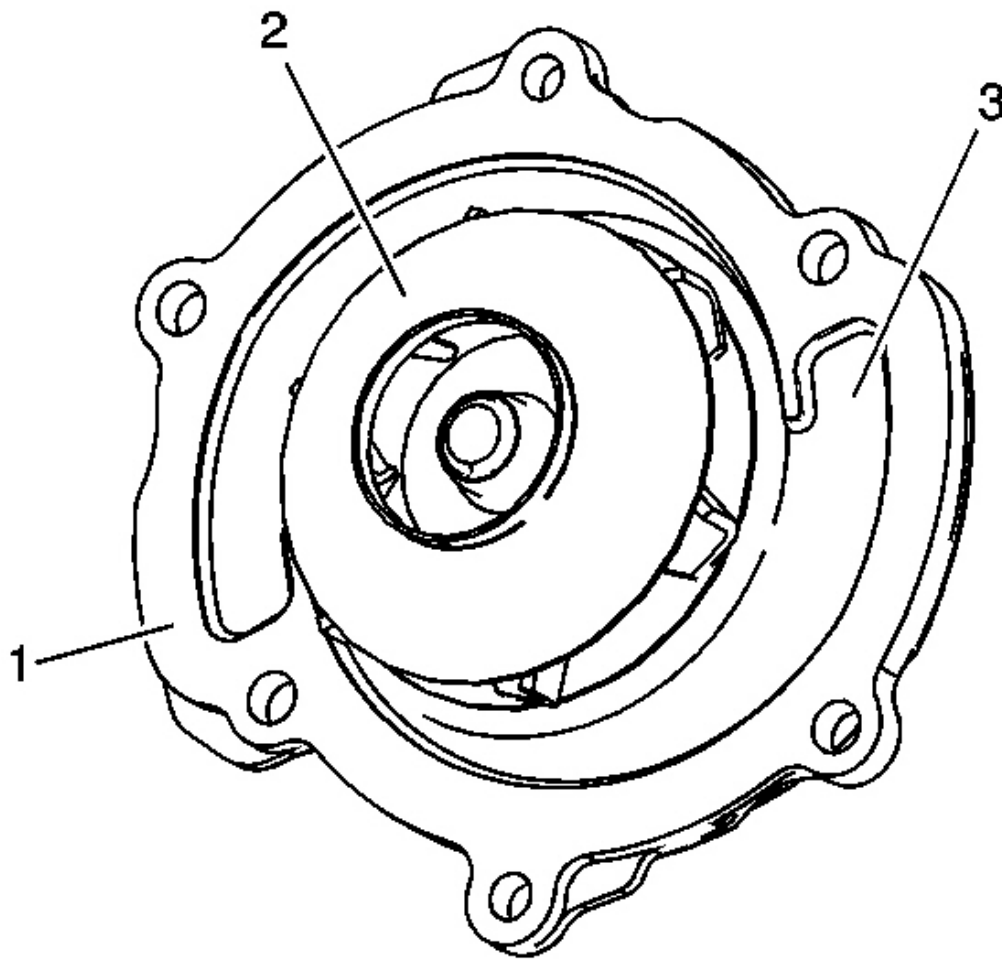


Fig. 207: Inspecting Interior Of Water Pump For Damage
Courtesy of GENERAL MOTORS CORP.

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.

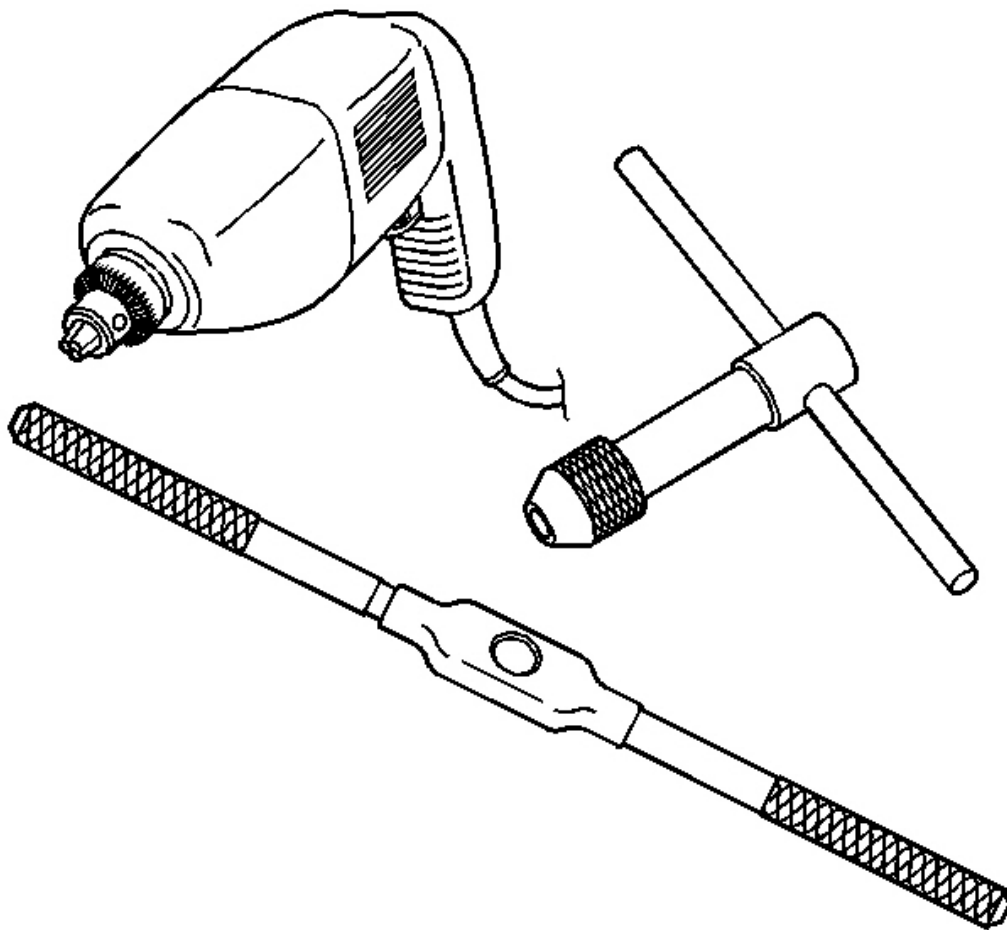


Fig. 208: View Of J 42385-400 Tool Kit
Courtesy of GENERAL MOTORS CORP.

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.

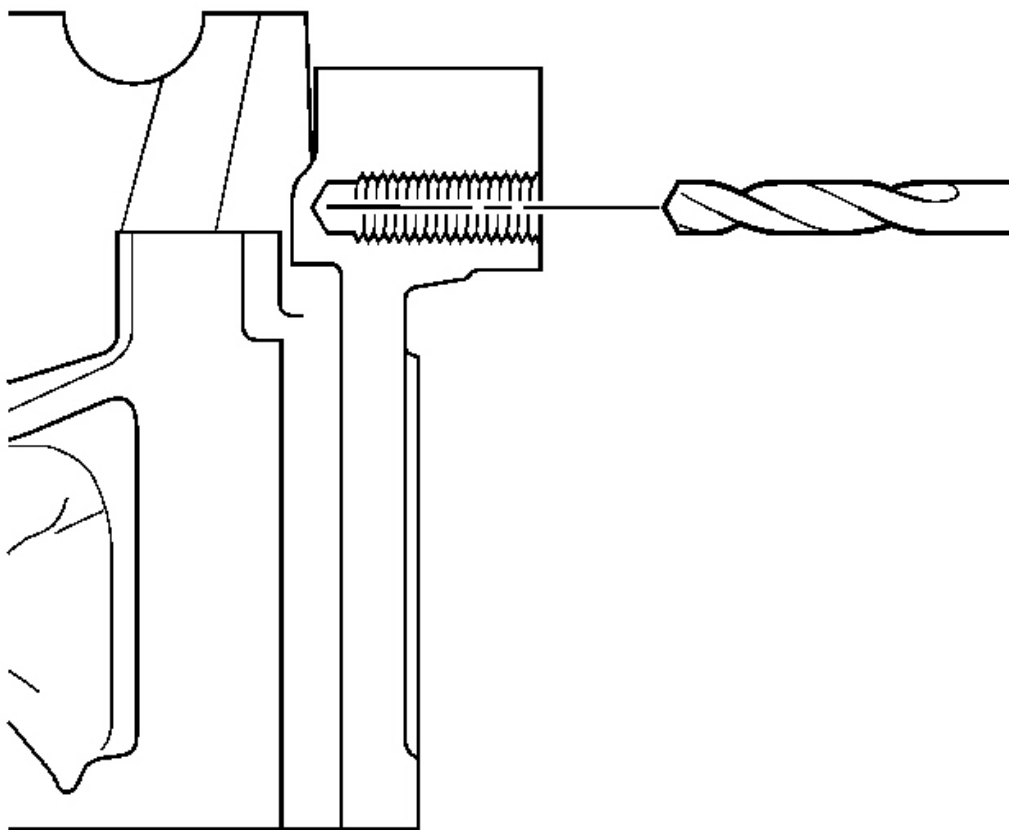


Fig. 209: Drilled Hole Centerline
Courtesy of GENERAL MOTORS CORP.

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

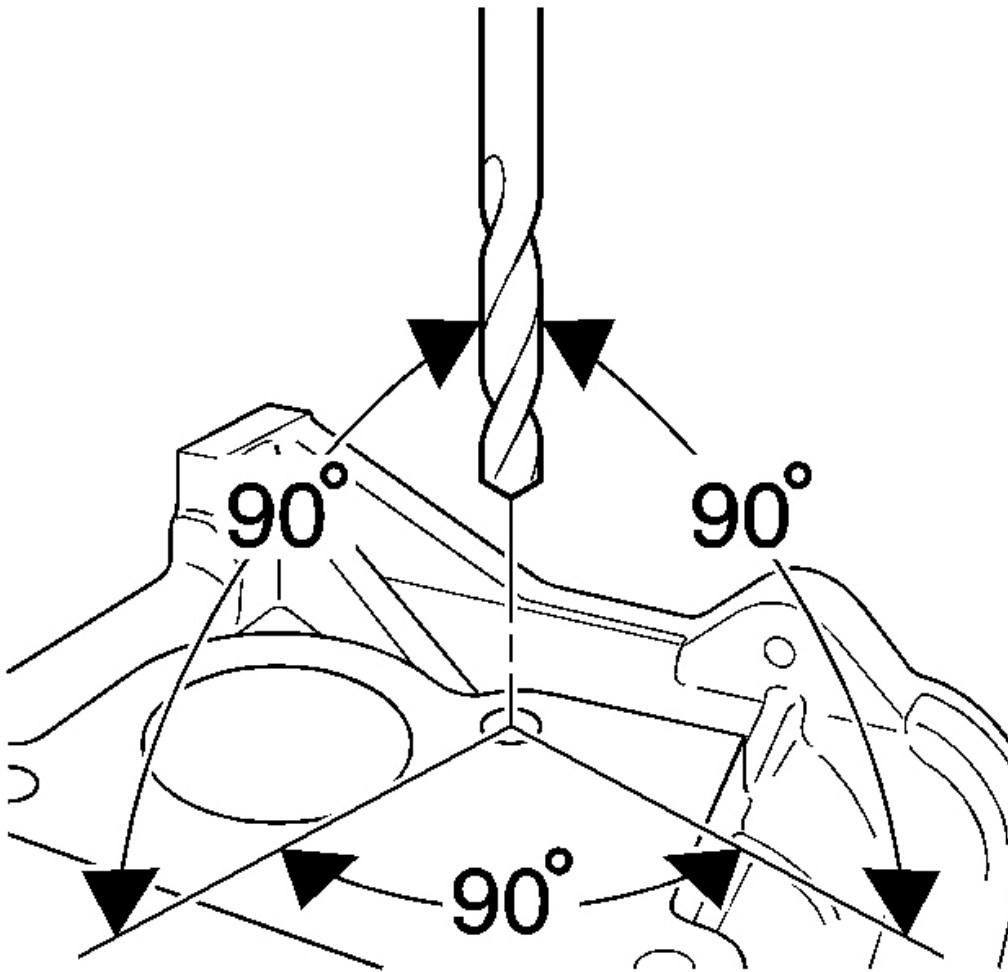


Fig. 210: Identifying Proper Drilling Angle
Courtesy of GENERAL MOTORS CORP.

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

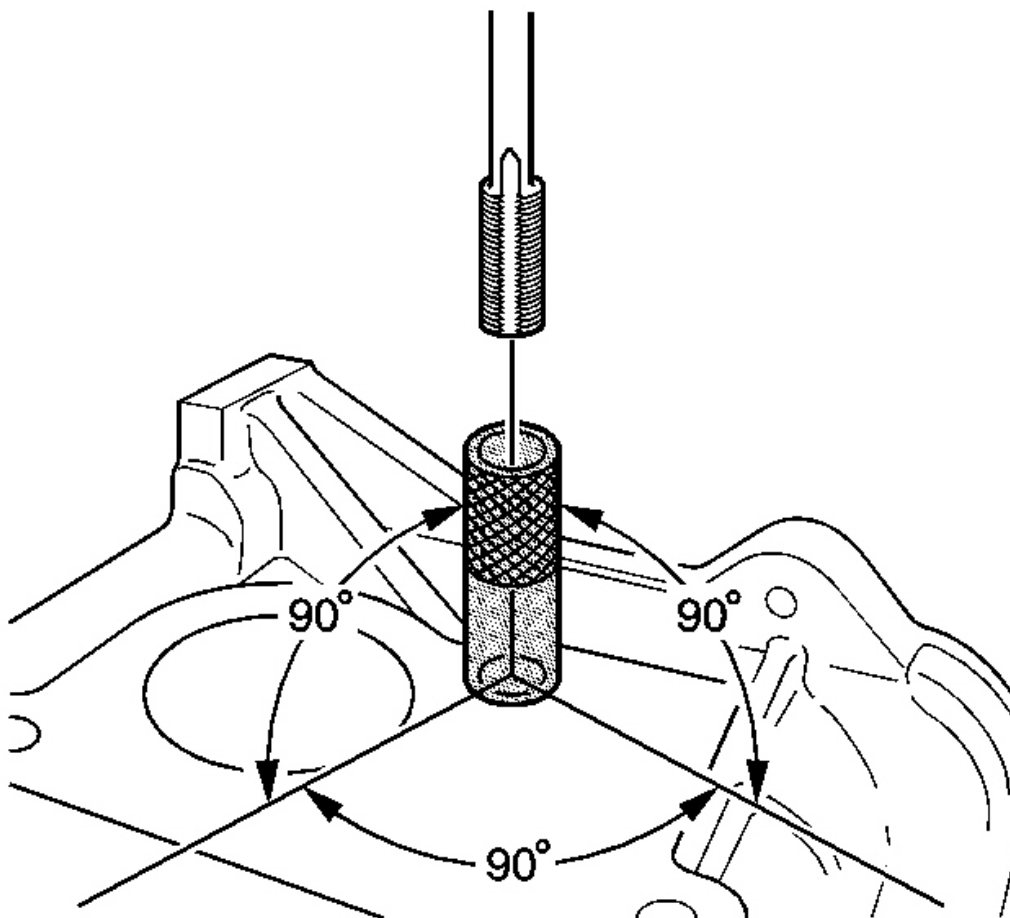


Fig. 211: View Of Tapping Guide
 Courtesy of GENERAL MOTORS CORP.

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

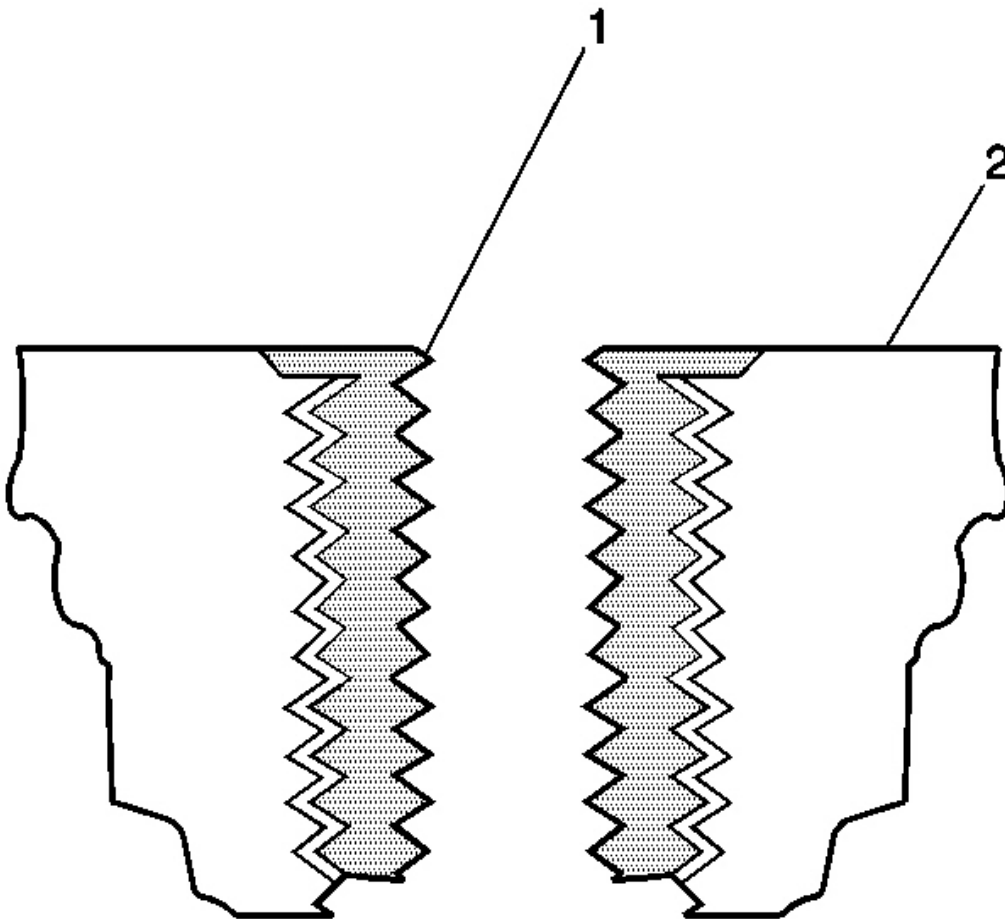


Fig. 212: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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.

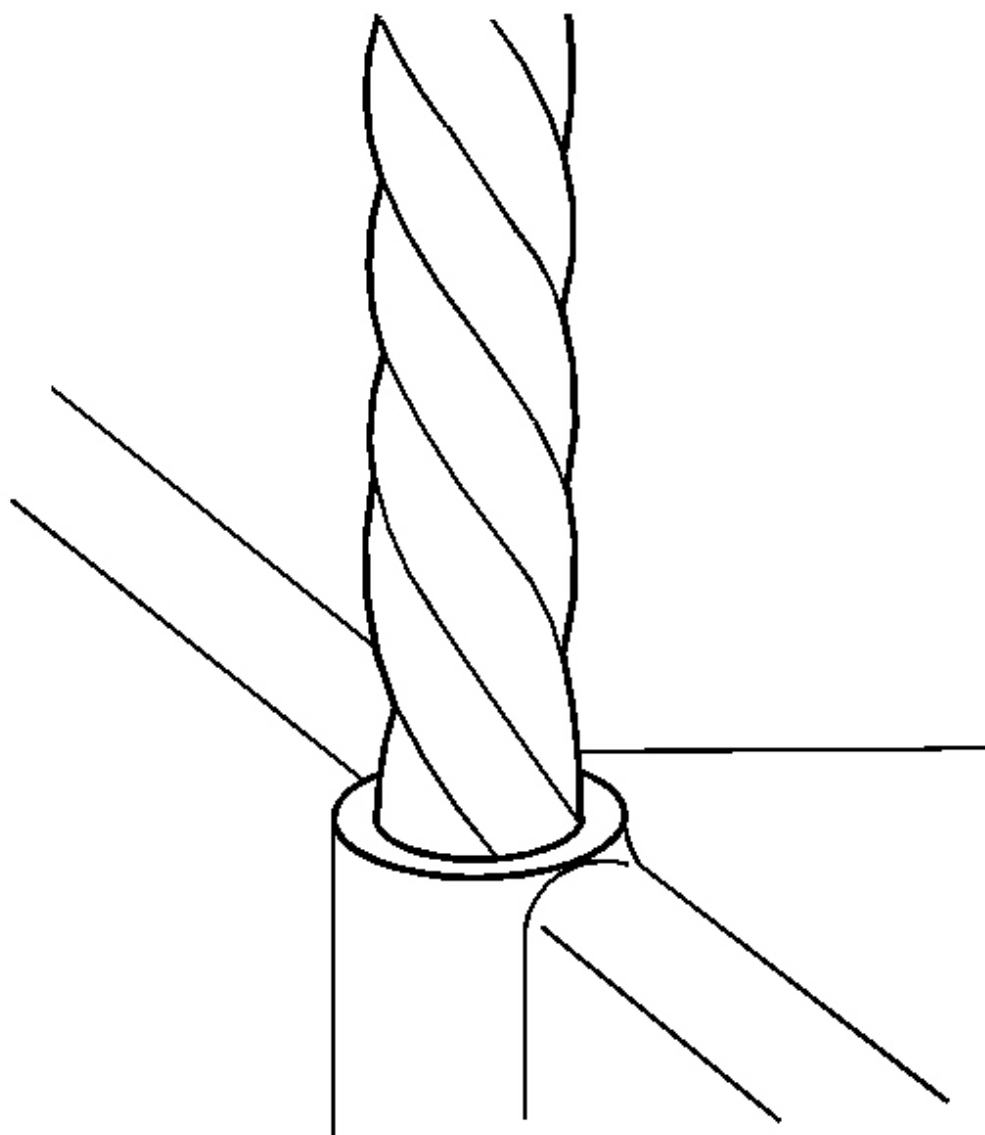


Fig. 213: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

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.

1. 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).

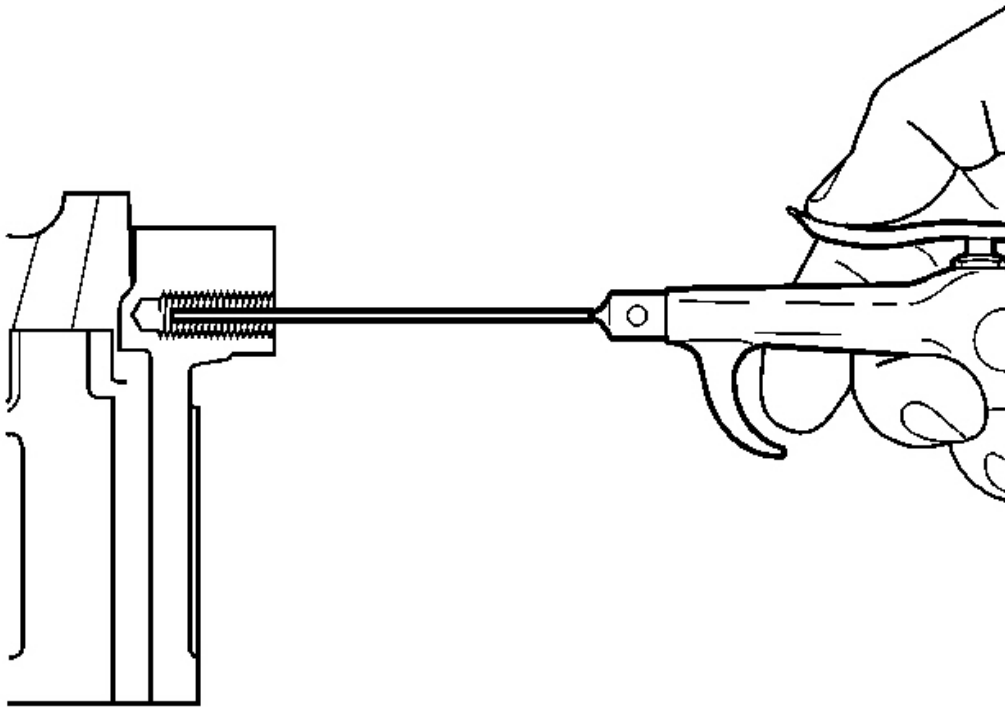


Fig. 214: Cleaning Out Metal Chips

Courtesy of GENERAL MOTORS CORP.

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

2. Using compressed air, clean out any chips.

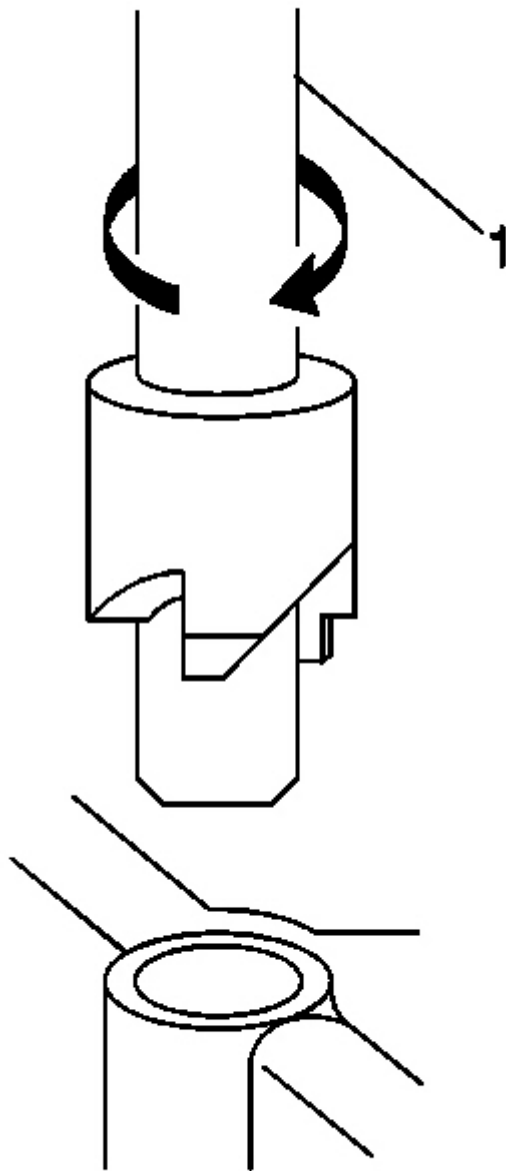


Fig. 215: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

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

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

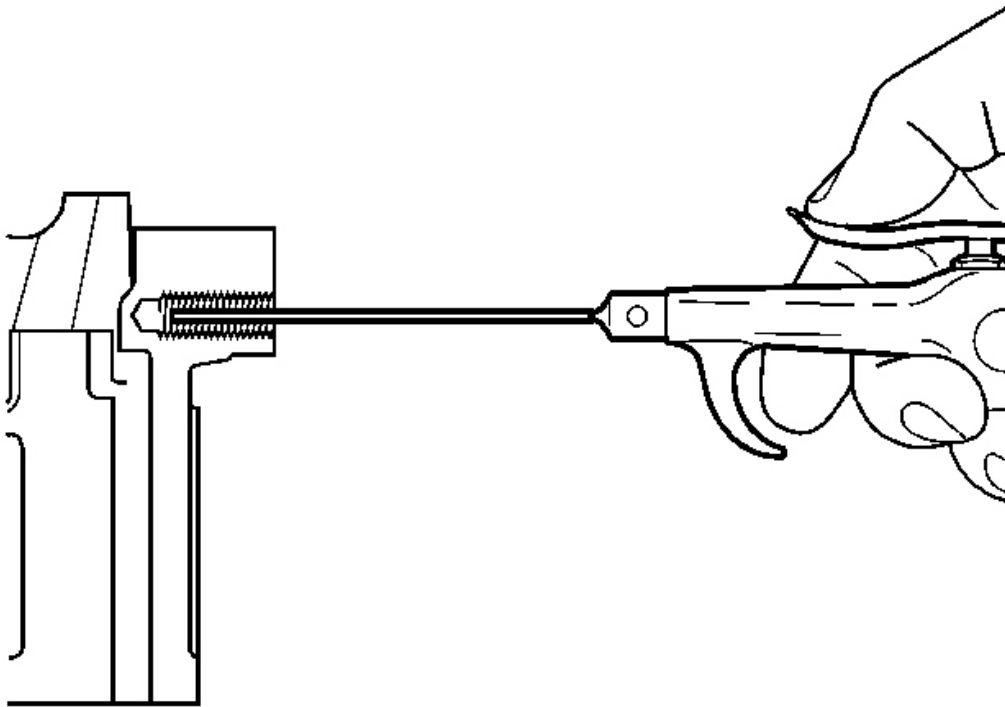


Fig. 216: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

4. Using compressed air, clean out any chips.

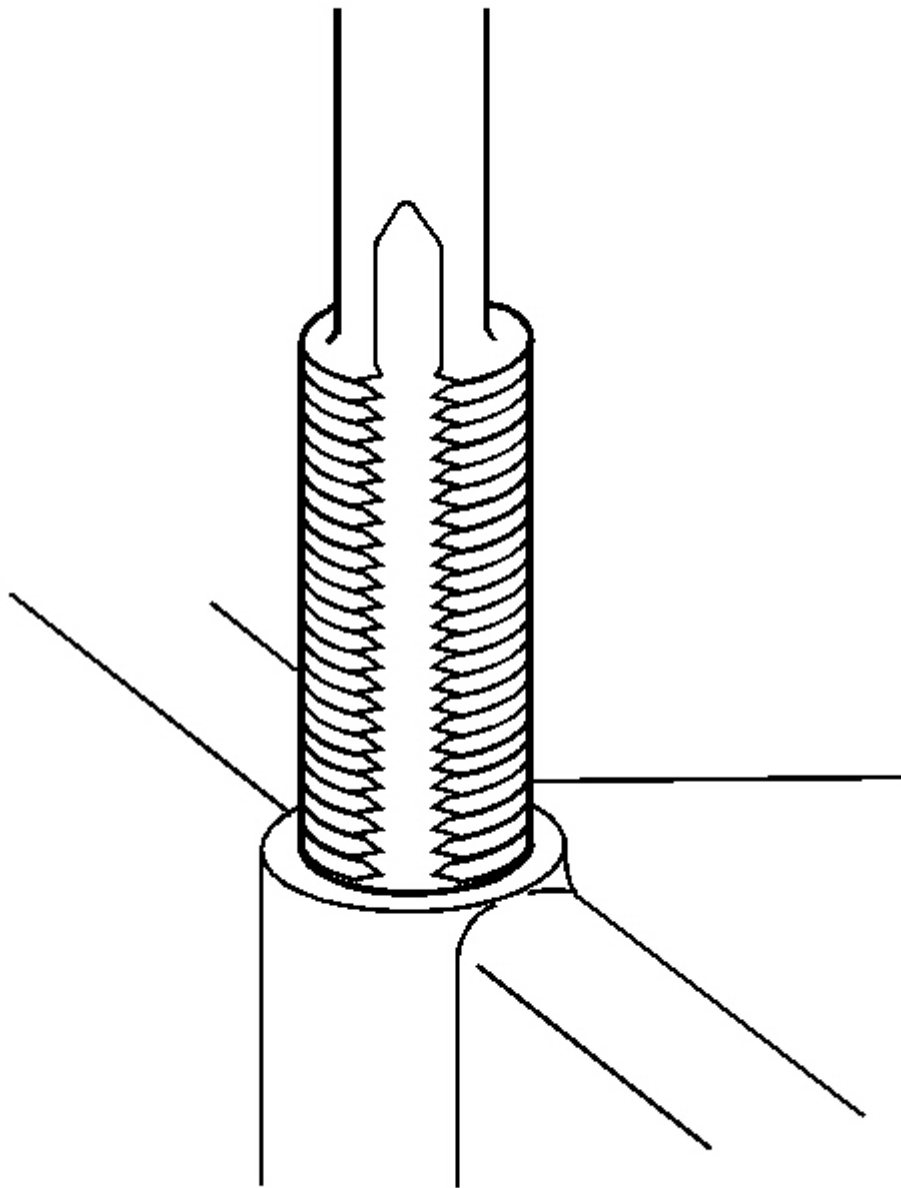


Fig. 217: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

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.**

5. 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).

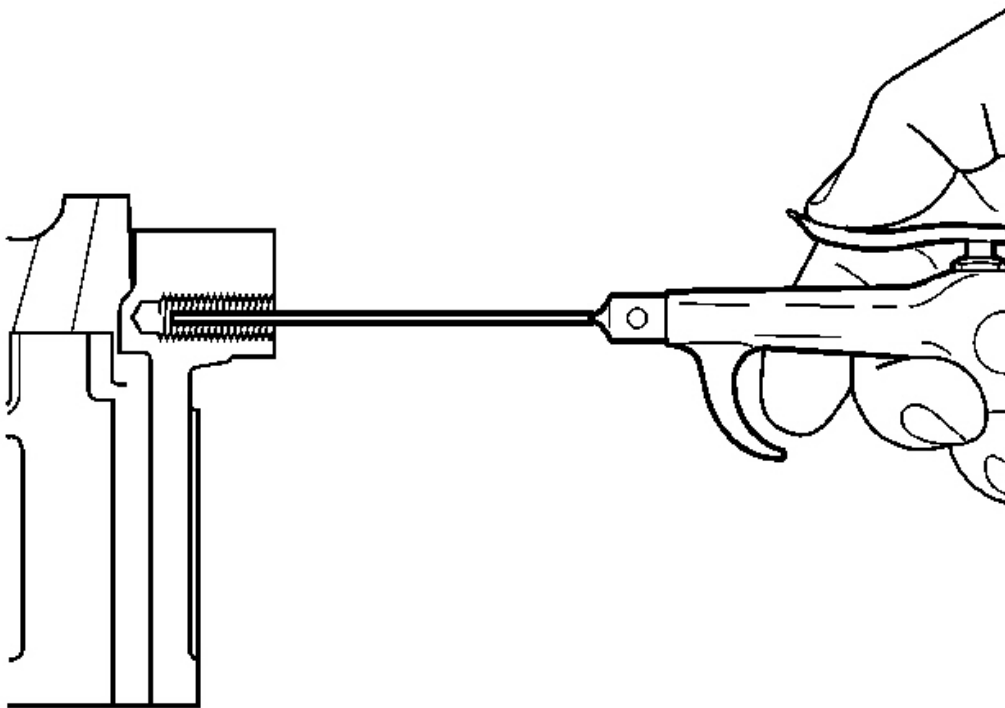


Fig. 218: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

6. Using compressed air, clean out any chips.

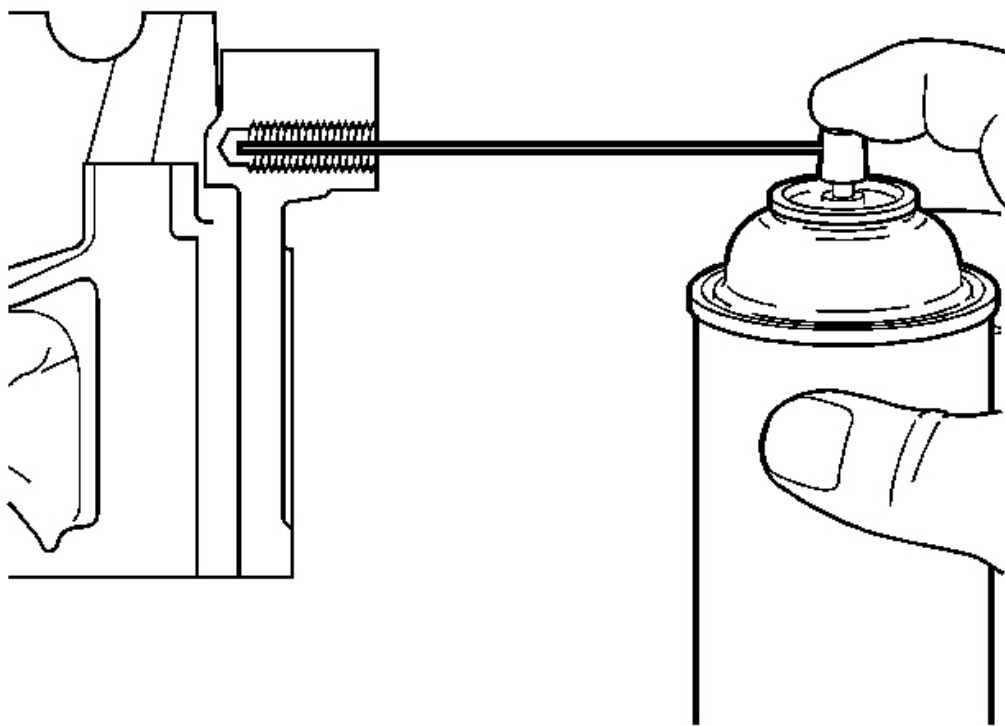


Fig. 219: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

7. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended cleaner.

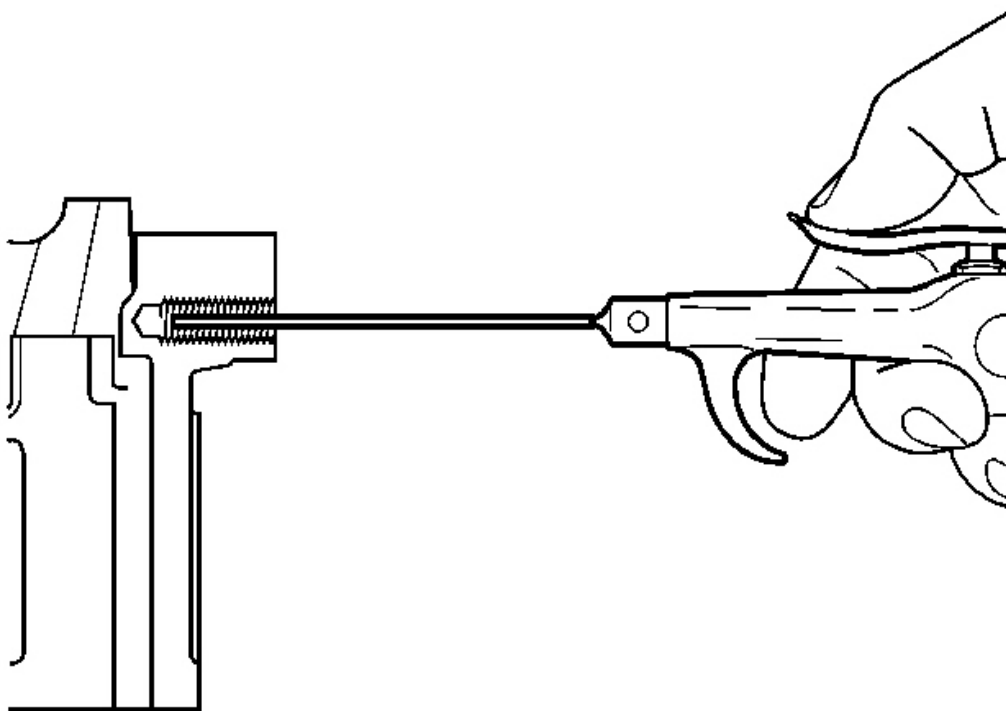


Fig. 220: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

8. Using compressed air, clean out any chips.

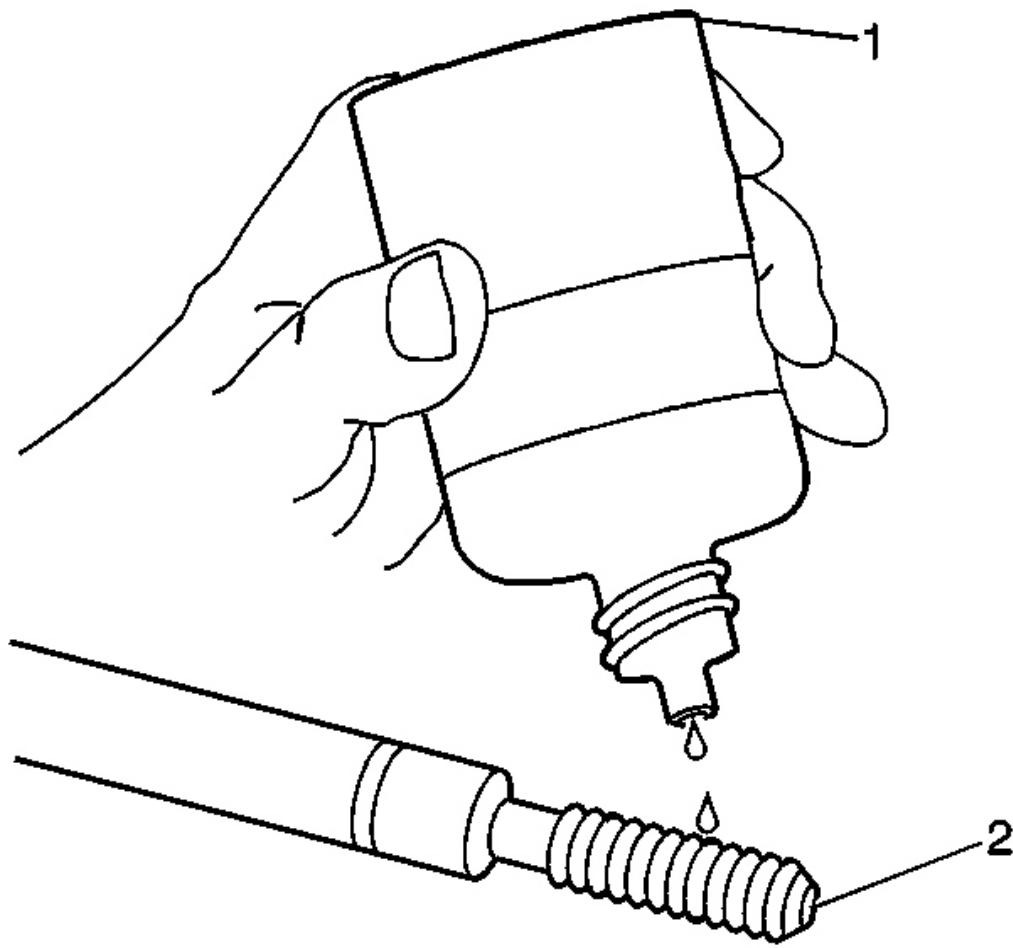


Fig. 221: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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

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

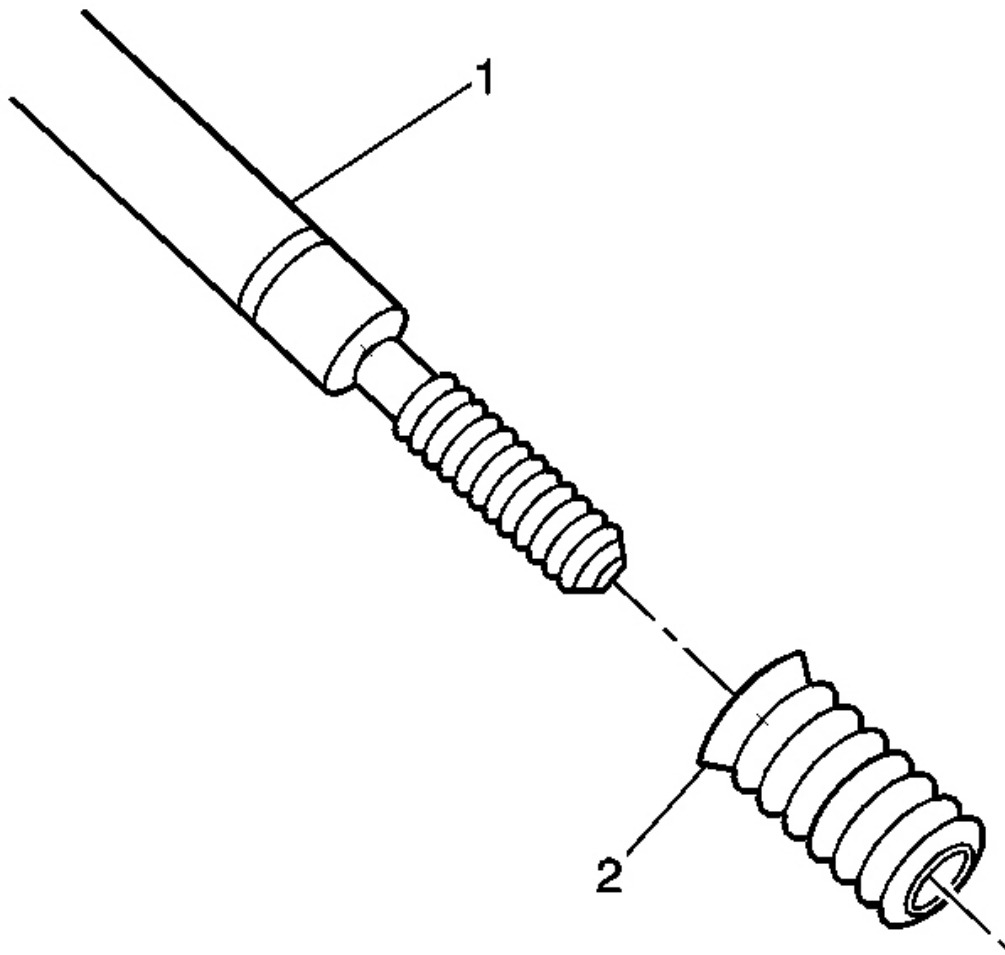


Fig. 222: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

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

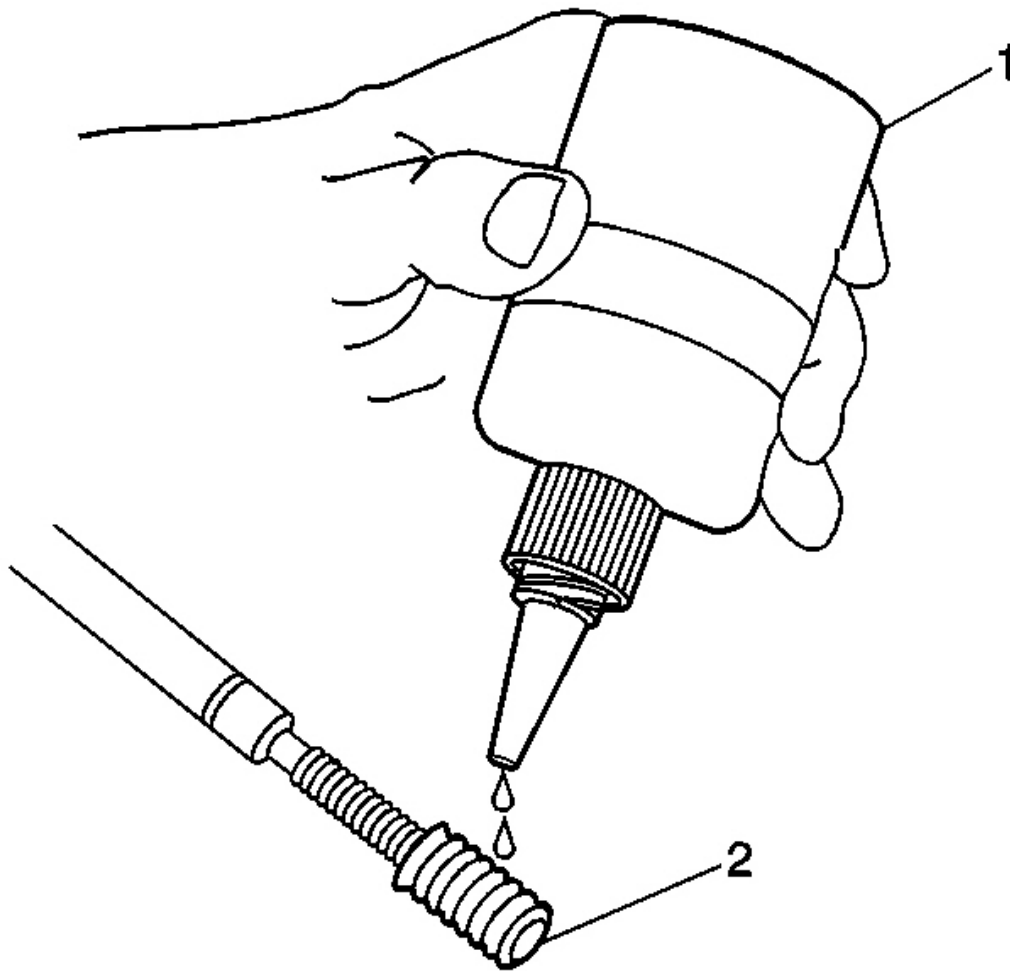


Fig. 223: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

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

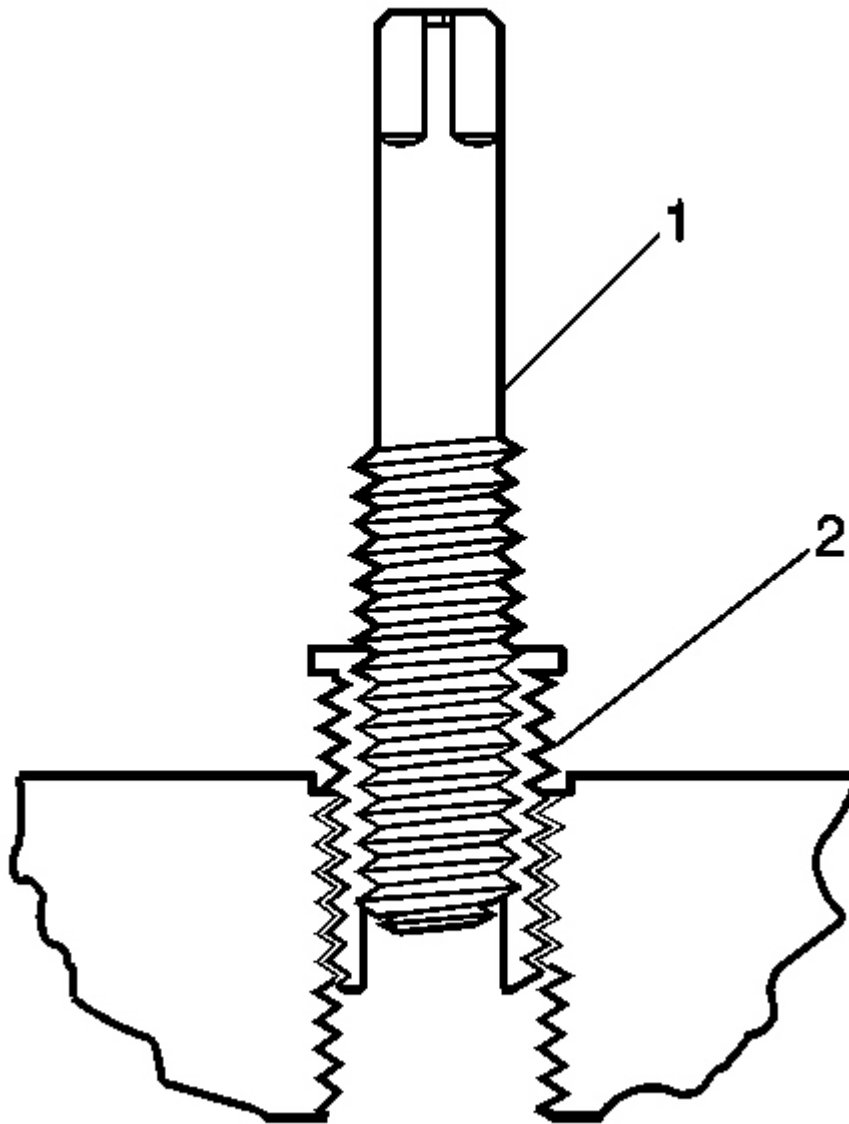


Fig. 224: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

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.

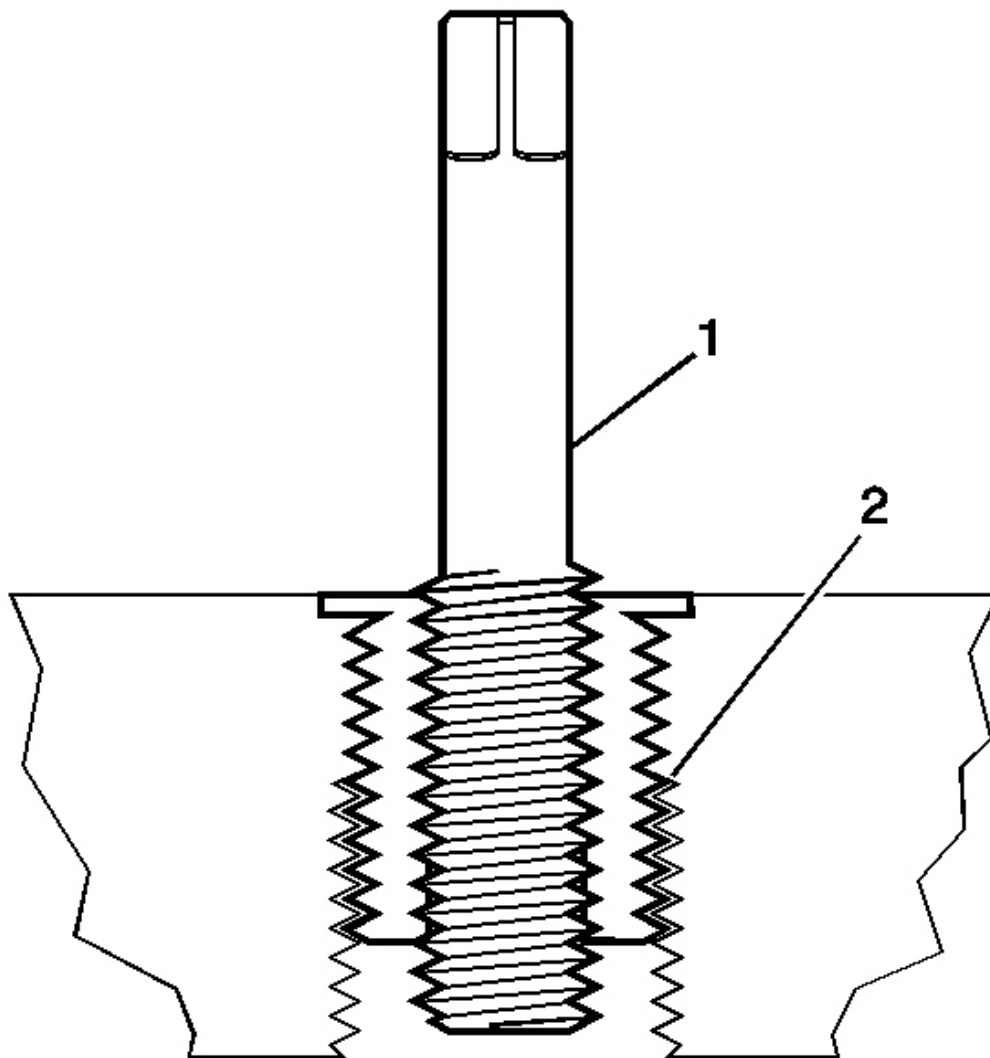


Fig. 225: View Insert And Tool - Standard Thread
Courtesy of GENERAL MOTORS CORP.

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.

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

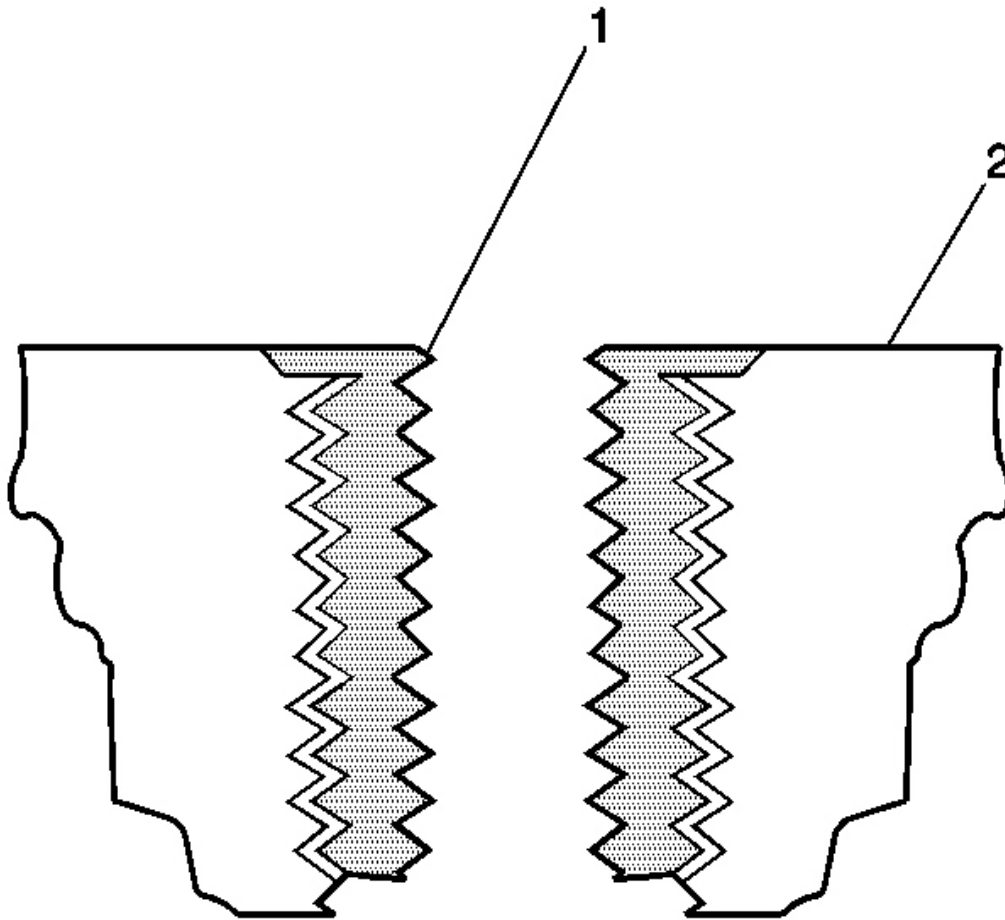


Fig. 226: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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).

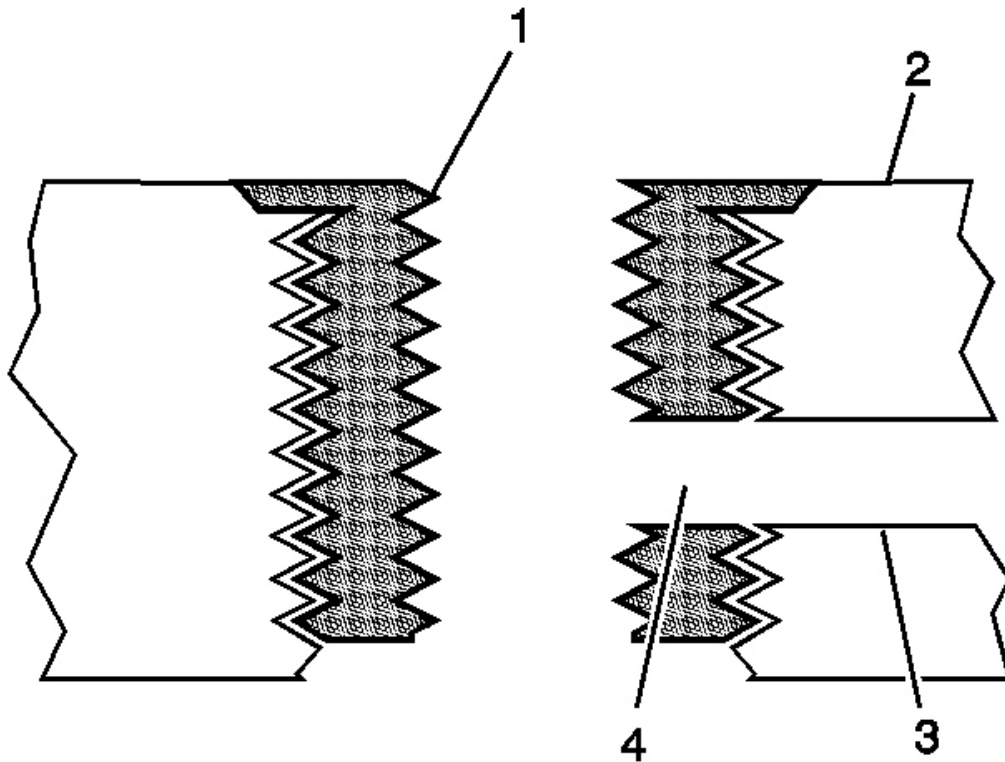


Fig. 227: View Of Restricted Engine Coolant Passages - Standard Thread Repair
Courtesy of GENERAL MOTORS CORP.

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

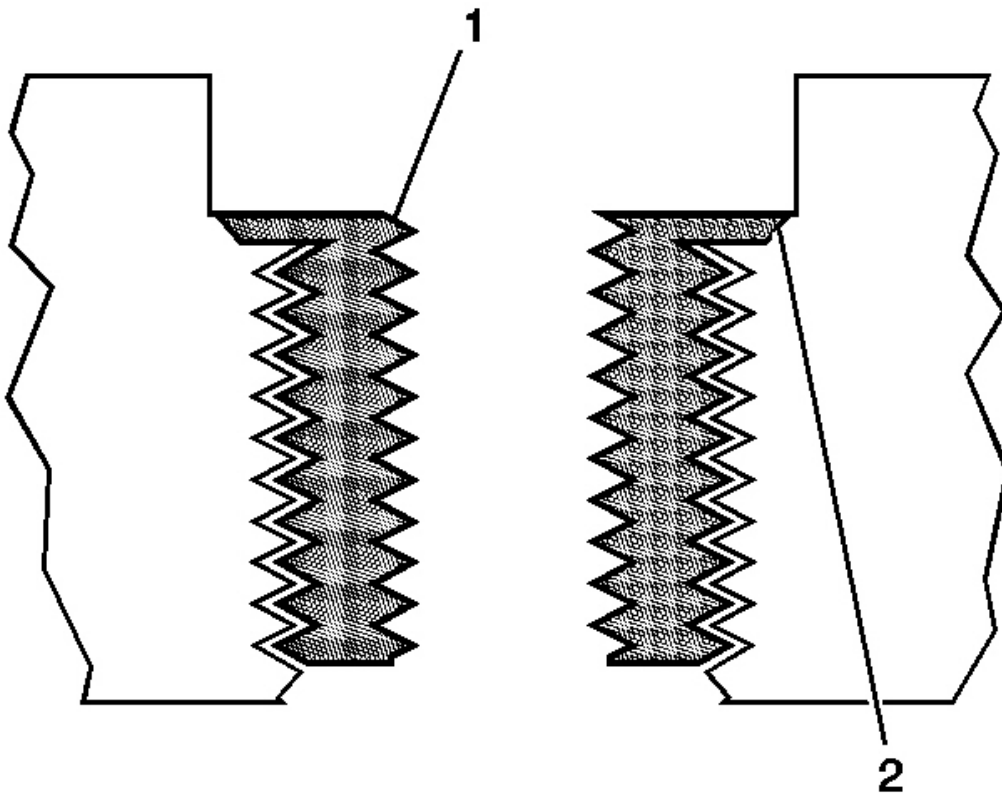


Fig. 228: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

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.

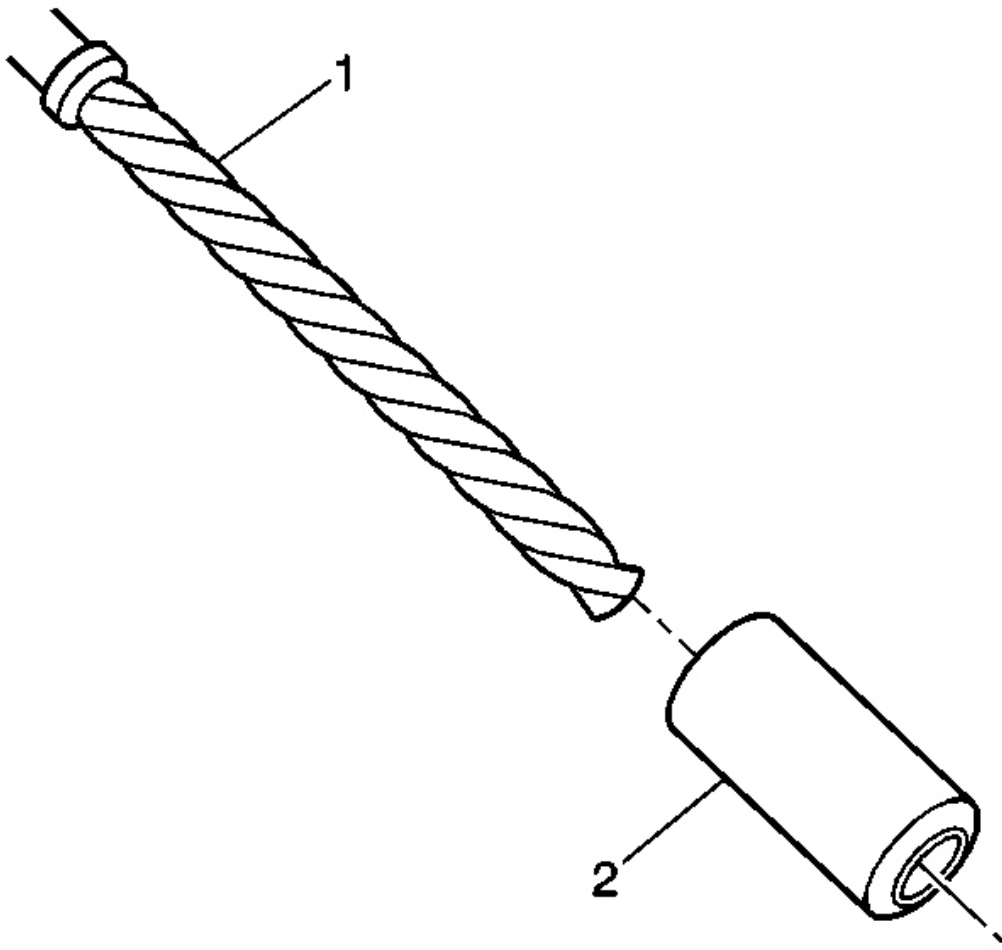


Fig. 229: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

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

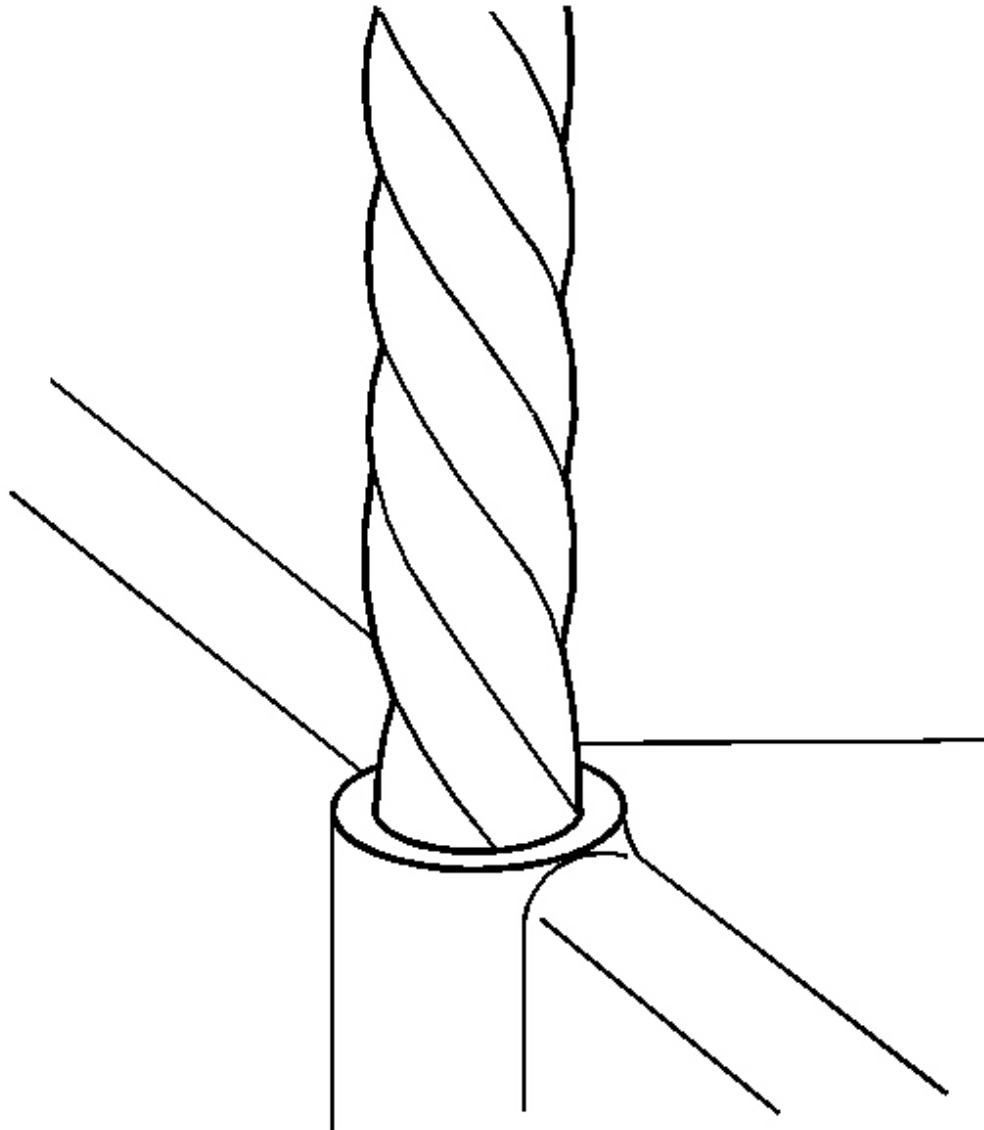


Fig. 230: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

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.

2. Drill out the threads of the damaged hole.

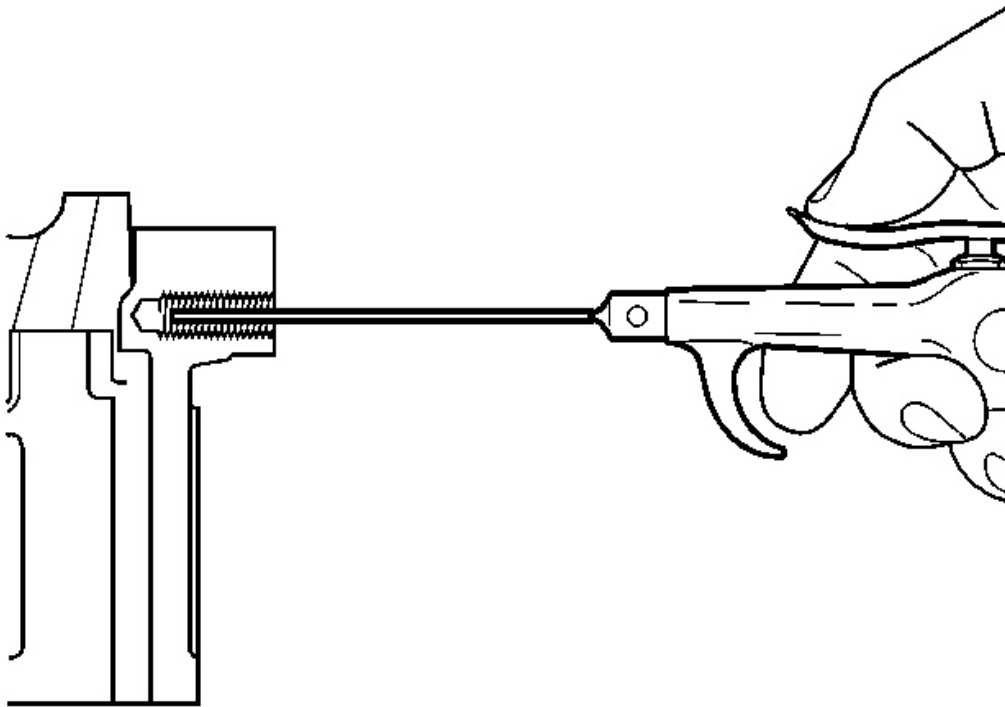


Fig. 231: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

3. Using compressed air, clean out any chips.

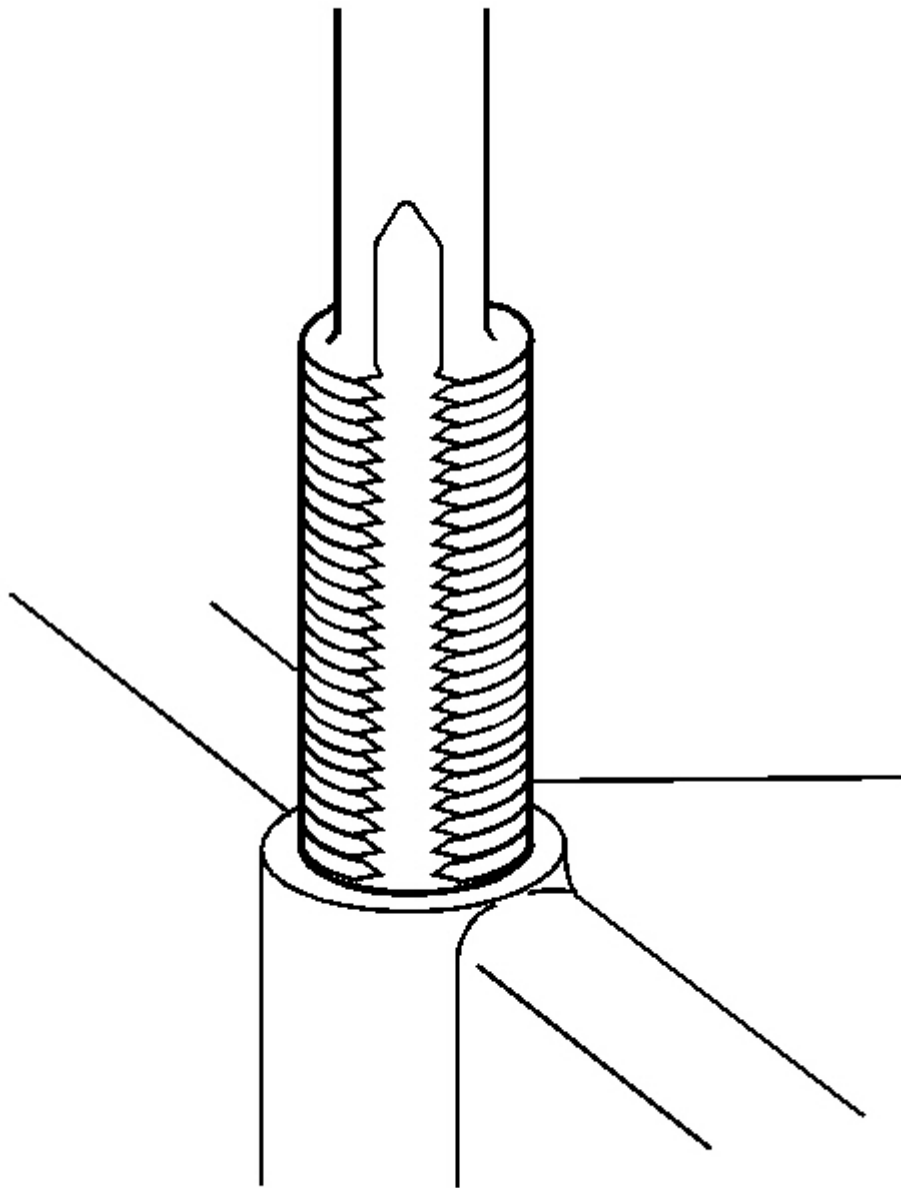


Fig. 232: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

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.

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

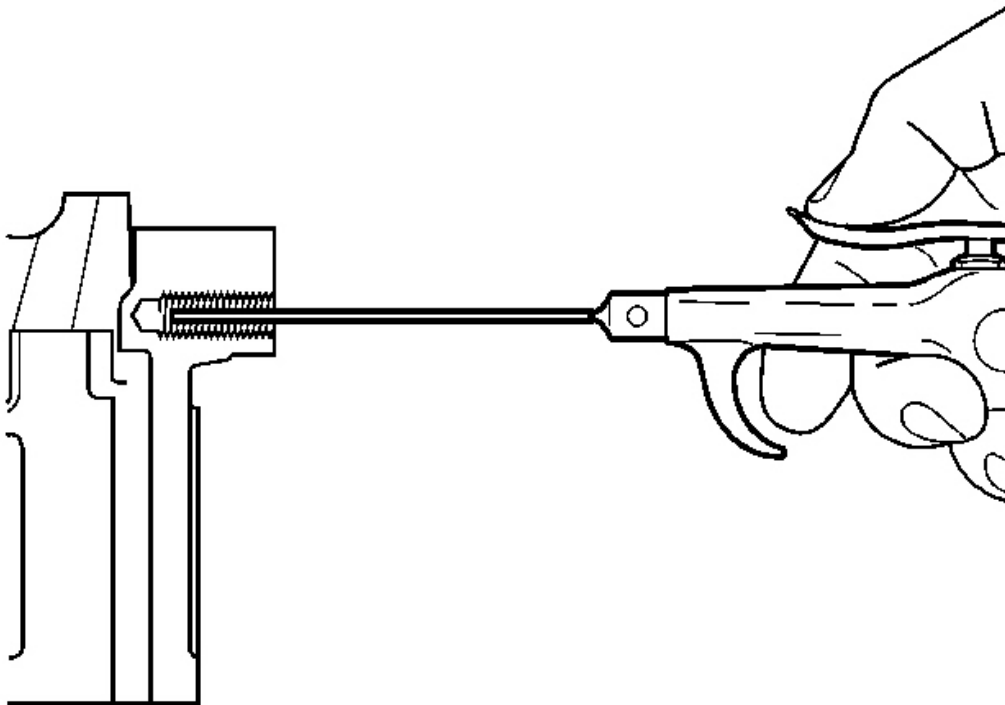


Fig. 233: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

5. Using compressed air, clean out any chips.

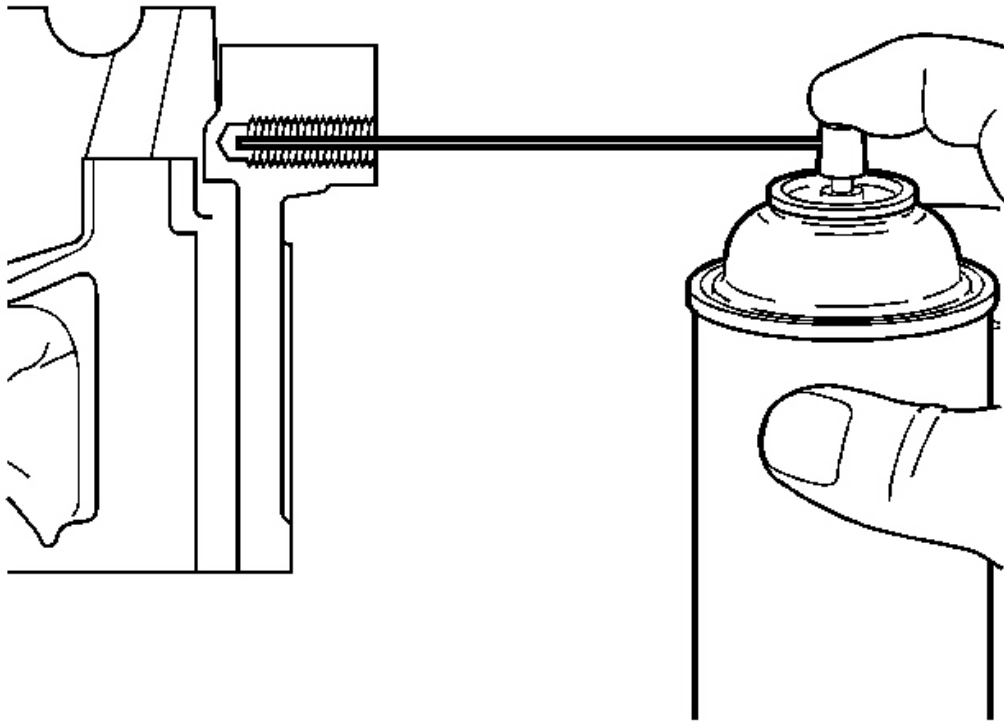


Fig. 234: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

6. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended cleaner.

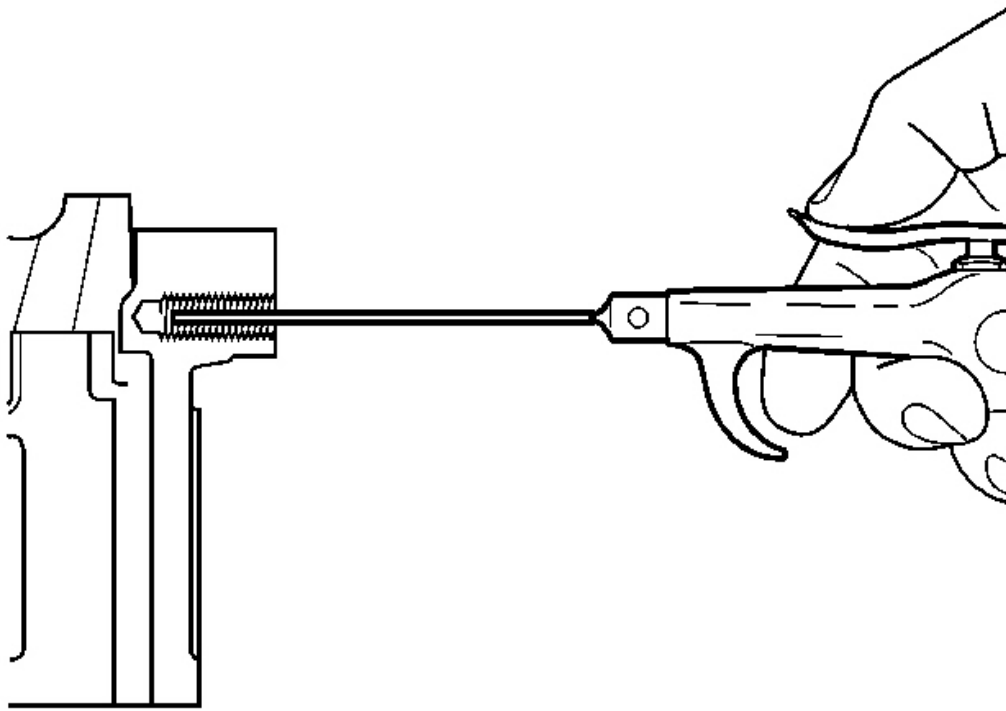


Fig. 235: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

7. Using compressed air, clean out any chips.

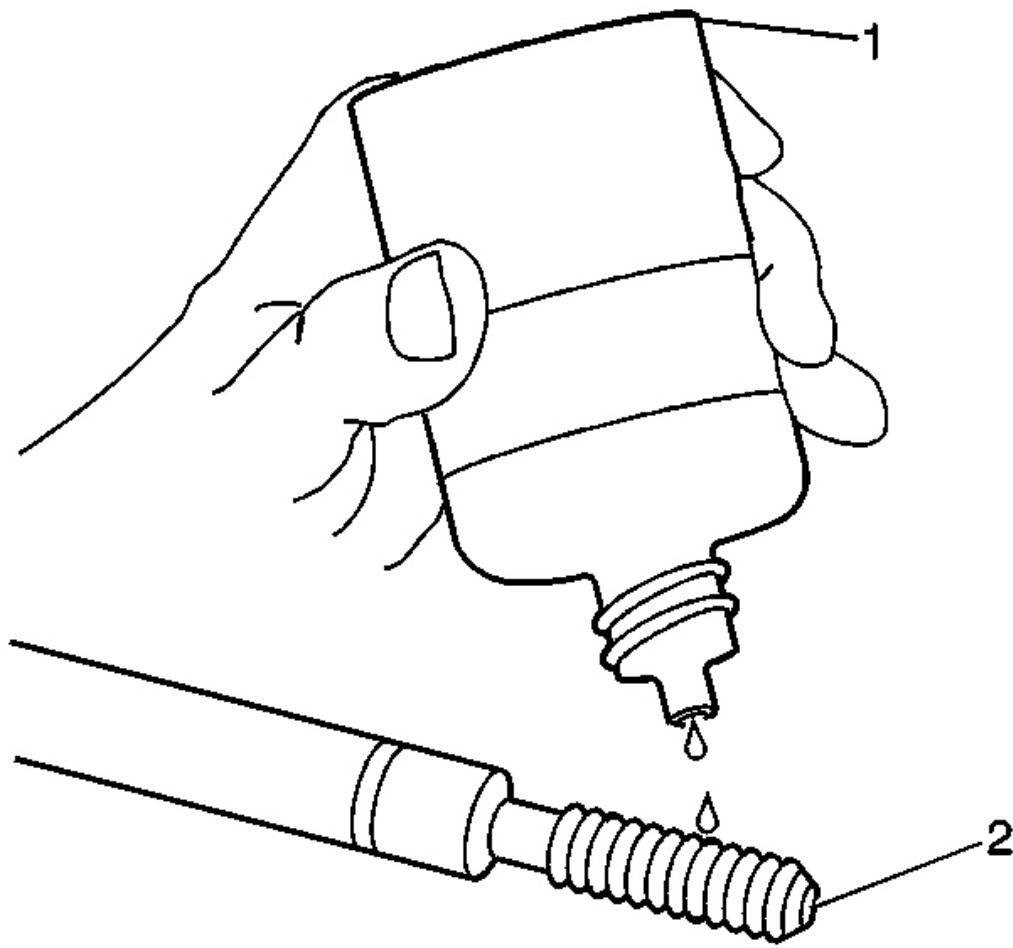


Fig. 236: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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

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

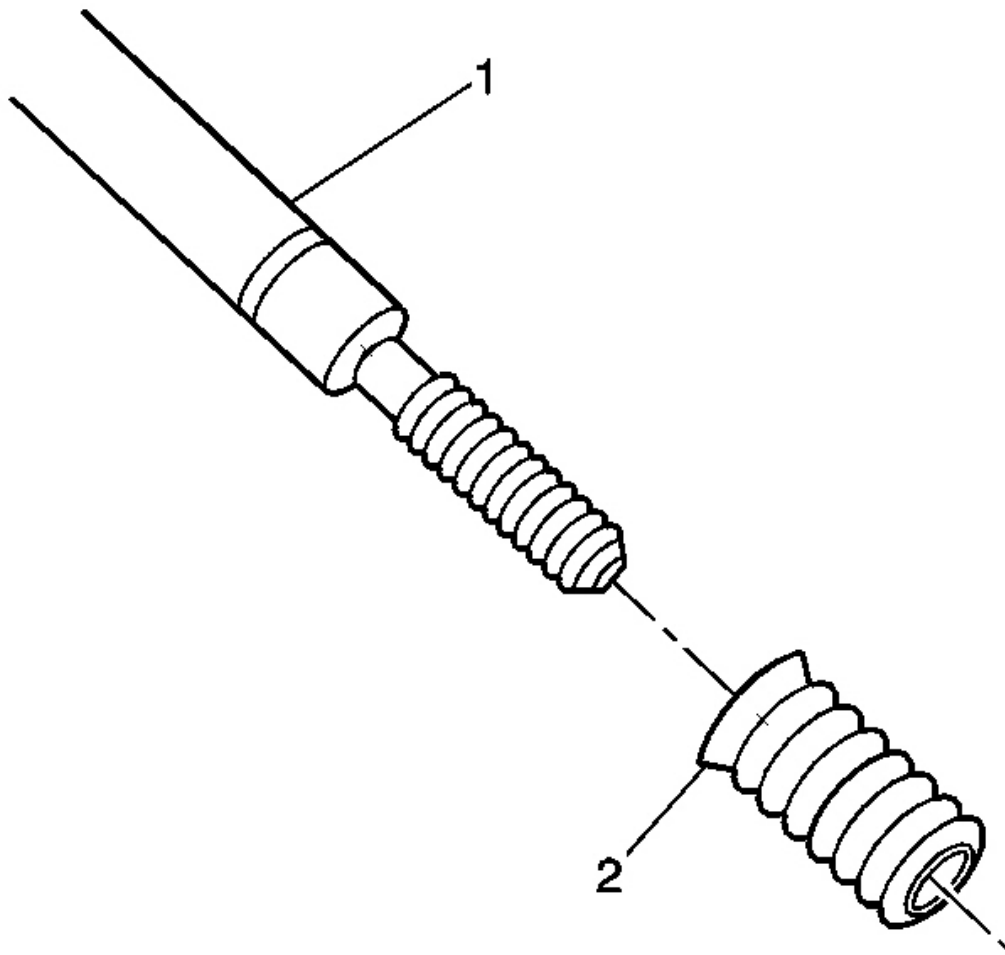


Fig. 237: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

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

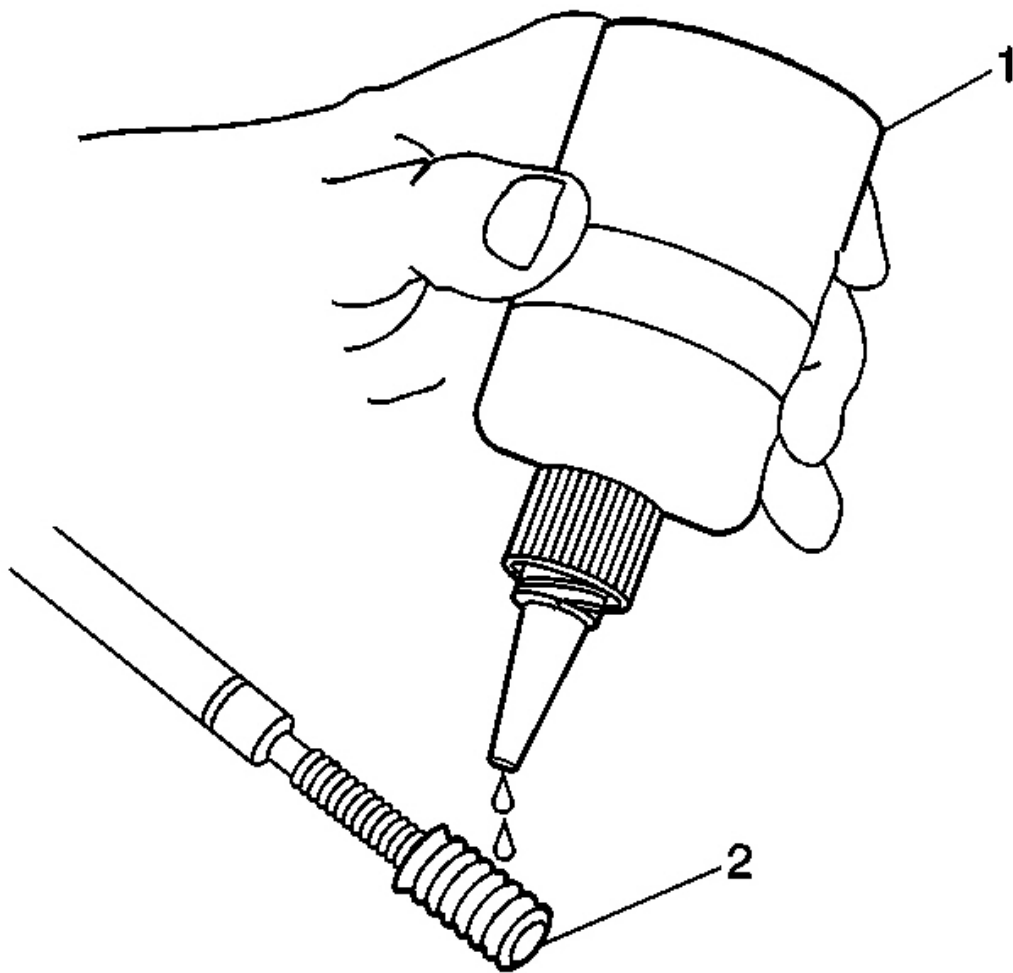


Fig. 238: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

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

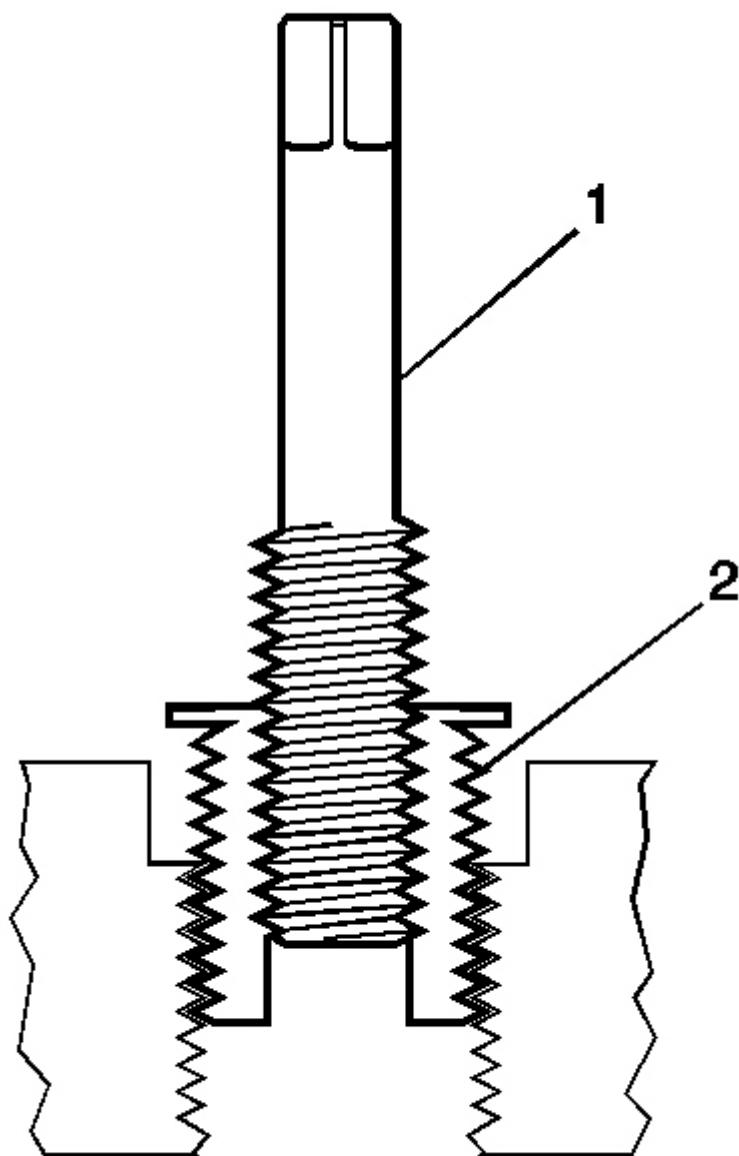


Fig. 239: Installing Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

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

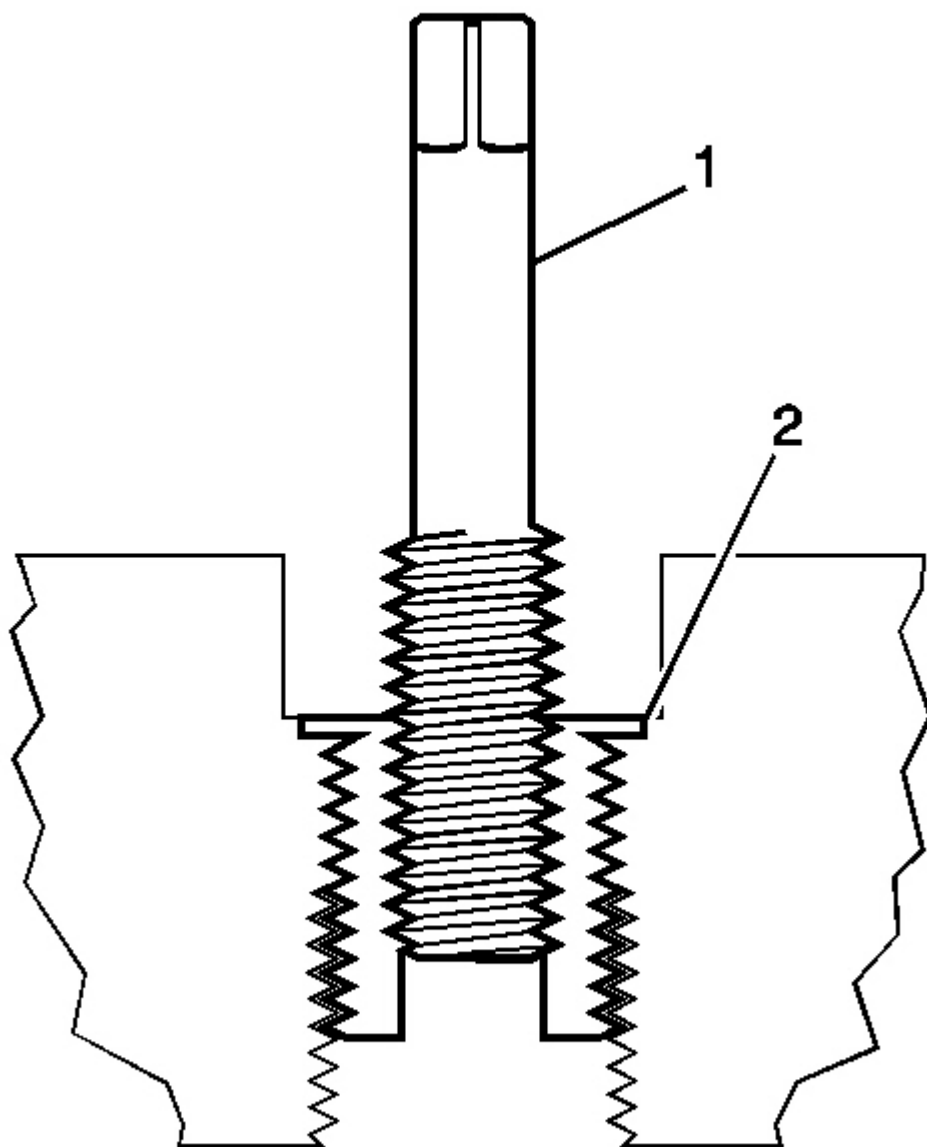


Fig. 240: View Of Installed Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

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.

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

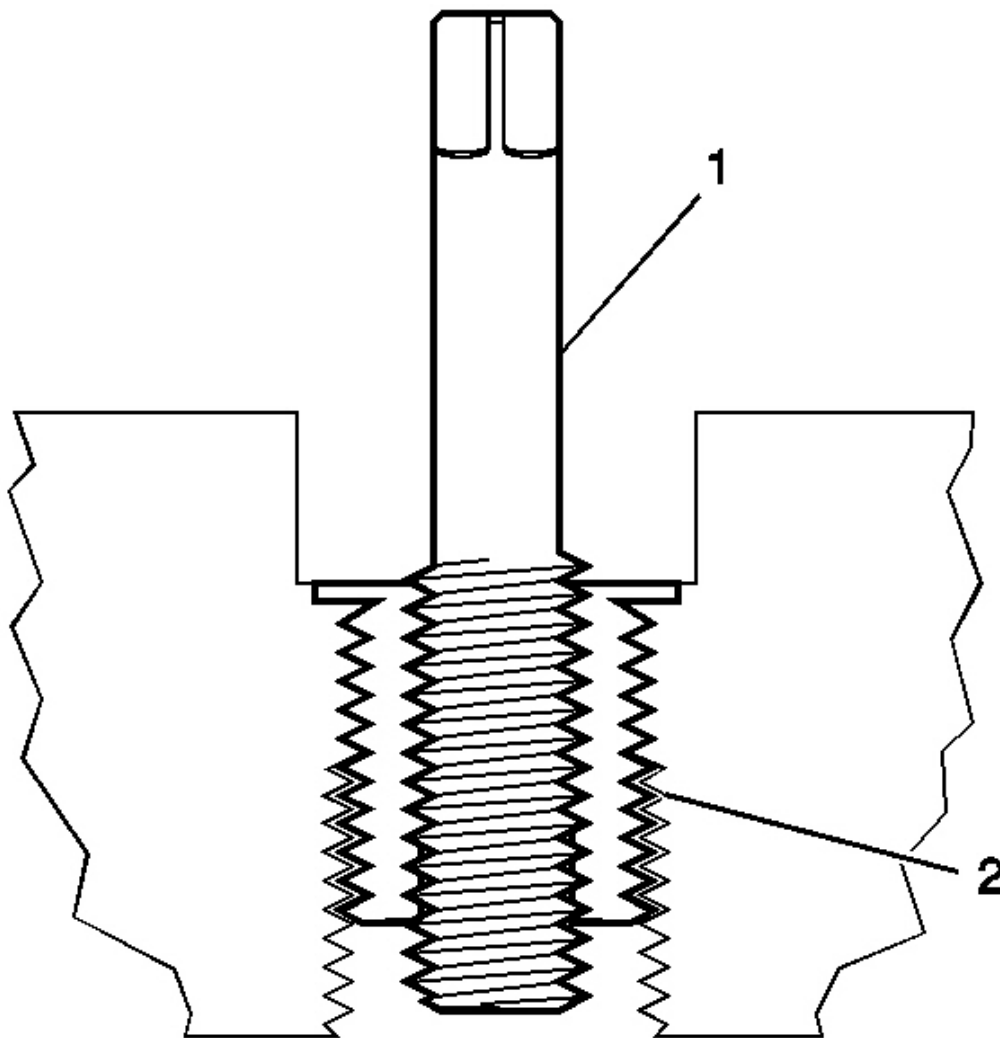


Fig. 241: Installed Insert - Recessed Thread Repair
Courtesy of GENERAL MOTORS CORP.

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) through the insert (2).

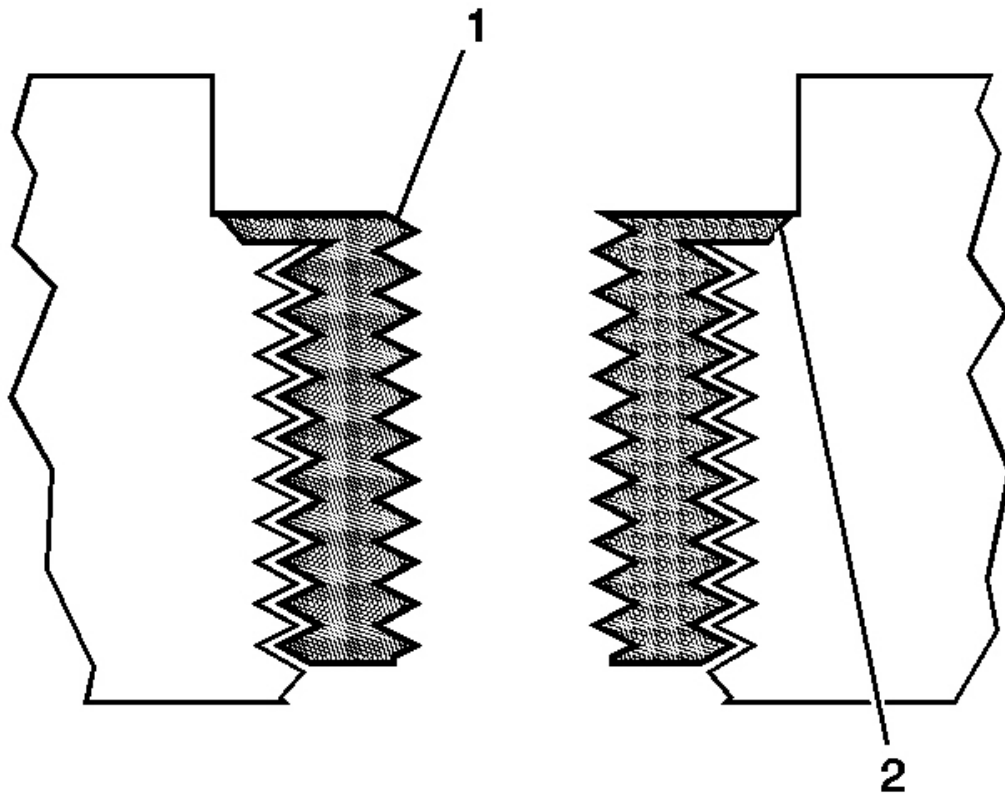


Fig. 242: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

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

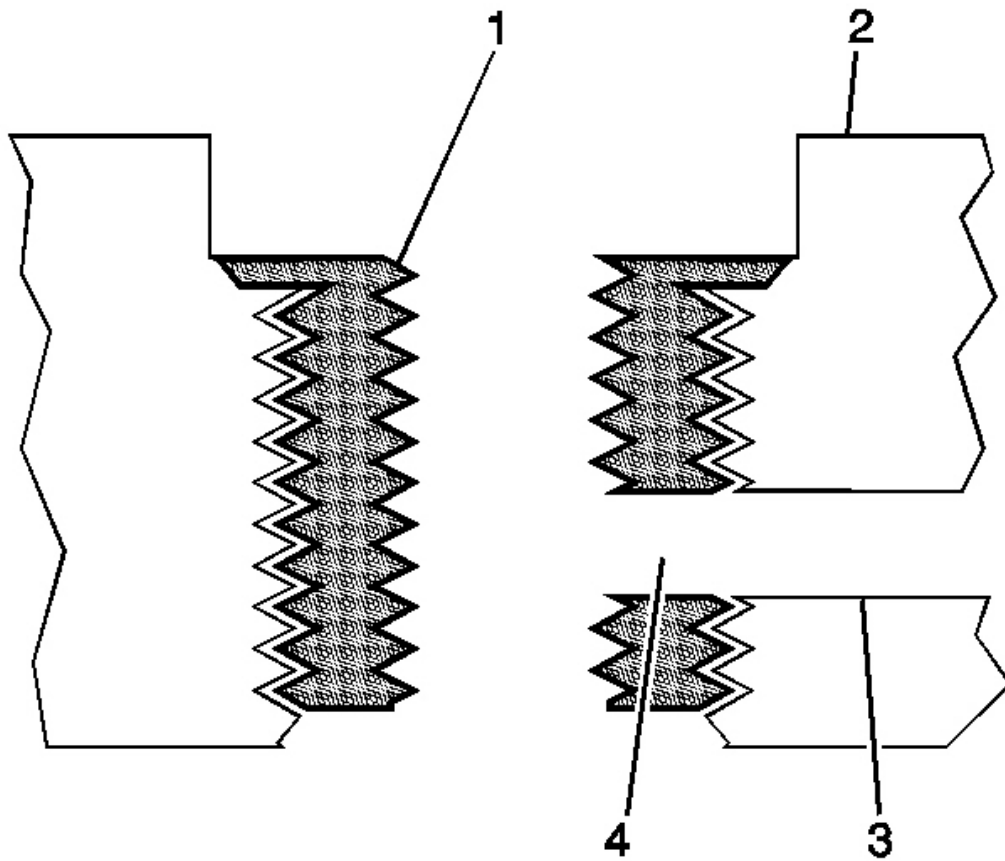


Fig. 243: View Of Restricted Engine Coolant Passage - Recessed Thread Repair
Courtesy of GENERAL MOTORS CORP.

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.

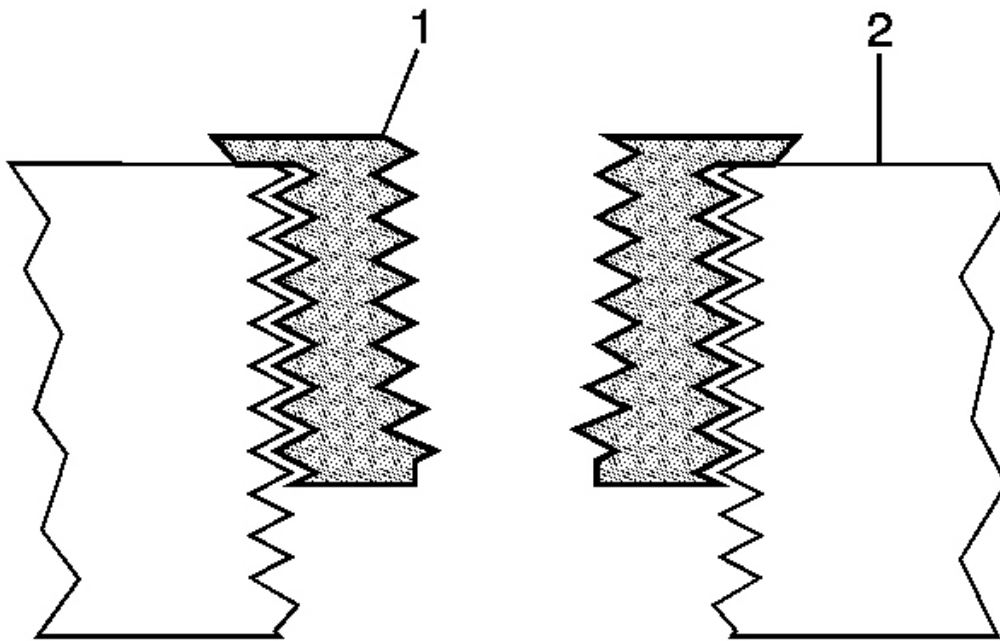


Fig. 244: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

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.

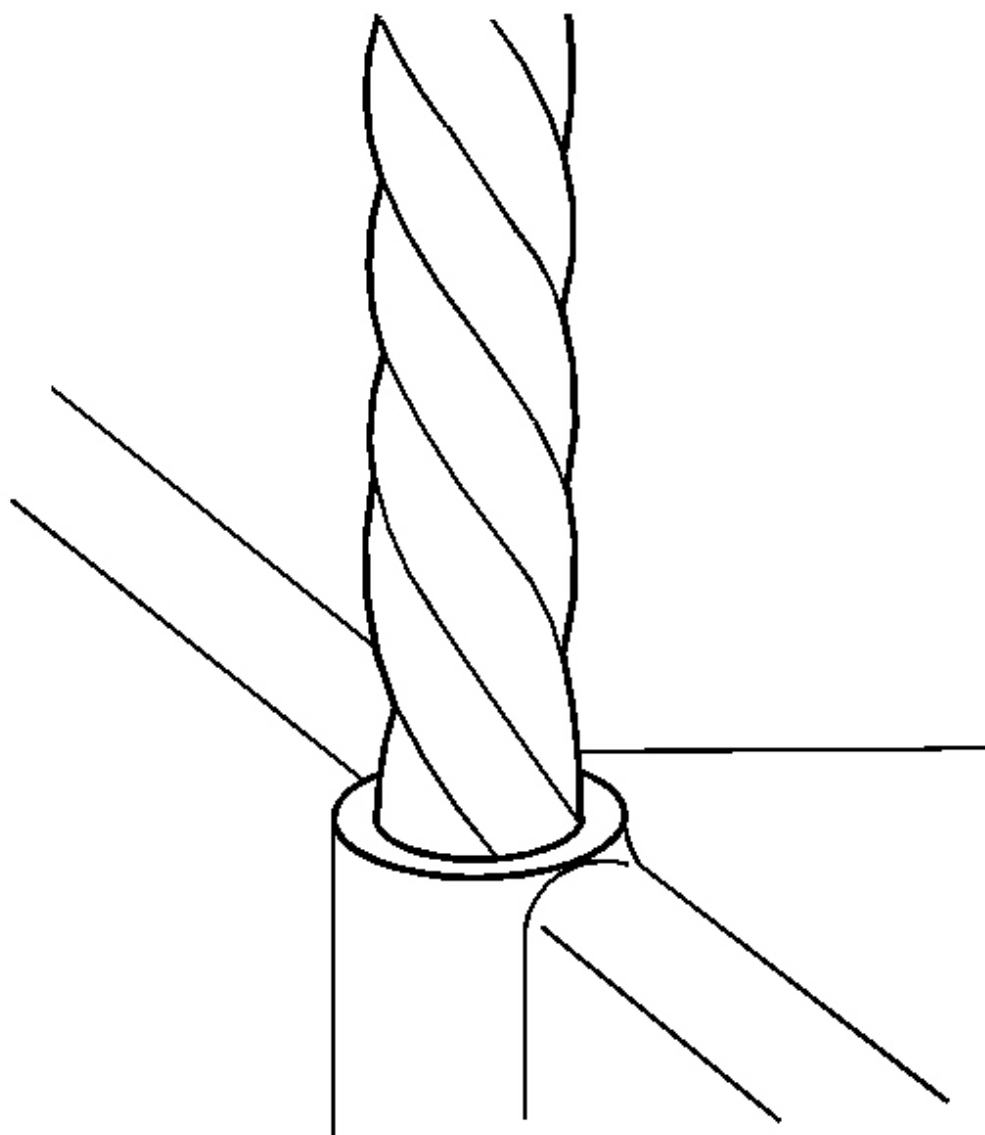


Fig. 245: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

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.

1. Drill out the threads of the damaged hole.

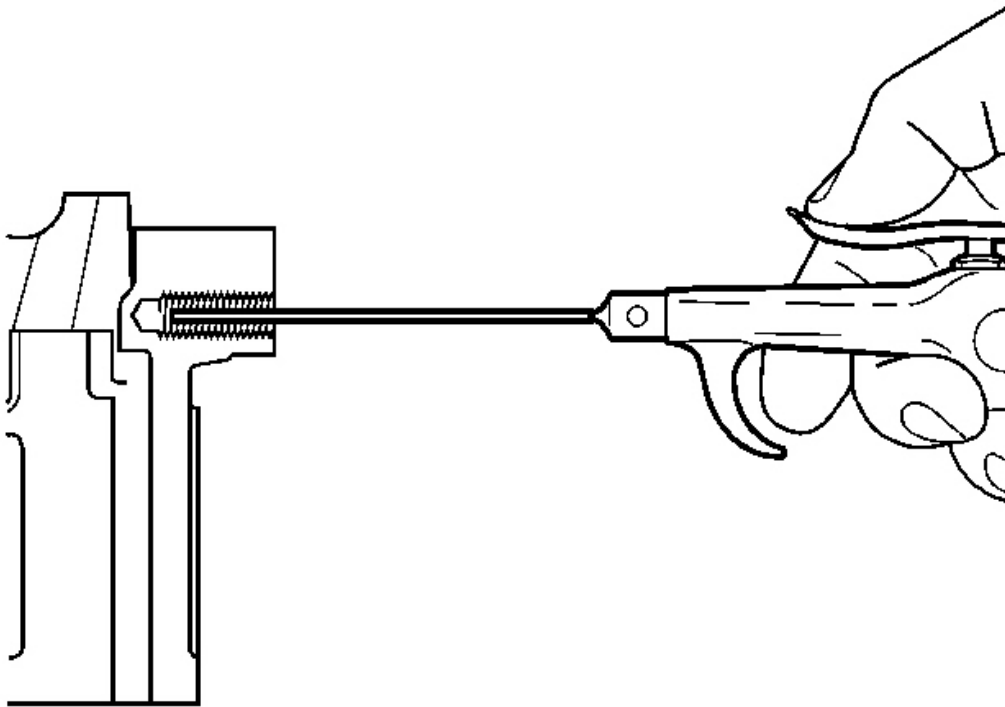


Fig. 246: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

2. Using compressed air, clean out any chips.

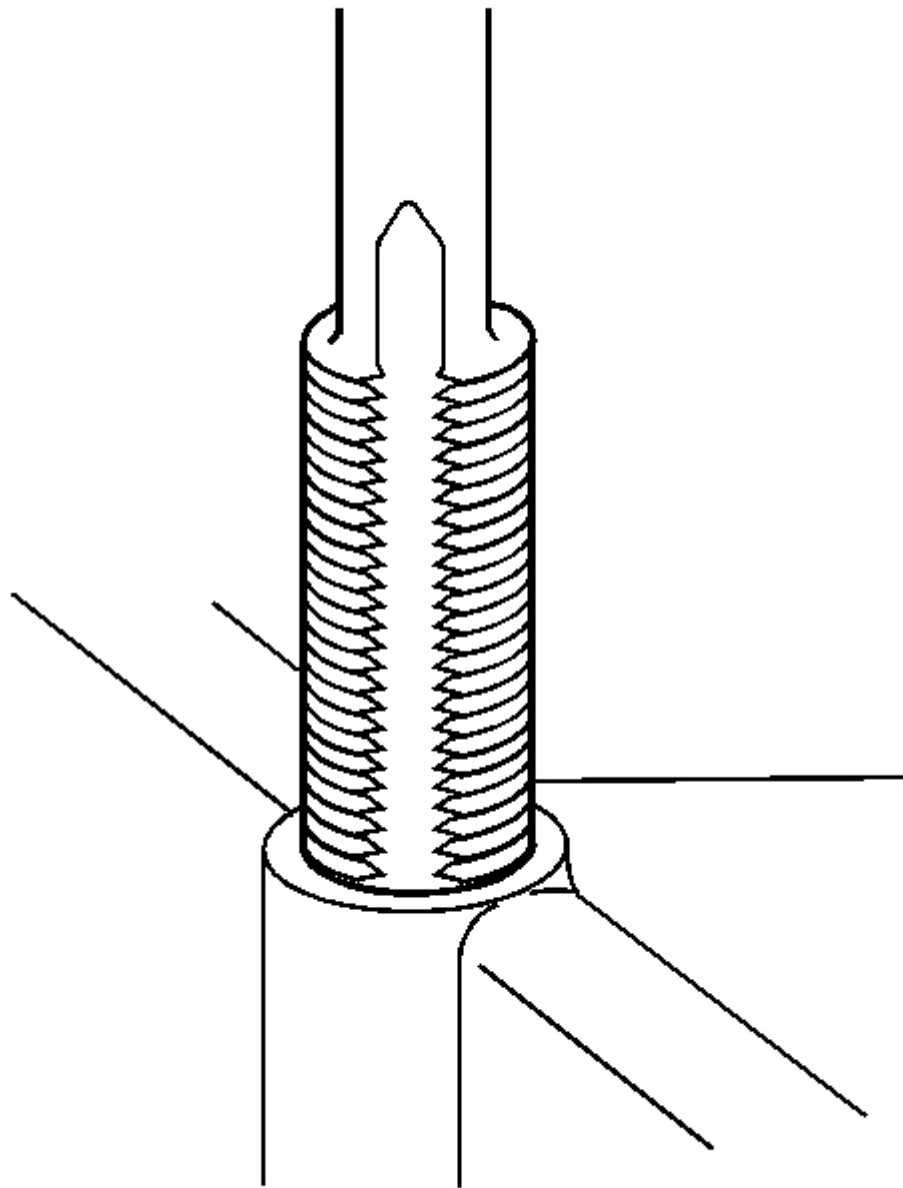


Fig. 247: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

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.

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

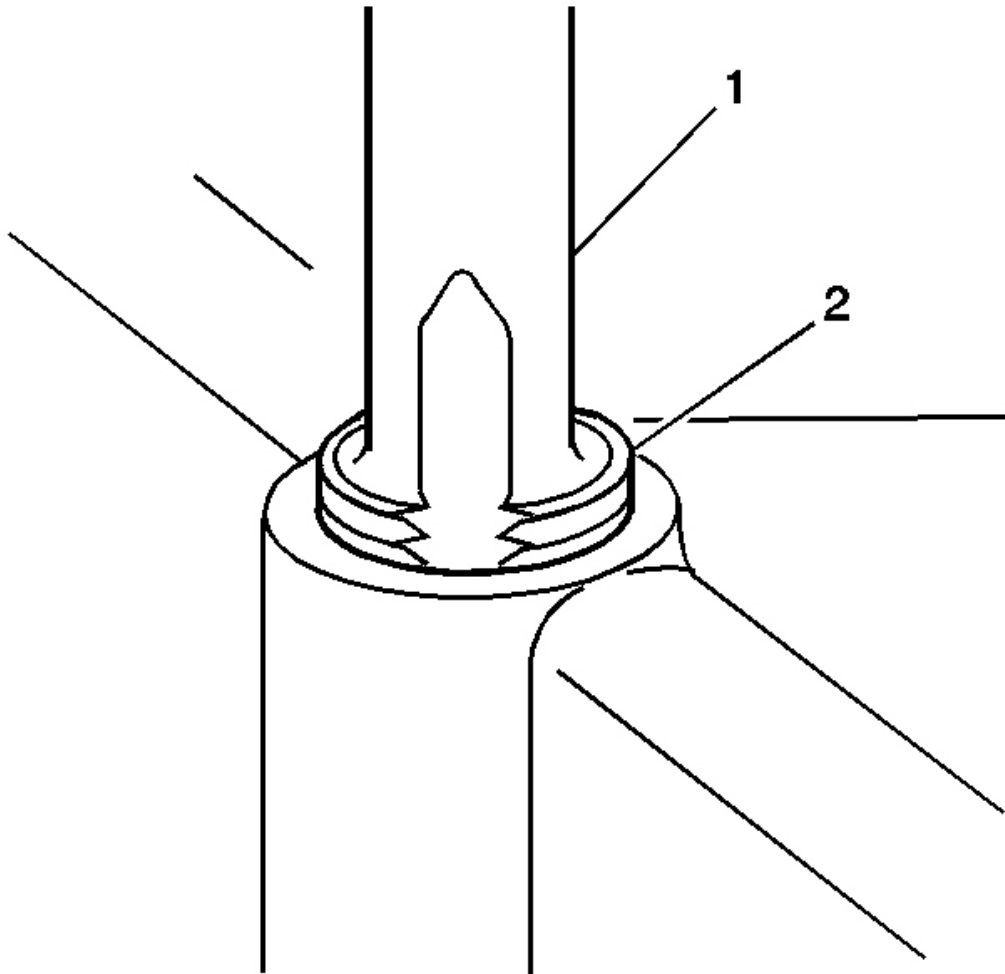


Fig. 248: View Of Proper Tapping Distance - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

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

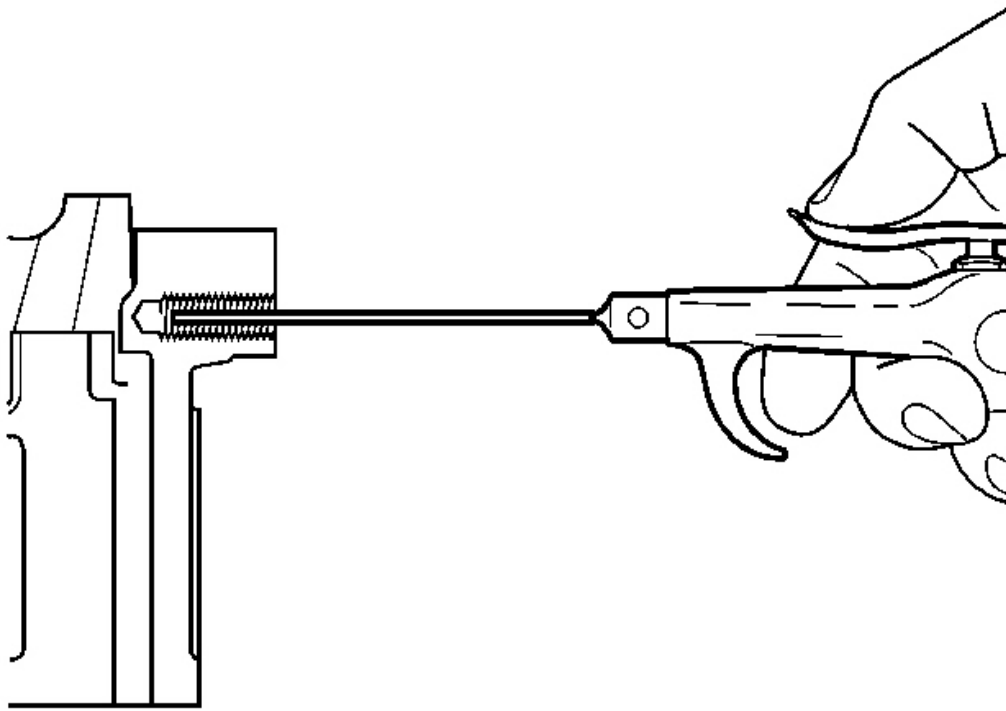


Fig. 249: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

5. Using compressed air, clean out any chips.

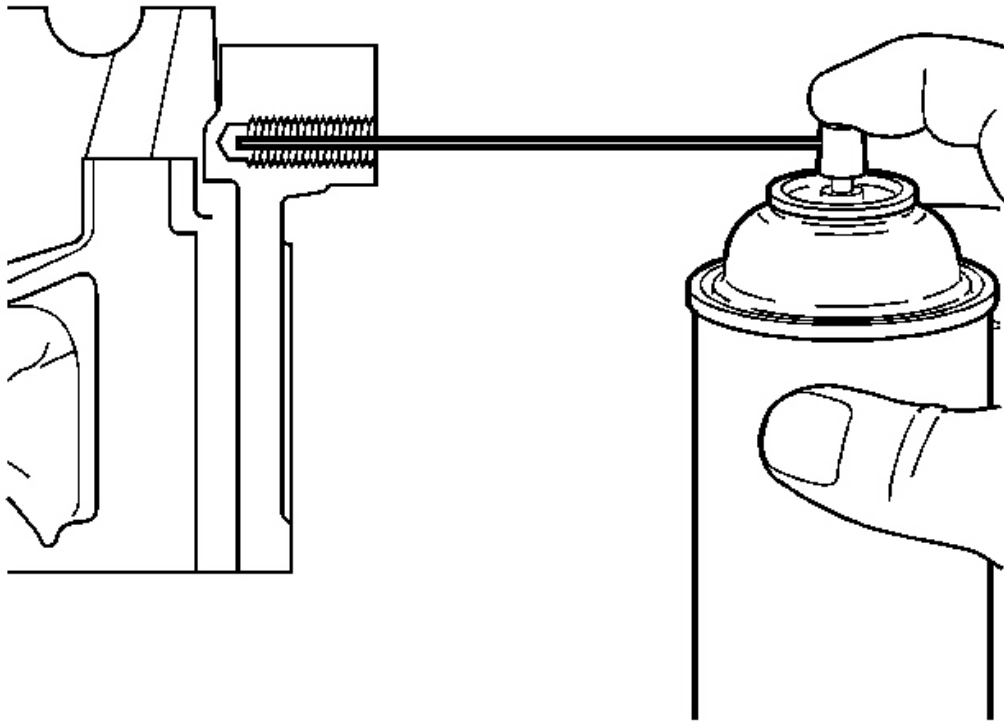


Fig. 250: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

6. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended cleaner.

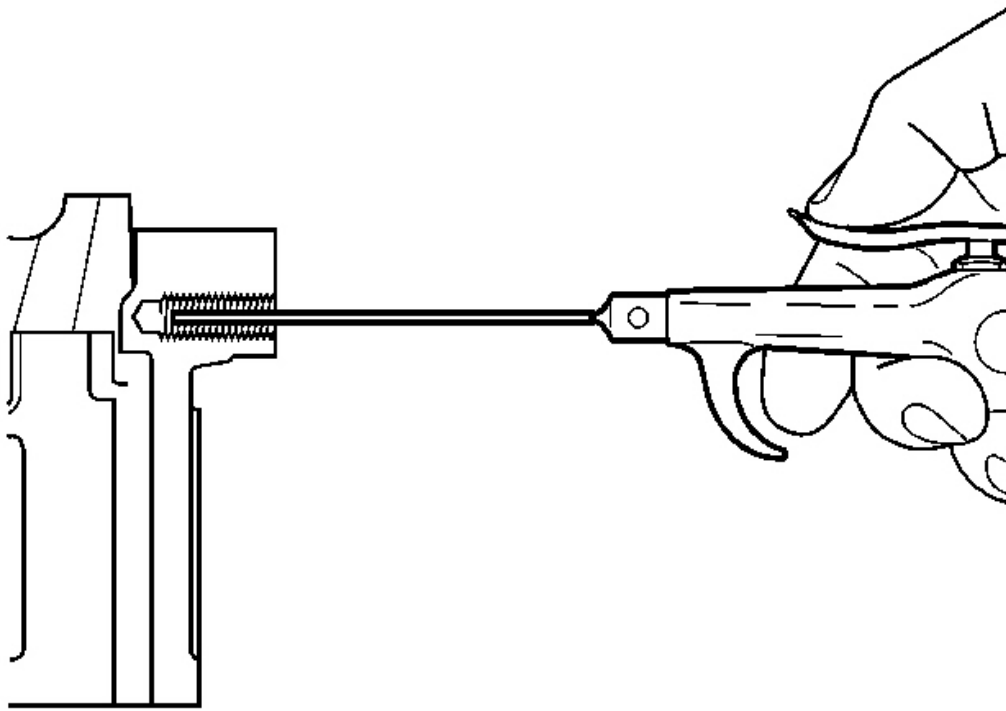


Fig. 251: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

7. Using compressed air, clean out any chips.

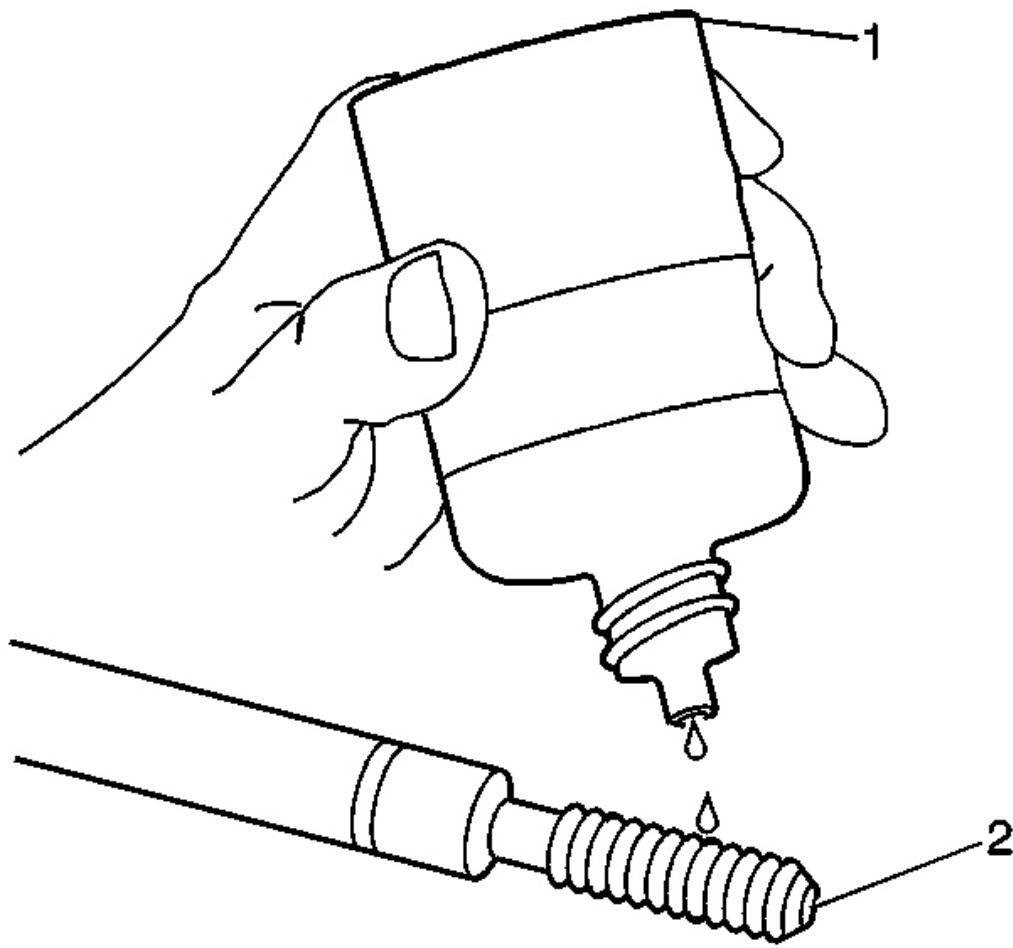


Fig. 252: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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

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

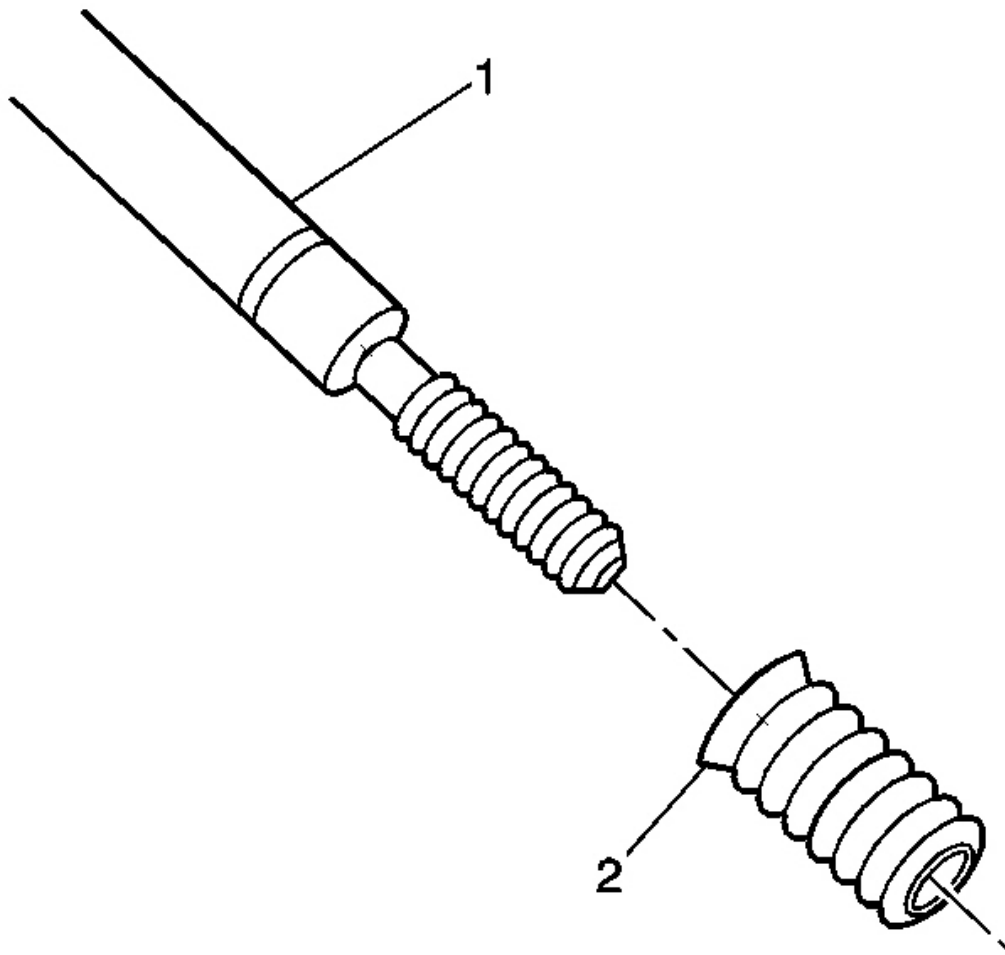


Fig. 253: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

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

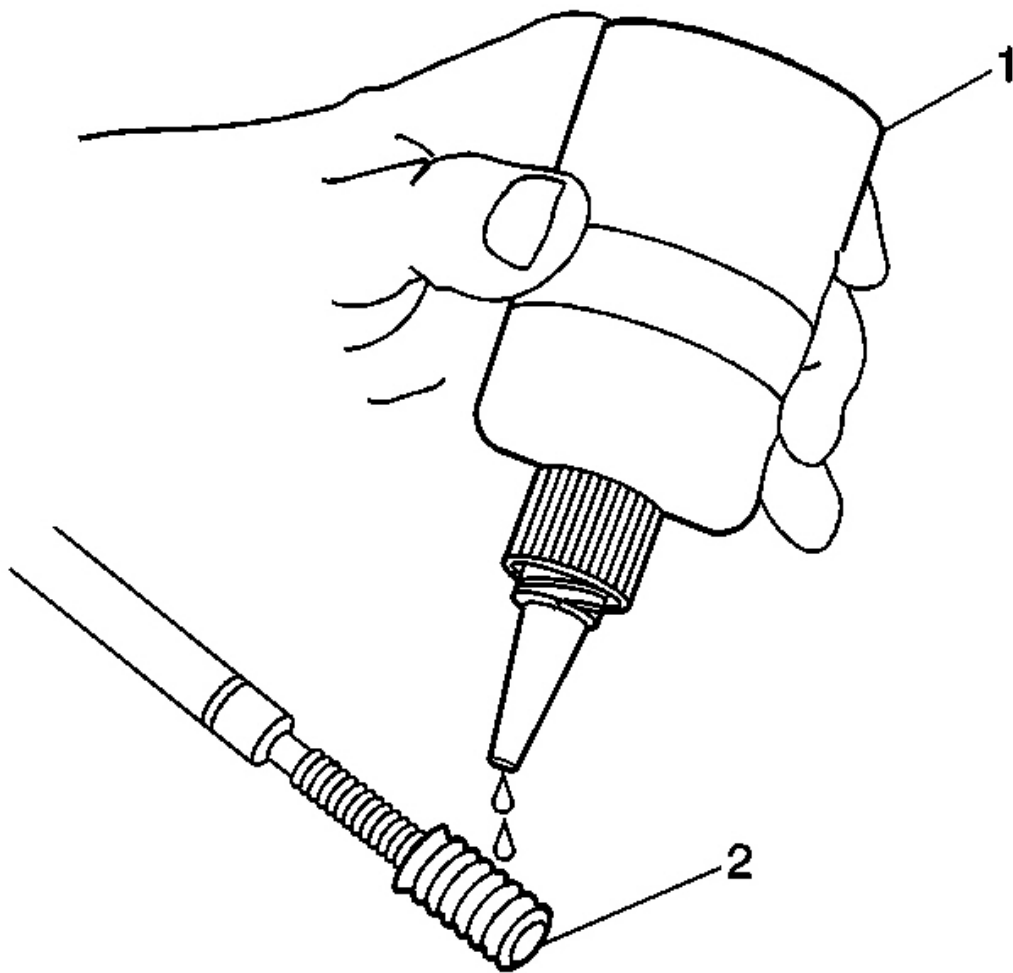


Fig. 254: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

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

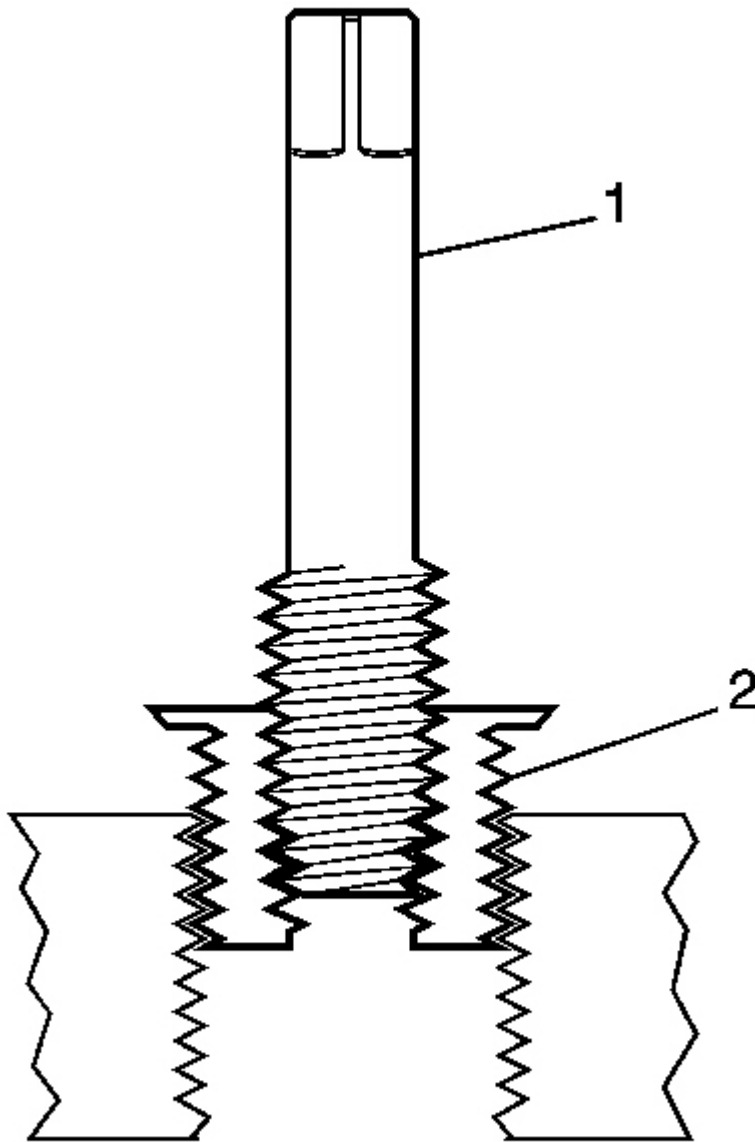


Fig. 255: Installing Insert - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

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

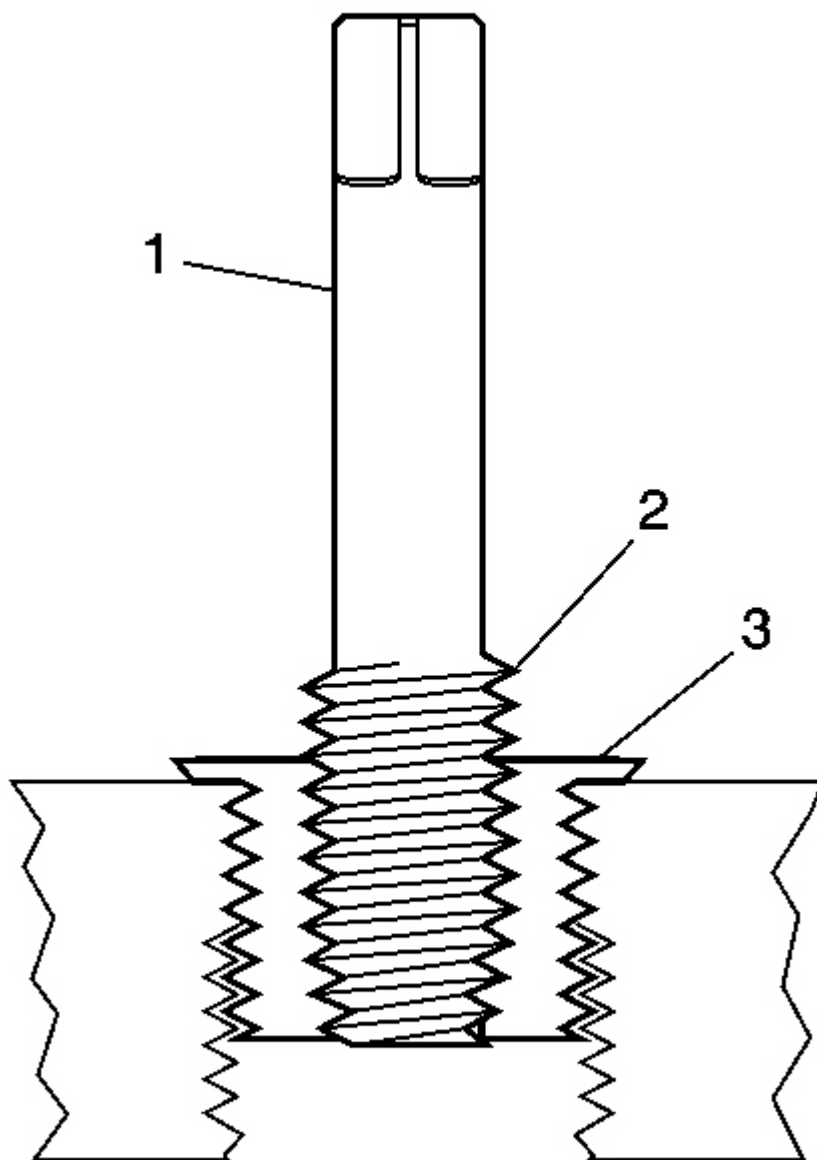


Fig. 256: Installing Insert - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

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.

12. 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).

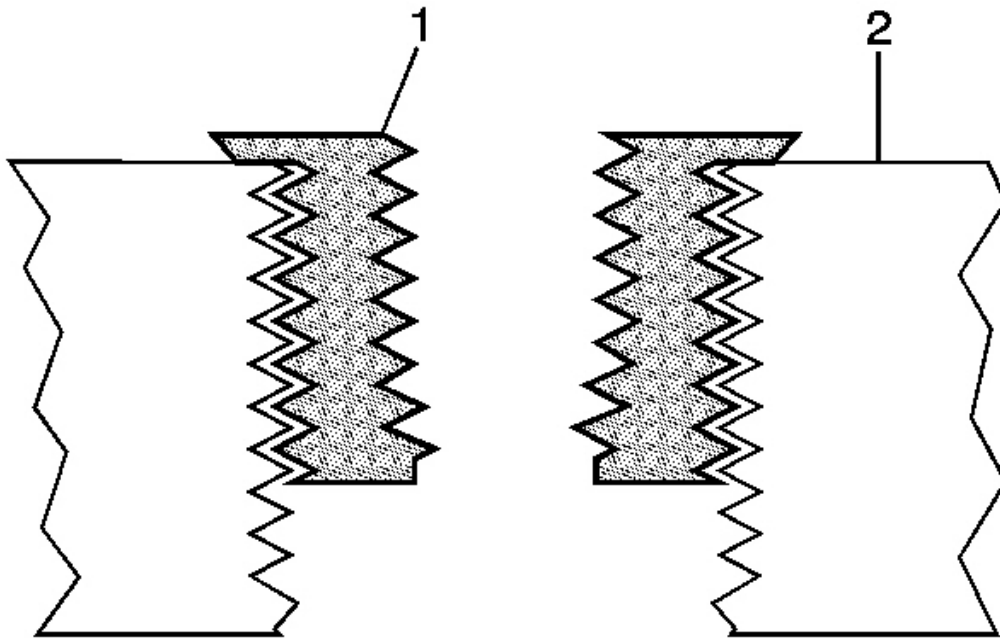


Fig. 257: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

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

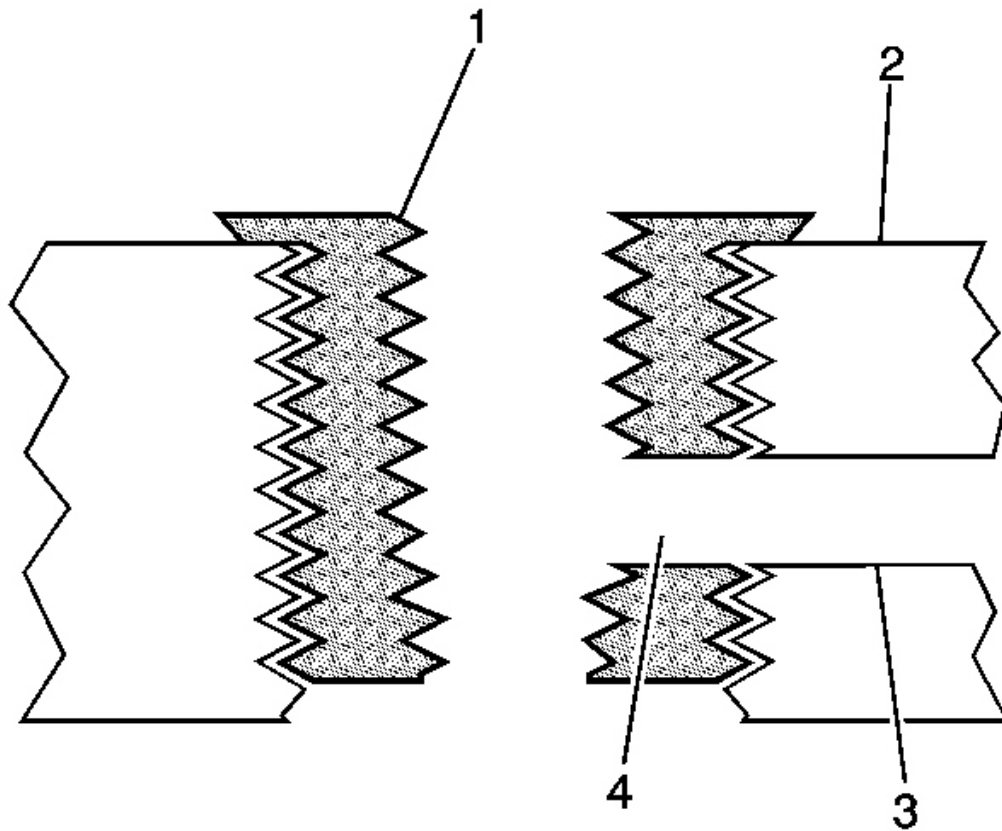


Fig. 258: View Of Restricted Engine Coolant Passages - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

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** .

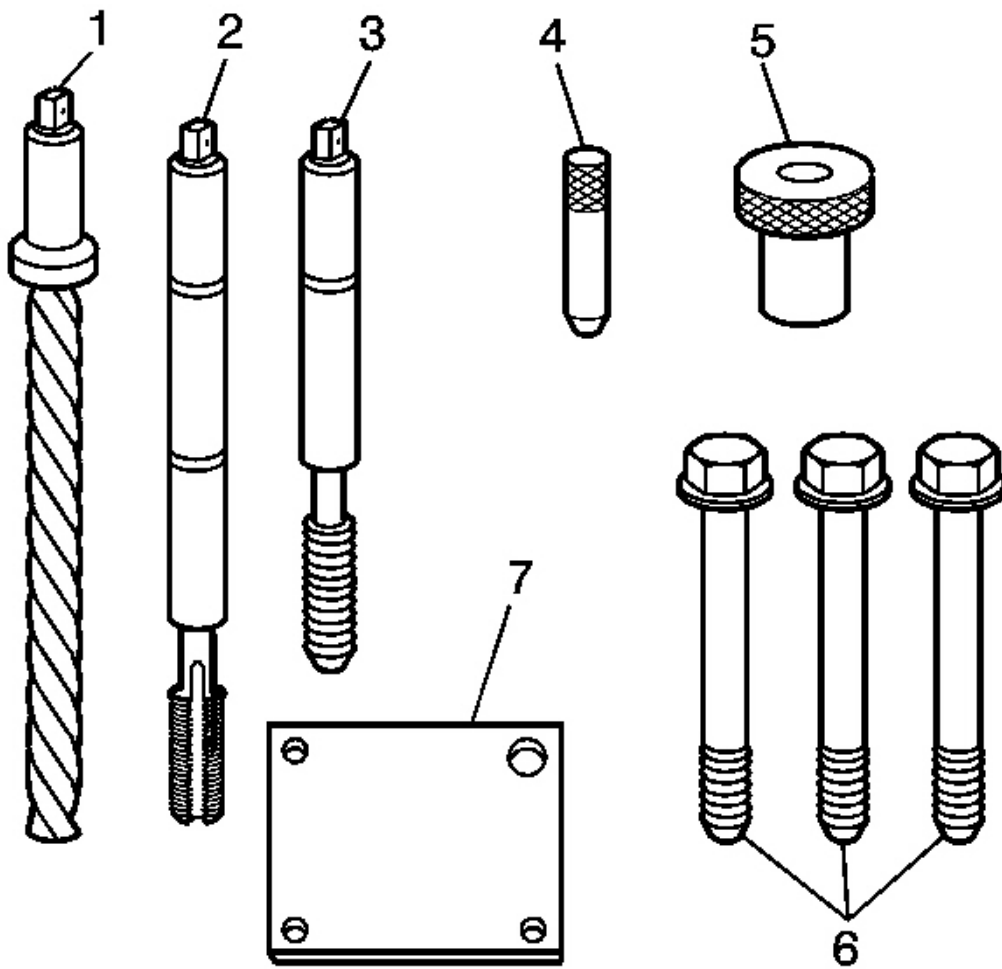


Fig. 259: Identifying Cylinder Head Bolt Hole Thread Repair Components
Courtesy of GENERAL MOTORS CORP.

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.

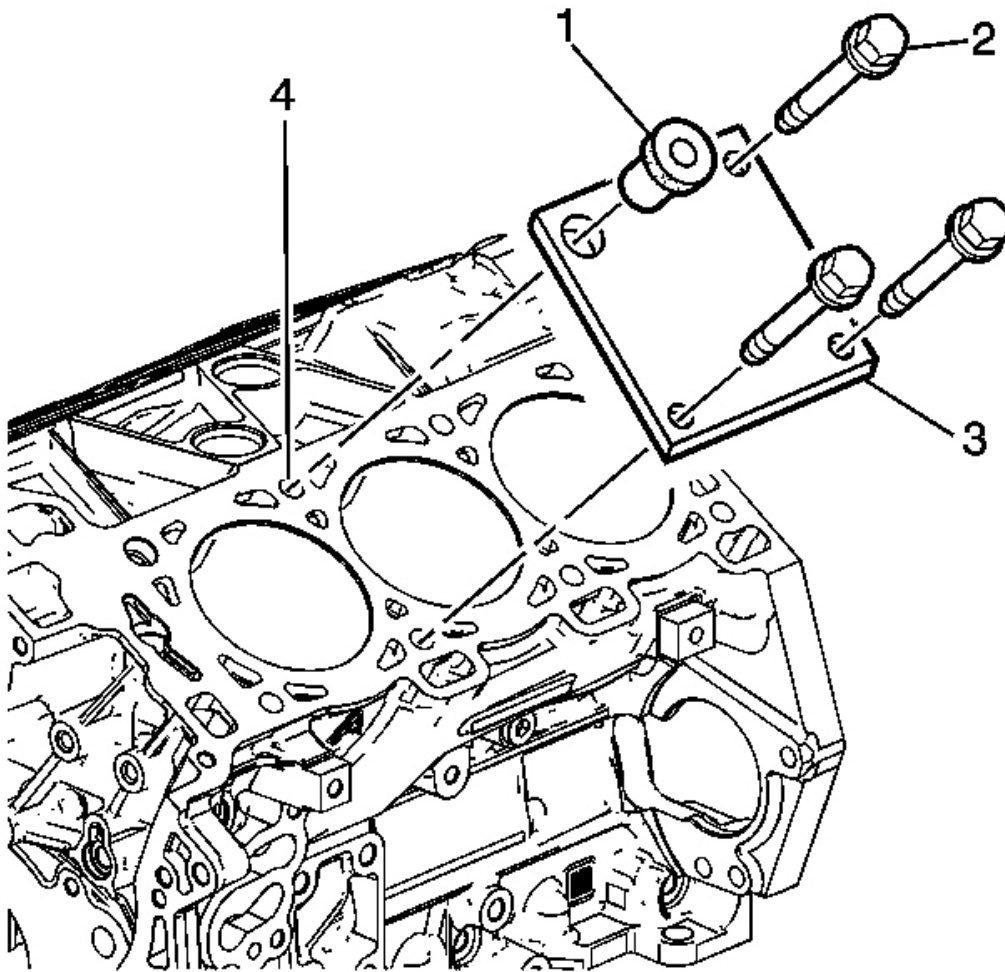


Fig. 260: View Of Fixture Plate With Bushing
Courtesy of GENERAL MOTORS CORP.

1. 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.

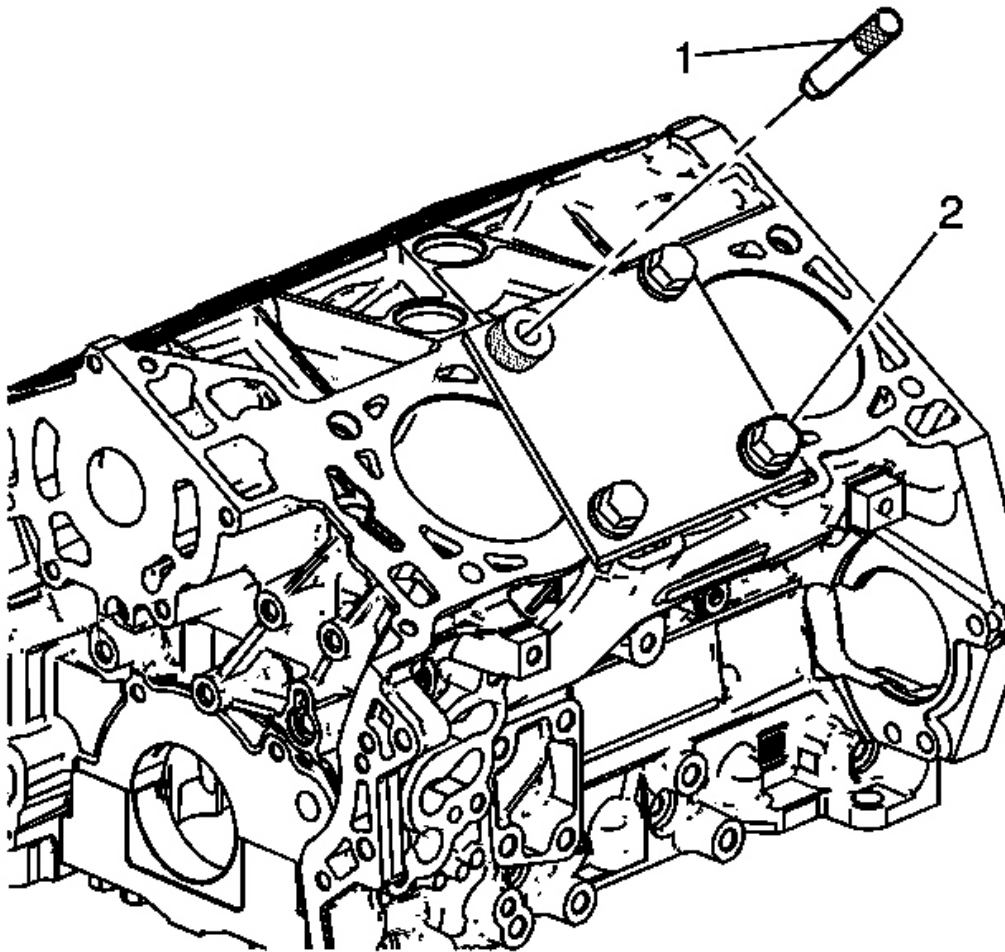


Fig. 261: Locating Alignment Pin
Courtesy of GENERAL MOTORS CORP.

3. 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.

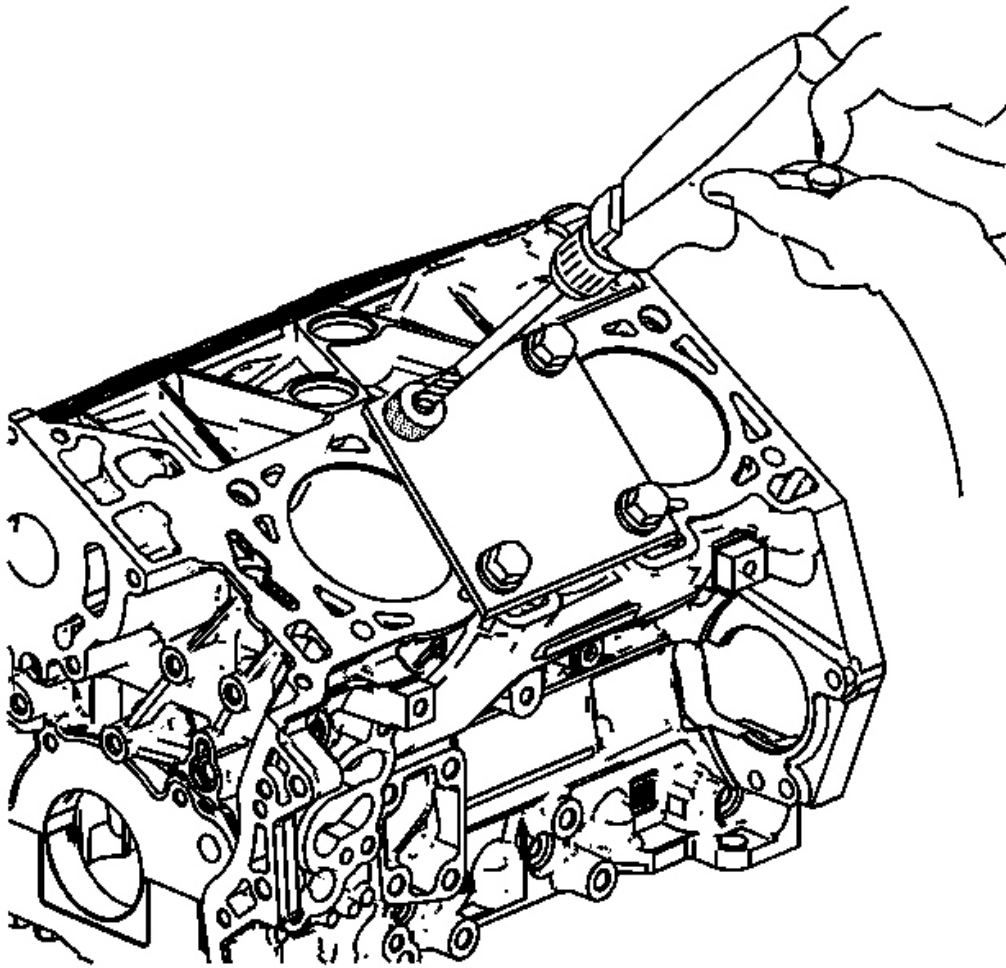


Fig. 262: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

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.

6. Drill out the threads of the damaged hole.

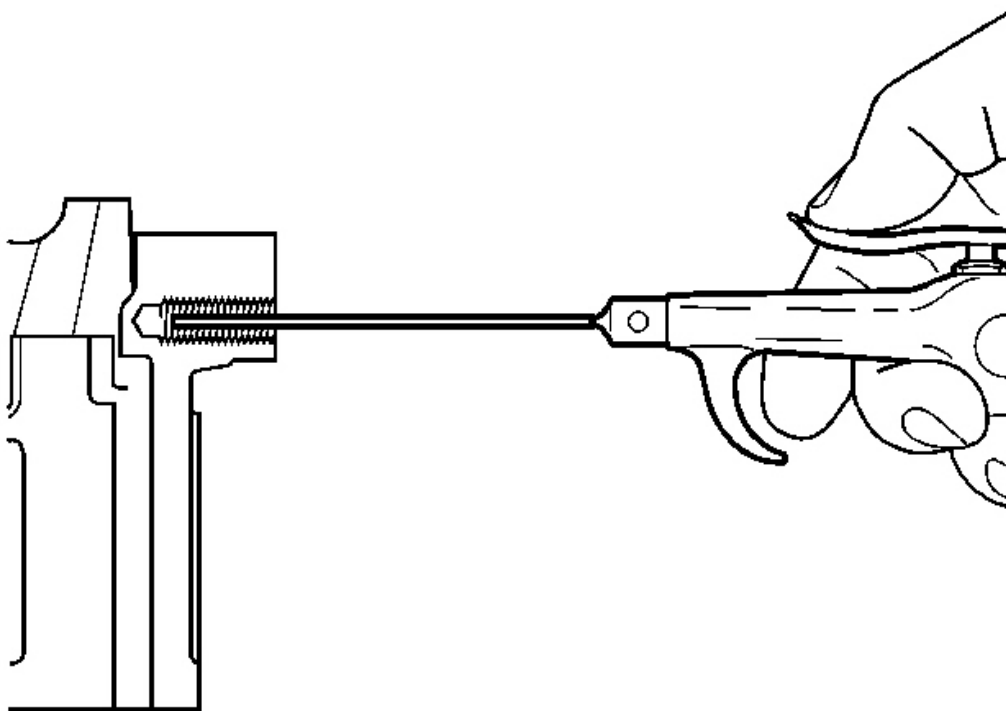


Fig. 263: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

7. Using compressed air, clean out any chips.

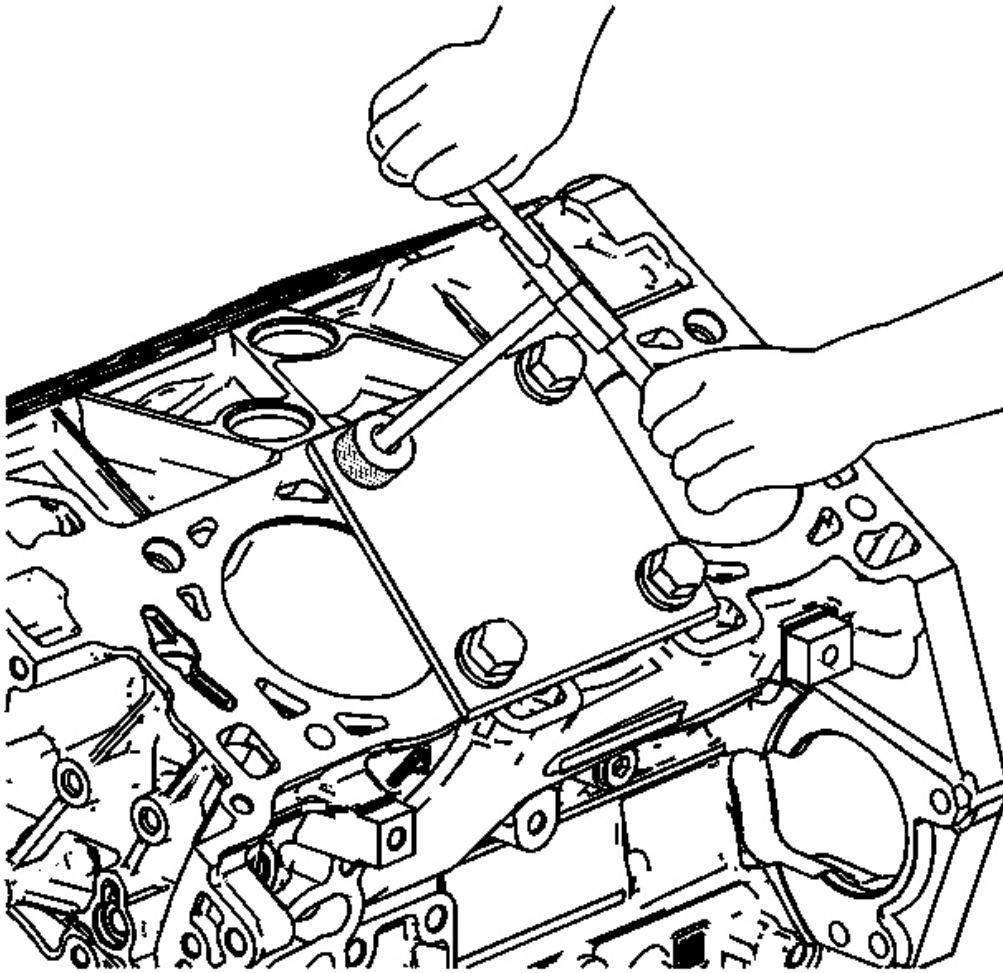


Fig. 264: Tapping Threads In Hole

Courtesy of GENERAL MOTORS CORP.

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.

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

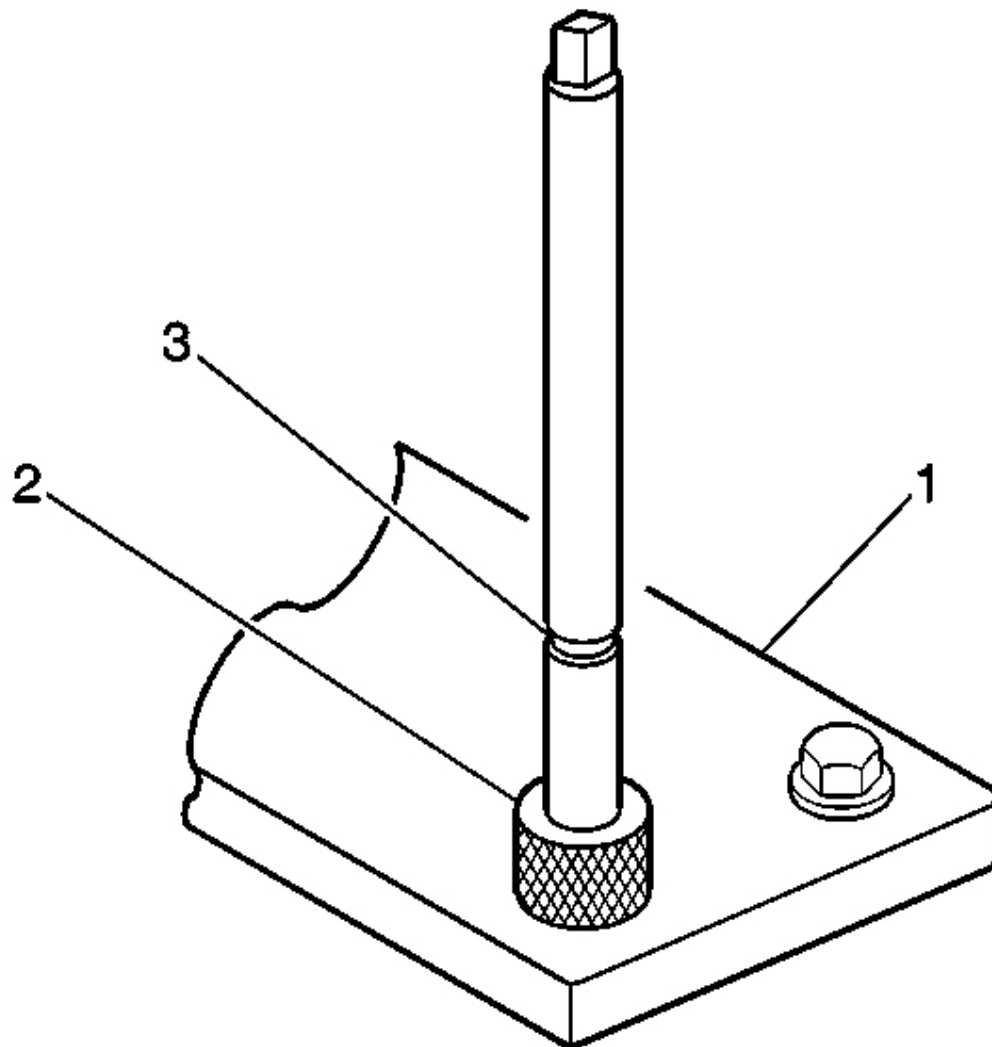


Fig. 265: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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).

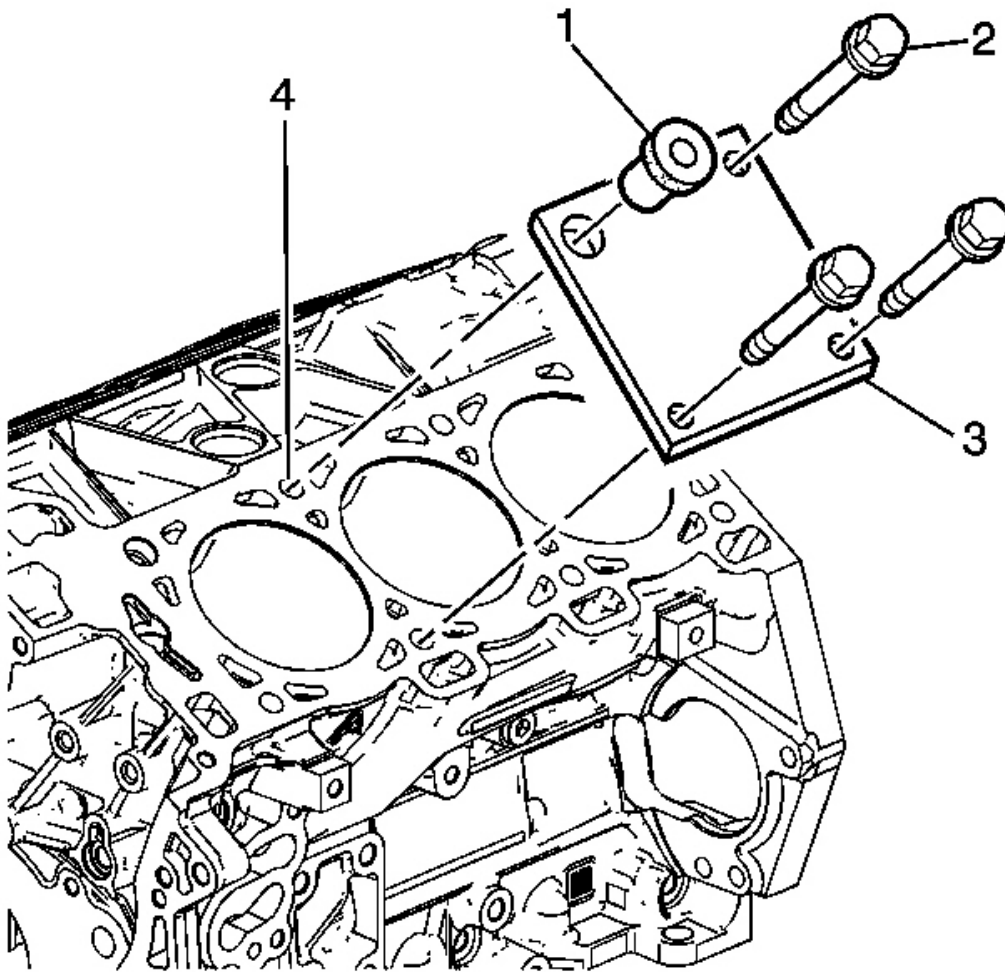


Fig. 266: View Of Fixture Plate With Bushing
Courtesy of GENERAL MOTORS CORP.

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

10. Remove the fixture plate bolts (2).
11. Remove the fixture plate (3) and bushing (1).

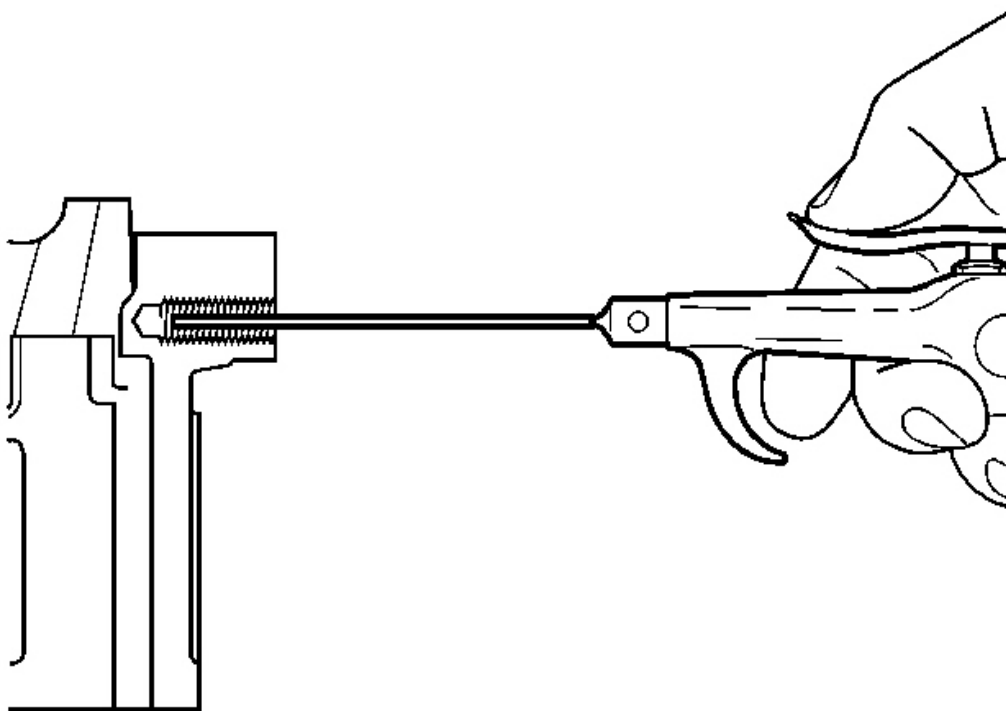


Fig. 267: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

12. Using compressed air, clean out any chips.

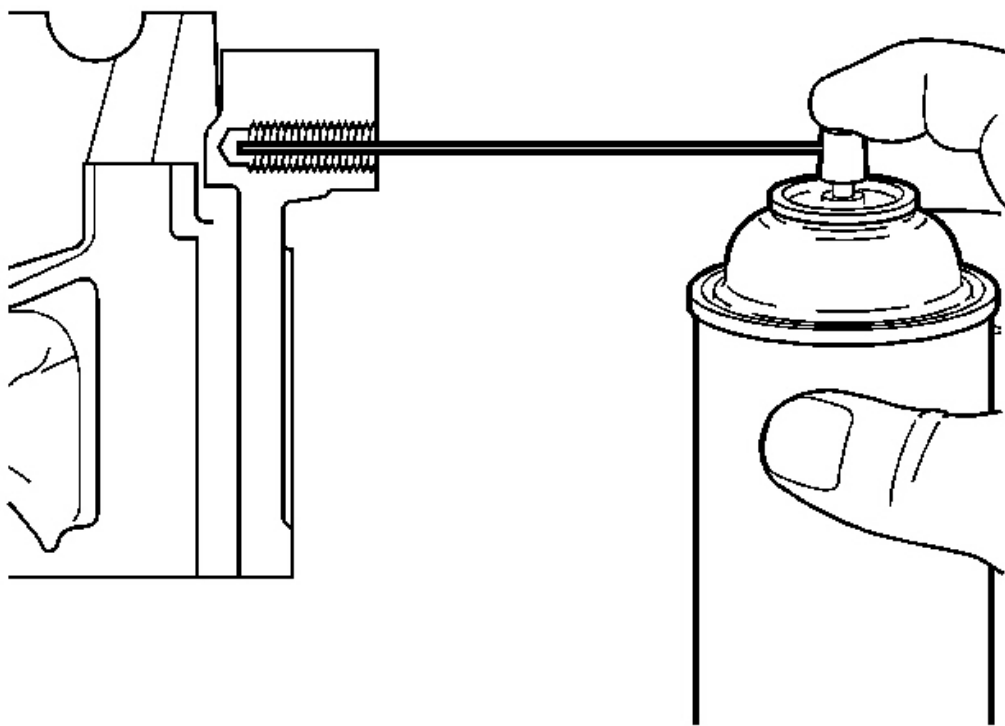


Fig. 268: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

13. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended cleaner.

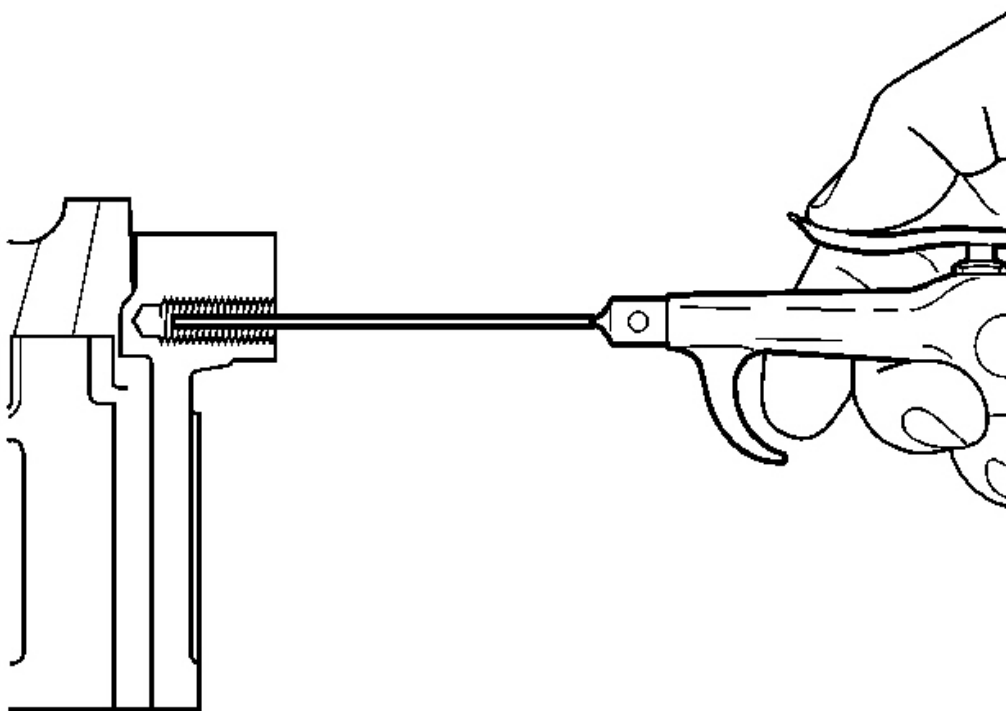


Fig. 269: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

14. Using compressed air, clean out any chips.

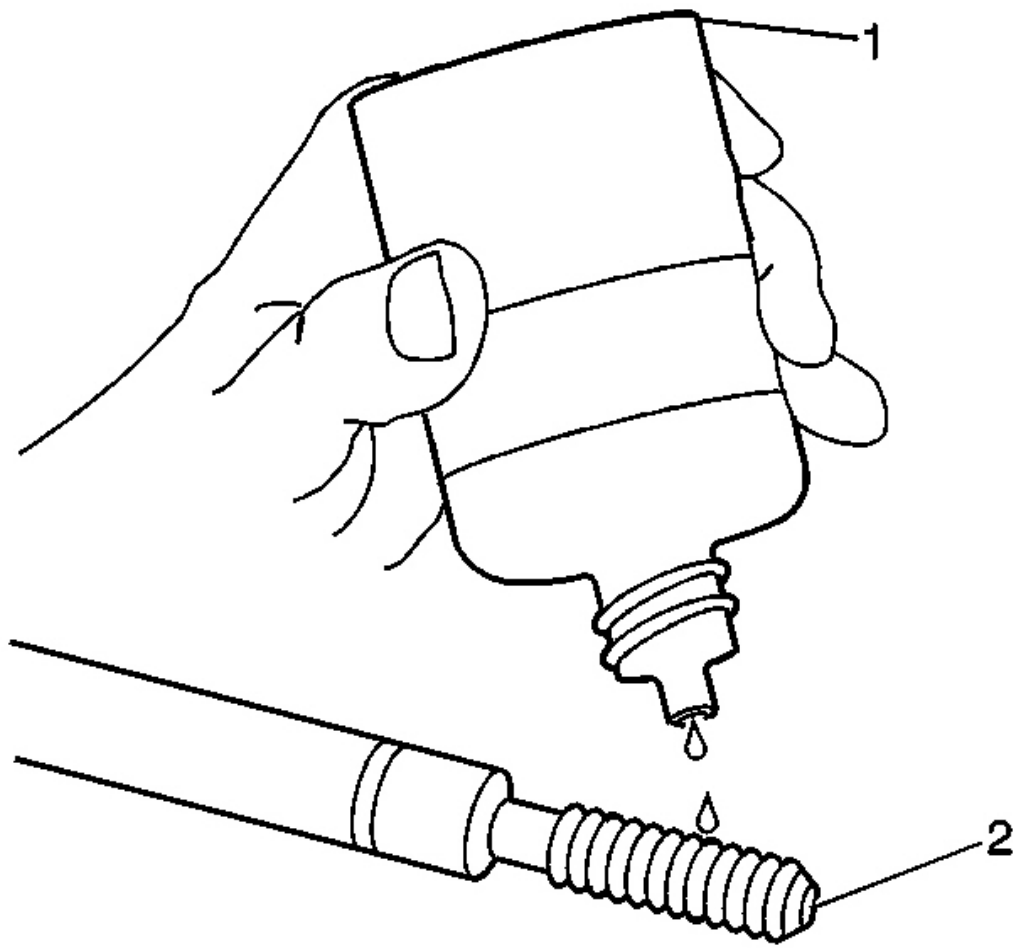


Fig. 270: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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

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

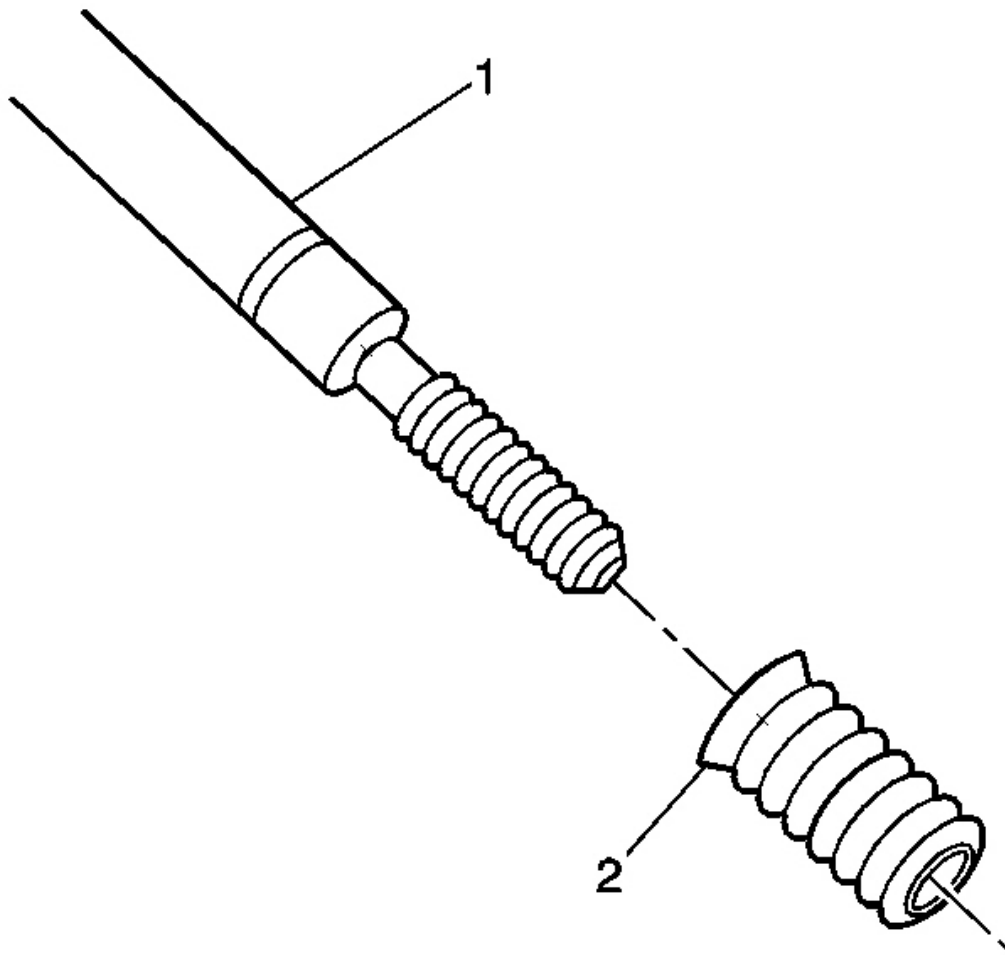


Fig. 271: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

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

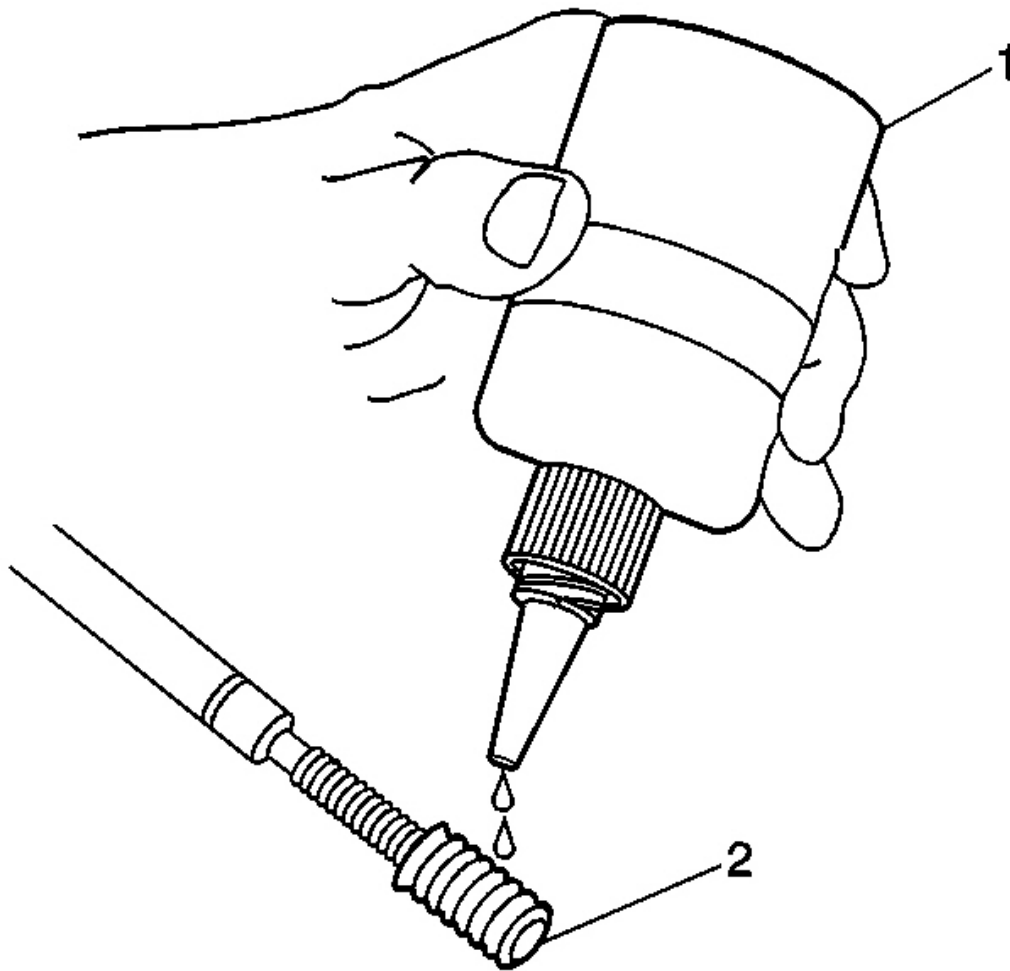


Fig. 272: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

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

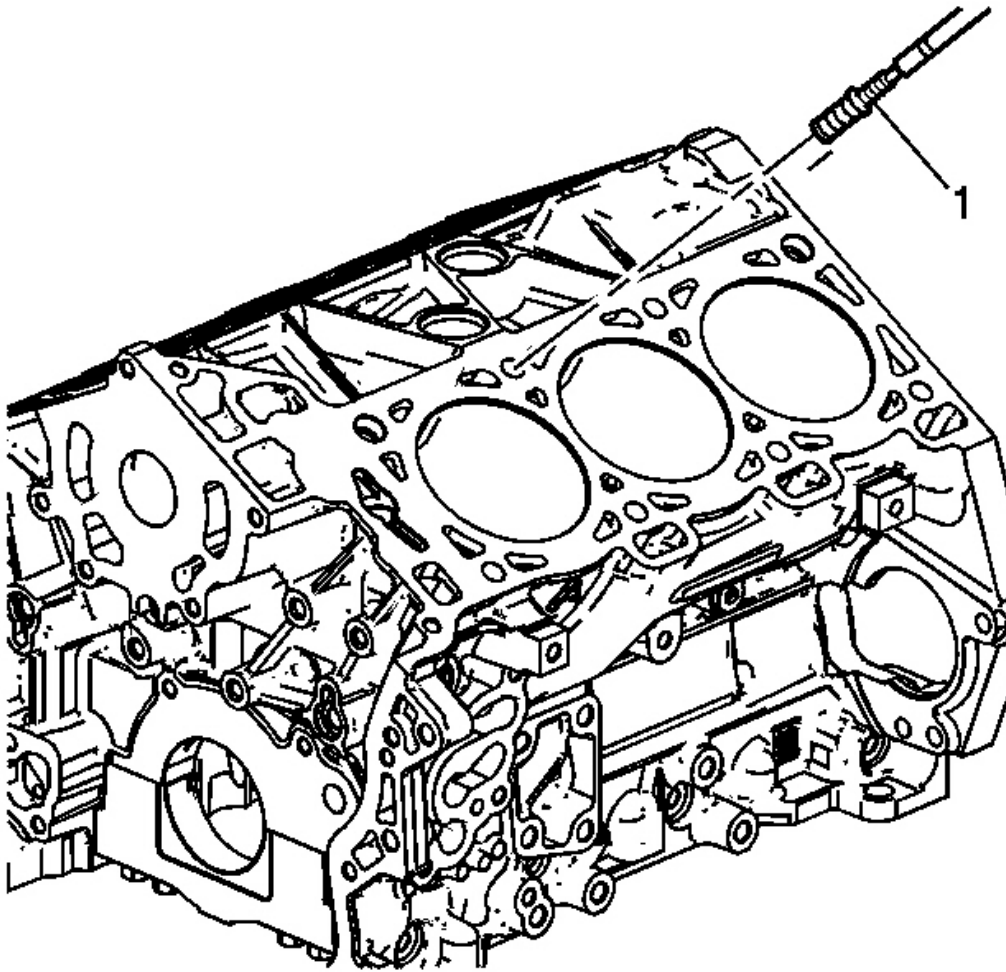


Fig. 273: Installing Installation Driver By Hand
Courtesy of GENERAL MOTORS CORP.

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.

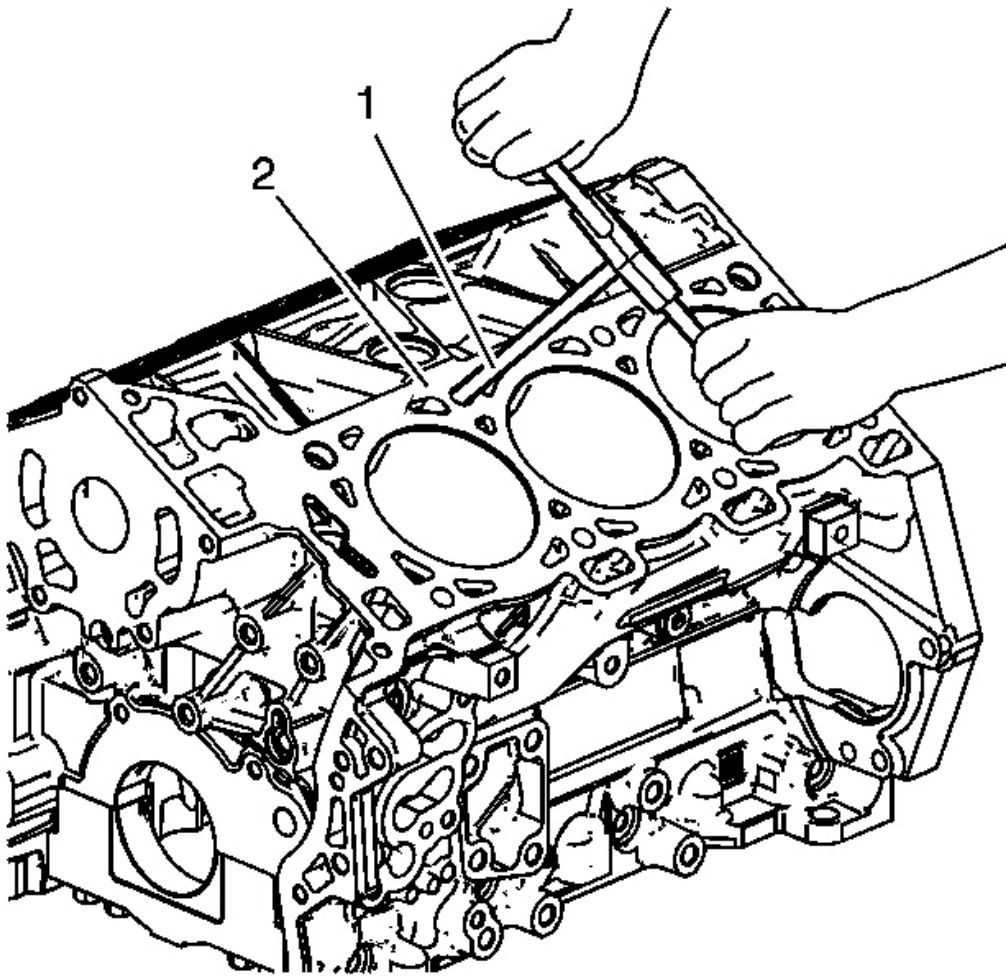


Fig. 274: Aligning Driver Installation Tool With Surface Of Engine Block Deck
Courtesy of GENERAL MOTORS CORP.

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** .

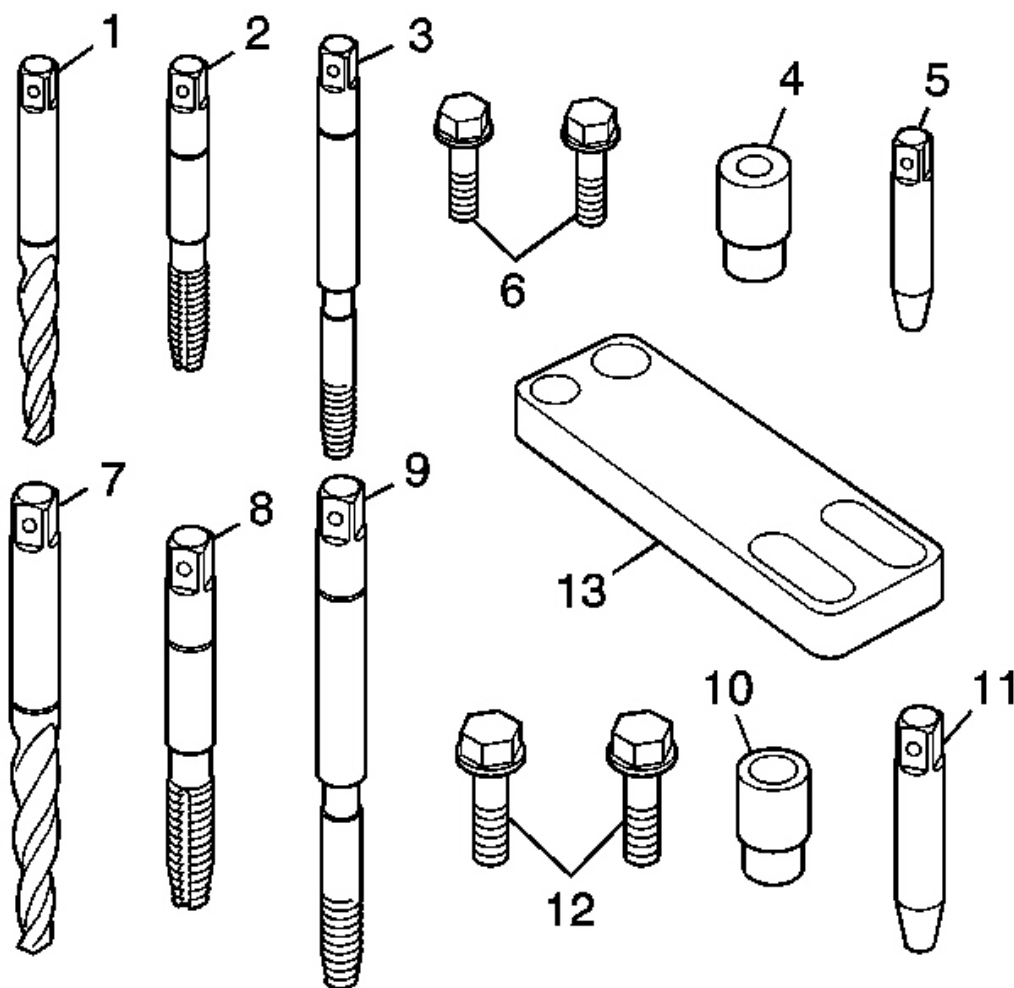


Fig. 275: View Of J 42385-2000 Components
Courtesy of GENERAL MOTORS CORP.

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)

OUTBOARD BOLT HOLES

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.

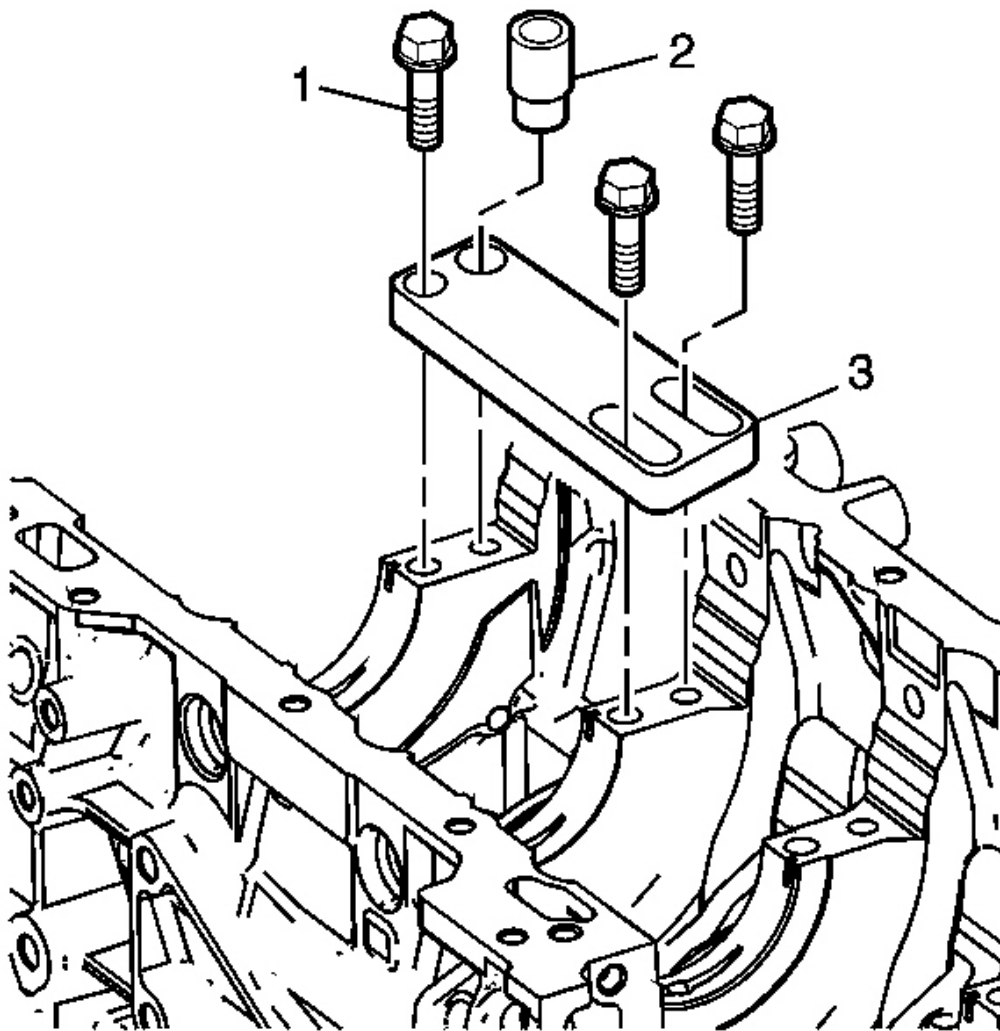


Fig. 276: Positioning Fixture Plate
Courtesy of GENERAL MOTORS CORP.

1. 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.

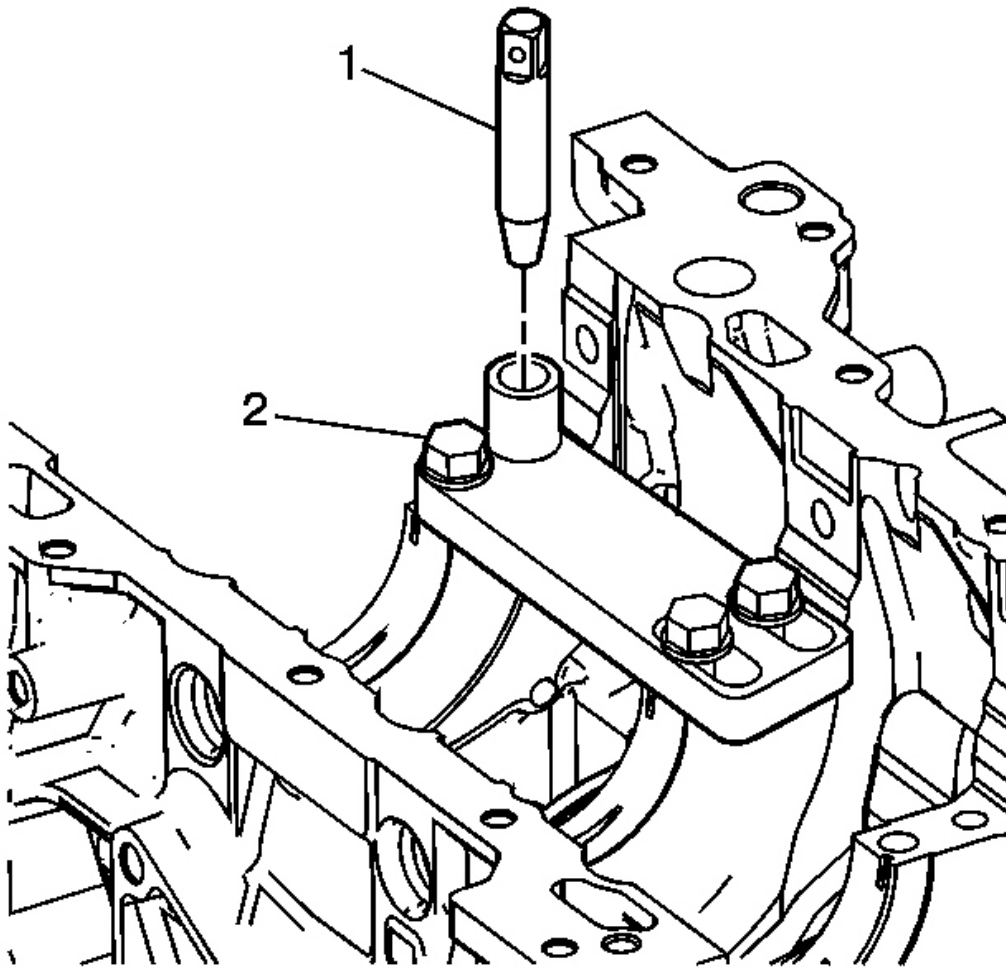


Fig. 277: Installing Alignment Pin & Bushing
Courtesy of GENERAL MOTORS CORP.

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.

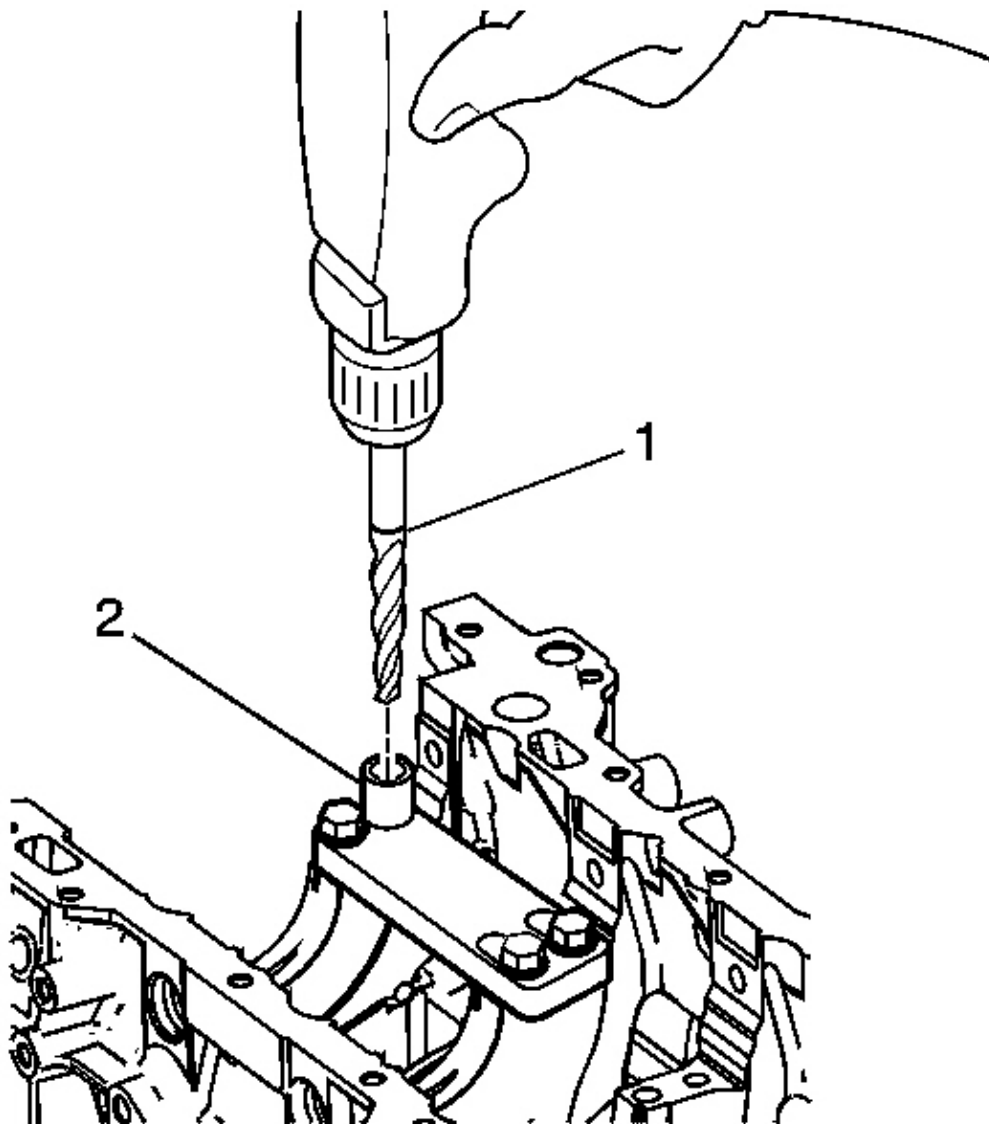


Fig. 278: Aligning Drill & Drill Bushing
Courtesy of GENERAL MOTORS CORP.

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).

6. Drill out the threads of the damaged hole.

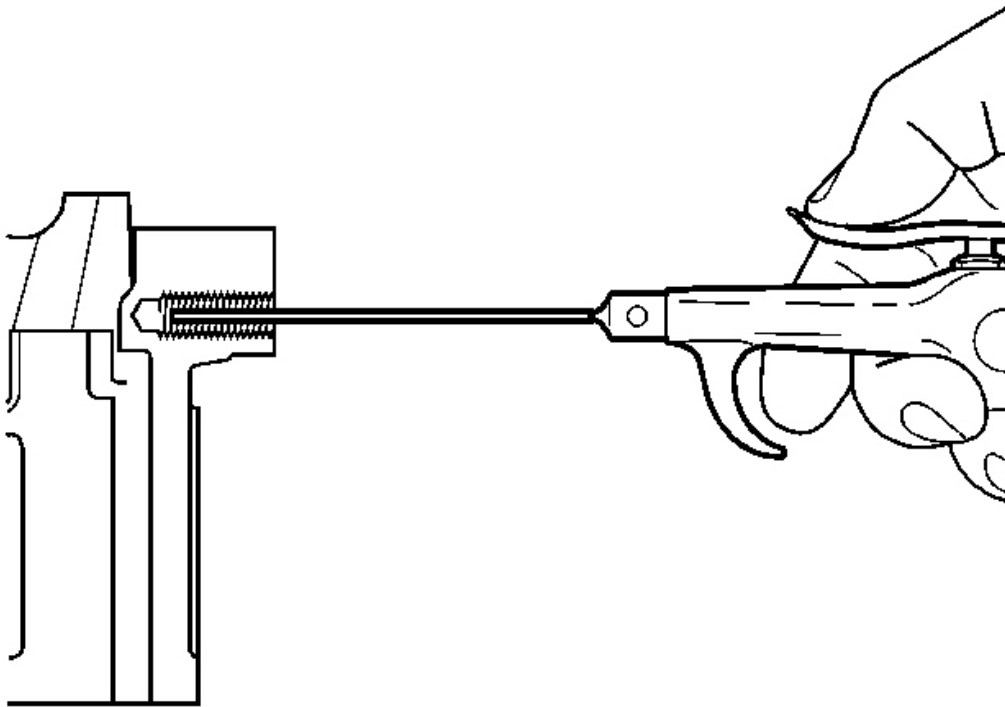


Fig. 279: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

7. Using compressed air, clean out any chips.

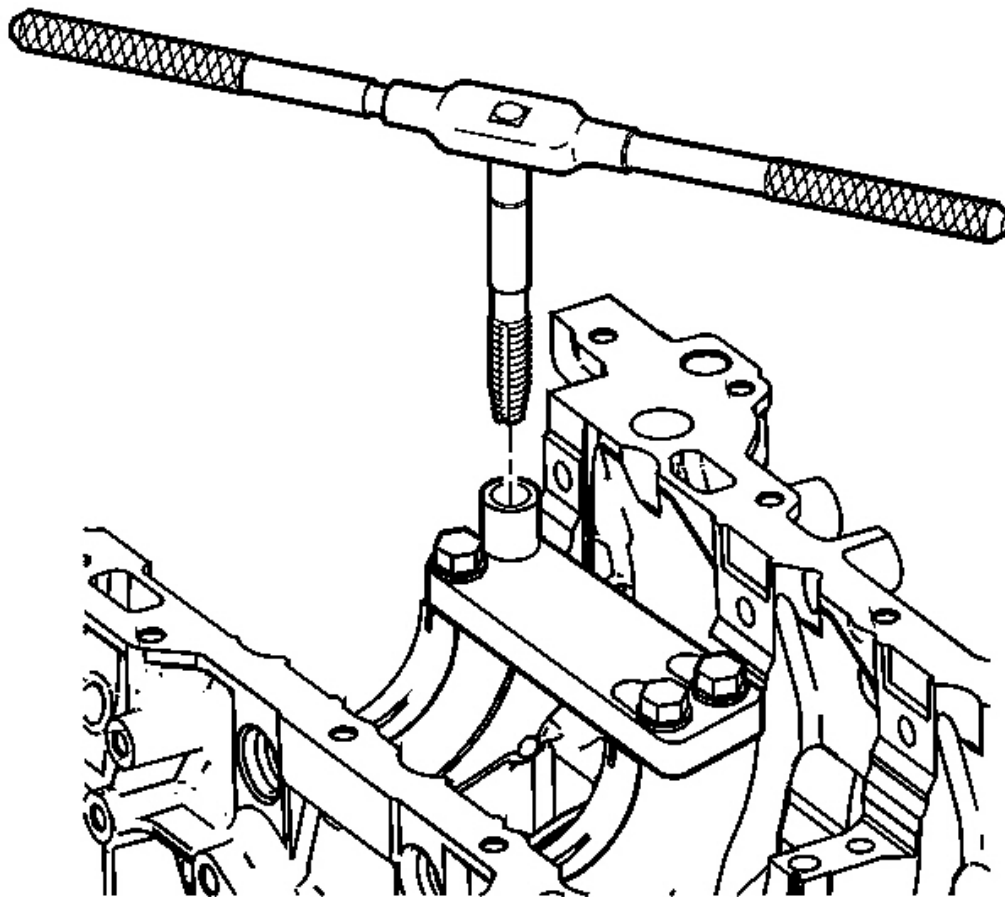


Fig. 280: View Of Tapping Wrench
Courtesy of GENERAL MOTORS CORP.

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.

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

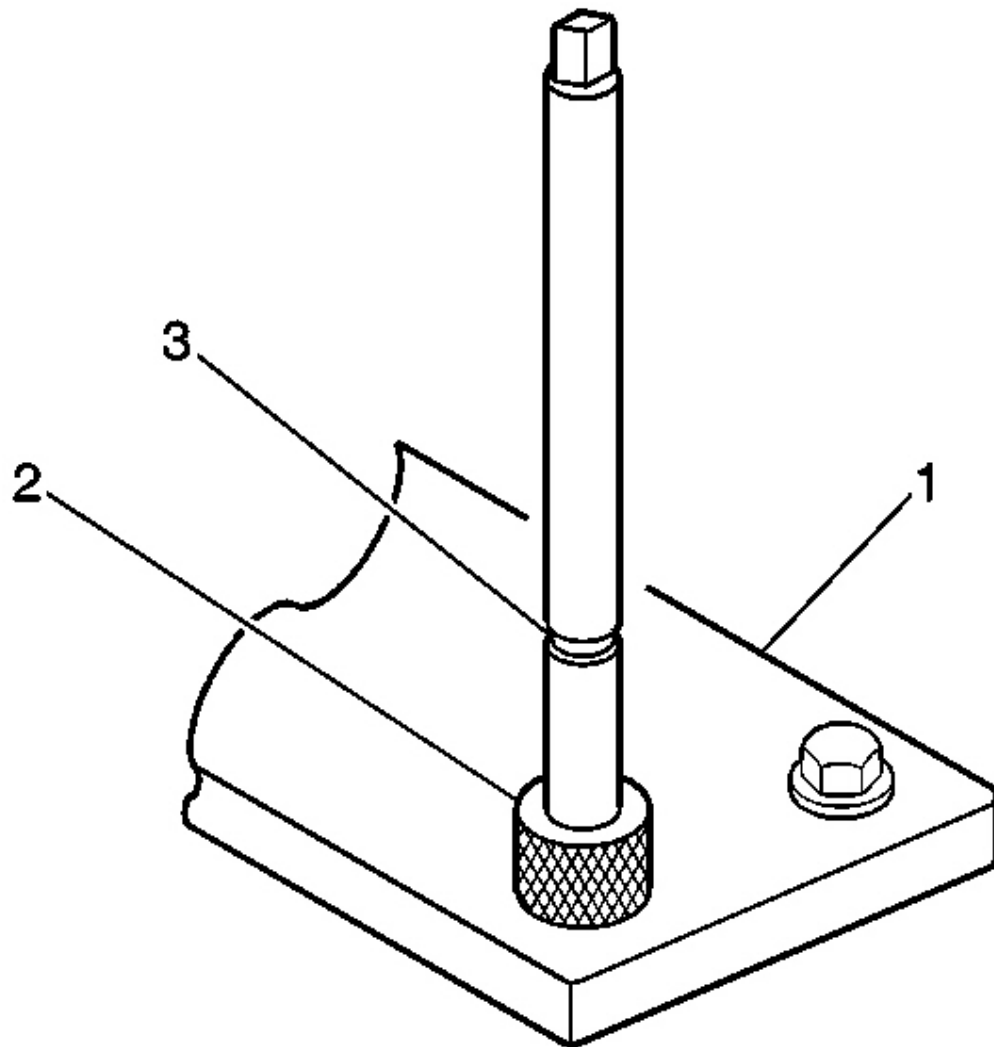


Fig. 281: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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).

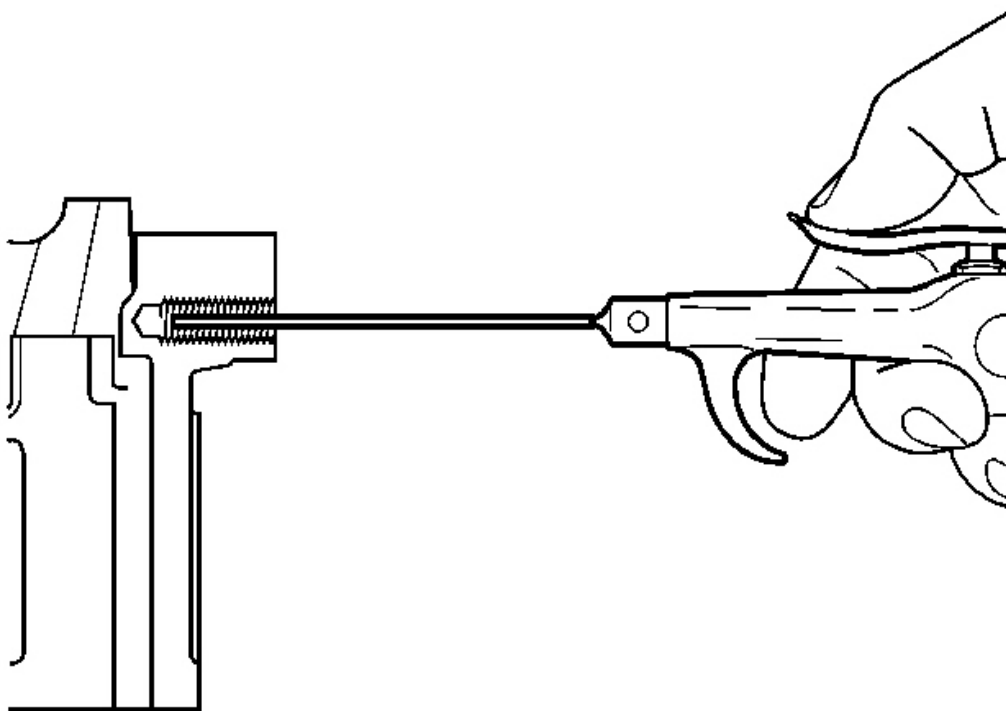


Fig. 282: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

10. Using compressed air, clean out any chips.

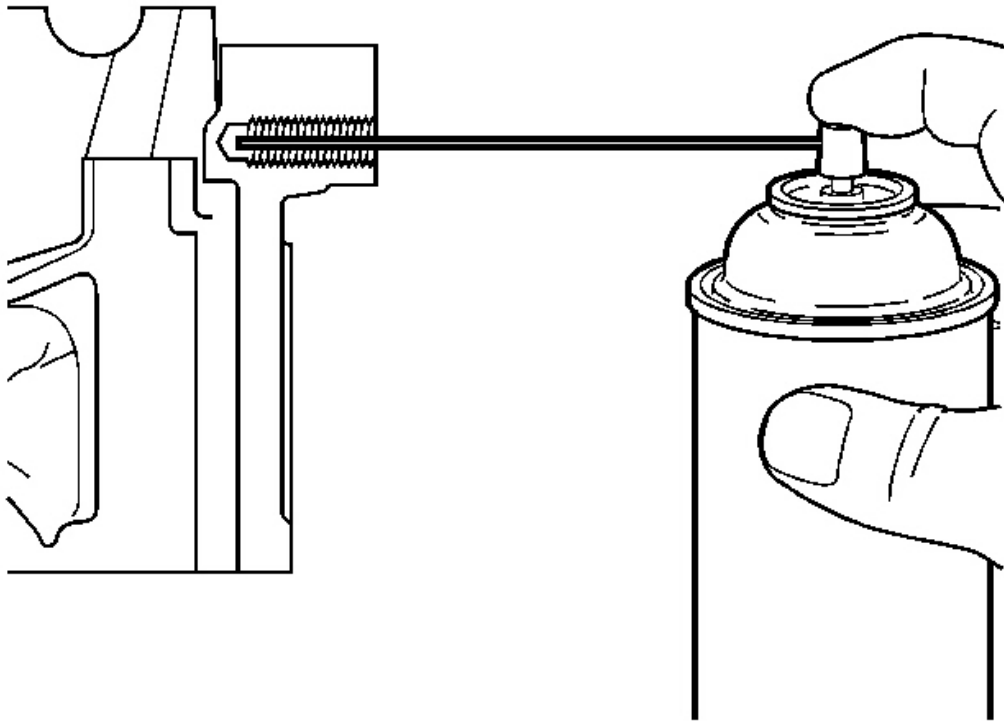


Fig. 283: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

11. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended cleaner.

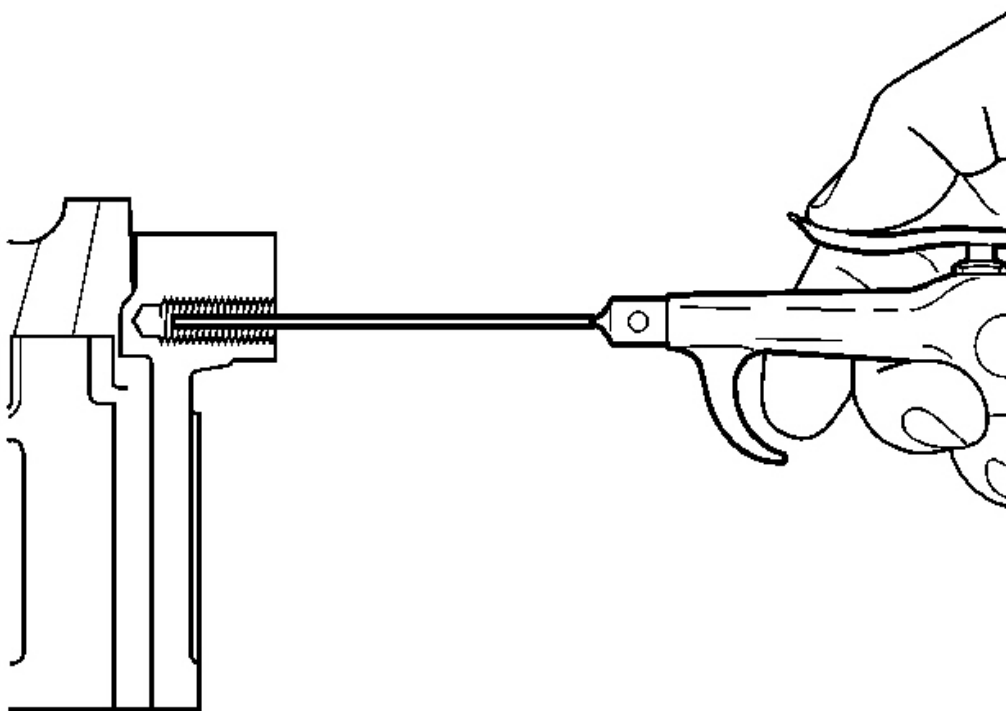


Fig. 284: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

12. Using compressed air, clean out any chips.

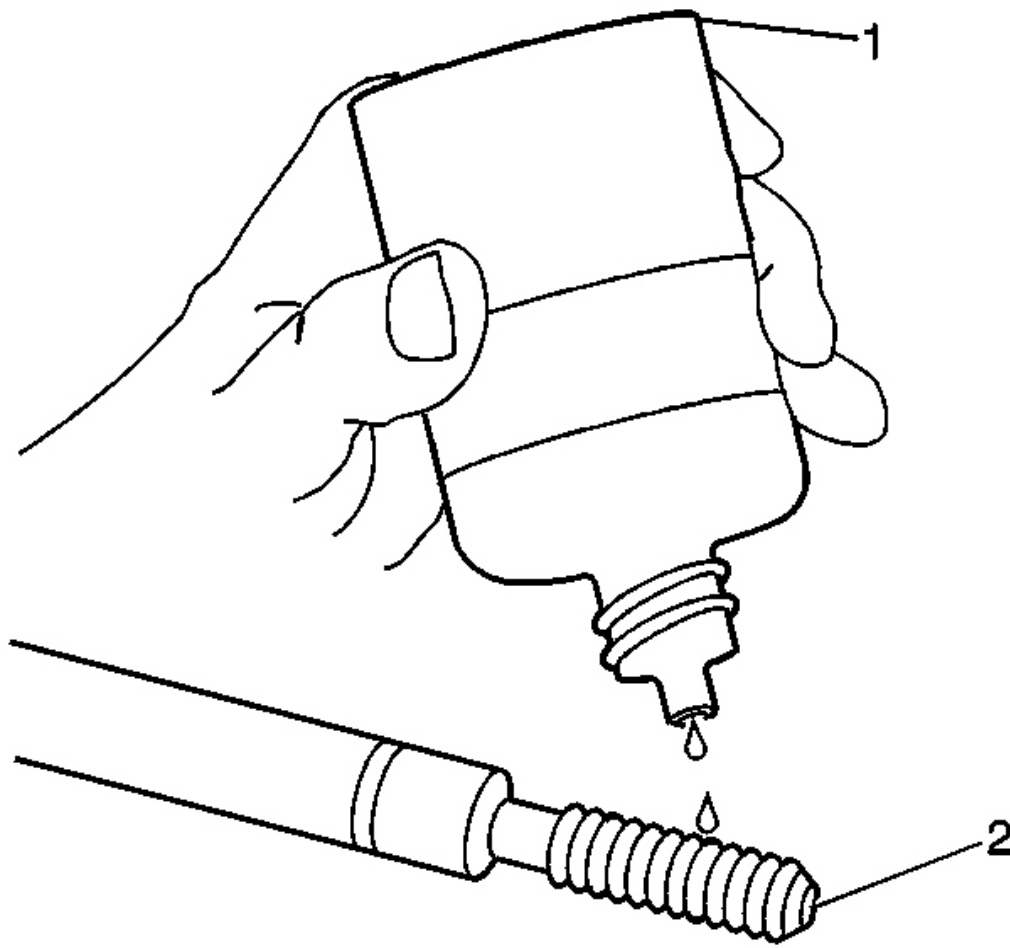


Fig. 285: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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.

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

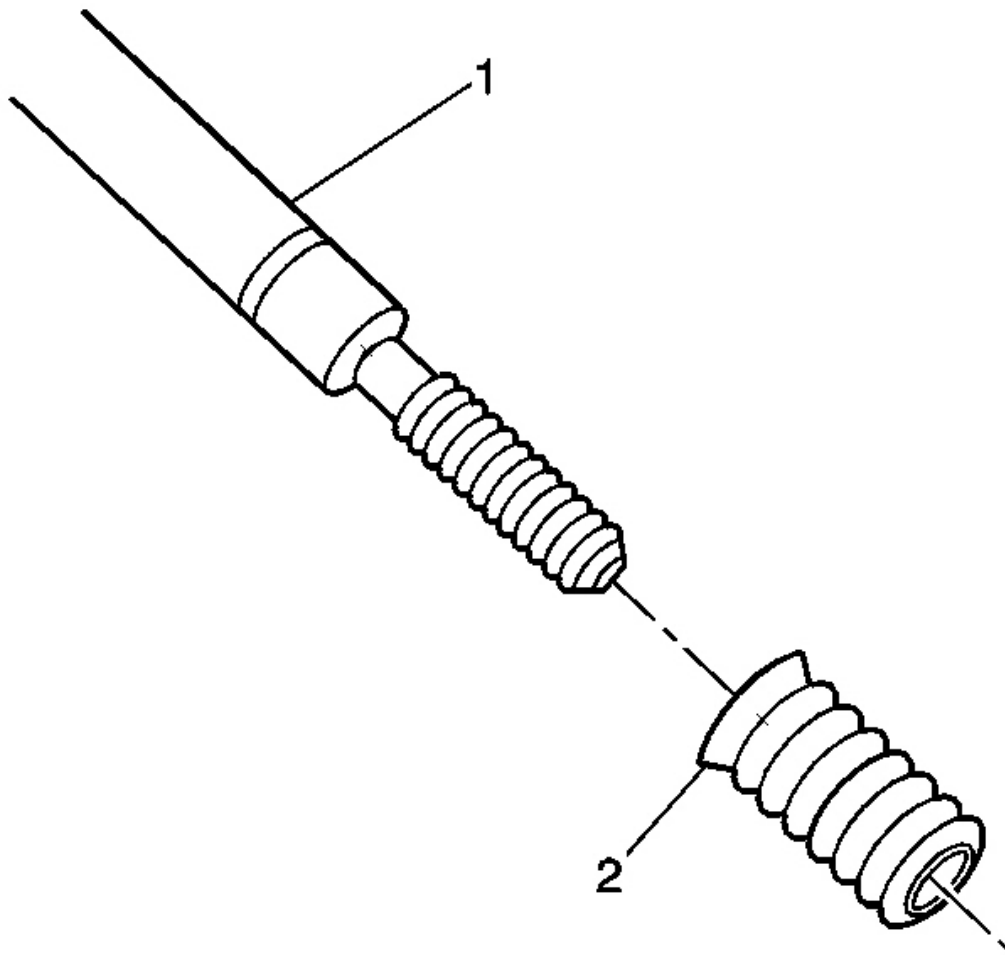


Fig. 286: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

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

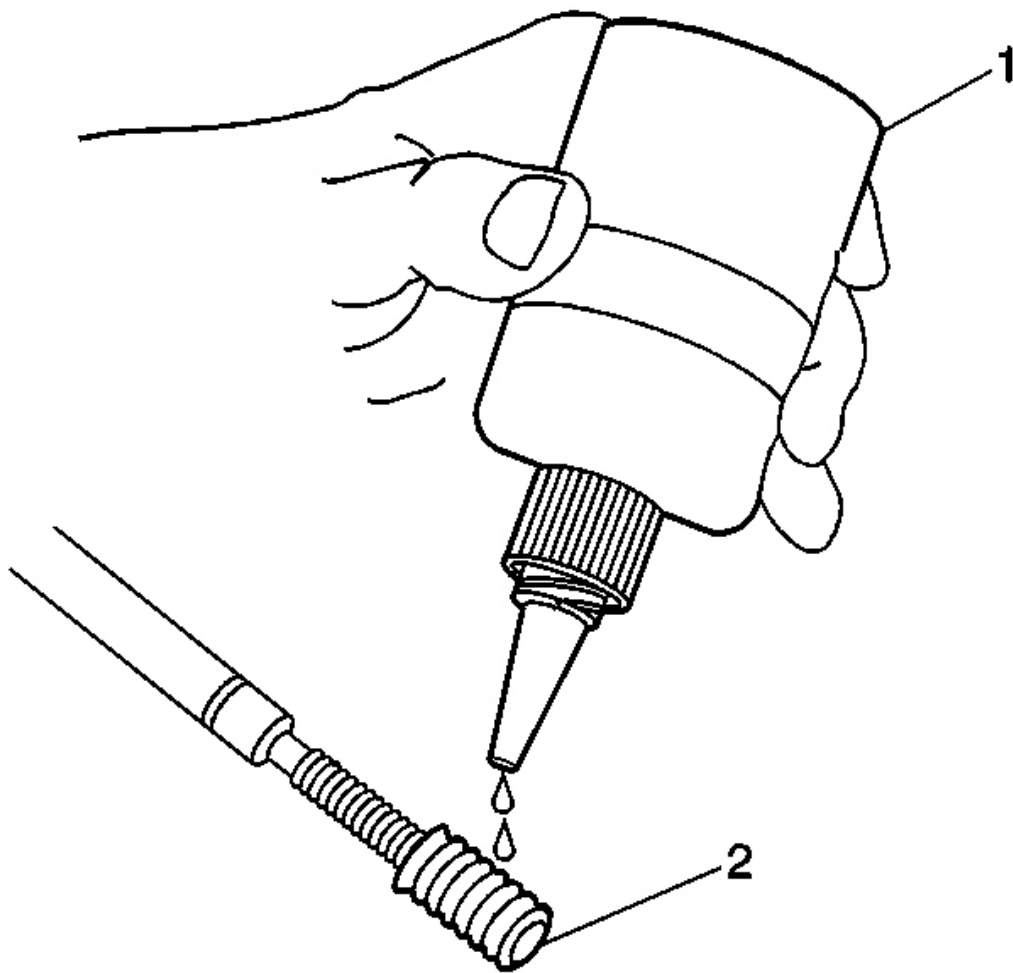


Fig. 287: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

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

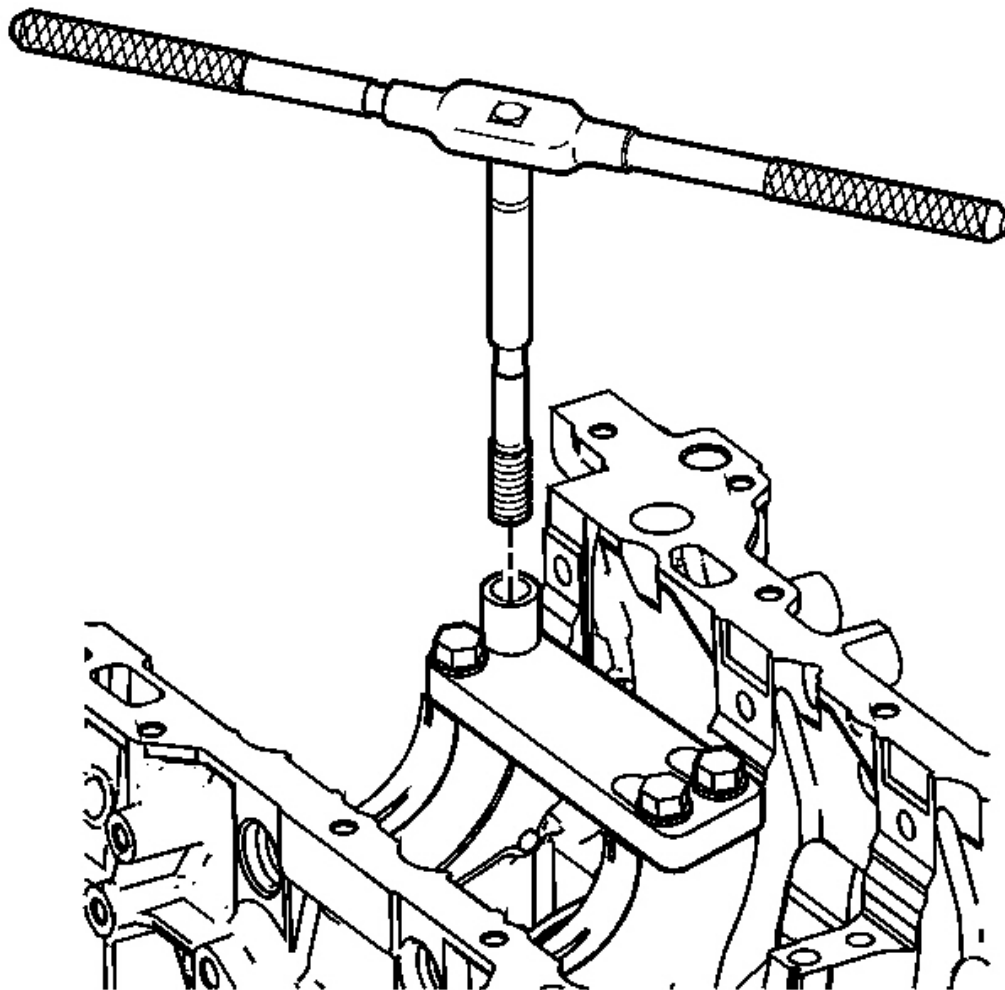


Fig. 288: Identifying Tapping Wrench
Courtesy of GENERAL MOTORS CORP.

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.

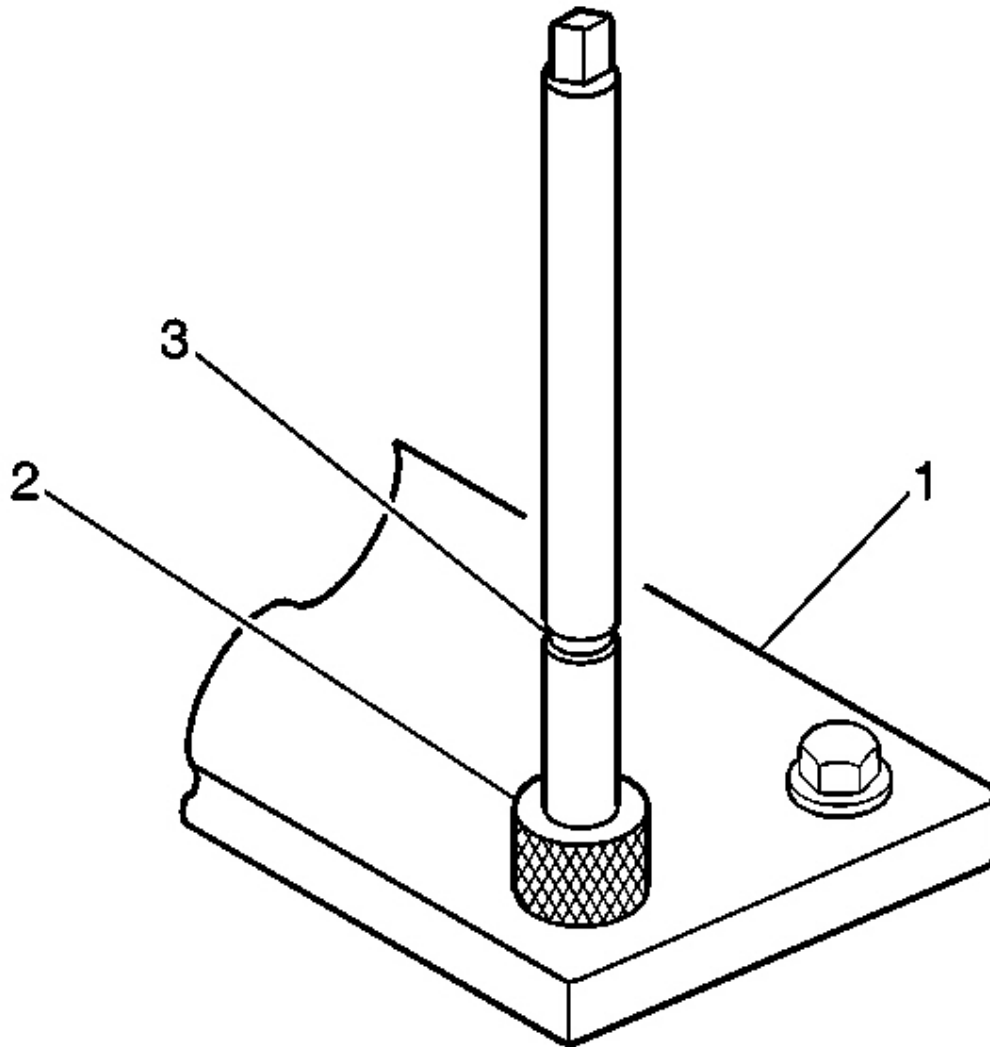


Fig. 289: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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.

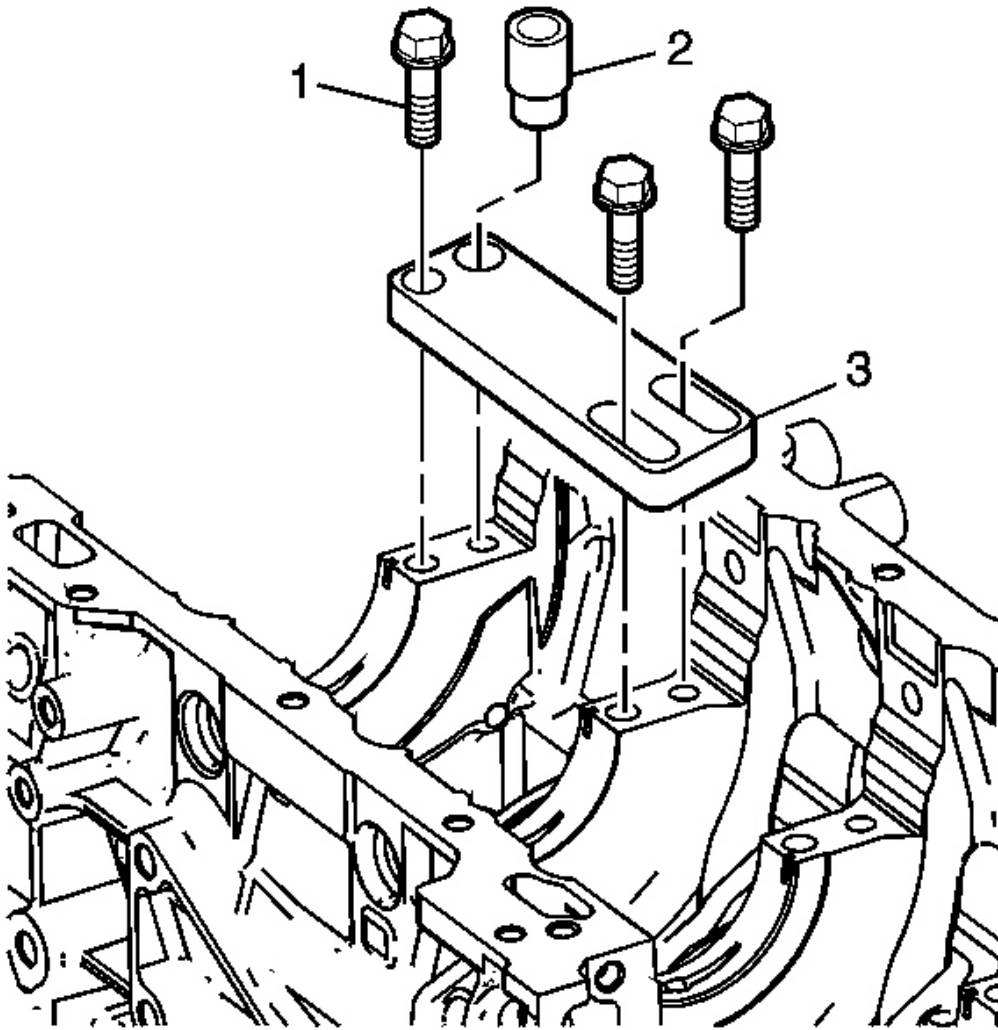


Fig. 290: Positioning Fixture Plate
Courtesy of GENERAL MOTORS CORP.

22. Remove the fixture plate bolts (1).
23. Remove the fixture plate (3) and bushing (2).

INBOARD BOLT HOLES

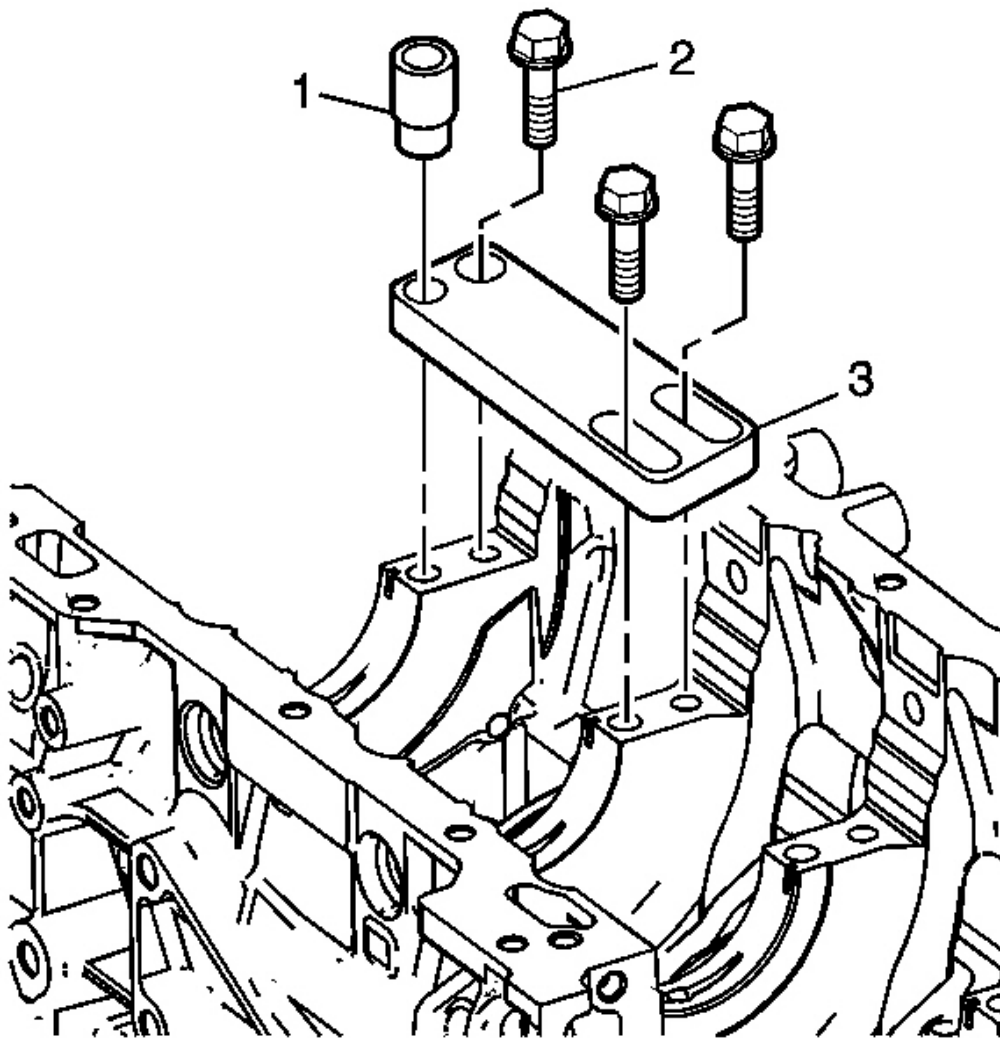


Fig. 291: Positioning Fixture Plate
Courtesy of GENERAL MOTORS CORP.

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.

1. 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.

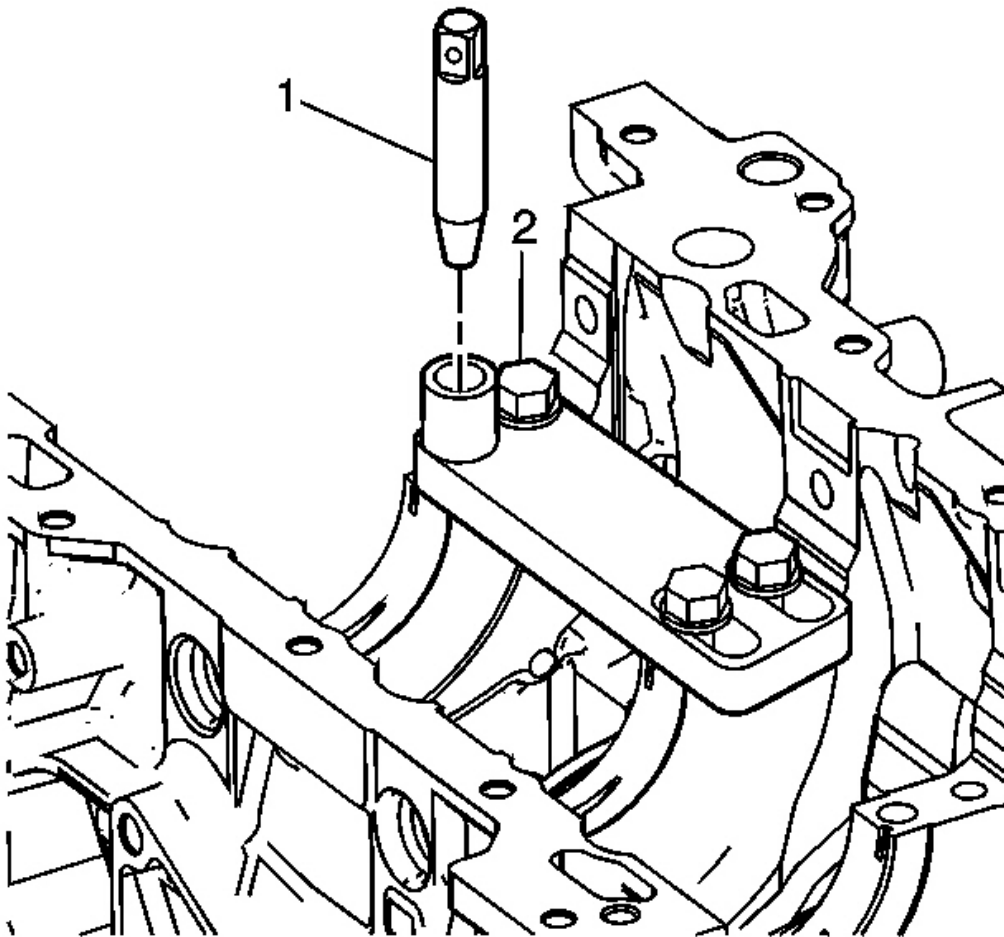


Fig. 292: Locating Alignment Pin
Courtesy of GENERAL MOTORS CORP.

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.

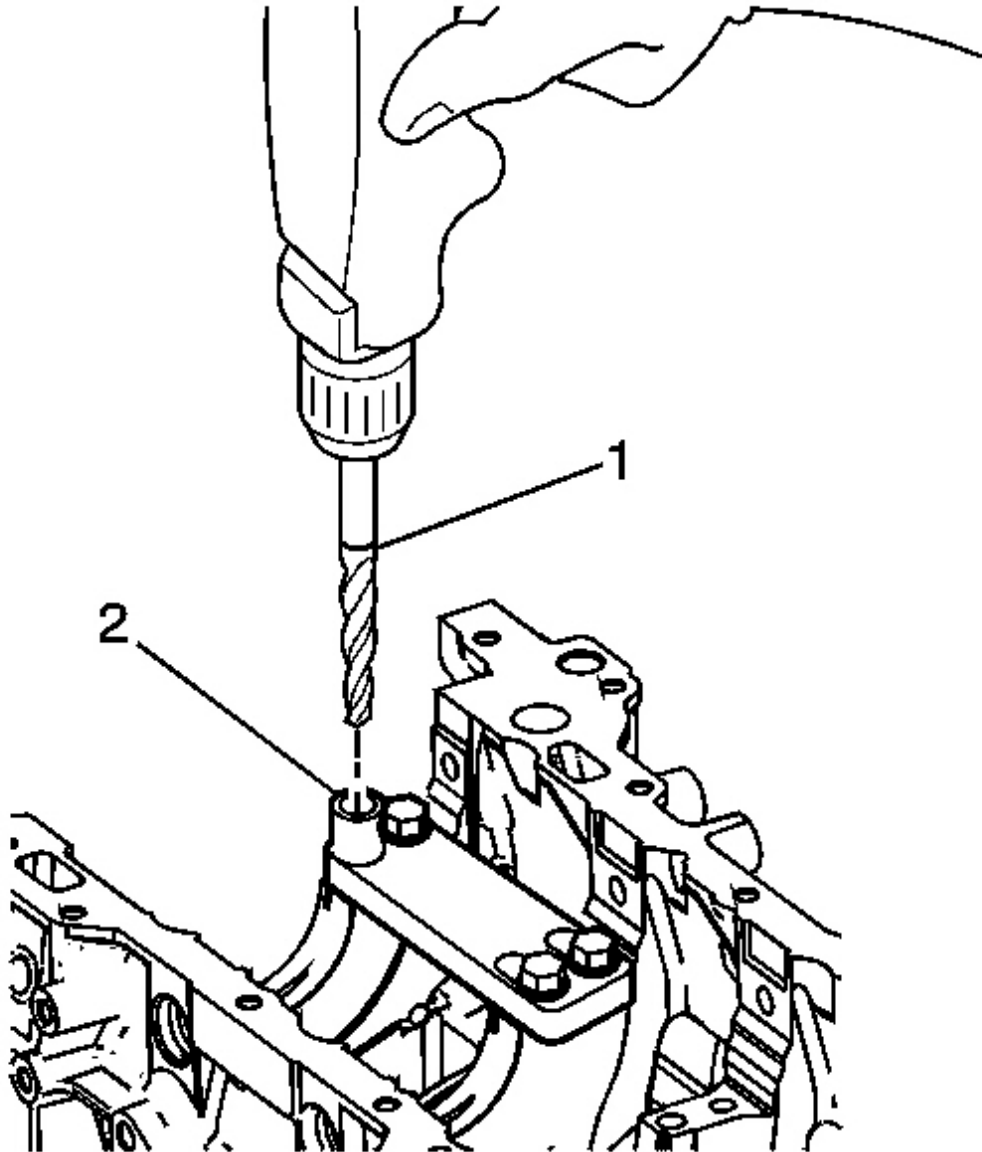


Fig. 293: Drilling Out Damaged Threads
Courtesy of GENERAL MOTORS CORP.

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).

6. Drill out the threads of the damaged hole.

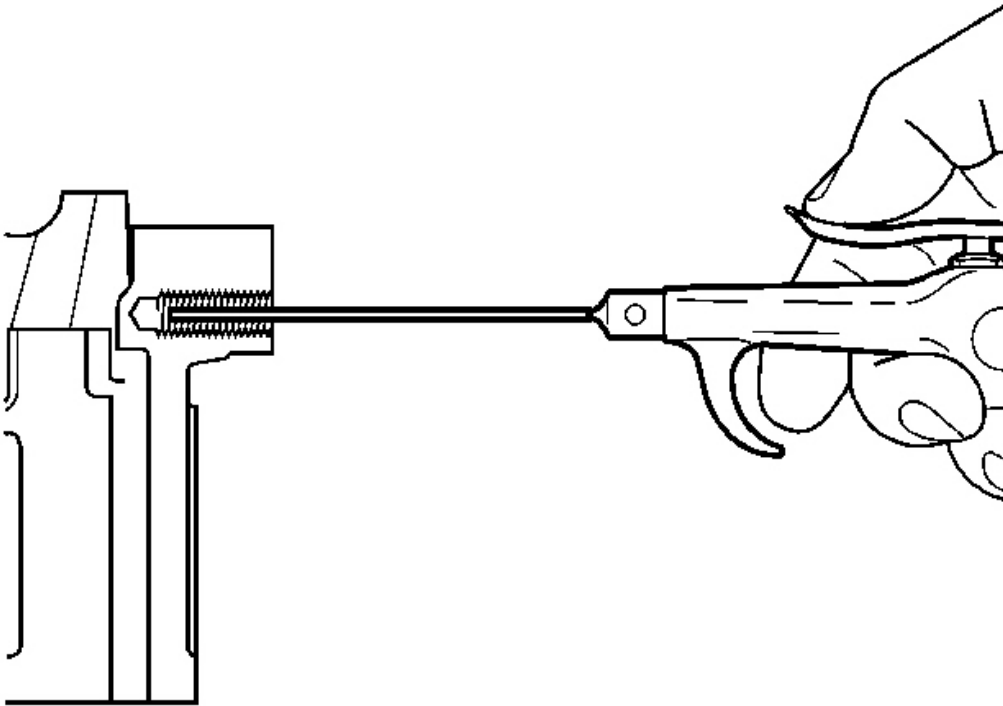


Fig. 294: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

7. Using compressed air, clean out any chips.

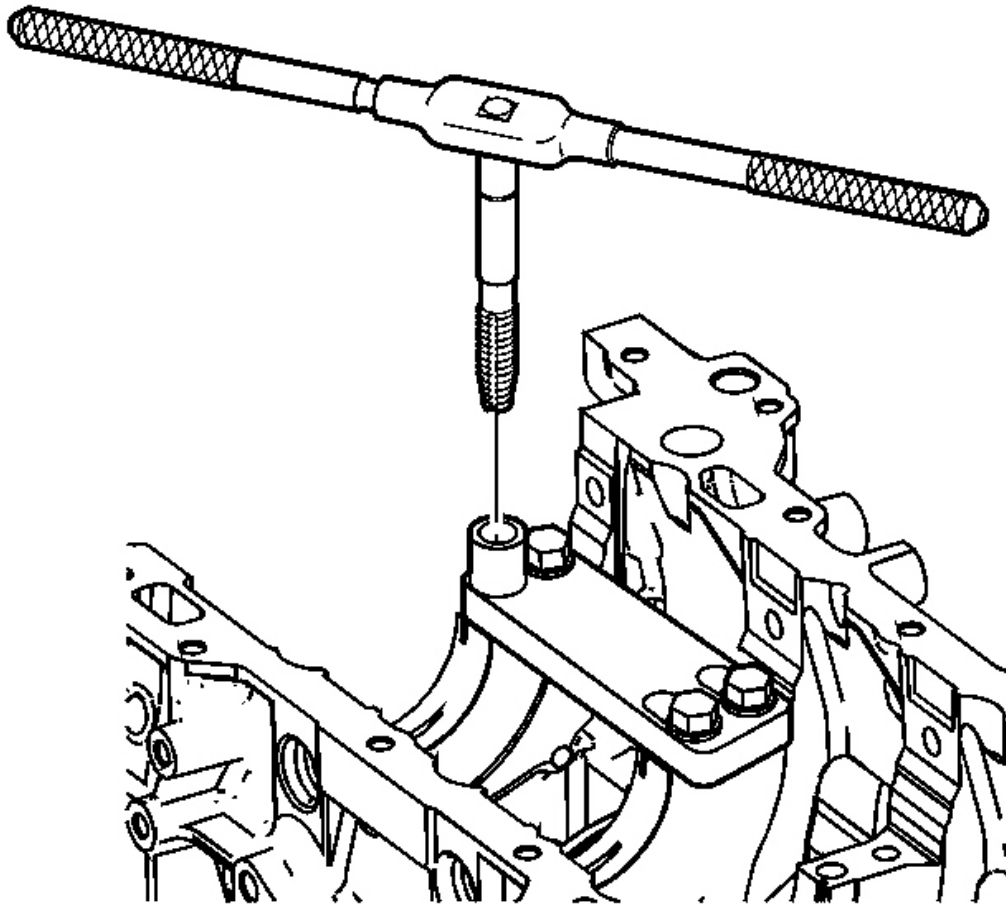


Fig. 295: Positioning Tapping Wrench
Courtesy of GENERAL MOTORS CORP.

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.

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

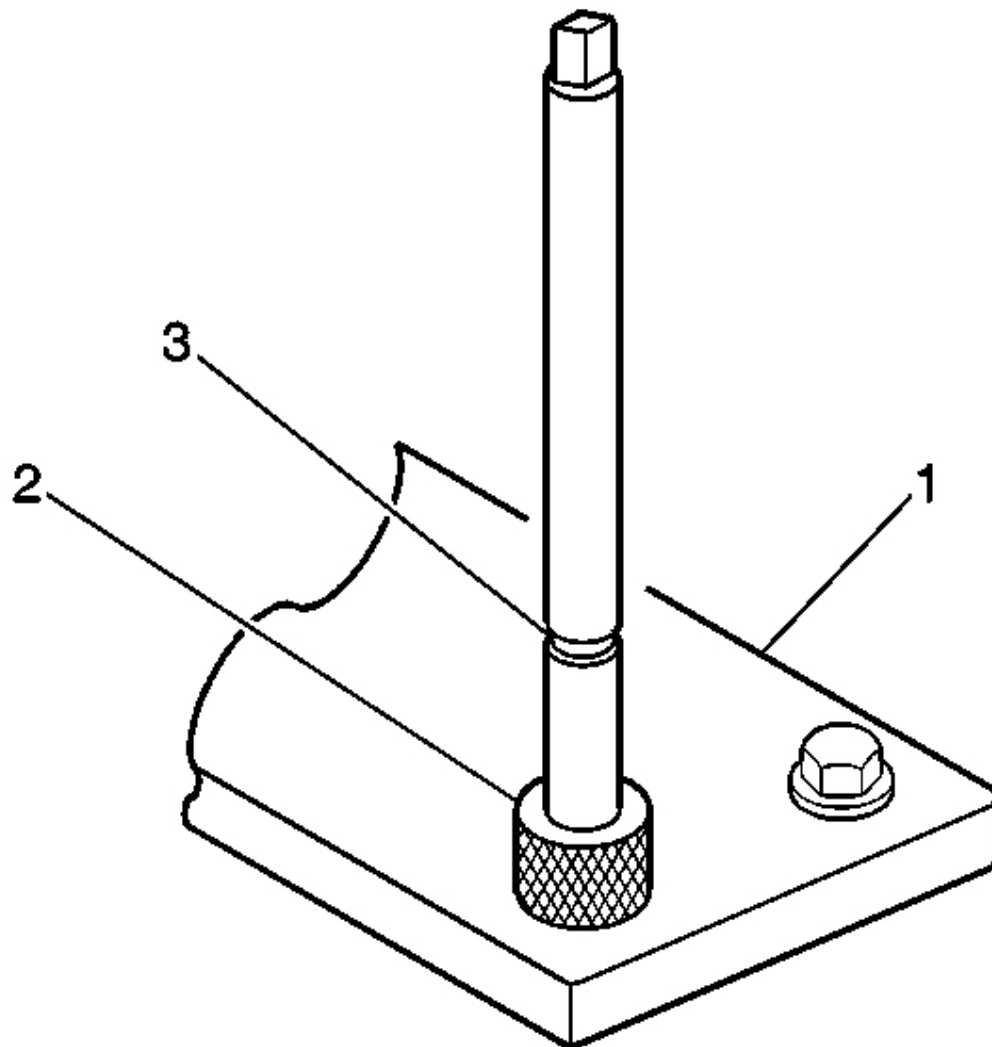


Fig. 296: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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).

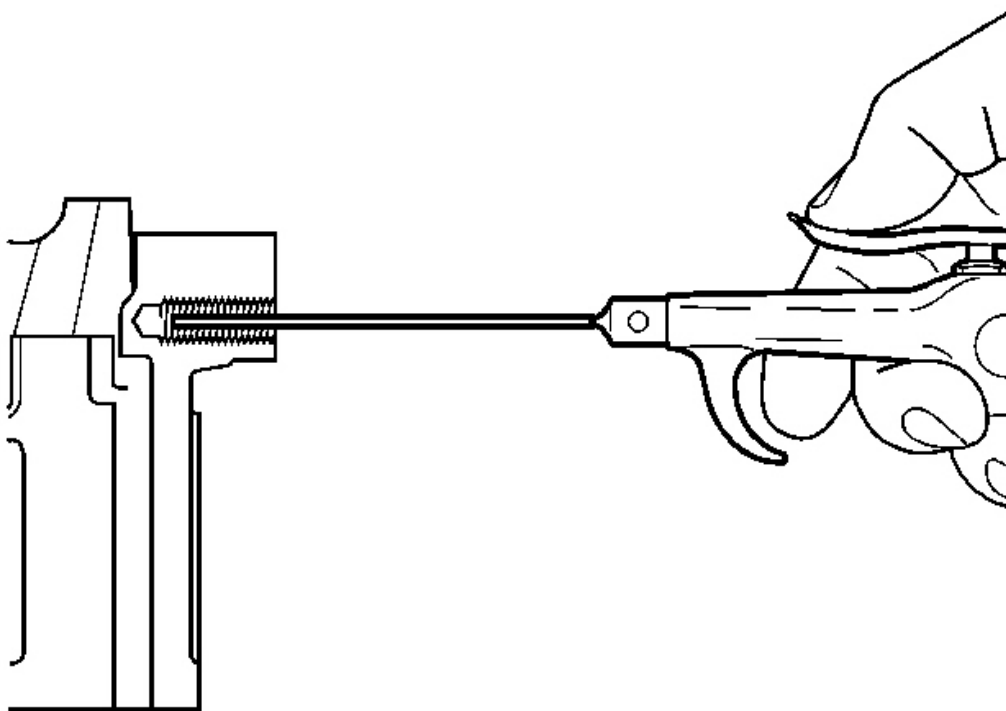


Fig. 297: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

10. Using compressed air, clean out any chips.

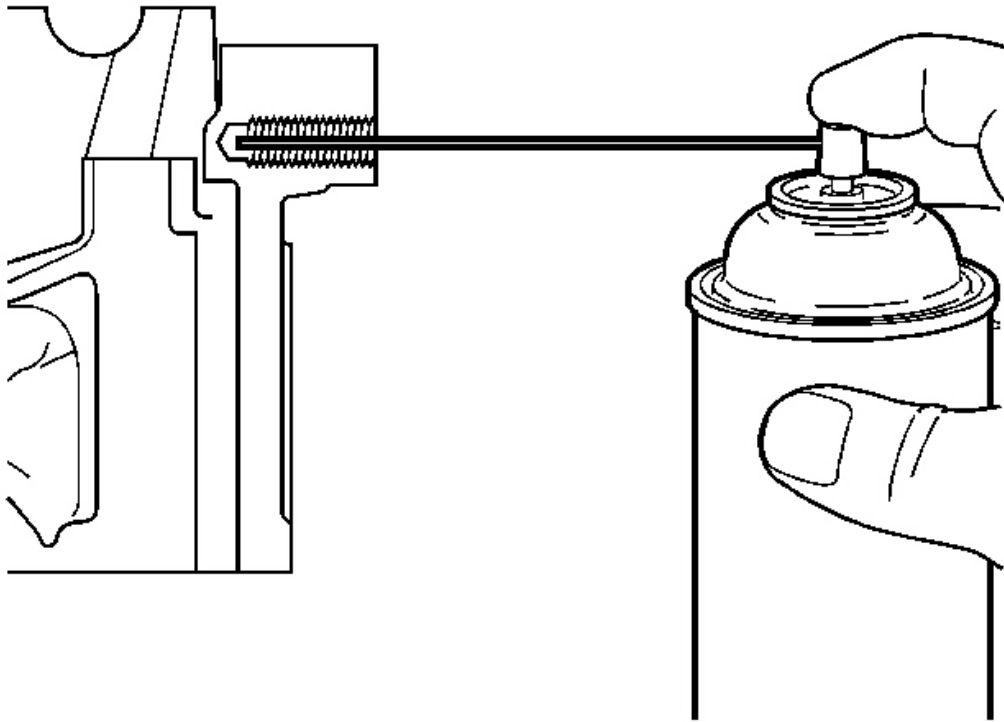


Fig. 298: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

11. Spray cleaner into the tapped hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended cleaner.

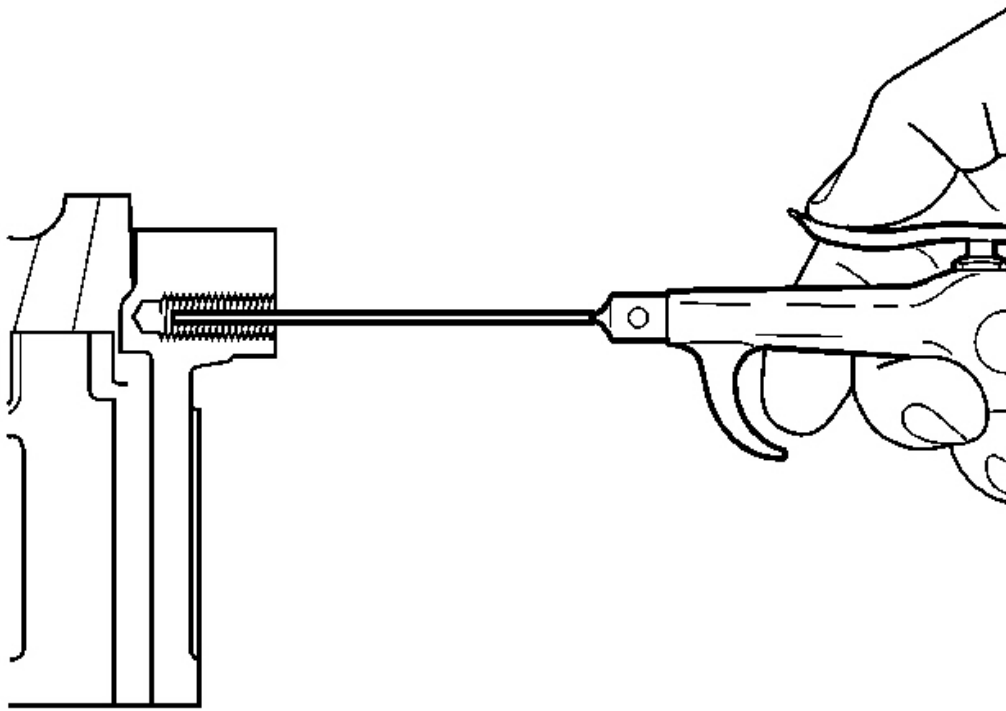


Fig. 299: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

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

12. Using compressed air, clean out any chips.

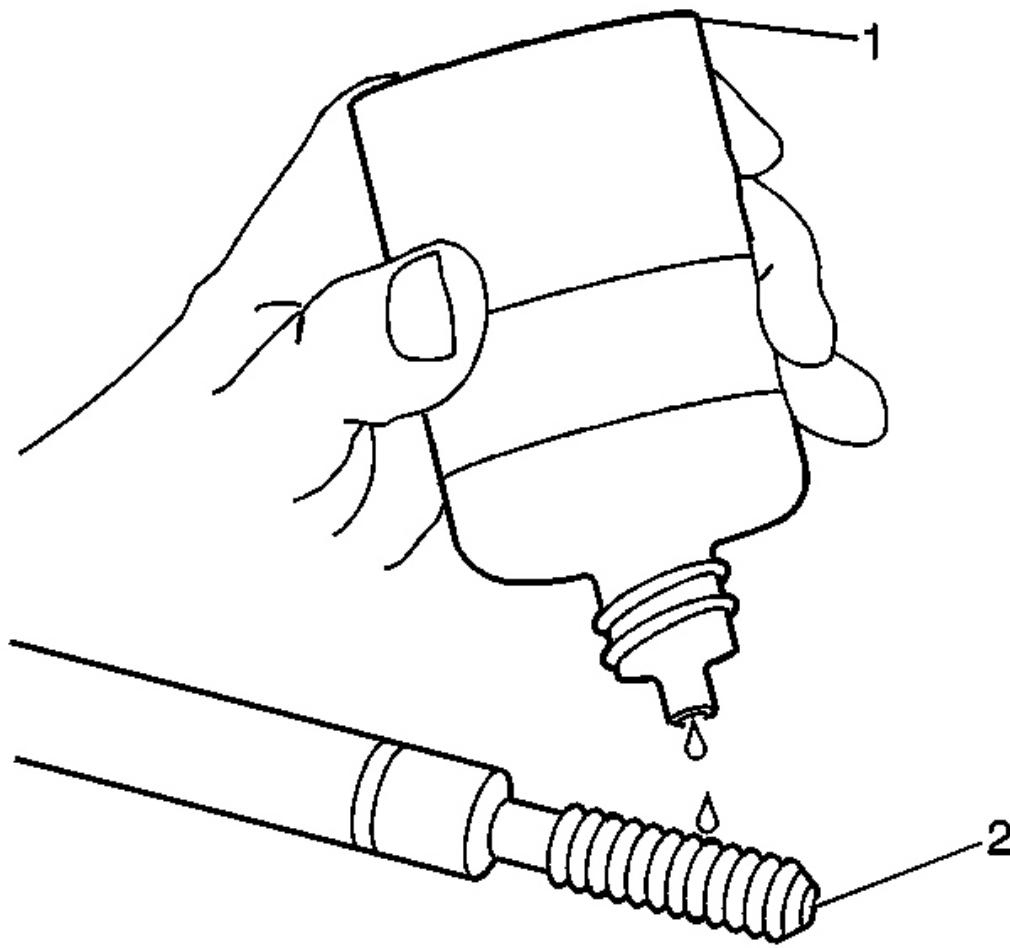


Fig. 300: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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.

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

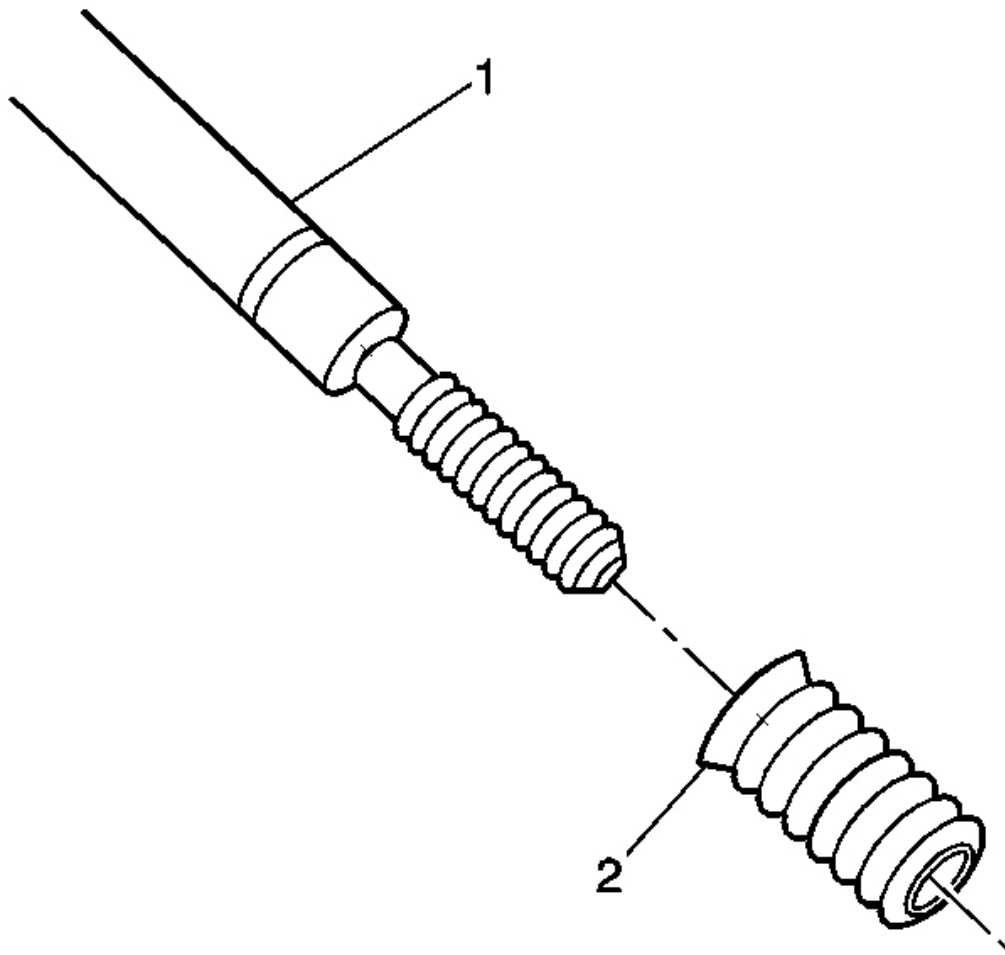


Fig. 301: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

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

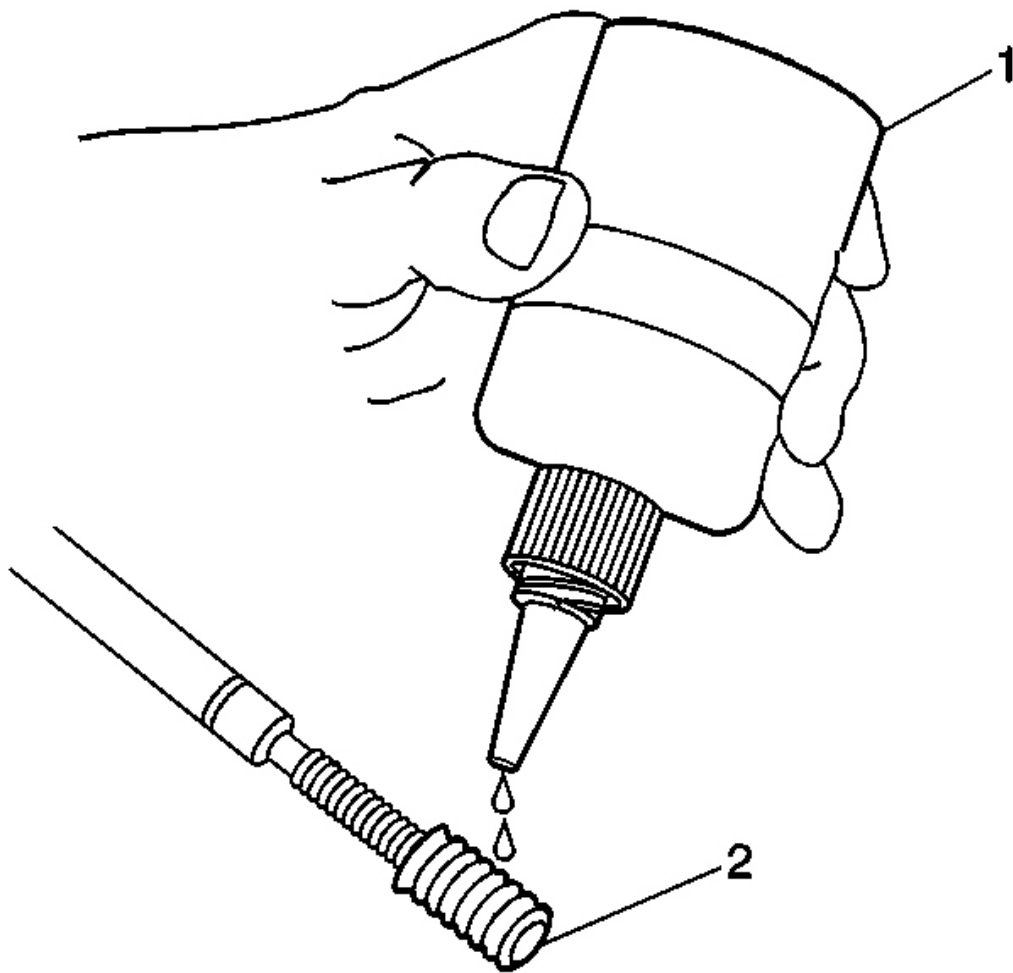


Fig. 302: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

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

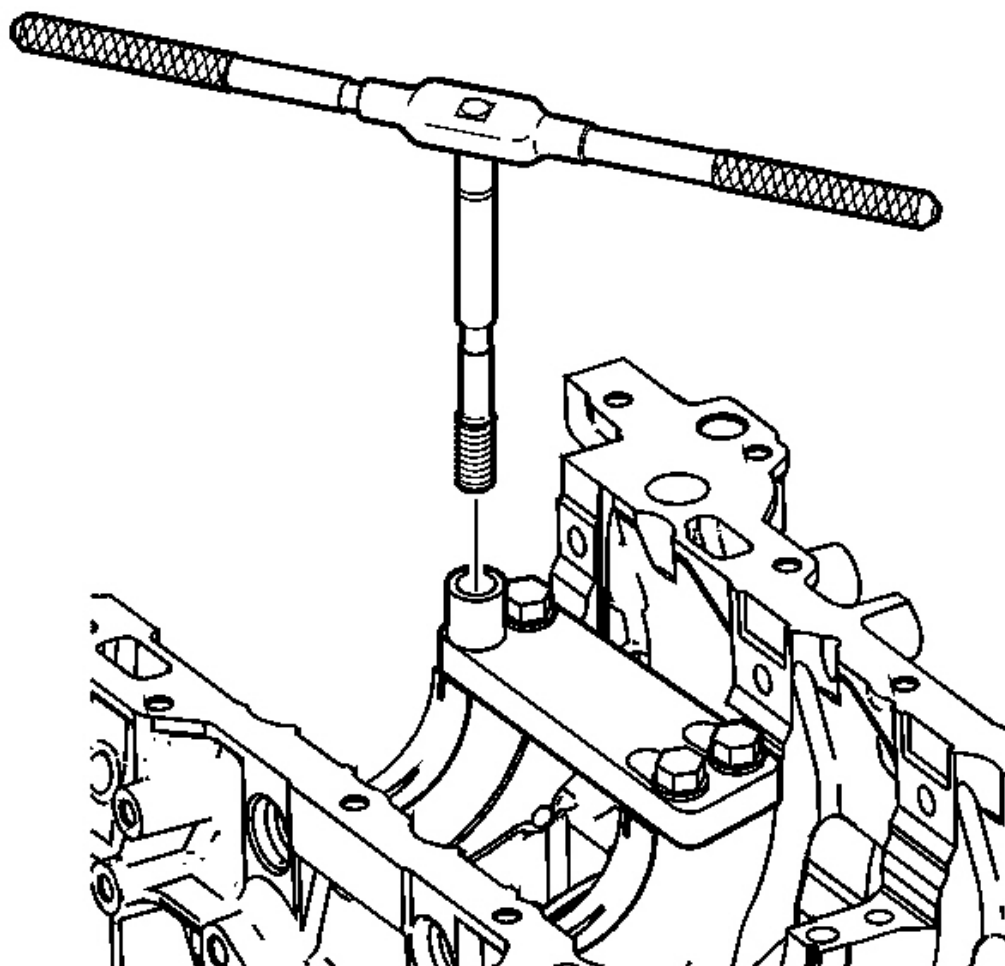


Fig. 303: Insert & Installation Driver
Courtesy of GENERAL MOTORS CORP.

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.

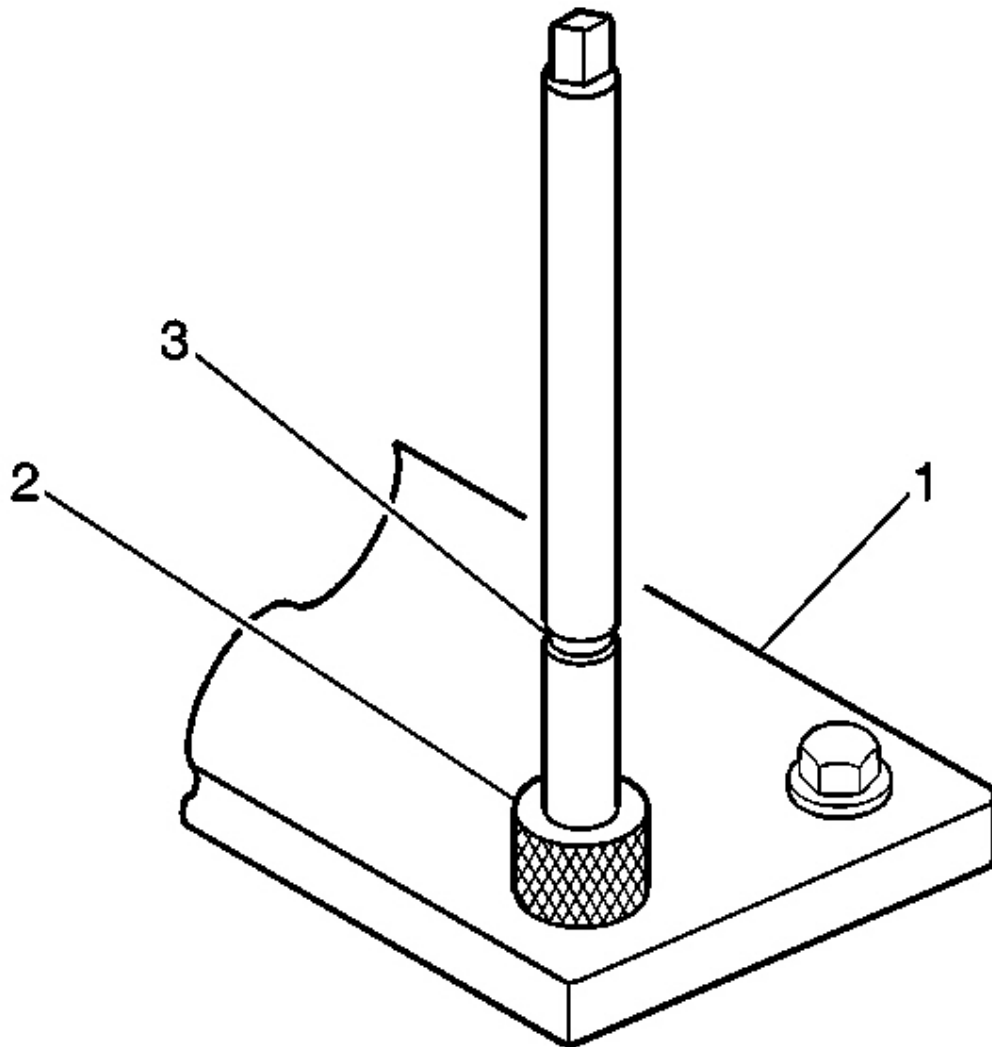


Fig. 304: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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.

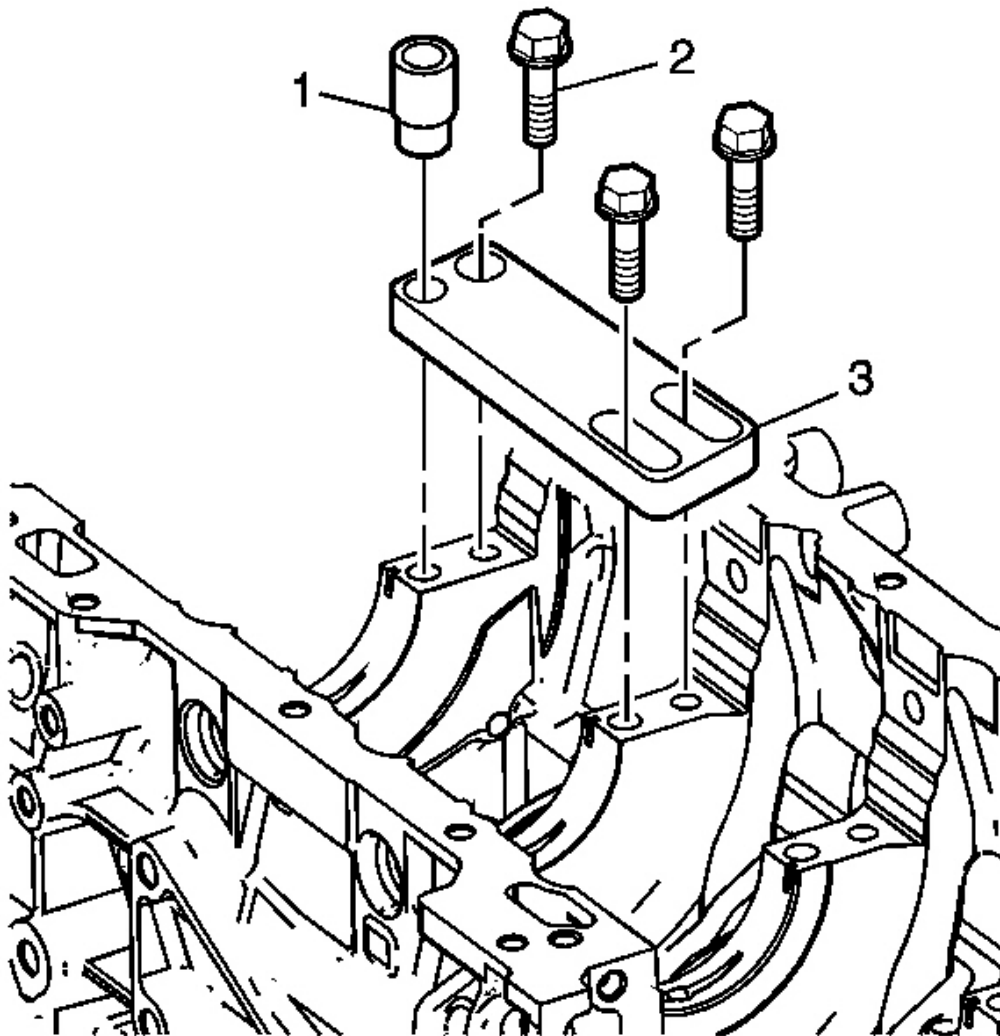


Fig. 305: Positioning Fixture Plate
Courtesy of GENERAL MOTORS CORP.

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

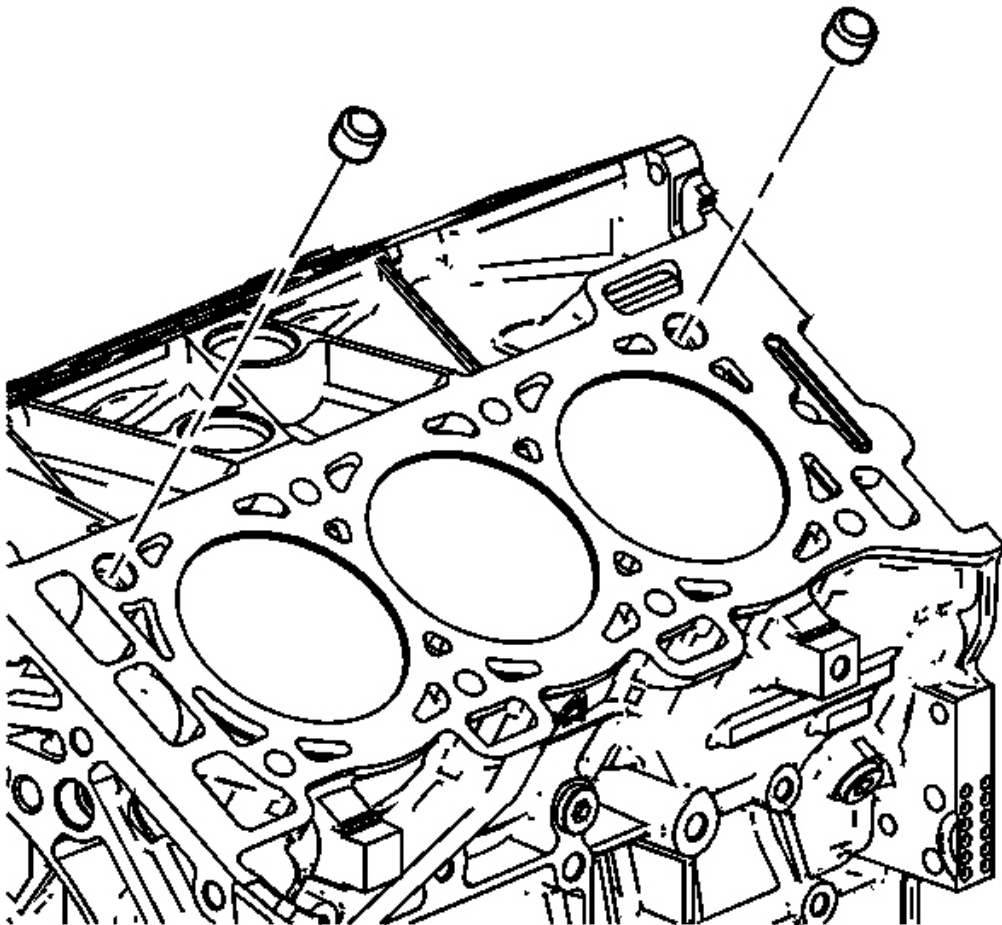


Fig. 306: Cylinder Block-To-Cylinder Head Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

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

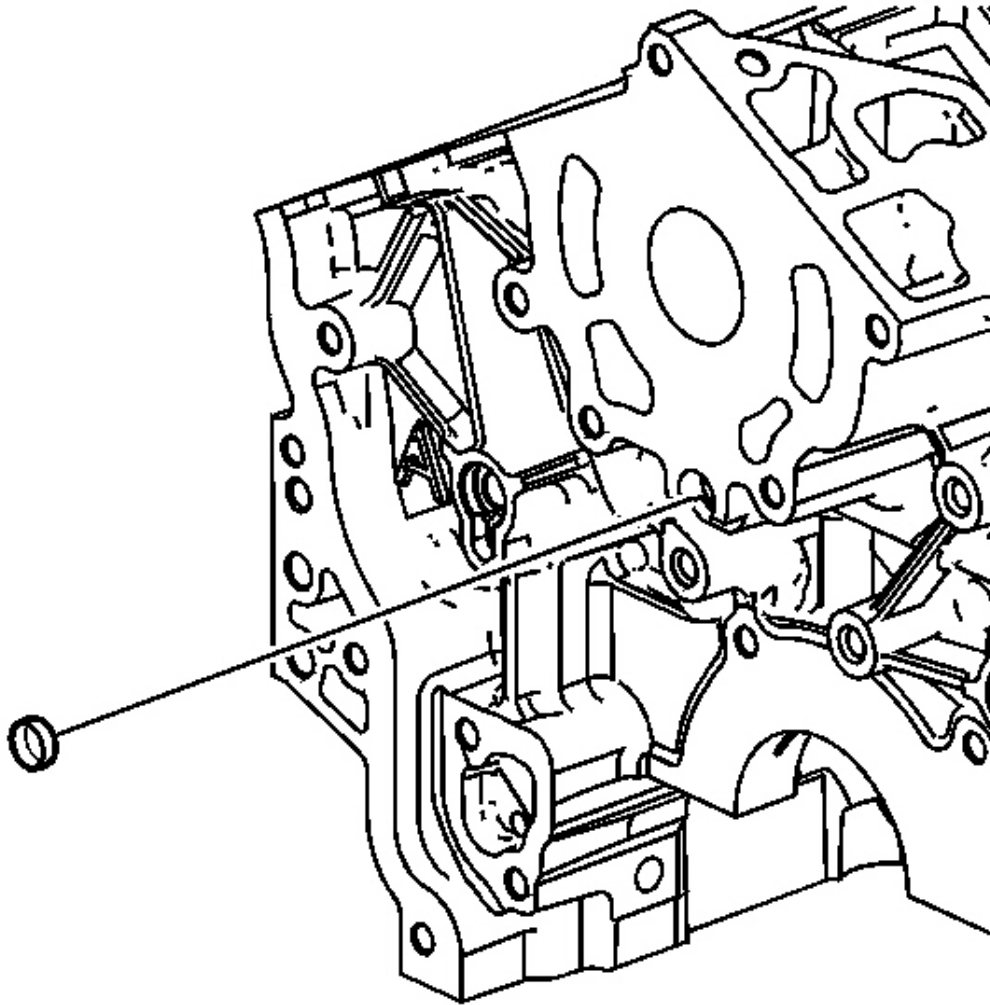


Fig. 307: Locating Front Oil Gallery Expansion Plug
Courtesy of GENERAL MOTORS CORP.

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

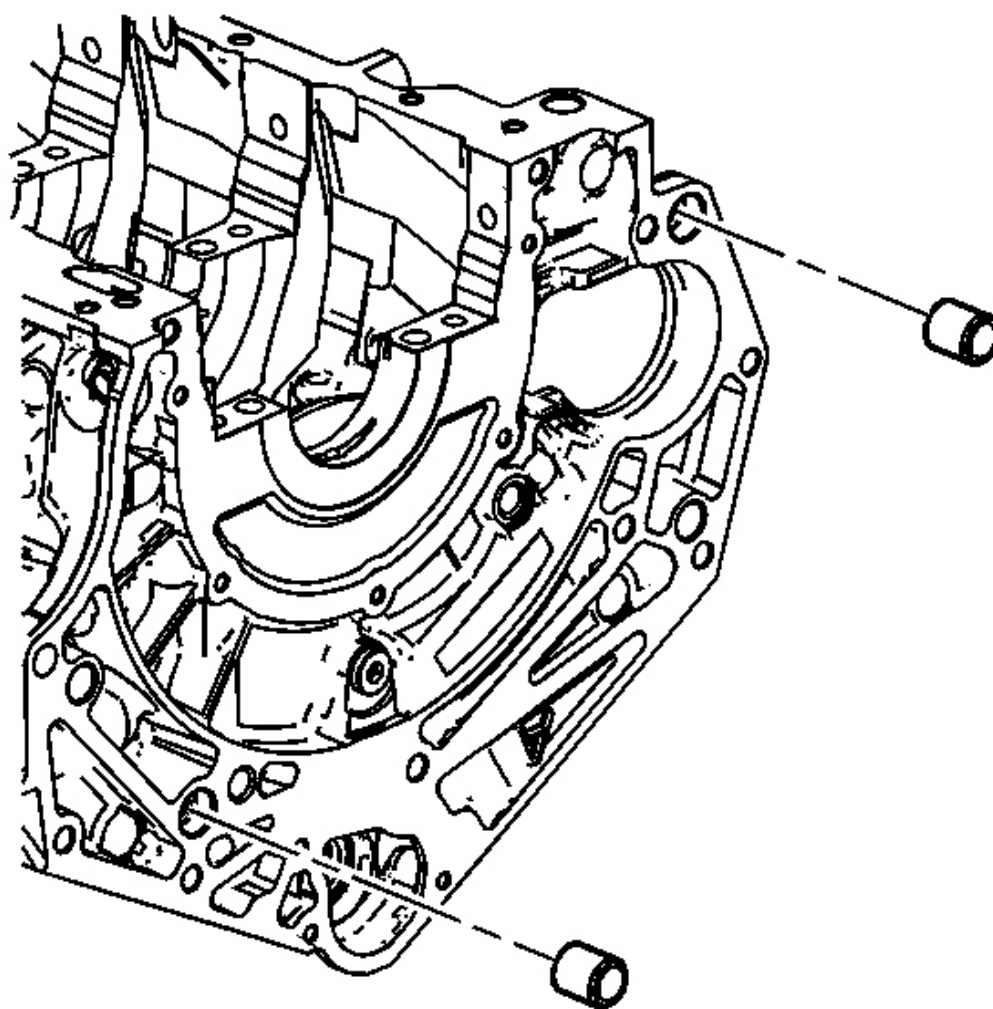


Fig. 308: Cylinder Block-To-Transmission Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder block-to-transmission alignment dowels.

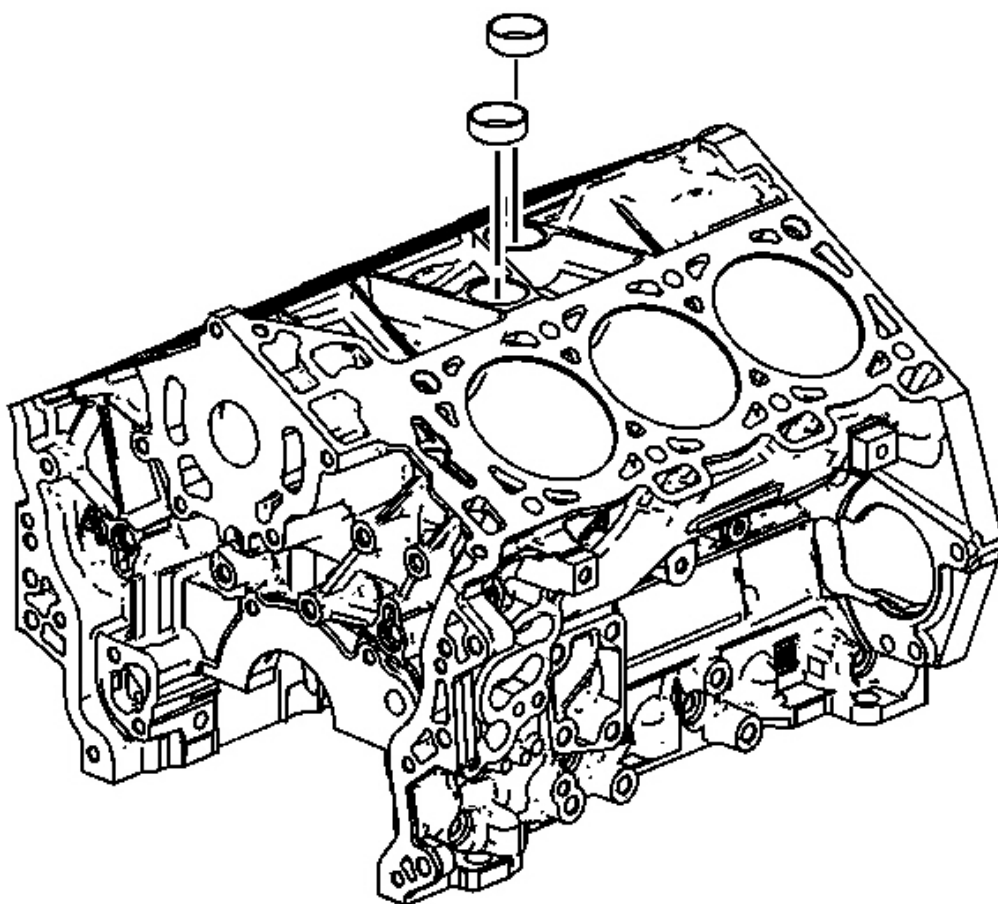


Fig. 309: Identifying Coolant Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

5. Apply the RTV sealant, GM P/N 12378521 (Canadian P/N 88901148) or equivalent on the NEW coolant expansion plugs.
6. Install the NEW coolant expansion plugs.
7. Ensure the NEW coolant expansion plugs are installed to the proper depth.

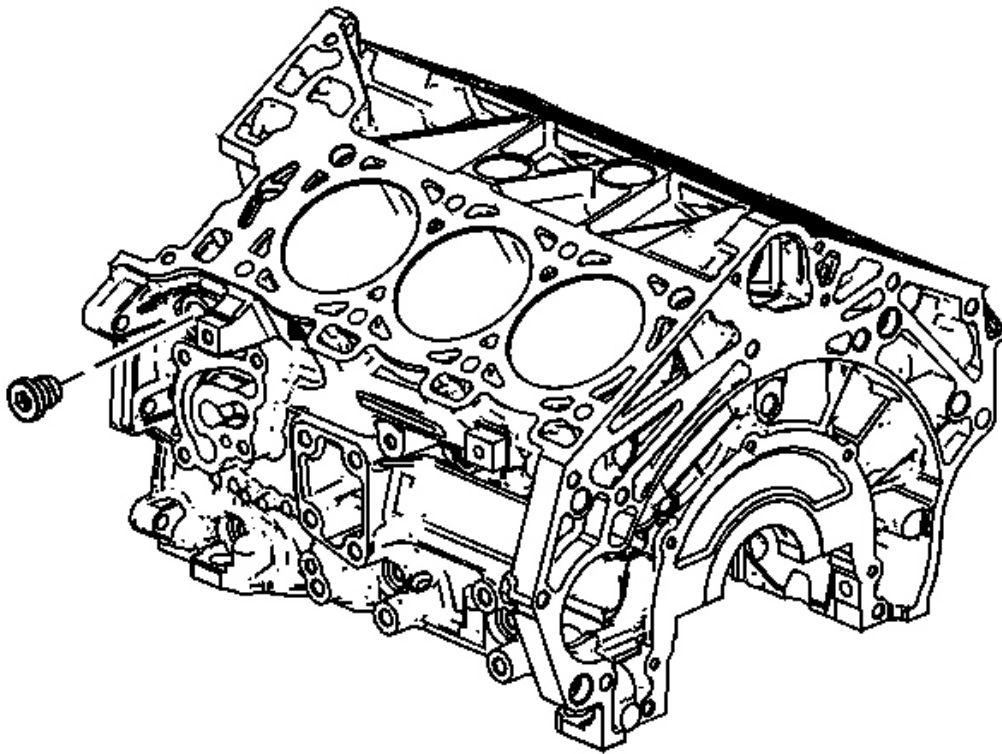


Fig. 310: Removing/Installing M20 Left Side Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

8. Apply thread sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent on the threads of the M20 left side oil gallery threaded plug.

CAUTION: Refer to Fastener Caution .

9. Install the M20 left side oil gallery threaded plug and tighten to 31 N.m (23 lb ft).

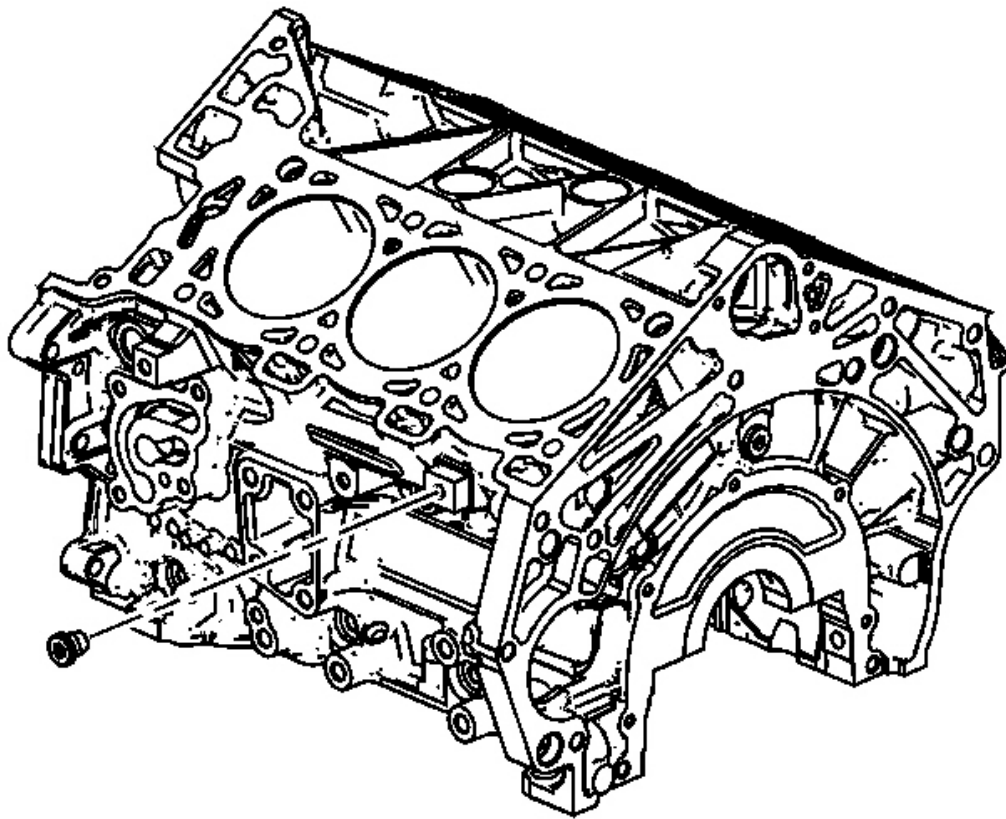


Fig. 311: View Of M14 Left Side Coolant Drain Threaded Plug
Courtesy of GENERAL MOTORS CORP.

10. Apply thread sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent on the threads of the M14 left side coolant drain threaded plug.
11. Install the M14 left side coolant drain threaded plug and tighten to 31 N.m (23 lb ft).

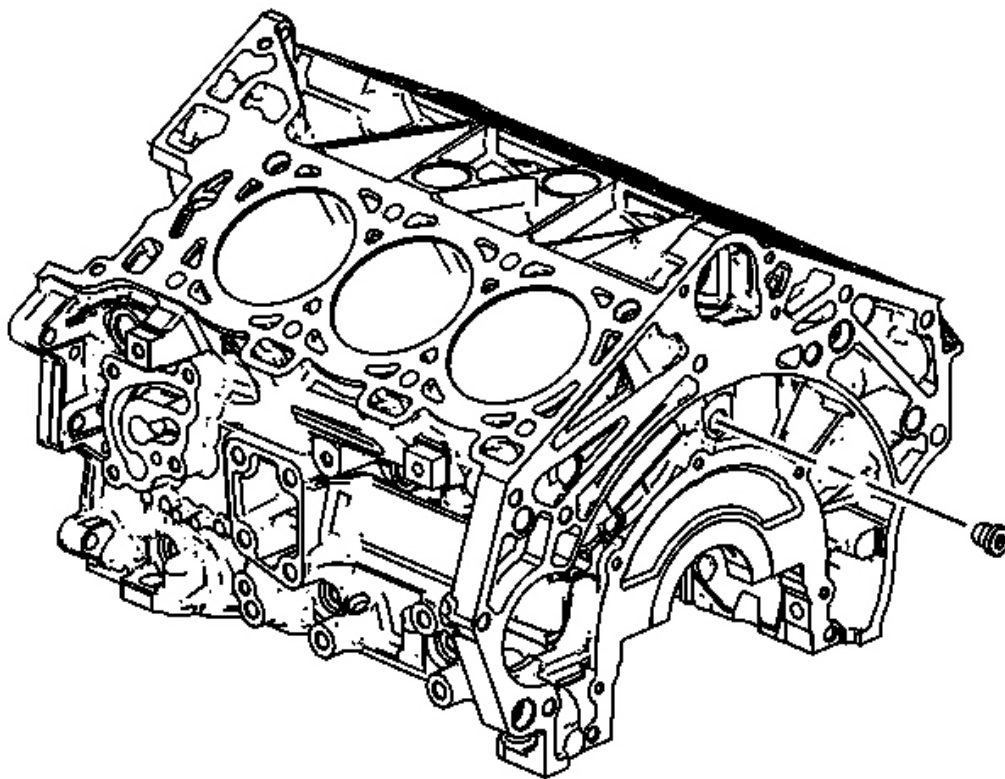


Fig. 312: M14 Rear Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

12. Apply thread sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent on the threads of the M14 rear oil gallery threaded plug.
13. Install the M14 rear oil gallery threaded plug and tighten to 31 N.m (23 lb ft).

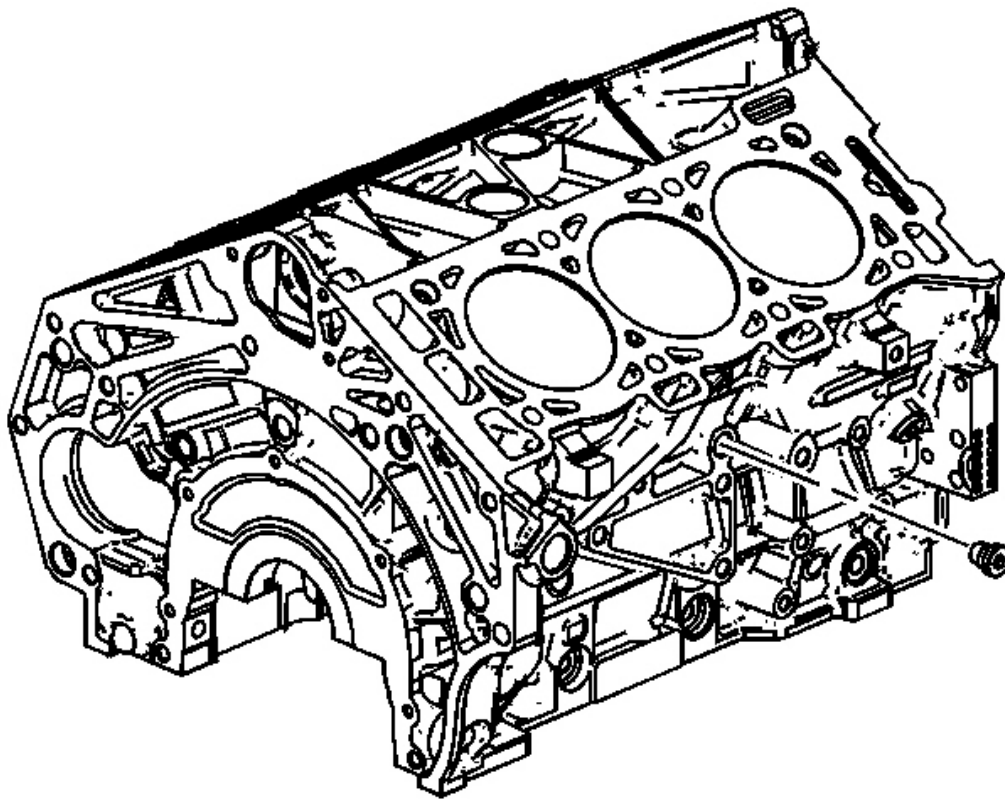


Fig. 313: Locating M14 Right Side Coolant Drain Threaded Plug
Courtesy of GENERAL MOTORS CORP.

14. Apply thread sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent on the threads of the M14 right side coolant drain threaded plug.
15. Install the M14 right side coolant drain threaded plug and tighten to 31 N.m (23 lb ft).

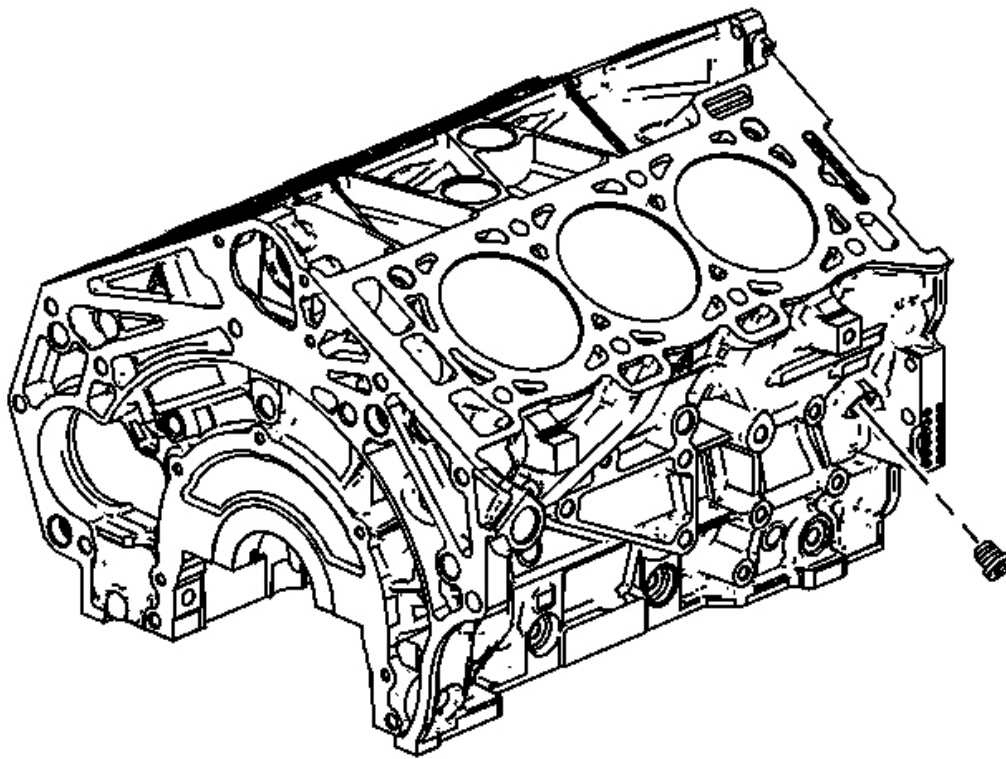


Fig. 314: Identifying M14 Right Side Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

16. Apply thread sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent on the threads of the M14 right side oil gallery threaded plug.
17. Install the M14 right side oil gallery threaded plug and tighten to 31 N.m (23 lb ft).

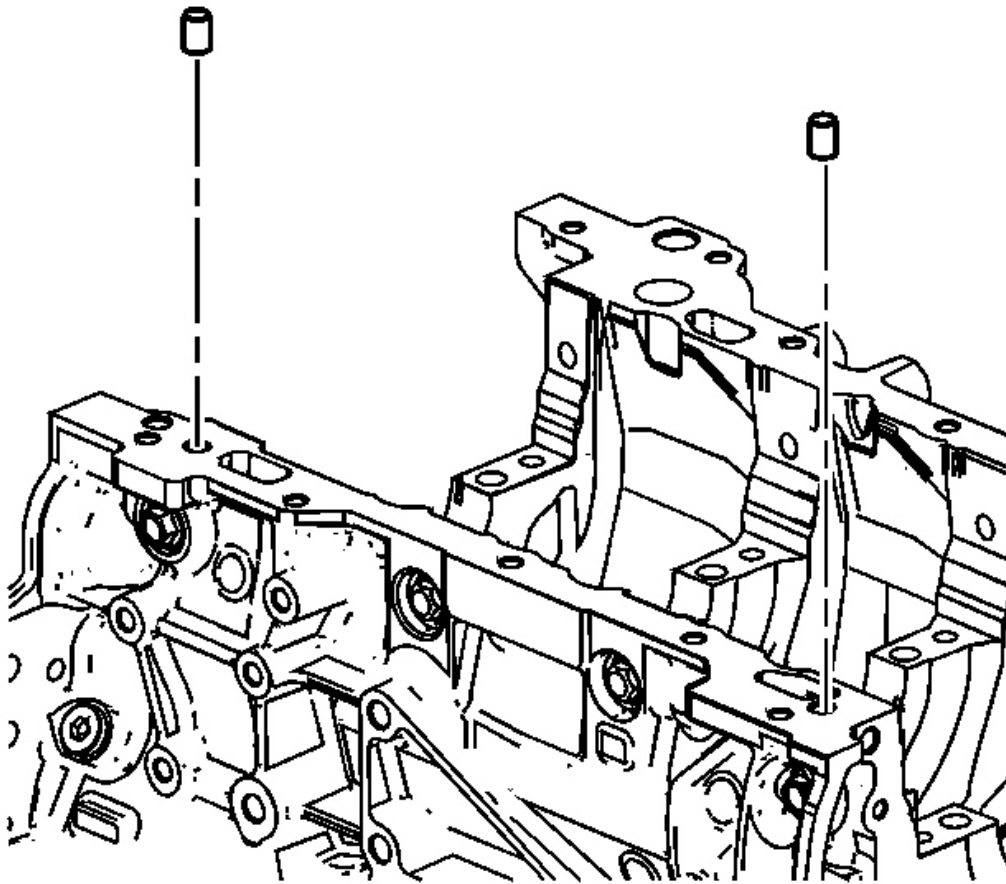


Fig. 315: Cylinder Block-To-Oil Pan Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

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

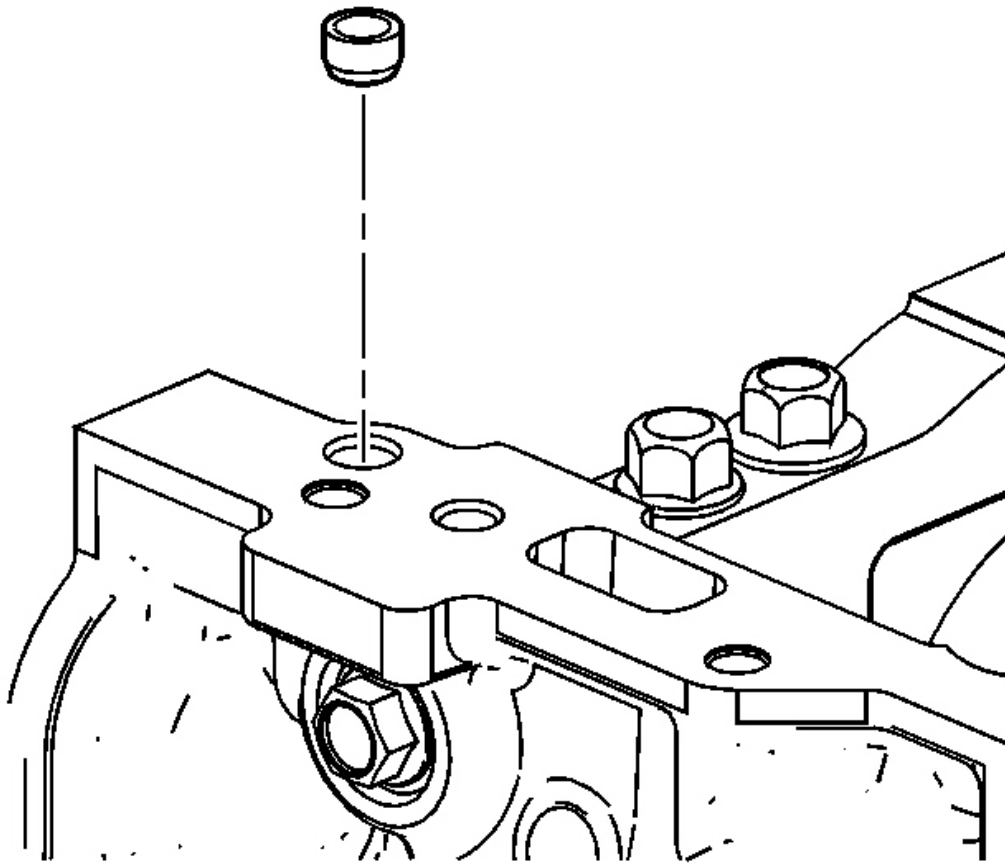


Fig. 316: Locating Right Front Oil Pan Rail Oil Gallery Expansion Plug
Courtesy of GENERAL MOTORS CORP.

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.

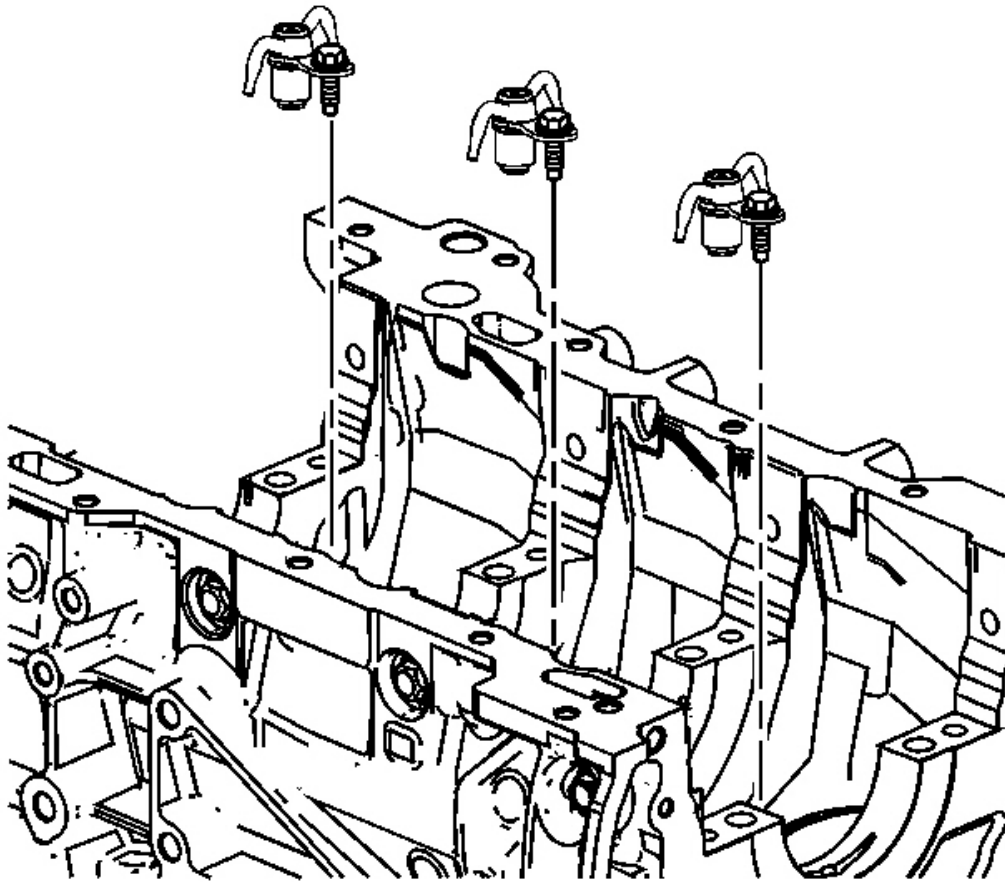


Fig. 317: Identifying Oil Jet & Bolts
Courtesy of GENERAL MOTORS CORP.

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

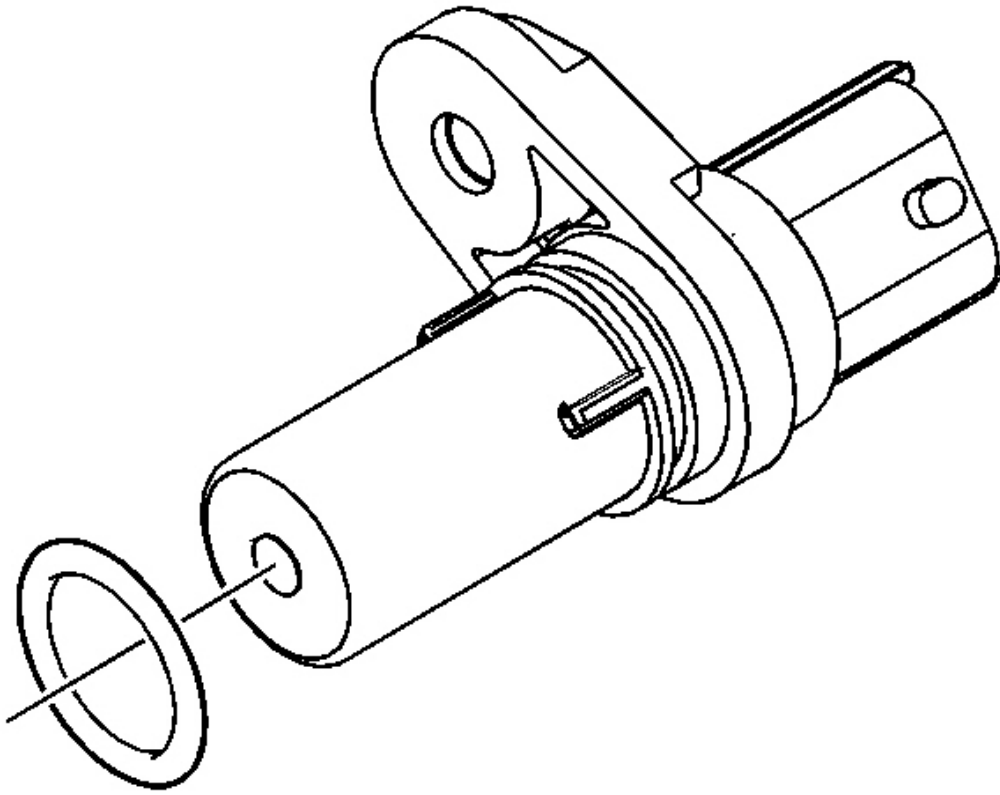


Fig. 318: View Of Crankshaft Position Sensor O-Ring
Courtesy of GENERAL MOTORS CORP.

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

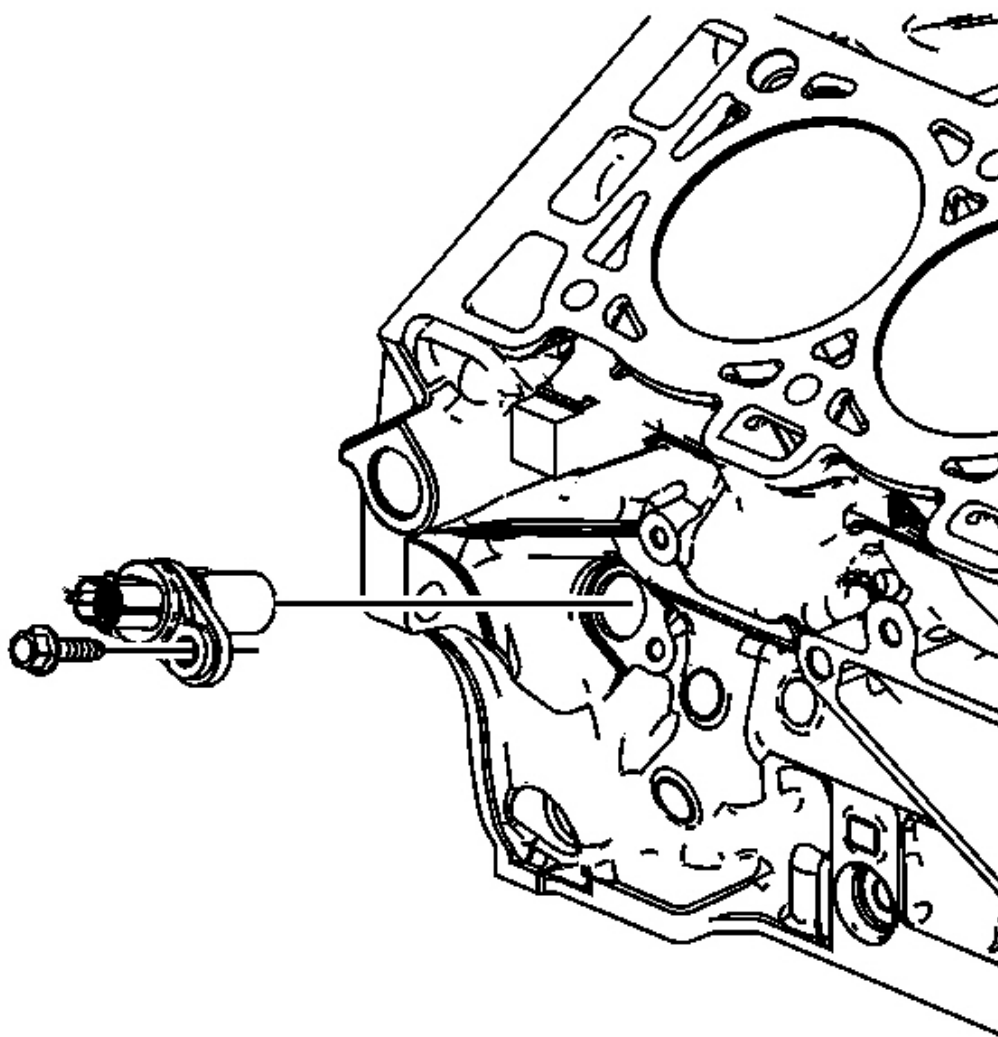


Fig. 319: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

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

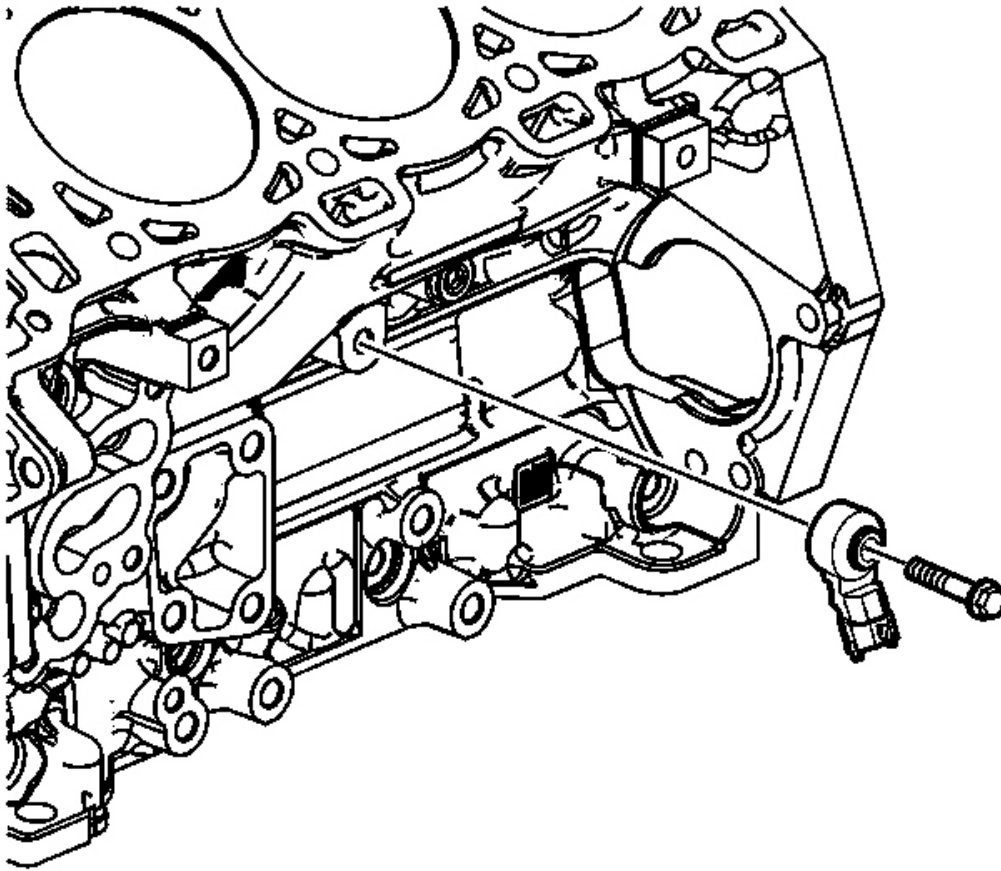


Fig. 320: Identifying Left Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

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.

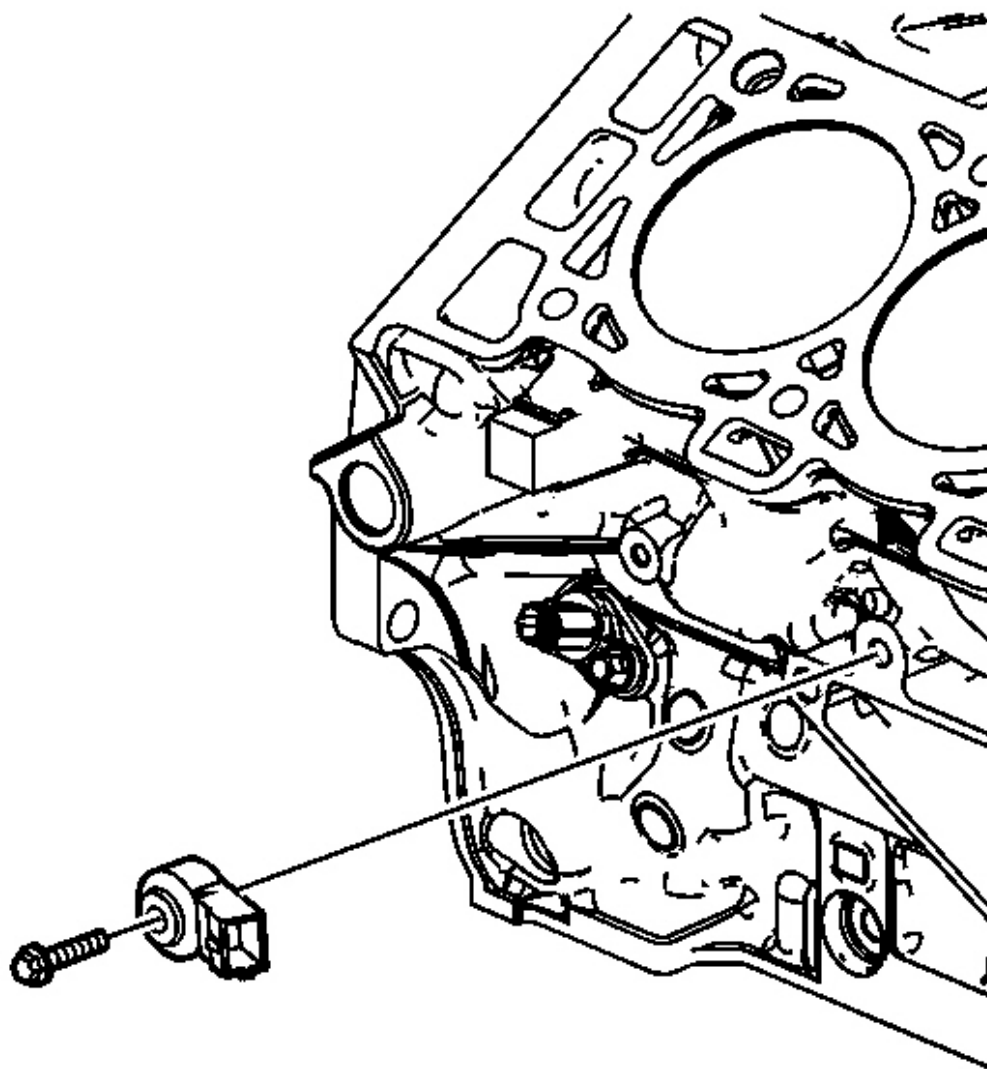


Fig. 321: View Of Right Knock Sensor
Courtesy of GENERAL MOTORS CORP.

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.

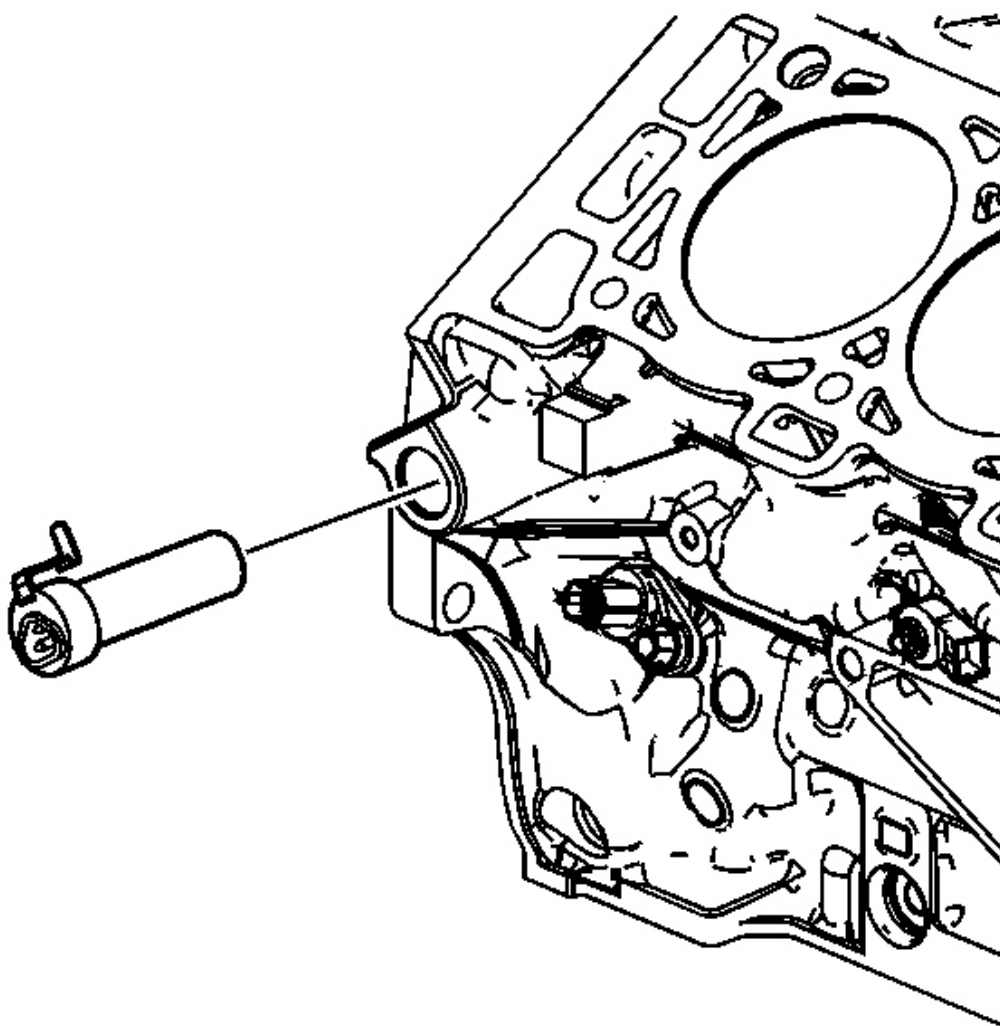


Fig. 322: View Of Block Heater Cartridge
Courtesy of GENERAL MOTORS CORP.

32. Install the block heater cartridge, if equipped.

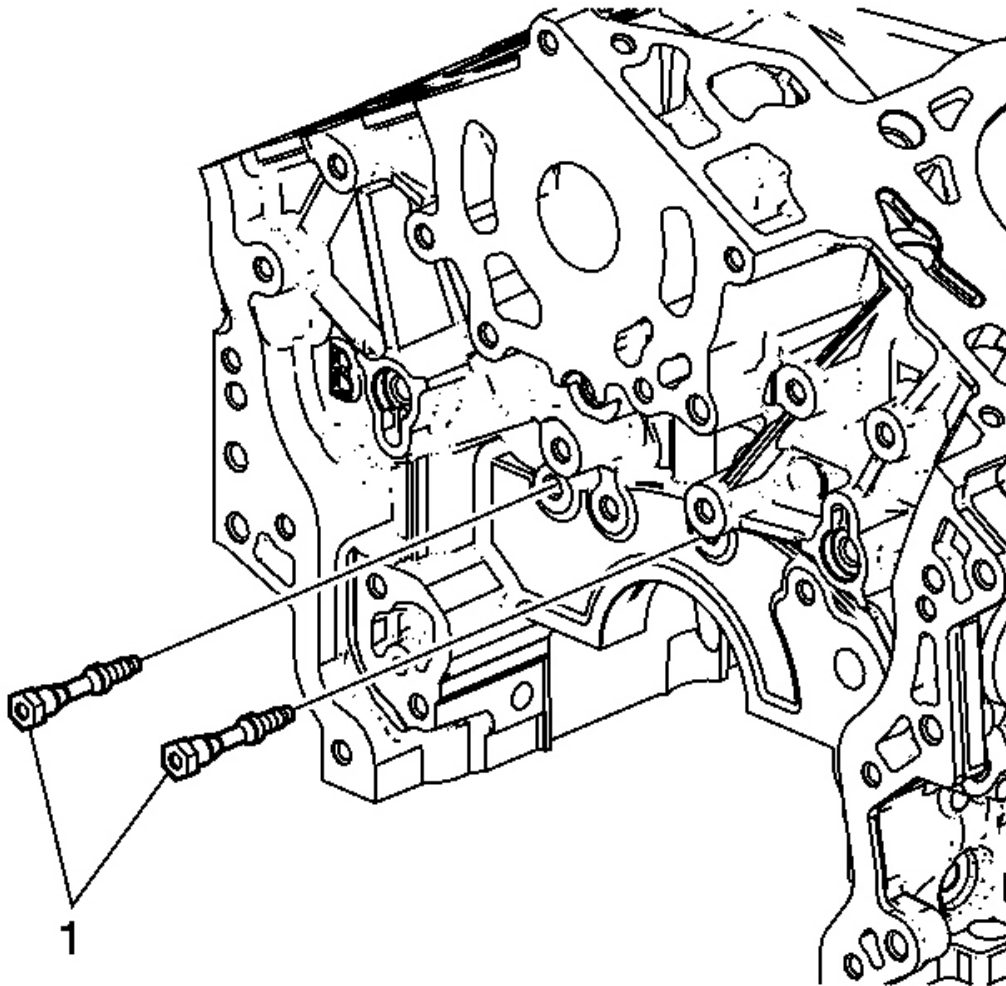


Fig. 323: Engine Front Cover Studs
Courtesy of GENERAL MOTORS CORP.

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

For equivalent regional tools, refer to **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.

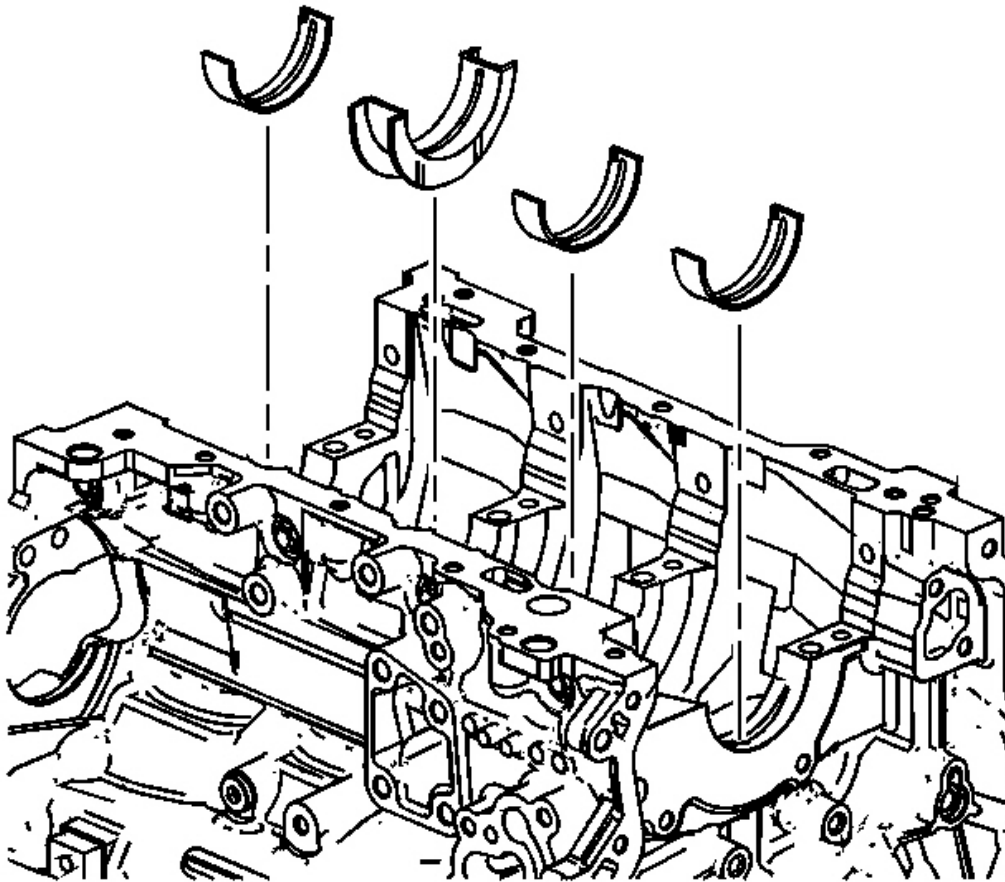


Fig. 324: Upper Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

3. Install the new upper crankshaft bearings into position. The thrust bearing belongs in the number 3 journal. 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.

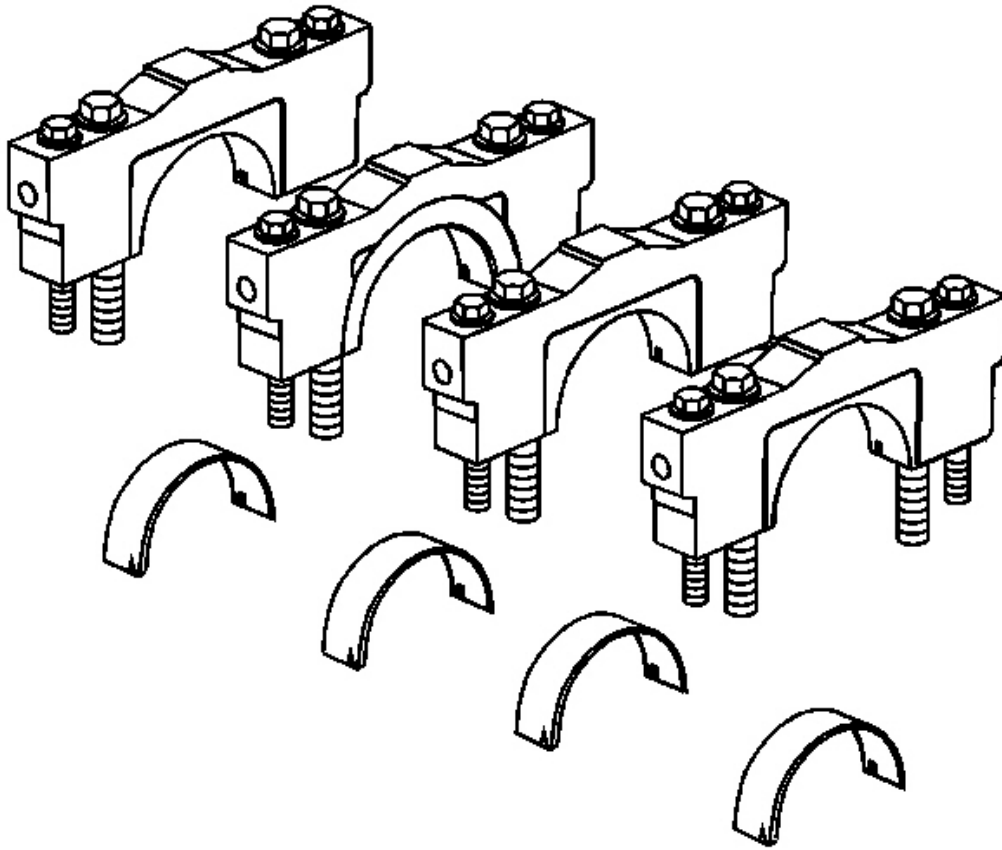


Fig. 325: Crankshaft Lower Bearing Halves & Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

4. Install the new lower crankshaft bearings into position in the main bearing caps. The lower crankshaft bearings are identified by NO grooves or holes. The bearings must fit flush with the crankshaft bearing caps.

CRANKSHAFT INSTALLATION PROCEDURE

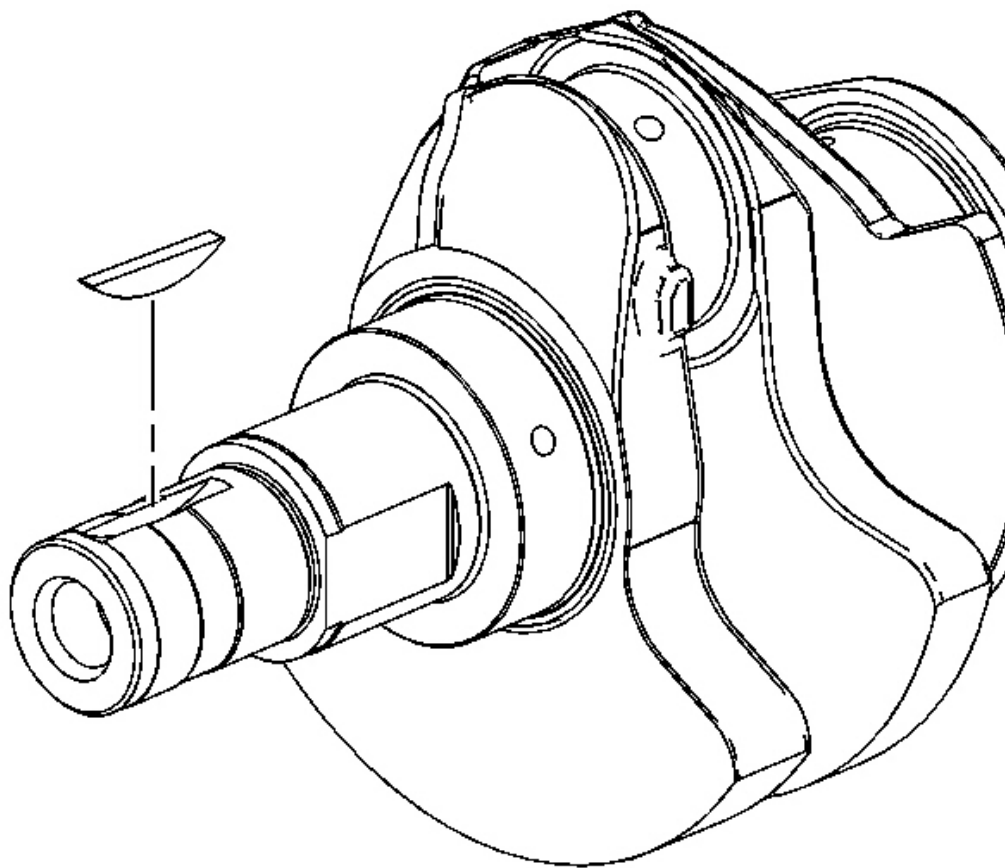


Fig. 326: Locating Crankshaft Sprocket Drive Pin
Courtesy of GENERAL MOTORS CORP.

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

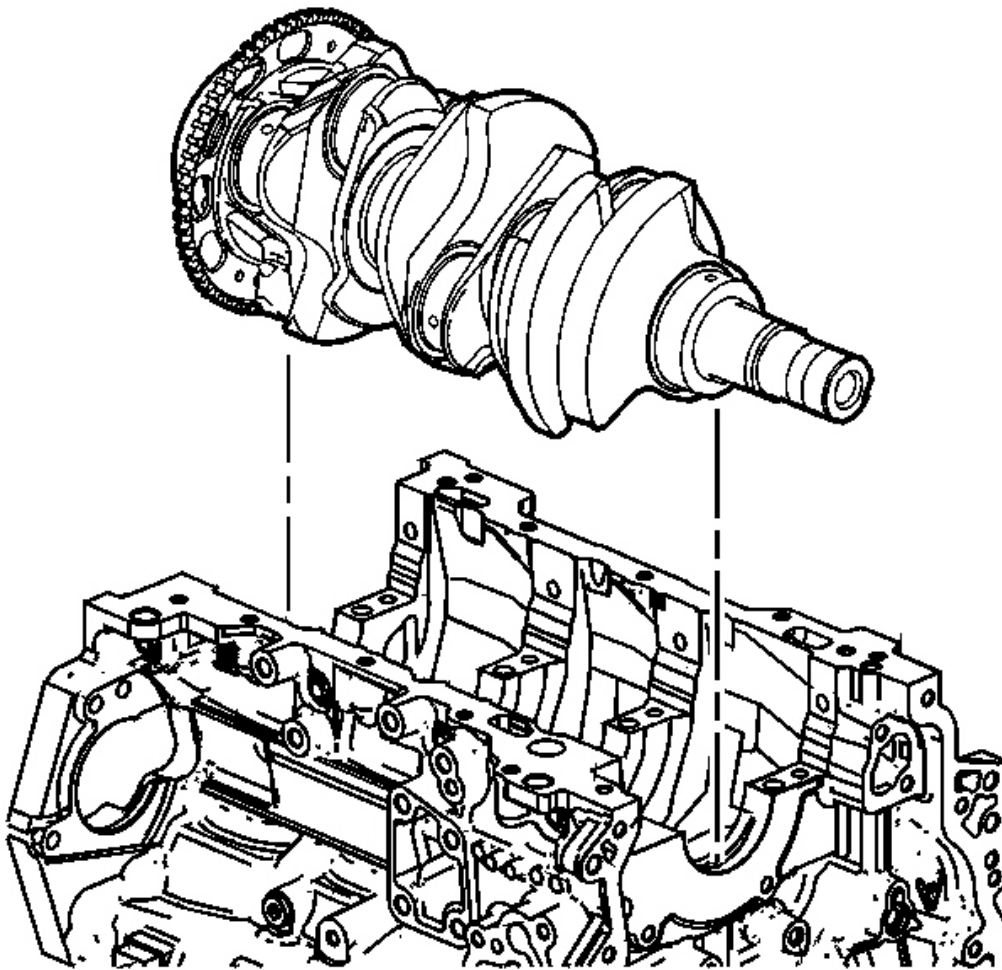


Fig. 327: View Of Crankshaft

Courtesy of GENERAL MOTORS CORP.

2. Gently lower the crankshaft into position in the cylinder block.

CRANKSHAFT BEARING CLEARANCE MEASUREMENT PROCEDURE

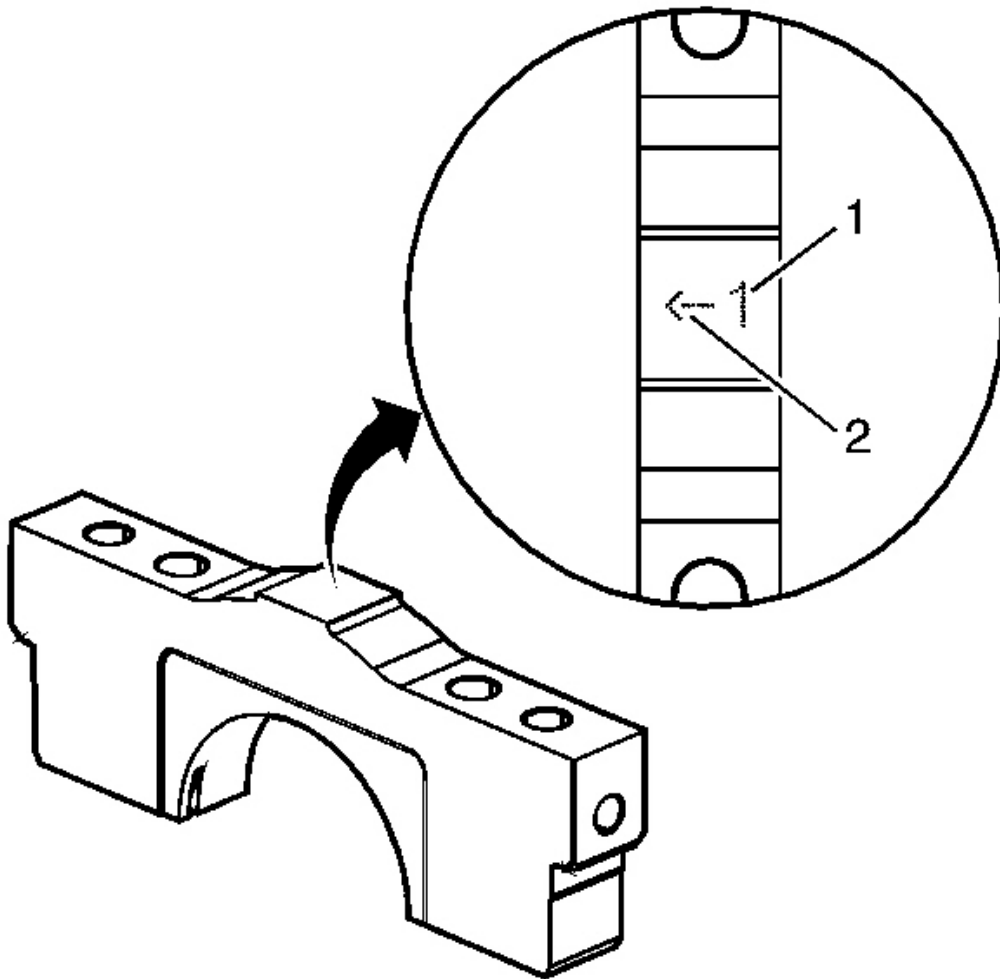


Fig. 328: Identifying Front Main Bearing Cap
Courtesy of GENERAL MOTORS CORP.

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.

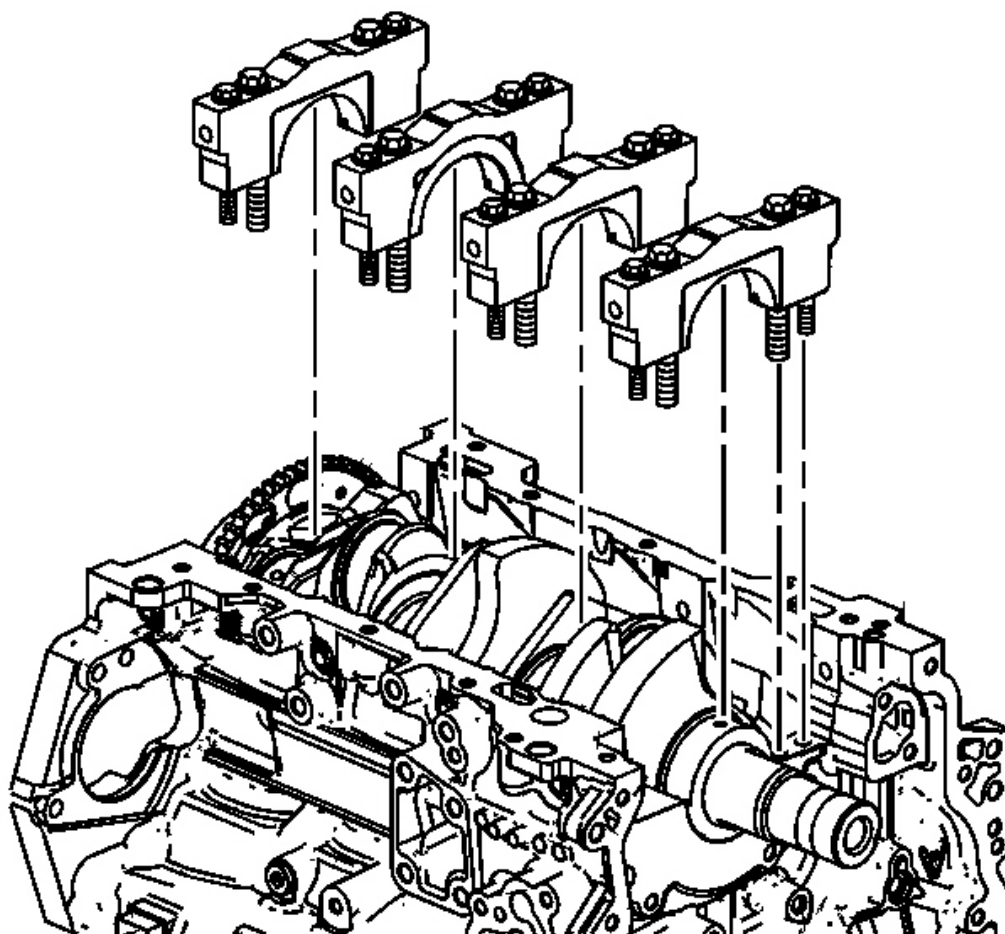


Fig. 329: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft main bearing caps.
4. Loosely install the original inner main cap bolts.
5. Loosely install the original outer main cap bolts.

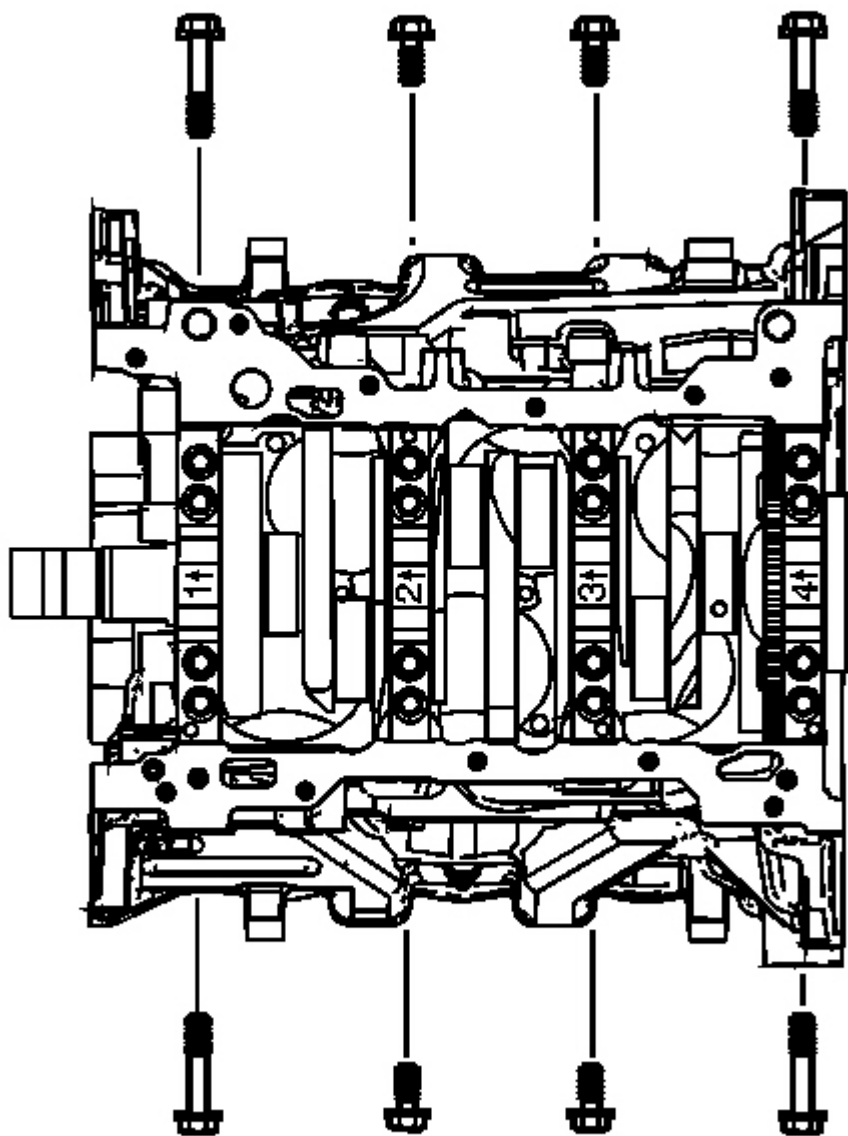


Fig. 330: Identifying Crankshaft Main Bearing Cap Side Bolts
Courtesy of GENERAL MOTORS CORP.

6. Loosely install the original short/inner side main cap bolts.
7. Loosely install the original long/outer side main cap bolts.

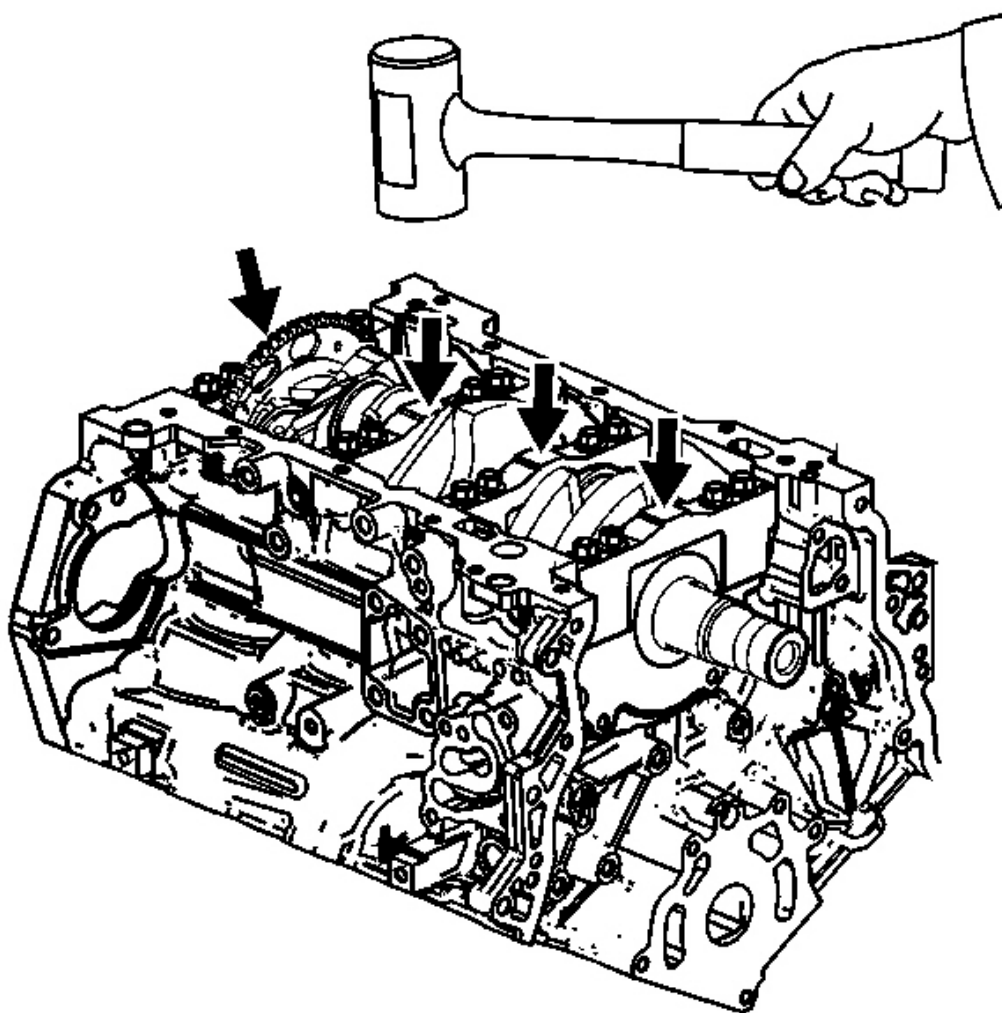


Fig. 331: Setting Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

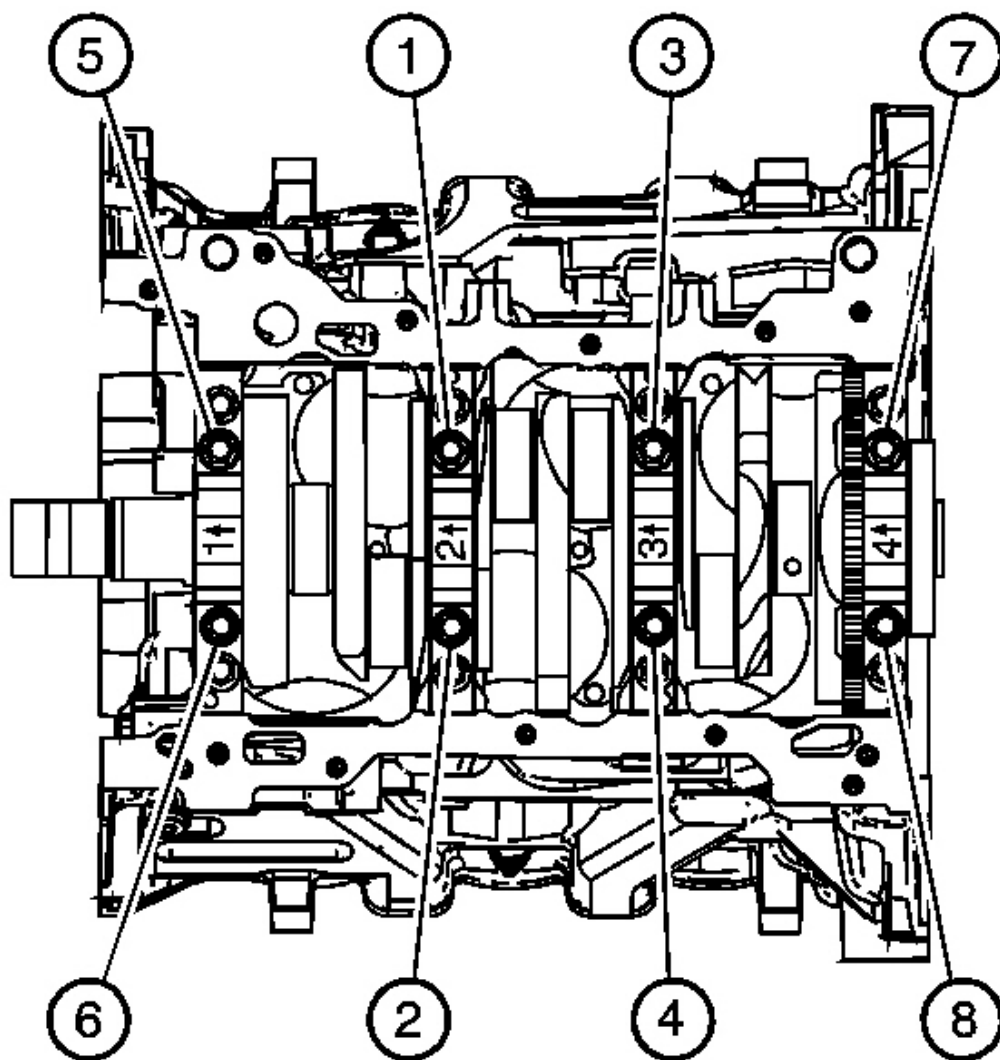


Fig. 332: Main Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

9. Tighten the main caps bolts using the **EN 45059**: 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.

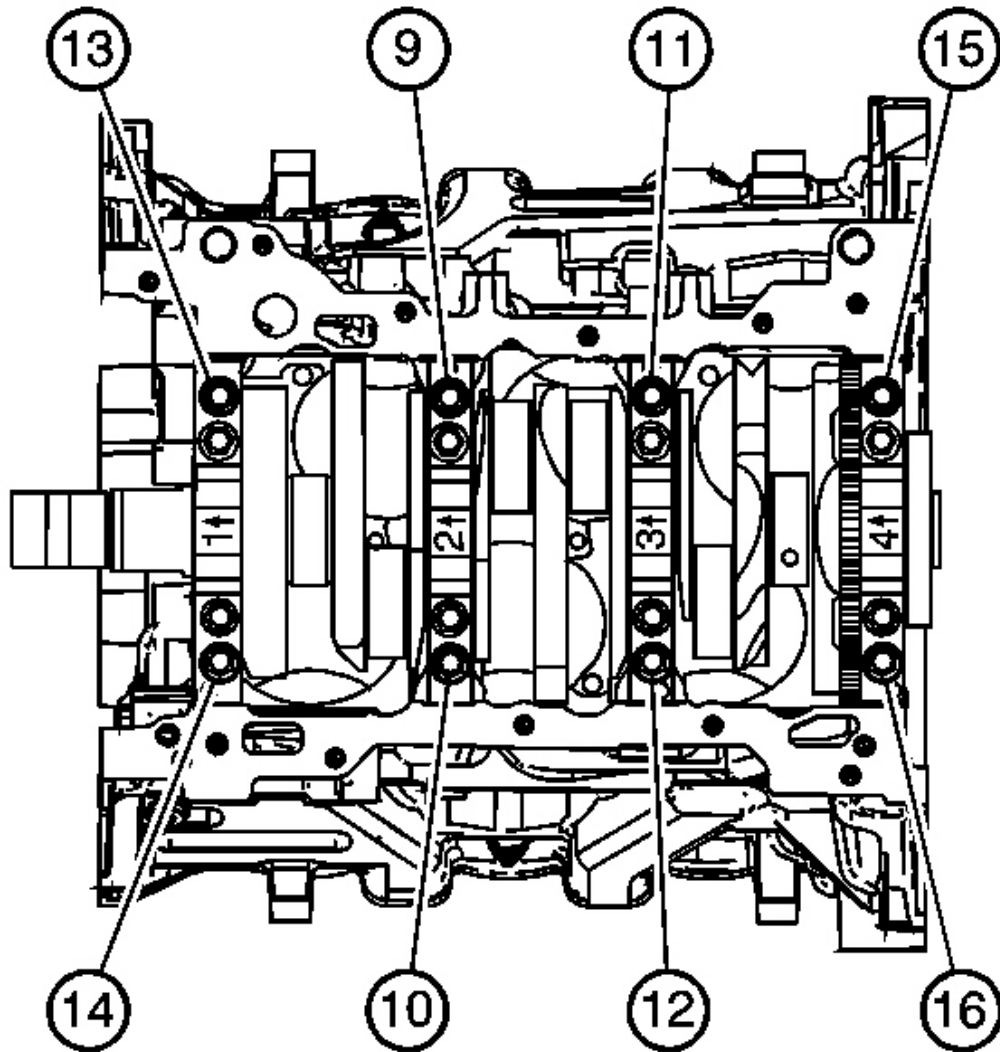


Fig. 333: Outboard Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

11. 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.

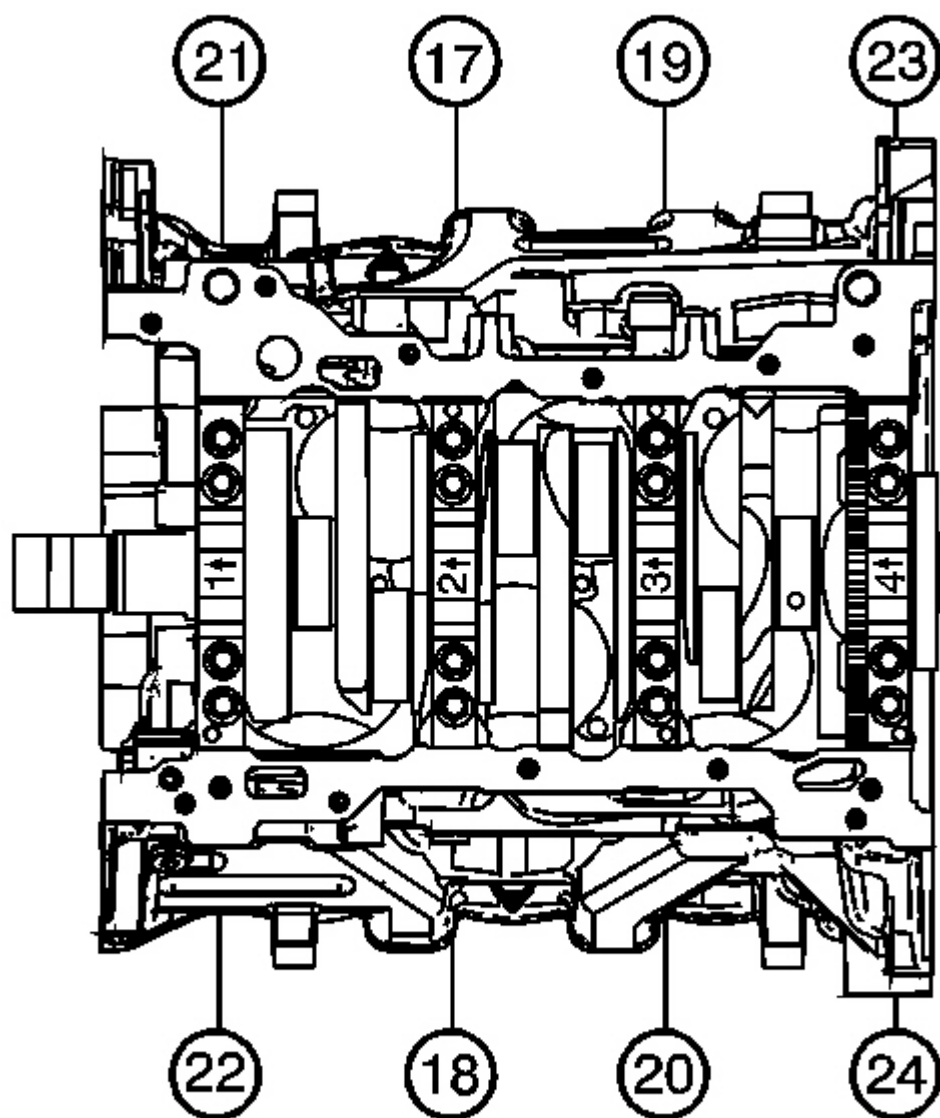


Fig. 334: Installing Short/Inner Bolts & Long/Outer Bolts
Courtesy of GENERAL MOTORS CORP.

12. 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.

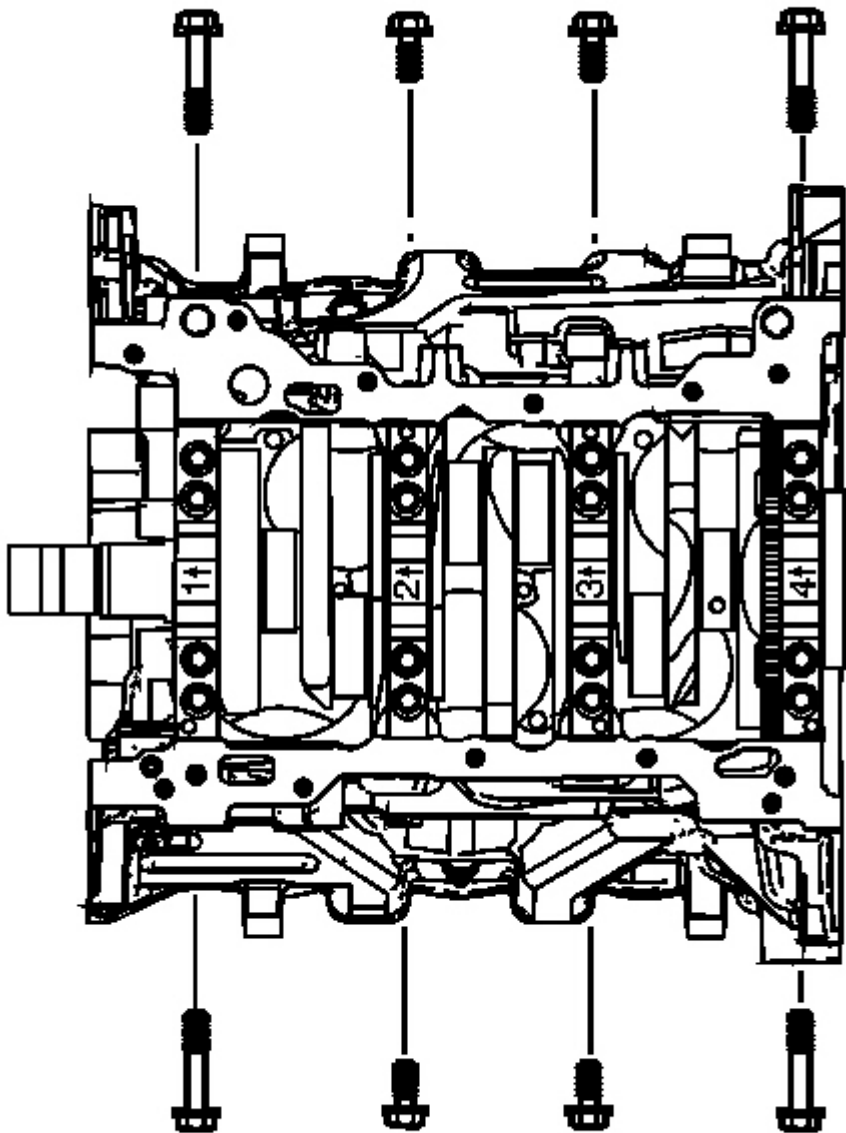


Fig. 335: Identifying Crankshaft Main Bearing Cap Side Bolts
Courtesy of GENERAL MOTORS CORP.

15. Remove the crankshaft bearing cap side bolts.

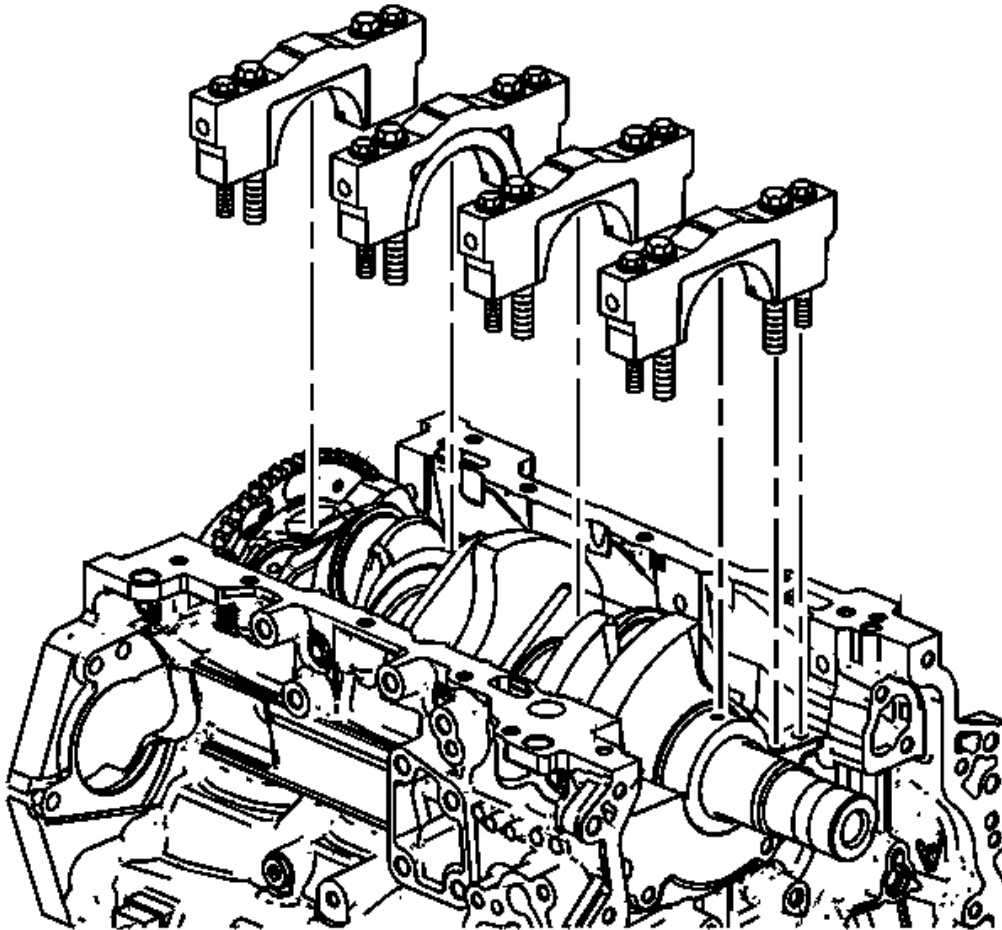


Fig. 336: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

16. Remove the crankshaft bearing cap outer bolts.
17. Remove the crankshaft bearing cap inner bolts.
18. Remove the crankshaft bearing caps using the **GE 6125-1B**: adapter and **EN 49102**: remover.

specification.

21. Clean the plastic gaging material from the crankshaft bearing journals with a soft, lint-free cloth.

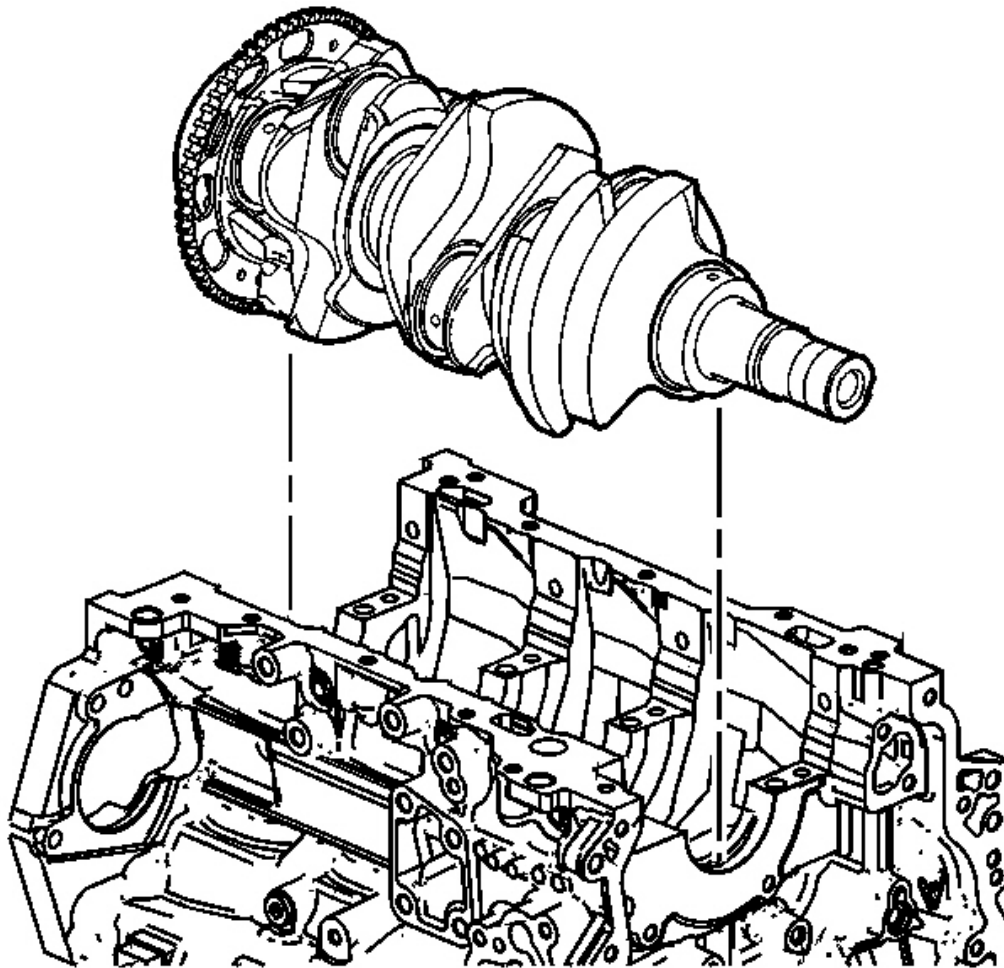


Fig. 338: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

22. Lift the crankshaft out of the cylinder block.

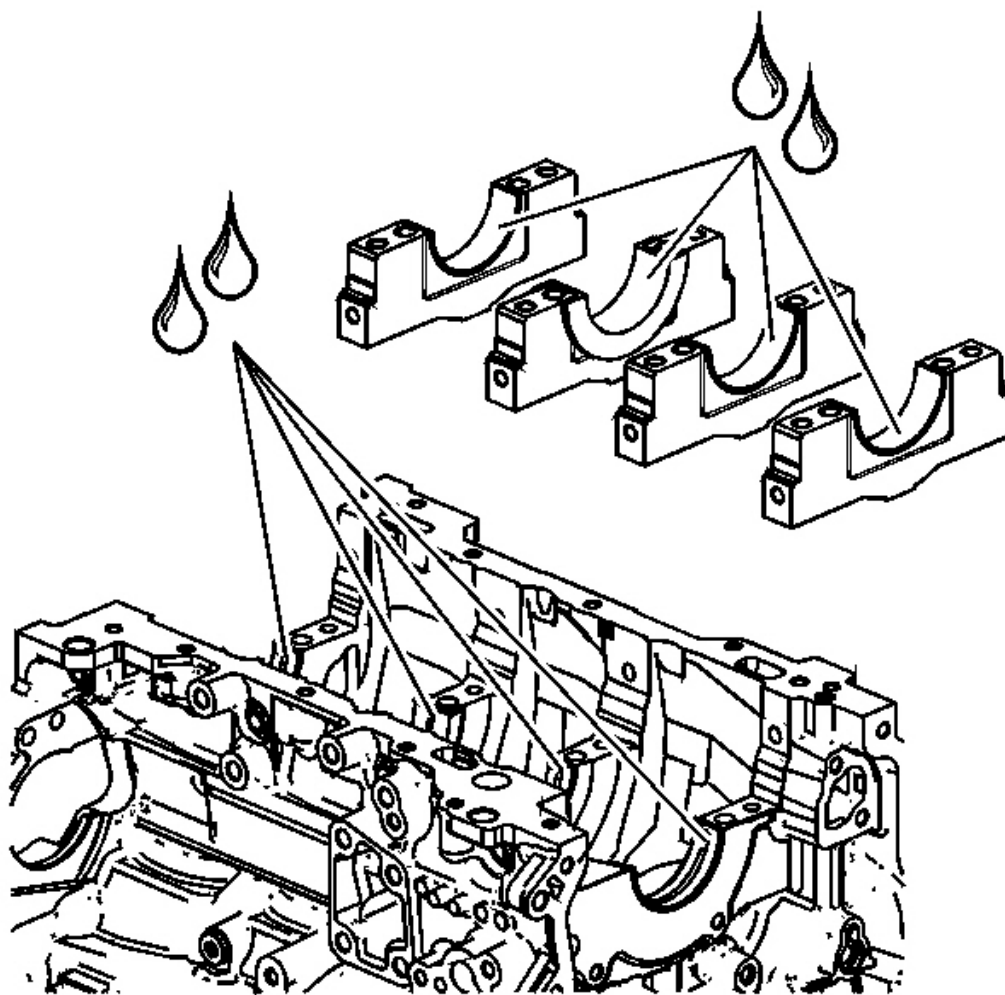


Fig. 339: Prelubing Upper & Lower Bearing Surfaces
Courtesy of GENERAL MOTORS CORP.

23. Apply a liberal amount of crankshaft prelube or clean engine oil to the upper and lower bearing surfaces. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended lubricant.

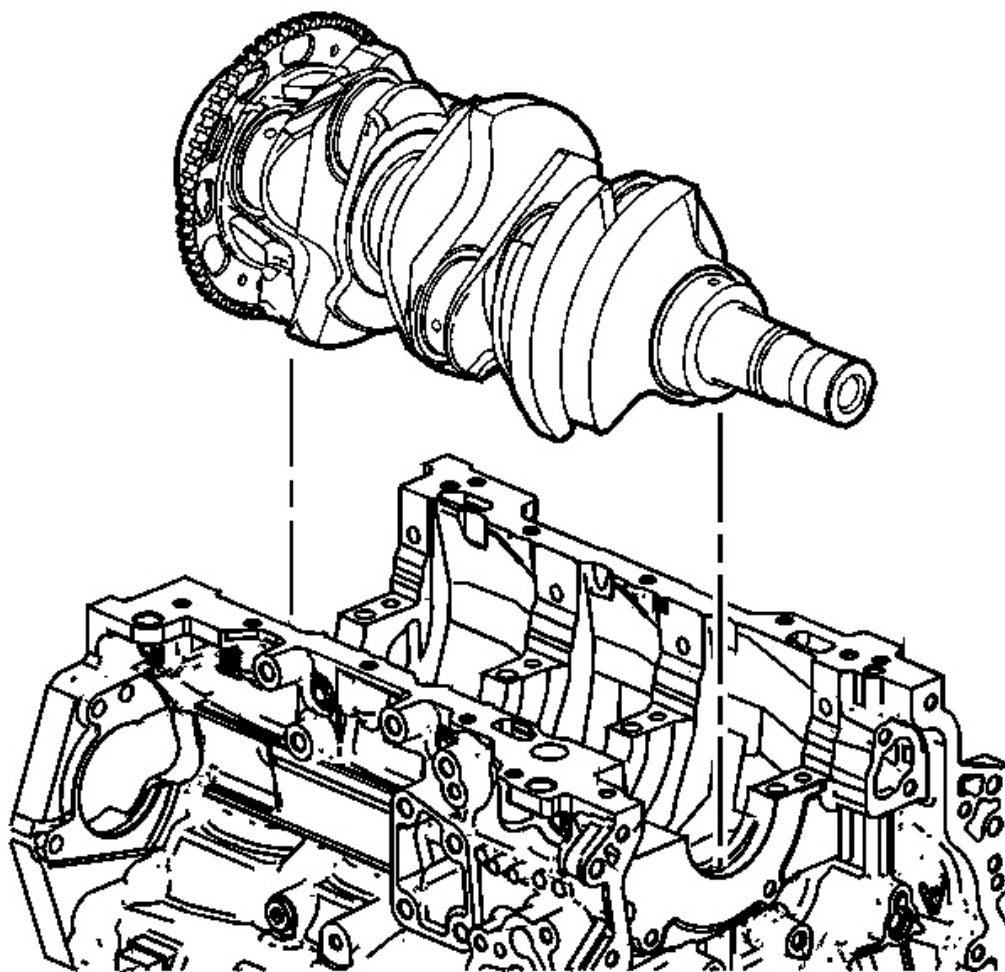


Fig. 340: View Of Crankshaft

Courtesy of GENERAL MOTORS CORP.

24. Gently lower the crankshaft into position in the cylinder block.

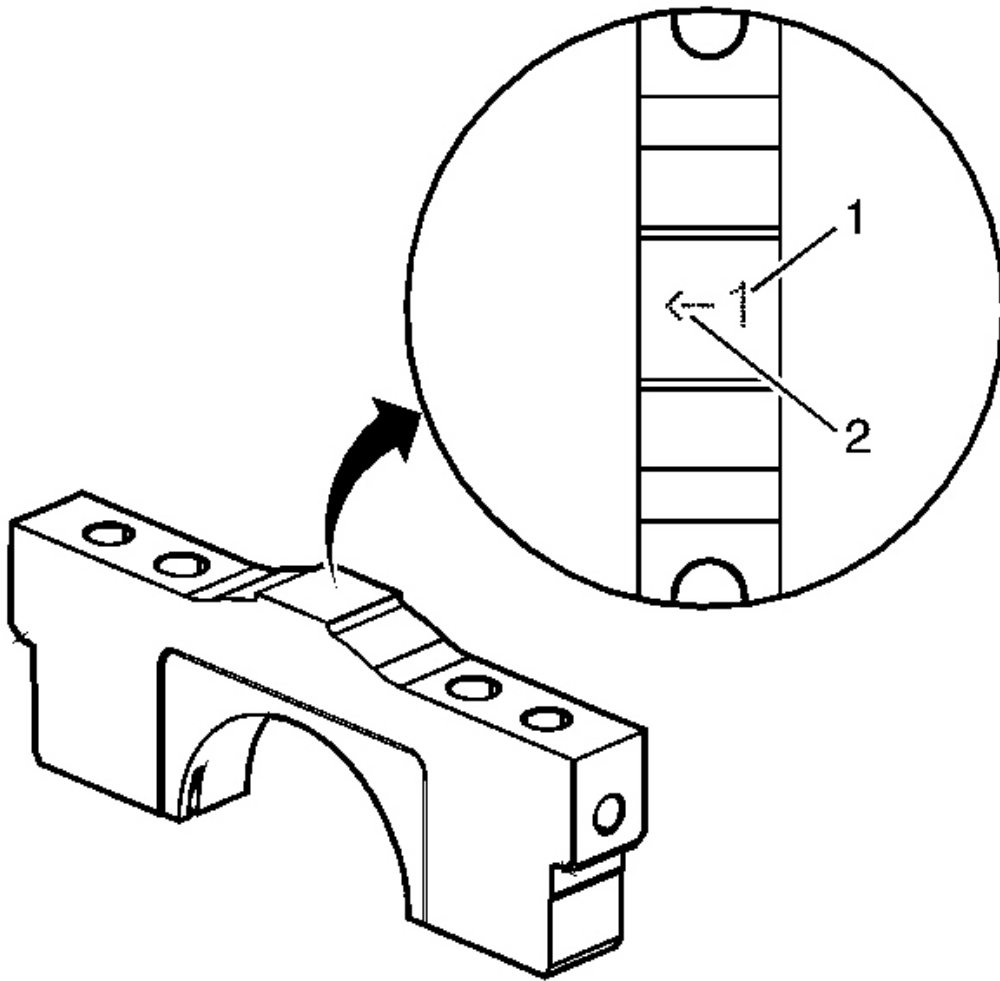


Fig. 341: Identifying Front Main Bearing Cap
Courtesy of GENERAL MOTORS CORP.

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.

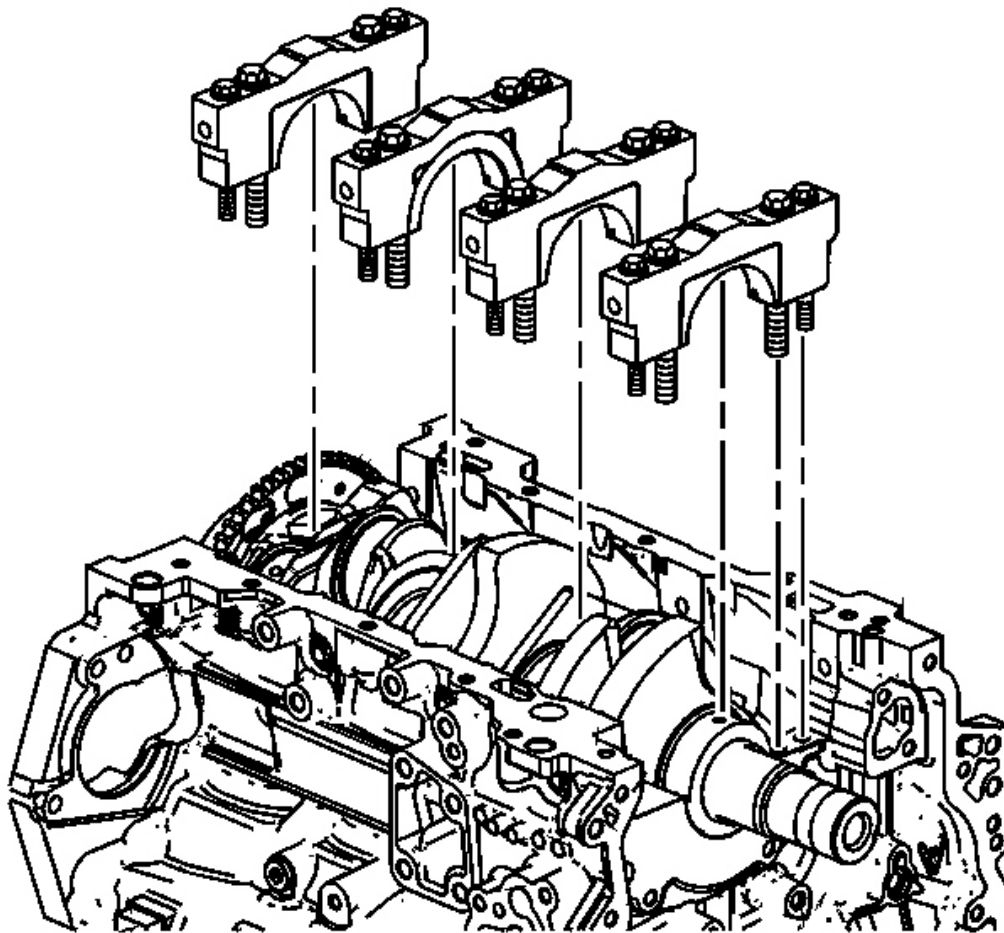


Fig. 342: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

26. Install the crankshaft main bearing caps.
27. Loosely install the original inner main cap bolts.
28. Loosely install the NEW outer main cap bolts.

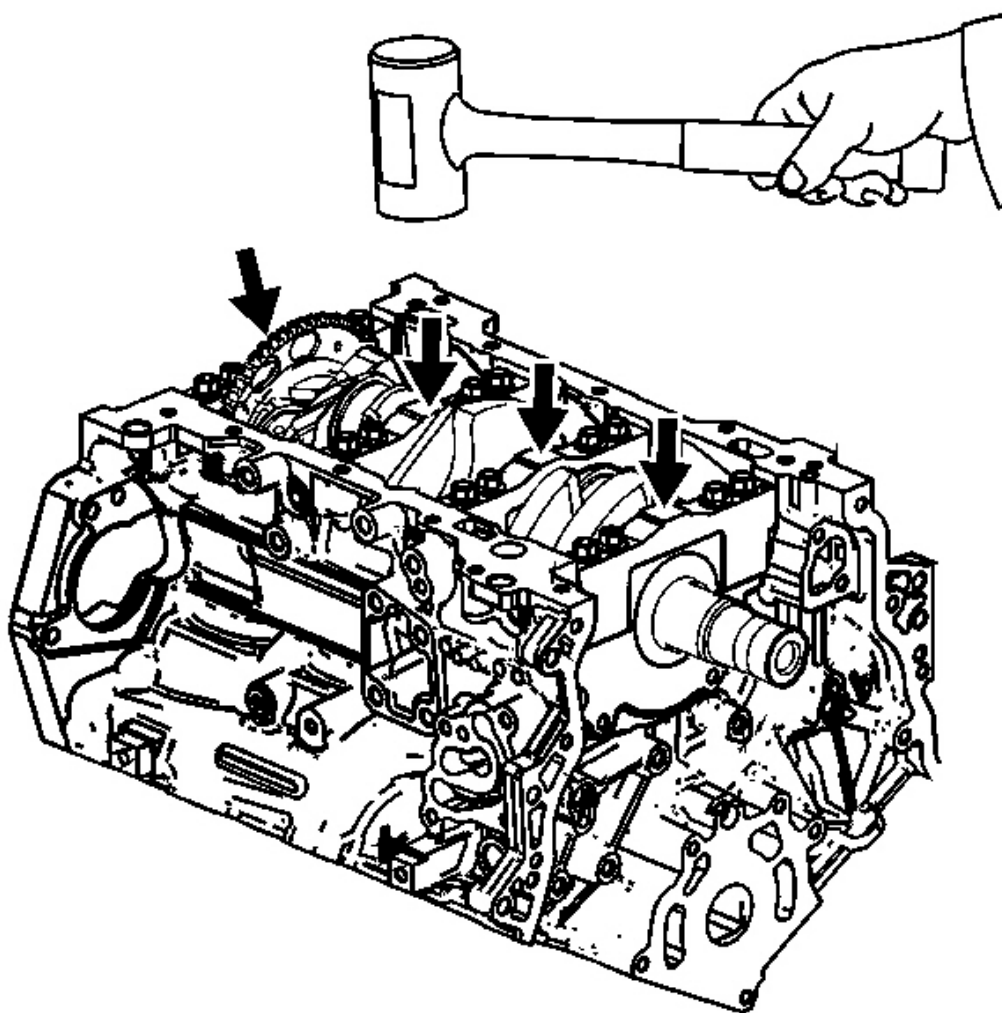


Fig. 343: Setting Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

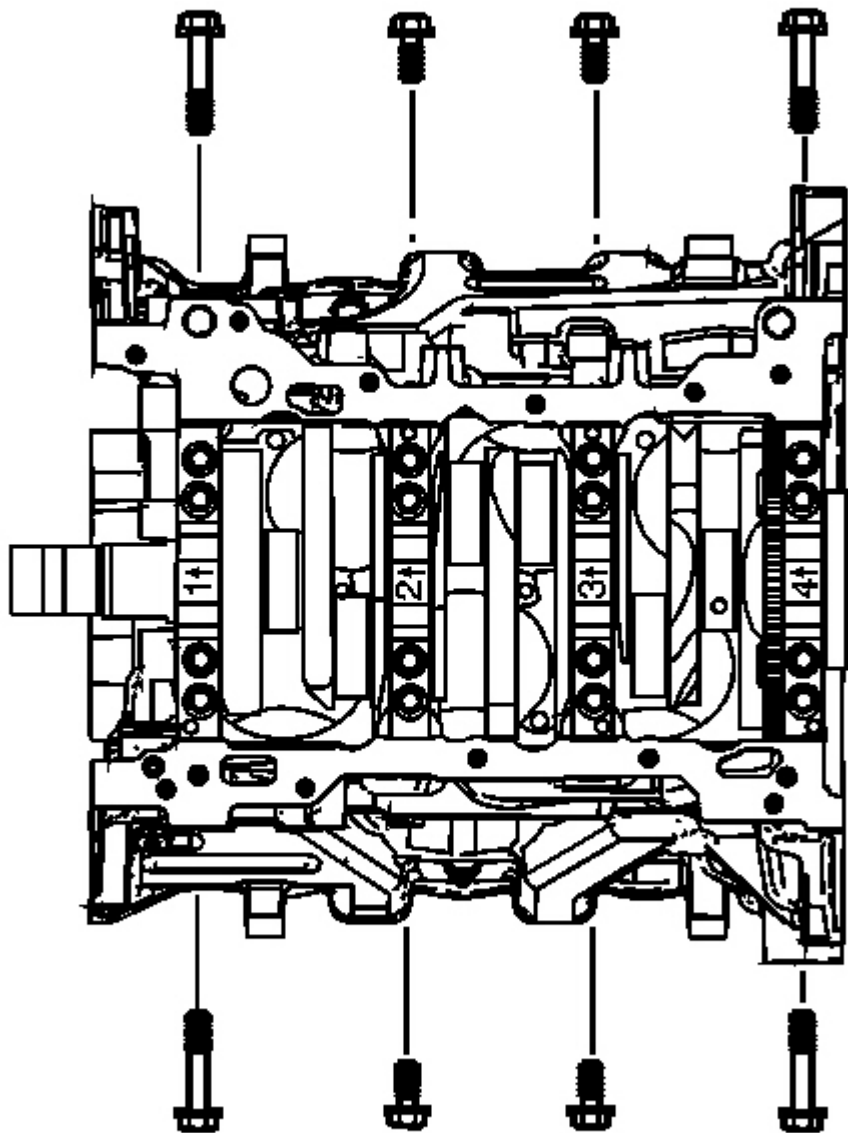


Fig. 344: Identifying Crankshaft Main Bearing Cap Side Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: The side main cap bolts originally have a sealant on the flange of the bolt head. **NEW bolts must be used.** If **NEW** bolts are not used, oil can leak from the crankcase past the bolts.

30. Loosely install the NEW short/inner side main cap bolts.
31. Loosely install the NEW long/outer side main cap bolts.

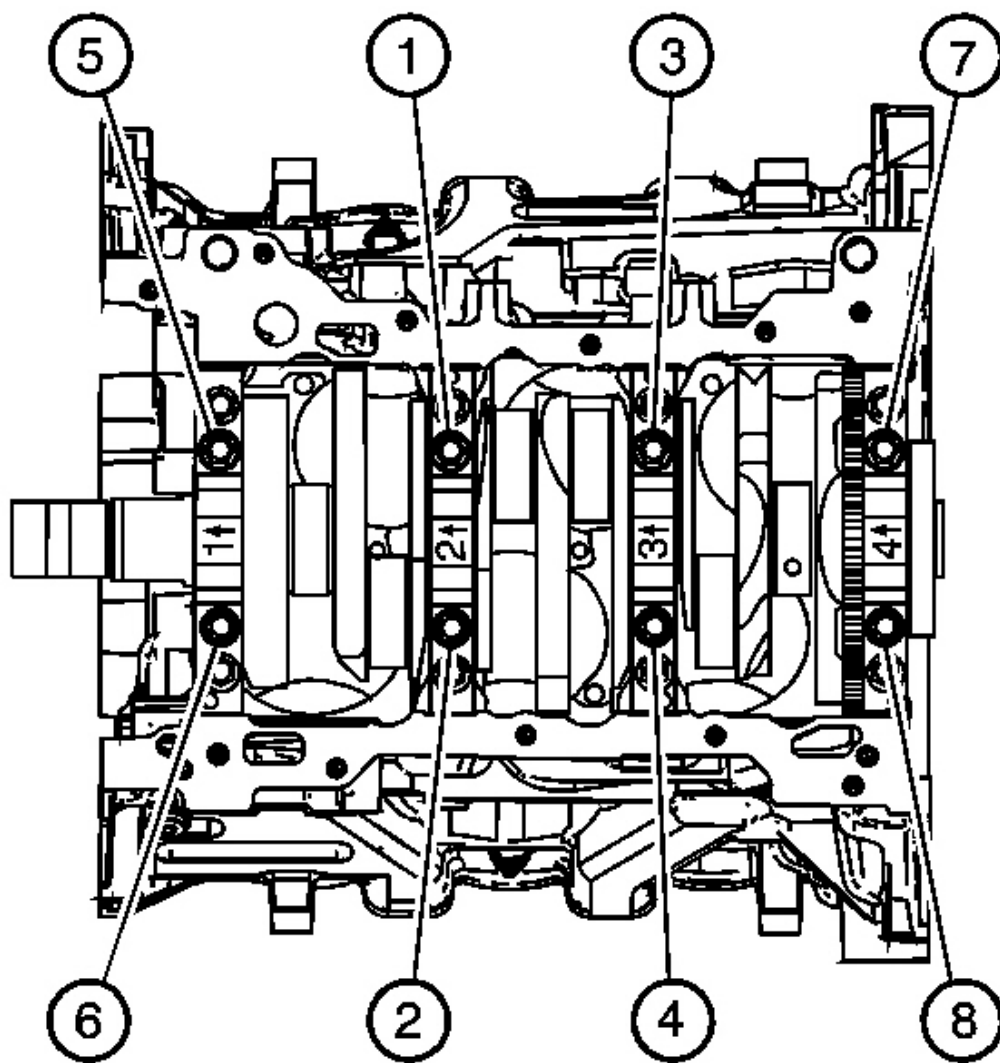


Fig. 345: Main Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

32. Tighten the main cap bolts using the **EN 45059**: 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.

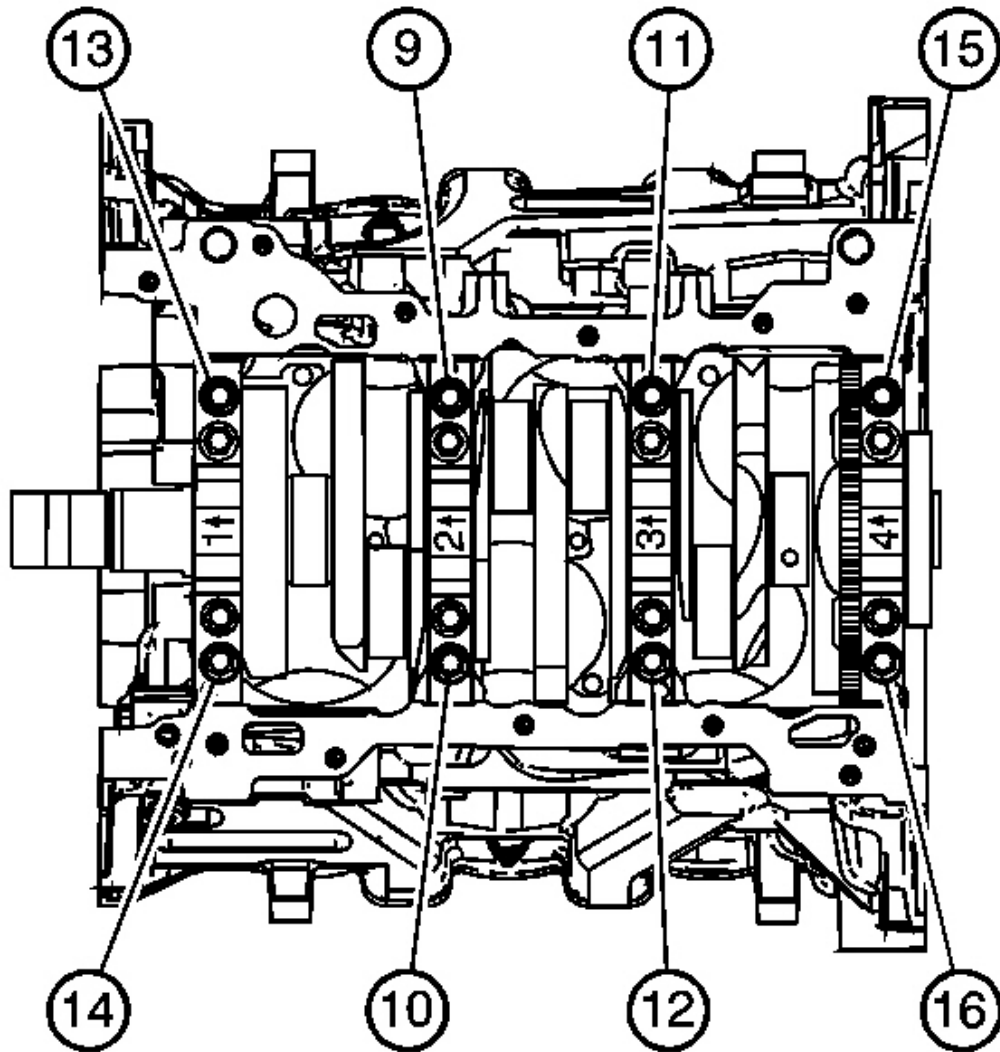


Fig. 346: Outboard Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

34. 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.

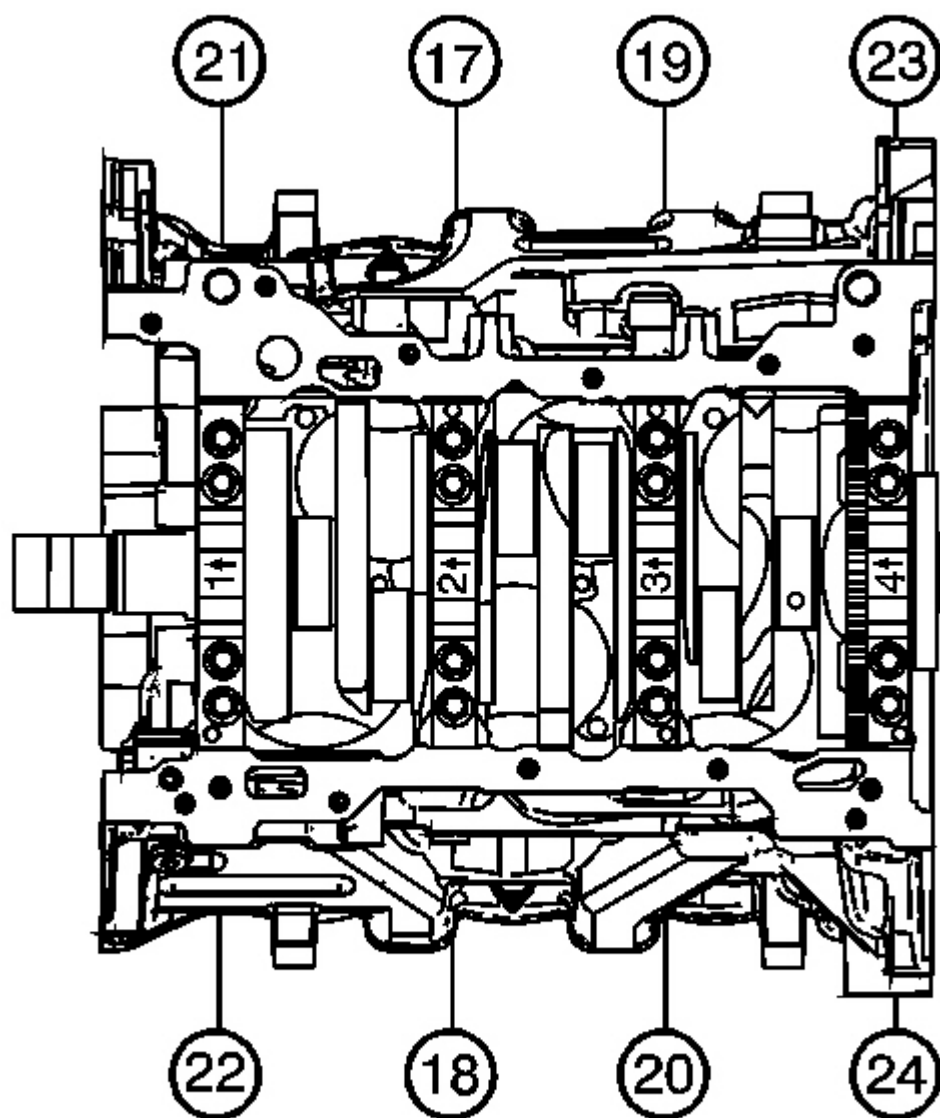


Fig. 347: Installing Short/Inner Bolts & Long/Outer Bolts
Courtesy of GENERAL MOTORS CORP.

35. 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 8037:** Ring Compressor
- **EN 43690-A:** Rod Bearing Clearance Checking Tool
- **EN 45059:** Angle Meter
- **EN 46121:** Connecting Rod Guide Pin Set
- **EN 48589:** Crankshaft Rotation Socket
- **J 43690-100:** Rod Bearing Clearance Checking Tool - Adapter Kit

For equivalent regional tools, refer to **Special Tools** .

PISTON AND CONNECTING ROD ASSEMBLY PROCEDURE

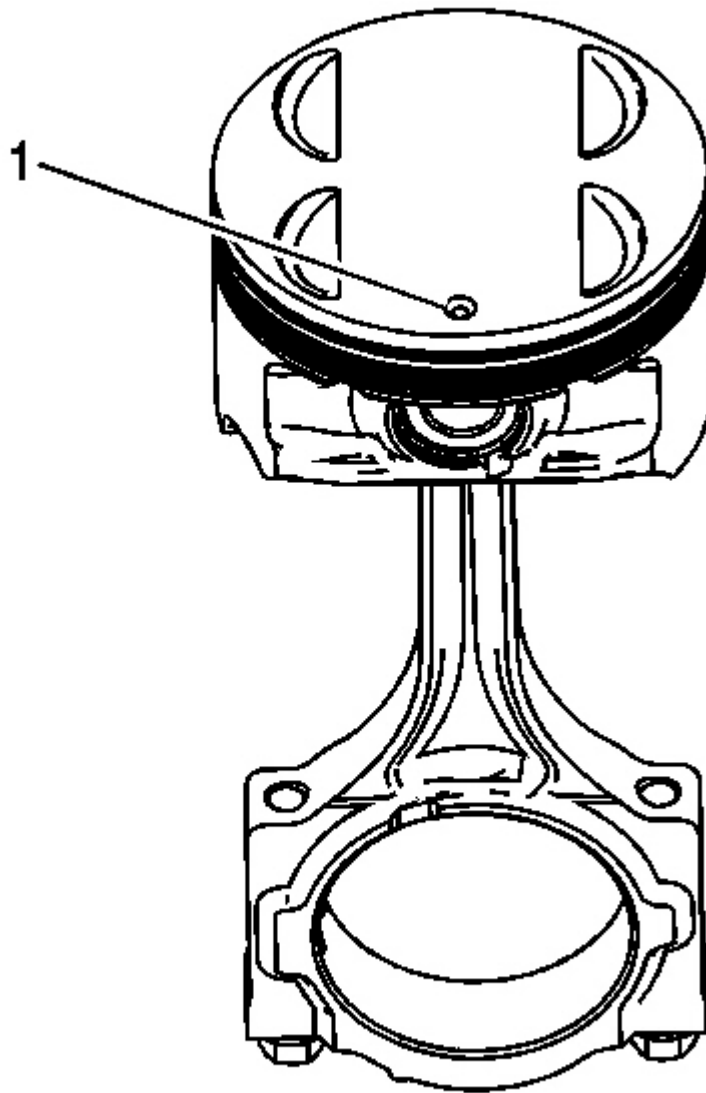


Fig. 348: Identifying Proper Piston Orientation
Courtesy of GENERAL MOTORS CORP.

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.

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.

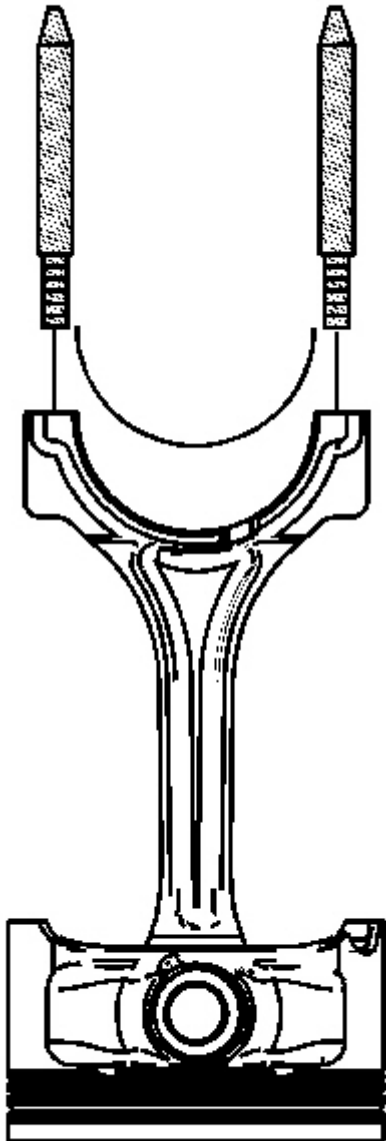


Fig. 349: View Of Piston/Connecting Rod Installation Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: If the connecting rod bearings have been used in a running engine, you

must replace them with **NEW** connecting rod bearings for reassembly.

3. 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 **EN 8037:** compressor or equivalent.

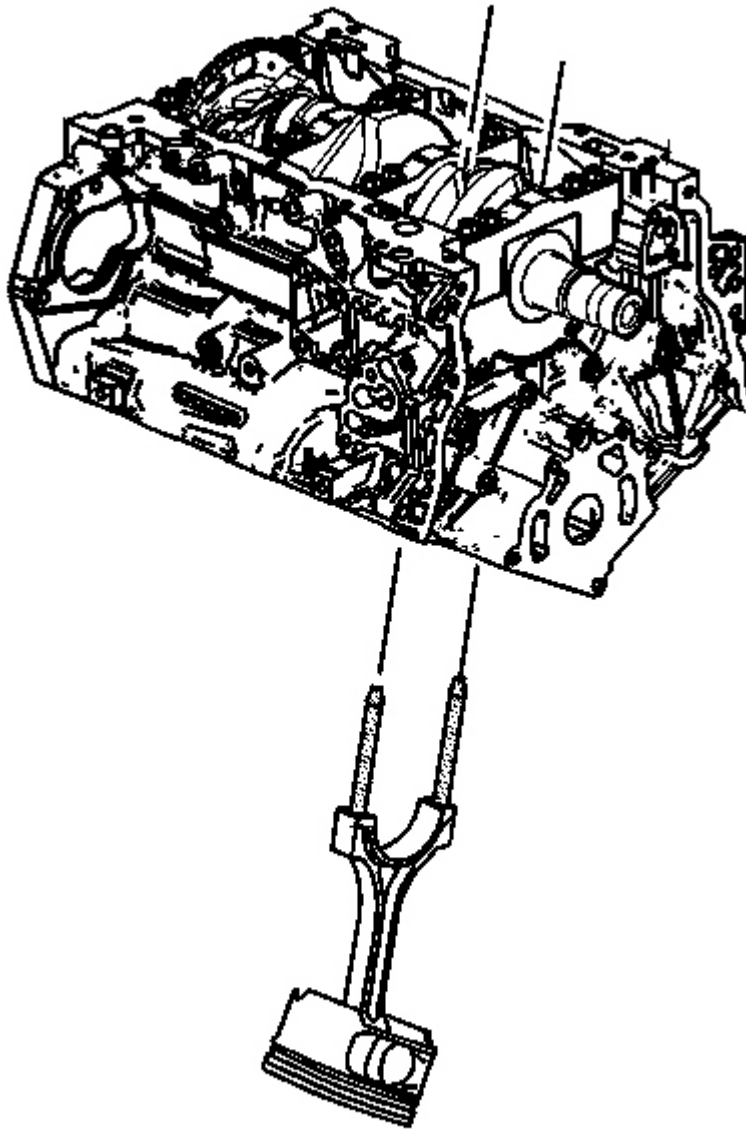


Fig. 350: View Of Connecting Rod & Piston Assembly

Courtesy of GENERAL MOTORS CORP.

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.

6. 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. When the **EN 8037**: compressor contacts the deck surface, gently tap the piston into the cylinder using the handle end of a dead-blow hammer. Guide the connecting rod onto the crankshaft bearing journal using the **EN 46121**: pin set while gently tapping the piston into the cylinder with a soft-blow hammer.

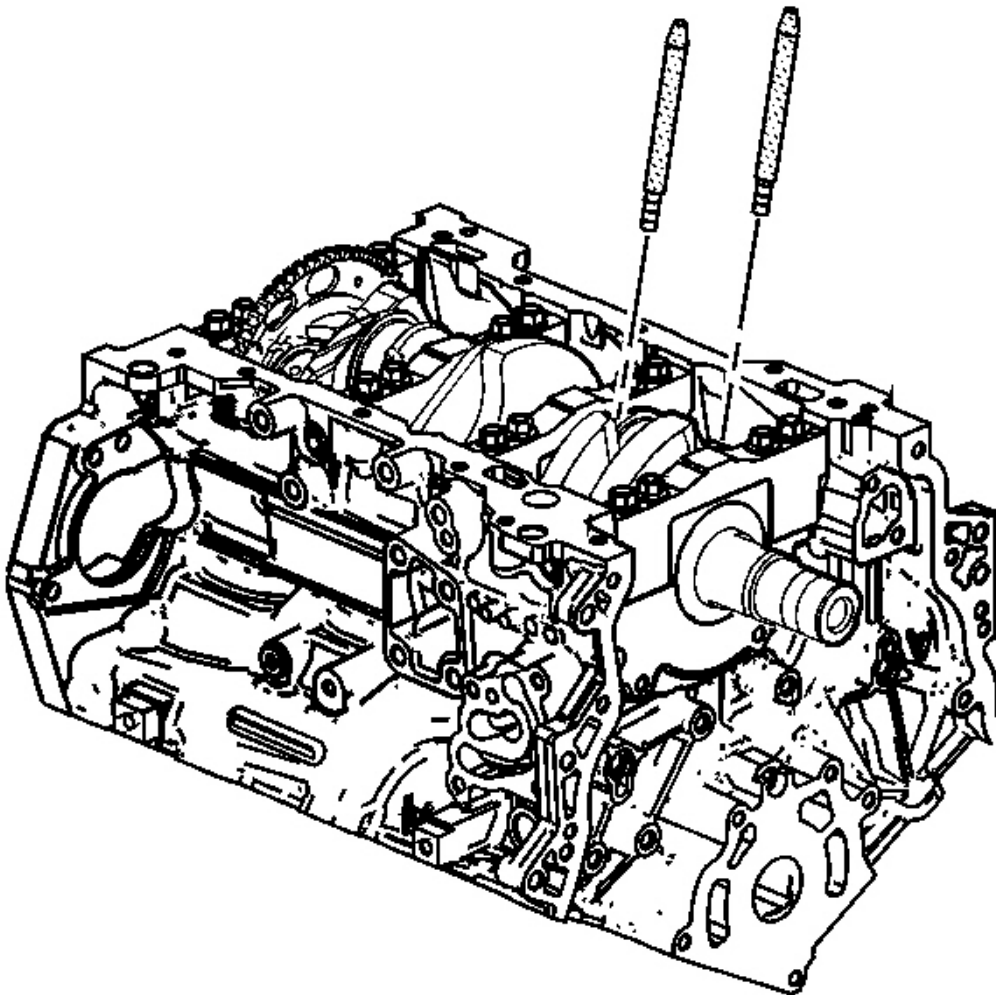


Fig. 351: Identifying EN 46121
Courtesy of GENERAL MOTORS CORP.

8. 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.

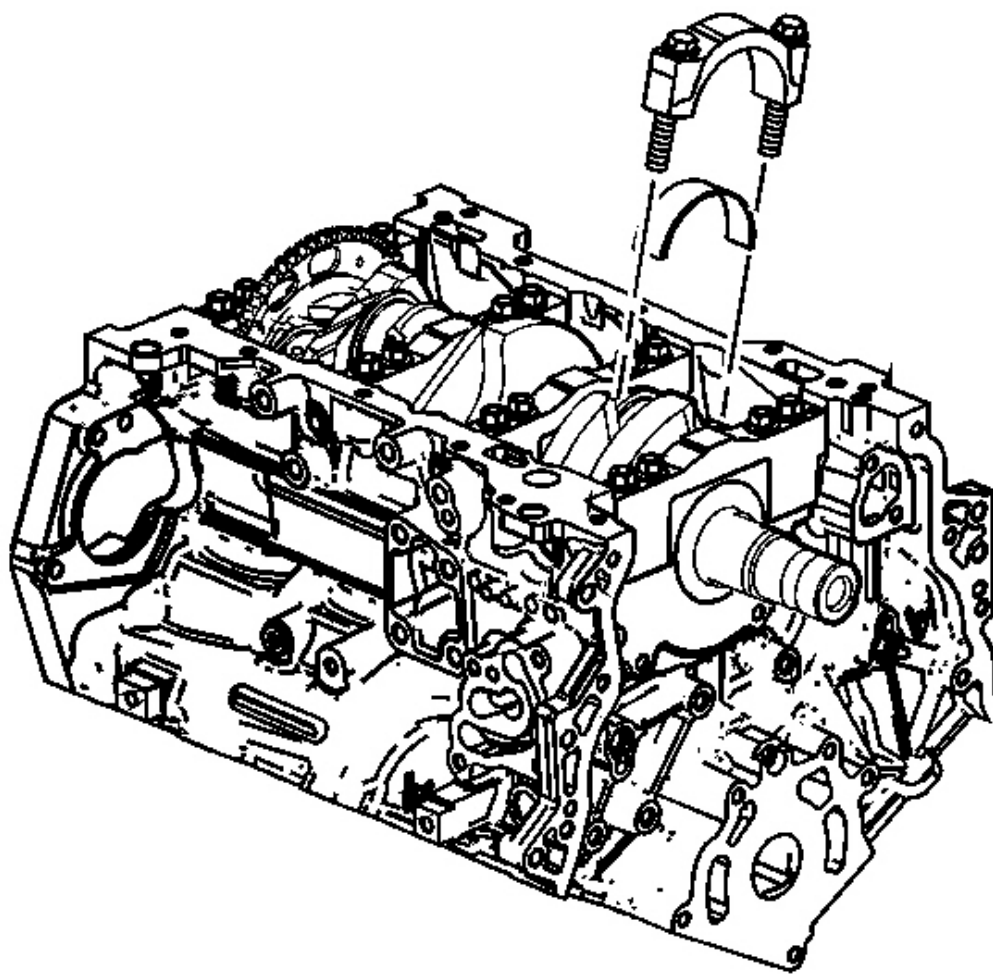


Fig. 352: View Of Connecting Rod Bearing & Cap
Courtesy of GENERAL MOTORS CORP.

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.**

4. Install the connecting rod bolts into the connecting rod cap and tighten the connecting rod bolts to 30 N.m (22 lb ft).
5. Loosen the connecting rod bolts until the torque reading is zero.
6. 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.

7. Allow the assembly to sit for at least 2 minutes.
8. Remove the connecting rod cap bolts.
9. Remove the connecting rod cap.

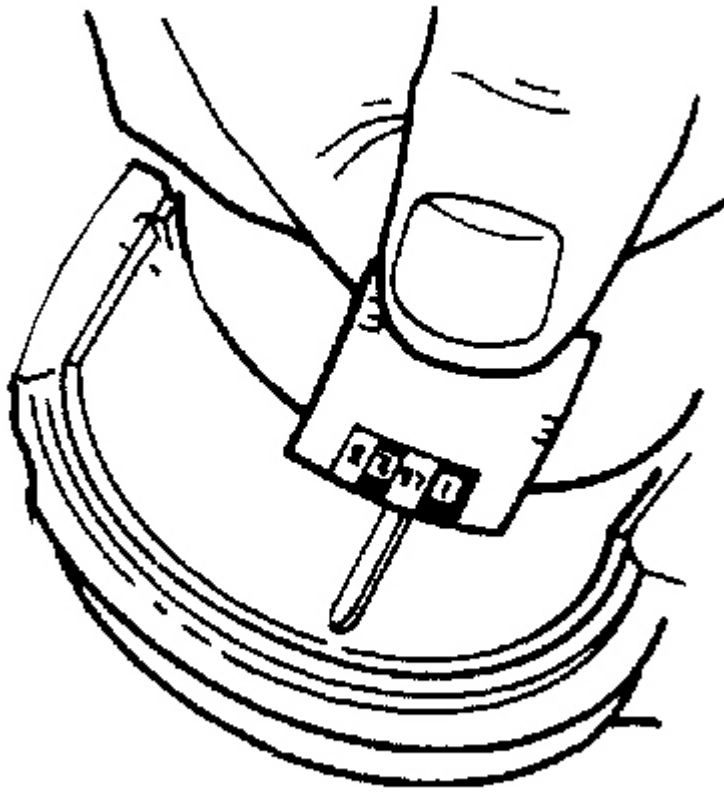


Fig. 353: Measuring Plastigage
Courtesy of GENERAL MOTORS CORP.

10. 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.
11. 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.
12. Clean the plastic gaging material from the connecting rod bearing journals using a soft lint-free cloth.

A AND J 43690-100

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

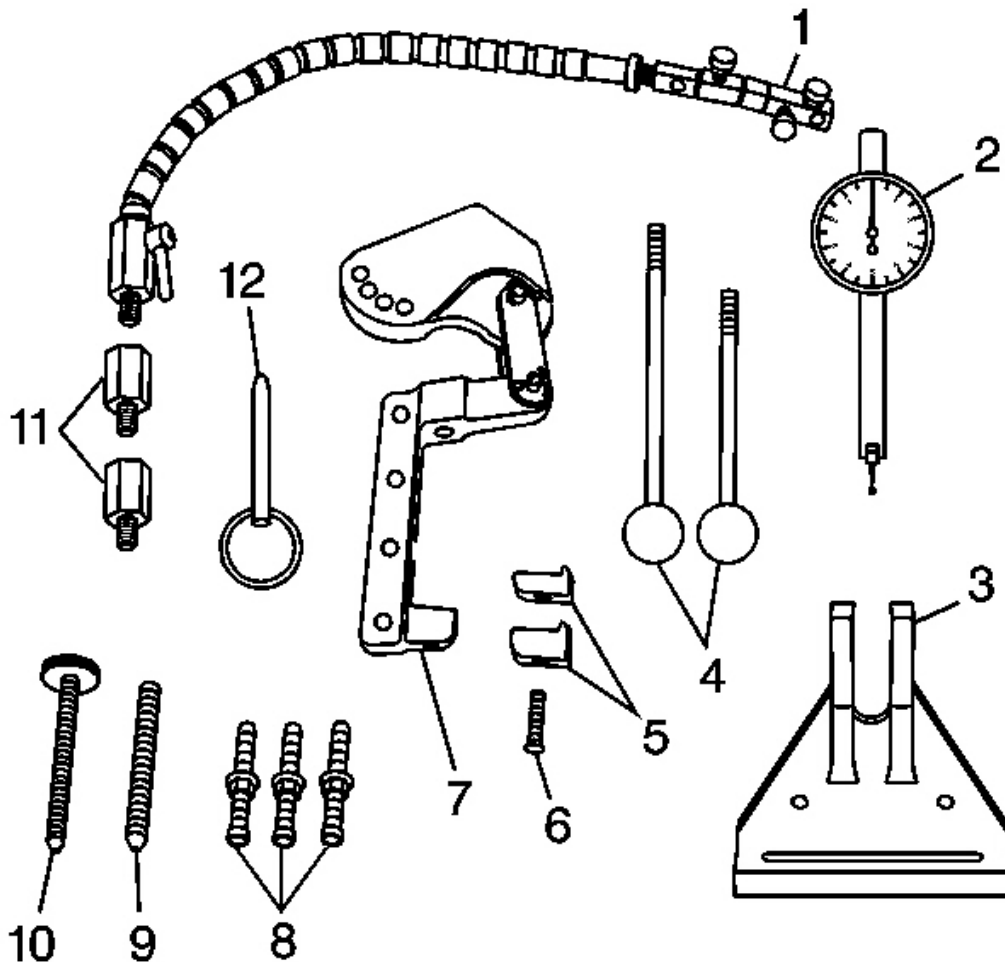


Fig. 354: Identifying Rod Bearing Clearance Checking Tool
Courtesy of GENERAL MOTORS CORP.

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)

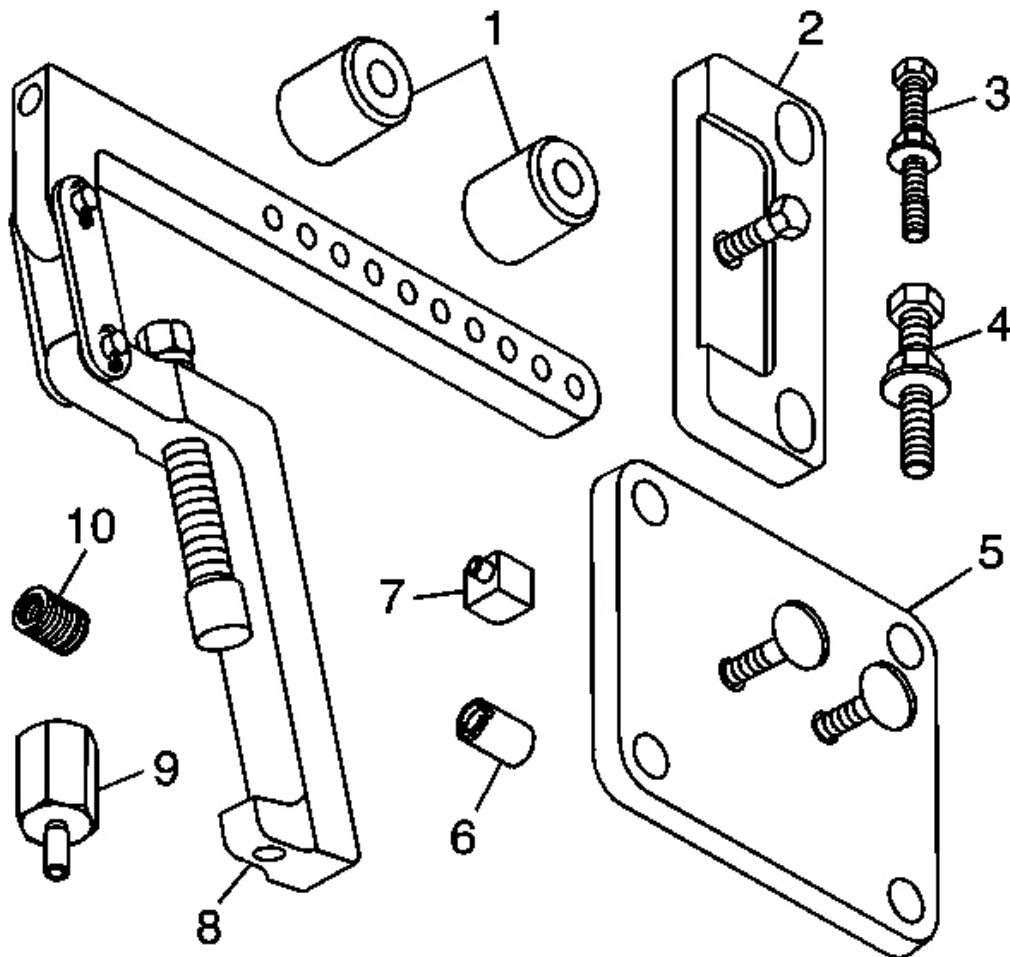


Fig. 355: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS CORP.

J 43690-100: adapter kit

- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

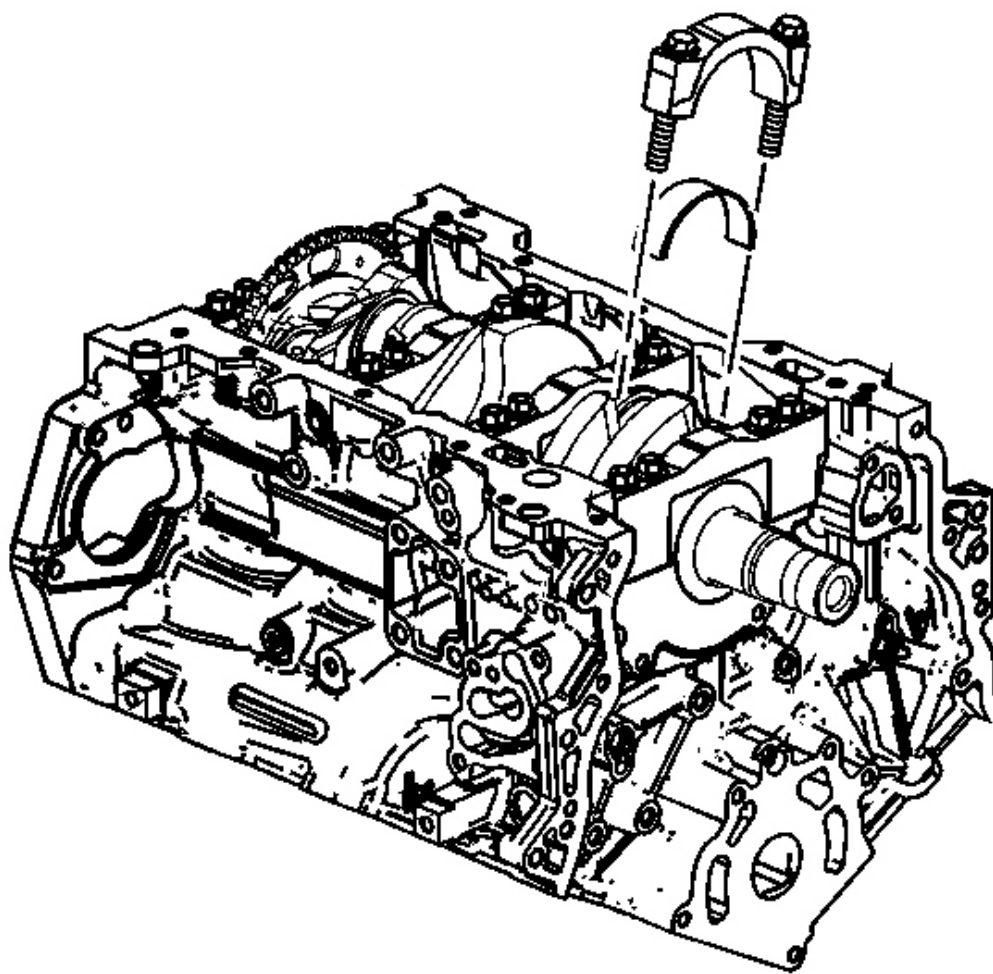


Fig. 356: View Of Connecting Rod Bearing & Cap
Courtesy of GENERAL MOTORS CORP.

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. 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 and tighten the connecting rod bolts to 30 N.m (22 lb ft).
4. Loosen the connecting rod bolts until the torque reading is zero.
5. 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.

6. 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.

7. Remove the crankshaft main bolts required to install the retainer plate J 43690-105.

NOTE: Do not allow the J 43690-105 retainer plate screw to contact the reluctor ring.

8. Install the J 43690-105 and crankshaft main bolts.
9. Loosen the connecting rod bolts until the torque reading is zero.
10. 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.

11. 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.
12. 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.

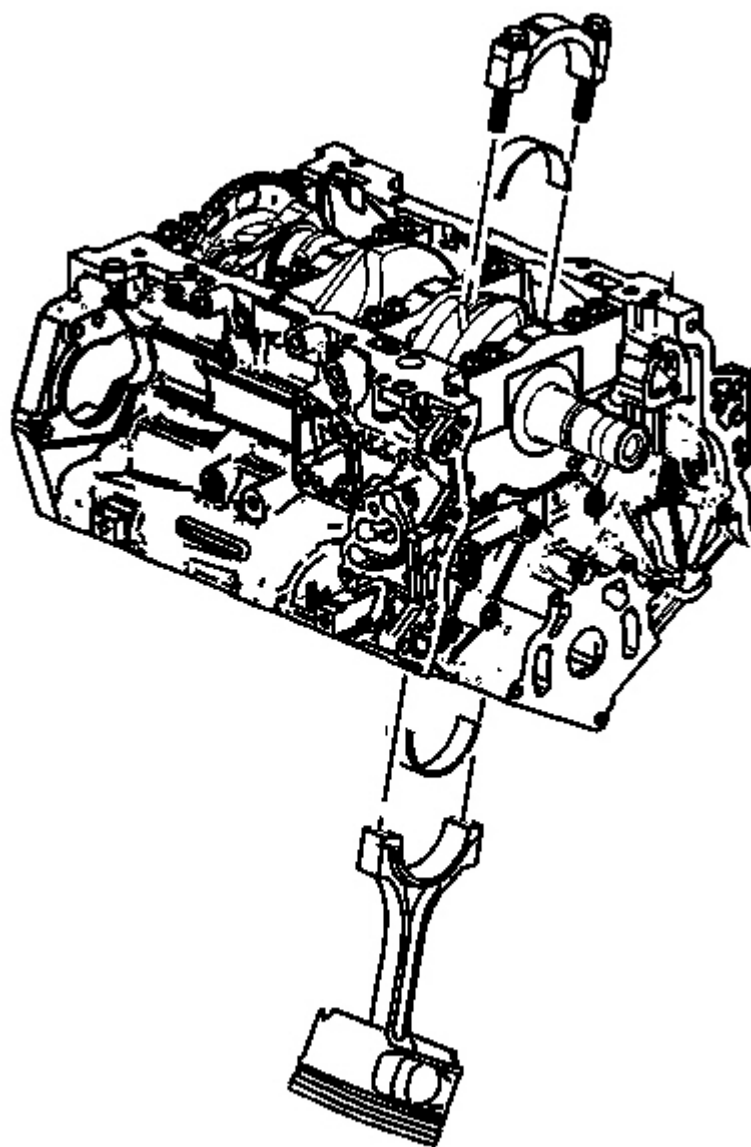


Fig. 357: Identifying Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

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: DO NOT reuse the old connecting rod bolts.

5. Install the NEW connecting rod bolts into the connecting rod cap and tighten the NEW connecting rod bolts to 30 N.m (22 lb ft).
6. Loosen the connecting rod bolts until the torque reading is zero.
7. 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.

8. 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.
9. 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

Special Tools

- **EN 42183:** Handle
- **EN 46109:** Guide Pin Set
- **EN 47839:** Crankshaft Rear Oil Seal Installation Tool

For equivalent regional tools, refer to **Special Tools** .

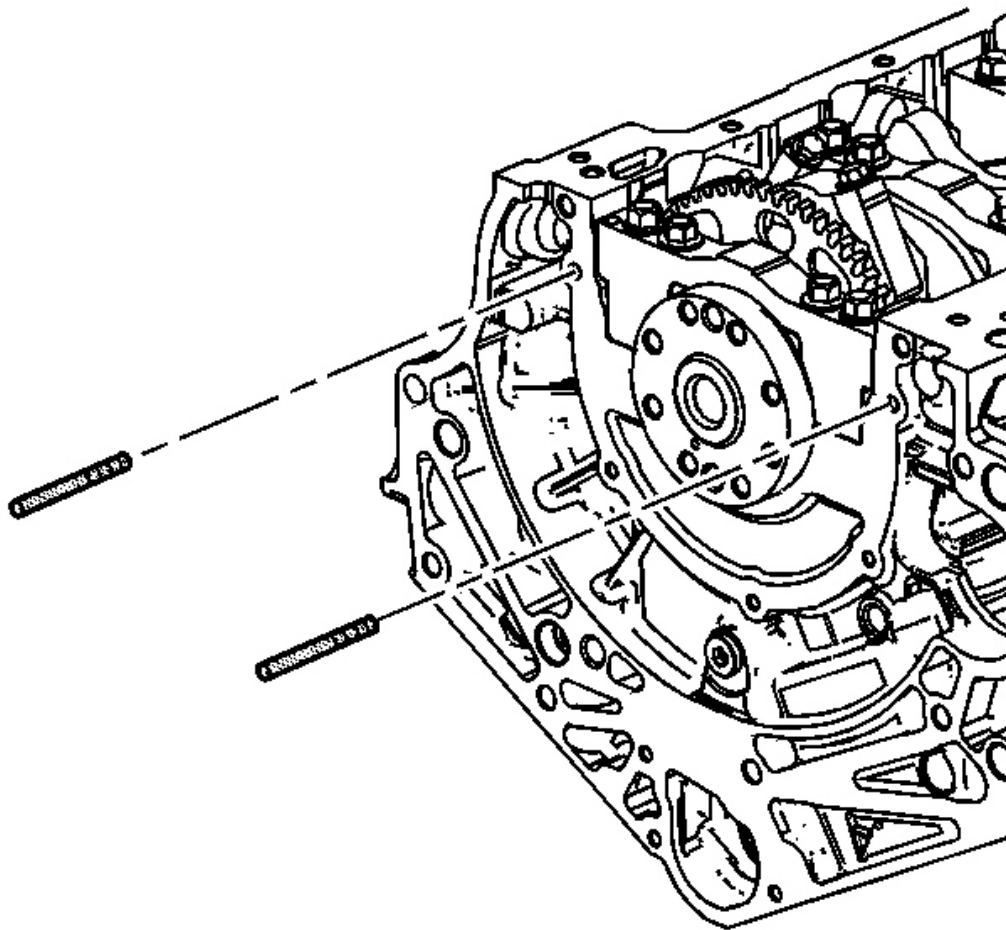


Fig. 358: View Of EN 46109

Courtesy of GENERAL MOTORS CORP.

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.

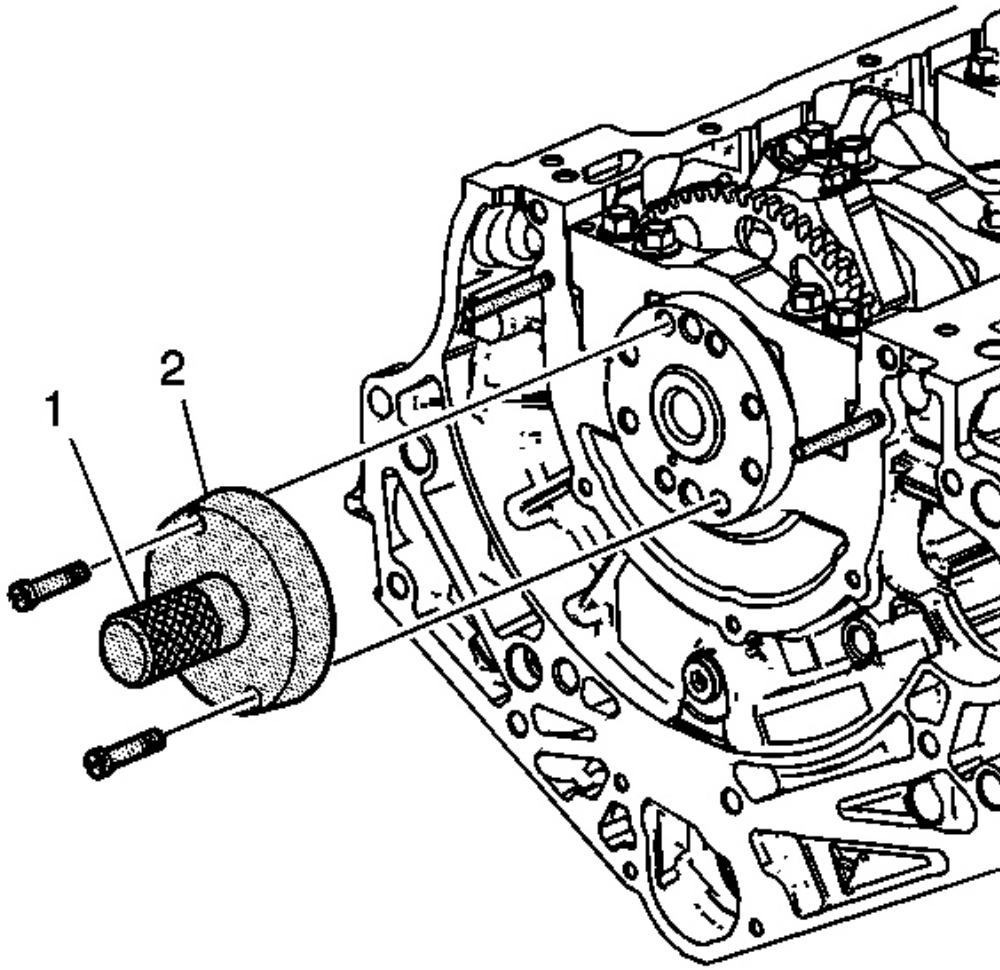


Fig. 359: Installing EN-47839
Courtesy of GENERAL MOTORS CORP.

2. Install the **EN-47839**: tool with the **EN 42183**: handle (1, 2) onto the rear of the crankshaft flange.

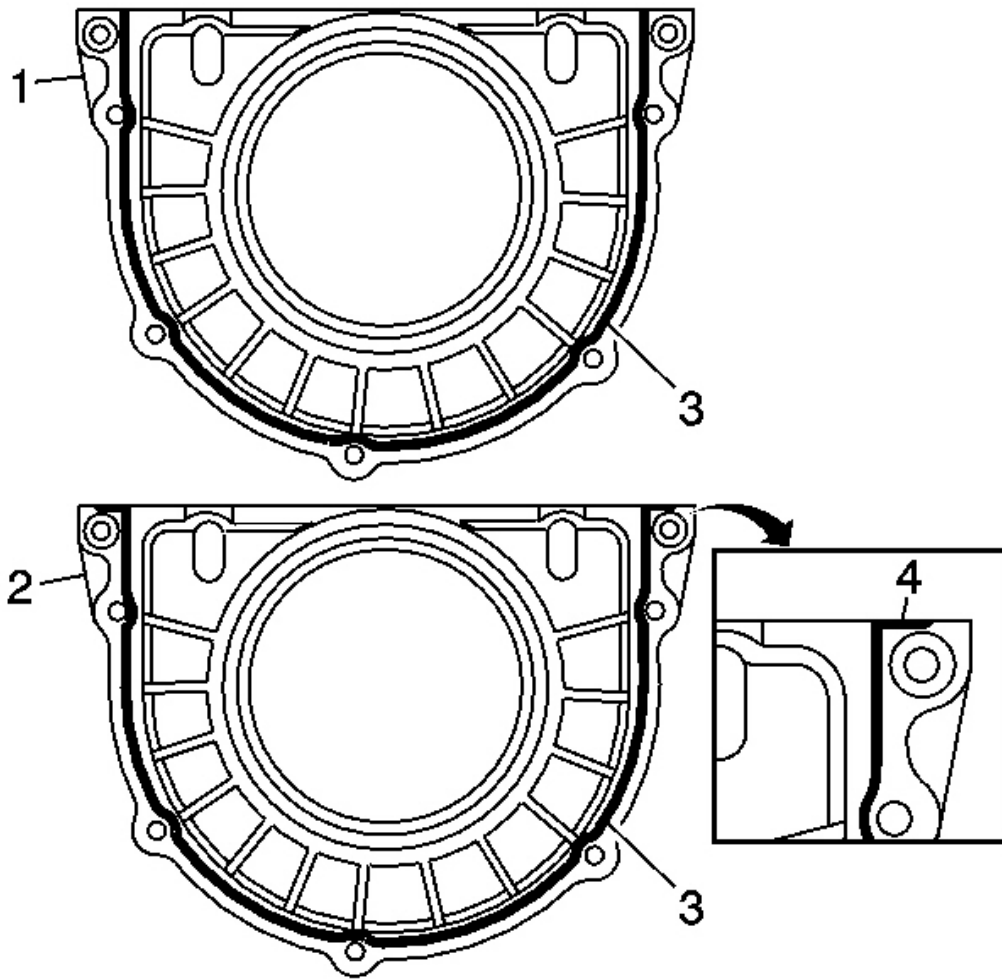


Fig. 360: Identifying First & Second Design Crankshaft Rear Oil Seal Housings
Courtesy of GENERAL MOTORS CORP.

NOTE: There are first design (1) and second design (2) crankshaft rear oil seal housings. Second design oil seal housings include additional grooves for RTV sealant near the oil seal housing to oil pan interface (4).

3. Place a 3 mm (0.118 in) bead of RTV sealant to the NEW crankshaft rear oil seal housing as shown (3). Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended sealant.

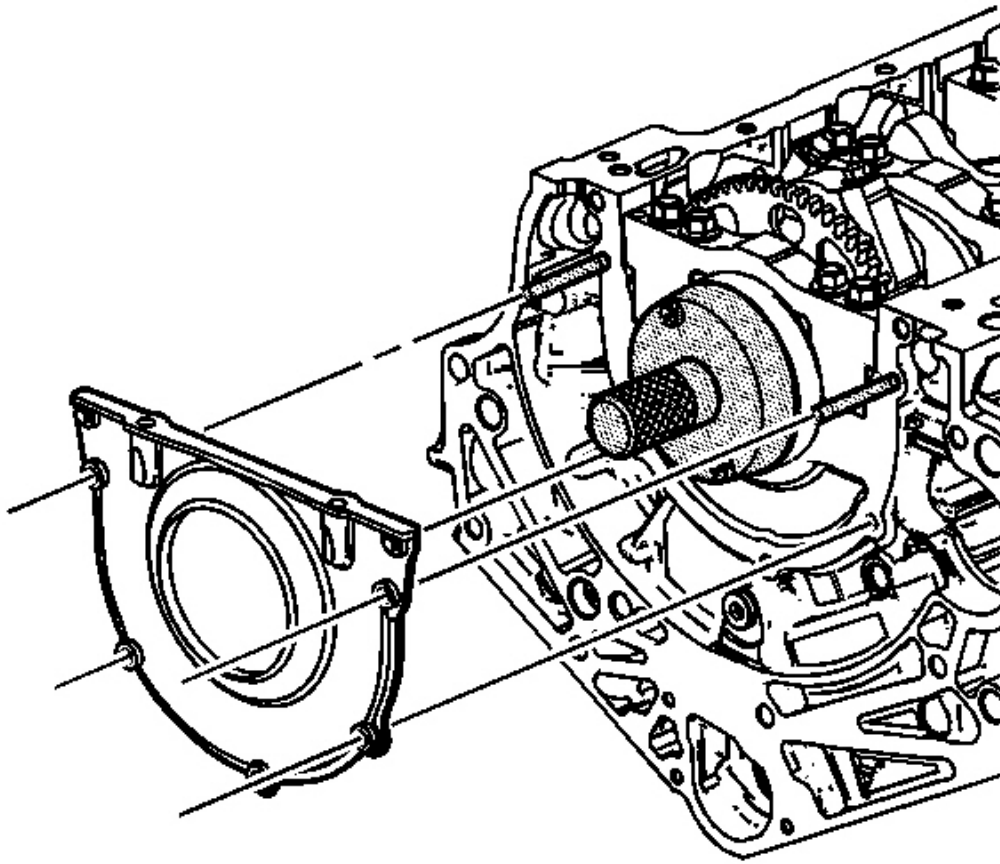


Fig. 361: Installing Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

NOTE: **DO NOT** allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed.

4. Install the crankshaft rear oil seal housing to the engine block.

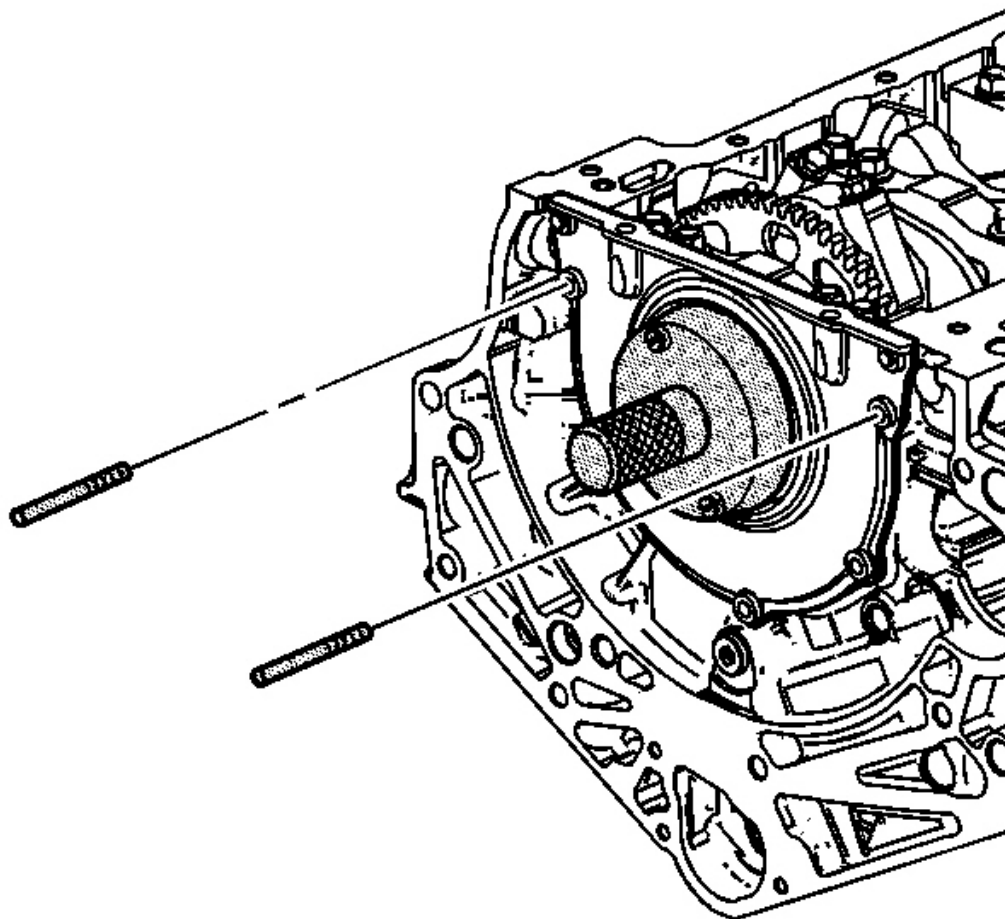


Fig. 362: View Of EN 46109

Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN-46109:** pin set 6 mm (0.236 in) guides from the engine block.

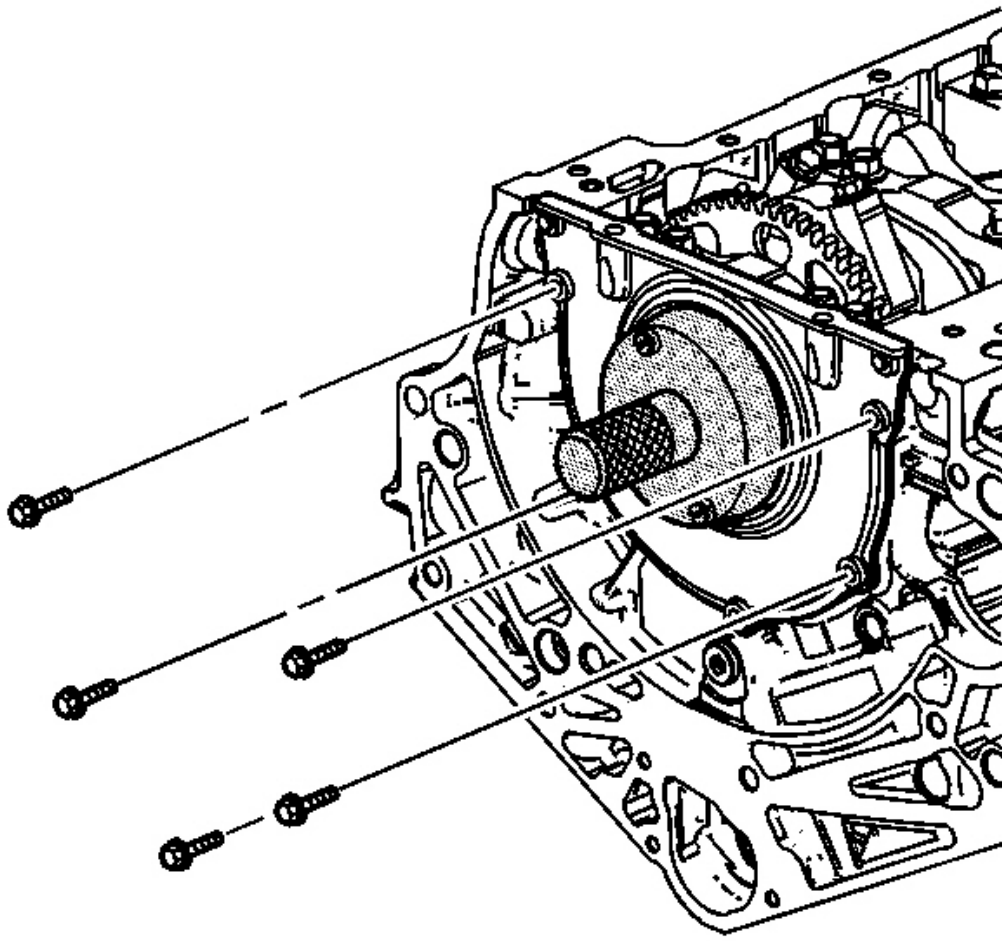


Fig. 363: Locating Crankshaft Rear Oil Seal Housing Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the crankshaft rear oil seal housing bolts.

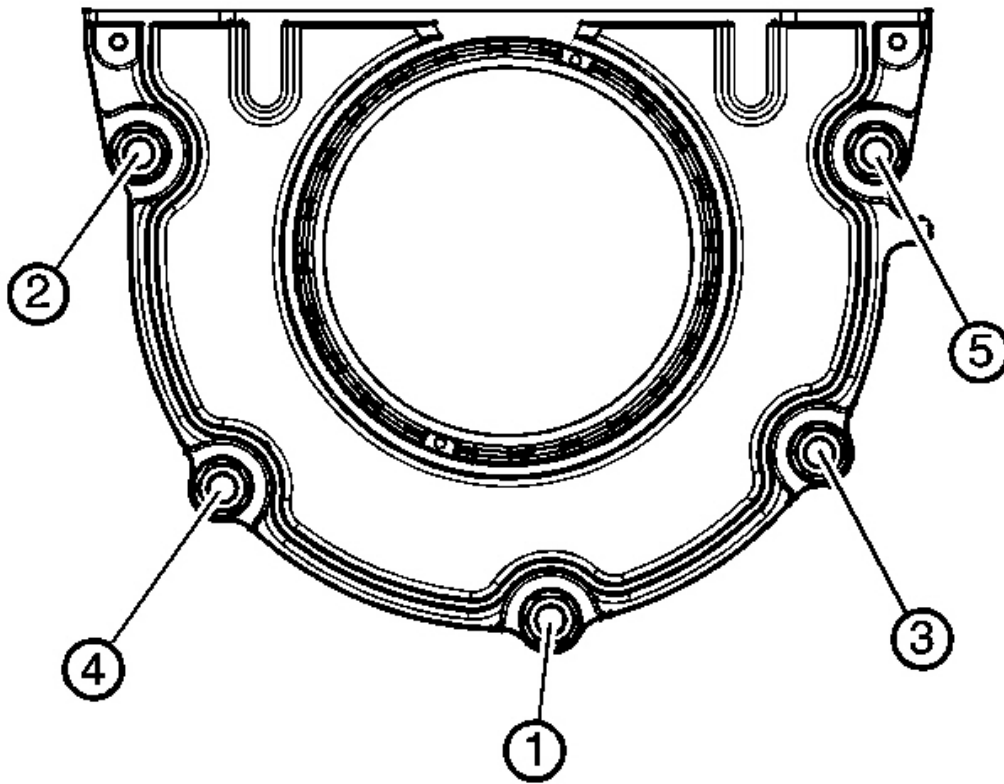


Fig. 364: Identifying Crankshaft Rear Oil Seal Housing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

7. Tighten the crankshaft rear oil seal housing bolts in sequence and tighten to 10 N.m (89 lb in).

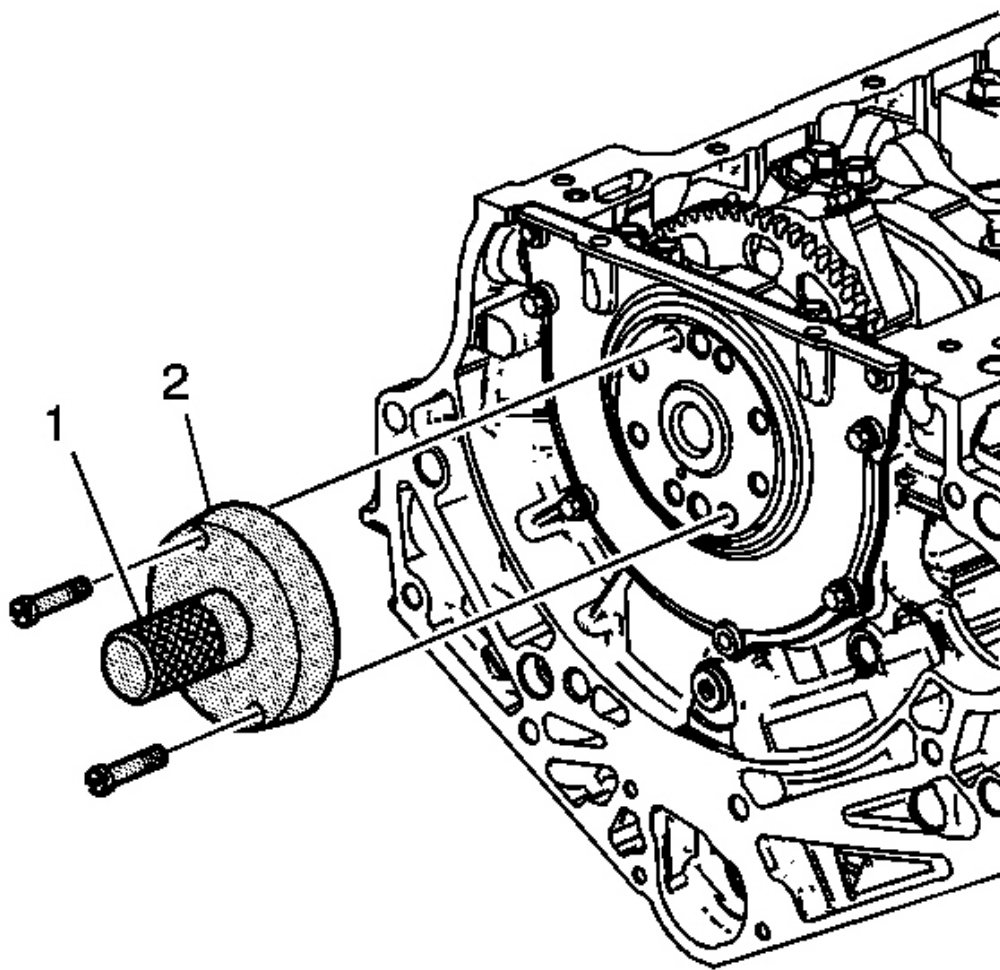


Fig. 365: View Of EN-47839 & J-42183
Courtesy of GENERAL MOTORS CORP.

8. Remove the **EN-47839**: tool and **EN 42183**: handle (1, 2) from the crankshaft flange.

OIL PUMP INSTALLATION

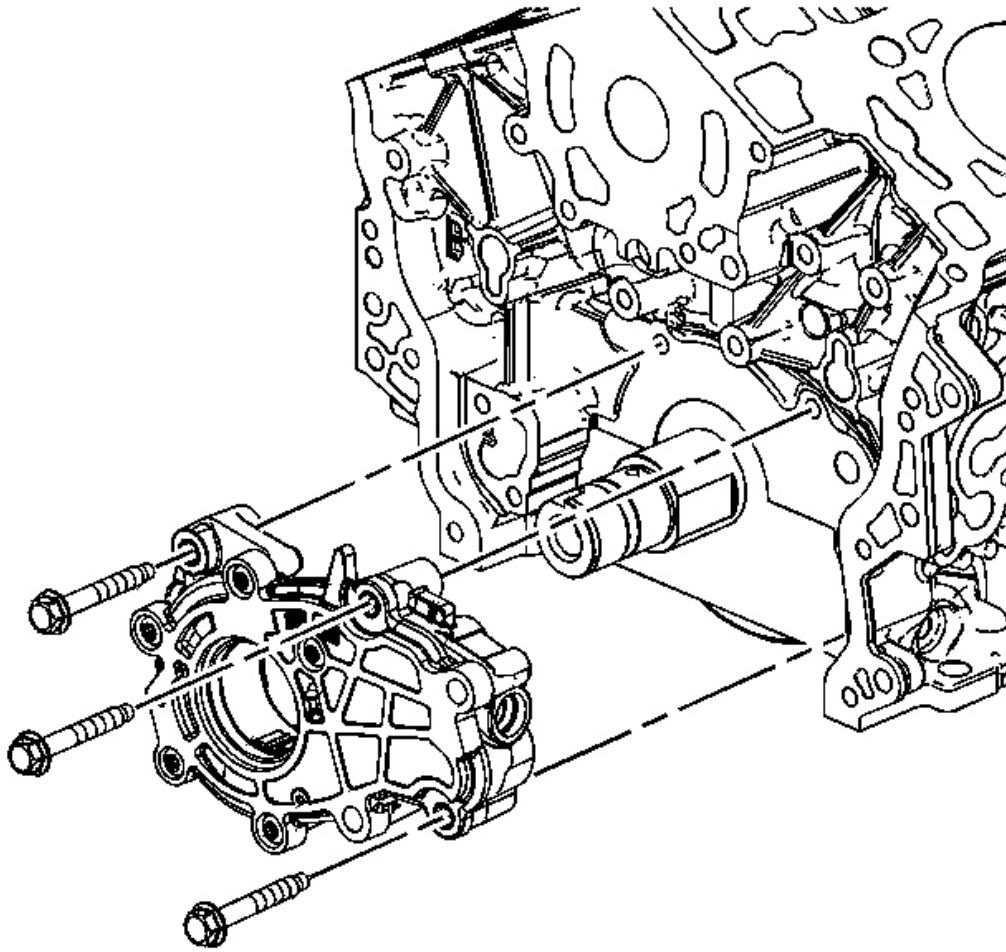


Fig. 366: Identifying Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

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.

CAUTION: Refer to Fastener Caution .

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

OIL PAN INSTALLATION

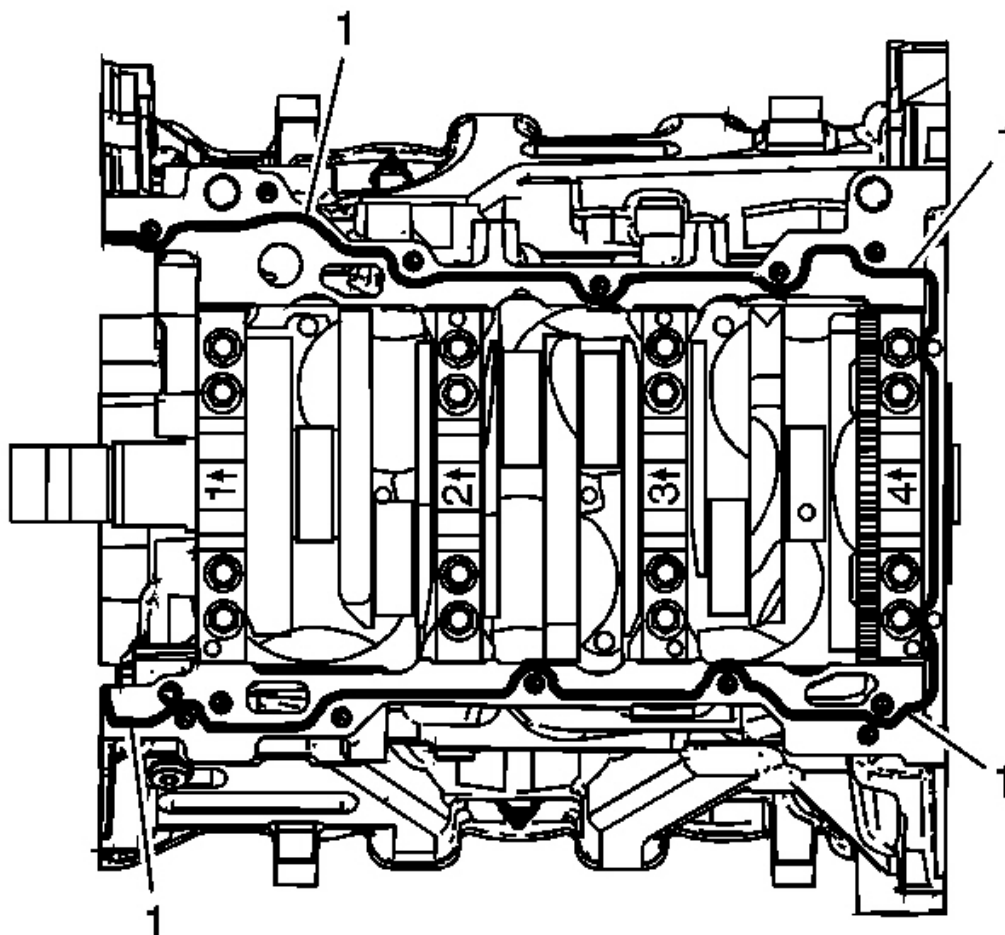


Fig. 367: Sealant Application Locations On Block Pan Rail & Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

1. Place a 3 mm (0.118 in) bead of RTV sealant, GM P/N 12378521 (Canadian P/N 88901148) or equivalent, on the block pan rail and the crankshaft rear oil seal housing (1).

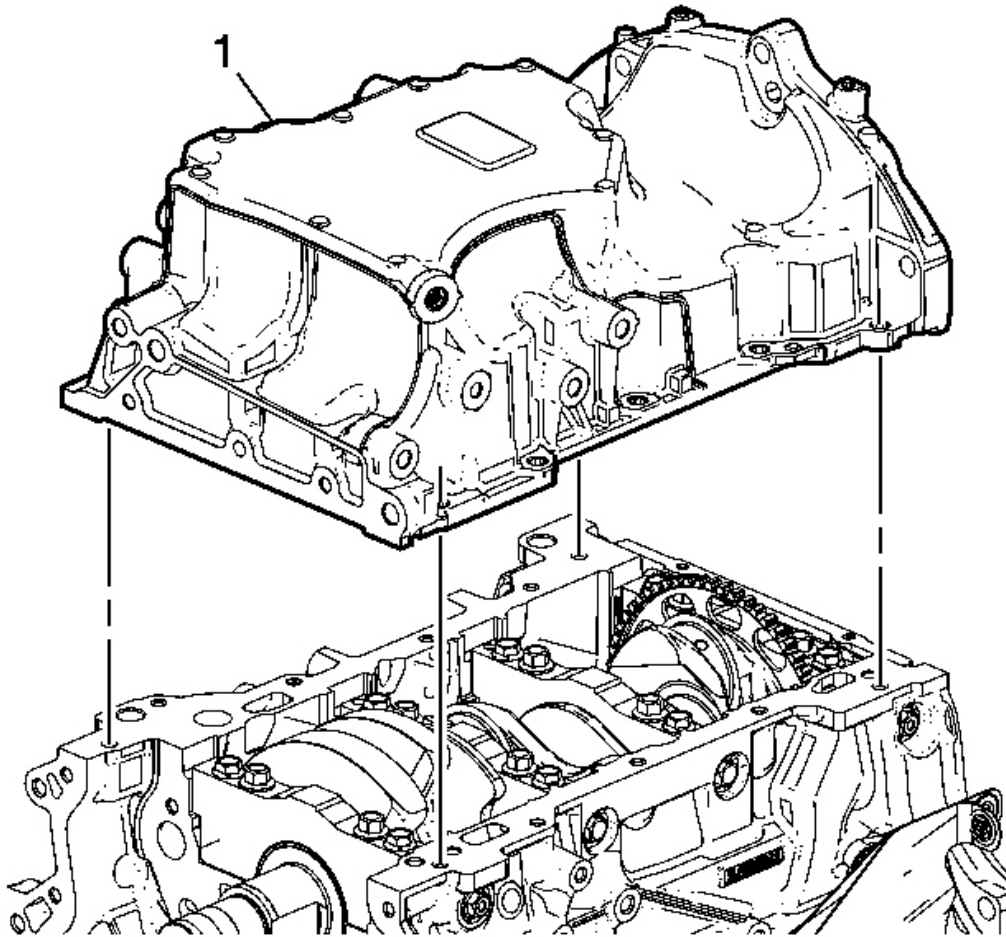


Fig. 368: Oil Pan

Courtesy of GENERAL MOTORS CORP.

2. Position the oil pan (1) onto the block.

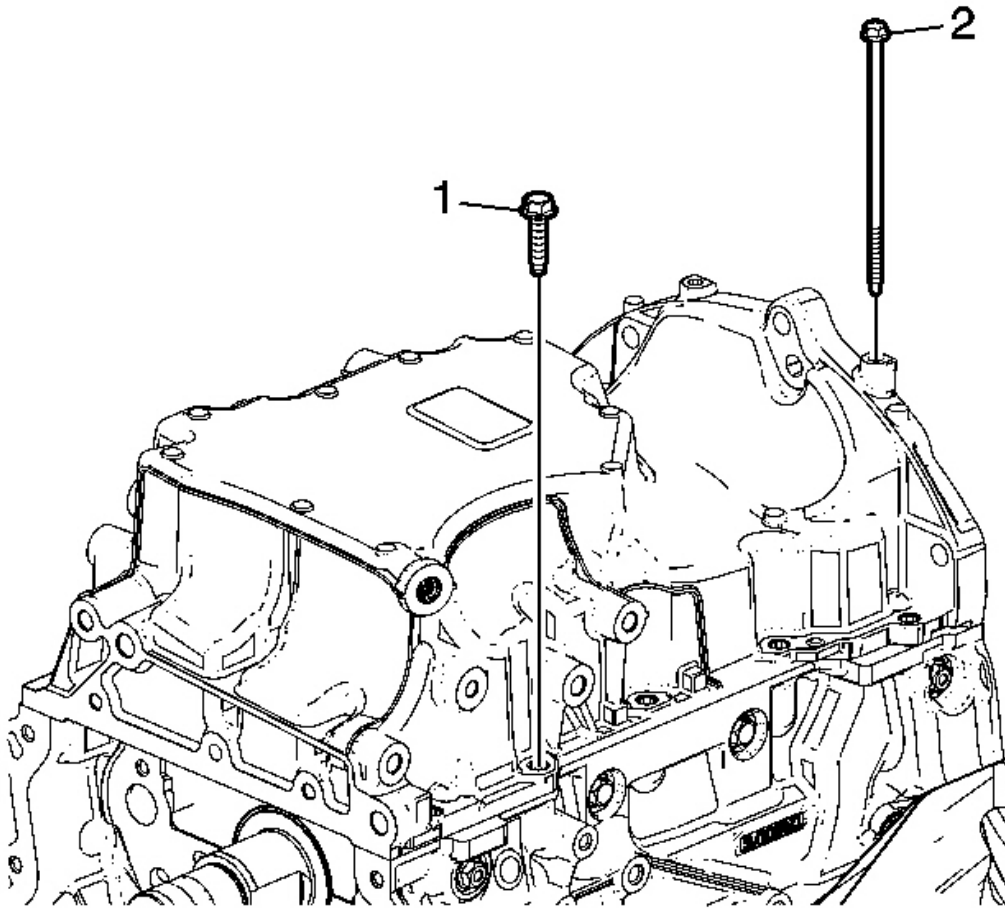


Fig. 369: Oil Pan Bolts

Courtesy of GENERAL MOTORS CORP.

3. Loosely install the oil pan bolts (1) and (2).

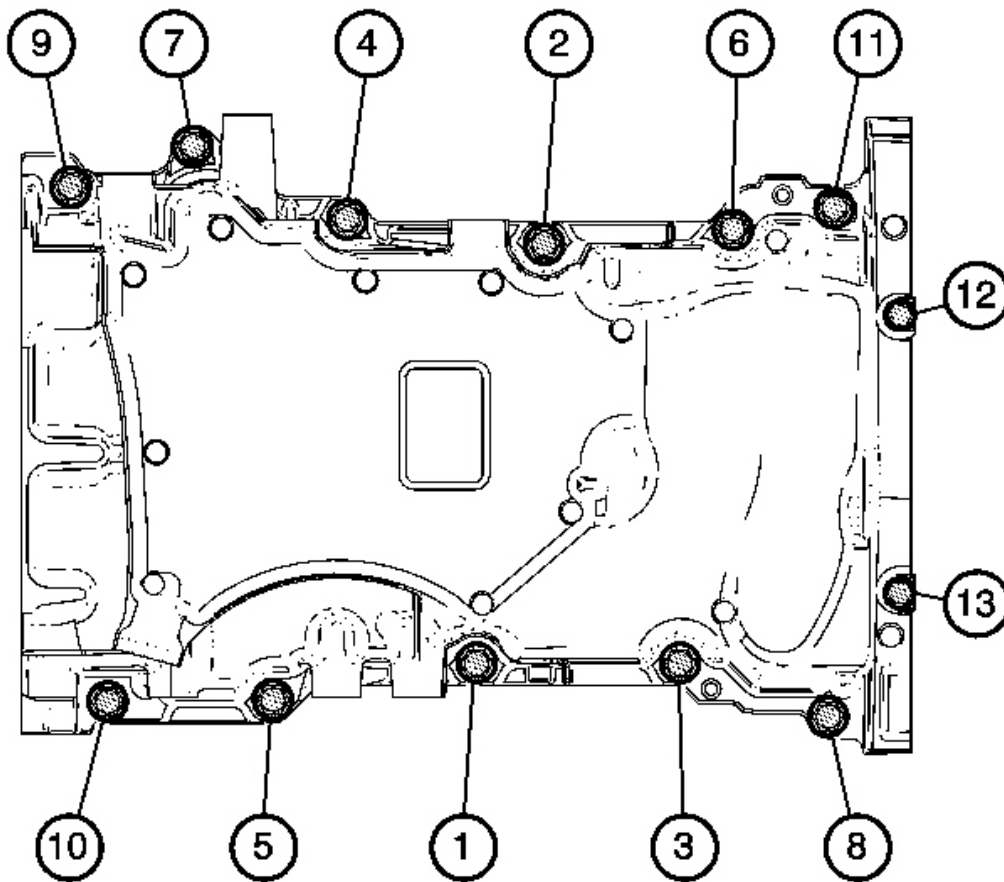


Fig. 370: Identifying Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Tighten the oil pan bolts in sequence shown.
 1. Tighten the 8 mm bolts (1-11) to 25 N.m (18 lb ft) .
 2. Tighten the 6 mm bolts (12, 13) to 10 N.m (89 lb in) .

CYLINDER HEAD INSTALLATION - RIGHT SIDE (LF1 OR LFW)

SPECIAL TOOLS

For equivalent regional tools, refer to **Special Tools**

INSTALLATION

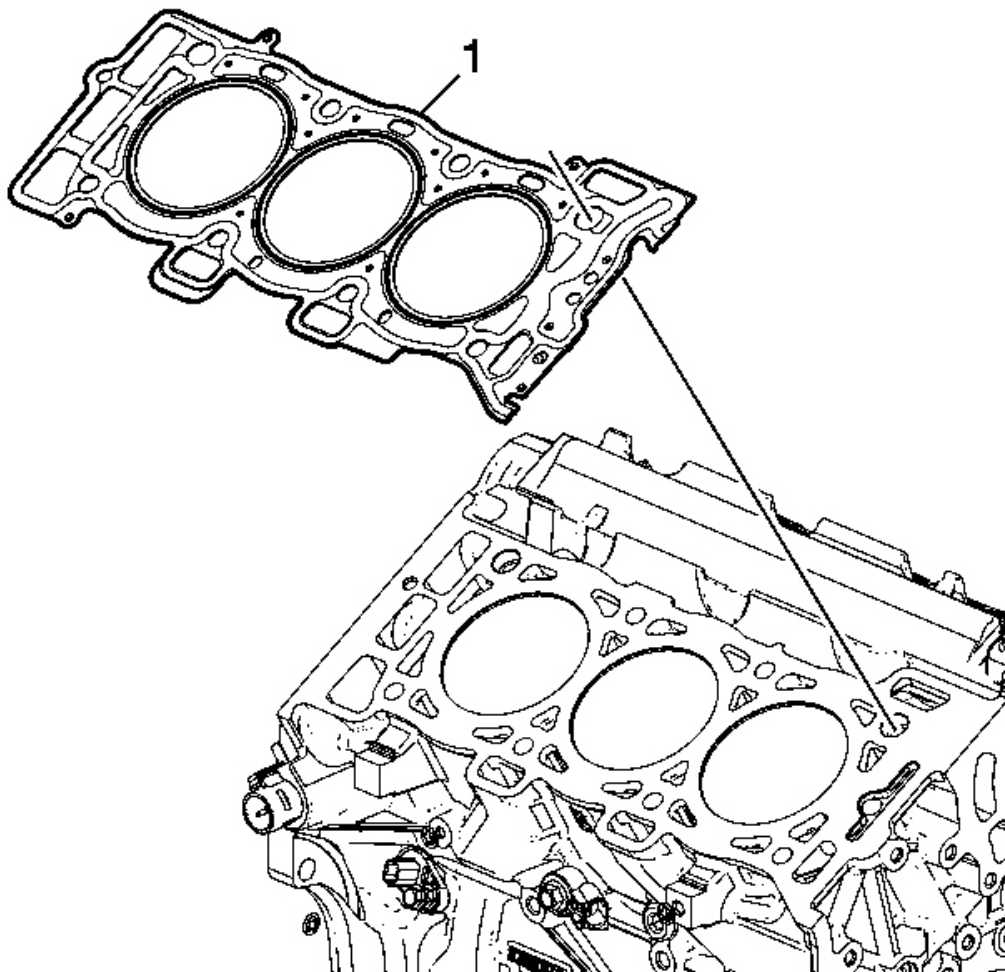


Fig. 371: Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face.
2. Install a NEW right cylinder head gasket (1) using the deck face locating pins for retention.

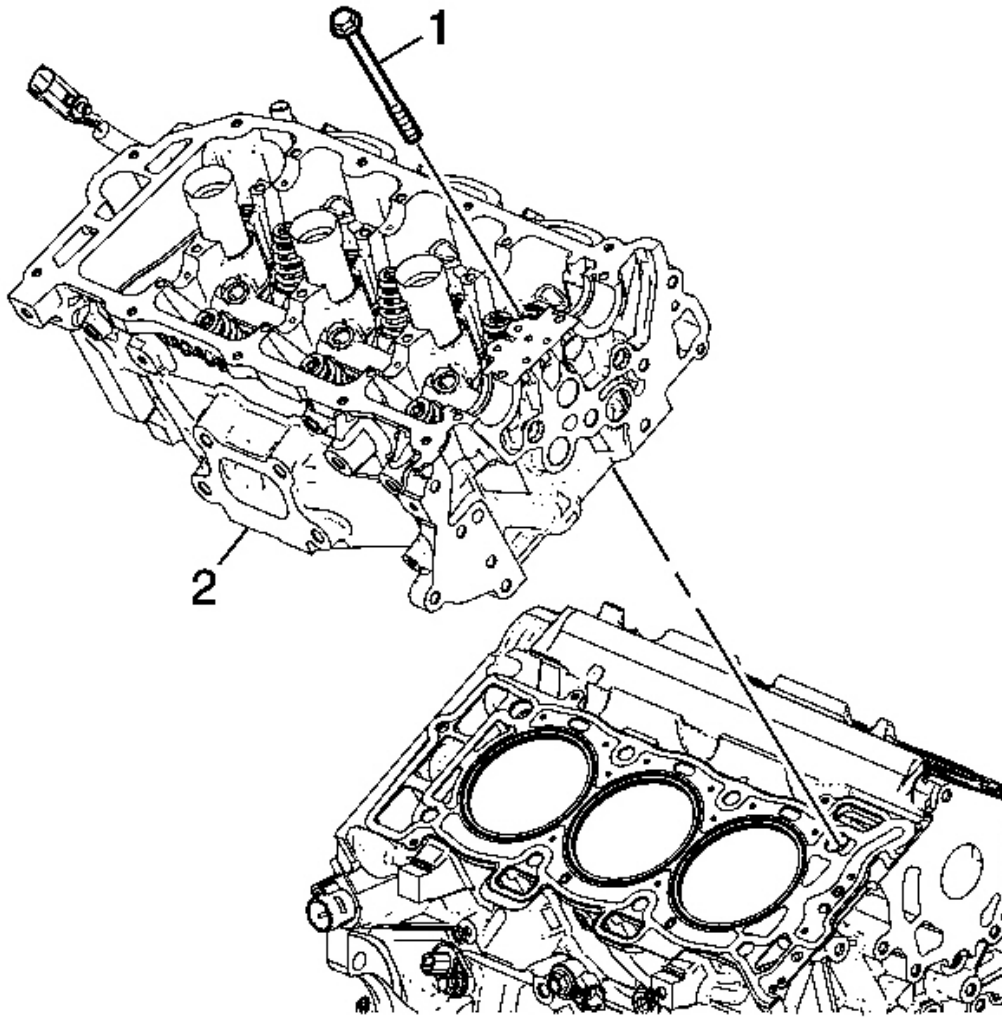


Fig. 372: Aligning Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Align the right cylinder head (2) with the deck face locating pins.
4. Place the right cylinder head in position on the deck face.

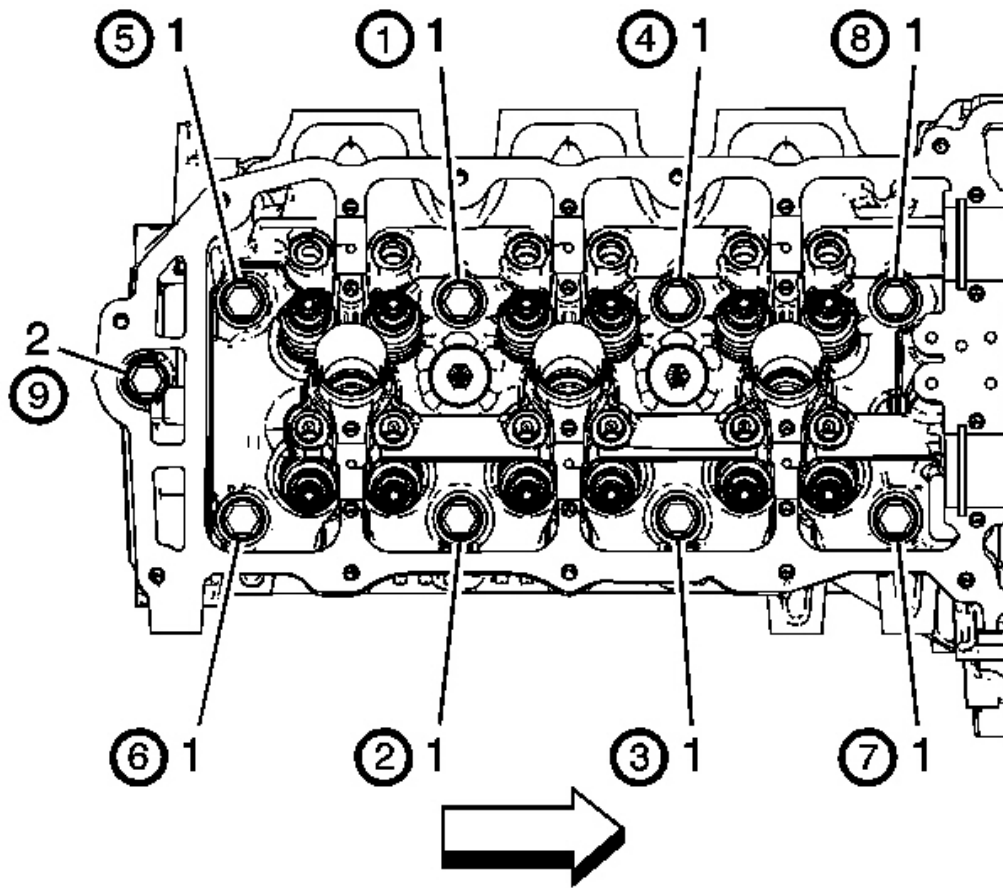


Fig. 373: Identifying M11 Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: DO NOT allow oil on the cylinder head bolt bosses.

NOTE: DO NOT reuse the old cylinder head bolts.

5. 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 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

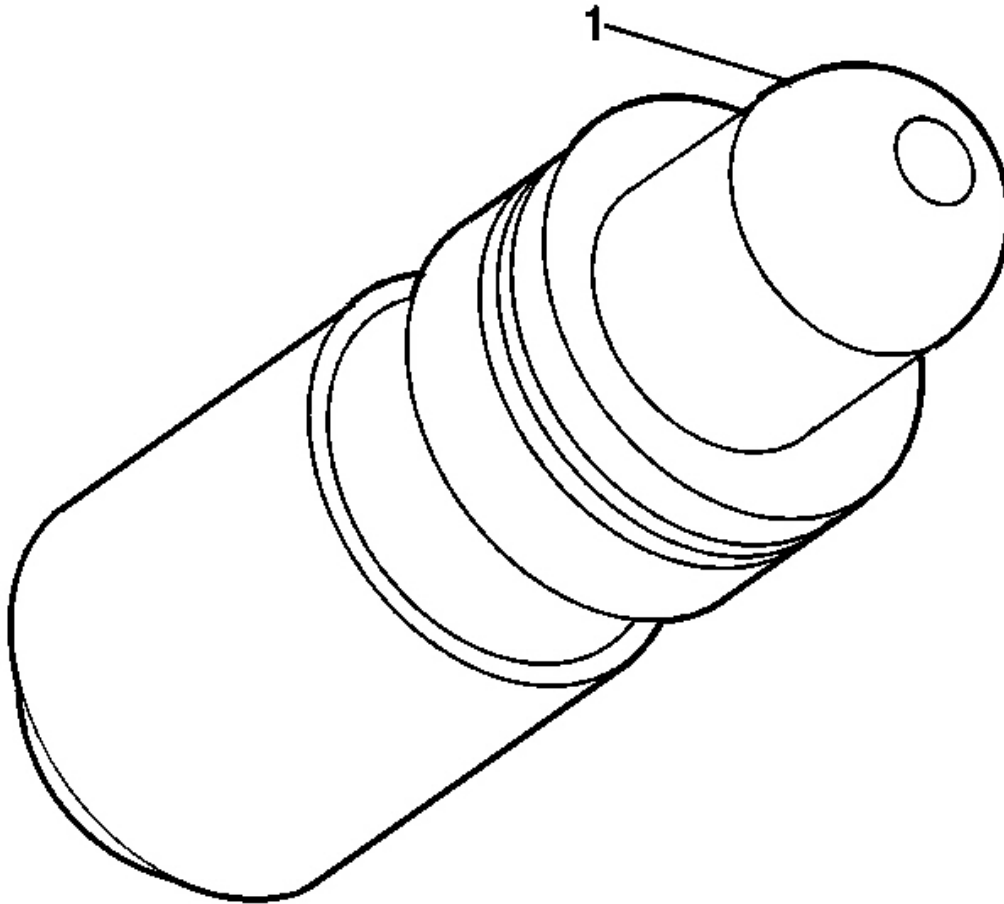


Fig. 374: View Of Valve Lifter

Courtesy of GENERAL MOTORS CORP.

NOTE: Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.

NOTE: Do not allow the stationary hydraulic lash adjuster to tip over, plunger

down, after the oil fill.

1. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended engine oil. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
2. Lubricate the SHLA bores in the cylinder head with clean engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended engine oil.

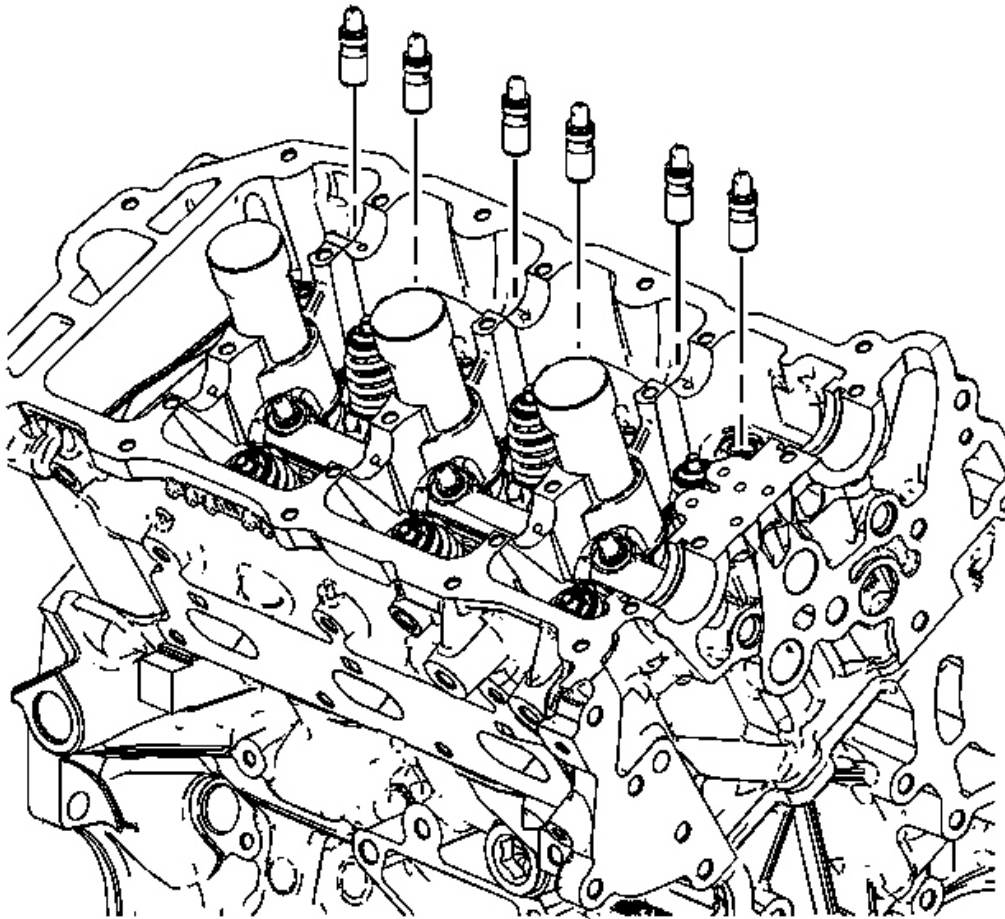


Fig. 375: View Of Stationary Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

3. Install the SHLAs in the cylinder head.
4. Apply a liberal amount of lubricant to the SHLA pivot spheres. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended lubricant.

VALVE ROCKER ARM INSTALLATION - RIGHT SIDE

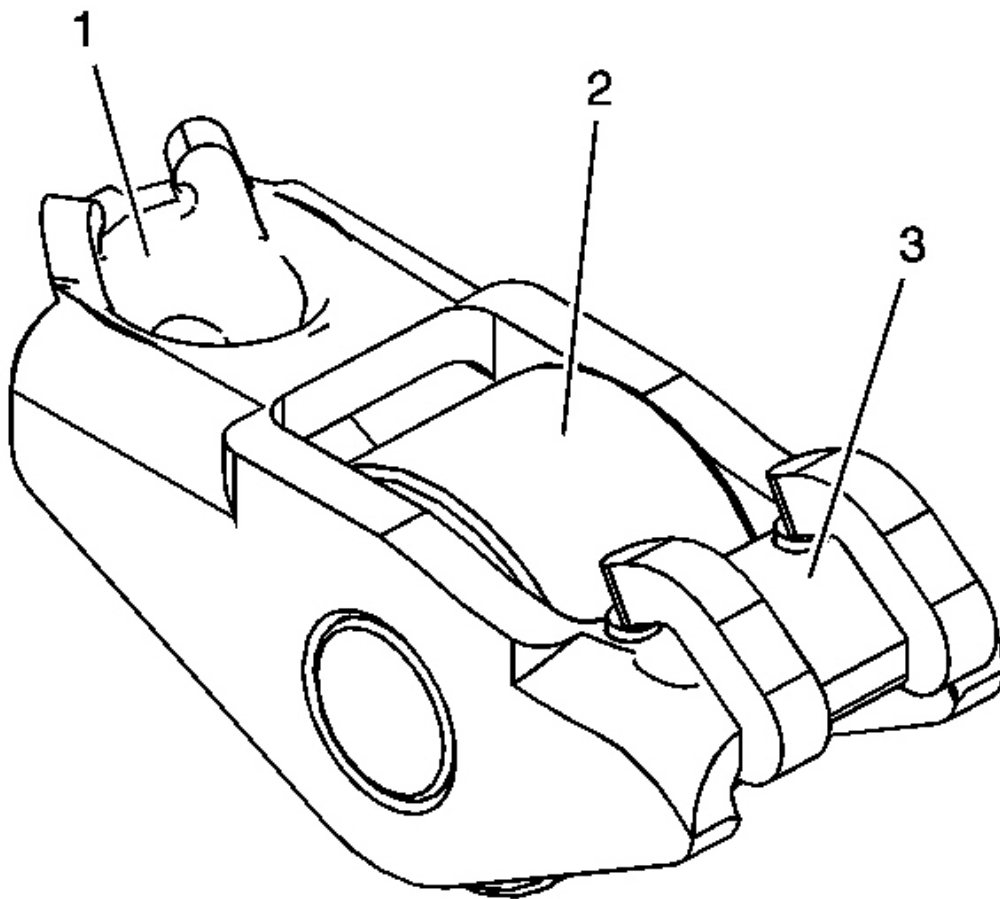


Fig. 376: Identifying Valve Rocker Arm Lubrication Areas
Courtesy of GENERAL MOTORS CORP.

1. Apply a liberal amount of lubricant to the pivot pocket (1), roller (2) and valve slot (3) areas of the camshaft followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended lubricant.

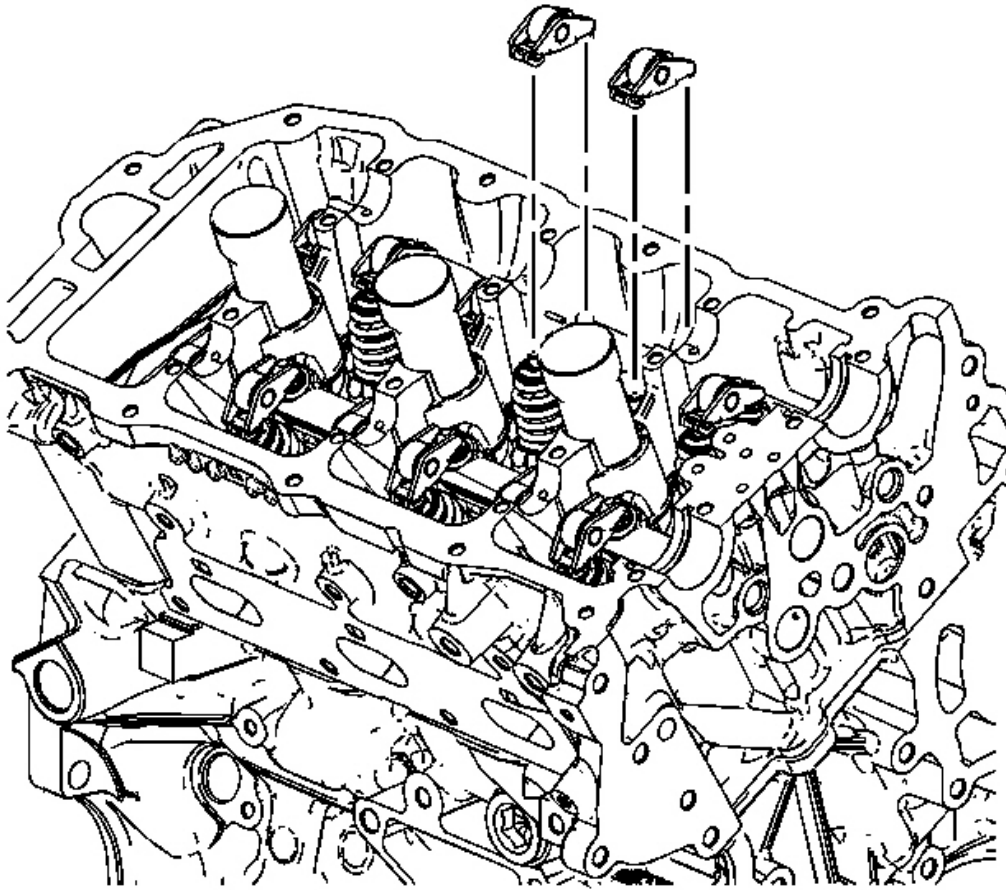


Fig. 377: View Of Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

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 - RIGHT SIDE

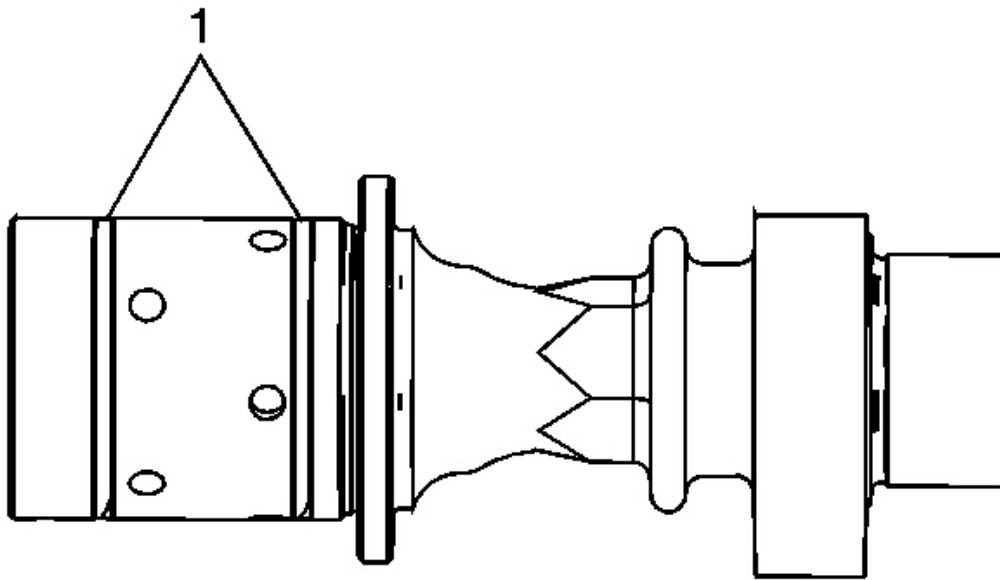


Fig. 378: Identifying Camshaft Sealing Rings
Courtesy of GENERAL MOTORS CORP.

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.

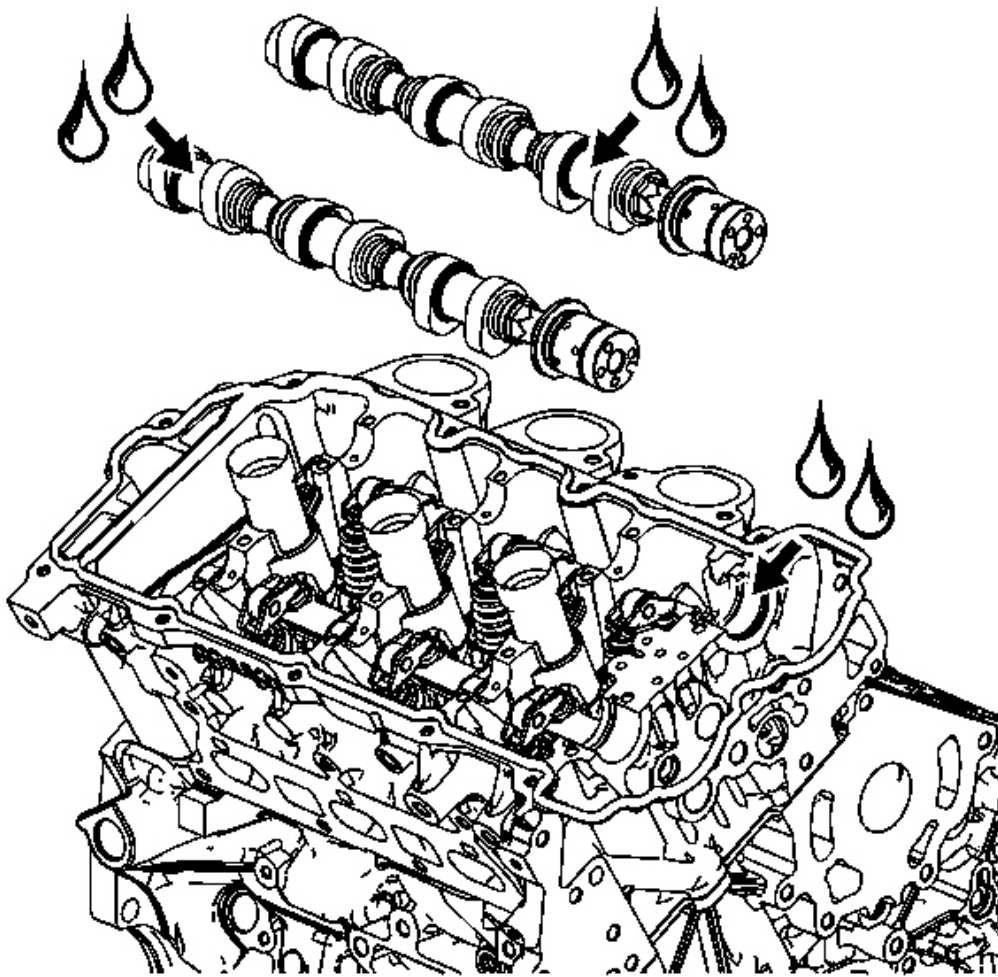


Fig. 379: Applying Lubricant Or Equivalent To Camshaft Journals & Right Cylinder Head Camshaft Carriers

Courtesy of GENERAL MOTORS CORP.

2. Apply a liberal amount of lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent to the camshaft journals and the right cylinder head camshaft carriers.

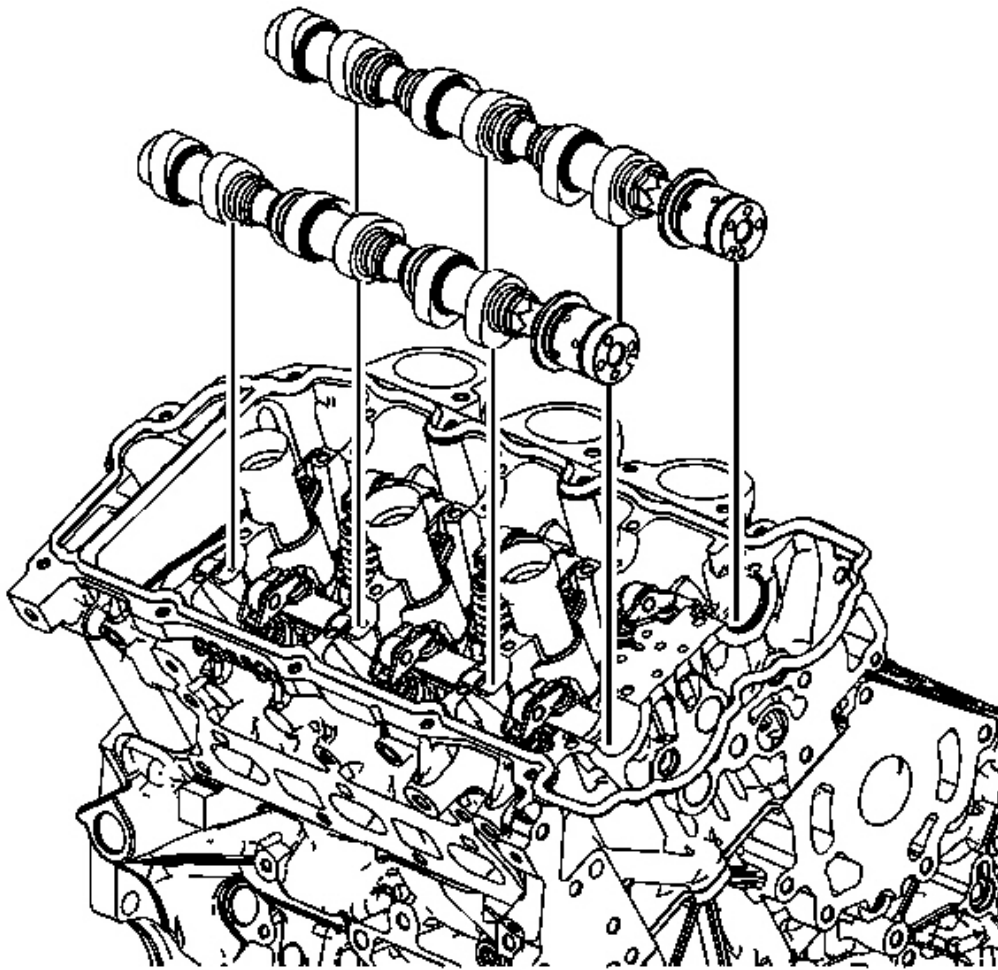


Fig. 380: Positioning Right Intake & Right Exhaust Camshafts In Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Place the right intake and right exhaust camshafts in position in the right cylinder head.

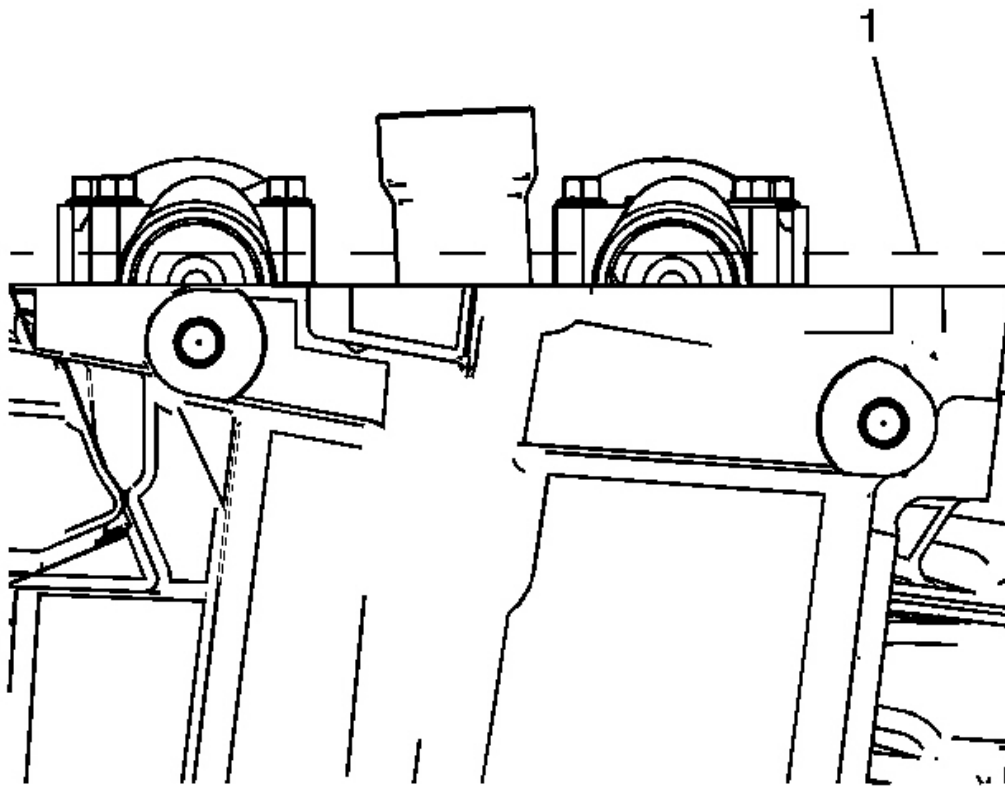


Fig. 381: Identifying Camshaft Neutral (Low Tension) Position
Courtesy of GENERAL MOTORS CORP.

4. 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.

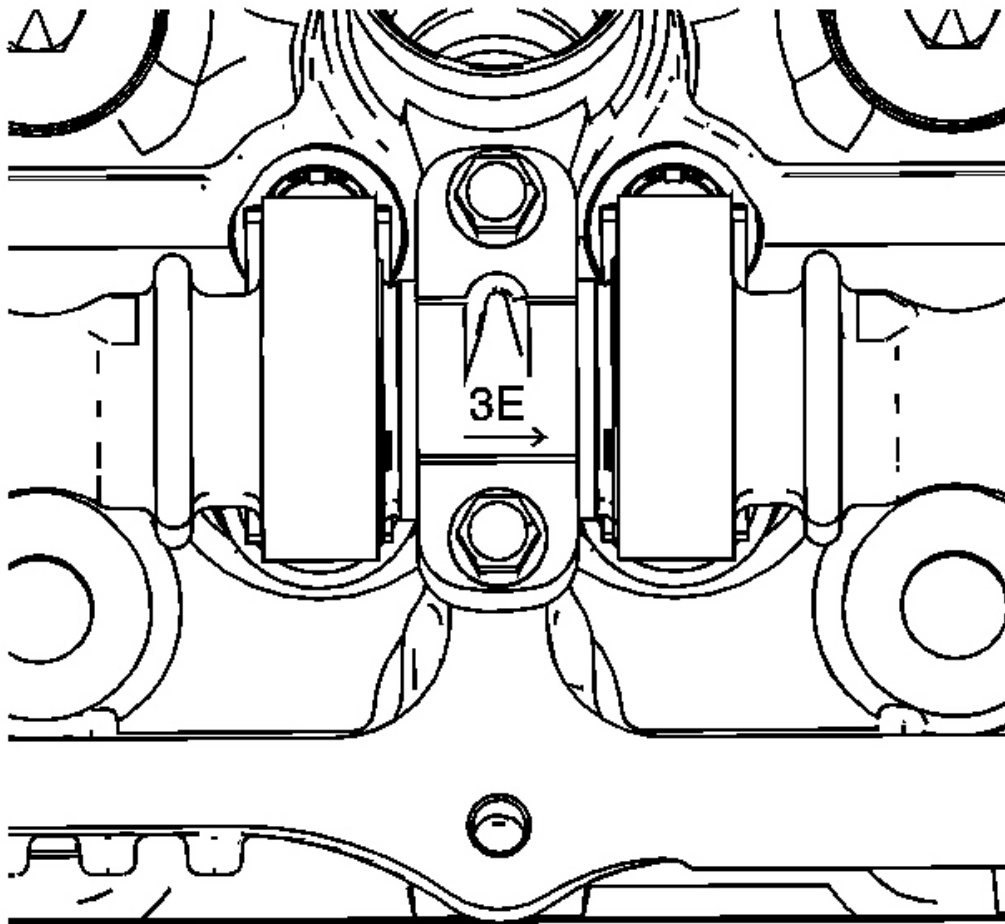


Fig. 382: Identifying Markings On Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. 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 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 GM P/N 12345501 (Canadian P/N 992704) or equivalent to the camshaft bearing caps.

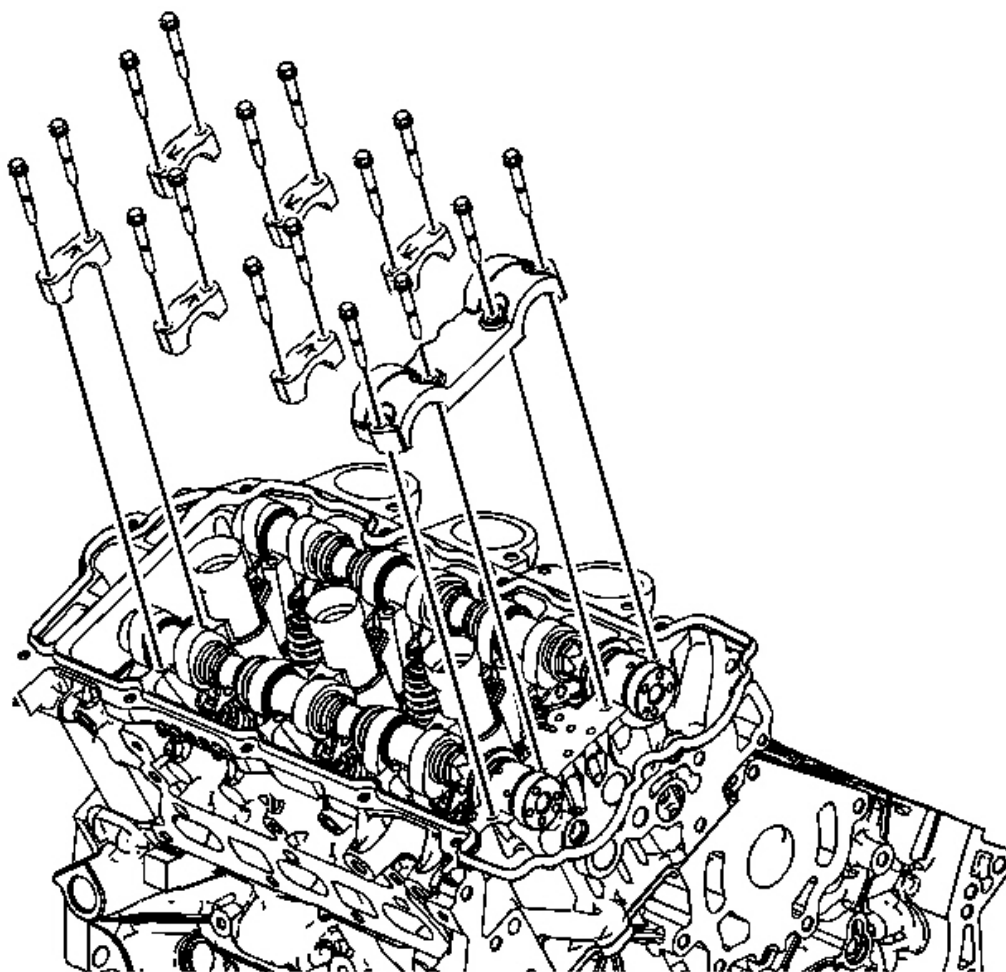


Fig. 383: Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the camshaft bearing thrust caps in the first journal of the right cylinder head.
8. Install the remaining bearing caps with their orientation mark toward the center of the cylinder head.
9. Hand start all the camshaft bearing cap bolts.

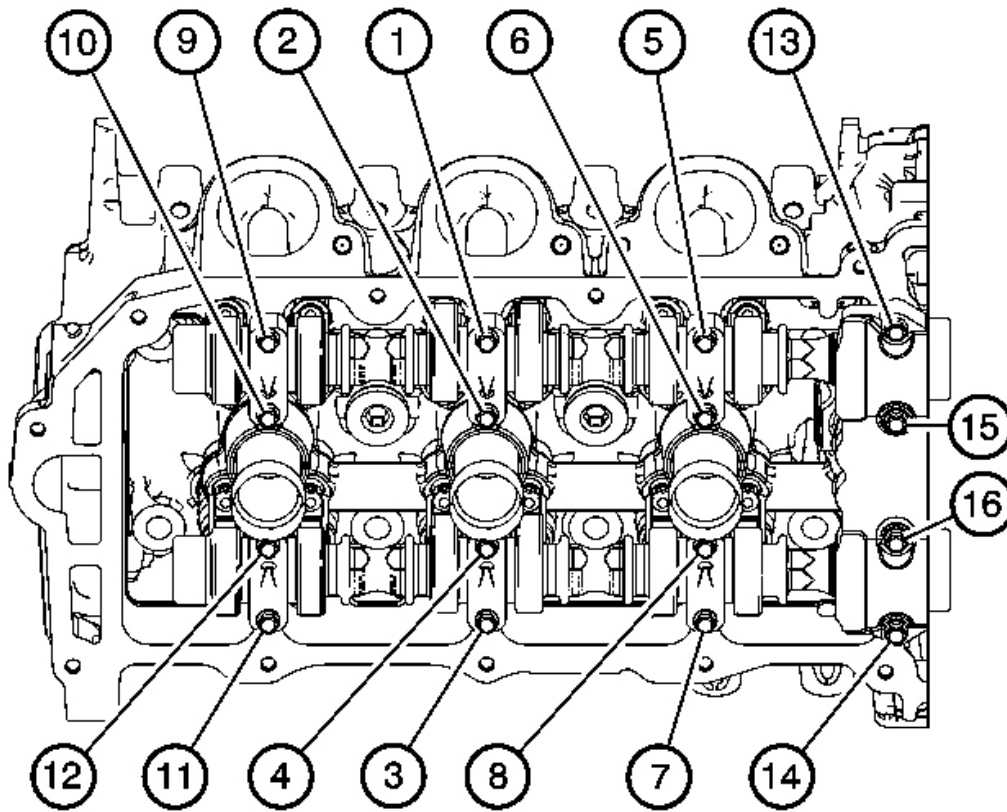


Fig. 384: Camshaft Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

10. Tighten the camshaft bearing cap bolts in the sequence shown and tighten to 10 N.m (89 lb in).
11. Loosen the center intake camshaft bearing cap bolts (1, 2) and the center exhaust camshaft bearing cap bolts (3, 4).
12. 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

Refer to Cylinder Head Assemble (LF1 or LFW).

CYLINDER HEAD INSTALLATION - LEFT SIDE (LF1 OR LFW)

SPECIAL TOOLS

EN 45059: Angle Meter

For equivalent regional tools, refer to Special Tools .

INSTALLATION

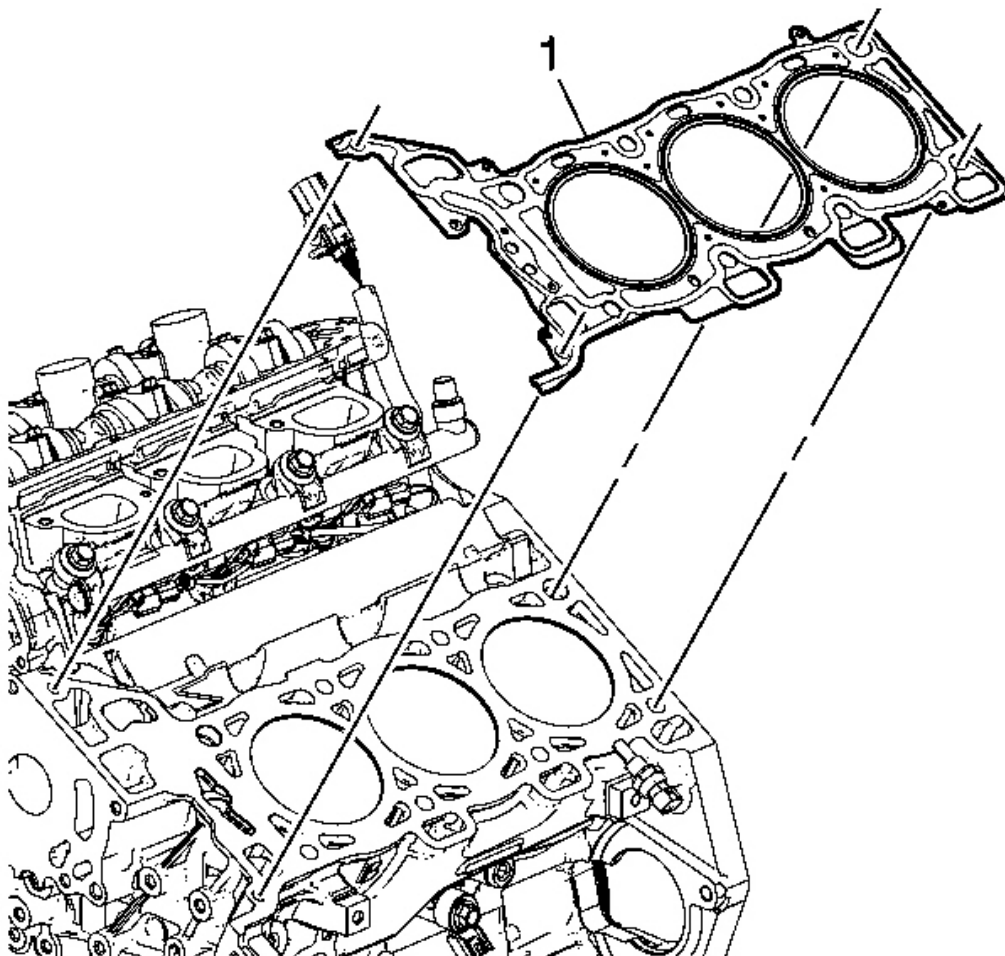


Fig. 385: Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. 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.

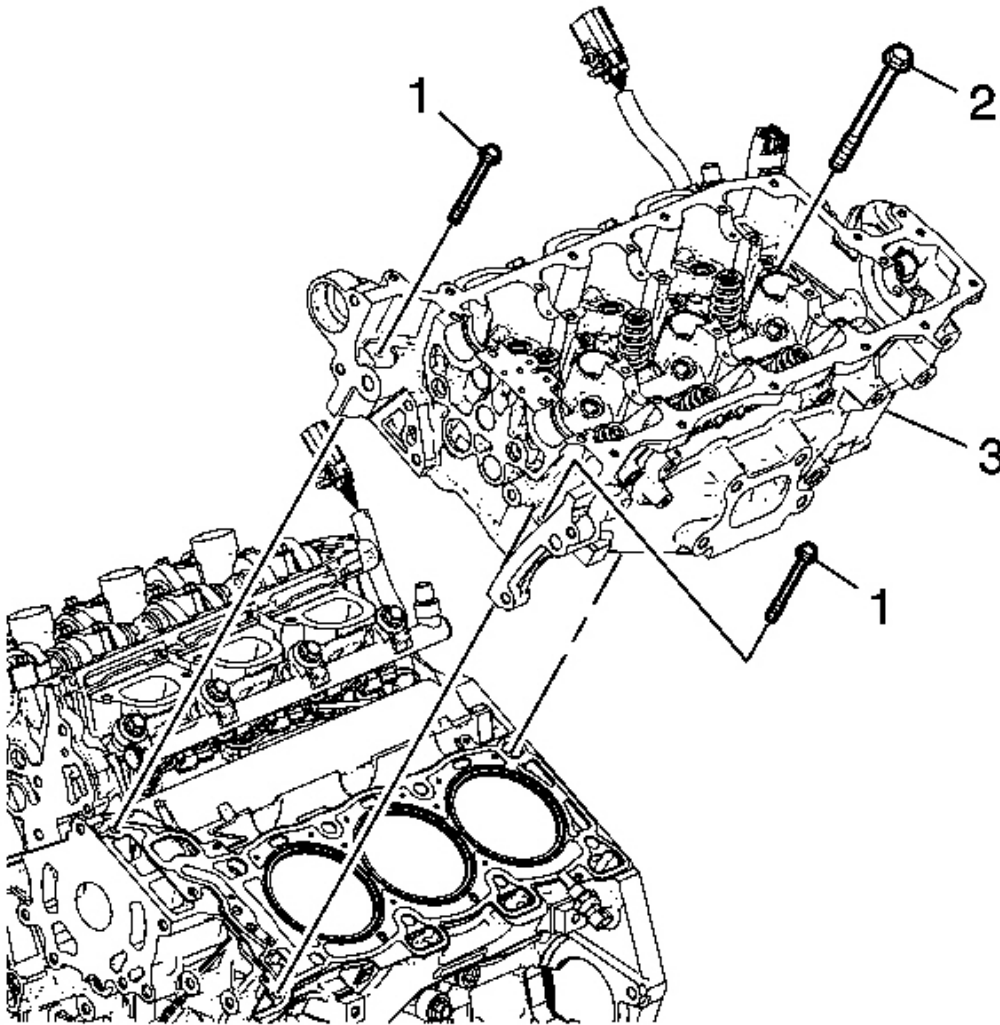


Fig. 386: Aligning Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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.

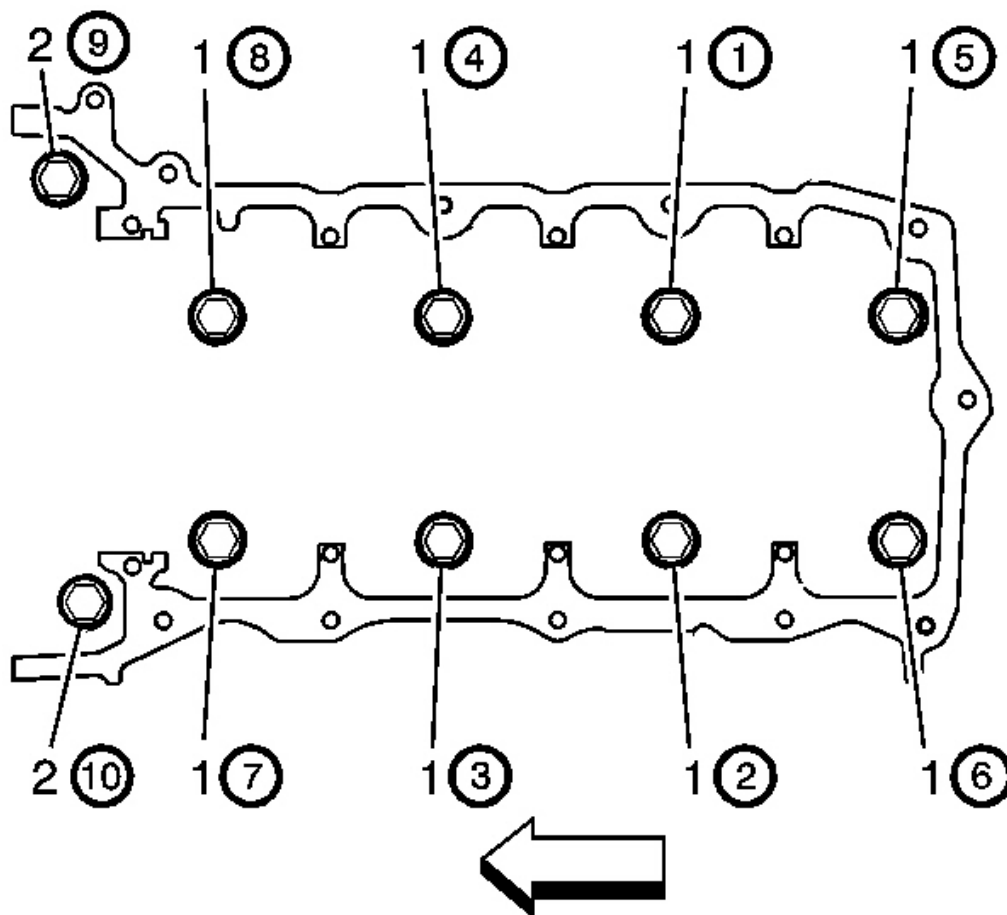


Fig. 387: Identifying M11 Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: DO NOT allow oil on the cylinder head bolt bosses.

NOTE: DO NOT reuse the old cylinder head bolts.

5. 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

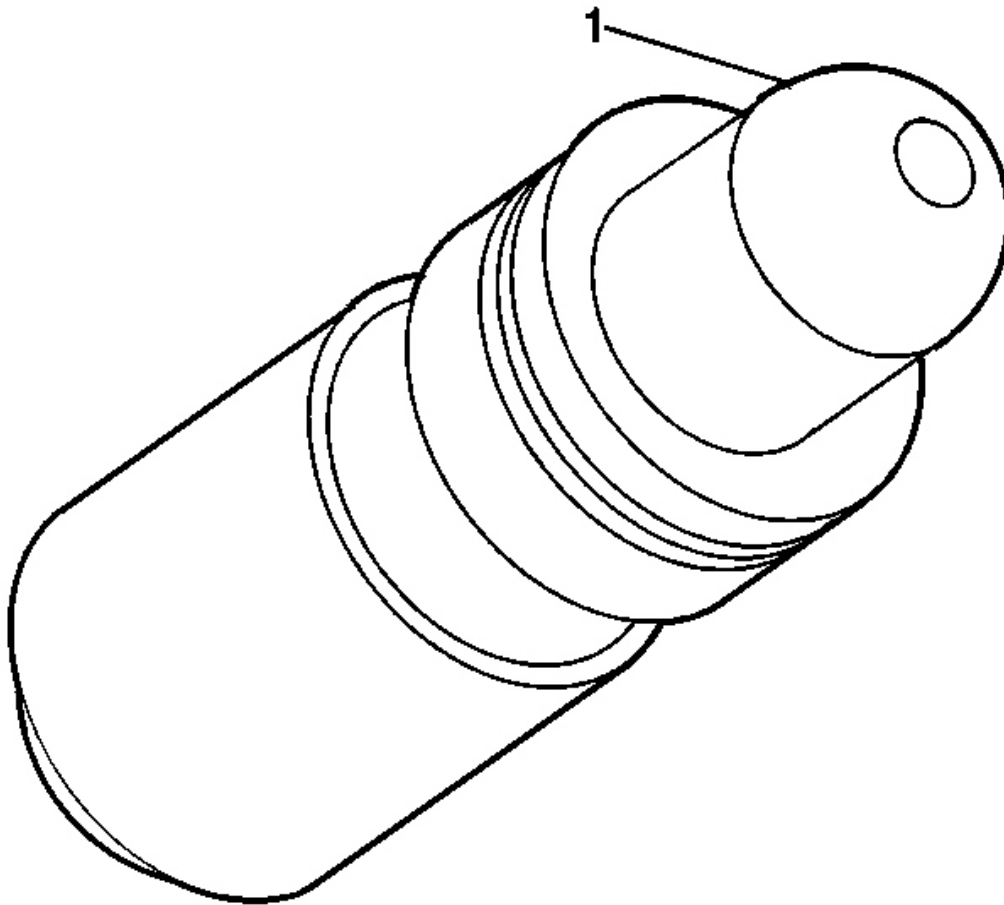


Fig. 388: View Of Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.

NOTE: Do not allow the stationary hydraulic lash adjuster (SHLA) to tip over, plunger down, after the oil fill.

1. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil GM P/N 12378006 or equivalent. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
2. Lubricate the SHLA bores in the cylinder head with clean engine oil GM P/N 12378006 or equivalent.

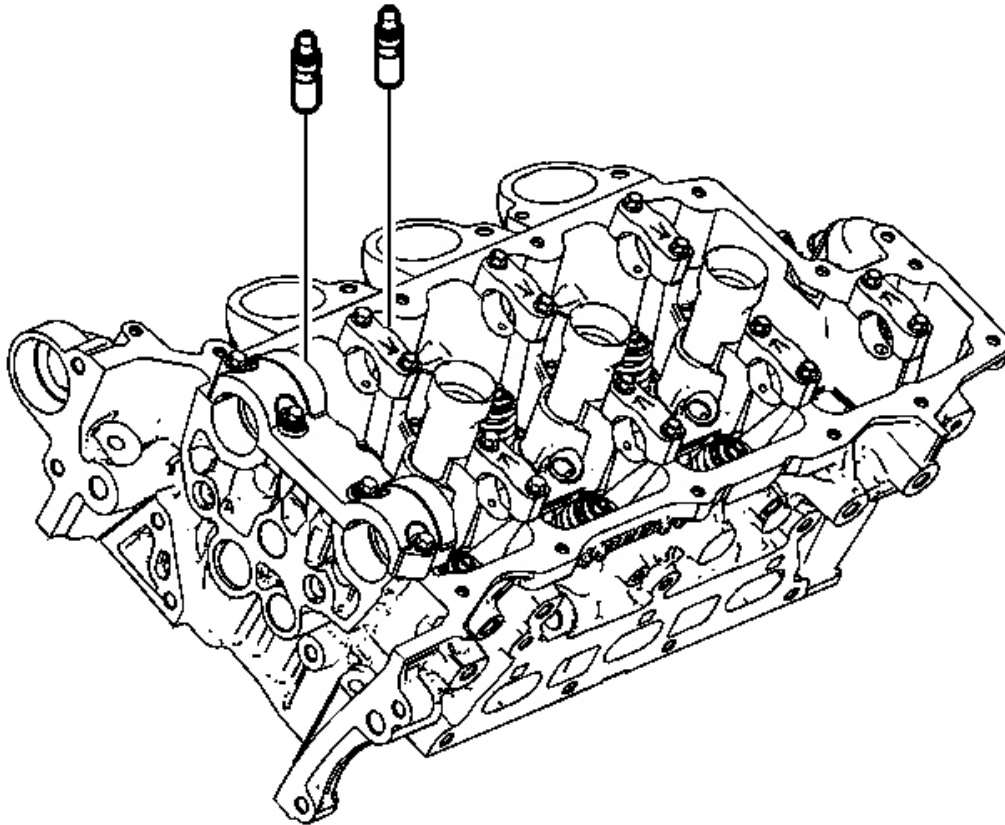


Fig. 389: Removing/Installing SHLAs In Cylinder Head
Courtesy of GENERAL MOTORS CORP.

3. Install the SHLAs in the cylinder head.
4. Apply a liberal amount of lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent to the SHLA pivot spheres.

VALVE ROCKER ARM INSTALLATION - LEFT SIDE

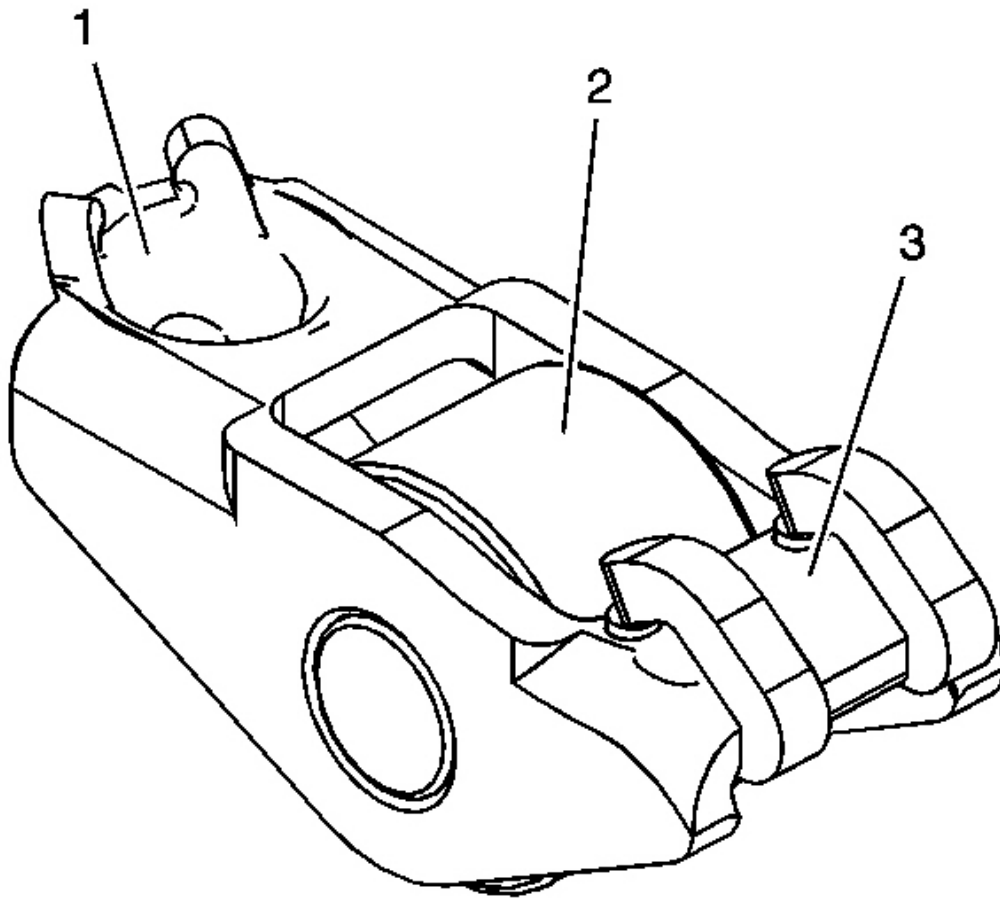


Fig. 390: Identifying Valve Rocker Arm Lubrication Areas
Courtesy of GENERAL MOTORS CORP.

1. Apply a liberal amount of lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent to the pivot pocket (1), roller (2) and valve slot (3) areas of the camshaft followers.

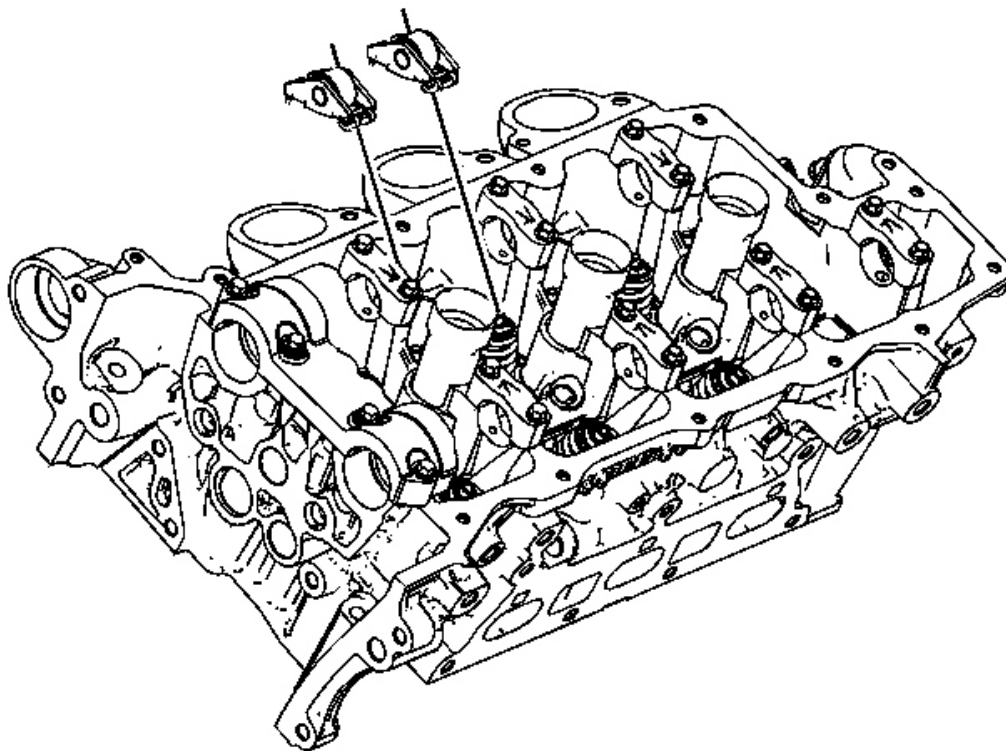


Fig. 391: View of Rocker Arm Assembly
Courtesy of GENERAL MOTORS CORP.

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.

2010 ENGINE

Engine Mechanical - 2.8L, 3.0L, 3.2L, or 3.6L - Repair Instructions - Off Vehicle - Equinox & Terrain

CAMSHAFT INSTALLATION - LEFT SIDE

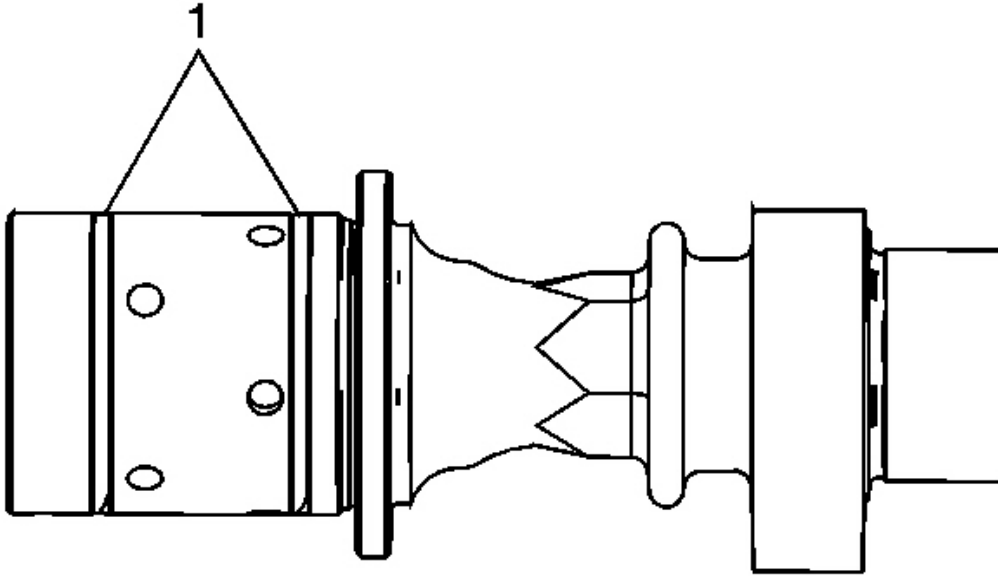


Fig. 1: Locating Camshaft Sealing Rings In Camshaft Grooves
Courtesy of GENERAL MOTORS CORP.

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.

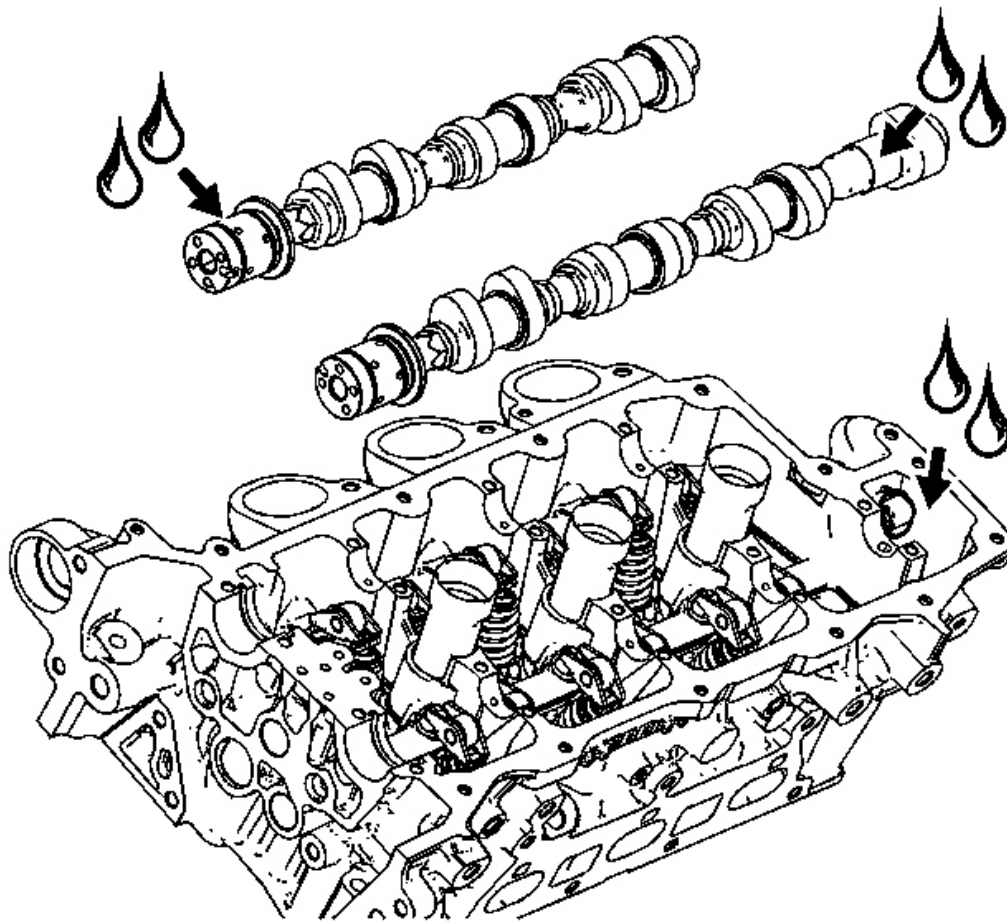


Fig. 2: Lubricating Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

2. Apply a liberal amount of lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent to the camshaft journals and the left cylinder head camshaft carriers.

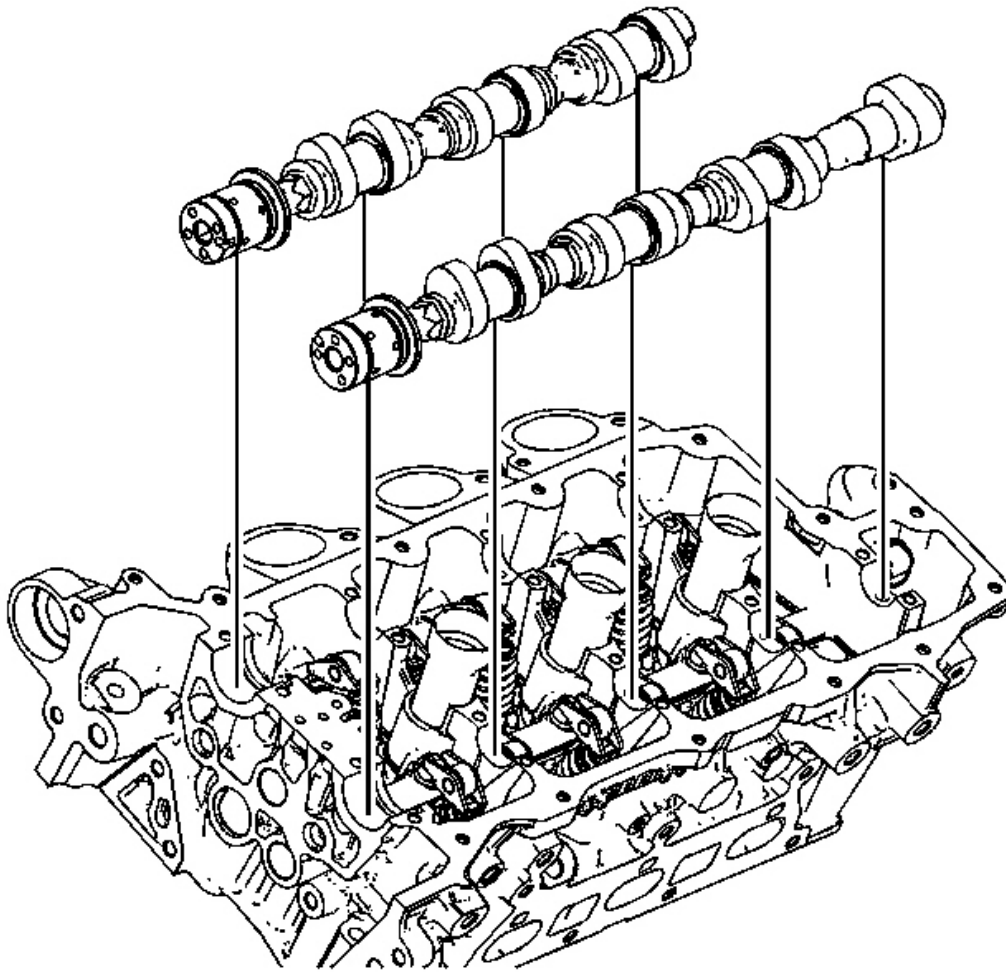


Fig. 3: Removing/Installing Camshafts
Courtesy of GENERAL MOTORS CORP.

3. Place the left intake and left exhaust camshafts in position in the left cylinder head.

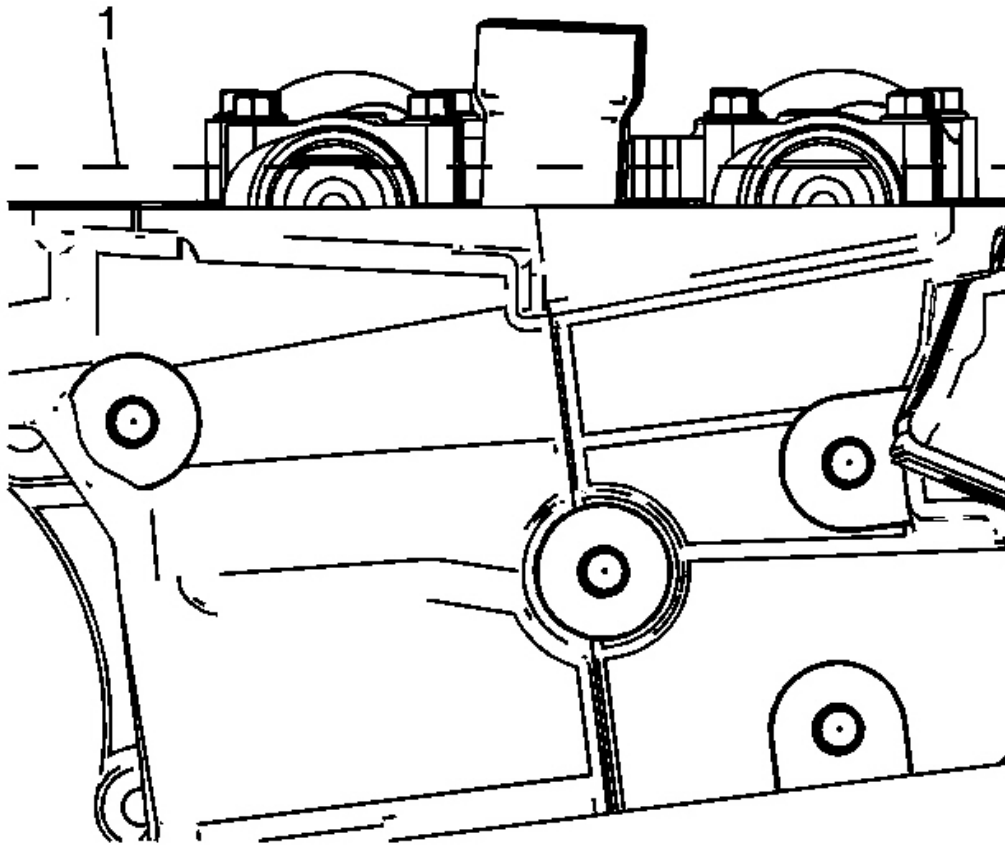


Fig. 4: Camshaft Flats Parallel With Camshaft Cover Rail
Courtesy of GENERAL MOTORS CORP.

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.

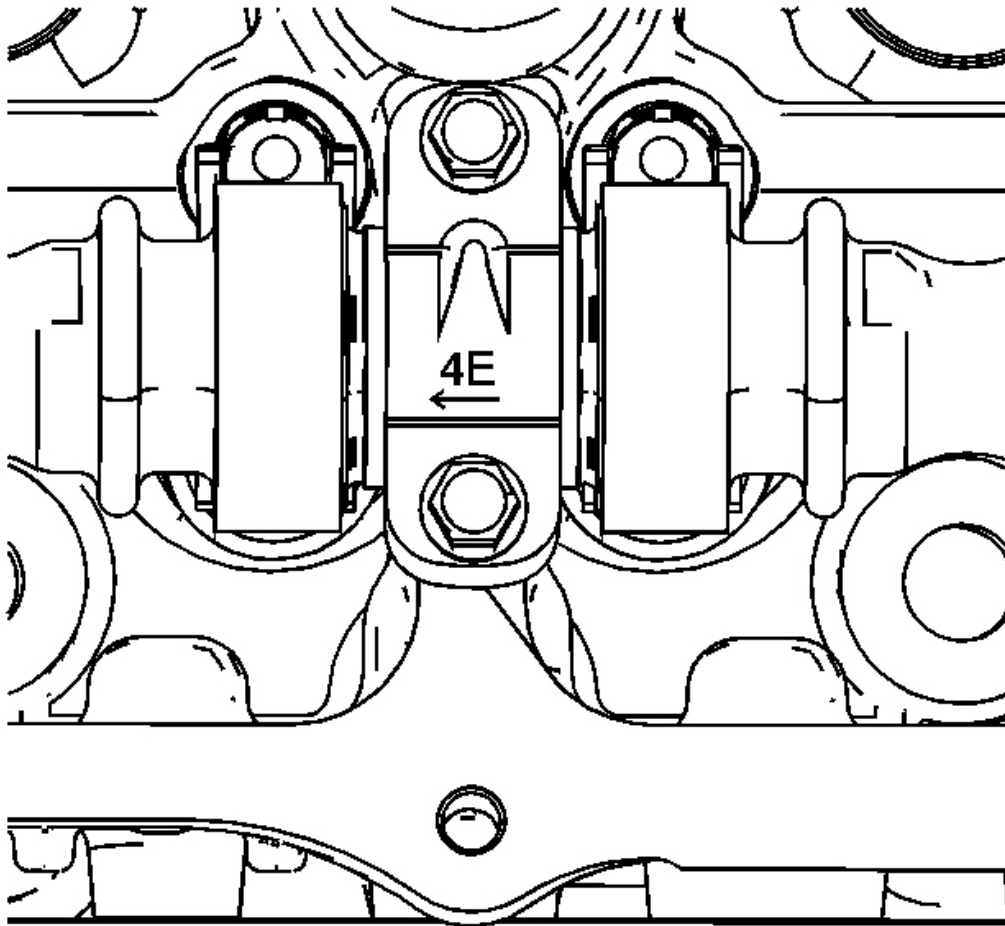


Fig. 5: Identifying Markings On Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. 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 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 GM P/N 12345501 (Canadian P/N 992704) or equivalent to the camshaft bearing caps.

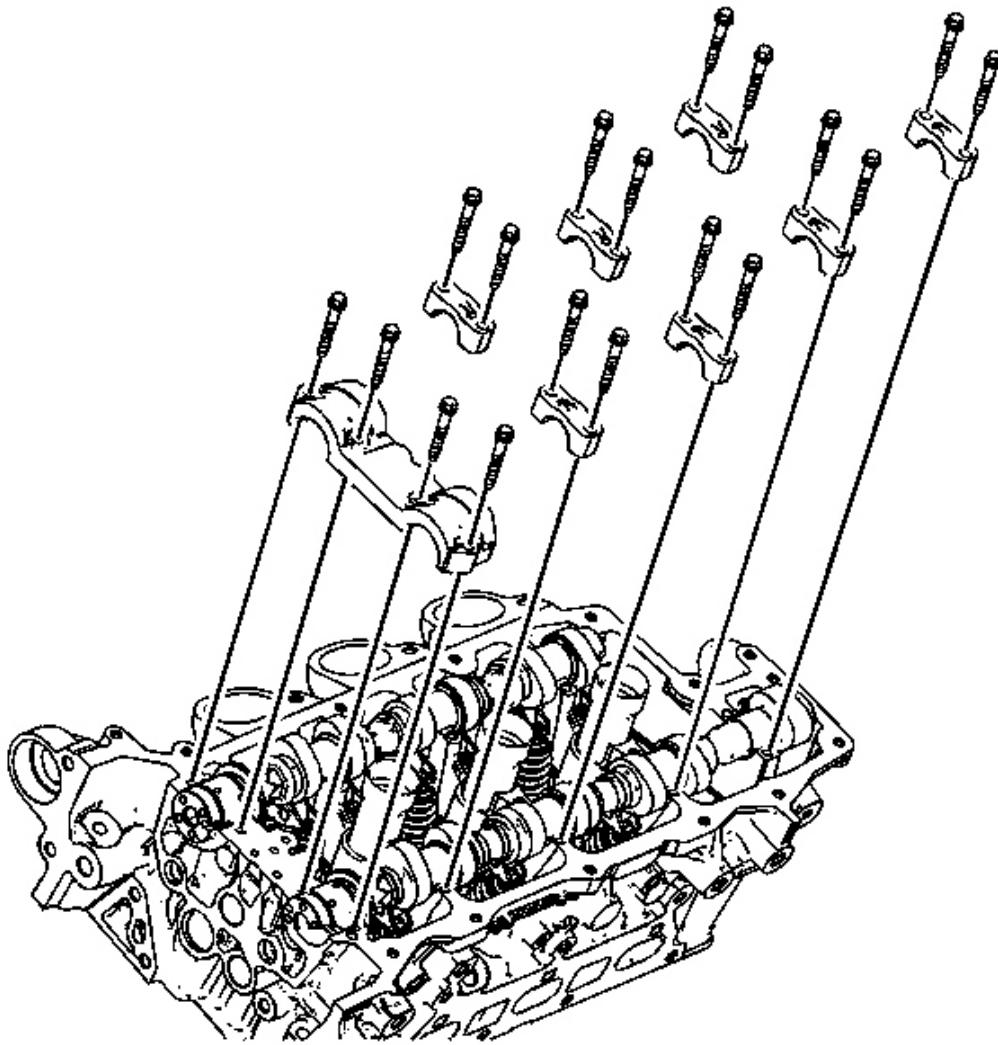


Fig. 6: Removing/Installing Camshaft Bearing Thrust Caps
Courtesy of GENERAL MOTORS CORP.

7. Install the camshaft bearing thrust cap in the first journal of the left cylinder head.
8. Install the remaining bearing caps with their orientation mark toward the center of the cylinder head.
9. Hand start all the camshaft bearing cap bolts.

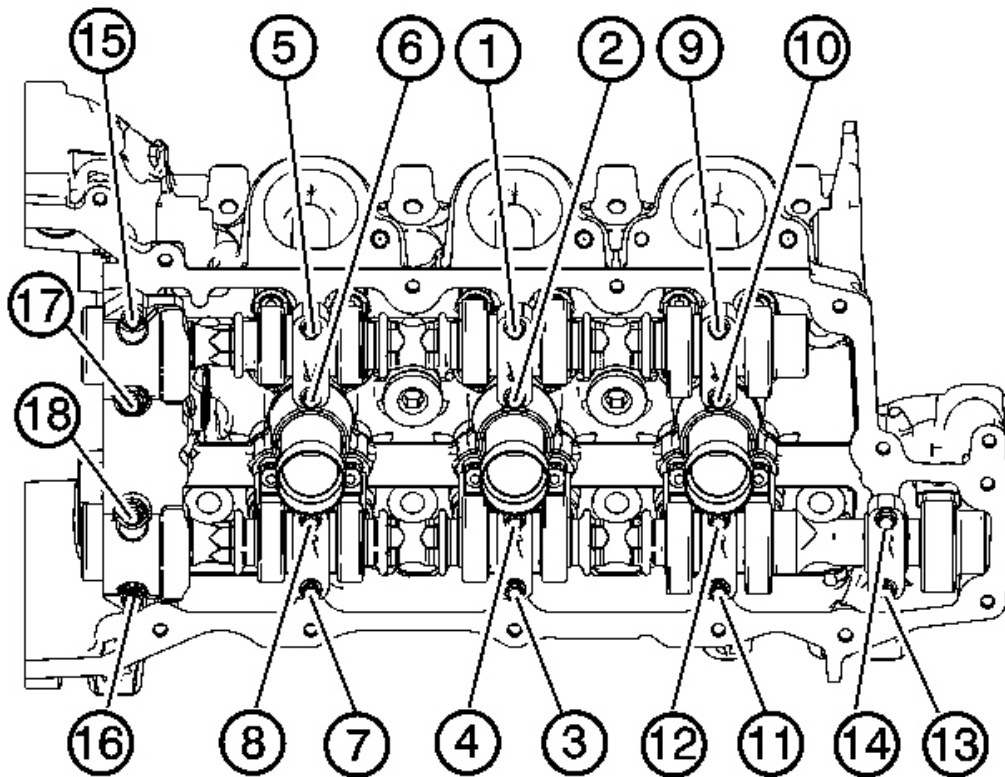


Fig. 7: Identifying Camshaft Bearing Cap Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

10. Tighten the camshaft bearing cap bolts in the sequence shown and tighten to 10 N.m (89 lb in).
11. Loosen the center intake camshaft bearing cap bolts 1, 2 and the center exhaust camshaft bearing cap bolts 3, 4.
12. 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 PUMP INSTALLATION (LF1 OR LFW)

SPECIAL TOOLS

EN 48896: HP Fuel Pump Installation Alignment Gauge

For equivalent regional tools, refer to **Special Tools** .

INSTALLATION

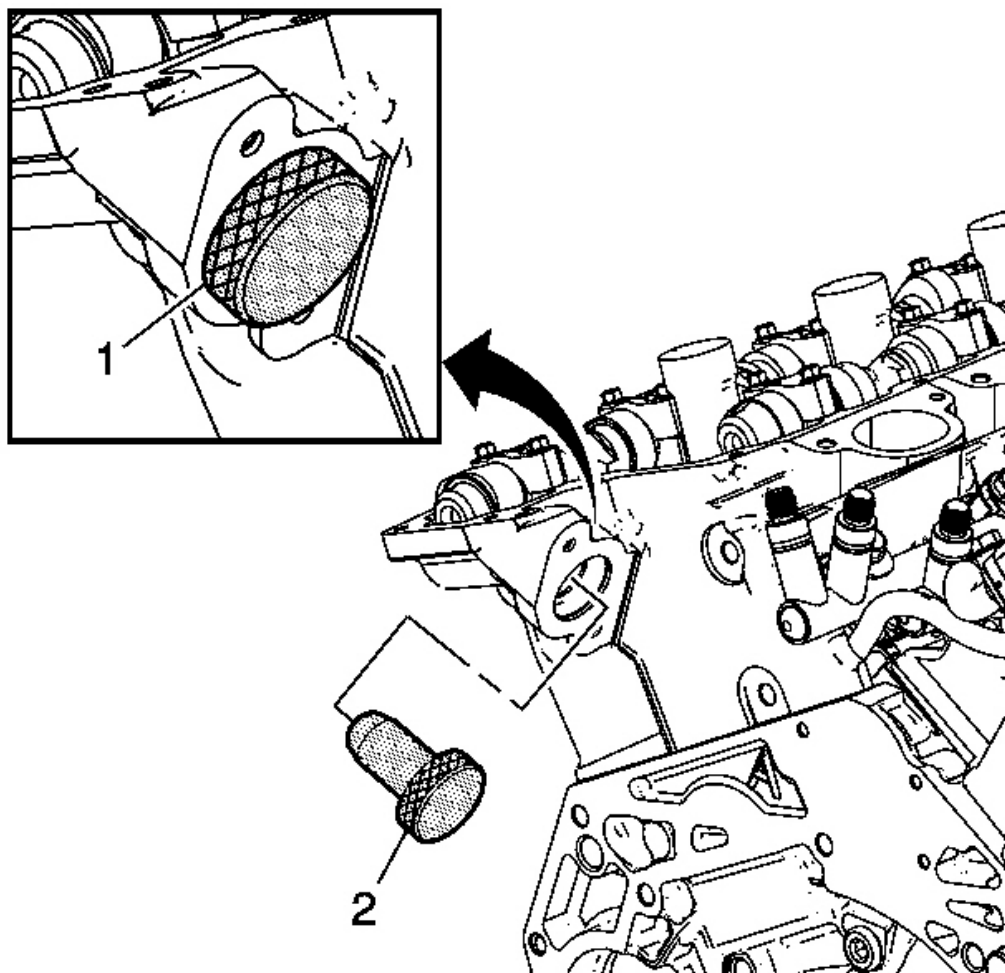


Fig. 8: Alignment Gauge

Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft must be in the base circle position before the high pressure fuel pump is installed.

1. 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).

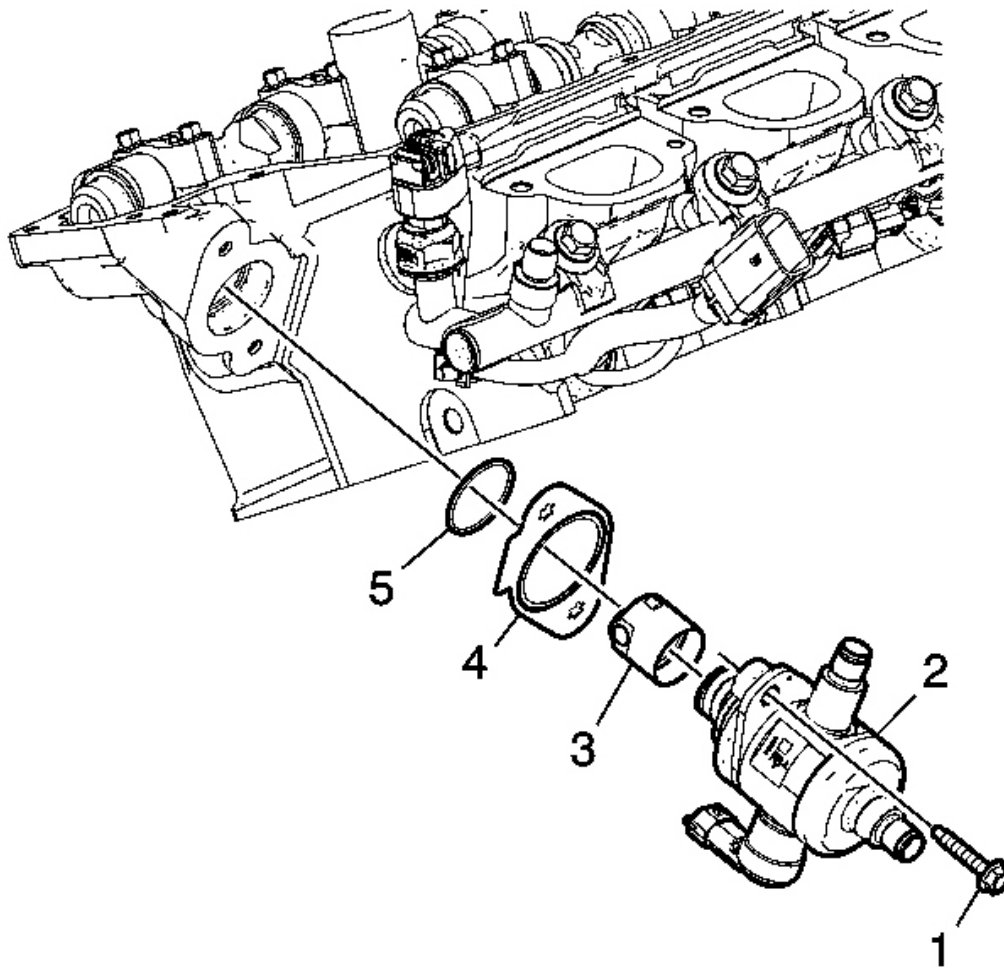


Fig. 9: High Pressure Fuel Pump Components
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the high pressure fuel pump cylinder head bore with 5W30 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 5W30 engine oil and install into the cylinder head bore.
4. Install a NEW high pressure fuel pressure fuel pump gasket (4).
5. Install a NEW high pressure fuel pump O-ring (5).

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.

8. Start and hand-tighten the NEW high pressure fuel pump bolts (1) evenly and tighten the high pressure fuel pump bolts to 15 N.m (11 lb ft).

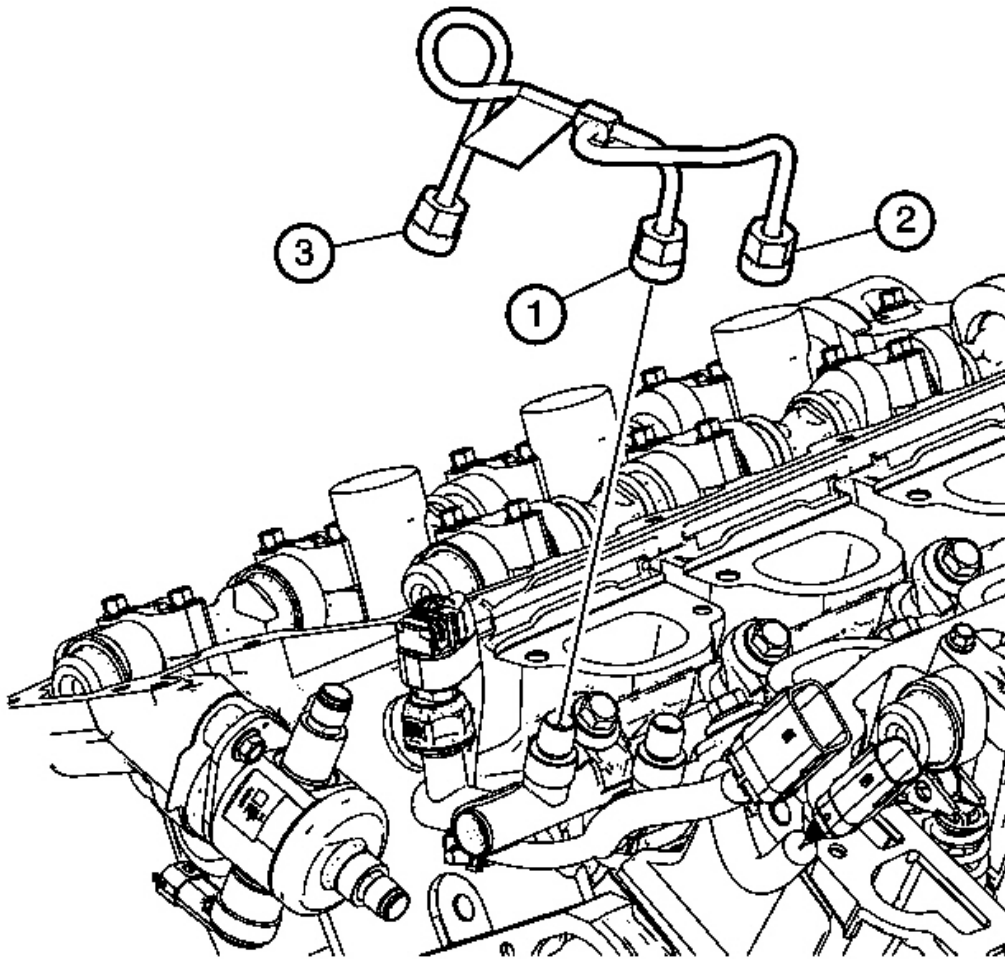


Fig. 10: Fuel Rail Crossover Pipe Components
Courtesy of GENERAL MOTORS CORP.

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.

9. 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 30 N.m (22 lb ft) in the following order: (1) Left Fuel Rail, (2) Right Fuel Rail, then (3) Fuel Pump.

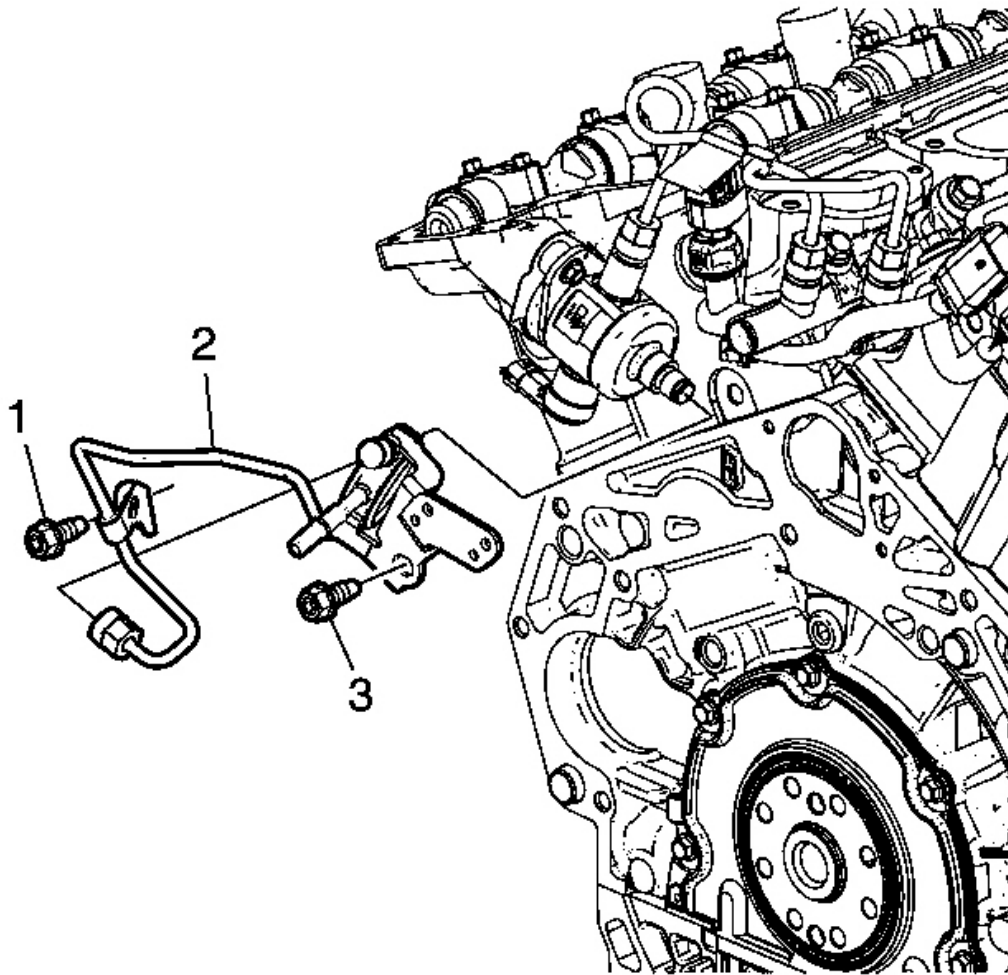


Fig. 11: Fuel Feed Pipe Components
Courtesy of GENERAL MOTORS CORP.

11. Install the NEW fuel feed pipe (2) by installing the fuel line nut to the fuel pump finger-tight.
12. Install the right fuel feed pipe bolt finger tight (3).
13. Install the left fuel feed pipe bolt finger tight (1).
14. Tighten the left fuel feed pipe bolt (1) to 10 N.m (89 lb in).
15. Tighten the right fuel feed pipe bolt (3) to 10 N.m (89 lb in).
16. Tighten the fuel feed pipe fitting nut to 30 N.m (22 lb ft).
17. Install the fuel rail wiring connectors to the fuel feed pipe bracket.

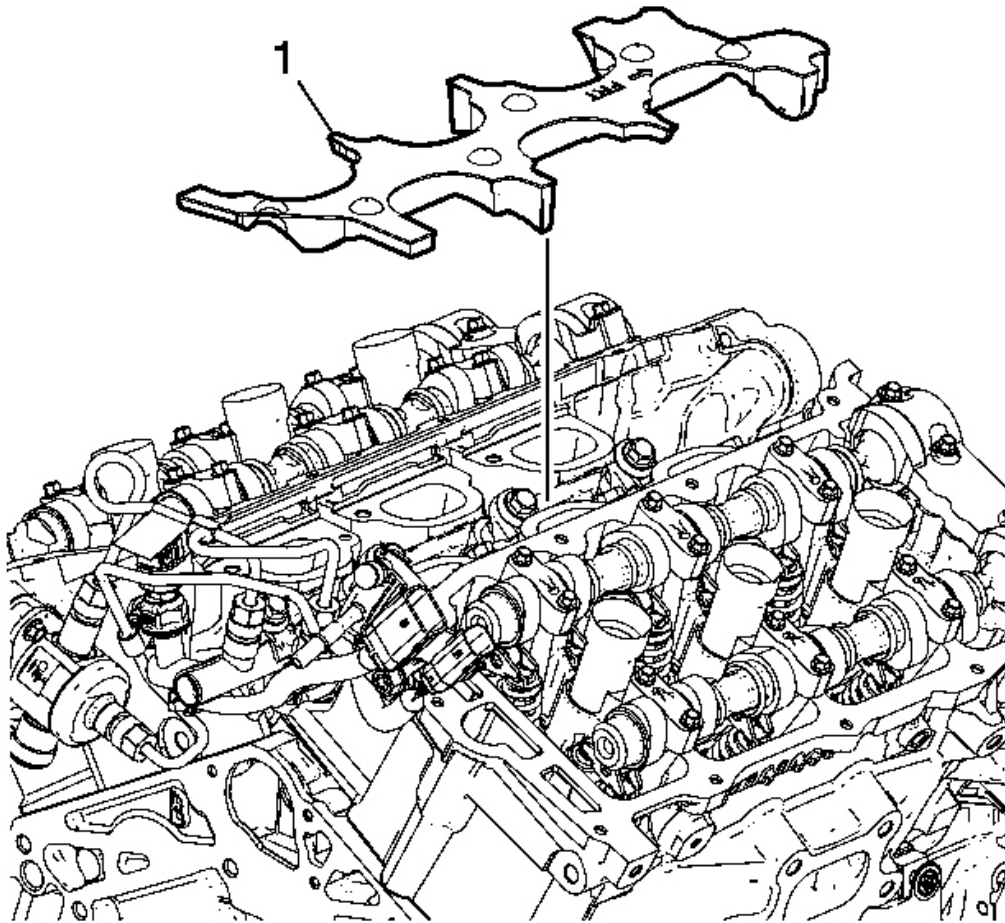


Fig. 12: Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS CORP.

18. Install the fuel rail noise shield (1).

CAMSHAFT POSITION ACTUATOR INSTALLATION - RIGHT SIDE INTAKE

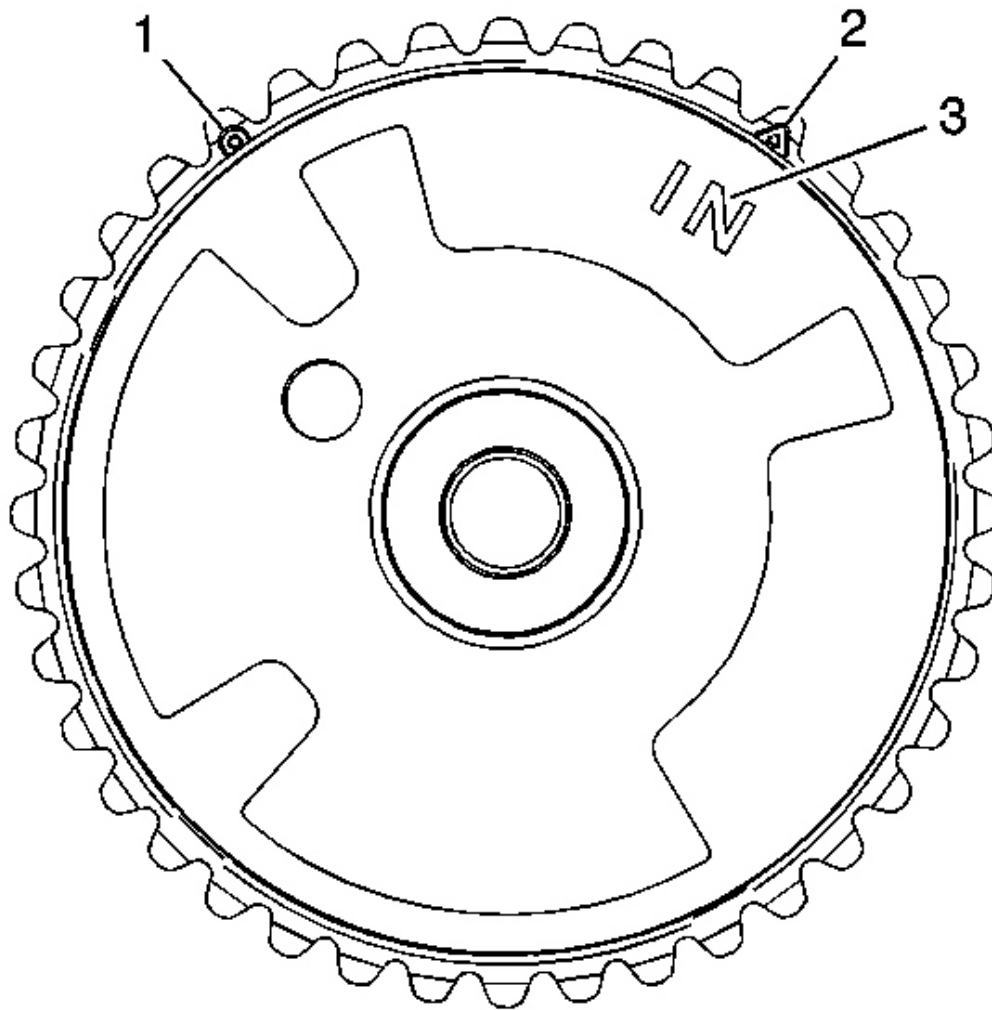


Fig. 13: View Of Camshaft Position Actuator Markings
Courtesy of GENERAL MOTORS CORP.

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.

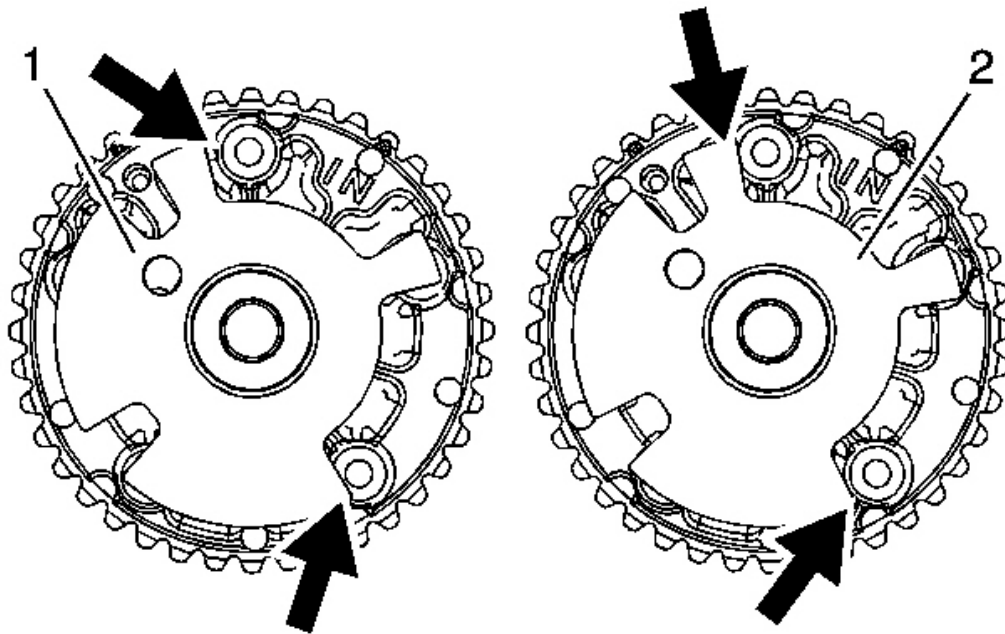


Fig. 14: View Of Right Intake Camshaft Position Actuator & Left Intake Camshaft Position Actuator

Courtesy of GENERAL MOTORS CORP.

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.

2. 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).

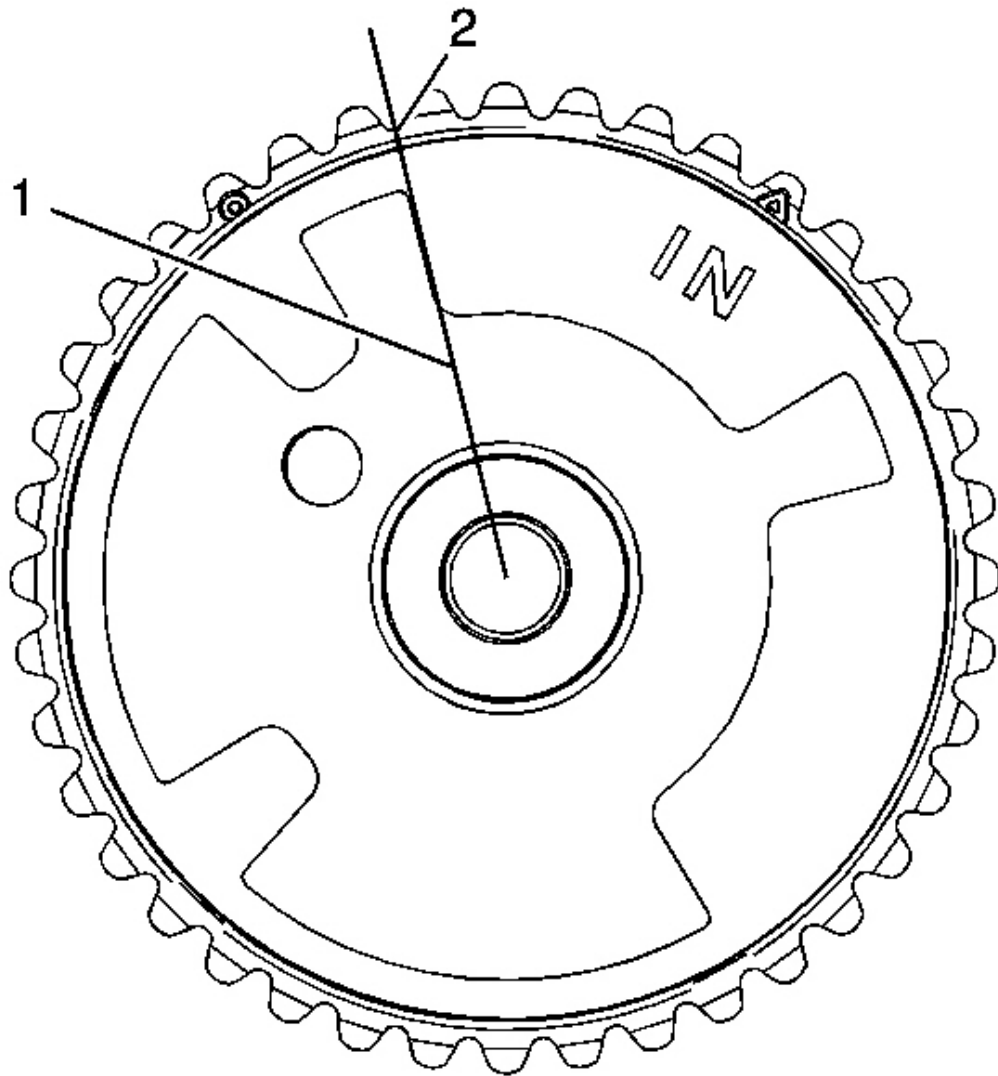


Fig. 15: View Of Reluctor Wheel & Valley
Courtesy of GENERAL MOTORS CORP.

3. On the right intake camshaft actuator the edge of the reluctor wheel (1) lines up with the valley (2) of the sprocket tooth.

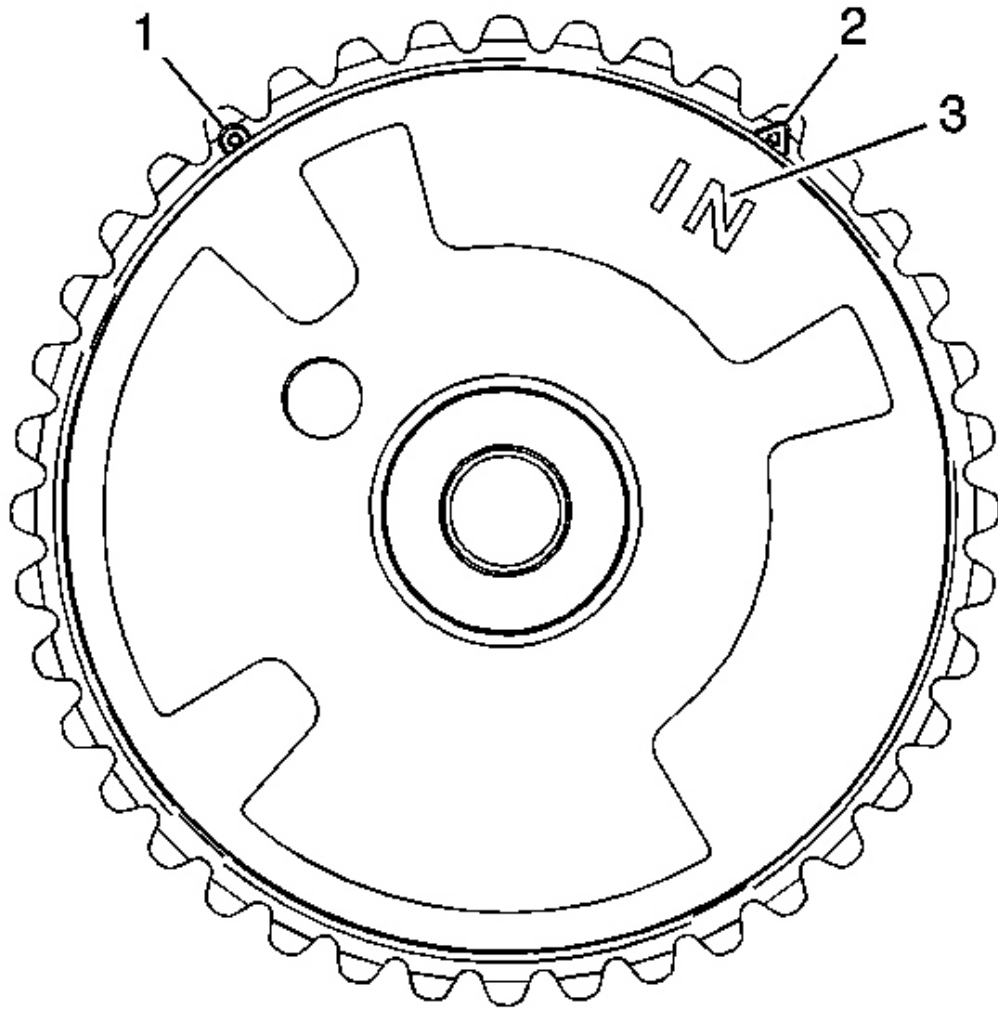


Fig. 16: View Of Camshaft Position Actuator Markings
Courtesy of GENERAL MOTORS CORP.

4. 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.

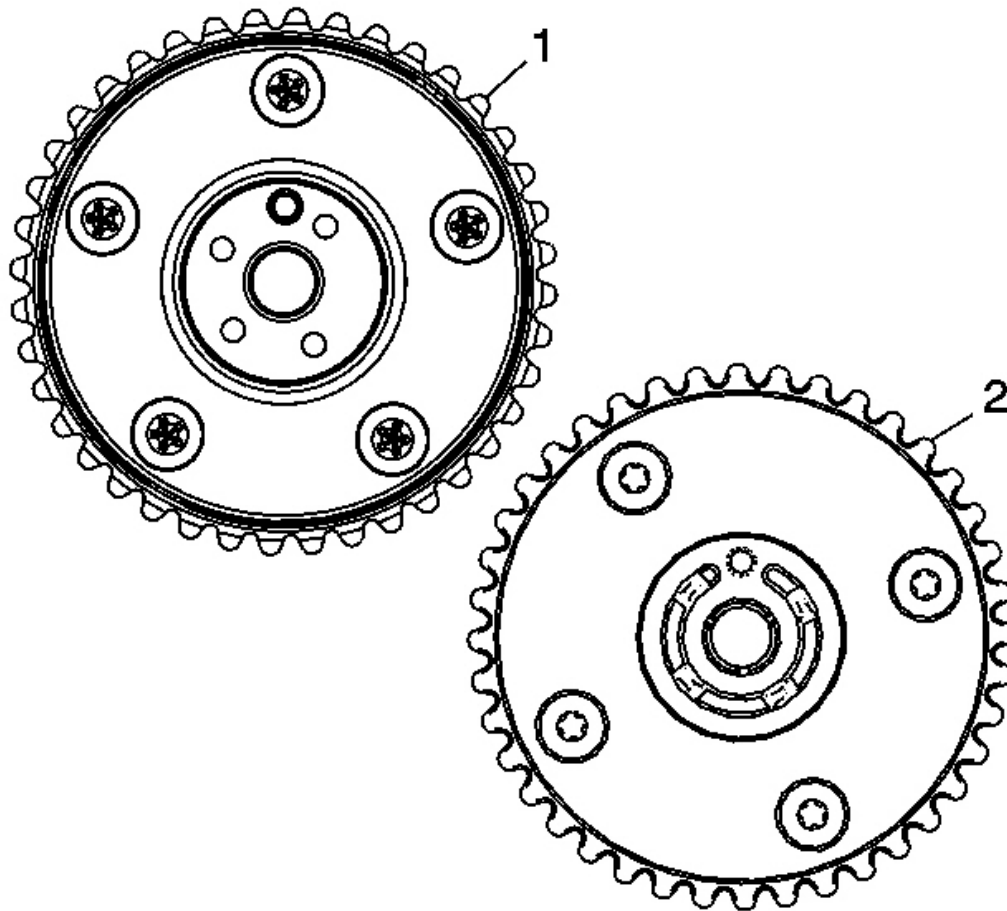


Fig. 17: Identifying Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft position actuator will vary depending on application.

NOTE: Camshaft thrust washers must be installed on all 2010 applications when servicing the camshaft position actuators. Do not install washers on 2009 applications if they are not already present.

6. Ensure the proper camshaft thrust washer is used. Use a 1.6 mm (0.063 in) thrust washer on applications that have 5 attaching screws on the back side of the camshaft position actuator (1). Use a 1.1 mm (0.043 in) thick thrust washer with yellow speckles on applications that have 4 attaching screws on the back side of the camshaft position actuator (2).

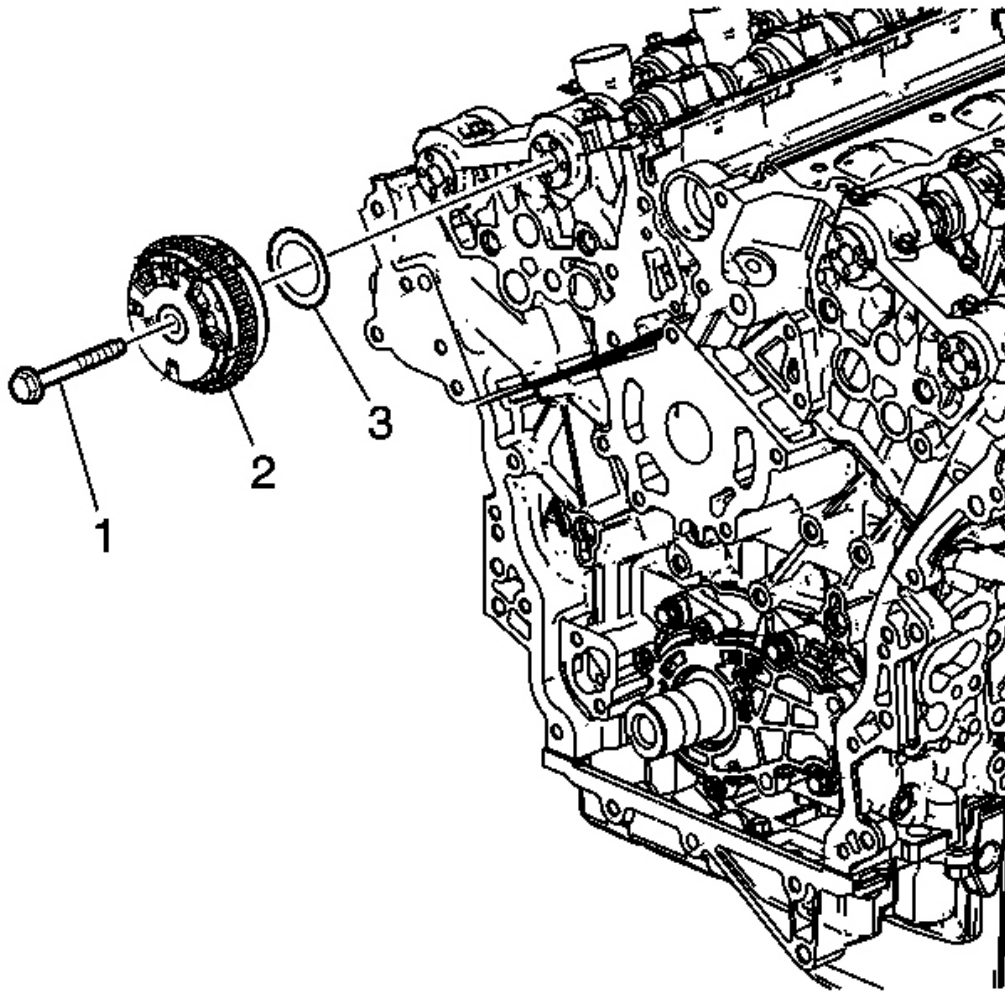


Fig. 18: View Of Intake Camshaft Position Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the thrust washer if applicable (3).
8. Install the right intake camshaft position actuator (2).

CAUTION: Refer to Fastener Caution .

9. Install the camshaft position actuator bolt (1) and tighten to 58 N.m (43 lb ft).

CAMSHAFT POSITION ACTUATOR INSTALLATION - RIGHT SIDE EXHAUST

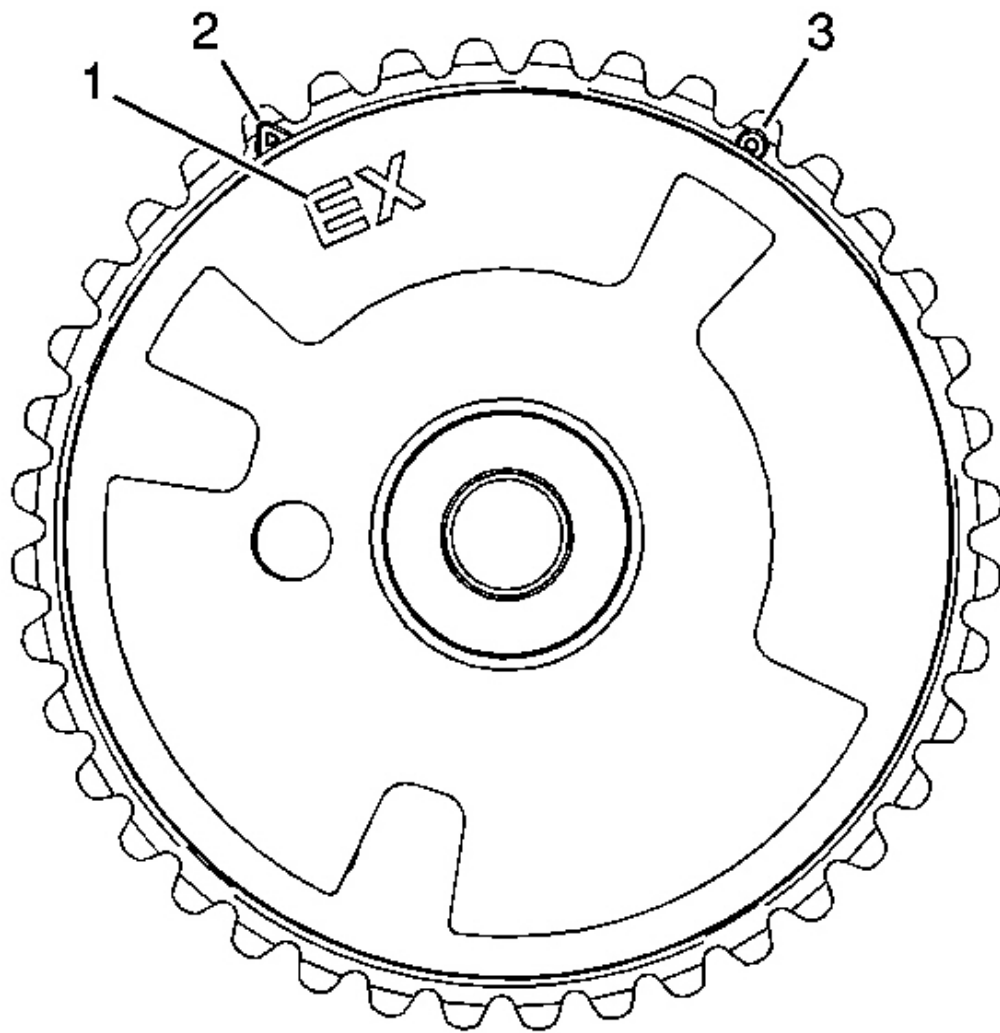


Fig. 19: View Of EX Marking, Triangle & Circle Marking
Courtesy of GENERAL MOTORS CORP.

1. 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.

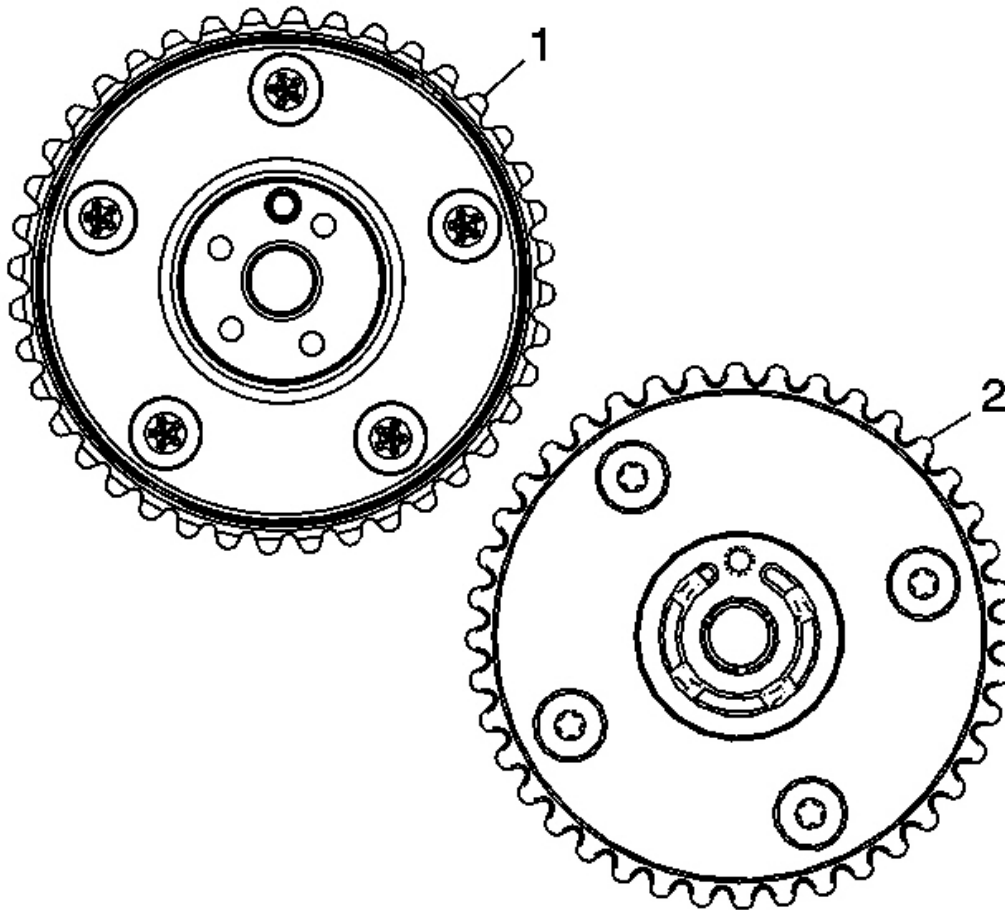


Fig. 20: Identifying Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft position actuator will vary depending on application.

NOTE: Camshaft thrust washers must be installed on all 2010 applications when servicing the camshaft position actuators. Do not install washers on 2009 applications if they are not already present.

4. Ensure the proper camshaft thrust washer is used. Use a 1.6 mm (0.063 in) thrust washer on applications

that have 5 attaching screws on the back side of the camshaft position actuator (1). Use a 1.1 mm (0.043 in) thick thrust washer with yellow speckles on applications that have 4 attaching screws on the back side of the camshaft position actuator (2).

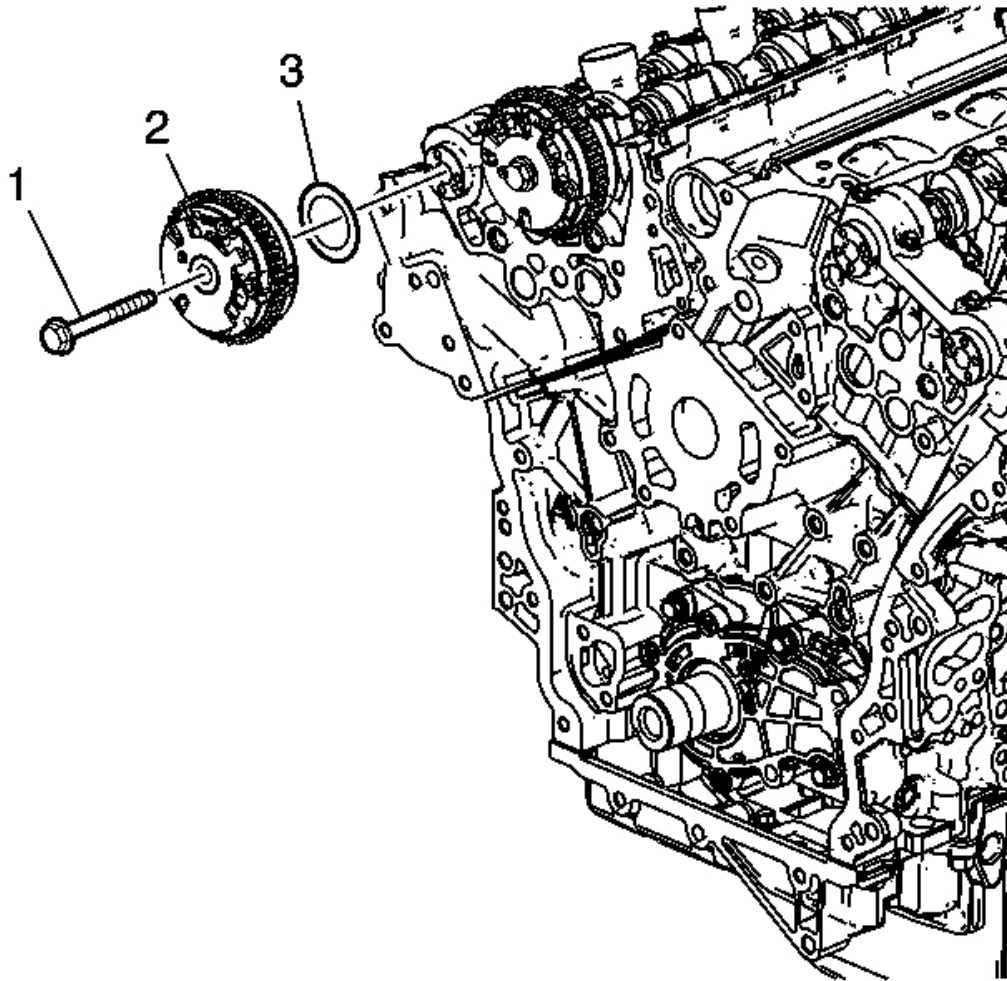


Fig. 21: Identifying Camshaft Position Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the thrust washer if applicable (3).
6. Install the right exhaust camshaft position actuator (2).

CAUTION: Refer to Fastener Caution .

7. Install the camshaft position actuator bolt (1) and tighten to 58 N.m (43 lb ft).

CAMSHAFT POSITION ACTUATOR INSTALLATION - LEFT SIDE INTAKE

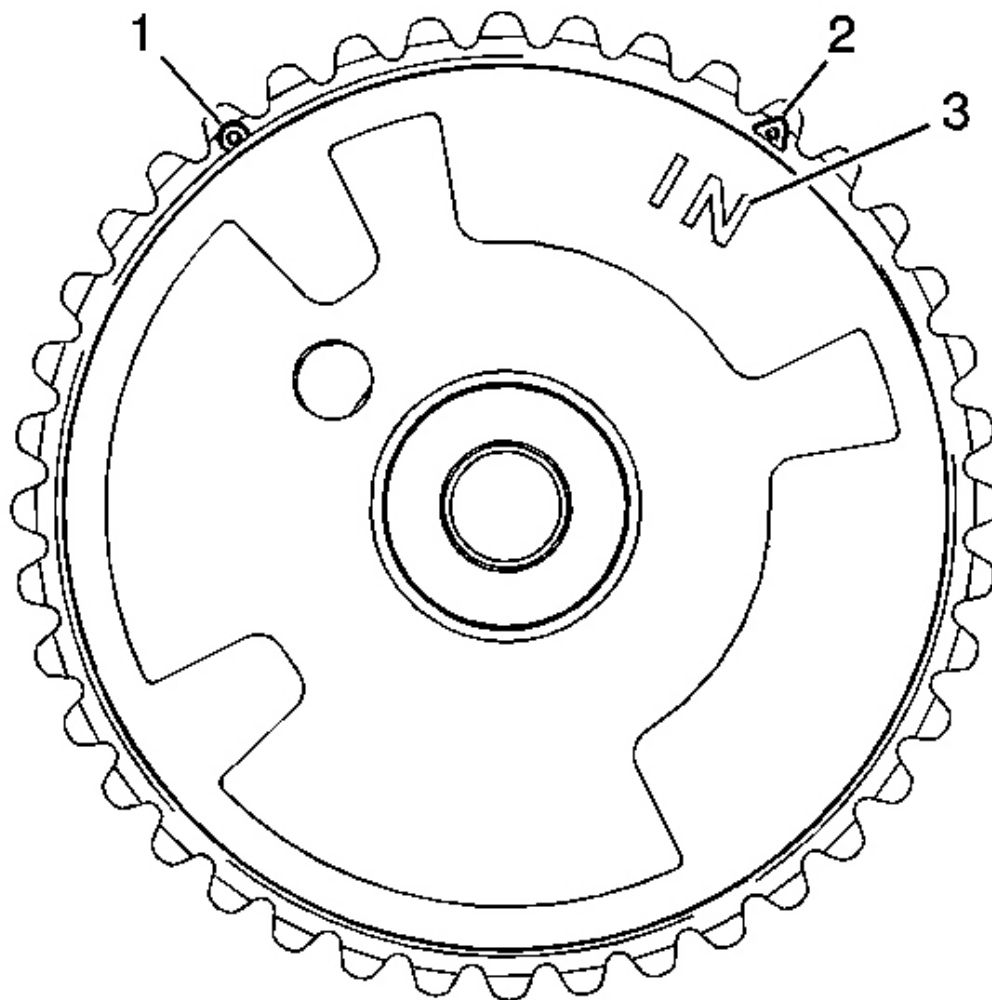


Fig. 22: Identifying Camshaft Position Actuator Marks
Courtesy of GENERAL MOTORS CORP.

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.

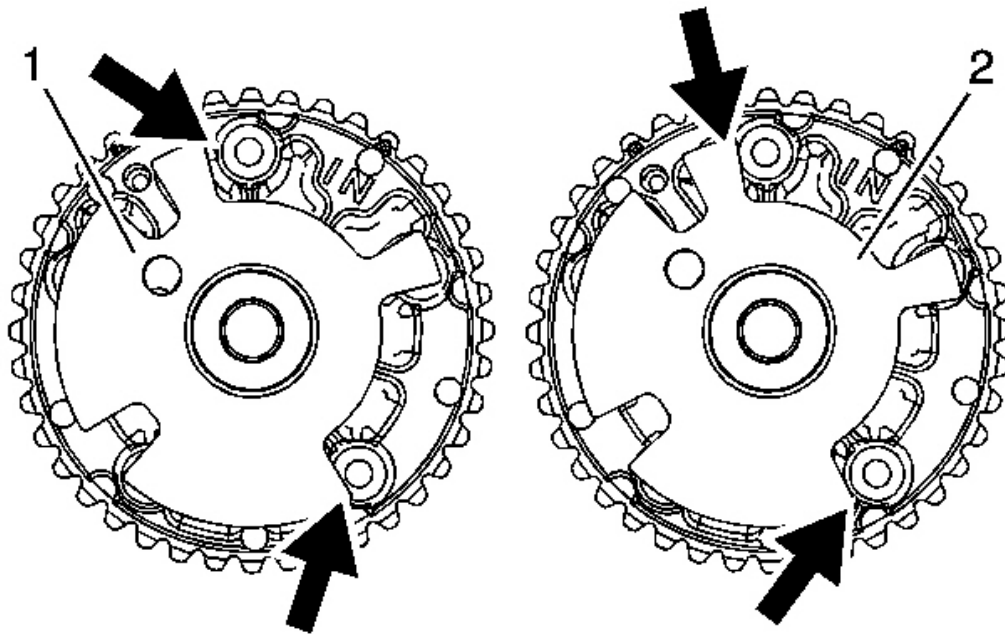


Fig. 23: View Of Right Intake Camshaft Position Actuator & Left Intake Camshaft Position Actuator

Courtesy of GENERAL MOTORS CORP.

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.

2. 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).

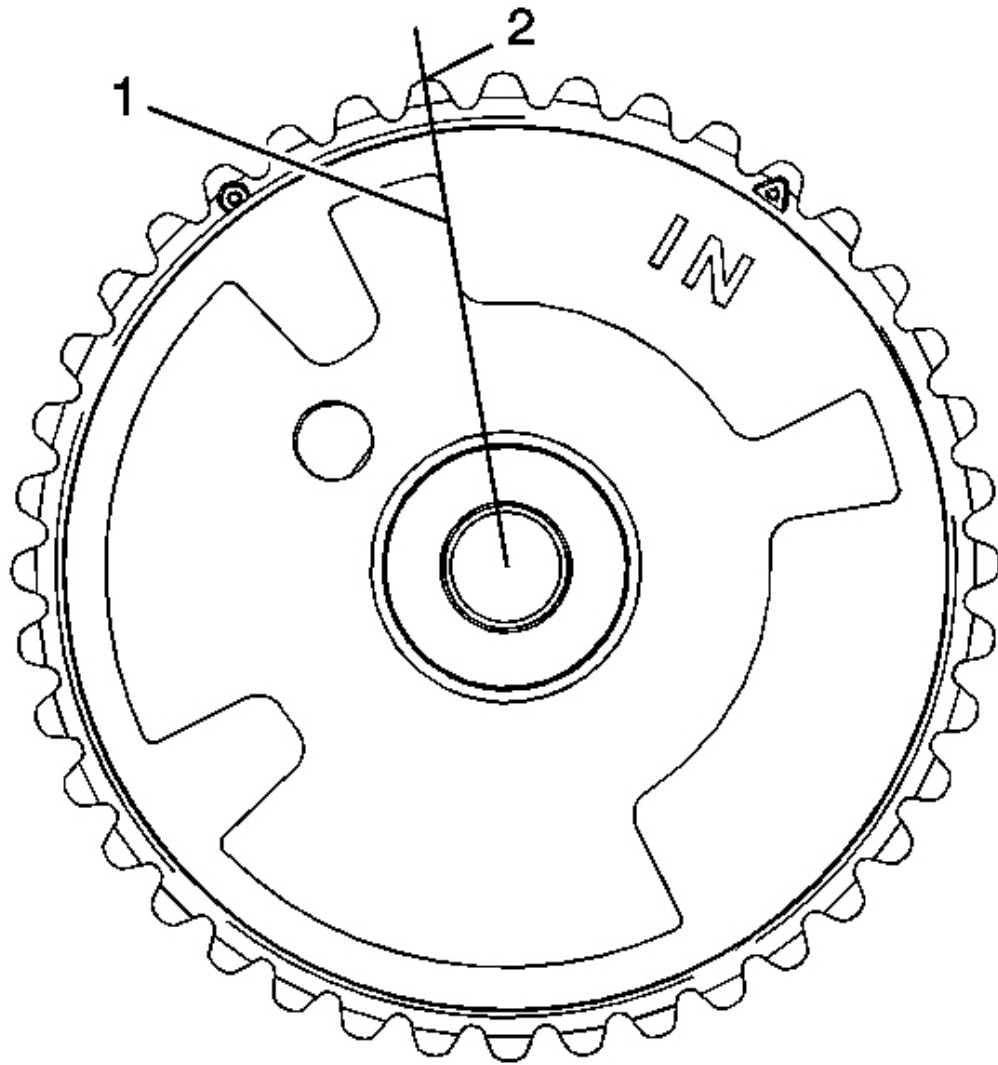


Fig. 24: Aligning Reluctor Wheel With Peak
Courtesy of GENERAL MOTORS CORP.

3. On the left intake camshaft actuator the edge of the reluctor wheel (1) lines up with the peak (2) of the sprocket tooth.

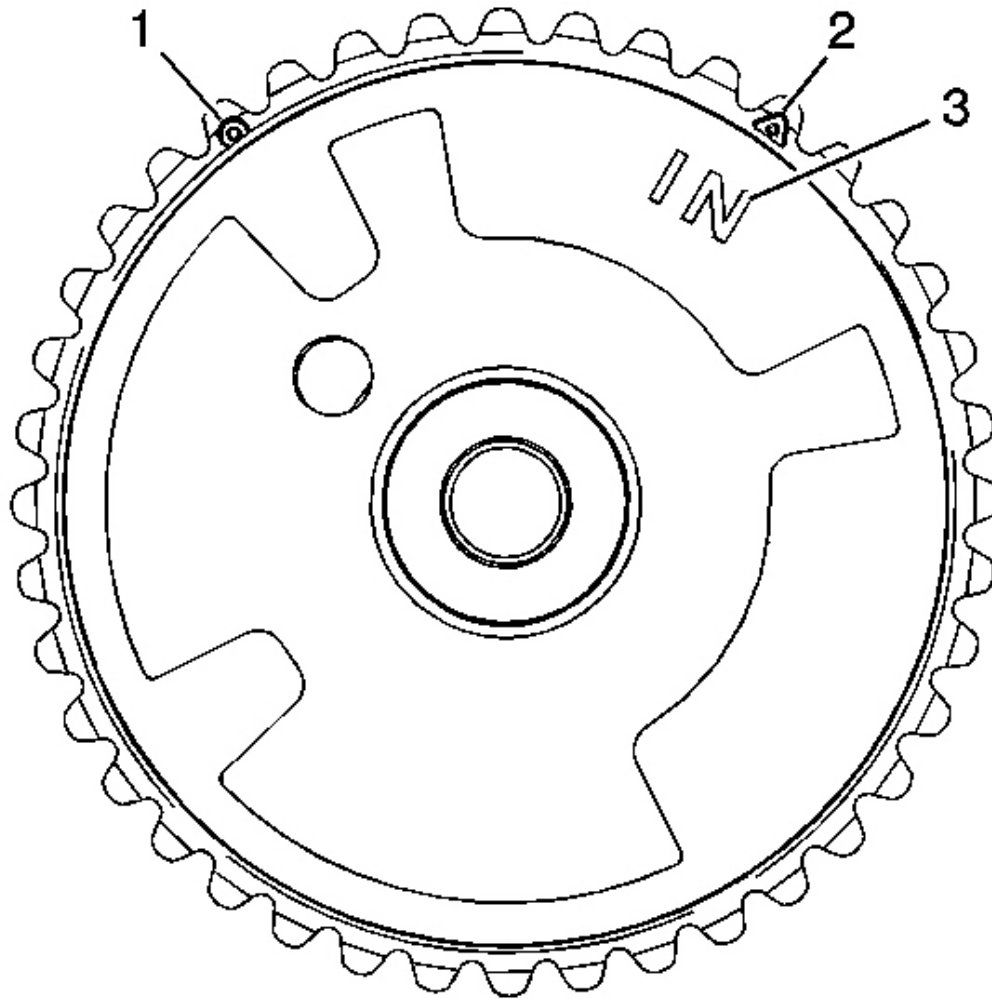


Fig. 25: Identifying Camshaft Position Actuator Marks
Courtesy of GENERAL MOTORS CORP.

4. 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.

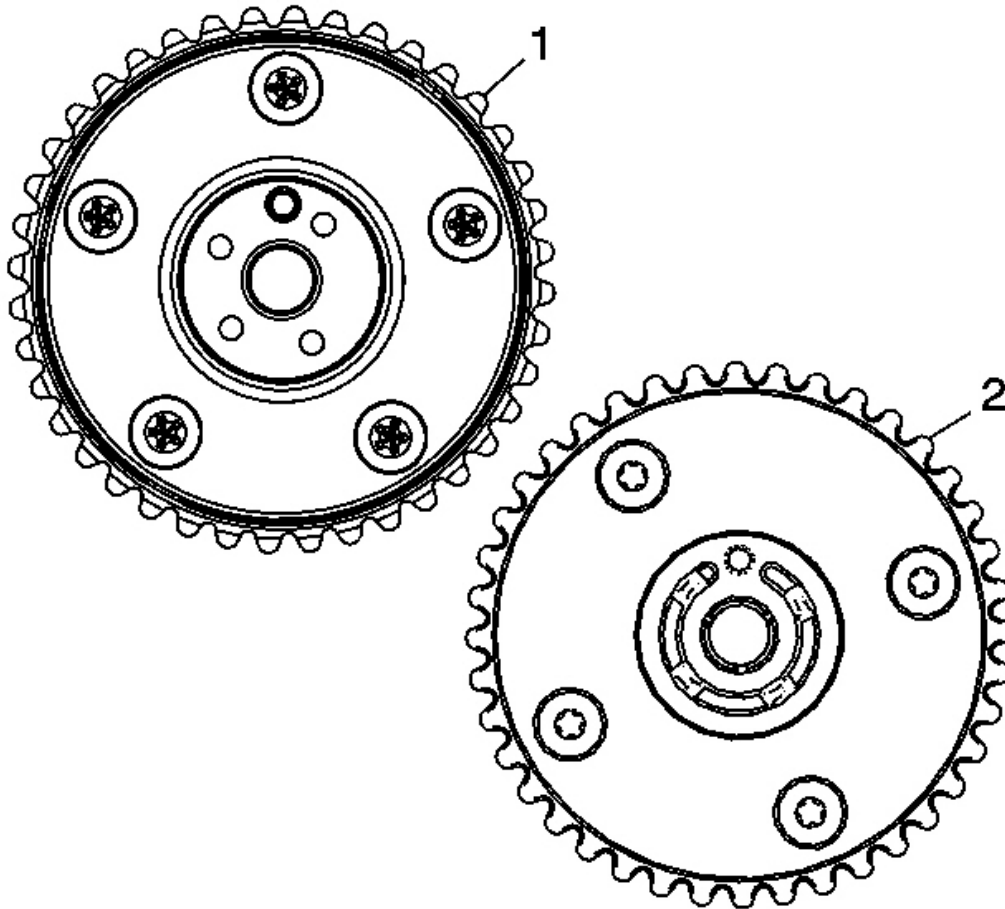


Fig. 26: Identifying Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft position actuator will vary depending on application.

NOTE: Camshaft thrust washers must be installed on all 2010 applications when servicing the camshaft position actuators. Do not install washers on 2009 applications if they are not already present.

6. Ensure the proper camshaft thrust washer is used. Use a 1.6 mm (0.063 in) thrust washer on applications that have 5 attaching screws on the back side of the camshaft position actuator (1). Use a 1.1 mm (0.043 in) thick thrust washer with yellow speckles on applications that have 4 attaching screws on the back side of the camshaft position actuator (2).

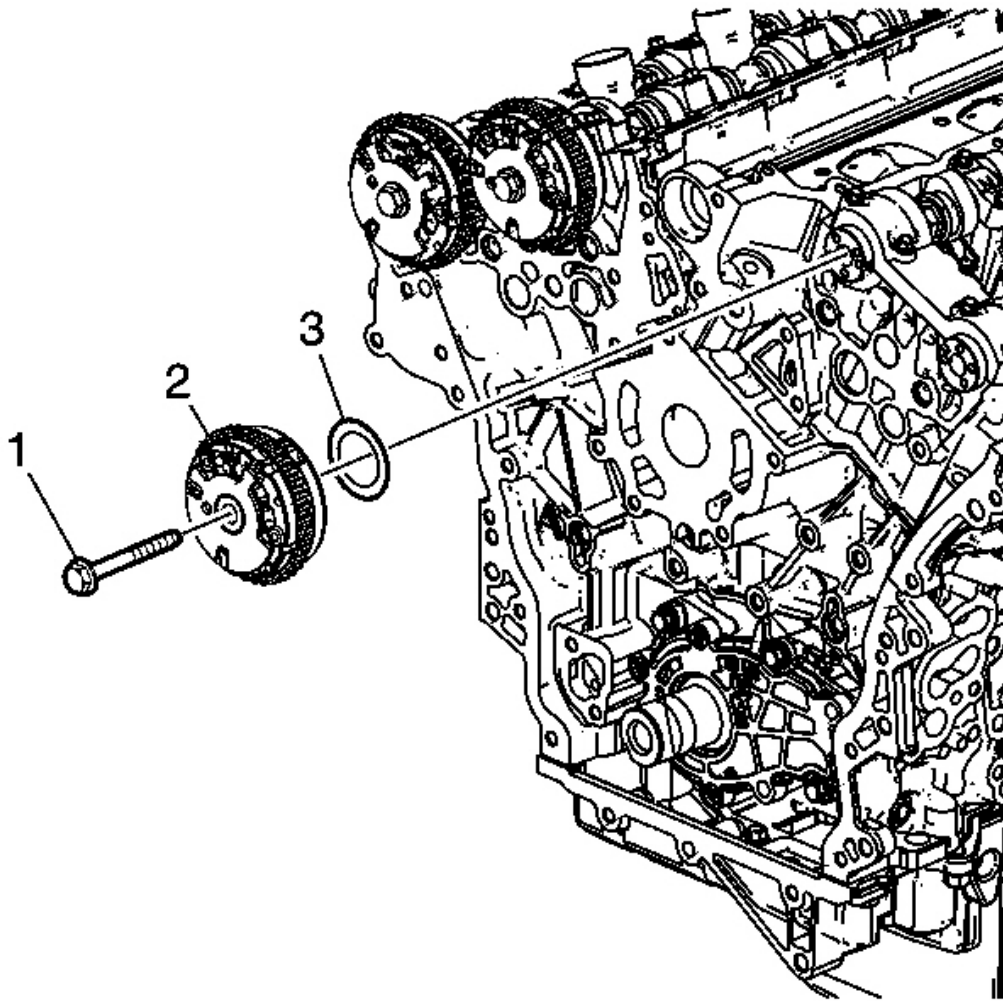


Fig. 27: View Of Camshaft Position Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the thrust washer if applicable (3).
8. Install the left intake camshaft position actuator (2).

CAUTION: Refer to Fastener Caution .

9. Install the camshaft position actuator bolt (1) and tighten to 58 N.m (43 lb ft).

CAMSHAFT POSITION ACTUATOR INSTALLATION - LEFT SIDE EXHAUST

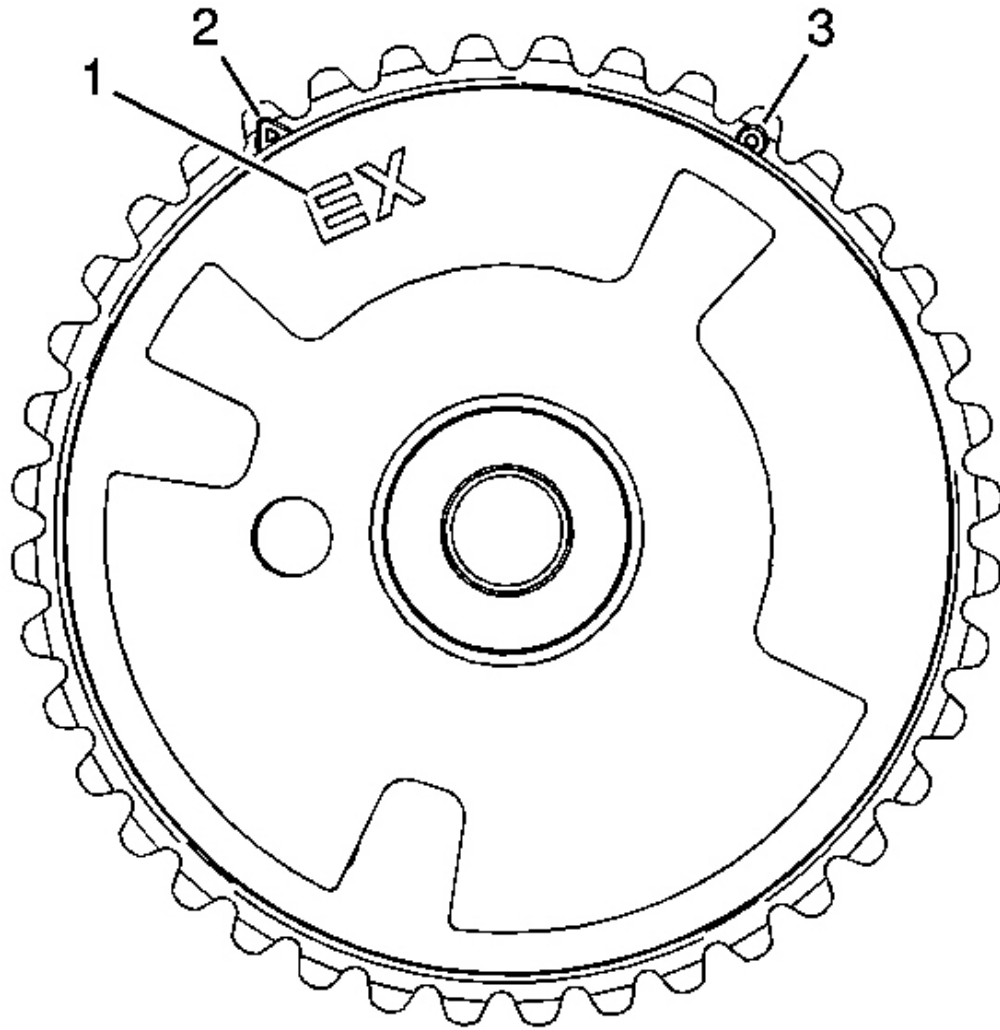


Fig. 28: View Of EX Marking, Triangle & Circle Marking
Courtesy of GENERAL MOTORS CORP.

1. 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.

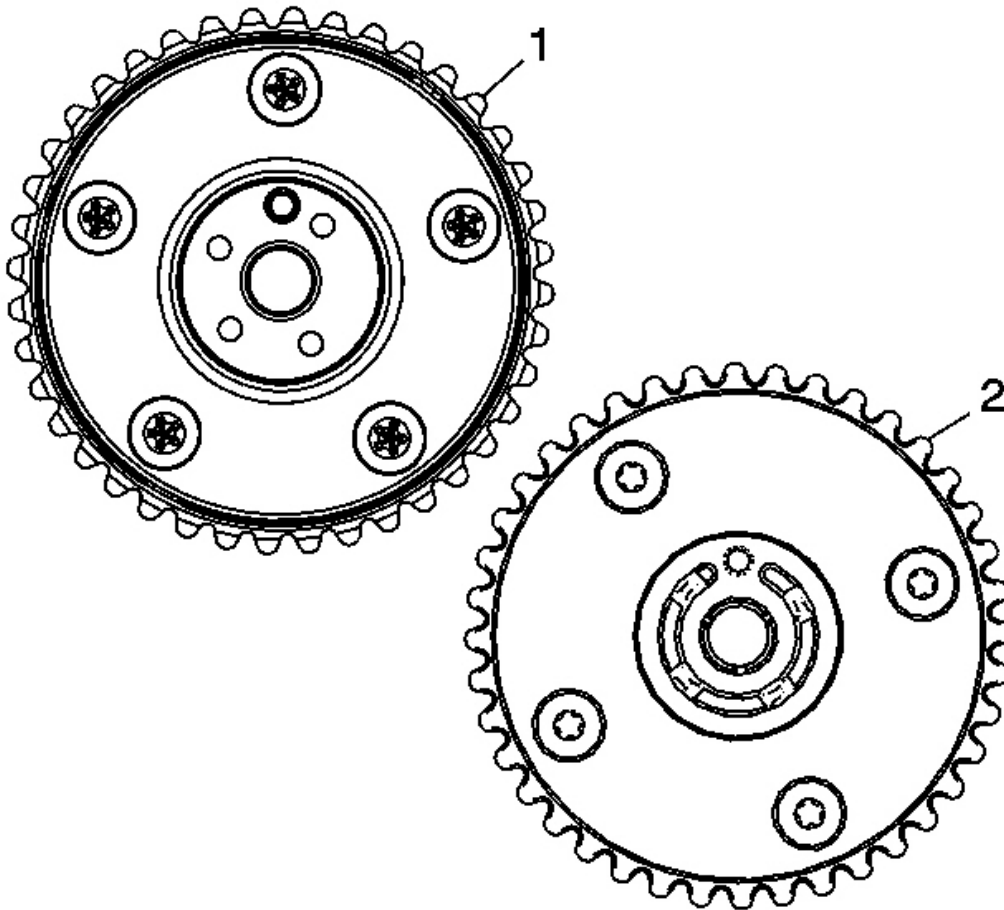


Fig. 29: Identifying Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft position actuator will vary depending on application.

NOTE: Camshaft thrust washers must be installed on all 2010 applications when servicing the camshaft position actuators. Do not install washers on 2009 applications if they are not already present.

4. Ensure the proper camshaft thrust washer is used. Use a 1.6 mm (0.063 in) thrust washer on applications that have 5 attaching screws on the back side of the camshaft position actuator (1). Use a 1.1 mm (0.043 in) thick thrust washer with yellow speckles on applications that have 4 attaching screws on the back side of the camshaft position actuator (2).

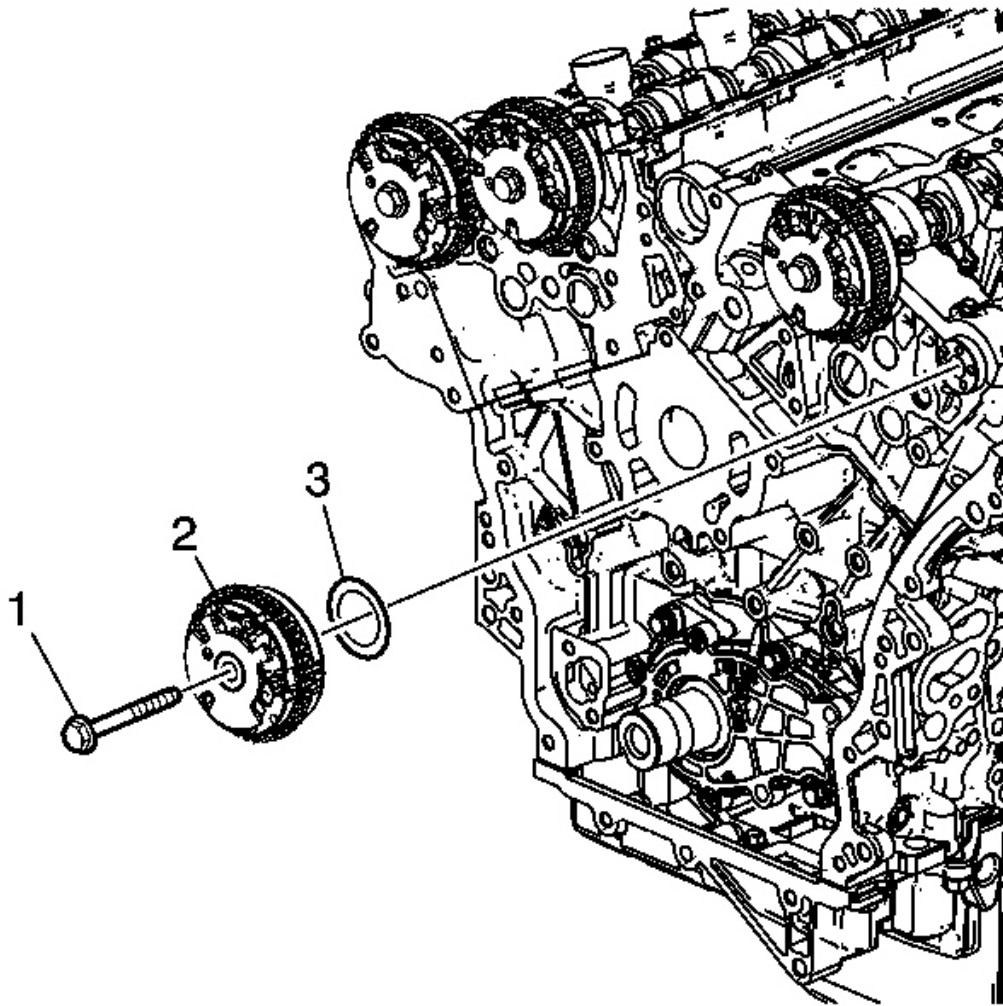


Fig. 30: View Of Exhaust Camshaft Position Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the thrust washer if applicable (3).
6. Install the left exhaust camshaft position actuator (2).

CAUTION: Refer to Fastener Caution .

7. Install the camshaft position actuator bolt (1) and tighten to 58 N.m (43 lb ft).

CRANKSHAFT SPROCKET INSTALLATION

SPECIAL TOOLS

EN-48589: Crankshaft Rotation Socket

For equivalent regional tools, refer to **Special Tools** .

INSTALLATION

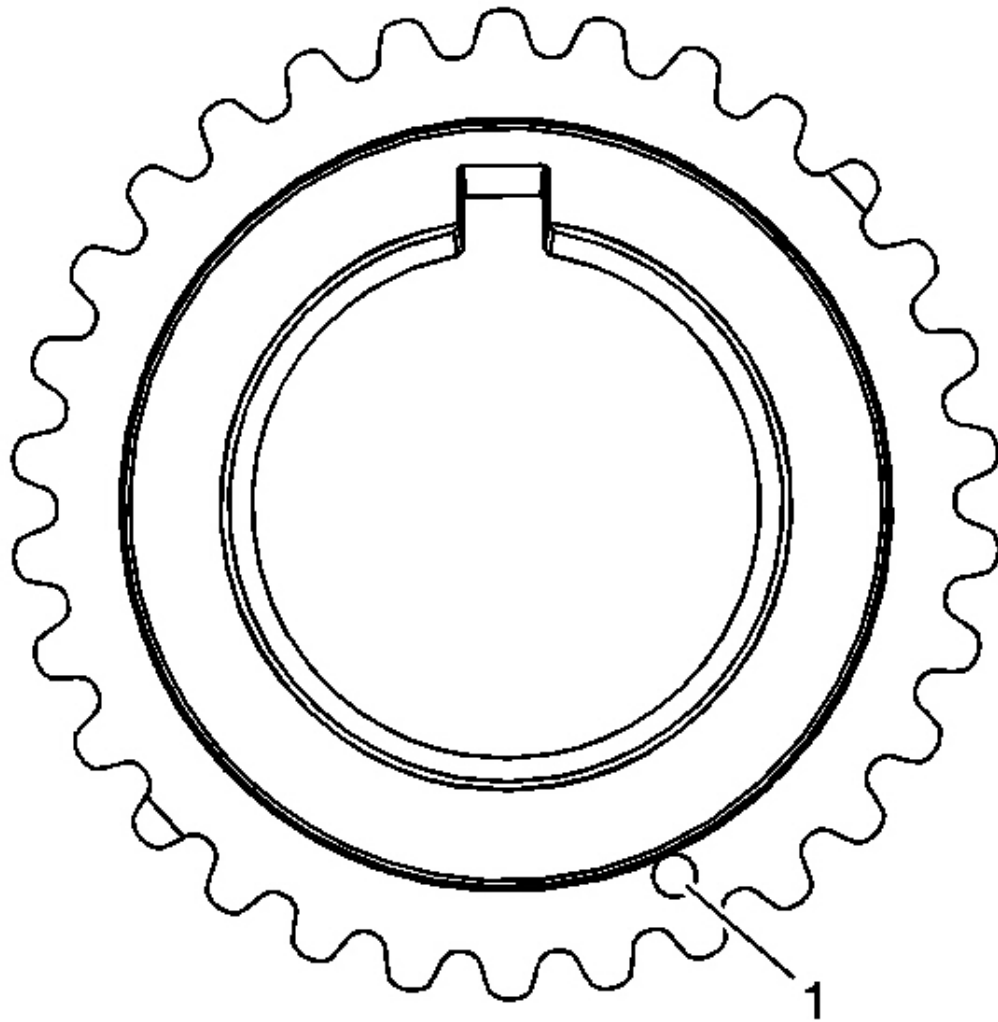


Fig. 31: Identifying Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

1. Ensure the crankshaft sprocket is installed with the timing mark (1) visible.

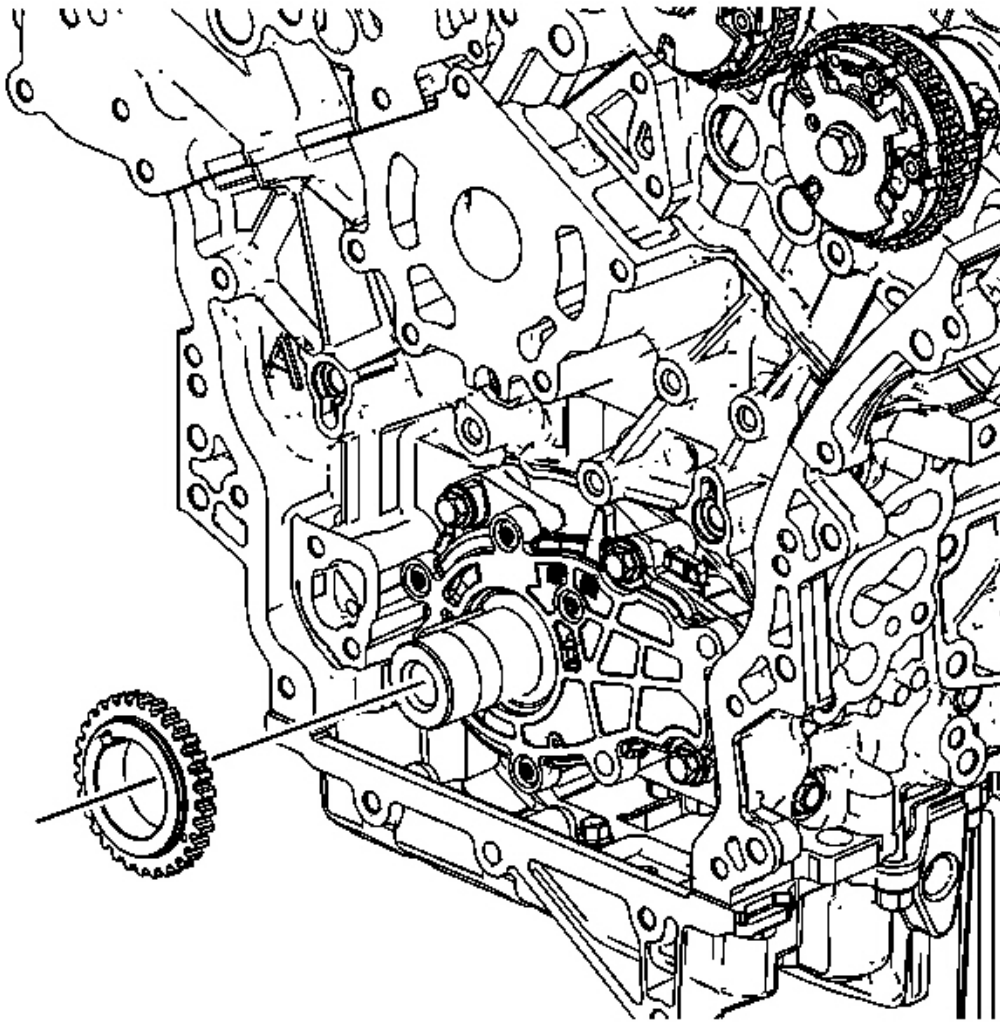


Fig. 32: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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.

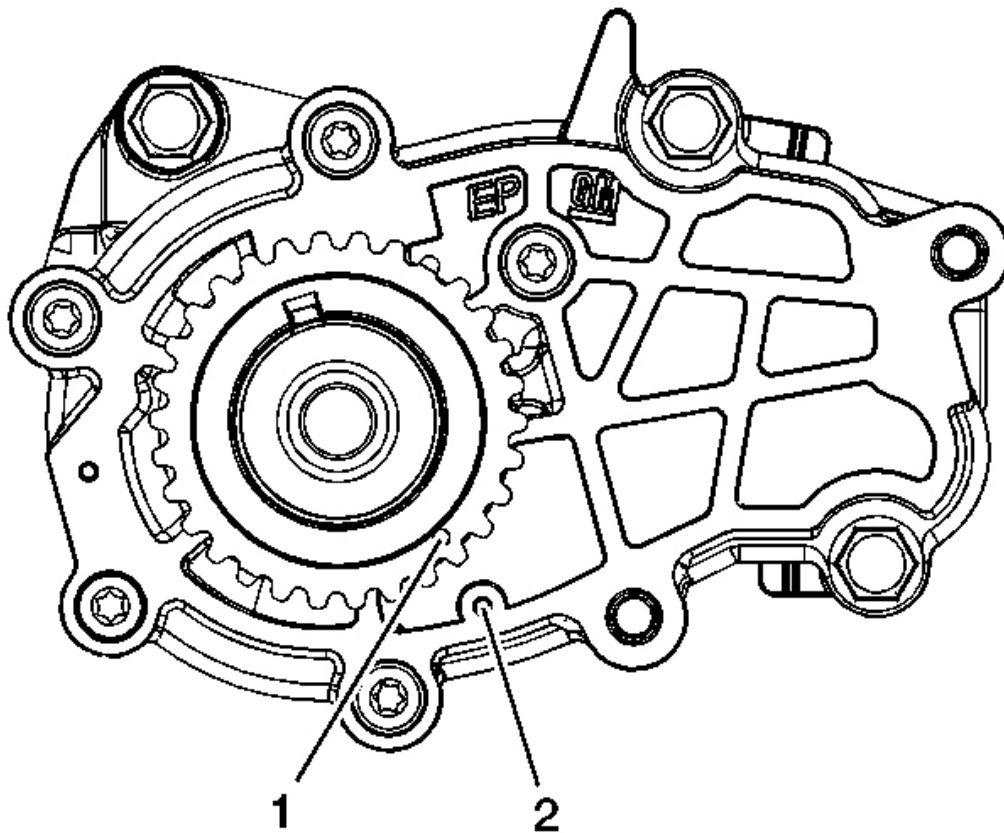


Fig. 33: View Of Stage One Timing Mark On Oil Pump Cover & Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark (1) aligned to the stage one timing mark on the oil pump cover (2) using the **EN-48589:** socket. Refer to **Timing Chain Alignment Diagram** .

TIMING CHAIN IDLER SPROCKET INSTALLATION - LEFT SIDE

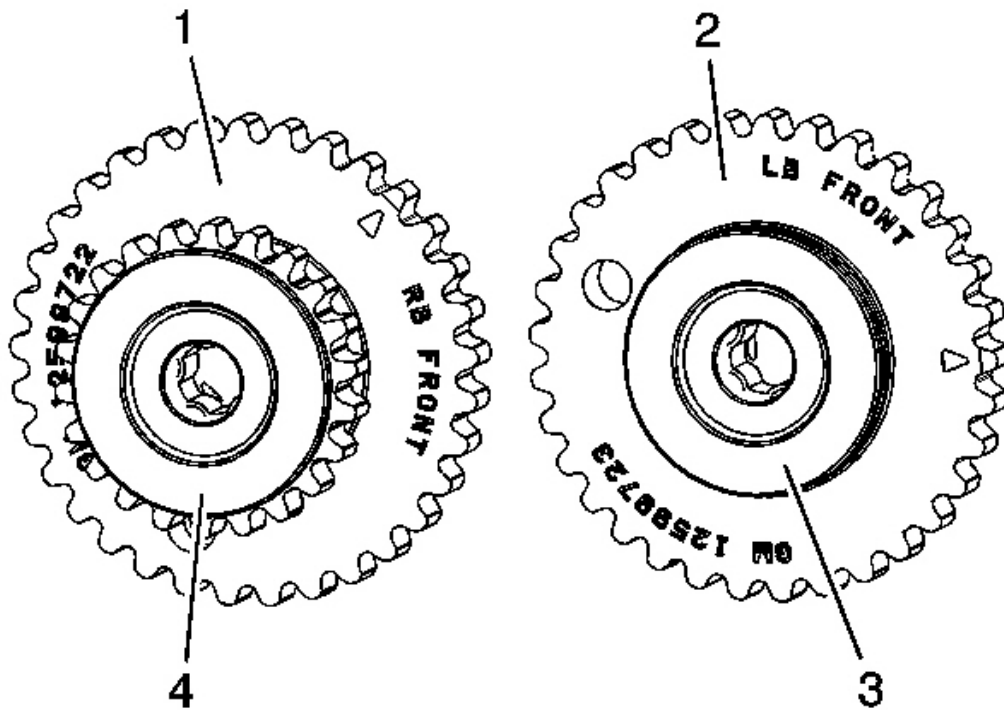


Fig. 34: View Of Camshaft Intermediate Drive Chain Idler - Left Side (Fourth Design)
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the left camshaft intermediate drive chain idler (2) is being installed. The recessed hub (3) and the larger sprocket of the left camshaft intermediate drive chain idler is installed outward. The raised hub and the smaller sprocket of the left camshaft intermediate drive chain idler is installed towards the block.

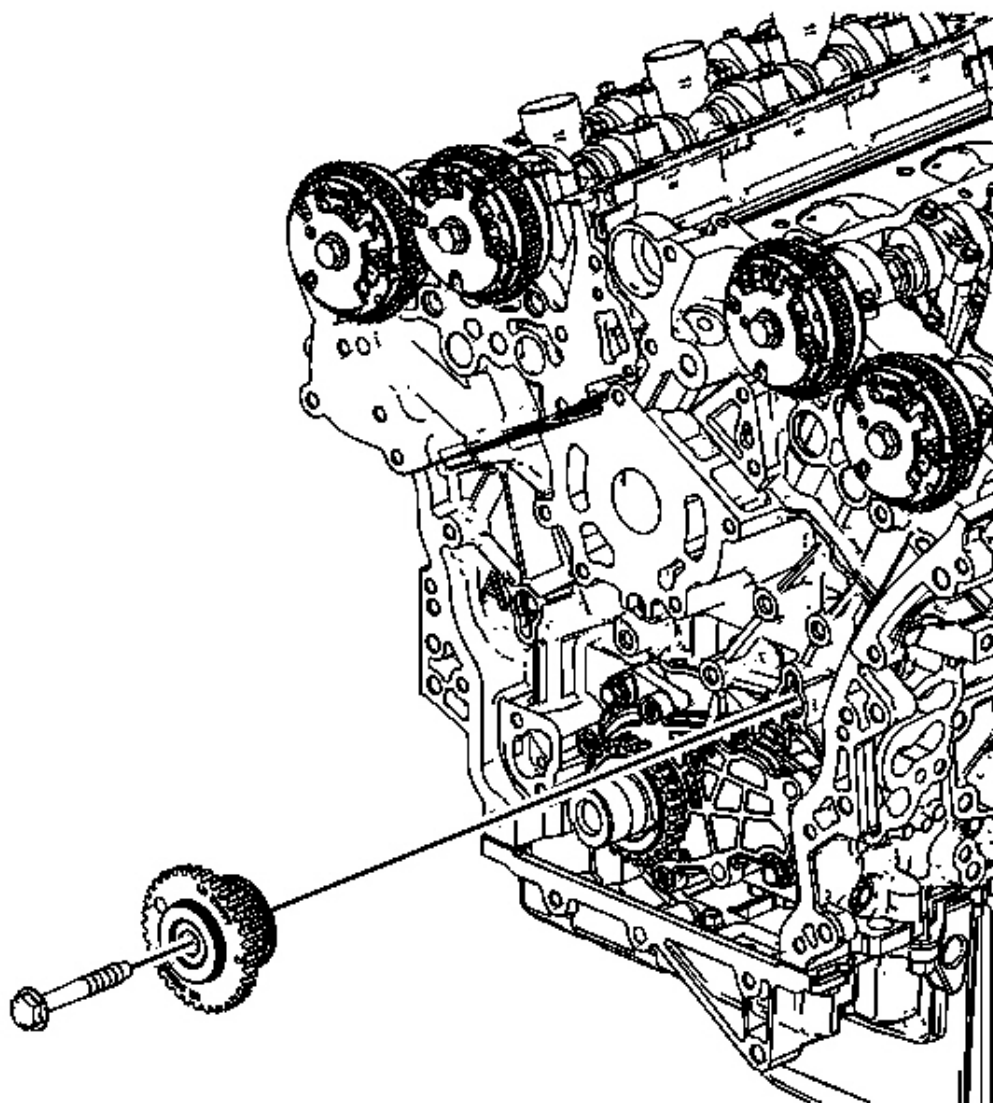


Fig. 35: View Of Camshaft Intermediate Drive Chain Idler & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Place the left camshaft intermediate drive chain idler to the cylinder block.

CAUTION: Refer to Fastener Caution .

3. Install the camshaft intermediate drive chain idler bolt and tighten to 58 N.m (43 lb ft).

SECONDARY CAMSHAFT INTERMEDIATE DRIVE CHAIN INSTALLATION - LEFT SIDE

Special Tools

- **EN 48383:** Camshaft Retaining Tools
- **EN 48589:** Crankshaft Rotation Socket

For equivalent regional tools, refer to **Special Tools** .

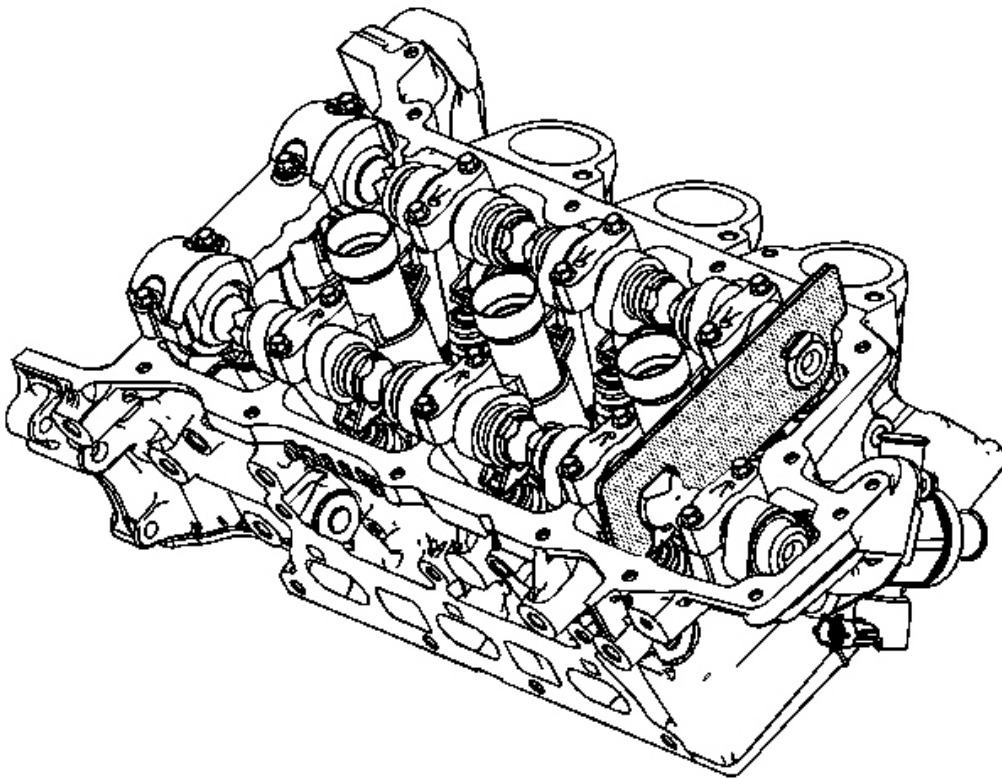


Fig. 36: View Of Camshafts & EN 48383-1
Courtesy of GENERAL MOTORS CORP.

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: tools.

1. Install the EN 48383-1 onto the rear of the left camshafts.

NOTE: All camshafts must be locked in place before installation of any camshaft drive chains.

2. Ensure that the EN 48383-1 is fully seated onto the camshafts.

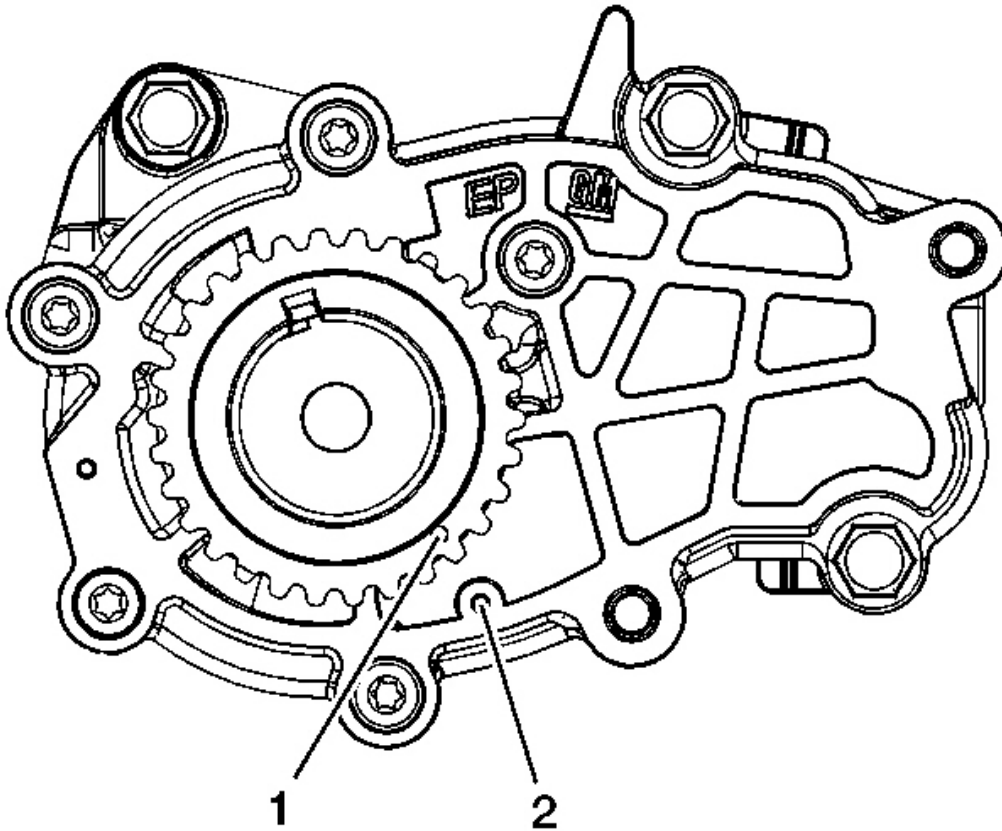


Fig. 37: View Of Crankshaft Sprocket Timing Mark & Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

3. Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark (1) aligned to the stage one timing mark on the oil pump cover (2) using the EN 48589: socket. Refer to **Timing Chain Alignment Diagram** .

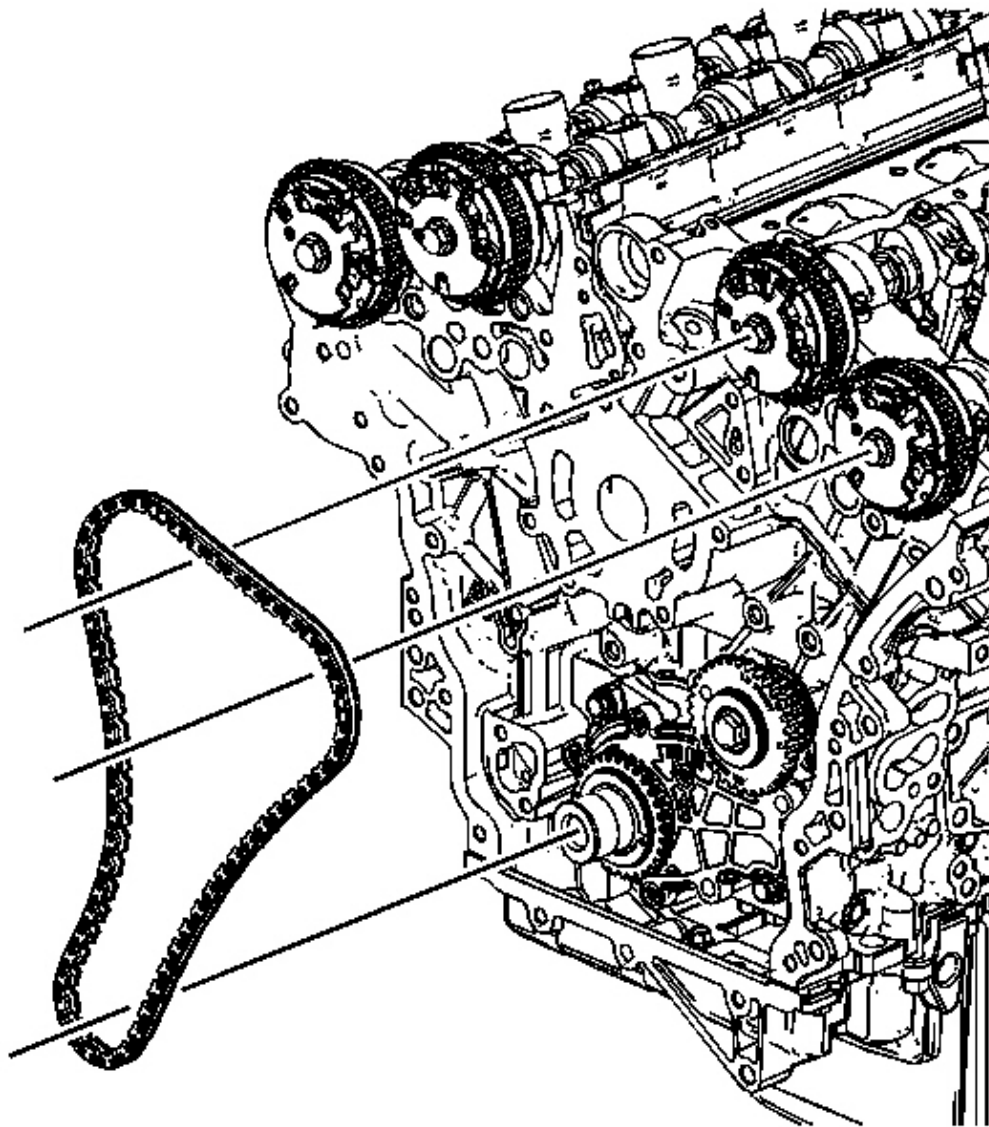


Fig. 38: View Of Left Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

4. Install the left secondary camshaft drive chain.

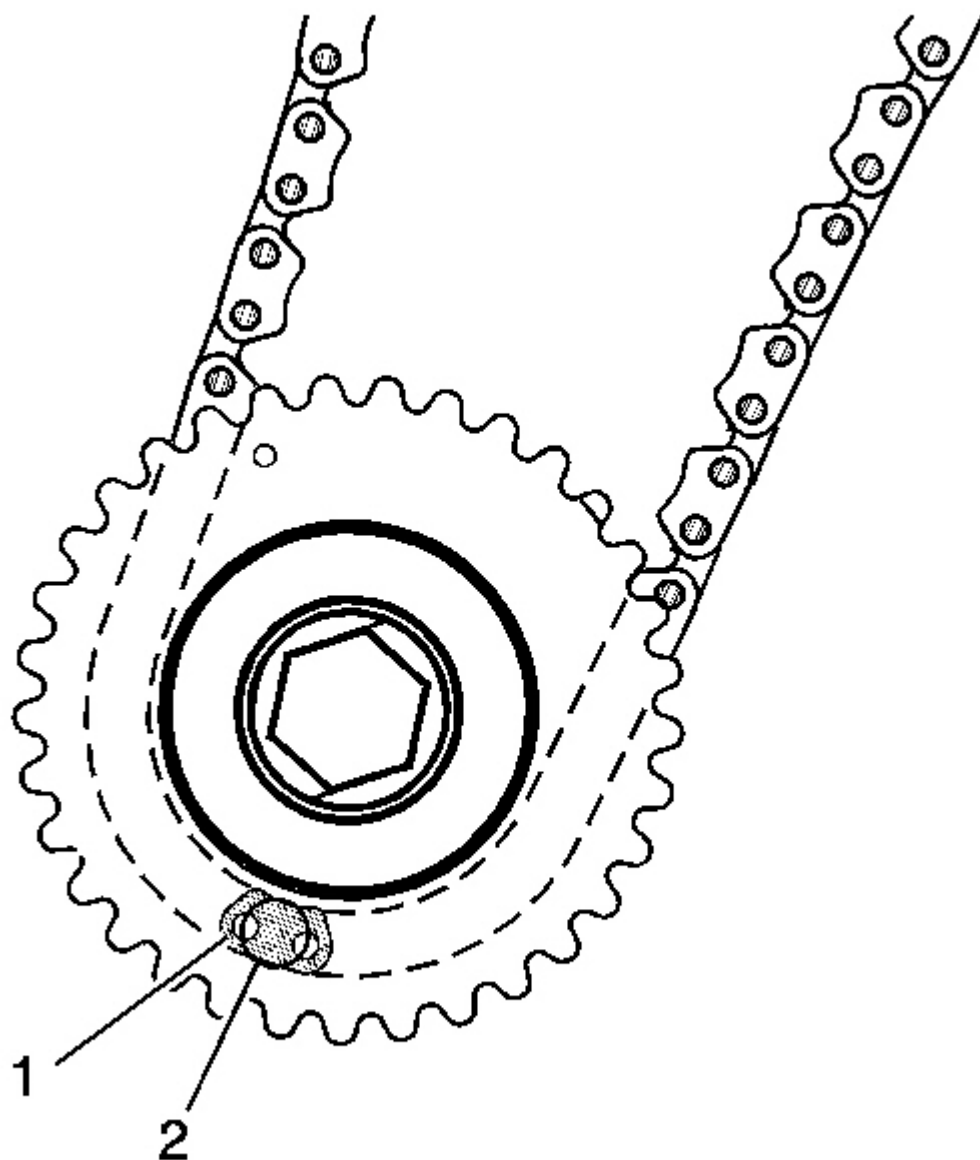


Fig. 39: View Of Timing Camshaft Drive Chain Link & Alignment Access Hole
Courtesy of GENERAL MOTORS CORP.

5. Place the left secondary camshaft drive chain around the inner sprocket of the left camshaft intermediate drive chain idler with the timing camshaft drive chain link (1) aligned to the alignment access hole (2) made in the left camshaft intermediate drive chain idler outer sprocket.

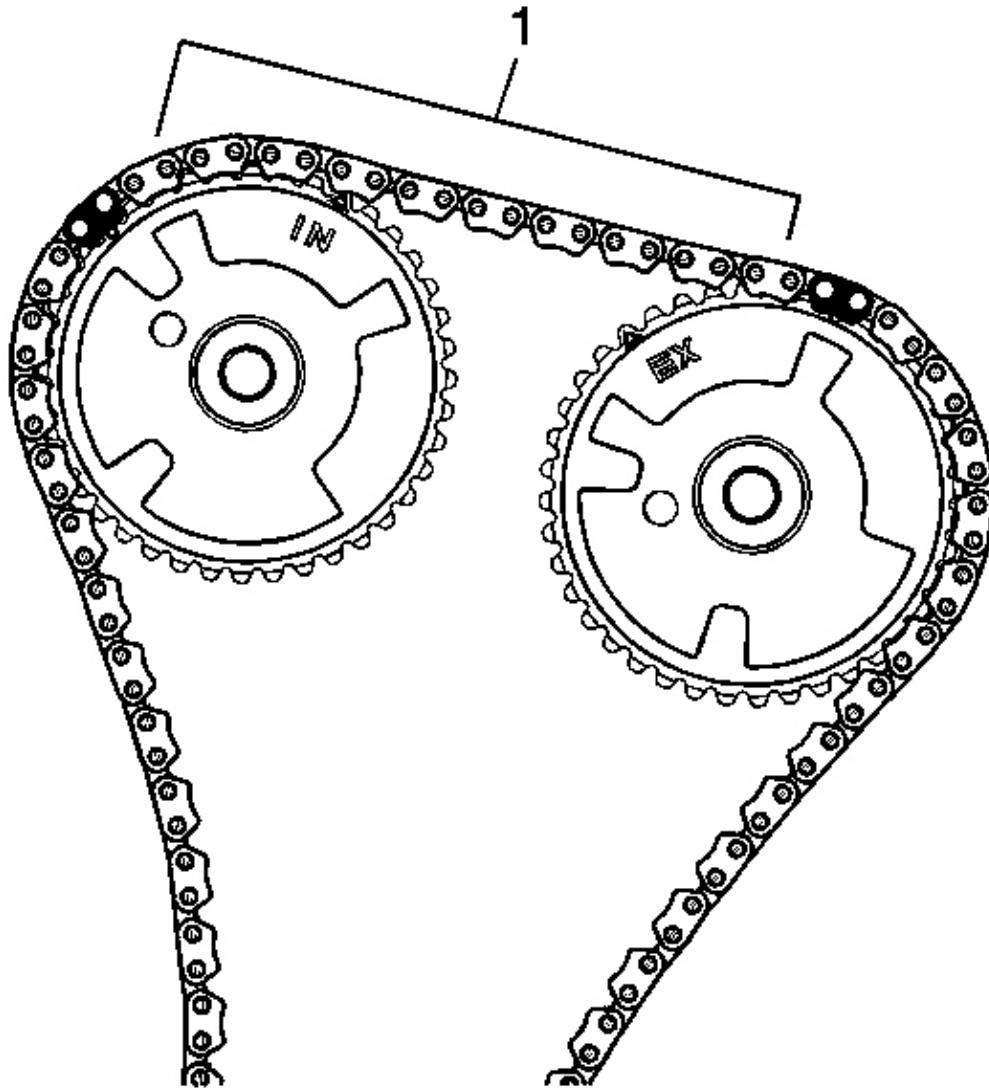


Fig. 40: View Of Camshaft Drive Chain Links
Courtesy of GENERAL MOTORS CORP.

6. Wrap the secondary camshaft drive chain around both left actuator drive sprockets.
7. Ensure there are 10 links (1) between the timing camshaft drive chain links for the camshaft position actuator sprockets.

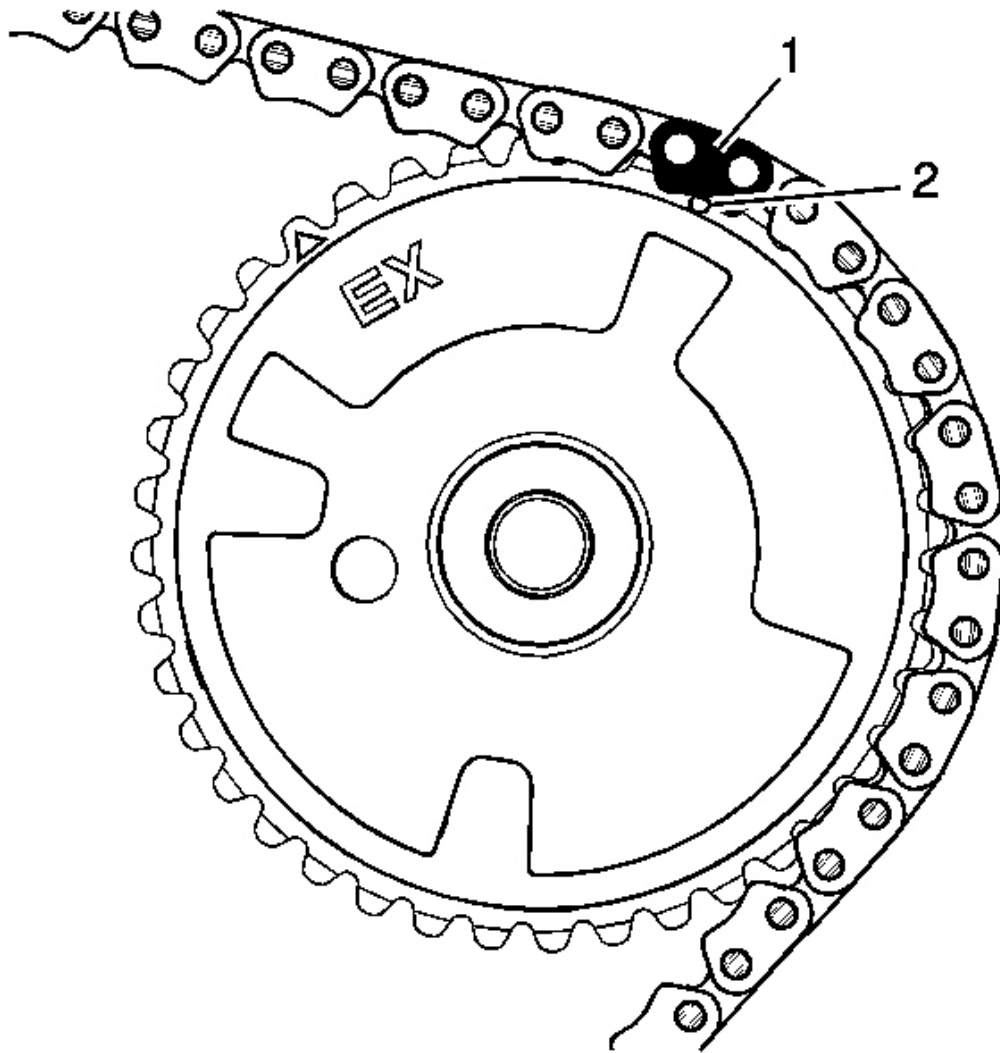


Fig. 41: View Of Exhaust Camshaft Marks
Courtesy of GENERAL MOTORS CORP.

8. Align the left exhaust camshaft position actuator sprocket alignment circle mark (2) with the timing camshaft drive chain link (1).

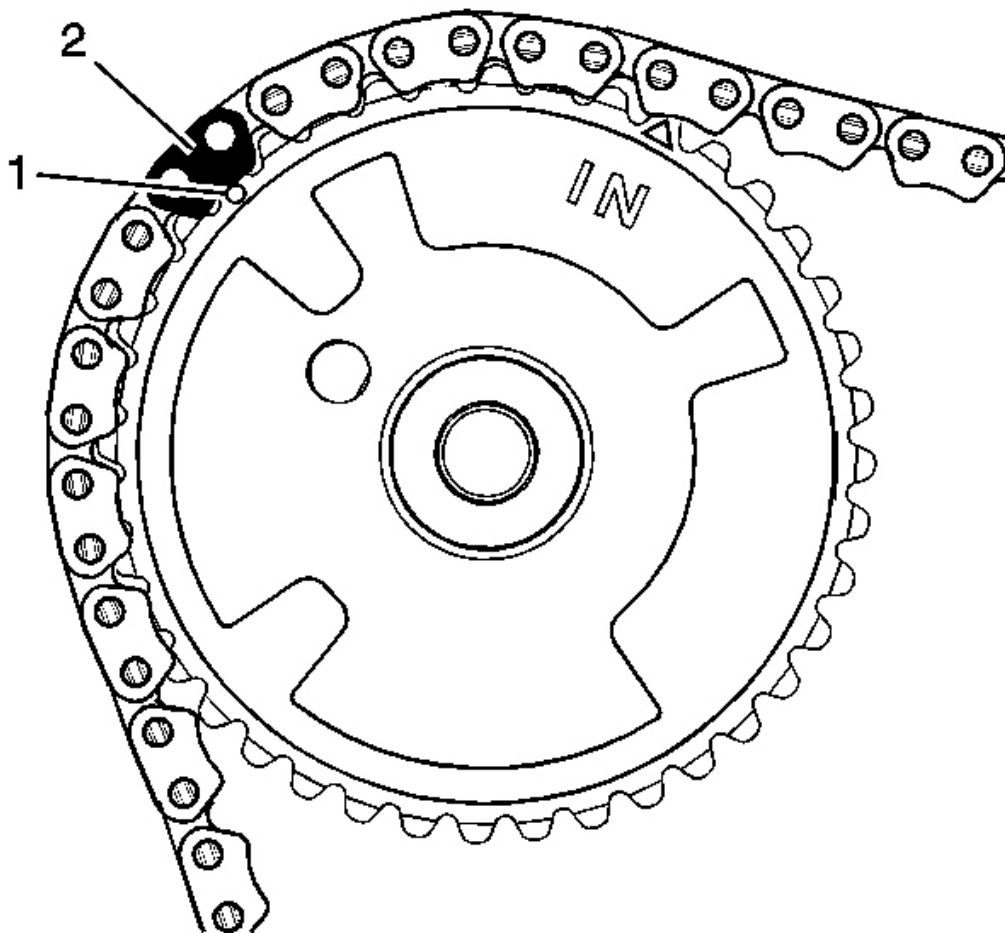


Fig. 42: View Of Intake Camshaft Marks
Courtesy of GENERAL MOTORS CORP.

9. Align the left intake camshaft position actuator sprocket alignment circle mark (1) with the timing camshaft drive chain link (2).

SECONDARY TIMING CHAIN GUIDE INSTALLATION - LEFT SIDE

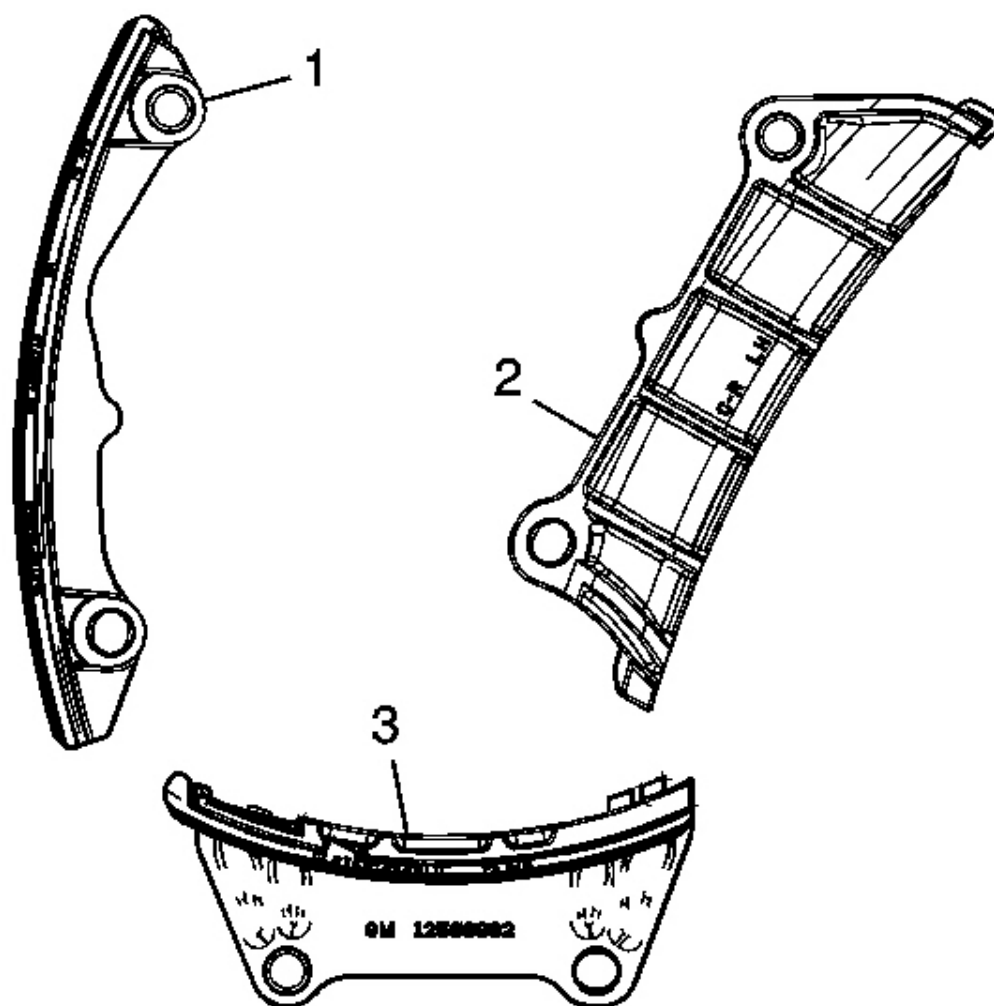


Fig. 43: View Of Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the left secondary camshaft drive chain guide (2) is being installed.

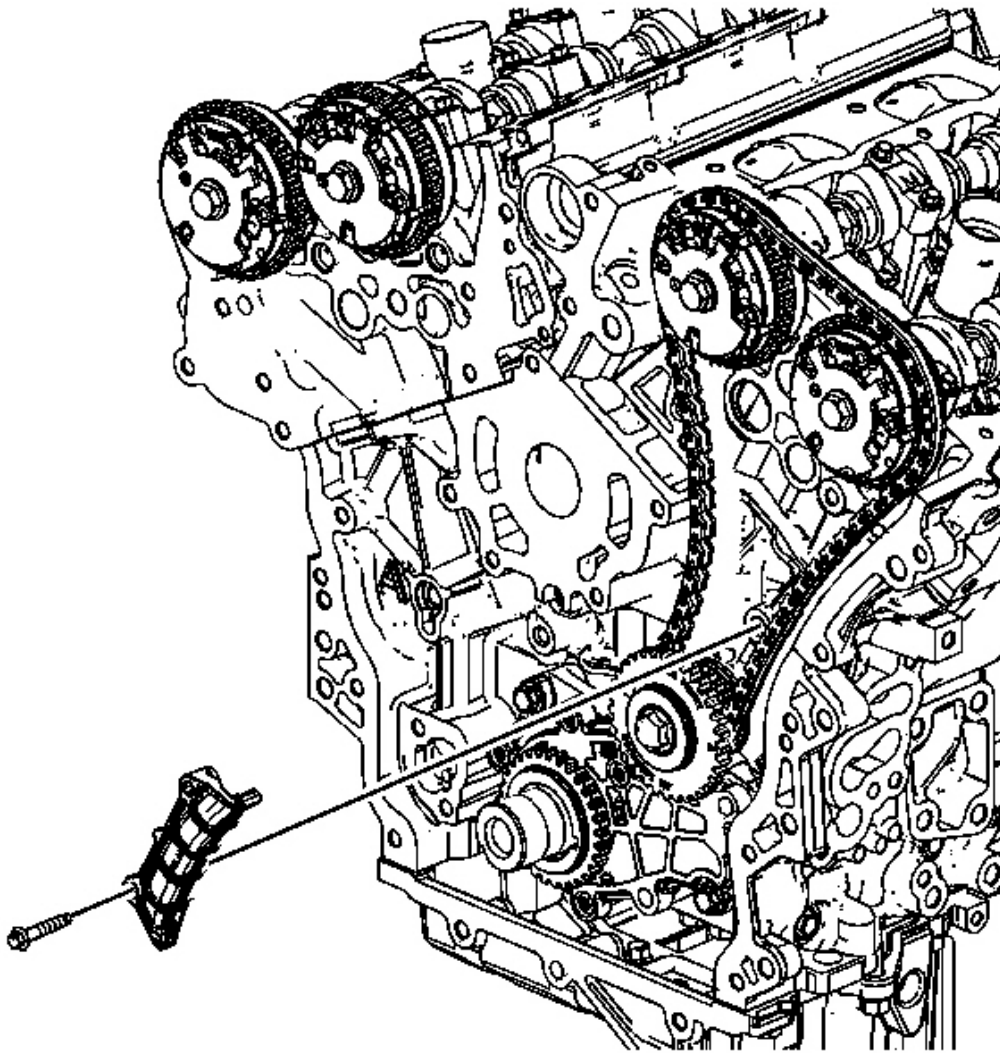


Fig. 44: View Of Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

2. Position the left secondary camshaft drive chain guide.

CAUTION: Refer to Fastener Caution .

3. Install the secondary camshaft drive chain guide bolts and tighten to 25 N.m (18 lb ft).

SECONDARY CAMSHAFT DRIVE CHAIN SHOE INSTALLATION - LEFT SIDE

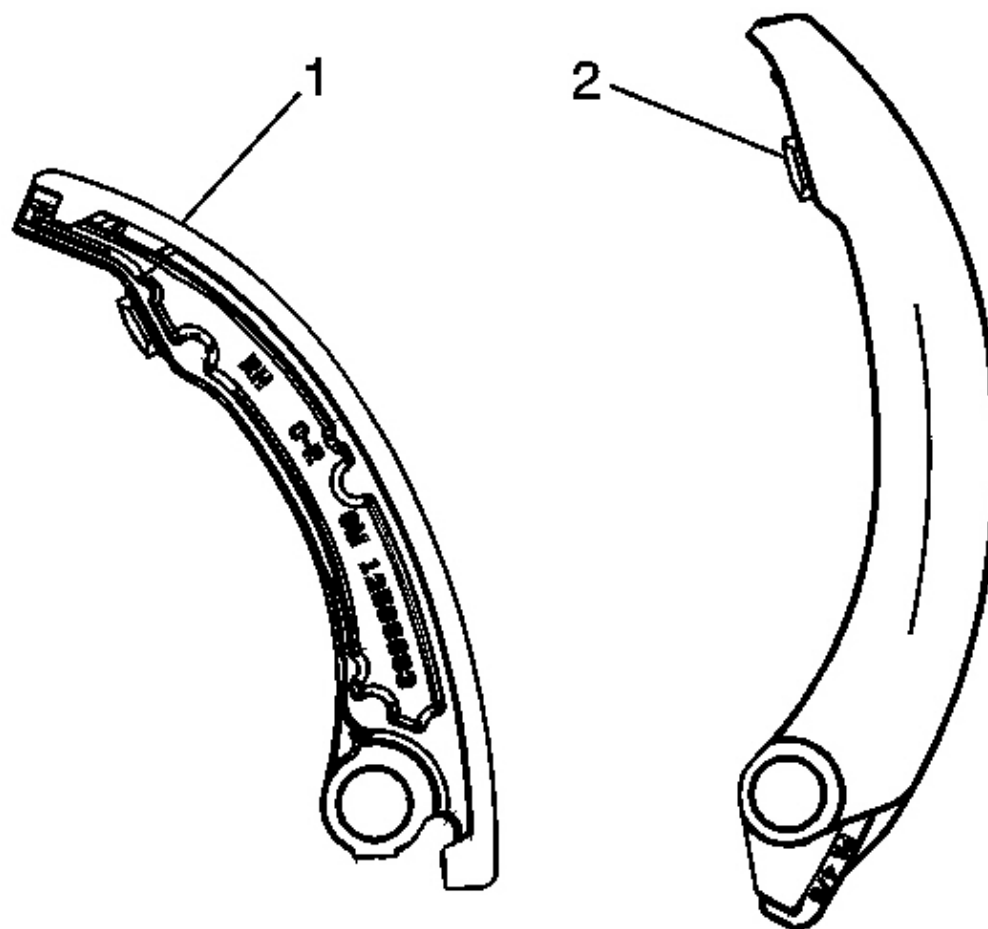


Fig. 45: Identifying Correct Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the left secondary camshaft drive chain shoe (2) is being installed.

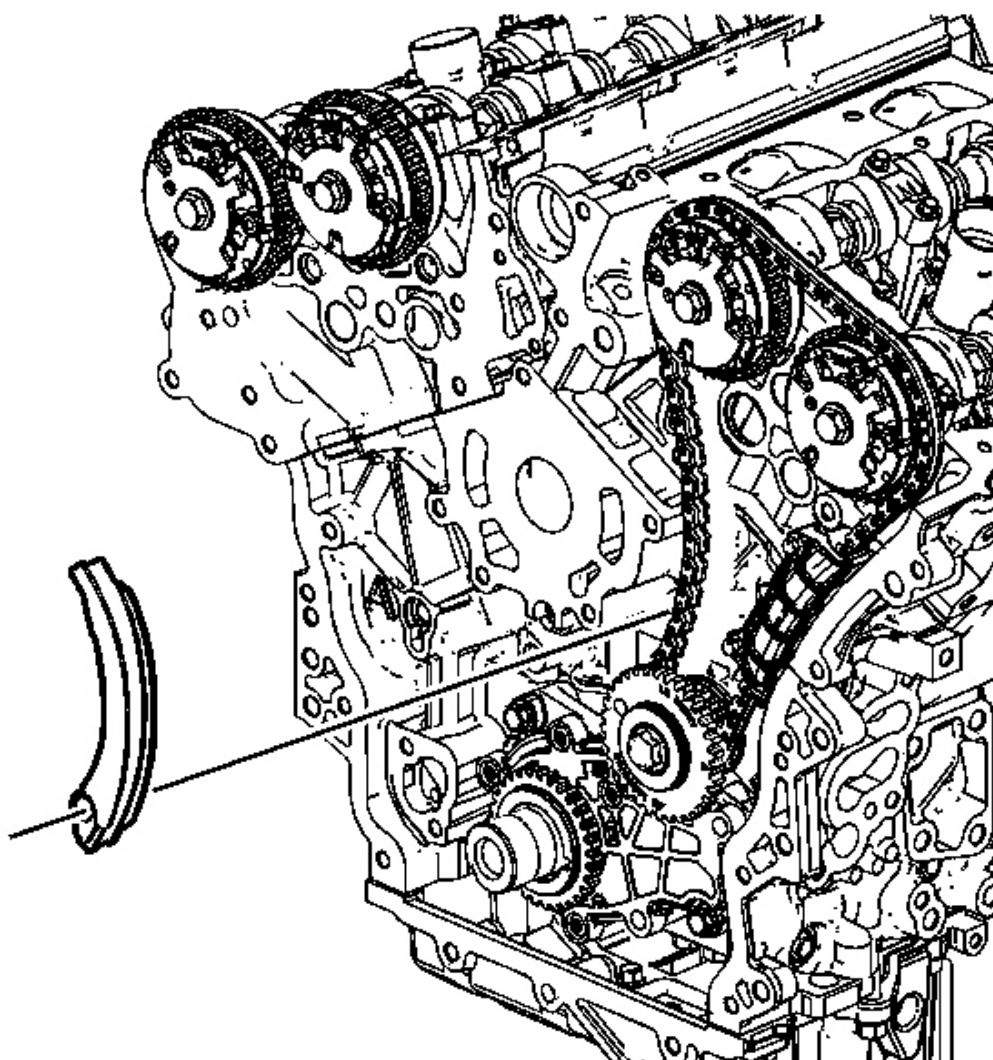


Fig. 46: View Of Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

2. Position the left secondary camshaft drive chain shoe.

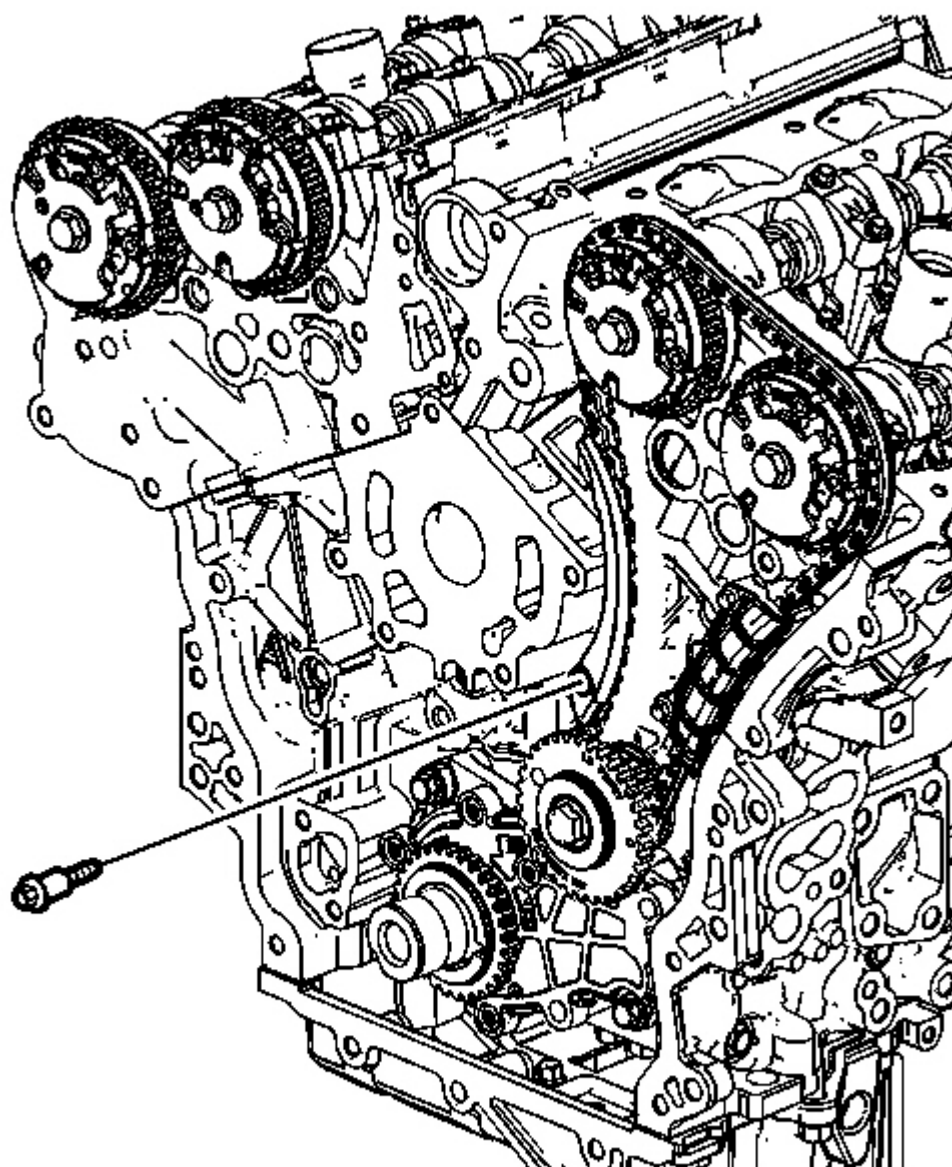


Fig. 47: View Of Secondary Camshaft Drive Chain Shoe Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the secondary camshaft drive chain shoe bolt and tighten to 25 N.m (18 lb ft).

SECONDARY TIMING CHAIN TENSIONER INSTALLATION - LEFT SIDE

Special Tools

- EN 45027: Tensioner Tool
- EN 46112: Tensioner Retraction Pins

For equivalent regional tools, refer to Special Tools .

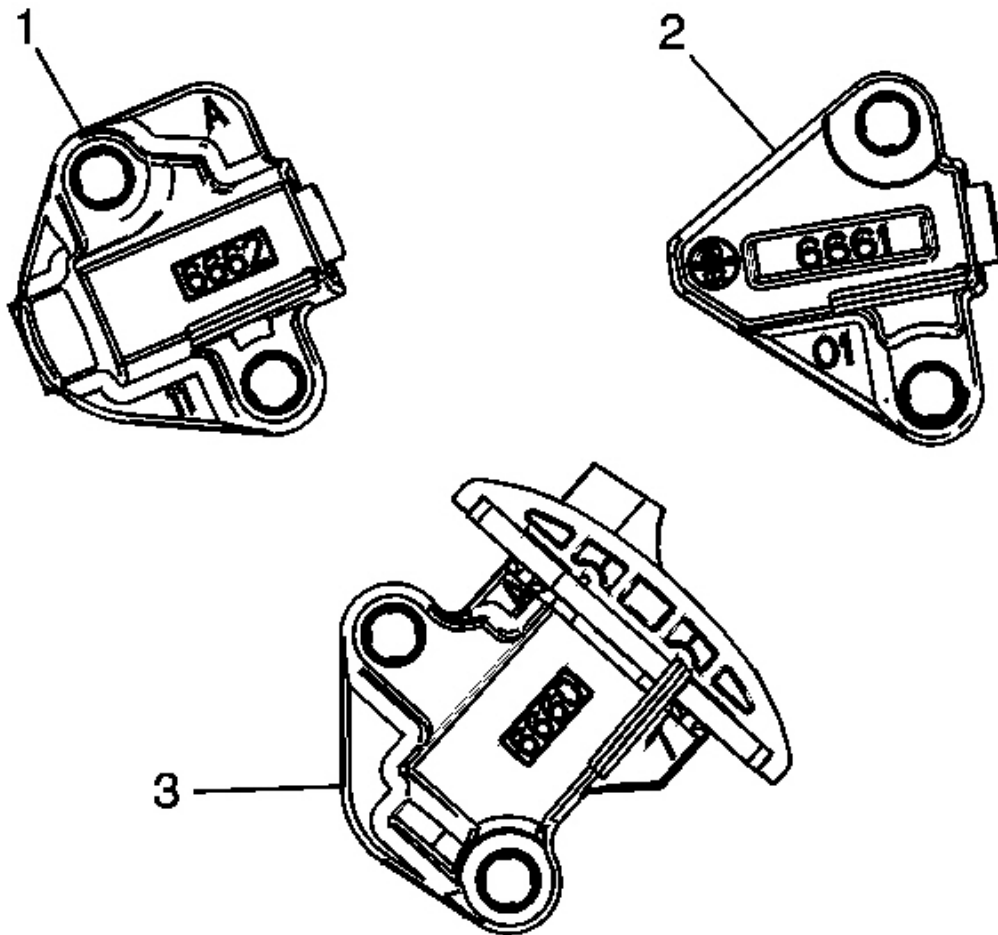


Fig. 48: Identifying Left & Right Secondary Camshaft Drive Chain Tensioner & Primary Camshaft Drive Chain Tensioner

Courtesy of GENERAL MOTORS CORP.

1. Ensure that the left secondary camshaft drive chain tensioner (2) is being installed.

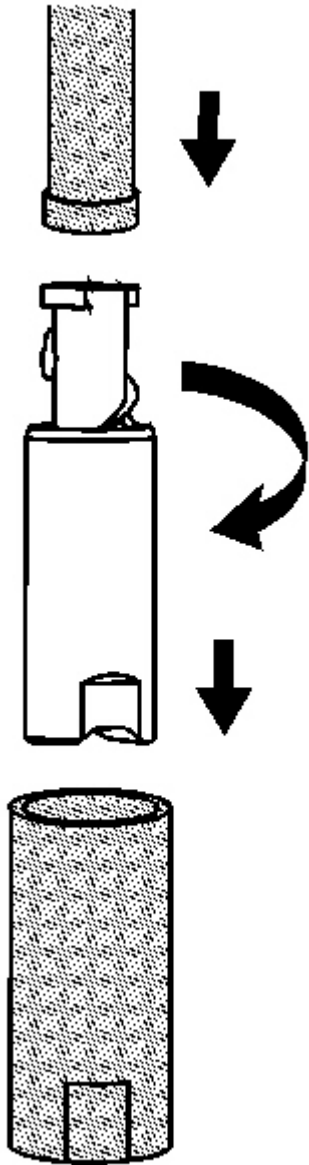


Fig. 49: Resetting Left Secondary Camshaft Drive Chain Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

2. Using the **EN 45027**: tool, reset the left secondary camshaft drive chain tensioner plunger.

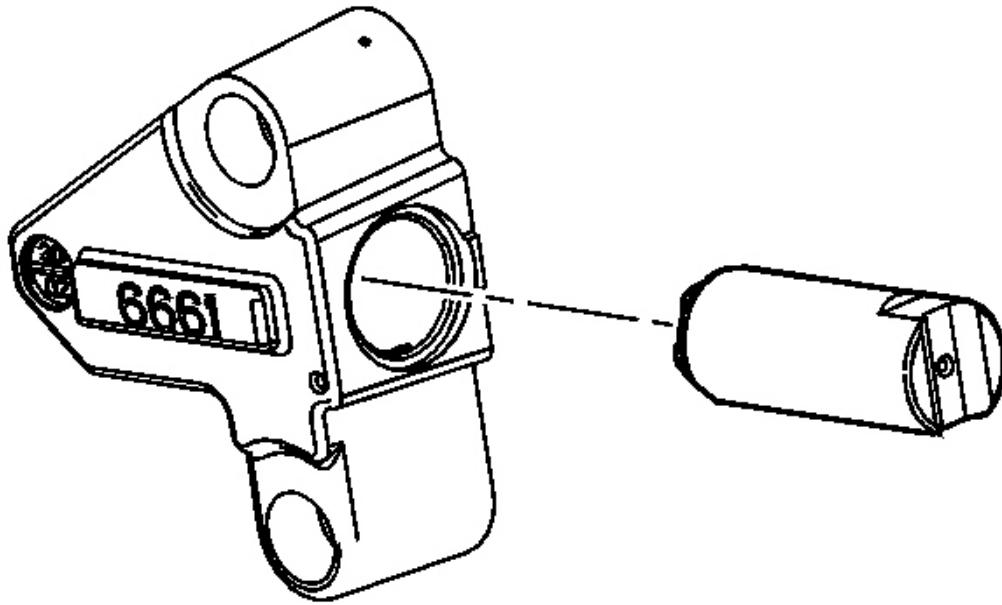


Fig. 50: Installing Plunger Into Left Secondary Camshaft Drive Chain Tensioner Body
Courtesy of GENERAL MOTORS CORP.

3. Install the plunger into the left secondary camshaft drive chain tensioner body.

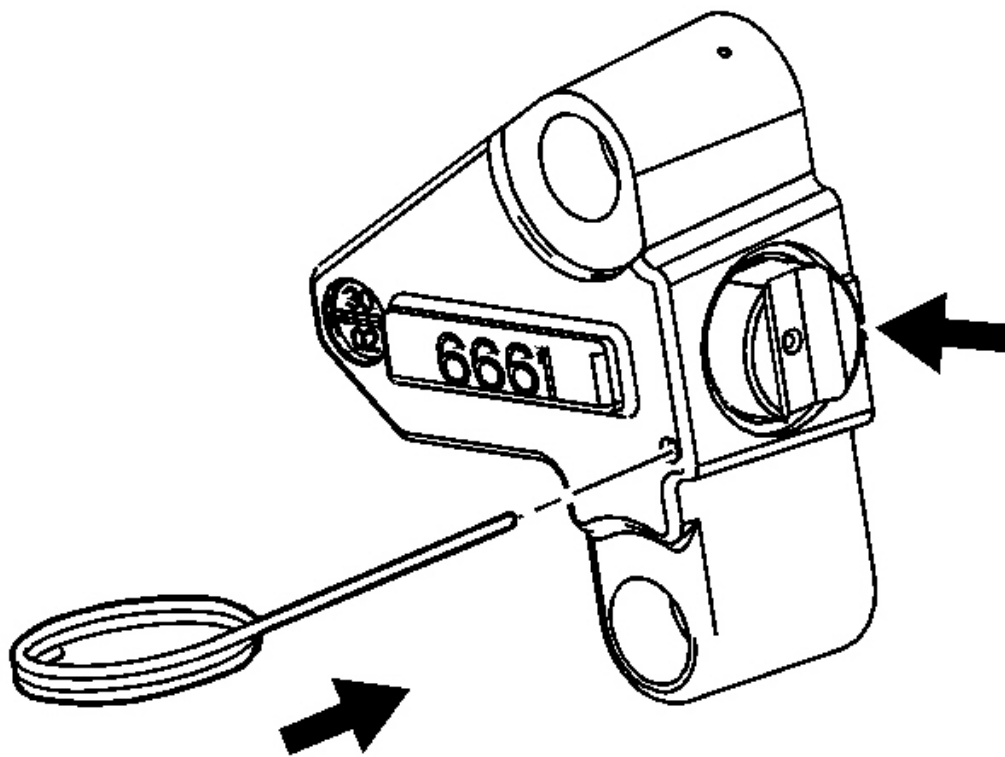


Fig. 51: Inserting EN 46112 Into Access Hole In Side Of Left Secondary Camshaft Drive Chain Tensioner Body

Courtesy of GENERAL MOTORS CORP.

4. Compress the plunger into the body and lock the left secondary camshaft drive chain tensioner by inserting the **EN-46112** pins into the access hole in the side of the left secondary camshaft drive chain tensioner body.
5. Slowly release pressure on the left secondary camshaft drive chain tensioner. The left secondary camshaft drive chain tensioner should remain compressed.

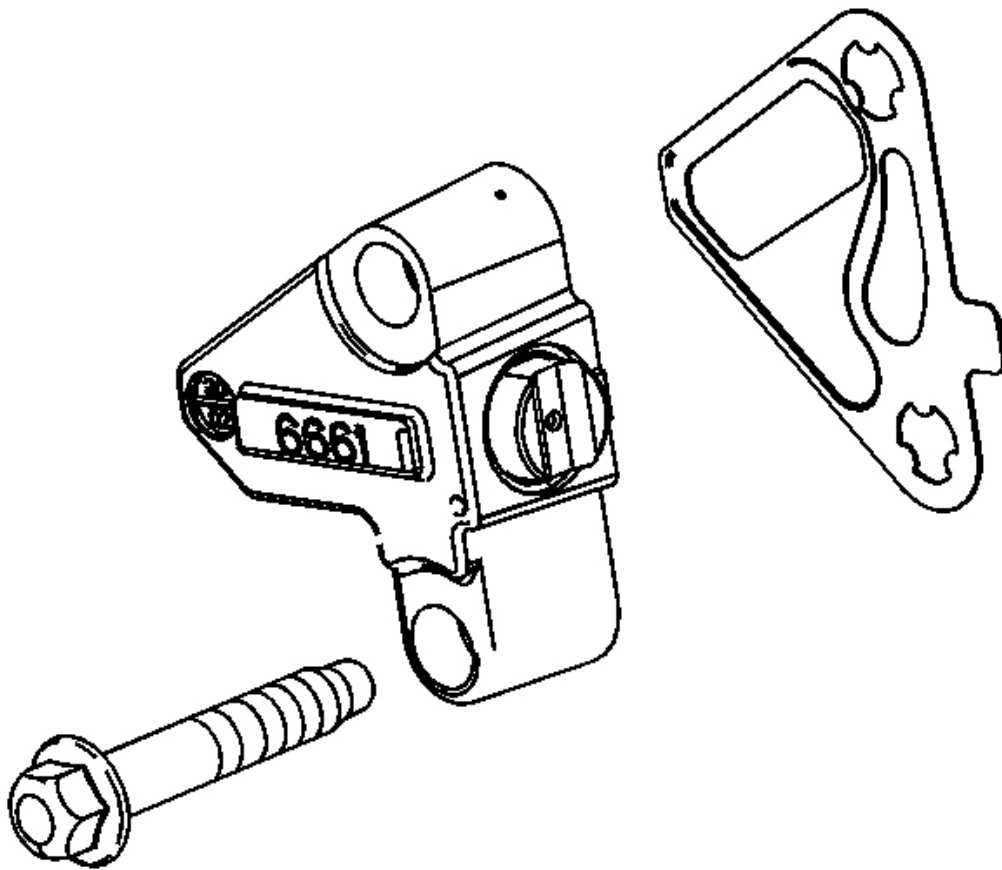


Fig. 52: View Of Left Secondary Camshaft Drive Chain Tensioner Gasket
Courtesy of GENERAL MOTORS CORP.

6. Install a NEW left secondary camshaft drive chain tensioner gasket to the left secondary camshaft drive chain tensioner.
7. Install the left secondary camshaft drive chain tensioner bolts through the left secondary camshaft drive chain tensioner and gasket.
8. 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.

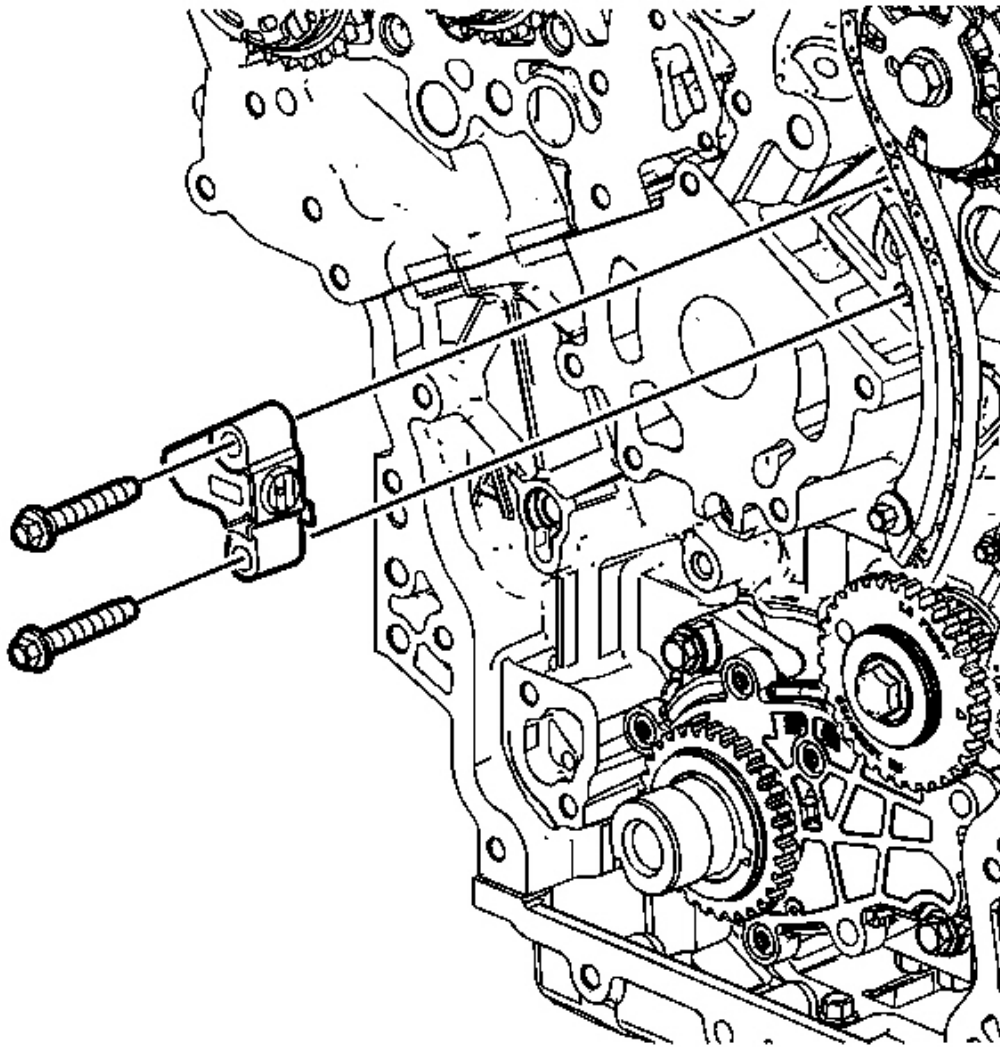


Fig. 53: View Of Secondary Camshaft Drive Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Place the left secondary camshaft drive chain tensioner into position and loosely install the bolts to the block.

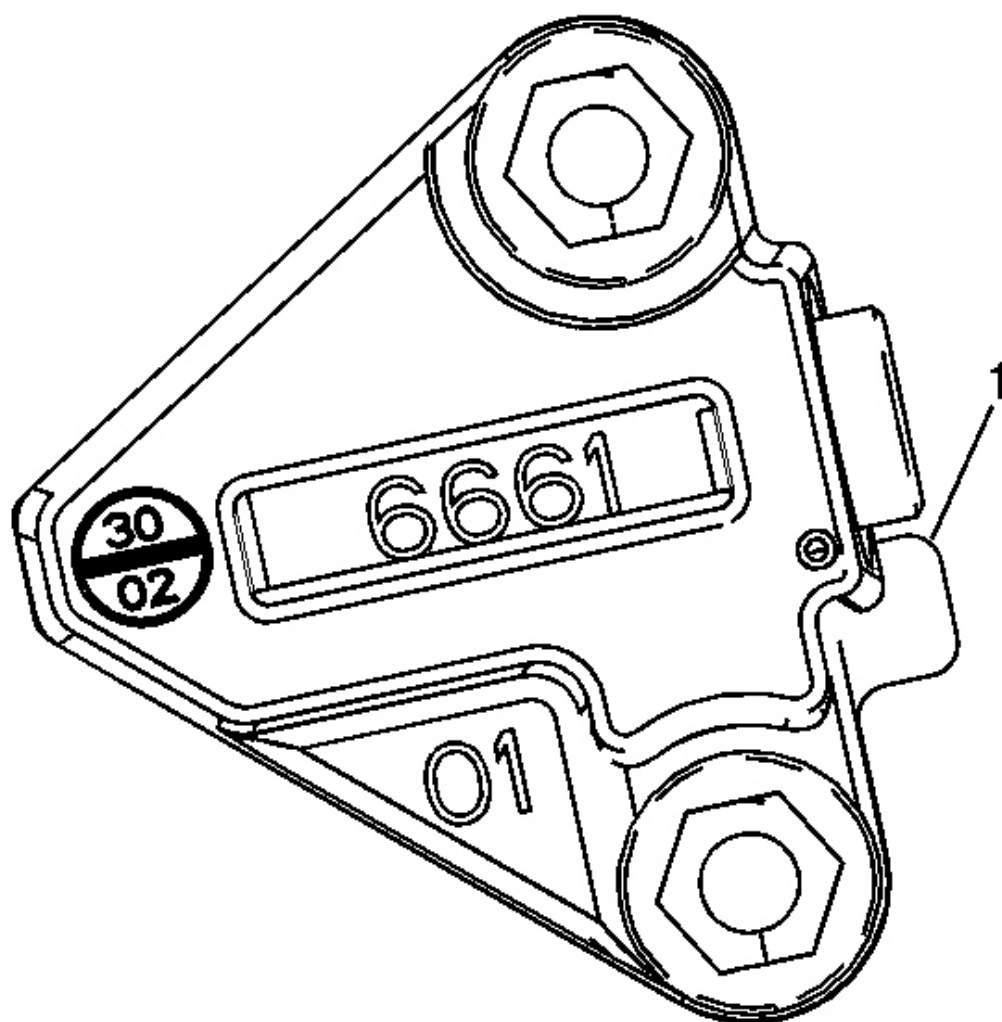


Fig. 54: Locating Left Secondary Camshaft Drive Chain Tensioner Gasket Tab
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

10. Verify the proper placement of the left secondary camshaft drive chain tensioner gasket tab (1).

1. First Pass

Tighten the left secondary camshaft drive chain tensioner bolts to 5 N.m (44 lb in) .

2. Final Pass

Tighten the left secondary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft) .

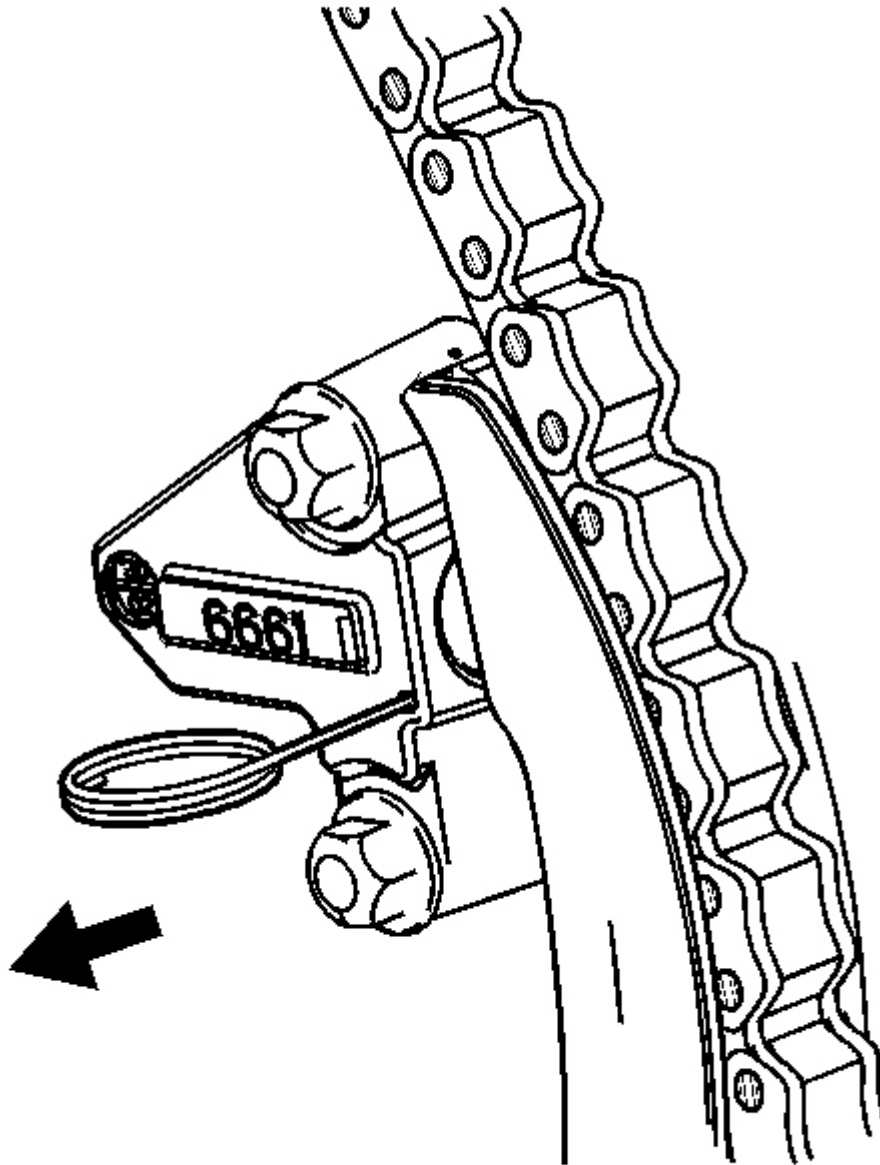


Fig. 55: View Of Left Secondary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

11. Release the left secondary camshaft drive chain tensioner by pulling out the **EN 46112**: pins and unlocking the tensioner plunger.
12. Verify the left secondary camshaft drive chain timing mark alignments by referring to **Timing Chain Alignment Diagram** - Stage One.

TIMING CHAIN IDLER SPROCKET INSTALLATION - RIGHT SIDE

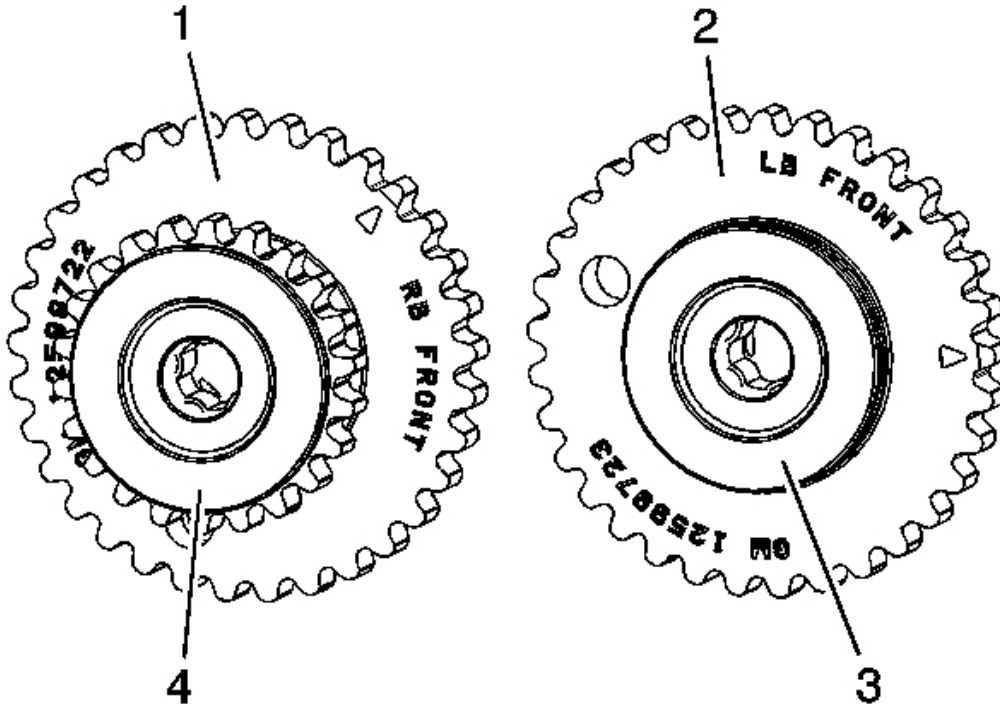


Fig. 56: View Of Camshaft Intermediate Drive Chain Idler - Left Side (Fourth Design)
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the right camshaft intermediate drive chain idler (1) is being installed. The recessed hub (4) and the smaller sprocket of the right camshaft intermediate drive chain idler is installed outward. The raised hub and the larger sprocket of the right camshaft intermediate drive chain idler is installed towards the block.

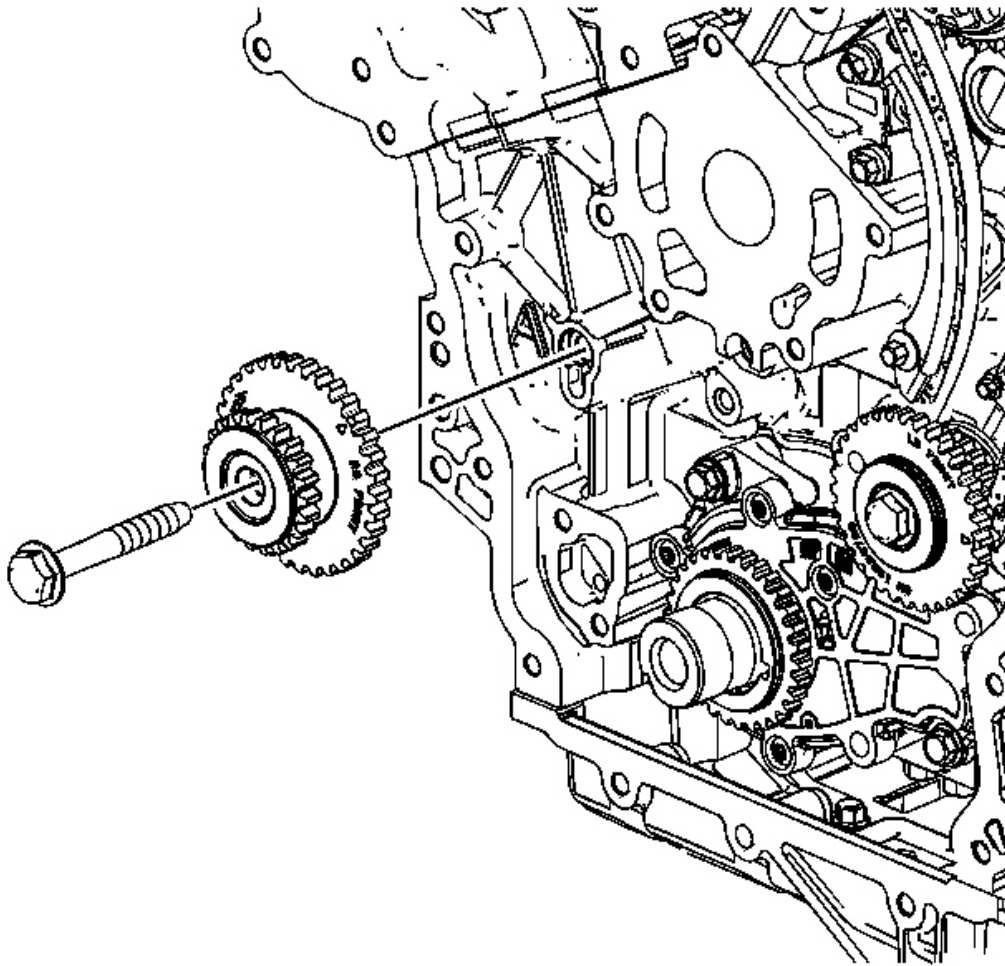


Fig. 57: View Of Right Camshaft Intermediate Drive Chain Idler & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Install the right camshaft intermediate drive chain idler.

CAUTION: Refer to Fastener Caution .

3. Install the camshaft intermediate drive chain idler bolt and tighten to 58 N.m (43 lb ft).

PRIMARY CAMSHAFT INTERMEDIATE DRIVE CHAIN INSTALLATION

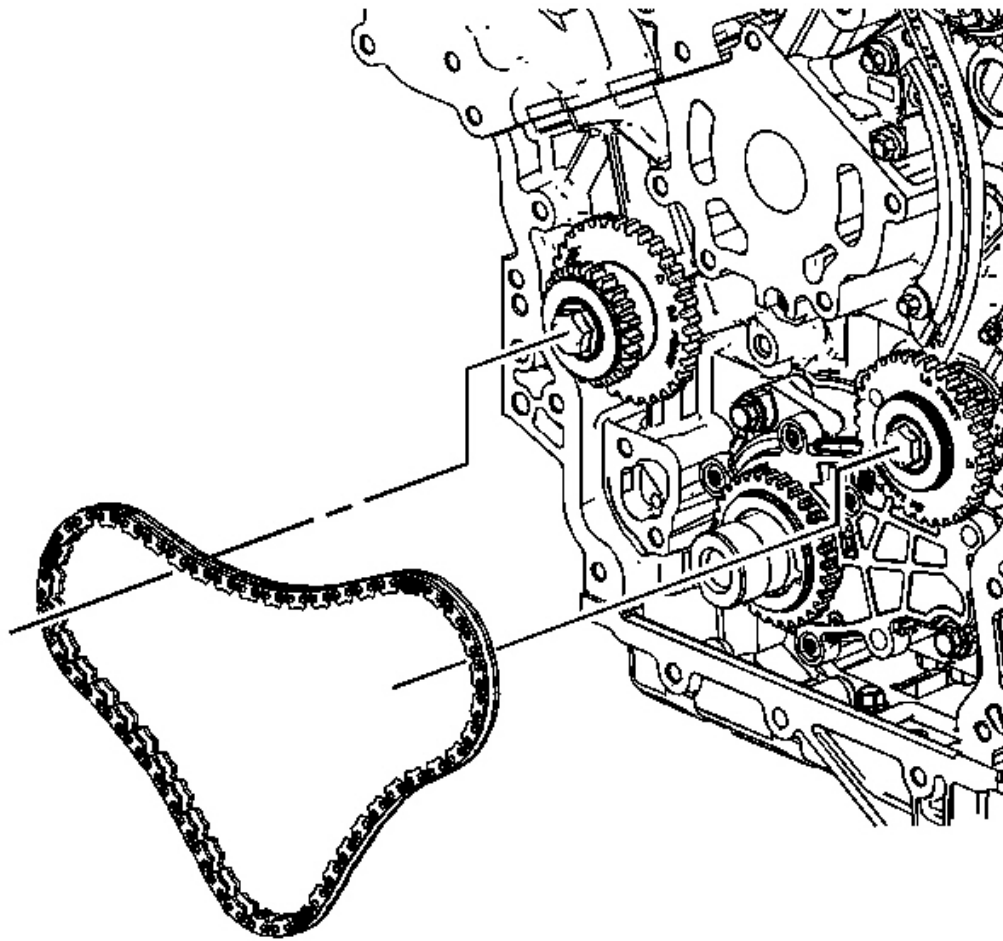


Fig. 58: View Of Primary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the crankshaft is in the stage one timing drive assembly position.

1. Install the primary camshaft drive chain.

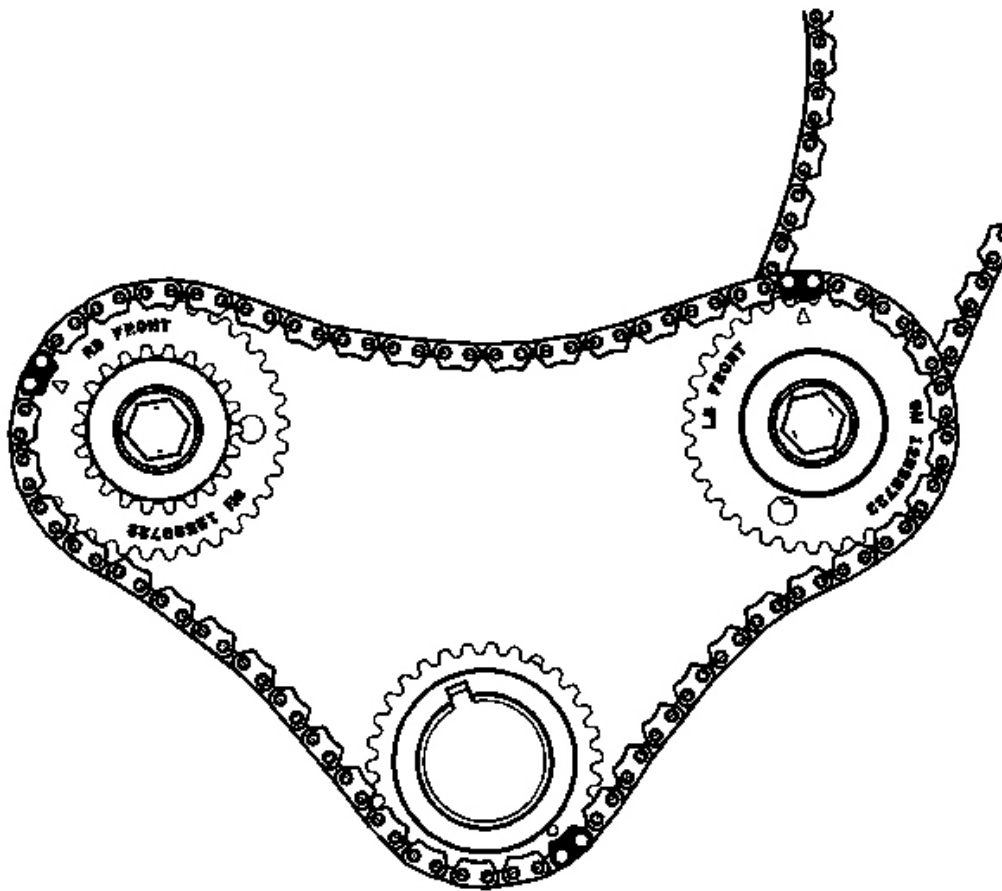


Fig. 59: View Of Primary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

2. Wrap the primary camshaft drive chain around the large sprockets of each camshaft intermediate drive chain idler and the crankshaft sprocket.

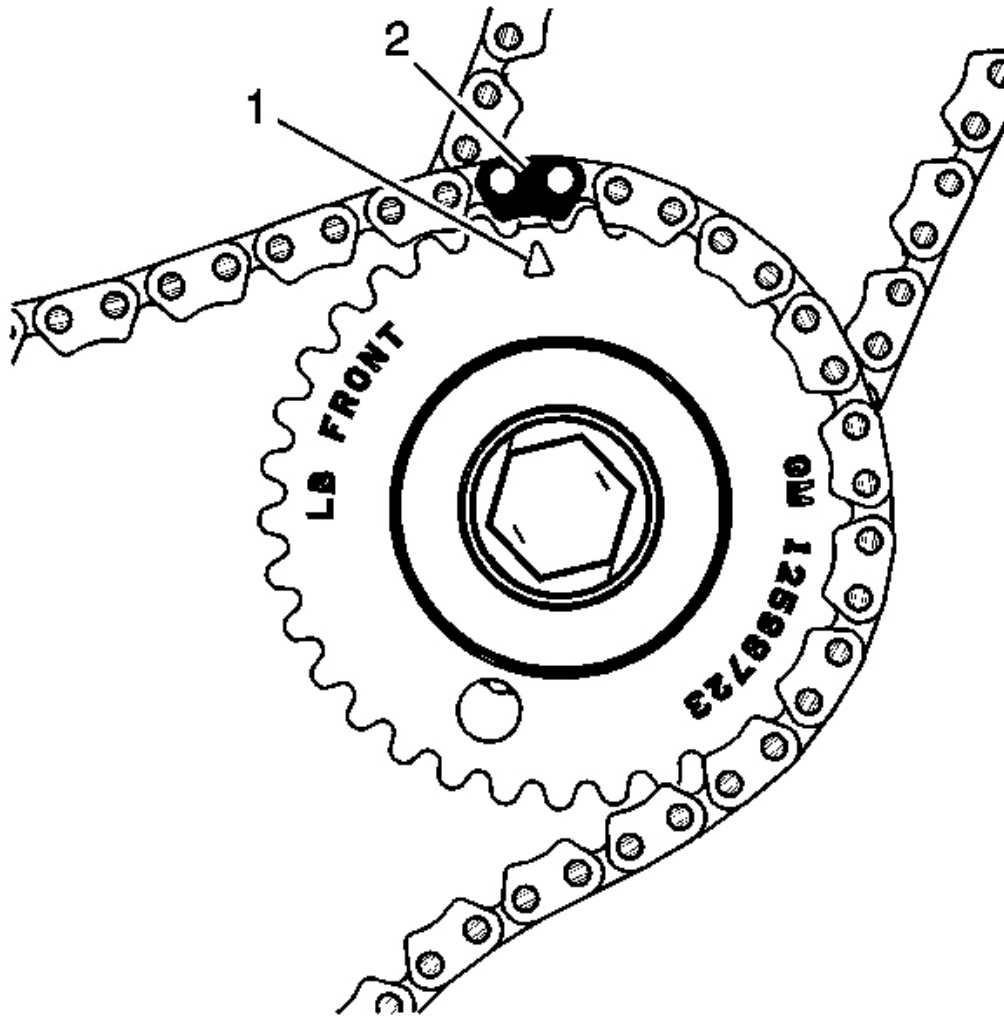


Fig. 60: View Of Camshaft Timing Marks
Courtesy of GENERAL MOTORS CORP.

3. The left camshaft intermediate drive chain idler timing mark (1) will align with a timing camshaft drive chain link (2).

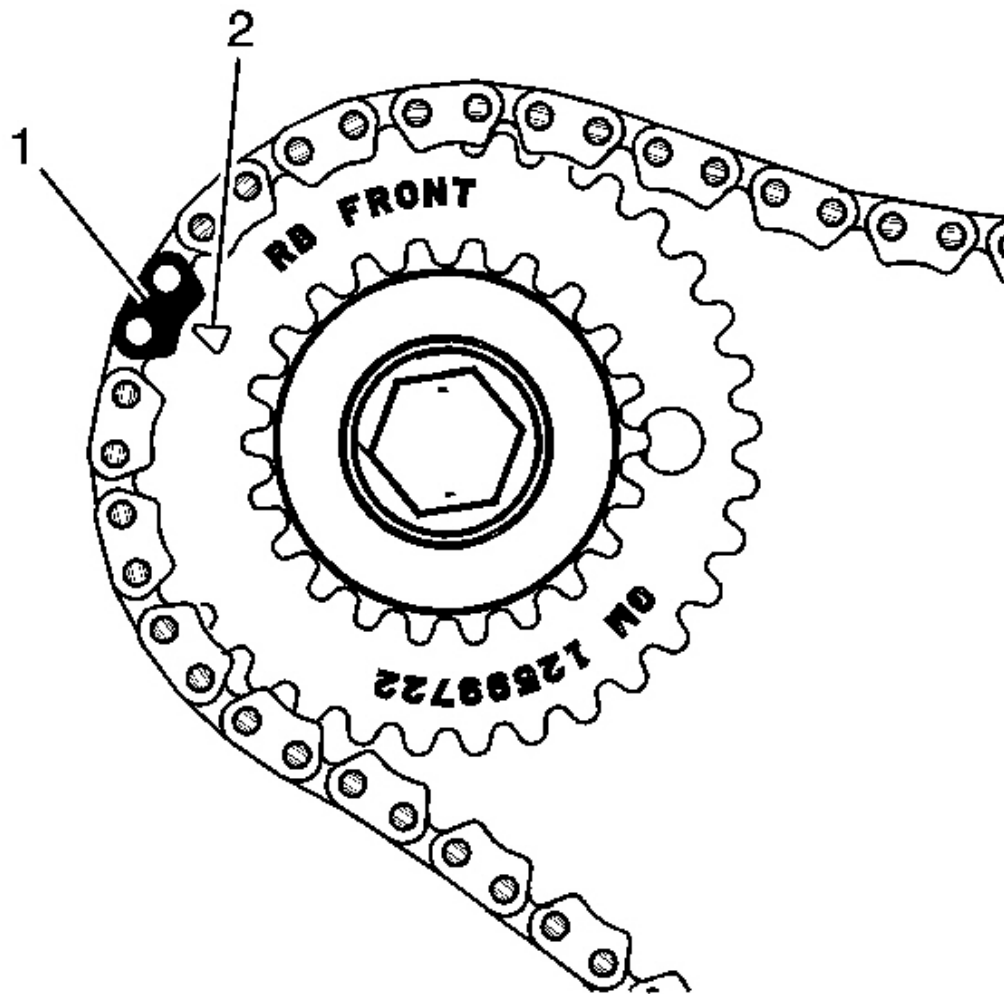


Fig. 61: View Of Right Camshaft Timing Marks
Courtesy of GENERAL MOTORS CORP.

4. The right camshaft intermediate drive chain idler timing mark (2) will align with a timing camshaft drive chain link (1).

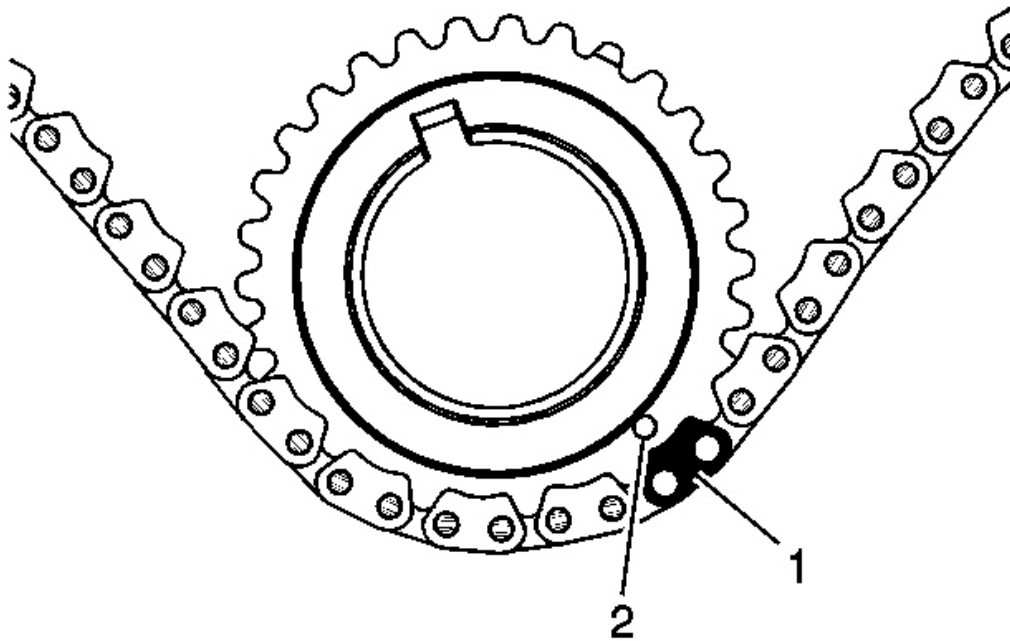


Fig. 62: View Of Crankshaft Sprocket Timing Mark & Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

5. The crankshaft sprocket timing mark (2) will align with a timing camshaft drive chain link (1).

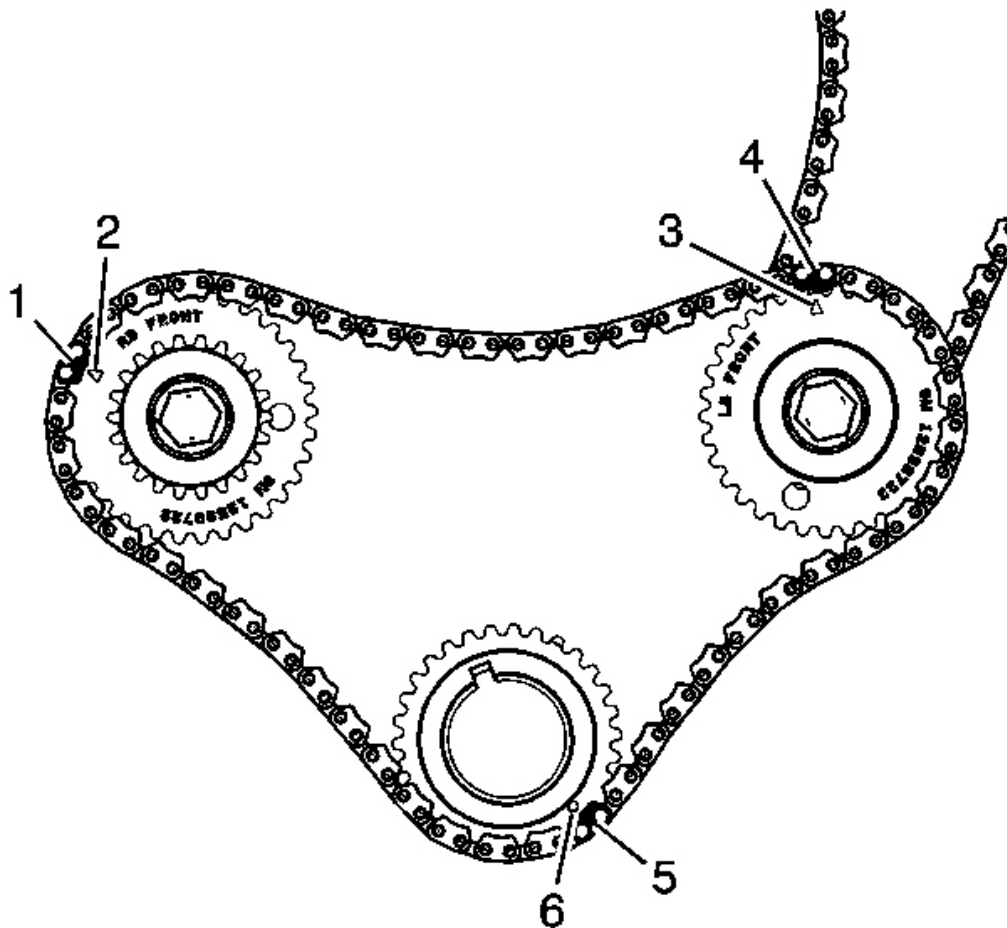


Fig. 63: Identifying Timing Marks & Drive Chain Links
Courtesy of GENERAL MOTORS CORP.

6. Ensure all the timing marks (2, 3, 6) are properly aligned with the timing camshaft drive chain links (1, 4, 5).

PRIMARY TIMING CHAIN GUIDE INSTALLATION - LOWER

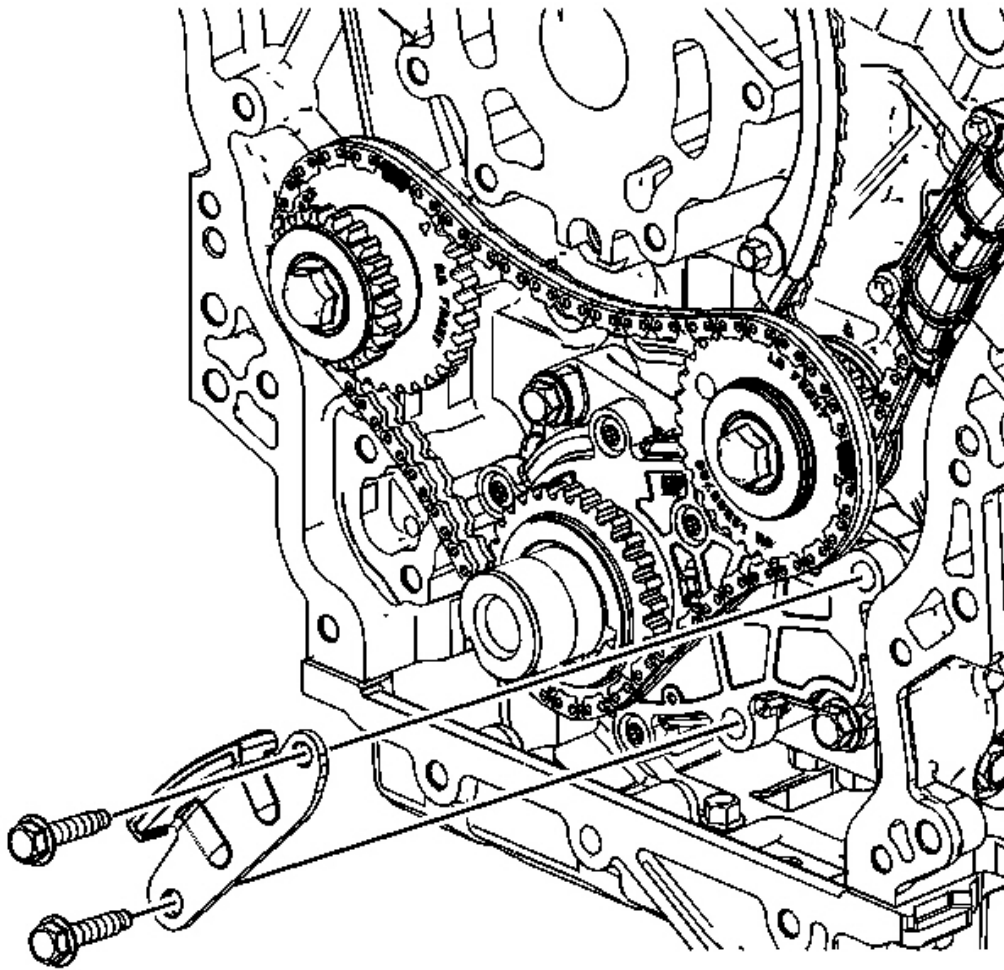


Fig. 64: View Of Primary Camshaft Drive Chain Lower Guide Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the primary camshaft drive chain lower guide to the oil pump.

CAUTION: Refer to Fastener Caution .

2. Install the primary camshaft drive chain lower guide bolts and tighten to 25 N.m (18 lb ft).

PRIMARY TIMING CHAIN GUIDE INSTALLATION - UPPER

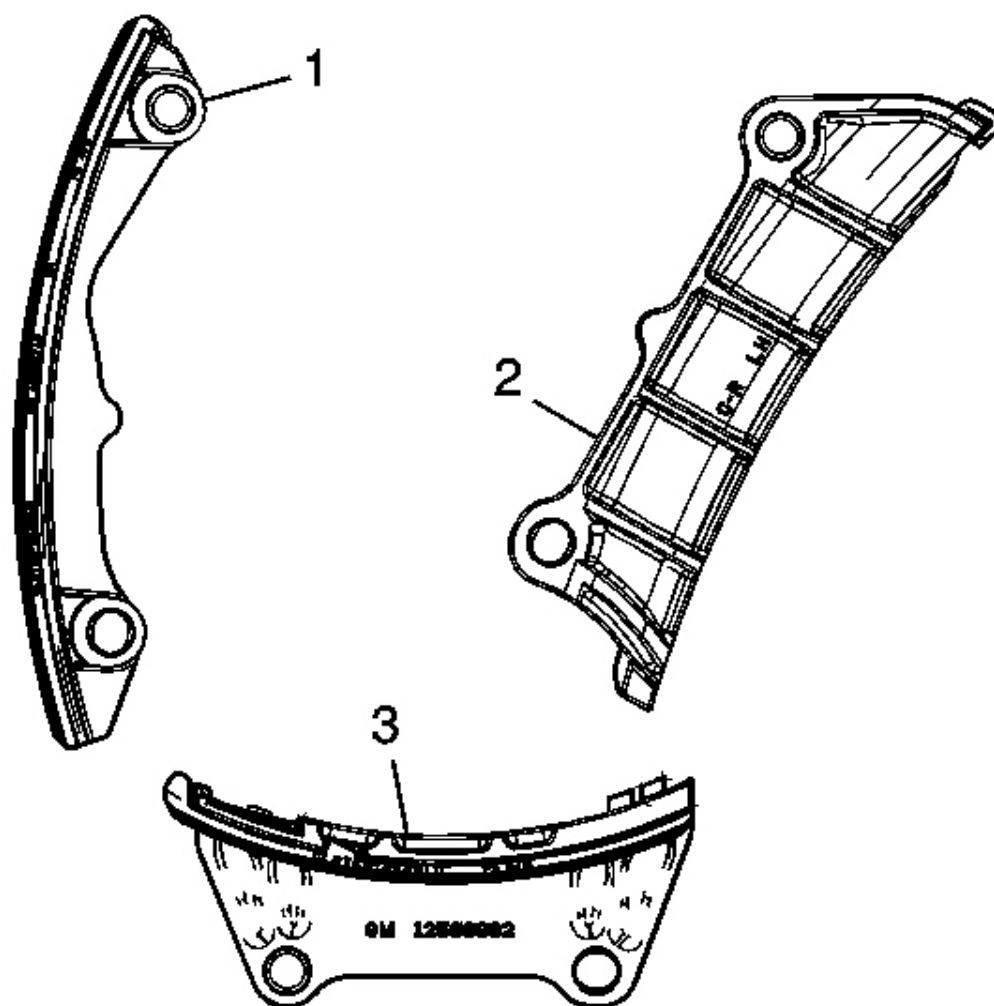


Fig. 65: View Of Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Ensure the upper primary camshaft drive chain guide (3) is being installed.

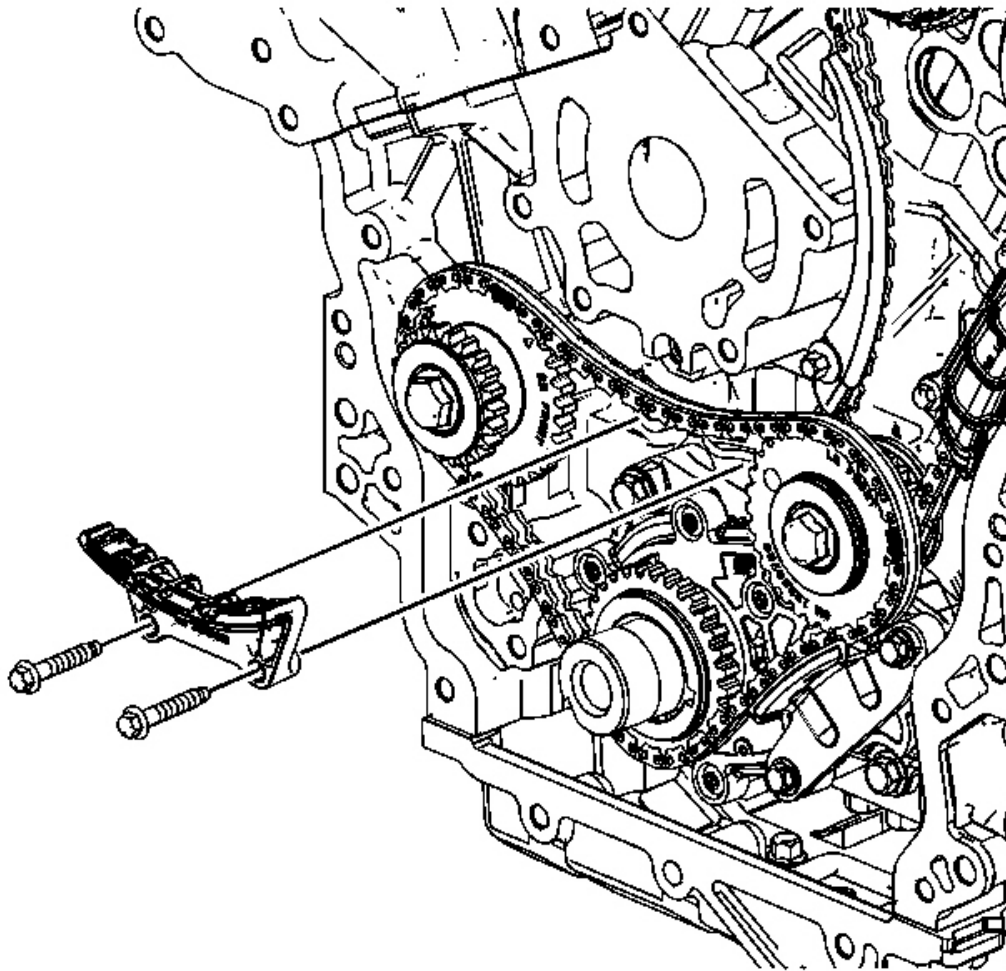


Fig. 66: View Of Primary Camshaft Drive Chain Upper Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the upper primary camshaft drive chain guides.

CAUTION: Refer to Fastener Caution .

3. Install the upper primary camshaft drive chain guide bolts and tighten to 25 N.m (18 lb ft).

PRIMARY CAMSHAFT INTERMEDIATE DRIVE CHAIN TENSIONER INSTALLATION

Special Tools

- **EN-45027:** Tensioner Tool
- **EN-46112:** Tensioner Retraction Pins
- **EN-48383:** Camshaft Retaining Tools
- **EN-48589:** Crankshaft Rotation Socket

For equivalent regional tools, refer to **Special Tools** .

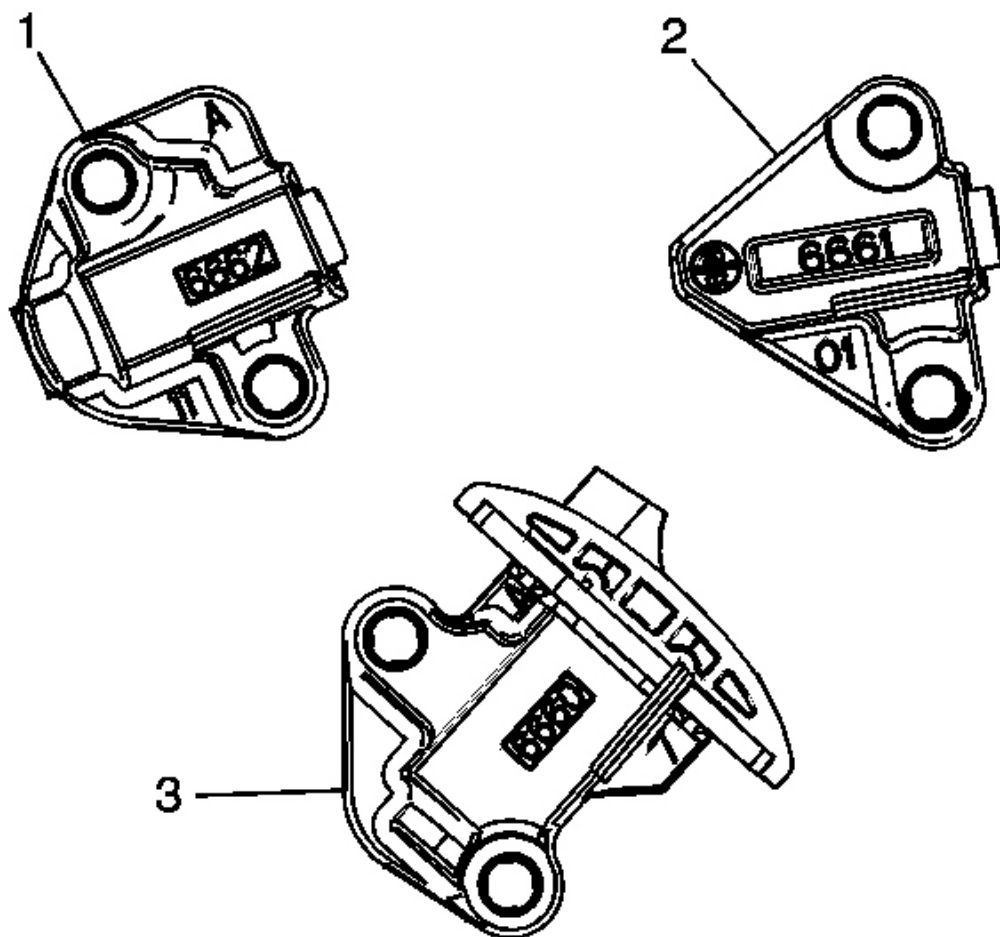


Fig. 67: Identifying Left & Right Secondary Camshaft Drive Chain Tensioner & Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the primary camshaft drive chain tensioner (3) is being installed.

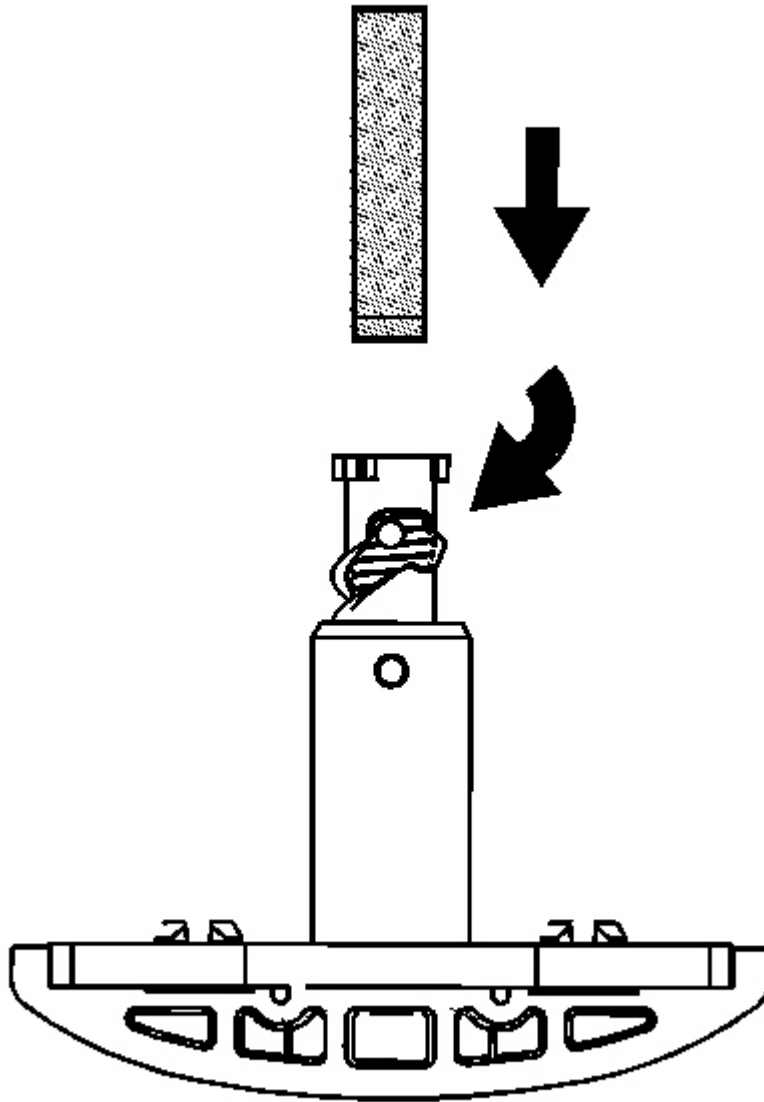


Fig. 68: View Of Primary Camshaft Drive Chain Tensioner Plunger & J 45027
Courtesy of GENERAL MOTORS CORP.

2. Using the **EN-45027**: tool, reset the primary camshaft drive chain tensioner plunger.

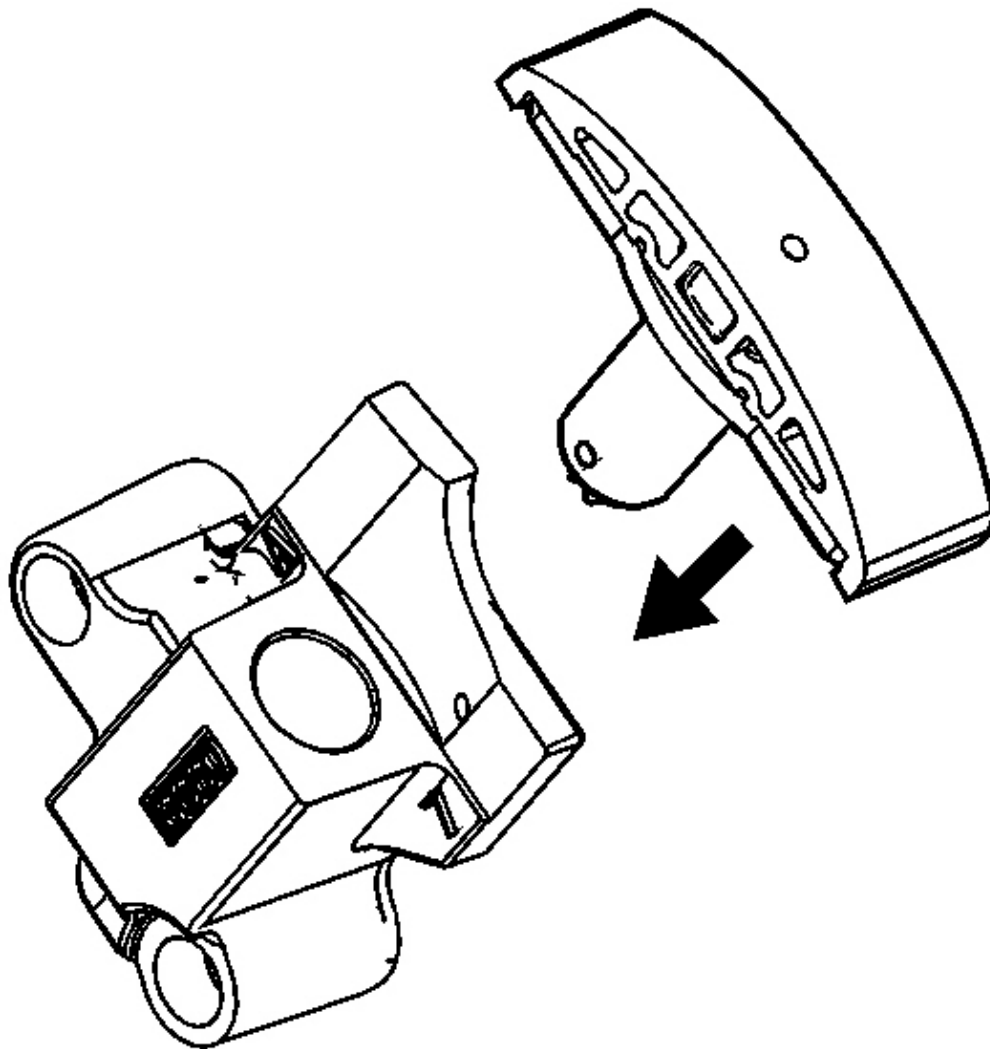


Fig. 69: Installing Plunger Into Primary Camshaft Drive Chain Tensioner Body
Courtesy of GENERAL MOTORS CORP.

3. Install the plunger into the primary camshaft drive chain tensioner body.

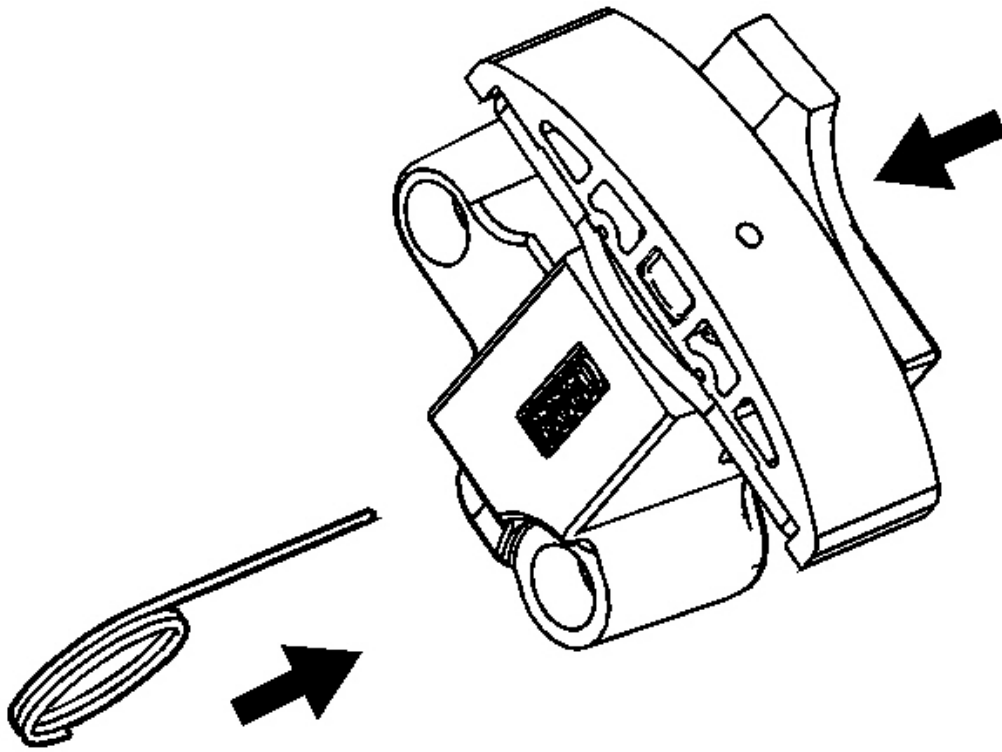


Fig. 70: Inserting EN 46112 Into Primary Camshaft Drive Chain Tensioner Body
Courtesy of GENERAL MOTORS CORP.

4. Compress the plunger into the body and lock the primary camshaft drive chain tensioner by inserting the **EN-46112** pins into the access hole in the side of the primary camshaft drive chain tensioner body.
5. Slowly release pressure on the primary camshaft drive chain tensioner. The primary camshaft drive chain tensioner should remain compressed.

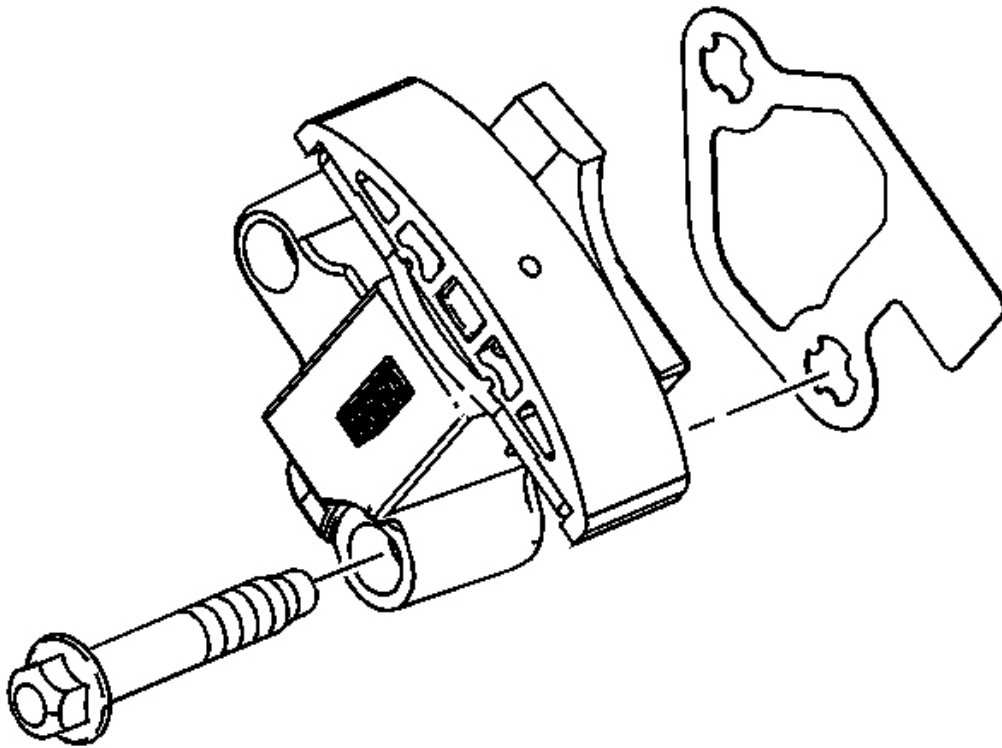


Fig. 71: View Of Primary Camshaft Drive Chain Tensioner Gasket
Courtesy of GENERAL MOTORS CORP.

6. Install a NEW primary camshaft drive chain tensioner gasket to the primary camshaft drive chain tensioner.
7. Install the primary camshaft drive chain tensioner bolts through the primary camshaft drive chain tensioner and gasket.
8. 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.

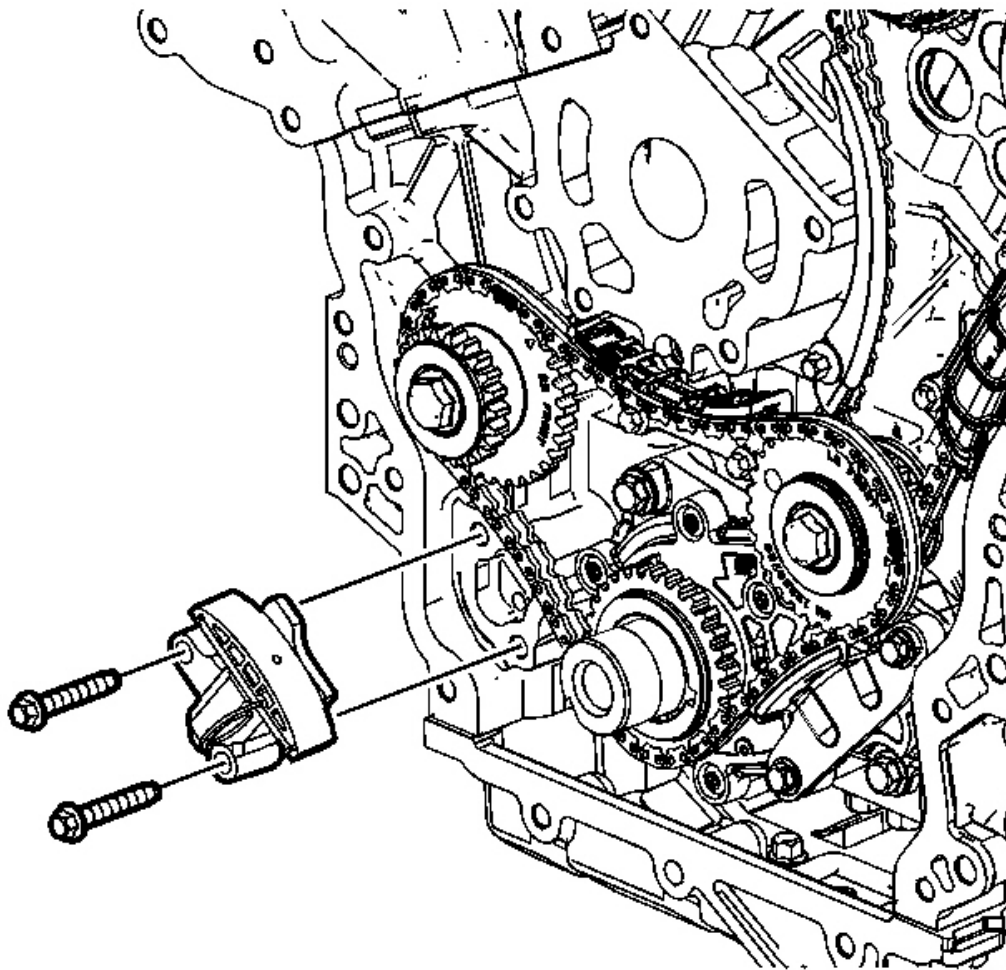


Fig. 72: View Of Primary Camshaft Drive Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Place the primary camshaft drive chain tensioner into position and loosely install the bolts to the block.

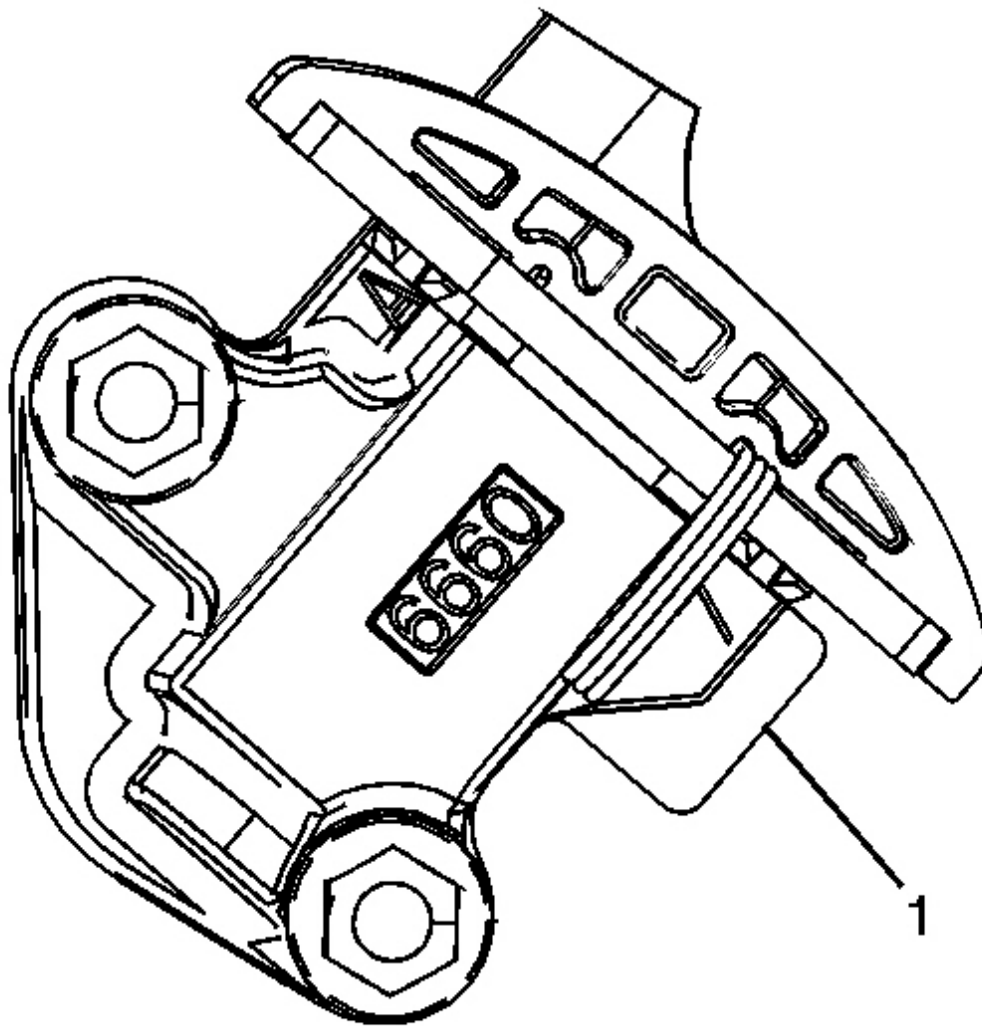


Fig. 73: Locating Primary Camshaft Drive Chain Tensioner Gasket Tab
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

10. Verify the proper placement of the primary camshaft drive chain tensioner gasket tab (1).
 1. First Pass

Tighten the primary camshaft drive chain tensioner bolts to 5 N.m (44 lb in) .

2. Final Pass

Tighten the primary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft) .

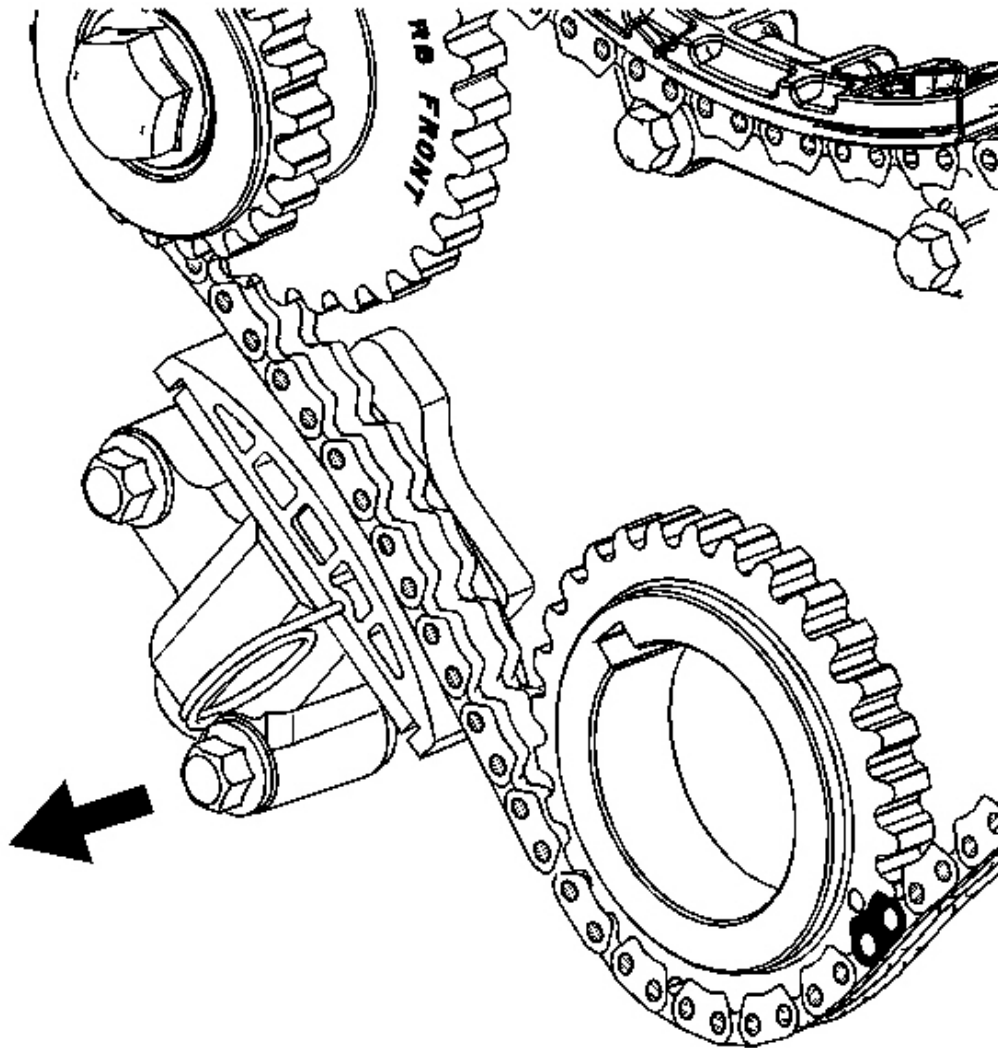


Fig. 74: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

11. Release the primary camshaft drive chain tensioner by pulling out the **EN-46112** pins and unlocking the tensioner plunger.
12. Verify the primary and left secondary camshaft drive chain timing mark alignments. Refer to **Timing**

Chain Alignment Diagram - Stage One.

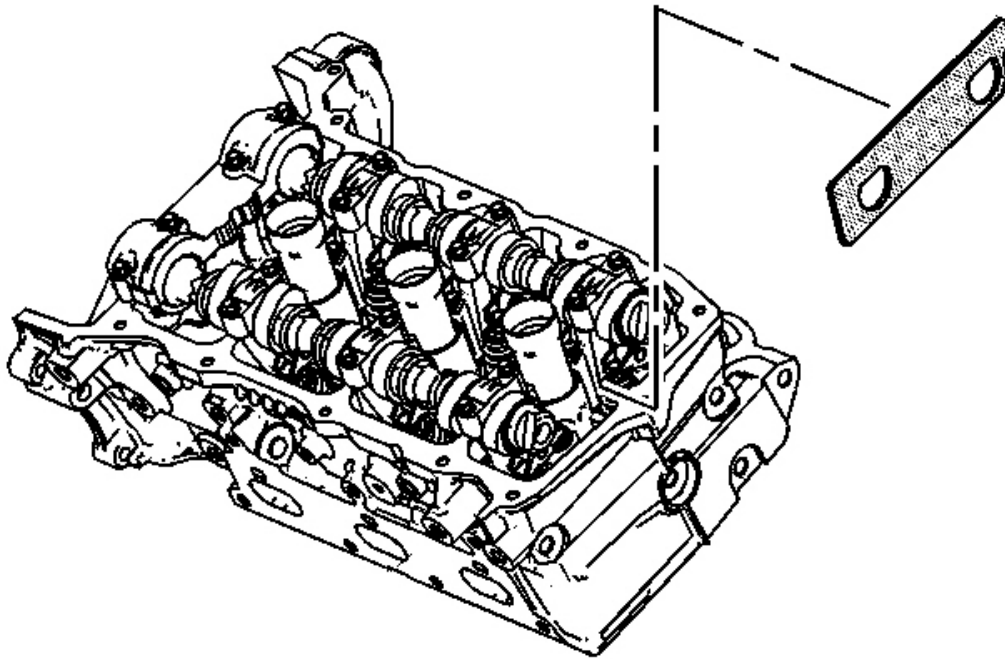


Fig. 75: Removing Special Tool
Courtesy of GENERAL MOTORS CORP.

13. Remove the EN 48383-1 from the rear of the left camshafts.

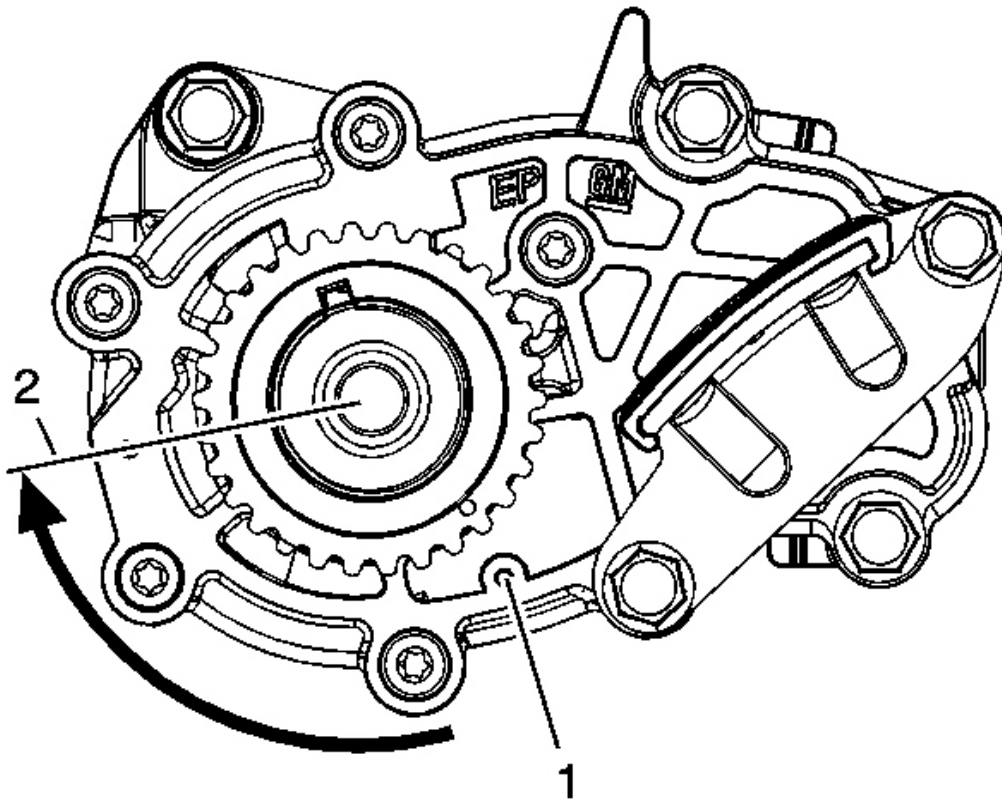


Fig. 76: View Of Stage 1 & Stage 2 Alignment Positions
Courtesy of GENERAL MOTORS CORP.

14. Using the **EN-48589**: socket, rotate the crankshaft and crankshaft sprocket from the stage 1 alignment position (1) to the stage 2 alignment position (2), 115 crankshaft degrees, in order to install the right secondary camshaft drive chain components.

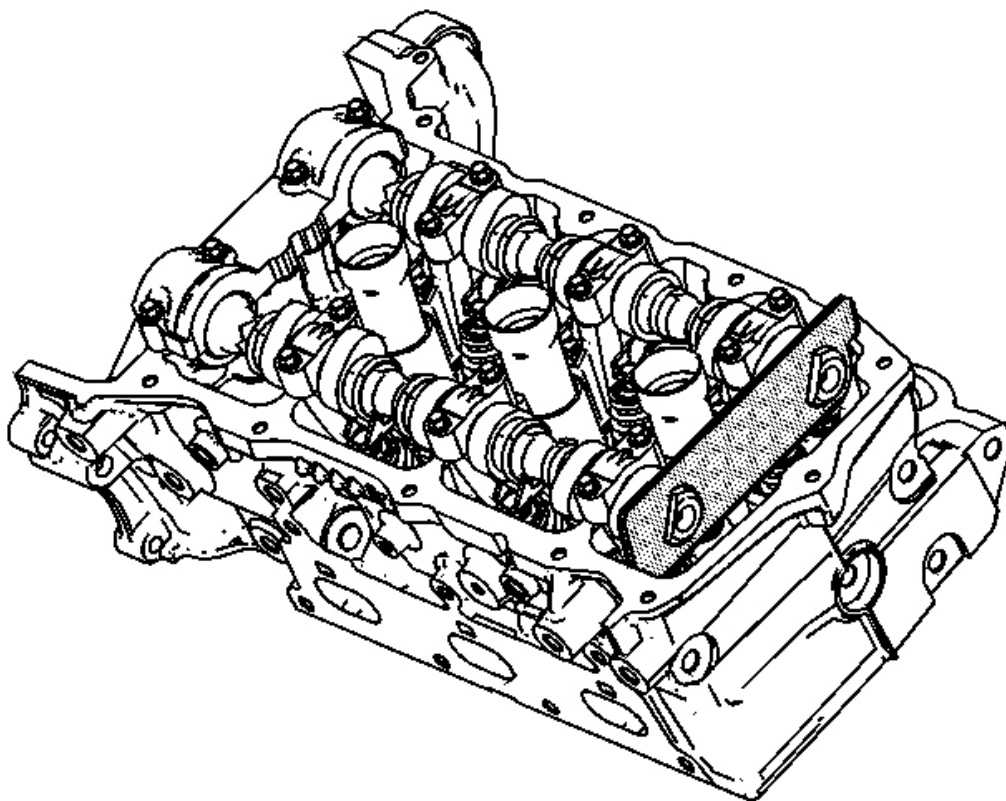


Fig. 77: EN 46105-2 Installed To Left Camshafts
Courtesy of GENERAL MOTORS CORP.

15. Install the EN 48383-2 onto the rear of the left camshafts.

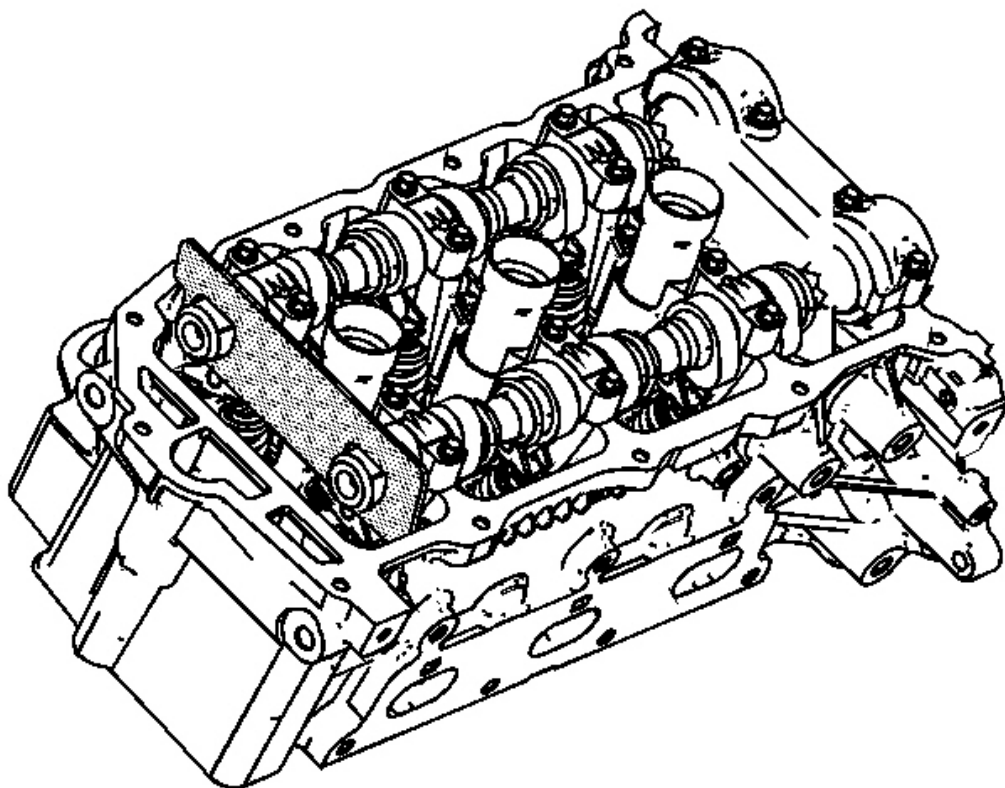


Fig. 78: EN 46105-1 Installed To Right Camshafts
Courtesy of GENERAL MOTORS CORP.

16. Install the EN 48383-3 onto the rear of the right camshafts.

SECONDARY CAMSHAFT INTERMEDIATE DRIVE CHAIN INSTALLATION - RIGHT SIDE

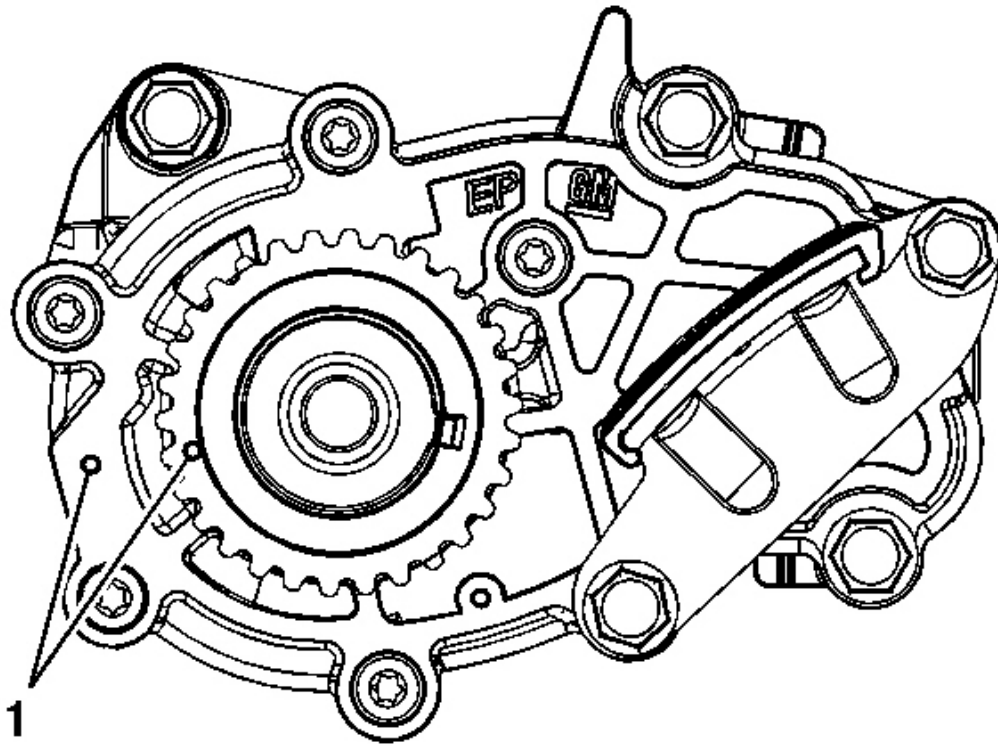


Fig. 79: View Of Crankshaft In Stage 2 Timing Drive Assembly Position
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the crankshaft is in the stage 2 timing drive assembly position (1).

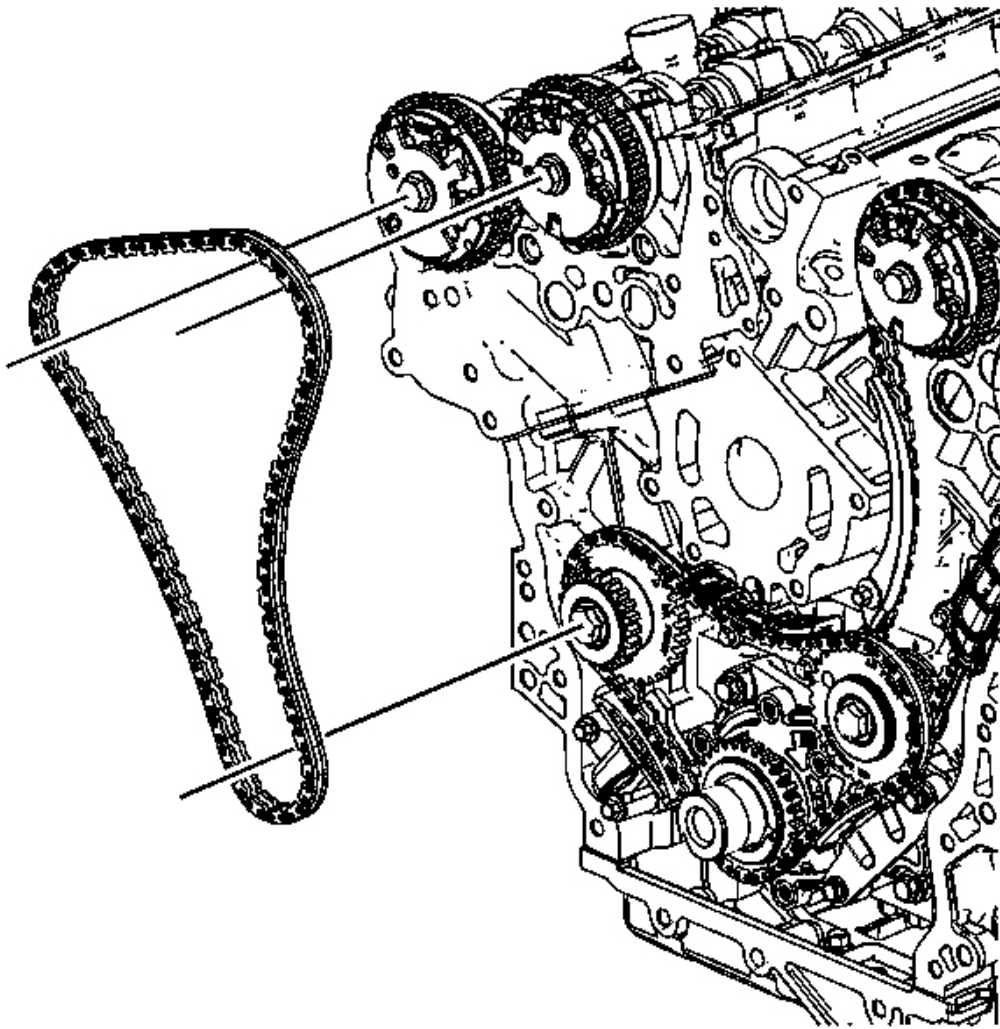


Fig. 80: View Of Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

2. Install the right secondary camshaft drive chain.

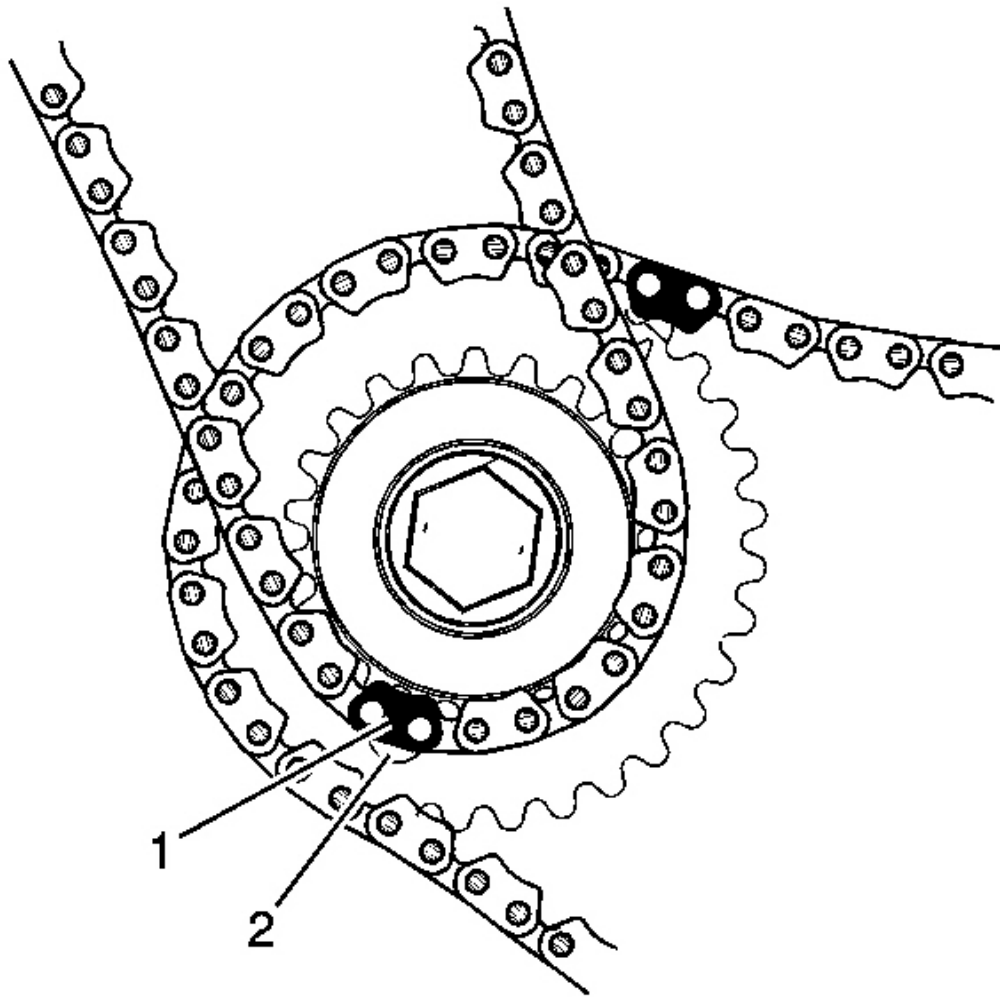


Fig. 81: View Of Timing Camshaft Drive Chain Link & Alignment Access Hole
Courtesy of GENERAL MOTORS CORP.

3. Place the secondary camshaft drive chain around the right camshaft intermediate drive chain idler outer sprocket, aligning the timing camshaft drive chain link (1) with the alignment access hole (2) made in the right camshaft intermediate drive chain idler inner sprocket.

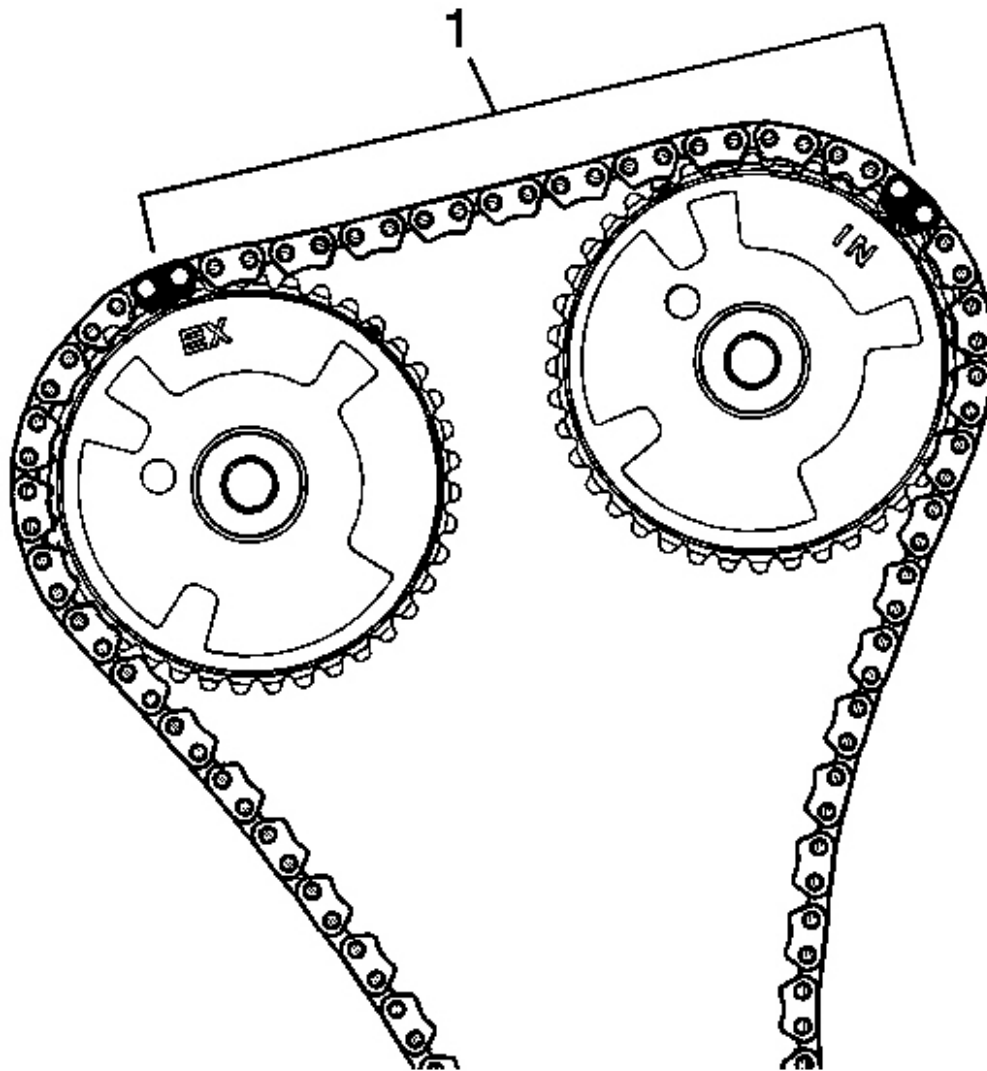


Fig. 82: View Of Links

Courtesy of GENERAL MOTORS CORP.

4. Wrap the secondary camshaft drive chain around both right actuator drive sprockets.
5. Ensure there are 10 links (1) between the timing camshaft drive chain links for the camshaft position actuator sprockets.

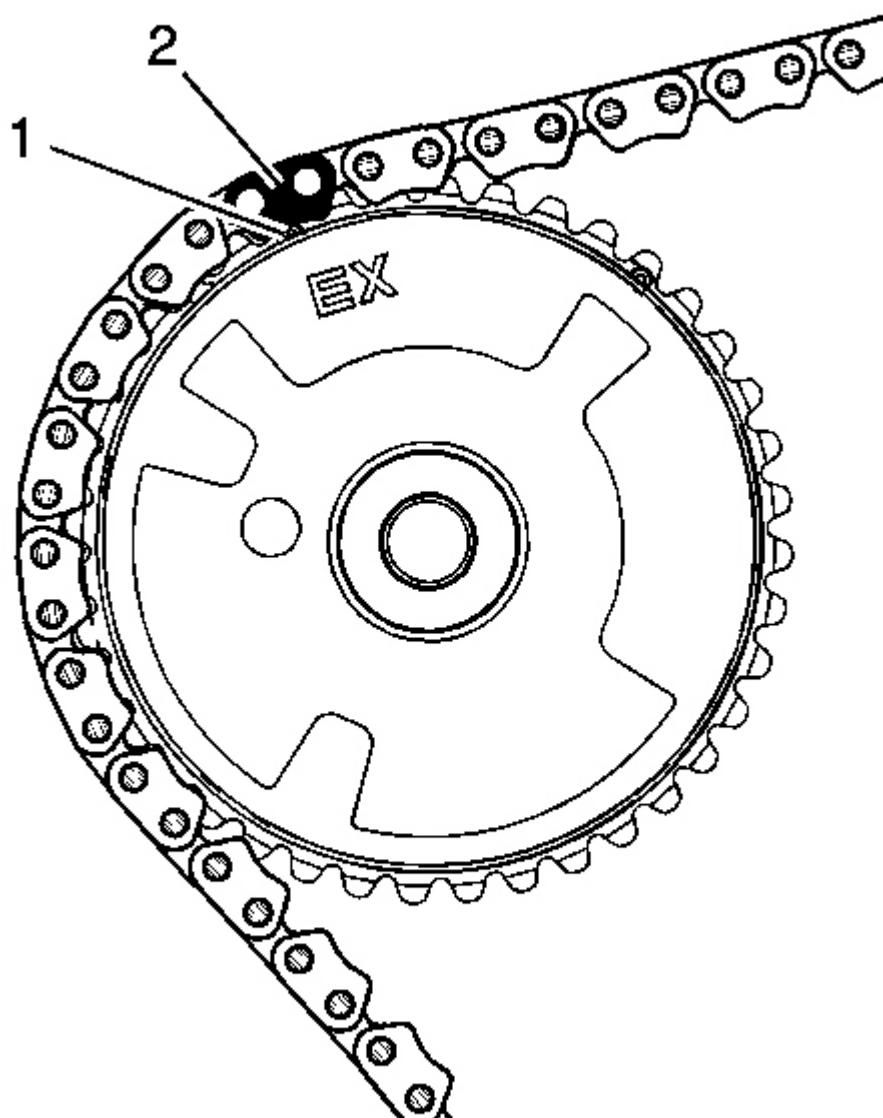


Fig. 83: View Of Camshaft Marks
Courtesy of GENERAL MOTORS CORP.

6. Align the right exhaust camshaft position actuator sprocket alignment triangle mark (1) with the timing camshaft drive chain link (2).

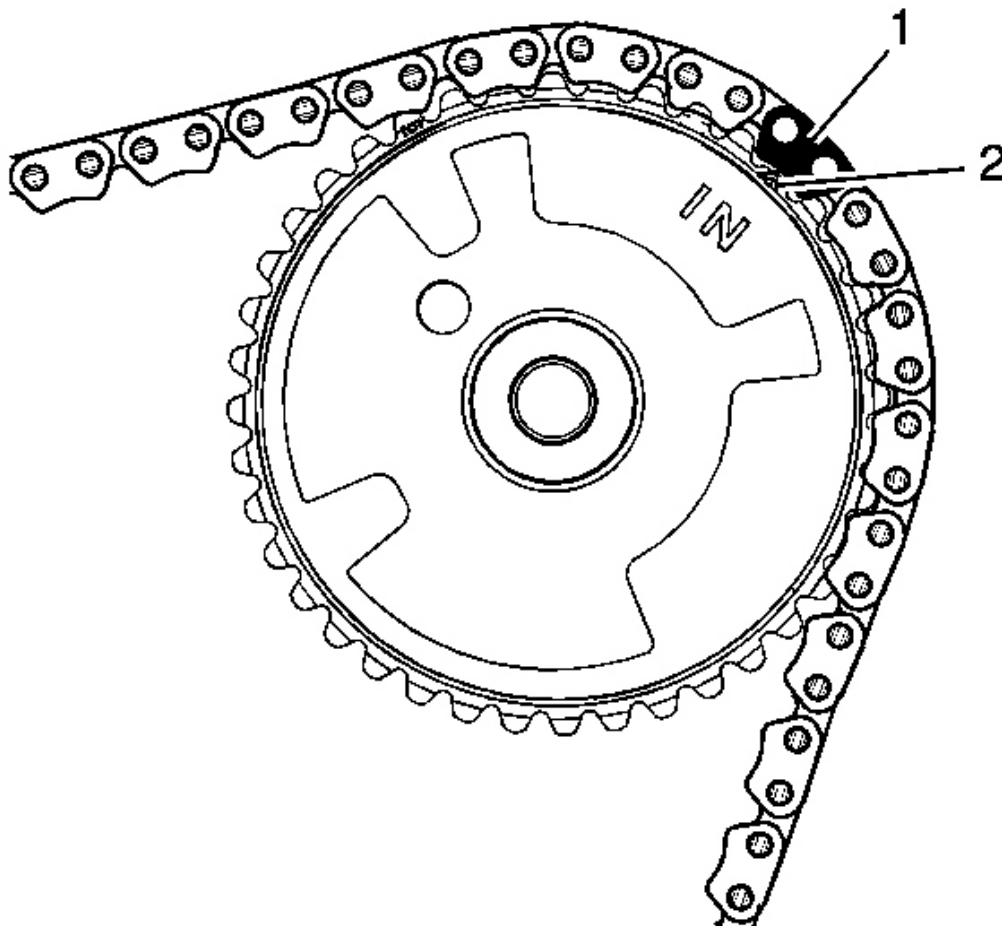


Fig. 84: View Of Right Intake Camshaft Position Actuator Sprocket Alignment Triangle Mark
Courtesy of GENERAL MOTORS CORP.

7. Align the right intake camshaft position actuator sprocket alignment triangle mark (2) with the timing camshaft drive chain link (1).

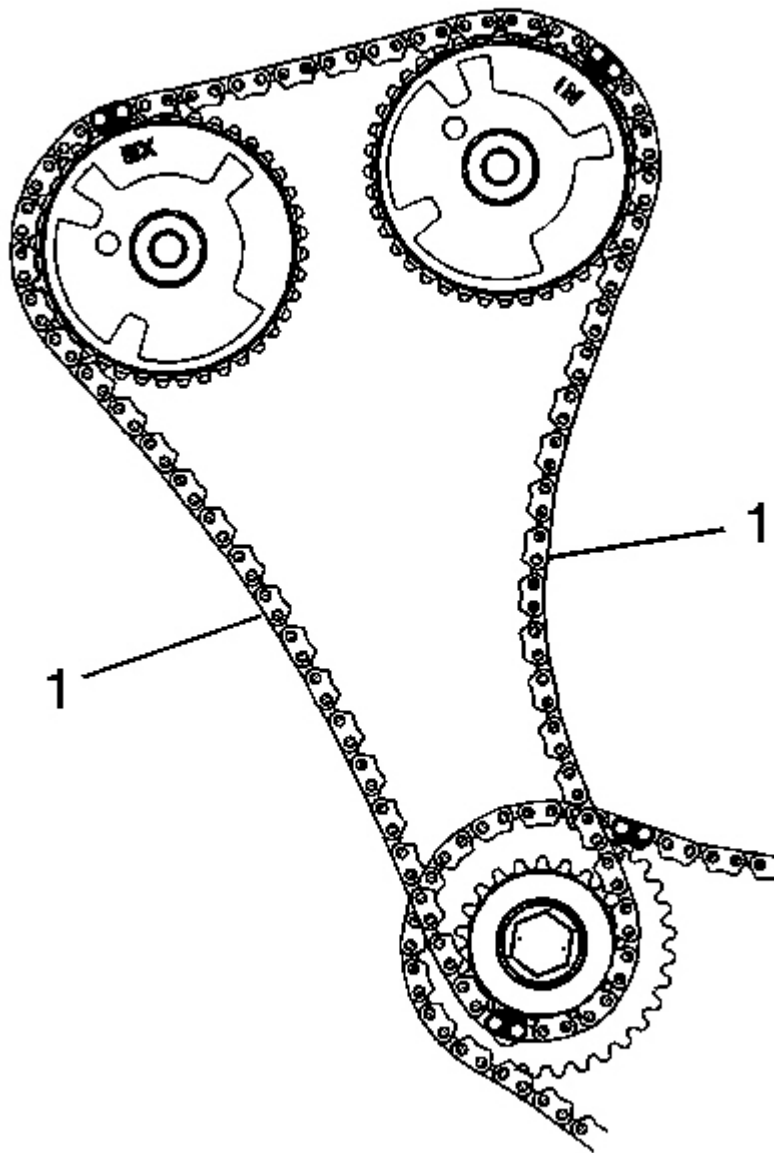


Fig. 85: Identifying Correct Number Of Links Between Points
Courtesy of GENERAL MOTORS CORP.

8. There will be 22 links (1) 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.

SECONDARY TIMING CHAIN GUIDE INSTALLATION - RIGHT SIDE

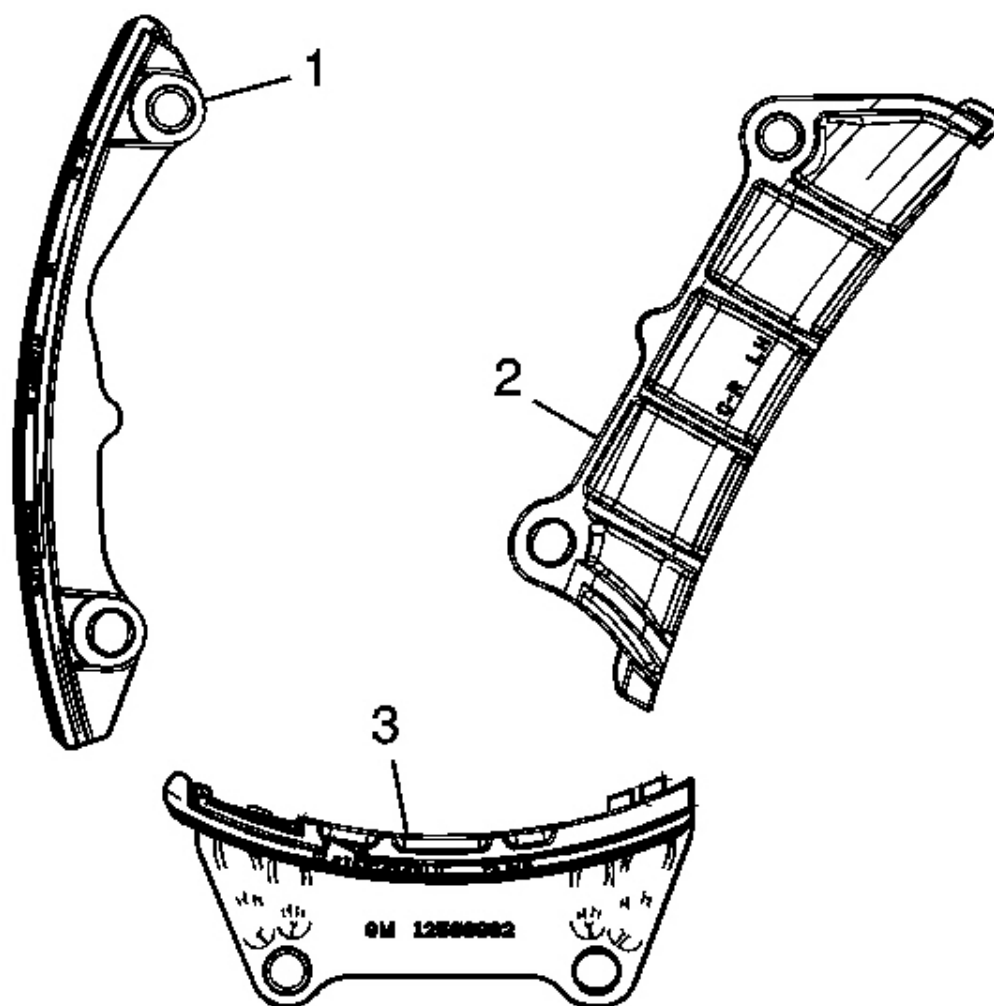


Fig. 86: View Of Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the right secondary camshaft drive chain guide (1) is being installed.

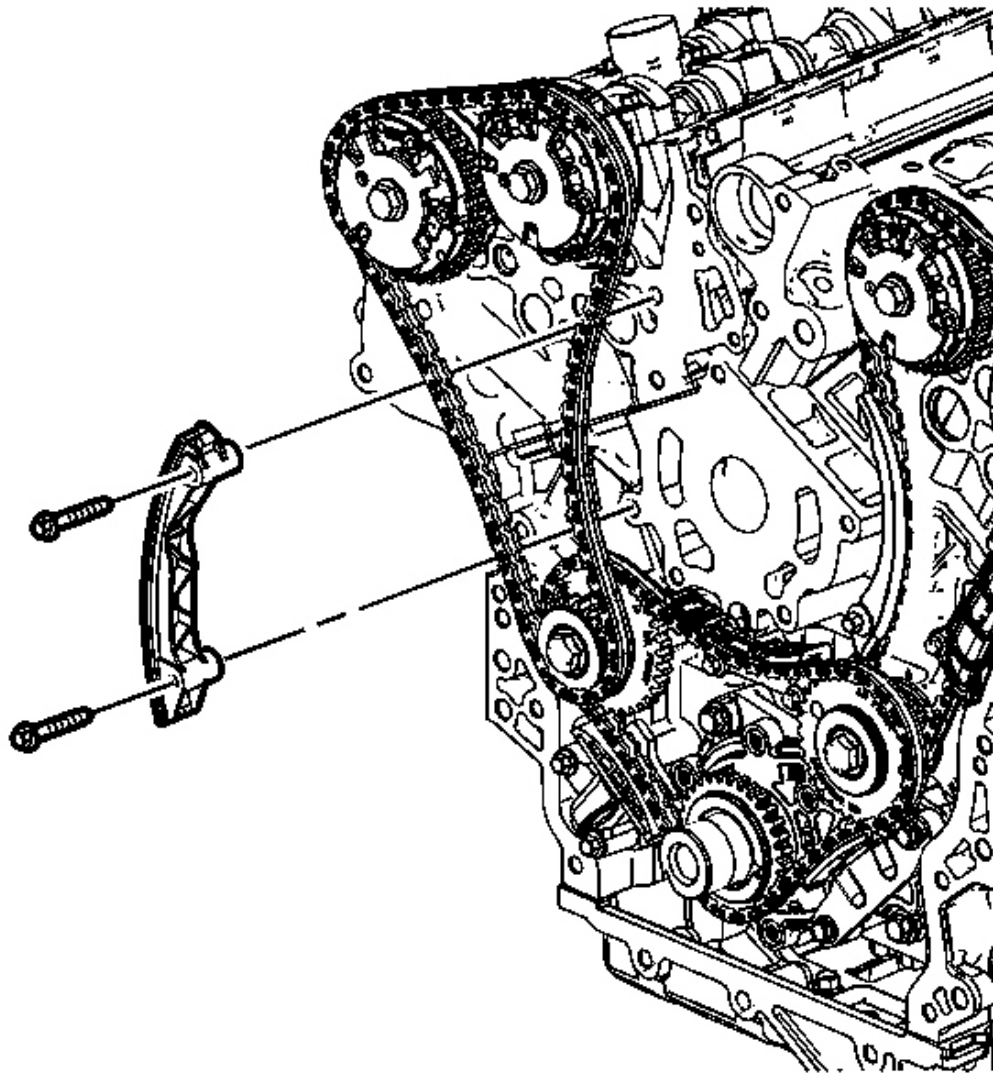


Fig. 87: View Of Right Secondary Camshaft Drive Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Position the right secondary camshaft drive chain guide.

CAUTION: Refer to Fastener Caution .

3. Install the secondary camshaft drive chain guide bolts and tighten to 25 N.m (18 lb ft).

SECONDARY CAMSHAFT DRIVE CHAIN SHOE INSTALLATION - RIGHT SIDE

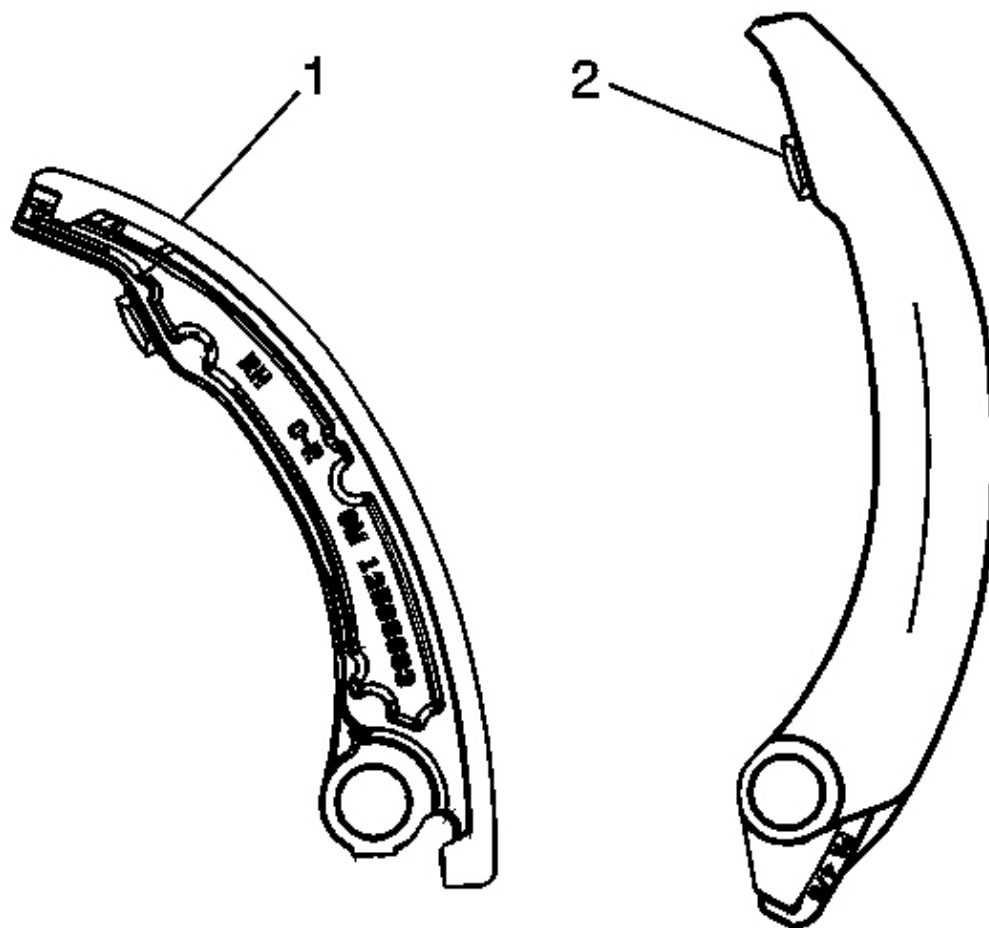


Fig. 88: Identifying Correct Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the right secondary camshaft drive chain shoe (1) is being installed.

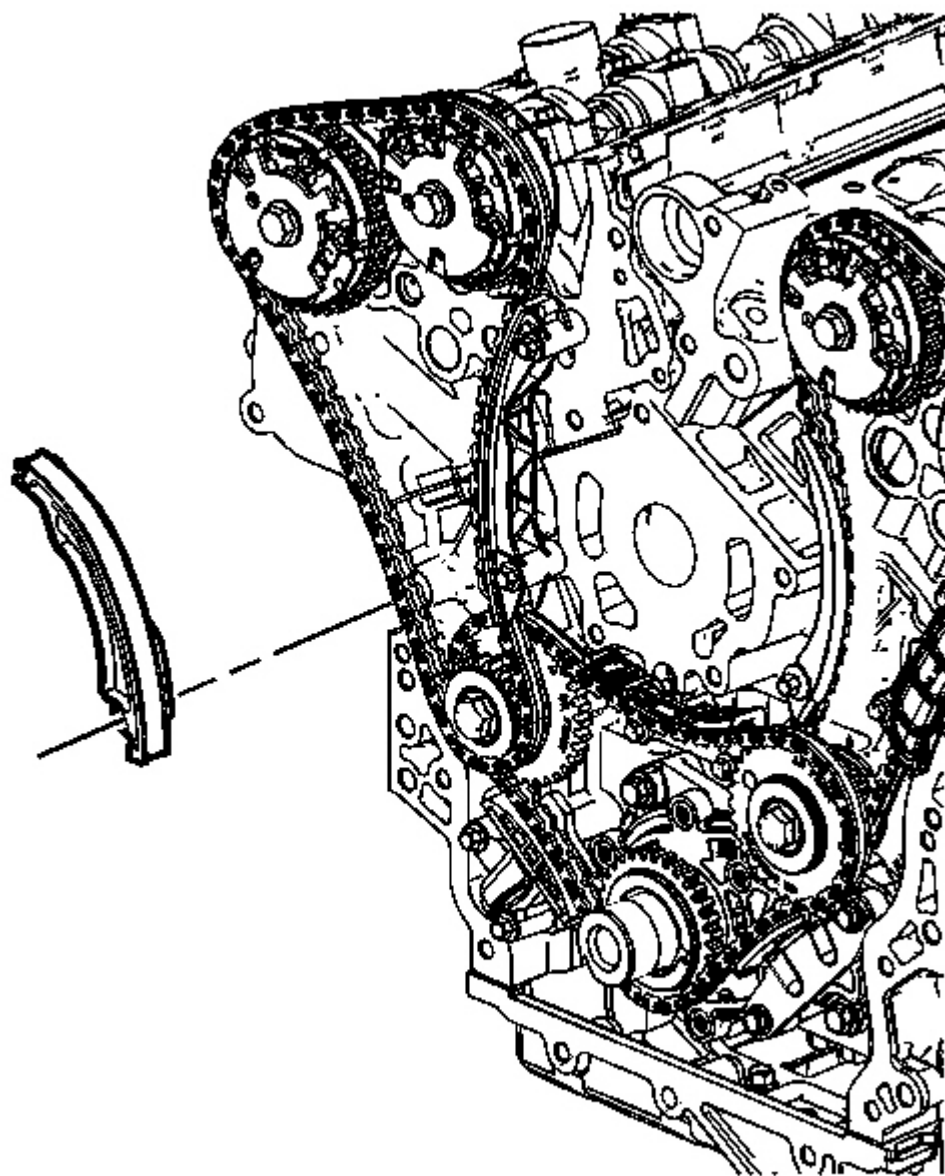


Fig. 89: View Of Right Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

2. Position the right secondary camshaft drive chain shoe.

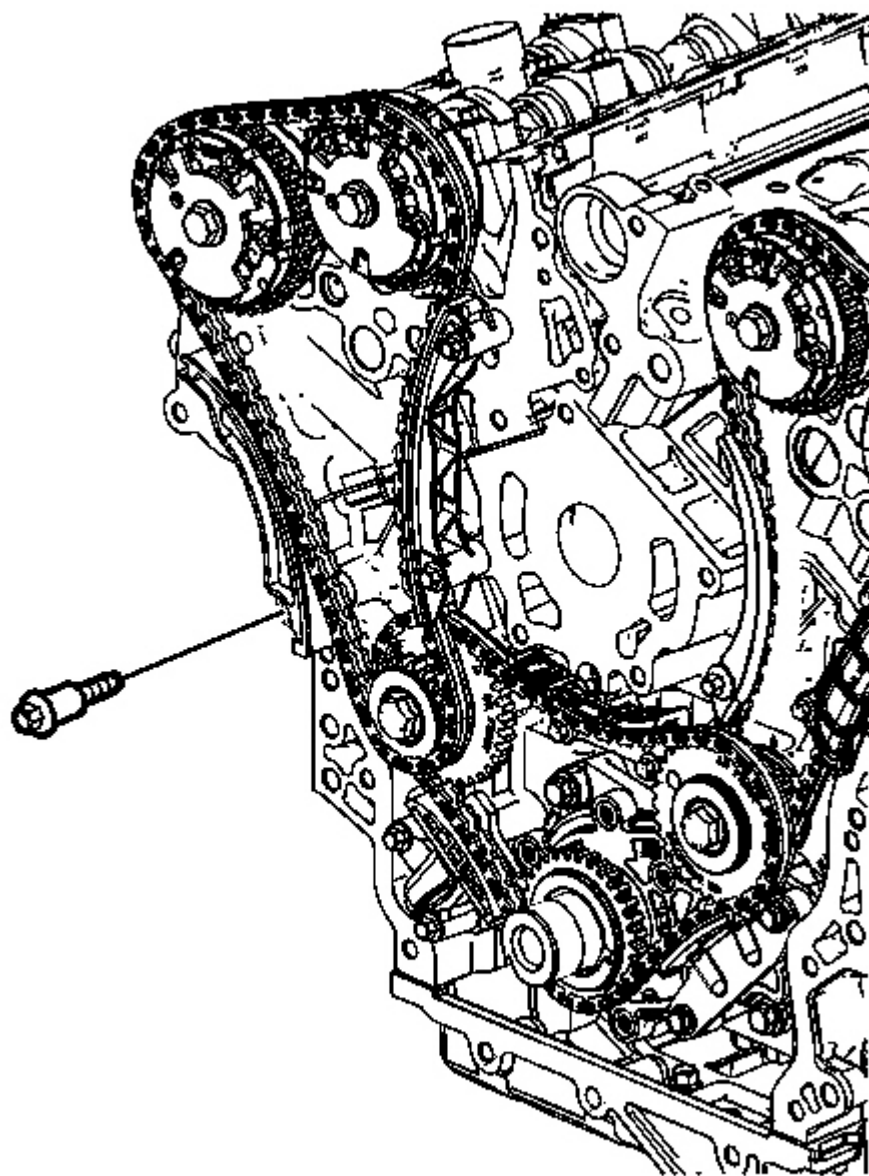


Fig. 90: View Of Right Secondary Camshaft Drive Chain Shoe Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the secondary camshaft drive chain shoe bolt and tighten to 25 N.m (18 lb ft).

SECONDARY TIMING CHAIN TENSIONER INSTALLATION - RIGHT SIDE

Special Tools

- EN 45027: Tensioner Tool
- EN 46112: Tensioner Retraction Pins

For equivalent regional tools, refer to **Special Tools** .

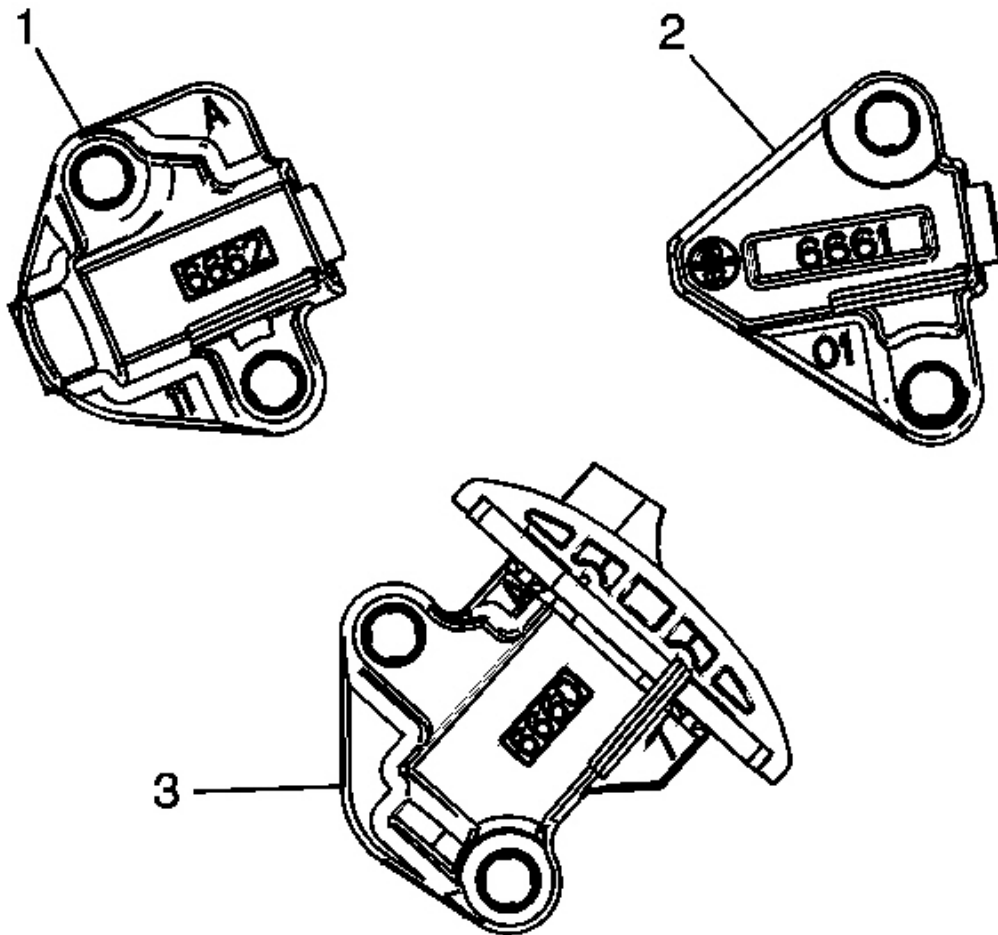


Fig. 91: Identifying Left & Right Secondary Camshaft Drive Chain Tensioner & Primary Camshaft Drive Chain Tensioner

Courtesy of GENERAL MOTORS CORP.

1. Ensure that the right secondary camshaft drive chain tensioner (1) is being installed.

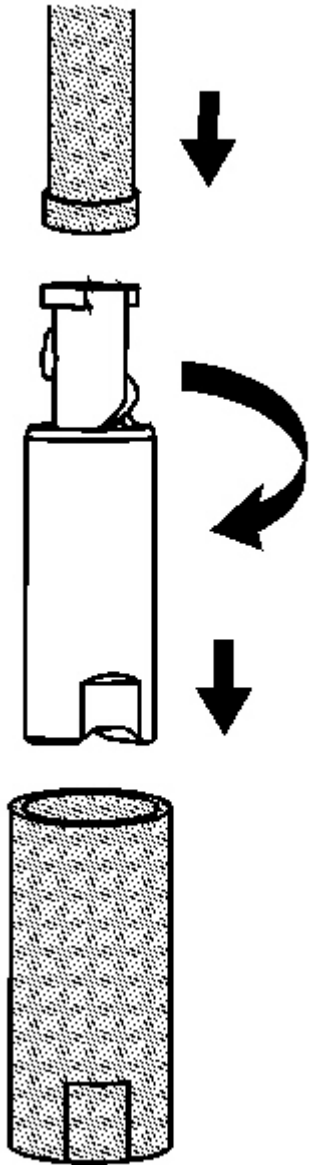


Fig. 92: Resetting Left Secondary Camshaft Drive Chain Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

2. Using the **EN 45027**: tool, reset the right secondary camshaft drive chain tensioner plunger.

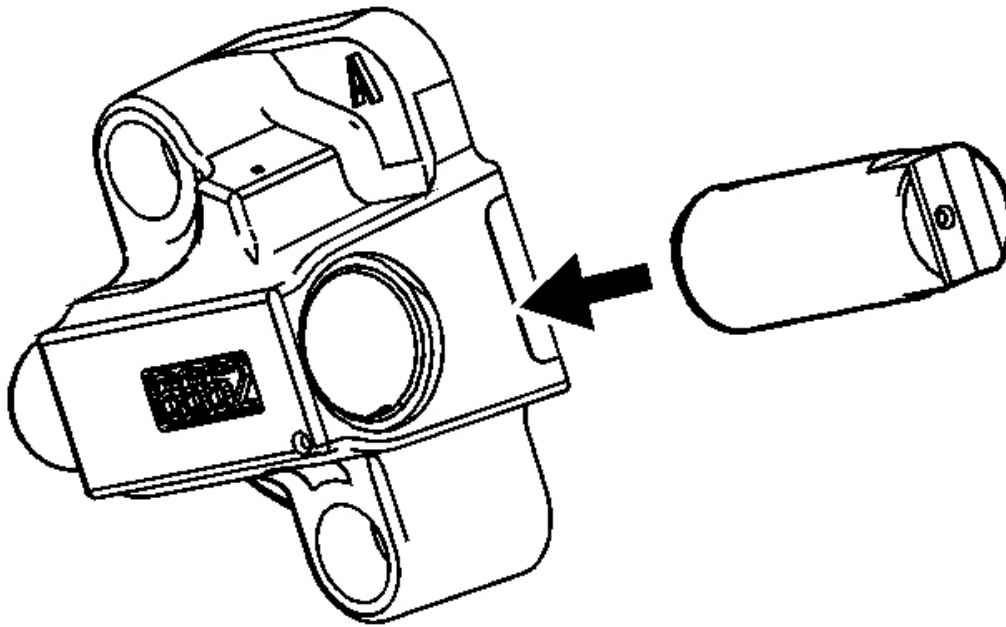


Fig. 93: Installing Plunger Into Right Secondary Camshaft Drive Chain Tensioner Body
Courtesy of GENERAL MOTORS CORP.

3. Install the plunger into the right secondary camshaft drive chain tensioner body.

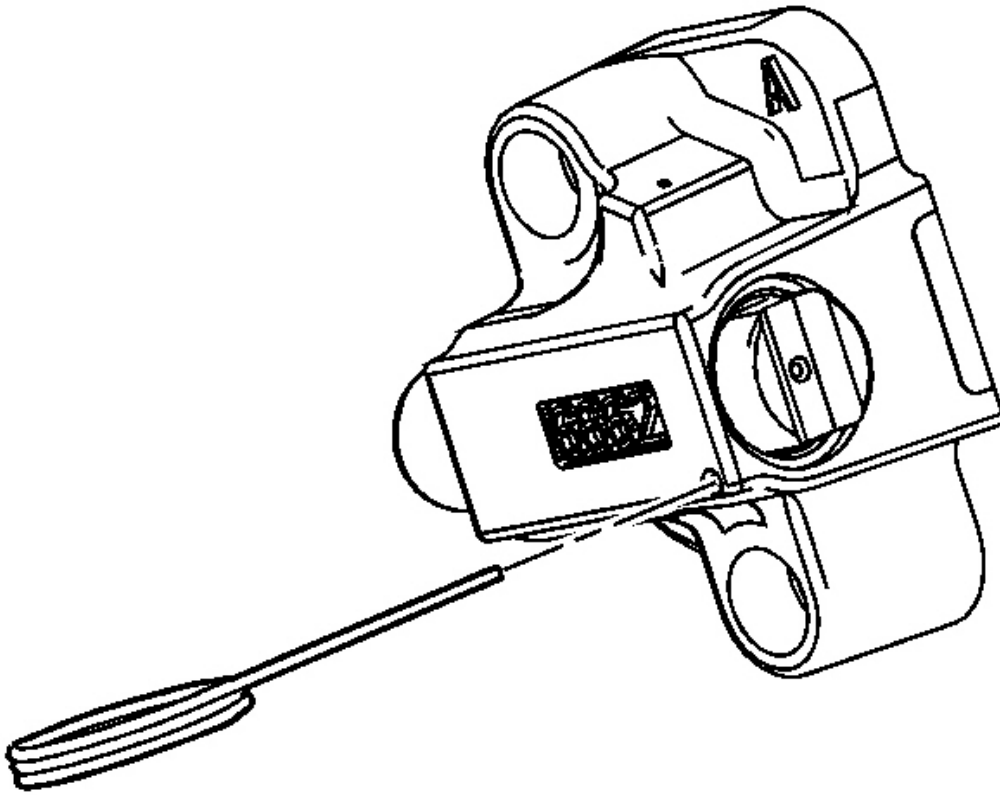


Fig. 94: Identifying EN 46112
Courtesy of GENERAL MOTORS CORP.

4. Compress the plunger into the body and lock the right secondary camshaft drive chain tensioner by inserting the **EN 46112**: pins into the access hole in the side of the right secondary camshaft drive chain tensioner body.
5. Slowly release pressure on the right secondary camshaft drive chain tensioner. The right secondary camshaft drive chain tensioner should remain compressed.

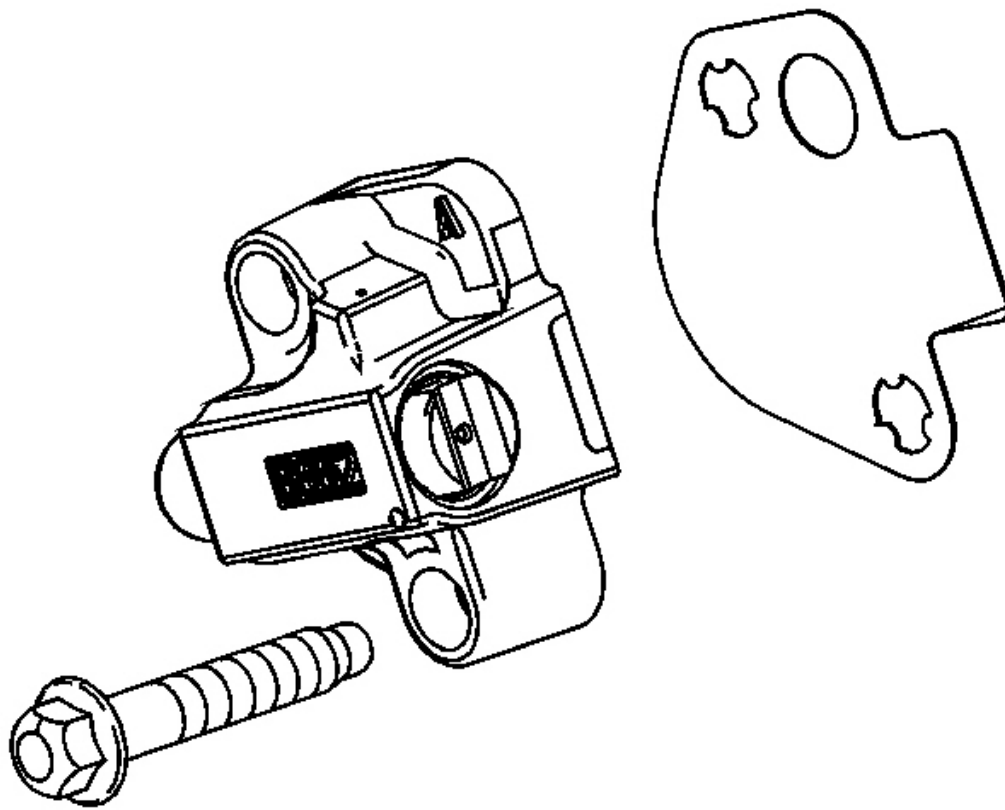


Fig. 95: View Of Right Secondary Camshaft Drive Chain Tensioner Gasket
Courtesy of GENERAL MOTORS CORP.

6. Install a NEW right secondary camshaft drive chain tensioner gasket to the right secondary camshaft drive chain tensioner.
7. Install the right secondary camshaft drive chain tensioner bolts through the right secondary camshaft drive chain tensioner and gasket.
8. 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.

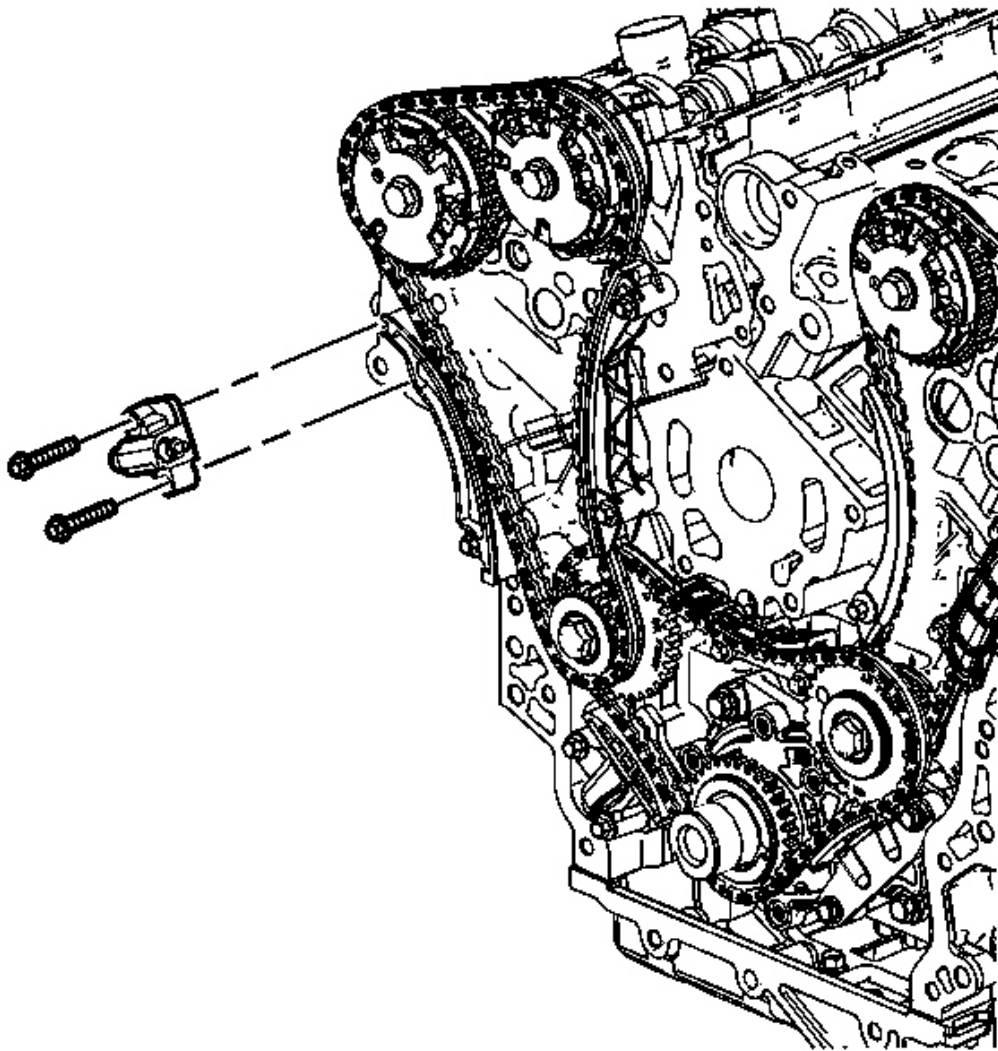


Fig. 96: View Of Secondary Camshaft Drive Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Place the right secondary camshaft drive chain tensioner into position and loosely install the bolts to the block.

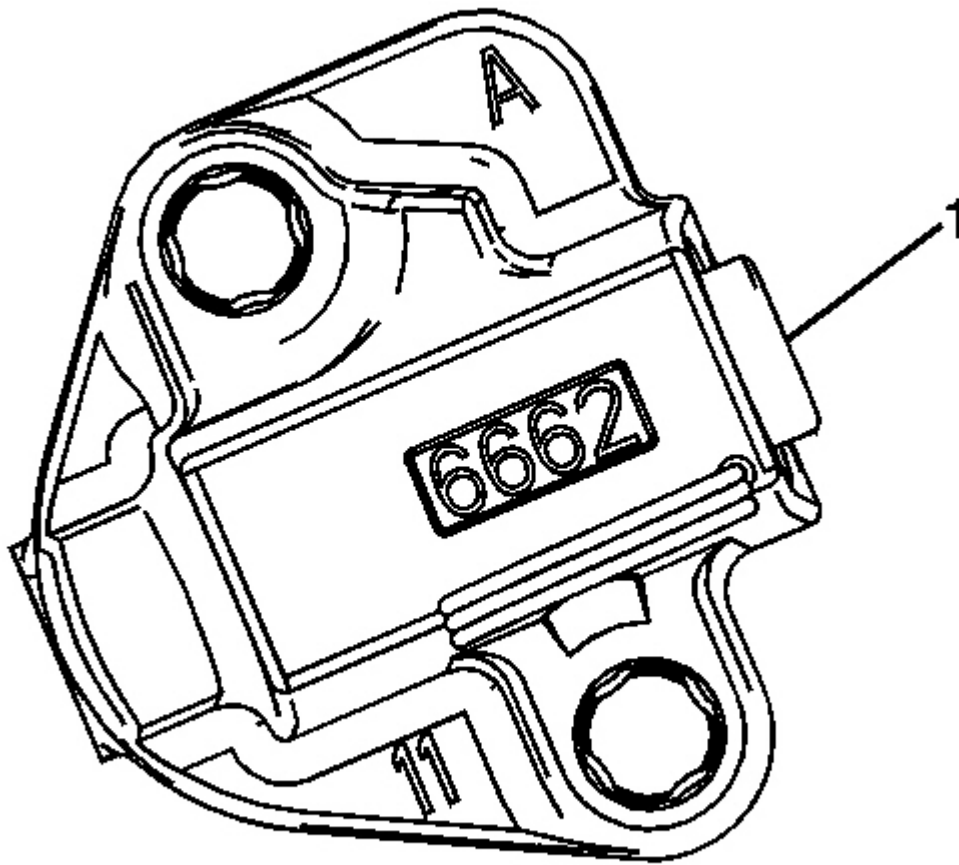


Fig. 97: Identifying Right Secondary Camshaft Drive Chain Tensioner Gasket Tab
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

10. Verify the proper placement of the right secondary camshaft drive chain tensioner gasket tab (1).

1. First Pass

Tighten the right secondary camshaft drive chain tensioner bolts to 5 N.m (44 lb in) .

2. Final Pass

Tighten the right secondary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft) .

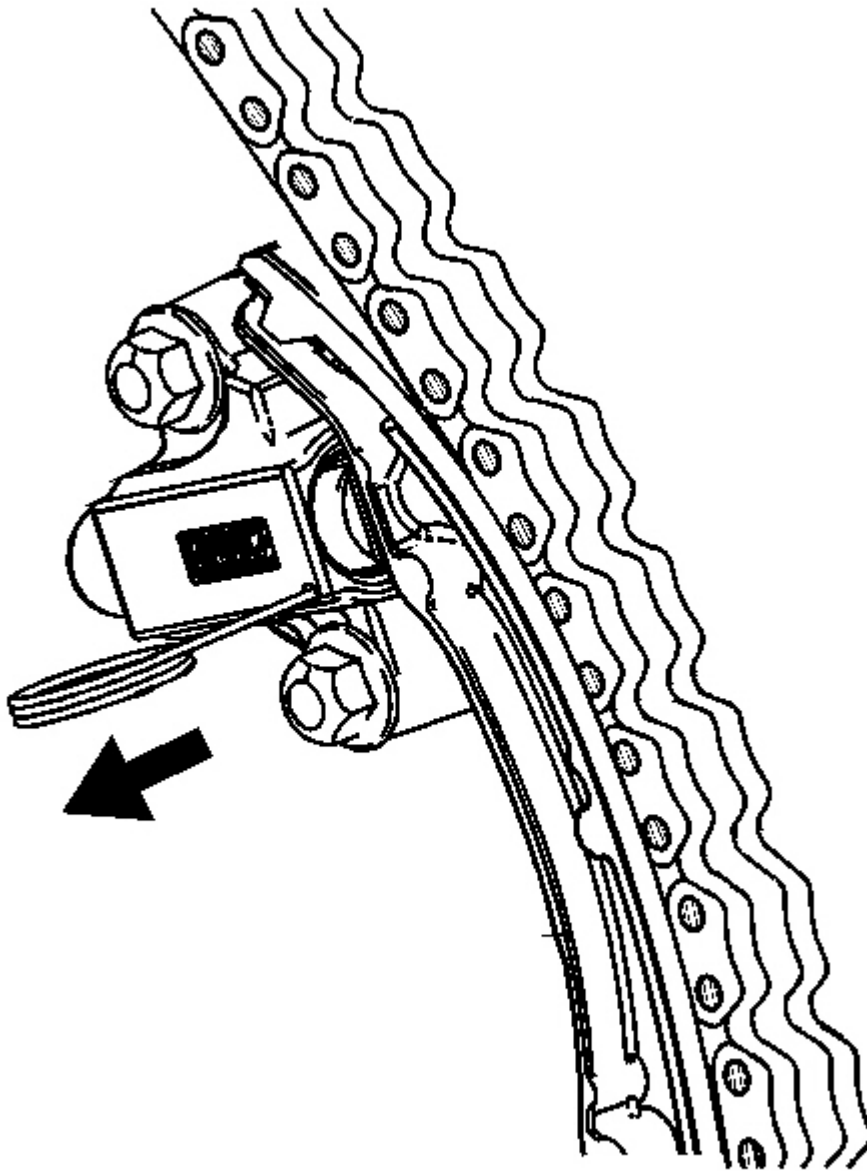


Fig. 98: Releasing Right Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

11. Release the right camshaft drive chain tensioner by pulling out the **EN 46112:** pins and unlocking the tensioner plunger.

CAUTION: Ensure that all timing chain tensioners are completely released. A timing chain tensioner that is not properly released can lead to serious engine damage.

12. Verify all primary and secondary camshaft drive chain timing mark alignments. Refer to **Timing Chain Alignment Diagram** - Stage Two.

ENGINE FRONT COVER INSTALLATION

SPECIAL TOOLS

EN 46109: Guide Pins

For equivalent regional tools, refer to **Special Tools** .

INSTALLATION

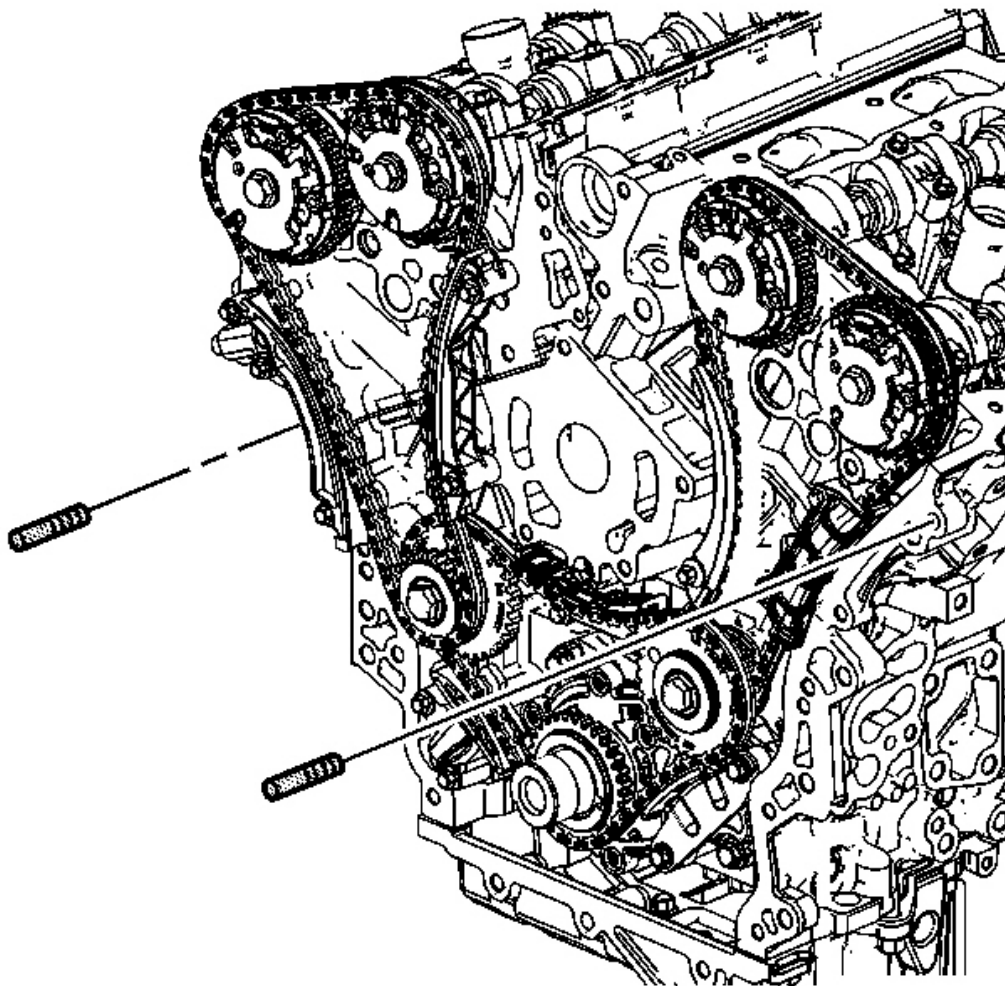


Fig. 99: View Of Front Cover Guides
Courtesy of GENERAL MOTORS CORP.

1. Install the 8 mm (0.315 in) guide from the **EN 46109:** pins into the cylinder block positions as shown.

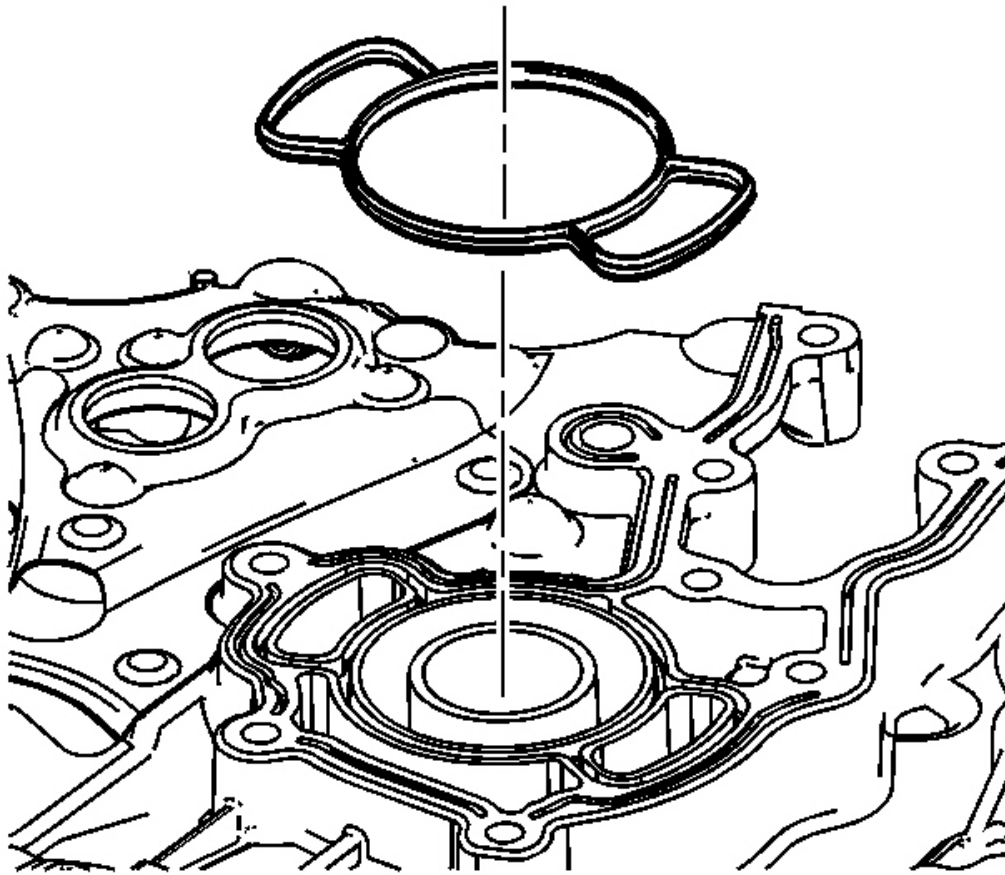


Fig. 100: View Of Water Pump Seal
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW engine front cover to cylinder block seal.

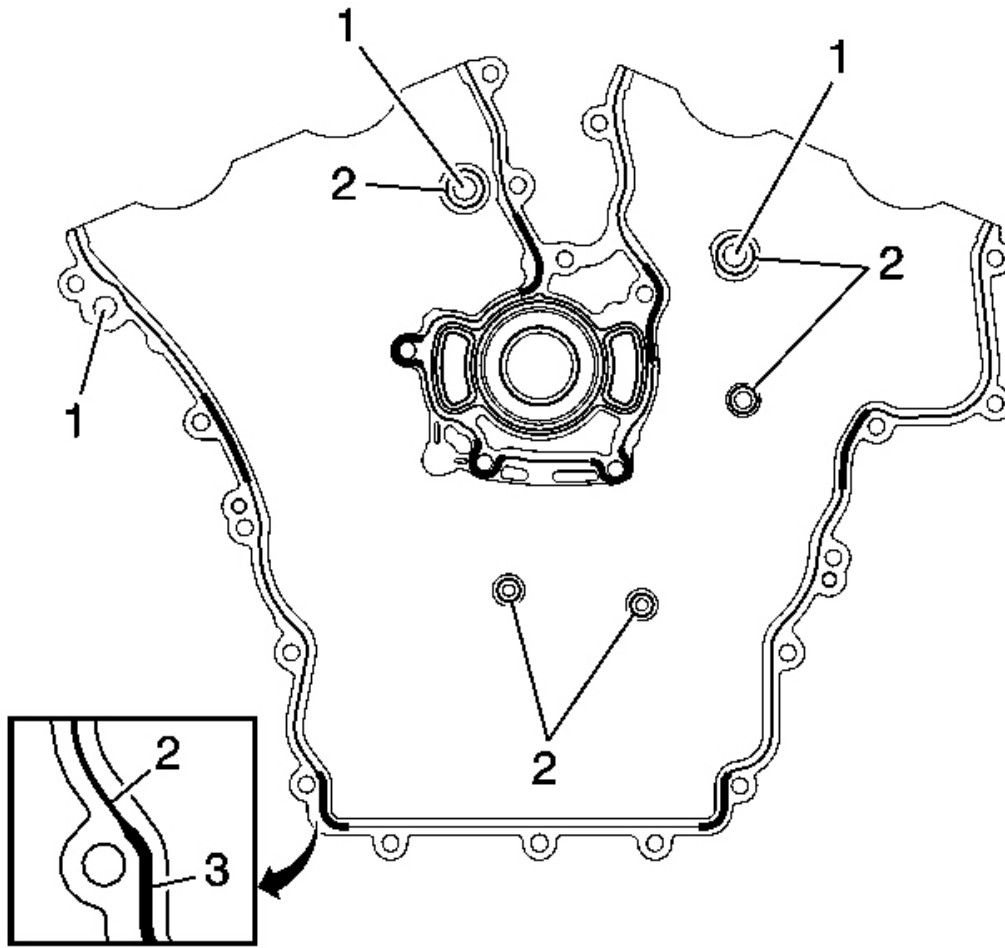


Fig. 101: Applying Sealant

Courtesy of GENERAL MOTORS CORP.

NOTE: No RTV sealant should be visible in the M12 bolt holes (1) upon final assembly of front cover to engine.

3. Apply a 3 mm (0.118 in) bead of RTV sealant, GM P/N 12378521 (Canadian P/N 88901148) or equivalent, on the engine front cover as shown (2). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (3).

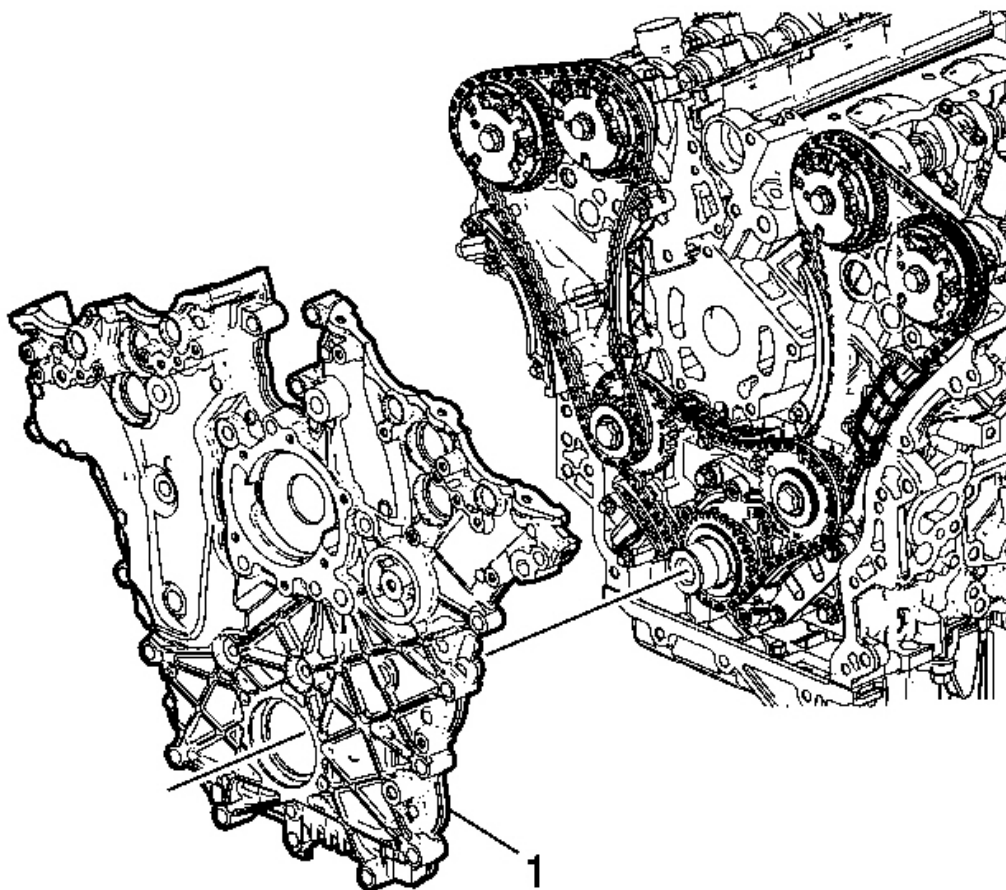


Fig. 102: Engine Front Cover

Courtesy of GENERAL MOTORS CORP.

4. Place the engine front cover (1) onto the **EN 46109:** pins and slide into position.
5. Remove the **EN 46109:** pins from the cylinder block.
6. Hand start all the engine front cover bolts.

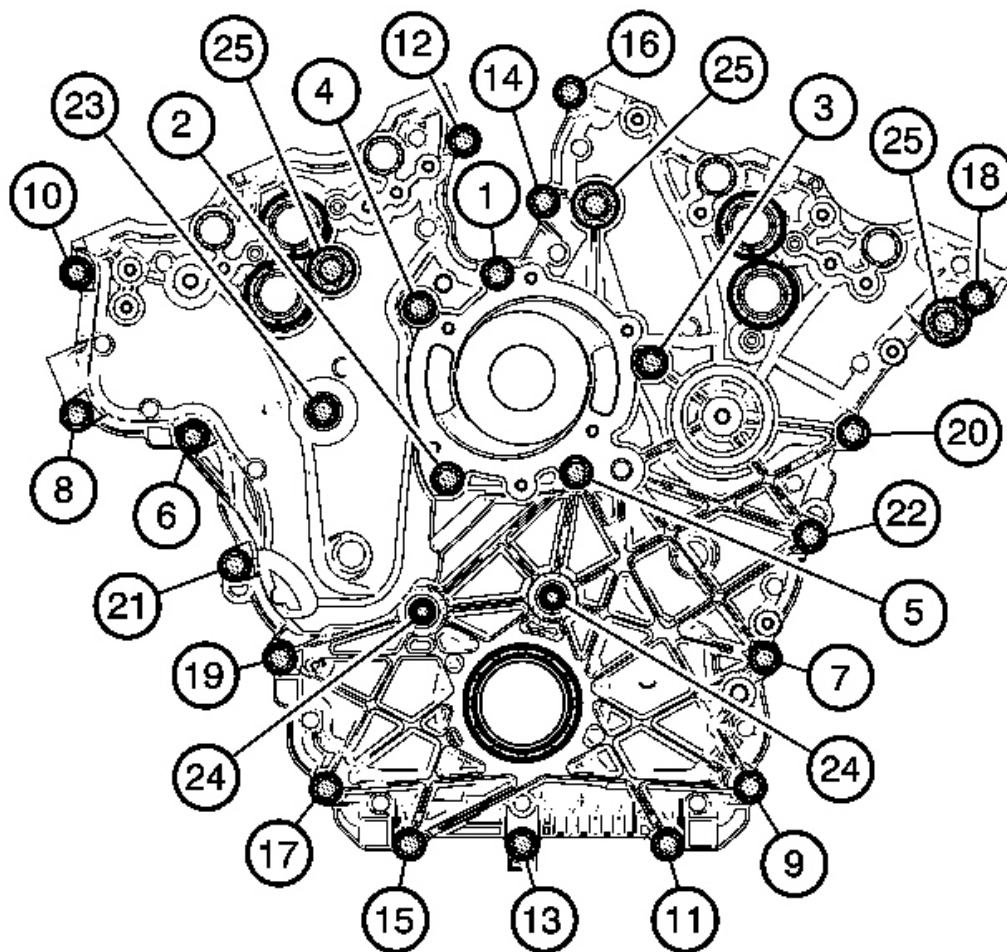


Fig. 103: Identifying Engine Front Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: Engine front cover bolts in the number (25) location are model dependent and may not apply.

7. Tighten the engine front cover bolts (1-23) in the sequence shown to 20 N.m (14 lb ft).
 1. Tighten the engine front cover bolts (1-23) a second pass in sequence to 20 N.m (14 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) .

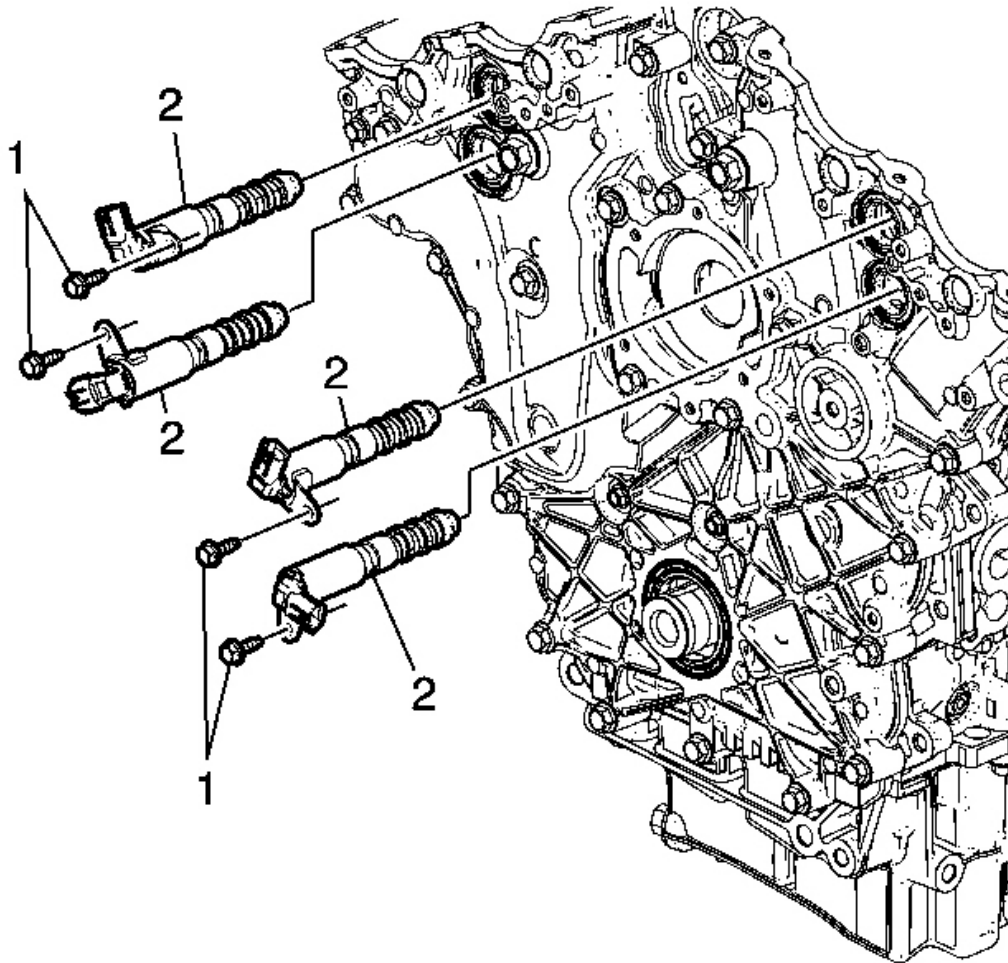


Fig. 104: Placing Camshaft Position Actuator Valves
Courtesy of GENERAL MOTORS CORP.

8. Place the camshaft position actuator valves (2) in position on the front cover.
9. Install the camshaft position actuator valve bolts (1) and tighten to 10 N.m (89 lb in).

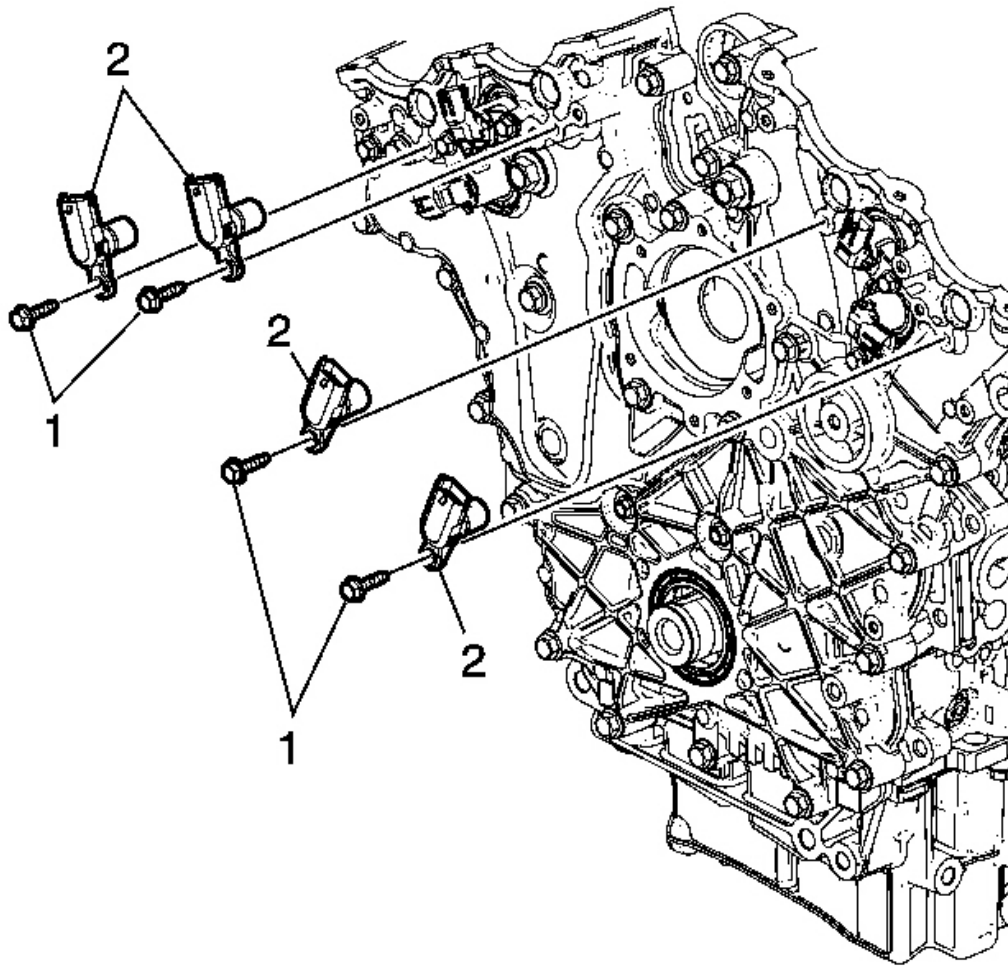


Fig. 105: Placing Camshaft Position Sensors
Courtesy of GENERAL MOTORS CORP.

10. Install NEW O-rings on the camshaft position sensor.
11. Place the camshaft position sensors (2) in position on the front cover.
12. Install the camshaft position sensor bolts (1) and tighten to 10 N.m (89 lb in).

WATER PUMP INSTALLATION

SPECIAL TOOLS

EN 46104: Water Pump Pulley Holding Tool

For equivalent regional tools, refer to **Special Tools** .

INSTALLATION

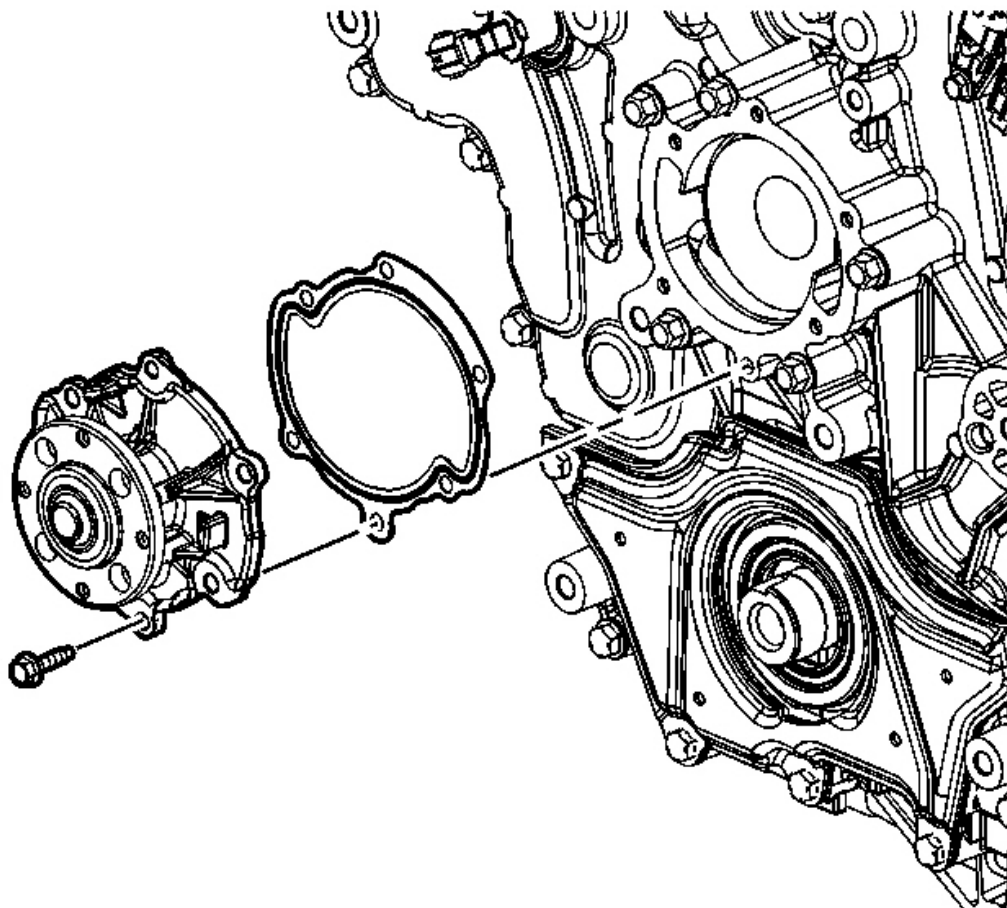


Fig. 106: View Of Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the engine front cover and water pump are clear of old gasket material.
2. Place a new water pump gasket on the water pump.
3. Place the water pump in position on the front cover.

CAUTION: Refer to Fastener Caution .

4. Install the water pump bolts and tighten to 10 N.m (89 lb in).

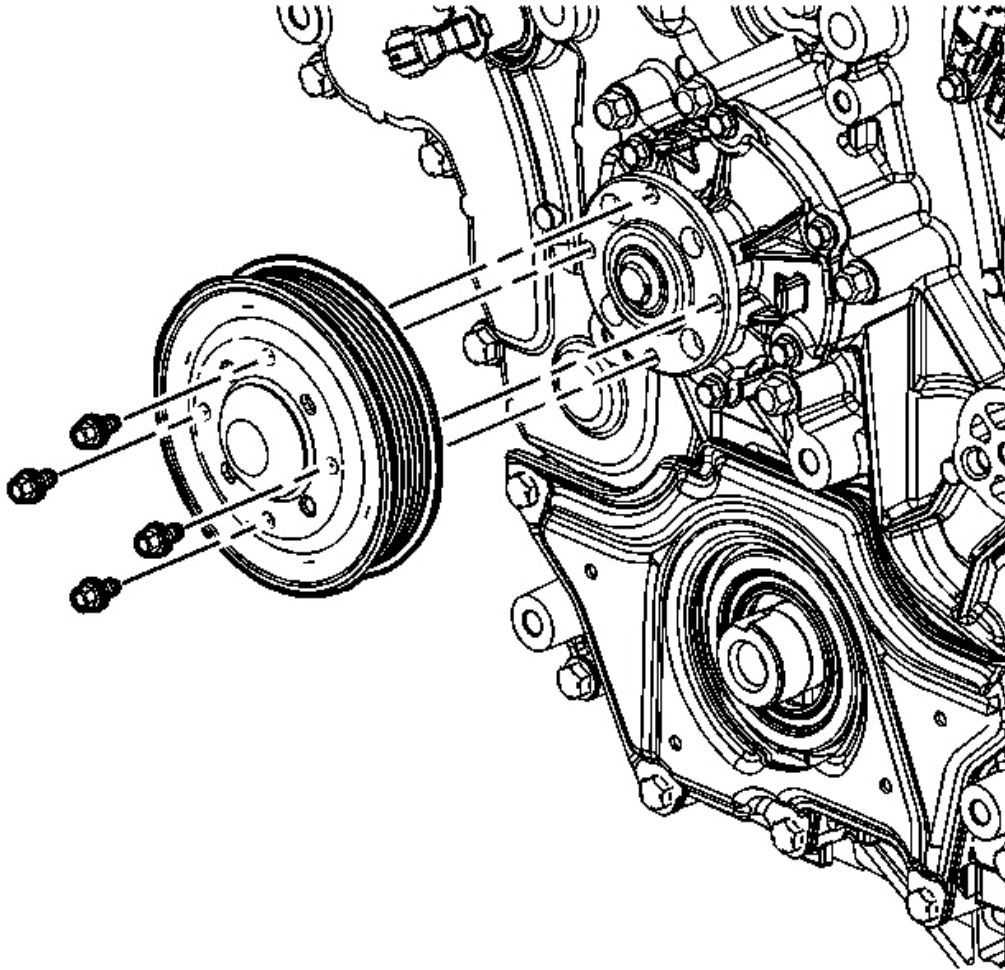


Fig. 107: View Of Water Pump Pulley Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the water pump pulley.
6. Loosely install the water pump pulley bolts.

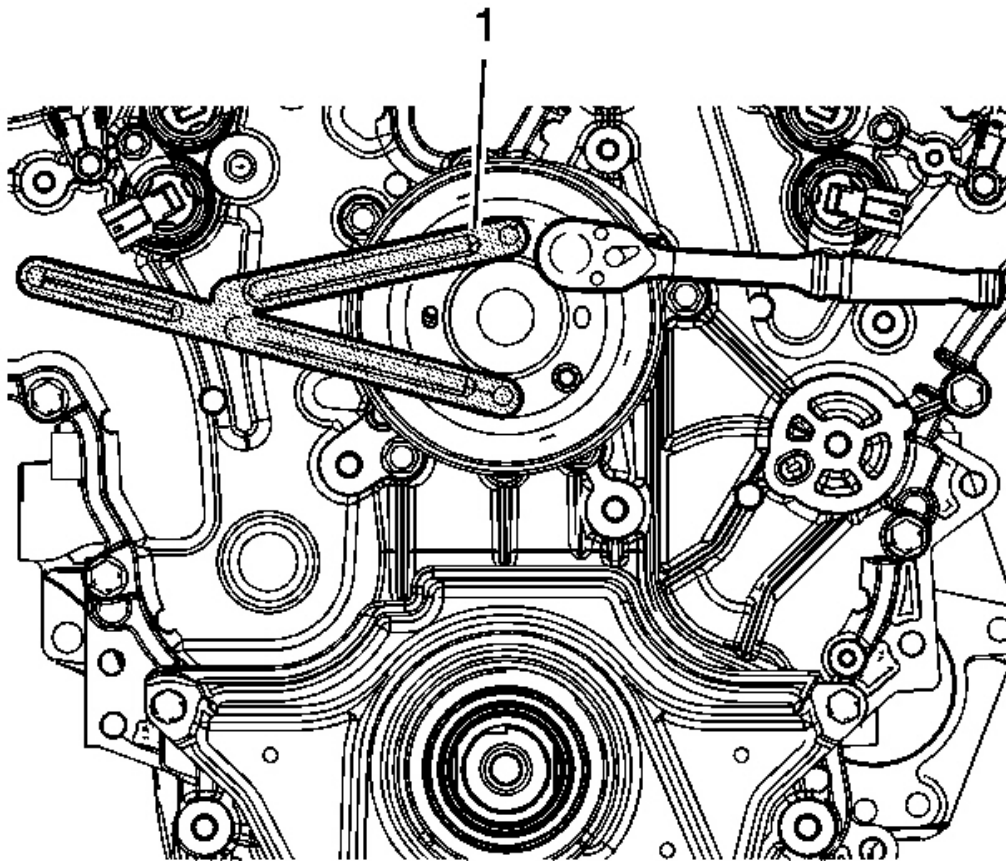


Fig. 108: View Of EN 46104
Courtesy of GENERAL MOTORS CORP.

7. Install the **EN 46104**: tool (1) onto the water pump pulley and tighten the water pump pulley bolts to 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** .

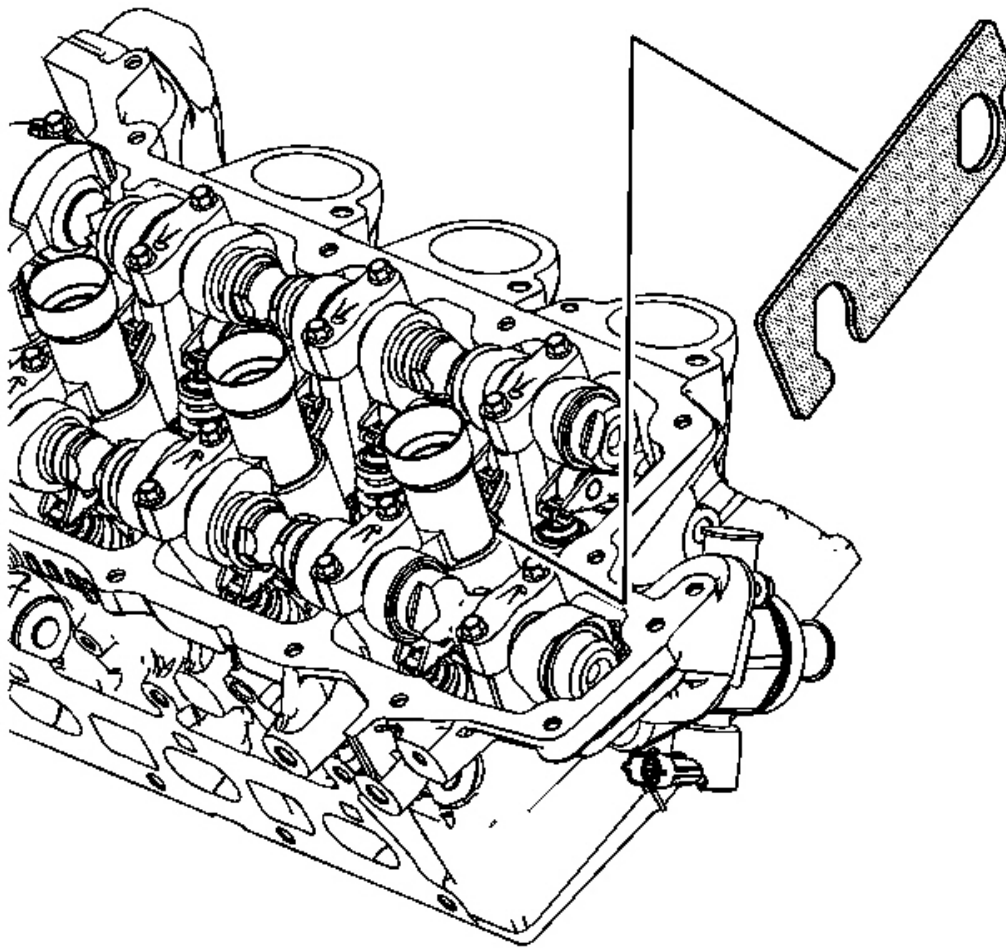


Fig. 109: View Of EN 48383-2 & Camshaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the EN 48383-2 from the rear of the left camshafts.

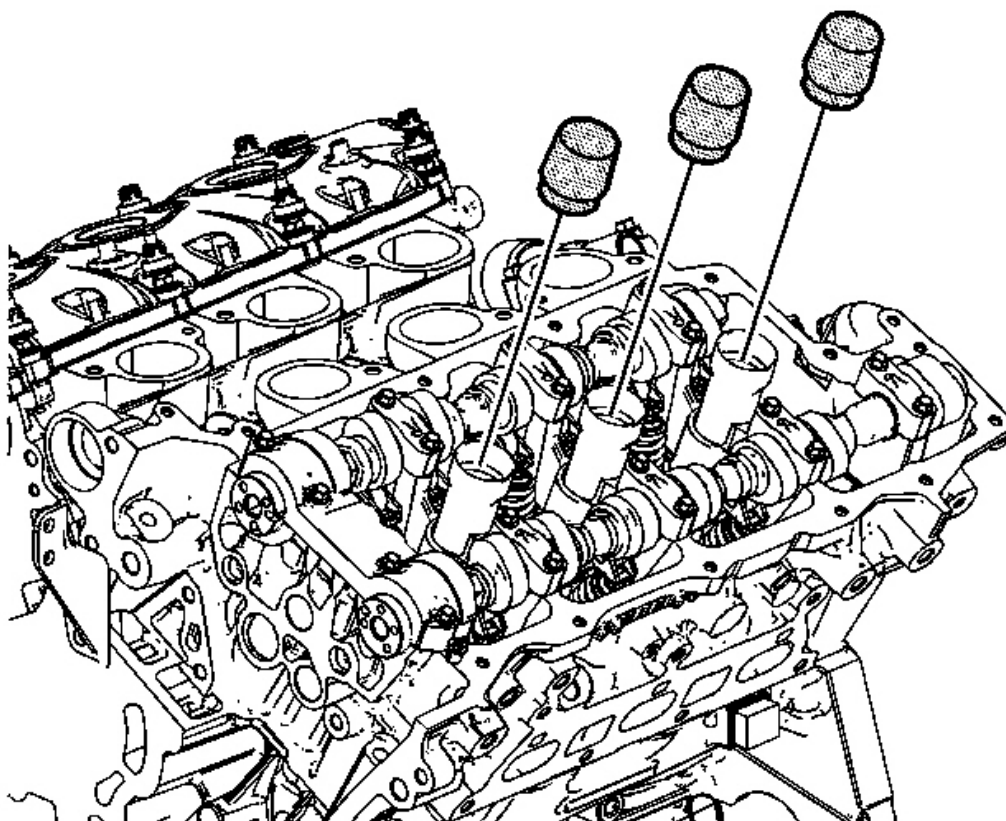


Fig. 110: Removing/Installing EN 46101 Onto Spark Plug Tubes Of Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

2. Install the **EN 46101**: guide onto the spark plug tubes of the left cylinder head.

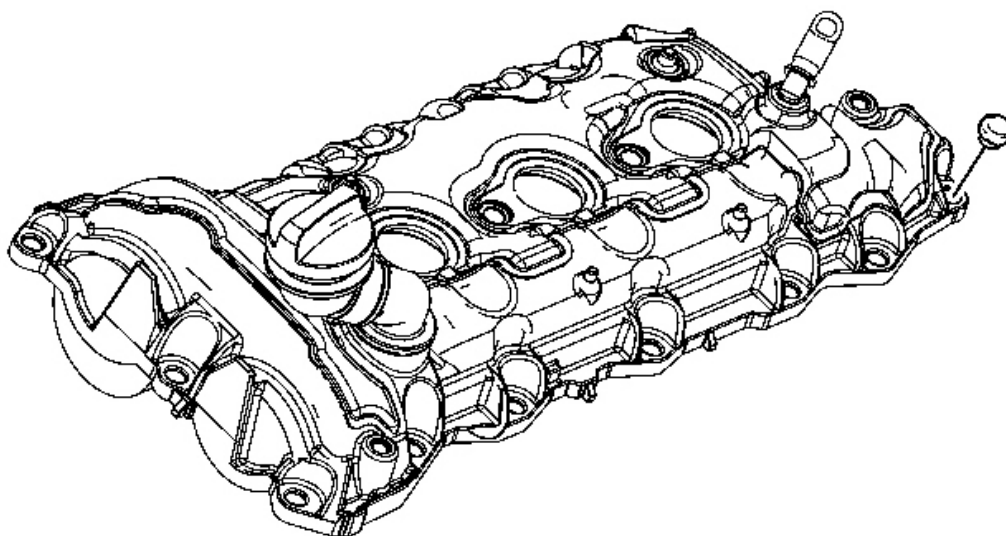


Fig. 111: View of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

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.

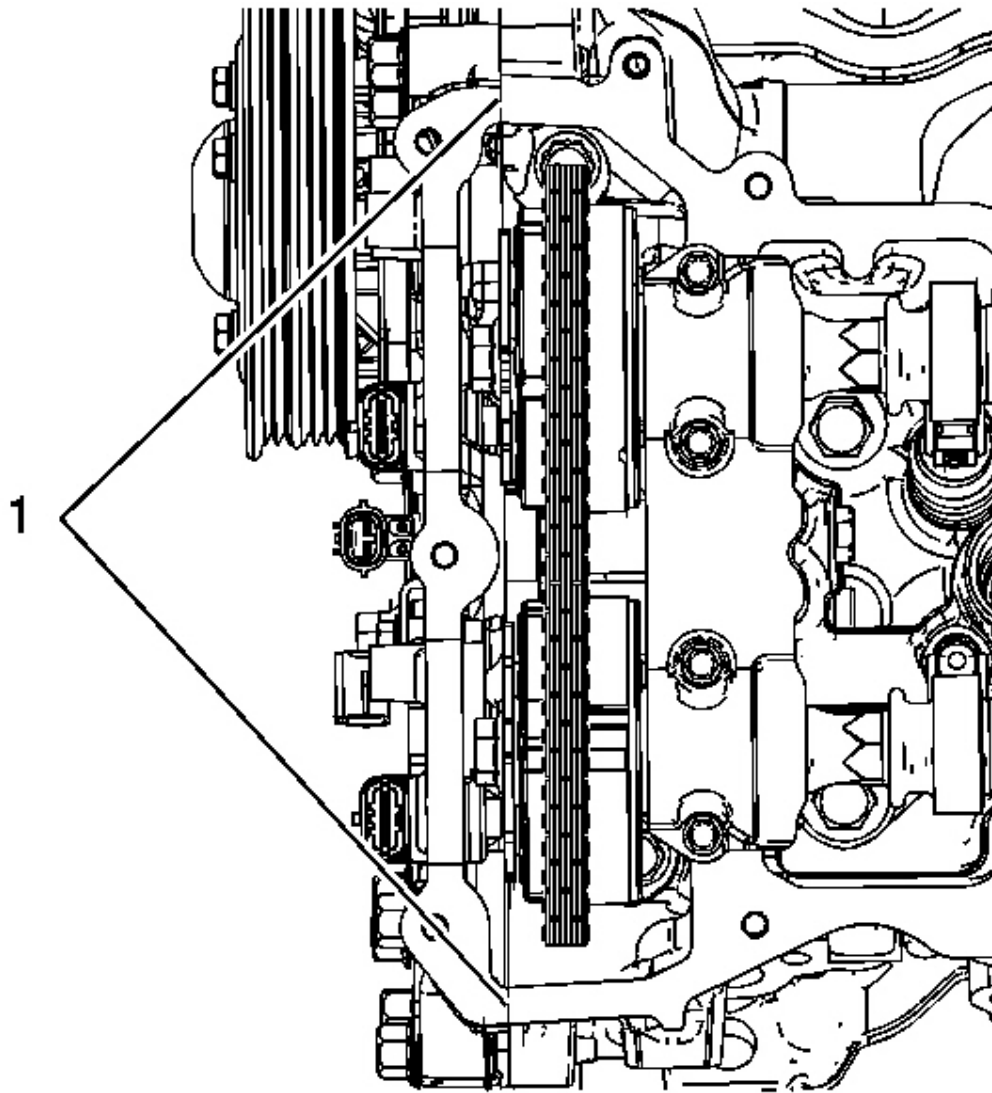


Fig. 112: Locating Engine Front Cover Split Lines
Courtesy of GENERAL MOTORS CORP.

5. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant, GM P/N 12378521 (Canadian P/N 88901148) or equivalent, on the engine front cover split lines (1).

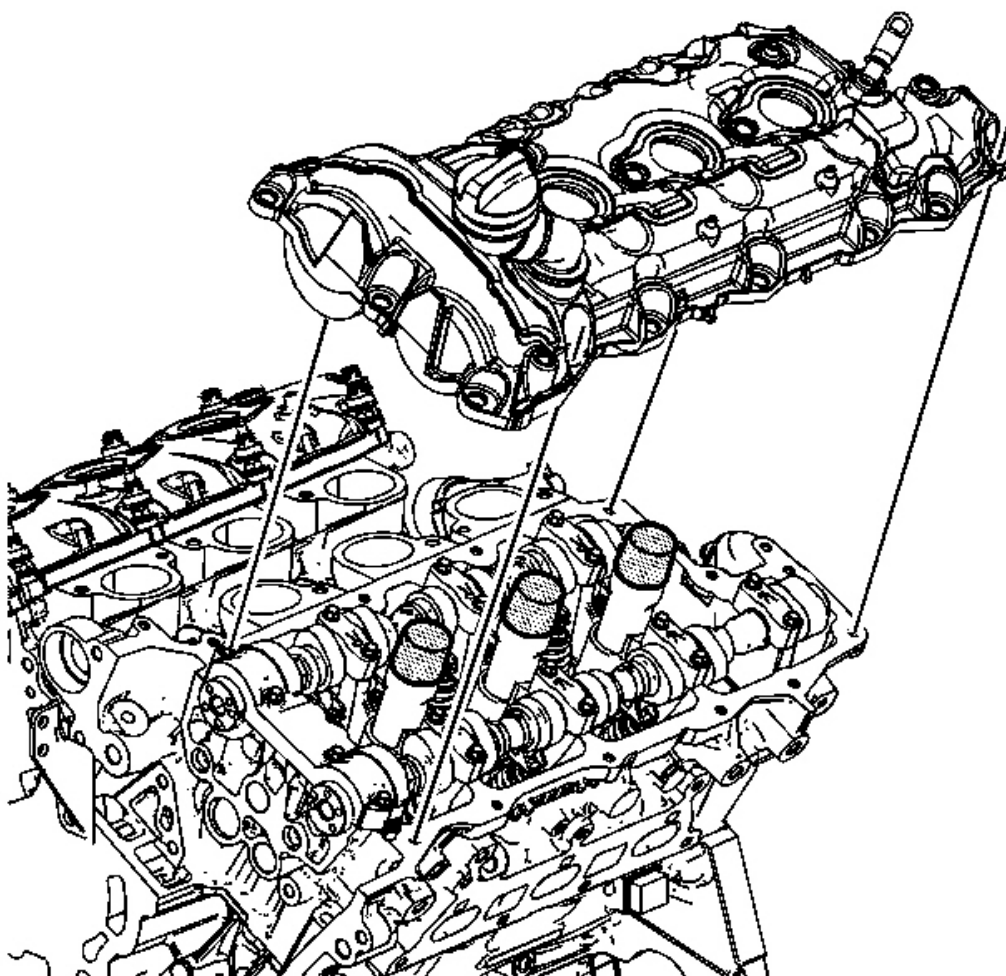


Fig. 113: Removing/Installing Left Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

6. Place the left camshaft cover into position onto the left cylinder head.

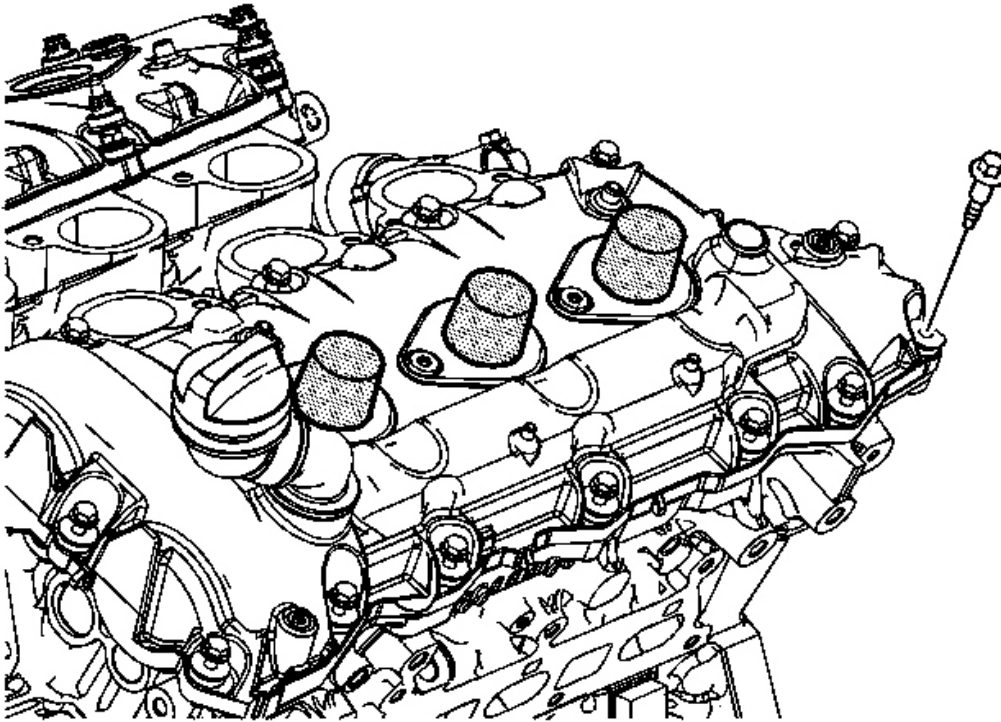


Fig. 114: Removing/Installing Left Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

7. Loosely install the left camshaft cover bolts.

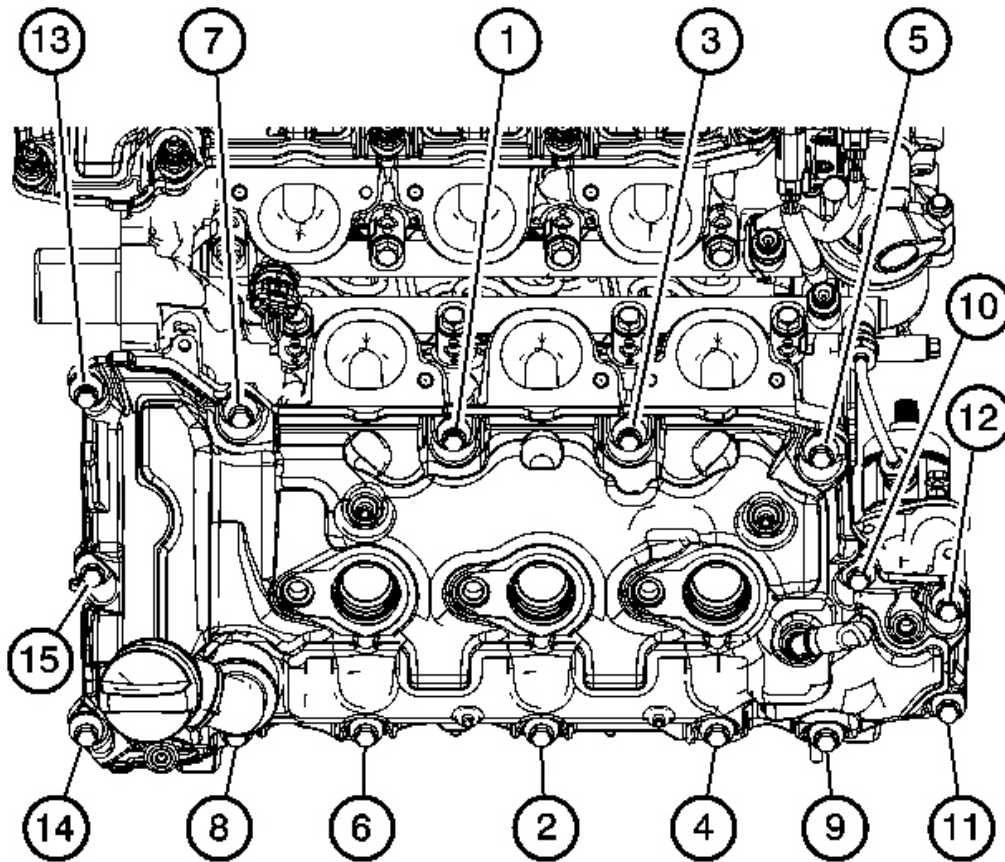


Fig. 115: Identifying Left Camshaft Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

8. 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) .

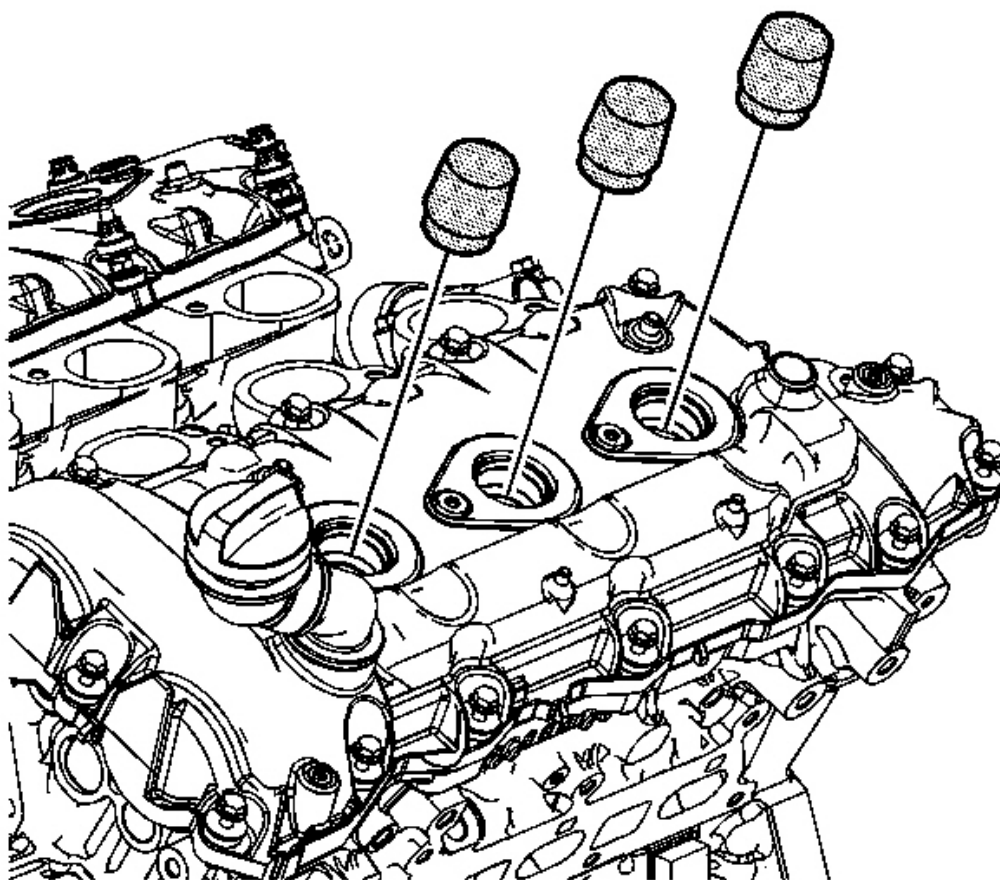


Fig. 116: View of Spark Plug Tubes & Cylinder Head
Courtesy of GENERAL MOTORS CORP.

9. Remove the **EN 46101**: guide from the spark plug tubes of the left cylinder head.

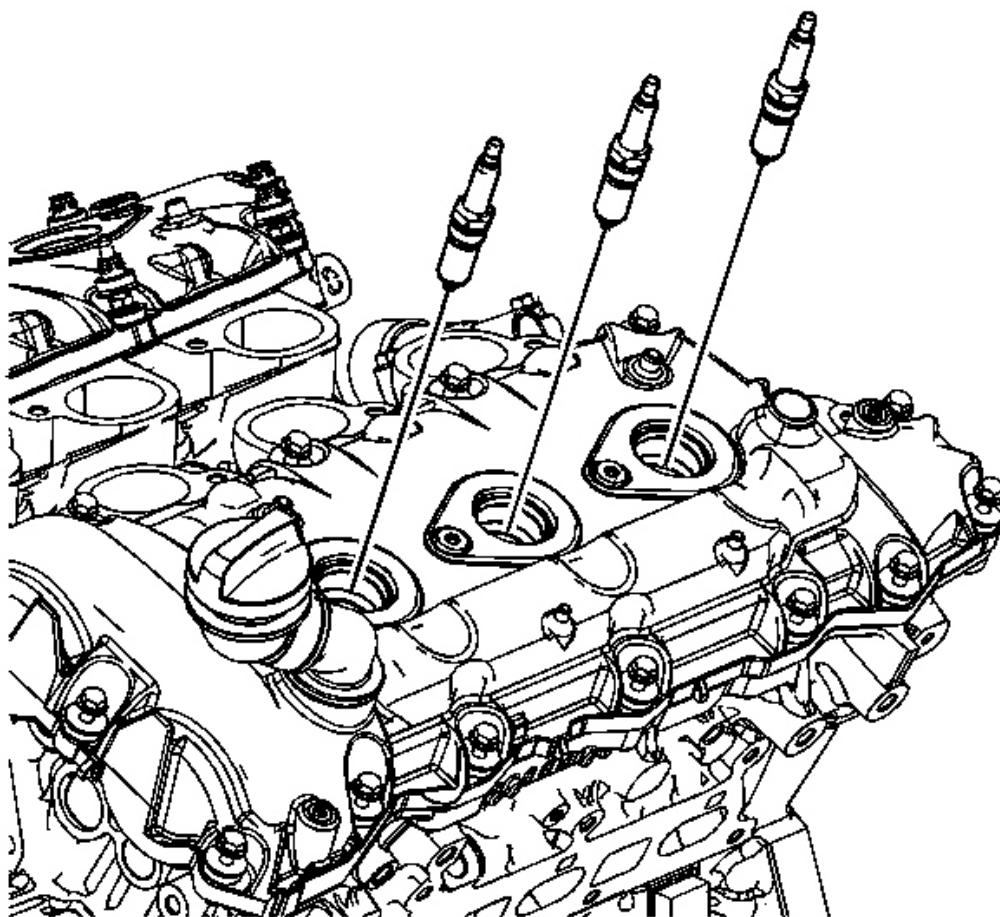


Fig. 117: Removing/Installing Spark Plugs Into Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

10. Install the NEW spark plugs into the left cylinder head and tighten to 18 N.m (13 lb ft)..

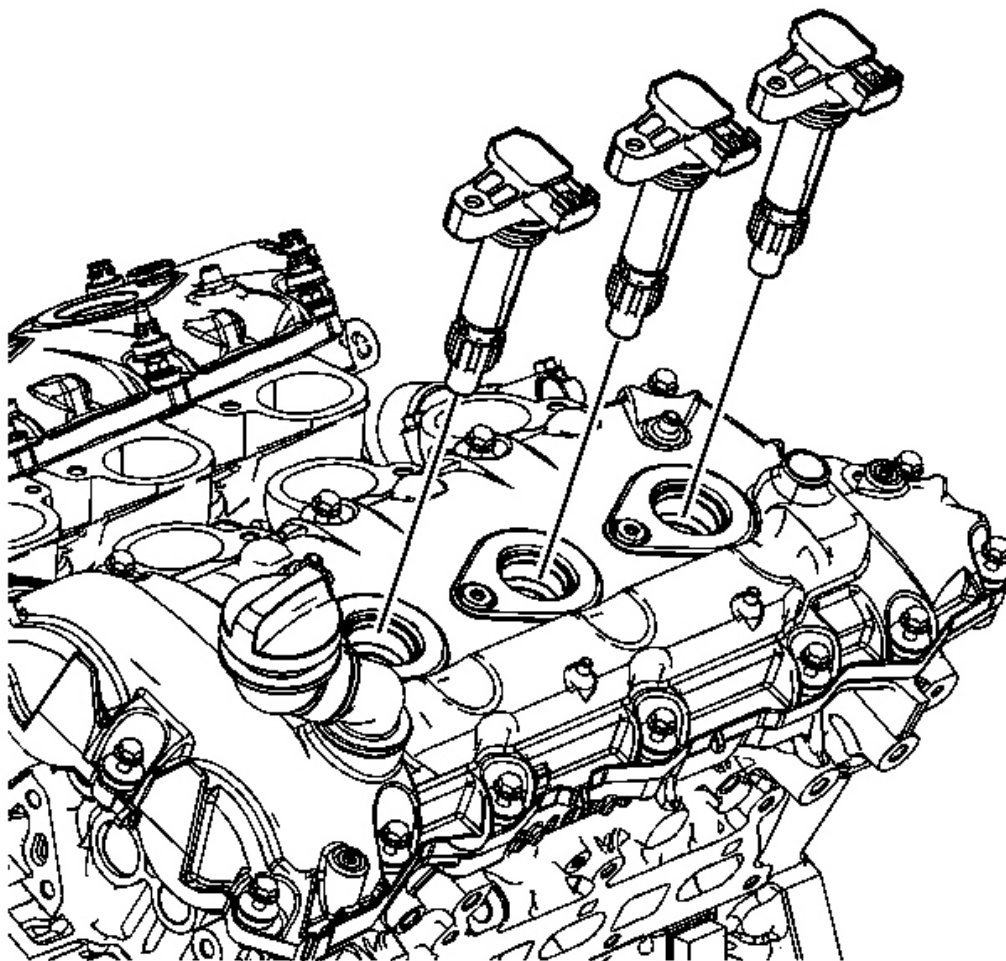


Fig. 118: Removing/Installing Ignition Coils
Courtesy of GENERAL MOTORS CORP.

11. Install the ignition coils.

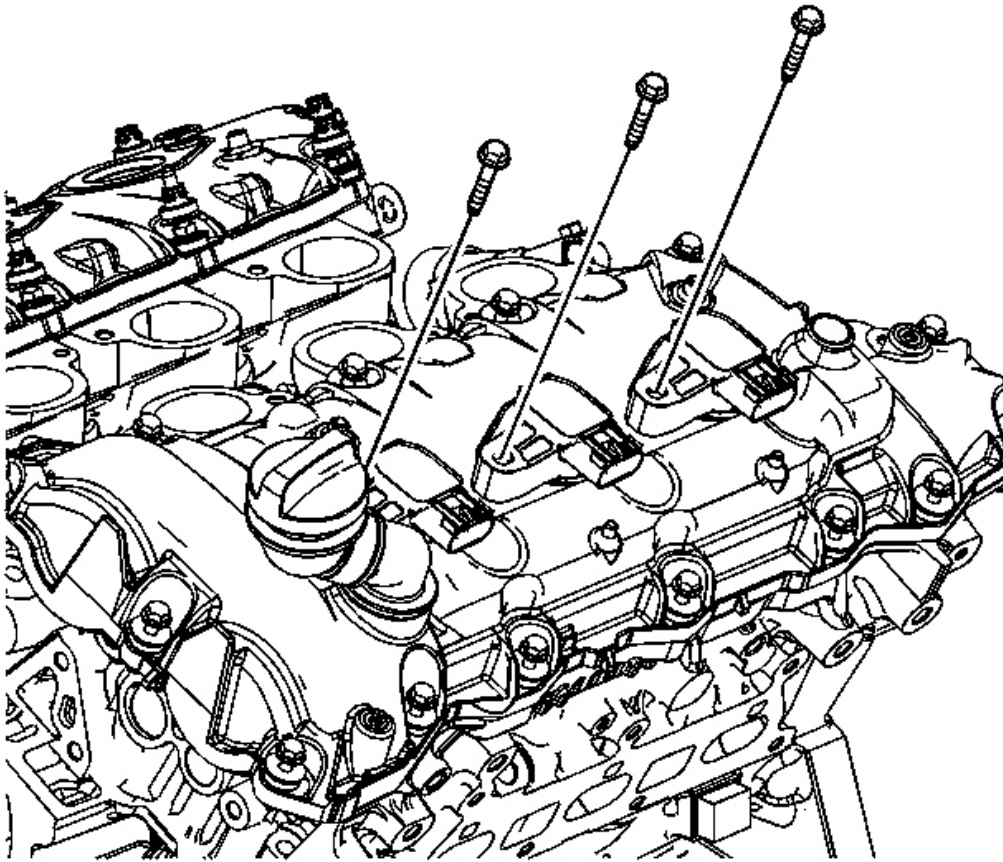


Fig. 119: Removing/Installing Ignition Coil Bolts
Courtesy of GENERAL MOTORS CORP.

12. 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** .

INSTALLATION

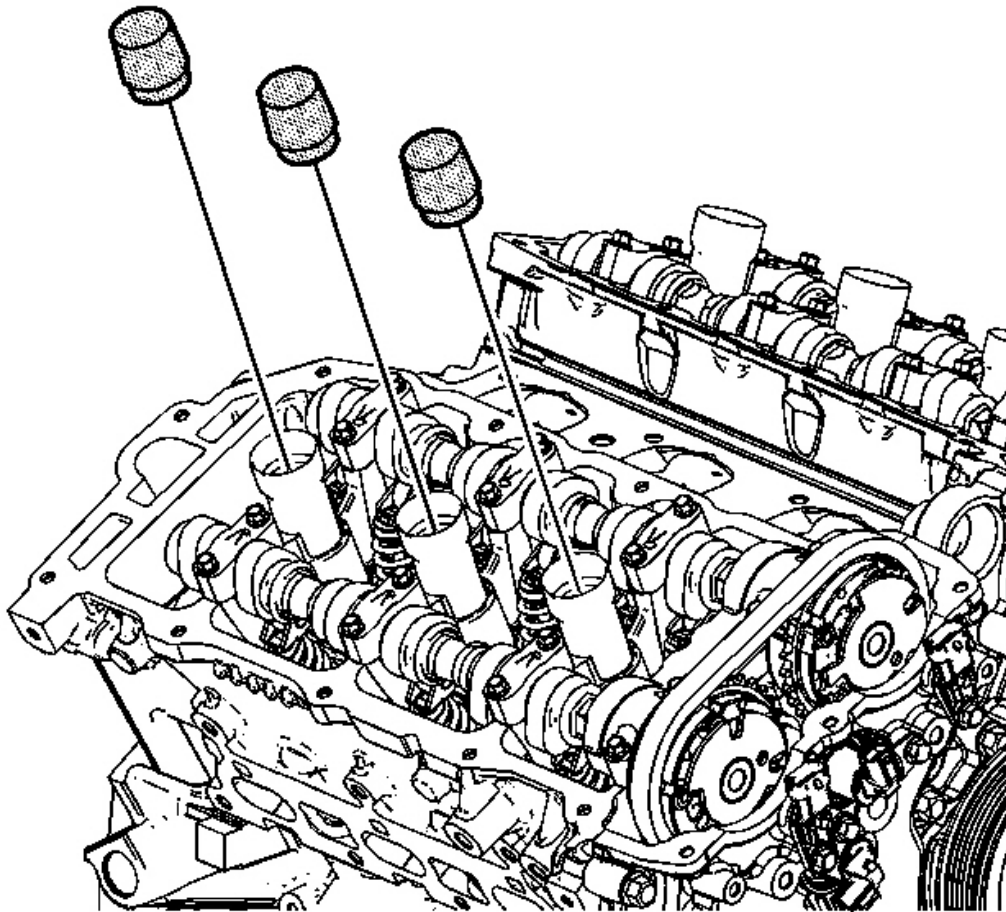


Fig. 120: Installing EN 46101 Into Spark Plug Tubes
Courtesy of GENERAL MOTORS CORP.

1. Install the **EN-46101**: guide onto the spark plug tubes of the right cylinder head.

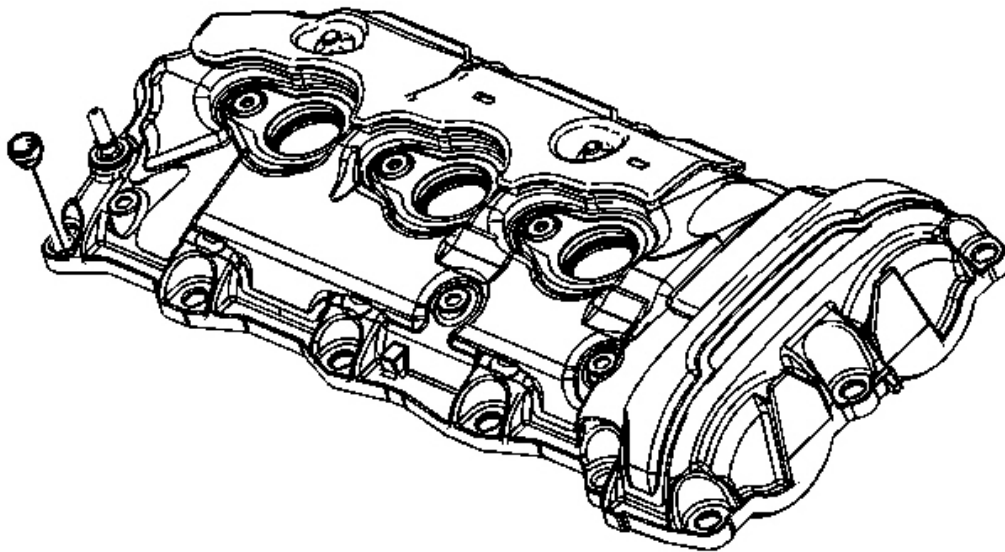


Fig. 121: View Of Right Camshaft Cover Bolt Grommets
Courtesy of GENERAL MOTORS CORP.

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.

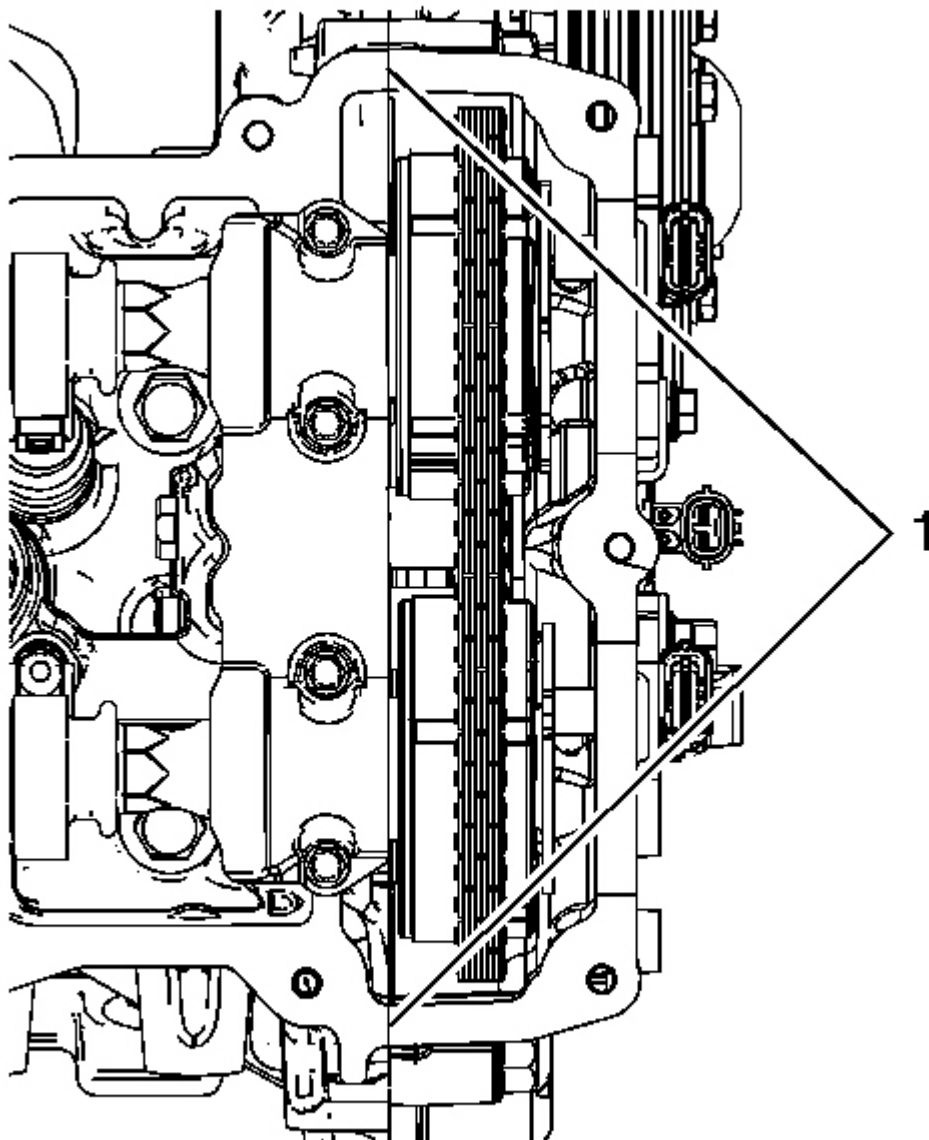


Fig. 122: Identifying Engine Front Cover Split Lines
Courtesy of GENERAL MOTORS CORP.

4. 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** for recommended sealant.

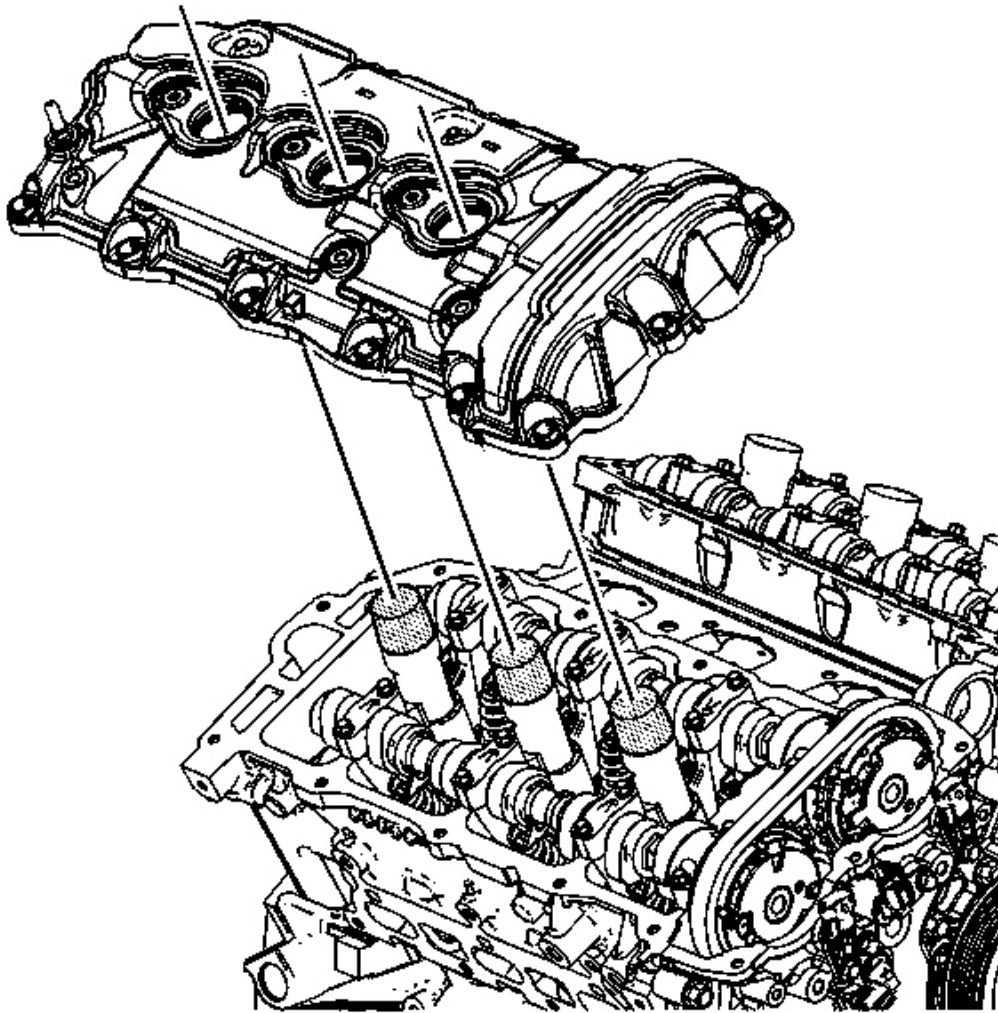


Fig. 123: View Of Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

5. Place the right camshaft cover into position onto the right cylinder head.

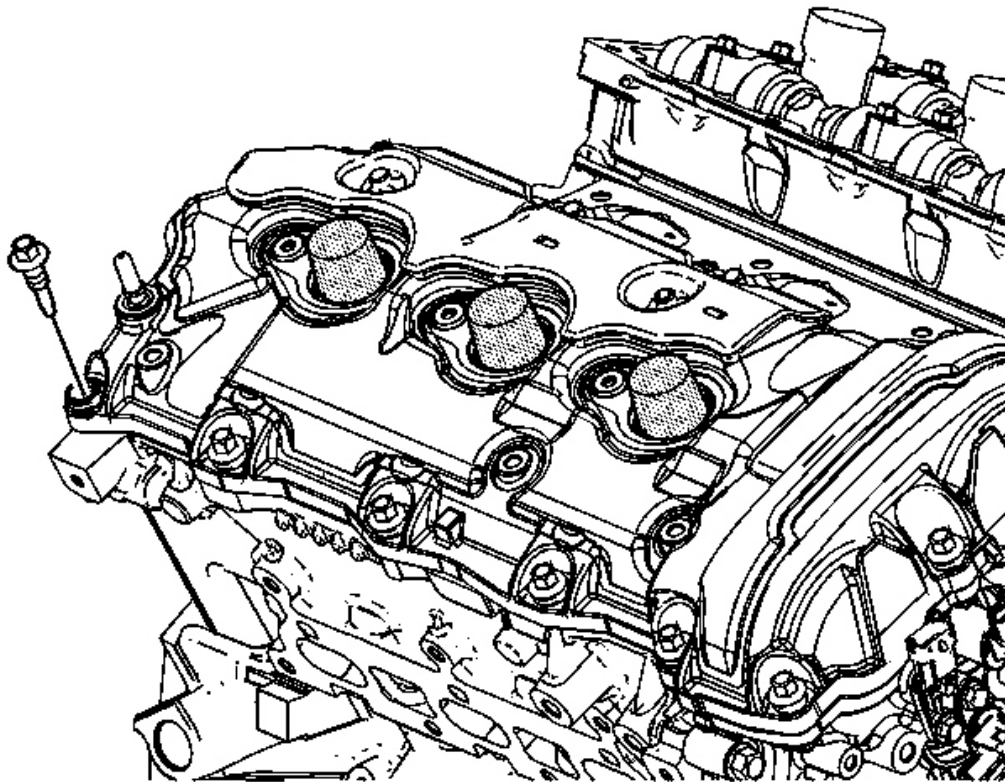


Fig. 124: View Of Right Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

6. Loosely install the right camshaft cover bolts.

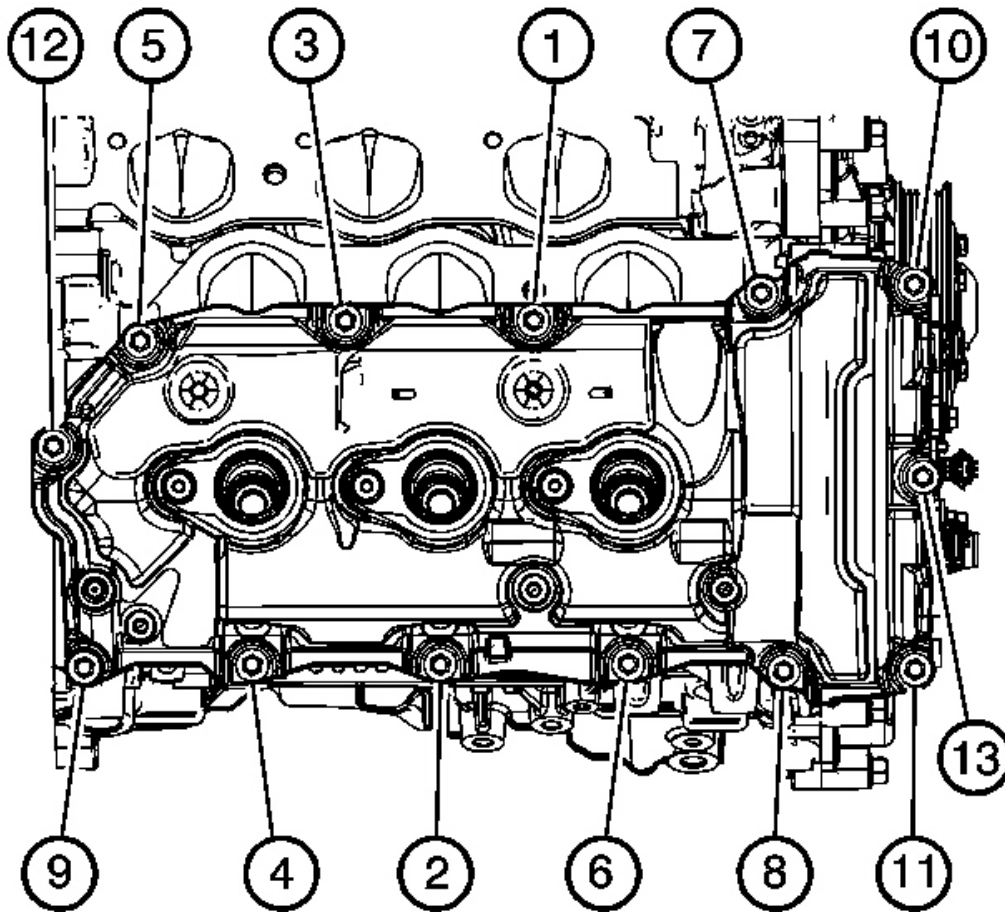


Fig. 125: Identifying Right Camshaft Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

7. 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) .

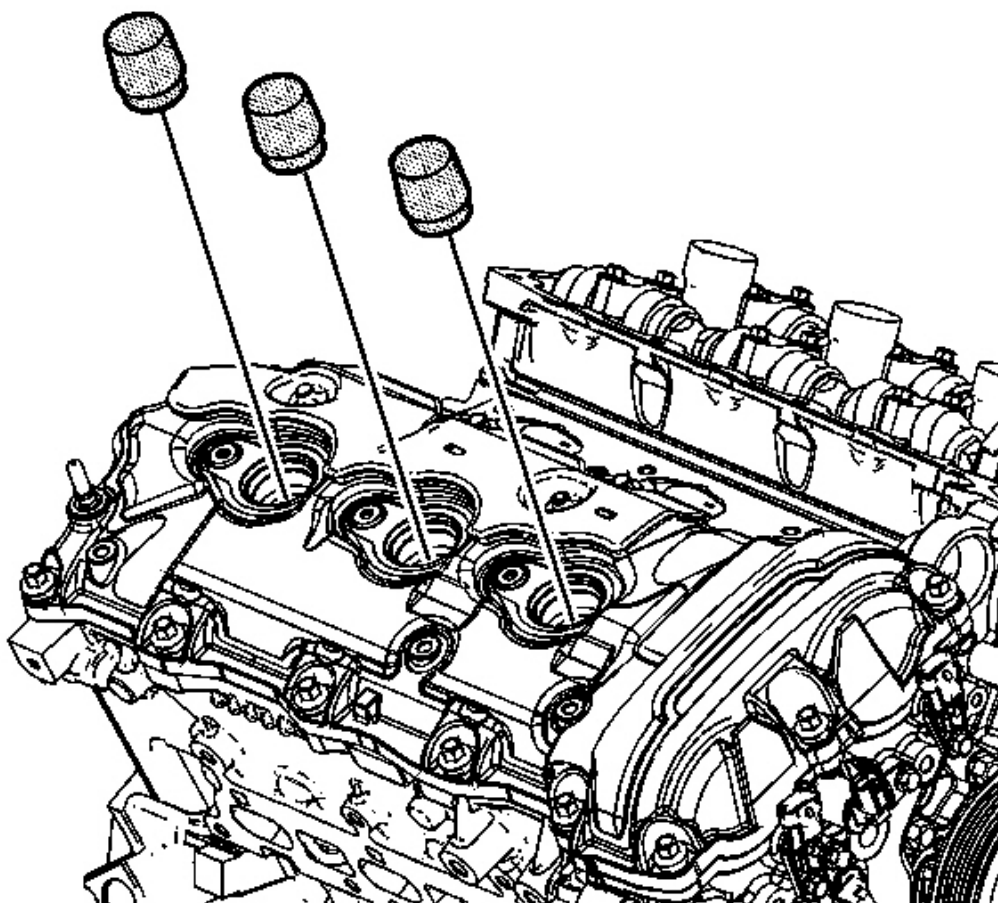


Fig. 126: View Of Spark Plug Tubes
Courtesy of GENERAL MOTORS CORP.

8. Remove the **EN-46101**: guide from the spark plug tubes of the right cylinder head.

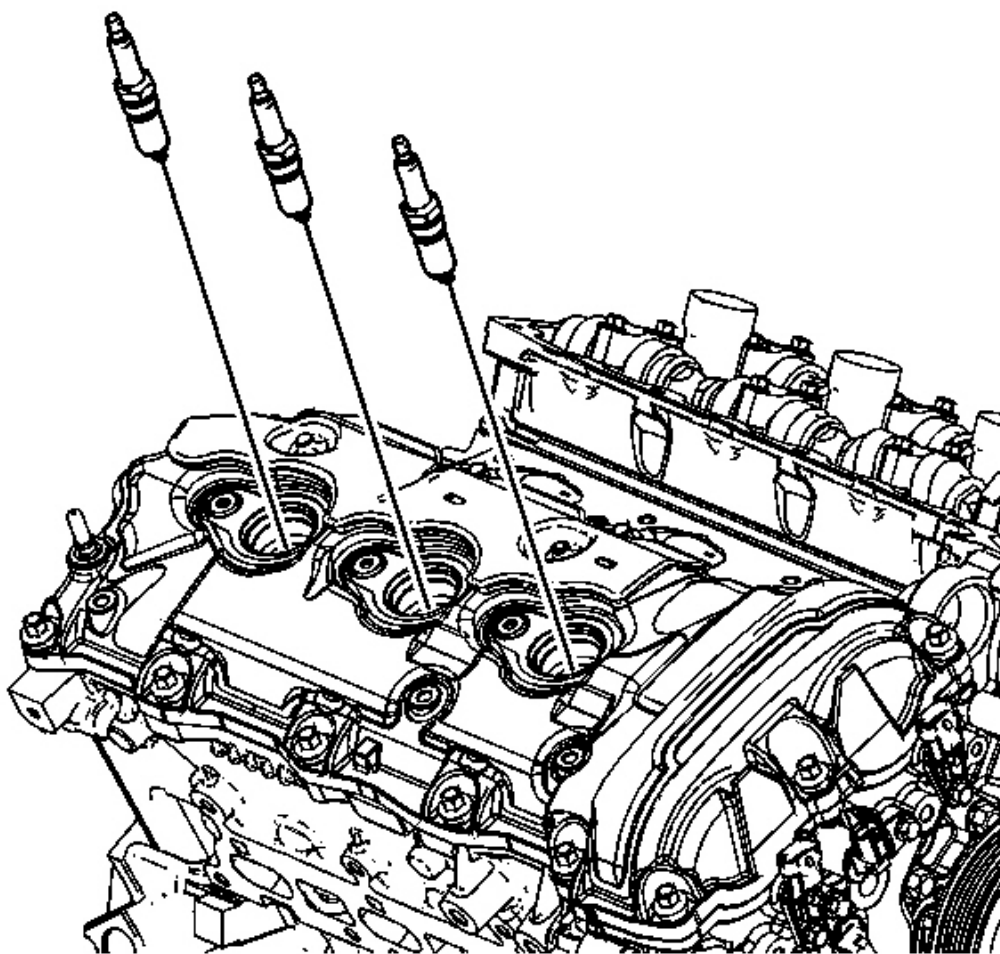


Fig. 127: View Of Spark Plugs

Courtesy of GENERAL MOTORS CORP.

9. Install the NEW spark plugs into the right cylinder head and tighten to 18 N.m (13 lb ft).

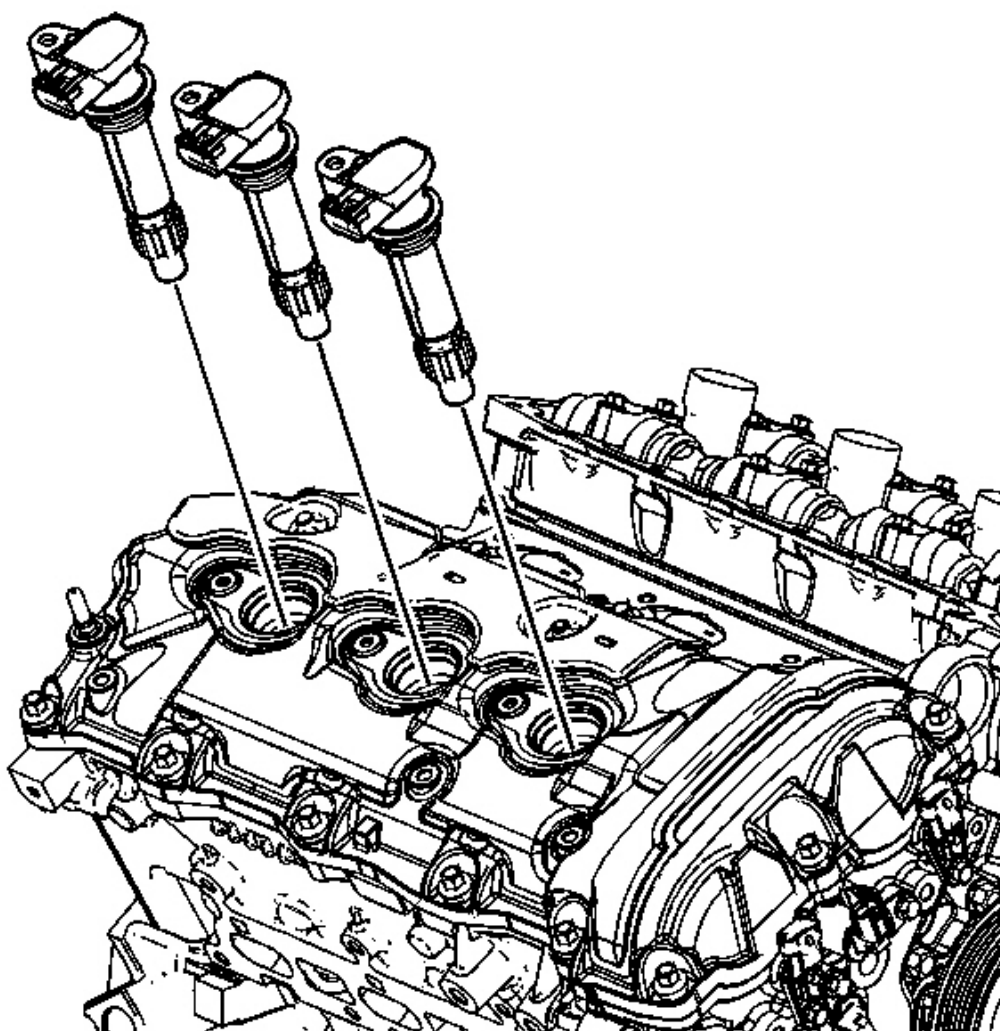


Fig. 128: View Of Ignition Coils
Courtesy of GENERAL MOTORS CORP.

10. Install the ignition coils.

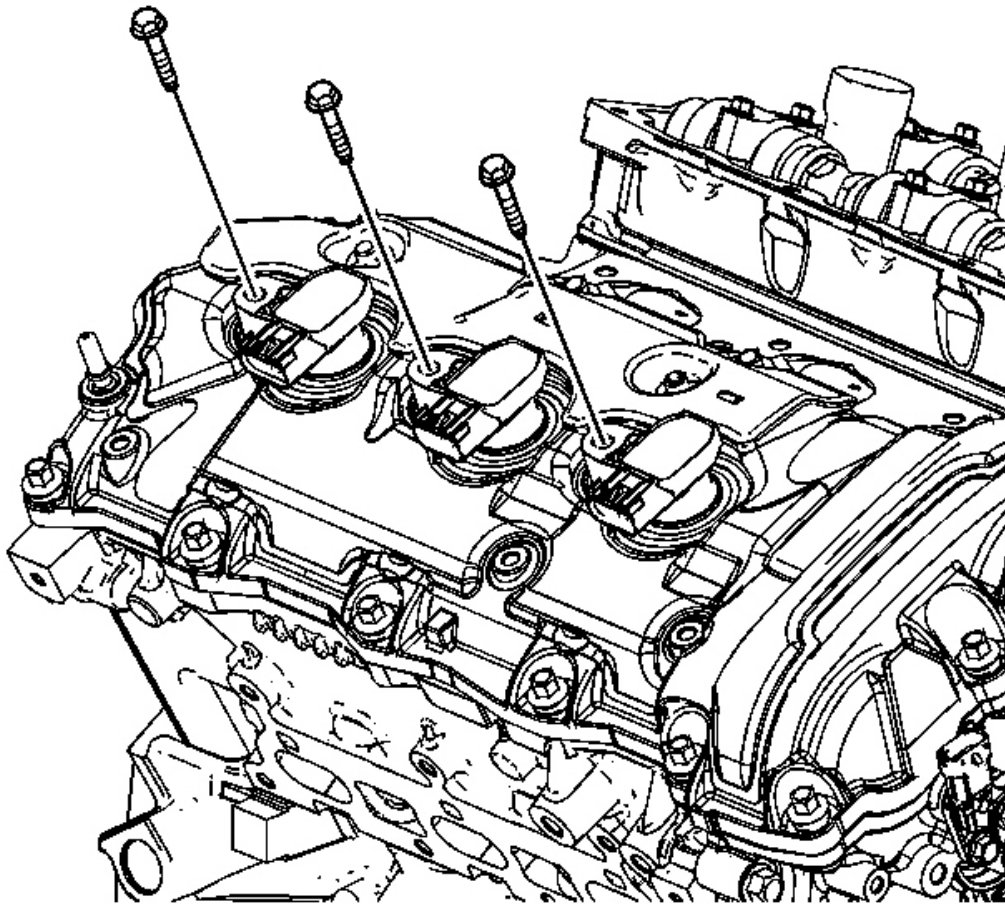


Fig. 129: View Of Ignition Coil Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the ignition coil bolts and tighten to 10 N.m (89 lb in).

INTAKE MANIFOLD INSTALLATION (LF1 OR LFW)

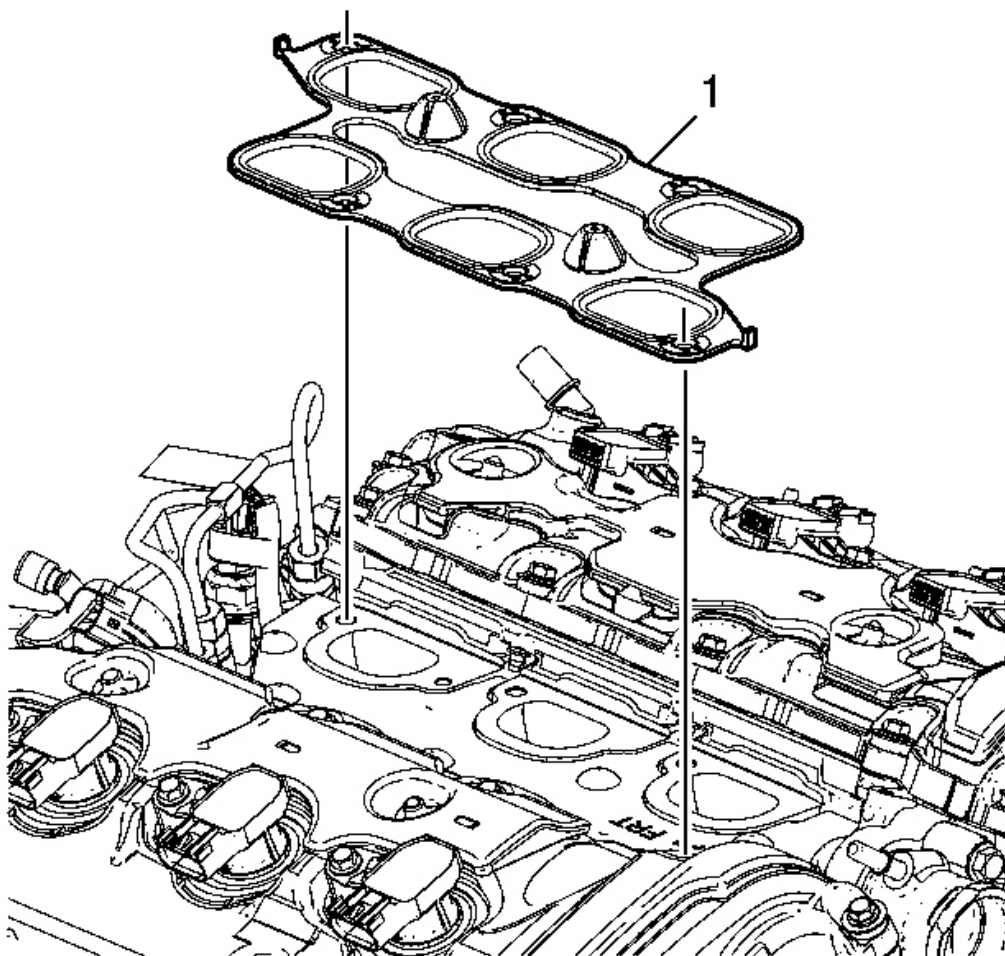


Fig. 130: Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW intake manifold gasket (1).

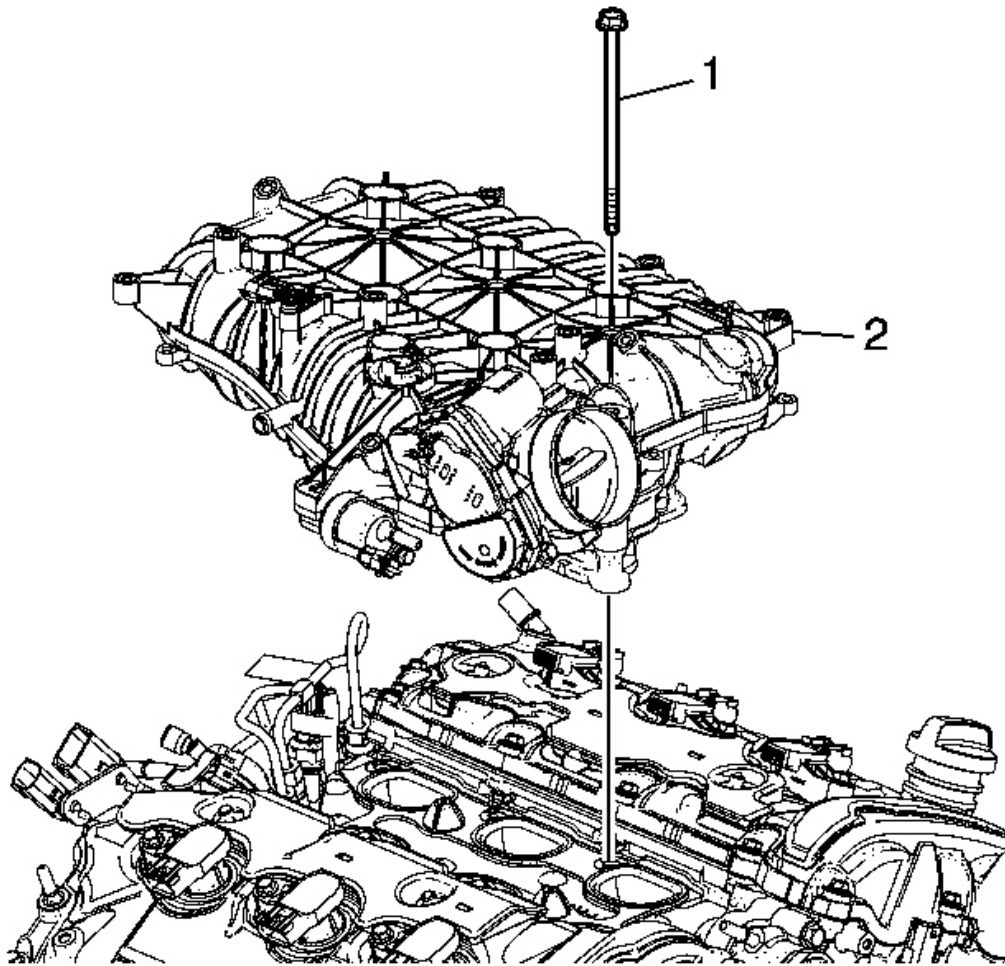


Fig. 131: Intake Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold assembly (2).
3. Install the intake manifold bolts (1).

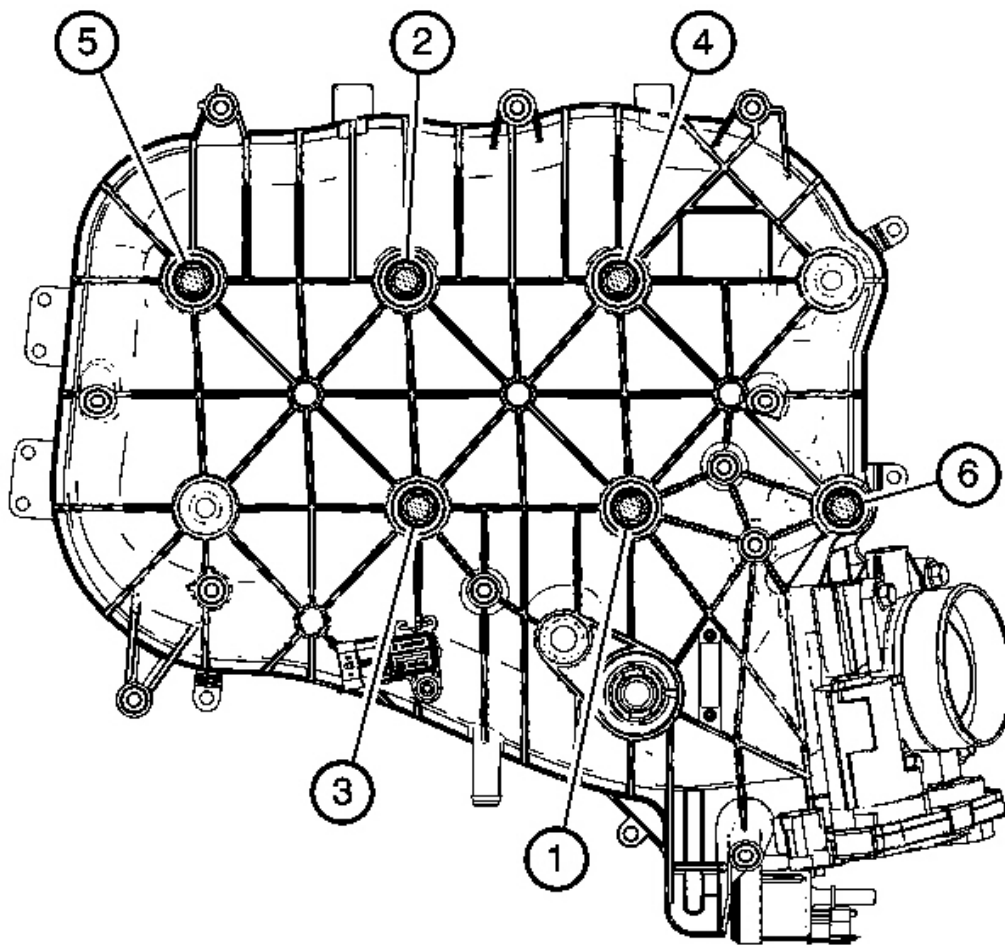


Fig. 132: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. 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).

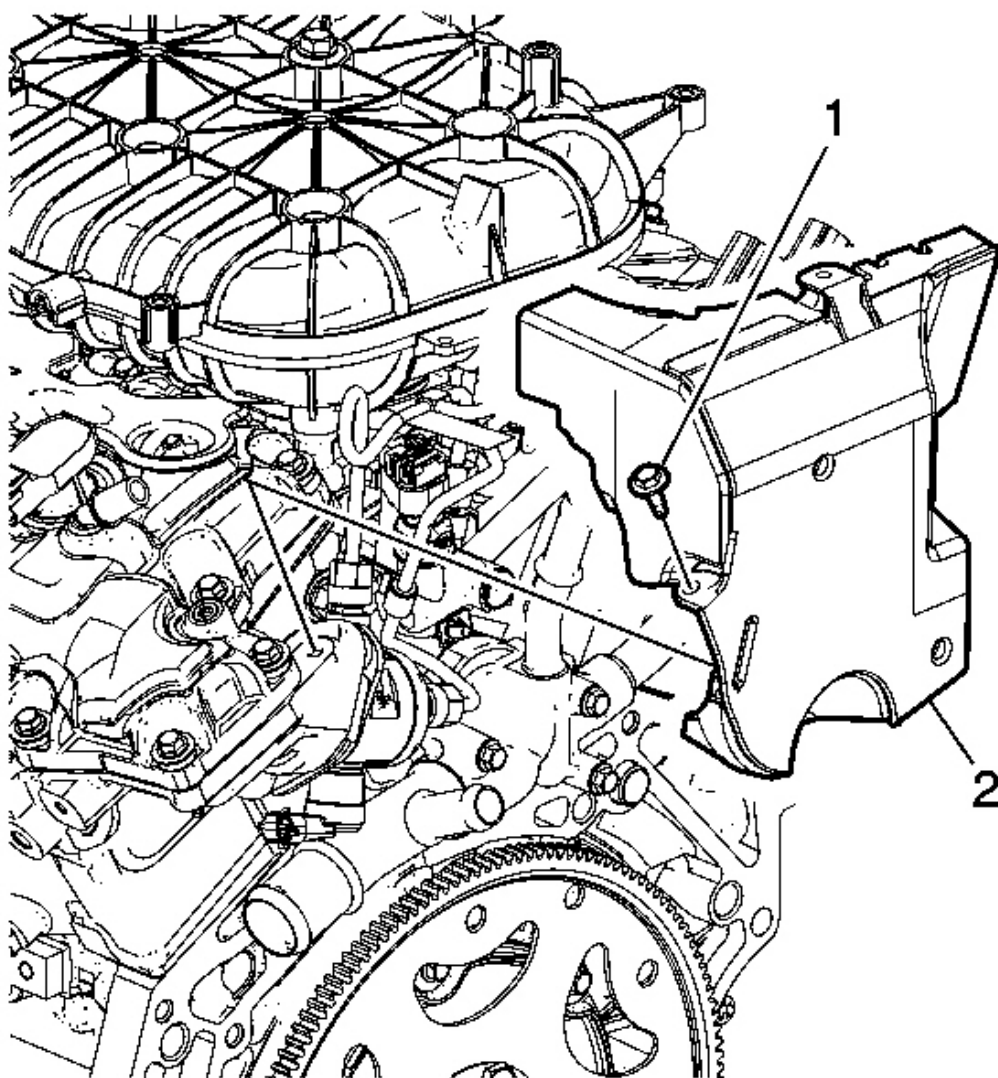


Fig. 133: Fuel Pump Cover

Courtesy of GENERAL MOTORS CORP.

7. Install the fuel pump cover (2).
8. Install the fuel pump cover bolt (1) and tighten to 10 N.m (89 lb in).

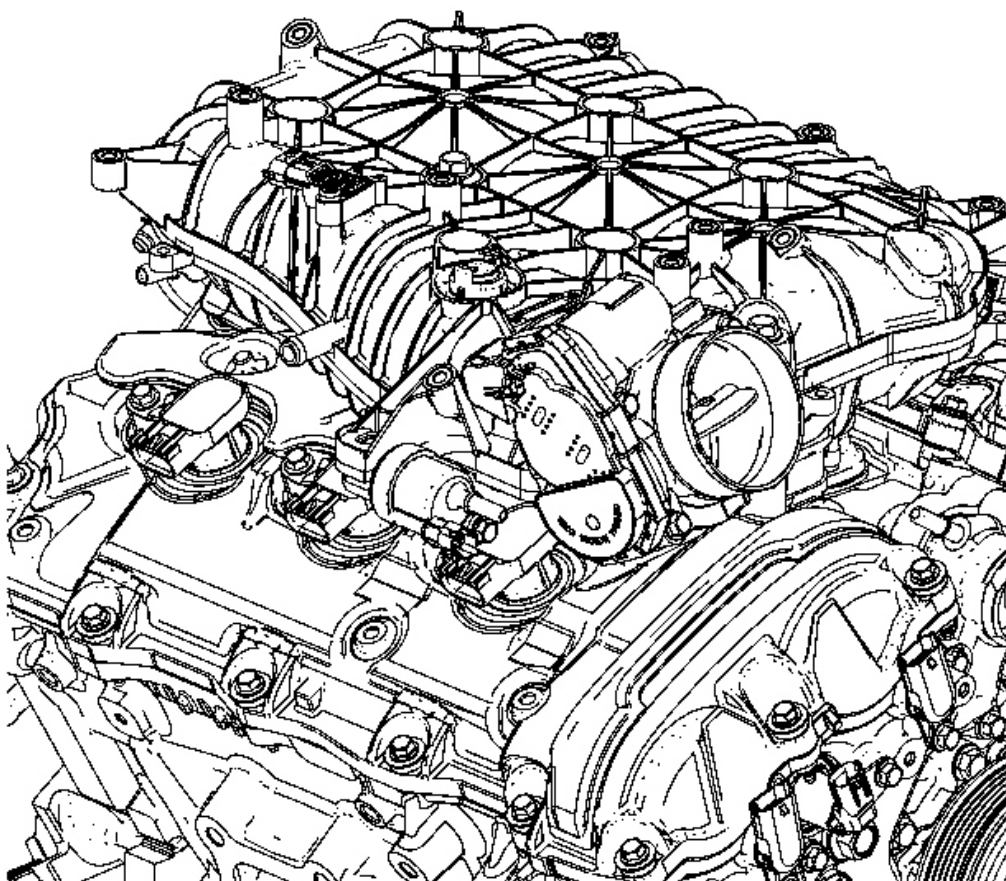


Fig. 134: Upper Intake Manifold & EVAP Solenoid
Courtesy of GENERAL MOTORS CORP.

9. Connect the evaporative (EVAP) hose to the upper intake manifold and EVAP solenoid.

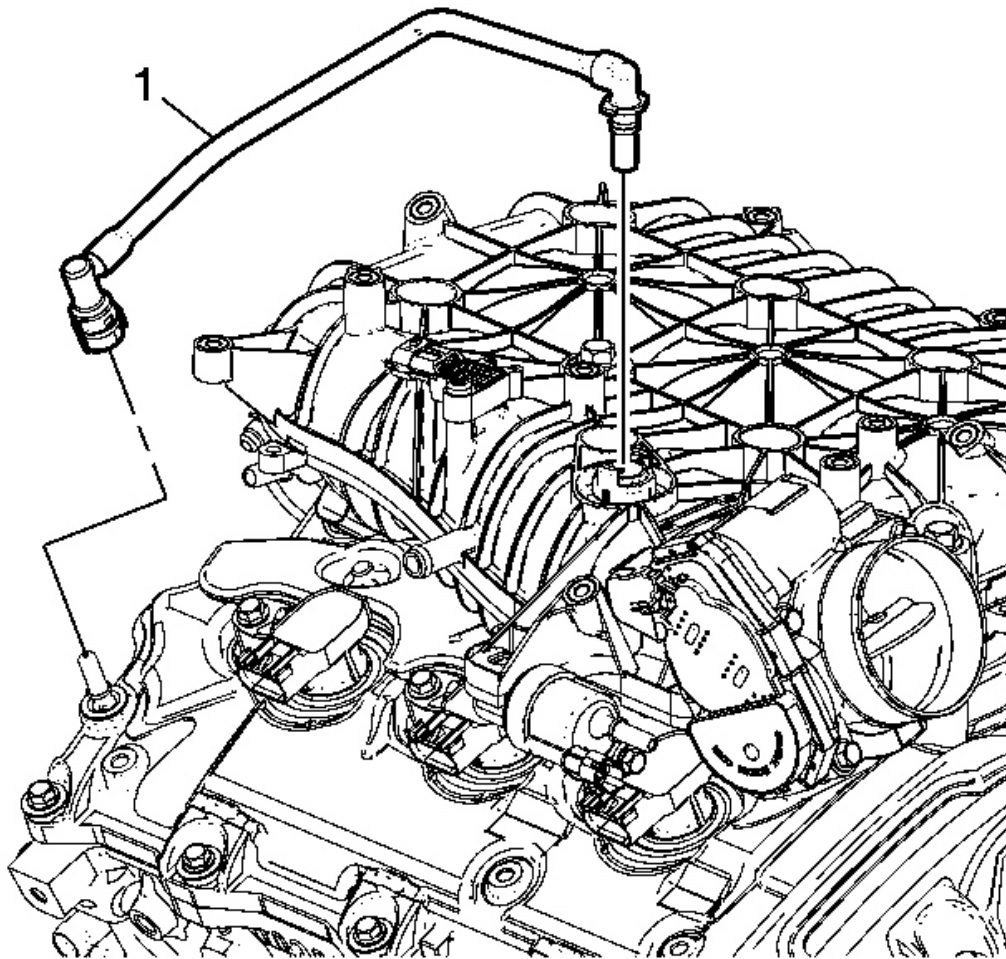


Fig. 135: Positive Crankcase Ventilation (PCV) Tube Assembly
Courtesy of GENERAL MOTORS CORP.

10. Connect the positive crankcase ventilation (PCV) tube assembly (1) to the upper intake manifold and the right camshaft cover.

ENGINE FLYWHEEL INSTALLATION

Special Tools

- **EN 45059:** Angle Meter
- **EN 46106:** Engine Flywheel Holding Tool

For equivalent regional tools, refer to **Special Tools**

1. Place the engine flywheel in position on the crankshaft.
2. Install 2 NEW bolts in location at the top and bottom of the engine flywheel bolt pattern allowing the engine flywheel to hang in position.

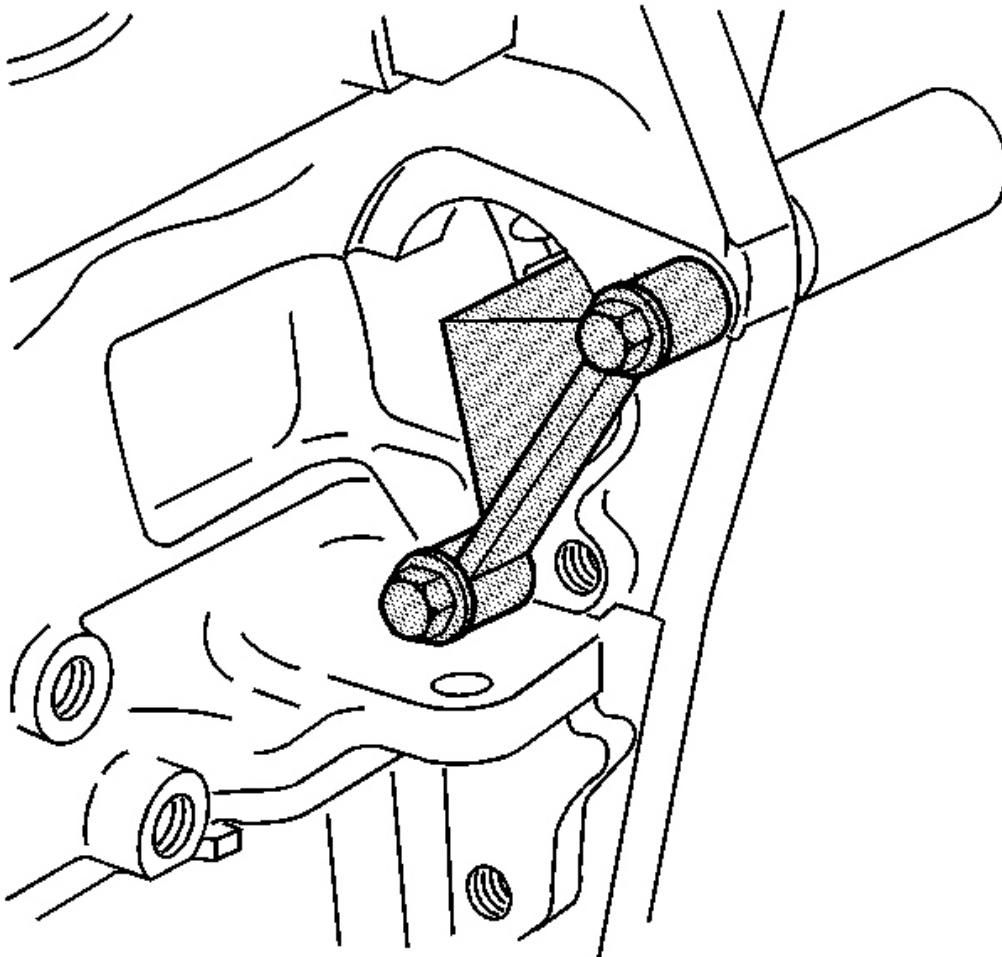


Fig. 136: View Of Tool EN 46106
Courtesy of GENERAL MOTORS CORP.

3. Install the **EN 46106**: tool.

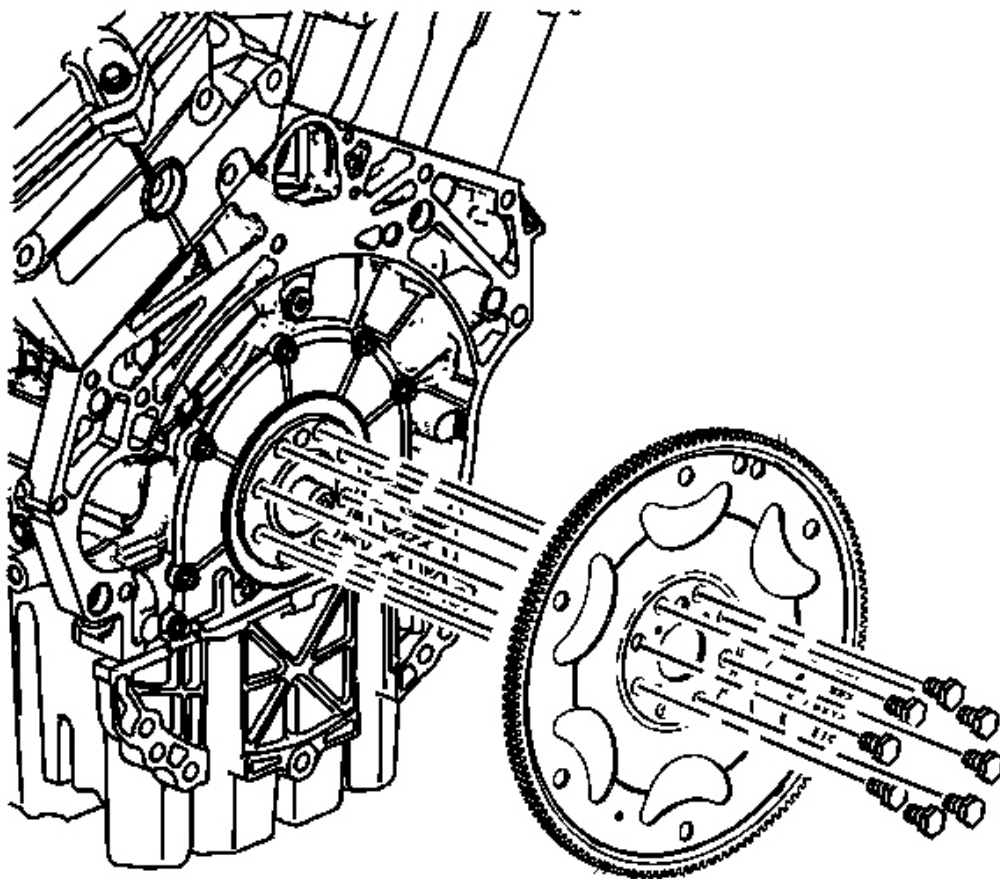


Fig. 137: View Of Engine Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Install the remaining NEW engine flywheel bolts.
 1. Tighten the NEW engine flywheel bolts to 30 N.m (22 lb ft) .
 2. Tighten the NEW engine flywheel bolts an additional 45 degrees using the **EN 45059:** meter .

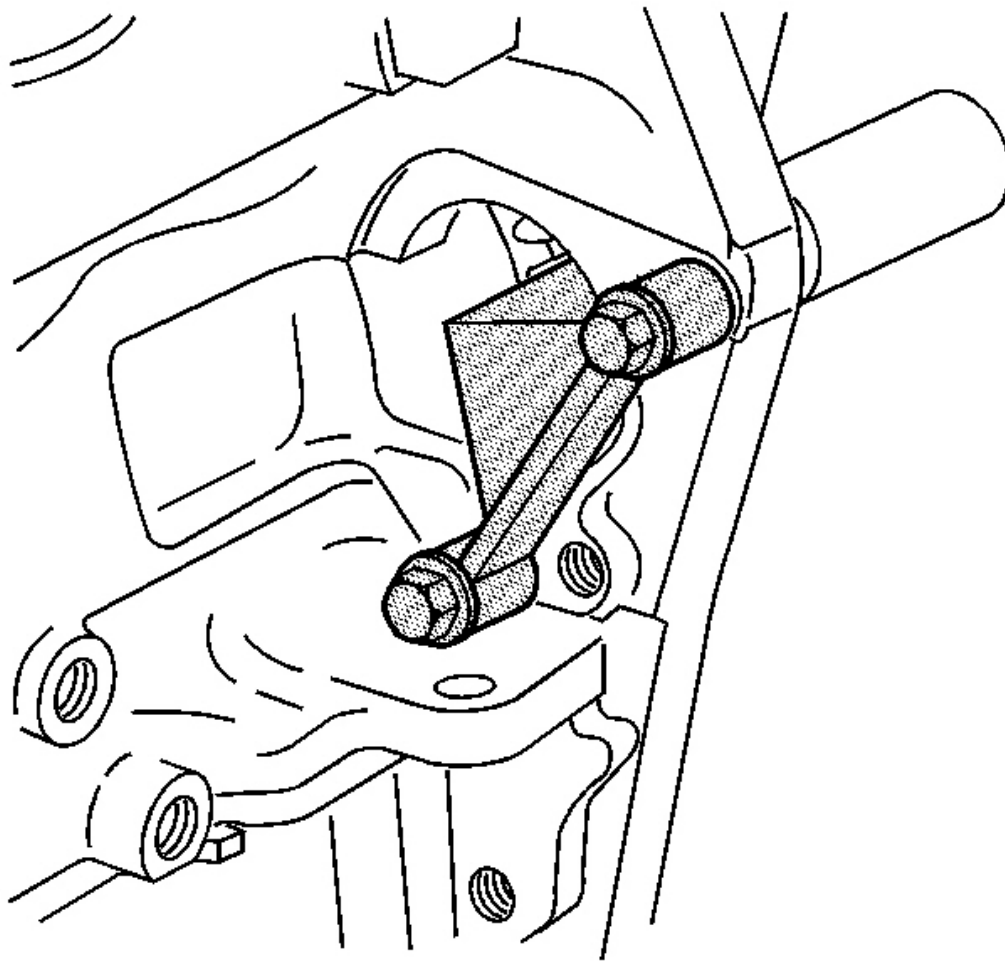


Fig. 138: View Of Tool EN 46106
Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46106**: tool.

CRANKSHAFT BALANCER INSTALLATION

Special Tools

- **EN 41998-B**: Crankshaft Balancer Installer
- **EN 45059**: Angle Meter
- **EN 46106**: Engine Flywheel Holding Tool

For equivalent regional tools, refer to **Special Tools** .

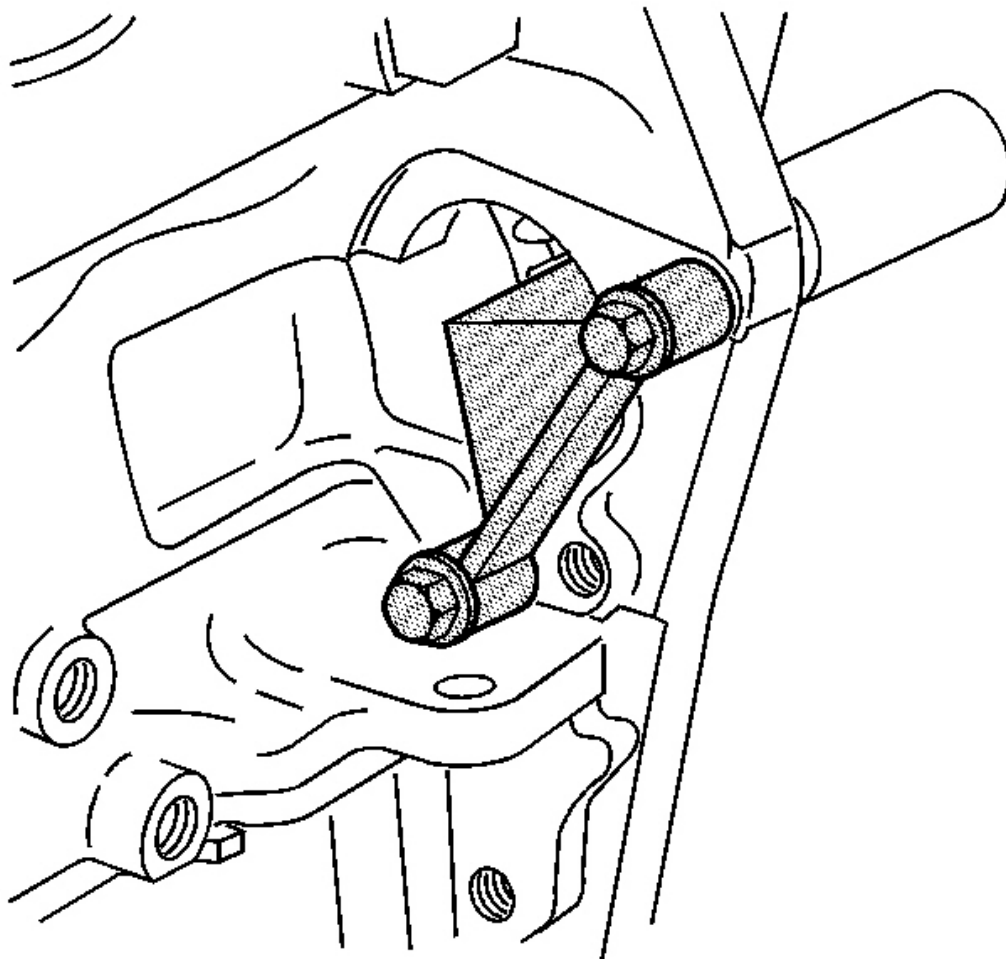


Fig. 139: View Of Tool EN 46106
Courtesy of GENERAL MOTORS CORP.

1. The **EN 46106**: tool must be installed onto the flywheel.
2. Use the **EN 41998-B**: installer, nut, bearing and washer to install the crankshaft balancer.

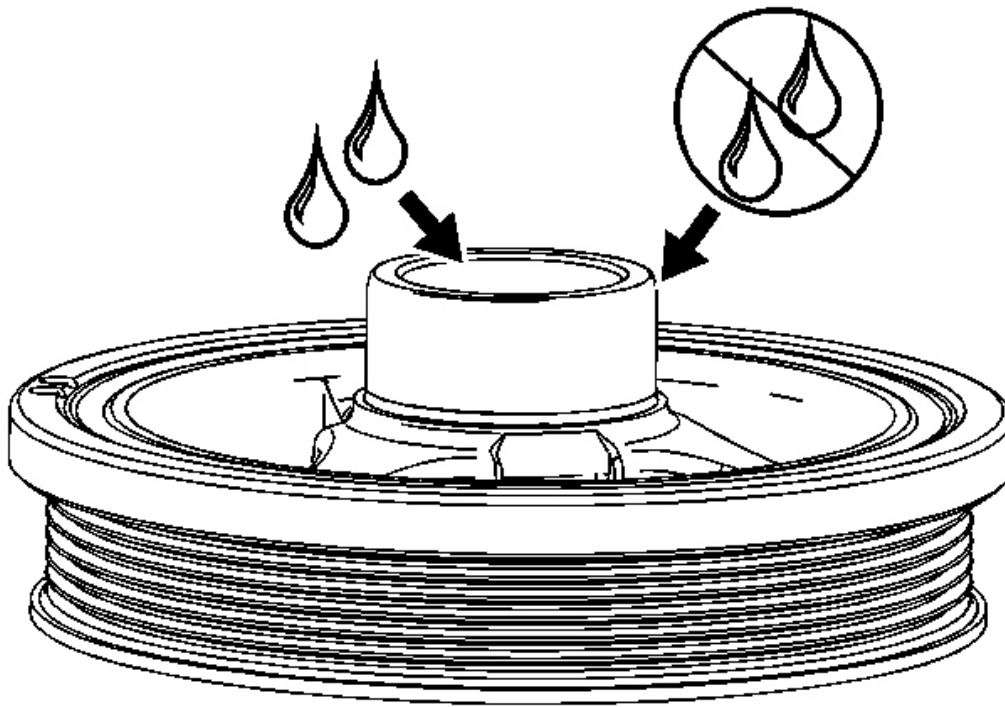


Fig. 140: Identifying Lubrication & Non-Lubrication Areas On Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

3. Apply lubricant to the inside of the crankshaft balancer hub bore.

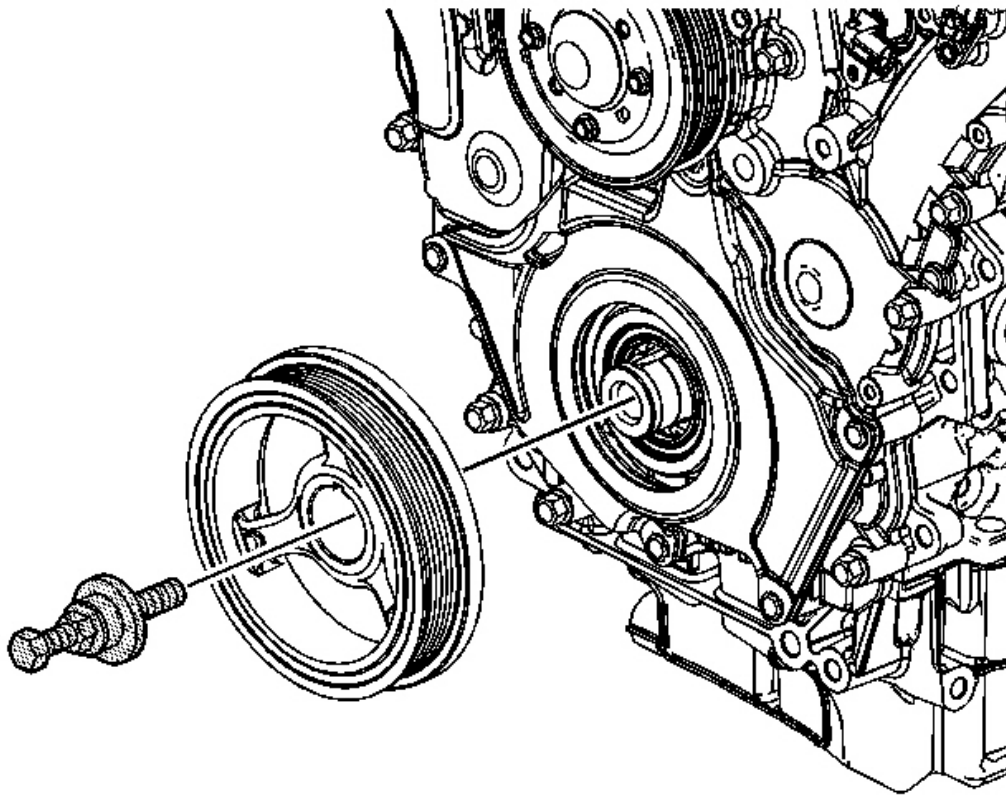


Fig. 141: View Of Crankshaft Balancer & Bolt
Courtesy of GENERAL MOTORS CORP.

4. Place the crankshaft balancer in position on the crankshaft.
5. Thread the **EN 41998-B:** installer in the crankshaft. Ensure you engage at least 10 threads of the **EN 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 **EN 41998-B:** installer.

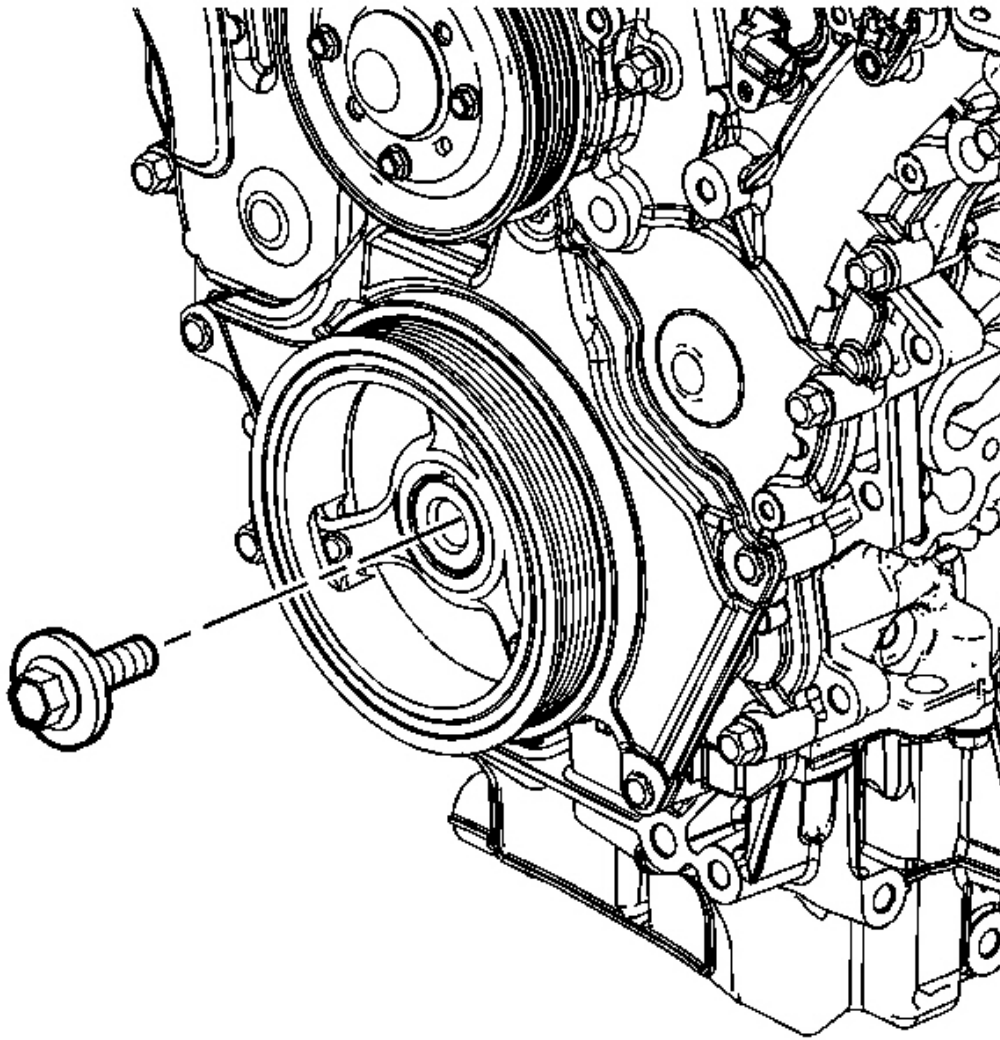


Fig. 142: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

8. Install the NEW crankshaft balancer bolt.

CAUTION: Refer to Fastener Caution .

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 **EN 45059:** meter .

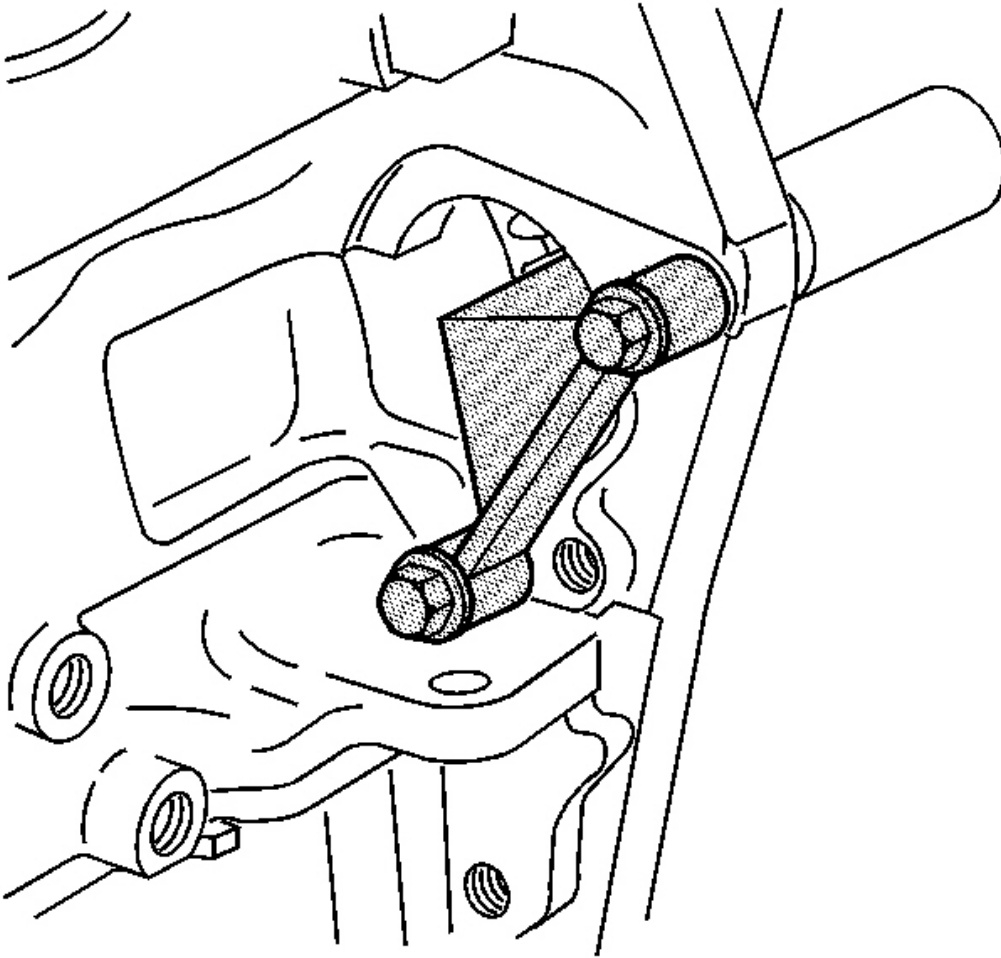


Fig. 143: View Of Tool EN 46106
Courtesy of GENERAL MOTORS CORP.

10. Remove the **EN 46106:** tool.

OIL FILTER ADAPTER INSTALLATION

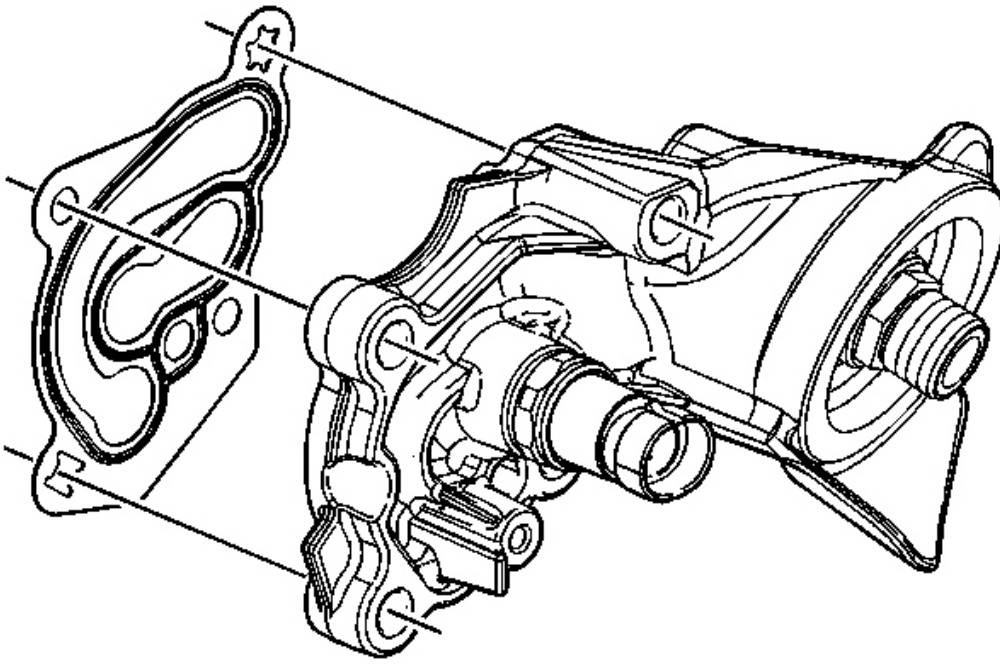


Fig. 144: View Of Oil Filter Adapter & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Position a NEW oil filter adapter gasket onto the oil filter adapter.

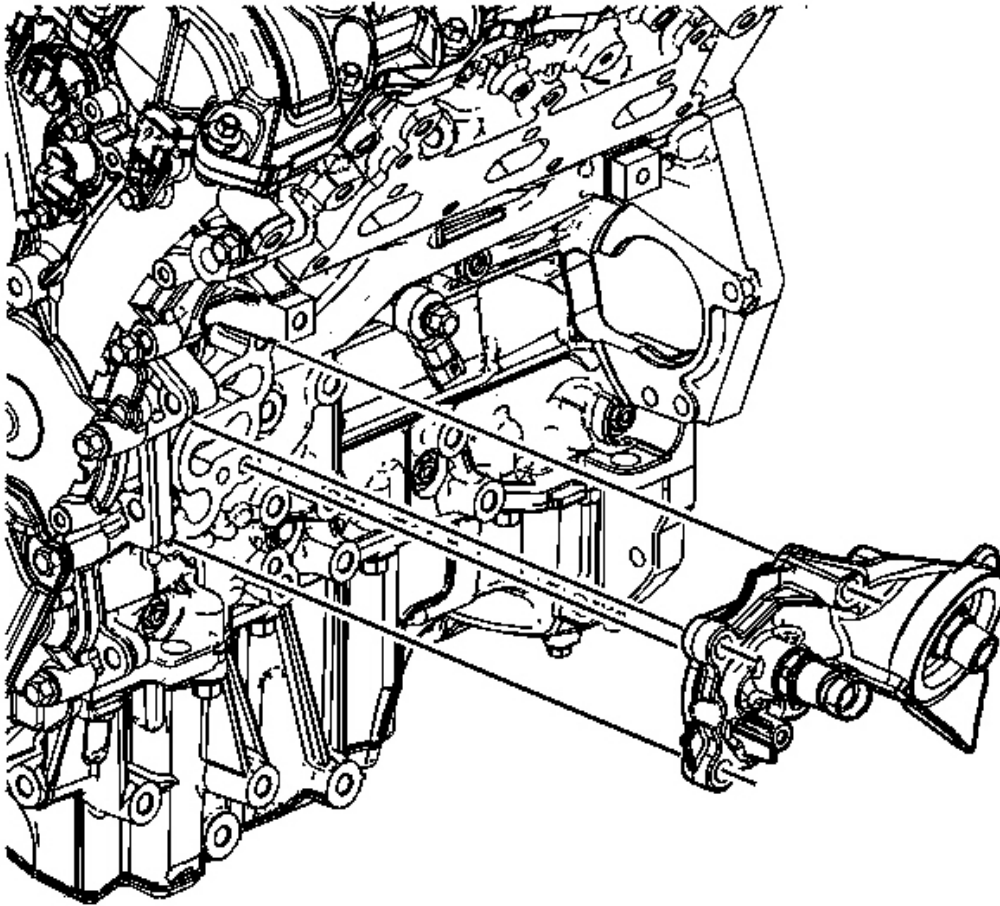


Fig. 145: Removing/Installing Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

2. Place the oil filter adapter into position.

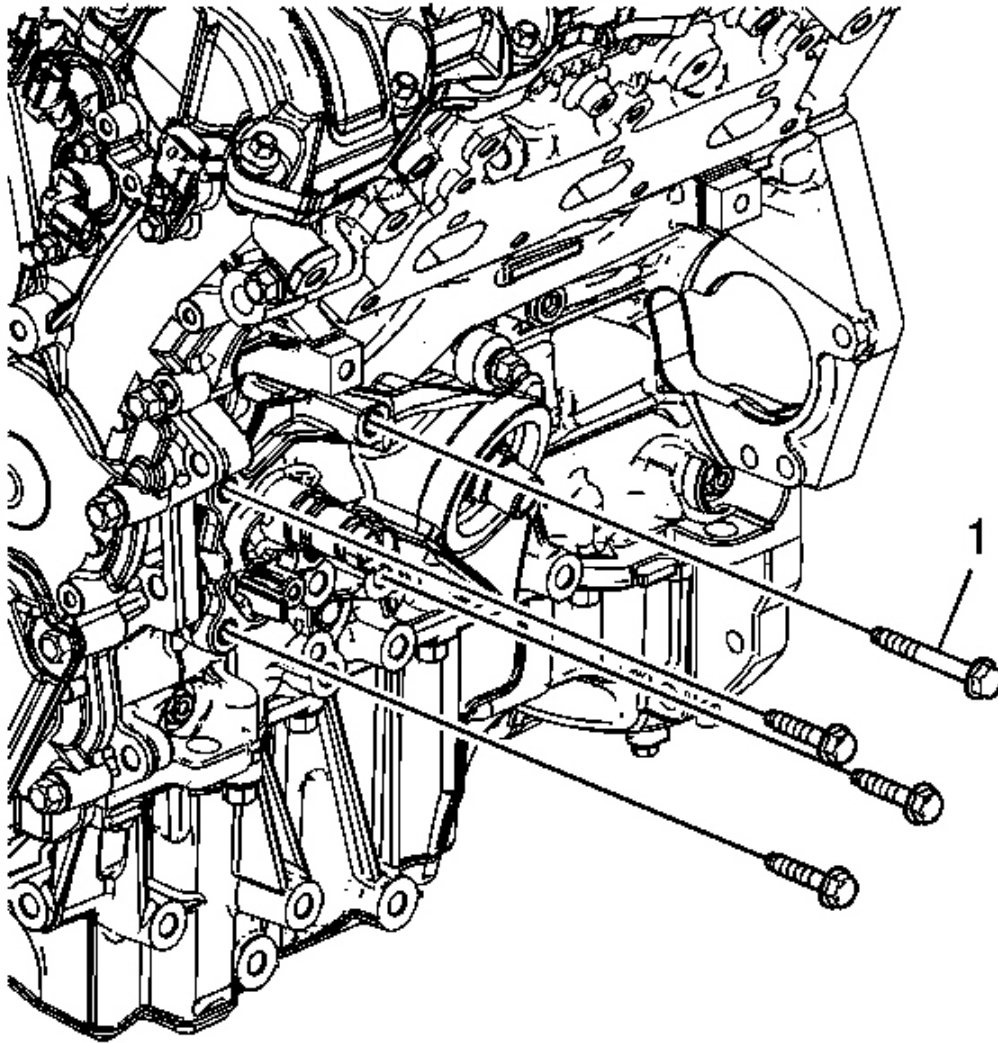


Fig. 146: Identifying Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the oil filter adapter bolts. Ensure the longer bolts (1) is installed in the upper rear position and tighten the oil filter adapter bolts to 25 N.m (18 lb ft).

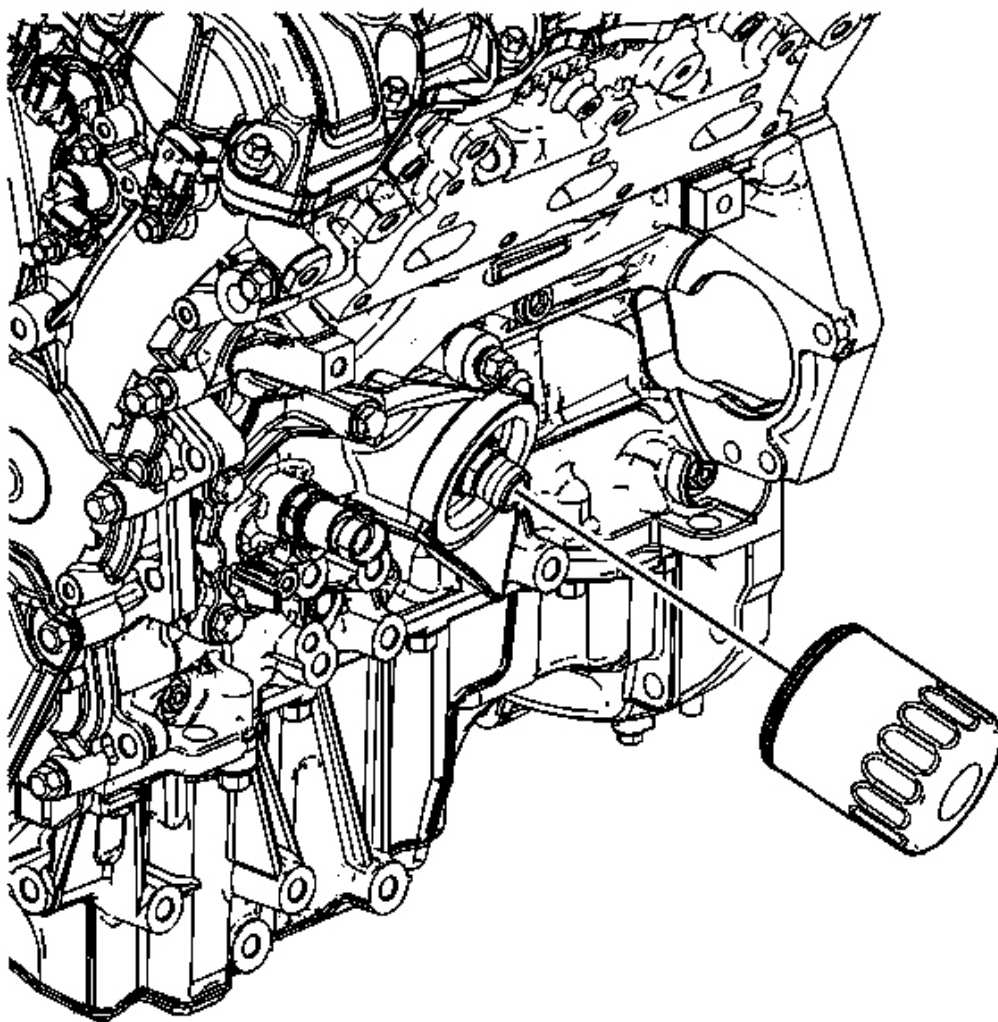


Fig. 147: Removing/Installing Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. Install a NEW oil filter.

OIL LEVEL INDICATOR AND TUBE INSTALLATION (LF1 OR LFW)

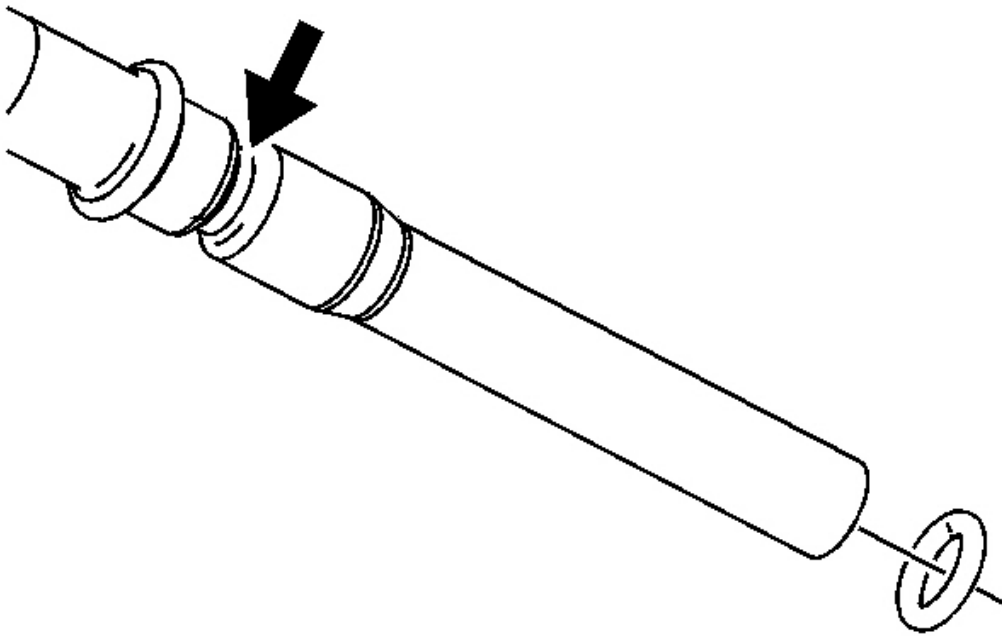


Fig. 148: View Of Oil Level Indicator Tube O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW O-ring on the oil level indicator tube.

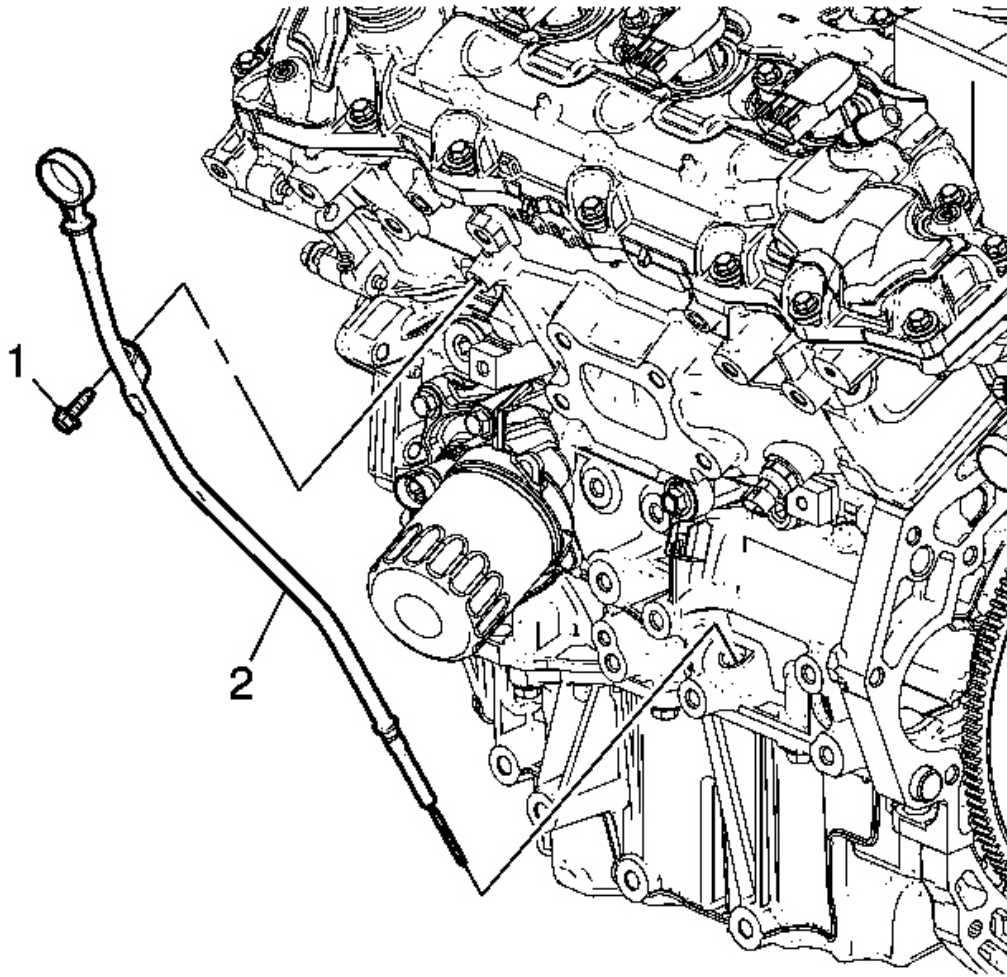


Fig. 149: Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

2. 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

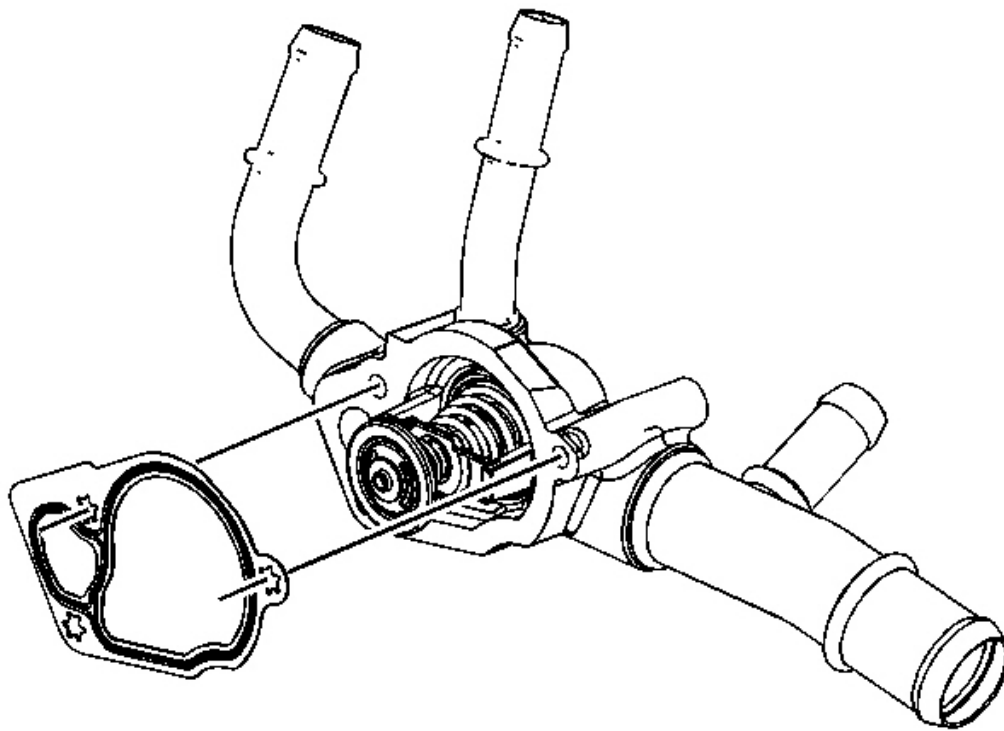


Fig. 150: View Of Thermostat Housing Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW gasket onto the thermostat housing.

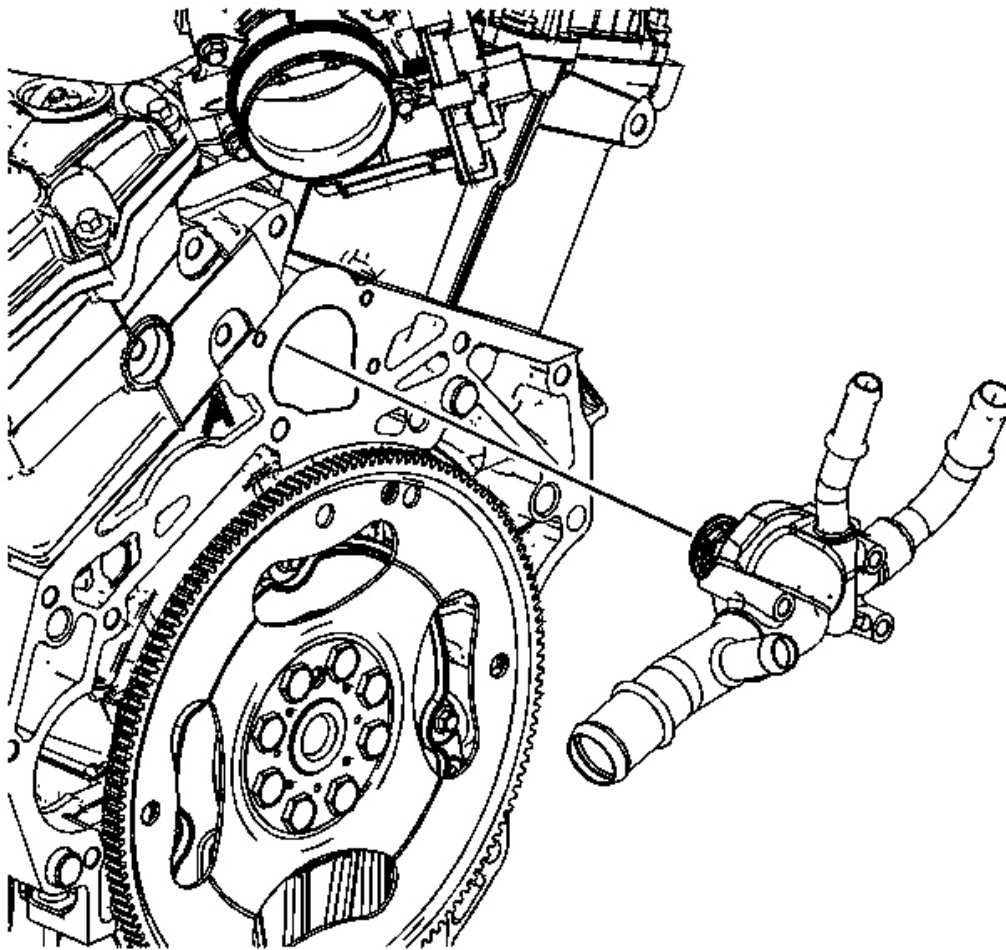


Fig. 151: View Of Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

2. Install the thermostat housing.

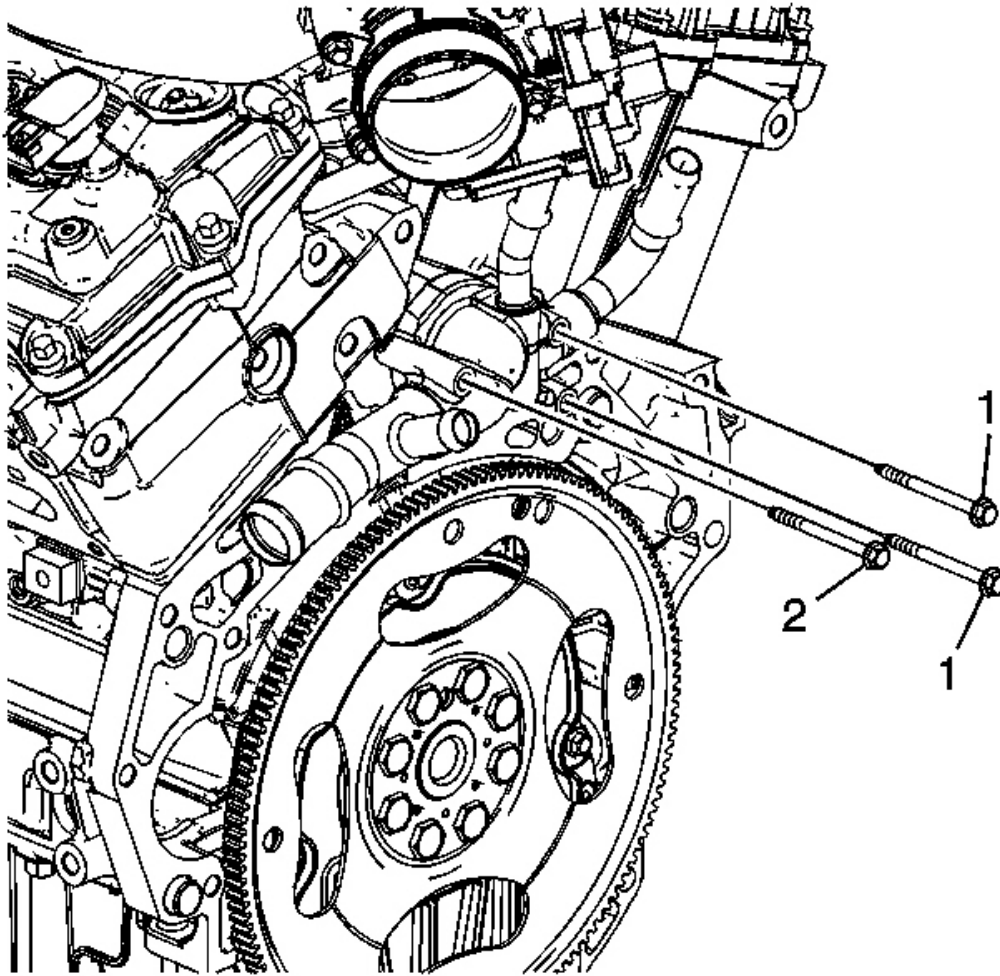


Fig. 152: Identifying Thermostat Housing Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the thermostat housing bolts. Ensure to install the short bolts (1) and the long bolt (2) in the proper position and tighten to 10 N.m (89 lb in).

WATER OUTLET INSTALLATION

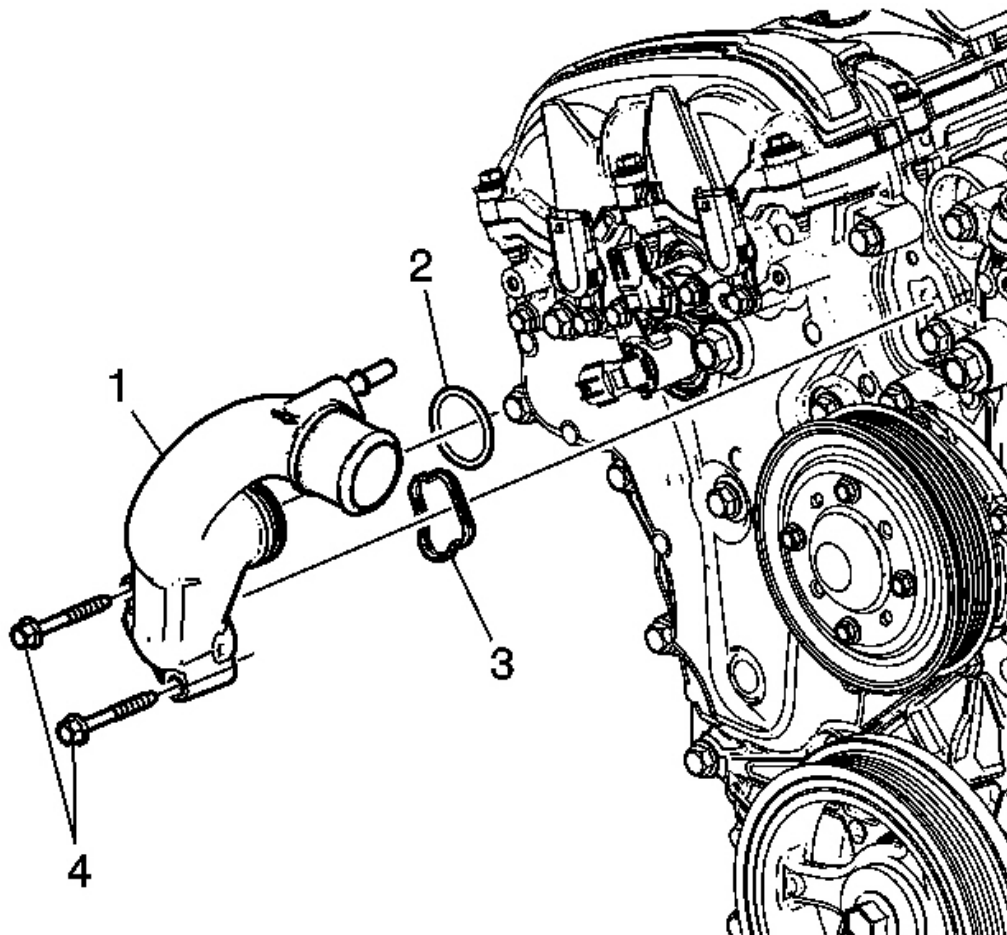


Fig. 153: Water Outlet Components

Courtesy of GENERAL MOTORS CORP.

1. Install the NEW water outlet seals (2) and (3).
2. Install the water outlet (1).
3. Install the water outlet bolts (4).

DRIVE BELT TENSIONER INSTALLATION

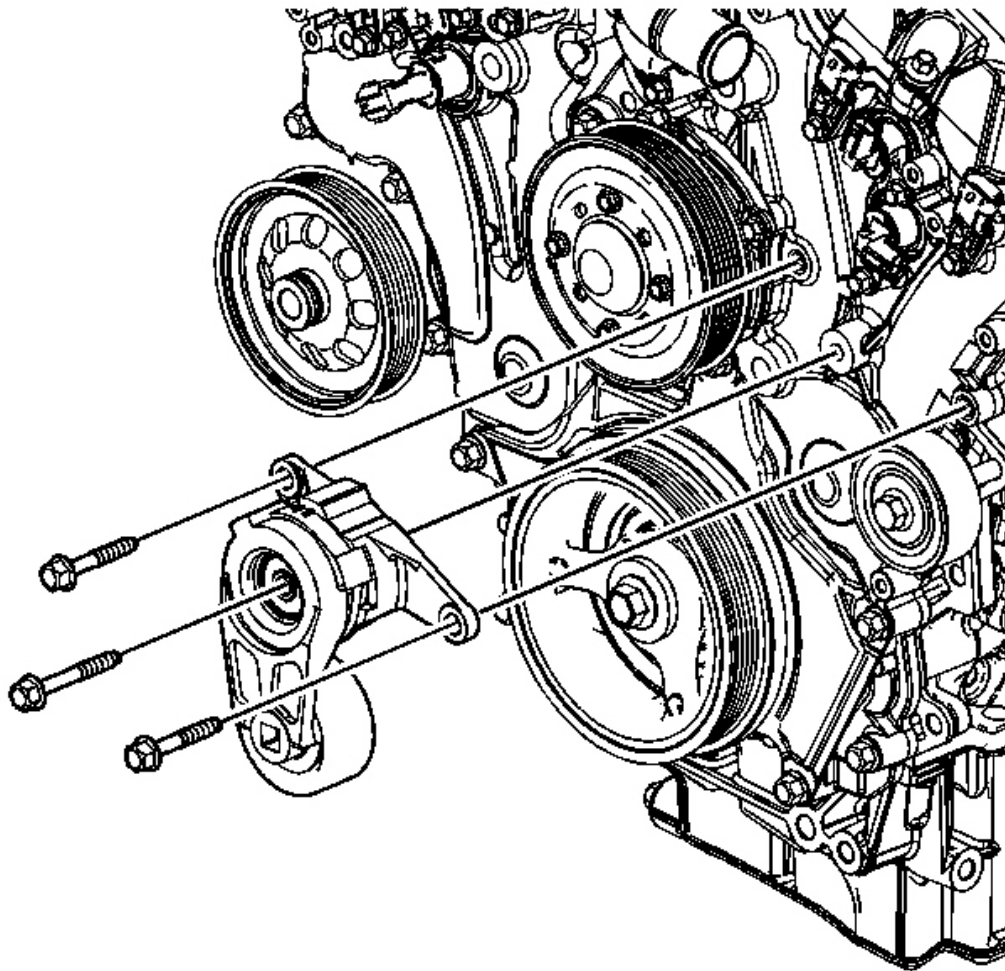


Fig. 154: View Of Left Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Place the left drive belt tensioner assembly in position to the engine front cover.

CAUTION: Refer to Fastener Caution .

2. Install the left drive belt tensioner bracket bolts and tighten to 25 N.m (18 lb ft).

ENGINE PRELUBING

Special Tools

- **EN 21867-6:** Oil Pressure Adapter Fitting
- **EN 45299:** Engine Preluber

For equivalent regional tools, refer to **Special Tools**

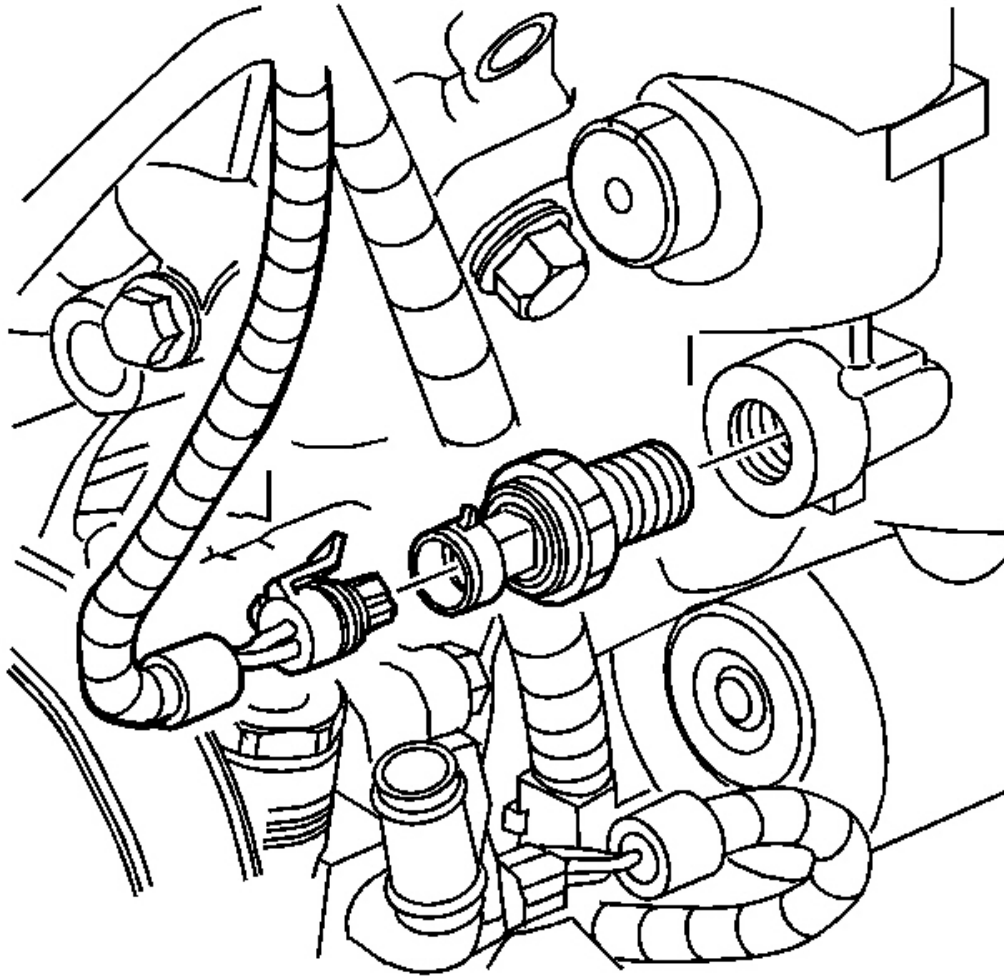


Fig. 155: View Of Oil Pressure Sending Unit
Courtesy of GENERAL MOTORS CORP.

NOTE: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the oil filter cap.
2. Install the NEW oil filter cartridge.
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.

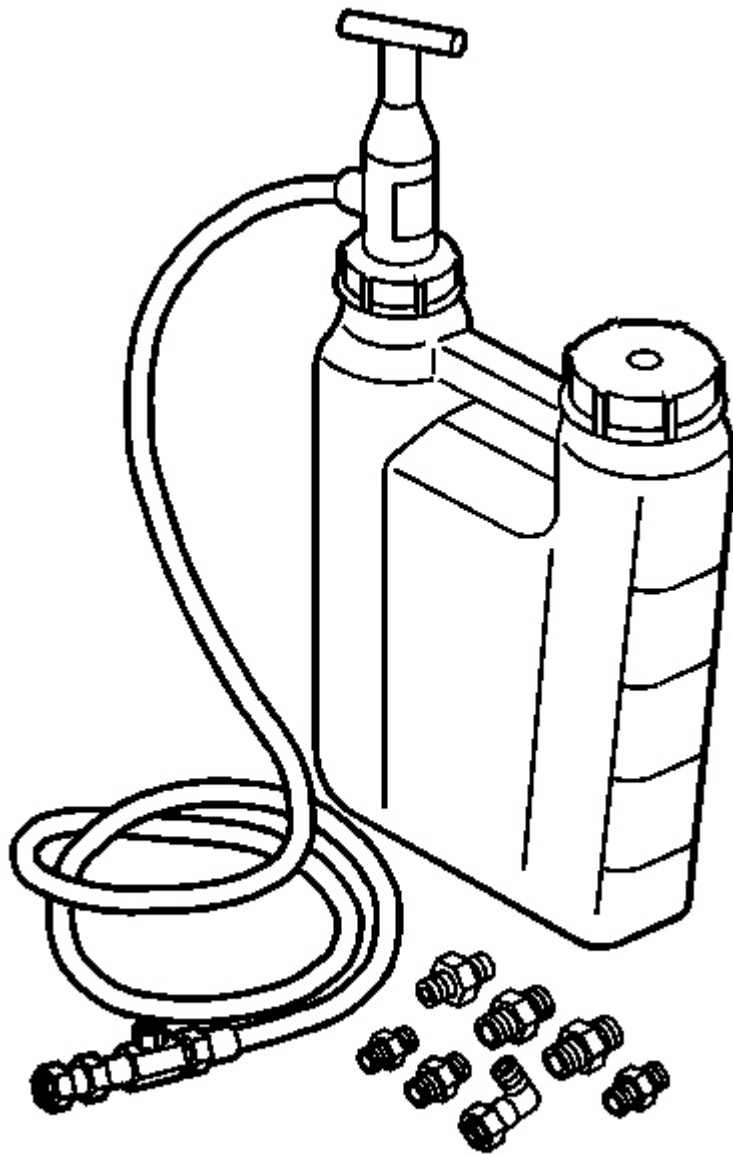


Fig. 156: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

7. Install the flexible hose to the adapter and open the valve.
8. Pump the handle on the **EN 45299**: preluber in order 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.